The Viking boat burial on Ardnamurchan

Oliver J.T. Harris, Hannah Cobb, Colleen E. Batey, Janet Montgomery, Julia Beaumont, Héléna Gray, Paul Murtagh & Phil Richardson

Introduction

Viking boat burials are iconic archaeological discoveries. Wonderfully preserved examples discovered at Oseberg and Gokstad in Norway have sparked the imagination, and both archaeologists and the general public remain fascinated by these acts of conspicuous consumption. In the UK, examples are well known from the Scottish islands, including Orkney (e.g. Scar: Owen and Dalland 1999), Shetland (e.g. Aith, Fetlar: Batey forthcoming) and Colonsay (Kiloran Bay: Anderson 1907), as well as from the Isle of Man (e.g. Balladoole: Bersu and Wilson 1966). Until recently, however, no intact boat burials had been excavated by archaeologists on the UK mainland. This changed in 2011 when the Ardnamurchan Transitions Project, which examines long-term change on the Ardnamurchan peninsula, Western Scotland, discovered and excavated a boat burial in Swordle Bay on the peninsula's north coast (figure 1). Although not as spectacular in size as some of the Scandinavian examples, it nevertheless represents a rich Viking grave, adding significantly to the corpus of examples from Britain. Dating most probably to the early 10th century AD, the grave assemblage included a rich collection of artefacts. An interim publication of our findings was made immediately after the excavation (Harris et al. 2012), and here we present the excavation in detail for the first time, alongside the grave goods and isotopic evidence that hint at a possible Scandinavian origin. This burial provides another important insight into the contacts between Scotland, Ireland, and the Viking homeland in the early 10th century. Furthermore, the assemblage also offers the opportunity to reflect on wider questions around the performance of identity.

The archaeology

The site in question was recorded in an initial survey as a low-lying mound close to the foreshore, which was respected by later rig and furrow agriculture. Upon excavation it was established that the mound itself was natural, with a central cut feature within which a large number of stones had been deliberately placed to form a boat-shaped setting measuring 5.2m by 1.7m at its widest point and orientated WSW-ENE (figure 2). This comprised numerous medium to large stones, including two layers of kerbing around the edge of the cut. Amongst the stones a spear head and shield boss were recovered, both significantly higher than the other finds described below, and presumably included as part of the process of closing the grave.

At the base of the feature, two finds-rich layers provided extensive evidence for the rivets of a complete clinker-built boat containing numerous grave goods. These included a sword, an axe, a large ladle containing a hammer and tongs, a drinking horn mount, a ringed pin, a sickle, a whetstone and flint strike-a-lights (all discussed below). Unlike the spear and shield, these items were placed next to the individual. The upper of these two layers also contained two teeth, lower left first and second molars from the same individual, which are the only identified human remains, the rest of the body having likely decayed in the acidic soil. Their location suggests the head was towards the west.

Turning this archaeological sequence around, we can reconstruct the burial. The process began with the cutting of a boat-shaped depression into a natural mound of beach shingle (figure 3). The boat was inserted into this cut after a brief period of silting (perhaps no more than a few hours). Into this was placed the body and around it the majority of the finds. Stones were then placed in and around the boat, beginning with two layers of kerbing, the spear and shield were included at this stage.

The finds

As noted above, the body was accompanied by a large finds assemblage (cf. Batey forthcoming). We will begin by discussing the boat itself, before moving round the craft to outline the artefacts, their spatial organisation and their potential relationship to the body. The vessel would have been a small rowing boat, and likely accompanied a larger ship, rather than being a serious sea going craft. It survived in the grave in the form of 213 rivets recovered in situ and recorded three dimensionally (figure 4), in addition to a handful of others which had been disturbed. This allows us to confirm the shape and size of the boat as being approximately 5.1m in length, clearly the burial of an intact craft. The survival of mineralised wood connected to the decaying rivets should allow for further information about the boat to emerge in due course as the project as a whole moves towards full publication.

Immediately behind the likely location of the head, towards the western end of the boat, was a large iron ladle. The pan was around 27cm in diameter with a handle over half a metre long. Various items had been placed within the bowl, including a hammer and a pair of tongs, as well as organic remains, potentially foodstuffs (Greaves 2011). Some mineralised wood fragments were also adhered to the base of the ladle, likely representing original boat timbers. The ladle has Scandinavian parallels as well as one more locally at Kiloran Bay on Colonsay, but is not a common find in a British context (Batey forthcoming).

Whilst the ladle was positioned behind the head, a number of other artefacts were placed on and around the body itself (figure 5). These included a single copper alloy ringed pin, which may have held the cloak or shroud around the deceased's neck (figure 6). The ring has three bosses, and this style appears to come from Ireland (Graham-Campbell and Batey 1998: 116), showing southward connections in addition to the Scandinavian associations elsewhere in the assemblage. In between the position of the pin and the ladle was a copper alloy drinking horn rim. Relatively undecorated, other than two simple incised lines, it could either be insular in origin or just as likely have a Scandinavian connection (cf. Paterson et al 2014: 149-151). The position of the drinking horn suggests it may have been laid to the south (or the right side) of the head. A series of other items were found more centrally in the grave, raising the question of whether they would have been on the body itself, or interred below it. These included a whetstone, probably made from southern Norwegian schist (Alsvik with Batey 2009, 294-5), flint strike-a-lights, and an iron sickle. The sickle is paralleled by several examples in Scotland such as Westness and Pierowall in Orkney (Graham-Campbell and Batey 1998: 135 fig 7.10 and 137 fig 7.11) and from Kneep in Lewis (Welander et al 1987: 151-2, 158-9). There are also many known in Norway as discussed by Petersen (1951: 515-516), particularly in the west of the country.

Located between the edge of the boat and the northwest (left) side of where the body may have lain was the sword (figure 7). This appears to have been deposited missing its tip, a feature also noted at Balnakeil in Sutherland (Batey and Paterson 2013: 637), and to have been bent in a shallow S-shape, potentially indicating deliberate damage before deposition – something we also see with the spear (see below). However this is uncertain because around the blade can be seen the remnants of leather from a sheath, and the latter's presence suggests that the change in sword shape took place after deposition. Further investigation of this material is required to resolve this question. What is clear is that adhered to the sword were mineralised textile remains. These may have come either from textile wrapping around the sword and sheath itself, or the clothes or shroud worn by the Viking in the burial, as perhaps paralleled at Scar (Nissan 1999, 109-110). Both the guard and the pommel of the sword are finely decorated with silver and copper wire. Typologically the sword seems to indicate a Petersen Type K, with suggestions of Type P and Type O (Batey forthcoming; Gareth Williams pers comm.; Petersen 1919). The sword provides the major evidence that this burial dates to, or at least has a *terminus post quem* of, the late 9th or early 10th century AD. To the east, perhaps near the feet, was a broad-bladed axe (figure 6). Similar examples from a slightly later date are known from Dublin (Halpin 2008: 164), and the wooden handle is present, in mineralised form, within the shaft. The last set of artefacts associated with the body was a closely packed selection of rivets found in the east end of the boat. These appear to have been deposited together, potentially in a bag; perhaps a repair kit?

The final artefacts found in the boat, the spear and shield boss (figure 6), come from higher in the burial deposited as part of the closing of the burial. This emphasis on the performative elements of the burial is supported by the fact that the spear head (Petersen Type E, Petersen 1919: 26-8) was deliberately broken before being deposited. The shield appears to have been deposited with this and although it has sustained damaged at the crown, and the flange is distorted (with traces of the shield board remaining), it remains unclear at what stage this damage occurred. Both were positioned centrally within the boat, and although the stones kept them separate from the corpse, it is likely they corresponded with the central or lower part of the body.

The isotopes

The two surviving teeth were micro-CT scanned to obtain a digital record prior to sampling for isotope analysis, as macroscopic preservation appeared to be poor (figure 8). As noted above they were identified (by the internal patterns of their root canals) to be lower left first and second molars. Both enamel and dentine were present in the lower second molar, and the CT scans demonstrated that both still retained the expected density and structure of modern tissues and the possibility of producing viable data.

To investigate this individual’s origins, strontium, oxygen and lead isotopes and strontium and lead concentrations were obtained from the enamel from the second molar crown which mineralises between the approximate age of two and six (AlQahtani et al. 2010). In addition, carbon and nitrogen isotope profiles were produced from incremental dentine samples from the same tooth following the method of Beaumont et al. (2013) and represent diet between the approximate ages of two and fifteen.

The Ardnamurchan individual appears to have consumed a largely terrestrial diet up to the age of fifteen with a period of increased marine protein consumption between the ages of three and five (figure 9). Isotopic evidence for marine protein consumption by humans is rare in Britain in the first millennium AD even at coastal sites (Barrett & Richards 2004; Buckberry et al. 2014; Curtis-Summer et al. 2014; Müldner & Richards 2007; Müldner et al. 2009) but both non-marine protein consumers and marine protein consumers are found in Viking Age Norway and children appear to eat less marine protein than adults (Kosiba et al. 2007; Naumann et al. 2014). Evidence for marine consumption in childhood may indicate the individual was living on or close to the coast.

The low oxygen isotope ratio of 16.7‰ shows that the Ardnamurchan individual did not originate from the place of burial on the western seaboard of Britain (figure 10). Oxygen isotopes also rule out the Northern and Western Isles of Scotland, western Britain and western Ireland. Both the strontium and lead isotopes are indicative of origins in a region of relatively old geology and thus rule out England and Wales, other regions of young sedimentary rocks, basalts and limestone and thus Denmark, which is predominantly limestones overlain by till and hosts a strontium isotope biosphere between 0.7081 to 0.7111 (Frei and Frei 2011). This would be difficult to reconcile with the Ardnamurchan individual's strontium isotope ratio of 0.7112. The combined evidence, including the very low level of lead exposure experienced by the Ardnamurchan individual (0.4 mg/kg), suggests origins in a region of ancient, possibly Precambrian, geology with little or no environmental lead pollution. Given there are no significant lead deposits in Denmark, southern Norway or western Sweden (Reimann et al. 2012), and Scandinavia lay outside the Roman Empire, which heralded the advent of increased lead levels in humans in first millennium AD Britain (Montgomery et al. 2010), lead levels below 0.5 mg/kg have been proposed as an indicator of Scandinavian origins in Viking period burials in Britain (Montgomery et al. 2014). Places which are consistent with all the isotopic and trace element evidence are thus eastern Ireland, northeastern mainland Scotland, Norway and Sweden. Further details and contextualisation of the isotope results can be found in the accompanying supplementary material.

