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The Greenland Norse

A Biological-anthropological Study

Niels Lynnerup

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Abstract

The study concerns all known Norse skeletal material from Greenland. The material represents the human remains of the Norse who sailed out from Iceland to colonize the south-western part of Greenland one thousand years ago, and maintained two major settlements there for five hundred years. Although the demise of the settlements, which was more or less contemporary with the southward migrations of the Thule Culture Eskimos, has traditionally been the focus of research, the tendency is now changing towards a broader multidisciplinary effort to reconstruct the Norse society. Data gleaned from the remains of the Norse Greenlanders themselves are intrinsic to this effort.

Comprehensive radiocarbon analyses were conducted to place the anthropological material in a chronological setting. These datings corroborated the general ideas of church chronology in Norse Greenland. Furthermore, the results of the radiocarbon analyses indicate a dietary shift from predominantly terrestrial to predominantly marine foodstuffs over the settlement period.

The analyses of burial practices and burial patterns point to a society which by and large followed the burial practices known from other contemporary medieval societies. However, a rather large number of non-clerical individuals seem to have been interred inside the church structures. This may indicate an organization of the church in Greenland much like that of Iceland, where the churches were owned, at least for some time, by the local magnates.

No statistically significant differences emerged from synchronic or diachronic analyses of anthropometric or non-metric traits. A tendency towards smaller dimensions, in accordance with previous studies, was however indicated. The Norse population seemed rather homogenous. There was no indication of assimilation with Eskimos.

The incidence of infectious middle ear disease was assessed as an indicator of general health conditions. The results, while not displaying a statistically significant secular trend, could indicate worsening living conditions, which seems to be supported by some of the demographic results. Besides middle ear disease, occurrences of other pathologies were noted. Evidence of traumatic lesions seemed to reflect a society where combat with swords or axes was not unknown.

Palaeodemographical analyses showed that mean age fell slightly over time, and that subadult mortality rose. Female mortality rates differed from male mortality rates, basically because more females died at a younger age. However, this trend was not statistically significant. An attempt was made to estimate the total population size by calculating burial densities and total burial area. This yielded a total population of about 26,000, i.e. an average of 1,400 individuals throughout 500 years of settlement. Finally, a hypothetical population profile was modelled by assuming average values for certain demographic variables (growth, immigration and emigration rates, etc.). This showed that a founder population of about 500 people could well have increased to about 2,000 over 200 years. Likewise, depopulation could be accounted for by assuming an average emigration rate of 10-13 individuals per year, with corresponding falling growth rates. The total summated population of this model was 26,500 individuals. The significance of these calculations is that hypotheses about the demise of the settlements need not resort to "catastrophic" events such as epidemics or warfare.

Foreword

This study was first submitted to the University of Copenhagen in 1994 as a PhD dissertation. The present publication is based on this dissertation, although several minor changes have been made.

The important chapter on radiocarbon analyses was co-authored by Jan Heinemeier and Niels Rud of the AMS-dating facility at Aarhus University.

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Introduction

The movement to settle Greenland, the Vikings' next Ultima Thule, was led by a habitual criminal named Eric the Red.

D.J. Boorstin, *The Discoverers*, 1983

According to the Icelandic sagas, Eric the Red founded the Norse settlement in Greenland in the year 986 AD (Bekker-Nielsen 1982; Jones 1986). This first settlement (the Eastern Settlement) was augmented with another settlement (the Western Settlement), situated about 400 km to the north of the first settlement (see Fig. 1). The landscape encountered by Eric the Red and his followers did not differ much from that of Iceland or northern Norway. The land was uninhabited, as the Thule Eskimos had not yet spread to the south-western part of Greenland. Grasslands, suitable to the Norse way of life, and a relatively mild climate, were found far up the fjords. In addition there were the plentiful resources of the sea, the fjords and inland streams. A measure of the prosperity of the settlements and their obvious regular contacts with Iceland, and thus Norway, was the consecration of a bishop for Gardar in the Eastern Settlement in 1124 AD (Arneborg 1991). It seems, however, that links with Iceland and Norway were gradually weakened, although the settlements were made subject to the Norwegian Crown in 1261 AD. According to written sources the Western Settlement was deserted by about 1360 AD (Jónsson 1930). The last known written testimony from the Eastern Settlement dates to 1408 AD (*Grønlands Historiske Mindesmærker* III:1[1] 145-150). It has been assumed that the Eastern Settlement was finally depopulated a century later (Meldgaard 1965).

The decline of the Norse settlements has always been foremost among the Greenlandic Norse issues studied. Indeed, this question has been presented almost as an enigma, hinting at some inexplicable and dramatic event veiled by the passage of time. Consequently, the explanations have also been dramatic, ranging from sweeping epidemics to pirate and Eskimo attacks or racial degeneration. However, more recent research, palaeozoological, cultural and historical, has downplayed the dramatic aspects, and a much more complicated picture has emerged. It involves climatic change, land over-use, changes in medieval commerce and local hierarchical and economical structures. This also means that research on the Norsemen has become ever more interdisciplinary. Biological anthropology may contribute to this with analyses of the human remains of the Norse themselves. This study is based on a comprehensive and, to the best knowledge of the author, exhaustive compilation of all the Greenland Norse skeletal material available at the Laboratory of Biological Anthropology in Denmark.[2] However, the material is fragmentary, comes from many different excavations and spans almost a century of archaeology. The aim of this study is thus fourfold: (1) to present a complete inventory of all the Greenland Norse skeletal material with accompanying archaeological data; (2) to analyse Greenland Norse burial customs; (3) to examine the health and living conditions of the settlers, including their diet, on the basis of direct analysis of the skeletal material itself; and (4) to attempt a reconstruction of the Greenland Norse population over time based upon mathematical modelling of various demographic scenarios.

[1] Grønlands Historiske Mindesmærker (The Historical Monuments of Greenland) was the first effort to collate all knowledge of the Norse settlements, including sagas, archaeological and historical data. It was published in 1838-1845 in three volumes. In the following, this work is referred to as »GHM« followed by the volume number.

[2] The Laboratory of Biological Anthropology at the University of Copenhagen serves as a repository for all skeletal material found by Danish archaeologists in Denmark and Greenland. In the following it is referred to as the Laboratory.

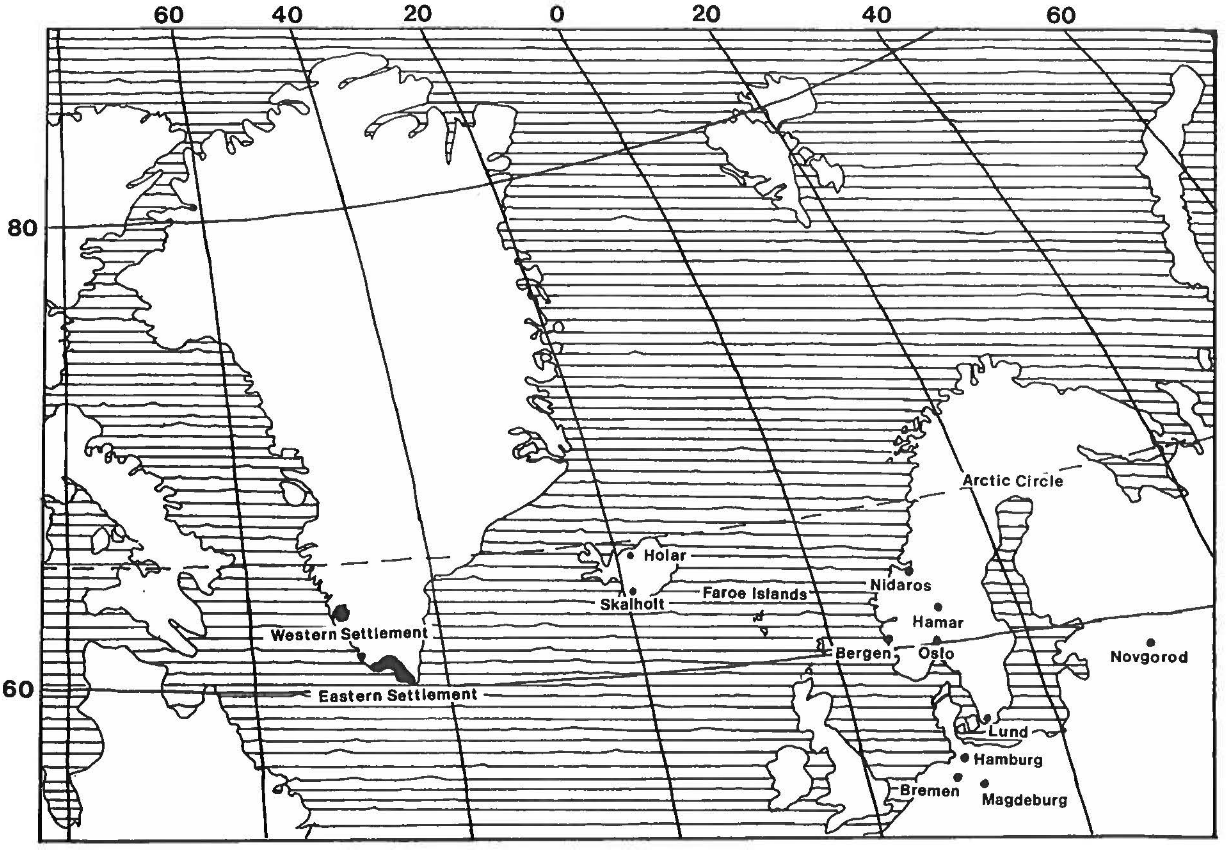


Fig. 1. Map of the North Atlantic showing the location of the Eastern and Western Norse settlements on the West coast of Greenland.

The Greenland Norse skeletal material

Provenance and archaeology

The first archaeological expeditions

Norse ruins were first described in detail by Hans Egede, the Danish-Norwegian minister of religion and missionary, who sailed to Greenland in 1721 (GHM III: 727ff). As a missionary his first task was to christianize the Eskimos; his second to investigate whether there were isolated communities with descendants of the old Norse settlers (Egede 1738). Egede set up a station at Godthåb (Nuuk), from which he made numerous observations of old Norse ruins (Arneborg 1989).

Later in 1723 Egede sailed south along the west coast, so he could sail round Kap Farvel and proceed up along the east coast. Egede thought, like most of his contemporaries, that the Norse Eastern Settlement, as implied by the name, would be on the east coast of Greenland. However, storms and drift ice prevented him rounding Kap Farvel. Egede did observe the Norse ruins in the Qaqortoq Fjord now known as Hvalsey Church (GHM III: 730). At this location Egede carried out the first recorded excavations of a Norse site (Albrethsen 1971).

Following Egede, several expeditions went out to locate the Eastern Settlement, still with the idea that it must be on the east coast of Greenland. Then in 1792 H.P. von Eggers, in a University of Copenhagen Gold Medal dissertation, expressed the view that the Eastern Settlement might in fact be on the west coast (GHM III: 759).

The first expedition to chart the south west coast systematically and locate Norse ruins was launched in 1829, under the command of Captain W.A. Graah (GHM III: 776). Graah made extensive observations of Norse ruins, conducting test excavations at presumed churchyards, and succeeded in locating several Norse churches (GHM III: 777).

Several geographical expeditions have gone out since, many locating new Norse sites. In this century most expeditions and excavations have been archaeological enterprises proper, and their results have included the collection of the bulk of the skeletal material (Arneborg 1989). General surveys of the archaeological expeditions have been published by Arneborg (1989) and Albrethsen (1971).

A detailed account of excavations at all known Norse churches and churchyards will be given in the following, focusing on sites where skeletal material was found and secured. The following features will be discussed for each identified site: a) grave plans (distribution of graves and skeletal finds in two-dimensional space); b) size of churchyard; and c) dating (the period during which the burial ground was in use). Results of radiocarbon analyses, initiated by this study, are given in a subsequent section.

The sites are ordered by their site ID number (Registry of the Danish National Museum, prefixed by either E or W, indicating Eastern or Western Settlement). The presumed old Norse placename and the Greenlandic placename are also given, the former in brackets. Sites are referred to by their ID number and the traditional site name (e.g. E1 Gardanes, W51 Sandnes) in the general text. An overview table (Table 1) shows, for each site, the year of excavation, the archaeologists who investigated it, whether human skeletal remains were found, and whether the material was available for this study.

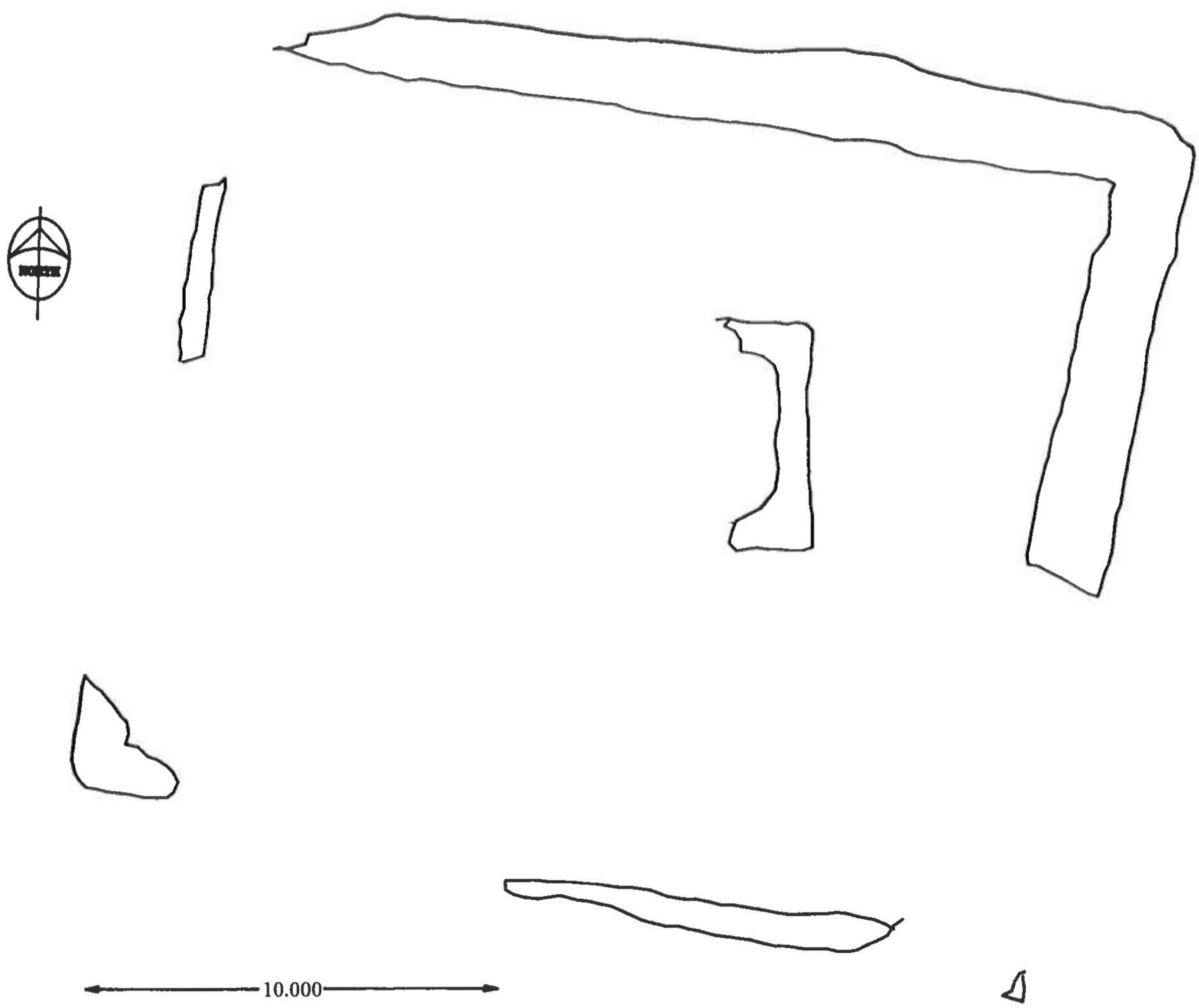


Fig. 2. Digitized map of E1 Gardanes. The map is based on data by Albrechtsen and Berglund (1971).

E1 Gardanes (Nunatoq)

The site was first surveyed by Daniel Bruun in 1894. He made a map of the area, including sketches of farmhouses. He also identified a kitchen midden. Fragments of animal bones and ashes were found in a small test excavation of the midden. He did not find any remnants of a church or churchyard (Bruun 1895: 206-215).

Albrethsen and Berglund found such remains in 1971, when they surveyed the site again (Albrethsen 1972), and a detailed map and report were produced (Albrethsen and Berglund 1971). They noticed remnants of a dike just south of Building No. 1 and the kitchen midden. Further examination and excavations yielded a rectangular churchyard dike. In order to establish that it was indeed a churchyard, they conducted a test excavation in the NE corner of the presumed churchyard. At a depth of 30 cm they encountered human bone fragments, which they presumed represented a disturbed burial. Along with the skeletal fragments which were exhumed, a piece of cloth was found. They concluded that the church was identical to the Gardanes church of the Flatøy Book (Albrethsen & Berglund 1971; Albrethsen 1972). The exhumed skeletal remains were brought to Denmark and analysed at the Laboratory (internal report dated 1/10 1971).

The churchyard is rectangular, measuring approximately 22.0 x 24.0 m on the outside of the dike, the dike itself being approximately 1 m in breadth. The size of the church building itself was very difficult to measure. The walls were badly damaged, but Albrethsen and Berglund tentatively set the maximum size at 12.0 x 5.6 m (see Fig. 2).

Nothing can be said with any certainty of the dating of the skeletal material from the archaeological context. No radiocarbon datings have been performed on material from this site.

E23 Undir Solarfjellum/Hardsteinaberg (Sillisit)

Daniel Bruun examined the site in 1894, but was not aware that there was a church ruin (Bruun 1895: 276). It was C.L. Vebæk who discovered the church ruin in 1950. Although at first he identified the church as Hardsteinaberg, he later proposed that it was Undir Solarfjellum (Vebæk 1966: 209), but he reverted to his former opinion in 1991 (Vebæk 1991: 8-9).

Although no plans of the church and churchyard ruins have been published, a copy of Vebæk's excavation report to the National Museum has been obtained (Vebæk 1969). In this he states: "I made some test excavations here and found overturned earth at a considerable depth and a few bones, which I thought to be human" (Vebæk showed the bones to the district medical officer, who indeed pronounced the bones to be human). The grounds were then cleared and the contours of church and churchyard became clear. Vebæk conducted excavations near the NE corner of the church and found at least two skeletons, at a depth of 50 cm, laid out in the usual orientation (i.e. east-west), with arms folded across the chest. Because of severe degradation, Vebæk only succeeded in exhuming a few teeth and fragments of femora.

In an accompanying letter to the Laboratory, Vebæk mentioned that the churchyard at E23 Undir Solarfjellum exhibited the usual Norse burial pattern: "Many burials, one above the other, at depths down to 1 m." Although Vebæk stated in his report that he had exhumed two skeletons, the material housed at the Laboratory is marked Skeletons 1 to 4. In addition, small notes written by Vebæk about the skeletal remains suggest that they represent at least four individuals. Further examination by this author identified a single tooth which belonged to none of the four identified individuals, thus suggesting the presence of least five individuals. Vebæk made no mention of coffin stones, coffins or cloth.

Krogh made a detailed sketch of the ruins in 1964 (Krogh 1964). Vebæk estimated the churchyard to be 20.5 m by 22.5 m. However, according to the plan made by Krogh, the dimensions are somewhat smaller, the interior measurements being approximately 17.35 m by 14.0 m (see Fig. 3). No radiocarbon datings have been produced for material from E23 Undir Solarfjellum. The material cannot be assigned to any specific period of the Norse settlement.

E29a Thjodhilde's Church, Brattahlid (Qassiarsuk)

This site has been identified as Brattahlid, Eric the Red's farmstead (Nørlund and Stenberger 1936). Ruins of a church and a rectangular churchyard were identified at this site, but the church ruin (E29 Brattahlid) was of a relatively late period, and no traces were found of either pagan graves or the reputed first church, Thjodhilde's Church, mentioned in the sagas (Meldgaard 1965; Meldgaard 1992; Krogh 1982) (see also the section on E29 Brattahlid).

In 1961, human skeletal material was found about 200 m from the already excavated church ruin E29 Brat-

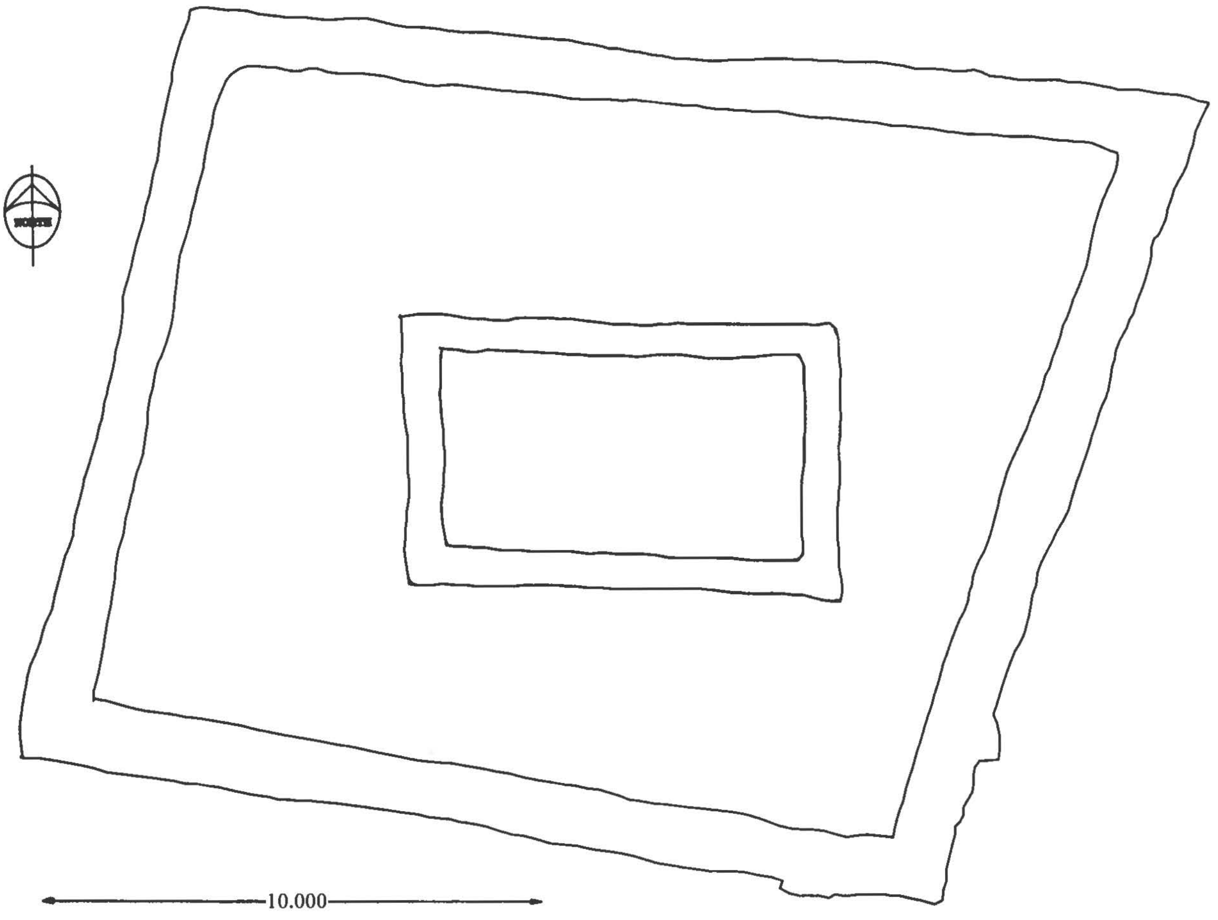


Fig. 3. Digitized map of E23 Sillisit. The map is based on data from Krogh (1964).

tahlid. The skeletal material, a cranium, was sent to Denmark, and quickly identified as Norse by Balslev-Jørgensen at the Laboratory. Thus it was thought that the first Christian church in Greenland, Thjodhilde's church, had been located (Meldgaard 1982).

This launched what has perhaps been the biggest and most ambitious archaeological excavation in Greenland to date. Jørgen Meldgaard led the excavations in the first period, and was later succeeded by Knud Krogh. The team also included Balslev-Jørgensen, and thus for the first time a physical anthropologist was present during the field work (Krogh 1982) (Fig. 4). The excavations revealed a small turf-built church surrounded by a circular churchyard. One hundred and fifty five interments were found in the churchyard. All the skeletons were laid out in the ordinary Christian fashion, i.e. along a west-east axis. There was seemingly a sex difference, with most males lying south of the church, and most females north. Only a few were in coffins. A mass grave with the disarticulated bones of thirteen individuals was also found (Krogh 1982: 43-50). Unfortunately, the original excavation plans and maps are not available. The map below (Fig. 5) is based on a map in a book by Krogh (1982: 47). The drawing does not show the remnants of a dike, nor is this mentioned by Meldgaard (1982). Jansen writes of the possible remains on an effaced turf dike: "It has not been determined whether this is a church dike or simply a croft dike" (Jansen 1972: 102). He does, however, mention an approximate churchyard diameter of 20 m, with a resulting approximate area of 314 m^2 (Jansen 1972: 104). The small church building itself was measured as 2 x 3.5 m (interior) with a turf wall thickness of 1-1.5 m (Krogh 1982).

Meldgaard dated the church, on the basis of the sagas, as one of the first churches – if not the first – in Green-

Fig. 4. The excavation of the mass grave at the churchyard at E29a Thjodhildes Church (Photo: Balslev-Jørgensen, 1962).

land, and thus thought it must have been built around the year 1000 AD. Judging from the relatively few interments, perhaps representing only one generation, and the durability of turf houses, he felt it had only been in use for some 30 years (Meldgaard 1982, 1992). Krogh arrived at the same conclusions, based on the church and churchyard layout (Krogh 1982). Apart from the E111 Herjolfsnes burials, the burials at E29a Thjodhilde's Church are the only burials which can be placed with some degree of certainty in a chronological context. While other churchyards display many disturbed burials, indicating a long period of use, there are a limited number of burials, and in particular very few disturbed burials, at E29a Thjodhilde's Church. This means that the period of use was limited, and that most of the interments were from the time when the church was built and shortly afterwards. This seems to be conclusively confirmed by radiocarbon datings of skeletal material from nine individuals, all samples dating to approximately 1000-1100 AD (cf. the chapter on radiocarbon analyses).

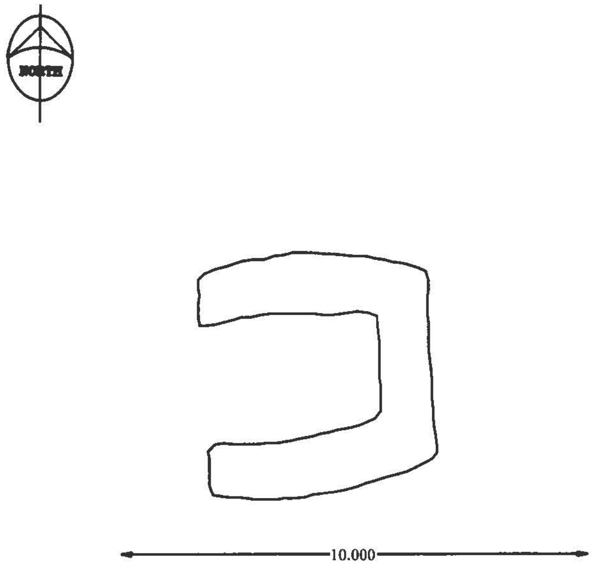


Fig. 5. Digitized map of E29a Thjodhilds Church. The map is based on data from Krogh (1982).

E47 Gardar (Igaliko)

The first identification of a church at Igaliko was reported by C. Pingel (1836). Excavations were first conducted by J. Mathiesen in 1830, and yielded a tombstone[3] and a heap of bones, among these seven crania, none of which was secured (although Mathiesen described the crania as fragile, he had intended to bring one cranium back, but was prevented by his Eskimo helpers, who reburied it) (Nørlund 1929a). Pingel remarked: "Whole rows of bodies lay so close to each other that one must presume that the whole churchyard was once filled up with dead" (GHM III: 813). M.W. Esmann excavated in 1832 and reported human bones at the NE corner of the churchyard (Esmann 1832). Four skeletons were found in the churchyard in addition to two inside the church ruin (one in a stone-lined grave below the possible altar). The remains were not brought to Denmark. Esmann also recovered narwhal teeth within the ruins. In 1839 J.F. Jørgensen excavated, and according to Pingel (1842) he found a large number of graves, wooden coffins and remnants of cloth. He revisited the site again in 1840, but found no graves (Jørgensen 1840; Nørlund 1929a). Daniel Bruun made an extensive topographical study of the site in 1894 (Bruun 1895).

Poul Nørlund and Aage Roussell conducted their detailed excavations and analyses of the site in 1926. During their excavation an accurate ground plan was drawn of a cathedral with two side chapels. The cathedral had the largest dimensions of any church found in Greenland, with a 9 m wide nave. Most interestingly, Nørlund also detected the ruins of an earlier, smaller church beneath the cathedral. Burials were identified underneath the cathedral walls (Nørlund 1929a: 42). Because it would be impossible to excavate the entire churchyard, they focused on the SE corner, the eastern part of the churchyard and the interior of the church. A few random test excavations were also done on the north and west side. The most spectacular find was made in the north chapel: a skeleton with a bishop's crozier with an ornamented head placed diagonally across the body (Nørlund 1929b) (see Fig. 6). A ring was also found. The location of the grave and the presence of such artifacts were taken as proof that the individual had been one of the Greenland bishops. The Bishop's bones were reinterred at Gardar some years later.[4] The bones of the left hand and the left patella were found in a box at the Laboratory. The bones

[3] The tombstone has the following inscription: VIGDIS:M:D:HVILIR:HER:GLEDE:GUÐ: SAL HE(N)NNAR: (Vigdis M's daughter rests here: God rejoice her soul).

Fig. 6. The Bishops grave at E47 Gardar, with the skeleton and crozier (Photo: Nørlund, 1926).

of the hand had been glued together in a slightly flexed position, presumably for exhibition purposes. Samples from the hand bones were submitted for radiocarbon dating. Other identified graves inside the church were all located in the eastern section (Nørlund 1929a: 65-75).

Nørlund found that the south side of the churchyard had functioned as a burial ground at a later period (Nørlund 1929a: 58-65). The area had been cleared to serve as a burial ground after the construction of the cathedral (Nørlund 1929a: 58-65). Nørlund and Roussell noted that the subsoil consisted of shingles, and that large quantities of fill had been used. The fill had consisted of midden material, and animal bones were found in large quantities (Nørlund 1929a: 58-65). On the west side of the church very few graves were found, while burials were found close together, side by side and in many cases one above the other, in the eastern part (Nørlund 1929a: 58-65). The overall dimensions of the rectangular churchyard were 31.5 x 48.8 m (see Fig. 7). The maximum outside dimensions of the cathedral were 27.1 x 15.8 m (Jansen 1972: 115). Remnants of a church tower were located by Nørlund, measuring approximately 5 x 4 m.

Nørlund and Roussell recovered 11 skeletons (the figure has now been now adjusted to 13) from Gardar (Nørlund 1929a). According to the archaeologists' descriptions and small identification tags found with the skeletal material, the location of a few of the skeletons could be reconstructed (four skeletons from the north chapel and one from the south-eastern part of the churchyard). The rest, nine in all, could not be assigned with any certainty to any original location.

Nørlund and Roussell dated the late cathedral to 1150-1250 AD. They also discussed the identity of the Bishop and concluded that he was Jon Smyrill, said to have died in Greenland in 1209 (Nørlund 1929a: 65-75). This has, however, been contested by among others Jansen (1972: 118). However, given the location of the grave, the Bishop must postdate the cathedral building. Two skeletons

[4] No references to this reinterment have been found. However, there is a letter written by Nørlund to the Laboratory where he states: »I would find it fitting... to rebury the bishop...«

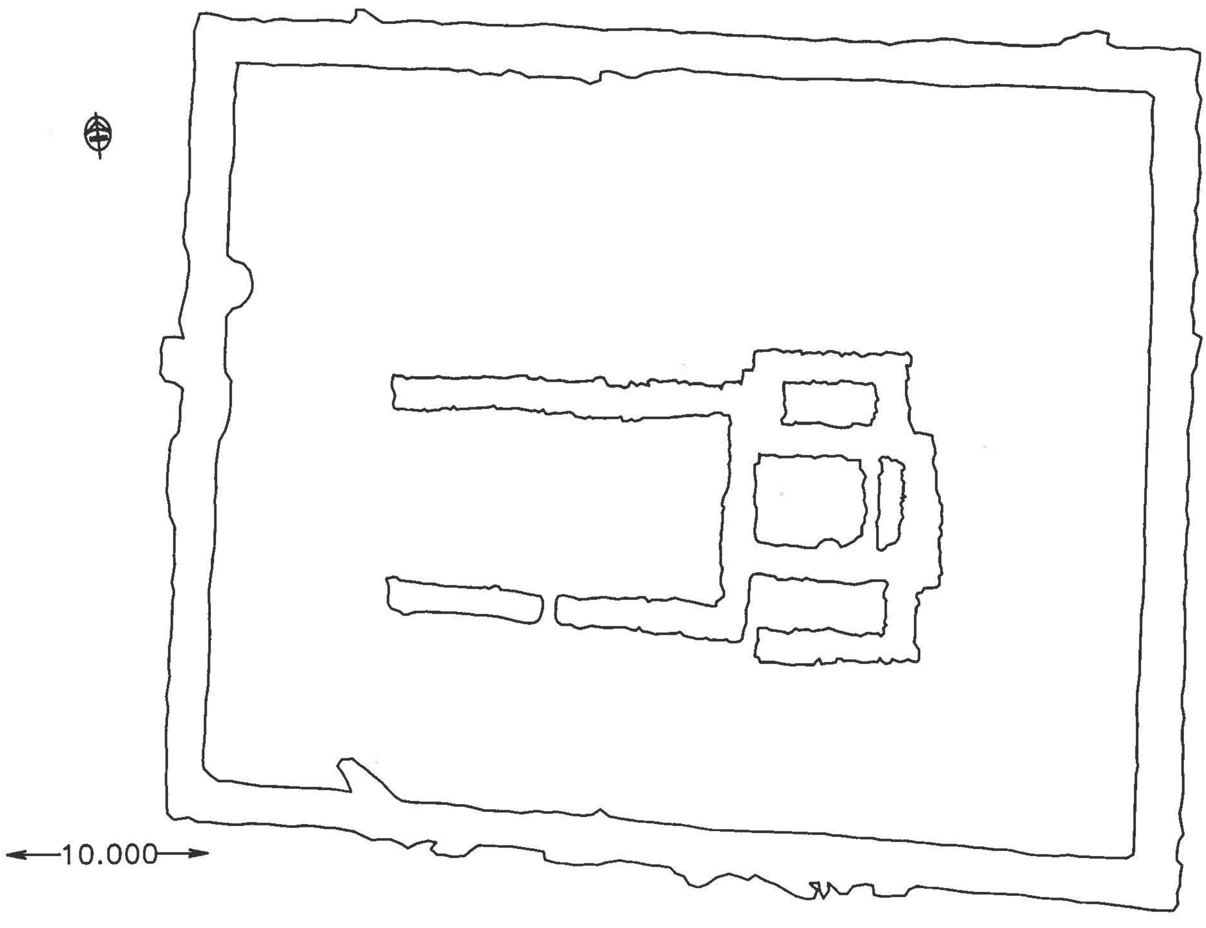


Fig. 7. Digitized map of E47 Gardar. The map is based on data from Nørlund (1930).

from the north chapel can be dated before the Bishop (Bröste et al. 1941). Radiocarbon dating of the Bishop and the two other skeletons from the north chapel places all three around 1225-1275 AD.

E66 Undir Høfdi (Igaliku Kujalleq)

This site was first excavated by J.F. Jørgensen in 1839 (Pingel 1842; GHM III: 811). He stated that numerous bodies were found, at a depth of 180 to 240 cm, and that there were remnants of cloth and coffins. H.J. Rink excavated in the area in 1854 (Rink 1854). In the sketch of the churchyard Rink marked a small area, and noted: "Skeletons were located here 1 Alen [approximately 60 cm] below the surface" (Rink 1854). Unfortunately, there are no other notes from Rink's expedition and excavations. In 1880, during his extensive expeditions to Julianehåb district, Gustav Holm conducted excavations both inside the church ruin and in the churchyard. He noted: "In the churchyard at Kagsiarsuk in the Igalikofjord some bodies were found not far below the ground, close to each other, between big stones, as in family graves. The bodies, with the heads towards the west, do not seem to have been placed in a stretched position, but crouched, and there were no traces of coffins or cloth" (Holm 1883: 75). Holm also noted: "Seven crania lying close to each other and partly embedded in ice were found at the floor level in the western end of the church....In the churchyard a number of skeletons were found approximately 2 Alen [approximately 1.2 m] below the surface in groups separated by large stones; the heads were toward the west and the legs to the east. No traces of coffins or cloth were identified. However, the bodies were covered by several large, flat stones. Some of the bodies were found ten paces from the church, one foot above the floor level of

Fig. 8. Present day Gardar. The ruins of the cathedral and farm complex are almost exactly in the center of the photo (Photo: Lynnerup, 1992).

the church....while others lay at a distance from the church of seven paces at the same level" (Holm 1883: 119). Holm drew a sketch of the churchyard and church ruin. The site was later investigated by Daniel Bruun in 1894. In his extensive account (Bruun 1895: 368-388), he described how he had the entire churchyard cleaned, but found no tombstones. Two excavations were carried out where he found some crania (which according to a Professor Chevitz "were not Eskimoes"); "...but although the bodies were placed close together in a west-East direction with the heads to the west, and in various layers between 2 and 5 feet, the area had been disturbed by earlier excavations. I also excavated at the church's east gable and found more disturbed burials. One cranium (not Eskimo) with a hole in the frontal bone was secured" (Bruun 1895: 373). The crania found by Bruun must have been brought to Denmark, but they have not been identified at the Laboratory, nor is there any mention of them in the Laboratory acquisition journals. When M. Clemmensen inspected the church ruin in 1910, he found a Norse cranium lying at the edge of Bruun's excavation pit (a) about 1.5 m below the surface. The cranium was taken to Denmark, where it was examined by F.C.C. Hansen, who pronounced it to be of Norse origin (Clemmensen 1911: 344). Clemmensen also excavated some bones from what he presumed to be the kitchen midden associated with the farm adjacent to the church. The bones where examined by the zoologist H. Winge, who identified bones from seal, reindeer, oxen, sheep and pig, fragments from a human skull and a mandible (Clemmensen 1911: 345). The human skeletal material was stored at the Department of Zoology of the University of Copenhagen, and has been made available for this study (the mandibular fragment was identified as non-human).

E66 Undir Høfdi was last excavated in 1926 by Aage Roussell. The primary aim of his excavations was to clarify the structure of the church foundations and other similar structural elements (Roussell 1941). He did not specifically report finds of human skeletal material, but his drawings include three skeletons located at the west end of the church (Roussell 1941, 118). In his unpublished report covering the 1926 excavations Roussell wrote that four skeletons were found in a common grave, approximately 4 m from the church's south wall, 20 to 40 cm below the surface. Below the four skeletons a fifth was found, 125 cm below the surface (Fig. 9). Roussell measured the skeletons in situ, and found the upper four to have a stature of between 145 and 150 cm, and the lower skeleton to have a stature of 180 cm (Roussell 1935). Roussell interpreted this as evidence of progressive degeneration, the older (lower) skeleton being of higher stature than the younger (upper) skeletons (Roussell 1935). The five crania were brought to Denmark and examined by Bröste, Fischer-Møller and P.O. Pedersen (Bröste et al. 1941). No skeletal material seems to have been secured from the three skeletons found at the west gable of the church.

E66 Undir Høfdi was surveyed by Albrethsen and Krogh in 1968. No additional excavations seem to have been conducted, however (Albrethsen and Krogh 1968). The churchyard measures approximately 27.5 x 24.5 m (interior). The church measures approximately 16.0 x 6.0 m (see Fig. 10). All excavations were conducted in the southern part of the churchyard and in parts between the east gable and the dike, and inside the church.

Roussell discussed the question of the dating of the Norse churches at some length. He concluded that the rectangular church design was proof that the churches (and among these E66 Undir Høfdi) were built at a late period (Roussell 1941: 135). These conclusions have been contested by Jansen (1972: 108) who, although agreeing that the church is of a later date, believed that the church-

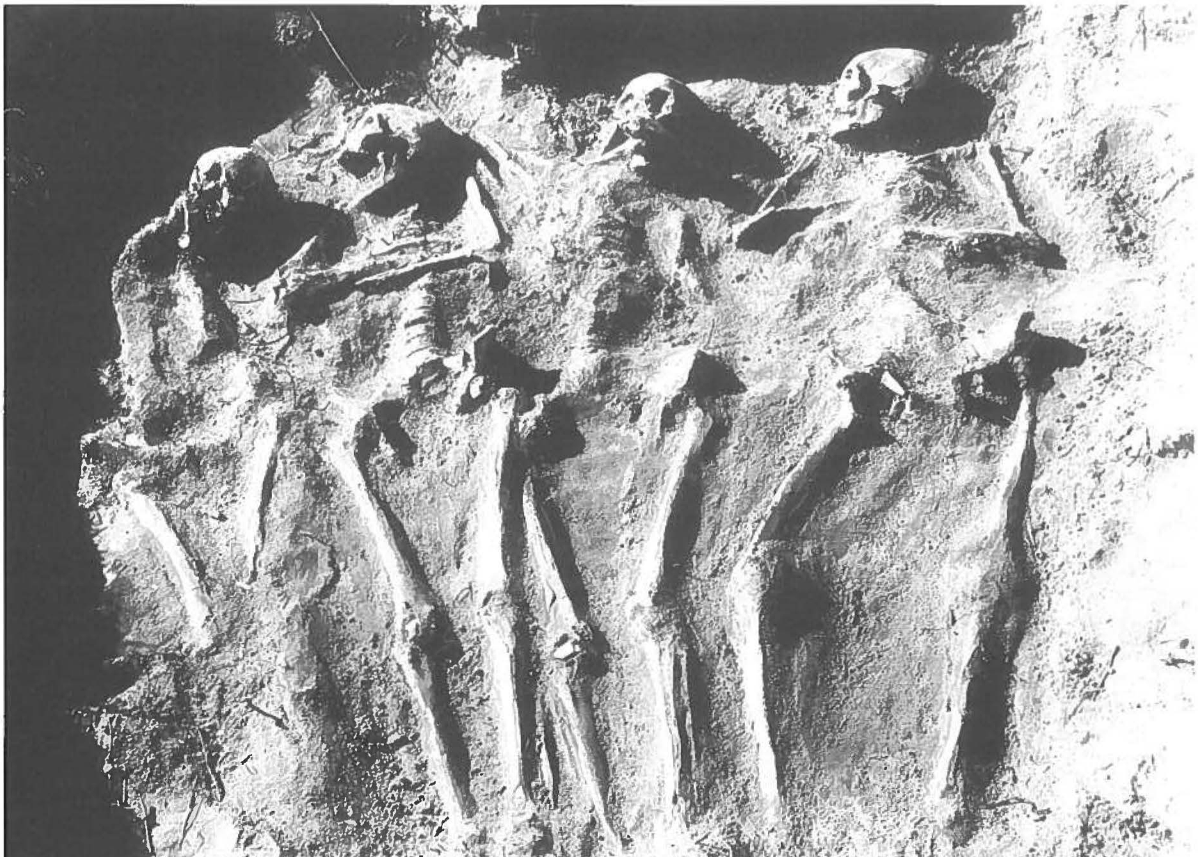


Fig. 9. The so-called mass grave at E66 Undir Høfda (Photo: Roussell, 1926).

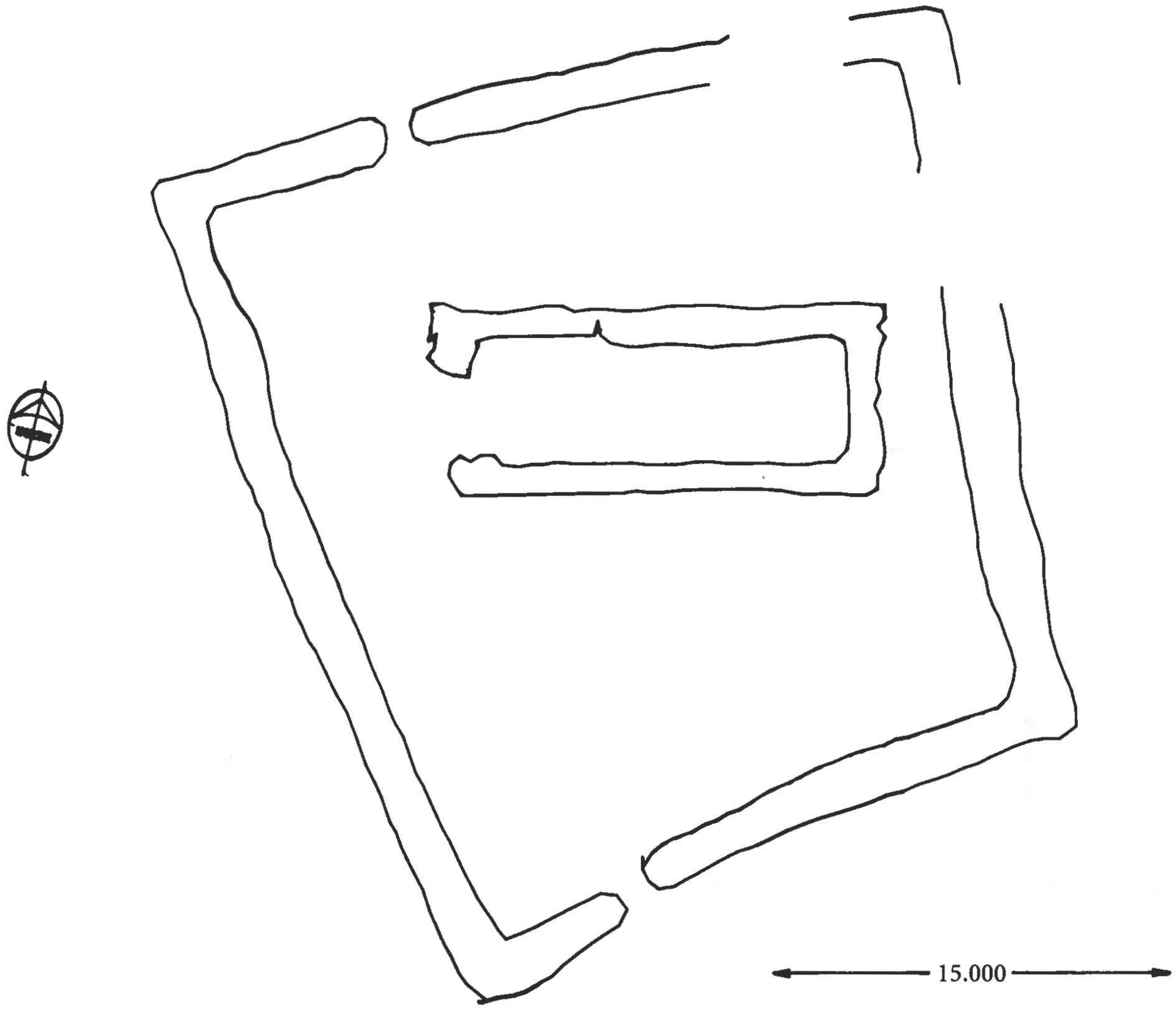


Fig. 10. Digitized map of E66 Undir Høfda. The map is based on data from Rink (1854), Holm (1883), Bruun (1895), Roussell (1941) and Albrethsen and Krogh (1968).

yard is older than the church. This is supported by the finds of three skeletons in the area of the west gable. Krogh suggests that the church was in use in the middle of the 14th century (Krogh 1982: 129). Although we have a relative chronology for the crania unearthed by Roussell, none can be assigned with any degree of certainty to a specific period. Radiocarbon dating of the recovered skeletal material indicates a date of approximately 1275-1375 AD (cf. chapter on radiocarbon analyses).

E111 Herjolfsnes (Ikigait)

The first find at this site was a funeral stone with runic inscriptions[5] found by deFries in 1830. It was sent to the Danish National Museum, where it is now on display (GHM III: 801; Mathiesen 1831; Nørlund 1924). O. Kielsen did the first excavations in 1840 (GHM III: Pl. 3; Pingel 1842). During a test excavation the year before "a cranium with hair" had been found (Pingel 1842). It should be noted that the site was exposed to severe erosion by the water at the coast, resulting in constant exposure of skeletal material and coffins. Records indicate

[5] HER:HVILIR:HRO,..KOLGRIMS:S.. (Here lies Hroar Kolgrims' son).

that some of this hair was sent to Copenhagen, and it was determined that it derived from a Norse settler (Pingel 1842). Among other objects there were "several pieces of wooden coffins, with skeletons lying inside, bits of shrouds, a couple of wooden crosses, several tombstones..." (GHM III: 801). Neither the hair nor other anthropological material from this excavation has been located. H.J. Rink conducted topographical studies in 1853 (Rink 1853), and Gustav Holm is reported to have found a coffin at the site in 1880: "I had excavations conducted here, and, as before, found skeletons in cloth and coffins". The skeletons were apparently not secured, but Rink marked the position on his map (Holm 1883). In 1900 the district medical officer Gustav Meldorf excavated some skeletal material at the site and noted numerous coffins and shrouds (Meldorf 1912). Because of the ongoing erosion, nearly all of the south part of the churchyard had vanished into the sea. Even parts of the church ruins had been eroded by the sea. The coastline formed a small cliff, from beneath which several partly exposed human bones were observed. Meldorf noted: "The bones lay in a horizontal position and noticeably close to one another" (Meldorf 1912). He found several crania, and the skull (cranium and mandible) of one individual was brought to Denmark. Some garments, including a cap, were shipped to Denmark (Nørlund 1924). Mylius-Erichsen visited the site in 1905. Although there is no report of any excavations, two crania at the Laboratory are said to be from the Mylius-Erichsen visit. The two crania are also mentioned in F.C.C. Hansen's anthropological study of the material from E111 Herjolfsnes (Hansen 1924). However, the boxes containing the crania are marked "Meldorf". There is even some inconsistency in the Laboratory's acquisitions journal; while the material is entered as being from Mylius-Erichsen, there should also be some postcranial material. However, no such postcranial material has so far been identified in the Laboratory.

Major excavations were conducted by Poul Nørlund in 1921 (Nørlund 1924). According to Nørlund (1924) the find comprised remnants of approximately 110-120 burials. However, a considerable number of burials were in such poor condition that no remains could be removed. This was especially true of the material in the upper layers. Nørlund estimated that about 200 burials were identified in the surveyed area. Nørlund noted that "within these areas burials were generally closely packed, often in three or four layers" (Nørlund 1924: 59). Nørlund managed to exhume many pieces of clothing which had been wrapped around the corpses. These items became the spectacular finds from Herjolfsnes because of their excellent state of preservation (indeed, the Herjolfsnes garments are almost the only known extant early medieval clothing) (Fig. 11). The garments have been dated to the beginning of the 15th century, on the basis of the style (Nørlund 1924).

Nørlund only found traces of two burials in the church. One burial (the so-called "Gudveg's grave"), close to the north wall of the nave, was a coffin burial containing a cross. Two fragments of a yellowish substance were also found, and Nørlund interpreted them as the remains of two individuals (Nørlund 1924).

It was possible to locate the south part of the churchyard dike accurately because of erosion by the sea. The best map is probably the one made by Nørlund in 1921. The east-west length (interior) is approximately 30 m according to this map. The church ruin measures 17.5 x 10.0 m (exterior) (see Fig. 12).

Nørlund found no traces of an earlier church, but burials had been found at both the east and west ends of the church, directly below the church structures. Nørlund therefore believed, also on the basis of architectural considerations, that there had been a burial ground and a church before the construction of the church represented by the present ruins (Nørlund 1924: 50). Dating has primarily been based on the analysis of clothing, including hoods and caps. Nørlund dated them between the 12th and late 15th century, allowing for the dissemination of fashions from Europe, presumably through Norway (Nørlund 1924). The skeletal material from E111 Herjolfsnes is the only Norse material from Greenland which can be dated with a reasonable degree of certainty on the basis of associated grave goods. This dating was borne out by the radiocarbon analyses done as part of this study. Thus, datings based on both cloth and skeletal material suggest 1400-1450 AD with good correspondence between the textiles and the skeletal material (cf. the chapter on radiocarbon analyses).

E149 The Benedictine Convent (Narsarsuaq)

This site was first located by Poul Nørlund in 1932 (Vebæk 1953; Jansen 1972). No excavations were undertaken, however, until C.L. Vebæk visited the site in 1945-46 and 1949 (Vebæk 1991). Vebæk identified the site as the

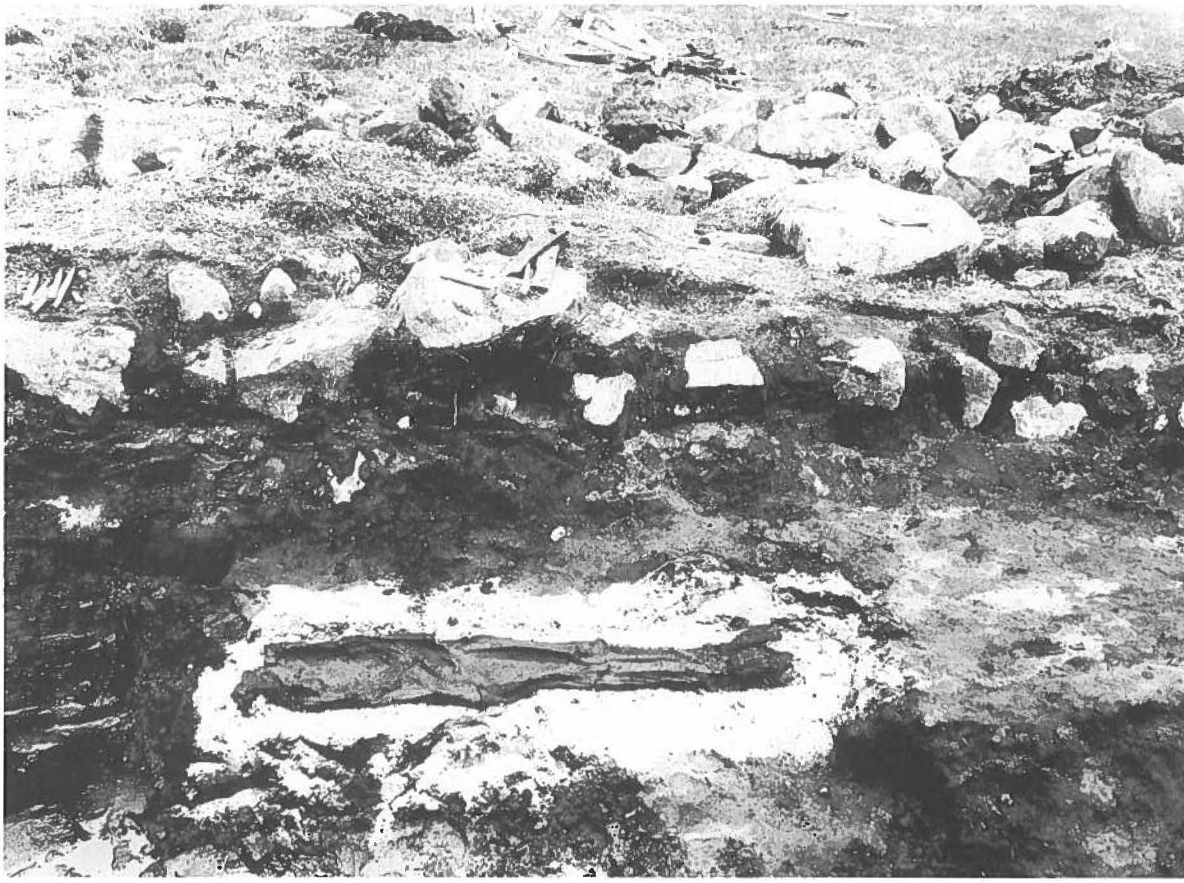


Fig. 11. Garments found in a grave at E111 Herjolfsnes. The garments were used as burial shrouds, and the outlines of the skeleton can be seen through the garments (Photo: Nørlund, 1921).

Norse Benedictine Convent mentioned by Ivar Bardson (GHM III: 248; Vebæk 1991).

The excavations showed that an earlier church must have existed before the one excavated by Vebæk. Although no traces were found of an earlier church, several interments were found below the church walls (Vebæk 1991). Vebæk identified 20 graves inside the church: "The graves were so numerous and so close to one another that there would have been room for only three or four more graves before the church was completely filled" (Vebæk 1991: 28). Unfortunately, the preservation was very poor, and no skeletal material could be secured. Vebæk did draw the graves on his map. The graves were all of the usual type with the bodies stretched out in an east-west orientation, most with arms folded across the chest. Vebæk suggested that since the church had been associated with the presumed convent, only abbots and nuns would have been buried inside the church (Vebæk 1991). He did, however, find a child, suggesting that other members of the surrounding community were also buried within the church; so it apparently also functioned as a parish church. On the basis of drawings made by Vebæk, it seems reasonable to say that the graves within the church were dug after the church was built; they all follow the walls at a slight distance, and none of them goes below the walls (Vebæk 1991).

