The settlement of Iceland; analysis of strontium isotopes in human teeth.

A preliminary discussion of results

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Cover photograph: Cranium of skeleton BBE-A-001 from Bakki in Norður Múlasýsla

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Introduction

This project involves the study of the settlement of Iceland through the analysis of strontium isotope of human tooth enamel from archaeological skeletons. The premise of this analytical technique is that the strontium isotopes of a particular geographical area are carried through the soil and into the food chain into the human skeleton where it replaces calcium in the skeletal and dental tissues. Due to the relative mass differences of strontium isotopes, their composition is not fractionised by the biological process, which means that the strontium isotope signature of an individuals bones and teeth should reflect that of the geology where they lived (Bentley, 2006; Price *et al.*, 1994)

As the enamel of teeth does not regenerate, the strontium isotope composition of an individuals enamel will reflect the strontium composition of the geology of the area where that individual lived until about 6 years of age, by which time most of the enamel of the permanent dentition (apart from the third molar) is fully formed (Hillson, 1996). Therefore, by studying the strontium isotope of dental enamel from early skeletons in Iceland it should be possible to identify the immigrants from those born in Iceland.

Iceland is a fascinating place in which to study strontium isotopes. It is one of the youngest landscapes on the earth, a volcanic island that emerged from the sea over the last 25 million years. This new volcanic bedrock has one of the lowest strontium isotope signatures on earth. Any migrants from northern Europe to the island will exhibit highly distinctive strontium isotope ratios in their tooth enamel, as they will most likely have come from geologically much older areas, such as south-western Norway, the Scottish isles and Ireland.

The aim of this study was to test the strontium isotope method on Icelandic material, to see, if by selecting a large enough sample, that those not born in Iceland could be isolated, and therefore make a larger scale study of the colonization of Iceland possible; e.g. how long did the "Settlement period" last, where did the settlers come from, did the settlers in one area come from the same place?

The sample

There are a total of 182 skeletons preserved from pagan burials in Iceland. Of these about 30% are well preserved. More than 90% of the burials are adults; approximately 68% are male and 32% are female (Hildur Gestsdóttir, 1998).

During the first phase of sampling 44 skeletons from two early Christian cemeteries were sampled (Haffjarðarey in Haffjörður – 10 skeletons & Skeljastaðir in Þjórsárdalur – 33 skeletons). In addition 46 skeletons from pre-Christian pagan burials (*kuml*) were sampled (Hildur Gestsdóttir & T. Douglas Price, 2003; Price & Gestsdóttir, 2006).

The second phase of sampling involved a further 37 skeletons from kuml sampled, bringing the total of pre-Christian samples to 83. These will be discussed as one group in this report. An assessment has been carried out of all the skeletons from known kuml preserved in Iceland and all the skeletons with preserved enamel which can be accessed have been sampled. For further detail see appendix 1.

The 83 skeletons from kuml come from 54 sites. The largest group, 25, were single inhumations. There were 4 cases of both burials from a double inhumation, on case each of all burials from a group of 3 and a group of 4. The rest were between 1 and 8 skeletons from burial groups which included between 2 to 14 individuals. In many cases there was no solid dating evidence for these burials. The pre-Christian period in Iceland is traditionally considered to last from the first settlement towards the end of the 9th century until AD 1000. Datable grave goods from pagan burials support this, all of them falling in the period between the middle of the 9th century – 10th century. Of the pagan-period skeletons sampled here, 49 (59.0%) have datable grave goods. There are 22 cases where radiocarbon samples have been analysed (27%) and three cases, all from one site (2.4%) where there is tephrachronological dating evidence. There is some overlap, so a total of 58 skeletons (69.9%) have some sort of dating evidence.

For the location of the sites sampled in this project, see Figure 1.