Materialising identities

There is clearly much to be gained from a comparison between this boat burial and others across the Scandinavian world (see papers in Crumlin-Perdersen and Thye 1995) both in terms of identity and the broader cosmological understandings at work. In this paper, however, we want to use the available space to focus on this specific grave, and on what it tells us about the identity of this particular person. Identity is a matter of performance and citation (Butler 1993; for discussion of identity in archaeology see Fowler 2010; on Viking funerals and performance see Price 2010). It is performative, in that it is produced through people’s actions, and through their relationships with the world around them. It is not somehow intrinsically held within a person, but rather is an ongoing process of becoming through life, a process that enfolds both the body (Robb and Harris 2013: 16-7) and material things (Harris 2016). That the dead do not bury themselves is an old archaeological maxim, but neither do the living produce a sense of identity alone. Whether dead or alive, the materiality of bodies and things has a force that cannot simply be ignored in the production of identity. Critical here is the notion of citation, the concept that when people act in certain ways, or deposit certain material things, they bring with them connections to other places, events and people (Butler 1993: 13; Jones 2007: 80-1).

When we consider this burial what can we say about identity? There are at least three terms we could potentially use to describe this: Norse, warrior and high status. The evidence for the former comes from the boat, and the connotations of travel and voyaging this brings with it (cf. Williams 2014: 397), from the material culture from Scandinavia and Ireland, and the evidence from the teeth that survive. Although a place of origin cannot be definitively proven from the isotope evidence alone, their combination with the material from the grave itself perhaps suggests a Scandinavian origin, though Ireland cannot be ruled out. The evidence for a warrior identity lies of course in the weapons in the grave, though this imposes a rather traditional assumption that grave goods belong unproblematically to the deceased, and simply disclose their identity. Finally, it is the whole assemblage, both the artefacts and the nature of their elaborate interment, which suggests a notion of high status. None of these categories exist as absolutes, however, they are all materialised and cited through the relationships expressed by the material objects in the grave. These identities emerge in the location of a person's final resting place and in the relationships that person may have held with other places and other times whilst alive.

What about gender? We have no evidence from the body on which to assign this. Although a traditional reading might suggest that this was the burial of a man based on the recovery of the sword and the wider set of grave goods (McGuire 2016; although see McLeod 2011), any reading remains highly interpretive. What a consideration of identity rooted in notions of citation and performativity allow us to do is to engage with how concepts of masculinity are being cited through the weapons in the grave, the absence of jewellery and so on. Whether the body itself would be biologically sexed in the present as male or female is of less importance than the kinds of identity cited by the assembled grave goods. Indeed perhaps there are material elements here that complicate the narrative we ourselves are weaving. Sickles in burials in Scotland are more often associated with females, although in the Norwegian context Peterson (1951: 515-516) has noted a much greater preponderance with males. Furthermore, new work on female Norse warriors also indicates the complexity of gender in this period (Gardela 2013). The assumption that Norse gender categories were as binary as was once suggested now needs to be approached with caution.

Beyond these major strands we can tease out a number of important other dimensions through which identity was performed; there are many other objects that equally embodied other connections, relations and possibilities for practice. The placing and treatment of different items within different parts of the burial – the sword and axe on the left, the drinking horn on the right, the ladle behind the head – point to potential conceptual schemas or cosmologies materialised in these deliberate choices. Meanwhile the pan, the hammer and tongs, the strike-a-lights and the whetstone speak to the rhythms of daily life, of cooking and work, just as the sickle links the body to farming and food production. The importance of repair, of the embodied work of maintaining objects and crafts, is cited in the bag of rivets at one end of the boat and the whetstone in the centre. We may not choose to label these activities with terms like 'Viking' or 'warrior', but they are nonetheless important elements of the identities that are materially constructed in these acts of deposition. Here identities of seafaring and farming, of distant journeys and local connections, entwine with those materialised around a hot forge, or a domestic hearth. The absent body is made present to us through the full range of relations disclosed. Similarly, whilst we concentrate on what the isotopes tell us about where this person grew up, they also tell us about their childhood, and the increase in consumption of marine animals between the ages of three and five show us the changing world in which this person grew up.

It is not, however, only the identity of the dead that are transformed through these kinds of performative practices. Places are changed by the links constituted between Norway, the Irish Sea and Ardnamurchan through the material associations engendered in the acts of deposition. Just as they speak to us of origins and connections, so these 'pieces of places' (*sensu* Bradley 2000: 88) created associations between Swordle Bay and the broader Norse world. They may have materialised the journeys the deceased took in life, the narrative of their individual history (Price 2010: 147) as they travelled from Scandinavia, over the sea and round the Scottish coast, potentially along the way meeting and trading with people from Dublin. New kinds of memory and connectivity are forged here as others have argued, connecting migrant identities to these new places (c.f. McGuire 2010: 193; 2016) We could use the stable isotope data to speculate further, with its similarities to the female burial A at Cnip (see figure 10 and supplementary evidence). This burial is also a similar date (Welander et al. 1987: 169). Could the occupants of these two burials, who likely grew up in close geographic, and probably chronological, proximity, have remained in contact after leaving their homeland? A visual contact is certainly maintained, with a view of the Outer Hebrides possible from Swordle Bay on a clear day.

We should also remember the other identities performed and transformed here amongst the people involved in digging the boat-shaped grave, dragging the boat on to the foreshore and burying it, 1000 years ago. It is all too easy to employ clinical archaeological conventions when we discuss the cut of the grave and the deposits therein; the stone lining, the deposition of the body and grave goods. Yet these are not just representative of physical 'events in time' but of bodily actions undertaken, of moments of grief, and of identities performed. For those individuals undertaking the actions caught up in the burial, and those watching, they too became different, through the memories and connections they made (Williams 2014). Price (2010) has written of the drama of Viking funerals, and we can imagine this here also. The boat set into the ground, the sword bent, the spear snapped. If the latter find and the shield associated with it were deposited later this suggests a different kind of relationship was being formed between these objects and the deceased, perhaps hinting at specific kinds of relations with the living that endured, and the way the grave facilitated 'post-funeral engagements' (Williams 2014: 404).

Assembling places and persons

In the final section of this paper we want to consider an important question: Why was this Viking buried *here* (cf. Williams et al. 2010)? Until very recently both local and long distance movement here was characterised by sea travel, and Ardnamurchan's place in the wider seaways of the Outer and Inner Hebrides was highly important. It is a distinctive swathe of land that is circled by islands; Mull to the south, Coll and Tiree to the West, the Small Isles of Eigg, Rum, Muck and the Isle of Skye to the North, various mainland peninsulas are also visible and easily accessed by sea. For people throughout the past, moving along the west coast by boat, and particularly on the well-travelled route from Scandinavia, via Orkney, to Dublin, Ardnamurchan is a natural stopping point. As we have seen, the material culture in the grave and the isotopic evidence speak to these regional connections, and the Scandinavian influence can be extended by the examination of local place names – including Swordle Bay – that have a Norse connection (Bankier 2006; Bankier PhD thesis, University of Glasgow ongoing).

Of course, those geographical connections could be said of anywhere on the peninsula. Crucially though, our wider work makes it possible to understand why it was here specifically, in Swordle Bay, that the location for this burial was chosen, for this place enables a citation of relations that are not just geographical but temporal too. Swordle Bay has a rich and deep history of use, and that history would have been clearly visible in Medieval times. The first evidence of occupation is the large Neolithic chambered cairn of Cladh Aindreis, which saw repeated moments of intervention from the first burials around 3700 cal BC through the Bronze Age and into the start of the Iron Age (Harris et al 2014). It is well attested that the Vikings knew of, respected, accessed and built mythology around Neolithic and Bronze Age monuments, such as at Maes Howe, Orkney, where evidence of both runic inscriptions in the chamber and the expansion of the encircling bank in the Viking period suggest significant interaction with the site (Artelius 2013; Graham-Campbell and Batey 1998: 60-1; see also McGuire 2016: 79). It thus seems highly likely that this site was equally the subject of important Viking narrative. Further, a Viking-age bead, Irish in type, was found in excavations of a disturbed context within one of the chambers of Cladh Aindreis, and the archaeology (although badly damaged by post-medieval digging) suggests this was present due to deliberate Viking intervention. Further potential links lie in the very stones that fill the boat burial itself, which may have been taken from the chambered cairn just a short distance away. This is indicated both by the shape, geology and size of the stones, which match many from the cairn, and the fact that it is the nearest available source of such material.

The answer to the question 'why here?' lies in the richness of Swordle Bay. It is of course resource-rich in a traditional sense; it is one of the few bays on the north coast of the Peninsula that has a sheltered natural harbour, a fresh water source and good farming land. But is it also rich in a conceptual sense, with a clear and visible ancestry to which the boat burial no doubt connected. As noted the use and re-use of older places and older sites of burial is a typical of feature of Viking burials and no doubt speaks to a deliberate attempt to gain associations and connections with a new landscape, to appropriate it in new ways, and so create new links and new memories (Williams 2014: 398). Thus this burial was able at once to cite the everyday and the exotic, past and present, as well as local, national and international identities.

Conclusion

The Ardnamurchan boat burial represents the first excavation of an intact Viking boat burial by archaeologists on the UK mainland and it makes a significant addition to our knowledge of burial practices from this period. The uncovering of a burial like this also offers opportunities for multi-scalar analysis, from local and regional connections, to the momentary act of depositing an object next to a body or breaking a spear and placing it in the grave. In this paper we have begun to trace some of these scales from the connections evident to Scandinavia and Ireland in the objects, to the way the isotopic profile suggests a varied history of diet and connections away from Swordle Bay. We have also touched on the way the boat burial brings together not only multiple geographical connections, but also ones that cross time, reaching back into prehistory and forwards to our work as archaeologists in the present. Much more remains to be said, not least about the ritual process of the funeral and the detailed performances that took place there. Critically, when considering a burial like this, it is essential to remember that each of these objects, and each of these actions, were never isolated but rather both emerge out of and help to form an assemblage that knits together multiple places, people and moments in time.