Numerous burials were found in the churchyard. There were no traces of coffins, but small fragments of garments were found. Two graves were excavated, as were two areas (called "gravefields" by Vebæk). Apart from these, there were several scattered finds. Gravefield I contained burials down to 0.8 metres, of which 12 could be exhumed. Again, the closeness of the burials was noted, and Vebæk hypothesized that this was due to an epidemic (Vebæk 1953; 1991). In Gravefield II, only the upper layer of the skeletal remains were examined. Eleven skulls were brought back for further examination from this gravefield. Additionally, Vebæk found several heaps of

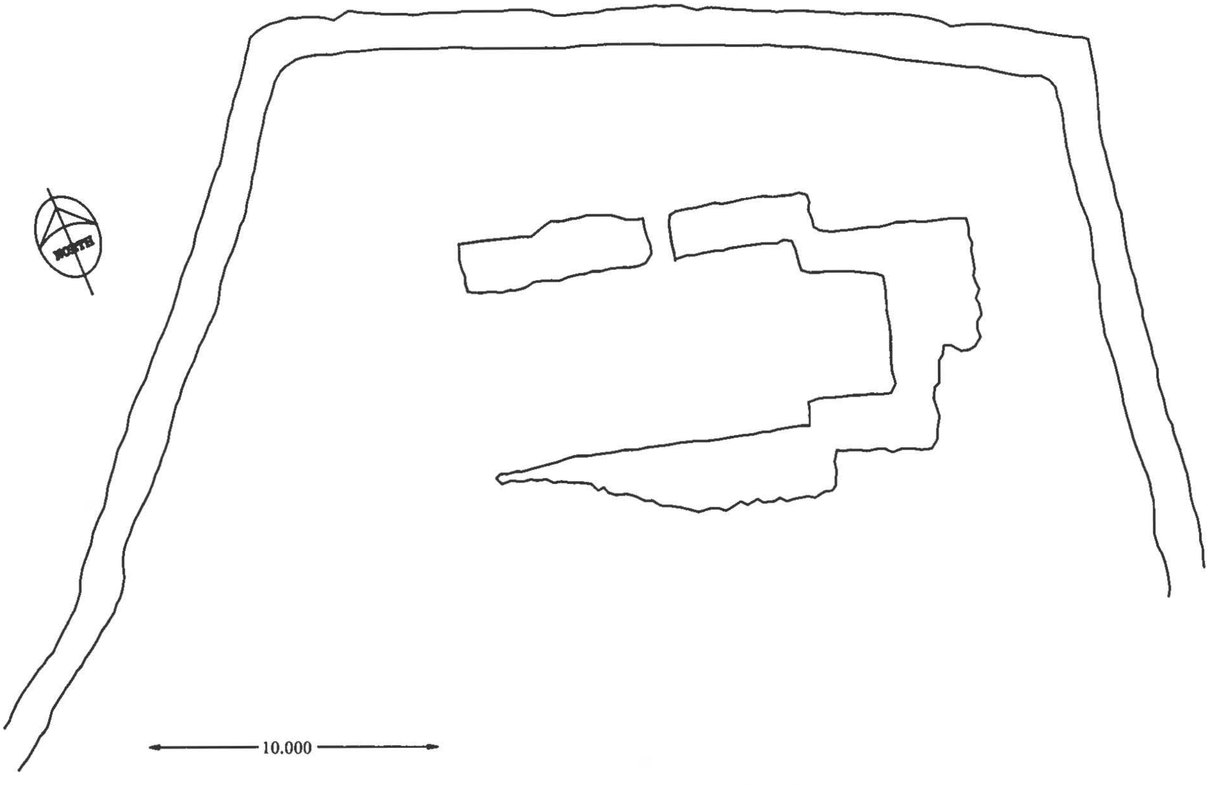


Fig. 12. Digitized map of E111 Herjolfsnes. The map is based on data from Rink (1853), Holm (1883) and Nørlund (1924).

Fig. 13. Excavations in churchyard at the so-called Convent, E149 Narsarsuaq (Photo: Vebæk, 1945).

bones from one or more disturbed burials. In all, Vebæk surmised that there were several hundred burials in several layers in the churchyard (Vebæk 1953). The interior dimensions of the rectangular churchyard were 20.0 x 25.0 m (500 m2), with the church measuring 15.0 x 9.0 m (exterior) (see Fig. 13).

Vebæk suggested that there had been two major settlement periods at the site: one very early, probably in the Landnama period (i.e. 1000 AD), and the second later, when the convent church and churchyard were constructed, presumably in the 12th century (Vebæk 1991). However, Vebæk also hypothesized that the churchyard was probably in use for several centuries, in fact throughout the settlement period. Radiocarbon analyses of excavated material from the houses adjacent to the church suggested a date of 885-1150 AD (Vebæk 1991: 73). Radiocarbon analyses from the churchyard indicated a somewhat later period; 1350-1425 AD (cf. the chapter on radiocarbon analyses).

W7 Anavik (Ujarassuit)

Ujarassuit has been known as a Norse site since the time of Hans Egede, and Pingel mentions ruins of a church building at this site (GHM III: 838). Since then the site has been surveyed on several occasions; Daniel Bruun mentions that J.A.D. Jensen, Ryder, Thorhallesen and Kleinschmidt had visited the site (Bruun 1918: 73). Although they all presumed that there was a church among the ruins, this was not verified until the site was excavated. The first archaeological excavations were done in 1932 by Roussell. He found a rectangular church, surrounded by a churchyard. No tombstones were found inside the churchyard; however the excavators did find "many interments...and a sample excavation outside the south-east corner of the church showed that in deep, very wet and frozen sand deposits there is a possibility of finding well preserved bodies and maybe even burial clothes" (Roussell 1941: 105). The map made by Roussell shows the location of 15 interments. The deepest interments were 150 cm below the surface. Only two skeletons could be recovered. Fischer-Møller mentions in his anthropological account that only six crania and some limb bones originate from W7 Anavik (Fischer-Møller 1942). The identification numbers bear no resemblance to the Roman numerals in Roussell's maps, though, so it has not been possible to link the skeletal material with Roussell's field data.

Excavations were resumed in 1982 by Kapel and Arneborg (Kapel 1982). Two areas were excavated. Six burials were registered in the so-called Field 1. The preservation of the burials was similar to that of Roussell's finds in 1932. Remnants of cloth were found, but no traces of coffins. Samples of bone were taken from four individuals for radiocarbon analyses. Bone and dental fragments from one individual remain. No interments seem to have been found inside the church and, perhaps significantly, no traces of an earlier church either (Kapel 1982).

The exterior dimensions of the rectangular churchyard are 22.0 x 28.0 m, the dike being approximately 1 m wide. The church ruin measures 13.9 x 6.8 m (Roussell 1941; Jansen 1972) (see Fig. 15).

Roussell suggested that W7 Anavik was a church from the period after 1300 AD (Roussell 1941). The radiocarbon analyses of the material excavated in 1982 indicated a burial period in the 14th century (Kapel 1982). Several layers of burials were encountered by both archaeological excavations, which might indicate that the churchyard had a longer period of use than the church, but no traces of an earlier church have been found.

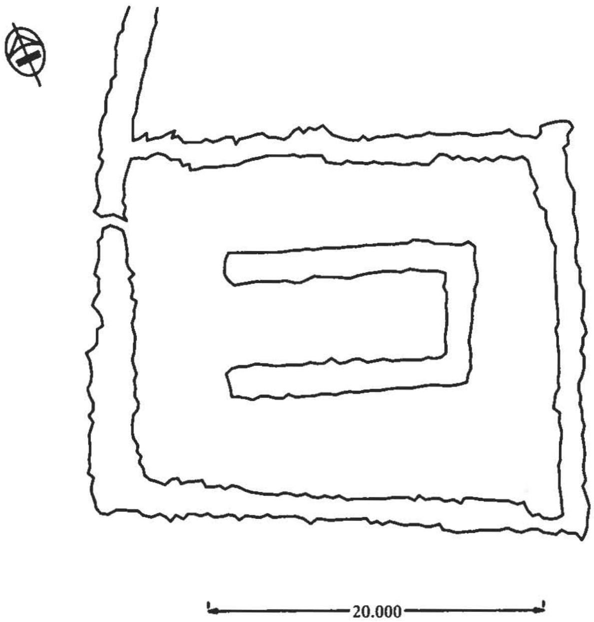


Fig. 14. Digitized map of E147 Narsarsuaq. The map is based on data from Vebæk (1991).

W51 Sandnes (Kilaarsarfik)

Kilaarsarfik is located by the shore of a small peninsula and even the very first archaeological surveys noted that the sea was eroding and submerging the site. E. Thorhallesen conducted the first excavations in 1765: "On a certain stretch, along the beach...human bones can be seen sticking out of the ground" (Thorhallesen 1776). He stated that some bones had been recovered, but no bones have been located at the Laboratory. Møller continued the excavations in 1840, also reporting finds of human bones along the eroded beach (GHM III: 837). J.A.D. Jensen drew maps of the area in 1885 and commented on rumours of human skeletal material in his report (Jensen 1889).

The first modern archaeological survey and excavation was carried out by Daniel Bruun in 1903. He suggested that the ruins adjacent to the shore could be those of a church and a churchyard, because of their shape and orientation. At high tide the ruins were completely submerged, but at low tide he was able to excavate along the cliff by the beach, finding five human crania and several other human bones (Bruun 1918: 98-99). He also found animal bones. All the bones were studied by the zoologist

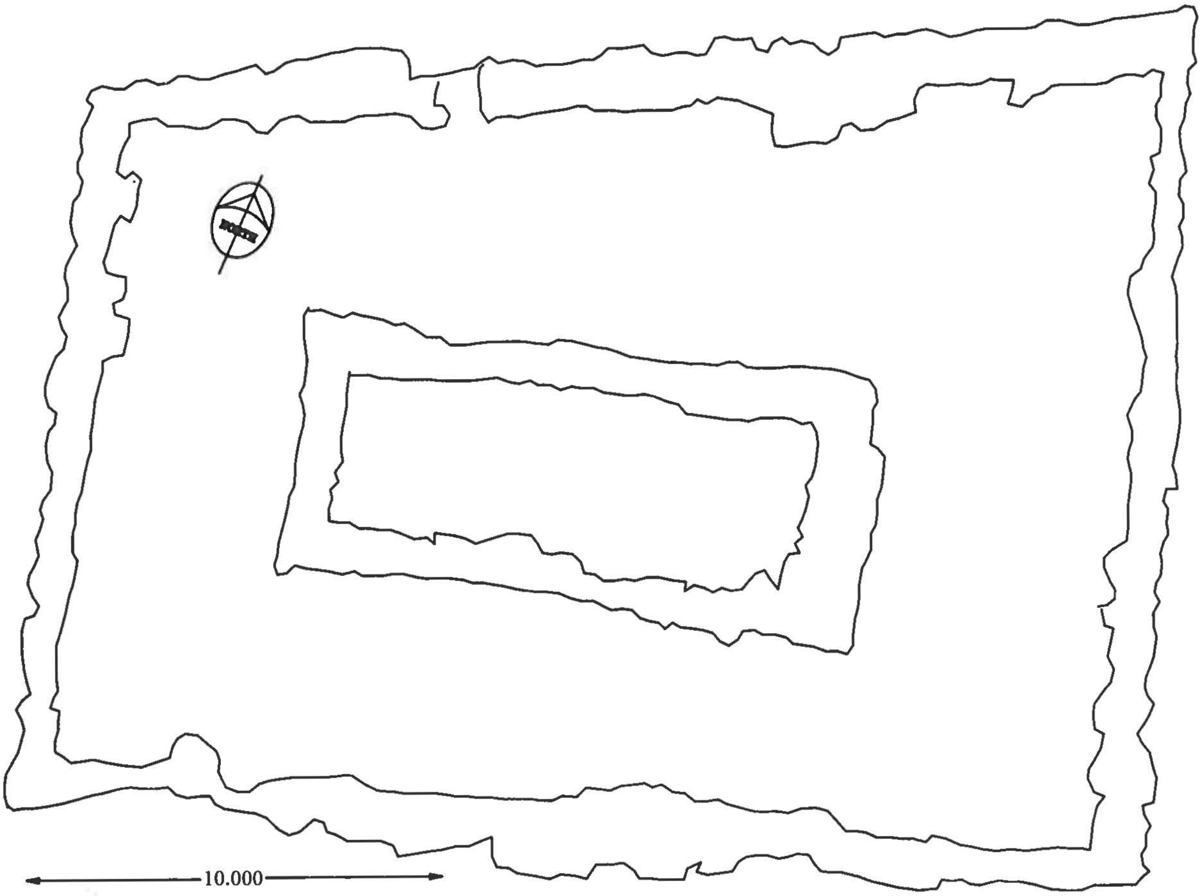


Fig. 15. Digitized map of W7 Anavik. The map is based on data from Roussell (1941).

Fig. 16. Excavations at W7 Anavik (Photo: Arneborg, 1976).

Winge (Bruun 1918). Daniel Bruun's excavation was followed up in 1930 by Nørlund and Roussell. At this point more of the church and churchyard had been eroded by the sea, and the ruins were by now completely submerged. However, by constructing a dike along the beach, they managed to secure an area measuring about 26 m2, near Bruun's original excavation (Nørlund 1930; Roussell 1932, 1936). They uncovered 42 individual interments and several disturbed burials. The bodies lay in an east-west orientation, on their backs, and with their arms crossed. One burial in particular caught their attention: a presumed male, a female and subadults, buried close together, almost certainly at the same time (Fig. 17). The archaeologists speculated that they might have been victims of some deadly infectious disease which struck down a whole family (Roussell 1936). Subsequent analysis by Fischer-Møller suggested, though, that the two adults were females (which is also my own opinion).

Jørgen Meldgaard excavated at the site in 1976 in connection with the so-called Inuit-Norse project (Meldgaard 1977), in which the physical anthropologist Balslev-Jørgensen also participated. Two crania and some fragments were found. During the most recent excavations of the farmhouses and the midden at the site in 1984, numerous animal bones were found. Among these there was a fragment of a human pelvis, and in the foundations of the turf wall of the stable building a human cranium was found (Arneborg 1985).

The original size of the churchyard has been difficult to reconstruct because of the continuing erosion by the sea. Jansen (1972) states that the shape of the churchyard dike could not be determined. However, superimpositions of the various maps made by the archaeologists have made the map shown below possible. The churchyard is thus probably rectangular with an interior width of 21.8 m. The results of a regression analysis of the churchyard dimensions suggest an estimated length of 31 m for the churchyard (cf. the chapter on demography). The exterior dimensions of the church ruin are 13.9 x 8.9 m (see Fig. 18).

Although Roussell and Nørlund made a map of the church ruin, they did not indicate where in the churchyard they excavated the human remains. These were nearly all excavated from a roughly square area sketched by Roussell (Roussell 1936). Unfortunately, besides not knowing precisely where this area was, I found that the skeletal remains were all unmarked, so the excavated material cannot be related directly to this sketch. However, by studying the excavation reports, diaries and small notes found with most skeletons, indicating their position in relation to others (e.g. "Skeleton No. III lay below No. II"), I have been able to place most of the material relatively. To complicate matters further, the material includes many unnumbered bones. In addition, several boxes marked as containing single skeletons turned out to contain bones or teeth suggesting more than one individual. The total number of individuals available for anthropological research was thus higher than the number given by the archaeologists and by the earlier anthropological examinations.

Roussell, speculating that the church chancel was a later addition to the nave, dated the church to an early period of the settlement, and, believing Ivar Bardson's account (GHM: 248), stated that it could not postdate 1360 AD (Roussell 1936). Jansen (1972), commenting on Roussell's analyses of the church dimensions, found it

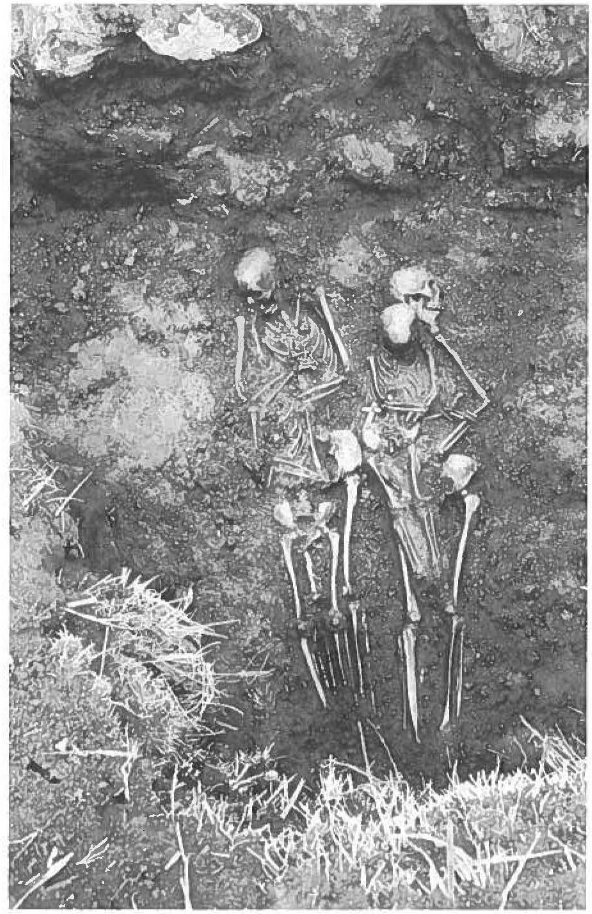


Fig. 17. The so-called family grave at W51 Sandnes (Photo: Roussell, 1930).

proven that the chancel was of an earlier date than the nave, and thought it likely that the nave was from the 1100s. This is supported by radiocarbon analyses of the skeletal material, indicating an earlier period.

Churches with no anthropological material

Several other church ruins have been surveyed, and more skeletal material has also been described, but the material had either not been recovered or was not available for analyses. A brief overview of these churches will be given, as it may supplement the data on churchyard size, burial customs, etc.

E18 Dyrnes (Narsap Ilua)

This site was first reported by J.F. Jørgensen, who noted of one of the ruins: "In this building there were burials,

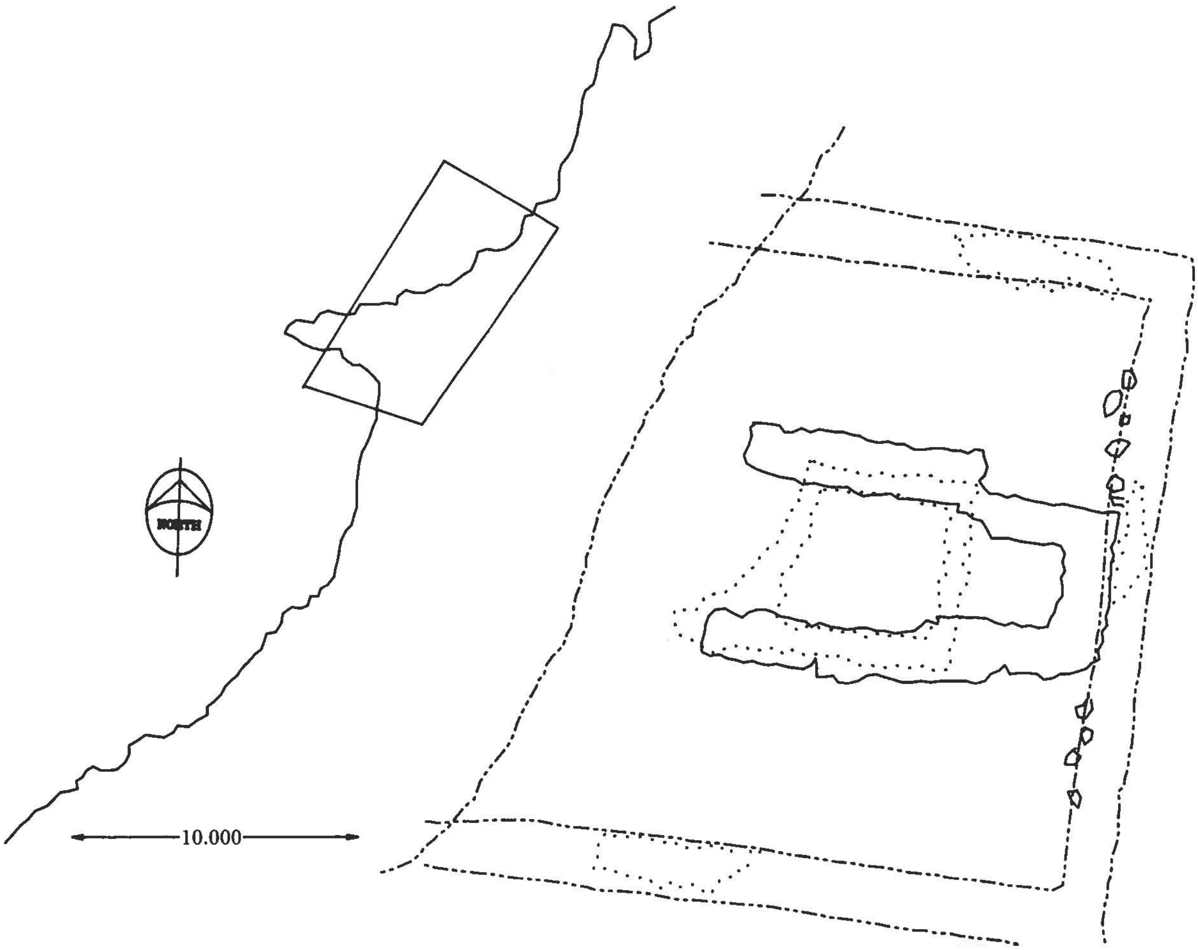


Fig. 18. Digitized map of W51 Sandnes. The structures drawn in solid linetype are based on maps by Roussell (1932, 1936) and Nørlund (1930), the structures drawn in dotted linetype are based on Bruun (1918). Data by Jensen (1889) has also been used. The boxed area the the upper left is the approximate position of Nørlund and Roussell's major excavation field. See also the chapter on churchyard dimensions.

which all the Eskimos say are of Norse origin." One skeleton was found "with the head eastwards, legs westwards. The detailed analysis of the cranium gave the result that it was of European, not Eskimo origin." Other burials, all stone-set, were found at this site by Jørgensen (GHM III: 865). There was no mention of who actually did the anthropological evaluation, nor of whether the cranium in question was brought to Denmark. The ruins were later described by Gustav Holm. However, he did not discern a church ruin at the site (Holm 1883). Nørlund was informed in 1931 (on his way to excavations at Brattahlid) that bones and a possible churchyard had been located at Dyrnes. Nørlund mentioned in his account that the graves previously identified by Jørgensen were definitely of an Eskimo type (Nørlund & Stenberger 1936). However, a test excavation was undertaken in 1932, and the presence of a churchyard was established. Ruin No. 4 on Holm's map was found to be surrounded by a fence. Inside this fence "disturbed human bones in large quantities at shallow depth" were found (Nørlund & Stenberger 1936: 11).

There have been no further excavations at the site, but Krogh and Albrethsen produced an accurate map of the church ruin. Krogh has speculated that it might have been be a cruciform church, in which case it is the only other cruciform Norse church in Norse Greenland besides E47 Gardar (Krogh 1982). The dimensions of the churchyard have not yet been established or estimated by the archaeologists. In view of the results of the regression analyses of churchyard dimensions and of aerial photography, the dimensions were estimated as approximately 30 x 40 m. The church itself has been estimated to measure 17 x 14 m.

E29 Brattahlid (Qassiarsuk)

The first excavations at this site were done by O. Kielsen in 1832. In his diaries he noted that "a few human bones were the only finds" (Kielsen 1833). In 1840 J.F. Jørgensen conducted excavations at the site and reported: "we only met human bones, but so old that they completely disintegrated when exposed to the air....And some fragments of cloth, of which the same is true". No human bones were shipped to Denmark according to the shipping list (Jørgensen 1840). Pingel (GHM III: 825) also referred to these skeletal finds (some with cloth remnants). In 1926 Nørlund and Roussell did a test excavation at E29 Brattahlid. North of the church they made an intriguing discovery: a stone-setting which formed a trapezoid coffin (dimensions 143.0 x 36.5 cm), large enough to contain a rather small body. However, no skeletal remains were found in the coffin interior. Nørlund reported: "On the other hand it was clear that the earth had been disturbed much deeper than the stones extended, and, by digging right down to the bottom, I found the very decomposed remains of a skeleton at a depth of 80 cm below the upper edge of the stone coffin. The lower jaw was the only piece that was taken out complete, but it lay at the proper place under the west end of the frame of the grave" (Nørlund 1929a: 60). A runic inscription on one of the stones read "Ingibjørg's grave". Unfortunately, the mandible cannot be located.

The main excavations were done in 1932 by Nørlund and Stenberger. In the chapter on the churchyard they stated: "The churchyard is full of interments, and must

Fig. 19. The site of the E18 Dyrnes (Photo: Lynnerup, 1992).

have been used throughout a long period, as such an enormous number of disturbed bones from earlier interments were found among the undisturbed skeletons of the bodies that were buried last. We find the same thing everywhere at the Norse churchyards in Greenland." They continued: "The state of preservation was so poor that although a great number of skeletons and remains of bones were excavated, not a single skeleton was found in such a condition that it could be removed in anything like a complete state." Later they noted: "The tissue of the bones was spongy or entirely decomposed, and the heavy pebbles had crushed every one of the skulls. Consequently no anthropological material was brought home from this churchyard" (Nørlund & Stenberger 1936: 39-40). Nørlund and Stenberger found ten stone graves and in several cases also fragments of wooden coffins.

The exterior dimensions of the church were 15.0 x 7.5 m. The churchyard dike measured 21.0 x 21.5 m exteriorly (Nørlund & Stenberger 1936: 34). Most interestingly, Nørlund and Stenberger found the remnants of an earlier church and churchyard. The earlier church seems to have been of almost the same dimensions as the later, but the churchyard seems to have been circular with a diameter of approximately 22 m.

E33 (Qorlortoq)

The first time this site at the south end of the Qorlortuup itinnera valley is mentioned as having a church is in GHM III (p. 823), although since no churchyard was located, the view was subsequently abandoned. In 1932 Nørlund and Stenberger came across a hitherto unknown ruin "which took the form of a round or octagonal fence with a very low mound around it. The diameter was only about seventeen metres. Within the fence a small heap of bones could be distinguished, and this was presumed to originate from a very small church. A test excavation yielded disturbed earth to a considerable depth and, farthest down, completely decomposed skeletons of human origin, for instance the enamel of a molar. The head lay correctly orientated towards the west" (Nørlund & Stenberger 1936: 15).

Jansen, like Nørlund, interpreted the church as a

Fig. 20. E29 Brattahlid (Photo: Lynnerup, 1992)

"prayer house" (Jansen 1972: 104), as did Krogh (1982: 123), who produced a detailed map of the ruin (Krogh 1964). The churchyard dike is circular with an interior diameter of approximately 15 m. The church ruin dimensions are estimated as approximately 10 x 11 m.

E35 (Qorlortup itinnera)

The Qorlortup itinnera church ruin was discovered by Nørlund and Stenberger in 1932, at a site already identified as Norse by Bruun (Bruun 1895: 305). Nørlund and Stenberger found that it was almost identical to E33 Qorlortoq in size and shape: "As at Qorlortoq, a test excavation inside the fence revealed disturbed earth down to one metre, and this can only confirm our assumption that there has been a churchyard at this place, even if we did not succeed in identifying skeletal remains. Everything has mouldered away" (Nørlund and Stenberger 1936: 16). Jansen identifies this church as a "prayer house", again in agreement with Krogh (Krogh 1982: 123). The ruin was surveyed in 1962 (Balslev-Jørgensen et al. 1962). The dike has an interior diameter of about 13-14 m. The church ruin itself measures about 7 x 6 m.

E48 (Igaliku)

The site was first reconnoitred by Daniel Bruun in 1894, but he found no evidence of a church or churchyard (Bruun 1895: 344). A church and an associated churchyard were first identified in 1968 by Albrethsen, Krogh and Motzfeld (Albrethsen & Krogh 1968). A small test excavation was conducted in the south-eastern corner of the presumed churchyard and about 35 cm below the surface, the contours of a probable interment were discovered. No bones were found (Arneborg, manuscript on file). E48 Igaliku seems to have been an almost square churchyard, measuring 16 x 15 m, although a circular plan cannot be ruled out. The church ruin itself measured 6 x 5 m. Again, Krogh suggested that the church was a "prayer house", rather than a parish church (Krogh 1982: 123).

E64 (Inoqquassat)

The site was registered by Daniel Bruun in 1894. Bruun's map shows a building surrounded by a dike. Bruun interpreted the building as an animal shed (Bruun 1895: 366). C.L. Vebæk visited the site in 1962. He was "very soon able to prove (from burial finds inside the dike) that this had been a churchyard with a church inside it" (Vebæk 1991: 9). Vebæk, like Jansen (1972) and Krogh (1982), felt that the church was less likely to have been a parish church than a private chapel or oratory. Krogh's survey (1968) indicated that the churchyard was circular, with an interior diameter between 15 and 20 m. The church ruin itself was barely discernible, but measured an estimated 6 x 7 m.

E78 (Eqaluit)

The ruins were recognized as being of Norse origin by J.F. Jørgensen in 1840, but a church ruin was first located at the site by Vebæk in 1951 (Vebæk 1991: 8). This was a surprise for Vebæk, and it proved that there were more churches in Greenland then those mentioned by Ivar Bardson (GHM III: 248). The discovery of the churchyard seems to have been made in the usual fashion: thanks to the detection of human bones. Unfortunately, no human bones were brought back to Denmark. Krogh and Jansen have both indicated that this small church may have been a "prayer house" (Krogh 1982; Jansen 1972). A survey seemed to suggest a circular churchyard dike with an interior diameter of about 16 m. The church ruin itself measures approximately 6 x 7 m (Motzfeldt et al. 1968).

E83 Hvalsey (Qaqortukulooq)

The ruin of Hvalsey Church is perhaps the most spectacular of all the Norse ruins in Greenland. Located near Qaqortoq in a fjord, it is exceptionally well preserved. Hans Egede initiated excavations at Hvalsey in 1723. Realizing he was working in a churchyard, he hoped to find some antiquities, but "found only some coal and small bones" (Egede 1925: 99). Hvalsey was surveyed in 1823 by W.A. Graah, who cleared the site and did some excavating, but no finds were reported (GHM III: 777). Jørgensen visited the site in 1834, excavated inside the church ruin and, according to Pingel (GHM III: 819), found a few much decomposed fragments of human bones and some cloth. Gustav Holm visited the site in 1880, and conducted a test excavation, possibly also within the church, and likewise found some greatly decomposed human bones. Finally, Clemmensen excavated, and found one coffin with the greatky decomposed fragments of bones (Clemmensen 1911: 306). He secured a small piece of a femur. This item cannot be located at the Laboratory. The interior measurements of the churchyard are 31.2 x 24.8 m. The church itself measures 16.1 x 7.9 m.

E90 (Sioralik)

The site had been mentioned by Pingel (GHM III: 807) as a probable church. Human bones were found beneath some stones in a fenced area. Since then, no additional archaeological analyses have been completed in this area. The site is probably of Eskimo origin (Arneborg, pers. comm.).

E105 Klostr (Tasermiutsiaat)

This site has been tentatively identified as the Augustinian monastery mentioned by Ivar Bardson (GHM III: 248; Roussell 1941). Pingel first reported a possible church and churchyard (GHM III: 804). No actual excavations have been completed at the site, although Nørlund in 1921 did a small test excavation to ascertain whether the west gable had been constructed of stone. He found "a completely decomposed interment (covered with charcoal), just below the wall foundation" (Nørlund 1926). Nørlund drew the churchyard dike as a hexagonal dike. Jansen has since argued that the site is not that of a monastery – rather of one of the presumed (and yet to be found) parish churches mentioned by Ivar Bardson (Jansen 1972). This uncertainty is also acknowledged by Krogh (Krogh 1982). The map produced by Nørlund shows a hexagonal churchyard covering approximately 828 m^2. The church itself measures 11.75 x 8.85 m.

E162 Vagar (Narsaq)

The site was discovered by Vebæk in 1946. In addition to a farm complex, he found a "small church surrounded by a churchyard fenced in by a low, but very distinct circular dike" (Vebæk 1991: 14). Vebæk suggested that this must be the Vagar church of Ivar Bardson's account (GHM III. 248): "Inside the fence we did some test excavations and found definite evidence of graves, including traces of a wooden coffin with iron nails. The skeletons were completely decomposed" (Vebæk 1991: 18-19). The dimensions were as follows: a circular dike with an exterior diameter of about 20-22 m, within which there is a church ruin without outside dimensions of 8 x 5 m (Vebæk 1991). Krogh has hypothesized that E162 was an oratory or chapel rather than a parish church because of its diminutive size (Krogh 1982: 123), a view also held by Jansen (Jansen 1972: 104).

W23a (Qaqssinguit)

This site was identified in 1930 by Nørlund and Roussell: "The plan of the church is not clear.....Test excavations in the churchyard have revealed interments in up to five strata. The skeletons were much decomposed" (Roussell 1941: 98). No notes or maps indicating the sizes or shapes of the church and dikes exist. Indeed, Jansen noted: "To date a very unsatisfactory investigation!" (Jansen 1972).

Fiskenæsset

Pingel (GHM III: 833) was the first to mention a possible Norse church located south of the Western Settlement, in the Aglormersæt Fjord: "...some graves are seen, which could possibly be of Norse origin, since they are bigger than the usual Eskimo graves." Reconnaissance has since shown that the graves were in fact of Eskimo origin (Arneborg, pers. comm.).

The Middle Settlement

No churches or churchyards have so far been located in the Middle Settlement. This is contrary to expectation, since there are a reasonable number of farms (Krogh 1982).

Skeletal finds outside churchyards

E167 Vatnahverfi

E167 Vatnahverfi is a Norse farm site, first identified as such by local inhabitants for Vebæk in 1948 (Vebæk 1992: 45). Excavations in 1949-50 by Vebæk and Meldgaard yielded two dwelling houses and several other buildings. Ruin No. 7, a large dwelling house, yielded both human and animal skeletal remains. The anthropological results were published with Vebæk's archaeological account and concluded that the human bones were of Norse origin (Lynnerup et al. 1992). Radiocarbon dating indicated that the human remains were from c. 1275 AD (Vebæk 1992).

E140 Tasersuaq

The site was first surveyed by Nørlund in 1921 (in connection with his excavations at Ikigaat). According to his notes (Nørlund 1921a) he thought the site was identical to the church called Vatsdal or Petersdal, described by Ivar Bardson (GHM III: 248). He located a ruin which he believed might be a churchyard, but "test excavations gave no indication that the earth had been turned previously". He did not continue the excavations. However, his notes include a cryptic remark: "N.B. cranium" (Nørlund 1921a).

The cranium was shipped to Copenhagen, along with the skeletal material from E111 Herjolfsnes. However, F.C.C. Hansen did not include it in the anthropological analyses of the material from E111 Herjolfsnes, as he states that it "does not belong to this locality" (Hansen 1924: 304). In a letter from Nørlund to Hansen, too, the find is referred to as "Cranial fragments from the big Tasersuaq farm" (Nørlund 1921b). Nørlund returned to the site in 1926, and strongly felt that a church was associated with the farm site. This is however contested by Vebæk (Vebæk 1991: 13). Nørlund did not say where he found the cranial fragment. Arneborg has mentioned that if the fragments had been found during the test excavation of the presumed churchyard in 1921, Nørlund would already then have proclaimed it to be a churchyard. Since he did not do so, Arneborg feels the cranial fragment was probably found among the possible farm ruins (Arneborg, manuscript on file).

The anthropological analysis indicates that the cranial fragment is of Norse origin (cf. chapter on anthropometry). There are no sketches or surveys of the site.

Stray find in the Western Settlement, Pisigsarfik

A box was found among the National Museum's permanent Norse exhibition items, containing the fragments of a maxilla, including three teeth. According to the old acquisition records at the National Museum, it derived from a "Greenlandic Norse ruin on the south coast of Pisigsarfik in the Godthåb district, between Ruin Group 27a and the promontory near No. 26a, almost directly opposite No. 23....Bruun does not know of any Norse Ruins at this site". The material was brought to the National Museum by an engineer, C. Folding, in 1882. The site may be identical to the site recorded as W64. The anthropological analyses do indicate that the remnants of the maxilla are of Norse origin.

Other stray finds already mentioned in E66 and W51

Stray finds, i.e. items found outside churchyards, have been made in a few other instances. As noted above, this was the case at E66 Undir Høfdi, when M. Clemmensen conducted excavations in the presumed midden (Clemmensen 1911). When farmhouses and the midden at W51 Sandnes were excavated, a fragment of a human pelvis was found in the midden, and a fragment of a human skull was found in the foundations of a turf wall.

Skeletal material without known provenance

Two fragments of mandibles were found on a shelf amongst the Norse skeletal material at the Laboratory. The mandibles bore no identification, and the boxes did not include identification. Nothing is known of their provenance. Since their provenance cannot be established, the specimens have been excluded from this study.

Summary of the provenance of material

The history of Norse archaeology falls into distinct phases (Albrethsen 1971; Arneborg 1989). Following the expeditions by Hans Egede et al. in the 18th and 19th centuries, there were many cartographical/topographical expeditions at the turn of the century. These were followed by the first "real" archaeological expeditions from about 1920 onward, mostly because the Danish National Museum became responsible for the Norse expeditions (Arneborg 1989). After the Second World War, archaeological expeditions did not reach the same proportions, although there were several excavations, culminating in 1961-65 with the excavations of E29a Thjodhilde's Church. In the 1970s Meldgaard launched new expeditions, linking Norse archaeology with Eskimo archaeology (Meldgaard 1977; Arneborg 1989). There were also several valuable expeditions which localized many of the small "prayer houses" (Krogh 1982). The most recent Norse archaeological excavations have resulted in reassessments of some of the older excavations, for example at W51 Sandnes in 1984, or have focused more on Norse farms than on churches and churchyards (Arneborg 1985).

Most of the Norse anthropological material now available for study was collected in excavations done by professional archaeologists and excavators. Only a small part of the material (N=7, 1.5%) derives from finds made by non-archaeologists (see Table I). The presence of a physical anthropologist during the excavation phase would probably have strengthened the material, as archaeologists (e.g. Vebæk 1991) have repeatedly said. This is mainly because burials were very abundant in the churchyards, often making it difficult even for the

Table 1 Available anthropological material according to sites, excavators, year of excavation, if the excavation was performed by archaeologists, if documentation exists and if human remains were found and recovered.

Site	Excavator(s)	Year	Archaeological excavation	Documented excavation	Human remains found	Skeletal mat. available
E1	Bruun	1894	No	Yes	No	n/a
	Albrethsen & Berglund	1971	Yes	Yes	Yes	Yes
E23	Bruun	1894	No	Yes	No	n/a
	Vebæk	1950	Yes	Yes		
E29a	Meldgaard & Krogh	1961	Yes	Yes	Yes	Yes
E47	Pingel	1828	No	Yes	No	n/a
	Mathiesen	1830	No	Yes	Yes	No
	Esmann	1832	No	Yes	Yes	No
	Jørgensen	1839	No	Yes	Yes	No
	Bruun	1894	No	Yes	No	n/a
	Nørlund & Roussell	1926	Yes	Yes	Yes	Yes
E66	Jørgensen	1839	No	Yes	Yes	No
	Rink	1854	Yes	Yes	Yes	No
	Holm	1880	Yes	Yes	Yes	No
	Bruun	1894	Yes	Yes	Yes	No
	Clemmensen	1910	No	Yes	Yes	Yes
	Roussell	1926	Yes	Yes	Yes	Yes
	Albrethsen & Krogh	1968	Yes	Yes	No	n/a
E111	deFries	1830	No	No	No	n/a
	Kielsen	1840	No	Yes	Yes	No
	Rink	1853	No	Yes	No	n/a
	Holm	1880	No	Yes	Yes	No
	Meldorf	1900	No	No	Yes	Yes
	Mylius-Erichsen	1905	No	No	Yes	Yes
	Nørlund	1921	Yes	Yes	Yes	Yes
E149	Nørlund	1932	Yes	Yes	No	n/a
	Vebæk	1945	Yes	Yes	Yes	Yes
W7	Jensen	n.d.	No	No	No	n/a
	Ryder	n.d.	No	No	No	n/a
	Thorhallesen	n.d.	No	No	No	n/a
	Kleinschmidt	n.d.	No	No	No	n/a
	Roussell & Knuth	1932	Yes	Yes	Yes	Yes
	Kapel &					
	Arneborg	1982	Yes	Yes	Yes	Yes
W51	Thorhallsen	1765	No	No	Yes	No
	Møller	1840	No	No	Yes	No
	Bruun	1903	Yes	Yes	Yes	Yes
	Nørlund & Roussell	1930	Yes	Yes	Yes	Yes
	Meldgaard	1976	Yes	No	Yes	Yes
	Arneborg et al.	1984	Yes	Yes	Yes	Yes
E167	Vebæk	1949	Yes	Yes	Yes	Yes
E140	Nørlund	1921	No	Yes	Yes	Yes
(W64)	Folding	1882	No	No	Yes	Yes

trained archaeologist to differentiate the burials (see e.g. Krogh 1982; Vebæk 1991). In cases of irrecoverable skeletal material, an anthropologist would indubitably also have made valuable in situ observations.

Most of the excavations are well documented by detailed reports and maps, and in most cases there are published accounts (see Table I). In the few cases (N = 8, 1.8%) where there is no documentation, the amount of recovered anthropological material is small, comprising at most four individuals from a single site (Meldgaard at W51 Sandnes in 1976). There is a wealth of information in the Norse Archives of the National Museum, including detailed sketches, diaries written by the excavators, etc. This material is not only the basis for the published accounts, it also provides the sole documentation of several sites (cf. the chapters on the individual sites). It is very unfortunate that in two major excavations, E47 Gardar in 1926 and W7 Anavik in 1932, the identification numbers assigned by the archaeologists to the skeletal material were lost during its time at the Laboratory. Thus not all the skeletal material from these excavations can be linked directly with the excavation plans.

The material covers many Norse sites, including material from a cathedral church (E47 Gardar); a (probable) convent church (E149 Narsarsuaq); major parish churches (e.g. W511 Sandnes, E66 Undir Høfdi, E111 Herjolfsnes); and an early church (E29a Thjodhilde's Church). Missing from this group is material from the so-called "prayer houses" (Jansen 1972; Krogh 1982).

Most types of churches are thus represented in the material, and in conjunction with the well-defined geographical setting and the limited timespan of the settlements, this makes the Norse skeletal material unique as a source of biological data on the medieval period.

Curatorial status of the Norse material

Location of material

All skeletal material identifiable as Norse material and housed at the Laboratory was used in the present study. In addition, any Norse material which could be located outside the Laboratory was used. The latter included material located at the Danish National Museum and the Zoological Museum. At the former institution three specimens were located and were subsequently handed over to the Laboratory. The material at the Zoological Museum was located after a study of reports by the zoologist Winge, who analysed the skeletal material recovered from middens by Clemmensen in 1910 at E66 Undir Høfdi (Clemmensen 1911) and by Bruun in 1903 at W51 Sandnes (Bruun 1918). Winge identified several human bones and bone fragments in this material. This material, comprising remains of at least seven individuals, was brought to the Laboratory.

When the records of the material that had definitely been recovered and sent to Denmark were compared with the available material, there was a discrepancy (by this authors' estimate) of some 10-20 specimens. Inquiries about Greenlandic skeletal material abroad were made as part of the Man and Environment Project (Arneborg et al., 1988), but although some Greenlandic Eskimo material is located in foreign institutions (e.g. in Norway, the USA and France) this does not seem to be the case for Norse material.

Preparation of the material

Much of the Norse material had been subjected to preparation. A lacquer of unknown type had been applied to material from E111 Herjolfsnes. Specimens from E29a Thjodhilde's Church and W7 Anavik had been prepared, probably with Bedacryl and/or some protein-based preservative. Apart from some reconstructions of pelvises, done by screwing the coxae and the sacri together, there seem to have been be no attempts to restore fragmentary bones (one exception was the reconstruction of the Bishop's hand from E47 Gardar, where the metacarpals, carpals and digits had been glued together).

On the whole, the Norse material appears to be in much the same condition as when it was originally delivered to the Laboratory. This can in fact only be an advantage, since it allows the observer to reassess the material, including the age, number and sexes of the individuals. Preparation can also spoil the material for future studies (White 1991; Bass 1987). This is the case with some of the material from E111 Herjolfsnes, where the lacquer has loosened the outermost cortical surface of the bones, which have become extremely brittle and tend to crumble at the slightest touch. The same happens with some of the skeletal elements from E29a Thjodhilde's Church, prepared with Bedacryl. The material would probably have been better preserved without preparation, but the application of Bedacryl was probably necessary for recovery and transportation. As for the pelvic restorations mentioned above, these were all done with screws (although clay had been used at the joints). The screws could thus be removed so the auricular surfaces of the coxae could be evaluated for age.

Preservation and extent of the material

The fragmentary nature of the Norse material posed some problems for the calculation of the total number of specimens and individuals. In this study, all skeletons which were definitively labelled and identified and for which there seemed definite archaeological evidence (either published or unpublished excavation reports, maps, drawings, etc.) were counted as single specimens.
To this material were then added all incidental finds of skeletal items which did not match the identified skeletons, including the finds of supernumerary skeletal items in boxes labelled as containing one skeleton.

The sum of this material was termed the total number of specimens (TNS). This tally was different from the minimum number of individuals (MNI), which was tallied by trying to link some of the fragmentary specimens to the excavation reports, photos, maps, etc. For example, two boxes labelled as containing single specimens from a specific site might yield some supernumerary bones, indicating the presence of two other individuals. Thus, these two boxes would add four specimens to the total number of specimens. However, the supernumerary bones might be found to complement one another, and could thus stem from one individual. Thus, the two boxes would add three individuals to the minimum number of individuals. When applied to commingled skeletal remains the MNI represents the number of individuals which at least were present (although the »real« number may in theory have been equal to the number of individual bones and bone fragments) in a given assemblage (White 1991, Snow & Folk 1970).

The total number of specimens reported in this study greatly exceeds the total number tabulated from all previous original studies (cf. Table 2). Apart from the few cases of incidental finds of additional material in boxes and crates, and the accession of newer material from recent excavations, the discrepancy between the present number of individuals and earlier reported numbers is mostly due to the fact that the W51 Sandnes material was apparently curated and studied more in terms of its suitability for measuring certain variables (especially cranial variables) than in terms of any wish to record all the existing material.

Three different tabulations were made to obtain the best overview of the material: 1) gross total of skeletal elements; 2) completeness of the specimens; and 3) actual versus expected number of skeletal elements (the latter only for one site: E29a Thjodhilde's Church). The tabulations were made by grouping the bones of the skeleton into 35 groups (= skeletal elements). The cranial bones were grouped into the neurocranium (cranial vault), the facial skeleton and cranial base. All bones of hands and feet were grouped as such, and the vertebral column was divided into atlas, axis, cervical, thoracic and lumbar vertebrae. Figure 21 shows the totals of the different skeletal elements present in the material. The skeletal elements most often represented were the cranial bones, along with the mandible, followed by the major long bones: the femora, humeri and tibiae. The major flat bones, specifically the coxae, were also reasonably well represented. A high number of the uppermost vertebrae were also preserved. On the whole, postcranial material is preserved in less than one fourth of the total number of specimens.

The tabulation of preserved bones only serves to give us an overview of the material. The subdivision into »complete« and incomplete« is based on a purely subjective gross morphological and anatomical assessment of the skeletal elements. Such a division, as noted by others (e.g, Garland 1989), tells us little about the state of preservation of the material; but it was convenient for the inventorying of the material.

Figure 22 shows that 94 specimens (20.6%) are only represented by one skeletal element. Very few specimens are represented by more than 30 (of 35 possible) elements, and none is totally complete. Twenty specimens are not represented by bone material at all, but by teeth alone. Figure 23 shows the cumulative counts for skeletal elements per specimen. Approximately half of the specimens (47.7 %, n=218) are represented by only three or less elements; approximately three quarters of the specimens (74.4%, n=340) are represented by nine or less elements.

The number of skeletal elements may also be compared with the number of elements one would expect if all skeletons (i.e. all skeletal elements) had been completely secured. This is a tabulation used by several other authors (Waldron 1987; Gregg & Gregg 1987), and requires that the total number of interments is known (i.e. the total number of discrete, recognizable burials, based on skeletal remains, but also on other archaeological evidence, e.g. traces of coffins, soil disturbance, etc.). The

Table 2. Table of material size by number of specimens, MNI and earlier reported number of individuals[1]. n/a means that the material has not previously been analyzed.

Site	Specimens	MNI	Earlier rep. N
E1 Nunatoq	1	1	1
E23 Undir S.	5	5	n/a
E29a Thjodhilde	150	147	155[2]
E47 Gardar	13	12	11
E66 Undir H.	7	7	5
E111 Herjolf.	23	23	25
E149 Narsarsuaq	52	49	n/a
W7 Anavik	11	8	8
W51 Sandnes	192	123	55
E167 Vatnahverfi	1	1	n/a
E140 Tasersersuaq	1	1	1
W64 Pisigsarfik	1	1	n/a
Total	457	378	261

1 The numbers have been tabulated by perusing the previous anthropological analysis.

2 The number given here is the total number of interments found at E29a (Krogh 1982), since there has been no publications of the anthropological analyses proper.

actual number of recovered claviculae, for example, can then be compared with the total number of claviculae one would expect if all claviculae of all interred skeletons had been recovered. This is a good measure of the survivability of the individual skeletal elements as well as an indicator of how well the material was excavated (from an anthropological viewpoint). These figures cannot be calculated for the Norse material, as the total number of interments for a given site is unknown in all cases except E29a Thjodhilde's Church. At this site the archaeologists managed to assess the number of interments, partly because this is the one site where the interments are in one undisturbed layer (Krogh 1982). Since the human skeleton in this study is broken down into 35 major skeletal elements, this yields an expected total of 5425 skeletal elements, of which 1558 (28.7%) were recovered.

When we compare this with other publications on skeletal finds, we can see that the pattern shown in Fig. 21 is common. Bennike (1985) found an almost identical distribution of skeletal elements when studying Danish skeletal material ranging from the Neolithic to the medieval (and with uniform distribution within the different periods), as did Sellevold et al. in their compilation of

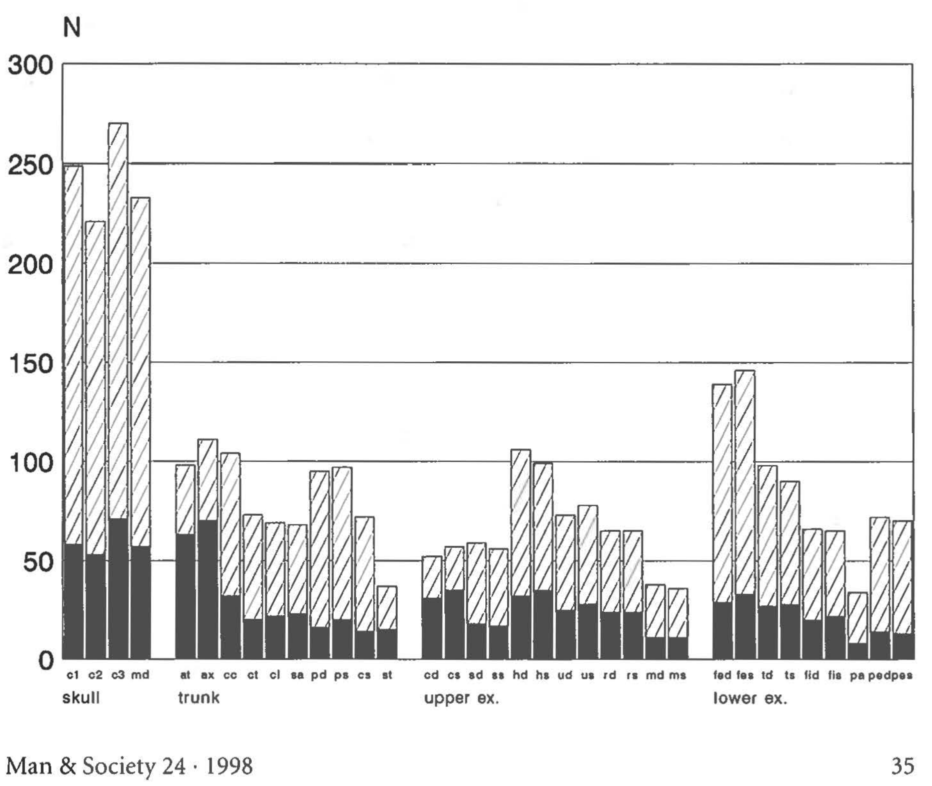


Fig. 21. Enumeration of skeletal elements present (hatched: incomplete elements; black: complete elements). Legend: Skull: c1: neurocranium; c2: facial skeleton; c3: cranial base; md: mandible. Trunk: at: atlas; ax: axis; cc: cervical vertebrae; ct: thoracic vertebrae; cl: lumbar vertebrae; sa: sacral and coccygeal bones; pd: right innominate; ps: left innominate; cs: ribs; st: sternum.
Upper extremity: cd: right clavicle; cs: left clavicle; sd: right scapula; ss: left scapula; hd: right humerus; hs: left humerus; ud: right ulna; us: left ulna; rd: right radius; rs: left radius; md: right hand bones; ms: left hand bones.
Lower extremity: fed: right femur; fes: left femur; td: right tibia; ts: left tibia; fid: right fibula; fis: left fibula; pa: patella; ped: right foot bones; pes: left foot bones.

Danish Iron Age material (Sellevold et al. 1984). Similarly, Frøhlich and Lynnerup (manuscript on file), when they studied the Greenlandic Eskimo material housed at the Laboratory (1572 specimens), found only 310 individuals (16.7%) with postcranial material.

A major reason for this apparent underrepresentation of postcranial material was the archaeological practice of the period when much Danish, Norse and Eskimo material was excavated: i.e. that the archaeologists only secured the crania. This was mainly because crania were considered the only interesting skeletal elements; most anthropological studies were concerned with racial typing and changes in cranial morphology. Only in more recent times has it become customary to excavate and secure as much postcranial material as possible (Sellevold et al. 1984: 26).

Another reason was logistics. The archaeologists, often travelling in the difficult Greenland terrain by foot, horse or boat with helpers, were simply unable to secure all the excavated material, including grave goods and other archaeological artifacts. This situation has only been remedied by the advent of modern airlifting capabilities, allowing the archaeologists to secure much more material (cf. for example the Skjoldungen Project 1992, one of the more recent archaeological expeditions (Projekt Skjoldungen 1992)).

Besides archaeological bias and logistical constraints on the collection of skeletal material, there is of course also a difference in the "survivability" of individual skeletal elements. Micozzi (1991: 67) concluded that the overall tendency is for larger bones to survive better than smaller bones, and for bones of the lower extremity to survive better than bones of the upper extremity (no mention is made of cranial material). This is probably mainly because the smaller bones have a large surface-to-volume ratio, and are thus more susceptible to weather-

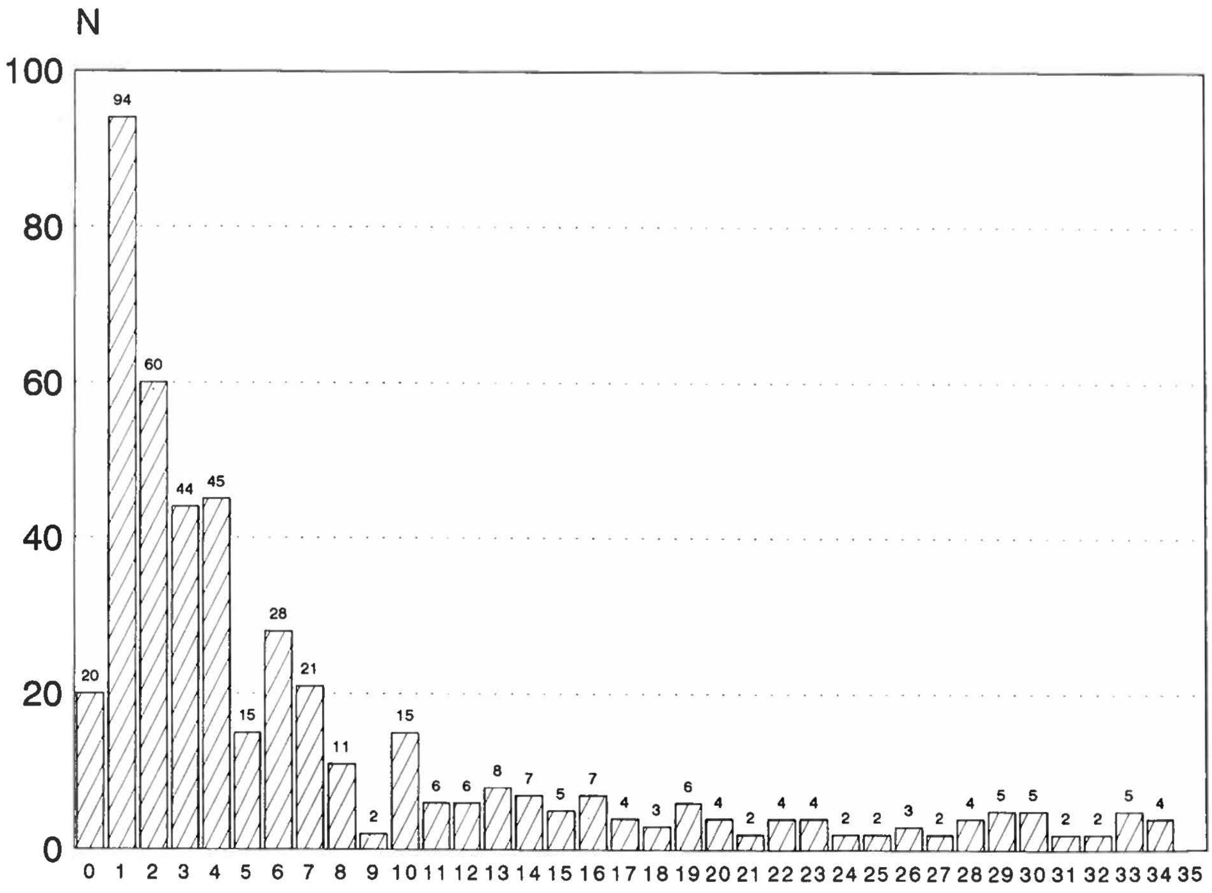


Fig. 22. Enumeration of skeletal elements present per specimen (e.g., 28 specimens consist of 6 skeletal elements. Zero skeletal elements means dental material only (the case for 20 specimens).

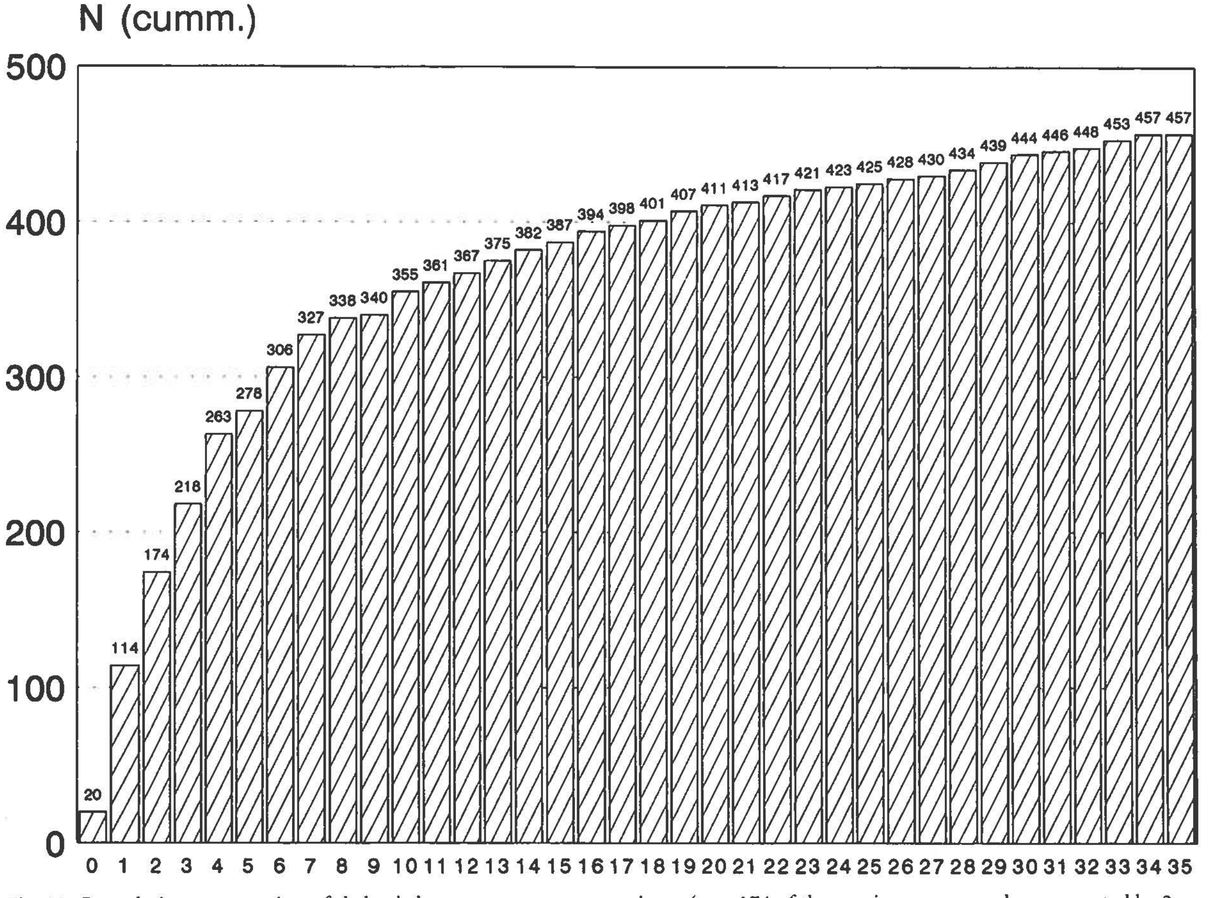


Fig. 23. Cumulative enumeration of skeletal elements present per specimen (e.g., 174 of the specimens were only represented by 2 or less skeletal elements).

ing and other diagenetic disturbances (Micozzi 1991), the size of the bone being inversely proportional to its rate of decay (Von Endt & Ortner 1984). Similarly, the rate of decay of bone is also affected by bone density (Boddington 1987; Waldron 1987; Henderson 1987). Incidentally, Boddington (1987) also found an inexplicable difference in decay among the vertebrae; the lumbar vertebrae are most often decayed. And this is also the case for the Norse material, where the lumbar vertebrae are least represented.

