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BY

BENT FREDSKILD

WITH 17 FIGURES AND 2 TABLES

Nyt Nordisk Forlag Arnold Busck
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Abstract

Pollen- and macrofossil diagrams have been worked out from transects in four peat-covered depressions between Norse ruins at Qagssiarssuk. Willow scrub, rich in ferns and herbs, covered the area at the time of the landnam. After a clearance, grass-sedge communities rich in weeds, especially annuals, covered the area. Towards the end of the Norse period some of the transects indicate moister local conditions. Later on willow scrub spread again in the area.

The history of some "Norse plants" is discussed, and finally the influence of the first agriculture on the vegetation in S. Greenland is compared with similar events in Scandinavia, Faroe Islands and Iceland.

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Fig. 1. Map indicating localities mentioned in the text.

INTRODUCTION

In 1962 the Danish National Museum excavated the oldest church in Greenland. This church, Tjodhildes kirke, was built a few years after the Norse landnam of A.D. 985(?) at Brattahlid (now Qagssiarssuk), the dwelling place of Erik the Red. After the extinction of the Norsemen half a millenium later, Eskimoes occasionally lived here, partly in summer camp sites, as shown by tent rings on the beach, partly in winter houses, the collapsed ruins of which are seen close to one of the sections investigated. In 1924 the present settlement of Qagssiarssuk was founded by sheep farmers.

In connection with the excavation I was given the possibility of making small transects in some moist depressions between the many Norse ruins, in order to investigate the effect of the introduction of agriculture on the vegetation and, if possible, to trace any climatic changes during and after the Norse period.

Qagssiarssuk is situated at the head of Tunugdliarfik (61°09′ N., 45°31′ W., Fig. 1) in the subarctic *Betula pubescens-Salix glauca* area, which is restricted to the heads of the South Greenland fiords. The average July temperature at Narssarssuaq, on the other side of the fiord, is 11°C, while that for January is −4.8°C (Lysgaard, 1969). To a height of c. 40 m a.s.l. sandy-gravelly raised terraces connect small ridges, which are composed of a great variety of bedrocks ranging from reworked precambrian lava to granites (Fig. 2). The present vegetation is strongly influenced by sheep and within the settlement only grassy communities are seen. Small areas are fenced and there the manured soil yields hay. When half a century ago the present landnam took place the first farmers had to clear large areas of scrub.

FIELD WORK

Small holes, usually 1×2 metres, were cut through the organic sediments to the gravelly or stony substrate of a number of peat covered depressions. A cleaned wall was measured, and a series of pollen samples at 2 cm intervals, and a series of macrofossil samples consisting mostly of 10×10 cm slices, 2 cm thick, were cut with a knife. As these slices were cut horizontally, not following the undulating boundaries between the layers, single samples seemingly well below a boundary in the measured section may contain some material from the neighbouring layer. The macrofossil samples were stored in 70 % alcohol with a touch of acetic acid and formalene.

After sampling, the layers were described according to the Troels-Smith system (TROELS-SMITH, 1955) and a 25 cm wide area behind the sampling wall was carefully scraped from the vegetation covered surface to the mineral substrate in order to reveal charcoal, artefacts etc. Finally, in the laboratory, the peat was examined under a microscope, and the field descriptions corrected. A summary description of the horizons is given under the relevant section. Three of the sections have been briefly mentioned in FREDSKILD (1973, pp. 125–28), but there the stratigraphical description was based solely on the field observations and is often corrected in the present paper.

LABORATORY WORK

Pollen analyses

The pollen samples were acetolyzed, treated with cold hydroflouric acid, stained, and mounted in glycerol. Details of the pollen determinations and the concept of some types are discussed in FREDSKILD (1973). For the sake of convenience the following summary is given. The species included under the types mentioned are as follows (in brackets) *Betula* (*B. pubescens*, *B. glandulosa* and possibly single exotic *Betula* grains), *Cerastium-Stellaria* (several species of both genera), *Dryopteris* type (*Polypodiaceae* excl. *Gymnocarpium dryopteris*), *Erigeron* type (several species of *Erigeron* and *Gnaphalium*), *Euphrasia-Rhinanthus* (*E. arctica*, *Bartsia alpina* and *Rhinanthus minor* coll.), *Minuartia-Silene* (*Minuartia* spp., *Arenaria* spp., *Silene acaulis*, *Honckenya peploides* and some grains of *Viscaria alpina*), *Potentilla-Comarum* (*Potentilla* spp. excl. most *P. crantzii*, but including *Comarum palustre* and *Sibbaldia procumbens*), *Potentilla crantzii* type (*P. crantzii* and possibly some *Alchemilla vulgaris* coll., *A. alpina* does not produce pollen), *Saxifraga oppositifolia* type (*S. oppositifolia*, *S. aizoides*, *S. paniculata*), *Sedum* (*S. annuum*, *S. villosum*, *Rhodiola rosea*). The nomenclature follows BÖCHER et al. (1968).

The pollen diagrams are relative diagrams with percentages based on the total pollen sum (ΣP) but excluding Pteridophyte spores. At least 500 pollen plus spores were counted in each sample. Common to all three diagrams is the often extremely high degree of destruction of the pollen in the deepest samples, which are usually from well aerated, more or less sandy layers. This means that spores, which are more resistant than pollen, are highly overrepresented. Furthermore, pollen are liable to differential destruction (HAVINGA, 1964) which tends to make the interpretation even more complicated. In some of the deepest samples

Fig. 2. Qagssiarssuk, vertical aerial photo indicating the position of the investigated transects. A: section LM, B: section ER, C: section QD, D: section F. Reproduced with permission (A. 422/77) of the Geodetic Institute, Copenhagen.

ΣP is well below 500 and detailed conclusions are therefore highly problematic. If the advice of FÆGRI & IVERSEN (1975, p. 179) that: "if more than half of the pollen grains of deciduous trees ..... show traces of corrosion the sample should be discarded", was to be followed, then the lower part of the diagrams are worth nothing. However, they do provide the only possibility of telling what the actual vegetation on the spot was when the Norsemen settled, and when the evidence of the macrofossils is combined with a cautious interpretation of the pollen spectra I find it justifiable to include the results of the deeper samples.

Macrofossil analyses

The samples were washed through a 0.4 mm sieve and then sorted under a low power microscope. As most small seeds and megaspores, like those of *Juncus ranarius* and *Selaginella selaginoides*, will pass through