Acknowledgements

The 2011 excavations were funded by The Universities of Newcastle and Manchester and the Leverhulme Trust. The post-excavation analysis, isotopic work and conservation were funded by Viking River Cruises, the latter carried out by Pieta Greaves then of AOC Archaeology, with further consultation from Will Murray of the Scottish Conservation Studio. Permission to excavate was granted by the Ardnamurchan Estate. The lead, strontium and oxygen isotope and concentration data were produced at the British Geological Survey, Keyworth by Vanessa Pashley, Jane Evans, Simon Chenery and Hilary Sloane and the carbon and nitrogen isotopes by Andy Gledhill at the University of Bradford. Thanks go to all along with the staff and students who have worked on the project since 2006. We are also grateful to Irene Garcia Rovira for drawing figures 4 and 5, and to the reviewers for their helpful comments.

BIBLIOGRAPHY

ALQAHTANI, S.J., M.P. HECTOR & H.M. LIVERSIDGE. 2010, Brief communication: The London atlas of human tooth development and eruption. *American Journal of Physical Anthropology* 142: 481-490.

ANDERSON, J. 1907. Ship-burial of the Viking time at Kilroan Bay, Colonsay. *Proceedings of the Society of Antiquaries of Scotland* 41: 443-449.

ARTELIUS, T. 2013. Inventions of memory and meaning: examples of Late Iron Age Reuse of Bronze Age monuments in south-western Sweden, in D. FONTIJN, A.J. LOUWEN, S. VAN DER VAART & K. WENTINK (eds) *Beyond Barrows: Current Research on the Structuration and Perception of the Prehistoric Landscape Through Monuments,* 21-40. Leiden: Sidestone Press.

ASKVIK, H. with C.E. Batey. 2009. The Whetsones: Petrology and Provenance, in g. LUCAS, G (ed.) *Hofstađir. Excavations of a Viking Age Feasting Hall in North-East Iceland*: 293-296. Reykjavik: Institute of Archaeology.

BANKIER, A. 2006. *Norse place names in Western Argyll.* Unpublished MLitt Dissertation, Glasgow University.

BANKIER, A. forthcoming. *The Norse of North Argyll*. PhD in Archaeology commenced 2007, ongoing. University of Glasgow.

BARRETT, J. H., & M. P. RICHARDS. 2004, Identity, gender, religion and economy: new isotope and radiocarbon evidence for marine resource intensification in early historic Orkney, Scotland, UK. *European Journal of Archaeology* 7(8): 249-271.

BATEY, C.E. & C. PATERSON. 2013. A Viking burial at Balnakeil, Sutherland, in L. WEBSTER & A. REYNOLDS (eds) *Early Medieval Art and Archaeology in the Northern World. Studies in Honour of James Graham-Campbell*, 631-661. Leiden: Brill.

BATEY, C.E. forthcoming. Viking Burials in Scotland: two "new" boat burial finds, in V.E. TURNER, O.A. OWEN & D.J. WAUGH (eds) *Shetland and the Viking World*: *Proceedings of the 17th Viking Congress*. Lerwick: Shetland Heritage Publications.

BEAUMONT, J., A. R. GLEDHILL, J. LEE-THORP & J. MONTGOMERY. 2013. Childhood diet: a closer examination of the evidence from dental tissues using stable isotope analysis of incremental human dentine, *Archaeometry* 55(2): 277-295.

BERSU, G. & D. M. WILSON. 1966. *Three Viking Graves in the Isle of Man*. London: Society of Medieval Archaeology.

BONSALL, C., G. T. COOK, C. PICKARD, K. MCSWEENEY & L. BARTOSIEWICZ. 2009. Dietary Trends at the Mesolithic–Neolithic Transition in Northwest Europe, in, P. CROMBÉ, M. VAN STRYDONCK, J. SERGANT, M. BOUDIN, and M. BATS (eds), Chronology and Evolution in the Mesolithic of Northwest Europe, 539-562. Cambridge: Cambridge Scholars Publishers.

BRADLEY, R. 2000. *An Archaeology of Natural Places*. London: Routledge.

BUCKBERRY, J., J. MONTGOMERY, J. TOWERS, G. MÜLDNER, M. HOLST, J. EVANS, A. GLEDHILL, N. NEALE & J. LEE-THORP. 2014. Finding Vikings in the Danelaw. *Oxford Journal of Archaeology*. 33(4): 413-434.

BUTLER, J. 1993. *Bodies that matter: On the discursive limits of sex*. London: Routledge.

CURTIS-SUMMERS, S., J. MONTGOMERY & M. O. H. CARVER. 2014. Stable isotope analysis for dietary contrast between Pictish and Medieval populations at Portmahomack, Scotland. *Medieval Archaeology* 58: 21-43.

CRUMLIN-PEDERSEN, O. & B.M.THYE (eds.). 1995. *The Ship as Symbol in Prehistoric and Medieval Scandinavia*. Copenhagen: Nationalmuseet.

FOWLER, C. 2010. From identity and material culture to personhood and materiality, In D. HICKS and M.C. BEAUDRY (eds) *The Oxford Handbook of Material Culture Studies*: 352-85. Oxford: Oxford University Press.

FREI, K. M. & R. FREI. 2011. The geographic distribution of strontium isotopes in Danish surface waters: a base for provenance studies in archaeology, hydrology and agriculture. *Applied Geochemistry* 26:326-340.

GARDELA, L. 2013. 'Warrior-women' in Viking Age Scandinavia? A preliminary archaeological study. *Analecta Archaeologica Ressoviensia* 8: 273‑340

GRAHAM-CAMPBELL, J. & C.E. BATEY. 1998. *Vikings in Scotland: An Archaeological Survey*. Edinburgh: Edinburgh University Press

GREAVES, P. 2011. Appendix Six: Conservation report. In O.J.T. HARRIS, H. COBB, H. GRAY & P. RICHARDSON. Viking Boat Burial, Swordle Bay, Ardnamurchan Season Six, 2011: Archaeological Excavations Data Structure Report. Ardnamurchan Transitions Report Number 17.

HALPIN, A. 2008. *Weapons and Warfare in Viking and Medieval Dublin*. *Medieval Dublin Excavations 1962-81*. Dublin: National Museum of Ireland.

HARRIS, O.J.T. 2016. Becoming post-human: identity and the ontological turn, in E. PIERCE, A. RUSSELL, A. MALDONADO & L. CAMPBELL (eds.) *Creating Material Worlds: Theorising Identity in Archaeology*, 17-37. Oxford: Oxbow.

HARRIS, O.J.T., H. COBB, H. GRAY & P. RICHARDSON. 2012. A Viking at Rest: New Discoveries on Ardnamurchan. *Medieval Archaeology* 56: 333-339.

HARRIS, O. J. T., H. COBB, H. Gray, & P. Richardson. 2014. New radiocarbon dates from Cladh Aindreis chambered tomb, Ardnamurchan. *Past: the newsletter of the Prehistoric Society* 76: 5-6.

JONES, A. 2007. *Memory and material culture*. Cambridge: Cambridge University Press.

KOSIBA, S. B., R. H. TYKOT & D. CARLSSON. 2007. Stable isotopes as indicators of change in the food procurement and food preference of Viking Age and Early Christian populations on Gotland (Sweden). *Journal of Anthropological Archaeology*. 26(3): 394-411.

MCLEOD, S. 2011. Warriors and women: the sex ration of Norse migrants to eastern England up to 900AD. *Early Medieval Europe* 19(3): 332-353.

MCGUIRE, E.H. 2010. *Manifestations of identity in burial: Evidence from Viking-Age graves in the North Atlantic diaspora*. Unpub PhD thesis University of Glasgow.

MCGUIRE, E.H. 2016. Move along: migrant identities in Scandinavian Scotland, in E. PIERCE, A. RUSSELL, A. MALDONADO & L. CAMPBELL (eds.) *Creating Material Worlds: Theorising Identity in Archaeology*, 63-85. Oxford: Oxbow.

MONTGOMERY, J., J. A. EVANS, S. R. CHENERY, V. PASHLEY & K. KILLGRAVE. 2010. "Gleaming, white and deadly": the use of lead to track human exposure and geographic origins in the Roman period in Britain, in H. ECKARDT (ed.) *Roman diasporas: archaeological approaches to mobility and diversity in the Roman Empire*, 199-226. Journal of Roman Archaeology: Portsmouth (RI).

MONTGOMERY, J., V. GRIMES, J. BUCKBERRY, J. EVANS, M. P. RICHARDS & J. H. BARRETT. 2014. Finding Vikings with Isotope Analysis – the View from Wet and Windy Islands, *Journal of the North Atlantic* 7: 54-70.

MÜLDNER, G., J. MONTGOMERY, G. COOK, R. ELLAM, A. GLEDHILL & C. LOWE. 2009. Isotopes and individuals: diet and mobility among the medieval Bishops of Whithorn. *Antiquity* 83(322): 1119-1133.

MÜLDNER, G. & M. P. RICHARDS. 2007, Stable isotope evidence for 1500 years of human diet at the City of York, U.K. *American Journal of Physical Anthropology* 133: 682-697.

NAUMANN, E., T. D. PRICE & M. P. RICHARDS. 2014. Changes in Dietary Practices and Social Organization During the Pivotal Late Iron Age Period in Norway (AD 550-1030): Isotope Analyses of Merovingian and Viking Age Human Remains. *American Journal of Physical Anthropology* 155(3): 322-331.

NISSAN, K. 1999. The textile remains, in O. OWEN and M. DALLAND (ed.) *Scar: A Viking boat burial on Sanday, Orkney*: 109-112. East Linton: Tuckwell Press.

OWEN, O. & M. DALLAND. 1999. *Scar: A Viking boat burial on Sanday, Orkney*. East Linton: Tuckwell Press

PATERSON, C., A.J. PARSONS, R.M. NEWMAN, N. JOHNSON & C. HOWARD DAVIS. 2014. *Shadows in the Sand. Excavation of a Viking-Age Cemetery at Cumwhitton, Cumbria*. Oxford Archaeology North, Lancaster Imprints.

PETERSEN, J. 1919. De *Norske Vikingesverd: en Typologogisk-kronologisk Studie over Vikingetidens Vaaben.* Kristiania (Oslo): Jacob Dybwad

PETERSEN, J. 1951. *Vikingetidens Redskaper*. Oslo: Det Norske Videnskaps-Akademi.

PRICE,N. 2010. Passing into poetry: Viking-age mortuary drama and the origins of Norse Myhtology. *Medieval Archaeology* 54: 123-156.

REIMANN, C., B. FLEM, K. FABIAN, M. BIRKE, A. LADENBERGER, P. NÉGREL, A. DEMETRIADES, J. HOOGEWERFF & TEAM TGP. 2012. Lead and lead isotopes in agricultural soils of Europe - the continental perspective. *Applied Geochemistry* 27: 532-542.