The results of the other tabulations show the same pattern: the cranial parts, and especially the cranial base, are well preserved/secured, as, to some extent, are the larger shaft bones. Comparing these with other tabulations of expected vs. actual representation, we find that the preservation of the cranial parts (including the mandible) is almost identical, with frequencies of roughly 60-65% (Waldron 1987; Gregg & Gregg 1987). However, the Norse material from E29a Thjodhilde's Church shows the same lack of postcranial material as the other Norse material (which is not noted to the same degree by Waldron and Gregg & Gregg). If the skewed totals of skeletal elements in the entire Norse material are partly explained by (earlier) archaeological bias and logistics, we might expect the tally for E29a Thjodhilde's Church to be less skewed: the excavation of E29a Thjodhilde's Church was the last major Norse excavation and posed no major logistical problems (the site is on open ground near modern habitations, with an international airport just across a fjord); and this was also the only Norse excavation where an anthropologist was present (Krogh 1982). This suggests that soil conditions detrimental to bone preservation are the major reason for the skewing of the Norse material. This has in fact been noted by several archaeologists in excavation reports (Vebæk 1991; Nørlund & Stenberger 1936). Nørlund and Stenberger, for example, were unable to secure any skeletal material at all from one of the major churches (E29 Brattahlid), since only faint traces and some extremely brittle and porous bone material were found. The damaging action of the soil seems to be caused by the roots in the turf, which easily penetrate the bones because the Norse settlers were often buried at shallow levels. When the Norse settlers were buried in coffins, the leaching of calcium from the bones by rain probably also played a role, making the bones brittle (Sellevold 1977: 40).

We can get a more detailed overview by tabulating how often measurements could be taken, and how often non-metric traits could be assessed. In general, the above-mentioned tendency in preserved bones can be noted again; that is, the number of single measurable skeletal elements clearly reflects the overall number of skeletal elements. However the distribution also shows how the single skeletal element may be incomplete. For example, the diameter of the femoral head could be measured in 79 instances, yet the maximal femoral length could only be obtained in 47 instances, showing how the small, compact femoral head has "survived" in more intact form than the femoral shaft. The mandible was present in a total of 233 specimens, and could be measured in 17.5-24.1% of all cases (43.3-47.2% of all mandibles present). This puts it among the most frequently preserved skeletal elements, and it is also one of the best preserved in terms of obtained measurements. Similar observations were made by Frøhlich about Eskimo material ranging from the Aleutian Islands to Greenland (Frøhlich 1979; Frøhlich & Pedersen 1992).

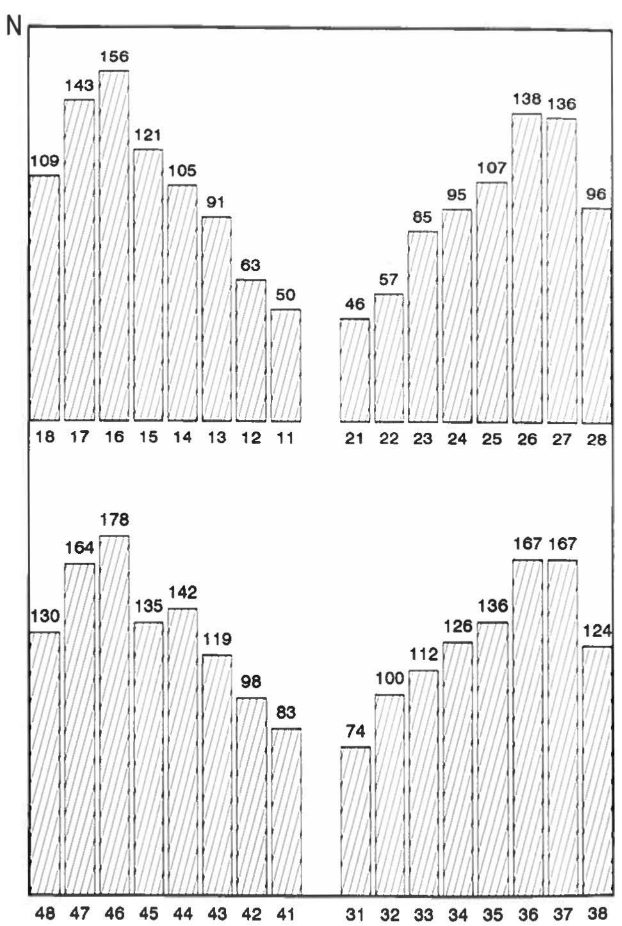


Fig. 24.Enumeration of teeth present. 18 – 11 and 21 – 28: maxillary teeth; 48 – 41 and 31 – 38: mandibular teeth. Total number of the single teeth given above bar.

Generally, several non-metric traits could be assessed in every third or fourth specimen, although a few traits, such as infraorbital foramina, could only be assessed in one in ten cases (see the section on non-metric traits). When we compare this with the few cases (5%) where bizygomatic width could be measured, this testifies to the preservation of the different parts of the cranium and the facial skeleton: most often, the frontal bone and adjoining structures are well preserved, whereas the middle facial skeleton, including the zygomatic arches and suborbital region, was often chipped, fractured or broken. These are among the most fragile structures because of their gracility (the infraorbital region) and the exposure of the structure (zygomatic arch). Conversely, the best preserved skeletal parts are the cranial base, including the petrous bones: for example the biauricular width could be measured in 19% of the specimens (one of the highest frequencies for cranial measures) and non-metric traits like double condylar facets and posterior Wormian bones could be assessed in approximately 30% of specimens.

The teeth show a characteristic preservation distribution: the most frequently preserved teeth are the molars, with a decreasing rate of preservation for premolars, canines and incisors (see Figs. 24 and 25).

Virtually identical distributions have been found for the dental material from Westerhus (Swärdstedt 1966) and Æbelholt (Lundström & Lysell 1953). That the incisors in particular are lost postmortally has been noted by others (e.g. Krogman 1935) and probably reflects several factors: the molars are bigger, with a larger base, and thus do not fracture as easily as the incisors; the molars are anchored by two or three roots; and finally they are in better protected bony environments than the incisors and canines. Furthermore, there is a clear difference between the maxillary and the mandibular teeth, with the lower teeth preserved most often. This must be

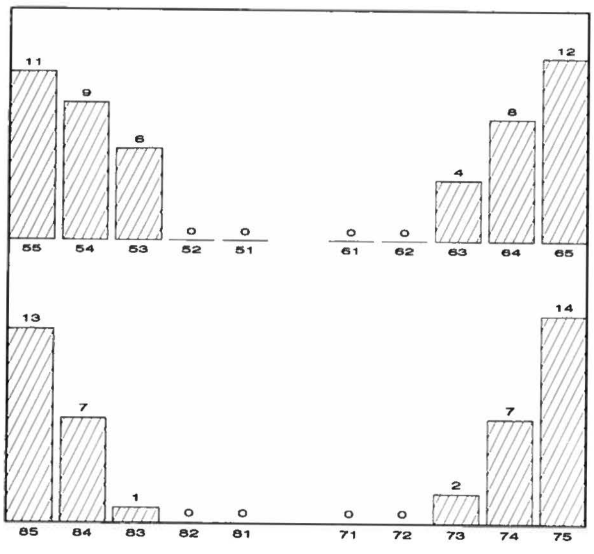


Fig. 25. Enumeration of deciduous teeth present. 55 – 51 and 61 – 65: maxillary teeth; 85 – 81 and 71 – 75: mandibular teeth. Total number of the single teeth given above bar.

seen in conjunction with the relatively high frequency with which the mandible is preserved.

Age and sex distribution

All specimens were aged and sexed by the author. At regular intervals, some of the skeletons that had been evaluated first were re-evaluated for age and sex to minimize intra-observer error.

Methodology of age evaluation

The specimens were classed in nine categories:

1.	0-1 yr.	Infans I	
2.	1-6 yrs.	- -	
3.	6-12/14 yrs.	Infans II	
4.	12/14-18/21 yrs.	Juvenilis	
5.	18/21-35 yrs.	Adultus	young adult
6.	> 35 yrs.	Maturus	old adult Senilis
7.	subadult		
8.	adult		
9.	age evaluation impossible		

These categories follow the conventional anthropological categories of Infans I and II, juvenilis, adultus, maturus and senilis, except that senilis and maturus were grouped together, since the distinction between maturus and senilis can be particularly difficult, mainly relying as it does on the appearance of degenerative changes. Categories 7 and 8 were also included to allow for specimens where the distinction between subadult and adult was the only one that could be made with a reasonable degree of reliability.

The specimens were grouped at 5-year intervals if a more reliable age determination was possible, most often if several methods could be used. In the cases where several methods were used, the total assessment was based on the combined results of the various methods, rather then on a simple arithmetic mean. Standard anthropological methods for aging were used. Each method is briefly summarized below. Some of these methods – tooth formation and eruption, long bone length and epiphyseal fusion and union of the sphenobasilar synchondrosis – were all used for subadults. The other methods were used for adults.

Tooth formation

As has been noted in the chapter on the material, some of the specimens consisted only of one or more loose teeth and some of the teeth were tooth germs, not yet completely formed. In these cases the degree of formation of the tooth was assessed (Moorrees et al. 1963a; Moorrees et al. 1963b). There is some variation – beyond sex differences – in the rate of formation and in the attainment of certain stages in the formation of permanent teeth (Ubelaker 1989) (and the sex cannot be evaluated with any confidence in subadults), although the Recommendations of the European Workshop (Ferembach et al. 1980) state that a reliable age estimate can be obtained using single, not completely developed teeth.

Tooth eruption

Several studies have dealt with dental growth and eruption in different population groups from Eskimos (Moorrees 1957) to Ugandans (Krumholdt et al. 1971). A widely used measure is the sequence mapped by Ubelaker and based on several studies (Ubelaker 1989; Ferembach et al. 1980), but the variability of the estimates pertains to Amerindians and other "non-white" populations, so the variances are very great. In this study, the work of Schour & Massler (1941) and Dabelsteen et al. (1982) was used to reduce the variances of the estimates, since their reference population is white and is strictly based on the number of teeth erupted at yearly intervals. It has been stated that the eruption and exfoliation of the deciduous teeth and the eruption of the permanent dentition are strongly controlled by genetic factors, with little environmental influence (Ubelaker 1989), and that the variance between the many studies of different population groups overlaps (Acsadi & Nemeskeri 1970; Krogman & Iscan 1986). However, the variance can be great (Ubelaker 1989, Krogman & Iscan 1986) and there seems to be a definite sex difference (Iscan 1988), although this is less pronounced than for the skeletal age (Harrison et al. 1990). Finally, it must also be kept in mind that the studies deal with living children and subadults, and here eruption means emergence of the tooth through the gums, not full eruption to contact with the antagonists or emergence from the alveolar bone. Eruption of deciduous and permanent teeth is used for age evaluation of subadults, up to the full eruption of all the third molars, usually set at the age of 21.

In this study the dentition of all specimens was assessed, and all erupted or erupting teeth were noted and compared with the standards provided by Schour & Massler (1941) and Dabelsteen et al. (1982). It has been recommended that X-rays should be used to note the position and formation of unerupted teeth (Knussmann 1988), but this was not feasible in this study.

Long bone length

The stature of a child or subadult, as observed in the length of the long bones, obviously reflects growth and hence age. Consequently, several studies have tried to establish correlations between long bone length and subadult age (Stloukal & Hanakova 1978 cit. in Ferembach et al. 1980; Ubelaker 1989; Hoffman 1979). All emphasize the great variability in this method: growth rates (stature) vary to some degree among populations and especially among individuals in the same racial group (Ubelaker 1989). Furthermore, the studies are mostly based on living children and use X-rays, whereas the anthropologist measures dry bones. The recommendations of the Workshop of European Anthropologists state that the method should at most be used to group specimens at 5-year age intervals (Ferembach et al. 1980; Knussmann 1988).

Epiphyseal fusion

Epiphyseal fusion has received much attention, and there are many sources of data for the fusion of the epiphyses of various bones (compiled in Krogman & Iscan 1986; Stewart 1979; Ferembach et al. 1980). The fusion happens earlier for girls than boys (Ubelaker 1989), and as with the above mentioned methods, this makes for wider variation in the anthropological material where the sex is unknown. It has also been emphasized that stages of fusion, rather than simple fusion or non-fusion, should be identified, since several years elapse between the inception of the fusion and its completion (McKern & Stewart 1975 cit. in Ubelaker 1989). Normally, all epiphyses are fused by the age of 25 (Knussman 1988).

Union of the sphenobasilar synchondrosis

The union of the sphenobasilar synchondrosis is a very valuable age indicator. Because of its location in the skull base it is often preserved, and studies seem to indicate a high degree of reliability: the closure takes place within a relatively short period and is complete in the early twenties (Redfield 1970; Krogman & Iscan 1986). Hence, it is commonly used to discriminate between adults and subadults (Ferembach et al. 1980).

Cranial suture closure

The use of cranial suture closure has gone through several stages of development. That the degree of obliteration of the sutures shows some correlation with age has been noted since the 16th century (White 1991), and in 1875 Broca tried to establish a standard for evaluating the degree of obliteration in four stages at fourteen different sites (Broca 1875). Todd and Lyon later evaluated the method using large samples and different racial groups, but found the method unreliable (Todd & Lyon 1924 and 1925 cit. in Krogman and Iscan 1986). The method fell into some disrepute, and although new evaluations were based on endocranial sutures rather than the presumably more variable ectocranial sutures (Krogman & Iscan 1986), and the method was combined with others ("The Complex Method" of Acsadi and Nemeskeri (1970)), it continued to be rated low as a method (e.g. Bennike 1985). However, in 1985 Meindl and Lovejoy published their revised method, based on ten ectocranial suture sites, using a simple scoring system (Meindl & Lovejoy 1985). This method is generally acknowledged to be quite reliable (Ubelaker 1989; Krogman & Iscan 1986).

Auricular surface of the ilium

This method was proposed by Lovejoy et al. in 1985 (Lovejoy et al. 1985a). One of its advantages is that the auricular surface of the ilium is often preserved (unlike the pubic symphysis, see below) (White 1991). In this study the method of Lovejoy et al. was used with the additional help of a series of slides showing the standard phases (Bedford et al. 1989).

Sternal rib ends

Although rib ends, both vertebral and sternal, have been the subject of much study (Krogman & Iscan 1986), the method generally used involves the staging of sternal age-related changes as identified by Iscan and Loth in several publications (Iscan et al. 1984a, 1984b, 1985; Iscan & Loth 1986). The method has been found to be reliable, and is only negligibly affected by the training and experience of the observer (Ubelaker 1989).

Dental abrasion

Dental abrasion or wear generally proceeds continuously during life (Ubelaker 1989). However, dental wear depends greatly on dietary habits, so great differences are found among different sociocultural groups (Krogman & Iscan 1986; Molnar 1971); Eskimo dentition, for example, has very different wear patterns from that of Europeans (Pedersen 1949). It is thus impossible to develop a general dental attrition standard for age determination. This study uses the evaluation methods of Brothwell (1963) and Miles (1963), which are considered among the best (Krogman & Iscan 1986). They were developed with Anglo-Saxon material and are based on the occlusal wear of the mandibular molars. Since the first molar erupts almost six years before the second molar and twelve years before the third molar, the difference in wear rate between these two teeth can be evaluated for each individual (Ubelaker 1989). This gradient can then be applied to adult and mature individuals to develop a more population-specific age-determined wear pattern. The standards are generally agreed to fit most medieval populations, Norse included (Alexandersen, pers. comm.). Thus, in this study, attrition rates were analysed using first and second molars when possible, and subsequently used to "calibrate" the stages in Brothwell's and Miles' standards in terms of chronological years.

Standard methods not used

A few standard techniques were not used. Pubic symphysis changes (Krogman and Iscan 1986; White 1991; Ubelaker 1989), especially as described by Suchey & Katz (1986) and Brooks and Suchey (1990), have not been used, mainly because the pubic symphyses are exposed skeletal structures which are often badly damaged. In this study it would only have been possible to use this method in nine cases. Radiological (Acsadi & Nemeskeri 1970; Krogman & Iscan 1986) and microscopic evaluation (Kerley 1965; Kerley & Ubelaker 1978) was not feasible because of the cost and the invasive, and thus destructive nature of the latter technique. Finally, dental transparency was not used either. This method, first described by Gustafson (1950), and since modified (e.g. Bang & Ramm 1970), is generally agreed to be among the better methods and is currently used in everyday dental forensics (Jakobsen, pers. comm.). The dental transparency method poses technical problems when one is dealing with archaeological material. Some investigators have found it impossible to evaluate transparency in archaeological material (Vlcek & Mrklas 1975), and it must be taken into consideration that the method calls for slicing of the teeth.

Methodology of sex determination

The sex of a skeleton can be determined on the basis of specific and characteristic morphological traits (Krogman and Iscan 1986; Knussman 1988). Specific traits are traits which are deemed specific, for biological reasons, to either the male or female skeleton, for example pelvic morphology; whereas characteristic traits are traits which are deemed characteristic of either the male or female skeleton because of the longer period of growth in males and because of physiological differences, for example more pronounced muscle insertion ridges on the male skeleton due to greater muscle mass (Ubelaker 1989; White 1991). The pelvic traits were used when possible. If postcranial material (apart from pelvic bones) existed, this was also assessed. However, because of the preponderance of cranial material, assessment of dimorphic cranial traits was by far the most frequently used method of sexing.

Several standard methods of morphometric assessment were not used for sex determination. In these methods an anatomical structure or index is measured and calculated, and according to whether the resultant value is below or above a demarcation point, the specimen is grouped as either female or male (Krogman & Iscan 1986; Bennett 1987). The methods, described for many structures – the cranium, pelvis, scapula, and several long bones and teeth -, all rely heavily on a "normal" reference population, so there are problems when such methods are used on a quite different body of material.

The specimens were assigned to one of three categories: "male", "female" or "unknown/evaluation impossible". All adults and subadults from the 12/14-18/21 age category were assessed. As with the age determination, scoring systems and subsequent averaging and weighting of scores (Ferembach et al. 1980) were not used (see below for discussion).

Results: Age and sex distributions

Figure 26 shows the total frequencies. It can be seen that the material covered all age groups, and that only 22 specimens (5%) could not be allocated to any age category. There was a 73/362 ratio of subadults to adults, subadults thus accounting for 16% of the material. Grouping at 5-year intervals was only possible in 229 cases (50.1%) (see Fig. 27). Apart from the subadults, where this was possible in 72 cases, allocation to a 5-year interval was thus possible in 157 adult cases. The resulting total age span was 0 to 60 years.

The total sex distribution is summarized in Figures 26 and 27. The overall distribution is close to 50% each (males:females ratio = 1.02). As noted above, only adult skeletons can be reliably sexed, but of the 31 specimens classified as subadults in the 12/14-18/21 age range, 15 could be sexed, since the observed traits were well developed. Of the 200 specimens which could not be sexed, 56 belong to the subadult groups, leaving 144 adult specimens in the total material (31.5%) which could not be sexed. In all cases this was because there were only fragmentary remains. Generally speaking, most females are represented in the juvenilis and adultus group, while most males are represented in the maturus/senilis group (Figure 26); similarly, males are predominant in the higher 5-year intervals (age 30-35 and above; see Fig. 27). The differences in distribution are significant both for the age categories (c2 = 9.14, df = 1, p=0.01) and for the 5-year intervals (c2 = 23.72, df = 1, p = 0.0025).

Figure 28 gives an overview of the age and sex distribution for the individual sites. Only sites with more than five specimens have been included. There is no significant difference in sex distribution among the sites shown (H=12.39, p > 0.05), or in the age distribution (using the overall subadult/adult ratio) (H=10.95, p > 0.05). The above-mentioned difference in age distribution between males and females can be seen for each site.

Discussion of age and sex determination

All the methods have degrees of inaccuracy (measured as intra- and interobserver variation), although surprisingly few researchers have tried to chart intraobserver and interobserver variation and degree of accuracy systematically using archaeological material (Saunders et al. 1992). The standard aging and sexing methods have generally been accepted without question (Jackes 1992), although the first doubts about the methods were published by Bocquet-Appel & Masset in 1982. It now seems clear that most methods have higher intraobserver and interobserver variation than previously noted (Bedford et al. 1989). This suggests that several methods fail to prescribe exactly what traits are to be observed at what stages. It has been suggested that one could score morphological traits, e.g. 1 to 5 or -2 to +2 from "most male" to "most female" (Ferembach et al. 1980; Acsadi & Nemeskeri 1970), or that one could serialize, i.e. classify the observed traits gradually from "most male" to "most female" (Meindl et al. 1985). This calls, however, for reasonably complete and comparable skeletal elements, and since this was not the case with the Norse material, this approach was not used.

Because of the variability of each method, it has generally been proposed that more than one method should be used for age determination (Maat 1987; Bedford et al. 1993). Consequently, there have been attempts to standardize such a combined approach: Acsadi & Nemeskeri proposed the "Complex Method" (1970) and Lovejoy et al. (1985b) proposed a "Multifactorial Method". It was not possible to use Acsadi and Nemeskeri's method as this includes radiological assessment. In addition, the resultant score is a simple mean value of the four methods used, an approach not recommended today (Brooks & Suchey 1990). In the "Multifactorial Method" the samples are first serialized with each method, then an intercorrelating matrix is calculated, followed by a principal-component analysis where the first principal component is taken to be representative of the true chronological age (Lovejoy et al. 1985b; Bedford et al. 1993). The problems of this method are 1) that it can only be used if the methods prescribed in the original publication can be used (pubic symphysis; auricular surface; radiographs of proximal femur; dental wear; and suture closure) – which they could not; and 2) that, ideally, weightings should be calculated for the population under study, which of course is impossible for archaeological material (Saunders et al. 1992).

In a study of the accuracy of sexing skeletons using both cranial and pelvic morphology a high level of accuracy was generally found, defined as 97% correctly sexed skeletons (Meindl et al. 1985). Morphological traits were as accurate as cranial morphometric traits, and pelvic traits were more accurate than cranial traits (Meindl et al. 1985).

Another major problem of the prevailing methods, regardless of intraobserver and interobserver variation, concerns the reference population. All of the above mentioned methods were devised using forensic autopsy material or anatomical collections, in the latter case going back to the 1920s. Not only can there be questions as regards the documentation of these collections (Hoffmann cit. in Ubelaker 1989; Meindl et al. 1990); we can also ask whether methods devised using a 20th century sample are adequate for medieval material. For the morphometric age determination methods, this was such an obvious problem that these methods, as mentioned above, were completely rejected at the outset of this study. As for the morphological methods, Lovejoy et al. tested their "multifactorial method" blindly (Lovejoy et al. 1985b) but used a non-archaeological sample. The same is the case for the rib aging technique (Russell et al. 1993), and for several of the sex determination techniques (Sutherland & Suchey 1991; Lovell 1988). Saunders et al. (1992) is to date one of the few studies to use an archaeological sample (with known ages and sexes thanks to coffin plates etc.), and they found great variations in the results of the four methods evaluated: pubic symphysis, auricular surface, ectocranial suture closure and rib phases. Although only the pubic symphysis method was inadequate enough to prompt serious questions, the other three methods still had an inherent high level of bias; i.e. the methods systematically tended to overage or underage, most frequently overaging younger adults and underaging older adults, thus lumping most individuals in a group in the mid-thirties (Saunders et al. 1992). The overall correlation of known age with auricular age was for example 0.6 in one study (Bedford et al. 1989).

Conclusion on age and sex determination

The presence of more females in the younger adult age groups and more males in the older adult age groups, a pattern also repeatedly found for all the major sites, indicates a higher mortality for females at a younger adult age than for males. The sex ratio is on the whole evenly distributed. The number of subadults, comprising 16% of the total material, is low. Apart from any palaeodemographic explanations, this may first and foremost reflect the excavation and preservation of the Norse material. Since subadult bones are more fragile than adult ones, and since the overall distribution of skeletal elements favours the major long bones and cranial base, it can be assumed that the low frequency of subadults is to some, if not to a high, degree caused by degradation and excavator bias. The importance of this factor for the low proportion of subadults is illustrated by the one site where

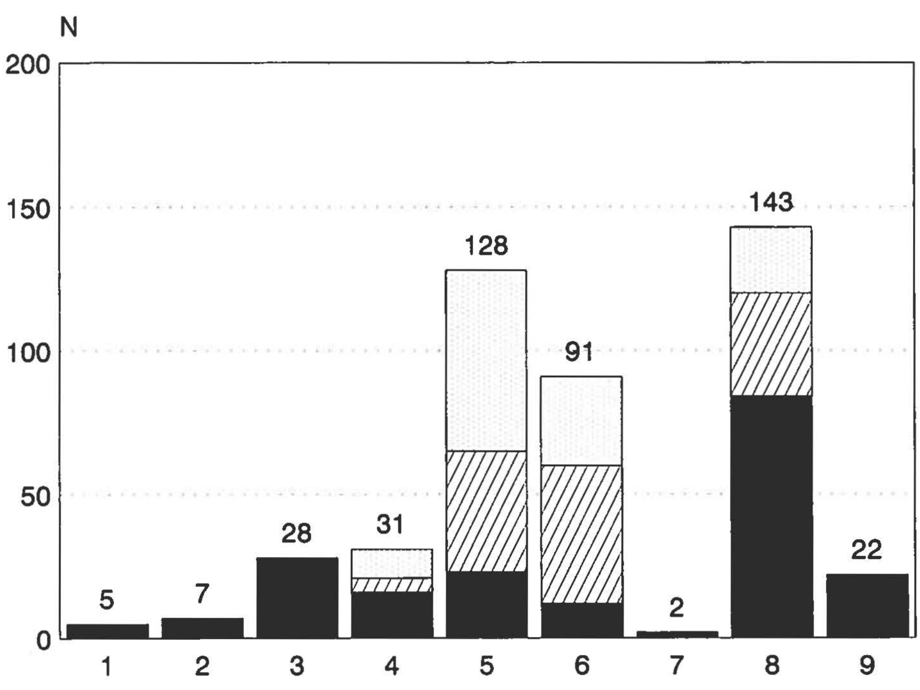


Fig. 26. Age distribution by age categories. Hatched: males; dotted: females; solid: sex unknown. 1: infans I (0 – 1 yr.); 2: infans I (1 – 6 yrs.); 3: infans II; 4: juvenilis; 5:adultus; 6: maturus/senilis; 7: subadult (more precise allocation not possible); 8: adult (further classification not possible); 9: age determination not possible.

the churchyard was completely excavated, E29a Thjodhilde's Church. The archaeologist identified 34 child graves and a total of 155 graves, yielding a proportion of 22% (Krogh 1982). When we use the figures from available anthropological material, the proportion is lower (18 subadults/148 ageable individuals) equalling 12%, clearly reflecting how it was not possible to secure subadult material. The implications of these distributions will be further analysed and fully discussed in the chapter on palaeodemography.

Dating of the Norse material

The establishment of a Norse chronology was essential to this study, since no diachronic analyses would be possible unless the specimens could be placed in some chronological framework. Although several archaeologists were able, using metrological and architectural studies (Roussell 1941; Krogh 1982), to give approximate datings for the church buildings, these datings cannot simply be taken to be representative of the anthropological material; the main problem is that the churchyard often antedates the church building; indeed faint traces of older churches often appear upon excavation (e.g. at E47 Gardar and E29 Brattahlid). To underscore this, several skeletons were in fact found extending below the actual foundations of the church (e.g. at E111 Herjolfsnes and E47 Gardar).

In earlier anthropological studies, the church datings were taken to be representative of the material (Bröste et al. 1941; Scott et al. 1991). An important reason for this was that until recently it was simply not possible to date the anthropological material itself. As will be seen in the following chapter, grave goods and artifacts were very rarely found with the interred individuals, excluding this as a viable method. Nor was stratigraphy in use at the time of most Norse excavations. Radiocarbon dating first came into use in the 1950s (Tauber 1992), and approximately 100 gr of bone were required (the equivalent of almost an entire femur), thus making radiocarbon dating a somewhat destructive procedure. Until now, only four specimens had been radiocarbon dated (all from W7 Anavik). Recently, however, radiocarbon dating by accelerator mass spectrometry (AMS) has been introduced, drastically reducing the amount of material required: only 100 mg of bone tissue are required for AMS dating. The main problem with the dating of the Norse material was that the datings were to be used in diachronic studies covering only 500 years. Hence, extreme accuracy was required. Not only can problems with calibration be anticipated (see below); for the Norse settlers special corrections are necessary because of their mixed terrestrial/ma-

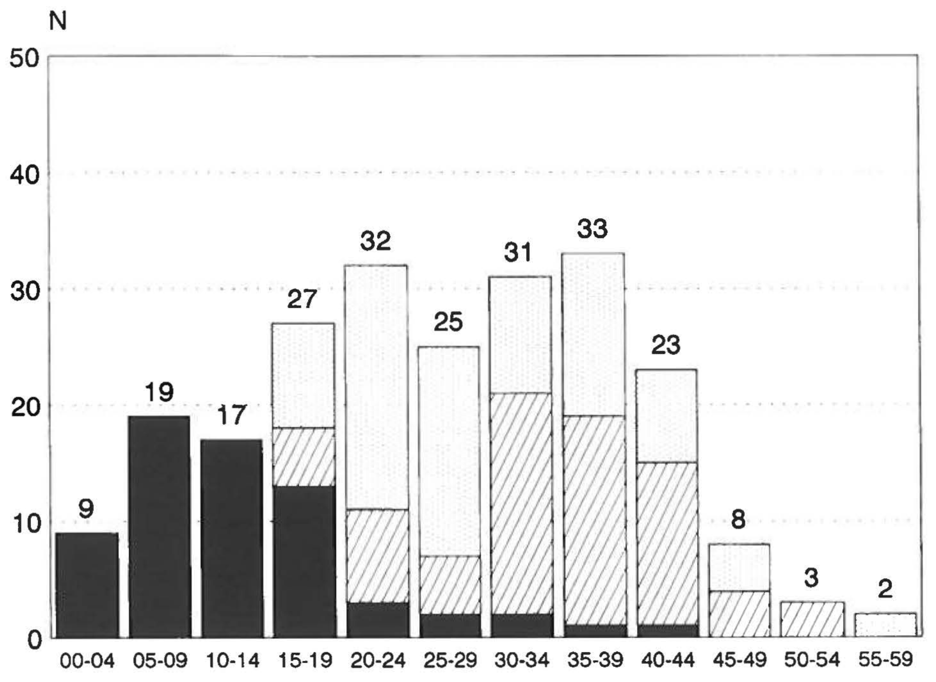


Fig. 27. Age distribution by 5-year intervals. Hatched: males; dotted: females; solid: sex unknown.

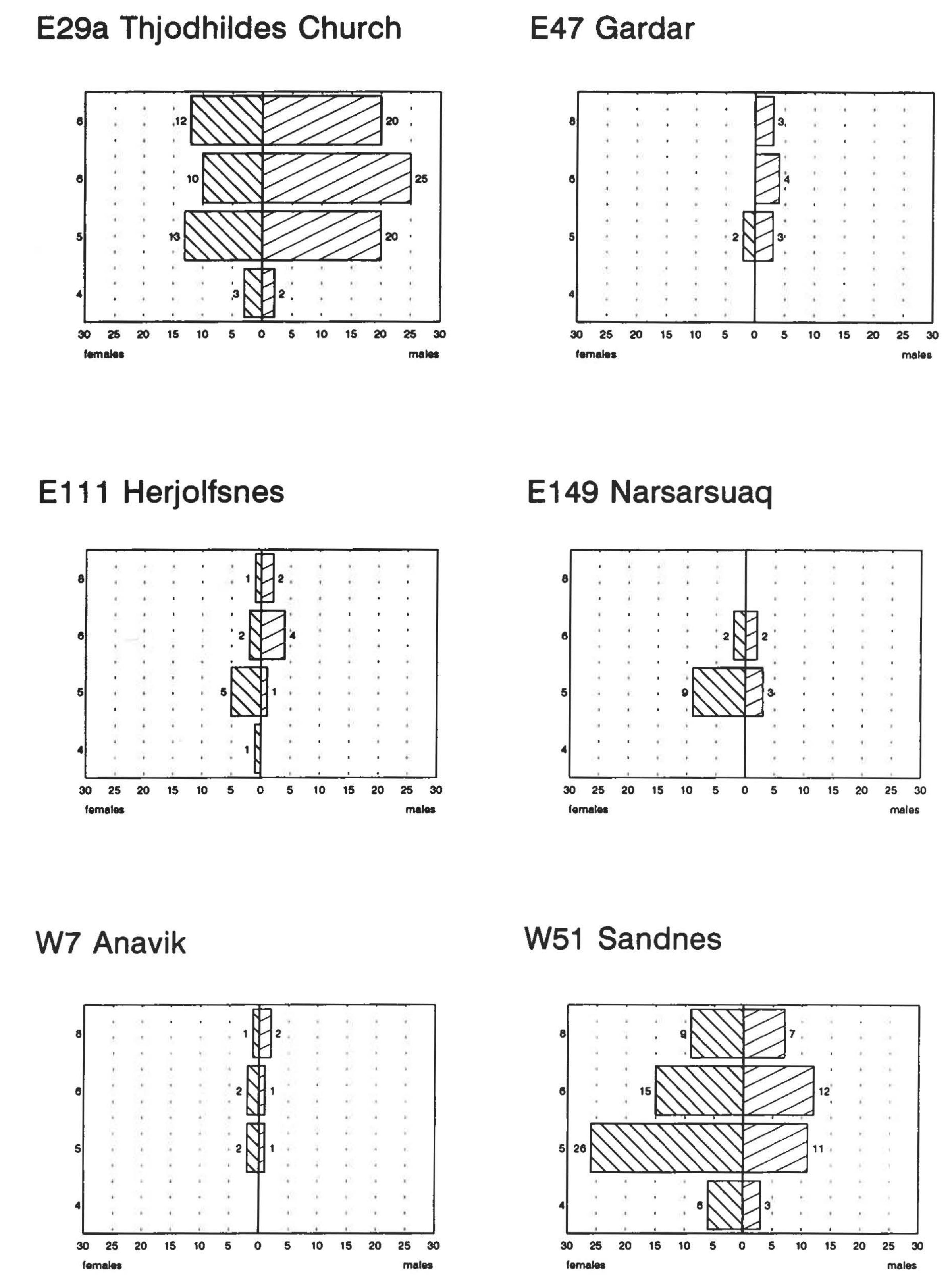


Fig. 28. Age distribution by sex for single sites. Age category indicated on y axis: 4: juvenilis; 5: adultus; 6: maturus/senilis; 8: adult (further classification not possible). Total number of specimens in each category given by bar.

rine diet. Given these problems, and earlier datings which did not match dendrochronological results[6] many people have been somewhat sceptical of radiocarbon dating of human bone material (Kieffer-Olsen 1993). There has probably been some failure to distinguish between the fractionation and marine effects, adding to the perception of radiocarbon dating as not precise enough (for use in dating the periods when churchyards were in use) (Trolle cit. in Kieffer-Olsen 1993). While there are problems with radiocarbon dating, allowances can be made for most of them, and anyway it remains the only way, in the absence of stratigraphical analyses and dendrochronological datings,[7] to date the Norse material. It was therefore decided, in order to make the best use of AMS dating, to date as many samples from the major sites as possible, and preferably to select material which had demonstrable topographical and stratigraphical relationships (e.g. skeletons lying below one another). Dating as many individuals as possible, rather than selecting one or two individuals, means that a model can be established, since all datings must fall within the fairly limited timespan of the settlement period. Thus the "correctness" of the results can be viewed in the light of their internal consistency. All specimens were analysed more than once to obtain the highest possible accuracy – in fact most material was dated within a range of 40-60 years. Mammal bones and textiles that lay in direct contact with the skeletons were also included. In all, 32 specimens were dated, and this constitutes the first comprehensive attempt to establish a chronological sequence for Norse anthropological material.

Because of the importance of these datings for this study in particular, and for the history of the Norse settlements in general, the samples and the AMS methodology, and especially the corrections and models used, are described in detail.

The material used for radiocarbon datings

E29a Thjodhilde's Church (Qassiarsuk)
Samples were taken from ten skeletons (but dating analysis was not possible with one of these). They were selected to cover the whole churchyard as well as possible; four lay close to the church, three at the periphery. Two samples were taken from the mass grave. A bone fragment from an ox found in the mass grave was also used.

E47 Gardar (Igaliko).
Samples were taken from three skeletons. Most human skeletal material from this site did not have demonstrable stratigraphical relationships, except for the skeletons found in the North Chapel. Here the skeleton of the presumed bishop was interred, and directly below, aligned with the church walls and foundations, lay the skeletons of a male and a female, side by side.

E66 Undir Høfdi (Igaliku Kujalleq)
From this site samples from three skeletons were taken (but dating analysis was possible only for two). As mentioned earlier, five skeletons were found south of the church, lying close together, four side by side, with the fifth skeleton directly below them. Unfortunately, it is not possible to identify the position of each skeleton because of the loss of original identification numbers.

E111 Herjolfsnes (Ikigait)
Three samples were taken from this site. There was a stratigraphical relationship, as the skeletons lay one above the other. The skeletons lay in the NE corner of the churchyard. Besides skeletal material, wool from garments wrapped around these skeletons was sampled.

E149 The Convent (Narsarsuaq)
Four samples were taken from this site. Three skeletons lay in stratigraphical order on the north side of the church, and a fourth sample was taken from a skeleton which lay amongst several others on the horizontal plane, on the south side of the church.

W51 Sandnes (Qilaarsarfik)
Six samples were taken from W51 Sandnes. Again, all the skeletons lay in chronological and stratigraphical order;

[6] The results almost always used to illustrate this are the datings of human bones from the Sct. Drotten Church in Lund. The discrepancy between radiocarbon datings and endrochronological datings was between 217 and 285 years. However, the radiocarbon results had not been corrected for the marine diet component, based on C-13, which would very probably have accounted for the difference.

[7] Wooden coffins have been found in several Norse cemeteries, but they were all probably made of driftwood.

one uppermost, two just below, side by side; and below these another three, one below another. The skeletons lay in the dense group of skeletons excavated by Nørlund and Roussell.

Dating Methodology

In conventional ^{14}C dating, the content of ^{14}C is evaluated by measuring (usually over a couple of days) the radioactive decay rate (Thomsen 1990). With the Tandem Accelerator Mass Spectrometry method, the actual content of carbon in a given specimen is measured directly by atom counting. Prior to this, the samples are treated chemically to extract the carbon compounds. In the case of bones, collagen is extracted and used as the dating material (Tauber 1986). Usually, only bone with a collagen content above a few per cent will give reliable results (Hedges & Law 1989). In one case from E29a Thjodhilde's Church, the collagen content was below 1% and the specimen was consequently excluded. Although diagenetic changes in this case made the specimen unavailable for dating, diagenetic changes probably do not alter the intrinsic composition of the individual carbon isotopes, although very significant differences between collagen ^{13}C and humus ^{13}C could alter the collagen ^{13}C slightly. Indeed, dating of individual amino acids has shown different ages for a single bone (Hedges 1989). This can be avoided to some degree by using cortical material from intact bones, which will minimize diagenetic changes, if there are any (Ambrose 1993). Post-mortem changes in isotope ratios have been observed, but these were mainly in animal bones which had been burnt (De Niro 1985). The purity of the samples may be assessed by radiocarbon dating, and if the radiocarbon dates are found to be in general agreement with the datings implied by for example cultural and archaeological analyses, the samples are considered uncontaminated (Ambrose 1993).

After the ^{14}C content is measured, but before the values are calibrated to obtain a chronological age, various corrections have to be made. Since the basic assumption of ^{14}C dating is that all living organisms, through the food chain, acquire the same ^{14}C content as the atmosphere, the two main reasons for a deviation from this equivalence, namely reservoir effect and fractionation, constitute the two most important factors for correction (Tauber 1977; Heinemeier et al. 1993).

The atmosphere is a well mixed ^{14}C reservoir which serves as the natural ^{14}C reference for the biosphere. In contrast, the deep seas are a less mixed ^{14}C reservoir which is older than the atmosphere. The difference in chronological age between the carbon isotope mixture in marine organisms and atmospheric organisms amounts to 200-2000 years, depending on geographical locality. Thus, an organism living on marine food chain products will acquire a marine ^{14}C composition, and a radiocarbon analysis will make it appear 200-2000 years older than an organism living on terrestrial food chain products. Such deviations are especially high in areas where there is upwelling of deep sea water to higher water layers (Tauber 1983). Correction is possible when the reservoir effect is known. In the case of West Greenland, the reservoir effect is of a magnitude of about 500 years. However, for organisms living on a mixed terrestrial/marine diet, the corrections have to reflect the proportion of these dietary constituents (Chrisholm et al. 1983). In relation to the Norse settlers these corrections are of paramount importance. Not only did the Norse have a mixed marine/terrestrial diet (as indicated by kitchen midden finds); they probably also had this in varying proportions. McGovern (1979, 1992) has proposed that the Norse settlers gradually moved from a mixed diet to a predominantly marine diet; thus the ^{14}C content of the Norse skeletal material was influenced more and more by marine ^{14}C concentration. The solution lies in assessing the ratio of marine and terrestrial food. This can be done by analysing the ^{13}C content (see below).

Fractionation is the depletion or enrichment of the heavy carbon isotopes (^{13}C and ^{14}C) by natural physical and chemical processes in the carbon cycle. Generally, fractionation means that the heavy carbon isotopes are enriched in the sea, because they tend to stay dissolved, whereas light carbon isotopes are enriched in the gaseous state and thus in the atmosphere (Thomsen 1990). The degree of fractionation is given by describing how much the ratio of ^{13}C to ^{12}C deviates from a standard (the so called PDB standard) (Tauber 1983), and is represented as the $\delta^{13}C$ value in per mills. By measuring the content of ^{13}C, which can be done with great precision by conventional mass spectrometry, we can calculate how much fractionation has affected the ^{14}C content. The bones of humans who have mainly eaten terrestrial food have observed $\delta^{13}C$ values of about -20 %, while bones in the marine food chain have a value of about -13 % (Tauber 1983). The value of $\delta^{13}C$ can thus also be used, in conjunction with fractionation correction, to assess the marine/terrestrial proportions of the food chain (Tauber 1981; Chrisholm et al. 1983), and thus to correct directly for the reservoir effect. The correction model in the present study assumes a strict linear relationship between the marine component fractions and the measured $\delta^{13}C$ values with 0% marine fraction (100% terrestrial) for $\delta^{13}C = -21$ ‰ and 100% marine fraction for $\delta^{13}C = -12.5$ ‰ for this population. It is sufficient here to note that the age correction calculated from this model is rather insensitive to the exact choice of $\delta^{13}C$ values for a 0 to 100% marine component. This is because the absolute age corrections are controlled by three date pairs (bone-textile) in the central part of the observed (25-80%) marine fraction distribution (see next section).

When used in assessing dietary habits, the ^{13}C content of human bones is thought to represent the composition of the average food intake over an extended period, probably 10 to 30 years (Ambrose 1993), although turnover rates may vary inter-individually. It is thought for example that high-protein diets promote rapid bone turnover due to protein-induced acidosis (Ambrose 1993), or that intense bursts of activity also stimulate skeletal dissolution (Ruben & Bennett 1987 and Ruben 1989, cit. in Ambrose 1993). However, these sources of variation will only play a role if one wants to determine how long an individual has relied on mainly marine or terrestrial foodstuffs. The ^{13}C content was measured by Dr. Arny E. Sveinbjörnsdottir in Reykjavik, Iceland.

Results

Figure 29 shows the distribution of samples by ^{14}C dating (age BP: Before Present (viz. 1950)) and $\delta^{13}C$. These are the "raw" results before correction for the reservoir effect, but after correction for fractionation, and they show a relatively uniform age BP, but a varying $\delta^{13}C$. The ^{14}C ages for the textiles appear younger than the skeletal material. Assuming that the datings for the three skeletons from E111 Herjolfsnes must be identical to those of their associated textiles (which were wrapped around the skeletons), the full reservoir effect used in the model discussed above was calculated. The result – 450 years – agrees remarkably well with the established reservoir effect (about 500 years) as determined by ^{14}C analyses of fully marine material of known age. With this reservoir effect, the model prescribes an increase of about 50 years in the correction for each 1 ‰ increase in the $\delta^{13}C$ value. Figure 30 shows the results of the E111 Herjolfsnes bone/textile pairs after reservoir-effect correction of the bone ages. We can note good agreement between each reservoir-corrected bone and its associated textile, even where the marine factors range from 50 to 80% ($\delta^{13}C$ from -16.5 ‰ to -14.4 ‰), leading to a difference of about 100 years in the calculated corrections. It can further be noted that the three textile ages are statistically identical, and their combined average age is calibrated at 1425 +/- 20 AD, which agrees excellently with the estimated age of 1400-1450 AD based on the textile fashion (Nørlund 1924). The full results of the radiocarbon analyses are given in the Appendix, Table V.

The specimens from E29a Thjodhilde's Church showed an especially high standard deviation for calibrated age. This was due to the calibration curve, which for the period around 1000 AD has a small peak, which means that several values are possible. This peak in the calibration curve (BP vs AD in the mixed terrestrial/marine model) might also explain the tendency for most of the E29a Thjodhilde's Church results to concentrate at about 900 years BP, and explains the rather large uncertainties in these datings when they are translated to years AD. This plateau therefore makes it very difficult to determine the termination of the period in which E29a Thjodhilde's Church was in use more accurately than the interval 1100-1200 AD. The material from E29a Thjodhilde's Church is thus the oldest analysed Norse material, dating to approximately 950-1200 AD. It is followed, in chronological order, by E47 Gardar, approximately 1200-1300 AD; W51 Sandnes, approximately 1300-1400 AD; E66 Undir Hofdi, approximately 1300-1400 AD; E149 Narsarsuaq, approximately 1300-1450 AD; and E111 Herjolfsnes, approximately 1400-1450 AD.

The ^{13}C content shows a distinct development over the period, with the lowest value for E29a Thjodhilde's Church and a rise running through the material from W51 Sandnes, V167 Narsarsuaq and E111 Herjolfsnes (Fig. 31).

Discussion

The resultant datings were used in a comprehensive model where corrections had been made for fractionation and the reservoir effect. The "raw" results (Fig. 19) show that before correction for the reservoir effect all specimens fall more or less within the same timespan. The correction for the reservoir effect was made, as mentioned above, by using a linear model and assuming synchronicity for textiles and bones from E111 Herjolfsnes. Although these basic assumptions may be criticized (i.e. the textiles may be somewhat older than the skeletal material, or another dependency than the linear can be postulated), the model is parsimonious and yields consistent results: E29a Thjodhilde's Church, the one site which can be described as early on the basis of the archaeological evidence, indeed becomes the earliest dated site; W51 Sandnes falls in a period consistent with the evidence of the written sources (it was described as having been abandoned in 1362 AD and the analysed skeletal material is from the north-west corner of the churchyard, probably the part of the cemetery that was used last). Finally, the material from E111 Herjolfsnes, which has the only specimens that can be dated culturally, and where another source than the bones can be used for dating, has been dated as the most recent material, with a high degree of homogeneity between bones and textiles.

The resultant datings for the various sites stay within a rather narrow range. Most of the material used for the dating analyses was selected because it was part of a relative chronological sequence, and it is surprising that no such sequence is detected by the radiocarbon datings, i.e. in all instances the individuals may well have died within a very short timespan. This applies especially to the material from W51 Sandnes.

Furthermore, the radiocarbon datings accord with the datings calculated from the arm positions (see the chapter on burial practices). This method is unreliable for the Norse material 1) because of the scarcity of skeletons with accurately recorded arm positions; 2) because only one churchyard was fully excavated; and 3) because of probable differences (at least in terms of timescale) in Danish and Greenlandic burial practices. Yet the methods still provide some degree of mutual corroboration.

As mentioned above, the ^{13}C content of human bones is thought to represent the composition of the average food intake over an extended period, probably between 10 and 30 years (Ambrose 1993). This has been used earlier to evaluate dietary patterns in Denmark from Mesolithic and later periods (Tauber 1981; Tauber 1983).

The radiocarbon analyses for ^{13}C thus display a dietary shift from a predominance of terrestrial resources to a more marine diet. The samples from E29a Thjodhilde's Church have (^{13}C values of -17.5—19.0 %, which accords for example with values from Denmark from the Iron Age (Tauber 1981). Over the next 500 years there is a shift to ^{13}C values of approximately -14.0 – -16.5 %, which is more on a par with values obtained from Eskimos (15th century) (Tauber 1981, 1989). The difference observed is more than one per mill, which suggests a significant dietary shift (Katzenberg et al. 1993).

On the basis of known ^{13}C values for organisms which rely 100 per cent on either terrestrial or marine food sources, a direct percentage can be calculated for the Norse specimens (Chrisholm et a. 1983). For the speci-

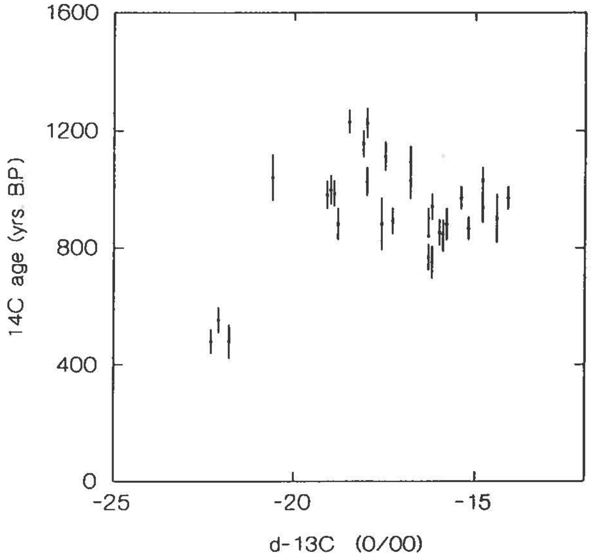


Fig. 29. Years BP by δ-13C, before corrections. Vertical bars denote ± 1 standarddeviation. Note the three samples with the lowest δ-13C values: these are the textile samples.

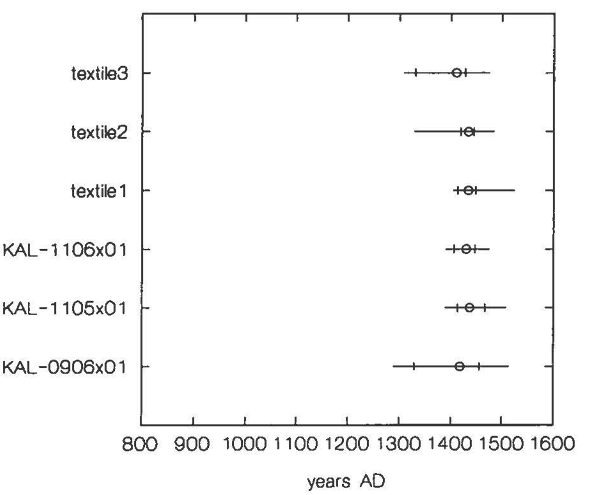


Fig. 30. Results in years AD (+/- 1 & 2 SD) for the paired bone and textile samples from E111 Herjolfsnes, after reservoir correction was applied to the bones. Note midpoints fall by approximately 1425 AD.

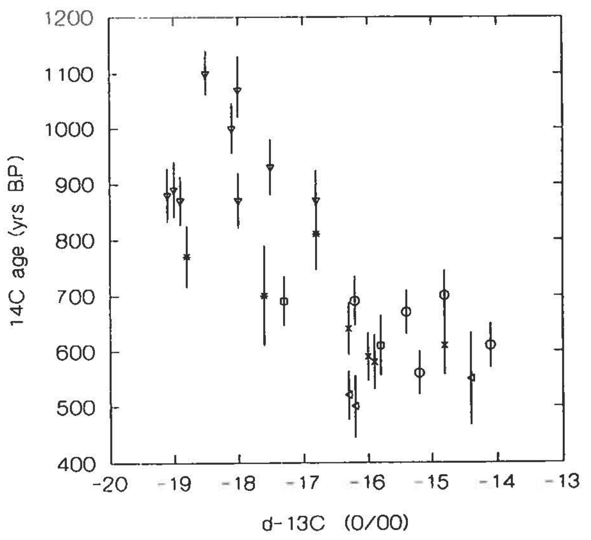


Fig. 31. Years BP by δ-[13]C after corrections (cf. fig. 29). Sites given by symbols: ∇: E29a; *: E47; □ E66; ◀ E11; x: E149; o: W51. Vertical bars indicate ±1 standarddeviation.

mens from E29a Thjodhilde's Church, this means that terrestrial proteins accounted for an average of 74.9% +/- 12% (range: 64.3%-87.1%). The specimens from E111 Herjolfsnes and E149 Narsarsuaq yield a pooled average of 41.9% +/- 12% (range: 27.1%-50%) of terrestrial proteins. This indicates that throughout the settlement period the Norse inhabitants of the Eastern Settlement increased their reliance on marine resources from approximately 25% to 60%. It is interesting to note that W51 Sandnes, which slightly predates E111 Herjolfsnes and E149 Narsarsuaq, shows a similarly high reliance on marine resources.

These results accord generally with the results of studies of kitchen midden material, which indicate diachronic shifts as well as differences between the Western and Eastern Settlement (McGovern 1992). Dietary shifts have also been observed for Iceland (Amorosi 1992). Generally, it seems that the Norse Greenlanders, unlike their Icelandic contemporaries, relied less on fish than on seal, and the tendency is even more pronounced for the Western Settlement. The terrestrial food sources included domesticates such as cattle and caprines (goats and sheep), and game (caribou) (McGovern 1992).

Conclusion on radiocarbon analyses

The results show that the main view that E29a Thjodhilde's Church was early and E111 Herjolfsnes was from the Late Settlement period basically holds true. The abundant material from E149 Narsarsuaq has finally been dated, making its use in diachronic and synchronic analyses possible. One interesting aspect of the results is that most individuals from the sites which had close stratigraphical relationships are almost synchronous: the burials at a given location all fell within a very short timespan.

Burial practices and principles of interment

We know now that concerning the fate of the Norsemen, it is only possible to ask the dead.

P. Nørlund, Nordbobygderne ved Verdens Ende, 1934

When the Norsemen came to Greenland in 986 AD, they were probably pagan, although according to the Landnamabok and Grønlændingesaga there was one "Christian man" on board one of the landnama ships (Krogh 1982: 27; GHM I: 181). Christianity was introduced in Denmark around 965 AD, in Iceland in 1000 AD, and in the various parts of Norway around 1000 AD (Olsen 1992; Roesdahl 1991). Thus the settlement in Greenland seems to have preceded the conversion to Christianity in most of Scandinavia by a narrow margin. According to the sagas, Christianity was introduced to Greenland by Eric the Red's son, Leif, who had converted when at the court of the Norwegian king Olaf Tryggvarsson (Krogh 1982). Few Norse pagan burials would thus be expected in Greenland if the sagas were assumed to have some kernel of historical truth. Indeed, the probably weak pagan influence in Greenland seems to be underlined by the fact that there is only one known piece of archaeological evidence of pre-Christian religion in Greenland: a Thor's hammer incised in a piece of soapstone found at E29 Brattahlid (Roesdahl 1991: 274; Krogh 1982: 51).

Pagan Norse burial practices

It seems that most people were simply buried by the farms, although villages might have had communal burial sites, marked by stones, poles or a mound (Roesdahl 1991; Bullough 1983; Arge 1991). For those at the upper end of society, chieftains and warlords, the burial might have been in a ship, together with slaves and many possessions (including animals such as horses), marked on land by runestones and mounds (Roesdahl 1991). Children might be left exposed to the elements (a practice the Christian church condemned strongly) (Roesdahl 1991).

One instance of a pagan burial in Greenland is described in the Landnamabok: Thorkel, one of the original "Landnama men" (he settled in the Herjolfsnes fjord), was interred in a dolmen in the field by his homestead (GHM I, 183). This description has led the archaeologists to search the site for remnants of such a dolmen or burial mound. A burial chamber or cairn was described by Roussell (1941: 94), but this has been discredited since the, as no direct evidence of a burial has been found (Jansen 1972: 100). Roussell also pointed to two stone mounds, found by W51 Sandnes, as probable pagan burial sites (1941: 95), but the mounds have since been designated as fox traps. A small test excavation in a stone enclosure at E29 Brattahlid produced some charcoal, steatite and fragments of burned bones, but more evidence is needed to conclude whether it represents remnants of a pagan burial (Jansen 1972: 101).

Burials outside churchyards

Anthropological material

Six specimens were found outside known churchyards (Table 3) (cf. the chapter on provenance). The skeletal remains from E167 Vatnahverfi were found in the floor of a major farm structure (Fig. 32). The archaeologist (Vebæk 1992) suggested that this might have been the last inhabitant of the area, which is why no one could bury him properly. However, radiocarbon analysis indicated that the specimen was from about 1275 AD (Vebæk 1992), which does not support the above hypothesis. The individual might also represent a secondary deposit, the origins of and reasons for which we can only guess (Lynnerup et al. 1992).

Another case concerns fragments of a skull found at the Tasersuaq farm. The archaeologist did not give the precise find location (Nørlund 1921b), although Arneborg believes that the fragments must have been found among the farm ruins, not at a churchyard (Arneborg, manuscript on file) (cf. the chapter on provenance). No further archaeological investigations have been made at the site, so the existence of a small "prayer house" with a churchyard, of the type found at other large farmsteads, cannot be ruled out. Moreover, only the calvarium remains, and although anthropological analysis indicates a Norse origin (cf. chapter on anthropometry), the possibility that the individual was of Eskimo origin cannot be entirely discounted.

