CLIMATIC CHANGE AND THE NORTH ATLANTIC SEAWAYS DURING THE NORSE EXPANSION

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It has long been appreciated that the expansion of Norse exploration and settlement in the lands surrounding the North Atlantic coincided with, and may have been aided by, a period of favourable climatic conditions, often called the 'medieval climatic optimum', while subsequent climatic deterioration has frequently been invoked as a principal influence behind the ultimate demise of the Norse colony in Greenland.[1] However, the chronology and nature of climatic variation in the North Atlantic area have rarely been considered in detail in relation to the Norse expansion. In addition, cause and effect links between Norse activity and climatic variations have usually been assumed rather than demonstrated convincingly. In recent years climatologists and other specialists in the physical sciences have produced much new evidence relating to the timing and cause of climatic fluctuations in the North Atlantic during the medieval period. The purpose of this article is to examine this evidence in relation to the known chronology of Norse voyaging and colonisation. It will be shown that the climatic changes which occurred in this area during medieval times were more complex, and varied more in space and time, that the simple models of early medieval warming and late medieval cooling which have often been used by historians. This more complex picture of climatic fluctuations does, however, provide a better framework for interpreting some of the main events in the Norse expansion including the discovery and settlement of Iceland and Greenland and the eventual disappearance of the Greenland colony.

In order to appreciate how the Norse expansion might have been influenced by climatic fluctuations it is necessary to consider in outline the mechanisms which control weather and climate in the North Atlantic area at the present day, and which also obtained in the past.[2] Most of the weather experienced in this area results from the characteristics of the upper westerly circulation, or circumpolar vortex, the band of strong winds from an altitude of 2 km. upwards which is the principal mechanism for transporting heat from the tropics towards the arctic. The upper westerlies generate and steer the low-level depressions and anticyclones which bring surface weather in the middle latitudes of the Northern Hemisphere. The path of the vortex around the hemisphere is affected by the major topographical barrier of the Rocky Mountains stretching right across its path and sufficiently high to deflect even the upper winds. The vortex is diverted in a wave pattern northwards and then southwards. This wave generates further waves downstream around the hemisphere. The wave patterns form vary between two extremes. The first of these, characteristic of a relatively vigorous circulation, is a ZONAL pattern in which only two or three waves occur, with little north-south amplitude. The second is a slower MERIDIONAL pattern in which four or five waves meander much more markedly from north to south (Figure 1). At a seasonal level a zonal circulation is more frequent in winter when the temperature contrast between equator and arctic is strongest and the westerly circulation correspondingly vigorous. A meridional pattern is more common in summer when north-south temperatures contrasts are reduced and atmostpheric flow is weaker.

Changes occur in the strength of the westerly circulation, and thus in the wave pattern which it adopts, not only from season to season but also in the longer term between climatic phases such as the medieval optimum and the Little Ice Age. When the Northern Hemisphere as a whole is relatively warm the vortex contracts northwards with room for fewer waves, and draws depression tracks with it so that they pass, on average, north of the British Isles. When the hemisphere is cooler the stronger vortex moves southwards, generating more depressions and steering them more frequently across Britain.

It should be noted that a tendency for the vortex to adopt a meridional pattern can produce marked contrasts in the climatic conditions experienced at places of the same latitude but at different longitudes within the North Atlantic sector. One location may be under the frequent influence of northward-pushing ridge in the circulation, bringing warmer conditions at the surface, while another locality at the same latitude, further east or west, may lie under a trough drawing cooler air down from the north. With a zonal pattern