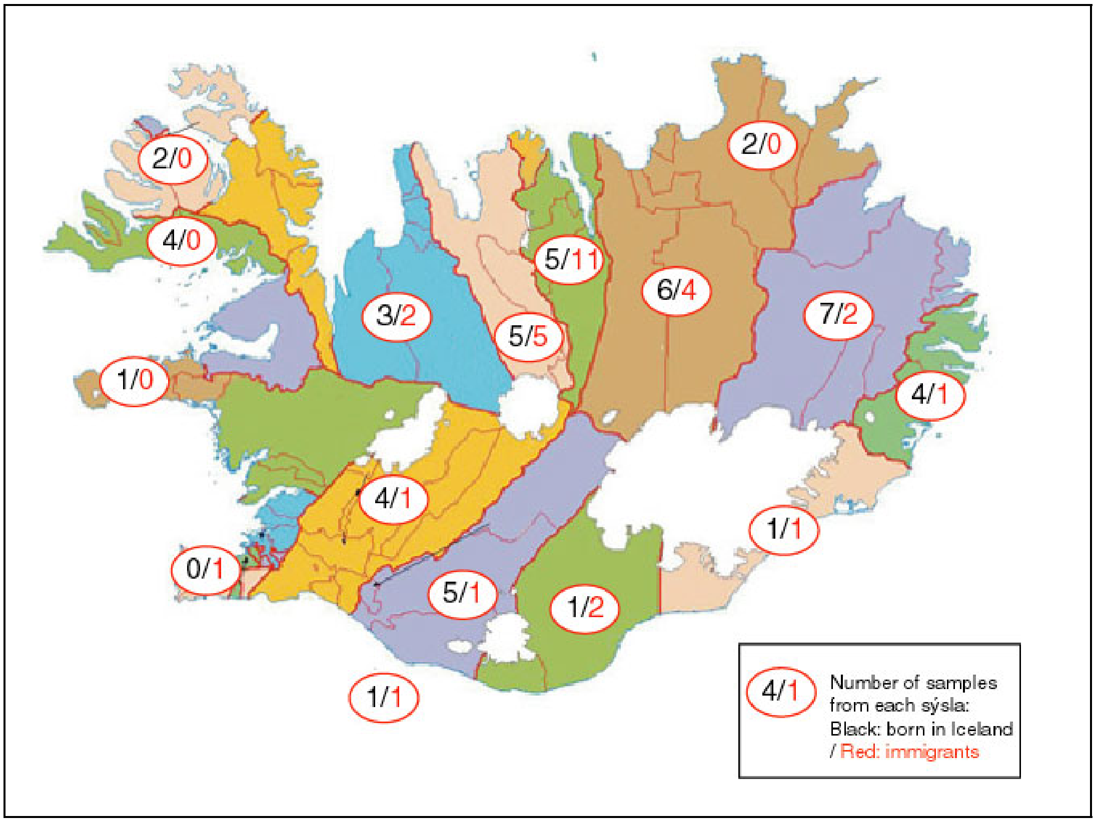

Figure 1. The samples by county

Method

Where possible the first molar was sampled, with a quarter of the tooth sawed off. In those instances where an incisor, canine or premolar was sampled, half the tooth was used for the analysis. Teeth displaying pathological lesions or non-metric traits were avoided, as were teeth still sat in the alveolar bone, even if it meant sampling teeth other than the first molar. The tooth samples were mechanically abraded with a Dremel tool fitted with a sanding bit to remove any visible dirt and/or preservative and drilled to remove the enamel layer from the underlying dentine.

Tooth enamel samples were then transferred to sterile savilex digestion vials and hot digested in ultrapure concentrated nitric acid, dried in a sterile laminar flow drying box, and redisolved in ultrapure 2.5 N hydrochloric acid. This procedure was repeated if there were any trace organics remaining in the sample. Strontium was then isolated using cation exchange chromatography with 2.5 N hydrochloric acid as the mobile phase.

Samples were then mounted on zone-refined tantalum filaments, and strontium was analysed using a thermal ionisation multiple collector mass spectrometer (TIMS). 87Sr/86Sr ratios were corrected for mass fractionation in the instrument using the exponential mass fractionation law and 86Sr/88Sr = 0.1194. The samples were measured using a MicroMass Sector 54. $^{87}Sr/^{86}Sr$ analyses (n = 40) of the NIST SRM strontium carbonate yielded a value of 0.710259 +/- 0.0003 (2 SE). Internal precision (standard error) for the samples analysed at UNC-CH is typically 0.000006 to 0.000010, based on 100 dynamic cycles of data collection.

Results

The results of the strontium analysis of the human dental enamel are detailed in Appendix 2, and the distribution of the strontium analysis, arranged from the lowest (0.705660) to the highest (0.725672) levels, is shown in Figure 2. Compared to the strontium results are the average levels for bedrock in Iceland (0.703), seawater (0.7092) and for modern sheep (0.706335). Bedrock and sea levels represent the lowest and highest strontium levels respectively to be found within the Icelandic environment while the levels for sheep indicate the expected strontium levels for a mammal living on entirely terrestrial diets.

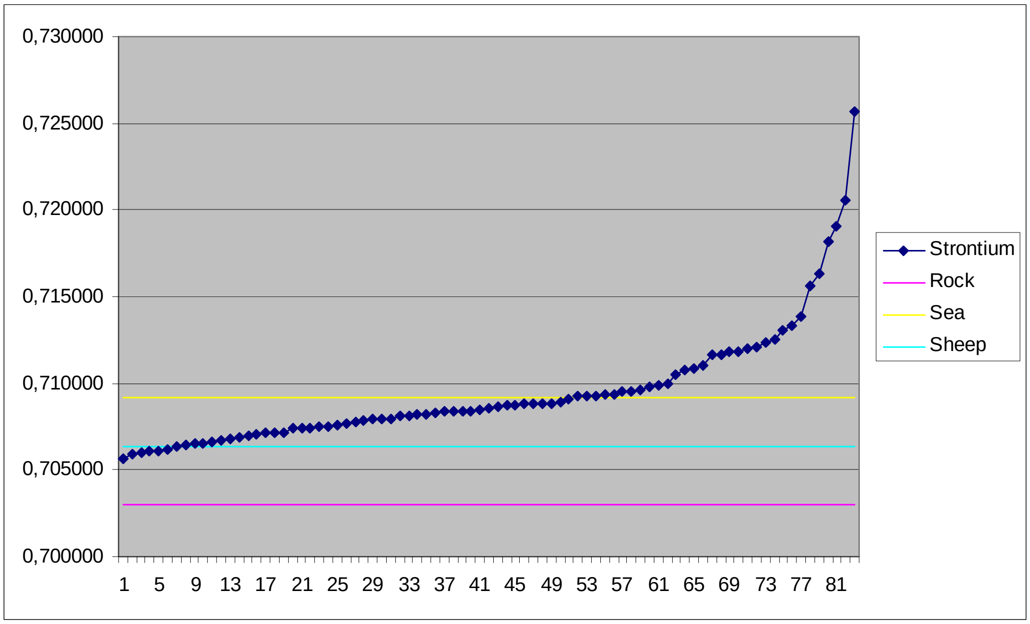

Figure 2. Strontium isotope signatures

Samples 1-51 (0.705660 – 0.709117) represent those individuals born in Iceland. The variation in strontium ratios is represented by dietary difference, from those whose diet was mainly terrestrial (lowest) to those with a mainly marine diet (highest). Samples 52-83 (0.709270 – 0.725672) are those individuals whose strontium ratios are level with or higher than that of the sea, which means that it is impossible for them to have spent the first 6 years of their lives within Iceland, as there is nothing within the Icelandic environment with higher strontium ratios than the sea. Those with ratios at the same level as the sea are unlikely to be raised in Iceland, as it is impossible for anyone to live on an 100% marine diet, everyone will have to at the very least ingest fresh water.