At Pissisarfik a fragmented maxilla was found. There are no data on the precise find location, so it cannot be ruled out that it could be from an as yet unidentified churchyard.

An almost complete cranium was found in the thick turf walls of the animal shed at W51 Sandnes. It has been suggested that the cranium may have been placed there in recent times, since the site has been disturbed by visitors and by a high degree of erosion (Arneborg, pers. comm.). If so, the find site may be irrelevant in the archaeological context. A fragment of an innominate bone was also found in a kitchen midden between the dwelling house and the church. Again, the reason for this find location may be disturbance or the fact that the churchyard seems to have been extended into the kitchen midden, which at that time was no longer in use.

Finally, Clemmensen found a cranial fragment in the kitchen midden of E66 Undir Høfdi. Further archaeological analyses are needed to clarify the extent of the midden and the adjacent churchyard.

Table 3. Summary of finds outside cemeteries.

Site	N	Circumstances
E167 Vatnahverfi	1	Skeletal remains found at ground level in passageway of farmstead ruin.
E140 Taserssuaq	1	None recorded.
W Pisigsarfik	1	None recorded.
W51 Sandnes	2	Cranium found in stable wall of a farm complex. Fragment of pelvis found in a kitchen midden.
E66 Undir Høfda	1	Cranium found in a kitchen midden.

Other sources for burials outside cemeteries

While the sagas, describing the deaths of several characters, also indirectly mention instances of burials outside churchyards, it is doubtful how historically correct these descriptions are. Krogh cites such an episode in Eric the Red's Saga (the episode is also mentioned, although not completely identically described, in Landnamabok). The setting is the deathbed of a farmer, who says: "It is an objectionable practice, which has been around here in Greenland since Christianity came, to bury people in unconsecrated earth, and almost without ceremony. I desire that I, and the others who have died here, be taken to the church" (Krogh 1982: 41). Krogh states that it seems to have been the custom to bury the dead in unconsecrated earth by the farms where they died. A pole could be placed by the body, projecting from the ground, and when the priest later arrived the pole would be pulled out and holy water would be poured down to the deceased (Krogh 1982: 41). Alternatively, as noted from Iceland, a piece of the homefield could be consecrated for burials when for example weather conditions prevented transportation of the deceased to the church (GHM II).

Finally, there seem to have been deviations from ordinary burial customs if the deceased was a criminal. In the Icelandic Annals, for example, it is recorded that a man was burned for adultery in 1406 AD in Greenland (GHM III: 41). The story of Einar Sokkesen tells us that Einar, on the command of the Bishop at Gardar, killed a man from Norway who had destroyed a boat belonging to the Bishop. The Bishop was very wary of having the proper burial rites performed for the slain man, and only when Einar insisted was the man buried at a church (but without the burial service) (GHM II: 695). The lengthy description of how the man was finally interred seems to indicate that otherwise he might well have been buried without the proper rites, outside a cemetery.

To sum up, it can be concluded that none of the Norse human remains found outside cemeteries in Greenland can be positively identified as heathen burials.

Christian Norse burial practices

The burial customs of the Norse must be seen in the light of the role played by the church in the society. Church practices were probably often irregular by ordinary Roman standards and might have been interpreted in different ways (Byock 1993). In Iceland a chieftain was consecrated as a bishop in about 1056 AD, and later his son inherited both the farm and the title (Arneborg 1991:

146). This testifies to a close connection between the wealthy land-owning families and the church in the early period of Norse Christianity (Byock 1993; Arneborg 1991). This probably changed as the Roman church became more powerful and bishops tried to affirm its authority (Thorsteinson 1985: 72-75; Arneborg 1991: 146). This effectively meant a power struggle between local interests and the centralized church, a compromise probably being reached in 1297 (Hastrup 1985: 196). The Greenland church was probably formed along the same lines (Arneborg 1991); first as a local church controlled locally by secular powers, later controlled in part by the Roman church via the Archbishopric in Nidaros (Trondheim). In Iceland it seems that many farmers and chieftains built churches on their farms at their own expense to facilitate the observance of Christianity, and thus exchanged their heathen religious roles for that of a priest. This may have added to their status and wealth (Byock 1993). The Greenlanders were recorded as having paid tithes in 1282 (Diplomatarium Norvegicum, I 1849-1976: 71, cit. in Arneborg 1991), and the seat of the Bishopric in Greenland was at Gardar, one of the most wealthy farms in all Greenland.

How this site was acquired is rather a puzzle. It may simply reflect a "conversion" of the Gardar chieftain, as noted above, not a direct acquisition by the Church. Local control probably continued to be exerted, making for an uneasy relationship between the bishops, who were sent out from Norway (GHM II: 682), and the local chieftains. The implications for the everyday ecclesiastical functions are doubtful: canon law was probably obeyed at least as much as in Iceland, including burial rites. In this respect a bishop would probably have been a guarantor. Indeed, in the late settlement periods, when the Bishopric was vacant, witnesses to a wedding in Greenland had to bear testimony in Iceland that the rite had been performed according to the laws of Holy Church (GHM III: 152, 156). This episode has been seen as proof of a distrust of the will of the Greenlanders to conform to the church rules (Arneborg 1991).

Fig. 32. The remains of the so-called "last Norseman" being excavated. These human remains (and a few animal bones) were found in a passageway at the farm E167 Vatnahverfi (Photo: Vebæk, 1949).

Comparisons of burial customs with those other Scandinavian countries must be made with caution. Canon law, while in principle identical for everybody, may have had a local character, especially in a remote area such as Greenland. The church laws for Iceland are incorporated in the Grågas, which seems to be fairly close to the Norwegian laws (the "Gulathing Law") (Gejvall 1960), and the laws of the Grågas very probably parallel Greenlandic conditions (Krogh 1982; Byock 1993). The combination of skeletal material and archaeological evidence is one of the few available resources for studying how closely the Norsemen conformed to the laws of the church in their everyday life.

Burial practices

The following section deals with burial practices, i.e. features of the individuals graves, while the next section deals with churchyard topography, i.e. the distribution of the graves inside the cemetery.

Secondary burials within the churchyards

Some burials inside the churchyards have been presumed to represent secondary burials, where individuals were first buried outside a churchyard and later reinterred. Two burials were found at E29a Thjodhilde's Church with the skeletal remains in anatomically incorrect positions. Indeed, the bones seem to have been "packed" as bundles wrapped in cloth (Krogh 1982: 48-49). Thirteen individuals were also found in a mass grave: twelve adult men and a child, completely commingled, indicating that the bones had been completely disarticulated at the time of interment.

Krogh speculated that the two "bundles" found at E29a Thjodhilde's Church might represent heathen Norsemen who had been moved from a primary burial place to the churchyard by later Christian relatives (Krogh 1982: 48-49). Since E29a Thjodhilde's Church is presumed to have been the earliest church in Greenland, the bones could not have been moved from an earlier churchyard. It is mentioned in the sagas that bones were moved from one churchyard to another if the church itself was moved (e.g. GHM II: 173).

Krogh felt that the mass grave at E29a Thjodhilde's Church, containing males (and one child) and therefore perhaps a ships' crew, might reflect two passages in the saga literature (Krogh 1982: 46-47). The first is the story told in "The Greenlandic Annals" (GHM II: 663) of "Lig-Lodin" (literally "Corpse-Lodin"), a nickname apparently earned because its bearer sailed in the northern areas and brought back the bodies and remains of deceased, shipwrecked, etc. The second passage is the story of "Einar Sokkesen" (GHM II: 691), where Einar and his men, landing in the "Udbygder" (lit. "Outposts", probably the areas north of the settlements) on an expedition, found a shipwreck and a small cabin. Several decomposed bodies were found in the cabin, and Einar ordered his men to "put the bodies in boiling water using the boilers which belonged to the dead men, so that the flesh can be separated from the bones, which then will be easier to bring to church". While the mass grave may not exactly corroborate these accounts, it may perhaps corroborate the existence of such customs (i.e. the securing of skeletal remains). There are other accounts of the finding of corpses in the sagas (e.g. the Sturlunga Saga mentions ship's crew found in a cave (GHM II: 755)) although there is no specific mention of whether they were brought back for interment.

The transportation of bodies from the place of death to the home churchyard seems to have been quite commonplace among the Norse settlers. In the account of Eric the Red's third son, Thorstein (in Eric the Reds' Saga (GHM I: 231)), it is not only stated that he sailed to Vinland to find his brother's body and bring it back (his brother Thorvald had been slain in a confrontation with the indigenous people and had been buried there); but, when they were wintering in the Western Settlement, a fatal disease killed many of his crew. He then commanded that coffins be made, and the bodies put on the ship, so that they could be brought back to the Eastern Settlement.

Conversely, there is one known case of a corpse that was not transported to a cemetery: when excavating at E111 Herjolfsnes, Nørlund found a rune stick in a coffin (Nørlund 1924: 61-62) with the inscription: "This woman, whose name was Gudveg, was laid overboard in the Greenland Sea" (Jónsson 1924). As human remains (probably adipocere) were observed in this coffin, Nørlund believed that the rune stick had been carved in Gudveg's memory, and laid in the coffin with the body (Nørlund 1924: 61-62). This may indicate how important it was for the Norse settlers to be represented in the cemetery, even when there were no physical remains. The transportation of bones after the flesh had been boiled off has also been described in Europe, for example during the Crusades. The practice was forbidden, however, in 1300 by Pope Boniface, under penalty of excommunication (Madsen 1990: 119).

Besides the secondary burials at E29a Thjodhilde's Church, other commingled skeletal parts in anatomically incorrect positions have been found in other churchyards. All of these cases were identified by the excavating archaeologists as disturbed burials. When Vebæk for example excavated E149 Narsarsuaq, the Convent Churchyard, he found "heaps of human bones. Very near the SE corner of the churchyard we found, at a considerable depth...just such a heap of bones, apparently all from the same individual. Another heap of bones contained the fragments of the skulls and the teeth of at least two individuals" (Vebæk 1991: 42). The bone heaps do in fact represent the remains of one and two persons respectively. Because of the context of the find, however, Vebæk did not find any evidence of "bundling", and Vebæk himself believed that these "bone heaps" were the remnants of demolished, disturbed graves (Vebæk 1991: 42). This is also the case for some of the W51 Sandnes material, where much of the skeletal material, judging by the context as described by Roussell (1936), is disturbed.

Orientation

Table 4 summarizes the orientation of the skeletons found in churchyards. In 253 cases (55.4%), the geographical orientation could be ascertained from archaeologists' notes, photos, drawings, etc. The usual orientation is EW (n = 229, 50.1%). Only a few differ from this (n = 24, 5.3%), and these cases include the above-mentioned secondary burials and the mass grave at E29a Thjodhilde's Church. In 198 cases (43.9%) the position had not been recorded or could not be reconstructed.

Table 4. Skeletal orientation in grave.

Site	East-West	Other	No data	Total
E1	0	0	1	1
E23	4	0	1	5
E29a	131	15	4	150
E47	11	0	2	13
E66	5	0	1	6
E111	20	0	3	23
E149	20	9	23	52
W7	6	0	5	11
W51	32	0	158	190
Total	229	24	198	451[1]

[1] Total pertains to all specimens found within a churchyard

These were usually cases of loose finds and fragmentary specimens.

Practically all burials found in Norse churchyards thus have an east-west orientation. In this orientation the head lies westwards, so that the deceased faces east (to see the coming of Christ on Doomsday) in accordance with Christian burial practices (Krogh 1982: 42; Kieffer-Olsen 1993: 122). This position has consistently been noted by the archaeologists excavating Norse cemeteries in Greenland. There have been observations of Christian burials with other orientations in Denmark (e.g. Æbelholt (Møller-Christensen 1958: 244)), Sweden, Norway and England, and it is believed that those with aberrant orientations were executed criminals or suicides (Kieffer-Olsen 1993: 122). No such burials have been observed in Norse Greenland[8] however. Nørlund, when excavating at E111 Herjolfsnes, stated that all graves were orientated in the ordinary fashion, with skeletons lying on their backs, with one exception: the find of a cap with skeletal remains to the west. However, when the cap was opened in Copenhagen it was found that it contained bones of the feet, so the cap had been wrapped around the feet of the deceased (Nørlund 1924: 63).

Position of arms

It has been demonstrated that there are variations over time in the way the arms were laid (Møller-Christensen 1958; Redin 1976; Kieffer-Olsen 1993). Arm positions can thus sometimes be used to date a burial.[9]

The archaeologists excavating the Norse churchyards often noted the position of the arms. An example is Nørlund's account of the excavations at Gardar: "The bodies were all laid with their heads to the west. There were really only variations in the positions of the arms. Two different positions were most frequent: either one arm was stretched down along the side, the hand lying over the pelvis, whilst the other was bent almost at right-angles so that this hand lay over the lower part of the breast, or both arms were bent, one at an acute angle, the other at a right angle, the latter hand lying by the elbow of the other arm. In one or two cases both arms were equally bent, the hands lying together on the breast" (Nørlund 1929a: 61). Rather than signifying a special custom, the one arm not bent probably simply means displacement at the time of interment, since a degree of symmetry was sought (Kieffer-Olsen 1993: 25). Unfortunately, the positions of the skeletons at E47 Gardar were not marked, nor does Nørlund give an overview tabulation of the frequencies of the various positions (data is only available for the Bishop, who lay with his hands over the pelvic region). At E66 Undir Høfdi Roussell had uncovered four skeletons on top of a lower fifth. While giving a detailed description of arm positions for the four uppermost in his diary, he did not describe the lower, and presumably older, fifth skeleton (Roussell 1935). Nørlund made no reference to arm positions in his publication on E111 Herjolfsnes (Nørlund 1924). For E29a Thjodhilde's Church, there is no detailed account of arm positions.

[8] There is a story in an Icelandic saga story about a man, Jón Flak, who was buried in a north-south orientation, according to different sources and variations either because he was a criminal, had committed suicide, or was interred in this fashion by accident. His ghost promptly haunted the site, whereafter he was reburied in the proper orientation (Kieffer-Olsen 1993: 122; Møller-Christensen 1958: 145).

[9] This shift has been attributed to the early Christian view of the afterlife – that Paradise was assured; thus the "open" position (arms by the body or only slightly bent) signified certain expectations of the afterlife. This optimistic feeling later changed to a more pious and anxious one: before Paradise came Purgatory, and admission to Paradise now involved a prior ordeal. The more "closed" or pious stance (arms folded tightly across the chest) reflected the more arduous and perhaps even frightening prospects (Kieffer-Olsen, pers. comm.).

Krogh stated that most lay with their arms by their sides (Krogh 1982: 42). This is consistent with some overview figures (Balslev-Jørgensen, unpublished data) which show that 68 individuals had their arms by their sides or hips; and 13 had arms folded at 90°.

At W7 Anavik, there is no information linking the burials as drawn on the maps with the skeletons. However, all the skeletons identified by Roussell were drawn lying on their backs with their heads westward, and six had their arms crossed over their chests (Roussell 1932). One case with the arms over the thoracic region and one case with the arms over the pelvic region have been demonstrated by Arneborg in her sketch of the interments found in 1982 at W7 Anavik (Kapel 1982). For W51 Sandnes, no definite links between the skeletons and burials have survived. However, it was possible to reconstruct the position of the bodies on the basis of the drawing made by Nørlund, and the arm positions of at least some of the skeletons could be determined. At first glance, all the burials drawn by Roussell seem to have had their arms crossed. However, in his diary he does in fact mention one burial with arms over the pelvic area, and one with the arms by the sides (Nørlund 1930).

Kieffer-Olsen has stressed that the most important fact is the position of the hands, rather than the angulation of the humero-ulnar joint (Kieffer-Olsen 1993). Thus the 13 cases where only the degree of flexion is given may represent any of the three arm positions with the hands over the body (the Bishop at E47 Gardar, or example, has elbows almost at right angles, yet his hands are placed across the pelvis).

In this study the positions of the arms have been divided into six categories (cf. Tables 5a & 5b) following Kieffer-Olsen (1993): 1) arms parallel along the thighs (Position A); 2) arms folded across the pelvic region (Position B); 3) arms folded across the abdominal region (Position C); 4) arms folded tightly across the thoracic region (Position D); 5) any other recorded position; and 6) no data. Data was only available for 63 individuals (14%). Only at two sites, E29a Thjodhilde's Church and E149 Narsarsuaq, is more than one type of position recorded (cf. Table 5).

Since a chronological sequence is assumed for the placement of the arms, it would be natural to tabulate the frequencies of the various positions at the different sites, as suggested by Kieffer-Olsen (1993), and to compare the results with the radiocarbon datings. We did so by using the above-mentioned archaeological data as shown in Table 5b. The figures were converted to percentages and compared with the figures published by Kieffer-Olsen (Fig. 33). This tabulation dates E29a Thjodhilde's Church to between 1000 and 1100 AD, and E149 Narsarsuaq, W7 Anavik and W51 Sandnes to between 1350 and 1375 AD. This does in fact correspond fairly well to the radiocarbon datings.

The chronological sequence may be further supported by the archaeologists' observations of unrecovered skeletons. In Vebæk's drawing of E149 Narsarsuaq, the innermost skeletons (closest to the chancel) have their arms by their sides. The outermost have their arms across the abdominal region, and this could be accounted for by the fact that the innermost burials were the oldest. Similarly, Nørlund noted that the skeletons at E29 Brattahlid were lying with their arms across their chests, and E29 Brattahlid is generally agreed to be later than E29a Thjodhilde's Church (Nørlund 1936: 44).

No records of the leg positions have been found.

Grave types

Table 6 shows the various grave types. Generally, two types seem to have been used: 1) burial directly in earth with a shroud or cloth wrapping (N = 20, 4.3%); and 2) burial in a wooden coffin (n = 10, 2.2%). Apart from these types, one grave at E29a Thjodhilde's Church was a stone grave (3) with two stones around the head, and two children's graves were covered with a large stone (4) (Balslev Jørgensen, unpublished data). In most cases there was no data on the grave type (5).

Coffin graves are only represented by anthropological material from E29a Thjodhilde's Church (n = 10). There was a marked gender difference: seven males, one female and two of unknown sex. When age distributions between coffin burials and other types were compared, a clear difference emerged: eight coffin burials were of older adults (the contents of two coffin burials could not be adequately aged) while the age distribution for the churchyard as a whole was generally more even: 34 younger adults and 35 older adults (61 individuals could not be adequately aged).

The coffin graves at E29a Thjodhilde's Church were mostly located on the south side of the church building and in general close to the church. Analysis of pathological changes showed a predominance of skeletons with degenerative changes (skeletons with one or more diagnoses after adjustments for age) in coffin graves (N = 4, 40.0%) as against other graves (N = 17, 12.1%). When differences in metric data were sought, the analysis showed no significant differences, although values for all measurements of skeletons in coffin graves were below the average for skeletons from other graves (stratified for sex).

It must be emphasized that a majority of the "no data" cases were recorded as such because no definite linkage between the archaeological data and the individual skeleton could be established. Probably the great majority of burials were in shrouds or cloth. However, coffins seem to have been be present throughout the entire settlement period from E29a Thjodhilde up to E111 Herjolfsnes, where 31 wooden coffins were found (Nørlund 1924).

Krogh did not mention any stone graves at E29a Thjodhilde's Church (Krogh 1982), although it seems that there was at least one stone grave at the site: a grave where two big stones supported the head (Balslev-Jørgensen, unpublished data). This type of grave, and other similar graves with stones at the head and feet, along the body axis, or more irregular stone arrangements, were well known in Europe in Early Medieval times, although the grave type has not yet been identified in Norway (Kieffer-Olsen 1993: 145). Stone graves were also apparently often found at E29 Brattahlid, where Nørlund and Stenberger reported stones placed on each side of the head, or as "pillow" stones below the head (Nørlund and Stenberger 1936: 40). Holm probably observed stone graves at E66 Undir Høfdi, when he noted several burials "close to one another, between big stones" and that "a number of skeletons were found...lying groupwise, with big stones in between" (Holm 1883: 75-76). A stone grave was also found at E47 Gardar (Nørlund 1936: 63). Conversely, no such graves were encountered at E111 Herjolfsnes. Indeed, Nørlund wrote: "Not even the medieval custom, so common in Scandinavia, and perhaps also elsewhere in Europe, of placing a couple of stones on end at the head, was observed" (Nørlund 1924: 60). Finally, stone graves have not yet been identified at any other Norse sites.

Stone-covered graves were observed at E29a Thjodhilde's Church, where two children's graves were covered with a large flat stone (Balslev-Jørgensen, unpublished data). At E111 Herjolfsnes, Nørlund encountered a coffin grave ("Gudveg's grave") above which an enormous stone had been placed (Nørlund 1924: 62). Nørlund speculated that the such a large stone could have served as a "safeguard against ghosts, or to secure undisturbed peace in the grave" (Nørlund 1924: 63).

Table 5a. Position of arms by sites.

Site	A ‖ ‖ (1)	B ‖ ∖/ (2)	C ‖ L_J (3)	D ∣/∖∣ (4)	Other pos. (5)	No data (6)	Total
E1	0	0	0	0	0	1	1
E234	0	0	0	0	0	5	5
E29a	0	0	0	0	0	150	150
E47	0	1	0	0	0	12	13
E665	0	0	0	0	0	6	6
E111	0	0	0	0	0	23	23
E149	0	1	18	0	9	24	52
W7	0	0	0	0	0	11	11
W51	1	1	26	0	0	162	190
Total	0	3	51	0	9	382	451

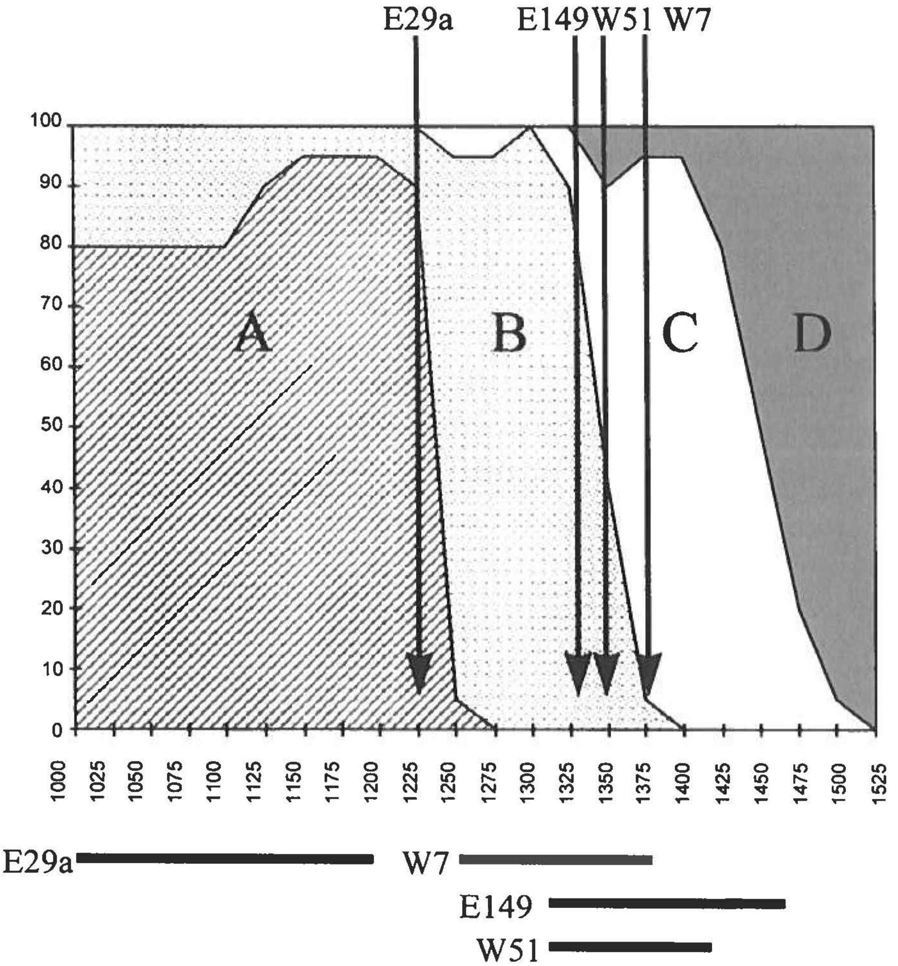
Table 5b. Position of arms by sites using archaeological data (only cases with known position included).

Site	A ‖ ‖ (1)	B ‖ ∖/ (2)	C ‖ L_J (3)	D ∣/∖∣ (4)	Total
E29a	14	67	0	0	81
E149	0	4	16	4	24
W7	0	1	7	0	8
W51	1	1	26	0	28
Total	15	73	49	4	141

Stone-set graves, too, have been found in Norse Greenland. Nørlund described one at E47 Gardar south of the South Chapel (Nørlund 1930: 62). Nørlund also described the case of "Ingibjørg's grave" at E29 Brattahlid. Nørlund was of the opinion that this did not represent an actual stone-set burial, but a tomb placed as a shrine over the grave (Nørlund 1930: 60).

By far the two most common grave types are burials in wooden coffins and coffinless burials, i.e. in shrouds or cloth only. For most of the "no data" entries in Table 7, it may be assumed that they were burials in shrouds or cloth. Although no intact coffins were found at E29a Thjodhilde's Church, ten burials were found with traces of coffins (Balslev-Jørgensen, unpublished data). While Krogh does not give any figures, he does state that "a few of the dead were laid in coffins" (Krogh 1982: 43). Coffins were found in abundance at E47 Gardar: "Besides these shrouded corpses, however, there were many coffin graves" (Nørlund 1930: 62), all wooden (except the case already mentioned above). The coffins were of both rectangular and trapezoid shape, and held together with

Fig. 33. Distribution of armspositions A – D (see text) throughout the medial period as described by Kieffer-Olsen based on analyses of Danish medieval cemeteries (diagram taken from Kieffer-Olsen 1993). X-axis: Years AD, Y-axis: Arms position type (percent). The horizontal bars below the diagram indicate norse dating intervals according to radiocarbon analyses. The vertical thick arrows indicate approximate norse datings according to arm position.



iron nails. At E29 Brattahlid, too, Nørlund made the observation that "the bodies have not infrequently been buried in wooden coffins" (Nørlund & Stenberger 1936: 41). While no coffins were intact, many iron nails were found in the churchyard. Traces of a wooden coffin were also reported at E162 Narsaq by Vebæk (Vebæk 1991: 18). At E111 Herjolfsnes, Nørlund found many coffin burials, and excavated and described 31 intact coffins (including two coffins which had already been secured on earlier expeditions). Fourteen were child coffins, some measuring only 43 to 55 cm, indicating that even deceased neonates could be interred in coffins. In one case, such a small coffin was placed directly on top of the coffin of an adult (Nørlund 1924: 64). Except for a few of the children's coffins, all were trapezoid. Most were held together with wooden nails, but three were held together with whalebone fibres (Nørlund 1924: 71). No iron nails were found at the site.

Even though E149 Narsarsuaq was only partly excavated, it was somewhat surprising that no coffins, not even nails, were found at this site (Vebæk 1991: 34).

Nørlund found several coffins without lids at E111 Herjolfsnes, and speculated that this might be due to re-utilization of the coffins (Nørlund 1924: 72). Unfortunately, no skeletal material was retrieved from these coffin burials. Nørlund made a good case for re-utilization at E47 Gardar, where he noted the following: "In the large coffin matters were more strange – in fact horrible; for from the position of the bones it could be seen that the last of the two buried there, found in an attitude that was quite undisturbed, had been interred there before the first one had quite decomposed and that its limbs had been very brutally parted from the trunk and pushed aside to make room in the coffin. Head and trunk were pressed down in the foot end of the coffin, where the skull lay on top of the pelvis of the later skeleton, the backbone and

Table 6. Grave type by sites.

Site	Coffin shroud (1)	Cloth, grave (2)	Stone covered (3)	Stone data (4)	No (5)	Total
E1	0	1	0	0	0	1
E23	0	0	0	0	5	5
E29a	10	0	1	2	137	150
E47	0	1	0	0	12	13
E66	0	0	0	0	6	6
E111	0	17	0	0	6	23
E149	0	0	0	0	52	52
W7	0	1	0	0	10	11
W51	0	0	0	0	190	190
Total	10	20	1	2	418	451

pelvis under its legs, which for this reason were bent at the knees. Arms and legs had, on the other hand, been pulled off and lay in the upper, northwest corner of the coffin; as the small bones of hands and feet had accompanied them, it may be concluded that the flesh must still have been on the bones when the grave was disturbed" (Nørlund 1930: 64). More doubtful is the case of Gudveg's coffin at E111 Herjolfsnes, where Nørlund found "in two places a yellowish substance which, taught by experience, we concluded to be brain-substance, thus inferring...that there had been two corpses in the coffin" (Nørlund 1924: 62). Nørlund is probably describing adipocere, and while it is well known that brain matter can decompose to form this substance (Tkocz et al. 1979), so may all fatty tissues, including subcutaneous fat (Simonsen 1989: 60; Micozzi 1991: 11). So Nørlund might well have been looking at the remains of one person.

The assumption that lidless coffins mean re-use of the coffin, as stated by Nørlund (Nørlund 1924: 72), is however contested. It seems that lidless coffins are frequently found (Kieffer-Olsen 1993: 140). Indeed, coffins can be found without proper sides, or, as Nørlund himself found at E111 Herjolfsnes, two coffins can be found side by side, with the side of one coffin also serving as a side for the other. Nørlund also found a bottomless coffin. Basically, coffins were not made for transportation as they are now, but were built directly on-site in the grave (also noted by Nørlund 1924: 80), so these variations were possible (Kieffer-Olsen 1993: 139). While this custom is not exclusive to Greenland, one cannot help speculating whether a shortage of wood played a role for the Norse settlers.

Probably the most common type of interment in Norse Greenland was simply in a shroud or cloth. This type of burial has been described for virtually all identified Norse cemeteries, most spectacularly at E111 Herjolfsnes, where many complete pieces of clothing were secured. The clothes, many used, mended and even threadbare, seem to have been everyday Norse clothing (Nørlund 1924: 91). Nørlund suggested that shrouds or cloth could be a substitute for a coffin, and that a coffin grave was probably preferred by "those who could afford it" (Nørlund 1924: 60). In support of this, he also noted that the coffin burials were placed close to the church, the most coveted burial place (see next chapter), whereas the "cloth" burials were more abundant in the periphery. Similar observations were made by Krogh at E29a Thjodhilde's Church, i.e. that most coffin burials were close to the church. Unfortunately, there is no skeletal material from the coffins at E111 Herjolfsnes, as the wooden coffins were in some way detrimental to conservation (Albrethsen 1972). However, analyses for social differentiation can be attempted for E29a Thjodhilde's Church, where both grave types exist. It is generally assumed that coffin burials represent high social status (Nørlund 1924; Krogh 1982; Albrethsen 1972). The anthropological results may in fact support this: as indicated above, the coffin burials at E29a Thjodhilde's Church were mostly of older males. There was also a higher frequency of degenerative changes, even after adjustment for age groups, and it has been proposed, perhaps somewhat paradoxically, that higher frequencies of pathologies reflect better living conditions (this issue is discussed in the chapter on palaeopathology). However, the skeletons from the coffin burials were smaller in all measured dimensions.

According to Kieffer-Olsen's observations on burial practices in the Danish medieval period, coffin graves, either wooden or stone-set, seem most abundant in early medieval times, while burials without coffins, i.e. in shrouds or cloth, became predominant in the later periods (Kieffer-Olsen 1993).

Grave goods and artifacts

The terms grave goods and artifacts are used for all non-human material found in the graves, excluding shrouds, cloth and coffins.

Wooden crosses were found in abundance at E111 Herjolfsnes, although only three could be linked to skeletal material (cf. Table 7). Nørlund observed that such wooden crosses, while widely used in France and Britain as late as the very late Middle Ages, had not yet been found in Scandinavia (Nørlund 1924: 64).

Items like rings (Nørlund 1936: 69), a weaver's knife (Nørlund 1924: 68), presumed ear beads (Krogh 1982: 43), a bear's tooth (probably a charm) and copper pins (probably related to an item of clothing) (Nørlund 1924: 68) have also been found. In one grave at E111 Herjolfsnes the pommel of a dagger was found, and in the same grave, under the head, an oval box, made of whalebone and deal, containing a yellowish mass, pronounced by professor Bille Gram to be animal tissue and dried blood (Nørlund 1924: 68). Nørlund then ventured that it could only have been be a box of food, intended for the voyage of the deceased person. A special case concerns the Bishop's grave at E47 Gardar, containing a crozier and a ring. This is the one case where grave goods can be said to denote social position and even a social function.

The kind of grave goods commonly found in late medieval interments, like pilgrim shells and stones, swords, seals and rosaries (Kieffer-Olsen 1993; Gejvall 1960) have not been found at all in Norse Greenland.

However, as in other European countries, the Norsemen did make use of charcoal in the graves. Several reasons for using charcoal have been proposed: either that it was a direct element in the liturgy of the burial, symbolizing cleansing; or that it marked off the grave (Madsen 1990, 122); or, more practically, that it absorbed humidity, for example to keep the grave dry until the deceased had been placed in it (Kieffer-Olsen 1993: 166).

Conclusion on burial practices

No Norse Greenlandic skeletal material recovered hitherto can be associated with pagan burial customs. Norse skeletal remains were found outside known churchyards in six cases. Two cases were skeletal material found in farm buildings, two were found in middens, and in two cases the exact context of the find was not given. It does seem incontestable that the two "bone-bundles" and the mass grave at E29a Thjodhildes Church represent secondary burials. There is no evidence of other secondary burials in the other churchyards.

In view of the traits related to the individual graves, namely orientation, arm positions, grave type and grave goods, the Greenland Norse burial practices seem to accord very well with other Scandinavian Christian traditions. No skeletons lying in other orientations than the usual EW were found (apart from secondary burials and disturbed graves). The arm positions reflect the chronological development described for other medieval grave sites. Although the data are scanty, the arm positions accord with radiocarbon analyses when we use Kieffer-Olsen's "time schedule". This may also indicate the general and rapid dissemination of burial customs from Scandinavia to Greenland.

While stone graves and stone-set graves are uncommon, the use of wooden coffins probably reflects social stratifications in the Greenland Norse society, although the skeletal material is not comprehensive enough for detailed analyses.

Table 7. Artifacts and gravegoods by site.

Site	crucifixes (1)	Bishop (2)	weapons (3)	none recorded (4)	N
E1	0	0	0	1	1
E23	0	0	0	5	5
E29a	0	0	1	149	150
E47	0	1	0	12	13
E66	0	0	0	6	6
E111	1	0	0	22	23
E147	0	0	0	52	52
W7	0	0	0	11	11
W51	2	0	0	188	190
Total	3	1	1	449	451

Burial patterns and churchyard topography

While the previous chapter dealt with features related to the individual graves, this chapter attempts to analyse the burial practices at the level of the whole churchyard; that is, the location of graves in the cemetery, evidence of gender and age differentiation, and of social stratification and kinship.

All tests of intercemetery and intracemetery differences used the Mann-Whitney non-parametric U-test and Fischer's Exact Test.

Horizontal stratigraphy

The horizontal stratigraphy was analysed by matching the place of interment with radiocarbon analysis results. The radiocarbon results have been discussed in a previous chapter. At E29a Thjodhilde's Church, late and early burials can be close to the church or at the periphery of the cemetery. At E111 Herjolfsnes all the dated individuals lay close to one another in a stratigraphical relationship. The datings indicated that the burials could have been almost synchronous. The specimens all lay at the very edge of the churchyard, although to the east. This was also true of the dated cases from W51 Sandnes. All the individuals were within such a close range that they are likely to have been interred at the same time. At E149 Narsarsuaq, all four dated individuals (three from the north side and one from the south side) were buried within a limited timespan (about 1322-1404 AD). There were fewer datings from the other churchyards, but they all show limited timespans, i.e. most burials were very close to one another in time.

Several principles have been proposed for interpreting "horizontal stratigraphy", i.e. the chronology of relationships among interments in different areas of the churchyard. A "westward movement" from early interments near the east end of the church to late interments farther west, was suggested for Westerhus (an early medieval cemetery in Sweden), although this hypothesis was later abandoned when radiocarbon analysis results became available (Gejvall 1960; Gejvall 1968). A centrifugal pattern, i.e. early interments close to the church and later interments towards the periphery, has also been suggested (Nilsson 1989, cit. in Kieffer-Olsen 1993). It is generally assumed that since burial close to the church, indeed close to the chancel, was the most coveted type of interment, these positions would be filled first. Later interments would then be closer to the periphery. In his analyses of eight medieval cemeteries, Kieffer-Olsen (1993) was not able to arrive at any firm conclusions about "horizontal stratigraphy".

At E29a Thjodhilde's Church the results seem to contradict the hypothesis of centrifugal burials, since the datings do not show such a pattern. The datings from W51 Sandnes may indicate a westward movement. The burials, all from the west part, date to about 1300-1400 AD, and if it is assumed that the Western Settlement was abandoned in the late 14th century, these would be among the last burials. For W51 Sandnes, however, other considerations may play a role: the sea apparently forced the inhabitants to move the cemetery farther inland (thereby also displacing it westward). That soil conditions play a role was also demonstrated at E47 Gardar, where the archaeologists did not find any burials at all in the western part of the cemetery. This was due to soil conditions, as a layer of shingle was encountered just a few centimetres down. Fill had probably been used in other parts of the cemetery (Nørlund 1930: 58). This, of course, completely confuses any horizontal analysis, and care must be taken to evaluate items such as soil conditions, physical barriers, etc., in churchyard topography (Gejvall 1960).

Radiocarbon analyses of specimens in stratigraphical relationships – that is, where the position of the skeletons could be defined in relation to one another, had somewhat surprising results. In all cases, the datings were almost synchronous. This means that the individuals could have died within a very short timespan.

Assuming an overall churchyard population of some 25,000 individuals over a 450-year period (see the chapter on demography), this equals about 55 deaths per year, and means that at the community or parish church level, burials could not have been all that common (if we assume an even distribution of deaths) – perhaps only 2-4 per church per year. The radiocarbon analyses carried out in this study showed that the sampled individuals at W51 Sandnes, E111 Herjolfsnes and E149 Narsarsuaq, all of whom had stratigraphical relationships, could very well have been interred at the same time. The results could be consistent with a pattern of utilization for the churchyard where a certain part was "filled up" over a few years, after which the gravediggers moved on to an adjacent part.

Gender distribution

The gender distribution was analysed by plotting assigned sex against burial coordinates for the different churchyards (shown for E29a Thjodhilde's Church in Fig. 34). Table 8 is an overview of the sex distribution for the total sample by location north and south of the churches (dividing lines drawn through middle of church structure). Table 9 shows gender by side, but excludes the E29a Thjodhilde's Church material, since it accounted for the vast majority of the material and since this site very clearly had gender separation (Fig. 34). Table 9 is an overview of the interment sides at all the other sites. This shows a female preponderance on the south side, where females numbered 10 as against 5 males (Table 9).

The figures are so small and incomplete that any further analysis would be rash. Although there seems to be a preponderance of females on the north side at E111 Herjolfsnes (9 females: 4 males), these frequencies cannot be compared with those for the unexcavated south side.

The gender differentiation at E29a Thjodhilde's Church (Fig. 33) yields a significant difference ($z = -2.61$, $p = 0.009$), even when we have corrected for the mass grave ($z = -2.67$, $p = 0.008$).

Cinthio reported clear gender segregation in 65% of the burials in the medieval cemetery at Löddeköping in Sweden (Cinthio 1993: 271). Kieffer-Olsen also demonstrated gender segregation in seven of eight medieval cemeteries studied (Kieffer-Olsen 1993: 118). He concluded that gender segregation presumably ended around 1300 AD, and probably at a later date in northern Scandinavia. Gender segregation has also been described for an early medieval cemetery in Bornholm (Grødby). This cemetery is similar in appearance and dating to E29a Thjodhilde's Church (Wagnkilde, pers. comm.). The cemetery at Skeljastadir in Iceland, also presumably very early, shows a slightly different pattern of sex segregation: females to the north, males to the east, and an equal distribution of males and females to the south (Steffensen 1943: 229). However, in none of the churchyards which did have gender segregation was the segregation complete. It has been proposed that social stratification may be the cause of this (see below) (Cinthio 1993: 271; Kieffer-Olsen 1993: 199) – that is, social differences may have overridden gender segregation (Sælebakke 1986).

Child burial distribution

Child burials were identified by plotting age groups against burial coordinates for each churchyard. The distribution seems to be rather random, with the possible exception of the four burials by the west gable at E111 Herjolfsnes. Although there seems to be a preponderance of subadults south of the southeast corner of the church, these lie close to adults (there were well preserved adult-sized coffins). Three foetuses were found at E29a Thjodhilde's Church. Two were found near the east gable of the church, while the location of the third was not recorded.

There are no indications of child burial clusters in the Norse churchyards when we look at the skeletal material in isolation. However, when we take other archaeological data into account, there does seem to be clustering around the east gable at E29a Thjodhilde's Church, where, according to Krogh (1982), there were 15 infant burials. Such clusters have not been noted at any of the other Norse sites, and may indicate an early custom which was abandoned later. The burial of infants in clusters, usually around the east gable, has been well documented by other Scandinavian churchyard excavations: at Sct. Drotten in Lund (Blomquist & Mårtensson 1963: 48); at Øm Kloster (Krogh & Voss 1961: 13); and in Danish medieval cemeteries (Kieffer-Olsen 1993: 92). The proper burial of children, as opposed to earlier pagan Viking practices, was strongly enforced by the Church (Roesdahl 1991).

This is further supported by the fact that foetuses were also buried, as demonstrated at E29a Thjodhilde's Church. Indeed, like the secondary burials, this attests to the overwhelming importance of being buried properly.

Table 8. Number of interments north and south of church by sex (unknown sex includes subadults). All sites.

Sex	North (n)	South (n)	total (n)
females	99	19	118
males	49	51	100
unknown sex	141	27	168
Total	289	97	3866

Table 9. Number of interment north and south of church by sex (unknown sex includes subadults), excluding the material from E29a Thjodhildes Church.

Sex	North (n)	South (n)	total (n)
females	73	10	83
males	43	5	48
unknown sex	125	4	129
Total	241	19	260

Burials inside the church

Anthropological material recovered from inside church structures is sparse, and is limited to E47 Gardar, where five skeletons (two males, one female, and two of unknown sex) were retrieved from the north chapel. While they provide too little material for use in comparative analyses, they are nonetheless very interesting finds (as already mentioned in the previous chapters), as they contribute to our understanding of burial practices in general.

Skeletal material was only available from five individuals found inside a church structure, all from the north chapel at E47 Gardar, among them the Bishop. If nothing else, this supports the hypothesis that individuals with high social status were buried inside the church.

However, when we look at the archaeological evidence, we also find burials inside the church structure at three other sites: E149 Narsarsuaq (n = 20), E66 Undir Høfdi (n = 7) and E111 Herjolfsnes (n = 2), as well as a total of 16 burials at E47 Gardar.

The two graves inside the church at E111 Herjolfsnes were both in the nave. At E66 Undir Høfdi seven crania were found in the west end of the nave (Holm 1883).

The greatest number of in-church burials was found at

E149 Narsarsuaq. In fact, most of the floor was filled with graves. Vebæk found 20 in all (Vebæk 1991: 28). Vebæk noticed that even though the graves were placed very close to one another, there were no disturbed burials, indicating that the graves had been marked carefully (Vebæk 1991: 29). As already noted in the chapter on arm positions, those lying farthest to the east had their arms at the pelvic region or hips, whereas the skeletons farthest to the west had crossed arms, perhaps indicating a chronological sequence of interment. Although no skeletal material could be secured, Vebæk did pronounce one of the skeletons to be an infant (Vebæk 1991: 31). Vebæk believed that in addition to the nuns, people from the parish could have been buried inside the church.

It seems natural to suppose that the most prestigious burial place would be inside the cathedral (E47 Gardar), followed by a monastery or convent (E149 Narsarsuaq and E105 Klostr), then inside a parish church, and finally in the churchyard (with sub-groups closer or farther away from the church building).

Burials inside a church seem to have been reserved for the clerics – the priest, the monks and nuns, and, of course, bishops and abbots (Kieffer-Olsen 1993), although a synod in Mainz, Germany, in 813 AD also allowed the lay faithful to be buried inside the church (Madsen 1990: 116). It has been hypothesized that the presence of a non-cleric inside the church structure indicates that it is the grave of the chieftain-farmer who founded, built or maintained the church (Stiesdal 1983; Byock 1993; Arneborg 1990). This was discussed in the introduction in the section on the Christianization of Greenland, and it may indicate the way the wealthy landowners were converted to Christianity: i.e. that they were simply enrolled as clerics in their own churches, and consequently were also granted the honour of being buried inside the church.

In Denmark, Kieffer-Olsen concluded that burials inside a church only became common after c. 1200 AD and then mainly for kings and bishops (Kieffer-Olsen 1993: 121). However, although there was a general rule that people were not to be buried inside a church, exemptions could be granted if the deceased was a person of high standing (Nørlund 1929a: 65; Kieffer-Olsen 1993).

In view of these factors, the burial of the Bishop in the northern chapel at E47 makes sense, but the presence of a female in the chapel alongside a male and below the Bishop made Bröste et al. speculate that celibacy was perhaps not observed by the clerics in Greenland (Bröste et al. 1941: 7). However, it may be a case of the above-mentioned type, where the family who initially founded and owned the church at E47 Gardar was buried inside the church.

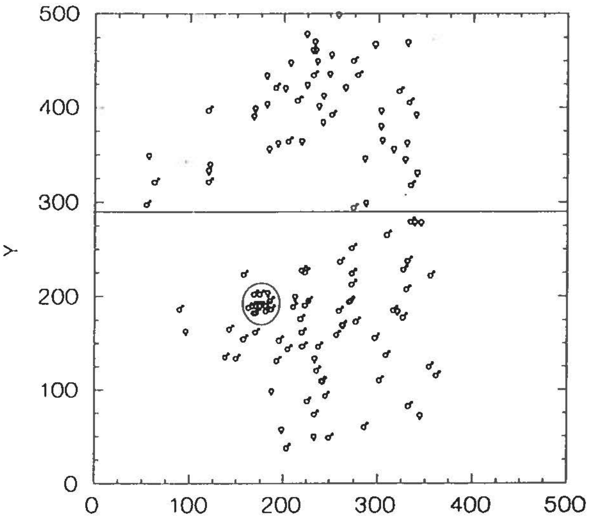


Fig. 34. Plot of burials at E29a Thjodhildes Church by gender. Horizontal line indicates demarcation between N and S (cf. text). Mass grave indicated by circle.

The high number of in-church burials in Greenland may then indicate differences in the power of the church: in Greenland (and probably in Iceland) it was necessary to solicit the good will of the wealthy and powerful, especially since there was no one person, for example a king, with the supreme authority to enforce the Papal will and the church laws (Arneborg 1991). Indeed, the church system in Greenland and Iceland has been termed the Eigenkirche or "own church" system (Byock 1993); a system which gave the church-owner control over the church and its revenues (Arneborg 1993). The burial pattern described here might then be evidence of a Greenland Norse society that was hierarchical (with the wealthy buried inside the churches), but without any strong presence of the Roman church (which would presumably have limited in-church burials to high-standing clerics), as described by Arneborg (1991 & 1993).

Burials in a churchyard at a point close to the church building might of course later be incorporated into the church if it was enlarged. Several burials at E47 Gardar and E111 Herjolfsnes were probably later covered by church walls, and the seven crania found by Holm at E66 Undir Høfdi were probably incorporated this way (though their exact original location is not known).

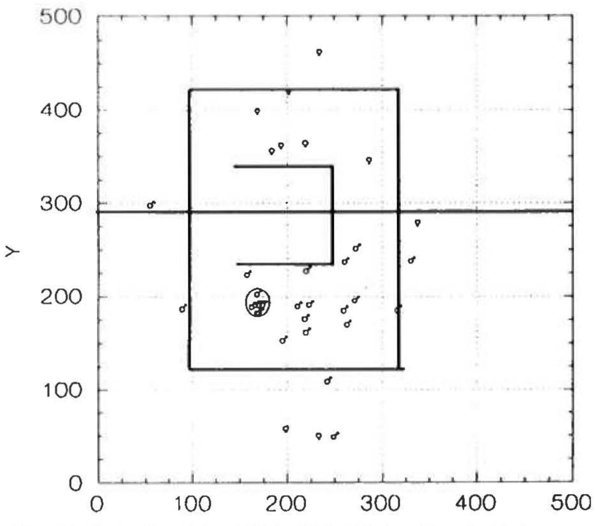


Fig. 35. Plot of burials at E29a Thjodhildes Church. Only cases were the femoral head diameter was obtainable are displayed. The approximate position of the church is shown with thick line. The horizontal thick line shows the dividing line between N and S (cf. text). The thickly drawn box indicates the demarcation between central and periferal burials (cf. text). The mass grave (not included in the analysis) is indicated by a circle.

Table 10. Comparison of maximum diameter of femoral head between males and females, north and south of church respectively at E29a Thjodhildes Church (cf. fig. 26).

	North		South		
	N	mean	N	mean	p
Males	1	46.62	17	47.24	-
Females	7	39.82	3	43.01	0.30

Table 11. Analyses of differences in femoral head diameter between peripherally and centrally buried at Thjodhildes Church (cf. fig. 26).

	Central		Peripheral		
	N	mean	N	mean	p
Females	6	41.11	4	40.08	1.00
Males	13	47.84	5	46.62	0.26

Family burials

It was not possible to analyse all the material for kinship. Instead, probable sites of family interments were identified by plotting burial location and examining cases where burials seemed "lumped" together. Such "lumping" together of burials was found at the following sites: W51 Sandnes, where two adults were buried with two subadults; the east and west areas of the E111 Herjolfsnes churchyard; the mass grave at E29a Thjodhilde's Church; the south and north areas at E149 Narsarsuaq; and the north chapel at E47 Gardar.

The methods included comparison of metric and non-metric data and sinus morphology (Szilvassy et al. 1987; Szilvassy 1986; Kaufmann 1986; cf. the following chapters). Only the mass grave at E29a Thjodhilde's Church differed somewhat from the rest of the churchyard, and may thus represent a burial of related individuals. There were no differences at any of the other sites selected.

In a few cases, the circumstances of burials had originally led to the supposition that they were family burials. This is probably best demonstrated by W51 Sandnes, where there was a group consisting of two adults, side by side, on top of whom lay two infants (Roussell 1936: 17) (see Fig. 17). However, this study found both the adult skeletons to be female. This does not mean of course that there was no family relationship. It is, however, extremely difficult to establish kinship on the basis of anthropological analyses. Certain metric and non-metric traits may be used, but at best one can arrive at a probability of kinship.

Analysis for kinship was attempted by identifying areas with "lumping" of burials. The available skeletal material was then isolated and analysed. However, proper analysis was only feasible for the mass grave at E29a Thjodhilde's Church, and the results were inconclusive, although several of the people interred in the mass grave might have been kin (cf. the chapter on non-metric data).

Social stratification

In a few cases the circumstances of burial seem to indicate that the interred individual was of high standing in the community. This was the case for the burials in the north chapel at E47 Gardar, and for the coffin burials at E29a Thjodhilde's Church. In the latter case, it was shown that the skeletons interred in coffins differed somewhat from the "coffinless" burials, but not in any definitive way (see the previous chapter).

Analysis for social stratification as reflected by burial topography was feasible only for E29a Thjodhilde's Church. It has been proposed that the south side was most desirable (because of the sun); so individuals with high social standing would be buried there. Alternatively, the closer to the altar (and hence the church) the better; that is, individuals with high social status were buried closer to the church. Two methods were used in the analysis: comparison of femoral head diameters of males and females from the north as against the south side; and central as against peripheral burials. The femoral head diameter was used because this was the most frequently obtainable postcranial measure. It was hoped that results relating to otitis media could also be used in the analyses of social stratification, but too few crania were reasonably intact for this analysis. The dividing-line for north and south burials was set arbitrarily at Y = 290 (Fig. 35). For the division between central and peripheral burials, the boundary was arbitrarily defined as halfway between the church and the outermost burial on all four sides (cf. Fig. 35; central area within 100 < X < 325 and 125 < Y < 425). The individuals from the mass grave were excluded from the analyses described below.

At E29a Thjodhilde's Church, males and females from the north and south of the church were compared first (Table 10). The females did show a tendency towards larger dimensions on the south side, although not a significant one (95% C.I. on median difference: -7.58 – 2.47). However, the sample size is too small to draw any conclusions.

Secondly, males and females were compared in terms of central and peripheral location (Table 11). Table 11 shows a tendency towards larger dimensions for centrally-buried individuals of both sexes (95% C.I. on median difference; females: -6.28 -4.72; males: -5.43 -1.32). The differences are not statistically significant.

There was no difference in age distribution between the females (p = 1.000) and males (p = 0.659) buried north and south of the church respectively.

In anthropological analyses for social standing, one implicitly assumes that individuals of high social standing are taller and sturdier than individuals of lower social standing. This is because high standing meant better food and living conditions, and children who grew up in much better conditions and ultimately achieved higher stature, etc. (Andersen 1968; Stini 1972; Harrison et al. 1988). However, this is probably oversimplistic, as the potential for achieving certain bodily dimensions is partly inherited. Variation in stature or other skeletal dimensions, as found in a graveyard population, is thus not solely determined by social factors (Stini 1972; Werdelin 1985). Indeed, anthropological data may conflict with archaeological data, as for example in the coffin burials at E29a Thjodhilde's Church, where the individuals were of shorter stature than the overall average, yet the coffin burial could be assumed to indicate higher social status. However, social standing as inferred from skeletal dimensions is the only method available in this study. In a following section various methods of assessing environmental stress, general health, etc., are discussed. Unfortunately, none of these other methods could be used in this part of the study because of the smallness of the samples.

On the assumption that social stratification took precedence over gender segregation, and that social standing is reflected by skeletal dimensions, as observed at Löddeköping (Cinthio 1993: 217), such an analysis was attempted for E29a Thjodhilde's Church. All "wrongly" placed skeletons, i.e. male skeletons to the north and female skeletons to the south, were compared with the others of the same sex, and, although the analysis was based on only one variable (femoral head diameter), there did seem to be a tendency for females buried in the southern part to have larger femoral heads than those to the north. That the north side of the church was not the best place to buried is however uncertain. There may have been both chronological and local variations in customs (Gejvall 1960).

Generally it is assumed that burial close to the altar, and hence near the east end of the church, was most desirable (Gejvall 1960). The altar was not only the centre for the liturgical practices, but also the place where the precious relics of saints and holy men were placed (Madsen 1990: 116). After this, burial as close as possible to the church was favoured. The analysis for dimensional differences between centrally-buried and peripherally-buried individuals does indeed show such a trend, although it is not statistically significant.

Conclusion on churchyard topography and burial distribution

No general picture of horizontal stratification emerged for the Norse churchyards. It would seem that soil conditions and physical barriers (e.g. changes in sea level followed by coastal erosion) played a major role in determining the layout of the churchyard. Radiocarbon analyses of several individuals at E29a Thjodhilde's Church failed to reveal any temporal stratification. However, it is difficult to control the many potentially confusing factors, such as social stratigraphy, which may have been practiced in parallel with chronological developments in the use of the churchyard. Furthermore, because of the small size of E29a Thjodhilde's Church, even if there was a general horizontal stratigraphy, it may not have extended over a timespan long enough to indicate significant chronological differences.

The Norse inhabitants of Greenland did segregate by gender at E29a Thjodhilde's Church, as has been found at other early Scandinavian cemeteries (e.g. Skeljasdattir in Iceland and Westerhus in Sweden). The segregation was not complete, however, presumably for social reasons. The custom is not evident at any of the other later Norse churchyards, which suggests that it was abandoned, a trend found in other Scandinavian cemeteries.

Segregation by age, i.e. the burial of infants and stillborn babies in a special area, was observed at E29a Thjodhilde's Church. This custom was also widely practiced in Scandinavia.

The data on burial location suggests that it was possible for non-clerics to be buried inside a church, but that this was practiced mainly in the biggest, central churches, and thus probably represents burials of high-ranking individuals. The find of a male and female in the north chapel at E47 Gardar, below the Bishop, may tell us something about the mode of conversion and the church system in Greenland (and Iceland).

Nothing conclusive could be said about family burials. Quite apart from the scarcity of material, the methods for these studies, which employ metrics and non-metrics, are simply too imprecise and inadequate. Studies of kinship could presumably be done with DNA analyses.

Finally, it seems that social stratification was reflected in burials, although no clear picture emerges. Very high-ranking persons could probably be buried inside the church near the altar. Only the early church, E29a Thjodhilde's Church, could be used in an analysis of the general churchyard topography, and it may reflect early customs which are not representative of practices at the other cemeteries. Furthermore, E29a Thjodhilde's Church had gender segregation, which may have confounded the social differentiation to some extent. The one pattern which emerges is that centrally-buried individuals have larger skeletal dimensions than peripherally-buried ones. However, skeletal dimensions may not be an adequate social indicator: males buried in coffins were generally shorter than the male average.

General conclusion

Generally, the Greenland Norse burial practices and churchyard topography conform with what we know about Scandinavia in general. Norse Greenland thus appears to have been well integrated with the rest of the medieval European community. Burial customs, for example arm positions and gender segregation, seem to have changed in the same ways as observed in Scandinavia. All the same, Iceland and Greenland had a church system which was much less centralized than those of the other countries: the so-called "own church" system, which may directly reflect the special "colonial" way of life that was instituted in these two countries by the Norsemen. Specifically, this system meant that the major landowners owned the churches. The many "in-church" burials which could include females and children could be seen as evidence of this.

It is unfortunate that only one churchyard has been fully excavated. While it has yielded much data, it still remains to be seen how representative E29a Thjodhilde's Church is, or whether it was a temporary church only used in the earliest settlement period. Much could be learned if a later church and churchyard, such as W7 Anavik, could be excavated in toto.

Finally, there remain all the small circular churchyards found by the farms. Do these represent early churches or local chapels? Again, none of these churches and churchyards has been fully excavated. Yet they could provide us with much information om the church system, and thus the society, of Norse Greenland.

The physical anthropology of the Norse

...the Greenland [Norse] sample is infamous in anthropological literature as physically degenerate...

C.L. Hanson, 1992

Anthropometry

One viable way of testing for differences between and within skeletal populations is to quantify the differences using morphometric analyses (Knussman 1988). There are definite patterns of size and shape variation among the peoples of the world (Howells 1973), and statistical analysis of cranial and postcranial variables is a classic method of study in physical anthropology. The question then arises of which variables one should use. Elaborate sets of measuring points have been defined (one anthropologist, Von Török, suggested that over 5,000 measurements should be taken on one skull (Howells 1969)), and vast quantities of cranial data used to be compiled (White 1991). This was mainly because anthropological analyses were typological analyses; the determination of "race" and various "types" was paramount if one was to compare individuals and populations (Howells 1969). Metric analyses still play a major role in physical anthropology (White 1991), although the emphasis is now on selecting the measurements that carry most information for the specific hypothesis to be tested (Howells 1969).

