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Cows, Harp Seals, and Churchbells: Adaptation and Extinction in Norse Greenland

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The extinction of the Norse colony in West Greenland (ca A.D. 985-1500) has intrigued generations of historians, medieval archaeologists, and climatologists. This longstanding interest has generated a considerable body of basic paleoclimatic and paleoecological data, as well as a number of largely monocausal explanations for the communities' end. The 1976-1977 Inuit-Norse Project and a variety of recent geophysical and palynological studies have provided the greater detail necessary for a more systematic analysis of cultural adaptation and extinction in Norse Greenland. A dual maritime/terrestrial Norse subsistence economy, combined with a transatlantic trade and long-range arctic hunting, supported a hierarchical social organization and elaborate ceremonial architecture. Elite information management and economic decision-making seems to have been a source of ultimately fatal Norse conservatism in the face of fluctuating resources and Inuit competition.

KEY WORDS: Greenland; Norse; climate; Little Ice Age.

INTRODUCTION

Nearly 1000 years ago the first European colony in the Western Hemisphere was planted in the fjords of West Greenland. Five hundred years later, that colony failed and died. The mysterious fate of this lost settlement has exercised the imaginations of generations of scholars: climatic deterioration, Inuit invasion, Basque piracy, and declining contact with Europe have all provided speculative explanations for the colony's extinction (Gad, 1970; McGovern, 1979a). Widespread dissatisfaction with such monocausal, "prime mover" explanations

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of complex cultural phenomena (Flannery, 1972; Jansen, 1972; Parry, 1979) suggests that a broader approach, emphasizing systemic interactions among fluctuating resources, culture contact, and economic organization, may prove more useful to our investigation of Norse Greenland.

HISTORICAL BACKGROUND

West Greenland was settled around A.D. 985 by land-hungry vikings from Iceland led by Erik the Red. Greenland was only the northernmost extension of a Scandinavian expansion into the North Atlantic basin that began around A.D. 700 (Jones, 1964). Exploiting a transoceanic maritime capability and a diversified and flexible subsistence economy, the Norse colonized the Faroe, Shetland, and Orkney Islands, The Isle of Man, the Northern Hebrides, Iceland, Greenland, and Vinland (Newfoundland) over a 300 year period. The Norse seem to have filled these island groups rapidly, altering mainland economies to fit diverse local conditions. While Vinland did not survive its first settlement phase, and Greenland eventually expired as well, the Norse populations of the other Atlantic islands endured the fluctuations of the Little Ice Age of ca 1200-1840 A.D. (Lamb, 1977) and late-medieval economic depression, and persist to the present.

The Norse colony of Greenland seems to have begun well enough. Encountering an unpeopled landscape, the Norse founded two separate settlements: the Eastern Settlement in modern Narssaq and Julianehaab Districts in the extreme southwest (about 4000-8000 inhabitants) and a much smaller (about 1000-1700) Western Settlement in modern Godthaad District about 575 kilometers (km) to the north (Fig. 1). By A.D. 1125, the Lawmen of the Greenlandic Assembly felt sufficiently prosperous to acquire a bishop from the Norwegian court and to build an episcopal manor and cathedral at Gardar in the Eastern Settlement (modern Igaliko). Around 1150 Norsemen, hunting far to the north of the settlements, encountered immigrating Thule Inuit moving southward. The *Historia Norvegiae* (written ca A.D. 1170, Jansen, 1972: 14) records the nature of the people they encountered:

> On the other (W) side of Greenland, toward the North, hunters have found some little people they call Skraelings; their situation is that when they are hurt by weapons their sores become white without bleeding, but when mortally wounded their blood will hardly stop running. They have no iron at all; they use missiles made of walrus tusk and sharp stones for knives. (Jansen, 1972: 35)

Thus began 300 years of contact between European and North American in Greenland.

In 1262 Greenland submitted to the Norwegian King Haakon Haakonsson, becoming a distant outpost of a short-lived Atlantic empire. Soon after A.D. 1300, Norse Greenland seems to have fallen on hard times. Around A.D. 1350, the Western Settlement suddenly became extinct. Espiscopal Steward Ivar

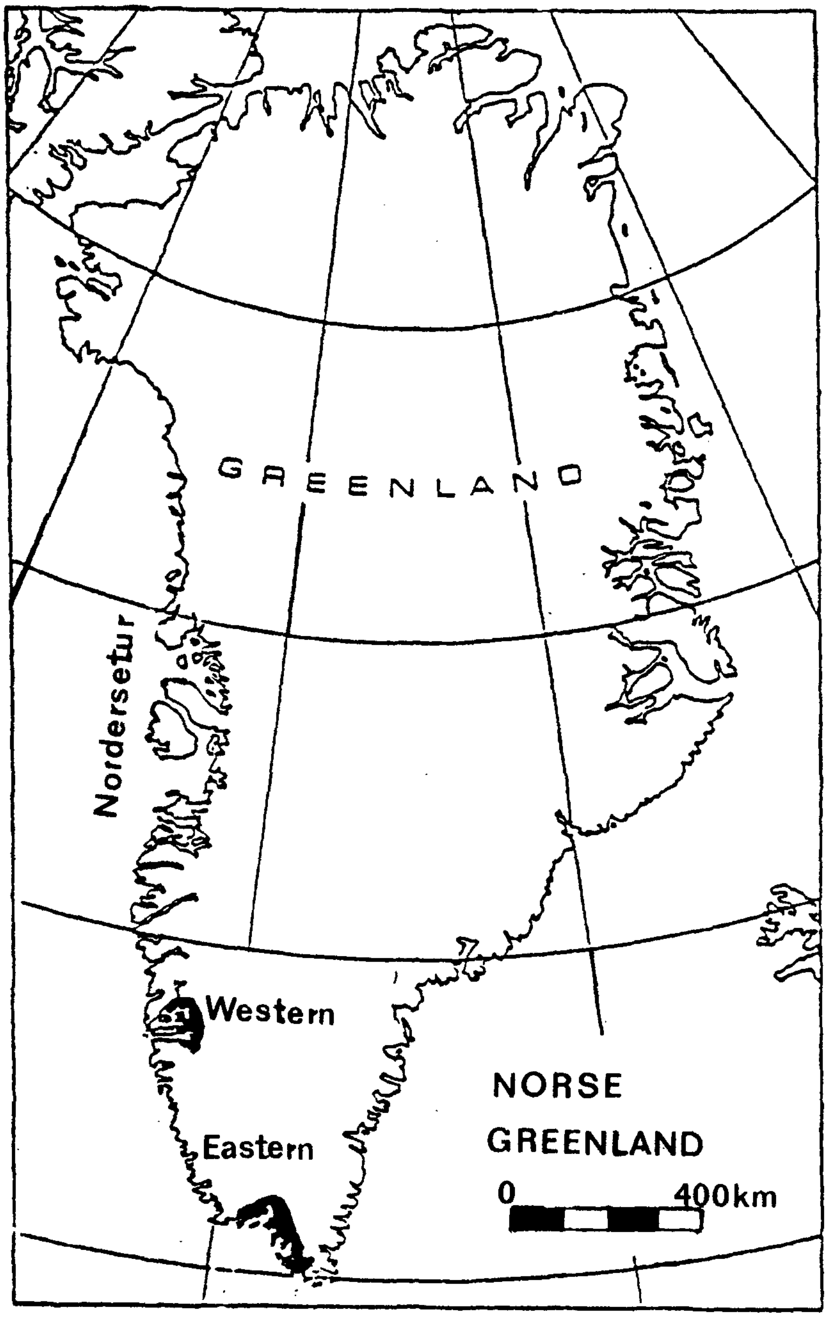

GREENLAND
Nordersetur
Western
Eastern
NORSE
GREENLAND
0
400km

Fig. 1

Baardsson reported: "Now the Skraelings have the entire Western Settlement, but there are horses, goats, cows, and sheep, all wild. There are no people, neither Christians nor heathens" (Gad, 1970: 141). Contact with Europe waned, and positive documentary evidence for the existence of the colony ends ca A.D. 1409 (Gad, 1970). Artifactual remains from the extreme southwest suggest that part of the Eastern Settlement may have struggled on for another 75-100 years (Nørlund, 1924), and the conventional view dates the end of Norse Greenland at A.D. 1500.

THE EVIDENCE

Scattered documentary references give tantalizing glimpses of medieval Greenland (Jonsson, 1930; Jansen, 1972; Gad, 1970) but nothing so detailed as the manorial and urban tax, tithe, and estate records that aid economic and climatic historians (Gribbin and Lamb, 1978) in their study of medieval Europe survives from the lost settlement. Existing fragments must be combined with paleoeconomic and paleoecological data before they can contribute significantly to our attempt to produce a workable outline of Norse culture history and economic strategy.

Fortunately, archaeological and ecological resources are unusually rich in West Greenland. As early as the 1720s, Danish missionaries and administrators began searching out Norse ruins. By the 1890s, systematic survey and excavation was underway in both settlement areas, and by the 1960s nearly all the Norse farms listed in Ivar Bardsson's mid-14th-century inventory (Jonsson, 1930) had been located. Nearly 30 were at least partly excavated (Bruun, 1896, 1916, 1918; Nørlund, 1924, 1930, 1936; Roussell, 1939, 1941; Vebaek, 1943, 1952, 1958, 1965, 1968; Krogh, 1967; Jansen, 1972). Accurate mapping of sites has long been stressed, and animal bone samples of varied size were often collected. While earlier excavations usually emphasized architectural elucidation at the expense of stratigraphic control and chronological ordering, a rich if uneven collection of locational, artifactural, and zoo-archaeological data was available by the mid-1970s. In 1976-1977, the Inuit-Norse Project carried out excavations in the old Western Settlement to collect fresh archaeological and paleoenvironmental data of known quality to match the increasingly detailed recent geophysical evidence for medieval climatic fluctuation (Meldgaard, 1977; McGovern and Bigelow, 1977; McGovern, 1979a).