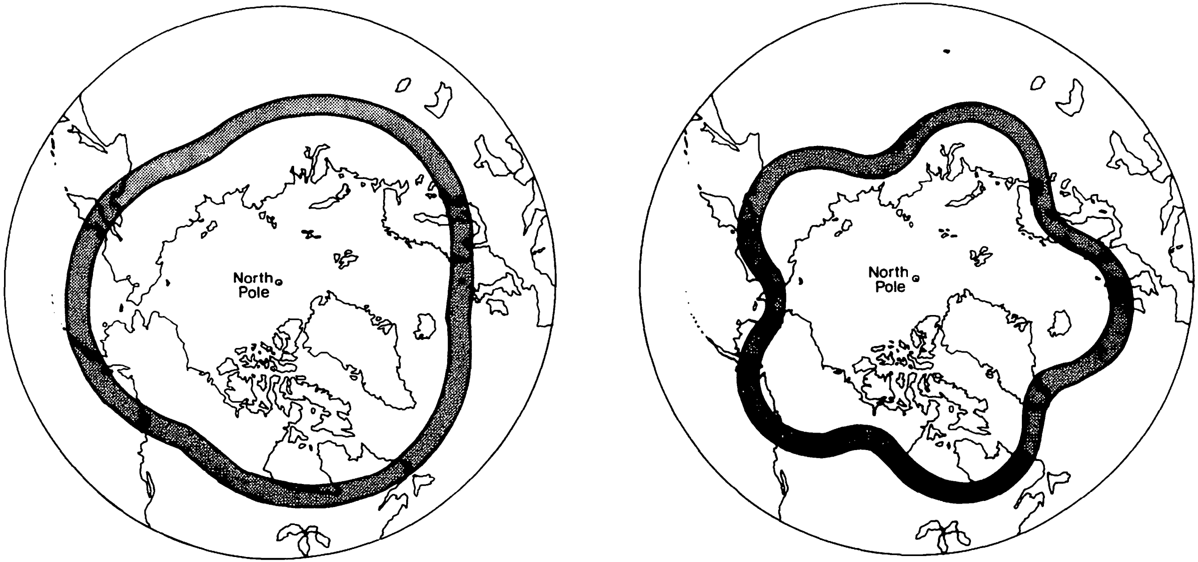


Figure 1
Zonal and Meridional circulation patterns.

north-south climatic contrasts predominate over east-west ones. If a long-term shift in the average wavelength of the vortex occurs there is a corresponding change in the areas in which depressions are generated, and in the paths along which they are steered. As a result, marked contrasts may occur in the weather conditions experienced at particular seasons, or over long runs of years in a particular locality as the wavelength of the vortex alters – an area may change from being under the influence of a warmer ridge to a cooler trough or vice versa.

The forerunners of the Norse in the North Atlantic were Irish monks who had discovered and settled Faroe by c700 a.d. and Iceland by c795 a.d.[3] They may have been aided in their voyages by a markedly meridional circulation pattern. Lamb has interpreted the evidence of contemporary chronicles recording marked extremes of conditions in different parts of Europe as indicating a persistent anticyclonic ridge over Western Europe bring warm summers with calm conditions and light winds, with a higher than average frequency of easterlies in the area between the British Isles and Iceland.[4] Such conditions would have aided summer voyages from Ireland to Faroe and Iceland in leather curraghs. The corollary of this, however, is the likelihood that in Iceland the monks had to put up with colder winter conditions than during the period of the Norse settlement.

The Norse are thought to have discovered Iceland around 860 a.d. They may have obtained information on the existence of the island in Ireland or Faroe but the first recorded sightings seem to have been accidental. Hauksbok claims that the discoverer was a viking called Naddod who was blown off course on a passage from Norway to Faroe, being carried into the Atlantic and eventually reaching Iceland.[5] Hauksbok also names Gardar, a Swede, who, when sailing from the Baltic to the Hebrides was caught by strong easterly winds while in the Pentland Firth and was blown into the Atlantic before finally fetching up in Iceland.[6] Unless the details of one voyage have been stretched into two the weather patterns experienced by these reluctant explorers were strikingly similar. In both cases strong easterly winds seem to have been followed by south westerly ones. Figure 2 illustrates likely conditions for this with high pressure over Iceland and a depression crossing Britain with its centre over Northern England. The pressure gradient on the northern edge of this depression could have produced