Discussion

Of the 83 skeletons from kuml sampled for this study, 27 individuals had strontium isotope signatures higher that that of seawater (0.7095) and an additional 5 had signatures at the level of seawater, indicating that at least 32 (39%) of the skeletons included in the study belong to individuals who could not have been born in Iceland. There is enough variation in the strontium levels to indicate that the settlers did not all originate in the same place. It is not possible to use strontium ratios alone to isolate the places of origin, although they can be used to exclude areas.

The Icelandic variation in strontium signature, from 0.705620 (ÞSK-A-28) to 0.709325 (SSG-A-3), is most likely explained by variation in diet, from almost entirely terrestrial (the lower figures) to almost entirely marine (the higher figures). This is because Iceland is geologically young and the rubidium has not had time to decay into strontium 87, so the strontium ratio of Icelandic rock is very low, circa 0.703, which means that the strontium ratio of people who lived mainly on a terrestrial diet will be closer to that figure. On the other hand the strontium ratio of seawater around the globe is much higher circa 0.7095 so people eating a fully marine diet will have strontium ratios nearer that.

These results suggest that the potential analysis of this material is great, as strontium in the human body is also stored in the bones, and as bones continue to be remodelled throughout life, the strontium isotope signature in the bones will reflect the geology and the diet of the region that that person spent the last few years of their life in. This means that it would be possible to look at individual changes in marine versus terrestrial diet and use that data to hypothesise about changes in diet, which is most likely to be associated with movement of people within Iceland.

Work has commenced in attempting to locate the areas of origins for the individuals which have been identified as immigrants to Iceland. Analysis of oxygen isotopes in 12 of the immigrant skeletons has already been carried out (for results see appendix 3), the theory being that the oxygen isotope composition of the biological phosphate found in teeth and bones can be related to that of drinking water which can be compared to known modern oxygen isotope zones in the areas where these immigrants are likely to have originated from (Evans *et al.*, 2006). As yet the result of this analysis has not proven conclusive and so further isotope analysis, in particular geological lead, is planned. It is hoped that the analysis of strontium, oxygen and lead isotopes together can be used to pinpoint the origin of those already identified as settlers in Iceland with the strontium isotopes.

Although the countries of origin can not be further discussed at this stage, it is possible to start looking at some of the patterning of settlement. As already stated, 39% of the individuals already sampled show a strontium ratio equal to or higher than that of sea-water, indicating that they could not have been born in Iceland. The sampling strategy involved as far as possible, including individuals from all areas of Iceland, allowing comparisons between different regions of Iceland. The sample includes a total of 83 individuals, so that any analysis of a geographical variation within the sample has to be carried out at a large scale. By the 10th century Iceland had been divided into 4 quarters; north – *Norðlendingafjórðungur* (33 individuals); south – *Sunnlendingafjórðungur* (14 individuals); east – *Austfirðingafjórðungur* (29 individuals) and west – *Vestfirðingafjórðungur* (7 individuals) for political and administrative purposes (see e.g. Gunnar Karlsson, 2000), and it was decided to use these divisions to look at the geographical distribution of settlers. The number of samples from each quarter is varied and in no instance very high and so any conclusions reached as to their meaning have to be made cautiously. However there are two factors which are quite noteworthy if one looks at these results. The first are the results from Norðlendingafjórðungur, where 55% of the individuals sampled are clearly not born in Iceland, a much higher percentage than the 39% of the country as a whole and the second are the results from Vestfirðingafjórðungur where all individuals are born in Iceland and lived on an heavily marine diet the first 6 years of their lives (although it must be noted that this is only 7 individuals). These results raise questions as to the nature and length of the settlement as well as questions as to the nature of burial practises during the settlement period.

Most simply put, the higher percentage of immigrants buried in kuml in Norðlendingafjórðungur can be explained by one of three factors:

1. This is where most of the original immigrants settled.
2. This is the part of the country where the "settlement period" lasted the longest.
3. This is where most of the immigrants were buried in kuml, i.e. there may have been immigrants using other burial practises which have to date not been recognised as belonging to the settlement period.

One of the main problems with answering these questions is the lack of absolute dating for these burials. Based on documented sources the practise of burying in kuml dates from the first settlement, until the Christianisation of Iceland in AD 1000 (Gunnar Karlsson, 2000). Only a handful of kuml have been dated through tephrachronology, and all of them fit into this period. Similarly, those graves that have datable artefacts mostly fit into the 10^{th} century (Kristján Eldjárn, 2000). A handful of radiocarbon dates exist for pre-Christian burials, some of which extend into the 11^{th} century while others predate the late 9^{th} century time of settlement by as much as 200 years (Price & Gestsdóttir, 2006). However recent work on radiocarbon dating from kuml and middens in northern Iceland indicates that the effect of both the marine reservoir and geothermally derived CO_2 in the groundwater are distorting the radiocarbon dates and that further work needs to be carried out to solve these issues (Ascough *et al.*, in pre). However, because of how short the period where people were being buried in kuml was (c. 200 years), it is unlikely that even with secure radiocarbon dating that a good chronology could be achieved

