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The Greenland Norse: bones, graves, computers, and DNA

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ABSTRACT. The remains of the Greenland Norse provide unique biological anthropological material for the investigation of human and environmental interaction. As a population, they were generally secluded from most of the contemporary European medieval society, and land suitable for their way of life was limited in Greenland. The archaeological and historical record is excellent, clearly establishing the 500-year period of colonisation. In other words, the Greenland Norse represent a relatively isolated population, constrained in both space and time.

Living in an environment with very little buffering capacity, ecological changes immediately had repercussions. Ten years of research have shown a direct climatic impact on the humans as well as changing subsistence patterns. It seems that the Norse in Greenland responded to these changes, although inside 'cultural' limits. Demographic modelling indicates that emigration may have accounted for the final abandonment of the settlements. A changing ecology thus seems to have pushed the Greenland Norse out of Greenland, because their sedentary way of life, relying on animal husbandry, and probably with a strong cultural sense of identity focused on farmsteads and domestication, became unsustainable. A further step will be clarifying the genetic history of the Norse as well as of the Thule Culture Inuit. These analyses have commenced by examining mtDNA variation and Y-chromosomal diversity among present-day Greenlandic Inuit, and preliminary results appear to provide some information as to the fate of the Norse people.

Contents

Introduction

According to the Icelandic sagas, Erik the Red founded the Greenlandic Norse settlement in the year AD 986 (Jones 1986). This first settlement (the Eastern Settlement) was augmented with another settlement (the Western Settlement), situated about 400 km to the north of the first one. The land was uninhabited, as the Thule Eskimos had not yet spread to the southwestern part of Greenland. A measure of the prosperity and the obvious steady contact with Iceland, and thereby Norway, was the ordination of a bishop to Gardar in the Eastern Settlement in AD 1124 (Arneborg 1991). It seems, however, that contact with Iceland and Norway gradually faded, although the settlements were still subject to the Norwegian crown in AD 1261. According to written sources, the Western Settlement lay waste in approximately AD 1360. The last known written testimony from the Eastern Settlement dates to AD 1408 (*Grønlands Historiske Mindesmærker* 1838–45: III, 145–150).[1] It has been assumed that the Eastern Settlement was finally depopulated a century later (Meldgaard 1965).

During the last 10 years the main author has been working extensively with the Norse (and Greenlandic Inuit) skeletal material, and certain patterns seem to emerge: patterns of climate change and shifts in dietary reliance as well as patterns of societal and demographic change. This paper summarises this research, which has been based on natural scientific and biological anthropological analyses of the actual Norse human remains. Most recently, genetic analyses have been performed, which also may shed light on the fate of the Norse in Greenland. The authors feel that the combined results support a hypothesis of abandonment of the Norse settlements in Greenland.

Isotopes and climate

Human societies are shaped by the environmental and physical constraints of the landscape and biosphere. Climate is an important variable in shaping the biosphere, and consequently changes in climate may influence human populations. The demise of the Norse settlements in Greenland has for some time been seen as a dramatic example of this: climate cooling led to a deterioration in living standards, ultimately forcing the Norse away from Greenland. This theory was first proposed at the beginning of the twentieth century, and later supported by the results of Dansgaard and others (1975), who analysed ice-core borings from central Greenland to reconstruct the past climate; these results have been corroborated by later ice-core borings. However, how did the climate change as measured by lowered temperatures over central Greenland relate to the actual climate experienced by the Norse, living, as they did, deep in the fjords?

The first such study (Fricke and others 1995) was able to assess the climate directly as experienced by the Norse and the Thule Culture Eskimos in medieval times. The method was based upon analysing oxygen isotope values in human dental enamel. Oxygen atoms are usually of the ^{16}O variety, but may also be present in other varieties,

or isotopes, of which one is denoted as ^{18}O. The amount of ^{18}O vs ^{16}O (designated as a proportion, $\delta^{18}O$) in the atmosphere is a reflection of local climate variables such as temperature and humidity. Oxygen binds readily with hydrogen to form water, which falls as local precipitation (meteoric water). The precipitation ultimately becomes spring water, which may be ingested by humans. The water thus ingested is incorporated in the body tissues. All body tissues are continuously being regenerated and replaced through the metabolism of the body, except the dental enamel. Dental enamel is formed within a relatively short period during childhood, and once formed does not remodel or regenerate. Thus, the $\delta^{18}O$ value of human tooth enamel can be used to infer the value of ingested local meteoric water that in turn reflects local climate at the time the tooth enamel was formed.