ROBB, J. & HARRIS, O.J.T. 2013. *The Body in History: Europe from the Palaeolithic to the Future*. Cambridge: Cambridge University Press.

WELANDER, R.D.E., C.E. BATEY & T.G. COWIE. 1987. A Viking burial from Kneep, Uig, Isle of Lewis. *Proceedings of the Society of Antiquaries of Scotland* 117: 149-74.

WILLIAMS, H. 2014. Memory through monuments: movement and temporality in Skamby's boat graves, in H. ALEXANDERSSON, A. ANDREEFF & A. BÜNZ (eds.) *Med hjärta och hjärna: En Vänbok till professor Elisabeth Arwill-Nordbladh*: 397-413. Gothenburg: University of Gothenburg.

WILLIAMS, H., RUNDKVIST, M. & DANIELSSON, A. 2010. The landscape of a Swedish boat-grave cemetery. *Landscapes* 11: 1-24.

Figures

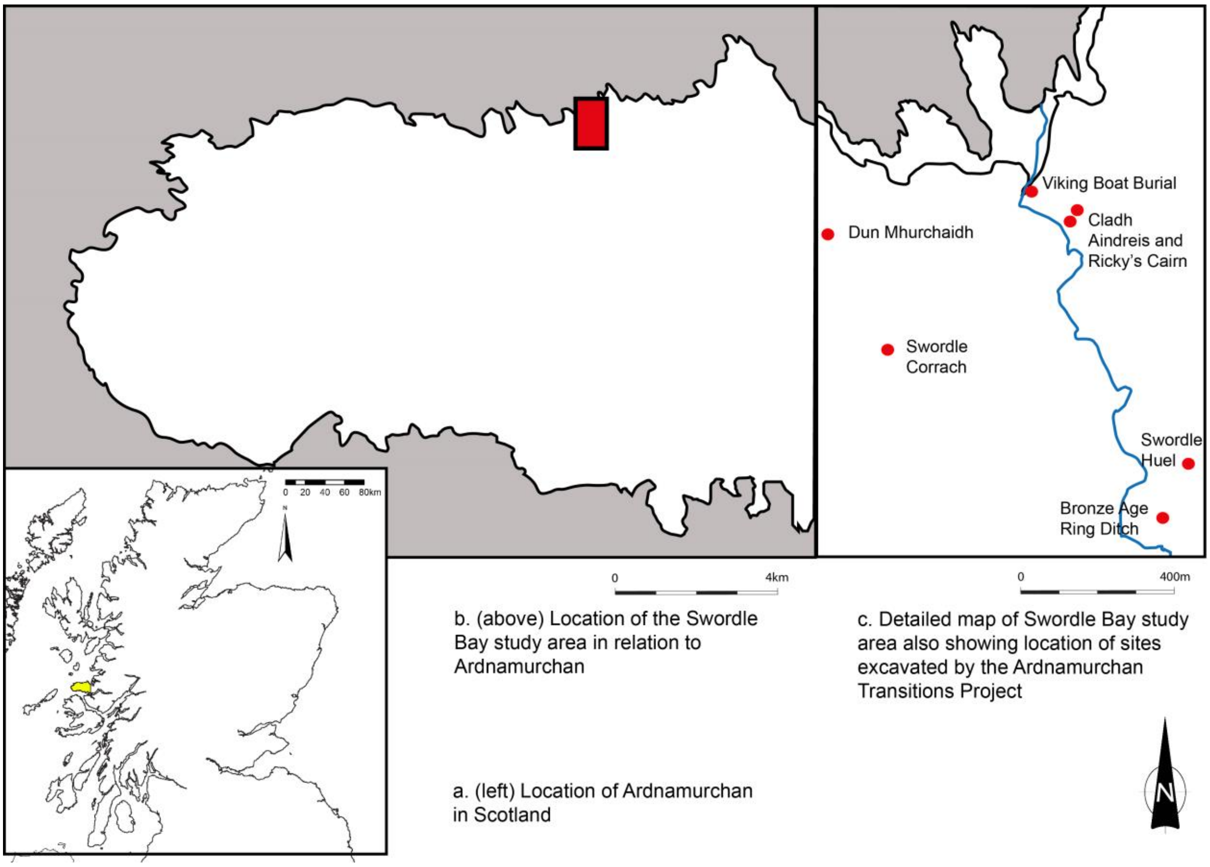

Figure 1: Location map

Figure 2: Pre-excavation shot after initial cleaning

Figure 3: Post-excavation photo of the cut

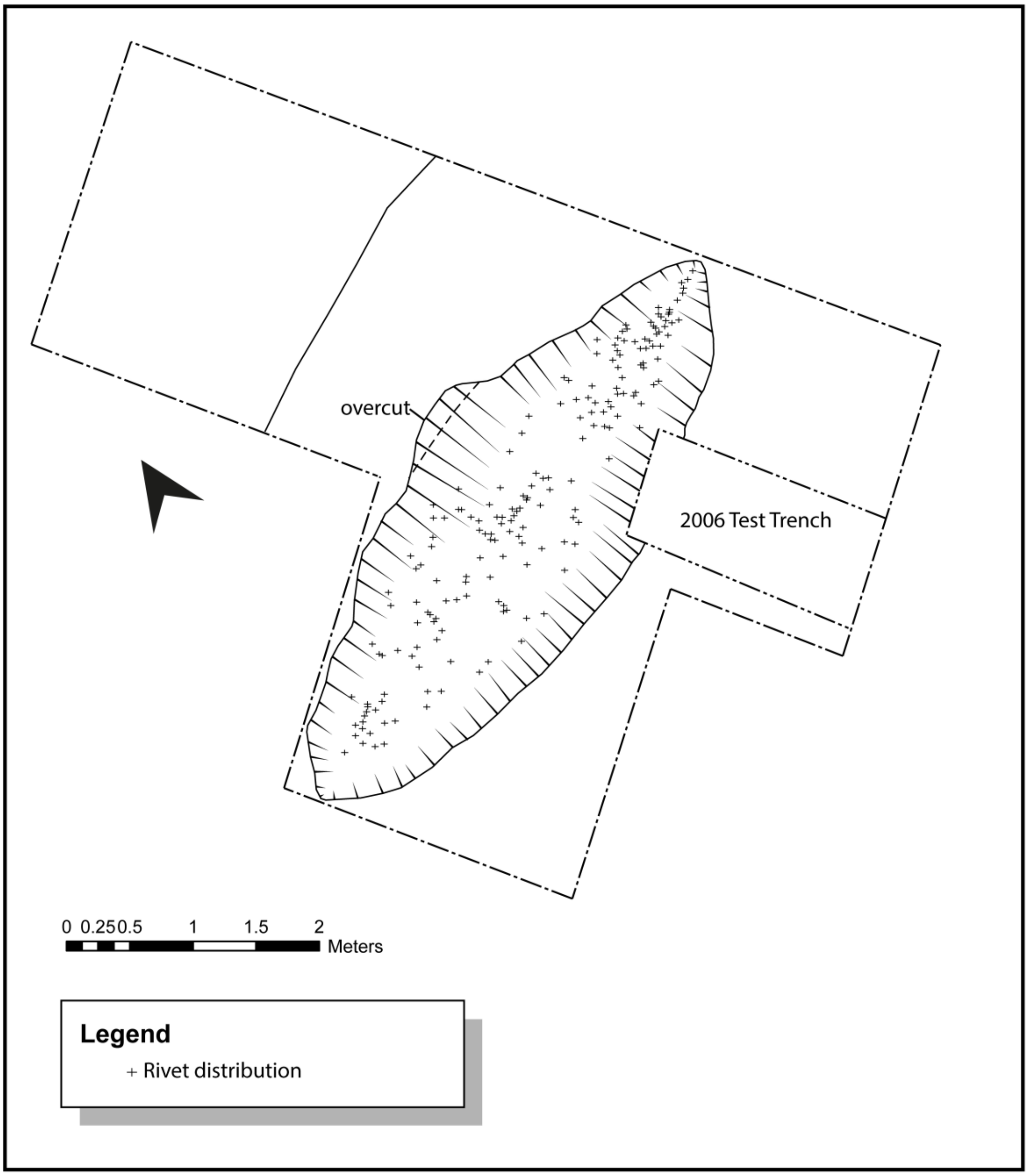

Figure 4: Plot of the in situ rivets (By Irene Garcia Rovira)