The Norse skeletal remains were measured for the purposes of various statistical analyses, the aims being to test for (1) synchronic morphometric variations, and (2) possible diachronic morphometric variations. In addition, (3) stature during life was estimated when applicable; and finally, (4) the Norse material was tested for Eskimo admixture.

Methodology

Ideally, to select the variables carrying most information for the solution of a given problem, a subsample of specimens could be measured comprehensively. Stepwise discriminant analysis, for example, or multivariate analysis of variance (MANOVA) would help us identify the variables with the highest discriminatory values and with the greatest inter-individual variances (Van Vark & Schaafsma 1992). These measures could then be used for the given population. Such an approach selects the most suitable variables for the study of a given population. Unfortunately, the Norse sample size is too small to permit this approach.

Instead, measurements were taken according to the guidelines given by Howells, whereby the cranial variables which have generally been shown to carry most information are measured. This excludes, among other measurements, "circumferences or arcs, [and] cranial capacity, since these give no information as to shape but only as to size" (Howells 1957). Linear variables were measured, covering the basic dimensions: width, height and length of the neurocranium, the facial skeleton and the mandible. This approach was of course less ideal, since a battery of measurements is used, and they are not all necessarily pertinent to the given population problem. For example, Howells selected these measurements for his attempt to describe population variation at the world level, and we might ask how suitable they are for describing population variations in a small geographic area like the west coast of Greenland. However, no better approach could be established at this time. The measurements used are summarized in Table 12. Finally, the various measurements were analysed with principal component analysis to see if some of the variables characterized the material better than others.

Postcranial measurements were taken on a more tentative basis. At the beginning of the study, it was not known how many postcranial elements would be present, much less how many would be measurable. They were included in case we obtained a sufficient number of specimens for analyses of stature during life and bodily proportions. Except for long bone lengths, all measurements were

Table 12. Measurements used (M-numbers according to Martin).

Skeletal element	Measure
Cranium	M5 Basion – nasion length M8 Maximal breadth of cranium M9 Minimal frontal breadth of cranium M11 Biauricular breadth M17 Basion – bregma length M40 Basion – prosthion length M45 Bizygomatic breadth M46 Maxillar breadth M51 Orbital breadth M52 Orbital height M54 Nasal breadth M55 Nasal height M57 Minimum nasal breadth M62 Palatal length M63 Palatal breadth M69 Mental height M70 Height of ramus M71 Minimum breadth of ramus
Humerus	M1 Maximal length M4 Bicondylar breadth M5 Maximal diameter M6 Minimum diameter
Radius	M1 Maximal length
Ulna	M1 Maximal length
Femur	M1 Maximal length M7 Midtransveral diameter M7 Midsaggital diameter M19 Caput diameter M21 Bicondylar breadth
Tibia	M1 Maximal length M4 Saggital diameter M5 Transversal diameter

done with electronic calipers interfaced to a computer (Lynnerup & Lynnerup 1993).

Descriptive statistics and variances between Early Eastern (EE), Late Eastern (LE) and Western Settlement (W) material (see below) were obtained for each measurement by assessing box plots with 95% confidence intervals as notches by site and sex (Wilson 1993; Wilkinson 1990a) and with Mann-Whitney non-parametric U-tests. Non-parametric analysis was chosen because a normality assumption would probably be unjustified and non-parametric analyses have the benefit of not assuming so-called normal distribution or "central tendency" (Hursh 1976). All non-parametric analyses were carried out using the NPAR module in the SYSTAT statistical package (Wilkinson 1990b).

Each variable was analysed separately. Multivariate analyses could conceivably "integrate" the variables into a single test, but this would require complete specimens (Kronborg & Skovgaard 1990). With few complete specimens, the results would be extremely vulnerable, and there would be no real controls (Hursh 1976). Instead, a principal component analysis (PCA) was carried out, in order to identify combinations of variables that characterized the individuals better than others. Such combinations would then be preferable in subsequent comparisons. The PCA was carried out using the SAS PROC PRINCOMP procedure (SAS 1985). Variables were first transformed to Z-scores (by sex), and missing variables were given a zero Z-score. This allowed us to include all cases, although with some loss of precision (since when one uses a Z-score of zero, the missing values are replaced by a mean calculated from the available specimens).

Racial affinity was assessed by discriminant analysis, using five variables (maximum length and width, basion-bregma and basion-nasion height and minimal frontal width). The available Norse crania were scored in one of four groups: male and female medieval Danish, and male and female pre-contact Eskimo. The former group of crania came from a medieval cemetery at Randers (Mikkelsen 1990), where this author participated in the excavations and the anthropological analyses (Frøhlich et al. 1994). The latter group of crania was from the south-west coast of Greenland. The group has also been studied and measured by the author (Frøhlich & Lynnerup, manuscript on file). The statistical analysis used the SYSTAT MGLH (multivariate general linear hypothesis) module. This module first estimates a model and then does hypothesis testing (Wilkinson 1990b). The MGLH procedure yields canonical scores and a distance statistic (Malahanobis' D2) upon which group allocation probabilities are calculated. The model was estimated only on the Eskimo and Danish crania. The reason for this approach was that even if there was a high degree of admixture, a discriminatory model might still easily discriminate the two racial groups, i.e. there would be no real controls, as there are no "pure" Norse specimens to use for comparison. Forcing the Norse specimens into either the Eskimo or Randers group meant that crania which might display both European and Eskimoid features could be better evaluated.

After this analysis another discriminatory model was set up to classify a single skull as having Norse or Eskimo racial affiliations.

Material

The following groups were created prior to analysis on the basis of the provenance and dating of the material (cf. previous chapters): Early Eastern Settlement (EE), comprising the material from E29a Thjodhilde's Church; 2) Western Settlement (W) comprising the material from W51 Sandnes and W7 Anavik; and 3) Late Eastern Settlement (LE) comprising the material from E111 Herjolfsnes and E149 Narsarsuaq.

Additionally, the skull from E140 Tasersuaq was included in the discriminatory test in order to classify it as either Eskimo or Norse. Forty Norse crania could be included in the discriminatory analyses.

The Danish material used in the discriminatory analyses consisted of 17 females and 15 males, while the Eskimo group consisted of 35 females and 24 males (their provenance has been described above).

All specimens included in the anthropometric analyses were adults.

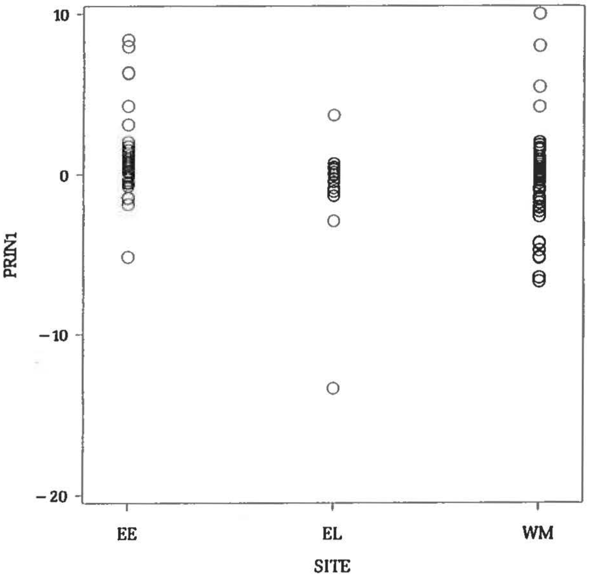


Fig. 36. Plot of eigen-values scaled by sex (EE: East Early material, EL: East Late material, WM: West Middle material).

Results

Synchronic and diachronic variation

These analyses were carried out by comparing the Late Eastern Settlement material (LE) with the Western material (W) (see Appendices). Statistical significance was achieved only for one variable, palatal length, and only for males ($U = 40.00$, $p = 0.02$).

Box plots of all the variables revealed no consistent trends: the Late Eastern material was slightly smaller than the Western material with respect to some variables, and the opposite was the case for other variables. Likewise, there was no sex consistency in the directionality of the inter-site differences.

Early Eastern Settlement (EE) material was compared with Late Eastern Settlement (LE) material (see Appendices). Statistical significance was achieved for the following variables: palatal width (females and males) and oblique ramus height (males). Palatal width was greatest in the Late Eastern Settlement, for both sexes, while oblique ramus height was greatest for the Early Eastern Settlement.

The first principal component eigenvectors were very uniform (except for the minimum breadth of the nasal bones and the palatal width, which are considerably lower than the others), indicating that no single variable characterizes the individuals significantly better than others (fig. 36).

Stature

Although several variables were recorded on the largest long bones, only the maximum femoral length and the diameter of the femoral head could be studied in sufficient numbers to warrant further analyses. Stature was calculated by using two regression equations (Tables 13 and 14)

Discriminatory analyses

A first multivariate test was statistically significant ($p < 0.001$), and a model was subsequently produced. The model's correctness was evaluated by tabulating the actual as against the predicted group for the Randers and Eskimo material. The correct re-classification ranges from 71% (Eskimo males) to 82% (Randers males). In terms of racial affiliation alone, 87.5% (Randers) and 94.9% (Eskimo) were correctly re-classified.

The predicted group membership for the Norse crania is shown in Table 15. Two crania were assigned to the Eskimo female group, while all other Norse specimens were assigned to the Randers group.

Once the low degree of affinity between Norse and Eskimo specimens had been established, a new model was set up using the Norse and Eskimo specimens with only two variables: maximum width and length. This was done in order to assign the single skull found at E140

Table 13. Medians[1] for calculated living stature from femoral maximal length, a.m. Trotter & Gleser (see text), by sites.

Site	Males		Females	
	N	Stature	N	Stature
W7	1	168.51	1	156.61
W51	4	162.03	15	154.75
E29a	12	173.51	2	153.58
E47	4	168.27	1	160.56
E111	-	-	5	149.81
All sites	21	169.70	24	153.89

[1] The stature was calculated for each single individual, followed by the median. Trotter and Gleser assign a SE +/-3.72 to the estimate.

Table 14. Medians[2] for calculated stature from femoral maximal length, a.m. Boldsen (see text), by sites.

Site	Males		Females	
	N	Stature	N	Stature
W7	1	166.21	1	155.67
W51	4	159.34	15	153.78
E29a	12	171.50	2	152.58
E47	4	165.96	1	159.72
E111	-	-	5	148.72
All sites	21	167.47	24	152.89

[2] Boldsen does not specifically an SE or SD for his estimates, however, a SE in the magnitude of the one given by Trotter & Gleser may be assumed.

Tasersuaq to either the Eskimo or Norse group. The correct re-classification ranges from 23% (Norse males) to 75% (Norse females), reflecting the greater margin of error involved in using only two variables. However, in terms of racial affiliation alone, 88% (Eskimo) and 90% (Norse) were correctly re-classified.

In Fig. 37 the cranium from E140 Tasersuaq is clearly grouped among the Norse crania. Indeed, the cranium was classified in the Norse female group with a probability of 0.954.

Discussion

Some measurements were not used – primarily because their values were uncertain (Howells 1969), and secondly because they were impossible to record in the Norse material. Certain measurements could only be recorded in 10 to 20 per cent of all the cases (the minimum height of the mandibular ramus was the most obtainable measurement in 24.1% of the cases). While it would be possible to measure the bigonial and bicondylar breadths of the mandible in many cases, these measurements were re-

Table 15. Re-classification results from the discriminatory analysis for the Norse material to either Randers and Eskimo based on five cranial variables.

Predicted Group	Randers		Eskimo		N
	Males	Females	Males	Females	
Norse males	7	9	0	0	16
Females	0	22	0	2	24
N	7	31	0	2	40

jected because it was apparent that the mandible had been influenced by diagenetic changes. In several instances the condyles could not be made to articulate with the base of the cranium, although the fit of the maxillar and mandibular dentition proved that it was not a case of curatorial or excavation mismatching.

Previous studies on the variables which carry most information seem to point to general measurements of breadth, height and length, rather than arcs, circumferences and subtenses (Howells 1973). Similarly, Lombardi (1976) in a study of craniofacial and dental dimensions, found that measurements of cranial base breadth and length, palatal (malar) length and breadth and facial height, as well as mandibular measurements, could effectively account for most of the craniofacial variation. Thus, the variables selected in this study not only reflect a wish to give as much consideration as possible to these observations; they also reflect the pragmatic approach that is necessary, given the state of the Norse material.

It may be argued that other variables might have revealed differences among the Norse sub-populations. As noted above, the optimal way of selecting measurements would have been to do a pilot study and then choose the variables. This was not feasible in this study; nor would it be satisfactory to submit every single individual to a battery of measurements, as this increases the chance of mass significance and related statistical problems (see below). However, it would be surprising, given the uniformity of the basic cranial and facial dimensions, if there were other variables which per se would show highly significant variation. In this instance, it must be kept in mind that every individual was assessed morphologically (anthroposcopic examination), and no special variations in morphology were noted which could give rise to a hypothesis that a specific variable showed more variation than others.

Cranial and postcranial measurements have commonly been seen as relatively "objective" (i.e. they exhibit low observer variation because of the clear definition of the landmarks used and the stability of the bones). Consequently, measurements of intraobserver and interobserver variation and coefficients of variability are seldom found in older anthropological studies, although measurements and indices are often compared with researchers' data (some workers have in fact painstakingly measured everything twice and used the resultant mean value for their analyses (e.g. Gejvall 1960)). However, there can be great discrepancies: Utermohle and Zegura (1982) found quite significant interobserver and intraobserver variation in an analysis of Eskimo craniometric data, and it seems that interobserver error is ubiquitous even in the best of situations (Utermohle et al. 1983). For this reason, although published measurements existed for much of the Norse material, it was completely remeasured by the author to ensure consistency.

Generally, it is assumed that bones, once excavated and dried, are stable and consequently do not change over time. Yet it seems that factors such as humidity during storage may increase skull size (Albrecht 1983), as Utermohle et al. (1983: 89) also found: "there is clear evidence that certain craniometric dimensions do expand with increasing levels of relative humidity ...especially for untreated human crania and that these changes can be detected with millimeter units of measurement". Although very small, these variations should be noted. In this study, all anthropological material was stored in the same room in identical packaging without sealing. Most material (except for a few specimens) had been excavated at least 30 years ago, and was consequently thoroughly dried. Re-measurement of several randomly chosen crania after a one-year interval did not show variation.

Synchronic and diachronic variation

There was no statistically significant difference between the skeletal material from the Late Eastern (LE) and the Western Settlement (W), nor between the Early Eastern (EE) and the Late Eastern Settlement (LE). Generally, the variation between EE and LE does not exceed the variation between LE and W. Only one variable, the palatal breadth in the male group, showed a statistically significant difference; it was greatest in the LE group. This result has been ascribed to mass significance (Andersen 1987a), i.e. it is a chance finding. Another way of judging the many tests, following the Bonferoni inequality (Andersen 1987b), is to divide the selected level of significance by the number of tests performed. This new significance level is then used to evaluate the results. This means that a significance level of 0.0013 (= 0.05/38 cranial tests) should be used, and it is a significance level none of the tests achieves.

The principal component analysis does not indicate whether any variables characterize the individuals better than others. For two variables, the eigenvector value is rather low, indicating that the variables do not contribute much to the characterization of the individuals. These are palatal breadth and minimum breadth of nasal bone, and this should also be considered when evaluating the results of the tests for these variables (that is, the significant difference between the palatal breadth for EE and LE (males and females) and LE and W (males only)). Indeed, the median values and the eigenvector plot (see Fig. 36) only show a very slight tendency for values to diminish between EE and both LE and W. No trends can be discerned between W and LE.

It has previously been hypothesized that the Norsemen were subject to secular changes, resulting in smaller dimensions in both the cranial and the postcranial material. The first observations were based on the study of the E111 Herjolfsnes material, where Hansen (1924) concluded that there had been a "striking decrease...of the size of their skulls". Since many saw cranial size, and hence cranial capacity, as directly related to brain size, and brain size as directly related to mental capacity, this meant that the Norse "race" experienced a "reduction of the extent and capacity of intellectual life" (Hansen 1924: 434), ultimately paving the way for the Norse extinction. The linkage of mental capacity with brain size and cranial size has since been abandoned (e.g. Gould 1981). However, implicit in Hansen's conclusion is the idea that the Norsemen, at the beginning of the settlement period, were tall and powerfully built (e.g. "The vigorous Northern race that originally colonized Greenland" (Hansen 1924: 520)). The description is unfounded, and analyses of the stature of skeletons from various Danish prehistorical and historical periods (Bennike 1985, see below) indicate that the people of the Viking Age were smaller than later medieval populations. In this study, while the E111 Herjolfsnes material is definitely some of the dimensionally smallest material, the difference was not found to be significant. Other researchers (Fischer-Møller 1942; Bröste & Fischer-Møller 1941; Krogh 1982), have since proposed that the E111 Herjolfsnes material was badly damaged by diagenetic changes, and that any measurements or observations should be used with great caution. The Norse crania from W51 Sandnes and W7 were characterized as "somewhat smaller than the contemporary Norwegians" (Fischer-Møller 1942: 78), and Fischer-Møller attributed this either to environmental causes (comparing the Norse with the Iceland horse or the Shetland pony), or to "racial peculiarities" due to the probable isolation of the Norsemen (Fischer-Møller 1942: 79).

The first direct study to compare early and late material was done by Scott et al. (1991), who examined dental morphology. From measurements of premolars and molars they concluded that there was a significant decrease in tooth size over the settlement period. It should be noted, though, that the tests were only statistically significant for female third molar (mesiodistal and buccolingual) measurements. In another analysis, Scott et al. summated the crown areas of all measurable teeth, including those of all males and females and individuals of unknown sex. They wrote: "Although sex ratio variation among the samples may introduce some bias in this comparison, the data...show a simple and striking pattern [of decreasing size]" (Scott et al. 1991: 188). Scott et al. have a table showing a clear sex ratio difference between E29a Thjodhilde's Church (46 males : 28 females : 21 sex unknown) and W51 Sandnes (8 males : 31 females : 48 sex unknown) (numbers according to Scott et al. 1991). Since these two sites provide much of the material (72% of the Norse material in Scott et al's study and 75% of the total number of specimens in this study), this imbalance in sex ratios could well affect the analyses. Scott et al. also found that the Greenland Norse dental dimensions were smaller than in other comparable North Atlantic samples. This is borne out by a study by Hanson (1986), concluding that of all the investigated Scandinavian samples, including Icelandic, Danish and Norwegian crania, the Greenlandic Norse specimens differed most from all others and were the smallest (Hanson 1986).

The results of the cranial morphometric analyses in this study show at best a trend towards diminishing dimensions in the Norse specimens in Greenland throughout the settlement period. This trend may well be in accordance with other studies showing significant reductions in Norse molar size.

Stature

Variations in the variables do suggest a decrease in the overall sizes, but like the trends observed in the cranial variables, these were not significant (see Appendix). The tests used the actual measurements of the femur rather than the calculated stature, i.e. before any transformation of the variables.

Stature during life was calculated using two sets of equations – one found in Trotter & Gleser (1952; 1958) and in Trotter (1970), and the other in Boldsen (1984); the former because it is the set of equations generally used, and thus makes the Norse results commensurable with other research; the latter because this set can give us a more "correct" evaluation of the "real" stature, since it is based on a medieval Danish skeletal sample, rather than a white American population. The mean difference between the two equations is 0.97 cm for females and 2.3 cm for males; that is, the stature estimate is higher when we use Trotter & Gleser. The reasons for this are most

Table 16. Living statures (cm) of Norse and others. All statures have been calculated a.m. Trotter & Gleser, except for the material from Æbelholt and Tronheim, which probably is a.m. Manouvrier (see text).

Material	Source	Males		Females	
		N	Mean	N	Mean
Vikings	Bennike (1985)	23	171.2	27	156.7
Medieval:					
Grenå	Bennike (1985)	43	172.6	21	160.7
Randers	Frøhlich et al. (1994)	40	173.8	41	157.4
Æbelholt	Møller-Christensen (1958)	138	170.9	82	160.6
Viborg	Boldsen (1983)	52	173.0	36	158.0
Westerhus	Gejvall (1960)	66	174.3	77	161.6
Tronheim	Faye (1914)	45	166.5	12	154.8
Norse:					
Early East.	Lynnerup	12	173.5	2	158.6
Late East.	Lynnerup	-	-	5	149.8
Late West.	Lynnerup	4	162.0	15	154.8

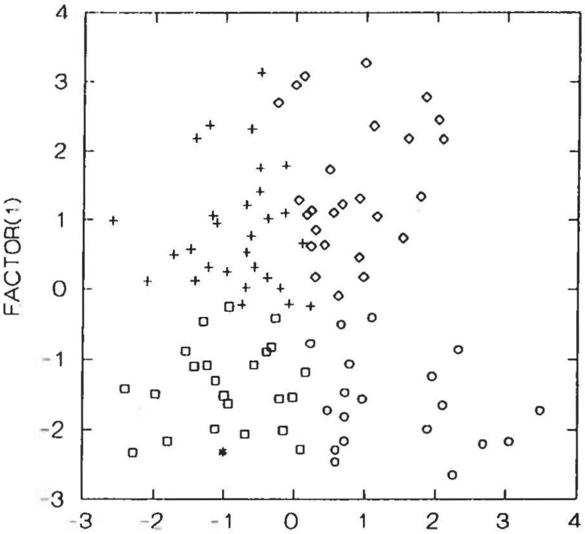


Fig. 37. Canonical plot of discriminant functions. +: Eskimo females; ◊ : Eskimo males; □ : Norse females; 0: Norse males; *: cranium from E140 Tasersuaq.

probably differences in the body builds of the reference populations for the equations.

The calculated statures during life were compared with those of other populations (Table 16). When we take the number of Norse males and females from the Early and Late periods into account, it is obvious that the comparisons must be used with great caution. However, if we focus on the stature of Early Norse and Viking males; and the female stature of Late Norse and other medieval populations, we can conclude that the Early Norsemen were probably of much the same stature as other Viking populations, whereas the Late Norse females were probably of lower stature than other medieval female populations. Bennike (1985) and Sellevold (1983) found that medieval populations were probably taller than the Viking populations, and Sellevold reported a mean stature of 172.1 cm for male Vikings (pooled from all over Scandinavia) and 158.75 cm for females (Sellevold, cit. in Roesdahl 1991). Thus it seems that stature did not change much between the Viking period and the Middle Ages. As regards the medieval period, Boldsen (1993) did not find evidence of any secular changes in stature for populations between 1000 and 1600 AD

In this context it is also worth noting that the statures reported for the Trondheim material are the lowest in Table 16, although these statures too have been reconsidered (Hanson 1992). It must be noted, however, that these statures are calculated with the Manouvrier (1892) method, as are the statures for the Æbelholt material, and this gives a slightly lower stature than the Trotter & Gleser method, approximately 0.5 cm lower for the females and approximately 1 cm lower for the males (Krogman & Iscan 1986). Yet, even when we have made this correction, the Trondheim samples are smaller than the medieval populations, and this group would probably be the best comparison for the Late Norse material.

Hansen (1924) was the first to consider a secular decrease in stature, based on his analysis of the E111 Herjolfsnes material. Hansen linked this with a hypothesis of racial degeneration (see above), but lacking the "baseline" material from E29a Thjodhilde's Church, postulated: "The tall Northern race degenerated into small, slight, and delicate women, and correspondingly slightly taller men" (Hansen 1924: 465). This belief was further fueled by Roussell's remarks (1935) on E66 Undir Høfdi, when he found that a shallower-buried skeleton was shorter than four skeletons buried beneath it. Later, when the material from Herjolfsnes was generally discredited, Fischer-Møller stated concerning his observations on the W51 Sandnes material: "There is all the less reason for talking of degeneration, inasmuch as the extremity bones, although they exhibit somewhat shorter lengths than Norwegian medieval bones, are certainly no less massive or less well-developed" (Fischer-Møller 1942: 79). This was seemingly supported by the finds at E47 Gardar, where Bröste et al. (1941: 58) concluded that the stature was "also quite considerable." They rightly stated that there were not enough cases available to reach a relevant conclusion.

Relying on the observations of Balslev-Jørgensen, Krogh (1982: 57) wrote that the skeletons found at E29a Thjodhilde's Church were of "tall and powerful people", and compared their stature to the mean Danish stature around 1930-1940. As I have already pointed out in the discussion of Hansen's observations, this common belief that the Vikings and the Early Norse were especially tall and powerful, cannot be corroborated (Bennike 1985; Sellevold & Hagland 1992; Hanson 1992). The first compilation of the calculated statures of the Greenland Norse from the various sites appeared in Scott et al. (1991). Apart from observations of secular trends in Norse dentition (cf. above) the statures during life, as distributed over the sites, were cited in support of the observed decrease in dental size. However, it must be remembered again that the statures had been calculated with different equations, which for example made the late E111 Herjolfsnes material appear even smaller. This situation was made even worse by Hansen's own subjective subtractions on the basis of perceived scoliosis and rachitic changes (Hansen 1924). The conclusion that "there was a 6.5% reduction in male stature and a 6.1% reduction in female stature" (Scott et al. 1991: 201) is thus not entirely correct. Rather, as stated above, the sample of measurable long bones is so small from several key sites that a secular decrease in height cannot be proven.

Racial affinity as suggested by discriminatory analysis

As shown in Table 15, the discriminatory model assigned 38/40 (95%) of the Norse crania to the Randers group. This clearly indicates a European rather than Eskimo racial affinity. It could be argued that the Randers material is not the best basis of comparison for the Norse material, compared with the Icelandic or Norwegian medieval material that would be preferable. However, the Randers material was used because the author was familiar with it. Furthermore, other analyses have shown very close affinities between Norwegian and Danish medieval material (Berry & Berry 1967; Hanson 1986). The samples were not large for the two base groups, especially the Randers sample, but all tests were significantly in favour of the model, and the correctness of group assignment is reasonable, ranging from 71% for Eskimo females to 82% for Randers females. It should be noted, though, that the correctness for racial group (disregarding sex) was very high: 88% for Randers and 95% for the Eskimos – that is, the model can adequately assign material to a racial group, although the sex within the racial group is less correct. This degree of correct assignment is also high when compared with similar procedures using discriminatory analyses (Jantz & Owsley 1993).

The results derived from the Norse material are interesting. Besides assigning two "Norse" females to the Eskimo female group, the model assigns most males to the Randers female group. This could be because of the slightly smaller Norse crania, and supports the earlier analyses. Morphological assessment of the two Norse crania designated as "female Eskimo" showed that one has no specific "Eskimoid" traits, while the other (KAL-0992) does indeed have several traits usually considered "Mongoloid", such as enamel pearls, broad palate, a torus mandibularis of "Eskimoid" character and fusion of the roots in the molars. However, these traits are also found among the Finno-Ugric or Uralic peoples and Balts. These traits were present in a certain percentage of all north and central Scandinavian populations (Iregren & Isberg 1993) during the Viking and medieval periods. Thus, although the results of the discriminatory analysis may point to a slight Eskimo gene influx, the morphological traits are ambiguous. The traits usually described as "Mongoloid" or "Eskimoid" may also be "Uralic" and indeed are not unusual for the Norse populations.

In his study on the skeletal material from W51 Sandnes, Fischer-Møller designated six crania as having Eskimo features (Fischer-Møller 1942). This was primarily due to an overall assessment of cranial features and skull size, two of the crania being, by "Norse" standards, quite large. However, Scott et al., when they looked at these specific crania, found that none of the crania displayed any Eskimoid dental morphological traits: "an examination of crown and root morphology in his [Fischer-Møller's] proposed cases, individual by individual, fails to reveal supporting evidence for hybridization" (Scott et al. 1991). Similarly, none of the six crania, all included in the discriminatory analysis, was re-classified in the Eskimo group.

Once it had been established that the Norse material does not show any Eskimo admixture, another discriminatory model was used, this time to compare Eskimo and Norse material, but with only two variables; maximum cranial width and length. The use of only two variables creates a less accurate model. However, it became evident that the model could distinguish between the racial groups (although the sex allocation within the racial groups was imprecise). For example, the re-classification success in the Norse group was 90% (excluding the E140 Tasersuaq skull), and it is worth noting that none of the Norse crania were allocated to the Eskimo group. The purpose of this model was to allocate the skull from E140 Tasersuaq to either the Norse or Eskimo group, as the archaeological data on the find were equivocal, and as the skull was fragmented, and only the two measurements mentioned were obtainable. The skull was allocated to the Norse group with a probability of 0.954, and was thus considered Norse.

Conclusion

The morphometric skeletal analyses seem to indicate a trend towards smaller dimensions. The differences were not statistically significant. There was no significant difference between material from the Eastern Settlement and the Western Settlement, indicating a rather homogenous Norse population in Greenland. However, in the only other diachronic study of Norse material a significant reduction in molar size among Norse females was found (Scott et al. 1991). The results may thus complement each other, and point to a slight general decrease in the skeletal dimensions of the Norse inhabitants.

Two Norse crania were re-classified as female Eskimos in the discriminatory analyses. The results are not conclusive, as the crania show no other Eskimo features. Conversely, six crania, which in previous analyses had been described as possessing Eskimo features, were scored as Europeans, in accordance with previous dental analyses. The overall result does not indicate an Eskimo influence of any importance, so any admixture must have been very slight. A final approach to settling the question of possible admixture would be to perform DNA analyses. Unfortunately, such analyses were not feasible at the time of this study.

The discriminatory analysis indicates smaller measurements for the Greenland Norse than for the medieval Danish material. Thus more than half of the Norse male crania were assigned to the female Danish group. This supports the above results indicating that the Norse inhabitants had smaller dimensions.

Non-metric traits

The description and characterization of the so called non-metric traits is another staple of anthropological research methods (White 1992; Sellevold 1977; Saunders 1989; El-Najjar & McWilliams 1978). Non-metric traits can be defined as "variation observed in bones and teeth in the form of differently shaped and sized cusps, roots, tubercles, processes, crests, foramina, articular facets and other similar features" (White 1991). Specifically, the traits represent data of the categorical kind, i.e. either the trait is present or not, or it can be graded by degree of expression. Synonyms for non-metric traits are discontinuous or discrete traits, or epigenetic variants, the latter reflecting the common proposition that these traits in some way reflect genetic information and ancestry (White 1991; Sellevold 1977). Some studies of the inheritance and appearance of non-metric traits in mice (Berry 1964; Berry & Berry 1967), have given rise to speculation about some degree of direct inheritance of the traits. For example, Torgersen stated that the metopic suture "behaves as a dominant trait with varying penetrance" (Torgersen 1951), on the basis of his studies of X-rays of several families. However, it is now held that the genetic basis of the traits, particularly the non-dental ones, is unknown (Kaul & Pathak 1984), and other researchers have stated that the criteria for their determination are poor and inadequate (Rösing 1982). Most of the traits may furthermore be directly influenced by environmental factors, as best seen perhaps in Ossenberg's study of Wormian bones and artificial head deformation (Ossenberg 1970; Bennett 1965). Other researchers have found significant environmental effects on certain nonmetric traits, such as dietary stress (Dahinten & Pucciarelli 1981; Dahinten & Pucciarelli 1983). In any case, it seems that a predisposition for a trait may be genetic, but that the actual appearance and expression of the trait may partly be due to environmental factors (Berry & Berry 1967; Berry 1964).

Whatever the genetic basis of the traits, their frequencies and expressions have been found to be in general agreement with metric analyses and the evidence of cultural history and linguistics (Ossenberg 1977; El-Najjar & McWilliams 1978). An example of this is Laughlin's and Balslev-Jørgensen's study on non-metric traits in Greenland Eskimos, which affirmed the pattern of Eskimo colonization of the island by converting the frequencies of the traits into distances. The Eskimo groups which according to the hypothesis of colonization had moved farthest from one another were also those with the greatest "converted distance" from each another (Laughlin & Jørgensen 1956). Similarly, Sellevold and Berry found clear differences in the occurrence of traits among Norsemen, Eskimos and medieval Danes (Sellevold 1977; Berry 1974). In a study on both metric and non-metric traits, Corruccini concluded that non-metric traits per se "are not of paramount value...but may be vital in comparison and conjunction with other types of data in analysing the population genetics" (Corruccini 1976). While this may be somewhat optimistic, as it is very difficult to infer genetic and environmental causes for what are after all phenotypic variants, it does support the validity of using traits to analyse different populations and their affinities, even though firm conclusions on "genetic distance" may not be warranted (Saunders 1989). Indeed, the term "biological distance" has been proposed instead.

This can be exemplified by the tori, which have been accorded special attention, at least in investigations of circumpolar populations (Mellquist & Sandberg 1939; Scott et al. 1991; Sellevold 1977). Greenland Eskimos and

Lapps have high tori frequencies, and it has been noted that the Greenland Norse seem to show a secular development in trait frequency towards the frequencies displayed by the Eskimos (Mellquist & Sandberg 1939; Scott et al. 1991). This does not imply a decrease in genetic distance between the Norsemen and the Eskimos, but perhaps rather adaptation to a common environment, as reflected for example in dietary habits (Scott et al. 1991; Eggen et al. 1994).

In addition to probable implications for whole populations, the non-metric traits have also been used extensively to study particular burial sites in order to establish kinship (Kaufmann 1986; Anderson 1968, cit. in El-Najjar & McWilliams 1978; Crubézy 1992). In fact, the analysis of small-scale populations has been proposed as the "proper" place for non-metric variation (Rösing 1982). Again, as noted by Saunders, while direct familial relationships cannot be inferred, tests for non-random distribution of the traits in mortuary patterns are valid (Saunders 1989; Sjøvold 1975).

The aim of the analyses of non-metric traits in this study was to test for non-random distribution of the traits among sites (intersite dispersion), and within individual churchyards (intrasite dispersion).

The selection of traits

More than 200 traits have been described for the cranium alone (Ossenberg 1976). However, there is no formal agreement on how to score the individual traits (Rösing 1982). An attempt at consensus has been made by the Paleopathology Association, which published Skeletal Database Recommendations (Rose et al. 1991), listing 38 traits, and giving a brief outline of the methodology of scoring them. However, major inter-observer variation must still be expected, and as with the metric analyses, all the traits used in this study were evaluated by the author.

Aside from problems associated with the scoring and identification of the single traits, there has been much controversy about how the frequencies should be calculated for bilaterally occurring traits, about how to handle sex and age, and about the extent to which traits are interrelated (Herzog 1968; Sjøvold 1973, 1977; Molto 1979; Saunders 1989; DeStefano et al. 1984; Trinkaus 1978; Ossenberg 1981; Finnegan 1978; Finnegan & McGuire 1979; McGrath et al. 1984; Benfer 1970; Berry & Berry 1967; Kellock & Parsons 1970; Bennett 1965; Lozanoff et al. 1985; Corruccini 1974 & 1976; Cheverud et al. 1979).

Only cranial traits were evaluated, as the sample of Norse postcranial material was too small and often too fragmented to be properly evaluated. Dental traits were not evaluated, since there had recently been a major study of these (Scott et. al, 1991). Cranial base foramina were omitted because of earlier reports of high levels of intra- and interobserver variation, and since many crania anyway exhibited postmortem damage in the relevant region. Palatine, maxillary and mandibular tori have been omitted from this study, as there have already been several detailed analyses of these traits, focusing on both biological distances from other Norse populations and Eskimos, and secular trends in trait expression (Mellquist & Sandberg 1939; Sellevold 1977; Scott et al. 1991; Halffman et al. 1992).

The traits chosen were: 1) metopic suture (Sellevold 1977; Berry & Berry 1967; Torgersen 1951); 2) anterior Wormian bones[10] (although other researchers have divided anterior Wormian bones into coronal, bregmatic and epipteric bones (Berry & Berry 1967; Sellevold 1977; Bennett 1965; Rose et al. 1991), these were all recorded together in this study); 3) posterior Wormian bones (like the anterior Wormian bones, the posterior Wormian bones have been divided into ossicles at lambda, lambdoid and asterionic ossicles (Berry & Berry 1967; Sellevold 1977; Bennett 1965)). In this study lambdoid and asterionic Wormian bones were grouped together; 4) ossicles at lamdba/Inca bone (Sellevold 1977). In this study, as in others (Berry & Berry 1967), all variants, including true Inca bones, were scored together); 5) parietal notch bone (Berry & Berry 1967; Sellevold 1977); 6) temporofrontal articulation (Berry & Berry 1967; Sellevold 1977); 7) supraorbital foramina (El-Najjar & McWilliams 1978;

Table 17. Frequencies of non-metric traits. Right and left side occurences have been added together. Calculation of frequency is based on the number of specimens available for determination of the single traits.

Trait	N	%
Metopic suture	4	3.3
Ant. Wormian bones	14	8.5
Post. Wormian bones	70	31.8
Ossicles at lambda/Inca bone	4	3.3
Parietal notch bone	29	13.7
Temporofrontal articulation	2	1.4
Supraorbital foramina	53	30.6
Supraorbital notch	141	80.1
Multiple infraorbital for.	16	19.3
Multiple mental foramina	8	4.1
Mylohyoid bridge	14	7.6
Double condylar facets	11	5.0

Berry & Berry 1967; Sellevold 1977); 8) supraorbital notches (El-Najjar & McWilliams 1978); 9) multiple infraobital foramina (El-Najjar & McWilliams 1978; Berry & Berry 1967; Sellevold 1977); 10) multiple mental foramina (El-Najjar & McWilliams 1978; Sellevold 1977); 11) mylohyoid bridge (El-Najjar & McWilliams 1978; Sellevold 1977; Kaul & Pathak 1984); and 12) double condylar articular facets (only completely separate facets were scored as "trait present" (El-Najjar & McWilliams 1978; Berry & Berry 1967; Sellevold 1977)).

Results

Site frequencies of traits

The frequencies of each trait were also analysed by site and by sex. Given the small number of specimens, the 95% confidence limits overlap for almost all traits. Generally, the highest incidences of the single traits were seen in the material from E29a Thjodhilde's Church and W51 Sandnes, which also are the sites with most specimens.

Significance of intersite differences was only tested for supraorbital foramina, comparing W51 Sandnes and E29a Thjodhilde's Church, as this was the one trait without completely overlapping confidence limits (E29a: left side: 10.8-50.5%; right side: 7.8-50.4%, vs. W51: left side: 27.6-59.1%; right side: 23.8-54.6%). The differences were not statistically significant (left side: $p = 0.2864$; right side: $p = 0.4168$).

Intrasite variation

A general plot for each trait was generated, showing the trait dispersion by individual within each cemetery. The plots were studied for any major differences in trait density. The following areas were particularly closely investigated for differences: the eastern against the western area of the E111 Herjolfsnes churchyard; the northern against the southern area of the E149 Narsarsuaq churchyard; the chapel against the rest of the specimens from E47 Gardar; the mass grave against the rest from E29a Thjodhilde's Church; and the presumed "family" burial against the rest from W51 Sandnes churchyard.

The only case of a possible increase in trait density was the mass grave at E29a Thjodhilde, which showed increased frequencies of double condylar facets and posterior Wormian bones compared with the cemetery as a whole. None of the differences was statistically significant.

Discussion

The results show no major intersite differences. Only from two sites were there enough specimens to warrant further analysis, i.e. a comparison of E29a Thjodhilde's Church with W51 Sandnes. These two sites can also be placed in a chronological sequence, since the latter is from the early settlement period, and the former is late (cf. the chapter on church sites). However, when the material was tested for the traits with the most pronounced differences in frequencies, these differences were not significant. Neither spatial nor secular development can thus be postulated. In his analyses of secular trends in the Norse dentition, Scott also studied third molar agenesis (Scott et al. 1991). This is often described as a non-metric trait. Indeed, Scott found a secular trend towards increasing levels of third molar agenesis, and attributed this to overall skeletal and dental size diminution (Scott et al. 1991). In this study, the generally similar levels of non-metric traits correspond well to the equally similar skeletal metrics: both indicate no statistically significant spatial or secular trends.

Because of the high interobserver variation in the recording of non-metrics, this author has not compared the Norse data with data from other studies. However, two previous studies have included some of the Norse material in a wider perspective. Berry compared the material from W51 Sandnes with a wealth of other skeletal material, including six (pooled) Norwegian samples; Stone Age and medieval material from Denmark; Norse medieval material from Iceland, the Hebrides, the Orkneys and the Shetlands; and finally medieval material from York, England (Berry 1974). After estimating divergence in the trait frequencies, Berry found that the Norse Greenlanders exhibited the closest affinities with the Icelandic and Hebridean samples. Berry further concluded that the Norwegian settlers in Iceland were probably followed by immigrants from Ireland and the Scottish islands (1974).

Sellevold compared material from E29a Thjodhilde's Church with precolonial Greenlandic Eskimos and medieval Danish material. She found that the Norse were not significantly different from the Danes in terms of most of the observed traits (except the tori) (Sellevold 1977).

It was hoped that the study of non-metric traits might provide more data on Norse burial patterns. Rösing (1982) scored non-metric traits in several burials in a cemetery, and found possible familial patterns. In this study, sub-groups within each cemetery were analysed visually for possible differences in trait density. Only in one case, the mass grave at E29a Thjodhilde's Church, did there seem to be a difference. However, the differences were not statistically significant. Analysing the dental anthropology of the E29a Thjodhilde's Church material, Alexandersen did find differences among several dental traits, and he assumed that some of the individuals in the mass grave were sibs (Alexandersen, pers. comm.).

Conclusion

The analyses for intersite dispersion showed no marked differences. The results thus support the metric analyses, in that no secular developments were evident. As regards the analysis of intrasite dispersion, only E29a Thjodhilde's Church can actually be evaluated. There may be a difference (although not a statistically significant one) between the individuals in the mass grave and the rest of the graveyard population (cf. also the chapter on churchyard topography) similar to the differences in the dental morphology.

As noted above, one method which could presumably provide more information on kinship structure among the interred in the various graveyards, and on relationships among settlements, is DNA analysis.

Palaeopathology

It is paradoxical that the samples from which osteologists attempt to make inte pretations regarding past health are in fact made up of those individuals who have not survived.

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Observations of gradual changes in the frequencies of certain pathological processes would be very relevant to a discussion of secular trends in Norse skeletal biology. They could contribute to an understanding of Norse society with a basis for comparing pathological data with burial data, and perhaps also by providing direct evidence of factors like malnutrition, warfare, etc. In this respect, special attention has been given to evidence of nutritional stress markers in the population, i.e. markers of dietary deficiencies or illnesses in childhood, reflecting overall living conditions in the society (Alexandersen et al. 1993). Generally, three methods seem to be widely acknowledged for this purpose: evaluation of porotic hyperostosis (cribra orbitalia), which presumably reflects iron-deficiency anaemia; evaluation of dental enamel hypoplasia, which presumably reflects bouts of illness or dietary deficiency inhibiting enamel formation in growing teeth; and the so-called Harris' lines (transverse lines in long bone radiographs), which presumably indicate periods of growth arrest (van der Merwe 1992). None of these methods was applied to the Norse material in this study. Only two cases of porotic hyperostosis were found (see below) and very few intact long bones remain, so the simple scarcity of material precludes the use of these methods. Finally, dental enamel hypoplasia of Norse teeth has previously been analysed (Scott et al. 1991), and it was therefore thought more interesting to find other ways of evaluating population stress.

In this study, the evaluation of the incidence of infectious middle ear disease (IMED) was used as a novel method of evaluating childhood "stress" and general health and living conditions. The first part of this chapter deals with this investigation, its methodology and results, and discusses the results as well as the notion of population stress as such. The next few sections deal with pathology encountered in the Norse material in a more conventional way, with chapters on osteoarthropathies, trauma and miscellaneous conditions. Detailed dental analyses were not done, since, as noted, several such studies have already been carried out by authors specializing in dental anthropology and pathology (Mellquist & Sandberg 1939; Scott & Alexandersen 1991; Scott et al. 1991).

Infectious middle ear disease

Theory of otitis media

Previous studies have shown a strong correlation between small pneumatized areas of the temporal bones and IMED, i.e. chronic secretory otitis media (CSOM), recurrent acute suppurative otitis media (RASOM) and chronic tubal dysfunction (CTD) (Diamant 1957; Sadé & Hadas 1979; Arora et al. 1978; Hug & Pfaltz 1982; Qvarnberg 1982; Tos & Stangerup 1984; Stangerup & Tos 1986), although there has been disagreement on whether this correlation is due to environmental or hereditary factors (Shulter-Ellis 1979; Wittmäck 1918; Diamant 1940; Tos & Stangerup 1984). In the 1920s-1940s anatomical material was studied, but since then most studies have been clinical surveys. The now accepted theory is that CSOM, RASOM and CTD all correlate with hypocellularity (i.e. small area) of the pneumatized systems in the temporal bones, and with the degree of asymmetry (i.e. bilateral difference in area).

These relationships have been investigated in a series of Greenland Eskimo skulls (Homøe & Lynnerup 1991) which were also CT-scanned (Homøe et al. 1992). On the basis of a clinical study where patients could be questioned about childhood episodes of IMED, and otological examinations could be performed, a statistical procedure based on the bilateral pneumatized cell areas was devised for calculating the likelihood of having had IMED in childhood (Homøe et al. 1994).

A major advantage of the method is that it can be used on fragmentary skulls, as long as the temporal bones are intact. This means that even in fragmentary skeletal samples, like the Greenland Norse material, many individuals can be examined.

Finally, the results of these analyses can be directly compared with the results of modern clinical research on pathogenesis and etiology.

Material

All available Norse crania of adults with complete temporal bones were included. The available material is shown by site and sex in Table 18.

Table 18. Material by site and sex.

Site	males	females	unknown	N
E29a	6	17	0	23
E47	1	4	0	5
E66	3	2	0	5
E111	3	1	0	4
E149	5	3	0	8
W7	4	1	0	5
W51	21	10	2	33
Total	43	38	2	83

Methodology

The crania were X-rayed using the Runström II lateral projection, with a 10o angle in the frontal plane (Runström 1933). The focus-to-slide, and object-to-slide distances were uniform (magnification factor 6.8%) and all X-rays were taken with the same X-ray apparatus and by the same radiologist. The pneumatized areas as seen on the X-rays were delineated and planimetric measurement was done in blind trials by computer (Lynnerup et al. 1992). Following previous studies, the antrum, the epitympanon and the cavum tympani were not included (Homøe & Lynnerup 1991; Homøe et al. 1994; Diamant 1957; Tos & Stangerup 1984; Stangerup & Tos 1986).

Fisher's Exact Test and chi-square-test were used for evaluating differences in incidence frequencies (Armitage & Berry 1991), Mann-Whitney's U-test for evaluating sexual dimorphism and Spearman's correlation analyses for establishing the relationship between area and cranial dimensions (Wulff & Schlichting 1988). The level of significance was set at 0.05.

To estimate the likelihood of IMED given the areas, a parametric polychotomous logistic regression model was used (Homøe et al. 1994). This model incorporates an "individual effect" and makes it possible to include the information concerning unilateral IMED carried by asymmetric areas. For example, if an individual with identical normal areas on both sides is compared with an individual with the same area on the left side but with an area twice as large on the right side, it is likely that the latter individual has had IMED in the left ear. The model thus specifies four probabilities for each individual, according to the four subgroups: ++, -+, +-, — (where ++ represents bilateral IMED; -+ IMED on the left side; etc.). On the basis of actual observations of IMED, these probabilities can be estimated for any combination of areas. Assuming that the group of individuals investigated is representative of the Norse Greenlanders, the classification can be performed by allocating an individual to the group with the highest estimated probability (Homøe et al. 1994).

While the pneumatized area seems independent of cranial size (see below) within a given population, areas may not be directly comparable in different racial groups. To ensure direct implementation of the above model in this study, the Norse area data were transformed to Z-scores (areas – mean area divided by the standard deviation of the areas) (Homøe et al. 1994).

Intrasite dispersion of IMED-afflicted specimens was evaluated visually; that is, if one plotted the individuals by their location in the churchyard and marked the individuals who had IMED, possible accumulations of individuals with IMED could be identified.

Results

The left median area was 781 mm^2 (range: 0-1531 mm^2), and the right median area was 868 mm^2 (range 0-1998 mm^2). There was no sexual dimorphism in the pneumatized area (left side: $U = 780.50$, $p = 0.730$; right side: $U = 743.00$, $p = 0.484$). In accordance with earlier procedures, the correlation between the left and right areas and various cranial measures was investigated. No statistically significant correlation was found. The areas were transformed to Z-scores and used as input in the polychotomous logistic regression formula. A total of 20 individuals were allocated to the IMED group, while 63 were allocated to the non-IMED group, giving an overall IMED frequency of 24.1%. There was no significant sexual dimorphism in the incidence (Table 19).

Table 20 shows the incidences by sites. EE (Early Eastern) is identical to E29a Thjodhilde's Church, while LE (Late Eastern) is E111 Herjolfsnes and E149 Narsarsuaq

Table 19. Sex distribution of IMED and non-IMED individuals.

	Male	Female	Unknown	N
IMED	12	8	0	20
non-IMED	26	35	2	63
N	38	43	2	83

pooled, and W (Western) is W7 Anavik and W51 Sandnes pooled. There is a difference in incidences: 34.8% affected individuals from the EE settlement period, and 16.7% and 18.4% affected individuals from the LE and W settlement period respectively. The differences were not significant (chi-square = 2.50; p = 0.300).

Discussion

The notion of population stress, in terms of either nutrition or general health, was developed to describe major changes in living conditions, such as the shift from hunter-gatherers to agriculturalists (Van der Merwe 1992; Cohen & Armelagos 1984). It was observed how greater foodstuff availability permitted dramatic increases in population, but that this was often accompanied by a general deterioration in health, as seen from dramatic increases in the frequency of porotic hyperostosis in skeletal material. The reasons for this range from a more uniform diet, with a higher risk of malnutrition, to developing class structures and social differentiation which left some of the population without proper dietary supplies, etc. (Cohen & Armelagos 1984).

In the study of the Norse Greenlanders it would be interesting to see whether any pattern suggestive of secular changes in "stress" can be found. If so, it might be indicative of a society that had an inadequate supply of animal and farming products, leaving the population exposed to periods of malnutrition. This scenario has received much attention because of the hypothesis of the "Little Ice Age", which presumably lowered temperatures, and thus also disturbed the delicate ecological balance which supported the Norse Greenlanders (McGovern 1979). While this will be dealt with in detail in the general discussion chapter, the results of the otitis media analyses will be discussed here, to see if they reveal any such secular changes.

First, however, the value of otitis media as a population stress marker must be discussed. Upper respiratory tract infections and otitis media are closely associated. Incidence of IMED may thus reflect general upper respiratory tract infections. Today, respiratory tract and enteric infections remain the major causes of infant mortality, and were very probably also so in medieval society (Cohen 1989). Incidence of upper respiratory tract infections and otitis media has been correlated with housing conditions (Vinther et al. 1982; Berg & Adler-Nissen 1976; Christensen 1956). Furthermore, epidemiological studies have shown high frequencies of otitis media among aboriginal groups such as Eskimos (Baxter 1977; Brahe-Pedersen & Zachau-Christiansen 1986), American Indians (Wiet et al. 1980) and Australian aborigines (Sunderman & Dyer, 1984).

It is therefore thought that IMED, as evaluated from cranial material, does to some extent reflect childhood living conditions in ancient populations.

To the advantages of the method in palaeopathology we can add the fact that the IMED approach makes good use of the cranial material. In this study 83 of 457 specimens (18.2%) could be evaluated with this method, which is a far higher number of specimens, for example, than the long bones available for the evaluation of Harris lines. In all, 270 specimens were represented by the cranial base (including specimens which only had fragments of the skeletal element), which means that 30.1% of the specimens with this skeletal element could be evaluated with this method (71 specimens had a "complete" cranial base, which means that all specimens with complete cranial bases and a few with marginally incomplete cranial bases could be used). This reflects the fact that the petrous bone is very resistant to diagenetic degradation.

Since the Norse skeletal collection is essentially a "cranial" collection, it is obviously important to use a method which is based on these structures. Porotic hyperostosis, which also affects the cranial elements, could thus also be used. There seem, however, to be major regional differences in the occurrence of these lesions – for

Table 20. The results only includes skulls from the »dated« sites. Frequencies by columns with 95% C.I.

	EE			EL			W			n
	n	%	95%C.I.	n	%	95%C.I.	n	%	95%C.I.	
IMED	8	34.8	16.7-57.3	2	16.7	2.1-48.4	7	18.4	7.7-34.3	17
non-IMED	15	65.2	42.7-83.3	10	83.3	51.6-97.9	31	81.6	65.7-92.3	56
n	23	100		12	100		38	100		73

example only two cases were found in the Norse material (and only a few cases have been found in Eskimo skulls).

The pneumatized area did not display sexual dimorphism. The area was not correlated with several cranial variables. Although it was somewhat unsatisfactory to test the cranial variables individually, a multivariate analysis was not possible because of missing data. However, this was done in another study (Homøe et al. 1994) and cranial size did not correlate with area. It is therefore assumed that the pneumatized areas do not reflect cranial size.

The logistic polychotonous regression model calculates the likelihood of having had IMED in left or right or both ears (or no IMED). Allocation to one of these groups is based on the highest likelihood. An earlier study of the sensitivity, specificity and positive predictive value suggests that a reliable minimum value for the occurrence of IMED in anthropological material can be obtained (Homøe et al. 1994). As the aim is to estimate the occurrence in a population, not in a single individual, this estimated value will also approximate the true value, because false negatives tend to be balanced by false positives (Homøe et al. 1994). While not statistically significant, the results for the frequency by sites show a decrease from the Early Eastern Settlement to the Late Eastern and Western Settlements.

The frequency of IMED seems to have declined slightly throughout the settlement period. If we accept this as a trend (although it is statistically non-significant), does it indicate a poorer health status at the time of settlement, and an improvement in living conditions throughout the whole settlement period?

Recently, there has been some discussion of how to interpret palaeopathological findings. For example, a study of prehistoric Indians in America showed higher frequencies of enamel hypoplasia in more recent samples than in early samples; and this was taken as a sign of worsening living conditions (Goodman & Armelagos 1988). However, it has been argued, on the basis of mathematical models of individual "frailty" and the risk of death at each age, that exactly the opposite can be inferred: that higher frequencies of enamel hypoplasia reflect a greater number of children overcoming childhood stress, which effectively means that more children survived childhood stress in the more recent period (Wood et al. 1992). Likewise, recent work seems to demonstrate a decrease in adult mortality in cohorts subjected to more disease stress in their early years (Meindl & Swedlund cit. in Lovejoy et al. 1977; Mielke & Swedlund 1993).

If the differences in incidence among EE, LE and W are accepted as evidence of an actual secular change in IMED frequency, at least two mutually exclusive explanations are possible: 1) IMED directly reflects childhood stress, and higher frequencies in the early period thus suggest a period of greater childhood stress than in the more recent settlement periods; 2) the decrease in IMED frequency is due to a higher mortality among afflicted children, so that fewer will survive to display hypopneumatization as adults. Consequently, higher frequencies of IMED in the early period suggest a better state of health which deteriorated during the settlement period. Unfortunately, this paradox is not easily resolved. Moreover, it applies to all known methods of assessing stress and pathologies.

Previous analyses of Norse dental health, and specifically analyses of dental enamel hypoplasia, showed no secular trends (Scott et al. 1991). Indeed, it was concluded that morbid or nutritional stressors were not particularly active during early childhood in the early or late settlement periods (Scott et al. 1991). Since the frequencies for IMED did not change significantly, the results as regards IMED may well be in accordance with that study. We cannot easily conclude how far the changes in IMED frequencies reflect a real secular decrease in frequencies. More complete excavations, i.e. of whole burial grounds and cemeteries, with a resulting better understanding of possible social differences, may conceivably help us to understand the health and social dynamics that are important for the palaeopathological issues (Wood et al. 1992). This is hardly the case with the Norse Greenlanders, with only one completely excavated churchyard, and only more or less random specimens from the other churchyards.

Evidence for the "paradoxical" interpretation of palaeopathological frequencies may perhaps be found in the fact that more (but not significantly more) males exhibited evidence of IMED and that the female Norse Greenlanders, both from E29a Thjodhilde's Church and W51 Sandnes, showed a trend towards higher mortality in young adulthood and lower average ages at death than males (cf. the chapter on demography).

Summary of IMED results

An evaluation of IMED, an indicator of childhood exposure to upper respiratory tract infection, was used to evaluate the general health of the population. While the raw results indicate a higher frequency in the Early Eastern Settlement than in the late settlements (eastern and western), this was not statistically significant. This accords well with a previous study of enamel hypoplasia, which likewise failed to demonstrate any secular changes. However, even if we accept that the observed differences reflect a real secular decrease in IMED frequencies, this does not automatically suggest an improvement in health throughout the settlement period. Indeed, exactly the opposite may be the case. The IMED frequencies must thus be evaluated with the other data generated in this and other studies, before we make any statements on trends in health and living conditions.

Osteoarthritic changes and arthropathies

Joint disease was one of the more frequently represented pathologies. Yet even here, an analytical approach to the data would be unwarranted. The tabulation of frequencies by sex, age, sites, etc. would give us such small numbers that any conclusions would be unreliable. In view of this not too much emphasis has been given to advanced methods of scoring, and the results must rather be viewed as illustrative and guiding.

Methodology of joint disorder registration

Few specimens were suitable for a comprehensive palaeopathological study of joint diseases. Very few specimens, for example, had a reasonably intact spinal column, and if any thoracic or lumbar vertebrae were present, they were often much damaged. As for changes in the extremity bones, it was not possible to study them for symmetry because of the lack of material, etc. So although comprehensive recording methods have been described (Rogers 1994), a rather rudimentary system was employed here.

Arthropathies were divided into two diagnostic categories: 1) osteoarthritic (OA) changes and 2) other joint diseases and related conditions. The basis for this diagnostic grouping was the lesionary patterns encountered (Ortner & Putschar 1985; Sneppen 1986; Cockburn et al. 1979; Nathan 1962) and the guidelines from the University of Bradford Palaeopathology Course. Spinal OA was furthermore divided into four stages, following Kellgren & Lawrence (1963), but the first stage was omitted as in other palaeopathological studies (Bennike 1985), as differentiation between normal and possibly pathological lesions of Stage I was considered too difficult given the material. The three other stages were defined as follows: (II) moderate osteophyte formation (any facet); (III) severe osteophyte formation, pitting, porosity, Schmorlsk nodes and joint deformation; and (IV) ankylosis of the joint. Osteoarthritic developments on other bones, and other joint affections, were all described separately.

Results for osteoarthritis.

Figure 38 shows the general distribution of affected joints. The sections below describe the cases in detail.

OA of the temporomandibular joint

There was one female with osteoarthritic changes in the temporomandibular joint (KAL-0916). Only the right joint was involved, showing a change in the condylar shape (flattening of the condylar surface), osteophytic build-up along the margins, pitting and cyst formation. Eburnation was only present to a very slight degree. Similarly, the mandibular fossa of the right temporal bone showed marginal osteophytes and pitting, especially the anterior part. None of the mandibular teeth had been lost intravitam, but both upper third molars, the upper right second premolar, and probably the left incisors and canine had been lost antemortem. The etiologies of mandibular joint OA include rheumatoid arthritis, trauma, subluxation and luxation. The mandible had not been fractured, but it would be difficult to further specify an etiology, since the specimen was not generally well preserved.