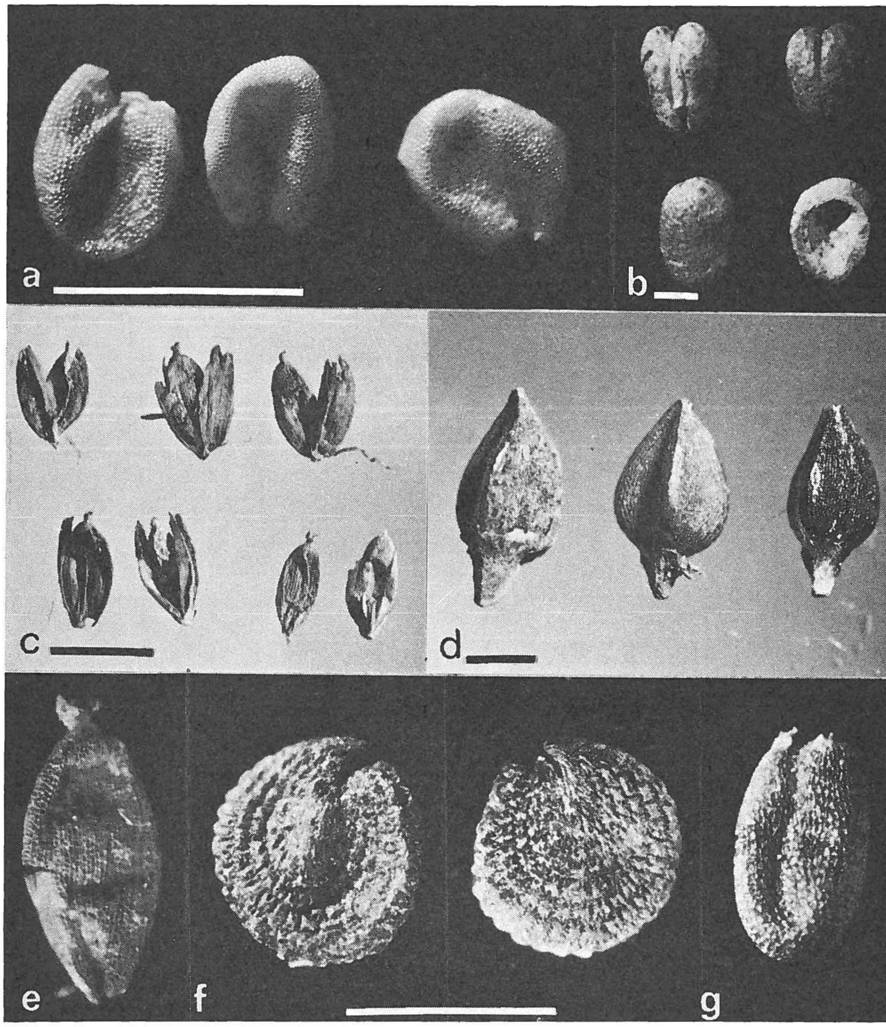

Fig. 3. Seeds from the Norse layers. a: *Rorippa islandica* ssp. *islandica*, b: *Potentilla anserina*, c and e: *Catabrosa aquatica*, d: *Polygonum aviculare*, f: *Stellaria media*, g: *Capsella bursa-pastoris*. Scale: 1 mm.

this mesh size, some supplementary samples were washed through a 0.2 mm sieve. The results concerning these species are discussed in connection with the three diagrams. The measuring unit used is 0.05 mm.

Betulaceae. Nutlets of both species present in the area today, *B. pubescens* coll. and *B. glandulosa* were found, but as most of them were without wings, they are lumped together under *Betula* sp.

Caryophyllaceae. Some 700 seeds of *Stellaria media* were found (Fig. 3,f). 71 seeds from sample ERA 2 were measured: greatest diameter 1.1–1.7 mm, average 1.35 mm. Of 13 seeds of *Cerastium alpinum/arcticum* 10

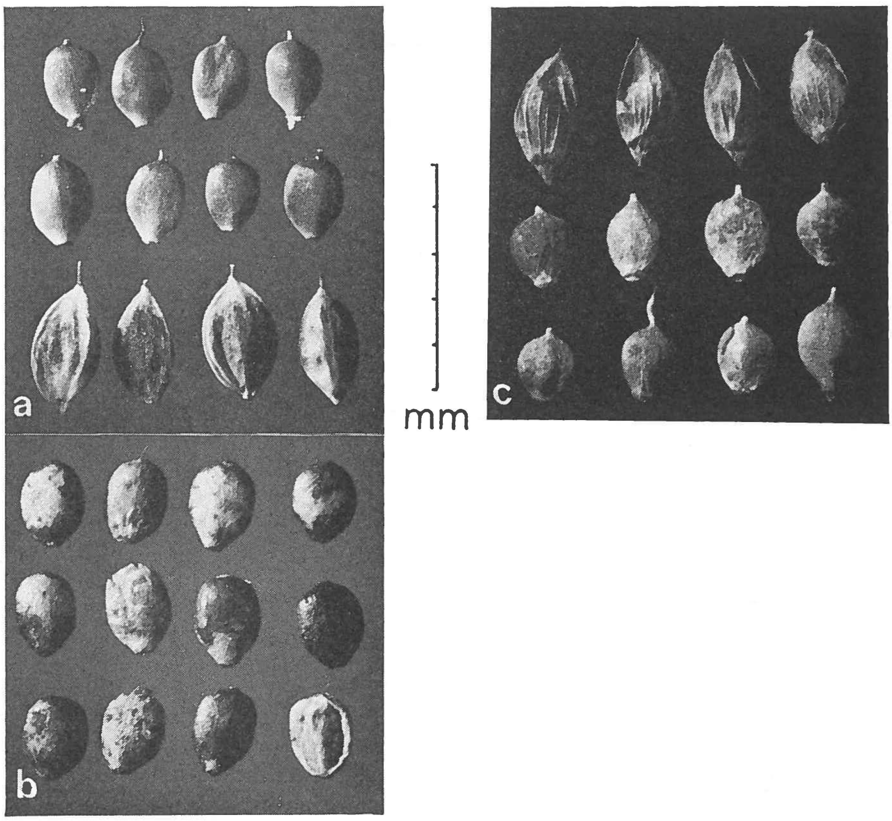

Fig. 4. Seeds and fruits of *Carex*. a: *Carex bigelowii*, recent collection from Jakobshavn (69°13′ N.), W. Greenland, b: *Carex* cf. *bigelowii*, subfossil, section LM, sample 6, c: *Carex nigra*, subrecent, section LM, sample 13.

were measurable, one being 0.75, the remainder 0.9–1.2 mm. One *Sagina* seed (0.6×0.5 mm) cannot be determined as to species. Three seeds of *Viscaria alpina* were found.

Corylaceae. One big fragment of a nutshell (*Corylus avellana*), evidently an import from the Norse period, occurs in ERA.

Cruciferae. 17 seeds of *Rorippa islandica* ssp. *islandica*, easily determinable because of their lustrous, empty, outer epidermal cells (Fig. 3,a), were found in two of the transects, while *Capsella bursa-pastoris* represented by c. 300 seeds (0.9–1.25×0.5–0.8 mm, av. of 25 seeds: 1.10×0.68 mm) occurred in three of them (Fig. 3,g).

Cupressaceae. The needles of *Juniperus communis*, especially the tips, seem quite resistent and are commonly encountered. In addition, fragments of seeds were found in two samples.

Cyperaceae. Most *Carex* achenes were found without perigynium. Nevertheless, a fairly reliable determination seems possible with many

Table 1.

	cm below surface	average size	range	l:b	number measured
Carex bigelowii					
20 collections, herbarium ...		1.72×1.19	1.35–2.05×0.90–1.45	1.45	100
Carex cf. *bigelowii* (see text)					
LM 4, 5, 6, 7, 9, 11........	7.5–35.5	1.89×1.37	1.60–2.20×1.15–1.60	1.38	50
ERA 6....................	24–26	1.84×1.28	1.50–2.20×1.15–1.50	1.45	16
ERA 2....................	52–57	1.78×1.29	1.40–2.00×1.00–1.50	1.38	15
ERA 3, 4, 5...............	32–44	1.85×1.31	1.50–2.20×1.15–1.50	1.41	18
Carex nigra					
13 collections, herbarium ...		1.59×1.39	1.25–1.85×0.95–1.60	1.14	100
LM 13, rec. turf..........	0–3.5	1.59×1.21	1.15–1.90×0.85–1.50	1.32	75
ERA 10 – –	0–2	1.57×1.29	1.30–1.85×0.95–1.60	1.25	100
QDB 17 – –	0–2	1.60×1.21	1.35–1.80×1.05–1.45	1.32	75
F – –	0–2	1.59×1.27	1.35–1.80×1.10–1.45	1.25	25
Carex cf. *nigra* (see text)					
LM 12, subrec. turf.......	3.5–5.5	1.67×1.24	1.35–1.90×0.95–1.50	1.34	98
ERA 9 – –	8–10	1.57×1.31	1.30–1.80×1.00–1.70	1.19	43
QDB 16 – –	2–4	1.58×1.15	1.35–1.90×1.00–1.40	1.37	66
QDB 8, subfos. turf.......	30–32	1.47×1.35	1.20–1.70×1.05–1.55	1.08	108

achenes. In addition to a large amount of reference material the keys and descriptions in NILSSON & HJELMQUIST (1967) and in BERGGREN (1969) have been used.