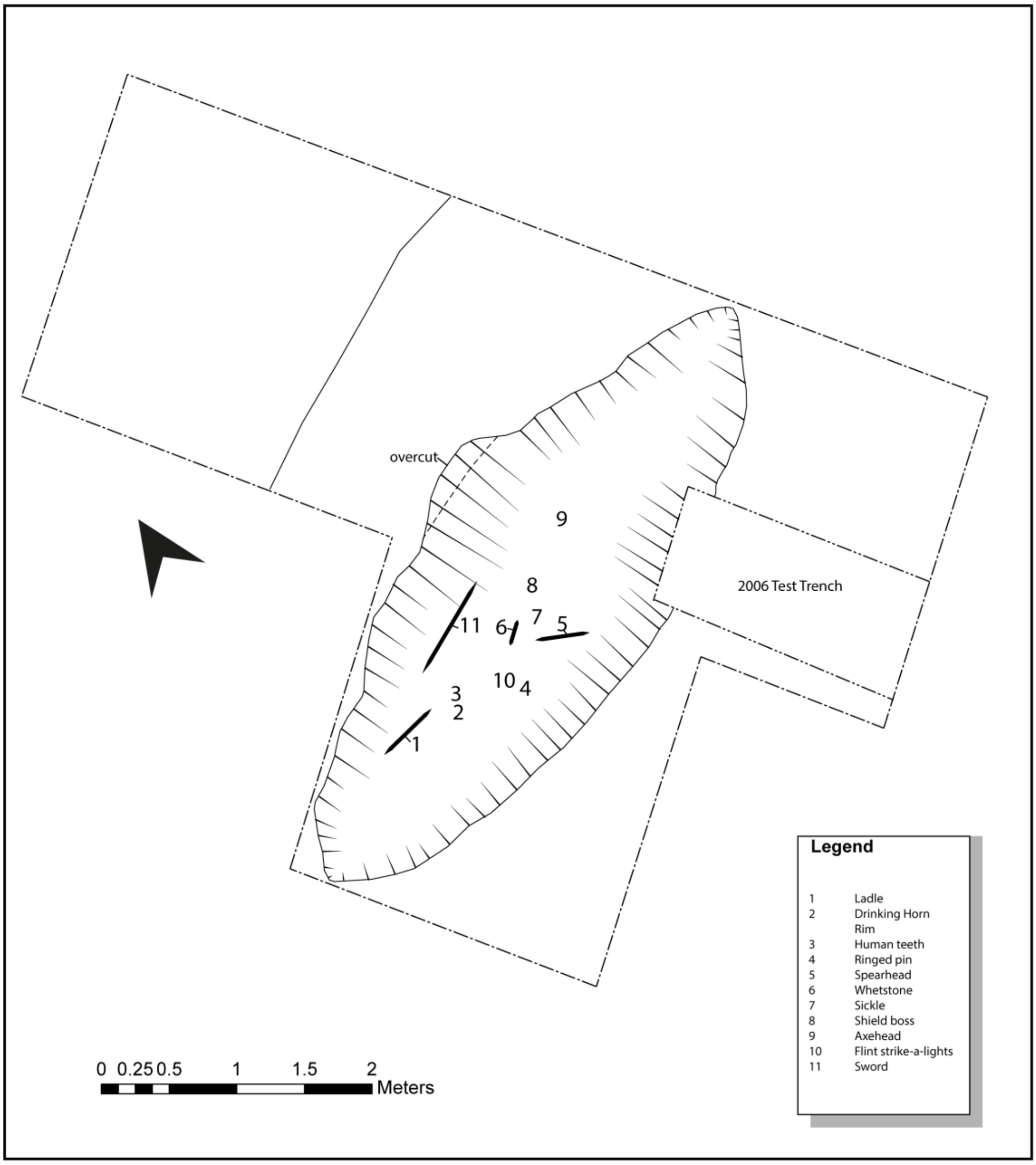

Figure 5: Plot of the major finds recovered from the grave – note this is a two dimensional plan, the spear and shield were higher in the fill than the other finds (By Irene Garcia Rovira).

Figure 6: Some of the other finds recovered from the grave (clockwise from the top left): broad-bladed axe, shield boss, ringed pin and the hammer and tongs (photos: Pieta Greaves / AOC Archaeology)

Figure 7: The sword. Top: the sword in situ. Below: the mineralised textile remains (right); detail of the decoration after conservation (left) (lower photos: Pieta Greaves / AOC Archaeology)

Figure 8: The Viking's teeth

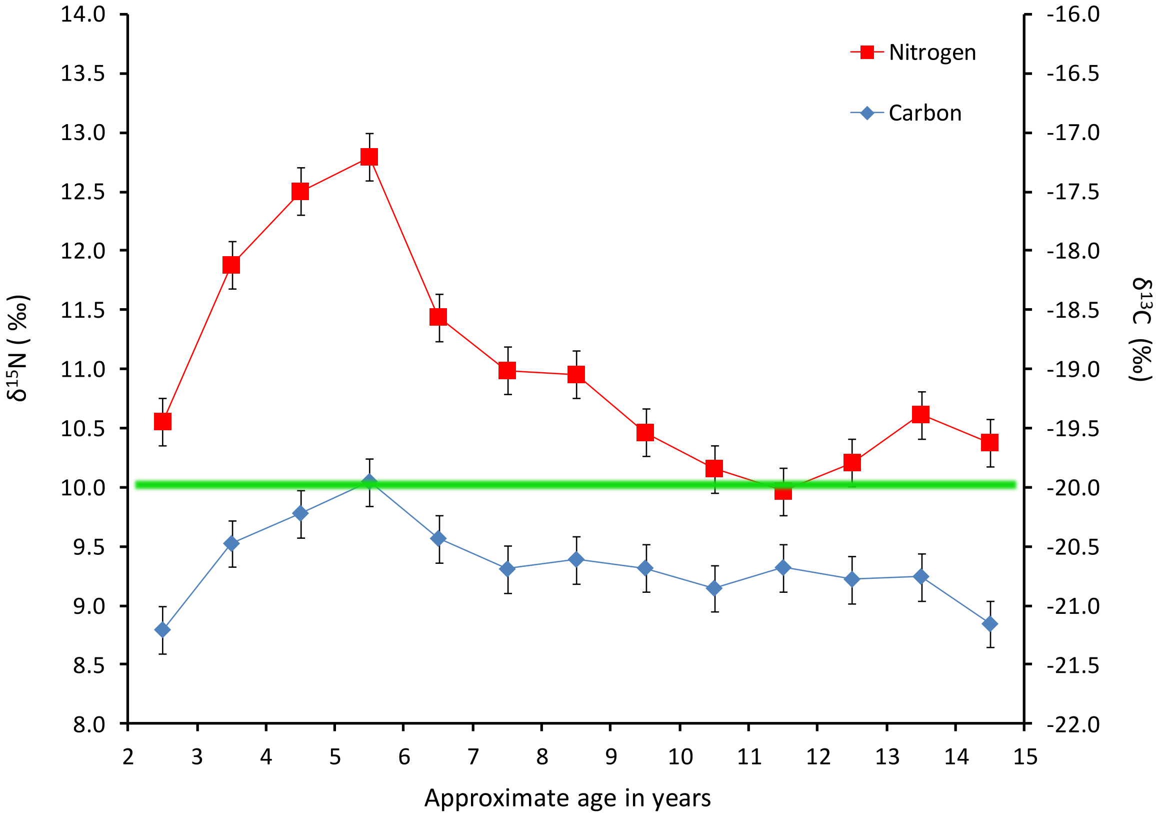

Figure 9: Plot showing the carbon and nitrogen isotope ratios against approximate age for dentine collagen extracted from the M2. The green line indicates the suggested upper limit for δ13C of -20 ‰ for solely terrestrial diets in prehistoric northern Britain (Bonsall et al. 2009). Analytical uncertainty is shown at +/- 0.2 ‰ (1σ).

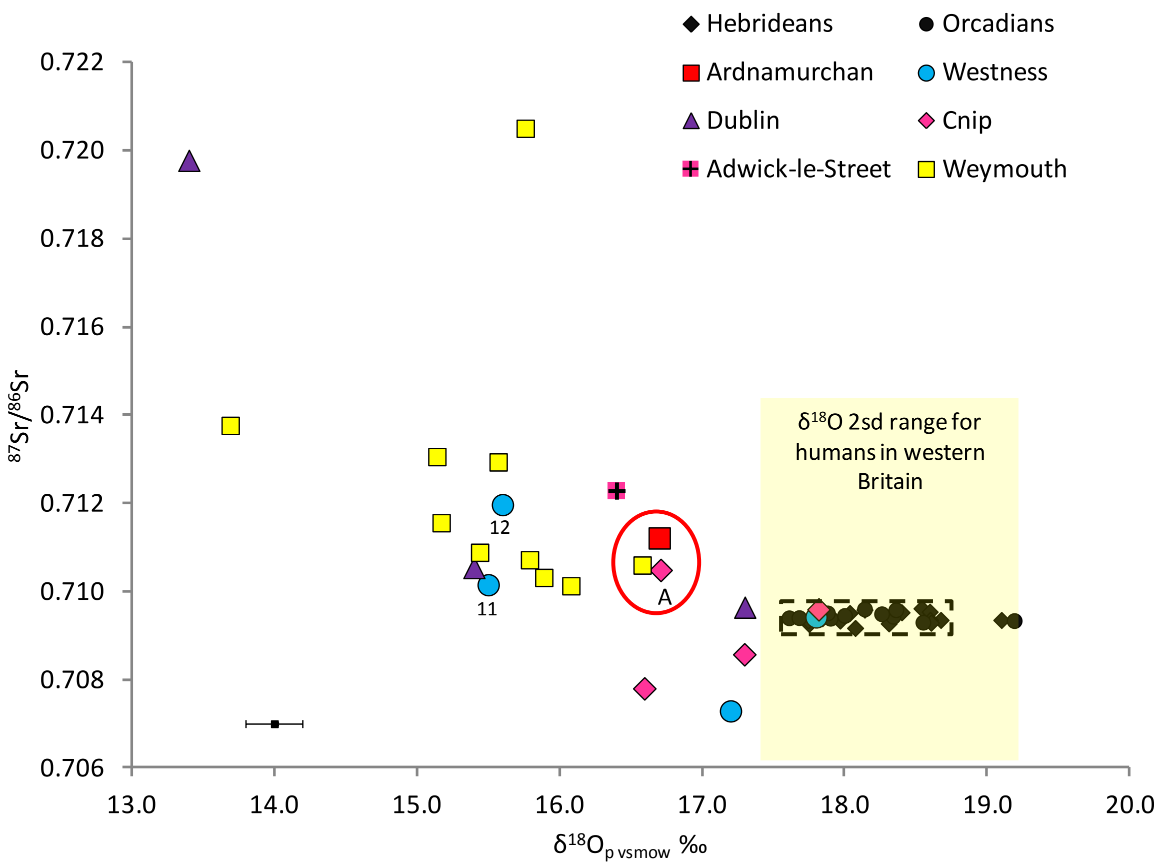

Figure 10: Enamel strontium and phosphate oxygen isotope data for the Ardnamurchan burial compared to data for other Viking period burials in Britain and Ireland. The estimated range indicated by the yellow box for biosphere strontium in the Ardnamurchan peninsula is taken from Evans et al. (2010) and the range of $\delta^{18}O$ for western Britain from Evans et al. (2012).

Supplementary text and figures and tables in support of Isotope evidence

Methods

Carbon and nitrogen isotopes

Collagen samples were measured in duplicate in the University of Bradford Stable Light Isotope Laboratory along with laboratory and international standards. The international standards were: IAEA 600, CH6, CH7, N1, and N2. The laboratory standards, fish gelatin and bovine liver, were calibrated against the international standards. The dentine samples were combusted in a Thermo Flash EA 1112 and the resulting N2 and CO2 was introduced to a Delta plus XL via a Conflo III interface. This instrument was used for the incremental dentine samples because it can analyse smaller (e.g. 0.5 mg) samples. Carbon and nitrogen isotope ratios ($\delta^{13}C$, $\delta^{15}N$) are reported in per mil (‰) relative to VPDB and AIR standards respectively. Analytical uncertainty determined by repeated analysis of the standards was better than +/- 0.2 ‰ (1σ).