This new paleoclimatic evidence is the result of the work of Dansgaard *et al.* (1975) and Patterson *et al.* (1977) on ice cores, Hillare-Marcel and Fairbridge (1978) on sea level changes, Koch (1945) on Icelandic sea ice records, and Fredskild (1973) on Greenlandic pollen. These multiple indicators now permit far more detailed modeling of climatic change in Greenland than was previously possible (Vebaek, 1962).

Working from Royal Greenland Company (KGH) catch statistics and Koch's (1945) sea ice data, zoologist Vibe (1967, 1978) proposed a three-phase model for the reactions of Greenlandic fauna to cyclical variations in sea ice, currents, and precipitation patterns, projecting it back to A.D. 1150. Using the early ice core data Conrad (1971) extended and slightly revised Vibe's phases. Thus we are provided with some powerful tools for modeling both the structure of Norse economy in Greenland and its reaction to changing environmental conditions.

DISTRIBUTION OF SETTLEMENT AND RESOURCES

West Greenland's long coastline is broken into a series of island-like pockets by deep fjord systems, glacial arms of the inland ice, and rugged mountain ranges. Floral communities range from polar desert lichen in the northeast to relatively lush copses of dwarf willow in the low-arctic fjords of the extreme southwest. West Greenland's climate is largely controlled by mixtures of the warm, north-flowing Irminger current (an offshoot of the North Atlantic Drift) with the colder, south-flowing East Greenland and Labrador currents. Variations in amount of cold East Greenland water and ice carried up the west coast by the Irminger current have major effects on both marine and terrestrial ecosystems throughout the southwest (Vibe, 1967). In the southwest, there is marked contrast in climate and flora between a widespread oceanic-maritime coastal zone and a few pockets of continentality in the inner reaches of a few fjord systems (Bocher, 1954). The oceanic zone is characterized by cool summers and moderate winters, high precipitation, and sparse vegetation. The continental pockets nearer the ice cap have warm summers, very cold winters, lower precipitation, and support the richest flora in Greenland.

These rich pastures clearly attracted the Norse settlers. Figure 2 illustrates the close association between Norse farms and the inner-fjord zone below 200 meters (m) with its relatively lush plant communities. Analysis of the location of individual farms indicates that minimization of distance to high-quality pasture rather than maximization of access to easy landing spots or fjord-side resources repeatedly determined the specific farm site (McGovern, 1978). The regular spacing of Norse farms and the absence of village clusters is revealed by the imposition of Higgsian 1 and 5 km catchment radii (Higgs, 1972, 1975; Flannery, 1976) on our map of the Western Settlement (Fig. 3).

As Fig. 3 suggests, the Norse seem to have filled their inner-fjord resource space quite completely. Radiocarbon dates from the Western Settlement farms V54 and V48 (Table I) indicate that these farms were founded in the earliest phases of the colony. The terminal dates likewise suggest that these rather marginal farms remained occupied right up to the end of the settlement. As the steep and rocky site of V48 in particular would hardly be settled by anyone

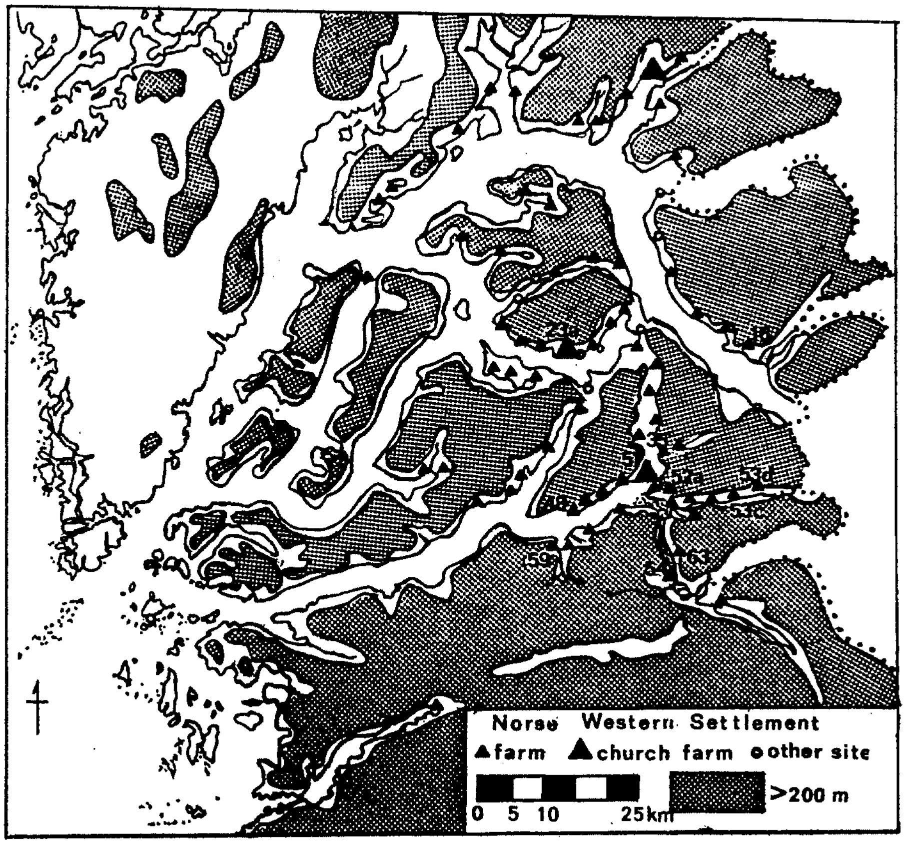


Fig. 2

with much alternative, we may reasonably model a rapid filling of inner-fjord space and an equally rapid collapse and desertion. Baardsson's account of ca A.D. 1350, listing 90 farms and four churches in the Western Settlement (Jonsson, 1930) also suggests that the 72 farms and three churches we can plot were probably contemporary, at least in their later phases.

Documentary sources (Jansen, 1972) and palynology (Fredskild, 1973) alike stongly indicate that grain agriculture never succeded in Norse Greenland. Unlike their contemporaries in the rest of Atlantic Europe, the Norse Greenlanders were wholly dependent upon domestic and wild animals for their subsistence.

THE NORSE ECONOMY

This dependence makes zoo-archaeological evidence (Degerbøl, 1929, 1934, 1936, 1941, 1943; McGovern and Bigelow, 1977b; McGovern, 1979a)

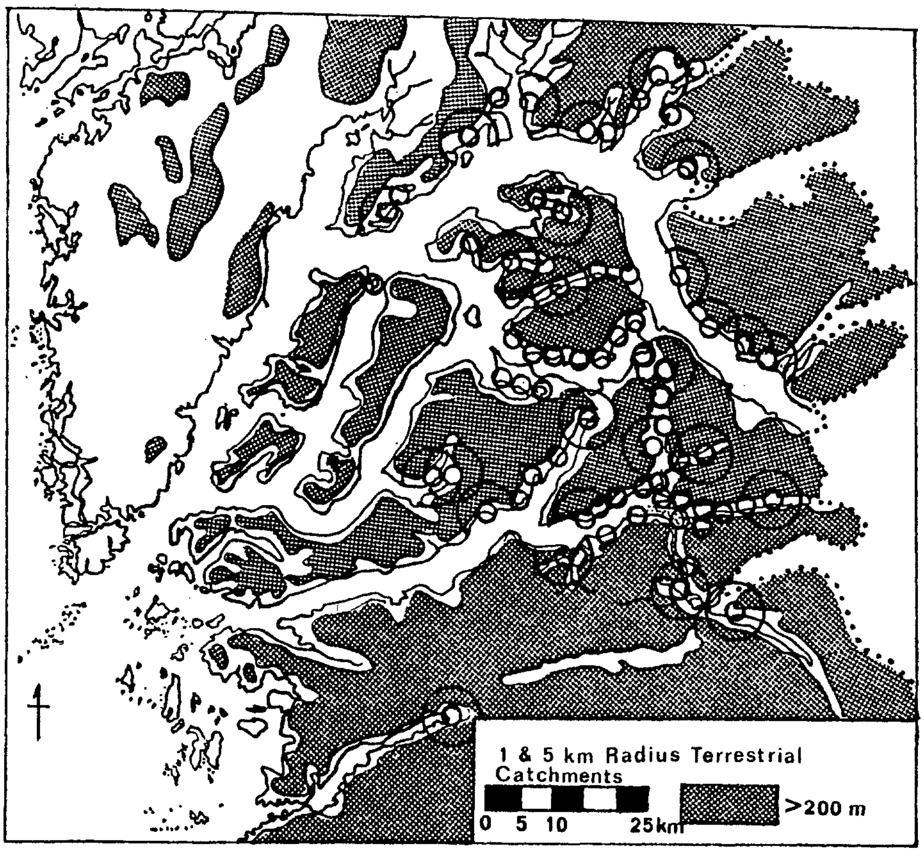


Fig. 3

and models of cyclical fluctuation in animal populations in West Greenland (Vibe, 1967, 1978) particularly valuable to our attempts to reconstruct the Norse economy. Existing faunal collections from Norse sites in Greenland indicate that cattle, sheep, and goats were the major domesticates. Pigs, dogs, and horses appear as trace species in several collections, but seem to have contributed little to the Norse diet. Adjusted Relative Frequencies (see Hesse and Perkins, 1974 and McGovern, 1979a for explanation of this statistic) for the Norse Western Settlement faunal collections that are large enough to reasonably quantify also reveal the major role played by caribou and seals in Norse subsistence (Table II). Caribou (*Rangifer tarandus ssp.*) spend winter and autumn in the inner fjords near the Norse farms, but the species of seals most exploited by the Norse Greenlanders were less immediately accessible. Particularly common in the faunal samples is the migratory harp seal (*Pagophilus groenlandicus*). Harps breed and pup on the March ice off Newfoundland and migrate to Southwest Greenland in huge numbers in early spring. They gradually move up the