Tooth enamel was sampled from skeletons of Norse and Thule Culture Eskimos from different sites. We found a 3‰ decrease in $\delta^{18}O_p$ from sites in Greenland dating from AD 1400 to 1700, implying rapid cooling during the so-called Little Ice Age. Rough estimates of local temperature change and rates of change can be made by applying the modern-day relation between $\delta^{18}O$ and temperature to the Greenland localities. The lowering of the temperature would thus correspond approximately to a drop of 6°C during a 300-year period, followed by an increase of approximately 3°C during the next 250 years.

The results thus not only support the hypothesis of the 'Little Ice Age,' but also add to this in terms of the impact on human societies: the lowered temperatures are reflected in the teeth of the people who once lived in those areas. The shift in climate did affect these populations. It is, of course, too simplistic to try to view the Norse disappearance from Greenland as a single-cause event, but a climate shift of the calculated magnitude must have had profound repercussions for the Norse society.

Isotopes and diet

Analyses for ^{13}C seem to indicate a dietary shift from a predominance of terrestrial resources to a more marine diet (Lynnerup 1998; Arneborg and others 1999). These results accord generally with the results of studies of kitchen midden material, which indicate diachronic shifts as well as differences between the Western and Eastern settlements (McGovern 1992). As the Norse were, above all, farmers, animal husbandry was integral to their way of life. The need to supplement their diet with more and more marine input could well reflect the fact that the Norse simply could not sustain their livestock production adequately. This was dependent on the carrying capacity of the land; a cooler climate would have reduced this capacity, thus resulting in a reduction of output in terms of feed for the animals. This would have been detrimental for the Norse societal structure.

Societal and demographic changes

In describing the Norse society, archaeologists and historians have relied mainly on the analysis of archaeological data and historical sources, respectively. The results are conflicting, showing that in some instances, the Greenland Norse did become more isolated, while in others they seemed to be 'up-to-date,' reflecting steady contacts. We wanted to contribute to this discussion, using skeletal material in conjunction with archaeological data. One way to do this was to analyse burial customs. Based on a large study of Danish and Swedish medieval cemeteries, it has become apparent that the position of the arms in the grave changed throughout the period. In early Christian times, the arms were placed down by the side of the corpse in the grave. Later, a shift occurred, and the arms were placed slightly bent, so that the hands would meet across the lower abdomen. Later still, the arms were placed across the abdomen crossing each other, the elbows being bent in right angles. Finally, by the fourteenth and fifteenth centuries, the arms were placed across the breast, folded as if the deceased were praying (Kieffer-Olsen 1993). The reasons for this shift are not clear, but perhaps it was related to a change in the perception of the after-life. During the earlier stages of medieval Christianity, the after-life was assured, but, later, purgatory became a focus of what happened at death, and thus the more pious position was adopted in the grave. When the data on the Norse arm positions are compared to those from the Danish and Swedish medieval periods, there is a good accordance between them and the radiocarbon analyses, which seems to indicate that the Norse, throughout the settlement period, adjusted their burial customs according to the prevailing customs in northern Europe, which again may indicate that, although remote, the Norse colonies were not completely isolated. Directly relating to a discussion of isolation is also the question of population size. How large was the Norse population in Greenland?