The bulk of distigmate *Carex* nuts was decidedly either *C. nigra* or *C. bigelowii*. The achene epidermis of each is very similar giving no clue to the distinction, but generally the shape of the achene is more elongate in *C. bigelowii* than in *C. nigra*, as shown in the l:b index (length:breadth) which is 1.45 and 1.14 respectively (Table 1 and Fig. 4).

Carex nigra. The distribution of this species within Greenland is restricted to the area between Kap Farvel and Arsuk Fjord (c. 61°N), Qagssiarssuk being situated in the middle of this area. Of 52 herbarium sheets from S. Greenland only 13 contained some, usually very few ± mature achenes. Measurement of 100 achenes gave an average size of 1.59×1.39 mm (1.25–1.85×(0.85)0.95–1.60). For S. Scandinavian material NILSSON & HJELMQUIST (1967) found the length to vary between 1.4 and 1.8 mm, and BERGGREN (1969) gives 1.5–2.0×1.0–1.4. She gives the l:b index for var. *recta* (FLEISCH.) HYL. to be 1.23. More reference material was obtained from the modern "grass-mat" at the four sites investigated, as the present vegetation is totally dominated by *Carex nigra* with no other *Carex* species growing within some distance. The achenes found often had to be separated from the nerved perigynia

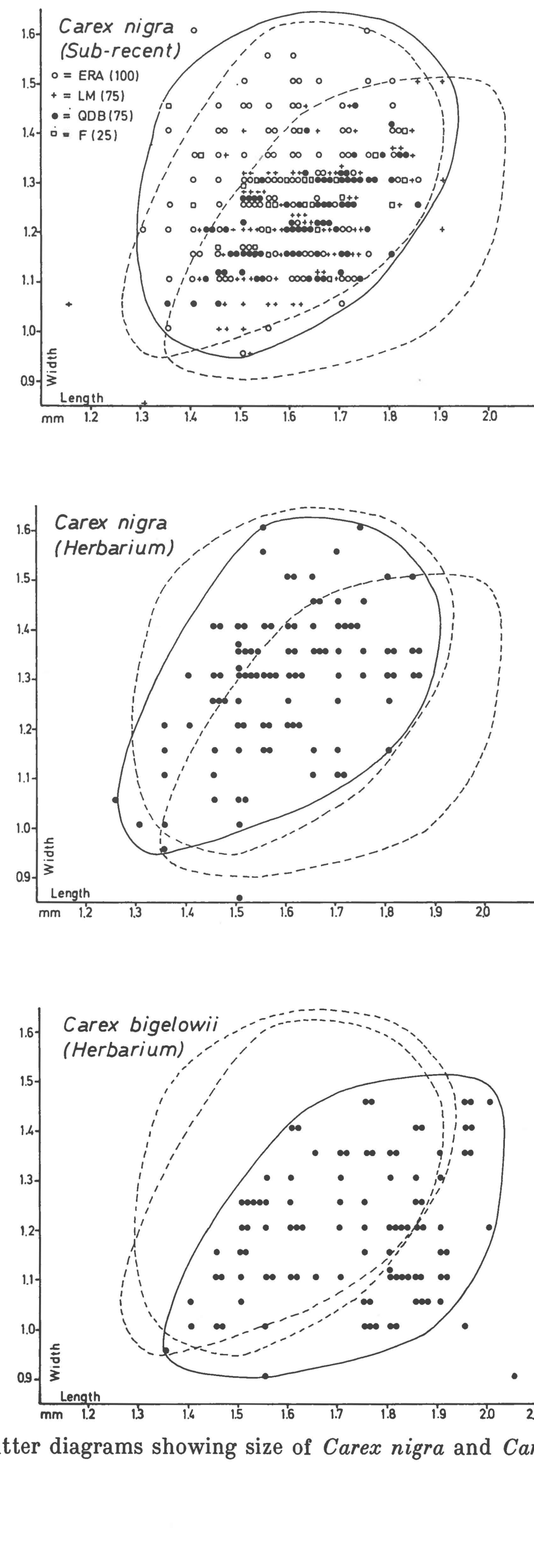

Fig. 5. Scatter diagrams showing size of *Carex nigra* and *Carex bigelowii*.

Table 2.

	Average S. Greenland	Average BERGGREN, 1969	Range	l:b
Carex canescens...	1.45×0.85	1.4×0.9×0.5	1.30–1.65×0.70–1.00	1.71
Carex glareosa....	1.44×0.99	1.6×1.0×0.6	1.20–1.60×0.80–1.10	1.45
Carex brunnescens.	1.35×0.94	1.4×1.0×0.5	1.20–1.55×0.80–1.10	1.44
Carex lachenalii...	1.35×0.95	1.5×0.9×0.4	1.15–1.55×0.75–1.20	1.35

(*C. bigelowii* perigynia are unnerved). The results of the measurements are given in Table 1 and illustrated in Fig. 5, in which the measurements are grouped in classes of 0.05 mm. E.g. four achenes of *Carex bigelowii* are 1.80×1.20 mm, two are 1.85×1.20 mm, etc. Generally, the base of *C. nigra* achenes is broader than that of *C. bigelowii*, and the style base is thicker.

Carex bigelowii. This species, distributed all over Greenland, is extremely variable and numerous hybrids are reported. Of c. 200 sheets in the herbarium a single or a few ripe achenes were found on only 20 sheets, the remaining 180 being totally sterile in spite of seemingly well developed perigynia. In about every second of the fertile collections the achene is regularly biconvex with sharp edges as in *C. nigra*, while in the other collections it is more or less triangular in section resembling tristigmate *Carex* achenes. Flowers with three stigmas were not rare. 100 achenes from 20 West Greenland collections from outside the area of *C. nigra* were measured (Table 1 and Fig. 4), giving an average of 1.72×1.19 mm, l:b being 1.45.

The following principles form the basis for the determination of the fossil achenes. In some samples, e.g. ERA 9, QD 8 and 13, all the achenes, often with a well preserved nerved perigynium, fall within the size range of *C. nigra* (Fig. 5). In these cases the whole material is considered to be *C. nigra.* In samples with a greater size variation only those from outside the size range of *C. bigelowii* are considered to be *C. nigra* (and vice versa) while achenes whose size falls within the range common to both species as well as broken achenes are termed *C. bigelowii/nigra.*

Table 1 includes the measurements of the two species from both the herbarium material and the modern turf. In addition, the measurements of some subrecent and subfossil achenes from samples considered to contain but one species are included. The fossil material termed *C.* cf. *bigelowii* includes all the measurable achenes of *Carex bigelowii/nigra* type in the samples in question, not only the material from outside the common size range. Likewise with *C.* cf. *nigra.*

Carex sect. *Heleonastes* is represented in the area by *C. lachenalii*, *C. glareosa*, *C. canescens*, *C. brunnescens* and *C. mackenziei*, the last mentioned known from only two localities in South Greenland. Common to

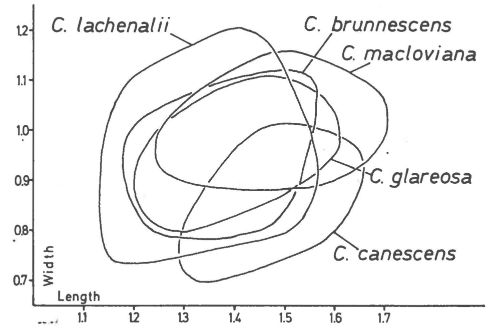

Fig. 6. Scatter diagrams showing size of *Carex* sect. *Heleonastes*.

the plano- to biconvex achenes of the four first mentioned species is the shortly stipitate base (*C. mackenziei* achenes have almost sessile bases), separating these from achenes of the remainder of the distigmate South Greenland *Carex* with a single exception (*C. macloviana*). Reference material of 5 Greenland, mainly South Greenland, collections of each species has been investigated, and 10 achenes were measured in each (Table 2). Only very narrow or very broad achenes can be determined with a reasonable reliability, viz. to *C. canescens* and *C. lachenalii*, but the bulk of achenes fall within the size range common to more than one of the species (Fig. 6).

