Bioarchaeological and climatological evidence for the fate of Norse farmers in medieval Greenland

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Greenland, far north land of the Atlantic, has often been beyond the limit of European farming settlement. One of its Norse settlements, colonized just before AD *1000, is — astonishingly — not even at the southern tip, but a way up the west coast, the 'Western Settlement'. Environmental studies show why its occupation came to an end within five centuries, leaving Greenland once more a place of Arctic-adapted hunters.*

Norse settlement in Greenland

According to medieval Icelandic sources, the Norse colonization of Greenland begun in *c.* AD 985. Two main areas of settlement were established: the Western Settlement, in the inner fjords east of present-day Nuuk (Godthåb) (FIGURE 1), the modern capital, and the Eastern Settlement at the southern tip of Greenland, near modern Igaliko (Garðar) (Ingstad 1966; Jones 1986). By the end of the 15th century, these Norse colonies had disappeared. This demise has frequently been linked to adverse changes in climate, specifically, the so-called 'Little Ice Age' (*cf.* Dansgaard *et al.* 1975; Lamb 1977). There has been much discussion regarding the reality of this climatic event (Grove 1988). Suffice it here to say, although low-temperature events in the latter half of the present millennium are well documented, it is clear that these are neither temporally nor spatially synchronous in all localities of the North Atlantic region. We therefore present the following data without invoking the term 'Little Ice Age', or the connotations surrounding it.

The Western Settlement, in particular, has been a focus of sustained multidisciplinary study, and it is primarily this settlement which is considered here. Some of the findings are compared with proxy climatic data extrapolated from the Greenland Ice Sheet Project (GISP2) ice core. This core was drilled between 1992 and 1993 in central Greenland, in the summit of the ice sheet at 3210 m above sea level, at lat. 72°28' N, long. 38°35' W. The proxy records provided by ice cores have been interpreted as indicators of climatic change. More recently, technological advances, combined with the long stratigraphic integrity of the GISP2 core, have resulted in highly detailed proxy records, which range in timescales from seasons to thousands of years (FIGURE 2). This high level of detail has already given new insights into the climate history of the North Atlantic region (Alley *et al.* 1993; Mayewski *et al.* 1993a; 1993b; 1994; Barlow 1994; Zielinski *et al.* 1994).

Studies, primarily archaeological, historical and anthropological, have shown that, from the start of the Norse settlement in Greenland, sub-

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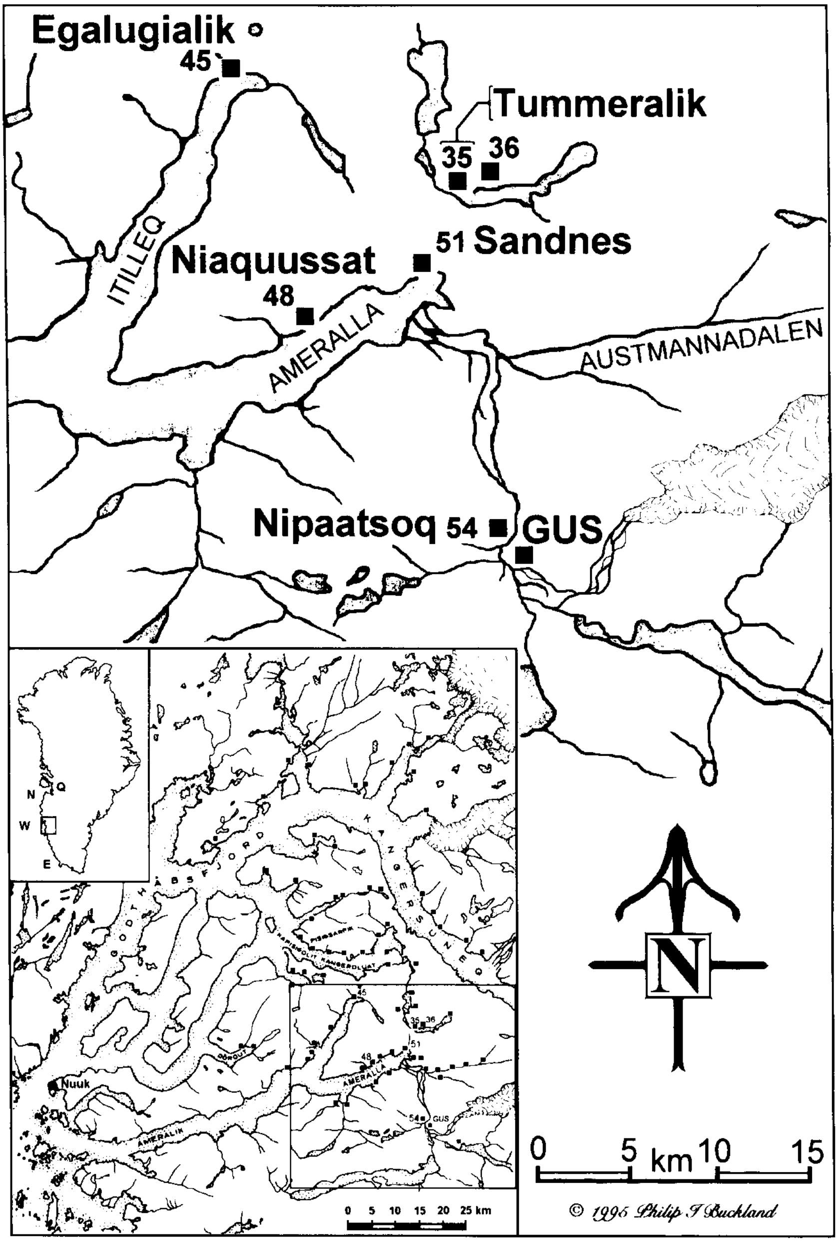