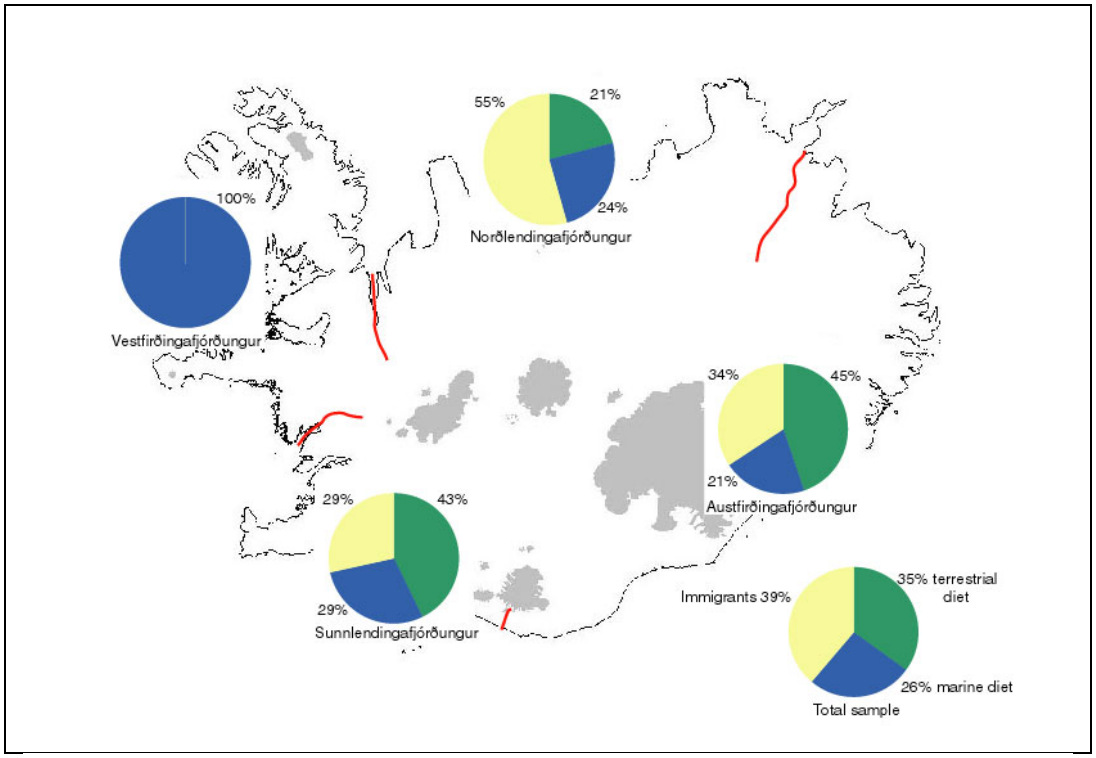

Figure 3. Geographical distribution of results by quarters

The *Book of the Settlements* which chronicles the settlement of Iceland, of which the earliest versions exist from the 13th century, records the settlement of Iceland in AD 874 and states that the entire country was settled simultaneously and that the settlement period only lasted for 60 years. Archaeological evidence appears to support this late 9th century date with little evidence of human activity in Iceland preceding the settlement layer (*landnámslag*), a tephra layer dated to AD 872±2 (see e.g. Gunnar Karlsson, 2000). If it is taken as a given that a large proportion of the people who died in Iceland in the first two centuries of settlement were buried in kuml, then the results of the strontium analysis do not support this. If Iceland was indeed settled in as short a period as 60 years the results would seem to indicate that a large proportion of the immigrants settled in the Norðlendingafjórðungur, with Vestfirðingafjórðungur being a place of secondary settlement, with people moving there from other parts of Iceland. It has long been noted that a large proportion of kuml have been found in the north of Iceland, with only a handful of sites known in the western part. A popular explanation for this (see for example Kristján Eldjárn, 2000) is that much more intensive roadwork, associated with a denser population, and increased erosion in the northern part explain the higher density of kuml there, i.e.

that those in the west simply haven't been found. However if the theory of the north being a focal point in the settlement process is to be believed then the higher percentages of kuml in the north would be explained by the fact that there simply are more kuml located there.

On the other hand, a preliminary review of the grave goods associated with the skeletons sampled for this study, as well as an assessment of the few radiocarbon dates available does not show any clear difference between the immigrants and those born in Iceland. As an example, of the eight skeletons sampled from the kuml burial ground at Dalvík (DAV) in Eyjafjarðarsýsla, six are clearly not born in Iceland. However, radiocarbon dates from the site place it in the late 10th-early 11th century (Price & Gestsdóttir, 2006), and all the datable grave goods (beads and oval broaches) can be dated to the 10th century. The same can be said for datable grave goods from other sites where immigrants are buried, for example Álaugarey (AEY) in Austur-Skaftafellssýsla and Daðastaðir (DAP) in Norður Þingeyjarsýsla (Kristján Eldjárn, 2000; Elín Ósk Hreiðarsdóttir, 2005). This would indicate that a significant percentage of immigrants were arriving in Iceland well into the 10th century. It must be added that a large percentage of datable grave goods from both immigrant and local kuml cannot be dated more specifically than mid 8th-10th century so a detailed analysis cannot be carried out.