Table I. Radiocarbon Age Determinations from Norse Greenland (Inuit-Norse Project 1976-1977) (Excluding Sea Mammal Dates)[a]

No.	Source	Radiocarbon age, yr	Calendar date, A.D.
K 3058	Willow charcoal, V54 midden	1000 ± 70	1030 ± 70
K 3059	Sheep/goat dung, V54 midden	1010 ± 70	1040 ± 70
K 3060	Willow charcoal, V54 midden	1200 ± 70	1255 ± 70
K 3061	Structural turf w/willow charcoal, V54	1410 ± 50	1405 ± 50
K 3062	Structural turf, V54	1500 ± 65	1440 ± 65
K 3063	Willow twigs, V48 midden (lowest layers)	990 ± 75	1020 ± 75
K 3197	Terrestrial mammal bone, V48 midden (lowest layers)	990 ± 50	1020 ± 50
K 3199	Terrestrial mammal bone, V48 midden (lowest layers)	960 ± 40	1000 ± 40
K3201	Terrestrial mammal bone, V48 midden (upper layers)	1310 ± 50	1355 ± 50
K 3203	Terrestrial mammal bone, V48 midden (upper layers)	1390 ± 50	1395 ± 50

[a]Source: Courtesy of Dr. H. Tauber.

west coast (Fig. 6) and generally summer near the edge of the drift ice far to the north of the Western Settlement. While this general migratory pattern seems to be followed under all climatic phases, the harps' rate and concentration of migration (and hence their vulnerability to Norse hunters) varied considerably in some periods (KGH, 1954-1974). Another migratory seal heavily exploited in the Eastern Settlement is the hooded seal (*Cystophora cristata*). Hoods now follow the harp seals' breeding pattern, but mainly move up Greenland's east coast, coming inshore only in the extreme southwest. This migratory pattern

Table II. Western Settlement Adjusted Relative Frequencies, %[a]

Site	Type	Cattle	Sheep/goat	Caribou	Seals
V51	LCFC	17.22	17.43	47.40	17.95
V35	IF	9.53	27.52	29.13	33.82
V54	IF	9.91	33.51	24.23	32.34
V53d	IF	9.57	20.93	33.07	36.43
V53c	IF	9.19	23.35	30.27	37.18
V52a	IF	8.97	24.11	41.63	25.28
V48 III	SCF	2.56	12.63	7.32	77.48
II	SCF	4.62	18.55	7.49	69.34
I	SCF	5.41	18.10	9.66	66.26

[a]LCFC: large coastal farm with church; IF: inland farm; SCF: small coastal farm.

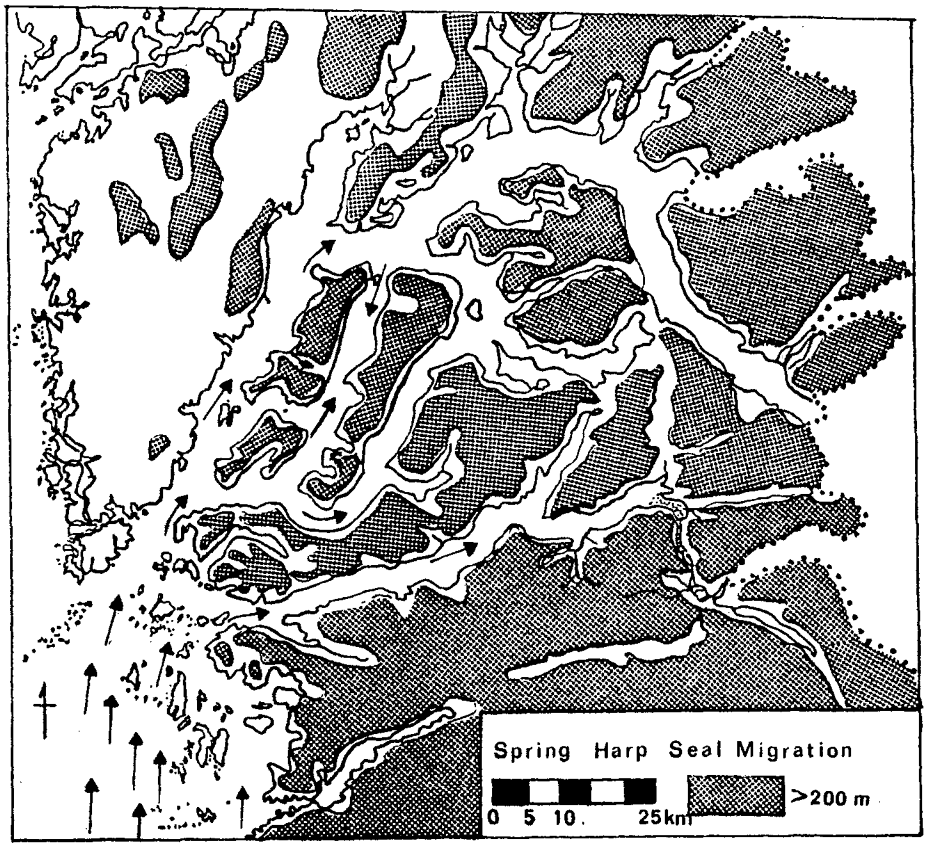


Fig. 4

also seems to have existed in Norse times, as hooded seal bones are virtually absent from Western Settlement collections.

A third seal species frequently appearing in Norse middens is the common seal (*Phoca vitulina*). Common seals are nonmigratory, but form spring breeding colonies in areas largely free from masses of drift ice. This requirement today effectively concentrates common seals in the midwest coast area around Godthaad district, though warmer periods with less drift ice from East Greenland and Baffin Bay may have seen an expansion of the range of this species.

All three species do enter the fjord systems, but all three are most plentiful and most concentrated in the oceanic outer fjords. This contrasting distribution of marine and terrestrial resource spaces posed a problem for the location of Norse settlements.

The *knarr* (cargo vessels) and longships that brought the original settlers had a potentially transatlantic range, but few of these vessels would be likely to be available to the later Norse Greenlanders. Lack of standing timber, shortage of iron fittings, and simple poverty robbed Iceland of ocean-going vessels as early as A.D. 1180 (Thorlaksson, 1978). While the Norse Greenlanders clearly retained a few "six-oared boats" (Bardsson, ca A.D. 1350, in Jonsson, 1930), and the courage and skill to take them far up the Greenland coast, it is likely that even this mid-sized type would become increasingly scarce in later Greenland. Probably the most common vessel would have been a small two to four oared craft like the modern Shetlandic *ness yole* (Morrison, 1973) or Faroese *tristur* (Williamson, 1948). While vital to daily communications in the inner fjords, these tiny vessels could not have been large or swift enough to make the long journey down-fjord to the sea easy or safe. Historical, ethnohistorical,