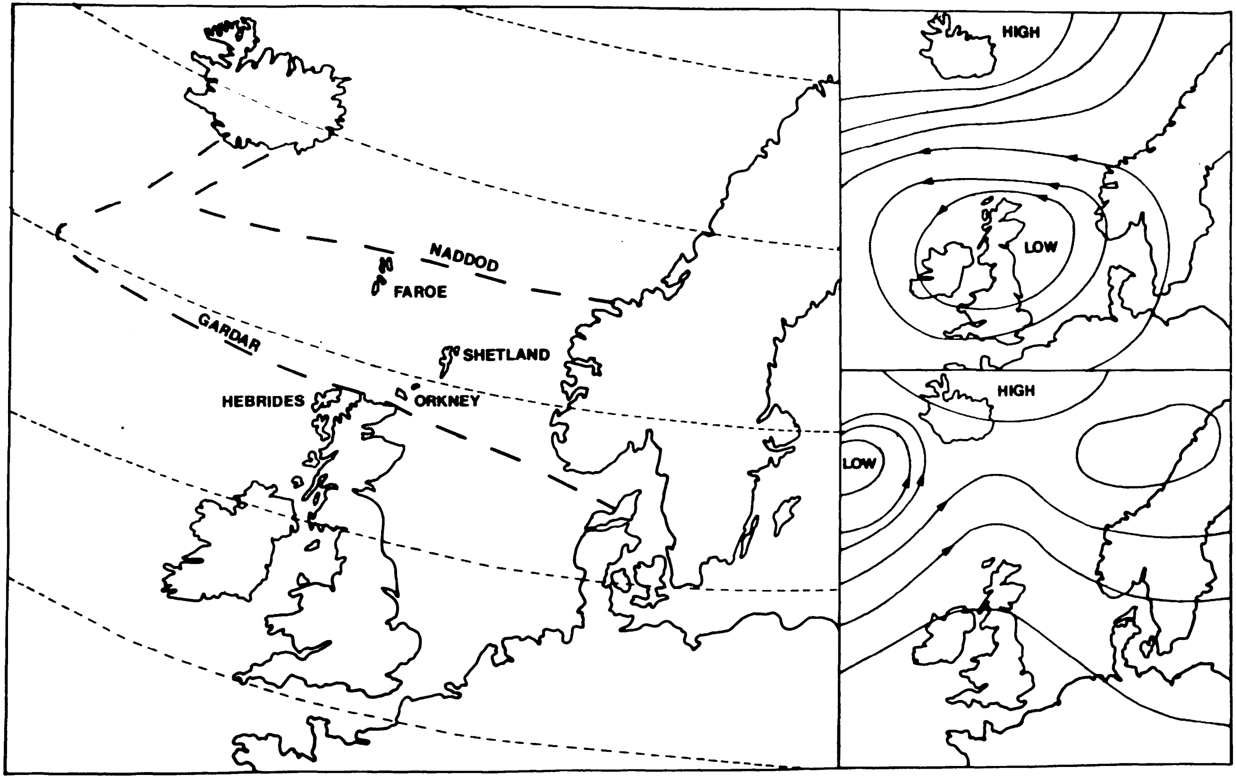


Figure 2
The voyages of Naddod and Gardar with reconstructed weather

strong easterly winds which carried Naddod and Gardar into the Atlantic. They may then have benefitted from the leading edge of the second, following depression, whose south-westerly winds could have carried them to Iceland. Such a sequence of weather is not unknown in spring today but the frequent passage of depressions so far south fits in well with cooler conditions, an expanded circumpolar vortex and a meridional circulation pattern.

According to both Hauksbok and Sturlubok Naddod had named the island 'Snowland'.[7] The name 'Iceland' was coined by Floki Vilgerdarson who attempted to settle there around 865 a.d. He was misled by fine summer weather and was caught unprepared by a severe winter. When he tried to leave the following summer persistent south-westerly winds bottled him up in one of the western fjords and forced him to stay for a second winter. On his return to Norway he painted a bleak picture of ice-choked fjords and cold conditions.[8] The Iceland described by Naddod and Floki would not, one might have thought, have attracted settlement, yet by the late 870s full-scale colonisation was in progress. An explanation is suggested by the temperature series which has been reconstructed from oxygen isotope variations in an ice core from Crête on the East Greenland ice cap. This suggests that conditions were cold in this sector of the North Atlantic for most of the 9th century but that rapid warming occurred from the 870s. Floki arrived at the end of the cold spell but full-scale settlement began during the succeeding warm phase.[9] The fledgling Icelandic republic was established under relatively favourable climatic conditions. This change may be explained by an alteration in the position and wavelength of the upper westerlies in which the vortex contracted polewards and the wavelength increased bringing Iceland under the influence of a ridge, and warmer conditions, in the place of the cooler weather associated with a trough.