FIGURE 1. *The distribution of known Norse farm sites in the former Western Settlement area (modern Nuuk district).*

Norse farms were restricted to the small areas of richer floral communities in the inner fjord zone of the west coast, where sufficient hay could be collected to overwinter domestic animals. Inuit hunters moved their settlements north and south along the coast to track changes in sea-mammal abundance.

E = *the Norse Eastern Settlement.*
Q = *the palaeo-Eskimo site of Qeqertasussuk, Disko Bay.*
W = *The Norse Western Settlement.*
Farms where palaeo-ecological research has been carried out are numbered.
48 = *Niaquussat.*
51 = *Sandnes.*
54 = *Nipaatsoq.*
GUS = *the recently discovered site of Gården under Sandet.*

Even the most marginal of sites had been occupied by c. *AD 1050.*

The fjords are indicated by stippling and the inland ice by suitable shading.

sistence was based upon milk and meat from cattle, sheep and goats (McGovern 1985a) (FIGURE 3). Fossil beetle faunas from the more recently excavated farms in the Western Settlement are dominated by introduced synanthropous elements (Sadler 1991), which lived in stored hay and related habitats. These underline the need for an adequate hay crop to overwinter indoors the domestic stock which could not otherwise survive. Shortfalls in subsistence were made up by intensive, largely land-based exploitation of seals and seabirds in the spring, and caribou drives with hunting dogs in the autumn. There is no evidence for any significant domesticated plant-food contribution to the diet, although the seeds of wild fruits, principally crowberry (*Empetrum nigrum* L.) and bilberry (*Vaccinium uliginosum* L.) are frequent in samples from the farm middens (McGovern *et al.* 1983). These core subsistence