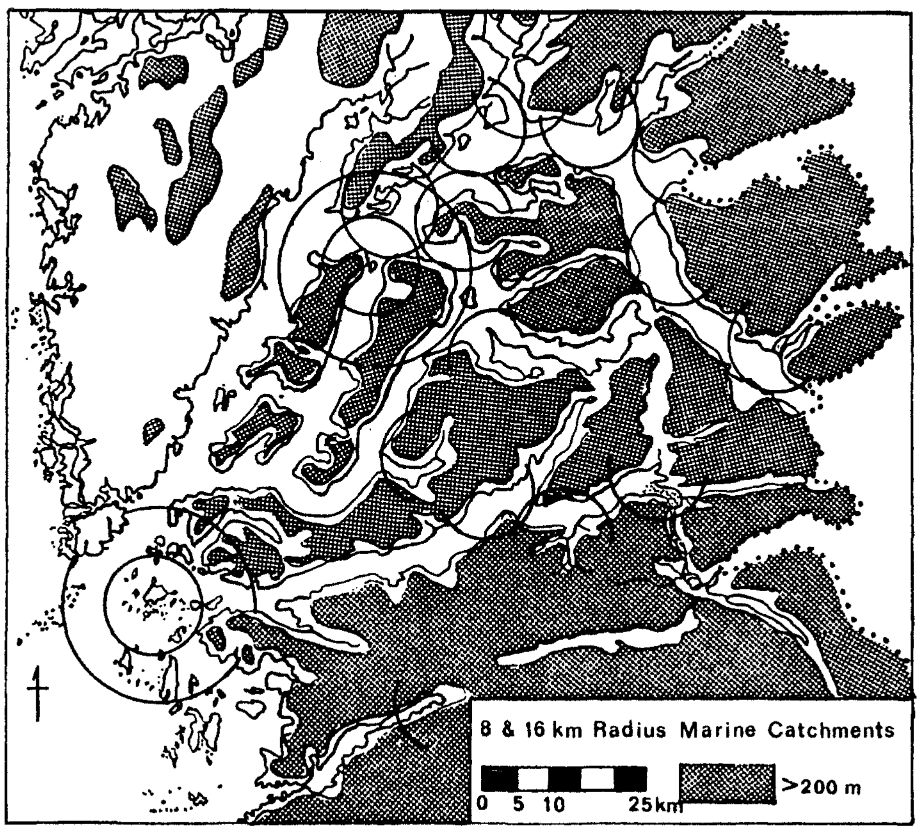


Fig. 5

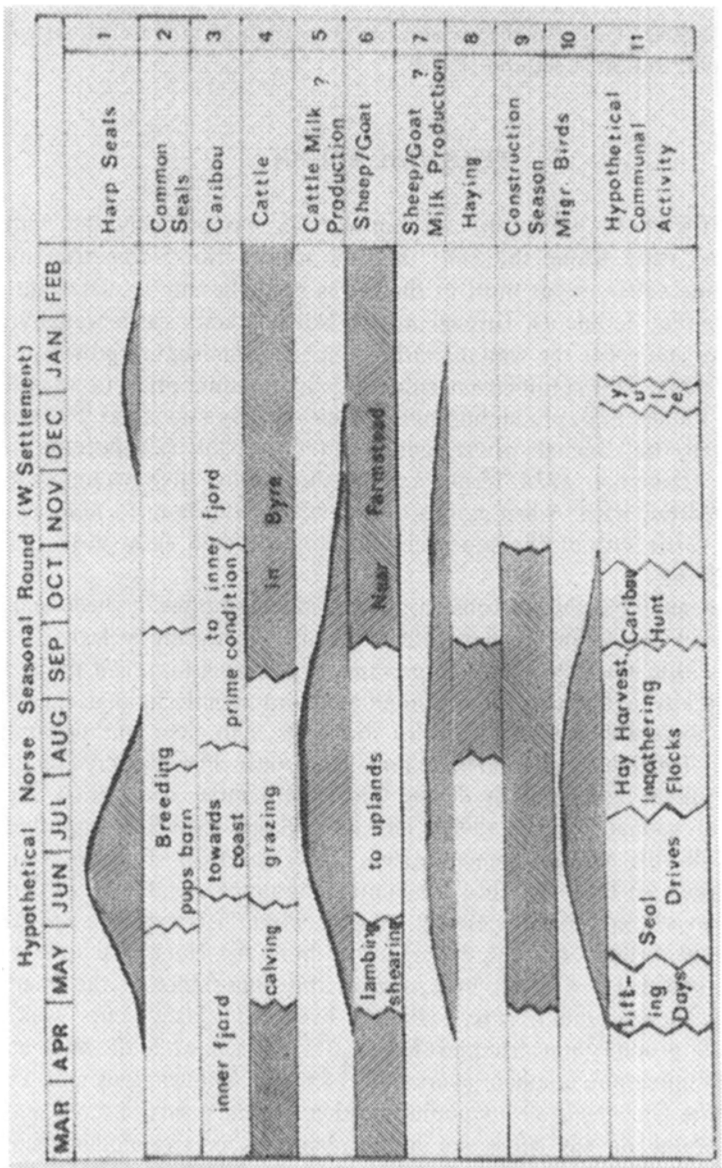
and experimental data (McGovern, 1978) indicate the relatively restricted *average* range of such craft (Fig. 5). Such ranges would have made seasonal exploitation of the outer fjords particularly hazardous and increased the importance of base camps on the coastal islands – such as the recently discovered Angissunguaq station (Berglund, 1973).

SEASONAL ROUND

For the Norse subsistence economy June was probably the "cruelest month" and early spring the most difficult season. Norse domestic animals, espeically the cattle, spent most of their lives inside heavily insulated turf and stone byres (Fig. 6, line 4). Throughout the North Atlantic cattle were byred in late autumn and spent the winter nearly immobile, standing in a growing pile of their own dung. This confinement reduced fodder consumption to an absolute minimum, though milk production must have ceased by midwinter. Norse cattle were generally tiny animals whose endurance was probably as important as their milk yield (Degerbøl, 1934; McGovern, 1979a). Spring thaw would probably bring the "lifting days" when groups of men went from farm to farm carrying emaciated cattle out of the byres and starting them on early spring pasture (Fenton, 1978).

Sheep and goat sheds (Roussell, 1941), concentrations of sheep and goat dung in farm buildings and middens (McGovern, 1979a), the life cycles of parasites preserved within the dung (Nansen, personal communication), and the absence of upland shelters (Blehr, personal communication) all indicate that most Norse sheep and goats also wintered close to the farms. This close herding contrasts with recent Icelandic and Shetlandic practice of out-wintering and would have increased fodder requirements during Greenland's more continental winters. Numbers of neonatal cattle, sheep, and goat bones recovered suggest either chronic stillbirths among the parasitized, undernourished stock or a critical spring shortage of dairy produce for human consumption (McGovern, 1979a). Scandinavian stockraising was clearly near its limits in Greenland, and a long winter would severely test the endurance of both the Norse and their stock.

This seasonal low point may explain the importance of the migratory seals to the Norse economy (Fig. 6, line 1). Even farms many hours' walk from the fjordside produce bone samples that are 25-30% seal, while the small coastal farm V48's uppermost midden layers were 78% seal. Though seals were clearly vital to Norse Greenland, no harpoons or other barbed spears of any kind have ever been found on any Norse site in Greenland. As in early modern Scotland (Clark, 1948), Iceland (Saemundsson, 1939), Denmark (Bynch, 1801), and the Faroe Islands (Jensen, 1976), seals and other sea mammals were probably taken in communal drives. A line of boats would herd seals onto beaches or into nets strung across narrow channels. The few small whale and porpoise appearing in



Hypothetical Norse Seasonal Round (W Settlement)
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
Harp Seals
1
Common Seals
2
Breeding
pups born
Caribou
3
inner fjord
towards coast
prime condition
to inner fjord
Cattle
4
calving
grazing
In Byre
Cattle Milk Production ?
5
Sheep/Goat
6
lambing
shearing
to uplands
Near Farmstead
Sheep/Goat Milk Production ?
7
Haying
8
Construction Season
9
Migr. Birds
10
Hypothetical Communal Activity
11
Lift-ing Days
Seal Drives
Hay Harvest ingathering Flocks
Caribou Hunt
y u l e

Fig. 6

Norse collections (McGovern, 1979a) could have been taken along with seals during such a spring hunt. Spring sealing, probably involving most of the communities' boats and men, is further suggested by the widespread bones of spring-killed harp and common seal pups found in Norse collections (McGovern and Bigelow, 1977; McGovern, 1979a). The timing and coordination of the communal hunt, weather conditions in the outer and mid-fjords, the security of the outer fjord bases (like the Angissunguaq station), and the duration and concentration of seal migration are all variables that would affect the success of the hunt.

After the lifting days and the seal hunt, the next activity to involve communal cooperation would probably have been the late summer hay harvest. Adequate winter fodder was vital to maintaining winter milk production as long as possible, as well as to control mortality of byred domesticates. Since the Norse Greenlanders lacked the storable grain that buffered the other Atlantic communities against short-term scarcity, the storable dairy products of their domesticates were especially valuable and each additional midwinter milking was a precious hedge against late-winter food shortage. Half-digested wads of dwarf willow and birch embedded in the dung in the byres at V54 (McGovern, 1979a) indicate that the Norse gathered rough fodder from every available source.

While faunal evidence indicates that some caribou were killed year-round, modern caribou seasonal movement and fat levels (McGovern, 1978) suggest that an autumn hunt may have been a feature of the Norse subsistence cycle. Communal caribou drives, probably involving cliffside jump traps (Blehr, personal communication) and long-limbed deerhounds (Degerbøl, 1934; McGovern, 1979a), may have closely followed communal harvesting of guillemots (*Uria sp.*) during their late August flightless phase (these are by far the most common bird remains in the collections).

As winter snows fell and domesticates entered their shelters the lucky Norse farmer had hay barns and *skemma* full. Skemma were drystone huts, often built on knolls, with chinks deliberately left between their stones. These were meat stores, where carcasses were hung to air dry, safe from dogs or foxes. The Norse lived off stored dairy produce and dried meat during the long, dark winter, apparently whiling away the hours with chess and draughts (Roussell, 1941).

OVERSEAS TRADE AND THE NORTHERN HUNTING GROUNDS

In addition to their herding/hunting subsistence round, the Norse Greenlanders carried on a transatlantic trade with Europe and a remarkable long-range hunt to maintain it. The *King's Mirror* (Larsen, 1917) makes clear that low-bulk, high-value arctic products like walrus ivory and hide and polar bear skins were what lured traders on the dangerous Greenland run. While a few walrus and polar bear occasionally entered the settlement areas, the richest hunting grounds for these species was always around Disko Bay, some 800 km North of the Western Settlement. This was the area of the *Nordrsetur* hunting ground (Gad, 1970), and this distant resource space was very much part of the Norse economy. A large skemma-like structure on the Nugssuaq peninsula in Disko is one evidence of Norse presence; another is a runestone found at Kingigtorssuaq, north of Disko, which dates to May 2, 1333 (Gad, 1970). Faunal evidence from home middens far to the south also suggest expeditions to the Nordrsetur.

Worked pieces of walrus skull (especially the maxilla around the tusk root) and penis bones are found in nearly all collections. Walrus post-canines provided raw material for buttons, chesspieces, and tiny walrus and polar bear figurines. The exportable tusk ivory itself is extremely rare in Norse collections of animal bone or artifacts. Polar bear remains are nearly as widespread as walrus. These usually consist of phalanges or other elements likely to be left in a hide by rough field-processing. This residue of final finishing of tusk and hide found on so many home sites strongly suggests that members of most farms participated at one time or another in this dangerous and time-consuming hunt. The scale of the northern hunting is further revealed by the special crusade tax of 635 kilograms (kg) of ivory paid by Norse Greenland in A.D. 1327 (Gad, 1970).