The discovery and settlement of Greenland followed a strikingly similar pattern to that of Iceland. After the first accidental sighting of land by Gunnbjorn around 900 a.d. there was a disastrous attempt at wintering on the inhospitable east coast followed by Eirik the Red's successful exploration and colonisation venture on the west coast.[10] Eirik's saga suggests rather cynically that he named the new land Greenland because 'men would be all the more drawn to go there if the land had an attractive name'.[11] That Eirik was not perpetrating a major confidence trick is, however, suggested by examining the temperature series reconstructed from oxygen isotope variations in an ice core taken from the Western part of the Greenland ice cap. This indicates that there was a time lag of about 250 years between the onset of warmer conditions in West Greenland, and warming in Iceland and Western Europe generally.[12] Warmer conditions began in West Greenland from the later 5th century and persisted almost without interruption until the early 12th century. The cold spell that affected East Greenland and Iceland during the 9th century was hardly felt in West Greenland.[13] The explanation for this time lag is that West Greenland was more or less continuously under the influence of a ridge in the upper westerly circulation. The pre-medieval meridional pattern of the vortex would have tended to produce a ridge, with warmer conditions, over the western and central Atlantic and a corresponding trough between East Greenland and Britain. As conditions warmed and the wavelength altered to a three-wave zonal configuration as the vortex moving polewards, this warm ridge would have extended further eastwards and northwards being warmer conditions successively to East Greenland and Iceland.[14]

Superficially one might expect that the warm conditions which occurred in West Greenland before and during the first century and a half of Norse settlement would have been associated with a high incidence of onshore, maritime airstreams bringing moist but mild conditions. The evidence suggests otherwise though. Studies of vegetation changes in West Greenland based on the analysis of pollen from peat deposits appear to indicate that this warm phase was associated with drier more anticyclonic conditions and easterly winds.[15] Figure 3. shows how this might have occurred with a zonal circulation pattern displaced northwards causing a high frequency of light surface winds off the Greenland ice cap over the areas of Norse settlement. Such conditions would have made voyages from Iceland to Greenland easier. A reduced frequency of westerly winds in summer may have allowed vessels to make quicker passages westwards from Iceland. The diversion of depression tracks further into the Arctic would have made summer sailing conditions less stormy while the generally warmer air and sea surface temperatures would have reduced the danger of encountering sea ice in summer.

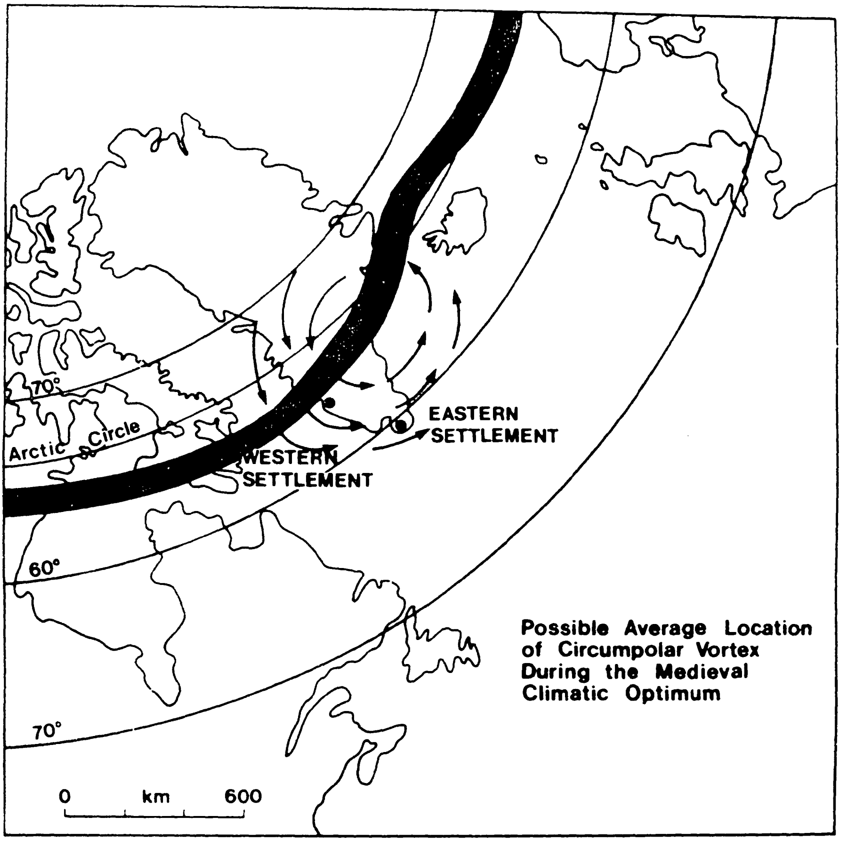
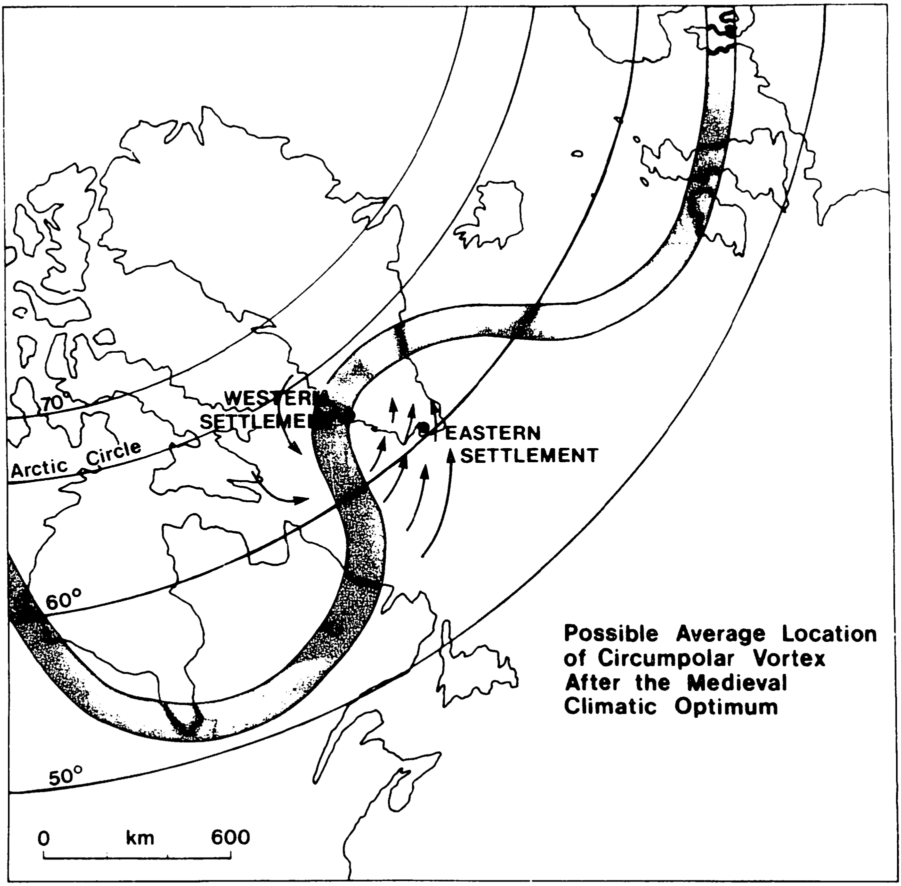