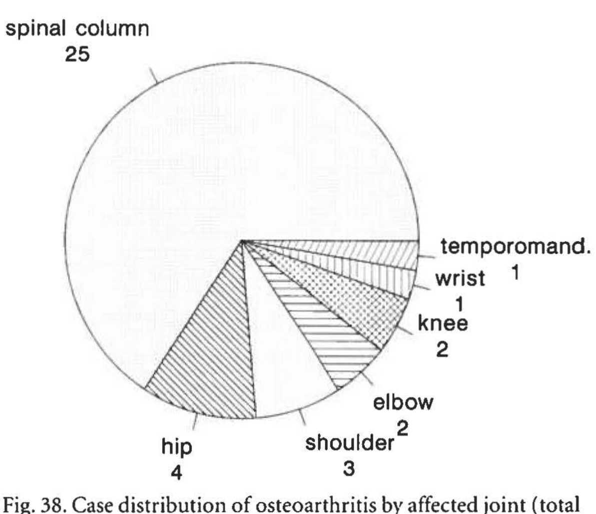


Fig. 38. Case distribution of osteoarthritis by affected joint (total joints affected: 38).

Table 21. Case summary on spinal OA. Vertebral segments affected denoted by At (atlas), Ax (axis), C (cervical), T (thorasic) and L (lumbar).

ID	Site	Age	Sex	Joint affected	Other joints?
KAL-0913	E47	Mature 50-55	Male	At, Ax, C, T, L	Elbows
KAL-0914	E47	Mature 40-45	Male	L	
KAL-0933	W51	Mature 40-45	Male	C, T, L	Shoulders
KAL-0944	W51	Mature 40-45	Female	C, T, L	
KAL-0994	V 7	Mature 35-40	Female C	At, Ax,	
KAL-1000	E149	Adult 25-30	Male	At, Ax	
KAL-1006	E149	Mature	Male	C	
KAL-1030	E29a	Mature 35-40	Female	C	
KAL-1036	E29a	Mature 35-40	Male	C, T, L	
KAL-1037	E29a	Adult 30-35	Female	C	
KAL-1039	E29a	Mature 35-40	Female	Ax, C	
KAL-1051	E29a	Adult 30-35	Female	T	
KAL-1060	E29a	Adult	Female	C	
KAL-1062	E29a	Mature 35-40	Male	L	
KAL-1064	E29a	Adult 30-35	Male	Ax, C	
KAL-1077	E29a	Mature 45-50	Male	T, L	
KAL-1081	E29a	Mature	Male	C	
KAL-1082	E29a	Mature 50-55	Male	Ax, C	Knee, shoulder
KAL-1083	E29a	Mature 40-45	Male	C	
KAL-1094	E29a	Adult	Male	C	
KAL-1128	W51	Mature 45-50	Female	Ax, C,	T, L
KAL-1132	E149	Mature	Unknown	Ax, C	
KAL-1578	V 7	Mature 35-40	Male	At	
KAL-1658	E29a	Mature 40-45	Male	Ax, C	
KAL-1659	E29a	Adult	Male	Ax, C	

OA of the spine

Twenty-five specimens showed osteoarthritic changes in the spine. The general sex and age distribution of affected specimens is shown in Table 21. The distribution of affected vertebrae (by the major segments: atlas, axis, cervical, thoracic, and lumbar segment) by sex is shown in Fig. 39. Generally, males were more affected than females and older adults (maturus) more than younger adults (adultus) (differences not statistically significant).

Figure 39 indicates that more males are affected in the lumbar region than females, and also more severely affected, whereas females seem more severely affected in the atlantic and axial segment. The numbers are too small for statistical significance.

No analyses could be carried out for secular changes; for instance, only two males from the Late Eastern Settlement period (pooling E111 Herjolfsnes and E149 Narsarsuaq) had remnants of the cervical spine.

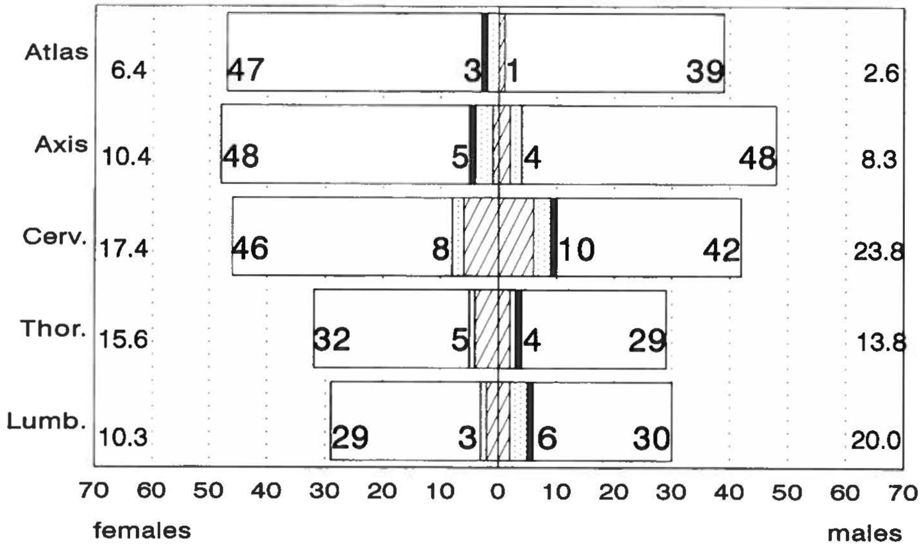


Fig. 39. Distribution of spinal column osteoarthritis by sex and by columnal segments (atlas, axis, cervical, thoracic and lumbar vertebrae). Innermost bars indicate stage of affection: hatched bars: stage II; cross-hatched bars: stage III; solid bars: stage IV (cf. text). Total number of affected segments given by the innermost bars. Outer white bars indicate number of vertebral segments which could be analysed. Outermost figures represent percentage of affected vertebrae.

OA of the upper extremities

Six instances of osteoarthritic changes were found in the upper limb. Three cases concerned the shoulder joint, two cases the elbow and one case the wrist.

One case of shoulder joint OA was bilateral (KAL-1082), while the others were unilateral (KAL-0933 and KAL-1081).

One case of elbow joint OA displayed severe bilateral changes (KAL-0913). Indeed, extensive osteophyte formation was found along all joint margins, comprising ulnae, radii and humeri. Furthermore, all joint surfaces showed pitting, cystic changes, eburnation and grooving. Neither caput humeri showed any pathological changes, nor did the wrist joints. Only the distal medial part of the right humerus and the proximal medial part of the ulna remained of the limb bones in the other case (KAL-1166).

There was one case of severe changes in the left wrist, involving the radiocarpal, the distal radioulnar and the ulnacarpal joints. Osteophytic formation was mostly restricted to the radioulnar joint margins of both the ulna and the radius, while all three joint surfaces showed pitting, cysts and eburnation and dorsal-palmar grooving. The incisura ulnaris was almost square, giving it a very tight "fit" with the caput ulnae, effectively completely inhibiting rotation. The elbow joint did not display any pathological changes. The carpal bones were not present, nor were any bones of the right upper limb.

OA of the lower extremities

Six instances of osteoarthritic changes were found in the lower extremities. Four cases concerned the hip joint, while two cases concerned the knee joint.

Two cases of hip OA were bilateral (KAL-1032 and KAL-1046) and presented marked degenerative changes in both the femoral head and the acetabulum. There was a massive build-up of marginal osteophytes, completely altering joint contour, pitting of the joint surfaces and eburnation, resulting in a "flattened" look in the femoral head (Fig. 40). The acetabulum likewise showed eburnation and osteophytes at the margins. The acetabulum also displayed cystic changes in the joint surface.

The other two cases of hip OA affected the right (KAL-1189) and the left (KAL-1644) femoral head respectively. Slight eburnation was observed in KAL-1189.

Of the two cases of knee joint OA one case (KAL-0913) presented only mild bilateral osteophyte build-up along the tibial joint margins, while the other case (KAL-1082) showed severe changes in the left tibial joint surface with eburnation and a sagittal groove formation in the medial condyle.

Results for other arthropathies

There were four cases of other joint afflictions. One case of localized, destructive arthropathy was found at E29a Thjodhilde's Church (KAL-1789), involving the proximal interphalangeal joint of the fourth right finger of a mature, 50-55 year-old male. The bones of the right hand were reasonably intact, although only one outer phalanx is extant. The proximal part of the inner affected phalanx was missing. The right radius, ulna and humerus were also present, although badly fragmented, while no bones of the left upper extremity remained. The bones of the lower extremities were also damaged, although the metatarsals and some of the phalanges were present. Consequently, nothing definite can be said about symmetry, or affliction of other joints. The phalangeal joint surfaces were irregular, with lytic foci, cyst formation and with only very slight marginal lipping. While they were not ankylosed, there was a close fit of the joint surfaces, in a position of 30° flexion, which would preclude any movements. No subluxation or axial deviation was evident. There was probably some osteoporosis of the phalangeal bones, although the bone was also brittle as a result of diagenetic changes. The metatarso-phalangeal joint surface of the left I metatarsus displayed lipping, especially on the plantar sides, extending about 2 mm from the joint margin. The joint surface was depressed medially, so that there must have been axial deviation of the phalanges distally.

The erosive changes and the localization might suggest erosive osteoarthritis, rheumatoid arthritis, gout or seronegative arthropathies. Diagnosis is precluded by the impossibility of evaluating whether the case represents an asymmetrical or symmetrical polyarthritis (that is, if the two identified arthropathies were part of the same clinical picture at all). The individual also had plantar fascitis of the calcaneus (see below).

One case of probable aseptic necrosis of the femoral head was found at E29a Thjodhilde's Church (KAL-1079), in an adult male. Besides fragments of the skull, only fragments of the two femora, coxae, and the right humerus and foot remained. The left femoral head was flattened, with broad overhanging margins. The neck was of the same length as the right femoral neck, and the left femoral head was not displaced caudally in relationship to the femoral neck axis. The proximal region of the neck and head were normal. There was no evidence of osteoarthritis. The morphology did not suggest slipped epiphysis or femoral neck fracture, but the flattening seemed indicative of Perthes'.

Two cases were found at E29a Thjodhilde's Church with bony exostosis at the insertion point of the plantar fascia on the plantar surface of the calcaneus. One was the case described above, involving a mature male with other arthropathies (KAL-1789), while the second case was an adult female about 30-35 years of age (KAL-1057). In the former case both calcanei were present, while in the latter only the left calcaneus was present. On all three calcanei, several spiky, bony exostoses project from the insertion site of the plantar fascia. The surrounding bone tissue is normal. No changes related to the joint surfaces or other parts of the bones were seen.

Fig. 40. Arthritic changes of the hip. Notice extensive bone formation at the joint margins and eburnisation on the femoral head (case KAL-1046) (Photo: Hahn, 1996)

Discussion of OA

Osteoarthritis is a disease affecting joint cartilage and the subchondral bone, and is at present the most common joint disorder throughout the world (Felson 1988).

OA of the temperomandibular joint has been linked to harsh living conditions (presumably because of greater wear on teeth, i.e. a greater functional demand on the dentition, caused by eating less refined food) (Griffin et al. 1979), but the one case described here can hardly be said to be representative. The case is a female, and both palaeopathological and modern clinical studies show a preponderance of females (Blackwood 1963; Griffin et. al 1979; Kelley 1979). In a recent palaeopathological study, however, OA of the temporomandibular joint was shown to be closely correlated with age but not sex (Hodges 1991). However, even though there was no evidence of earlier fracture of the mandible, trauma leading to subluxation or luxation is a common etiology for OA in the joint. In this case it was not possible to specify the etiology.

In this study spinal OA was more common in males. This accords with other palaeopathological examinations (e.g. Bennike 1985). The incidence of spinal OA increased cranially, which accords with modern clinical studies (Bennett & Wood 1968), although others have found the incidences were highest at the sites of greatest curvature (Nathan 1962), or that the incidence increased caudally (Bennike 1985). However, direct comparison with other studies, especially palaeopathological studies, is problematical because of the fragmentary material. Other studies have used other criteria and classifications (Waldron & Rogers 1991).

OA of the shoulder joint has often been directly linked to physical strain, e.g. the use of a bow and arrow or spear (Jurmain 1977) and carrying heavy burdens (Edynak 1976). It is uncommon in archaeological skeletons (Ortner & Putschar 1985; Waldron 1992), although in this study three cases were found, i.e. almost as many as cases of OA of the hip. One case was symmetrical, one unilateral (only the right humerus was present in the last case), and speculation on linkage with any single specific work-related strain is of course unwarranted. In contrast to shoulder OA, the elbow is reported as a common site for OA (Ortner & Putschar 1985). Again, causes have been proposed, always linking a specific work-related habit of a given gender (in a given society) to the occurrence of OA (Ortner 1968; Kennedy 1989), or to major shifts in cultural and subsistence patterns (Walker & Holliman 1989). In the case of OA of the elbow, this has been linked to sledging in Eskimo groups (Jurmain 1978) or to hard (female) work in hunting societies (Pickering 1979). Bennike (1985) was probably correct when she stated that "it is apparently always possible to find a reason for the picture [of joint involvement in OA] obtained". The two cases found in this study do not suggest any such specific reasons.

The one case of OA of the wrist displays quite severe changes. OA of the wrist, in particular, is thought to be due to earlier trauma or fracture (Bennike 1985). While the ulna, radius and metacarpals seemed normal in shape, an earlier remodelled fracture cannot be ruled out. Unfortunately, symmetrical involvement cannot be judged.

Although nothing much can be deduced from the four cases of hip OA, they do conform to the results of modern clinical studies, where it has been found that males are generally more affected, and that hip OA is age-correlated (Felson 1988). While it is not possible to calculate precise incidences in the Norse material because the remains are so fragmentary, it does not seem a very common affection. Modern epidemiological studies have shown low incidences of hip OA in many third-world countries (compared with Europe and North America) (Felson 1988). The causes and risk factors given for hip OA range from obesity with age and trauma to occupational exposure, and several researchers have suggested that a high proportion of hip OA is caused by clinical and subclinical developmental diseases and mild anatomical abnormalities of the hip (Acheson 1982; Harris 1986; Murray 1965; Solomon 1976). Foremost among these latter diseases and conditions would be unrecognized or mild-degree congenital dislocation of the hip, Perthes' disease or slipped epiphysis. Although others have contested this (Meachim et al. 1980; Lloyd-Roberts 1955), it is nonetheless interesting that one case of presumed Perthés disease was found in the Norse material.

As for knee OA, a generally high incidence has been reported clinically (up to 60%-70% in individuals who died around 70 years of age (Stankovic et al. 1980)). However, changes involving complete cartilage denudation and bony changes are less frequent (Felson 1988). The etiology, to a greater extent than OA of other joints, has pointed towards occupational stress, i.e. repetitive bending at the joints, heavy work etc., as risk factors for knee OA (Felson 1988). The two cases found in the Norse material were both in mature males.

While no detailed analyses of combinations of affected sites were possible, the cases with OA of the shoulder also presented OA of the spine, which accords with previous studies (Waldron 1992).

The case with an erosive arthropathy of the right proximal interphalangeal (PIP) joint is interesting. While several differential diagnoses are possible, and even though actual diagnosis seems impossible because of the lack of the opposite appendicular skeleton, the case does strongly resemble a previously-published case of erosive osteoarthritis (Rogers et al. 1991). In any case, the nature of the lesions points to some form of arthropathy not commonly found in archaeological material (Rogers et al. 1991).

Plantar fascitis, (also called adductor hallucis enthesopathy) resulting in bone formation at the site of a muscle or ligament insertion is a well known orthopaedic entity, often resulting in pain, especially during physical strain (Sneppen 1986). Enthesopathy at this location has been attributed in modern clinical studies to overstressing of specific muscles, for example by people who do a lot of walking or running on hard surfaces (Lehmann 1984; Niepel & Sit'aj 1979). Palaeopathological cases have also been described (e.g. Dutour 1986).

Summary of OA results

Thirty-eight cases of OA were found in thirty-one specimens, mostly afflicting the cervical spine, but most major joints were also represented. The cases of OA and the sites of affection conform with those found in other medieval skeletal populations (Bennike 1985; Waldron 1991, 1992). On the whole males were more affected than females, which contrasts interestingly with modern epidemiological studies, which show a fairly even incidence by gender (Waldron 1992). Analyses for dispersion of afflicted individuals did not reveal any specific patterns in terms of place of interment etc. However, it is worth noting that the males buried in coffins in E29a Thjodhilde's Church generally displayed more degenerative joint disease than the other males, even when stratified for age. Since the pathogenesis and pathophysiology of OA is still widely discussed (Gardner 1983), it would be unwarranted to interpret the pattern of OA amongst the Norse Greenlanders in any specific cultural or social context.

One case displaying erosive arthropathy was found, as were three cases of plantar fascitis.

While it may be concluded that the Norse Greenlanders exhibit joint diseases which to a greater or lesser extent may be induced by strain and a heavy work load, we cannot judge how far this is representative of the Norse population as a whole. The present Norse material is simply not suitable for palaeoepidemiological studies of joint disease.

Trauma

Several instances of trauma were found. Although few in number, some of the cases suggest specific causes and show interesting wound patterns and site dispersions.

Methodology of trauma registration

Most of the skeletal material, especially the crania, was fragmented, which made assessment of possible trauma difficult. Only the cases that exhibited clear, well preserved cut marks and edges or healing lesions were counted as possible trauma (Maples 1986). The traumatic lesions were registered by topography, and for cranial trauma the probable cause was considered by dividing them into lesions inflicted with sharp instruments or blunt instruments (blunt force) (Simonsen 1989).

Results

The topographical distribution is shown in Fig. 41.

Twelve cases were found with evidence of probable cranial vault lesions. Five cases were from E29a Thjodhilde's Church, while seven were from W51 Sandnes (see table 22). The cranial vault lesions were either cut lesions or penetrating lesions.

Cranial vault cut lesions

Two of the cases of cut wounds showed advanced healing (KAL-0932 and KAL-1082). The first case was a female, aged approximately 20-25, with an oblong, irregular depression of the right parietal/frontal bone, measuring 6 x 2 cm. The lesion was well demarcated medially, while the lateral edge was more irregular. The depressed area exhibited some porosity, and a small circular area with sharp margins. The inner table was normal. There were no other cranial lesions, and no other lesions could be observed on the bones of the upper extremities (the bones of the lower extremities are not present).

The other case with healing was a mature male, aged approximately 50-55. The skull had a circular depressed area, located posterior to the right parietal, just above the lambdoid suture, and lateral to the sagittal suture. The area measured 4 x 5 cm, with well demarcated margins,

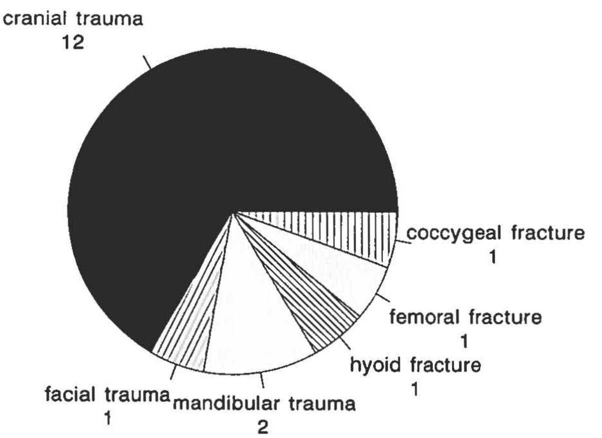


Fig. 41. Distribution of trauma (17 cases in all).

Table 22. Summary on cranial trauma.

ID	Site	Age	Sex	Trauma location	Trauma morphology
KAL-0932	W51	Adult 20-25	Female	right frontal	cut wound healed
KAL-1082	E29a	Mature 50-55	Male	post. right parietal	cut wound healed
KAL-1086	E29a	Mature 40-45	Male	right occipital	cut wound healed
KAL-0950	W51	Adult	Female	left frontal	cut wound
KAL-1089	E29a	Adult 17-23	Male	left parietal	cut wound
KAL-1091	E29a	Adult 25-30	Male	right temporal	cut wound
KAL-1100	E29a	Mature 35-40	Male	left parietal	cut wound
KAL-0975	W51	Sub-adult	n/a	right frontal	slingshot(?)
KAL-0970	W51	Adult 20-25	Female	right frontal	slingshot(?)
KAL-0972	W51	Adult 20-25	Female	right frontal	slingshot(?) 2 lesions
KAL-1751	W51	Adult	Female	right frontal	slingshot(?)
KAL-1751	W51	Adult	Female	left occipital	slingshot(?)

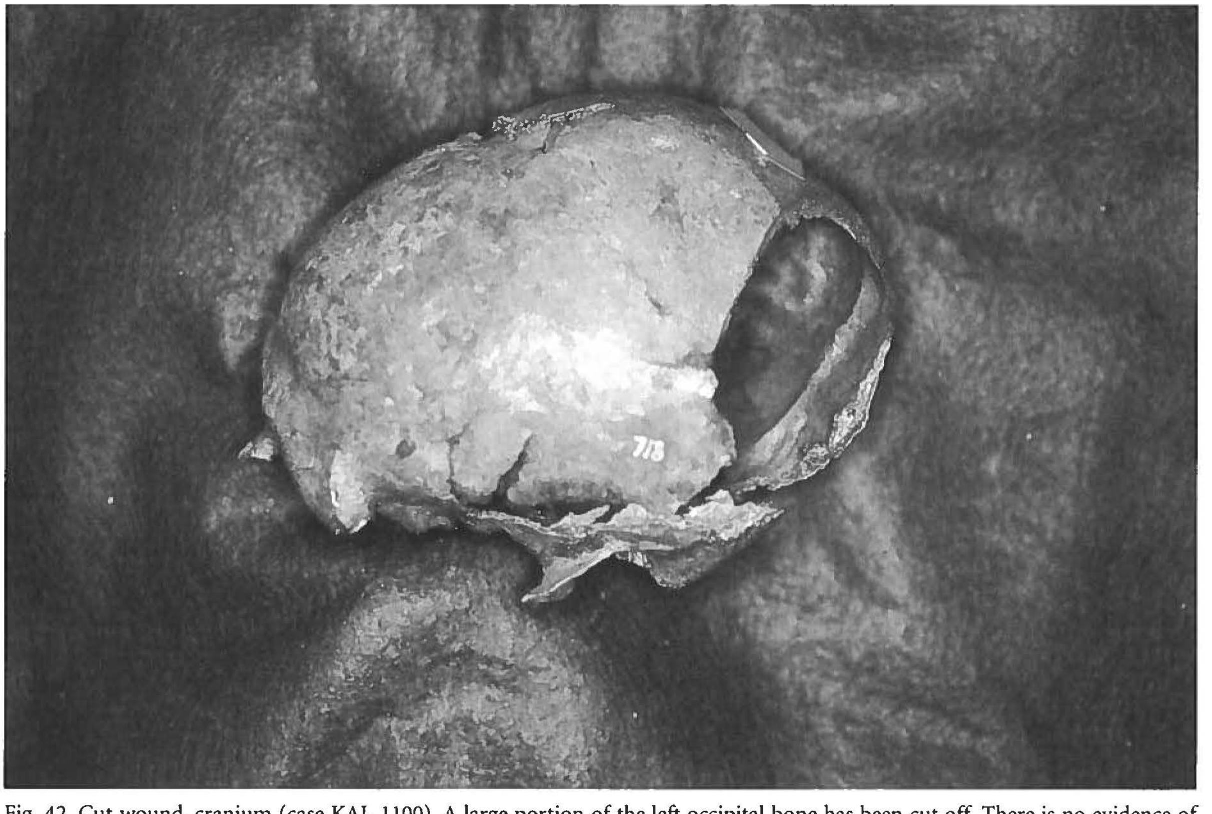


Fig. 42. Cut wound, cranium (case KAL-1100). A large portion of the left occipital bone has been cut off. There is no evidence of healing (Photo: Lynnerup, 1996).

especially anteriorly, where the margin was sharp and slanting.

The other five cases show little or no healing. The first case was from E29a Thjodhilde's (KAL-1086), and was a mature male, 40-45 years old. There was a thin, sharply demarcated groove, originating on the left posterior part of the occipital bone, spanning the lambdoid suture, and proceeding up to the left parietal region, curving slightly laterally. In the lower portion, just around the lambdoid suture, there was slight depression. The region around the groove was slightly porous, perhaps indicating haematoma and incipient organization.

The second case was an adult female from W51 Sandnes (KAL-0950). Only the frontal bone remained. On the left side of the frontal bone, 5 cm above the orbital margin, an oblong lesion measuring 5 cm (length) by 2 cm (width) was seen. The lateral side was depressed, with fracture on the outer and inner table. The medial side slanted medially, so that the margin widened inward. A fragment of bone had been loosened completely, exposing the spongiosa. There was a fracture line posteriorly on the inner table extending to the coronal suture. The margins on the outer table were sharp without any signs of healing.

The last three cases were all from E29a Thjodhilde's Church (KAL-1089, KAL-1091 and KAL-1100), and were a young male about 17-23 years old; an adult male 25-30 years old; and a mature male, probably 35-40 years old. KAL-1100 had a wide cut margin extending from the posterior part of the right temporal bone, along the posterior part of the left parietal bone to lambda, and then caudally into the left part of the occipital. The inferior margins along the occipital and temporal were damaged postmortem. The wound measured 9 cm in width and 6 cm in height. There was no evidence of healing. A large fragment, almost the whole left part of the occipital, was missing. The cranium was damaged in the right temporal and right parietal regions, but it is impossible to say whether this was antemortem (Fig. 42).

KAL-1091 displayed a broad cut margin extending from the right temporal region across the right side of the frontal bone to the sagittal suture. A major vault fragment was loosened. The cut wound measured 7 cm. There was no evidence of healing.

The last case (KAL-1089) concerned a damaged skull. The facial skeleton and the frontal bone, the occipital and part of the right temporal and part of the left parietal were intact, while no other fragments remained. There was a cut margin on the upper left part of the frontal bone, measuring 8 cm, but it had probably extended into the parietal and temporal bones, although these are missing.

Fig. 43. Possible penetrating wound, cranium (case KAL-0975). The lesion is ellipsoid with sharp margins and depression of the cranial table. (Photo: Lynnerup, 1996)

Cranial vault penetrating lesions

Five cases presented a distinctive lesionary pattern. It is uncertain whether they represent trauma or are cases of pseudopathology. All the cases were found at W51 Sandnes. Two of the crania were reasonably complete, one consisted only of the cranial vault, while two cases consisted only of an occipital and a frontal bone respectively.

The case KAL-0975 was a subadult, approximately 6-10 years of age. There was a penetrating, ellipsoid lesion of the right part of the frontal bone, approximately 1.5 cm above the orbital margin, measuring 3.5 cm (length) by 1.5 cm (width). There was depression of a fragment, located posteriorly. The margins were sharp and perpendicular to the vault surface. Parts of the inner table were bent inward (Fig. 43).

The second case (KAL-0970) was an adult female, approximately 20-25 years of age. There was a round penetrating lesion, about 1 cm above the right orbit, measuring 1 cm in diameter. The rims were sharp, and wider on the inner table then on the outer table. There were no fragments. There was no depression of the margins.

Case KAL-0972 was a 20-25-year-old female displaying two penetrating lesions. Both were located on the right frontal bone, the most medial 2 cm above the right orbit and 1 cm lateral to the midline, the other was just medial to the coronal suture, approximately 2 cm above the temporal suture. The two lesions were 1.5 cm apart. The most lateral had a diameter of 1.5 cm, the medial measured 1.5 by 2 cm. The rims were sharp, there were no depressed fragments, the most lateral had a fracture line extending to the coronal suture, and the inner tables were wider than the outer. Nothing was left of the facial skeleton.

Case KAL-1751 was probably an adult female. Only part of the frontal bone remained. Just to the right of the midline, some 5.5 cm above the frontonasal suture, there was a round penetrating wound, measuring 1 cm in diameter. The rims were sharp. A fracture line extended to the right side. There was some diagenetic degradation of the rim to the right side too.

The last case was an occipital bone, presumably from an adult female (KAL-1752). There was a round penetrating lesion just to the left of the midline, approximately 2 cm from lambda. Margins were sharp, with inner widening. There were no fracture lines.

Facial skeleton injuries

There was one case with a nasal fracture, found at E47 Gardar (KAL-0909). The individual was presumably an adult female. Only the skull and mandible remain.

The nasal aperture was pear-shaped, and new bone had formed on the middle margins. The nasal bones also seemed slightly deformed. The two central, upper incisors were lost antemortem, and so were the first two molars on the left side, as well as the second premolar and the first two molars on the right.

Mandibular injuries

Two cases of mandibular fractures were found at W51 Sandnes (KAL-1749 and KAL-0951). In one case only part of the mandible was present, the right ramus being broken off. In the other case the mandible was almost complete, but only the occipital portion of the skull was present. The first case displayed much remodelling and new bone formation extending from the region of the

Fig. 44. Healed fracture of the mandible (case KAL-1749)(Photo: Hahn, 1996)

first molar and premolars caudally to the inferior margin of the corpus mandibulae. Here the protuberantia mentalis was greatly enlarged to the right side, with a smooth surface suggesting advanced remodelling. All right premolars, incisors and the canine had been lost antemortem. The left condyle was normal. There was bilateral development of mandibular tori (Fig. 44).

The other case, an adult female, displayed a probable oblique fracture by the left angulus mandibularis, with thickening and some irregularity (although smoothed) of the surface, both ventrally and externally. The right condyle was missing, but the mandible did not display other pathology.

Fracture of the hyoid bone

One case of hyoid bone fracture was found at E47 Gardar (KAL-0913). It was in a mature male, 50-55 years old. The remains consisted of a complete skull and mandible.

The right cornu majus of the hyoid bone was shortened and displayed a small exostosis by the site of the joint with the corpus. Both horns were fused to the corpus, although a small space was visible indicating the joint site. Although the different morphology of the two horns might merely suggest difference in ossification (Ubelaker 1992), the exostosis on the inferior aspect of the right horn, with slight porosity, does indicate post-fracture remodelling.

Fracture of the femur

One case was found at E47 Gardar, probably an adult male femur (no other bones of this individual were recovered) (KAL-1119). Only the posterior aspect of the bone was well preserved. The femur was bent, displaying a lateral convex shape, at an angle of approximately 20°. At midshaft there was bulging. No fracture lines were visible, and extensive remodelling had already taken place. There were no signs of infection.

Fracture of the coccygeal bone

In one youngish female (KAL-0927), who also displayed sacral spina bifida (see Chapter on Congenital Malformations and Growth Disturbances), the coccygeal segments were not aligned along the vertical axis, displaying a rightward curvature. Although a fracture line was visible, there was evidence of remodelling along the coccygeal vertebral margins, all of which had fused together and to the sacral segments. It is not certain whether this represents results of an earlier trauma, or must be seen in conjunction with a local developmental disturbance along with the spina bifida.

Discussion

The perimortem cranial injuries sustained by the three individuals in the mass grave at E29a Thjodhilde's Church all seem to have been inflicted by a sharp instrument, for example an axe or sword. There was also one male in the mass grave with a healed cut wound. They are very similar to other lesions of the type described (Møller-Christensen 1958; Knowles 1983; Merbs 1989; Courville 1965). The injuries do not suggest crushing, as they would if the individual had for example been smashed against rocks in a shipwreck, or the use of blunt instruments. In the light of the burial circumstances these wounds might suggest a warrior or a clan group who had been in combat. Blood feuds and family revenge were certainly not unknown to the Norsemen, at least according to the sagas, which regularly give examples of such feuds (Byock 1993), and of the use of axes and swords in such conflicts (e.g. GHM II: 325, -337, -353).

The anatomical distribution of cut wounds also exhibits certain characteristics. Usually, such cut wounds are predominantly on the left side, because the two combatants were right-handed (Knowles 1983; Courville 1965). This was only true of two of the cut wounds. However, the cut wounds found in the occipital part of the cranial vault in two other cases were on the right side, which would fit with a right-handed assailant attacking from behind (or, of course, a left-handed assailant – see below).

While it seems plausible to infer combat from the cut wounds, given the gender and anatomical position, there remain the two cases from W51 Sandnes, both of whom were females. In these two cases, the cut wounds were inflicted in the right temporal region.

The penetrating wounds are also somewhat problematical. Weapons which could have inflicted these injuries are slingshots, the tapered back of an axe blade, or crossbows (Merbs 1989) or perhaps even arrowheads (Berglund 1986). These weapons were well known and were used throughout medieval Western Europe (Møller-Christensen 1958), and Roussell stated that there was no reason to think that the crossbow was not imported to Greenland (Roussell 1936). While a crossbow bolt could certainly have achieved penetrating impact, it should be noted that no such metal bolts have been found in Norse Greenland. Arrowheads with a long tapering point have been found (Berglund 1986). On the other hand, if small stones were used as slingshot, they might well go unnoticed during excavation, especially if the skull was damaged and fragmented by diagenetic changes. Shallow dents, 2 cm wide, in the cranial vault have been described as a typical slingshot injury (Knowles 1983). No such depressed, non-penetrating fractures of the same size and morphology were found in this study. In four cases the lesions were located frontally or anteriorly-temporally, but in three of these four cases, the lesions were on the right side, which perhaps does not suggest being struck by an axe in a close confrontation.[11] On the other hand, if we surmise that the lesions stem from crossbows or slingshots, the use of such long-range weapons might suggest warfare. This would then be further supported by the fact that the cases are four females and one child; and this, combined with the above, could well indicate general warfare with indiscriminate attacks on a whole farmstead or settlement. Since the demise of the settlements has been linked to Eskimo attacks (cf. last chapter), or attacks by "pirates", these probable lesions are extremely interesting. Presumably the Eskimos possessed slings.[12] However, it cannot be ruled out that the lesions described here are postmortem and represent pseudopathology.

Another interesting case, from W51 Sandnes, may be mentioned: a bone fragment was found with a chip or splint of iron lodged in it. Unfortunately, this observation was only recorded on a scrap of paper later found with one of the skeletons, and the note ends with the remark: "Specimen is kept separately". Roussell does not mention this find in his publication on W51 Sandnes (Roussell 1936), and the bone fragment has not been found among the skeletal material from W51 Sandnes.

The two mandibular fractures described were at a healing and remodelling stage, and were thus not acute. Oblique mandibular fracture at the angulus has been described previously, as have fractures of the corpus (Alexandersen 1968; Nielsen 1970). Mandibular fractures seem infrequent in the medieval period (Alexandersen 1968), although six per cent of all injuries sustained to the head region among the warriors found at Visby were mandibular (Ingelmark 1939). These injuries were however all cut wounds, while the two Norse cases most probably represent wounds from blunt instruments or perhaps simply accidental causes.

The occurrence of a possible hyoid horn fracture is interesting, as this suggests attempts at manual strangulation (Ubelaker 1992; Simonsen 1989), i.e. direct assault.

Traumas most probably arising from accidents, falls, etc., were on the whole not common. Indeed, only one long bone fracture was found. Aside from this one case, there was a case of probable fracture of the coccygeal bone. The common cause of this is falling on the behind, and the fracture usually heals without complications (Sneppen 1986).

Apart from the cases presented above, the excavation notes include one other case of definite violence. This was the find of a knife blade stuck between the ribs of a male at E29a Thjodhilde's Church (probably indicative of feuding) (Krogh 1982).

Summary of traumatic lesions

The cranial lesions caused by sword or axe cuts are consistent with what is known from Norse tradition (in the sagas) about feuds and single combat. Five crania presented lesions which could be caused by slingshots, crossbows or axes. Since they were all inflicted on females (and one subadult), this might suggest more general warfare. However, this is highly speculative, and further discussion must await finds of similar lesions and further analysis of medieval Norse weaponry.

Other possible evidence of personal violence was the find of a hyoid bone fracture. Traumas of the kind which mostly indicates accidents, such as falls, were few (there was for example only one case of a midshaft fracture of a femur). The two mandibular fractures described could be either accidental or due to violence.

Miscellaneous pathology and non-normal variation

The preceding chapters dealt with the pathological features most commonly found among the Norse Greenlanders. Besides these, however, various pathological conditions and instances of non-normal anatomical variation

[11] This is on the presumption that close combat lesions are usually found on the victim's left side. However, the sagas actually mention a feud where a man was struck with an axe by a left-handed assailant (GHM II: 343).

[12] It is mentioned in Thorfinn Karlsefnes' Saga that the natives of Vinland (North America) used slingshots with stones (GHM I: 427).

were encountered. These are summarized below. The cases are discussed individually.

All of the cases listed below were "chance" findings; that is, the material was not specifically scrutinized for these conditions. However, the ribs were studied directly for any lesions indicative of tuberculosis (Kelley & Micozzi 1984), and special attention was also given to changes that might indicate osteomalacia. When encountered, all pathological specimens were viewed in a dissection microscope and in most cases X-rayed.

Neoplasms

Two neoplasms were found (KAL-1650, KAL-0947) in the material from W51 Sandnes. Only the skulls of the individuals remain. One case was an adult male, probably 30-35 years old, and the other an adult female, probably 30-35 years old. Both presented a hard bony smooth lump, approximately 1.5 cm in diameter, the former on the left side of the frontal bone, approximately 6 cm above the left orbital roof, the latter on the left parietal, approximately 7 cm above the meatus acusticus. There were no other lesions on either of the skulls (although the facial skeleton of the female skull was fragmented).

A "button" osteoma is a benign borderline-neoplastic lesion, commonly found on the cranial vault, especially the frontal bone (Ortner & Putschar 1985; Brothwell 1967), occurring in at least 1% of all autopsies (Ortner & Putschar 1985). The osteoma may represent the site of a former injury, such as a subperiosteal haematoma or a localized inflammatory process (Rosai 1990). Although osteomas may be part of the clinical picture of Gardner's syndrome (which includes hereditary polyposis in the colon, multiple soft tissue tumours and ampullary cancers), this is probably not the case here, as there was only a single vault lesion (Mayer 1994).

Endocrine disorders. Acromegaly

One probable case of acromegaly was found (KAL-0912) at E47 Gardar. A large fragment of the cranial vault, the right part of the mandible and the left femur were found (Figs. 45a and 45b). The individual was probably an adult male (age determination was difficult because of the possible disease-related changes).

The fragment consists of the right half of the theca, the posterior part of the right frontal bone, the right parietal and a fragment of the left and the upper part of the right occipital. The occipital prominences are enormous. The cranial fragment, left side from frontal to occiput, is thickened, and the occipital processes are greatly enlarged. The sutural patterns, sagittal, coronal and lambdoid are normal; the sagittal display 1 cm of obliteration. The mandible is greatly enlarged. Five teeth remain: 48, 47, 46, 45 and 44. No. 46 is enlarged and is big even by modern standards (Alexandersen, pers. comm).[13] The femur is powerful with pronounced linea aspera and trochanters.

The case has been extensively discussed before. At first it was described as an "atavism" (an evolutionary throwback) by Hansen, who saw the specimen as a "monstrosity" – the result of inbreeding of the Norse Greenlanders (Hansen 1924). Hansen did not publish this find scientifically,[14] but the case was subsequently discussed in Nature (Seligman 1931; Perkins 1931). Hansen made a profile reconstruction, assigning several Neanderthal features to the individual. However, when Bröste, Fischer-Møller and Pedersen (1941) re-examined it as part of their study of the material from E47 Gardar, the "atavistic" diagnosis was abandoned and acromegaly was proposed instead.

Acromegaly is induced by hyperproduction of growth hormone in the adult individual, and is most often due to a pituitary tumor (Baumann 1987). This stimulates, among other things, appositional bone tissue growth, especially at the "acral" sites: the head, hands and feet (Lang & Bessler 1961). Cranial changes include "frontal bossing" with enlargement of the frontal sinus, and growth of the maxilla (Baumann 1987).

This case displays marked condylar hyperplasia, with resulting growth of the ramus mandibulae, effectively drawing the teeth away from occlusion, which is in accordance with the almost non-existent dental abrasion (the tongue, which also enlarges in acromegalics, can become interponated between the upper and lower jaw (Stein-

[13] A full dental analysis of the specimen was conducted by P.O. Pedersen (in Bröste et al. 1941). Also, the various dimensions of the cranial fragments are given in this article.

[14] There are several newspaper clippings with interviews with Hansen, where the find is said to be as important as the Neanderthal finds.

Fig. 45a. The mandible of the so-called "Homo Garderensis". Case KAL-0912. (Photo: Hahn, 1993).

Fig. 45b: The cranial vault of the so-called "homo Garderensis", right posterior view. Case KAL-0912. (Photo: Hahn, 1993).

bach et al. 1959)). The growth of the ramus can also result in a growth of the alveolar part of the mandible, effectively trying to maintain occlusion, resulting in excessive height of the mandibular corpus, which is also the case here. Finally, this may result in the resorption of the mandibular angle (Steinbach et al. 1959), a feature also displayed by the specimen.

Congenital malformations and growth disturbances

One case of cranial synostosis (KAL-0925) was found at W51 Sandnes (Fischer-Møller 1942). The individual was a child, approximately 6 years of age. Only the skull remains. The sagittal suture had closed completely, except the anterior 5 cm. The other sutures are open. There is some widening of the skull, especially bulging of the parietals, while there does not seem to be undue elongation of the skull (Fig. 46). Facial skeleton and mandible are normal.

Premature closure of cranial sutures has been extensively described palaeopathologically (Ortner & Putschar 1985). Premature closure is most common in the sagittal suture (Riishede 1985), and cranial synostosis has been reported in 0.5% of European skull collections (Stewart 1972). Modern clinical studies report an incidence of 1 per 2,000-4,000 births (Tange et al. 1994). Premature closure can be part of several craniofacial malformation syndromes (Tange et al. 1994), although this does not seem to be the case here (Kreiborg, pers. comm.). While compensatory elongation of the cranium is most often seen (Riishede 1985), parietal bulging, as in this case, has also been reported (Bennett 1965).

Although a higher mortality has been reported for children with synostosis (Stewart 1972), the cause of death may equally well have been totally unrelated to the synostosis in this case.

Three cases of spina bifida were found (KAL-0927, KAL-1123 and KAL-1608) at W51 Sandnes. In the first case there had been some diagenetic damage in the sacral bone, mainly flattening of the bone, but also loss of the upper part, while the sacral bone in the other two cases was well preserved (Fig. 47). The cases concerned a 35-40-year-old female (KAL-0927), a 20-25-year-old female (KAL-1123) and a 55-60-year-old female (KAL-1608).

In the case of the younger female (KAL-1123) there is fusion only at the second and third sacral segments, with no fusion at the lower segments down to the coccygeal segments, and no fusion at the upper sacral segment.

There were arthritic changes related to the upper segment. The lumbar vertebrae were not available for study. The coccygeal segments were aligned along the vertical axis, but had a rightward curvature. Another of the three cases (KAL-1608) displayed lack of fusion at least from the second segment through to the fifth segment and probably longer, although the lower and upper part are missing.

Spina bifida is non-fusion of the spinal canal, occurring lumbosacrally (more rarely cervically, and very rarely thoracically) (Riishede 1985). Spina bifida can either be occult, which probably affects 15-20% of all adults, giving no clinical symptoms, or cystic, which means that there is extraspinal herniation of the subarachnoidal space as myeloceles or meningoceles. This last form is usually combined with severe neurological symptoms (Riishede 1985).

Spina bifida has often been found in anthropological studies (Ferembach 1962; Gregg & Gregg 1987), and there is probably a genetic basis for the expression of the malformation (Ortner & Putschar 1985). However, comparisons with other studies are not relevant, as what constitutes an abnormal condition has not been adequately defined (Ortner & Putschar 1985: 356). The three cases presented here are most probably of the occult kind with no clinical symptoms or impairments. The curvature of the coccygeal segments of the younger female suggests an earlier fracture (see previous Chapter on trauma). She was buried with a foetus, the remains of which were found by the right femur according to the excavation reports (Fischer-Møller 1942), but whether a possible earlier fracture of the coccygeal played a part in obstetric difficulties which resulted in the death of mother and child can only be speculation. The prevalence of sacral spina bifida was thus 13% in this material, which seems to accord with present-day levels. Only one of the specimens could be traced back to a particular burial place, so it was not possible to investigate whether the three cases were buried close to one another (as a sign of genetic affinity).

One case from E29a Thjodhilde's Church (KAL-1095), a subadult, probably 15-20 years of age, displayed non-fusion of the anterior part and semi-fusion of the posterior part of the atlas, and a bifid dens axis. The remains consist of partly fragmented cranial vault, facial skeleton, and remnants of the mandible. The third and fourth cervical vertebrae are also present (and do not display any pathological changes). The frontal arcus has a sharply defined defect measuring approximately 2-3 mm in the middle. There was no proper fovea dentis. The posterior arcus had a defect in its middle cranial portion. The dens axis is bifid in its upper half. Posteriorly, the processus spinosus is clearly bipartite. Cases of cervical spina bifida or cleft atlas have only been published very rarely (e.g. by Gregg & Gregg 1987), although incidences ranging from 0.0% to 5.6% have been reported for various prehistoric, early historic and medieval English material (Brothwell & Powers 1968).

Fig. 46: Child skull with premature closure of the saggital suture. Case KAL-0925. (Photo: Hahn, 1993).

One case of probable cleft palate (palatoschisisis) was found at W51 Sandnes (KAL-0934). The remains consist of the skull and mandible of a mature male, probably 35-40 years of age. The palate has an enlarged foramen incisivum and the sutura mediana is open except for a part around the crossing with the sutura transversa. Posteriorly, the sutura mediana opens up, effectively completely dissecting the two horizontal laminae of the palate. The spina nasalis, vomer and the maxillary alveolar process are all normal. This case of cleft palate probably never presented any clinical symptoms, as the hard palate as such was intact (and therefore functional). The individual may have had a cleft uvula, so this was probably a borderline case.

Fig. 47. A case of occult spina bifida. Case KAL-0927. (Photo: Hahn, 1993).

The cases of cleft palate which have been described anthropologically usually present much more pronounced features like the absence of most of the hard palate, and bilateral manifestation incorporating the maxilla (Ortner & Putschar 1985; Brothwell & Powers 1968; Balslev-Jørgensen 1953). In modern clinical practice an incidence of 2 ‰ has been reported (Krasilnikoff 1985).

A case of processus paramastoideus was found on one of the skulls in the mass grave at E29a Thjodhilde's Church (KAL-1101). The skull was of an adult male, aged approximately 25-30. The facial skeleton, the mandible and the basis cranii frontally to the foramen magnum is intact, while most of the cranial vault and baso-occipital region is missing. It was not possible to connect the disjointed postcranial material with the crania, but in this case the atlas could be positively joined with the skull. The specimen has a bony growth, measuring 8 by 9 mm, on the jugular surface of the left occipitalis. The bony growth is damaged apically. On the opposite occipitalis (right side) there is only a small 5 mm long laterally projecting cone-shaped bony growth. The left processus transversus of the atlas bears an articular facet, measuring 4 x 5 mm. This facet had most probably articulated with the processus paramastoideus. The right processus transversus has a bony overgrowth forming a roof over the foramen transversum. On the cranial part of this overgrowth a not fully developed articular facet can be seen which would have been very close to the small cone-shaped outgrowth on the right occipitalis as described above (Fig. 48). When the atlas was articulated with the occipital condyles, it was apparent that the paramastoid process had caused an lopsidedness of the joint, resulting in a tilting of the basis cranii to the right. Paramastoid processes have been described as rare (Carpasso 1992), although others have reported frequencies as high as 7.6% (Crow Amerindians) (Gregg 1993). The process is generally well developed in herbivores, and it has been speculated that the trait in humans represents so-called cranial shifting (Anderson 1993). The processus paramastoideus would probably not have produced any clinical symptoms, apart from the lopsided heads position, but we may speculate whether osteoarthritic developments in the region would have been accelerated.

Fig. 48: Paramastoid process. Posterior view of the cranial base, showing the basi-occipital region and the atlas (putty interspersed in the atlanto-occipital joints. The paramastoid process is seen lateral to the left atlanto-occipital joint. The left atlantoid transverse process has an articular facet (edges just visible on the photograph) indicating that the paracondylar process has been in articulation with the atlas. Note resultant skewing in the horizontal plane of the atlas. Also note complete bridging on the right transverse process. Case KAL-1101 (Photo: Hahn, 1993).

One case displaying senile atrophy of the parietals was found in the mass grave at E29a Thjodhilde's Church (KAL-1087). The skull is reasonably intact, and the mandible is present. The individual is a mature male, aged approximately 40-45 years. The skull could not be linked with any of the postcranial bones found in the mass grave. Oblong depressions could be seen bilaterally and posteriorly on the parietals. The cortex was thinned and the outer table showed exposed spongy bone. No other parts of the skull were affected; nor was the internal table (the skull was X-rayed). It has been speculated that biparietal atrophy may be due to masticatory stress, a congenital disposition, or correlated with generalized osteoporosis (Ortner & Putschar 1985).

Porotic Hyperostosis

Two cases with cribra orbitalia were found; a mature male, approximately 40-45 years of age (KAL-0902) and an adult female, approximately 20-25 years of age (KAL-0906), both from E111 Herjolfsnes. Only the skull of the former remains, while the mandible of the latter is also present. The male skull presented bilateral slight porotic hyperostosis of the orbital roofs. There was no involvement of the cranial vault. The orbits of the female skull were damaged, so that only the left orbital roof could be evaluated. The porotic changes were slight, but in this case there was also slight involvement of the occipital bone, near lambda. The linkage between the orbital lesions and occipital lesions has been well described (Stuart-Macadam 1989). Porotic hyperostosis is thought to represent remnants of periosteal changes in childhood, resulting from a demand for enhanced haematopoiesis, and has been linked especially to iron-deficiency anaemia in childhood (Hengen 1971). Infections and scurvy have also been proposed as causative agents (Ortner & Putschar 1985), but anaemia also occurs in chronic infections and scurvy (Wilson 1994), thus making anaemia the most likely explanation. It has been emphasized in recent studies that even though childhood anaemias may play an important part in the etiology, other factors such as diet and pathogen load must also be analysed (Stuart-Macadam 1992).

Interestingly, while iron-deficiency anaemia used to be seen as a "stress" marker, i.e. as indicating dietary iron deficiencies, the view is now shifting to what is perhaps a more controversial view; that it represents an adaptation to a high pathogen load, since slightly lowered iron levels would be beneficial against infection (Stuart-Macadam 1991). According to this theory, if cribra orbitalia is found in a skeletal population, it indicates an adaptive response rather than a population "stress", for example malnutrition. Thus, higher frequencies of cribra orbitalia should be expected in regions and times of greater disease/pathogen load, i.e. in situations of high population density, in tropical rather than temperate areas, and in lowland rather than highland regions (Stuart-Macadam 1992). This accords well with the low frequency of cribra among the Norse Greenlanders. It is also worth remarking that the two instances are both from the same churchyard, which has been dated to the late settlement period.

Summary of miscellaneous and non-normal variation

Various pathologies were encountered in the Norse skeletal material. Cases included acromegaly, various congenital malformations, and benign neoplasms. The diseases, while in some cases possibly detrimental to the individual (acromegaly, cranial synostosis), would hardly have significantly affected the general constitution of the population. As noted in the introductory remarks, the ribs were given special attention. All ribs were evaluated for any evidence of lesion suggestive of tuberculosis. These lesions include diffuse periostitis or signs of local abscess on the internal aspect of the rib (Kelley & Micozzi 1984). No such lesions were found. Nor were any changes indicative of osteomalacia encountered. While Hansen did indicate that several individuals from E111 Herjolfsnes did display such changes (Hansen 1924), this was rejected later by Fischer-Møller (1942).

Palaeodemography of the Greenland Norse

That a race so small in number, so weakened by internally and externally unfavourable life conditions, was nevertheless able to stay so gallantly at its post so long, much longer than was formerly conceived possible, speaks highly of the original quality of the race.

F.C.C. Hansen, 1924

Palaeodemography based on the skeletal material

Methodology

Much controversy has arisen concerning palaeodemography based on skeletal material. After an initial, seemingly successful start (e.g. Vallois 1960; Angel 1969; Acsadi & Nemeskeri 1970), several researchers pointed out inherent errors, especially problems related to the precision of age determination techniques (Bocquet-Appel & Masset 1982). While this will be more fully discussed below, it does mean that in this study, as a result of this criticism, ordinary life tables will not be presented. Other demographic parameters, such as life expectancy at 20 years of age, juvenile-to-adult ratio and mean child mortality were used instead. In addition, calculations of survival functions by sex and site were based on individuals who had reached 20 years of age.

In order to examine sex differences in adult mortality, Kaplan-Meier estimates were calculated as implemented in the SYSTAT statistical software package (Steinberg & Colla 1988). The standard error of the survival function was calculated as Greenwood's estimate (Kragh Andersen & Væth 1984; Steinberg & Colla 1988). The Mantel variation of the log-rank test was used for evaluating differences between strata (Kragh Andersen & Væth 1984; Steinberg & Colla 1988). Fischer's Exact Test was used to test differences in juvenile:adult indices. The Mantel-Haenszel test was used to analyse differences in mean child mortalities (Wulff & Schlichting 1988).

Material

Only two subsamples were used in these analyses: the material from E29a Thjodhilde's Church and the material from W51 Sandnes. These are the only two samples with a reasonable size (> 100 specimens). The radiocarbon analyses indicated that the material from E29a Thjodhilde's Church is from the Early Settlement period, while the material from W51 Sandnes is from the Late Settlement period.

Age and sex profiles

Of the total number of specimens from E29a Thjodhilde's Church and W51 Sandnes, 48% and 46% respectively could be grouped into age cohorts of five years. Analyses were done on a sex-specific basis (neither population by itself varied statistically significantly from a hypothetical 1:1 sex ratio ($p = 1.000$), which indicated that the material was not too skewed (Lovejoy 1973)).

Figures 49-50 show the age and sex profile of the two samples (the population "pyramid"). The subadults have arbitrarily been divided equally into males and females, following the practice of earlier studies (e.g. Bennett 1973).

There seems to be a sex difference, with more females than males, in the 20-39-year age cohorts. This has already been mentioned in the first chapter, and was found statistically significant.

Kaplan-Meier estimates by sex and by sites

Kaplan-Meier estimation (Foldspang et al. 1990; Kragh Andersen & Væth 1984) was grouped by sex for each site. Only adults were included (>= 20 yrs) in the calculations. Figure 51 shows the survival plot for females and males from W51 Sandnes. There was no statistically significant difference ($p = 0.754$). Nor was there any significant difference for E29a Thjodhilde's Church (Fig. 52), ($p = 0.631$).

Stratification was also carried out by site for each sex.

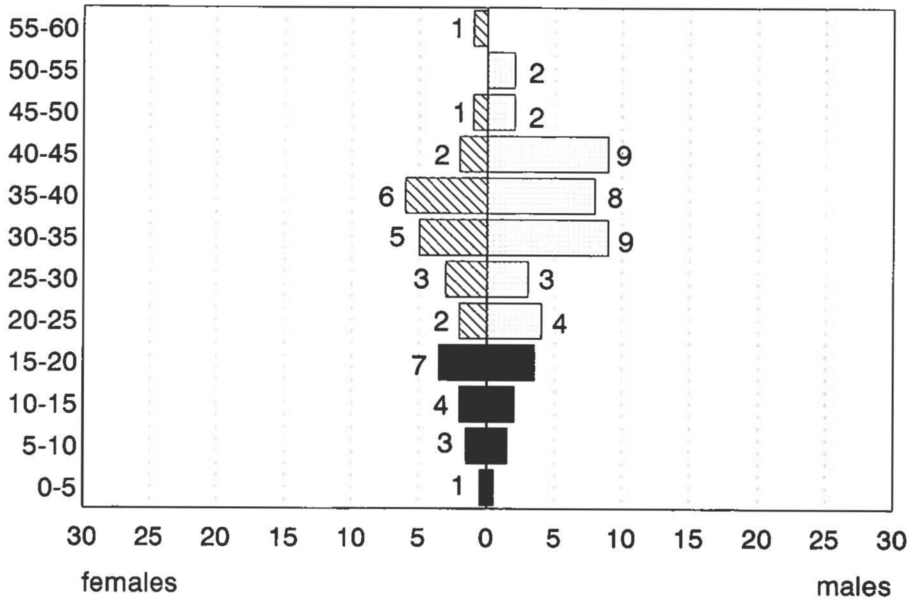


Fig. 49. E29a Thjodhildes Church: Age distribution in 5 yr. intervals by sex. Dotted bars: males; hatched bars: females; solid bars: subadults (note that subadults have been divided equally between sexes).

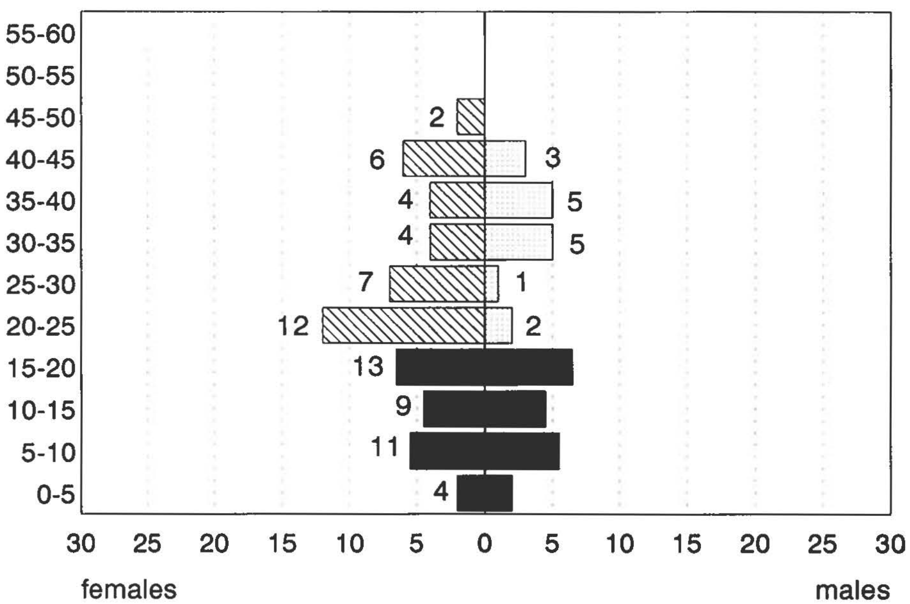


Fig. 50. W51 Sandnes: age distribution in 5 yr. intervals by sex. Dotted bars: males; hatched bars: females; solid bars: subadults (note that subadults have been divided equally between sexes).

Fig. 53 shows higher mortality for young females from W51 Sandnes than for females from E29a Thjodhilde's Church, although the difference was non-significant (p = 0.390). The difference in male mortality was also non-significant (Fig. 54) (p = 0.229).

Mean age at death, life expectancy

The mean age at death for adults (> 20 years of age) was calculated as an average of the sum for all individuals in each age cohort multiplied by the interval midpoint (Jackes 1992) (Table 23). While the mean age at death may also be calculated starting with individuals aged 0 years, this was considered too unreliable because of the apparent underrepresentation of infants. The mean age at death is equivalent to life expectancy at birth if the population is assumed to be closed and stable (Johansson & Horowitz 1986), and if the probability of dying within a given age interval is equal across the age interval. The latter is probably not the case, but attempts to circumvent this seem to show that the error introduced is in the range of 1-3 years only (Boldsen 1988). The median life expectancies as calculated in the Kaplan-Meier analyses are equal to the calculated average mean ages at death (a difference of 2.5 years is due to the life expectancy formula, which adds the mean interval length (Armitage & Berry 1987)).