Another feature of the results of the strontium analysis which needs to be looked at regarding the length of the settlement period is the ratio of males v. females. Of the 83 skeletons in the sample 65 could be sexed (in general the preservation of skeletal material from Icelandic kuml is quite poor and does therefore not allow for sexing of the remains). Of these 44 were male and 21 were female. However 11 of the females were immigrants (52% of the total females) as opposed to 12 (27%) of the males. So although males represent a larger proportion of those buried in kuml, a higher percentage of the females were immigrants. This could also be a reflection of the nature of immigration. It is not unknown in periods of mass immigration that the males will be a larger proportion of the first wave of settlers, with women following in an extended period until the ratio has evened out. This is perhaps reflected in this sample, that a large proportion of the females living in Iceland in the first 200 years of settlement are represented by a trickle of immigrants over a long period of time being brought in to balance the ratio of males to female. Again such theories are difficult to support without more absolute dating for the skeletons in the sample.

There remains however the issue of the nature of burials in the settlement period in Iceland. The traditional, simplistic view is that the first settlers buried their dead in kuml associated with grave goods, but after the Christianisation of Iceland in AD 1000 (see e.g. Gunnar Karlsson, 2000) burial in Christian cemeteries took over. It is however recorded in the *Book of the Settlements* that Christians were among the first settlers, and undoubtedly they would have buried their dead according to Christian customs, and although the start of use of some early cemeteries in Iceland have been tentatively dated to the latter part of the 10th century, e.g. Hofstaðir in Mývatnssveit (Hildur Gestsdóttir, 2006), there are no cemeteries which have been dated conclusively well into the settlement period. On the other hand, conclusive dating of the start of use of many medieval cemeteries is often lacking (for example the dating of the start of use of the cemetery at Skeljastaðir in Þjórsárdalur at c. AD 1000 (Matthías Þórðarson, 1943) seems to be largely based on the documented date of the Christianisation of Iceland), so it cannot be excluded that Christian cemeteries were in use during the settlement period. This raises questions as to how accurate a sample of the population the individuals from kuml represent of the population in the first two centuries of settlement in Iceland.

Another issue is what should be considered a kuml. Because of the lack of absolute dating, in many instances only those burials which include grave goods are considered kuml. There are however several finds of isolated graves which are topographically akin to kuml and are clearly not associated with a traditional Christian cemetery, but because of the lack of grave goods these are not included. However it is known that there are instances of sites of groups of more than one kuml (*kumlateigur*), where individuals without grave goods are considered to be buried in a kuml because of their association with other individuals buried with grave goods (Kristján Eldjárn, 2000). This would indicate that it is highly likely that some single inhumation kuml would not include grave goods. This again raises the question as to how accurate a sample of the population these burials associated with grave goods represent, especially if it is considered who was being buried with grave goods. A large proportion of artefacts from graves include imported material. Does this indicate that those buried with grave goods represent the immigrants who brought the goods themselves and that their descendants, those born in Iceland, simply didn't have the material or were aware of the fact that these items were not easily replaceable and therefore chose not to put them into the graves? If this is the case, then the results of the strontium analysis would be heavily biased towards the immigrants rather than those born in Iceland and are again not representative of the population living in Iceland during the settlement period.

These are issues which can hardly be solved here, and involve a more accurate look at the dating of all burials, not only from kuml, but also the early cemeteries and isolated burials with no associated grave goods. In addition a more detailed look at the artefacts associated with the burials in relation to immigrants and non-immigrants might help to improve our understanding.

Work on this project will continue, both with, as already discussed further isotope analysis of the Icelandic material, and analysis of skeletal material from other parts of the North Atlantic, which will hopefully make mapping of the places of origin easier.

Acknowledgements

Thanks are due to the Icelandic Centre for Research (RANNÍS) & the National Science Foundation (NSF) for funding this study and to the National Museum of Iceland, The Archaeological Heritage Agency of Iceland & Glaumbær Folk Museum for allowing the teeth to be sampled.

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Appendix 1 – Samples

Place name	Hreppur	Sýsla	Kuml & haugfé[1]	Ísleif[2]	National Museum[3]	Sex[4]	Age[4]
Aðalból	Jökuldalshreppur	Norður Múlasýsla	129	NM-130:003	ABH-A-001	Female?	45+
Álaugarey	Nesjahreppur	Skaftafellssýsla	151	SF-019:151	AEY-A-001	Female	36-45
Álfsstaðir	Skeiðahreppur	Árnessýsla	29	ÁR-236:029	ASS-A-001	Unknown	35-45
					ASS-B-001	Female	18-25
Bakki	Skeggjastaðahreppur	Norður Múlasýsla	127	NM-016:127	BBE-A-001	Male?	35-45
Brandsstaðir	Bólstaðarhlíðarhreppur	Húnavatnssýsla	68	HV-272:068	BRB-A-001	Unknown	18-25
Brimnes	Viðvíkurhreppur	Skagafjarðarsýsla	79	SK-277:016	BRV-A-003	Unknown	Adult
				SK-277:016	BRV-A-004	Unknown	Adult
				SK-277:016	BRV-A-005a	Unknown	Adult
Brú á Jökuldal	Jökuldalshreppur	Norður Múlasýsla	128	NM-122a:022	BAJ-A-001	Male?	45+
Daðastaðir	Presthólahreppur	Norður Þingeyjarsýsla	126	NÞ-075:043	DAP-A-001	Unknown	45+
Dalvík	Svarfaðardalshreppur		89	EY-101:020	DAV-A-001	Male	25-35
					DAV-A-002	Male?	35-45
					DAV-A-004	Male	45+
					DAV-A-005	Male	45+
					DAV-A-006	Female	45+
					DAV-A-007	Male	< 35
					DAV-A-008	Female?	25-35
					DAV-A-009	Female?	18-25
Draflastaðir	Hálshreppur	Suður Þingeyjarsýsla	109	SÞ-070:109	DSH-A-001	Male	35-45
Dufþaksholt	Hvolhreppur	Rangárvallasýsla	8	RA-236:008	DUH-A-001	Male	35-45
Einholt	Mýrarhreppur	Skaftafellsýsla	153	SF-048:026	EIM-A-001	Female	25-35
Fellsmúli (gamli)	Landmannahreppur	Rangárvallasýsla	20	RA-437:020	VDS-A-001	Adult	Adult
					VDS-B-001	Male?	45+