Of 14 achenes from QDB 6, two were included in a nerved perigynium which excludes *C. lachenalii*. The size and the epidermis cells, which in *C. glareosa* are often wider and more distinct than in the other species, seem to indicate this species. Similar, stipitate achenes are found in *C. macloviana*, the average size of 5 coll. each of 10 achenes being 1.48 × 1.01 mm (1.25–1.70 × 0.90–1.15, Fig. 6). The perigynium in this species is broadly winged, so that the two achenes with preserved but unwinged perigynia cannot originate from *C. macloviana*. Moreover, the size of some of the twelve remaining achenes excludes this species. Since they fall within the range of *C. glareosa* they have all been referred to this species. As, however, the determination of the small, stipitate, distigmate achenes is not fully reliable a cf. is added to the species name.

The achenes of some further distigmatae Carices common to the area today might be expected in the samples. In the case of *C. gynocrates* the shape is obovate or ± broadly elliptic with a broad, slightly stipitate base and a thick style base, and the size (3 coll. of 10) is 1.49 × 1.05 mm (1.25–1.75 × (0.85)0.95–1.15). Being somewhat similar to small *C. bigelowii/nigra* achenes it cannot be precluded that individual fossil achenes of *C. gynocrates* are included under these species. In the case of C. arctogena the shape is obovate, rarely ± elliptic, the style base usually rudimentary, and the edges are set off by a bright border. The size

(5 coll. of 10) is 1.44 × 1.56 mm (0.90) 1.05–1.30 × 1.20–1.60). *C. praticola* has obovate, slightly stipitate achenes with a long, slender stylebase. The size (2 coll. of 10) is 1.40 × 1.22 mm (1.50–1.95 × 1.10–1.35). No fossil achenes have been referred to the two last mentioned species.

Of tristigmate Carices only one species, *C. rariflora*, occurs in quantity (68 achenes in QDB and LM). The achene is elliptic in shape with a broad base. The edges are not prominent, giving the achene a rounded transect. The size (5 coll. of 10) is 1.78 × 1.11 mm (1.55–2.00 × 0.90–1.40) which is in accordance with BERGGREN (1.8 × 1.1 × 1.0). In QDB 30 of the usually highly corroded thin-walled and broken achenes could be measured, giving an average of 1.90 × 1.08 mm (1.60–2.15 × 0.90–1.35). *Carex atrata* has sharp-edged, obovate, stipitate (the stipe is often slightly curved), thick-walled achenes, 1.77 × 1.10 mm (5 coll. of 10, range 1.60–2.00 × 0.90–1.30), in agreement with BERGGREN: 1.8 × 1.1 mm. Nine fossil achenes, of which eight were measurable, (1.65–1.90 × 1.00–1.25) have been referred to *Carex* cf. *atrata*.

Small, tristigmate achenes are found in *C. capillaris* which has small epidermis cells, and in *C. scirpoidea* and *C. norvegica* which have bigger cells. Three achenes (1.5 × 0.8, 1.45 × 0.85 and 1.4 × 0.75 mm) have been referred to *C.* cf. *capillaris*, three (1.45 × 1.9, 1.4 × 0.9 and 1.25 × 0.85 mm) to *C. norvegica*, and three to *C. scirpoidea* (1.3 × 0.8, 1.25 × 1.9, and 1.0 × 0.65 mm).

Empetraceae. Nutlets of *Empetrum hermaphroditum* were common, but a few leaves also occurred.

Gramineae. The key in KÖRBER-GROHNE (1964) and reference material of South Greenland grasses artificially fossilized with sulphuric acid according to the method described herein, have been used. Grass seeds are not usually preserved in peat samples, but in ERA and QDB more than one thousand were found, often surrounded by their glumes. Most of them were *Alopecurus aequalis*, *Catabrosa aquatica* (1.4–1.85 mm long, Fig. 3,c,e) and *Poa annua* (1.55–1.80 mm long). In addition to these part of a spikelet with two seeds (the best preserved 3.3 × 1.05 mm) of *Festuca rubra*, one badly preserved seed of *Festuca* sp. and 14 of *Poa pratensis* type (1.6–2.2 mm long) were found.

Hippuridaceae. One fruit of *Hippuris vulgaris* was found in ERA 3.

Juncaceae. The only *Juncus* seeds found belong to *J. bufonius/ranarius*, easily distinguished from all other Greenland *Juncus* by their small size and the many longitudinal rows of minute testa cells. KÖRBER-GROHNE (1964), with some reservation, mentions a possible way of separating the seeds of the two species, viz. that the cells of *J. bufonius* are arranged in clearly longitudinal rows, while in *J. bufonius* ssp. *ranarius* the cells are irregularly arranged. The reference material at hand does not confirm this suggestion. The size range of the fossil material is: 0.40–0.65 × 0.20–

0.40, giving averages of 0.52×0.30 mm (ERA 10, 16 seeds), 0.51×0.27 (ERA 9, 25 seeds) and 0.48×0.30 (ERA 5, 18 seeds).

62 seeds of *Luzula* cannot be determined to species since the caruncle is always missing. 22 of the seeds were found in ERA 6. As their length is 0.9–1.1 mm only the two species with the smallest seeds need be considered, viz. *L. confusa* (length 0.8–1.3, mostly 1.0–1.1 mm, 5 coll.) and *L. spicata* (0.95–1.15 mm, 3 coll.). In QDB 9 the length of 26 seeds is 1.2–1.4 mm which may indicate the occurrence of species of the *L. multiflora* complex but could also include *L. parviflora.*

Polygonaceae. Achenes of *Polygonum aviculare* were common in the three transects (Fig. 3,d). Bulbils of *P. viviparum* were found only in the uppermost sample at QDB. 139 achenes of *Rumex acetosella* (length 0.95–1.35 mm) occurred in QDB and ERA, while none of *R. acetosa* ssp. *lapponicus* which has much longer and sharp-edged achenes was found. 2 achenes of *R. longifolius* (2.8×1.8 and 2.5×1.6 mm) were found in QDB 17.

Portulacaceae. About 4,000 seeds of *Montia fontana* ssp. *fontana* were found in the three transects.

Ranunculaceae. The only *Ranunculus* found was *R. acris* (2.4–3.0×2.0–2.3 mm).

Rosaceae. Most Greenland *Potentilla* have more or less ribbed achenes, and the variation in shape and structure prevents determination of individual achenes. *P. anserina* and *P. egedii* differ somewhat in that the achenes of *P. anserina* are thickly-ovoid to subglobose, thick-walled, often corky, with a deep and wide, dorsal furrow (Fig. 3,b), while in most Greenland collections of the closely related *P. egedii* the laterally compressed achenes are smaller, 1.5–1.8 (–2.0) mm long in nine collections, with usually only a hint of furrow. The size seems to be correlated to a certain degree with the size of the plants in such a way, that the small specimens of the typical, glabrous form, prevailing in the northern part of its distribution area within Greenland, have small achenes, while the white-hairy var. *groenlandica* (Tratt.) Polunin, most common in South Greenland, has bigger achenes, in one collection even 2.0–2.2 mm long but still without a deep furrow. Most fossil achenes determined as *P. anserina* are 2.2–2.8 mm long, but a few of the achenes in ERA 10 are smaller and with a less distinct furrow. These few may originate from *P. egedii* but could equally well be small *P. anserina.*

The fossil achenes of *Alchemilla alpina* (1.4–1.7×0.95–1.15 mm) are withish, somewhat opaque, with distinct epidermis cells. Achenes of *Comarum palustre* are subglobose, glabrous, becoming darker towards the apex (1.1–1.5×0.9–1.1 mm). Only one *Dryas integrifolia* leaf was found.

Salicaceae. Buds, budscales, twigs and fragments of leaves of *Salix glauca* or *S. arctophila* were common in QDB, rare in ERA.