Oxygen isotopes

Oxygen and carbon isotope ratios were measured in enamel carbonate following the method of Chenery *et al.* (2012) at NIGL, Keyworth, Nottingham. Isotope ratios are reported as delta (δ) values, in parts per thousand (per mil; ‰) normalized to the VPDB scale using an in-house carbonate reference material, Keyworth Carrera Marble (KCM) calibrated against NBS19. Analytical uncertainty determined by repeat analysis of the standard was estimated to be ± 0.09 ‰ (1 σ) for $\delta^{18}O$ and ± 0.04 ‰ (1 σ) for $\delta^{13}C$. $\delta^{18}O_{carbonate}$ values were normalized to VSMOW using the equation of Coplen (1988). Conversion between $\delta^{18}O_{carbonate}$ to $\delta^{18}O_{phosphate}$ was then undertaken using the regression equation of Daux Eq. 6 (2008) introducing an error of +/- 0.28 ‰ (1sd) (Chenery et al. 2012).

Lead and strontium isotopes

Samples of core enamel were removed from the M2 tooth, mechanically cleaned of all adhering dentine and surface contamination to produce c. 10 mg samples of cleaned enamel for strontium and lead isotopes and elemental concentrations. The samples were transferred to the clean class 100, HEPA©-filtered laboratory at the NERC Isotope Geosciences Laboratory (NIGL), Keyworth, Nottingham where strontium and lead were isolated using standard laboratory column chemistry separation procedures (Lamb et al. 2014).

In short, lead isotope ratios were measured in solution using a thallium spike and a Nu Industries *Nu Plasma* multi-collector inductively-coupled plasma mass spectrometer (MC-ICP-MS) and compared to known values of NBS981 Pb standard (Thirlwall, 2002). The precision and accuracy of the method was determined by repeated analysis of 50 ppb NBS standards to be: $^{206}Pb/^{204}Pb$ ±0.010; $^{207}Pb/^{204}Pb$ ±0.017; $^{208}Pb/^{204}Pb$ ±0.020; $^{207}Pb/^{206}Pb$ ± 0.010; $^{208}Pb/^{206}Pb$ ±0.012.

Strontium spiked with an ^{84}Sr tracer was loaded onto a single Re filament with TaF following the method of Birck (1986). Strontium isotope ratios and concentrations were measured using a *Thermo Triton* multi-collector mass spectrometer (TIMS). The international standard for $^{87}Sr/^{86}Sr$, NBS987, gave a value of 0.71025±0.00001 (n=8, 2s) during the analysis of these samples. Blanks were in the region of 100 pg.

Results

Carbon and nitrogen isotopes

Collagen was obtained from sequential dentine sections of the M2 using the method given by Beaumont et al. (2013). C:N ratios and %C and %N of the resulting collagen were deemed of acceptable quality according to van Klinken (1999). The carbon and nitrogen isotope ratio profiles indicate a largely terrestrial diet, i.e. $\delta^{13}C$ below -20 ‰, between the ages of 2 and 15 years (figure X1). Such values and apparent absence of evidence for any significant marine protein consumption are typical for pre-Viking Age humans in northern Britain even when excavated in coastal regions (Barrett & Richards 2004; Buckberry et al. 2014; Curtis-Summer et al. 2014; Müldner & Richards 2007; Müldner et al. 2009) and the Ardnamurchan burial sits within the range of values obtained for Pictish and medieval burials in the Hebrides, Orkneys, and east and west coast of northern Britain (figure X1). The increase in marine protein consumption in the Viking Age (9th-11th centuries AD) in Scotland has been linked to Norse settlement and influence (Barrett and Richards 2004) and is seen in two Viking male burials (11 and 12) from Westness and to a lesser extent in the female (A) found with a Viking burial assemblage at Cnip (figure X1). However, individuals with little or no isotopic evidence for marine protein consumption are also found in Scandinavia at this time amongst those with significant marine diets, and children appear to have lower marine protein consumption than adults (Kosiba et al. 2007; Naumann et al. 2014). As the dentine data obtained for the Ardnamurchan individual reflect diet up to the age of approximately 15 years of age, the largely terrestrial-based diet found for the Ardnamurchan individual does not, of itself, rule out Scandinavian origins. There is a peak in both the carbon and nitrogen isotope profiles between the ages of approximately 3 and 5 years suggesting a shift to a higher trophic level diet at this time (figure 9 in main article). Such a change in diet could be explained by the consumption of an increased proportion of either terrestrial (meat or milk) or marine animal protein, although the trend in the data for a positive correlation between carbon and nitrogen isotopes, rather than just an increase in nitrogen isotope ratios, would suggest the latter (figure 9 in main article), but it is not sufficient to take the $\delta^{13}C$ values outside the range for terrestrial protein.

Strontium and oxygen isotopes

There is little comparative strontium isotope data from the west coast of mainland northern Scotland from any period as the survival of skeletal materials is generally poor. It is significantly better in soils dominated by the coastal shell sands found in the Western and Northern Isles and particularly the Old Red Sandstones of Orkney. A comparison with humans from these places indicates that the combined strontium isotope and concentration of the tooth enamel from the Ardnamurchan individual is not consistent with origins in the Outer Hebrides, Orkney or Shetland nor on basaltic or limestone terrains (Montgomery et al. 2010). The strontium isotope ratio of 0.7112 obtained from the second molar cannot rule out origins in the Ardnamurchan peninsular as the complex geology of the region could provide a wide range of biosphere values from 0.705 up to 0.714 (Evans et al. 2010) and consumption of food grown on such varied geological terrain could result in an averaged value of 0.7112 (Montgomery 2010). However, the oxygen isotope ratio of 16.7 ‰ is too low for humans from the entire western seaboard of Britain (including the Northern and Western Isles) which have a 2 sd range of 17.2 - 19.2 ‰ (Evans et al. 2012). For example, four surviving skeletons from the nearby islands of Tiree, Mull and Skye range from 17.5 to 18.0 ‰ (Armit et al. 2015; Evans et al. 2012). A similar combination to the strontium and oxygen isotopes obtained from the Ardnamurchan individual have also been found in other burials of Viking Age (indicated by the red oval in figure 10 in the main article) that are also inconsistent with their place of burial such as the female Cnip A (Montgomery et al. 2014) and one of the decapitated Viking period males found at Weymouth in Dorset (Chenery et al. 2014). A $\delta^{18}O$ value of 16.7 ‰ is nonetheless consistent with origins in eastern Britain (2 sd range = 15.9 to 18.5 ‰, Evans et al. 2010) and other Viking burials such as 11 and 12 from Westness and two from Dublin have much lower oxygen isotopes which do fall outside the range for Britain and Ireland. As a consequence, the oxygen isotopes demonstrate that it is highly unlikely that the Ardnamurchan individual originated on the western seaboard of Britain and must have travelled there either during life or for burial from a region with lower $\delta^{18}O$ precipitation values. This place of origin will be to the east, including eastern

Britain, or to the north in Scandinavia. Other possibilities include eastern Ireland and central Europe. The strontium isotope ratio would not rule out any of these places although it is of note that it falls within the large range of values reported for Viking period burials from coastal Norway: 0.7092 to 0.7175 (Naumann et al. 2014). Origins in Denmark which is predominantly limestones overlain by till and hosts a strontium isotope biosphere between 0.7081 and 0.7111 (Frei and Frei 2011) would, however, be difficult to reconcile with the strontium isotope ratio of 0.7112 obtained from the Ardnamurchan individual.

Lead isotopes

The amount of lead in the enamel of the Ardnamurchan individual is 0.4 mg/kg which is below the limit of exposure to solely natural sources proposed by Montgomery et al. (2010) and figure X2 shows that the $^{207}Pb/^{206}Pb$ ratio is higher than the English/Welsh lead ore ratios $^{207}Pb/^{206}Pb$ of ~ 0.846 found with much higher levels of lead in Viking period burials in England such as those from Repton and Riccall. As a consequence, origins in England and Wales at this time when the majority of people with enamel lead > 0.5 mg/kg had a $^{207}Pb/^{206}Pb$ ratio of ~ 0.846 can be ruled out. A similar combination of lead level and ratio to the Ardnamurchan individual has been found in prehistoric individuals from the Outer Hebrides. Whilst the strontium and oxygen isotopes rule out the Outer Hebrides as a place of origin, this does suggest that the Ardnamurchan individual grew up in a region of ancient Precambrian geology with little or no environmental lead pollution. Given there are no significant lead deposits in Denmark, southern Norway or western Sweden (Reimann et al. 2012), and Scandinavia lay outside the Roman Empire which heralded the advent of increased lead levels in humans in first millennium AD Britain (Montgomery et al. 2010), lead levels below 0.5 mg/kg have been proposed as an indicator of Scandinavian origins in Viking period burials in Britain (Montgomery et al. 2014). However, such low lead exposure may also be true of northern Scotland which was also beyond the zone of direct Roman influence and has comparably ancient geology.

To investigate this further, figure X3 compares the $^{208}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ ratios of the Ardnamurchan individual with data for Scottish and Irish lead deposits. The Ardnamurchan individual sits within the field of both Scottish and Irish ores (Rohl 1996) in Figure X3a ($^{208}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$) which indicates exposure to an ancient Precambrian source of lead but falls largely outside both these fields in Figure X3b ($^{207}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$) when both ore fields drop below the Stacey-Kramer (1975) curve for conformable lead ore deposits. Only a few Irish ore sources appear to be able to provide lead isotope ratios consistent with the Ardnamurchan individual. The human with the most similar ratios on both plots is a female Pictish burial from Kilpheder South Uist who is also unlikely to be indigenous to the Outer Hebrides but who has a much lower and incompatible strontium isotope ratio (Montgomery and Evans 2006). None of the Viking period burials in figure X3 have comparable lead isotope ratios: all have higher ratios indicative of younger sources of lead such as the Palaeozoic ores of England and Wales and in northern Europe outside of Norway and Sweden. Whilst it is not possible when all the isotope data are taken together to rule out origins in north or eastern Ireland, neither is it currently possible to rule out origins in eastern Scotland, Norway and Sweden as little is currently known about the lead isotopes that humans exposed to only natural levels of lead, in an analogous manner to strontium ingestion, from soils and plants on the ancient rocks of these places.

Conclusion

Currently, no direct comparator can be found in Britain for the lead isotope ratios obtained from the Ardnamurchan individual but this evidence and that from other isotopes strongly points to origins not at Ardnamurchan nor the western seaboard of Britain, but in a region of ancient Precambrian geology to the north of the Roman Empire. The isotope data would all be consistent with origins in Norway or Sweden but equally with north or eastern Ireland and possibly eastern mainland Scotland.