This is a central question when one wants in some way to reconstruct the past society. Various explanations of the demise of the Norse settlements very much hinge upon how large the population was: if it was small then even slight perturbations may rapidly have brought the population below sustainable levels, whereas a large population would have had a better 'buffering' effect. Estimating the population size may be achieved by, for example, analysing the number and size of farms and correlating this with population size. Indeed, several archaeologists have done this, with estimates ranging from an average population of about 3000 (Gad 1984), to 4000 (Berglund 1986), 4000–5000 (Meldgaard 1965), and 5000–6000 (McGovern 1979). However, very few farms have been dated in terms of functional periods, and the Norse Greenlanders probably used the saeter system, where the livestock was moved to outlying grasslands for part of the grazing season (Berglund 1986). This means that the archaeological values probably represent maximum figures. But if these figures do not seem large, it must remembered that they represent the population number at a given point in time. Such population levels accumulate into much larger figures when the total

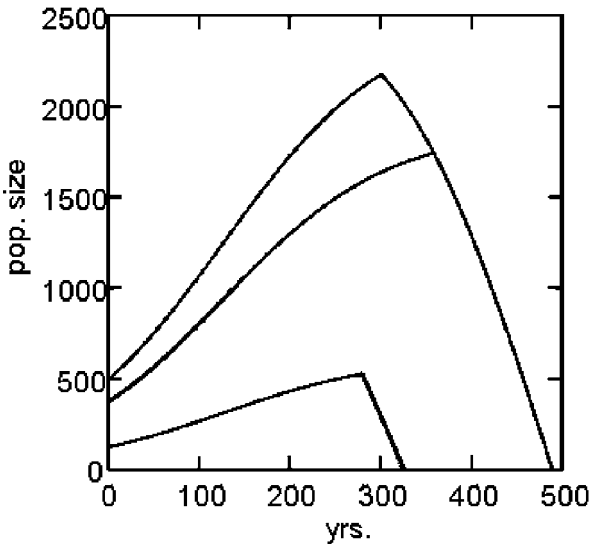

Fig. 1. Modelled population levels for the Norse in Greenland during 500 years of settlement. Population levels could reach a maximum of over 2000 (see text). The upper curve represents cumulative numbers for both Eastern and Western settlements, while the other two show numbers for the single settlements. The Western Settlement (the lower of the curves) went into extinction first.

number of deaths over the settlement period is calculated. For example, during a 500-year period, a population of around 5,000 people will 'produce' perhaps some 70,000 deaths. Is it plausible that the Norse churchyards contain so many skeletons? Based on calculations of those churchyard sites that have been thoroughly excavated, and then calculating an average burial density, it is possible to extrapolate from the known churchyard areas to a total inhumed population. This figure is much lower, pointing at an average population of some 1500–2000 people (Lynnerup 1998).

Another method for analysis would be to look at the biological framework for such a population. Was an increase from a starting population of 400–500 individuals to at least 2000 individuals possible within a 300-year period, without having to assume extreme values for life span, mortality, and fertility? And, consequently, could a population of this size pass into extinction?

A starting population for this analysis was set arbitrarily at 500 individuals. This was based on historical research, drawing on the accounts in the *Grønlændinge Saga* and Eric the Red's Saga, saying that '32 ships sailed for Greenland. . .but only 14 made it there' (*Grønlands Historiske Mindesmærker* 1838–45: I, 179, 207). Allowing for a capacity of approximately 30 individuals per ship — it has been estimated that some of the larger Viking cargo ships in AD 1000 had a cargo capacity of 40 tonnes (Crumlin-Pedersen and others 1992) — this means that approximately 300–400 people could have settled in Greenland in the first wave (Meldgaard 1965). Keller has mentioned that the capacity of the ships may have been smaller, but that there was more regular immigration, leading to a starting population of between 300 and 800 people (Keller 1986). A minimum starting population of some 500 people would fit with the accepted minimum levels for sustainable populations of about 400–500 (Geist 1978; Dyke 1984). Using an exponential model, a rate of increase of 0.62% would have to be assumed for the population level to increase to 2000 within 200 years. But this rate actually parallels a calculated population increase in Iceland in the period AD 970–1095 (using population figures from Thorarinsson 1961), and fits with rates calculated for many other populations in ethnographical analyses (between 0.15% and 0.40%). A slight continuing immigration would probably also be realistic. This rate probably dropped to zero (or rather the net rate of immigration and emigration was zero) during the years AD 1100–1200. This, along with a slowing of population increase (as the population approached carrying capacity and thus began to strain resources), could be consistent with a levelling-out by AD 1200.