Scrophulariaceae. Two seeds of *Euphrasia frigida* and one of *Rhinanthus* sp., easily determinable because of its suborbicular, winged seed, occurred in QDB.
Selaginellaceae. In the lower part of two of the transects macrospores of *Selaginella selaginoides* were too numerous to count, especially since many passed through the sieve used. In the third transect (ERA) only a few occurred.
Typhaceae. One badly preserved fruit of *Sparganium hyperboreum* was found in ERA 5.
Umbelliferae. Of the *Umbelliferae* only one fragment of a badly preserved carpel was found. It most closely resembles *Ligusticum scoticum*, but the determination is not fully reliable, and the other Greenland species of the family, *Angelica archangelica*, cannot be precluded.
Vacciniaceae. *Vaccinium uliginosum* leaves occurred in one sample (QDB 5). In the same sample and in the one just below it 3 nutlets of a *Vaccinium* occurred, but it is not possible to distinguish between *V. uliginosum* and *V. vitis-idaea.*
Violaceae. One *Viola* seed from ERA 4 (1.6×1.0 mm) could not be determined as to species but two seeds from another section (LM 2 and 5) are referred to *V. canina.*

Besides the phanerogam remains some oospores of *Chara* sp. and numerous scleroties of *Cenococcum geophilum* occurred. Ephipiae of *Daphnia pulex* and larval houses of *Tricoptera* and of *Simmulium* were also found.

INVESTIGATED TRANSECTS

Section LM

The transect was cut at the bottom of a small valley-like depression, only 5–10 m wide and 1–2 m deep (the dark, oblong area at A in Fig. 2), at an elevation of 16–18 m, some twenty metres west of one of the older houses at Qagssiarssuk. The present vegetation of the site consists of a dense mat of *Carex nigra* and *Poa pratensis* with some *Ranunculus acris*, *Equisetum arvense* and *Polygonum viviparum.* Only a few mosses occur. The following layers were distinguished (Fig. 7):

6. The present vegetation mat.
7. Swamp peat, with traces of the present habitation. Yellow-brown. $Th^2 4$, Ga (+)
6. Swamp peat, very dark brown. Sh 2, $Th^2 2$, Ga (+)
5. Swamp peat, dark brown, Sh 3, $Th^2 1$, Ga ++, Gs +
4. Swamp peat, felty, bright brown, $Th^2 3.5$, Ga 0.5, Gs (+), charcoal
3. Sandy humus layer, greyish, speckled. Heterogenous. Charcoal and wooden chips present together with fragments of twigs, seemingly

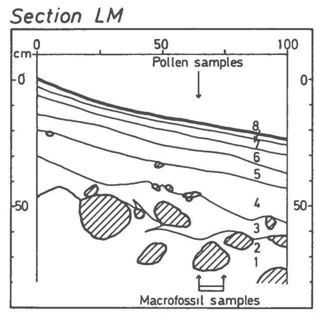

Fig. 7. Section LM.

washed together. Ga 1.5, Sh 1.5, Gs 0.5, (Ag + As) 0.5, Th^2 ++, Dl ++

2. Clay with sand and stones, and with a touch of humic substances. Rusty yellow to grey. Heterogenous, with solifluction stripes, and with ± humic schlieren from layer 3.
1. Clay with sand and big stones.

The macrofossil samples were washed on a 0.4 mm sieve, but part of the finer fraction of each sample was inspected under a low power microscope. No *Juncus* seeds were found.

In scraping the section numerous bits of charcoal were found in layers 3 and 4, and a single piece in the lower 1–2 cm of layer 5, which otherwise, like layer 6, was sterile with regard to cultural traces. However, the boundary between layers 4 and 5 is very indistinct.

In addition to the pollen shown in the diagram (Fig. 8) the following were recorded: *Alchemilla*, sample 12 (1 (number of pollen grains)), *Avena*, 7 (1), *Chamaenerion*, 4 (1), *Empetrum*, 6 (1), *Erigeron* type, 1 (1), *Euphrasia-Rhinanthus*, 5, 6, 13 (one pollen in each), *Gentianaceae*, 10 (1), *Hippuris*, 11 (1), *Lathyrus japonicus*, 5, 6, 9 (1), *Plantago maritima*, 13 (1), *Potentilla crantzii* type, 10 (1), *Saxifraga oppositifolia* type, 6 (1), *Huperzia selago*, 4, 12 (1), *Lycopodium dubium*, 1, 2, 4 (1), 7 (3), 12 (1), *Sphagnum*, 6, 7, 12 (1). The following are long distance transported pollen: *Ambrosia*, 13 (1), *Chenopodiaceae*, 14 (1), *Coniferae*, 2 (1), 6, 7, 8, 12, 13 (0.5), *Tsuga*, 12 (1), *Ulmus*, 13 (1).

Only a minor part of the macrofossil sample no. 13 was inspected and more species than those marked by a + in the diagram (Fig. 9) undoubtedly occur.

The assemblage zones

On the basis of the micro- and macrofossil analyses the diagrams (Figs 8 and 9) can be divided into four zones. Contrary to common practice in palynological papers the description of the zones, including

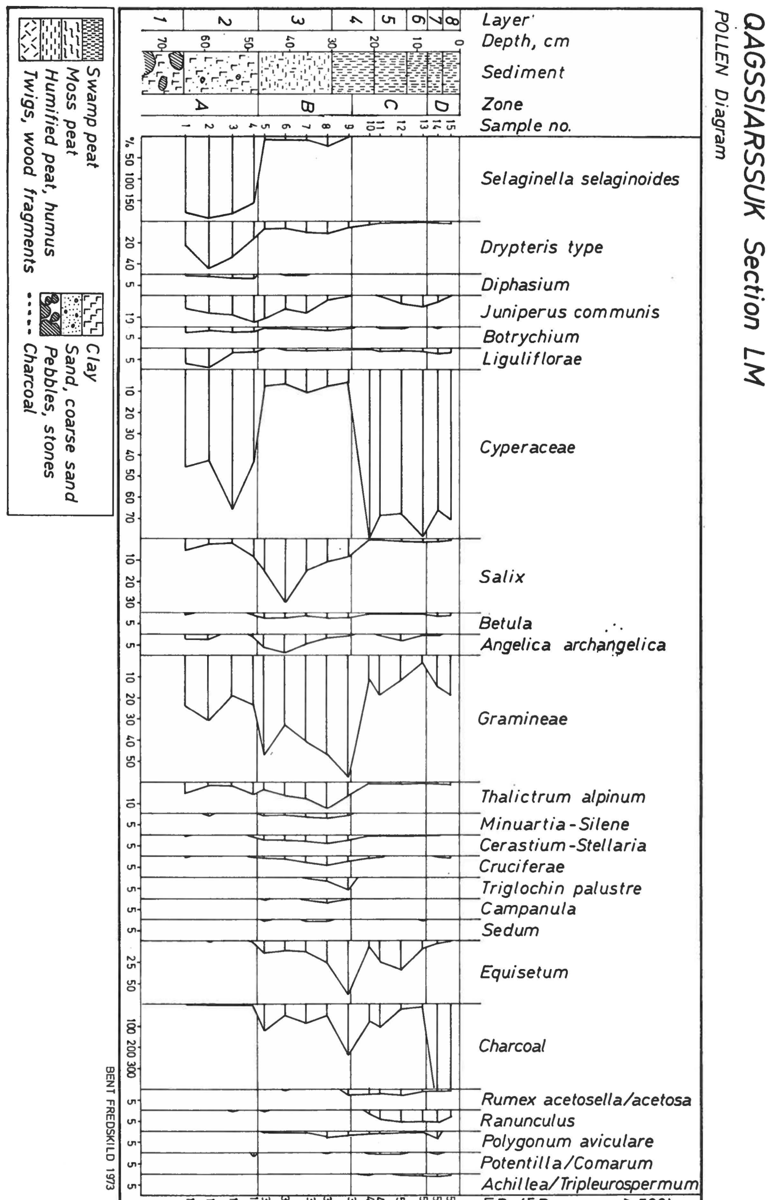

Fig. 8. Section LM, pollen diagram.