References

ARMIT, I., F. SHAPLAND, J. MONTGOMERY & J. BEAUMONT. in press 2015. Difference in death? a lost Neolithic inhumation cemetery with Britain's earliest case of rickets, at Balevullin, western Scotland, *Proceedings of the Society of Antiquaries of Scotland*.

BARRETT, J. H. & M. P. Richards. 2004. Identity, gender, religion and economy: new isotope and radiocarbon evidence for marine resource intensification in early historic Orkney, Scotland, UK. *European Journal of Archaeology* 7(8): 249-271.

BEAUMONT, J., A.R. Gledhill, J. Lee-Thorp & J. Montgomery. 2013. Childhood diet: a closer examination of the evidence from dental tissues using stable isotope analysis of incremental human dentine, *Archaeometry* 55(2): 277-295.

BIRCK, J. L. 1986. Precision K-Rb-Sr isotopic analysis - application to Rb-Sr chronology. *Chemical Geology*: 56(1-2): 73-83.

BONSALL, C., G. T. COOK, C. PICKARD, K. MCSWEENEY & L. BARTOSIEWICZ. 2009. Dietary Trends at the Mesolithic–Neolithic Transition in Northwest Europe, in, P. CROMBÉ, M. VAN STRYDONCK, J. SERGANT, M. BOUDIN, and M. BATS (eds), *Chronology and Evolution in the Mesolithic of Northwest Europe*, 539-562. Cambridge: Cambridge Scholars Publishers.

BUCKBERRY, J., J. MONTGOMERY, J. TOWERS, G. MÜLDNER, M. HOLST, J. EVANS, A. GLEDHILL, N. NEALE & J. LEE-THORP. 2014. Finding Vikings in the Danelaw. *Oxford Journal of Archaeology*. 33(4): 413-434.

CHENERY, C., V. PASHLEY, A. LAMB, H. SLOANE & J. EVANS. 2012. The oxygen isotope relationship between the phosphate and structural carbonate fractions of human bioapatite, *Rapid Communications in Mass Spectrometry* 26: 309-319.

CHENERY, C., J. A. EVANS, D. SCORE & A. BOYLE. 2014. A boat load of Vikings? *Journal of the North Atlantic* 7: 43-53.

COPLEN, T. B. 1988. Normalization of oxygen and hydrogen isotope data, *Chemical Geology (Isotope Geosciences Section)* 72: 293-297.

CURTIS-SUMMERS, S., J. MONTGOMERY & M. O. H. CARVER. 2014. Stable isotope analysis for dietary contrast between Pictish and Medieval populations at Portmahomack, Scotland. *Medieval Archaeology* 58: 21-43.

DAUX, V., C. LÉCUYER, M.-A. HÉRAN, R. AMIOT, L. Simon, F. FOUREL, F. MARTINEAU, N. LYNNERUP, H. REYCHLER & G. ESCARGUEL. 2008. Oxygen isotope fractionation between human phosphate and water revisited, *Journal of Human Evolution* 55(6): 1138-1147.

EVANS, J., C. A. CHENERY & J. MONTGOMERY. 2012. A summary of strontium and oxygen isotope variation in archaeological human tooth enamel excavated from Britain, *Journal of Analytical Atomic Spectroscopy* 27: 754-764.

EVANS, J. A., J. MONTGOMERY, G. WILDMAN & N. BOULTON. 2010. Spatial variations in biosphere 87Sr/86Sr in Britain, *Journal of the Geological Society* 167(1): 1-4.

FREI, K. M., & R. FREI. 2011. The geographic distribution of strontium isotopes in Danish surface waters: a base for provenance studies in archaeology, hydrology and agriculture. *Applied Geochemistry* 26:326-340.

KNÜSEL, C. J., C. M. BATT, G. Cook, J. MONTGOMERY, G. MÜLDNER, A. R. OGDEN, C. PALMER, B. STERN, J. TODD & A. S. WILSON. 2010. The Identity of the St Bees Lady, Cumbria: An Osteobiographical Approach, *Medieval Archaeology* 54(1): 271-311.

KOSIBA, S. B., R. H. TYKOT & D. CARLSSON. 2007. Stable isotopes as indicators of change in the food procurement and food preference of Viking Age and Early Christian populations on Gotland (Sweden). *Journal of Anthropological Archaeology*. 26(3): 394-411.

LAMB, A. L., J. E. EVANS, R. BUCKLEY & J. APPLEBY. 2014. Multi-isotope analysis demonstrates significant lifestyle changes in King Richard III, *Journal of Archaeological Science* 50: 559-565.

MCCARTHY, M. 2014. A post-Roman sequence at Carlisle Cathedral, *The Archaeological Journal* 171: 185-257.

MONTGOMERY, J. 2010. Passports from the past: Investigating human dispersals using strontium isotope analysis of tooth enamel, *Annals of Human Biology* 37(3): 325-346.

MONTGOMERY, J. & J. A. EVANS, 2006, Immigrants on the Isle of Lewis - combining traditional funerary and modern isotope evidence to investigate social differentiation, migration and dietary change in the Outer Hebrides of Scotland, in R. GOWLAND, and C. KNÜSEL (eds) *The Social Archaeology of Funerary Remains*, 122-142. Oxbow Books, Oxford.

MONTGOMERY, J., J. A. EVANS, S. R. CHENERY, V. PASHLEY & K. KILLGRAVE. 2010. "Gleaming, white and deadly": the use of lead to track human exposure and geographic origins in the Roman period in Britain, in H. ECKARDT (ed.) *Roman diasporas: archaeological approaches to mobility and diversity in the Roman Empire*, 199-226. Journal of Roman Archaeology: Portsmouth (RI).

MONTGOMERY, J., V. GRIMES, J. BUCKBERRY, J. EVANS, M. P. RICHARDS & J. H. BARRETT. 2014. Finding Vikings with Isotope Analysis – the View from Wet and Windy Islands, *Journal of the North Atlantic* 7: 54-70.

MÜLDNER, G., J. MONTGOMERY, G. COOK, R. ELLAM, A. GLEDHILL & C. LOWE. 2009. Isotopes and individuals: diet and mobility among the medieval Bishops of Whithorn. *Antiquity* 83(322): 1119-1133.

MÜLDNER, G. & M. P. RICHARDS. 2007, Stable isotope evidence for 1500 years of human diet at the City of York, U.K. *American Journal of Physical Anthropology* 133: 682-697.

NAUMANN, E., T. D. PRICE & M. P. RICHARDS. 2014. Changes in Dietary Practices and Social Organization During the Pivotal Late Iron Age Period in Norway (AD 550-1030): Isotope Analyses of Merovingian and Viking Age Human Remains. *American Journal of Physical Anthropology* 155(3): 322-331.

REIMANN, C., B. FLEM, K. FABIAN, M. BIRKE, A. LADENBERGER, P. NÉGREL, A. DEMETRIADES, J. HOOGEWERFF & TEAM TGP. 2012. Lead and lead isotopes in agricultural soils of Europe - the continental perspective. *Applied Geochemistry* 27: 532-542.

ROHL, B. M. 1996. Lead isotope data from the Isotrace Laboratory, Oxford: Archaeometry Data Base 2, galena from Britain and Ireland, *Archaeometry* 38(1): 165-180.

STACEY, J. S. & J. D. Kramers. 1975. Approximation of terrestrial lead isotope evolution by a two-stage model, *Earth and Planetary Science Letters* 26: 207-221.

VAN KLINKENB, G. J. 1999. Bone Collagen Quality Indicators for Palaeodietary and Radiocarbon Measurements, *Journal of Archaeological Science* 26(6): 687-695.

Figures to accompany supplemental data

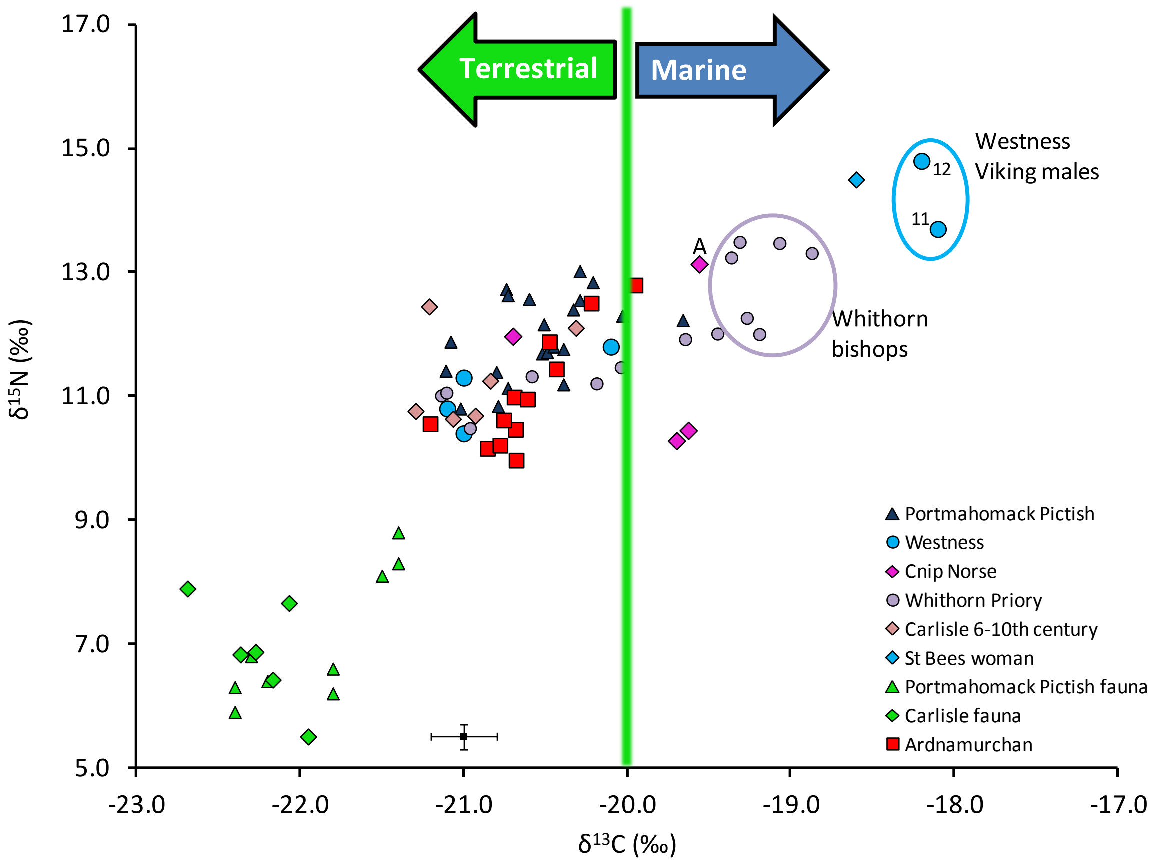

Figure X1. Carbon and nitrogen isotope bi-plot comparing the Ardnamurchan burial to other medieval humans from coastal sites in northern Britain. The green line indicates the suggested upper limit for $\delta^{13}C$ of -20 ‰ for solely terrestrial diets in prehistoric northern Britain (Bonsall et al. 2009). Analytical uncertainty is shown at +/- 0.2 ‰ (1σ). Data sources: Carlisle: McCarthy 2014; Cnip: Montgomery unpublished data; 2010 Portmahomack: Curtis-Summers et al. 2014; St. Bees: Knüsel et al. 2010; Westness: Barrett & Richards 2004; Whithorn: Müldner et al. 2009.