What was bought for this expenditure of scarce time, boats, and lives? Imports included iron and wood, stained glass, churchbells, and rich church vestments. Iron and wood were necessary for daily subsistence tasks, as Greenland's driftwood resources did not extend to the large-scale charcoal-making that would have made extensive local smelting feasible. Smelting of Greenlandic bog ore was attempted on a few large farms (Nielsen, 1941), but whalebone padlocks, belt buckles, and a bone battle-axe indicate how chronically the demand for metal exceeeded supply (Roussell, 1939, 1941). The other imports lead us from economics to politics.

HIERARCHICAL ORGANIZATION

Norse Greenland was never a community of equals. At *landnam* (first settlement) wealthy chieftains claimed fjord arms and whole fjord systems (as Eriksfjord, Einarsfjord, Hrafnsfjord) for later division among their followers. After A.D. 1125 the power of the episcopal court seems to have grown rapidly; by A.D. 1350 Baardsson lists most of the best grazing of the Eastern Settlement as church property. After A.D. 1262 there were royal taxes to pay, and a royal agent to see them collected (Gad, 1970).

Even without such documentary evidence, the archaeological record would leave little doubt of the hierarchical structure of Norse society in Greenland. Several different types of data indicate a three-tiered settlement hierarchy whose first-order sites included the bishop's estate at Gardar in the Eastern Settlement and a few of the largest Eastern Settlement farms. A larger number of relatively prosperous second-order church farms included V7, V23a, and V51 in the Western Settlement (see Fig. 2), above the majority of small to medium sized secular farms.

Even the briefest trip through the inner fjords of West Greenland reveals that the plant communities so vital to Norse pasturage are very patchy in their distribution. Lush meadows that green up early in the spring and stay green late into autumn are restricted to a few favored glacial tunnel valley bottoms. While a few farms are located in the midst of extensive, level, well-watered pastures, many more are perched on steep rocky slopes among scattered patches of vegetation and bare stone. Table III presents a quantification of the pasturage contained within a 1 km radius of three Western Settlement farms; V51 Sandnes (church farm), V54 (moderate sized inland farm), and V48 (small coastal farm). While erosion, braided stream meanders, and marine transgressions have locally altered topography and vegetation, Fredskild's (1973) pollen profiles indicate no radical alteration of vegetation since Norse times. Plant communities (modified from Bocher *et al.*, 1968) are scored according to their pasturage potential (derived in part from medieval husbandries). The percent of slope is factored in to include the liabilities of steep farm sites: greater movement costs, higher probability of snow cover blow-off and frost killing of vegetation, greater likelihood of erosion. The resulting adjusted pasture scores (Table IV; see also Fig. 7) illustrate the dramatically different pasture resources available to different farms.

Table III. Comparative 1 km Site Territories (Preliminary Data)[a]

Site	V51 Sandnes	V54	V48
Type	LCFC	IF	SCF
Landing/harbor	Excellent	–	Poor-fair
Average % of slope	0-10	0-30	35-40
% below 200 m	100	75	50
Pasture assessment			
% Marsh/wet meadow (+20)	35	20	0
% Grass-slope (+15)	40	20	10
% Modified copse (+15)	15	35	70
% Herbslope (+10)	5	0	0
% Steppe/heath (+5)	5	15	5
% Rock/fellfield (0)	0	5	5
% Screeslope (−10)	0	5	10
Raw pasture score:	1600	1250	1125
Adjusted pasture score:	320	83.3	30

[a] LCFC = large coastal farm with church; IF = inland farm; SCF = small coastal farm; raw pasture score = % of plant community × community rating (+20 through -10); adjusted pasture score = raw pasture score/mean % of slope.

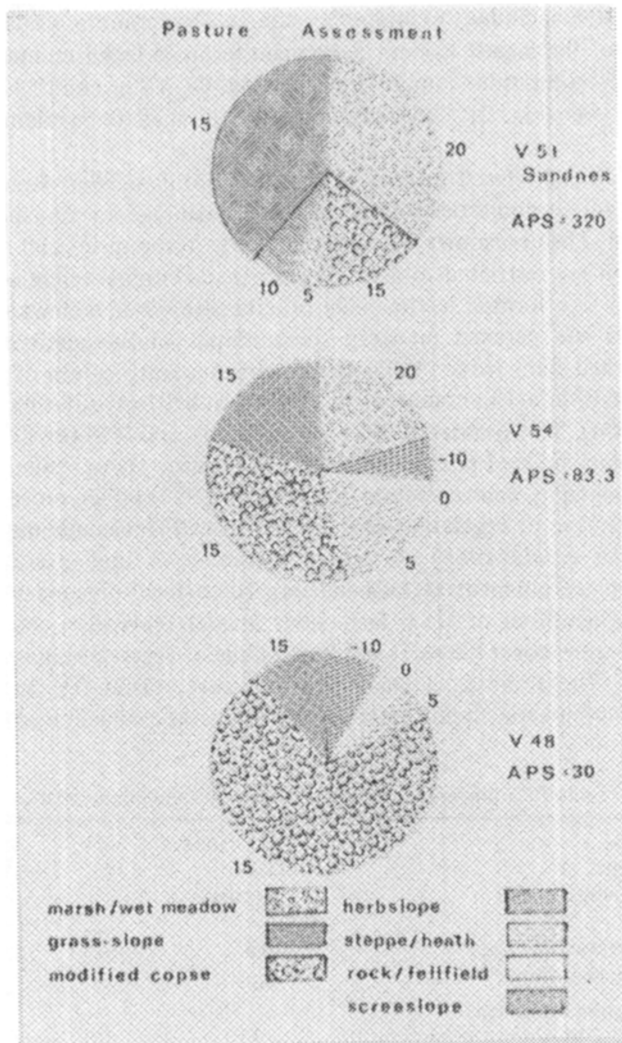


Fig. 7

Animal bone data also support a hierarchical model for Norse economy and society. Figures 8 and 9 graphically present the Western Settlement ARF% (for an explanation of this statistic, see McGovern, 1979a) data of Table II. Note that the larger church farm V51 Sandnes shows by far the greatest percentage of cattle bone, and least of seals. From our ethnohistoric sources (Ahrensburg and Kimball, 1968; Fenton, 1978) we know that cattle were status markers in the whole North Atlantic region. Farms in the Northern Isles are still ranked as

Table IV. Comparative Floor Space Evidence[a]

Site	Type	Storage, (m^3)	Byre est. cattle
Ø 47 Gardar	EF	52.2 m^2	150-175
V7 Anavik	LCFC	3823	20-30?
V51 Sandnes	LCFC	?	20-30
V54	IF	?	5-10
V35	IF	24	?
V52a	IF	33	12-15
V53c	IF	?	10-13
V53d	IF	30	5-10
V63	IF	35	?
V48	SCF	25?	?2-4?
V8	SCF	?	2-4
V16	SCF	?	4-5

[a]EF: Episcopal farm; LCFC: large coastal farm with church; IF; inland farm; SCF: small coastal farm.

places of so many cows. Seals, on the other hand, seem to have been somewhat less favored (Low, 1774). The high percentage of caribou bone at V51 and V52a (the largest secular farm in the sample) is rather surprising, considering that V35, 53c, 53d, and 54 were all far better placed to intercept migrating caribou, and V51 and V52a are far from likely jump drive sites. Did elite farms get a disproportionate share of choice deer meat (highly regarded in medieval Europe) after communal hunts? Were tithes and rents paid in meat as well as in dairy produce and labor (as in Iceland and Shetland)?

Since Norse cattle in Greenland required winter byre protection and since stone stall dividers give us a measure of byre space needed for each cow, it is possible to use the size of excavated byres as a rough indicator of the maximum cattle herd size of some farms (Table IV). Note the gulf between the capacity of the unique set of Episcopal byres at Ø 47 Gardar in the Eastern Settlement and the second-order Western Settlement centers of V7 Anavik and V51 Sandnes. Equally clear is the gap between the byre capacity of these second-order church farms and the moderate-to-poor secular Western Settlement farms for which we have data (note that question marks in Table IV designate estimated capacities). Though this measure is inherently imprecise, it probably gets us into the correct order of magnitude.

The often well-preserved, rectilinear, drystone storage sheds (skemma) provide another rough architectural measure of relative economic potential (Table IV). While the huge skemma at V7 Anavik may be exceptional, there still seems to be a clear suggestion of radically different storage capacities between church farms and the smaller secular farms.

Note that high percentages of cattle bones, large byre capacities, and high pasture scores all seem to covary. A regression of cattle bone percentage on byre size produced a positive correlation coefficient of .946, which is significant at the

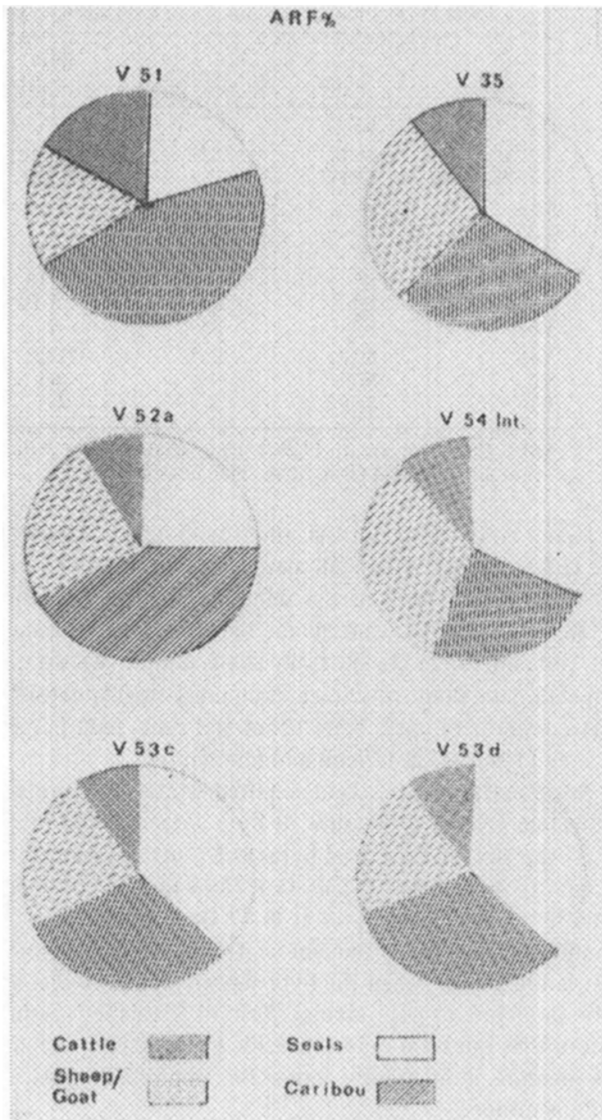


Fig. 8

.01 level. Though neither data set was chosen randomly, and more points might be likely to produce a less strongly linear relationship, these separate lines of evidence do seem mutually supporting.