[1] *Kuml* number in Kristján Eldjárn (2000).
[2] Number in Ísleif, the Institute of Archaeology field survey database
[3] Number in the National Museum Human skeletal remains database
[4] Hildur Gestsdóttir, 1998

Place name	**Hreppur**	**Sýsla**	**Kuml & haugfé**[1]	**Ísleif**[2]	**National Museum**[3]	**Sex**[4]	**Age**[4]
Gauksstaðir	Jökuldalshreppur	Norður Múlasýsla	Beinafundur	NM-126b:017	GSJ-A-002	Male?	45+
Gautlönd	Skútustaðahreppur	Suður Þingeyjarsýsla	118	SÞ-194:118	GLÞ-A-001	Male	35-45
Gilsárteigur	Eiðahreppur	Suður Múlasýsla	147	SM-004:147	GTE-A-001	Male	18-25
					GTE-A-002	Male	35-45
Glaumbær	Reykdælahreppur	Suður Þingeyjarsýsla	120	SÞ-270:020	GBR-A-002	Male?	Adult
Grásíða	Kelduneshreppur	Norður Þingeyjarsýsla	122	NÞ-015:122	GSV-A-001	Male	18-25
Grímsstaðir	Skútustaðahreppur	Suður Þingeyrjarsýsla	116	SÞ-209:031	GRM-A-001	Male	35-45
				SÞ-209:031	GRS-A-001	Male	35-45
				SÞ-209:031	GRS-A-002	Male	35-45
Hafurbjarnarstaðir	Miðneshreppur	Gullbringusýsla	140	GU-077:040	HBS-A-006	Male	35-45
Hólaskógur	Gnúpverjahreppur	Árnessýsla	34	ÁR-673-028	ÞHS-A-001	Female?	35-45
Hraukbær	Glæsibæjarhreppur	Eyjafjarðarsýsla	Beinafundur	EY-284:004	HRB-A-001	Male	Adult
					HRB-A-002	Female	18-25
Hrífunes	Skaftártunguhreppur	Skaftafellssýsla	155	SF-188:029	HRS-A-002	Unknown	35-45
Hrífunes	Skaftártunguhreppur		155	SF-188:029	HRS-B-001	Unknown	Adult
Hrífunes	Skaftártunguhreppur		155	SF-188:029	HRS-C-001	Female?	35-45
Hrólfstaðir	Jökuldalshreppur	Norður Múlasýsla	131	NM-114:131	HSJ-A-001	Male	35-45
Karlsnes	Landmannahreppur	Rangarvallasýsla	21	RA-435:021	KNS-A-001	Male	35-45
Keldudalur	Rípuhreppur	Skaftafellssýsla		SK-450:007	*Kuml 1*[5]	Female[6]	40-50
					Kuml 4[5]	Female[6]	30-40
Kolsholt	Villingaholtshreppur	Árnessýsla	24	ÁR-021:031	KHF-A-001	Unknown	35-45
Kornhóll (Skansinn)		Vestmannaeyjar	1	VE-001:003	SVE-A-001	Male	45+
				VE-001:003	SVE-B-001	Female?	Adult
Kroppur	Hrafnagilshreppur	Eyjafjarðarsýsla	101	EY-314:101	KRE-A-001	Male?	35-45
Ljótsstaðir	Hofshreppur	Skaftafellssýsla	80	SK-329:012	LSS-A-001	Unknown	Adult
Lyngbrekka	Helgastaðahreppur	Suður Þingeyjarsýsla		SÞ-281:014	*DAD-001*[7]	Female?[8]	35-45
Njarðvík	Borgarfjarðarhreppur	Norður Múlasýsla		NM-209:048	NNM-A-001	Unknown	Adult
Núpar	Helgastaðahreppur	Suður Þingeyjarsýsla	121	SÞ-236:022	NUA-A-001	Female?	25-35

[5] Skeletal code from excavation (Guðný Zoega, pers. comm.)
[6] Guðný Zoega, pers. comm.
[7] Skeletal code from excavation (Adolf Friðriksson, pers. comm.)
[8] Analysis by author (HG)