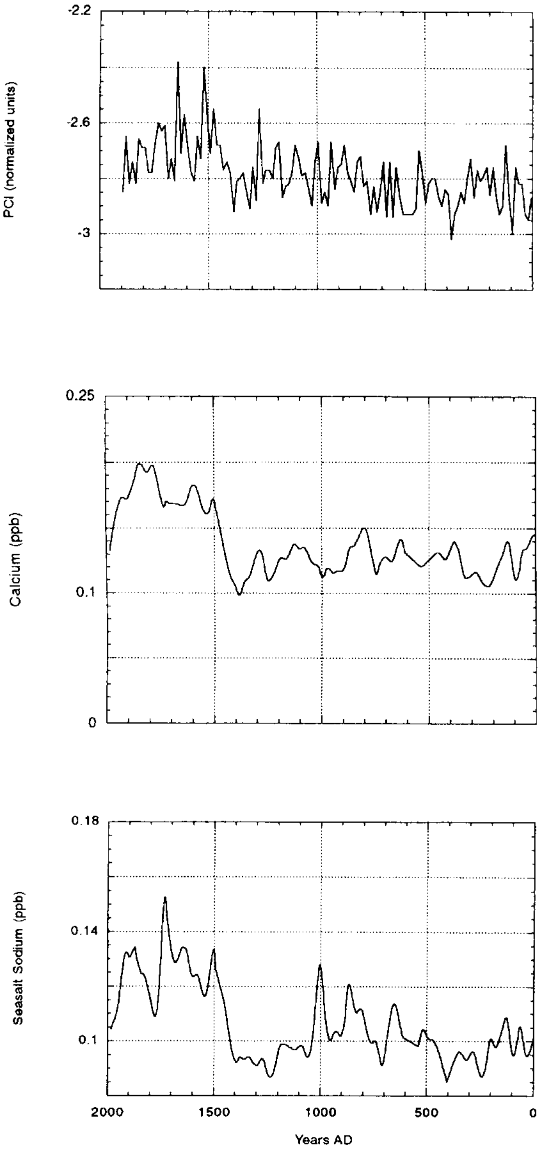

FIGURE 2. *The record for a range of organic and inorganic input for the last 2000 years in the GISP2 ice core, Greenland.*

PCI, the Polar Circulation Index, provides a measure of the intensity of polar atmospheric cell circulation in normalized units. A positive increase in value reflects an expansion of the cell. Calcium (Ca) is a measure of atmospheric dustiness in p.p.b., and sea-salt sodium (Na) provides a measure of storminess in the marine environment in p.p.b. The PCI series displayed here is at 4-year resolution, and the calcium and sea-salt sodium are robust spline smooths (approximately 100-year smoothing) of the original biannual data.

The inferred climatic change during the early 15th century is the most marked in the past 8000 years. The abandonment of the Western Settlement of Norse Greenland took place before this event.

activities required tight co-ordination of communal labour resources and produced little storable surplus. Nevertheless, by 1300 this mixed dairying-hunting society had invested heavily in stone architecture. In the Eastern Settlement, monasteries and parish churches, as well as a cathedral at Garðar (Igaliko) had been built, equipped with imported stained glass and bronze church bells. Stone churches similarly served the Western Settlement (Berglund 1986; 1991; Keller 1991; McGovern 1980). Trade with Europe throughout the period of the settlement was based on the prestige-goods trade in walrus hide and ivory from animals taken in the Norðsetr, some 800 km north of Nuuk (McGovern 1985a; 1989).

Investigations at the church farm at Sandnes (V51) and surrounding farms have generated important bioarchaeological data (McGovern *et al.* 1983), with well-preserved organic materials, including bones, dung pellets, lice, fleas, beetles and flies. These data provide additional insights into the nature of the subsistence base and some indications of the final days of the settlement. Many of these data, discussed previously (*cf.* McGovern *et al.* 1983; Sveinbjarnardóttir & Buckland 1983; Buckland & Sadler 1989), will not be considered in detail here. The principal new line of palaeoecological information is that provided by the fossil flies.

Insect remains in the Greenland sites

Remains of Coleoptera (beetles), and various ectoparasites of both people and sheep have been the subject of research from a number of Greenland sites (McGovern *et al.* 1983; Sveinbjarnardóttir & Buckland 1983; Buckland & Sadler 1989; Böcher & Fredskild 1993), but a detailed study of the remains of Diptera, the true flies, has added significantly to the interpretation. Nearly 7000 Dipterous puparia have been examined from the Norse farms, and comparison made with the flies from the pre-European contact palaeo-Eskimo Saqqaq site at Qeqertasussuq, 700 km to the north (Böcher & Fredskild 1993). The greater part of the Norse