Apart from pasture, skemma, and byre capacity, and animal bone relative frequencies, we have the location of churches, churchyards, and large farms at

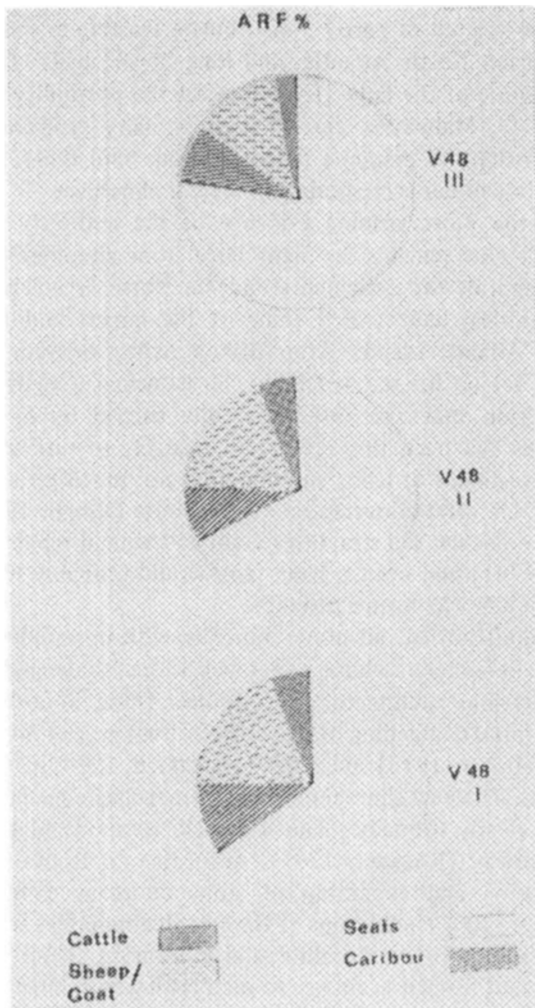


Fig. 9

convenient centers of communication, and a concentration of imported luxuries on these sites (Roussell, 1941; McGovern, 1979a). As in early Iceland, large fjordside farms with churches and chieftains may have served as centers for trade with outsiders and for redistribution of imports within the community (Thorlaksson, 1978; Nørlund, 1924). It is also likely that the outsized byres and skemmas of the larger farms (particularly the episcopal farm at Gardar) may partly reflect a redistributive function. It is difficult to see how the tiny three to five cow herds of the smaller farms could have remained viable without periodic borrowing of bull service or replacement stock from the larger herds.

Ethnohistoric sources tell of partly redistributive feasting at yule in other parts of the Scandinavian North Atlantic, and long "festal halls" (Roussell, 1941) associated with some of the larger farms suggest the possibility of similar traditions in Greenland. Midwinter alms of meat or dairy produce might become increasingly important to marginal farmers during hard times, thus amplifying the power of the wealthier ecclesiastical or secular alms-giver.

However, the most striking evidence of the authority and managerial skill of the Norse elite remains the many large stone churches whose ruins still dot West Greenland. By the settlements' end, the Norse Greenlanders (one of the smallest communities) had erected some of the largest and most impressive churches in the Atlantic islands. After Bishop Arnald arrived in Greenland ca A.D. 1127 and set up his see at Gardar, he launched a vigorous program of church construction that was enthusisastically carried on by his successors. Previous churches had been tiny affairs, built largely of turf and stone and representing an investment of labor and materials not much greater than that required for a typical semi-subterranean Norse house (Krogh, 1967). Informally designed Norse vernacular sod structures required frequent repair and reconstruction (Roussell, 1941) and even a large farm would probably have resembled a series of grassy hummocks from a distance.

The new multistoried, all-stone churches, with upstanding, carefully laid and mortared walls (some of whose stones weigh tons) thus represented a radical alteration of previous architectural traditions. These imported eccesiastical designs were far more demanding of scarce labor, timber, and imported materials like churchbells (Bruun, 1918) and stained glass (Gad, 1970; Ingstad, 1966) than earlier local types. The new churches were no provincial hodge-podge of outdated styles, but were clearly formally planned and closely modeled on contemporary structures in Norway (Roussell, 1941). According to Roussell's architectural analysis, elaboration and expansion of stone churches continued unabated until at least A.D. 1300. The bishops of Gardar, all appointees from Norway, are the most likely source of such architectual innovation. Their ability to divert labor, materials, and foreign exchange to such lasting monuments to display and ritual intensification is a mark of their power in Norse Greenland.

CULTURE CONTACT

The bloody first contact recorded in *Historia Norvegiae* does not seem to have deterred Thule Inuit from moving southward along Greenland's west coast, nor does it seem to have blunted their interest in things Norse. Indeed, the medieval Inugsuk Inuit culture of the west coast was defined largely on the basis of the presence of Norse artifacts (Mathiassen, 1930). Iron and bronze objects are common finds, but so are curios like wooden spoon cases and draughtsmen (often made into tops). Inuit-carved dolls representing Norsemen are widespread in Greenland, and one is reported from Baffin Island (Sabo and Sabo, 1978). Norse objects are also found in a variety of Inuit contexts throughout much of the Canadian Eastern Arctic (McGovern, 1979 Schledermann, 1978, McGhee, personal communication), probably distributed through Inuit exchange networks. While the Inuit were clearly interested in the strange *Kavdlunait,* there is no evidence that Inuit subsistence or technology was irrevocably altered by Norse contact, and the Thule Inugsuk transition may have been as much related to adoptation to open-water maritime hunting possibilities or Dorset influence (Jordan, 1979). By ca A.D. 1300, large, unusually nucleated Inuit settlements existed in Disko Bay in the middle of the Nordrsetur (Mathiassen, 1958). This nucleation may have been a response to Norse hostility, and such Inuit settlements would certainly have posed a threat to overwintering Norse hunters and provided highly efficient competition in sea mammal exploitation.

Inuit movement into the Norse Settlement areas is still undated, but existing evidence (Mathiassen, 1936) indicates that Inuit winter settlements in the oceanic outer fjords were contemporary with Norse occupation of thr inner fjords. Sporadic Inuit hostility thus posed an immediate threat to Norse use of two resource zones critical to overseas trade and the subsistence round.

European documentary sources suggest that some such hostility was a recurrent feature of Inuit-Norse relations. Baardsson's account of ca A.D. 1350 seems to implicate the Skraeling in the collapse of the Western Settlement, as does King Magnus Eriksson's unheeded call for a military expedition against the heathen in Greenland in A.D. 1355 (Gad, 1970: 145). The Icelandic annals for 1379 report "the Skraelings assaulted the Greenlanders, killed 18 men and carried off two swains and a bondswoman" (Gad, 1970: 147). However, some Inuit legends (Krogh 1967: 136-137) and the ca A. D. 1378 tale of the Icelander Bjorn's two faithful Skraeling servants (Gad, 1970: 146) suggest occasionally more friendly contacts. No archaeological evidence has been found for any widespread massacre or burning of the Norse Settlements. While Inuit competition may have adversely affected the Norse economy, it is unlikely to have been the sole cause of Norse extinction (McGovern, 1979b).

Without the documentary evidence and the Norse finds in Inuit contexts, we would have little indication that the two cultures ever met. Though the Norse inhabited a treeless arctic island and relied heavily upon seals, they never adopted efficient, arctic-adapted Inuit skin clothing, skin boats, or toggling harpoons. Frozen clothing at Herjofsnes (Nørlund, 1924) and elsewhere (Bruun, 1918) indicates that the Norse kept to the latest European fashions in woolen gowns, caps, and trailing liripipe hoods. Boat parts and a steatite boat model (Roussell, 1939) indicate the persistence of Scandinavian traditions of clinker-built wooden boats. The absence of harpoons from Norse artifact inventories is further suggested by the near absence of the ringed seal (*Phoca hispida*) from the Norse middens. Modern hunting statistics show that 92% of the seals caught at Kapisigdlit (in the heart of the Western Settlement area) in 1968 were ringed seals (KGH, 1968). Though clearly not uncommon, ringed seals do not form seasonal concentrations vulnerable to communal hunts, but are better taken by single hunters watching breathing holes. Since we know that regular face-to-face contact occurred between Inuit and Norseman for a period of several hundred years, and that Inuit technology and hunting expertise offered clear adaptive advantages in Greenland, we must explain the cultural barrier that prevented acceptance of Inuit skills and equipment by the Norse.