Place name	Hreppur	Sýsla	Kuml & haugfé[1]	Ísleif[2]	National Museum[3]	Sex[4]	Age[4]
Ormsstaðir	Eiðahreppur	Suður Múlasýsla	148	SM-002:148	ORE-A-001	Male	45+
Selfoss	Sandvíkurhreppur	Árnessýsla	26	ÁR-217:041	SFA-B-001	Female?	Adult
Sílastaðir	Glæsibæjarhreppur	Eyjafjarðarsýsla	98	EY-272:007	SSG-A-001	Male	45+
				EY-272:007	SSG-A-002	Male	45+
				EY-272:007	SSG-A-003	Male	35-45
				EY-272:007	SSG-A-004	Female?	35-45
Skarðstangi (Merkurhraun)	Landmannahreppur	Rangárvallasýsla	16		MEH-A-001	Female?	45+
Skíðastaðir	Lýtingsstaðahreppur	Skagafjarðarsýsla	73	SK-171:073	VSL-A-001	Female?	36-45
Smyrlaberg	Lýtingsstaðahreppur	Húnavatnssýsla	65	HV-223:004	SBT-A-001	Male	45+
				HV-223:004	SBT-B-001	Unknown	Adult
Sólheimar	Seyluhreppur	Skagafjarðarsýsla	70	SK-078:021	SHS-A-001	Male?	Adult
Stafn	Bólstaðarhlíðarhreppur	Húnavatnssýsla	67	HV-279:008	STB-A-001	Male	35-45
Stóri Klofi	Landmannahreppur	Rangárvallasýsla	18	RA-463:003	STK-A-001	Male?	Adult
Straumur	Tunguhreppur	Norður Múlasýsla	134	NM-086:134	STT-A-002	Male	45+
Sturluflötur	Fljótsdalshreppur	Norður Múlasýsla	137	NM-157:009	SFA-A-001	Unknown	Adult
Surtsstaðir	Hlíðarhreppur	Norður Múlasýsla	132	NM-110:132	SSJ-A-002	Male	35-45
Svínadalur	Kelduneshreppur	Norður Þingeyjarsýsla	141	NÞ-025:008	SVK-A-001	Male	35-45
Syðra-Krossanes	Glæsibæjarhreppur	Eyjafjarðarsýsla	100	EY-241:100	SYK-A-001	Male	45+
Tyrðilmýri	Snæfjallahreppur	Ísafjarðarsýsla	56	ÍS-240:056	TMY-A-001	Male?	Adult
					TMY-A-002	Male?	25-35
Urriðaá	Ytri-Torfulækjarhreppur	Húnavatnssýsla	57	HV-057:031	UAM-001	Unknown	Adult
Vað	Skriðdalshreppur	Suður Múlasýsla	145	SM-069:145	VAS-A-001	Male	35-45
Vatnsdalur	Rauðasandshreppur	Barðastrandarsýsla	54	BA-148:046	VDP-A-003	Male	18-25
				BA-148:046	VDP-A-005	Female	35-45
				BA-148:046	VDP-A-006	Male	25-35
				BA-148:046	VDP-A-007	Male	35-45
Vestdalsvatn		Suður Múlasýsla			*Fjallkonan*[9]	Unknown[10]	Adult
Víðar (Másvatn)	Helgastaðahreppur	Suður Þingeyjarsýsla		SÞ-285:029	MKR-A-001	Male	35-45

[9] Skeleton code from excavation (Sigurður Bergsteinsson pers. comm.)
[10] Guðný Zoega, pers. comm.

Place name	Hreppur	Sýsla	Kuml & haugfé[1]	Ísleif[2]	National Museum[3]	Sex[4]	Age[4]
Öndverðarnes	Breiðavíkurhreppur	Snæfellsnessýsla	47	SN-123:047	DKS-A-001	Unknown	18-25
Öxnadalsheiði	Akrahreppur	Skagafjarðarsýsla	76		OXH-A-001	Female?	35-45
					OXH-A-002	Unknown	Adult

Appendix 2 – Results[11]

Place name	National Museum[12]	Strontium ratio	Standard deviation	Date - ^{14}C[13]	Date - Typology[14]	Date - tephra-chronology
Öxnadalsheiði	OXH-A-001	0,705660	0,0008		900-1000	
Álfsstaðir	ASS-B-001	0,705878	0,0007		900-1000	
Karlsnes	KNS-A-001	0,706031	0,0008		950-1050	
Fellsmúli (gamli)	VDS-A-001	0,706084	0,0007		900-1000	
Gilsárteigur	GTE-A-001	0,706095	0,0008			
Njarðvík	NNM-A-001	0,706157	0,0007			
Dufþaksholt	DUH-A-001	0,706333	0,0006			
Hraukbær	HRB-A-002	0,706400	0,0009			
Víðar (Másvatn)	MKR-A-001	0,706498	0,0007	X		
Glaumbær	GBR-A-002	0,706552	0,0008	X		
Gautlönd	GLÞ-A-001	0,706613	0,0008	X		
Hrífunes	HRS-B-001	0,706699	0,0006		850-1000	pre 934
Grásíða	GSV-A-001	0,706836	0,0008	X	900-1000	
Straumur	STT-A-002	0,706909	0,0008	X	900-1000	
Aðalból	ABH-A-001	0,706975	0,0007			
Stóri Klofi	STK-A-001	0,707032	0,0007		900-1000	
Grímsstaðir	GRM-A-001	0,707107	0,0006			
Brimnes	BRV-A-005a	0,707122	0,0007		900-1000	
Grímsstaðir	GRS-A-001	0,707132	0,0007	X		
Brandsstaðir	BRB-A-001	0,707373	0,0008			
Dalvík	DAV-A-005	0,707427	0,0008	X	900-1000	
Hrólfstaðir	HSJ-A-001	0,707435	0,0007			
Gilsárteigur	GTE-A-002	0,707466	0,0008			
Keldudalur	*Kuml 4*[15]	0,707489	0,0008			
Selfoss	SFA-B-001	0,707631	0,0008			
Surtsstaðir	SSJ-A-002	0,707669	0,0008		850-1050	
Svínadalur	SVK-A-001	0,707778	0,0007	X		
Syðra-Krossanes	SYK-A-001	0,707822	0,0007			
Fellsmúli (gamli)	VDS-B-001	0,707913	0,0008		900-1000	
Urriðaá	UAM-001	0,707926	0,001			
Gauksstaðir	GSJ-A-002	0,707934	0,0007			
Hólaskógur	ÞHS-A-001	0,708113	0,0008		950-1050	
Öxnadalsheiði	OXH-A-002	0,708138	0,0008		900-1000	
Dalvík	DAV-A-001	0,708200	0,0008	X	900-1000	
Vatnsdalur	VDP-A-003	0,708221	0,0006		850-1050	
Álfsstaðir	ASS-A-001	0,708261	0,0007		900-1000	