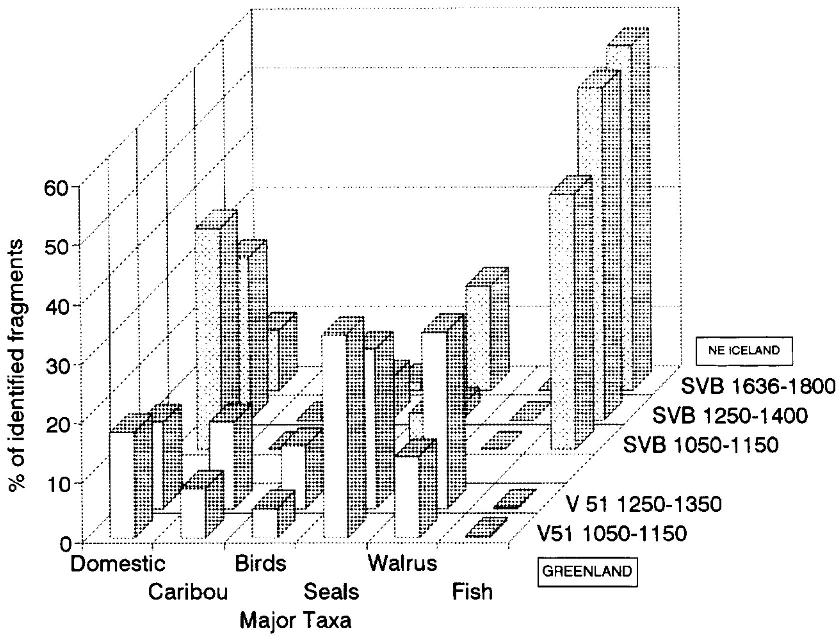

FIGURE 3. *A comparison of the animal bone collections from the site of Svalbarð (SVB) in Þistilfjörður (Amorosi 1992), northeast Iceland and Sandnes (V51) in Ameralla fjord in west Greenland.*

Both farms were occupied by AD *1000–1050, and both were church farms playing a central role in their districts. Note the different organization of subsistence and the contrasting roles of walrus and fish in the trading economy. By* c. *1050–1150, the Svalbarð farm was already involved in intensive fishing, probably entering the growing staples trade in dried fish. By contrast, Sandnes remained a centre for the Viking-age prestige goods trade in walrus products down to its extinction c. 1350. Farmers in the Svalbarð district of Iceland appear to have intensified sealing efforts in the 16th–17th centuries, perhaps to compensate for poor hay crops. These might, in turn, have resulted from lowered temperatures associated with changes in climate or an increase in drift ice. The latter is indicated by the appearance of harp seals, including new-born pups, in the bone assemblage (Amorosi 1992).*

For a discussion of the effects of sea-ice on grass growth and agriculture, see Friðriksson (1969) and Ogilvie (1982; 1995). Greenlandic farmer/hunters, strongly dependent on seals since first settlement, could have further intensified marine mammal hunting by acquiring Inuit technology; this they failed to do. Svalbarð farm, still occupied, remains one of the most prosperous farms in its district.

farm faunas reflect introductions which became extinct along with the farmers. *Telomerina flavipes* was a thermophilous, troglodytic alien in Greenland and is an excellent indicator of the farms' foetid living-room floors (Buckland *et al.* 1994). The picture of insanitary conditions, extending throughout the life of the settlements, however, differs little from contemporary Dublin or York (*cf.* Coope 1981; Hall *et al.* 1983). The dominant element in the fly fauna (>81%) is necrophilous in the larval state. Even on the middens, the assemblages are clearly those which have bred indoors in carrion, including faeces with animal protein, in the warmer parts of the buildings. Those taxa which breed outdoors in carrion, including the Piophilid flies characteristic of fat and bone marrow accumulations, are virtually absent. In contrast, the evidence from the palaeo-Eskimo site (TABLE 1) indicates that meat and fat were routinely left unused there. Animal-bone collections from medieval Icelandic and Greenlandic sites indicate a far greater degree of fragmentation for marrow-fat extraction in the Norse Greenlandic materials. While both palaeo-Eskimo and Norse Greenlanders lacked substantial carbohydrate sources and had to consume more fat to allow effective protein metabolism (Speth 1991), the Norse farmers evidently had to process their kills far more completely than the palaeo-Eskimos.