And extinction? Given a positive growth rate, emigration remains a possible explanation of a decreasing population. Emigration may occur when a population exceeds its optimum level in relation to living conditions (Hasan 1981). It could be that the Norse population reached the carrying capacity of its habitat, which may in fact itself have been decreasing. Allowing for a decreasing rate of growth (particularly as young people tend to emigrate, thereby not only counting themselves out of the population but also removing their potential offspring), this means that the emigration rate would have to have been about 8 individuals per year. For a small population like the Norse, such a level of emigration would certainly have a massive effect. The question is: are such rates realistic? Of course these rates represent averages; that is, emigration would probably have taken place in waves of, for example, 100 people every 10 years. Furthermore, there can be stochastic variation: once the population is sufficiently small it becomes vulnerable to fluctuations in fertility and mortality (Weiss and Smouse 1976). Incipient decline could thus have been precipitated, and the population could have fallen sharply, perhaps with short periods of relative stability.

The size difference between the Western and Eastern settlements must also be taken into account. Judging by the numbers of farmhouses (west 80, east 250) (Gad 1984) and by the number of churches (west 3, east 11), there seems to have been a 1 : 3 ratio between the settlement population sizes. Viewed in isolation, the Western Settlement would rapidly approach the minimum population size of 500. Indeed, given the above emigration rates and lowered fertility rates, the population would fall below this level after just 20 years. It is thus possible that decline set in around 1300 AD, and, by some 50 years later, most people would have had emigrated from the Western Settlement, leaving perhaps only a few, mainly old, settlers. The Western Settlement could thus have been completely depopulated during the fourteenth

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century. Perhaps the Eastern Settlement then experienced immigration that for some years offset the rate of decline, but then decline proceeded at the same rate as in the Western Settlement. This would leave the Eastern Settlement depopulated by the mid-fifteenth century (Fig. 1).

A population may also become extinct due to exceptionally high mortality rates. High mortality rates are usually linked with war and epidemics. However, even rates of up to 10% of young adults killed in warfare would not substantially decrease birth rates. This leaves practically only highly lethal epidemics as the cause of a dramatic reduction in the population within a short time span. Plague struck both Iceland and Norway in the fourteenth and fifteenth centuries, and total mortality rates of between 30% and 50% have been suggested. Clearly, a halving of the Norse population in just one or two years would be disastrous for such a small group, and on the basis of the numbers alone could quite plausibly explain the population reduction.

Assuming the above rates and population levels, an accumulated population size of 26,500 was calculated, equivalent to an average population size of 1377. These figures are very close to the figures arrived at in the preceding section, based on the number of interments. This does not in any way constitute proof, but rather points to the fact that the Norse population could have reached reasonable levels and conversely pass into extinction within the 500-year span of Norse settlement, without assuming undue biological parameters.

The population models used in this study show that depopulation was possible, assuming a steady emigration rate. Theories of migration have mostly centred on the Norse population in Greenland 'returning' to Iceland, after a first relocation of the people of the Western Settlement to the Eastern Settlement (Berglund 1986). A few also have entertained the thought that the Norse moved to the American continent or northern Britain and Ireland (see Fyllingsnes 1990). While it has been proved, based on the finds at L'Anse aux Meadows in Newfoundland by Ingstad (1970), that the Norse did indeed reach the American continent (Vinland), there are absolutely no indications of any major resettlements there. This also applies to resettlements to the British Isles and Ireland.