[11] Arranged in order of strontium ratios from lowest to highest
[12] Code in National Museum Human Skeletal Database
[13] Existing radiocarbon dates are only indicated, all analyses have been carried out by other investigators and are to date unpublished. None of the dates are later than the mid 11th century
[14] Based on Kristján Eldjárn, 2000, except for analysis of beads; Elín Ósk Hreiðarsdóttir, 2005
[15] Skeletal code from excavation (Guðný Zoega, pers. comm.)

Place name	National Museum[12]	Strontium ratio	Standard deviation	Date - ^{14}C[13]	Date - Typology[14]	Date - tephra-chronology
Hraukbær	HRB-A-001	0,708351	0,0007			
Kornhóll (Skansinn)	SVE-A-001	0,708351	0,0007		900-1000	
Smyrlaberg	SBT-A-001	0,708372	0,0007			
Bakki	BBE-A-001	0,708401	0,0007			
Vatnsdalur	VDP-A-007	0,708498	0,0006		850-1050	
Vatnsdalur	VDP-A-005	0,708539	0,0007		850-1050	
Vað	VAS-A-001	0,708629	0,0007	X	800-1000	
Ormsstaðir	ORE-A-001	0,708745	0,0007		900-1000	
Öndverðarnes	DKS-A-001	0,708773	0,0008		850-1000	
Tyrðilmýri	TMY-A-002	0,708797	0,0007			
Tyrðilmýri	TMY-A-001	0,708804	0,0006			
Einholt	EIM-A-001	0,708820	0,0006		900-1000	
Grímsstaðir	GRS-A-002	0,708842	0,0006	X		
Vatnsdalur	VDP-A-006	0,708884	0,0007		850-1050	
Skíðastaðir	VSL-A-001	0,709117	0,0009			
Álaugarey[16]	AEY-A-001	0,709270	0,0008		900-1000	
Kornhóll (Skansinn)	SVE-B-001	0,709277	0,0008		900-1000	
Hrífunes	HRS-A-002	0,709304	0,0008		850-1000	pre 934
Núpar	NUA-A-001	0,709310	0,0008	X		
Sílastaðir	SSG-A-003	0,709325	0,0008		850-1000	
Sílastaðir	SSG-A-002	0,709533	0,0008		850-1000	
Sturluflötur	SFA-A-001	0,709542	0,0005		900-100	
Vestdalsvatn	*Fjallkonan*[17]	0,709634	0,0007		900-100	
Keldudalur	*Kuml 1*[18]	0,709835	0,0008			
Hafurbjarnarstaðir	HBS-A-006	0,709906	0,0007		900-1000	
Dalvík	DAV-A-007	0,709927	0,0007	X	900-1000	
Ljótsstaðir	LSS-A-001	0,710543	0,0007			
Skarðstangi (Merkurhraun)	MEH-A-001	0,710792	0,0007			
Hrífunes	HRS-C-001	0,710883	0,0008		850-1000	pre 934
Draflastaðir	DSH-A-001	0,711042	0,0007			
Dalvík	DAV-A-004	0,711672	0,0007	X	900-1000	
Sílastaðir	SSG-A-004	0,711674	0,0007		850-1000	
Dalvík	DAV-A-009	0,711835	0,0007	X	900-1000	
Kroppur	KRE-A-001	0,711861	0,0007		900-1000	
Brimnes	BRV-A-003	0,711989	0,0007		900-1000	
Dalvík	DAV-A-008	0,712090	0,0008	X	900-1000	
Kolsholt	KHF-A-001	0,712372	0,0007			
Brimnes	BRV-A-004	0,712540	0,0007		900-1000	
Dalvík	DAV-A-006	0,713033	0,0008	X	900-1000	
Sólheimar	SHS-A-001	0,713347	0,0008			

[16] Results in red indicate those skeletons strontium ratios higher than found within the environment in Iceland

[17] Skeleton code from excavation (Sigurður Bergsteinsson, pers. comm.)

[18] Skeleton code from excavation (Guðný Zoega, pres. comm.)

Place name	National Museum[12]	Strontium ratio	Standard deviation	Date - ^{14}C[13]	Date - Typology[14]	Date - tephra-chronology
Brú á Jökuldal	BAJ-A-001	0,713839	0,0008	X	900-1000	
Smyrlaberg	SBT-B-001	0,715603	0,0008			
Daðastaðir	DAP-A-001	0,716354	0,0007	X	950-1000	
Sílastaðir	SSG-A-001	0,718212	0,0008		850-1000	
Lyngbrekka	*DAD-001*[19]	0,719087	0,0008			
Stafn	STB-A-001	0,720571	0,0006		900-100	
Dalvík	DAV-A-002	0,725672	0,0008	X	900-1000	

[19] Skeleton code from excavation (Adolf Friðriksson, pers. comm.)

Appendix 3 – Oxygen isotopes

National Museum	^{13}C	^{18}O
BAJ-A-001	-16.72	26.46
DSH-A-001	-15.57	26.29
HBS-A-006	-15.01	24.65
KRE-A-001	-16.35	26.38
SSG-A-004	-15.66	25.83