70°
Arctic Circle
WESTERN
SETTLEMENT
EASTERN
SETTLEMENT
60°
70°
Possible Average Location
of Circumpolar Vortex
During the Medieval
Climatic Optimum
0 km 600

Figure 3

Just as the medieval optimum came earlier to West Greenland than to Western Europe so the subsequent deterioration began sooner. Western Europe continued to enjoy warm conditions until the late 13th century but in West Greenland the downturn of temperatures began as early as the mid 12th century.[16] These less favourable conditions seem to have been caused by an overall cooling of the Northern hemisphere which was linked to an expansion of the circumpolar vortex wavelength. Colder conditions returned to the area between Iceland and Greenland bringing the summer limit of sea ice further south so that by the mid 13th century it had cut the traditional sailing route to Greenland due west from Iceland along the 65th parallel forcing vessels to divert well to the south.[17] In West Greenland temperatures also fell. Sea ice, carried around Cape Farewell by the East Greenland current, beset the western fjords and permafrost began to encroach upon the soils around the settlements. These conditions were not the result of more severe winters so much as poorer summers. The change in wavelength of the upper westerlies would have deepened the cold trough over Eastern Canada. Depressions, generated on the eastern side of this trough, would have been steered towards south-west Greenland, bringing more stormy conditions and more frequent onshore maritime winds (Figure 4.). This would have caused increasing precipitation and probably also a substantial reduction of sunshine in summer.

Greenland's trading contacts with Europe were reduced in the 13th and 14th centuries by the Norwegian crown's monopoly on trade after this outpost of settlement had been absorbed by Norway in 1261, and possibly by decline in demand within Europe for some of Greenland's high-value exports such as walrus ivory.[18] However, the combination of ice in the East Greenland area and more persistent westerlies as depression tracks moved southwards, causing longer, stormier passages to Greenland, is also likely to have provided a major disincentive to trading voyages.