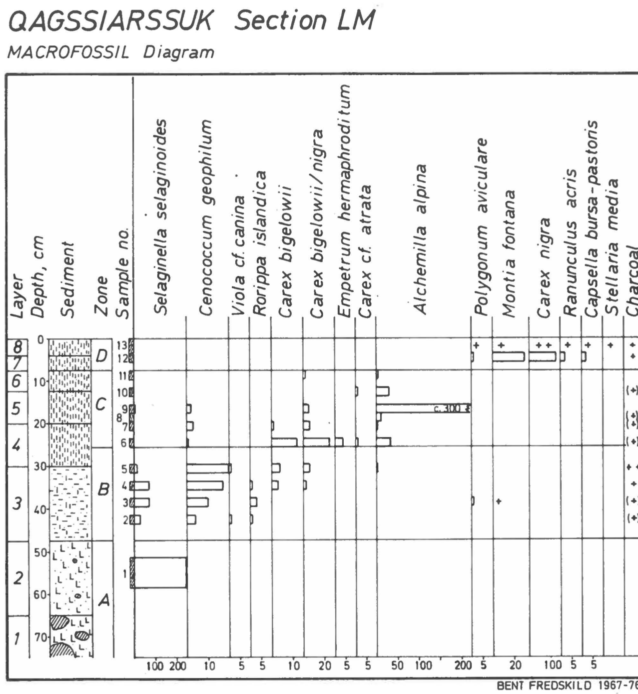

Fig. 9. Section LM, macrofossil diagram.

both the definition of the zone boundaries and the interpretation, is included in the discussion of the zones.

Zone A. Spores, mainly of *Selaginella*, dominate the pollen diagram, partly due to the differential "pollen" destruction, and among macrofossils *Selaginella* macrospores are the only fossils left. Pollen of *Gramineae* and *Cyperaceae* make up c. 80 % of ΣP. *Juniperus* attains its maximum, whereas no indices of moisture demanding communities are found. *Salix* pollen amounts to only a few percent, but *Salix* pollen are greatly susceptible to corrosion (Havinga, 1964), whereas *Gramineae*, in my experience, are more resistant (see also Königsson, 1969). Layers 1 and 2 have been exposed to solifluction of unknown age, but if the microscopical charcoals are considered to be of Norse age, then the solifluction appeared after the landnam. The sandy clay was not deposited by running water, which means that the majority of the plant remains found within it originates from the very spot or from the immediately adjacent slopes to a distance of a few metres.

The most significant plant in zone A in this, as in all the other transects investigated, is *Selaginella selaginoides*. This plant, fairly common in South Greenland, is found in moist heaths, herb-slopes, open scrub and sandy river beds. *Botrychium* ssp., are also common in the herb-rich and grassy slopes. Of the possible ferns contributing to the *Dryopteris* type curve, *Dryopteris dilatata*, *D. filix-mas*, *Polystichum lonchitis*, and *Phegopteris connectilis*, all characteristic of scrub and herb-slopes, are the most likely (*Gymnocarpium dryopteris* has a distinct spore type). Unfortunately it is impossible to separate the *Diphasium alpinum* spores from those of *D. complanatum.*

Most probably the vegetation during this period prior to the landnam was a low, open *Salix glauca* scrub, moist in the deeper part of the depression, drier and more heath-like towards the tops of the slopes, where on the bedrock outcrops, some espalier-like *Juniperus* also occurred. Among the *Cyperaceae Carex bigelowii*, *C. capillaris*, *C. scirpoidea* and *C. atrata* are likely. In addition to grasses, *Angelica* and *Thalictrum* also grew at the site.

Zone B. The shift in sediment from layer 2 to 3, the cultural layer, is accompanied by a change to better preserved pollen and macrofossils. The increase in *Salix*, *Angelica*, *Thalictrum* and others may well be caused by this, but it cannot, however, account for the big change in the ratio *Cyperaceae* to *Gramineae*. One weed only, *Polygonum aviculare*, is proved to have been present, but part of the *Cruciferae* pollen may originate from *Capsella*, whose seeds are only slightly resistant to corrosion. Of the macrofossils, only the most thick-walled or morphologically characteristic are found. *Rorippa islandica* ssp. *islandica* is the most remarkable. This plant is known from only a few localities within a radius of 6–7 km of Qagssiarssuk, where it grows in moist sand at the edge of ponds and lakes and along paths. It has also been found on a lake shore at the head of Sdr. Strømfjord, 650 km further north thus confirming its preference for open, unstable, moist soil, and its only slightly weedy tendencies. JONSELL (1968) discusses its occurrence and uncertain history within its Atlantic distribution area, leaving open the question whether man or bird (or both) are responsible for its spreading. Its natural habitat seems to make dispersion by birds more likely, and at least its occurrence at Sdr. Strømfjord in 1884 must be quite natural. Scleroties of *Cenococcum geophilum* which occur preferentially in heath-like or meadow-like vegetation on humic soil, are found throughout this zone.

During that part of the Norse period in which layer 3 was formed, the extent of the low *Salix* scrub with *Angelica* and ferns was reduced, and a grass-rich vegetation with herbs, including a few weeds, covered most of the area. The duration of this period is unknown, but the more or less allocthonous character of the layer may indicate a relatively short period. In any case, at a certain time the formation of a bright, felty peat was initiated contemporary with the invasion of *Triglochin palustre.* This species is usually found in saltmarshes, on lake shores and along water courses but it may also occur in marshes or bogs with *Carex saxatilis*, *C. norvegica*, *Scirpus caespitosus*, *Salix arctophila*, *Eriophorum angustifolium* and others. In South Greenland it is often associated with *Carex nigra* (e.g. the present vegetation at ERA, see p. 22). The only *Carex* achenes found are of the *C. bigelowii* type, a plant, however, with an extremely wide ecological range occurring in almost all Greenland plant communities. *Cenococcum* disappears. The lower part of layer 4 was formed under the most humid conditions registered in this section.

Zone C. This zone covers the period from the close of the Norse habitation in the recent landnam. The pollen diagram is dominated by *Cyperaceae* averaging 70 % and by *Gramineae*. The *Salix* scrub did not recapture its former area, which was at first covered by a moderately moist vegetation which later on and parallelling the increasing humification of the peat, was replaced by a slightly drier sedge-grass vegetation rich in *Alchemilla alpina*. This species is not registered in the pollen diagram as it produces no pollen. It has its main occurrence at the transition between low willow scrubs and surrounding heath-like vegetations and at the edge of snowbeds. It also occurs in herb-slopes and in heaths, which are not too dry. Böcher (1954 p. 73) has vegetation analyses from West and South Greenland of "The *Alchemilla vulgaris-Phleum commutatum* Type" in which *A. alpina* is dominant, growing with a number of herbs, i.a. *Taraxacum croceum* and (in the South Greenland analyses) *Angelica*. *Phleum commutatum* and *Deschampsia flexuosa* are the only grasses represented. In the same paper (l.c. p. 61) he describes some South Greenland *Alchemilla alpina* sociations rich in *Deschampsia flexuosa*, a type mentioned also by Feilberg (1976). Rosenvinge (1896) writes, that in the S. Greenland grass meadows, the two most common grasses are *Anthoxanthum odoratum* and *Deschampsia flexuosa*, and among other herbs *Ranunculus acris*, *Taraxacum officinale*, *Angelica*, *Carex macloviana*, *Alchemilla vulgaris* and *A. alpina* are the six most frequent of the 48 species mentioned in his list.

Only two *Carex* species have their presence proved by macrofossils, but several others may have contributed to the maximum of *Cyperaceae* pollen. In addition to the degree of humification, the increasing desiccation is reflected in the increasing frequency of *Juniperus* pollen towards the end of the zone. The perennial weeds hold the field throughout, whereas the annuals, with the exception of *Polygonum aviculare*, are reduced. The fact that tiny fragments of charcoal were observed during the washing of the samples may either be ascribed to some Eskimo activity or to the washing or blowing down of Norse age material from the ridge and the slopes. The latter assumption seems to be supported by the presence of sand grains up to 11 mm diameter.

Zone D. The present habitation caused the formation of a fairly fast growing *Carex nigra* peat with seeds of a number of species which, like *Carex nigra*, are favoured by, or even dependent on, human activity.