The Norse elite, particularly its powerful ecclesiatical component, is a likely source of this carefully maintained barrier. During the Middle Ages, heathen gods and spirits were not considered harmless fabrications to be ignored, but active, malevolent powers against whom Christians must ever be on guard. Where heathens were also of a radically different culture, strictures against friendly contact were particularly severe – as the history of Norse relations with North Scandinavian hunters shows (Simonsen, 1967). Our few documentary sources for Norse-Inuit relations suggest that the uncanny, unbleeding, troll-like Skraeling with their impressive shamanism and alien egalitarian morality would have been anathema to officials steeped in the dogma of the medieval church.

A more ecumenically minded Norse hunter, intent on raising his extractive efficiency by subsituting Inuit winter breathing hole hunting for chess would undoubtably receive instruction on the proper ritual for honoring the departed seal-spirit along with pointers on harpoon casting (Rink, 1875). Communication of his newly acquired skills to other Norsemen would thus probably involve also spreading heathen magic, bringing down the harshest sanctions of the church. It may be significant that our last documentary source for Norse Greenland A.D. (1409) records both a proper Christian marriage and a burning for witchcraft at Hvalsey church in the Eastern Settlement (Gad, 1970).

CLIMATIC CHANGE

Fluctuations in Greenland's climate have long played a role in speculative explanations of Norse extinction. However, geophysical and palynological data have only recently provided enough detail to allow small-scale modeling of the response of Greenlandic ecosystems to short-term changes in temperature, precipitation, and circulation. Figure 10 presents (in highly simplified form: see original sources for greater detail) existing paleoclimatic indicators for the period of the Norse settlements. Line 2 presents a summary of the O^{18}/O^{16} ice-core data collected by the recent Camp Century and ongoing Greenland Ice Sheet Project (GISP), providing a detailed air-temperature record. Line 3 presents Hudson Bay Mean Sea Level (MSL), reflecting ice-mass changes (Hillaire-Marcel and Fairbridge, 1978). Line 4 presents Finnish tree-ring data (Lamb, 1977) reflecting growing conditions in a distant, but climatically related part of the

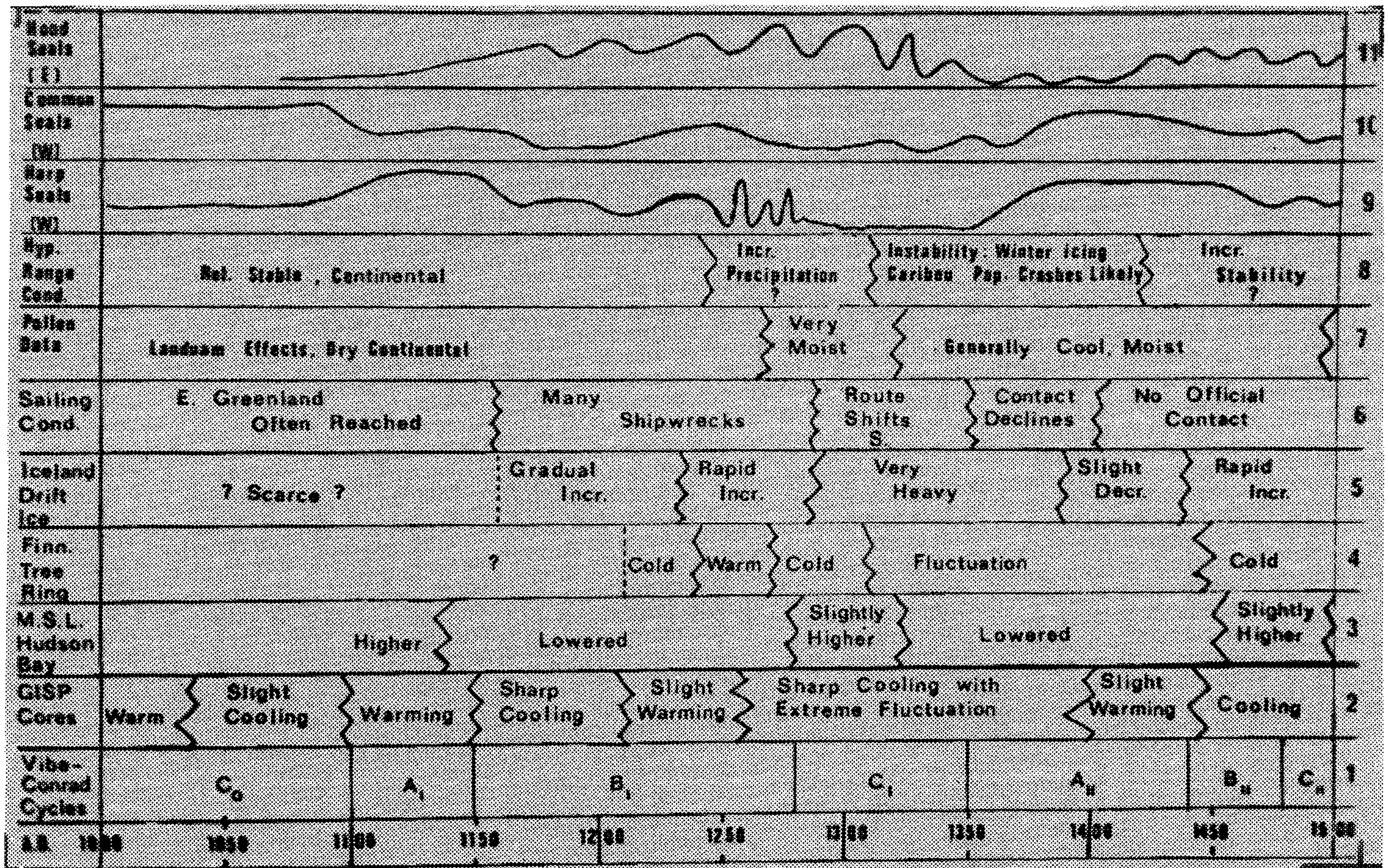

Hood Seals (E)
Common Seals (W)
Harp Seals (W)
Hyp. Range Cond.
Rel. Stable, Continental
Incr. Precipitation ?
Instability: Winter Icing Caribou Pop. Crashes Likely
Incr. Stability ?
Pollen Data
Landnam Effects, Dry Continental
Very Moist
Generally Cool, Moist
Sailing Cond.
E. Greenland Often Reached
Many Shipwrecks
Route Shifts S.
Contact Declines
No Official Contact
Iceland Drift Ice
? Scarce ?
Gradual Incr.
Rapid Incr.
Very Heavy
Slight Decr.
Rapid Incr.
Finn. Tree Ring
?
Cold
Warm
Cold
Fluctuation
Cold
M.S.L. Hudson Bay
Higher
Lowered
Slightly Higher
Lowered
Slightly Higher
GISP Cores
Warm
Slight Cooling
Warming
Sharp Cooling
Slight Warming
Sharp Cooling with Extreme Fluctuation
Slight Warming
Cooling
Vibe-Conrad Cycles
C_0
A_I
B_I
C_I
A_{II}
B_{II}
C_{II}
A.D. 1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
11
10
9
8
7
6
5
4
3
2
1

Fig. 10

Northern Hemisphere. Line 5 presents Koch's (1945) drift ice data culled from monastic records in Iceland back to about A.D. 1100. Line 6 presents a rough collation of sailing route changes, shipwreck reports, and official transatlantic contacts. Line 7 presents Fredskild's (1973) pollen data collected from the immediate vicinity of Norse farms in both settlements. Line 1 presents Vibe's (1967) ecological model as modified by Conrad (1971). Lines 9, 10, and 11, presenting seal accessibility, are derived from the Vibe/Conrad cycles, and line 8 (range conditions) is derived from both Vibe/Conrad and Fredskild. Note that these three lines are interpretation rather than data.

Note that our various direct and proxy indicators of paleotemperature are in reasonable agreement (lines 1, 2, 3, 4, 5), allowing for different rates of response of different media. The GISP ice cores, in common with the recent Devon Island results (Paterson *et al.,* 1977), show a long, stable "little climatic optimum" period of ca A.D. 500-1100, with a brief colder phasė ca A.D. 860. This period seems to have enjoyed higher temperatures than today's, with less short-term fluctuation. This early medieval warmth seems to have ended nearly 250 years earlier in the higher latitudes than in temperate Europe (Dansgaard *et al.,* 1975; Lamb, 1977), with the first chill of the Little Ice Age occurring ca A.D. 1150-1225. The ice cores show a slight recovery ca A. D. 1225-1250, followed by a period of renewed cooling and extreme short-term fluctuation ca A.D. 1250-1375. A second brief warming ca A.D. 1400 was followed by continued cooling after A.D. 1450. Note that the Finnish tree-ring data (line 4) broadly support the Greenaland ice cores' picture of medieval cooling, espeically in the extreme variability of the 14th century in the far north. The Icelandic drift ice data (line 5) likewise suggest the general cooling of the Little Ice Age, and seem to correlate with reported saling conditions on the Greenland voyage (line 6).

However, even the best paleoclimatic data are of little use in the explanation of culture change if specific fluctuations cannot be convincingly linked to specific effects upon resources critical to a past human economy. Correlation is not causation, and cultural responses to even extreme variations can be unexpectedly flexible (Parry, 1979). In the case of Norse Greenland, our paleoecological data suggest that the cooling and fluctuation of the 14th century would have very immediate impacts upon both terrestrial and maritime components of Norse subsistence.