The effects of a stormier, more maritime climatic regime with cooler summers and more precipitation on the pastoral economy of the Norse Greenlanders have been discussed by McGovern.[19] The complex of adverse conditions which faced the settlers under these circumstances can only be hypothesised but close analogies can be



WESTERN SETTLEMENT
EASTERN SETTLEMENT
70°
Arctic Circle
60°
50°
0 km 600
Possible Average Location of Circumpolar Vortex After the Medieval Climatic Optimum

Figure 4

found in the difficulties faced by farmers in Iceland at a later date[20] or even in the Scottish uplands during the worst period of the European Little Ice Age at the end of the 17th century.[21] The quality of the pastures on which the cattle of the Norse Greenlanders depended would have been adversly affected by the cooler, wetter summers. Heavier spring snows would have delayed the onset of new growth of grass and required animals to be stall fed for longer. Wet autumns would have interfered with the hay harvest and reduced the nutritional value of the winter fodder. Wetter summer conditions may also have encouraged various livestock diseases while a reduced food intake would have diminished the resistance of the livestock to both disease and more severe weather conditions. McGovern has, however, suggested that there was no inevitability behind the extinction of the Greenland colony.[22] In the face of climatic stress the Norse clung tenaciously to their cattle-rearing economy which was increasingly vulnerable and out of step with environmental conditions. They failed to adapt their economy, lifestyle and settlement locations to potentially more successful ones based on hunting and fishing. Had they emulated the eskimoes the colony might have survived in a different form but they failed to do this. It may have been their inflexibility to climatic change rather than the nature of the changes themselves which led to their demise.

This article has attempted to sketch in the climatic background to the Norse expansion in the North Atlantic in the light of recent research in climatic history. It has tried to indicate how the pattern and timing of Norse voyaging and settlement may have been influenced by medium and long-term climatic shifts. It is hoped that the outline discussion of the mechanisms of climatic change in the middle latitudes of the Northern Hemisphere will help to provide a better framework for understanding the nature of climatic change in this period and their complex spatial and temporal variations. Given the limitations of the historical evidence the influences of climate upon human activity can only be suggested rather than proved at present. It is possible however, that further environmental and archaeological evidence may help clarify the picture in the future.

NOTES

1. Eg. M. Magnusson and H. Palsson (ed.) *The Vinland Sagas*. Penguin edition, London 1965 pp. 18, 19, 22.
2. The workings of the upper westerlies are discussed in N. Calder. *The Weather Machine*. London. 1974 and H.H. Lamb. *Climate history and the modern world*. London. 1982, chapter 3.
3. G. Jones. *The Norse Atlantic Saga*. Oxford 1964 pp. 7-11, 22-3.
4. H.H. Lamb. *Climate: Past, Present and Future. Vol. 2 Climatic history and the future*. London. 1977 p. 428. Lamb (1982) *op. cit.*. p. 163.
5. G. Jones (1964) *op. cit.* p. 117.
6. Ibid. p. 117.
7. Ibid. p. 115, 117.
8. Ibid. p. 118.
9. W. Dansgaard, S.J. Johnson, H.B. Clausen, N. Reen, N. Gundestrup, C.U. Hammer. Climatic change, Norsemen and modern man. *Nature*. 225. 1975 pp. 24-8.
10. M. Magnusson and H. Palsson (1965) *op. cit.* pp. 16-17.
11. G. Jones (1964) *op. cit.* p. 166.
12. Lamb (1982) *op. cit.* p. 86, W. Dansgaard et. al (1975) *op. cit.*
13. Lamb (1977) *op. cit.* p. 430.
14. W. Dansgaard et. al. (1975) *op. cit.*
15. B. Fredskild. Studies in the vegetational history of Greenland. *Meddeleser om Grønland* 198 1973 no 4 pp. 86, 132.
16. Lamb (1982) *op. cit.* p. 86, (1977) *op. cit.* pp. 449-52.
17. G. Jones 1964 *op. cit.* p. 58.
18. Ibid. pp. 66-67.
19. T.H. McGovern. The economics of extinction in Norse Greenland. In T. Wigley, M. Ingram, G. Farmer eds. *Climate and History* London 1981 pp. 417-23.
20. A.E. Ogilvie. Climate and economy in eighteenth-century Iceland. In M.L. Parry and C. Delano Smith, (eds.) *Consequences of Climatic Change*, Nottingham 1981 pp. 54-69.
21. I.D. Whyte. Human responses to short- and long-term climatic fluctuations: the example of early-modern Scotland. In M.L. Parry and C. Delano Smith, (eds.) (1981) *op. cit.* pp. 17-29.
22. T.H. McGovern (1981) *op. cit.* pp. 423-30.