Genetics

Another theory advanced has been assimilation with the Inuit. However, there has never been any archaeological indication of this (Arneborg 1993). If assimilation were indeed the case, the most probable place to look for it would be among the Greenland Inuit. As such, recent analyses of mitochondrial DNA (mtDNA) and Y-chromosomal DNA among present-day Greenlanders have shown some striking results (Saillard and others 2000; Bosch and others, in press). In the 82 individuals sampled, covering different localities in Greenland, not a single European mtDNA sequence (haplotype) was found. Only 10 different mtDNA haplotypes were found among the 82 individuals, all belonging to the Eastern Siberian (sub)haplogroup A2. Since mtDNA is inherited maternally, this means that in the present-day Greenland Eskimo population there has been no admixture of mtDNA from European females (albeit this is probably rapidly changing now). On the other hand, analysis of Y-DNA haplogroups showed that almost 60% of the Y-chromosome material was of European extraction. Since Y-chromosomes are inherited paternally, this is indicative of a massive infusion of European male genetic material. The distribution of Y-DNA haplogroups among the 69 analysed Inuit males does not conclusively rule out medieval Norse admixture. In other words, the admixture (or some part of it) could have happened in medieval times, because some haplogroups showed a higher affinity with Icelandic rather than Danish ones, which would be indicative of infusion at the time of modern colonization. However, other haplogroups fit best with admixture from Danish males, an admixture that is well documented through the historical records since the colonisation of Greenland by Denmark in 1721. Based on a total assessment of the genetic analyses, it seems most plausible that, even though some Norse may have added to the Greenland Inuit gene pool, this was very little, and there is no indication of assimilation, as this certainly would also have involved the Norse females.

Abandonment

Several theories of extinction have been put forward, and we feel that some may be rejected on the basis of the results of the biological analyses: assimilation with the Eskimos, eradication by Eskimos or pirates (there are no consistent signs of trauma during the later settlement periods), and 'degeneration.' Other theories seem more plausible; that is, the biological anthropological data might 'fit' the theories (although not specifically proving them).

In the first place, there seems to have been a massive depopulation in most European countries at that time. As mentioned previously, a 60% decrease in population has been projected for northern Norway, and at least a 30% decrease for Iceland. This massive depopulation, usually ascribed to the great plague epidemics, had enormous demographic, economic, and social repercussions. In the wake of the plague, there was large-scale population resettlement, where inhabitants of the more unproductive areas left for the better, 'vacant' areas. Whether Norse Greenland was directly affected by plague or not, it would most certainly have been affected indirectly. For instance, the export prices of several Icelandic commodities fell dramatically (Keller 1986), and this may well also have had economic consequences for Greenland. Since it seems that the decline in population levels in fact had already started before the plague epidemics reached the northern European countries, it can be assumed from palaeoclimatic and archaeozoological results that there was a climatic change in the years after AD 1300. This shift 'stressed' the population, probably resulting in a

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trend towards ever-harsher living conditions. Adaptive responses would have included increasing reliance on marine foodstuffs and seeking to increase land yield, the former evidenced by the radiocarbon analyses and the latter reflected by irrigation systems and the buffering capacity of the local community, headed by large farmsteads.

However, perhaps after some internal resettlement, emigration accelerated in the fifteenth century. Better land became available in a larger community, such as Iceland, and it is even possible that old family claims were invoked. The marginal land of Greenland no longer held the same attraction. The population pressure of the Viking times that had led to emigration had now reverted to an involution.

Conclusion

If the above scenario does present something like the true picture of the past, it would also serve to eliminate some of the 'spectacularity' of the demise of the settlement. The Norse moved to Greenland because of a perceived gain and the possibility of owning land, perhaps pushed to some extent by population pressure and the rapid exploitation of Iceland. They moved back when this possibility arose elsewhere. It would be surprising, in the light of the almost universal demographic changes and overall depopulation in Norway, Iceland, England, etc, if a remote and already economically vulnerable settlement like the Norse settlement in Greenland did not decline.

In other words, perhaps the Norse did not give up Greenland, they gave up some land and fjords that had become less and less profitable for their way of life, and moved back to more auspicious shores where new opportunities had arisen.

Notes

1. Grønlands Historiske Mindesmærker (*Historical monuments of Greenland*) was the first effort to collate all knowledge about the Norse settlements, including sagas and archaeological and cultural historical data. It was published in 1838–45 as three volumes.

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