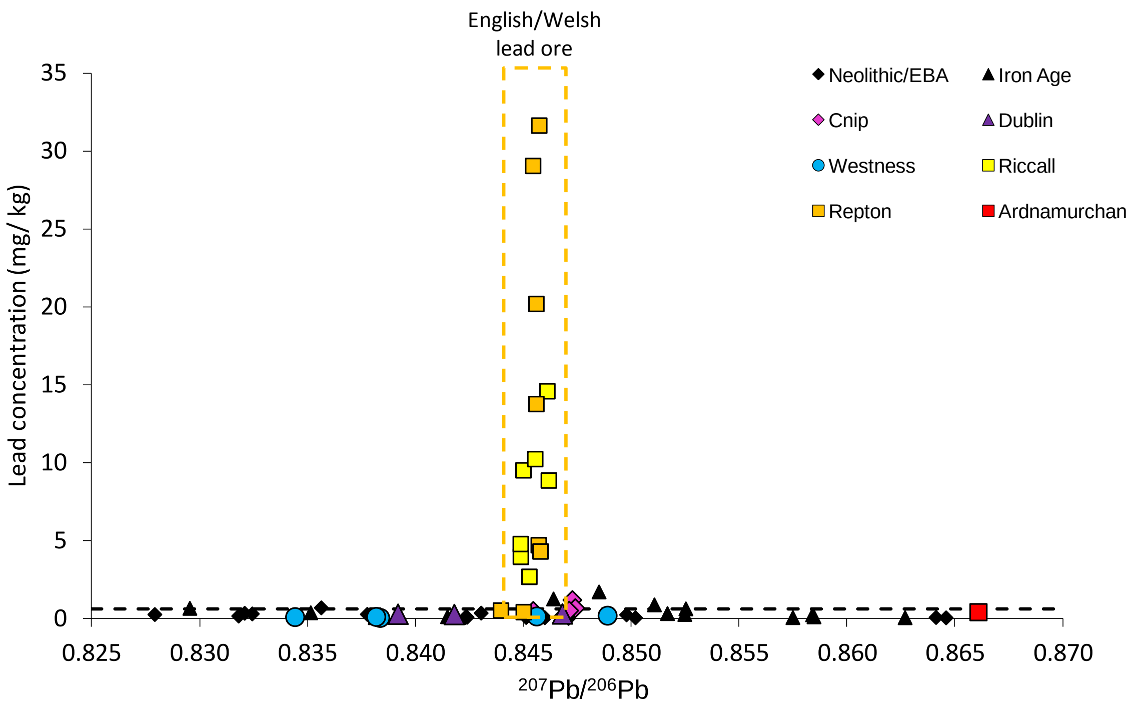

Figure X2 Enamel lead isotope ratios and concentrations for the Ardnamurchan individual compared to other prehistoric individuals and Viking period burials from Britain. The dashed line indicates the upper ~0.5 mg/kg limit of enamel lead burdens of individuals not exposed to anthropogenic pollutant lead sources and the individuals with high lead levels have values of ~0.846 which is characteristic of English and Welsh lead ores (Montgomery et al. 2010; 2014).

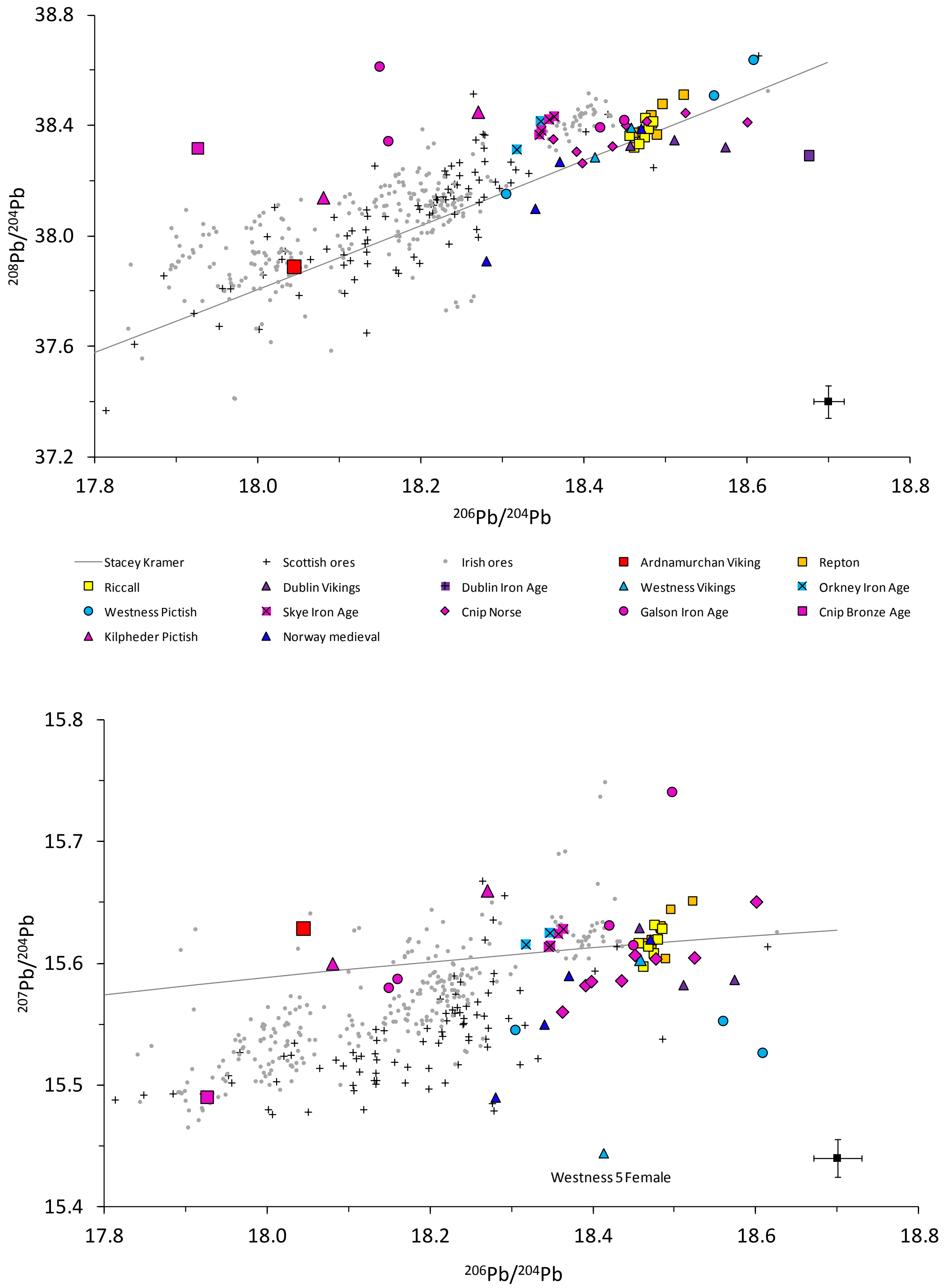

Figure X3 enamel lead isotope plots of the Ardnamurchan individual compared to Scottish and Irish ore fields (data from Rohl 1996 and sources therein), the Stacey and Kramer (1975) growth curve for conformable lead ore deposits, and other humans from the Viking period or the Western and Northern Isles (data from Montgomery et al. 2010; 2014) Error bars indicate 2σ analytical uncertainty for TIMS.

Tables

Table X1. Incremental and mean carbon and nitrogen isotope data from the second molar. *Estimated ages are calculated according to Beaumont and Montgomery (2015).

section number (from crown)	$\delta^{15}N$ ‰	$\delta^{13}C$ ‰	Amt%N	Amt%C	C:N	age in years*
ARD1	10.6	-21.2	13.4	40.5	3.5	2.5
ARD2	11.9	-20.5	14.2	40.7	3.4	3.5
ARD3	12.5	-20.2	14.6	42.1	3.4	4.5
ARD4	12.8	-20.0	14.3	41.6	3.4	5.5
ARD5	11.4	-20.4	14.3	41.2	3.4	6.5
ARD6	11.0	-20.7	14.2	41.1	3.4	7.5
ARD7	11.0	-20.6	14.2	41.4	3.4	8.5
ARD8	10.5	-20.7	14.4	41.5	3.3	9.5
ARD9	10.2	-20.9	14.2	41.1	3.4	10.5
ARD10	10.0	-20.7	13.8	40.5	3.4	11.5
ARD11	10.2	-20.8	13.8	40.4	3.4	12.5
ARD12	10.6	-20.8	13.9	40.8	3.4	13.5
ARD13	10.4	-21.2	13.5	40.8	3.5	14.5
Mean for crown (1-6)	11.7	-20.5				
Mean for root (7-13)	10.4	-20.8				
Mean for tooth	11.0	-20.7				

Table X2 Oxygen and carbon isotope data measured and calculated from the second molar enamel.

	$\delta^{13}C_{PDB}$	δO^{18}_{PDB}	$\delta^{18}O_{VSMOW}$	$\delta^{18}O_{VSMOW}$	δO^{18}_{VSMOW}
	carbonate	carbonate	carbonate	phosphate	precipitation
Equation			Coplen (1988)	Chenery et al. (2012)	Daux et al. (2008) Eq. 6
Units	‰	‰	‰	‰	‰
ARDV-1	-15.2	-5.2	25.6	16.7	-8.0

Table X3. Strontium and lead isotopes and concentrations from the second molar enamel.

	Sr mg/kg	$^{87}Sr/^{86}Sr$	**Pb mg/kg**	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$
ARDV-1	142	0.71122	0.4	18.044	15.629	37.890	0.8661	2.0999