	***Heleomyza* spp**	***?Scoliocentra* sp.**	***Telomerina flavipes***	**Piophilidae**	***Calliphora* sp.**	***Phormia* sp.**
1 site/group of sites						
Norse Western Settlement	*	+	*	+	o	o
Inuit midden, Qeqertasassuk	+	o	o	*	*	*
2 light tolerance						
exophilic	t	–	–	P	t	P
endophilic	t	P	P	–	t	–
3 thermal tolerance						
highly cold resistant	t	t	–	t	t	t
thermophilous	t	t	P	t	t	t
4 materials						
pure carrion and bone marrow	t	P	t	P	P	P
dung, some animal protein content	t	t	t	t	t	–
5 colonization wave						
early colonizer	t	t	t	P	P	P
late colonizer	t	t	t	t	t	–

key
1 * = dominant; + = presence; o = absence.
2–5 P = strong preference; t = tolerance.

Notes
a Certain Piophilids (e.g. *Lasiopiophila pilosa*, *Phormia atriceps* and, to a lesser degree, *Calliphora uralensis*) have strong preference for colder climates, the first two being essentially High Arctic species.
b In the entire Western Settlement count of 6915 Dipterous remains, Piophilids are as follows: *Allopiophila vulgaris* 135, *Lasiopiophila pilosa* 1.
c At Qeqertasussuk, the same species are *P. vulgaris* 617, *L. pilosa* 229. These results would be expected from a High Arctic site.

TABLE 1. *The necrophagous flies of Greenland.*

	Sandnes	**Qeqertasussuk**
stercoricolous (herbivore dung, e.g. *Scathophaga furcata*)	114	1
endophilic coprophages/necrophages (e.g. *Heleomyza/Telomerina* spp.)	1424	–
exophilic necrophages (e.g. Piophilidae, Calliphoridae)	8	1897*
phytophages (e.g. Agromyzidae, *Delia, Botanophila, Pegomya* spp.)	176	69
algaecoles (e.g. Ephydridae, *Zaphne, Spilogona* spp.)	180	18
fucicoles (*Orygma, Fucellia* spp.)	9	203
ripicoles (e.g. adults only of *Simulium* spp.)	52	–
humicoles (e.g. *Phaonia, Tipula* spp.)	2	2
ectoparasitic (*Melophagus ovinus* on sheep)	8	–
spp.	1974	2198

* includes 486 individuals of *Heleomyza borealis*, which will breed in an unshaded situation.

TABLE 1b. *Absolute numbers of identified Diptera from Sandnes, the Norse farm site at Sandnes, Ameralla, Greenland, compared with the Saqqaq palaeo-Eskimo site at Qeqertasussuk, Disko Bay, Greenland.*

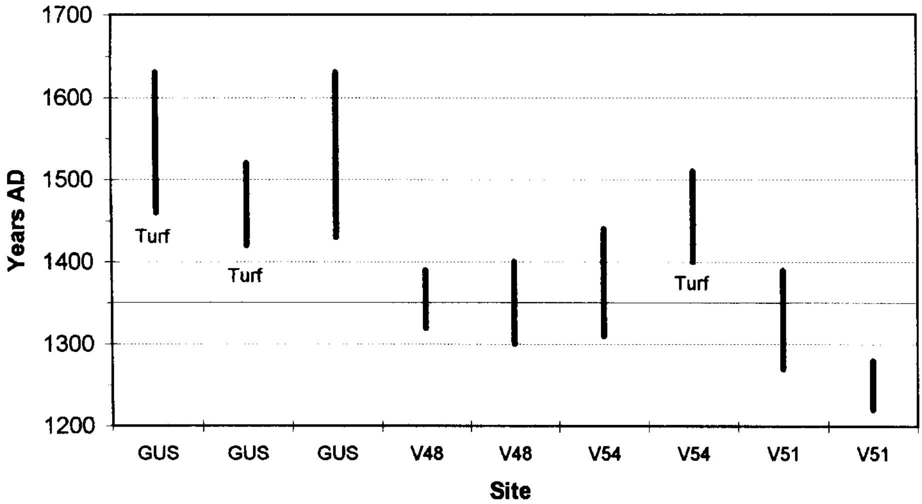

FIGURE 4. *Calibrated radiocarbon dates (1σ range) for the abandonment of farms in medieval Greenland. Documentary sources suggest a terminal date of* c. *1350–1360 for the Western settlements (Ogilvie 1996). Radiocarbon assay supports this date range for desertion. Some dates are on turf growing over the ruins.*