Ratios

The juvenile:adult (JA) index (the 5-14/20+ ratio) was calculated (Table 24). This is a ratio of subadults between 5 and 14 years of age to all adults. Children below 5 years

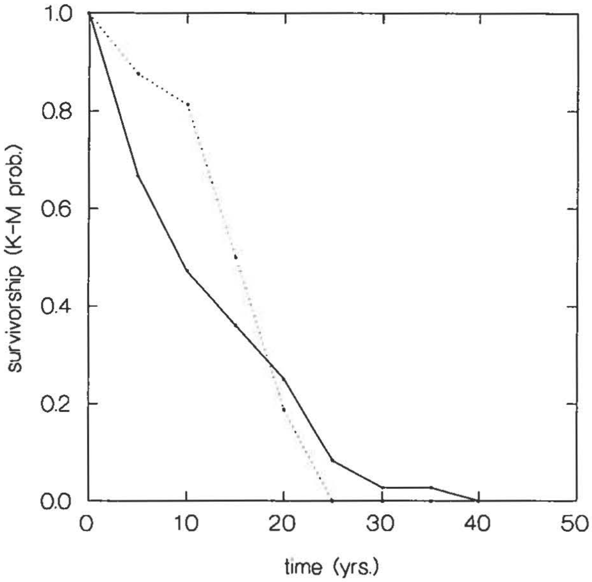


Fig. 51. Survivorship functions (Kaplan-Meier probabilities) for males (broken line) and females (solid line) from W51 Sandnes.

of age are omitted (Bocquet-Appel & Masset 1982; Jackes 1992).

The difference between the two ratios is statistically significant ($p = 0.036$).

The mean child mortality (MCM) was also calculated (Jackes 1992) (Table 25). This is calculated as the mean of the summed mortality rates for the three age intervals 5-10, 10-15 and 15-20, where the mortality rate is the number of individuals who died within the given age interval divided by the total number of individuals at the beginning of the age interval. The calculation includes all adults.

The child mortality rates for each of the three subadult age cohorts are plotted in Fig. 55. The difference between the MCMs is significant ($p = 0.026$).

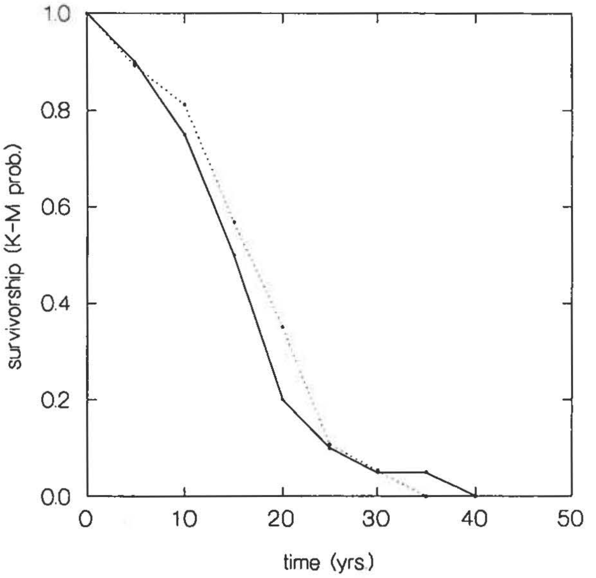


Fig. 52. Survivorship functions (Kaplan-Meier probabilities) for males (broken line) and females (solid line) from E29a Thjodhildes Church.

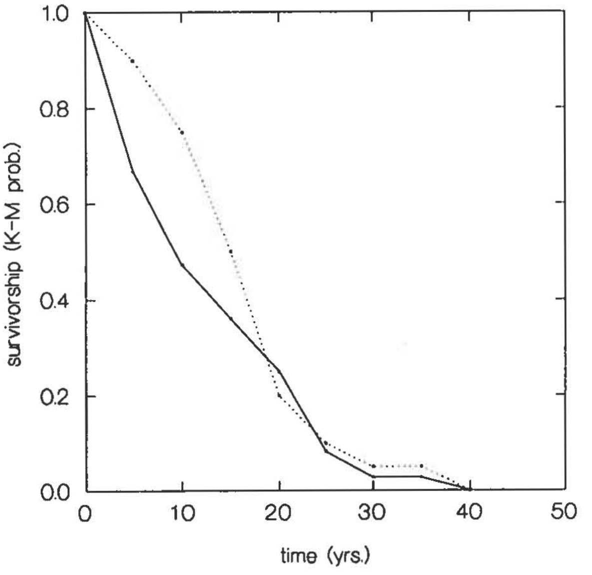
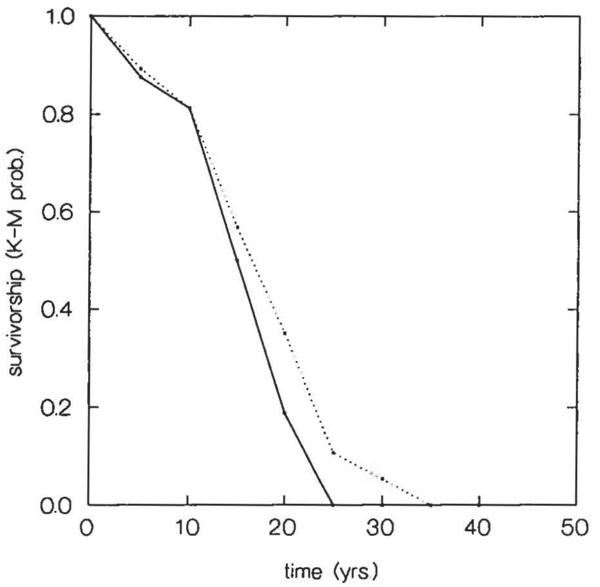


Fig. 53. Survivorship functions (Kaplan-Meier probabilities) for females from E29a Thjodhildes Church (solid line) and W51 Sandnes (broken line).

Discussion

As noted in the introductory remarks to this chapter, there has been much controversy about the feasibility of palaeodemographic studies. The main criticism is that age determination of anthropological material is too unreliable (Bocquet-Appel & Masset 1982, 1985; Bocquet-



54. Survivorship functions (Kaplan-Meier probabilities) for males from E29a Thjodhildes Church (broken line) and W51 Sandnes (solid lines).

Table 24. Juvenile: Adult indexes.

Site	JA
E29a Thjodhilde«s Ch.	0.054
W51 Sandnes	0.138

Appel 1986). This is due both to the inherent inaccuracies of the age estimation methods used, and, as discussed in a previous chapter, to the inherent bias that comes from the development of these methods with modern skeletal populations. To this problem we must add the difficulties caused by selectivity, i.e. the degree of underrepresentation of subadults, gender skewing, incomplete excavations, and variations in mortuary practices (Meindl et al. 1983). While some researchers (e.g.

Table 23. Mean life expectancy at having achieved 20 years of age.

Site	Average age at death (e^{20})	
	FEMALES	MALES
E29a Thjodhilde«s Ch.	35.25	36.42
W51 Sandnes	31.94	34.38

van Gerven & Armelagos 1983; Buikstra & Konigsberg 1985; Roth 1992) defend the use of palaeodemography, they also acknowledge that there are problems, and it would seem that many of the usual demographic parameters cannot be used in a palaeodemographic context (Jackes 1992; Johansson & Horowitz 1986).

The child mortality rates may serve as an example of how difficult demographic parameters are to evaluate. Indeed, the calculation of this rate from skeletal material is based on a host of assumptions; for example that the skeletal population represents one single generation cohort (which it does not) and that the population is biologically stable (no immigration or emigration) (Angel 1969). It also assumes that all infants below five have been recovered, which again assumes complete excavation, etc. The crude child mortality rates (0q5) were calculated on the basis of the number of children in the 0-4 year age interval divided by the total number of speci-

Table 25. Mean child mortaliy (a.m. Jackes).

Site	MCM
E29a Thjodhilde«s Ch.	0.035
W51 Sandnes	0.066

mens. A value of 1.54 child deaths per 1,000 per year was calculated for E29a Thjodhilde's Church and a value of 4.16 child deaths was calculated for W51 Sandnes. The same value for present-day Denmark (1980) is 2.26 child deaths per 1,000 per year (Foldspang et al. 1990). In other words, it would seem that infant mortality in E29a Thjodhilde's Church was lower than it is today. This is highly unlikely. If adjustment is made for underrepresentation of child skeletons, as described below, and if the figures are doubled, this still results in low figures, at least for E29a Thjodhilde's Church (2.69 child deaths per 1000 per year). In comparison, most countries of present-day sub-Saharan Africa have child mortality rates between 20 and 24 child deaths per 1,000 per year (Moore et al. 1993).

Since it was evident that the Norse material was not well suited for palaeodemographical analyses, it was decided only to calculate a few well-defined demographic parameters, and to restrict comparative analyses to the E29a Thjodhilde's Church and the W51 Sandnes material. Direct comparison with other skeletal populations or with living populations was therefore only done on a purely tentative basis.

Only half the total number of specimens from both E29a Thjodhilde's Church and W51 Sandnes could be grouped within five-year age cohorts. However, only 1.3% and 5.2% respectively could not be grouped in one

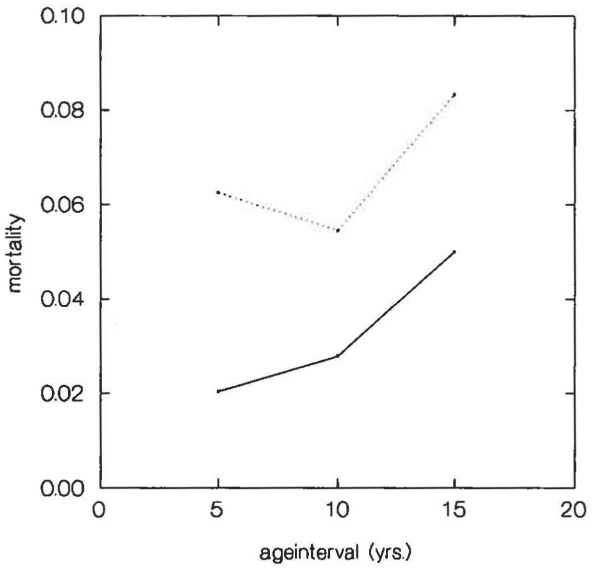


Fig. 55. Mean child mortality for three age intervals: 5: 5 – 10; 10: 10 – 15; 15: 15 – 20 for subadults from W51 Sandnes (broken line) and E29a Thjodhildes Church (solid line).

of the broad age categories, i.e. infans I or II, adultus or maturus/senilis. This means that calculations which rely less on small age cohorts probably utilize the material better. And calculations which do not rely on infants below 5 years of age avoid the problem of variable infant representation.

In the excavations of E29a Thjodhilde's Church, a total of 34 subadult graves and 122 adult graves were counted (Krogh 1982). This gives a subadult:adult ratio of 22%. The subadult:adult ratio calculated from the material of E29a Thjodhilde's Church which was available for the current study is 18/148 = 12%. In other words, subadult skeletal remains were secured from only about half of the identified subadult graves. Since comparison with W51 Sandnes was essential to this part of the study, it was important to establish whether the sampling bias at that site was equivalent. Even though infants below 5 years of age are left out of most of the calculations, differences in JA and MCM might reflect differences in the amount of retrieved material rather than actual differences in mortality. However, no similar data on graves is available for W51 Sandnes.

Instead, possible sampling variation was evaluated by looking at the "un-ageable" skeletal fragments at E29a Thjodhilde's Church and W51 Sandnes. This was based on the proposition that the number of bones found and retrieved outside identified graves reflected the thoroughness of the collector. In other words, if the collector (archaeologist/anthropologist), besides skeletal material from well defined and recognizable graves and skeletons, did secure many single and fragmentary bones from the entire excavation area, he or she was thorough. The more diligent the collector was in retrieving such bone material, the higher number of subadult remains were presumably collected (all other things being equal), since subadult graves in particular can be difficult to recognize. At E29a Thjodhilde's Church 1.33% of the material could not be aged, and represents single and fragmented bones. At W51 Sandnes approximately 5% of the material could not be aged. On the basis of the above proposition, the archaeologists were just as diligent in securing even small bone fragments as the archaeologists and the anthropologist at E29a Thjodhilde's Church. In other words, at W51 Sandnes the archaeologists did not just secure the well preserved crania from easily identifiable graves (as has otherwise often been the case in Norse excavations). Consequently, on the assumption that preservation is equal at the two sites, there is no significant subadult underrepresentation at W51 Sandnes compared with E29a Thjodhilde's Church. Therefore, comparisons of the two skeletal populations, even when they involve subadults, were carried out.

In a previous chapter a simple nonparametric test performed on the broad age categories showed a significant difference when sex differences were investigated within age cohorts. Indeed, for all sites, proportionally more females than males had died in young adulthood, while proportionally more males died in older adulthood (maturus). However, when the more detailed Kaplan-Meier analysis was performed on the individuals who could be grouped in five-year age intervals, the difference was no longer significant.

A sex difference in adult mortality has been found fairly consistently in historic and prehistoric populations (Russell 1983; Acsadi & Nemeskeri 1970; Bennike 1985; Møller-Christensen 1958; Wells 1975). Attempts have been made forward to explain this as female supermortality due to childbirth, or healthier environments for the male (Angel 1969), or cultural discrimination of females (Russell 1983; Wells 1975), or even inherent bias in sexing, where older adult females may be misclassified as males (Meindl et al. 1985). The main use of the analysis here was to avoid confusion due to the different sex composition of the two subsamples, so that the sites could be compared for each sex. In this analysis, there was no significant difference, although there was a trend towards higher female mortality at W51 Sandnes than at E29a Thjodhilde's Church.

The issue of the "osteological paradox" in relation to palaeopathological evidence was discussed above. If it is assumed that the survivorship functions show a trend (albeit non-significant) towards higher female mortality, this should perhaps be reflected in infectious middle ear disease (IMED) frequencies. In fact, more males had evidence of IMED than females. This would then be in accordance with the "paradox", i.e. higher morbidity reflects lower mortality.

The parameters "average life span" and "life expectancy" involve many assumptions, the most important being an assumption of the accuracy of the aging methods within five-year cohorts (Jackes 1992), and the assumption that the churchyard population represents one population cohort. While one can limit the error caused by incomplete subadult representation by calculating life expectancy for adults over 20 (e20), the subadult underrepresentation is really only a minor source of error (Jackes 1992). The greatest source of error probably lies in the inability to set the highest age at death correctly. While others have maintained that the oldest members of a given prehistoric/historic population probably constituted so small a number that they would not contribute significantly to life expectancy calculations (van Gerven & Armelagos 1983), this is not the case. In fact, the general calculations rely heavily on the oldest members of the population, and since there is a tendency for many aging methods to underage old adults, this distorts the results (Bocquet-Appel & Masset 1982; Jackes 1992). Furthermore, it seems that many of the specimens which cannot be aged adequately are indeed the older adults (Jackes 1992).

In this study, however, it was assumed that errors due to age determination (primarily the underaging of older adults) would be equally prevalent in both samples. This means that the calculated life expectancies are meaningful relatively between the two samples, but not as a direct comparison with other populations (although the values actually do fall quite close to average life span values calculated for Danish Viking Age and medieval material (Bennike 1985)). There is thus an evident decrease in life expectancy from E29a Thjodhilde's Church to W51 Sandnes, assuming that the individuals had reached adulthood. The difference is about 3 years for females and 2 years for males (see Table 23).

Changes in life expectancy are often misconstrued as meaning that the oldest members of a given population have shorter or longer lives. This is not the case, as such changes are caused by changes in the mortality of the different age groups (Bjerregård & Juel 1993). In other words, the decrease in e20 between E29a Thjodhilde's Church and W51 Sandnes does not mean that the oldest members of the population did not live as long. Looking at Figs. 42-45 we can see that proportionately more females died in the 20-24 age interval at W51 Sandnes than at E29a Thjodhilde's Church, which was also evident from the Kaplan-Meier analyses.

After attempts to calculate a few of the ordinary demographic parameters (and to demonstrate their weaknesses in relation to this material), other parameters, considered more appropriate for skeletal material, were calculated. These included the juvenile:adult (JA) ratio and mean child mortality (MCM).

The advantages of the JA ratio are that it excludes infants, who may be underrepresented, and that by treating all adults as one single group it not only eliminates many of the age determination errors (it is assumed that one can discriminate reliably between subadults and adults); it also permits the inclusion of all adult specimens that could not be grouped in five-year age intervals. The grouping of subadults in the 5-15 age interval is usually considered reliable (Bocquet-Appel & Masset 1982; Jackes 1992).

The results show an increased ratio of subadults to adults in the W51 Sandnes material in contrast to the E29a Thjodhilde's Church material. This could have two reasons: a higher mortality for the subadults and/or an underrepresentation of adults at W51 Sandnes. However, the latter does not seem to be the case, given the generally small number of subadults; so the JA may indicate a population (W51 Sandnes) with a higher level of subadult mortality than the other (E29a Thjodhilde's Church).

The MCM reflects mortality in the subadult group, but leaves out the infants below 5 years of age – again to prevent underrepresentation. The MCM for W51 Sandnes is double the value for E29a Thjodhilde's Church, and testifies to an increased mortality for subadults at this site. Jackes tried to distinguish between population increases and decreases by focusing on the "q-curves", i.e. the mortality figures for each of the three age cohorts (see Fig. 55) (Jackes 1992). This figure shows that there was a higher mortality among the 5-10-year cohort at W51 Sandnes, while the other two age interval mortalities show the same increasing pattern. This could indicate higher mortality among children, and thus presumably an even higher infant (< 5 years) mortality.

Summary

I have discussed the extent to which comparison of the two sites (E29a Thjodhilde's Church and W51 Sandnes) was relevant, given the sampling biases, especially as regards subadults. However, on the basis of an analysis of fragmentary bones I cannot conclude that the excavators at W51 Sandnes were less thorough in securing the skeletal material, including fragmentary bones, than the excavators at E29a Thjodhilde's Church (who included a physical anthropologist).

The sex-specific survival functions, as estimated by the Kaplan-Meier method, show a non-significant difference in mortality rates, with proportionally more females dying in young adulthood than males. This was also reflected in the general life expectancy (at 20 years of age). If these trends reflect actual circumstances, there are several possible reasons, including cultural discrimination of females (e.g. female subadults not being fed as well as male subadults), although childbirth hazards could also have played a role. However, females did not show significantly higher frequencies of IMED, which is a childhood disease.

Focusing on differences between sites, the Kaplan-Meier estimates showed a non-significant difference in survivorship, with higher mortalities for the W51 Sandnes population. The JA and MCM ratios, however, do yield significant differences, with W51 Sandnes values reflecting higher mortalities.

It is therefore probable that there was a demographic shift between E29a Thjodhilde's Church and W51 Sandnes, the latter population experiencing higher mortality rates among the subadults and younger adult females. Life expectancy declined by about 1.5 to 3 years, which reflects increased mortality rates, especially among younger adult females.

Number of interred Greenland Norse

This section will begin with an estimate of the total Norse population. Although we cannot expect the total number of interred bodies to equal the total cumulative Norse population in Greenland exactly, the numbers should still be roughly of the same order. To do this, two key parameters must first be established: the total burial area and the burial density. This permits the calculation of the total number of interred individuals. Although it is not within the scope of this study to analyse the topology of the churches and churchyards per se, some comments will be made on the shape and size of the churches and churchyards, as this is necessary if we are to calculate the projected number of interments at the sites, and thus obtain a projected total of interred bodies.

Dimensions of churches and churchyards

From the detailed archaeological excavations described in the earlier chapters, three distinct shapes of Norse churchyards have emerged; rectangular, circular and hexagonal/trapezoid (Jansen 1972: 102), where the hexagonal/trapezoid shape may be viewed as a variation of the rectangular. The churchyards which have been described as trapezoid (E111 Herjolfsnes and E105 Klostr), have not been fully excavated, so it has not been ascertained whether these churchyards differed in shape from a broadly rectangular ground plan. While some of the other churchyards, such as E23 Sillisit, are not exactly rectangular, it is adequate for our purposes to describe them as such. Table 26 is an overview of the shapes and dimensions.

Plotting church area against churchyard area (Fig. 56) gives us two distinct groups of churches: the churches with the smallest dimensions and a circular churchyard are located at the innermost corner of the scatter diagram, while the bigger churches with rectangular churchyards show a wider spread, and (see below) have a generally linear relationship between church size and churchyard size. The churches which have a rectangular churchyard but lie among the churches with circular churchyards are E48 Igaliku and E23 Sillisit. E 48 Igaliku has not been fully excavated, so we could hypothesize that the churchyard maybe is circular.

Church dimensions

Figure 57 shows a plot of NS against EW church dimensions (of churches in rectangular churchyards). It must be kept in mind that some churches (e.g. E18 Dyrnes) have not been completely excavated. Linear regression analysis gives us the following equation:

$D_{NS}=0.772 + 0.531 \times D_{EW}$

where

D_{NS}: north-south dimension

D_{EW}: east-west dimension

This means that the NS length is generally half the EW length (R^2 is 0.672, SEE = 1.94).

Churchyard dimensions

Figure 58 plots churchyard dimensions. Two churchyards, E66 Undir Høfdi and E105 Klostr, deviate somewhat from the general impression of the correlations. E66 Undir Høfdi does have a rather unique layout. The maps give the impression that the churchyard has been rotated 90° in relation to the church. Since this is the only church with such a layout, local soil conditions could be the cause. However, the churchyard still seems to conform to certain dimensions. If we rotate it 90° clockwise, and then re-plot (Fig. 58), E66 Undir Høfdi is aligned like the other churchyards. This seems to indicate that even if the churchyard had to be rotated, the builders still aimed for a certain ratio in the dimensions.

As for the dimensions of E105 Klostr, the rather inadequate archaeological investigation has already been mentioned. Indeed, neither dike nor church have been properly excavated (all observations of this site were made by Roussell during a stay of just a few hours) (Jansen 1972; Roussell 1941). So data on this churchyard must be considered somewhat speculative and are thus not included

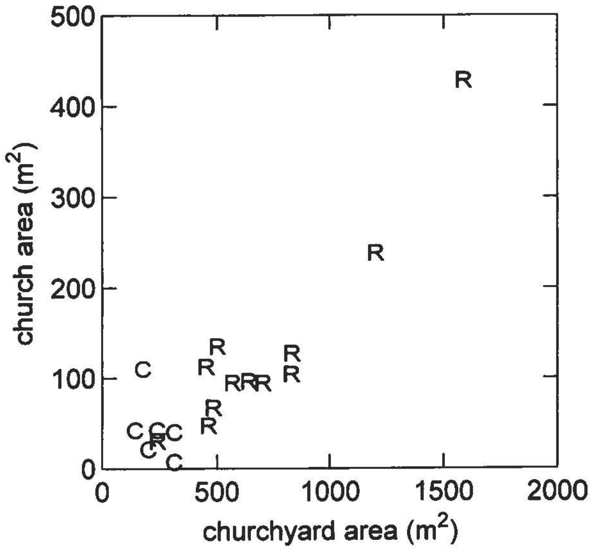


Fig. 56. Scatterplot of church dimensions (area) and churchyard dimensions (area). Church type indicated by label (R: rectangular churchyard; C: circular churchyard). Churches with circular churchyards have much smaller churchyards than do churches with rectangular churchyards.

Table 26. Dimensions and area are based on the archaeologists' observations (refer to the sections on the individual sites).

Site	Shape	Churchyard size (int.) NS x EW[1] *m*	Area of churchyard m^2	Church size (ext.) NS x EW *m*	Area of church m^2
E1	Rect.	21.0 x 23.0	483.00	5.6 x 12.0	67.20
E23	Rect.	14 x 17.35	242.90	8.7 x 5.5	47.85
E29a	Circ.	20.0	314.00	4.5 x 3.0	13.50
E47	Rect.	31.5 x 47.8	1505.70	15.8 x 27.1	428.20
E66	Rect.	27.5 x 24.5	673.75	6.0 x 16.0	96.00
E111	Rect.	23.5 x 30.0[2]	705.00	10.0 x 17.5	175.00
E149	Rect.	20.0 x 25.0	500.00	9.0 x 15.0	135.00
W7	Rect.	21.0 x 27.0	567.00	7.0 x 14.0	98.00
W51	Rect.	21.8 x 31.0[3]	675.80	8.9 x 13.9	123.70
E18	Rect.	30.0 x 40.0[4]	1200.00	14.0 x 17.0	238.00
E29	Rect.	20.0 x 20.5	410.00	7.5 x 15.0	112.50
E33	Circ.	15.0	177.00	11.0 x 10.0	110.00
E35	Circ.	13.0 - 14.0	143.00	6.0 x 7.0	42.00
E48	Rect.	16.0 x 15.0	240.00	5.0 x 6.0	30.00
E64	Circ.	15.0 - 20.0	240.00	7.0 x 6.0	42.00
E78	Circ.	15.0 - 17.0	201.00	6,0 x 7.0	42.00
E83	Rect.	31.2 x 24.8	773.76	7.9 x 16.1	127.20
E105	Rect.	(41.5 x 23.0)	828.00	8.9 x 11.8	105.00
E162	Circ.	20.0 - 22.0	314.00	5.0 x 8.0	40.00
W23a	(Rect.)	?	692.17[5]	?	94.80

[1] The diameter is given for circular churchyards
[2] The NS length determined by regression analysis.
[3] EW length based on map superimposition and regression analysis (see text).
[4] Dimensions based on aerial imaging and regression analysis (see text).
[5] Area based on mean of churchyard areas for rectangular churches (see text).

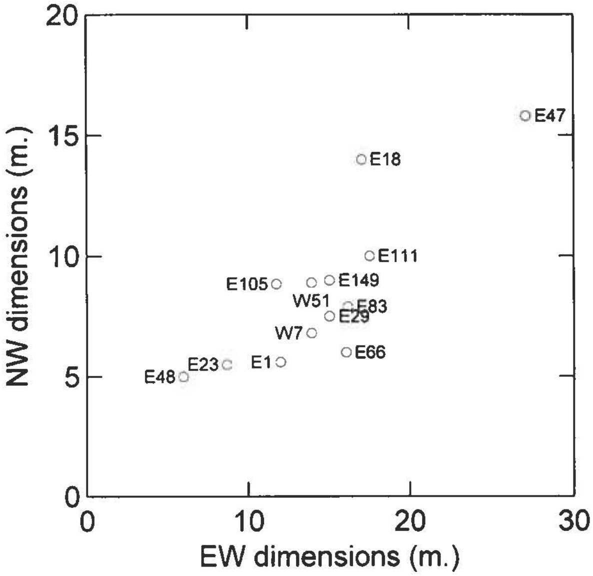


Fig. 57. Scatterplot of church dimensions (only churches with rectangular layout).

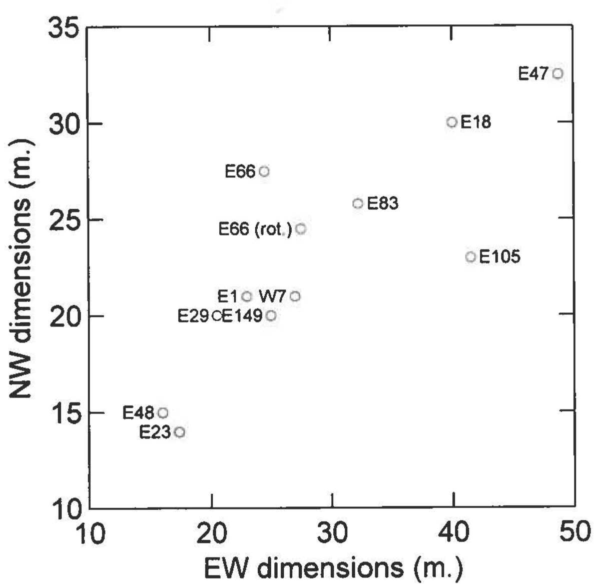


Fig. 58. Scatterplot of NS and EW churchyard dimensions. E66 Undir Høfda is shown twice: unrotated (E66) and rotated (E66 rot.), see text.

in the subsequent regression analysis. The line derived from the regression analysis has the equation:

$D_{NS} = 7.123 + 0.547 \times D_{EW}$

The slope is calculated at 0.547, again reflecting a general approximate ratio of 1:2 for the sides ($R^2 = 0.921$, SEE = 1.697).

This allows us to assess the dimensions and areas of W51 Sandnes and E111 Herjolfsnes. Figure 9 showed how the superimposition of various maps of the W51 Sandnes site allowed us to create an integrated picture of the structures. However, the EW length of the churchyard was not determined. The maps show that the length must have been at least about 31 m judging from the burials found. Using the regression equation, we can calculate the length as 26.8 m (SEE = 1.7 m). The churchyard was thus probably not much longer than the minimum value of 31 m.

The EW length of E111 Herjolfsnes was measured as 30 m. Consequently, the NS length would be about 23.5 m (SEE = 1.7 m). The regression equation also gives a reasonable fit with the data from E18 Dyrnes. The churchyard has not been measured or excavated, but aerial imaging showed that the dimensions were approximately 30 x 40 m, and these dimensions are in accordance with those of the other churchyards (cf. Fig. 58).

Dimensions of burial grounds

The areas available for interment were tabulated on the basis of the above results (Table 26). For each site, the area occupied by the church was subtracted from the churchyard area. Although some burials have been found inside a church building (and this does not include individuals who as a result of church enlargement came to be buried "inside" the church), they are few (the great majority were found at E149 Narsarsuaq, where 20 bodies were observed there (Vebæk 1991: 28)).

Since we have no data for W23a, the churchyard area was calculated as a mean based on what were considered similar churches (all rectangular churches, excluding E47 Gardar and E18 Dyrnes).

At E47 Gardar things are complicated by two factors: the remains of an earlier, smaller church beneath the existing one; and the fact that certain buildings (a bell tower etc.) at some point occupied the southern part of the churchyard. Furthermore, it seems that burials were predominantly sited in the eastern part, whereas very few graves were encountered in the western part. The usable churchyard area was arbitrarily set at 753 m^2 (half of the total).

Burial density

Burial density was calculated by dividing each excavated area by the number of specimens. As an example, Vebæk excavated an area of 3.25 m^2 at E23 Sillisit (Vebæk 1969). In this area five specimens were found, resulting in a density of 1.54 burials/m^2. The excavation areas and the number of interments found are listed in Table 27. The computed site burial density is further divided by the estimated "functional period" (in 100s of years) of the churchyard. The functional period is the approximate timespan during which the churchyard was in use as such. Since no exact dating of the functional periods of the various churchyards is possible, the values of 400 years for Eastern Settlement churchyards and 300 years for Western Settlement churchyards have been set arbitrarily. On the basis of these assumptions, the average burial density was calculated as 0.709 bodies/square metre/100 years.

The various sites show some variation in burial densities. However, the individual values for burial density seem to be in general accordance with those for other medieval churchyards. For example in the cemeteries at Torup, Tryglsjö, Risby and Rathhausmarkt (Kieffer-Olsen 1993), the average density was approximately 0.73 burials/m^2/100 yrs (values calculated by this author). At Westerhus a density of approximately 0.243 burials/m^2/100 yrs. could be calculated (Gejvall 1960). The burial densities at W51 Sandnes, W7 Anavik and E149 Narsarsuaq are thus higher than those at other medieval churchyards, and this seems to be well reflected in the remarks of the archaeologists who excavated the Norse churchyards. A high density may reflect a scarcity of available land, or perhaps adverse soil conditions, which meant, as at E47 Gardar, that fill was needed to create a suitable burial area. Thus, the resultant "layering" and disturbance of other burials may have been the "price" of having a relatively accessible burial ground.

Total number of burials

On the basis of the calculated burial density, the total number of burials per churchyard was calculated (Table 28). A major potential source of error is the functional period of the churchyard. The functional period for the churches in the Eastern Settlement was set arbitrarily at 400 years, while the corresponding period for the Western Settlement churches was set at 300 years (E29a Thjodhilde's Church was set at 100 years). While these figures are probably not too far off for the bigger parish churches (e.g. E111 Herjolfsnes, E47 Gardar, etc.), the functional periods for the smaller circular churches may well have been shorter.

The total number of burials in Norse Greenland has thus been calculated as representing approximately 22,000 individuals. However, this figure stems from calculations based on the number of retrieved specimens. The average percentage of subadults in the total retrieved material is 16.67%. The resulting figures for total population size, given different levels of subadult mortality, are shown in Table 29. The figures were arrived at by calculating how large the total population size would have to be to yield the subadult mortalities shown, given an adult population of 18,260 individuals.

These calculations thus assumed that not all subadult skeletons were retrieved. A subadult mortality of 16.7% is probably too low, whereas a subadult mortality of 50% is probably the upper limit. Assuming a 30-40% subadult mortality, the total number of buried individuals can thus be estimated at about 26,000-30,000.

Average population size

On the basis of the above calculations, the average popu-

Table 27. Excavated areas.

Site	Part	Excav. Area m^2	Inter-Ments[1] N	Burial Density N/m^2	Func. Period years	Avg. Burial Density N/m^2/100yrs.
E23	NE	3.25	5	1.54	400	0.385
E29a	All	300.50	155	0.52	100	0.520
E66	S	4.80	6	1.25	400	0.313
E111	N	290.00	200	0.69	400	0.172
E149	N	12.00	45	3.75	400	0.938
W7	N	2.20	7	3.18	300	1.060
W51	NW	26.00	123	4.73	300	1.577

[1] When possible the Minimum Number of Individuals are used (rf. to chapter 4).

lation size throughout the 500 year settlement period may be calculated from the following equations:

(i) $N = \frac{B \times e}{L}$

where:
N = average population
B = number of burials
e = average life span
L = settlement period

and:
(ii) $N = \frac{B \times 1000}{L \times d}$

where (see also (i)):
d = average mortality

Equation (i) is taken from Hasan (1981) and equation (ii) from Siven (1991). However, since a closed stable population is assumed, where d (per 1.000) = 1/e (Jackes 1992), this effectively means that the formulae are identical (Knussman 1992).

The average age at death calculated in the preceding chapter cannot simply be used here, since it was specifically based on individuals who had reached adulthood. Since the subadult representation in the samples probably does not reflect the actual subadult mortality, the average population size was calculated for different average life span values, which are in turn based on different subadult mortality rates (Table 29). The average life span was calculated by constructing model life tables where the number of subadults was increased stepwise so that they constituted between 0.20% and 0.50% of the total sample, and then by calculating life expectancy at birth (e^0), given an equal probability of death in the age interval 0-20 years.

Table 29. Population size adjusted to various subadult mortalities

Subadult mortality	Total population
0.17	22,000
0.20	22,825
0.30	26,085
0.40	30,433
0.50	36,520

Based on the above formulae and assumptions, the average population size throughout a 500-year period was calculated to be approximately 1,400 individuals.

Discussion of church and churchyard shapes and number of burials

Roussell noted the uniformity in the proportions of Norse church structures, although his analyses mostly

Table 28. Number of individuals are shown as whole numbers

Site	Burial Area m^2	Func. Period yrs.	Burials N	Church Burials N	Total Burials N
E1	416	400	1180		1180
E23	195	400	553		553
E29a	300	100	213		213
E47	753	400	2136	16	2152
E66	578	400	1639	7	1646
E111	530	400	1503	2	1505
E149	365	400	1032	20	1052
W7	469	300	998		998
W51	552	300	1174		1174
E18	962	400	2728		2728
E29	297	400	842		842
E33	68	400	193		193
E35	101	400	286		286
E48	210	400	596		596
E64	198	400	562		562
E78	159	400	451		451
E83	647	400	1835		1835
E105	723	400	2050		2050
E162	274	400	777		777
W23a	597	300	1270		1270
Total	8.417		22018	45	22063

aimed to establish a chronological sequence of church construction (Roussell 1941). The rectangular churchyards show the greatest range of areas (cf. Fig. 35): from a church/churchyard area of 50/500 m^2 to the enormous dimensions (by Greenland Norse standards) of E47 Gardar with an area of 450/1550 m^2. As noted, the smallest rectangular churchyard, E48 Igaliko, which is among the circular churchyards in the graph, may be in fact be circular.

Jansen (1972) and Krogh (1982) have both discussed issues that could arise in relation to church design. Jansen concluded that although the circular churchyard conforms to early Icelandic design, nothing can be said about the dating on this basis, except as regards E29a Thjodhilde's Church. The rectangular churches conform to later Norwegian design, perhaps indicating a shift from mostly Icelandic to mostly Norwegian ties in 1100-1200 (Jansen 1972: 120). The length/width ratios for churches and churchyards (i.e. rectangular churchyards) are both very uniform. This certainly means that the builders followed a common plan.

While one might expect the sizes of the churchyards to have been relatively well established, this is not always the case. First, the churchyard dike has not been totally excavated at several sites (e.g. E111 Herjolfsnes, E18 Dyrnes and W51 Sandnes). Furthermore, the churchyards are assumed to have been delimited by dikes. In the case of E29a Thjodhilde's Church, no dike was found, so the cemetery boundaries are uncertain. It is also assumed that all the area enclosed by a dike is burial area. At E47 Gardar it was clear that not all the enclosed area served as a burial ground, probably because of adverse soil conditions. This may have been the case at other churchyards. Only full excavation can establish this.

Besides the problems of incomplete enumeration and the partial preservation of the skeletal material, which make population calculation difficult (Howells 1960), there is the problem of the "degree" of excavation. In the first chapter, I emphasized the accounts of the archaeologists who had excavated the churchyards. It seemed to be almost the norm that skeletons were encountered in several layers in the Norse churchyards. And there seemed to be a large number of disturbed or spoiled graves, which meant that skeletal parts of more than one individual were often outside graves. It is thus pertinent to assess whether the excavations of the churchyards were "complete", i.e. whether all skeletal material was noted and the area was excavated throughout the grave layer, or whether the excavation was more "exploratory", and was thus stopped when skeletal material was encountered (and the presence of a churchyard had been established). On the other hand, there may have been considerable variation due to soil conditions in burial density within a cemetery, as at E47 Gardar. Burial practices such as a preference for interment on the south side of a cemetery may also have played a role. At E111 Herjolfsnes, there is a conspicuously low density on the north side, compared with the areas near the east and west gable.

The number of individuals used to calculate burial density is probably too low because of subadult underrepresentation. This was corrected by assuming different subadult mortalities, and then calculating the resultant total population. It should thus be clear in view of the above that the burial density and the computed total number of burials must be regarded as purely hypothetical. First of all, there is a major risk of error in the arbitrarily set functional periods of the churchyards. In addition, the estimates for average life span are overly reduced, since they were based on an equal probability of dying throughout the 0-20 year age interval. However, the probability of death was almost certainly higher during infancy than in adolescence, and the possible spread in the average population over 500 years is probably not as much as shown in Table 28. An average population throughout the settlement period of about 1,400 individuals seems reasonable, with a total summated population of about 26,000 individuals (this also reflects a reasonable estimate of 30% subadult mortality). It must also be remembered that the figure of 1,400 per year was calculated as a constant average over 500 years, though of course the population was not as large from the very beginning until the end. The population profile would rather have been bell-shaped, with rising population numbers at the beginning, probably followed by a period of relative stability, and finally by a period of decline. This means that the peak population level, lasting perhaps for a 100-year period, may have been about 2,000.

Other possible reasons for overenumeration or underenumeration would be undiscovered churchyards or burials outside the churchyards. While there may be undiscovered or unrecognized church sites (perhaps in the Middle Settlement), they are unlikely to amount to more than a few. Even assuming that these could be large churches with large churchyards, they would not represent an underenumeration of more than 2000-5000 individuals. Likewise, while we must assume that some Norse Greenlanders died of drowning or on expeditions, even a high mortality estimate (10%) would not greatly influence the grand total. Furthermore, only the remains of three individuals have been found outside the churchyards. The Norse Greenlanders appear to have insisted on burying their dead in consecrated earth, as evidenced by the secondary burials.

Conclusion on number of burials

The analysis of churchyard size and shape, and church size, revealed a clear relationship between these topological features: the circular churchyards were all among the smallest and were associated with small church structures. The rectangular churchyards had the largest areas, not least because of the grand dimensions of Gardar. The differences probably reflect their use: the small circular churchyards would have been associated with local "prayer houses", while the rectangular ones would have been associated with parish churches. Dating on the basis of shape alone does not seem possible, especially since the rectangular churchyards may represent later changes in earlier circular churchyards.

On the basis of the known proportions of the rectangular churchyards, the probable dimensions of W51 Sandnes and E18 Dyrnes were calculated. The burial area (churchyard area minus church area) was calculated for all identified churchyards (except for W23a for which we have no observations).

Given the area of individual excavations and the number of individuals identified in these excavations, a series of burial densities could be calculated, and burial totals for each site were calculated from these figures. This yielded a grand total of about 26,000 burials. However, since subadults are most probably underrepresented in the samples, several total population sizes based on different subadult mortalities were calculated. Likewise, an average population number over the 500-year settlement period could be adjusted on the basis of estimates of average life span. A total population size of 26,000 individuals, equivalent to an average population size of 1,400 individuals, could be assumed from the skeletal material and churchyard evidence. These figures are lower than population figures based on archaeological assessments of farm sizes and numbers. However, it may be assumed that the latter figures represent a maximum, since it is unlikely that all farms were simultaneously in use throughout the settlement period. Furthermore, since the value of 1,400 individuals is an average, the population may well have been around 2,000 individuals for a 100-year period. In this light, the archaeological figures and the figure based on the skeletal material and churchyard evidence do not seem too far from each other.

Population models

The two preceding sections dealt with analyses based on the skeletal and archaeological data in order to arrive at demographic variables. This section will try to establish possible population models based on average population growth rates and other demographic variables.

Theory

Basically, two approaches – a deterministic and a stochastic – can be used to make population models (Renshaw 1991, 1ff). The former is perhaps the most straightforward: population size is expressed as a function (usually exponential) of time (Renshaw 1991; Keen & Spain 1992; Hiorns 1972). This is the approach often used for population forecasts. While population increases often seem to fit well with exponential functions, one must not infer some biological "law" from this. Furthermore, these exponential models only suit limited timespans (for example, while exponential growth can be postulated for the beginning of the settlements, simple extrapolation beyond this initial phase would result in a Norse population in excess of 14,000 individuals by the year 1450 AD). Another widely used deterministic function is the logistical growth curve, or the Verhulst-Pearl Logistic (Renshaw 1991; Keen & Spain 1992; Hiorns 1972; Kingsland 1982). This function incorporates the "carrying capacity" parameter, i.e. it assumes that the population size reaches a maximum at some point. The carrying capacity is the number of individuals who can subsist in a given region. This model will also be used.

The stochastic models incorporate an element of chance, which is why they are also known as "Monte Carlo models" (Barrett 1971). While the deterministic functions are basically linear functions, stochastic models are "event-based" (Howell & Lehotay 1978). By setting the chances of birth and death so that they roughly reflect factors like overall birth and mortality rates, the computer "chooses" an event, i.e. either birth or death, at some given point in time. This is usually implemented by generating random numbers, and the event is chosen on the basis of these random numbers (Renshaw 1991: 20; Keen & Spain 1992: 277). For example, the chance of birth may be set at 0.70 while the death risk is 0.30. By generating random numbers between 0.0 and 1.0 the computer chooses a "birth" if the number is $0.0 < x < 0.70$, and otherwise chooses a death. This gives the overall population curve random variation. After many runs or simulations it can be seen that while the results of most runs are probably close to those obtained with deterministic models, there is much more fluctuation, and, especially in small populations, a chance series of death "events" may lead to extinction. If the outcomes of many stochastic simulations generally lie close to deterministic curves, one can be satisfied that the deterministic approach will provide an adequate description of population development (Renshaw 1991: 3).

In this study the settlement period was arbitrarily divided into two parts: a first part with population increase and a second part with population decrease. This was based on the following assumptions: 1) that the initial settlement population was about 4-500 individuals; 2) that the peak population had to reach at least 2,000 individuals; 3) that the population size had to decrease to below 500 after the peak level.

The first part of the settlement period: population increase

Exponential growth curves

The simple deterministic model lets the population increase exponentially as a function of time (Keen & Spain 1992: 17):

$$N(t) = N(0)\exp(rt) \qquad (i)$$

where:

N(t) = population at time t
N(0) = starting population (t = 0)
r = growth rate
t = time

If it is assumed that a starting population of 500 had to increase to 2250 in the course of 200 years, this would mean that r = 0.0075 (0.75%). This curve is shown in Fig. 59.

Given an average female life span of 29 years and an average female reproductive period of 13 years, with 4.5 live births per female, Hasan calculated a gross reproduction rate of 2.22 based on model life tables. With a corresponding net reproduction rate of 1.11, this leads to a rate of potential natural increase of 0.52% (Hasan 1981). This figure seems to be in general accordance with other studies and with ethnographical data (Hasan 1981). If we apply this value, the Norse population would not have reached 2250 until after 289 years.

Exponential growth curves with immigration

The above model assumes no immigration or emigration. However, it would seem natural to assume some continuing immigration throughout the early stages of the settlement period; even if the majority of the population came over in one major wave, minor waves consisting of small groups may have followed. The formula for exponential growth with immigration is (Renshaw 1991, 41ff):

$$N(t) = N(0)\exp(rt) + a/r(\exp(rt)-1) \qquad (ii)$$

where (see also (i)):

a = immigration rate

Assuming a low immigration rate of 1 person per year on average over 200 years, the result is the curve shown in Fig. 60. A population of 1700 individuals is reached after 200 years, assuming r = 0.0052. Assuming a slightly higher r of 0.0065, a population of 2250 is reached after 200 years (see Fig. 60).

Stochastic models

This model was constructed by setting the probability of death (p_D) at u/l+u and the probability of birth (p_B) at l/l+u, where u is the death rate and l the birth rate (Renshaw 1991: 38). These probabilities were the given values, so that they approached the rate for overall potential increase described above (p_B= 0.70 and p_D = 0.30). A small computer program was then written which, on the basis of a random number (the so-called seed), first calculates the inter-event times as:

$$s = -\ln(Y)/N(l+u) \qquad (iii)$$

where:

s = inter-event time
Y = random number
N = population size
l = birth rate
u = death rate

Secondly, another random number was chosen, and if $0 < Y < 0.70$ then the event was a birth, and if $Y > 0.70$ it was a death. The computer program then adds or subtracts for each event depending on whether the event is a birth or a death. Random numbers with uniform distribution between 0 and 1 were generated by the computer, using randomly selected seeds for each run (Wilkinson 1990b).

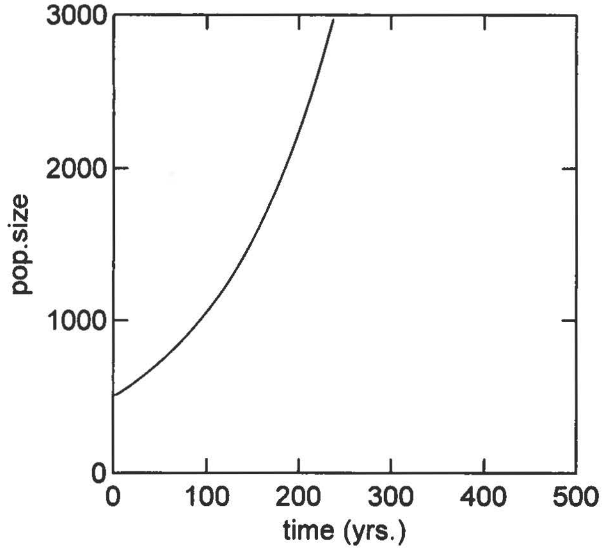


Fig. 59. Simple exponential growth (r = 0.0075).

Figure 61 shows two runs. While most simulations produced results fairly close to the exponential curves, several runs produced other results. The lower of the two curves in Fig. 61 shows practically no population increase, even though births should occur with a higher probability than deaths. If a smaller starting population had been assumed, such a sequence might conceivably have led to extinction (Ward & Weiss 1976).

Logistical growth curve

Growth cannot continue unlimited in any population. Usually, because of environmental factors, there is a limit to the population level. This limit is often termed the carrying capacity of a given biosphere or ecological niche (Renshaw 1991: 50). The logistical growth curve models population increase so that the rate of increase drops as the population reaches the maximum carrying capacity. This may be expressed as a linear function:

$N(t) = K/(1+\exp(-rt)$ (iv)

where (see also (i)):

K = carrying capacity (max. population)

If the function is modelled so that it follows the previously noted exponential growth at the beginning, the constants become $r = 0.011$ and $t_0 = 1.4$. With a presumed carrying capacity of 2500, the formula thus becomes:

$N(t) = 2500/1+\exp(1.40-0.011t)$

This curve is shown in Fig. 62, and is initially in close accordance with the exponential growth curve. However, as the carrying capacity limit is reached, the rate of increase drops and the population size comes asymptotically close to the carrying capacity.

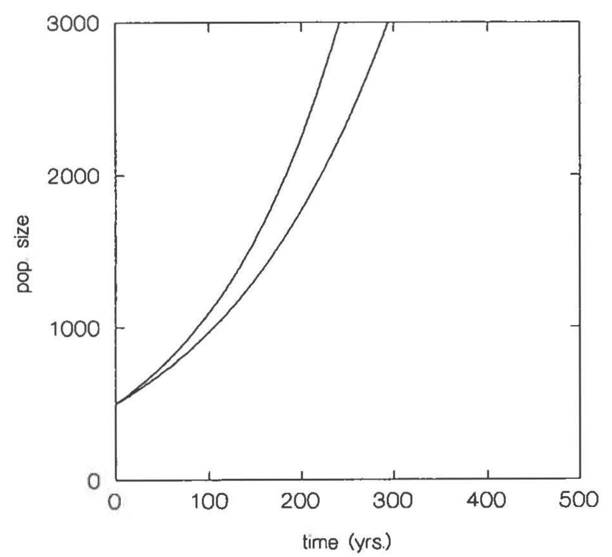


Fig. 60. Exponential growth with immigration (r = 0.0065 (left) and 0.0052 (right)).

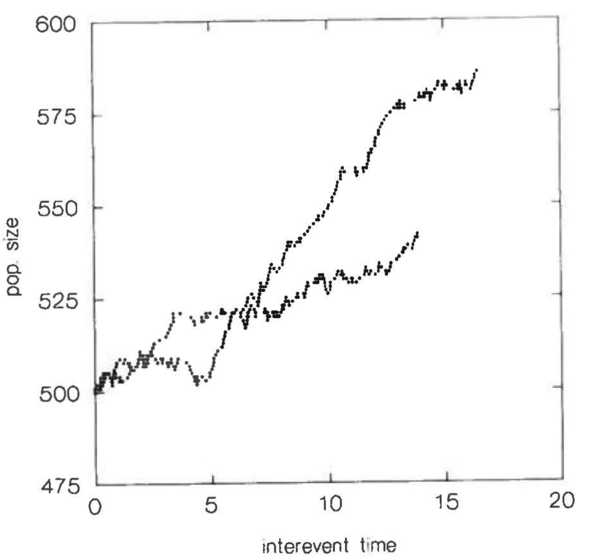


Fig. 61. Stochastic modelling of population growth, showing two "runs" (cf. text).

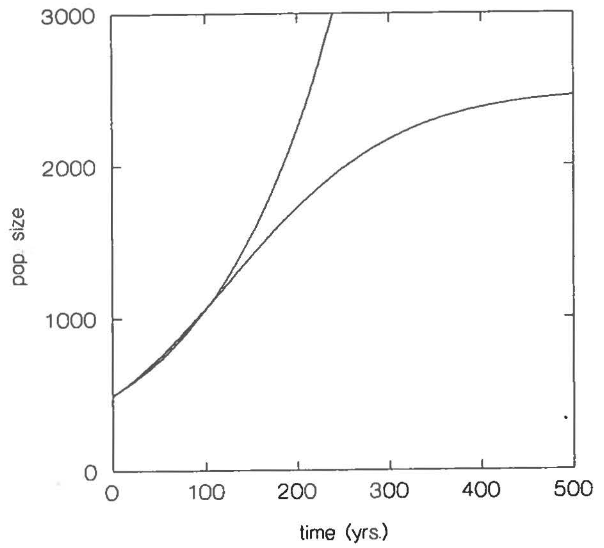


Fig. 62. Logistic growth model. Note how growth rate decreases as carrying capacity limit is approached. The exponential growth curve (fig. 60) has been overlaid for comparison (cf. text).

The last part of the settlement period: population decrease

Extinction at constant rates

If it is assumed that the population decreased from 2000 individuals to 0 within about 200 years, the formula for exponential increase and immigration may be changed to assume a negative a, i.e. emigration:

$N(t) = N(0)\exp(rt) - a/r(\exp(rt)-1)$ (v)

where (see also (i))

a = emigration rate

Since a positive growth rate (due to childbirths) must still be assumed, the values of a and r may be balanced to produce this decrease as shown in Table 30 (cf. Fig. 63).

The higher the r value, the higher the emigration rate that must be assumed. On the assumption that $r = 0.0035$, the emigration rate would be 13 people per year. With these values the population would be extinct within 200 years.

Extinction with linear decrease in growth rate

If it is assumed that the growth rate was not constant as in the above model, but decreased from 0.0035 to 0.0 over 200 years, extinction could be accomplished with an emigration rate of 8 individuals/year (Fig. 64).

Overall population size

A total population profile was drawn up on the basis of the above models of population change (Fig. 65). This makes it possible to calculate the total population throughout the settlement period and the average population per year. The average population was simply calculated by generating the population number per year, summating these numbers and dividing the result by 500 (for 50 years). This yields an average yearly population of 1,377 individuals.

On the basis of the formulae in the preceding chapter, the total population was calculated by assuming a subadult mortality rate of 0.30, corresponding to an average life span of 27 years for the first three hundred years, and a subadult mortality rate of 0.40 and a corresponding average life span of 24 years for the last two hundred years. This yields a total of approximately 26,500 individuals.

Discussion of population models

The aim of this chapter was to investigate feasible population models. Was an increase from a starting population of 4-500 individuals to at least 2000 individuals possible within a 300 year period, without having to assume extreme values for life span, mortality and fertility? And, consequently, could a population of this size pass into extinction? This does indeed seem to be the case, but before we arrive at this conclusion, some of the assumptions used in the above models must be discussed.

The starting population was set arbitrarily at 500 individuals. This was based on historical research, drawing on the accounts in the Grønlændingesaga and Eric the Red's Saga, saying that "32 ships sailed for Greenland...but only 14 made it there" (GHM I: 179, 207). Allowing for a capacity of about 30 individuals per ship (it has been estimated that some of the larger Viking cargo ships in 1000 AD had a cargo capacity of 40 tons (Crumlin-Pedersen et al. 1992)), this means that about 3-400 people could have settled in Greenland in the first wave (Meldgaard 1965). Keller has mentioned that the capacity of the ships may have been smaller, but that there was more regular immigration, leading to a starting population of about 300-800 people (Keller 1986). A minimum starting population of some 500 people would fit with the accepted minimum levels for sustainable populations of about 4-500 (Geist 1978; Dyke 1984).

Table 30. Corresponding values of emigration and growth rate.

Emigration Rate A (indiv./year)	Growth Rate r
15	0.0050
14	0.0040
13	0.0035

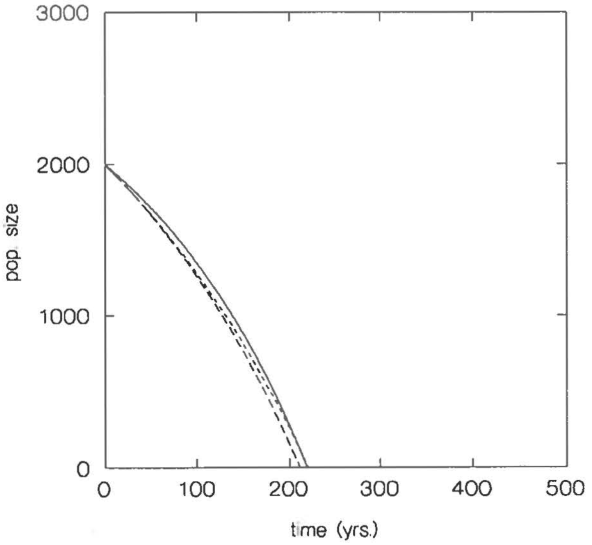


Fig. 63. Depopulation rates assuming different emigration and growth rates (cf. text and Table 30).

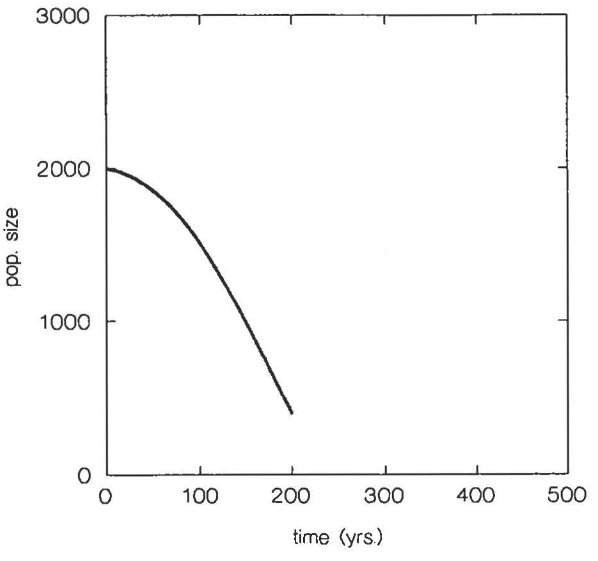


Fig. 64. Extinction model assuming linear decrease in growth rate (rf. to text).

In the above exponential model, a rate of increase of 0.62% was assumed so the population level could increase to about 2,000 within about 200 years. The 0.62% rate parallels a calculated population increase in Iceland in the period 970-1095 AD of about 0.68% (using population figures from Thorarinsson 1961). Keller has also suggested rates of about 0.7% (Keller 1986). Hasan has proposed rates of 0.52% for prehistoric populations with up to 50% subadult mortality (Hasan 1981), and Polgar suggests rates between 0.15-0.40%, although he also suggests that rates may have been particularly high for colonizing populations (at the beginning of settlement (Polgar 1972)). Rates over 3.0% may be found in present-day underdeveloped countries (Nigeria for example has a rate of 3.5% (Lithell et al. 1992)).

A small rate of continuing immigration (1 individual per year) was also assumed. Probably this rate dropped to zero (or rather the net rate of immigration and emigration was zero), over the years 1100-1200 AD. This, along with a slowing of population increase (as the population approached carrying capacity and thus began to strain resources), could be consistent with a levelling-out by 1200 AD. While in the logistical model (Fig. 62) the population level approaches carrying capacity asymptotically, population studies seem to show that "real" populations often experience much fluctuation around the carrying capacity (Renshaw 1991). This would also be the case for the Norse Greenlanders, so the model in Fig. 65 must be taken to represent a sort of "average".

Such fluctuations are best seen in stochastic models, as was shown in Fig. 61, where the initial population increase fluctuated much more than if one simply assumed linear functions. Several hundred stochastic simulations were done, and most lay close to the exponential growth curve. This means that although direct linear growth cannot be assumed, it can be assumed that the exponential growth curve gives a reasonable estimate of population increase (Renshaw 1991).