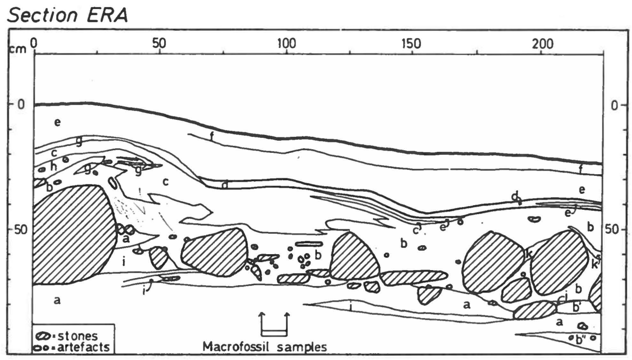

Fig. 10. Section ERA.

Section ER

A 2.5×1 m wide hole (Fig. 2 B) was cut between two tiny streams draining a very moist, gently sloping area some 50 m wide, just above the sea cliff, which is only a few metres high and which has been eroded as a result of the present submergence. The vegetation is dominated by *Carex nigra* and *Poa pratensis* and contains a large number of *Potentilla egedii. Polygonum viviparum* and *Carex glareosa* grow on the small hummocks while *Triglochin palustre*, *Montia fontana* and *Cardamine pratensis* prefer the wettest area and grow especially along the streams. Only a few mosses occur, i.e. *Campylium stellatum.* Two walls were measured, viz. ERA and ERB (Figs 10 and 11), at right-angles to one another, with the point ERA 0 cm being the same as ERB 100 cm. The following layers were distinguished:

f. Swamp peat, yellow brown, Th^2 4, Ga +, (Ag + As) +

e. Humified swamp peat, dark brown, darkening to black brown. Heterogenous with scattered spots of sand, charcoal and other cultural traces. Th^3 4, Ga ++

d. Slightly clayey sand, greyish. Small pieces of charcoal, especially at the boundaries. Ga 3, (Ag + As) 1, Gs ++

c. Swamp peat. Yellow-brown, darkening to brown. The uppermost cm slightly darker. The layer is sterile with regard to cultural traces but the washing revealed tiny bits of charcoal. Th^2 4, Ga +, Gs (+). c' a heterogenous swamp peat of a composition something between layer c and e.

b. Culture layer, a sandy-clayey, humified swamp peat. The colour, spotted reddish or yellowish-brown, darkens immediately to dark-brown on exposure. Heterogenous. Many wooden chips, especially at the lower boundary. In addition charcoal, twigs, bones, worked antlers, a fragment of a stave, etc. Th^3 4, Ga ++, (Ag + As) ++. b' is like b, but more sandy (Ga 0.5), b'' is even more sandy (Ga 1).

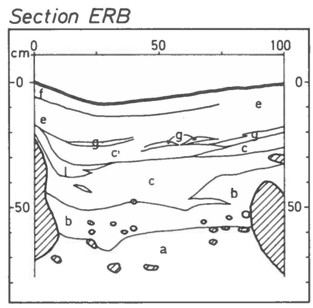

Fig. 11. Section ERB.

a. Clayey sand with gravel and stones, yellow grey. As a result of solifluction some schlieren of the culture layer are seen: b', b'' and i. Gg 1, Gs 1, Ga 1, (Ag + As) 1

The following layers were found in other parts of the transect:

g. Sandy swamp peat, greyish brown, Th^3 3, Ga 1
h. Swamp peat with charcoal.
i. Sand with humus, evidently a mixture caused by solifluction of layers a and b.
k. Like i, but with smaller humus content.
l. Clay with swamp peat. Th^2 2, (Ag + As) 2

In addition to the macrofossils mentioned in the diagram (Fig. 12) the following were found: *Carex* cf. *canescens*, sample 2 (1 achene), *C.* cf. *lachenalii*, 4 (1), *C.* cf. *norvegica*, 10 (1), *C.* cf. *capillaris*, 5 (1), *Dryas* leaf, 5 (1), *Potentilla* sp., 4, 5, 9, 10 (1 in each), *Viola* sp., 4 (1), *Corylus avellana*, fragment of a nutshell in sample 2. Some fragments of *Drepanocladus* sp. and a few of *Philonotis* cf. *fontana* were found in sample 4.

The macrofossils found have been arranged in five groups in the diagram (Fig. 12): I: species from heath, scrub, herb-slope and other dry or at least not too moist communities, II: annual weeds, III: perennial weeds, IV: plants from moist to wet communities, and V: plants and animals from ponds, puddles, streams or the like.

Assemblage zones

Zone A. Only the very resistant macrospores of *Selaginella* and the scleroties of *Cenococcum* are preserved. Presumably they originate from the original vegetation of the site, where they grew with other plants on the minerogenous soil of the raised beach; but as an allocthonous origin cannot be excluded, nothing definite can be deduced about the local vegetation at the time of the landnam. The few weeds represented evidently originate from the thin schlieren of the culture layer.

Zone B. The opening of this zone is characterized by the spreading of plants indicating a very wet habitat and by a contemporaneous invasion

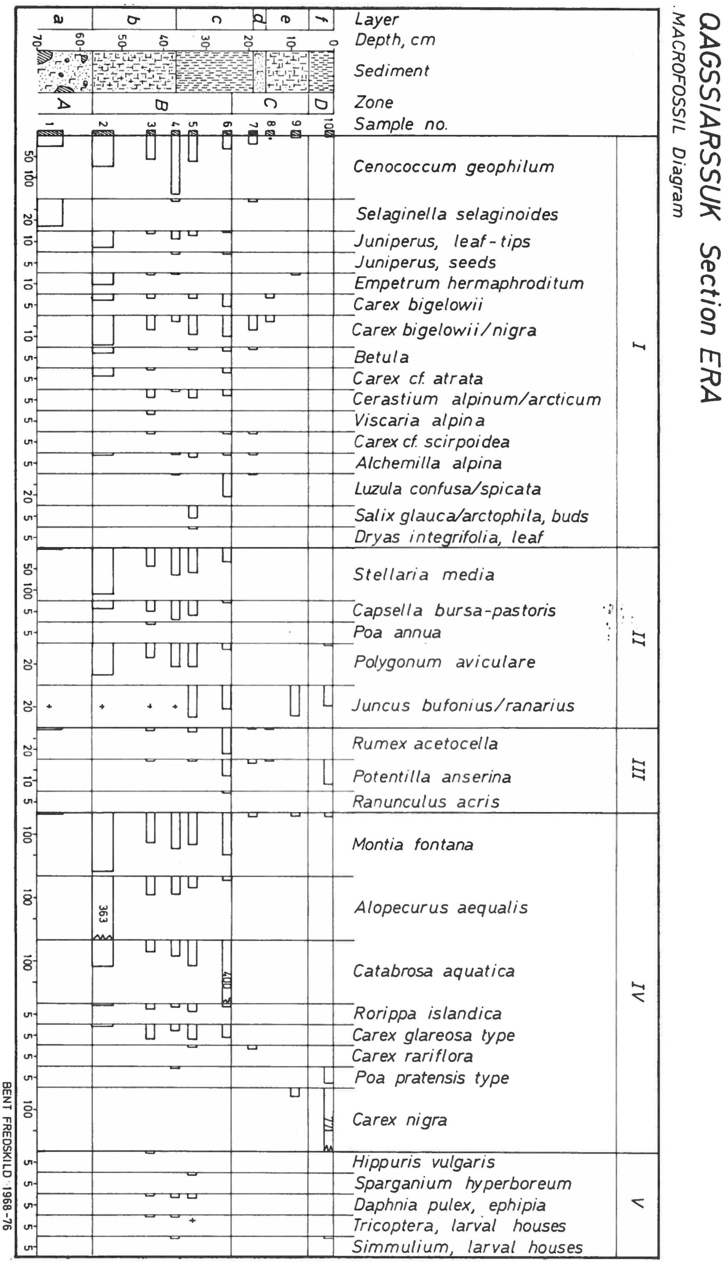

Fig. 12. Section ERA, macrofossil diagram.