The moderate-sized farms of GUS (Andreasen & Arneborg 1992; 1993) and V54 (McGovern et al. *1983) (see FIGURE 1) are near-neighbours; V48 (McGovern* et al. *1983) was a small fjord-side farm, whilst V51 (Sandnes) was the largest in the district, with a church (Roussell 1936). Although the number of available dates remains small (TABLE 2), all sites appear to have been abandoned in the mid 14th century. The radiocarbon dates have been calibrated using Oxcal (Ramsey 1994).*

site	context	material	lab. no.	uncalibrated determination b.p.	date AD lower	date AD upper	reference
GUS	turf over structure	peat	K-5821	360±55	1460	1630	Andreasen & Arneborg 1992
GUS	turf over structure	peat	K-5822	415±55	1420	1520	Andreasen & Arneborg 1992
GUS	over structure	antler	K-5823	395±50	1430	1630	Andreasen & Arneborg 1992
V48	latest phase	terrestrial mammal bone	K-3201	640±50	1320	1390	McGovern *et al.* 1983
V48	latest phase	terrestrial mammal bone	K-3203	610±50	1300	1400	McGovern *et al.* 1983
V54	turf over structure	peat/ willow charcoal	K-3062	540±50	1310	1440	Andreasen 1982
V54	turf over structure	peat	K-3061	450±65	1400	1510	Andreasen 1982
V51	late phase	caribou bone	K-4605	670±50	1270	1390	McGovern unpublished
V51	late phase	cattle bone	K-4606	760±50	1220	1280	McGovern unpublished

Calibration is after Ramsey (1994) using OxCal Calibration Program.

TABLE 2. *Radiocarbon dates for the terminal phases of farms in the Western Settlement, Greenland.*

Thule culture Inuit hunters, who came to Greenland from Ellesmere Island around AD 1100, were in direct contact with the Norse for nearly 300 years (McGovern 1985b). In spite of this, the Norse failed to emulate their example and did not acquire sophisticated skin clothing, harpoons and suitable equipment for hunting out on the sea ice. They were therefore unable to expand their sea-mammal hunting to include ringed seals and the great whales. The virtual absence of fish remains and fishing equipment, and indications from the bone evidence that most common seals were taken on their pupping areas, serves to emphasize further the limits of maritime adaptation amongst the Norse Greenlanders. Despite some evidence of seaweed (Buckland *et al.* 1993), isotopic ratios indicate little intake of marine products by domestic animals. While contact with the Thule Inuit appears to have been deliberately restricted (McGovern 1985b), the Norse economy seems to have stagnated. Tied to the limited pastures of the southwest, it was increasingly isolated from continental markets by a declining demand for walrus ivory and other changes in trading conditions (Carus-Wilson 1933). Furthermore, a possible increase in drift ice could have made sailing more hazardous (Ogilvie 1991; 1996). Norse society in the early 14th century had created a disastrous vulnerability to any curtailment in growing season and pasture productivity.