In his article on palaeodemography, Keller (1986) operates with a larger starting population, and assuming a 0.7% rate increase, reaches a "maximum" population level of about 6,000 by 1300 AD. Keller relates this figure to the number of farmsteads, and to estimates of the number of people per farmstead (15 individuals per farmstead). Keller (1986) himself mentions that there is some uncertainty in such a direct calculation, since, for exam-

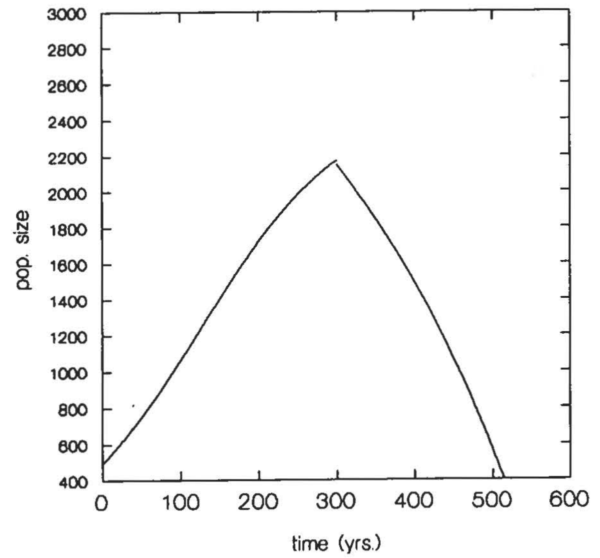


Fig. 65. Population profile throughout 500 years of settlement.

ple, not all farmsteads were in use simultaneously, the farmsteads were of different sizes, etc.

Once we have shown that a population of about 2,000 can be reached within 250 years, assuming that the figures for growth and immigration are realistic, the question remains whether the reverse can be modelled. Is it possible, still assuming realistic parameters, to model an "extinction" curve? In the above, it was assumed that the overall rate of population growth fell from an initial 0.62% to 0.35%. This was based on two assumptions: 1) that average age at death fell from the Early to the Late period, and 2) that child mortality may have been risen (see above). Furthermore, any emigration would probably involve young adults in particular, further lowering fertility rates.

Given a positive growth rate, emigration remains a possible explanation of a decreasing population. Emigration may occur when a population exceeds its optimum level in relation to living conditions (Hasan 1981). This could be because the Norse population reached the carrying capacity of their habitat, which may in fact itself have been decreasing. Several analyses point to a shift in climate which may have restricted the Norse ecological niche, lowering the carrying capacity (Berglund 1986; McGovern 1979). Assuming a 0.35% growth rate, the emigration rate would have to be about 13 individuals per year. This is probably a high figure, perhaps reflecting a whole household per year. Even allowing for a decreasing rate of growth to 0.0 over 200 years, as shown in Fig. 64, this still means that the emigration rate would have to be about 8 individuals per year. For a small population like the Norse one, such a level of emigration would certainly have a massive effect. The question is, of course, whether such rates are realistic. We must first remember that these rates represent averages; that is, emigration would probably have taken place in waves of for example 100 people every 10 years. Furthermore, there can be stochastic variation: once the population is sufficiently small it becomes vulnerable to fluctuations in fertility and mortality (Weiss & Smouse 1976). Incipient decline could thus have been precipitated, and the population could have fallen sharply, perhaps with short periods of relative stability.

The size difference between the Western and Eastern Settlements must also be taken into account. Judging by the numbers of farmhouses (west 80, east 250) (Gad 1977) and by the number of churches, omitting the minor "prayer houses" (west 3, east 11) (cf. the first few chapters), there seems to be a 1:3 ratio between the settlement population sizes. Viewed in isolation, the Western Settlement would rapidly approach the minimum population size of 500. Indeed, given the above emigration rates and lowered fertility rates, the population would fall below this level after just 20 years. It is thus possible that decline set in around 1300 AD, and by some 50 years later, most people would have had emigrated from the Western Settlement, leaving perhaps only a few, mainly old, settlers. The Western Settlement could thus have been completely depopulated during the 14th century. Perhaps the Eastern Settlement then experienced some immigration which for some years offset the rate of decline, but then decline proceeded at the same rate as in the Western Settlement. This would leave the Eastern Settlement depopulated in the mid-15th century.

Decline may also have been caused by exceptionally high mortality rates. High mortality rates are usually linked with war and epidemics. However, even rates of up to 10% of young adults killed in warfare would not substantially decrease birth rates (unless strict monogamy prevailed and the remarriage of widows was prohibited) (Polgar 1972). This leaves practically only highly lethal epidemics as the cause of a dramatic reduction in the population within a short timespan. Plague struck both Iceland and Norway in the 14th and 15th centuries, and total mortality rates of between 30% and 50% have been suggested (see next chapter). Clearly, a halving of the Norse population in just one or two years would be disastrous for such a small population, and on the basis of the numbers alone could quite plausibly explain the population reduction.

With the model shown in Fig. 65 a total population size of 26,500 was calculated, equivalent to an average population size of 1,377. These figures are very close to the figures arrived at in the preceding chapter, where the calculations were based on the number of interments and yielded a total population size of 26,000.

While the growth rate could have been higher than the 0.62% assumed here, allowing the population to reach a larger size of, say, 3-4,000, the population still had to decline over a couple of hundred years. The larger the population in the mid-settlement period, the higher the emigration rates or negative growth rates we have to assume. Indeed, after assuming a maximum population of 6,000, Keller (1986) proposes several depopulation scenarios which involve very dramatic increases in child mortality, etc., in order to bring down the population level by 1500 AD. Furthermore, such a high peak population would result in rather more than 70,000 Norse dead over the whole settlement period. This is almost thrice the number of burials calculated in the preceding chapter.

Conclusion

The model shown in Fig. 65 is, of course, purely hypothetical, and is only one of an almost indefinite number of possible models. However, this model corresponds to the assumptions made at the beginning of this chapter: a starting population of 500, reaching a peak of some 2,000 over a period of about 200 years, followed by a "stable" interval of about 100 years, followed finally by a decline to 0 over 200 years.

To achieve this, a population growth rate of 0.65% and an immigration rate of 1 person per year was assumed for the first period of population increase. These values allow the population to reach a level of about 2,000 over 200 years. This is followed by a period of decline, where the population falls below the level of viability, usually set at 4-500 individuals. To achieve this, a decreased growth rate of 0.35% was assumed, which results in an emigration rate of about 10-13 people per year. These values are averages, and the "real" population was probably subject to many fluctuations, as shown in the stochastic model (Fig. 61). However, the values are "feasible" values; that is, no unduly high or low values have to be posited to model the population.

The figures arrived at here may be compared with figures obtained in other ways – for example the total population as hypothesized by the archaeologists. Estimates have ranged from an average population of about 3,000 (Gad 1984) to 4,000 (Berglund 1986), 4,000-5,000 (Meldgaard 1965) and 5,000-6,000 (McGovern 1979). These estimates are primarily based on the number of farm sites and the sizes of farmsteads. However, very few farms have been dated in terms of functional periods. Furthermore, the Norse Greenlanders probably used the sætter system, where the livestock was moved to outlying grasslands for part of the grazing season (Berglund 1986). This means that the archaeological values probably represent maximum figures. Assuming larger population sizes like 4-5,000 means: 1) that growth rates or starting populations must be bigger; 2) that population decline must correspondingly be of a higher magnitude; and 3), that there must be some accordance between the number of interments and total population size. So while the decline of a population from 4-5,000 to near-extinction could conceivably be explained by very high mortality rates and negative growth (due for example to plague epidemics), the population must still reach such a size within 200 years, which involves growth rates in excess of 1.0% or starting populations of about 1,000. Rates of 1.0% have been observed in several present-day African countries, but were probably not the norm in medieval times.

In summary, then, we can conclude that the Norse population could well have reached an average size of about 1400, with a peak of over 2000 individuals. Even if the population had been larger, which could conceivably have been the case if a higher growth rate or a larger starting population is assumed, the total projected population of 26,500 (given an average population of about 1,380) accords well with the figure calculated from the number of interments (a total population of about 26,000). Higher population levels must also result in a higher number of interments. If we postulate a population of 6,000, there should be more than 70,000 buried Norse Greenlanders. Even if we allow for individuals not buried in churchyards, for example those who died in shipwrecks, this number would mean that many churchyards have not yet been found.

The population decline could be explained by an emigration rate of about 10 individuals per year over a 200 year period. Another explanation would be a sudden increase in mortality, as with plague epidemics, with mortality rates between 30 and 50%. This would also reduce the population size to below the sustainable level over a short period. These issues will be discussed in the next chapter.

General discussion

The little colony was too remote to stay permanently strong and healthy. Half a millennium it endured. All honour to it for that.

Poul Nørlund, 1928.

Several theories have been advanced to explain the demise of the Norse settlements in Greenland. Fyllingsnes (1990) has compiled a list of most of them, and groups them as 1) eradication by Eskimos; 2) isolation; 3) eradication by pirates; 4) migration; 5) degeneration and diseases; and 6) climatic change. Each of these theories will be commented on briefly here, with a discussion of whether the results gained from this study support any of them.

The Eskimos

The theories that the Eskimos played a decisive role in the decline of the Norse settlements either say that the Eskimos simply eradicated the Norsemen, or that the Norsemen were assimilated into the Eskimo population.

The Thule culture Eskimos were expanding slowly down the west coast of Greenland, probably reaching the Disko Bay area around 1300-1400 AD (Arneborg 1993). Very probably, the first Norse-Inuit encounter took place there, as the Norse Greenlanders often sailed up to this area to hunt. Expanding southwards, the Eskimos would eventually reach the Western Settlement.

Eradication

The eradication theory is chiefly based on the accounts by Ivar Bardson, an official at the Bishop's residence at E47 Gardar, which he maintained in the Bishop's absence (Berglund 1986). Bardson travelled up to the Western Settlement and on his arrival found no people, only abandoned cattle and sheep (GHM III: 259). This journey is usually dated around 1350 AD (Gad 1984). In what is probably a later addition to Bardson's account, the journey was described as a relief expedition, since it had been rumoured that the Western Settlement had been attacked by Eskimos (Arneborg 1993). Berglund has mentioned that the whole part of Ivar Bardson's account which concerns the Western Settlement may be a much later addition (Berglund 1986). This also means that the date of the extinction of the Western Settlement, 1350 AD, which for many researchers since has stood as a definitive "terminus post quem", should be treated with caution (Berglund 1986).

Furthermore, a few sagas mention minor instances of conflict with the Eskimos (Krogh 1982), and some researchers have also cited Eskimo legends which tell stories of conflicts with the Norsemen (Gad 1984; Krogh 1982). Yet the written (and oral) accounts do not say how the Eastern Settlement became extinct, nor what the motives for such strife could be. Nørlund has mentioned that two peoples so different will naturally always view each other with suspicion, and that the Norse may have antagonized the Eskimos (Nørlund 1934). However, much criticism has been levelled at the written and oral accounts. In an analysis of the written historical records suggesting possible Eskimo attacks on the settlements, Arneborg concluded that too much weight had been given to possible conflict between Eskimos and the Norse settlers (Arneborg 1988).

As for the reasons for conflict, they could virtually only involve competition for natural resources. The Norse Greenlanders are unlikely to have possessed many items viewed as extremely valuable by the Eskimo; and indeed very few items of Norse origin have been found at Eskimo sites (Gad 1984; Krogh 1982). And these items have in fact later been described as the result of the looting of depopulated Norse farms (Arneborg 1993). The climate may have been changing (see below), and this might conceivably have led to greater competition for resources. Even though the two populations made completely different use of the resources – the Norsemen living up the fjords while the Eskimos stayed out by the sea

– there may have been conflicts over hunting and fishing grounds (Gad 1984).

Five cases were found at W51 Sandnes with what could be interpreted as slingshot wounds, along with one case with a perimortal cut wound. All cases were females (and one subadult), and could thus indicate a more general conflict. Since the "Vinland sagas" mentioned that slings were used by Eskimos (though not by Greenland Eskimos) (GHM I: 427), we could of course speculate that this supports the Eskimo attack theory. However, the wounds could as easily come from disputes among the Norse settlers themselves. Moreover, all these specimens are from disturbed burials, making any statements about dating impossible. Even though there may very well have been minor clashes and conflicts with the Eskimos, a war of extermination is quite another matter; not because the Norsemen were a superior race, and therefore "In a fight the Norse must no doubt have been superior to the Eskimos" (Hansen 1924: 520); but because both populations lived in scattered groups. The Eskimos in particular were fragmented into small colonizing groups (Jordan 1984; Gad 1984), and it would be difficult to imagine them engaging with the Western Settlement, which in the 11th and 12th century could have had a population of 500-700.

In other words, the anthropological evidence might support theories of minor clashes between Inuit and Norse, but, not least in the light of demographics, the total eradication of the settlements by the Eskimos does not seem plausible.

Assimilation

Fyllingsnes has pointed to Fridtjof Nansen as the main proponent of this theory: that the Norse were peacefully assimilated into the Eskimo population (Fyllingsnes 1990). In support of this, Nansen had claimed that the Eskimos were essentially a peaceful people, and Nansen was probably also influenced by his own visits to Greenland, where he saw how rapidly intermixture had already taken place between the European settlers and Eskimos (Fyllingsnes 1990).

The arguments against the assimilation theory are both archaeological and anthropological. There have been very few finds of items (Mathiassen 1953) that suggest a mixture of Norse and Eskimo culture. For example, the clothes found at E111 Herjolfsnes from the late settlement period are all distinctly European in fashion, and indeed Nørlund used this to argue against the assimilation theory (Nørlund 1934). More recent research, like studies of kitchen middens, also fails to show any major shifts in the pattern of resource reliance, with the Norsemen adopting more "Eskimoid" ways of living (McGovern 1985). In this connection, it must also be remembered that the Norse Greenlanders saw themselves as agriculturists: social status and wealth were directly linked with land ownership (Arneborg 1993).

The notion that Eskimos were a peaceful people unlikely to cause conflict or warfare is probably also overly romantic. It has been suggested that the Eskimos were probably as likely as anyone else to fight for their living if competition arose over resources (Meldgaard 1965).

The possible admixture of Eskimos in the population has nearly always been addressed in anthropological studies of the Norse: "...none of the skulls showed characters, not even in the jaws or facial regions, that indicated a possible intermixture of Eskimo blood!" (Hansen 1924: 430); "It has not been possible to demonstrate the presence of Eskimo elements in the Gardar finds as a sign of mixture...In this connection it must be borne in mind that the Gardar finds belong to the first centuries of the colonization, when the possibilities of bastardization were perhaps not so obvious" (Bröste et al. 1941: 57); "Even though there might have been low levels of Inuit gene flow into the medieval Greenlandic populations, this is not revealed in their pattern of crown and root frequencies" (Scott et al. 1991: 198). Only Fischer-Møller proposed, on the basis of his study of the material from Sandnes, that three Norse crania exhibited Eskimo traits: "...there are several skulls on which the Eskimo stamp is so pronounced that we can only believe that we have before us mixtures of the Nordic and Eskimo races...[but]....this blood mingling is relatively limited." (Fischer-Møller 1942: 79).

In this study no evidence of Eskimo traits was found in the Norse skeletal material. Two crania were allocated to the Eskimo group following a discriminatory analysis, but upon close examination, one of the crania at best exhibited what should rather be termed Uralic traits. These traits are slightly "mongoloid", and are known to occur in Scandinavian populations (Alexandersen, pers. comm.). All the crania that Fischer-Møller indicated, in his earlier anthropological investigations, might show signs of Eskimo admixture (Fischer-Møller 1942), were scored to the Norse group. This is also in accordance with a previous dental anthropological study (Scott et al. 1991) which also failed to reveal any Eskimo traits in the dentition of these skeletons. Moreover, no Norse traits have been found in the pre-contact Thule Eskimo skeletal material (Balslev-Jørgensen 1953; Meldgaard 1965). In a serological study of Eskimos in the Julianehåb district Persson found evidence of Norse-Eskimo mingling (Persson 1970), but this was later refuted by Balslev-Jørgensen (1975).

Isolation

If we assume that the Norse Greenlanders were dependent on supplies and goods from abroad (Arneborg 1993), then of course a decline in shipping to the settlements would have severe implications. It does seem that shipping between Greenland and Norway suffered such a decline, especially in the 14th century (Frydendahl 1992). Judging from written accounts, it seems that the Greenland knarre or trading ships did not resume activity after a shipwreck in about 1368 AD (Gad 1984). One reason cited for this is climatic: colder weather gave rise to more drift ice, cutting off the shipping lanes. Another is that merchant sailing to Greenland was simply not economically sound, as the main markets and interests shifted southwards towards the Hanseatic states (Gad 1984; Krogh 1982; Fyllingsnes 1990; Arneborg 1993). In the broader perspective, the political situation of the Danish-Norwegian Union contracted in 1380 AD perhaps also contributed to a shift in attention away from the northernmost settlements (the Danish king Christian I in fact pawned the Shetlands and Orkneys in 1480 AD) (Gad 1984).

Historians in the 19th century discussed this situation heatedly: Danish historians accused the Norwegian Crown of stifling contacts with Greenland by imposing a strict trading monopoly (when Greenland came under the Norwegian crown in 1261 AD); while the Norwegian historians claimed that it was only when the Danish Crown imposed its sovereignty that contacts dwindled (Fyllingsnes 1990). These various arguments were salvoes in a general argument at the beginning of this century when Norway claimed sovereignty over Greenland.

There does seems, however, to be some archaeological evidence that the Norse did not live through the last centuries of the settlement period in total isolation. The clothing found at E111 Herjolfsnes was in the European fashion; indeed, it indicates rather rapid dissemination of fashions from Europe (Nørlund 1924). Furthermore, the church architecture has been cited as evidence of close contacts with Norway (Roussell 1941). This would appear to be further borne out by the burial practices demonstrated in this study.

Even if commerce declined between Greenland and Norway, the Norsemen appear to have been "admirably suited for self sufficiency" (Kleivan 1984). However, contact with Norway must have had an important cultural function for the settlements. At the biological level, according to the results of this study, population levels seem to have been high enough (at least over 500 in both settlements) to sustain a population. As an intrinsic feature of the isolation theory, it is often said that the isolation led to "degeneration" of the Norse. This will be discussed further below.

Pirates

That the Norse were attacked by "pirates", i.e. Europeans, is a theory somewhat akin to the theories of eradication by Eskimos. Researchers have suggested English, Basque, Portuguese and German attackers (Gad 1984; Krogh 1982). This is based on accounts of "pirate" attacks on Iceland, whaling expeditions and early expeditions of discovery (e.g. John Cabot's expeditions to Newfoundland in 1497) (Kleivan 1984; Gad 1984; Fyllingsnes 1990), which suggest that there might have been contact with the Norsemen.[15]

However, even though an occasional pirate attack cannot be ruled out, it is difficult to imagine how they could have led to the complete extinction of the Norse settlements. As noted above, the Norse settlers lived fairly scattered, so it would only seem worthwhile for any attackers to raid the few major farms, primarily E47 Gardar. Raiding parties would have to spread out along all the fjords and valleys to plunder small farms and hamlets.

There is no archaeological evidence for the "pirate" theories: for example no finds of weapons, and no indications that farms had been plundered (Gad 1984). As already mentioned in connection with the Eskimo theo-

[15] It has even been suggested that the Norsemen were taken as slaves to Madeira and Tenerife to work in the banana plantations (Hilstrøm 1993).

ries, the osteological evidence suggests that some individuals from the Western Settlement might have been killed by slingshot, but the results were inconclusive. Even assuming high proportions of male deaths during war, much more massive warfare than suggested archaeologically or anthropologically would have to be postulated for this to account for the extinction of the Norse population.

Degeneration and disease

This theory mainly stems from the first anthropological studies of Norse skeletal material. The material from E111 Herjolfsnes was examined by F.C.C. Hansen, who concluded that the skeletons bore evidence of degeneration. According to him the Norse settlers of E111 Herjolfsnes had become "a race of small people, with little strength, physically weakened, and with many defects and pathological conditions" (Hansen 1924: 520). This was due to isolation "as regards race hygiene" (Hansen 1924: 520). Of course, Hansen's statements must be seen in the light of the prevailing scientific views, not least those involving racial studies, and the emergent theories of population biology. His findings were quickly discredited by the next major anthropological studies in the 1940s, when the E111 Herjolfsnes material was reassessed (Fischer-Møller 1942; Bröste et al. 1941). They concluded that the material had been subject to severe postmortem degradation, and could hardly be representative of the Norse population at E111 Herjolfsnes in general. Still, Hansen's results are often cited in studies as evidence, if not of degeneration, then of some form of secular change (Hanson 1992; Scott et al. 1991).

In this study, no significant difference was found between the Early and Late Settlement periods, although there does seem to have been be a small secular trend towards generally smaller dimensions. However, there may well be a basis for a view that the Norse Greenlanders differed from other medieval populations in both cranial and postcranial dimensions. The possible causes of such shifts are briefly discussed below.

Genetic causes

It is generally assumed that morphology mainly reflects an underlying genotype (Hanson 1986). This assumption seems to be generally valid, as shown by several studies of factors like variability within and between families (Osborne & DeGeorge 1959; Brown 1973; Nakata et al. 1976), and since most linear measures have been shown to have a high coefficient of heritability (Susanne 1977; Sjøvold 1985 cit. in Hanson 1986). In addition, when metric data have been compared with other types such as geographical, linguistic, cultural and historical data (Laughlin & Jørgensen 1956; Howells 1966; Ossenberg 1977; Hiernaux 1972; Koch 1989; Rightmire 1976; Corruccini 1972; Sokal et al. 1987; Sokal & Uytterschaut 1987) general correlations have been found. We can thus conjecture that the "limits" of changes in facial and cranial morphology are genetically determined, although the variation within these "limits" is determined by environmental factors.

If morphological differences are found, the main possible genetic reasons are admixture of another genetically different population; heterosis; transformation; or genetic drift (Ferák & Lichardova 1969; Beals et al. 1983). In the following the results are discussed with reference to these mechanisms, followed by an assessment of disease levels among the Norse.

The small likelihood of admixture with Eskimos has already been discussed. However, it must be mentioned that other possible admixtures have been proposed for the Norsemen. Anthropological studies of Norse material from Iceland led Steffensen to propose that there had been a significant admixture with Celts, i.e. the Irish or Scots (Steffensen 1953), and this also seems to be partly confirmed by more recent analyses (Eriksson et al. 1986). Admixture with Saamis ("Lapps") has also been proposed (Vilhjálmsson 1993). While such admixture has not been directly proposed for the Norse Greenlanders, it might explain differences between them and other medieval Scandinavian populations, since the Norse Greenlanders probably represent a subsample of the Icelandic population. Unfortunately, attempts to prove or disprove these theories of admixture have been inconclusive, not least because of the lack of well documented material – for example comparative skeletal material from Ireland or Scotland. In general, the archaeological record cannot support theories of large-scale admixture in Iceland (Vilhjálmsson 1993).

Heterosis, i.e. an increased level of heterozygoty in the population, is very difficult to assess in human populations. It has been proposed that heterosis correlates with the distances at which mates are found. For example, if a given population shows high mobility in finding partners, this should indicate a high level of heterosis (Ferák & Lichardova 1969; Billy 1980, 1981; Marquer 1981). This does not seem likely for the Norse, as their numbers, on the basis of archaeological data on the number of farmsteads, farm sizes, etc., seem to have been large enough to sustain a population with adequate partner choices.

Genetic drift is the opposite of heterosis: a higher level of homozygoty. This is commonly supposed to happen when a population is small and isolated (Crow 1986), with consanguinity becoming more common. This is in effect the "degeneration" proposed by Hansen (Hansen 1924). One way of determining the level of genetic drift is to look at the frequencies of non-metric traits. A temporal shift, whether a decrease or increase, could be a sign of increasing homozygoty. However, this requires that one can separate the genetic and environmental determinants of the traits from one other. While some traits, such as tori (see below) are most certainly very susceptible to environmental factors, other non-metric traits perhaps better reflect direct genetic factors. In any case, none of the investigated non-metric traits showed evidence of any secular trend.

Finally, a possible "genetic" reason for the divergence of a relatively small population such as the Norse Greenlanders from other Norse populations is the "founder effect". If the Norse population in Greenland differed from the "parent" population in Iceland it could be because the Norse Greenlanders were not a true random subsample of the Norse Icelanders. Emigration was probably not random. It would have been selective migration, and we could perhaps even assume that there was some degree of interrelatedness among the "first wave" colonist families, which would make it a kin-structured migration. Such a migratory pattern would have clear genetic implications (Hiorns 1984); for example the movement of an extended family group might well completely remove a rare allele from the population (Little & Leslie 1993). Indeed, computer simulation models show that the potential importance of kin-structured migration is considerable (Rogers & Jorde 1987), and there may be substantial genetic differentiation among settlement populations even when the settlements are not isolated from one other (Fix & Lie-Injo, cit. in Little & Leslie 1993). Moreover, differentiation may proceed rapidly in such circumstances (Fix 1984), and this may explain the observed differences in morphometry between the Norse sites themselves and other medieval populations.

Unfortunately, the present Norse material does not allow us to assess possible selective, kin-structured immigration to Greenland. A possible future option would be to attempt to extract DNA to establish possible genealogies. Nevertheless, the hypothesis that some of the divergences between Greenlandic Norse and other Norse populations may be due to such kin-structured migration is interesting.

Environmental causes

Many non-genetic determinants of morphology have been listed: from intentional deformation of the crania to climate (Ossenberg 1970; Steegman 1970; Lasker 1969). In the specific case of the Norse Greenlanders, it is pertinent to focus on two main factors: adverse living conditions due to dietary limitations, and cold adaptation and functional stress.

An inadequate diet in the growth period may stunt growth and, if the period with an inadequate diet is long enough, it may eventually lead to reduced body size and stature (Stini 1972; Harrison et al. 1990; Komlos 1993). It has been observed that if growth stunting occurs in a given population, this may also decrease the degree of sexual dimorphism (Stini 1969; Ferembach 1978). Besides reduced stature and body size, inadequate dietary supply may of course also result in pathological changes due to factors like vitamin deficiencies, higher disease frequencies etc. Indeed, foetal undernutrition can be linked to increased disease levels in adult life (Barker et al. 1993; Saunders & Hoppa 1993).

Smaller body size has been seen as an "adaptation" to limited food resources, since people of smaller size require fewer calories (Geist 1978). Growth stunting as a result of dietary insufficiency probably already takes place in utero (Barker et al. 1993). A difference between body size in "Early" and "Late" Norse specimens could thus be construed as such an "adaptation", and this has in fact been proposed by several researchers (Hansen 1924; Hanson 1986; Scott et al. 1991).

A changing morphology may also be seen as a response to changed environmental conditions. The concept of cold adaptation has been suggested as an explanation of the Eskimoid features which differentiate Eskimos from other Mongoloids (Koertvelyessy 1972; Hylander 1977). While there may be some general correlation between certain morphometric variables and climate, as proposed in "Allen's rule" (Harrison et al. 1990; Hanson 1986), it has been very difficult to distinguish between adaptation (if any) due to climate and adaptation due to changing cultural patterns – for example as a result of masticatory stress (Waugh 1937; Hylander 1977). It would be more pertinent to propose, like Scott et al. (1991), that any morphological changes may have resulted from changes in dietary habits. While this study did show evidence of changes in dietary habits in terms of (^{13}C content in bone, signifying more reliance on marine foodstuffs, the question is how far this altered the Norse morphology and biology. Indeed, the differences in dentition identified by Scott et al. probably simply reflect altered masticatory stress rather than some special environmental adaptation. The much-debated tori probably also reflect changes in diet and increased masticatory stress (Scott et al. 1991). The tori show a rather dramatic increase in frequency over time and, compared with other Norse populations, one would have to postulate, as stated by Scott et al. (1991), potent selective pressures to account for such changes. However, Scott et al. also add that tori may indicate chronic undernutrition. This is probably not correct; Scott et al. rely basically on the reported decrease in molar size and stature (Scott et al. 1991), issues which have already been discussed in this study. Furthermore, the skeletal material does not show signs of dietary deficiencies. Recent research has rather indicated that there may be a link between tori and dietary intake of marine foodstuffs (Eggen et al. 1994). The higher occurrence of tori among the Norse Greenlanders over time thus supports the results of the (^{13}C analyses, which indicated increased marine reliance.

If there were increasing periods of chronic undernutrition, they only resulted in very slight dimensional changes, so they were probably not a major factor, and in any case they present no evidence of biological adaptation.

Disease status among the Greenland Norse

Infectious middle ear disease (IMED) was used to evaluate general living conditions. The results showed a secular trend towards lower IMED frequencies among the crania from the Late Settlement period than from the Early. However, as discussed in Chapter 4, it does not follow that this meant improvements in living conditions. On the contrary, it could also be explained as the result of deteriorating living conditions. At all events the differences were not significant. But these results can be compared with the results on bone mineral content, which showed no diachronic changes, and with demographic data which indicated higher subadult mortality rates in the Late Settlement period. As usual, the main problem in interpreting the results is the question of whether the material from the late period is representative, as no churchyards have been completely excavated. Any differences may equally well reflect social differences.

The Norse skeletal material thus does not testify to a population "racked with disease", at least not the kind of infectious diseases that leave their marks on the bones (Merbs 1992). Levels of degenerative diseases such as osteoarthritis do not differ considerably from those in other medieval populations (Bennike 1985; Frøhlich et al. 1994). In the available material, there is no evidence of more disease among the Norse Greenlanders than in other contemporary populations.

The skeletal material cannot however disprove the theory of violent epidemics with a fulminant course leading to the death of the afflicted before any marks had been left on the bones. Plague and smallpox have therefore been proposed as causes of the extinction of the settlements. It is generally acknowledged that plague swept Iceland in 1408-14 AD, after devastating Europe, killing up to 60% of the total populace in Norway (Benedictow 1992). Recent studies indicate that plague epidemics could also be highly lethal for scattered populations (not just densely populated cities) (Benedictow 1992).

Besides plague, smallpox epidemics have been mentioned as possible reasons for the demise of the settlements (Hopkins 1983). "In one of these early invasions [of smallpox in Iceland in the 13th century] the disease extended to Greenland, and so ruined its small settlements that the existence of Greenland was forgotten for three centuries afterwards" (Edwardes 1902).

The "epidemic theories" gained some credence when Vebæk, excavating E149 Narsarsuaq, stated that the burials were so closely spaced, and furthermore contemporary, that they indicated mass burials which he attributed to epidemics (Vebæk 1953).

In this study, the burial densities were found to be generally high. The high burial density is a feature of Norse cemeteries that has been consistently mentioned by practically all archaeologists. In the chapter on burial practices it was discussed whether the close temporal spacing of several burials at single sites could be due to simultaneous burials, but it cannot be concluded that these burials were mass graves.

To summarize, if we accept that the Norse specimens do show a slight chronological trend towards smaller dimensions and an overall greater biological difference from other Norse populations, several causes (non-random migration and environmental factors, primarily dietary shift) are possible; while other explanations, both genetic and environmental, such as genetic drift, heterosis, admixture and cold adaptation, seem less plausible.

Finally, while the Norse Greenlanders show no evidence of having been more afflicted with pathological conditions than other medieval populations, the occurrences of epidemics cannot be ruled out. However, even if they were not directly struck by major epidemics, the Greenland settlements may have been affected by the demographic and mercantile repercussions of the great epidemics in the source countries (Merbs 1992). This will be discussed further below.

Migration

Theories of migration have mostly centred on the Norse population in Greenland "returning" to Iceland after a relocation of the people of the Western Settlement to the Eastern Settlement (Berglund 1986), while a few have also entertained the idea that the Norsemen moved on to the American continent or northern Britain and Ireland (Fyllingsnes 1990). While it has been proved by the finds made by Ingstad (1970) at L'Anse aux Meadows in Newfoundland that the Norse did indeed reach the American continent (Vinland), there are absolutely no indications of any major resettlements there. This also applies to resettlements in Britain or Ireland.

As for resettlement in Iceland, this is more plausible. While there is no direct archaeological or historical evidence of resettlement in Iceland, the complete absence of certain types of finds, such as valuable sacramental objects, in the Norse settlements in Greenland is puzzling. Only common, everyday items have been found (Berglund 1986). This, as indicated by Berglund, could well indicate an "ordered" resettlement, rather than some dramatic change and extinction. Berglund concludes that such an "ordered" resettlement must have gone to Iceland (Berglund 1986).

The population models in this study show that depopulation was possible, assuming a steady emigration rate. Resettlement movements did take place in Late Medieval Europe on a large scale. This was probably caused by the plague epidemics, which, as mentioned above, literally eradicated whole villages and settlements, for example in Iceland and Norway, with an aftermath of large-scale resettlement and abandonment of the least profitable farmsteads (Krogh 1982; Benedictow 1992; McEvedy 1988). Plague in Norway and Iceland laid many farmsteads waste. For example 37 of 99 holdings in the hands of nine churches in northern Iceland were still deserted 20 years after the plague epidemic struck the island (Benedictow 1992). Such vacancies may have prompted the Norse Greenlanders to resettle there, if they felt they had better economic prospects there (see below).

Climatic change

Finally, climatic changes have been proposed as the main cause of the Norse decline. This theory is not new: Gustav Holm hinted at an early stage that the climate in the settlement period must have been better than in the later periods (Holm 1883: 72). The first argument for a climate change was presented by Nørlund during his excavations at E111 Herjolfsnes. Nørlund noted how the bodies lay in permafrost, yet many had clearly been disturbed by plant roots (Nørlund 1924). Nørlund was forced, however, to reconsider this argument when new observations just a few years later indicated greater short-term fluctuations in climate and temperature than he had thought (Nørlund 1928).

While analyses of pollen at first seemed to show a relatively constant climate over the centuries (Iversen 1935), later analyses seem to indicate "a humid and cool period in the centuries around the disappearance of the Norsemen" (Fredskild 1973: 235). That a climate change is now generally acknowledged ("Drastic climatic change was certainly a major contributory factor in the collapse of the Greenland colony" (Gribbin & Lamb 1978)) is due to the ice core drillings and studies by Dansgaard and co-workers. Working from the isotopic levels in ice cores drilled from the inland ice in Greenland, they produced temperature curves for the preceding centuries (Dansgaard et al. 1975). These curves showed a general reduction of annual mean temperatures in the period between 1300 and 1800 AD.

The climatic changes must be viewed in the light of studies of resource use. It has been indicated that the Norse Greenlanders were probably already straining the carrying capacity of the land, and becoming more and more reliant on marine resources (McGovern 1979). It has also been mentioned that large herds of sheep may have overgrazed the land to such a degree that the topsoil was eroded (Krogh 1982).

There is both archaeological and anthropological evidence in support of these theories. Studies of kitchen middens have confirmed changes in resource use, and the discovery of irrigation canals at E47 Gardar could very well point to an attempt at "technical" adaptation so as to increase the land yield (Krogh 1982). The radiocarbon analyses in this study have shown a clear dietary shift over the settlement period, confirming the above. Furthermore, studies of oxygen isotopes in Norse dental and skeletal material have been initiated, and these may support the theories of climate change (Fricke et al. 1995).

McGovern furthermore saw evidence of a hierarchical social order dominated by the bishops at E47 Gardar. This ecclesiastical elite, with its close relations with the continental church elites, deflected the Norse Greenlanders from adaptive changes (McGovern 1992), although Arneborg has later questioned how subservient the Greenland Church was to the continental authorities (Arneborg 1991). It would seem that the Norse society in Greenland was unique in many ways, and parallels with other Norse societies must be drawn with care (McGovern 1992).

Conclusion: a depopulation scenario

The various theories of the causes of the decline of the Norse settlements in Greenland have been reviewed. On the basis of the results of this study, some can be rejected: admixture with the Eskimos, eradication by Eskimos or pirates and degeneration. Other theories seem more plausible; that is, the anthropological data might "fit" the theories (although not specifically proving them). As McGovern stated (1992): "...it seems probable that all the models [of the Norse society] advanced are at least partly correct (some perhaps more relevant to certain periods than others)." Indeed, as was noted already in the introduction, attempts at explanatory models should include many elements and factors, effectively trying to combine as much of the data as possible.

In this context, it is also important to consider developments in the other Scandinavian countries, and indeed the in the rest of the European continent; not in order to infer direct, specific societal similarities, which, as mentioned above, may be erroneous because of the probable uniqueness of the Norse Greenlandic soceity, but in order to place medieval Greenland in a wider framework.

In the first place, there seems to have been massive depopulation in most European countries at that time. As mentioned earlier, a 60% decrease in population has been projected for northern Norway, and at least a 30% decrease for Iceland. This massive depopulation, usually ascribed to the great plague epidemics, had enormous demographic, economic and social repercussions. In the wake of the plague, there was large-scale population resettlement, where inhabitants of the more unproductive areas left for the better, "vacant" areas. Whether Norse Greenland was directly affected by plague or not, it would most certainly have been affected by the indirect effects of plague. For instance, the export prices of several Icelandic commodities fell dramatically (Keller 1986), and this may well also have had economic consequences for Greenland. Since it seems that the decline in population levels in fact had already started before the plague epidemics reached the northern European countries, we could assume from palaeoclimatic and archaeozoological results that there was a climatic change in the years after 1300 AD. This shift "stressed" the population, probably resulting in a trend towards ever harsher living conditions as reflected by common disease levels (IMED), increased subadult mortality and a marginal trend towards diminished physical dimensions. Adaptive responses would include increasing marine foodstuff reliance and seeking to increase land yield, the former evidenced by the radiocarbon analyses and the latter perhaps reflected by irrigation systems and the buffering capacity of the local community, headed by large farmsteads.

However, perhaps after some internal resettlement, emigration accelerated in the 15th century. Better land became available in a larger community (Iceland), and it is even possible that old family claims could be invoked. The marginal land of Greenland no longer held the same attraction. The population pressure of the Viking times that had led to emigration had now reverted to an involution. Because of the size of the Western Settlement, with a projected population just above the minimum level for sustaining a community, the emigration of young adults would soon leave it in a state of irreversible decline, perhaps within 20-30 years. Thus, even without "drastic" causes like widespread famine, Eskimo or pirate attacks or epidemics, such a scenario may have led to swift decline. Perhaps there was first resettlement in the Eastern Settlement, offsetting population decline there for some years. As mentioned above, this resettlement may then have continued to Iceland. Indeed, Arneborg, on the basis of her cultural and historical research, has also proposed a scenario of "slow and quite undramatic emigration from the Norse settlements in Greenland" (Arneborg 1993). Such an "ordered" resettlement would also explain the lack of finds of precious items in the Norse settlements. An emigration rate of 10 per year would depopulate the settlements within a 200-year period, assuming a peak population of some 2,000-2,500 people.[16]

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

What then becomes of the apparent historical indifference to the fate of the Norse settlements in Greenland? Written accounts of the demise of the populations in Greenland are scarce, and surely such an influx to Iceland would have been noticed? However, the peak population of the Greenland settlements, probably at most 2,500 people, must be compared with the Icelandic population size, which has been estimated at 70,000 people (pre-plague). Even allowing for a 30-50% decrease due to plague, an influx of perhaps 10 people a year would hardly be noticeable – especially if there was some concurrent turmoil in the midst of plague and internal resettlement.

And the rest of the world, also in the throes of plague and its repercussions, also had other concerns. In 1453 AD Constantinople fell and the Turks advanced up to Vienna. Such events probably also served to divert the Church's attention from the small settlements, which were no bigger than most European country villages.

Earlier studies of the Norse Greenlanders very clearly reflect the ideas of the periods when they were carried out, and this has probably contributed to the idea that the demise of the settlements was a great "enigma" (Fyllingsnes 1990). For example the issues of race and the fear of population degeneration that were very much in the foreground in the 1920s and 30s pervade F.C.C. Hansen's analyses of the E111 Herjolfsnes material. And the theories of isolation very much reflect the political disputes over the sovereignty of Greenland in the 19th and 20th centuries.

On the whole, much earlier Norse research presupposes a clear identification of Greenland as an isolated entity. The Norsemen may not have held such a view themselves. To them, Greenland was probably an extension of inhabitable lands and fjords stretching from Norway over the Shetlands, Orkneys, Faroes and Iceland, all the way to Labrador and Newfoundland. For example, the Norse were not aware of having "discovered" a new continent when they arrived in Vinland; they had simply set out to look for exploitable land. This they found, but, probably as a result of a decrease in population pressure and the uneconomically long distances, they never formed a proper settlement there. It is perhaps distinctly "modern" (or at least post-medieval) to see Greenland as a distinct entity.

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

[16] A possible way to investigate such a theory of the demise would be to study medieval liturgical objects found in Iceland. Perhaps some of them – chalices, crucifixes, etc. – may in fact bear seals or the like indicating origins in the Greenland churches?

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Appendix

Table I Median values for cranial measures. Males. p1: Tests between Early Eastern (EE) and Late Eastern (LE). p2: Tests between Late Eastern (LE) and Western (W) settlement mate,rial. Significance denoted by *.

Measure	Early Eastern (EE)		Late Eastern (LE)			Western (W)		
	median	N	median	N	p1	median	N	p2
M1 Max Length	185.28	9	181.00	3	0.116	178.50	13	0.736
M5 Bas Nas	103.04	12	94.00	4	0.146	98.00	9	0.394
M8 Max Breadth	140.20	2	135.00	3	0.248	139.50	12	0.311
M9 Min Frontal	95.04	12	94.33	2	0.715	95.18	11	0.844
M11 Biaur	118.94	16	114.00	5	0.186	116.14	13	0.805
M17 Bas Breg	129.64	7	125.00	3	0.425	125.00	9	0.926
M40 Bas Pros	95.64	12	89.00	3	0.060	89.40	7	0.569
M45 Bizyg	137.62	3	118.80	1	0.180	130.06	5	0.380
M46 Maxillar	94.46	8	77.63	1	0.114	90.88	5	0.143
M51 Orb Breadth	39.01	9	35.06	1	0.110	38.31	6	0.134
M52 Orb Height	34.30	9	34.84	2	0.693	33.45	6	0.317
M54 Nasal B	23.41	10	21.12	3	0.392	22.67	6	0.796
M55 Nasal H	53.93	11	50.00	3	0.122	50.78	6	0.439
M57 Min B Nasal	7.91	11	9.91	4	0.480	7.36	7	0.058
M62 Palatal B	34.64	16	37.00	5	0.048*	32.74	9	0.020*
M63 Palatal L	46.10	16	44.00	4	0.508	44.30	10	0.888
M69 Mental H	32.22	17	35.04	2	0.232	31.08	14	0.152
M70 Ramus H	65.27	12	59.14	3	0.043*	59.68	6	1.000
M71 Ramus Min B	34.65	22	34.57	2	0.700	32.95	9	0.239

Table II Median values for cranial measures. Females. p1: Tests between Early Eastern (EE) and Late Eastern (LE). p2: Tests between Late East ern (LE) and Western (W) settlement material. Significance denoted by *.

Measure	Early Eastern (EE)		Late Eastern (LE)			Western (W)		
	median	N	median	N	p1	median	N	p2
M1 Max Length	175.26	5	175.00	5	0.600	174.00	28	0.687
M5 Bas Nas	93.03	5	94.00	5	0.602	93.50	21	0.625
M8 Max Breadth	—	0	133.00	3	—	136.00	27	0.555
M9 Min Frontal	91.40	2	92.50	6	0.505	92.11	29	1.000
M11 Biaur	110.79	7	110.00	9	0.222	109.31	24	0.903
M17 Bas Breg	126.47	2	120.00	3	0.248	122.00	21	0.827
M40 Bas Pros	92.49	2	88.00	3	0.248	89.07	15	0.515
M45 Bizyg	123.00	2	—	0	—	120.75	9	—
M46 Maxillar	88.57	2	91.63	1	1.000	88.65	14	0.487
M51 Orb Breadth	—	0	35.39	2	—	38.06	17	0.207
M52 Orb Height	—	0	36.00	3	—	32.86	17	0.112
M54 Nasal B	20.31	1	22.16	2	0.683	20.87	12	0.715
M55 Nasal H	48.21	2	45.04	3	0.827	46.74	15	0.859
M57 Min B Nasal	7.87	1	8.50	4	0.480	7.49	18	0.349
M62 Palatal B	30.70	8	36.00	8	0.009*	34.83	21	0.283
M63 Palatal L	44.53	6	44.00	3	0.606	42.86	22	0.277
M69 Mental H	29.03	5	27.48	6	0.143	28.31	30	0.252
M70 Ramus H	57.84	8	49.94	3	0.066	51.90	26	0.352
M71 Ramus Min B	32.08	11	33.49	4	0.467	31.56	30	0.557

Table III. Medians of postcranial measures. Males. p1: Tests between Early Eastern (EE) and Late Eastern (LE). p2: Tests between Late Eastern (LE) and Western (W) settlement material. Significance denoted by *.

Measure	Early Eastern (EE)		Late Eastern (LE)			Western (W)		
	median	N	median	N	p1	median	N	p2
Humerus:								
M1 Max Length	354.50	5	- -	0	- -	301.75	6	- -
M4 Bicond B	63.22	9	- -	0	- -	56.42	6	- -
M5 Max Dia	24.10	5	- -	0	- -	22.39	7	- -
M6 Min Dia	20.09	5	- -	0	- -	18.09	7	- -
Radius:								
M1 Max Length	253.00	3	- -	0	- -	225.75	2	- -
Ulna:								
M1 Max Length	266.50	3	- -	0	- -	243.00	3	- -
Femur:								
M1 Max Length	467.00	11	- -	0	- -	425.00	5	- -
M7a Mid Sag Dia	30.03	9	- -	0	- -	29.95	7	- -
M7b Mid Tra Dia	29.00	9	- -	0	- -	27.15	7	- -
M19 Caput Dia	48.03	30	- -	0	- -	42.95	6	- -
M21 Bicond B	79.13	10	- -	1	- -	70.98	5	0.143
Tibia:								
M1 Max Length	372.75	6	- -	0	- -	303.25	2	- -
M4 Sag Dia	28.87	4	- -	0	- -	24.06	4	- -
M5 Tra Dia	23.07	4	- -	0	- -	19.09	4	- -

Table IV. Medians of postcranial measures. Females. p1: Tests between Early Eastern (EE) and Late Eastern (LE). p2: Tests between Late Eastern Late (LE) and Western (W) settlement material. Significance denoted by *.

Measure	Early Eastern (EE)		Late Eastern (LE)			Western (W)		
	median	N	median	N	p1	median	N	p2
Humerus:								
M1 Max Length	304.25	2	280.00	2	0.655	294.50	21	0.113
M4 Bicond B	52.65	2	50.28	2	0.439	54.36	18	0.089
M5 Max Dia	21.61	1	20.43	2	0.121	20.49	23	0.689
M6 Min Dia	18.94	1	15.37	2	0.180	16.23	23	0.317
Radius:								
M1 Max Length	- -	0	- -	0	- -	218.00	17	- -
Ulna:								
M1 Max Length	- -	0	- -	0	- -	231,75	16	- -
Femur:								
M1 Max Length	402.75	2	388.50	4	0.245	411.25	16	0.156
M7a Mid Sag Dia	24.76	1	26.07	5	0.617	26.09	17	0.906
M7b Mid Tra Dia	23.55	1	23.58	5	1.000	24.74	17	0.667
M19 Caput Dia	40.33	11	42.29	4	0.865	41.57	20	0.877
M21 Bicond B	68.01	3	71.26	5	0.517	68.80	13	0.085
Tibia:								
M1 Max Length	333.75	2	- -	0	- -	329.50	17	- -
M4 Sag Dia	- -	0	- -	0	- -	25.18	17	- -
M5 Tran Dia	- -	0	- -	0	- -	19.75	17	- -

Table V Radiocarbon datings. The ^{14}C age is given in conventional radiocarbon years BP (before present = 1950). The calculated ^{14}C age has been corrected for fractionation so as to refer the result to be equivalent with the standard $\partial^{13}C$ value of -25 ‰ (wood). Dates of marine samples (eg. shells and marine mammals) have to be corrected for reservoir effect to be comparable to contemporaneous terrestrial material. The ocean reservoir correction (Marine Fraction * 450 y reservoir age) is subtracted from the conventional ^{14}C age to obtain the reservoir corrected age given in the second ^{14}C age column. Calibrated ages in calendar years have been obtained by means of the Seattle calibration programme, version 3.03 (Stuiver and Reimer, Radiocarbon vol 34, 1993, mixed terrestric/marine model). The intercept of the measured ^{14}C age with the calibration curve is given in the first line (as a time interval if more than one intercept). The intercept method has been used to calculate the calibrated age interval (second line) corresponding to ± 1 standard deviation in the conventional ^{14}C age.

AAR-#	Sample Type	Collection Site	^{14}C Age (BP)	Reservoir corrected ^{14}C Age (BP)	Calibrated age ± 1 stdv.	$\delta^{13}C$ (‰) PDB	Submitter ID
AAR-1143	bone (human)	Greenland, Kilaarsarfik (Sandnes) Geograph. coordinates: 64V2-III-511 (V5) *Exp. age*: 1000-1300 AD	1030 ± 45	700 ± 45 (Marine Fraction: 0.729)	AD 1297, AD 1275-1317	-14.8	KAL-0929x01 AS11
AAR-1144	bone (human)	Greenland, Kilaarsarfik (Sandnes) Geograph. coordinates: 64V2-III-511 (V5) *Exp. age*: 1000-1300 AD	865 ± 40	560 ± 40 (Marine Fraction: 0.682)	AD 1413, AD 1393-1432	-15.2	KAL-0928x01 AS10
AAR-1145	bone (human)	Greenland, Kilaarsarfik (Sandnes) Geograph. coordinates: 64V2-III-511 (V5) *Exp. age*: 1000-1300 AD	940 ± 45	690 ± 45 (Marine Fraction: 0.565)	AD 1301, AD 1282-1322	-16.2	KAL-0960x01 AS30
AAR-1146	bone (human)	Greenland, Kilaarsarfik (Sandnes) Geograph. coordinates: 64V2-III-511 (V5) *Exp. age*: 1000-1300 AD	970 ± 40	610 ± 40 (Marine Fraction: 0.812)	AD 1390, AD 1323-1412	-14.1	KAL-0961X01 AS29
AAR-1147	bone (human)	Greenland, Kilaarsarfik (Sandnes) Geograph. coordinates: 64V2-III-511 (V5) *Exp. age*: 1000-1300 AD	940 ± 40	690 ± 40 (Marine Fraction: 0.565)	AD 1301, AD 1284-1320	-16.2	KAL-0959x01 AS31
AAR-1148	bone (human)	Greenland, Kilaarsarfik (Sandnes) Geograph. coordinates: 64V2-III-511 (V5) *Exp. age*: 1000-1300 AD	970 ± 40	670 ± 40 (Marine Fraction: 0.659)	AD 1307, AD 1290-1328	-15.4	KAL-0964x01 AS35
AAR-1263	bone (human)	Narsarsuaq (Uunartoq Fjord), Greenland. Coord. 60V2-IV-504 (Ø149) *Exp. age*: 1200-1300 AD.	845 ± 50	580 ± 50 (Marine Fraction: 0.600)	AD 1404, AD 1329-1428	-15.9	KAL-1000x01 (I,7)
AAR-1264	bone (human)	Narsarsuaq (Uunartoq Fjord), Greenland. Coord. 60V2-IV-504 (Ø149) *Exp. age*: 1200-1300 AD.	937 ± 53	610 ± 53 (Marine Fraction: 0.729	AD 1389, AD 1312-1414	-14.8	KAL-1001x01 (I,10)
AAR-1265	bone (human)	Narsarsuaq (Uunartoq Fjord), Greenland. Coord. 60V2-IV-504 (Ø149)	886 ± 48	640 ± 48 (Marine Fraction:	AD 1322, AD 1301-1399	-16.3	KAL-1002x01 (II,1)

		Exp. age: 1200-1300 AD.		0.553)			
AAR-1266	bone (human)	Narsarsuaq (Uunartoq Fjord), Greenland. Coord. 60V2-IV-504 (Ø149) *Exp. age*: 1200-1300 AD.	852 ± 44	590 ± 44 (Marine Fraction: 0.588)	AD 1399, AD 1325-1418	-16.0	KAL-0999x01 (I,6)
AAR-1267	bone (human)	Qagssiarsuk (Brattahlid), Greenland. Coord: 61V3-III-539 (Ø29a) *Exp. age*: 1050 AD	1155 ± 46	1000 ± 46 (Marine Fraction: 0.341)	AD 1020, AD 995-1043	-18.1	Fællesgrav, CLA-2
AAR-1268	bone (human)	Qagssiarsuk (Brattahlid), Greenland. Coord: 61V3-III-539 (Ø29a) *Exp. age*: 1050 AD	1112 ± 51	930 ± 51 (Marine Fraction: 0.412)	AD 1065-1115, AD 1028-1171	-17.5	Fællesgrav, CLA-1
AAR-1269	bone (human)	Ikigaat (Herjolfsnes), Greenland. Coord: 59VI-IV-502 (Ø111) Lower skeleton, with textile AAR-1289 *Exp. age*: 1450 AD	899 ± 84	550 ± 84 (Marine Fraction: 0.776)	AD 1418, AD 1329-1456	-14.4	KAL-0906x01 (XVIII)
AAR-1270	bone (human)	Ikigaat (Herjolfsnes), Greenland. Coord: 59VI-IV-502 (Ø111) Middle skeleton, with textile AAR-1288 *Exp. age*: 1450 AD	750 ± 56	500 ± 56 (Marine Fraction: 0.565)	AD 1437, AD 1413-1467	-16.2	KAL-1105x01 (I)
AAR-1271	bone (human)	Ikigaat (Herjolfsnes), Greenland. Coord: 59VI-IV-502 (Ø111) Upper skeleton, with textile AAR-1290 *Exp. age*: 1450 AD	767 ± 45	520 ± 45 (Marine Fraction: 0.553)	AD 1430, AD 1407-1447	-16.3	KAL-1106x01 (IV)
AAR-1272	bone (human)	Qagssiarsuk (Brattahlid), Greenland. Coord: 61V3-III-539 (Ø29a) *Exp. age*: 1050 AD	980 ± 49	880 ± 49 (Marine Fraction: 0.224)	AD 1169, AD 1061-1222	-19.1	KAL-1060x01 (70)
AAR-1273	bone (bos taurus)	Qagssiarsuk (Brattahlid), Greenland. Coord: 61V3-III-539 (Ø29a) *Exp. age*: 1050 AD	1040 ± 80		AD 1011, AD 960-1040	-20.6	380
AAR-1274	bone (human)	Qagssiarsuk (Brattahlid), Greenland. Coord: 61V3-III-539 (Ø29a) *Exp. age*: 1050 AD	Lav collagen				KAL-1032x01 (7)
AAR-1275	bone (human)	Qagssiarsuk (Brattahlid), Greenland. Coord: 61V3-III-539 (Ø29a) *Exp. age*: 1050 AD	1229 ± 41	1100 ± 41 (Marine Fraction: 0.294)	AD 976, AD 854-996	-18.5	KAL-1180x01 (110)
AAR-1276	bone (human)	Qagssiarsuk (Brattahlid), Greenland. Coord: 61V3-III-539 (Ø29a) *Exp. age*: 1050 AD	1025 ± 50	870 ± 50 (Marine Fraction: 0.353)	AD 1192, AD 1122-1228	-18.0	KAL-1789x01 (90)
AAR-1288	textile (wool?)	Ikigaat (Herjolfsnes), Greenland. Woman´s clothing (prob. conservatet). Belongs to middle skeleton , 1105x01	480 ± 60		AD 1434, AD 1413-1449	-21.8	39 (Nørlund) D10581
AAR-1289	textile (wool?)	Ikigaat (Herjolfsnes), Greenland.	480 ± 43		AD 1434,	-22.3	77 (Nørlund)

		Cap. Belongs to middle skeleton , 0906x01			AD 1419-1445		D10605
AAR-1290	textile (wool?)	Ikigaat (Herjolfsnes), Greenland. Cap. Belongs to upper skeleton , 1106x01	553 ± 45		AD 1410, AD 1330-1428	-22.1	78 (Nørlund) D10606
AAR-1437-1	bone (human)	Igaliku (Gardar), Greenland. Skeleton below Bishop (see AAR-1437) Coord. 60V2-IV-521 (Ø47) *Esp. age:* 1300 AD	1030 ± 65	810 ± 65 (Marine Fraction: 0.499)	AD 1233, AD 1170-1281	-16.8	KAL-0915x01
AAR-1438-1	bone (human)	Igaliku (Gardar), Greenland. Skeleton below Bishop (see AAR-1437) Coord. 60V2-IV-621 (Ø47) *Esp. age:* 1300 AD	880 ± 90	700 ± 90 (Marine Fraction: 0.254)	AD 1295, AD 1256-1392	-17.6	KAL-0916x01
AAR-1439-1	bone (human)	Igaliku (Gardar), Greenland. Bishop (see AAR-1437) Coord. 60V2-IV-621 (Ø47) *Esp. age:* 1300 AD	880 ± 55	770 ± 55 (Marine Fraction: 0.612)	AD 1272, AD 1223-1290	-18.8	KAL-1118x01
AAR-1441-1	bone (human)	Igaliku kujalleq (Undir Høfda), Greenland. Coord. 60V2-IV-611 (Ø66) *Exp. age:* 1300 AD	880 ± 55	610 ± 55 (Marine Fraction: 0.612)	AD 1392, AD 1312-1417	-15.8	KAL-0919x01
AAR-1442	bone (human)	Igaliku kujalleq (Undir Høfda), Greenland. Coord. 60V2-IV-611 (Ø66) *Exp. age:* 1300 AD	890 ± 45	690 ± 45 (Marine Fraction: 0.441)	AD 1297, AD 1279-1317	-17.3	KAL-0920x01
AAR-1568	bone (human)	Qagssiarsuk (Brattahlid), Greenland. Coord: 61V3-III-539 (Ø29a) *Exp. age:* 1050 AD	997 ± 51	890 ± 51 (Marine Fraction: 0.235)	AD 1165, AD 1046-1218	-19.0	KAL-1041x01 (36)
AAR-1569	bone (human)	Qagssiarsuk (Brattahlid), Greenland. Coord: 61V3-III-539 (Ø29a) *Exp. age:* 1050 AD	985 ± 45	870 ± 45 (Marine Fraction: 0.247)	AD 1175, AD 1061-1226	-18.9	KAL-1043x01 (41)
AAR-1570	bone (human)	Qagssiarsuk (Brattahlid), Greenland. Coord: 61V3-III-539 (Ø29a) *Exp. age:* 1050 AD	1092 ± 55	870 ± 55 (Marine Fraction: 0.494)	AD 1172, AD 1063-1227	-16.8	KAL-1059x01 (133)
AAR-1571	bone (human)	Qagssiarsuk (Brattahlid), Greenland. Coord: 61V3-III-539 (Ø29a) *Exp. age:* 1050 AD	1225 ± 51	1070 ± 51 (Marine Fraction: 0.353)	AD 985, AD 909-1017	-18.0	KAL-1054x01 (66)

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