The Vibe/Conrad ecological model indicates that common seals would be likely to extend their breeding colonies to the extreme southwest (the Eastern Settlement area) during the prolonged stable warmth of the little climatic optimum, and retreat to their refuge in the fjords of the Western Settlement area during periods with heavy East Greenland drift ice. Our stratified faunal collection from the Eastern Settlement site of Ø17a (Vebaek, 1965; McGovern, 1976) supports this part of the model, as common seal relative frequencies drop from 59% in the lower layers (11th century, Vebaek, 1965) to 13% in the upper (ca 12th-14th century). In contrast, hooded seals would be expected to linger in the southwest in periods of heavy East Greenland ice, and thus provide Eastern Settlement hunters with a critical second option. The Ø17a data again support the model: hooded seal relative frequencies rise from 8% in the lower layers to 20% in the upper. Stratified collections from the Western Settlement site V48, as predicted, show no such dramatic reduction of common seals and lack hooded seal remains entirely.

With zoo-archaeological support for these retrodictions of the Vibe/Conrad model, it seems reasonable to accept its projection of past harp seal migration. Thus line 9 in Fig. 10 presents a picture of increasing variability in timing and concentration of migration beginning ca A.D. 1300 and continuing at least through A.D. 1350. Chronic failure of the spring harp seal hunt during this period seems likely. Such failures would have their most dramatic effects on Western Settlement small-holders increasingly dependent upon seal (Fig. 9) and denied the second option of the hooded seals.

Fredskild's (1973) pollen data (Fig. 10, line 7) as well as the Vibe/Conrad model indicate that this period also saw stress placed upon the terrestrial elements of Norse subsistence. Pollen profiles indicate a long initial period of stable continentality, marked by locally significant "landnam effects" of browsing domesticates on inner fjord vegetation. Around A.D. 1300, this comparatively dry continental regime of the inner fjords seems to have been disrupted by intrusive oceanic storms and their increased precipitation (probably associated with the short-term variability recorded in the ice cores). Deeper winter snows (and especially ice-crusting from frozen rain) erect a deadly barrier between caribou and their winter grazing. Similar periods of instability in Southwest Greenland have caused dramatic crashes and even extinctions of local caribou populations in recent times (Vibe, 1967).

Byred domesticates would be spared the worst effects of the winter storms, and valley-bottom farmers might see real improvement in their summer pastures. However, such improvement would be less evident on hillside farms like V48, while persistent spring snow cover and increased summer precipitation could disastrously extend winter byring and reduce vital summer milk production and hay collection. Declining bone frequencies of all terrestrial species at V48 may reflect such worsening conditions in the inner fjords. Such small farms with poorer, steeper pastures, less substantial byres, barns, and dwellings, and scantier storage would be the first to feel the effects of reduced caribou populations and unpredictable extensions of byring.

The intrusive oceanic storms whose precipitation may have altered inner-fjord flora and disrupted the inner-fjord continental regime might also increase the hazards of inshore navigation. The long trip to the outer-fjord sealing grounds (often through steep-walled mid-fjords with no safe anchorage and evil modern reputations for shipwreck) would be made significantly more dangerous by more frequent spring storms. Day-to-day communication within the inner-fjord settlements would likewise be disrupted by such increasing storminess.

As we have seen, the Norse economy in Greenland was a skillful balancing act, coordinating communal concentrations of labor and seasonal abundances of terrestrial and marine resources. The economy lacked the buffering effects of storable grain and was beyond the range of significant famine relief from Europe (Gad, 1970). Spacing of resource zones (inner fjords, outer fjords, Nordrsetur) constantly exacted movement costs and complicated the tight scheduling of summer subsistence activity. Such an economy would work best in stable periods of high resource predictability, and would be as much disrupted by periods of instability as by extremes of cold or precipitation.

Inuit competition (first in the Nordrsetur and then in the outer fjords of the settlements); declining contact with Europe (the result of Hanseatic competition as well as increasing drift ice): rising costs of exploitation of Nordrsetur, outer-fjord, and inner-fjord resources; declining caribou hunting, stockraising, and seal hunting conditions; and declining predictability of all resources would pose significant threats to the Norse economy as we understand it. The question, then, is whether the coincidence of all these factors in the 14th century explains the contraction and collapse of Norse society in Greenland.

ECONOMIC OPTIONS AND CULTURAL CHOICES

There is little doubt that the Greenlandic Norse economy, as established in the little climatic optimum, faced serious if not fatal challenges in the 14th century. With full inner-fjord resource space, heavy investment in ceremonial architecture, and strong linkages to distant and increasingly disinterested European markets, Norse society of ca A.D. 1300 showed a dangerous lack of resilience (in the sense of Holling, 1973) in the face of waning extractive efficiency, fluctuating resources, and Inuit competition. Norse reaction to these challenges seems to have been an intensification of existing strategies. The large stratified bone collections from V48 (Fig. 9) show some changes through the Western Settlement's history, but indicate no radical revision of resource exploitation. It is possible that elite redistributive activity may have been expanded with larger byres at Gardar and the huge skemma at V7 Anavik, but such increased short-term storage could not compensate for prolonged crises in different segments of the economy. This singleminded conservatism ended in extinction, either through sudden, step-like "cusp catastrophe" (McGovern, 1980) or by a more gradual dwindling. Was this process inevitable? If not, why did it happen?

Fourteenth-century West Greenland was by no means destitute of resources, nor were the fluctuations of the Little Ice Age so severe as to make the island totally uninhabitable. While the Norse colony waned and died, the Inugsuk Inuit hunters spread and prospered. As the modern catch data suggest (KGH, 1968), the Norse never fully exploited the ringed seal so common in their very inner-fjord strongholds. The economic option of permanent occupation of the inner fjords and seasonal use of selected outer-fjord species was not the only one open to the Norse. Much of the locational inflexibility and rising cost of marine resource exploitation that hampered the Norse economy of the 1300s can be traced to decisions that made domesticates (and thus pasturage) the primary criterion of site location. This decision, and its reaffirmation in later decades, chained the Norse to the restricted ecological pockets that proved deadly traps as seal migration and weather patterns fluctuated. Had the Norse emphasized sea mammal exploitation year-round and flexible oceanic zone settlements, they would have been far better able to respond to altered concentration and accessibility of migratory seals. An active, year-round Norse presence in the outer fjords would also have discouraged intensive Inuit settlement of this vital resource space.

Such a presence could have been gained by reducing inner-fjord farms to the few most favored locations, and switching emphasis to sheep and goat herding and caribou hunting (reducing hay harvest labor). Regular exchange of outer-fjord and inner-fjord products, coupled with an enhanced seafaring capability incorporating wood-sparing skin boats, could have overcome many of the locational liabilities of the actual economy.

Alternatively, the Norse could have moved entirely to the coast, establishing seal and whale hunting stations and expanding their fishing efforts. A settlement pattern similar to the modern Danish-Greenlandic towns would be the likely result. Friendlier relations with the Inuit could have evolved into the sort of intercultural trading that proved so profitable to the Dutch in West Greenland by A.D. 1600.

Thus a range of alternate adaptive strategies were open to the Norse in Greenland. While investments in the inner fjords and the initial success of the actual subsistence strategy during the little climatic optimum might discourage early experimentation, by A.D. 1300 Norse economy and society were clearly in trouble in Greenland. Why did the Norse Greenlanders, who adapted their Icelandic/Norwegian economic strategy so creatively to Greenland's local resources around A.D. 1000, show such resistance to innovation 300 years later? What caused this once-pioneering settlement to close out its options, intensify, dig in, and die?

To attempt an answer, let us consider the likely source of economic decisions in Norse Greenland at the beginning of the Little Ice Age. Multiple lines of evidence indicate the existence of a powerful, partly ecclesiastical elite in Norse Greenland. This elite seems to have occupied ecologically favored locations in the inner fjords, consumed a disproportionate share of imported goods, and operated domestic economies significantly different from the poorest Norse farmers (Figs. 7, 8, 9). The diversion of labor and capital that turned precious summer days and hard-won tusk into stone walls and bronze churchbells and produced the centrally planned churches and cathedral of later medieval Greenland testifies to the power and authority of the ecclesiastical elite over both economy and ideology. Both secular and ecclesiastical elites profited from a system that made elaborate religous ceremony and cattle-keeping marks and guarantors of status. Holding land least affected by deteriorating weather, enjoying a diet least likely to be disrupted by changing sealing conditions, these powerful farmers might be well able to ignore a declining ratio of subsistence costs to benefits. The irregular onset of the Little Ice Age and the extreme 14th-century short-term fluctuations recorded by the ice cores might also lull such insulated decision-makers and bolster their resistance to change. In any case, the restructuring of settlement and subsistence resulting from the various "coastal options" outlined above would threaten to devalue the economic basis for elite authority: pasture. Technical innovations that would have eased transition were the property of the ideologically unacceptable Skraeling. Political and spiritual control of mobile outer-fjord hunters might also be harder to establish and maintain. As Feuer (1978) has noted, innovation may be inherently dangerous to elites in stabilized or contracting societies.

Elites in Norse Greenland did not lack the means for imposing their decisions on the community as a whole. Redistributive alms, loans of cattle and produce, and the structure of rents and tithes would all tend to increase the dependence of marginal farmers on wealthier patrons during periods of scarcity. The supernatural and temporal sanctions and rewards of the medieval church also seem to have punished deviance and reinforced orthodoxy in Greenland – perhaps most actively in times of crisis.

Thus a coincidence of cattle, churches, and ultimately fatal decisions to eschew innovation and to intensify an already stabilized economy need not surprise us. No one prime mover can bear the onus of Norse Greenland's extinction, but the important role of Norse elites and their decision-making cannot be undervalued. While elite management in some circumstances may lessen the impact of environmental fluctuation (Bowden *et al.,* 1980) and enhance a culture's adaptive response, the case of Norse Greenland suggests that the reverse may also be true.

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