Although the number of radiocarbon dates from sites in Ameralla remains small (FIGURE 4 & TABLE 2), they appear to indicate desertion by the middle of the 14th century, during an apparently minor cooling event in the ice core record (FIGURE 2). This accords well with the documentary evidence (Ogilvie 1996). In a landscape where all available timber would be reused, doors and roofs were left to collapse onto floors as farms decayed. The end is graphically indicated at the small farm at Nipaatsoq (McGovern *et al.* 1983), at the middle-rank farm at Tummeralik, and at the large farm Sandnes at the head of the fjord (Degerbøl 1936). The final floor layers at each farm contained the partly articulated remains of Norse hunting dogs, some displaying cut-marks indicating butchery. The minimum number of dogs killed at Sandnes (V51) was nine, Tummeralik (V35) three and Nipaatsoq (V54) two. The implication is that this butchery was a desperate act that destroyed future ability to hunt effectively. The fly faunas from a room interpreted as the bedroom at Nipaatsoq mirror the end as a thermophilous indoor fauna is replaced by a cold one and finally by outdoor species as the roof collapses. There is also hint in the faunas of other stresses. The Anthomyid fly *Delia fabricii* (Holm.), which breeds in the meadow grass *Poa pratensis* L., is often abundant in samples from other Norse farms; it is absent in the final floors at Nipaatsoq. This could be interpreted in terms of poorer, less grass-rich hay yields as the farmers desperately sought to maintain their livestock. The recent discovery of a frozen Norse farm neighbouring Nipaatsoq, containing large amounts of well-preserved wood further confirms the impression of a sudden and final end to the Western Settlement (Andreasen & Arneborg 1992; Arneborg & Berglund 1993) and offers further opportunities to study the demise of a farm.

Climate and settlement in medieval Greenland

The GISP2 ice-core documents at least two sets of proxy climatic parameters which are important for the study of Norse settlements in Greenland. Several environmental indicators, including calcium and sea-salt sodium, demonstrate the most abrupt and the largest change of the last 8000 years between AD 1400 and 1420 (FIGURE 2). Increased calcium concentrations provide evidence of stronger circulation over continental regions and the presence of more easily eroded soils, suggesting a response to cooler climates and reduced vegetation cover, while increased sea-salt sodium is interpreted as resulting from intensification of marine storminess and increased cyclogenesis (Mayewski *et al.* 1993b). Both parameters suggest a change in atmospheric circulation patterns which persists into the 20th century (FIGURE 2). Isotopic signals of deuterium and oxygen from Greenland ice cores suggest that overall the 14th century was lower in temperature than the 15th century in central Greenland (Dansgaard *et al.* 1975; Barlow *et al.* 1993). Seasonally resolved isotopic records suggest clusters of low-temperature time-periods. Among these are AD 1308 to 1319, representing the longest time-period of low winter values until the 1560s, and a 20-year time-period of low summer values between AD 1343 and 1362 (Barlow 1994).

Climatic regimes in Iceland and Greenland are by no means the same. However, the historical climatic record from Iceland may help to increase our understanding of events in Norse Greenland. We know from the Icelandic record that the 14th century was a period of considerable climatic instability. Furthermore, there is clear evidence for cold conditions and hardship amongst people during the mid to late 14th century. The early 15th century, however, appears to have been mild (Ogilvie 1991). Knowledge of what occurred in Iceland during years of grass failure may also cast light on what happened in Greenland; these invariably led to deaths amongst the livestock and frequently to human mortality and desertion of farms (Ogilvie 1984). In Iceland, many landholders increasingly integrated their subsistence with the European urban demand for fish (Amorosi *et al.* 1994). In contrast, Greenland's connections with Europe remained tied to the luxury goods trade in walrus hide and ivory (FIGURE 3).

Throughout Europe, the 14th century was a period of population decline and settlement retrenchment (*cf.* Kershaw 1973; Abel 1980). The role of climate in these events is controversial and the same may be said for Greenland. The new GISP2 ice- core data indicate that the extinction of the Western Settlement pre-dated the most profound changes in atmospheric circulation, but also show that multi-year stretches of low-temperature seasons occurred during the 14th century. In a system heavily dependant upon the harvesting of sufficient hay to overwinter domestic animals, a concentration of closely spaced cool and wet summers followed by cold winters or springs could have been sufficient to trigger widespread abandonment. Certainly, all the bioarchaeological evidence from the Norse sites indicates the precarious nature of their subsistence. This vulnerability was exacerbated by a conservative social system, wider economic changes and activities which degraded the very parts of the ecosystem upon which they depended (Fredskild 1988; 1992; Jacobsen 1991). While climate change certainly made Greenland far less habitable for the Norse, even the coldest parts of the post-medieval period failed to interfere with Inuit settlement and subsistence. When John Davis and other 16th-century voyagers explored Greenland, they found only arctic-adapted hunters.

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