of weeds. The dominant species is *Alopecurus aequalis* which is frequent in South Greenland on lake shores, in shallow water and in temporary ponds. Its slightly hemerophilous character is also illustrated by its occurrence on moist soil along foot-paths. *Montia fontana*, the natural habitats of which are found along streams, in puddles and springs, is common in most Greenland settlements where it grows, often as an extremely vigorous specimen, in moist, heavily polluted and manured depressions between the buildings. *Catabrosa aquatica* has only been found a few times in S. and S.W. Greenland, occurring in springs and other places where water is constantly being supplied to the ground surface. Thus Polunin (1943, p. 364) found it "growing in heavily trampled and pastured turf in the village, low down near the sea". Nordhagen (1943) describes some vegetation in Norway in heavily grazed alpine pastures intersected by ditches containing spring water polluted by liquid manure, where the dominant species are *Ranunculus hyperboreus*, *Montia rivularis*, *Epilobium palustre*, *Agrostis stolonifera* and *Carex nigra*. *Alopecurus aequalis*, *Ranunculus reptans*, *Sagina procumbens*, *Calamagrostis neglecta*, *Deschampsia caespitosa*, and *Eriophorum polystachyum* are frequent and weeds are common, especially near roads and paths.

It is tempting to ascribe the *Carex bigelowii/nigra* achenes to the latter species, but in terms of their size, the 56 achenes found fall within the "common area" (Fig. 5) or to the right of it, i.e. in all probability *C. bigelowii*. This species may have been growing on the hummocks but most likely, as in the case of the other plants grouped under I in the diagram (Fig. 12), the macrofossils have been blown or washed down from the slope above the moist area. Noteworthy are the plants which provide evidence of open water in samples 3–5: *Hippuris vulgaris* and *Sparganium hyperboreum*. Both species grow in very small, shallow ponds which may dry up during the summer and yet still have a moist muddy-clayey bottom. This pond need not have been at the very spot but within tens of metres. *Daphnia*, *Tricoptera* and *Simmulium* may have lived in the pond, or in a small watercourse like the present two, which are only 2–3 m from the site.

Among the weeds, annuals are dominant, except in the uppermost sample where *Rumex acetosella* and *Potentilla anserina* take over. *Juncus bufonius/ranarius*, common throughout the culture layer, is placed among the annual weeds, group II, in spite of its uncertain taxonomic status and history in Greenland. At higher latitudes at the head of Godthåbsfjord, Sdr. and Ndr. Strømfjord in West Greenland, and at Storefjord (71°05′N.) in E. Greenland, *J. ranarius* has been found growing in quite natural habitats on muddy or clayey soil near the coast, and by salt lakes. I have found numerous seeds of *J. bufonius/ranarius* in lake sediments older than 8,640 ± 130 radiocarbon years (K-2294) at the head of Godthåbsfjord, thus proving its immigration by natural means, but its present occurrences in South Greenland are all of a weedy character (PEDERSEN, 1972), and it is common in Qagssiarssuk today, growing i.a. in a moist, heavily trampled and grazed meadow, which is temporarily inundated by brackish water.

Towards the end of the zone the local disturbance of the soil and the vegetation by human influence is reduced: The perennial weeds become more common at the expense of the annuals, and the "pond" seems to have been overgrown.

Zone C. The samples are poor in macrofossils but it seems indisputable that all weedy annuals disappear as does *Catabrosa* and other moisture indicators. 20–25 m from the site some ruins of Eskimo winter houses of the seventeenth-eighteenth century type can be seen (NÖRLUND & STENBERGER, 1934). The building of these stone and sod houses may well have influenced the vegetation at ER. The sandy layers (d and g) are most likely the result of one single event, e.g. a meltwater flood carrying sand from the slope above the swampy area, or may have been caused by the paring off of the sod. It is not possible, on the basis of this diagram, to reconstruct the vegetational changes since the disappearance of the Norsemen up to the present habitation.

Zone D. The macrofossils partly reflect the present vegetation, and partly provide information of plants which must have been growing locally until quite recently, e.g. *Juncus bufonius/ranarius* and *Potentilla anserina*. One or a few of the achenes referred to as *P. anserina* may be *P. egedii*, but most of them are definitely *P. anserina*.

Section QD

A shallow depression, c. 100×200 m wide, behind one of the many raised beaches (the dark area at C in Fig. 2), is filled by peaty deposits and covered with a dense fen vegetation. Today the area is fenced, fertilized and used for haymaking. As it is normally water-logged, an open drainage ditch has been dug. Close to the road, some 50 m from the fiord, at an elevation of c. 7 m a section was measured along the ditch (Fig. 13). Apart from *Carex nigra* which is the overall dominant some *C. rariflora*, *Cardamine pratensis* and *Poa pratensis* grow on the spot. The samples were taken from a peat monolith cut 20–40 cm in front of the measured section (QDC). The pollen series (QDA) was taken 15 cm away from the macrofossil samples (QDB) all of which, except no. 1, were 11×12×2 cm. As the boundaries between the layers are not quite horizontal the sediment columns in the two diagrams are not identical with regard to depth. The following layers were distinguished:

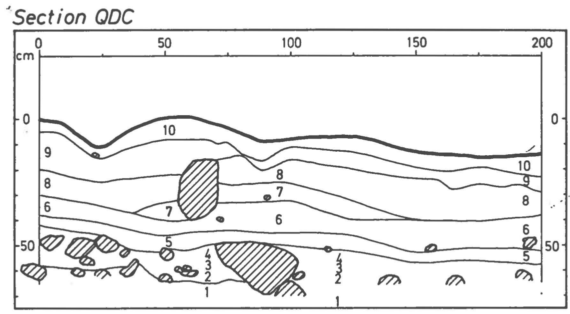

Fig. 13. Section QDC.

10. Swamp peat, dark brown, very felty mainly because of recent roots. Some *Salix* twigs. Th^2 4, Ga (+), Dl +
9. Swamp peat, bright brown, very felty, slightly sandy, many Salix twigs and woody fragments. Th^2 4, Dl ++, Ga +
8. Swamp peat, dark brown, darkening immediately on exposure to black brown. The still very felty structure is caused by recent roots, whereas the matrix in between seems to be a highly humified peat, reflected i.a. in the usually glossy surface of the *Montia* seeds now appearing dull, and in all other seeds being highly corroded. The deeper half of the layer slightly brighter. Some twigs, *Salix* buds, and wood fragments. Slightly sandy. Th^3 3, Sh 1, Ga +, Dl +
7. Swamp peat, banded in bright brown to yellow brown tunes, thus at 28 cm in QDB a one cm thick, very bright band occurs. Very felted. Th^2 4, Ga (+), Dl (+)
6. Swamp peat, dark, greyish-brown. Very felted. Twigs, wood, charcoal, sand and coarse sand. Th^2 3.5, Ga 0.5, Dl ++, Gs +
5. Mossy swamp peat. Yellow brown, felted, sandy. Many twigs. Numerous fragments of *Calliergon giganteum* and a single leaf of *Pseudobryum cinclidioides*. Th^2 1.5, Tb^2 1.5, Dl 0.5, Ga 0.5
4. Heterogenous layer with some swamp peat, high content of fine humic particles, sand, many worked wooden chips, charcoal. Dark greyish-blackish, partly because of the layer being soaked with water. The upper part brighter, resembling layer 5. Sh 2.5, Th^2 1, Dl 0.5, Ga ++, Gs +
3. Transitional layer consisting of schlieren of layer 2 and 4 in the ratio 3:1.
2. Sandy-clayey humic layer, dark grey. Sh 3, Ga 1, Th^2 ++, Dl ++, (Ag + As) ++
1. Stones with sand and clay and some humic matter. Sh 1.5, Ga 1.5, Gs 0.5, (Ag + As) 0.5

In addition to the macrofossils shown in the diagram (Fig. 14), the following were recorded: *Carex lachenalii*, sample 11 (1 achene), *Festuca*

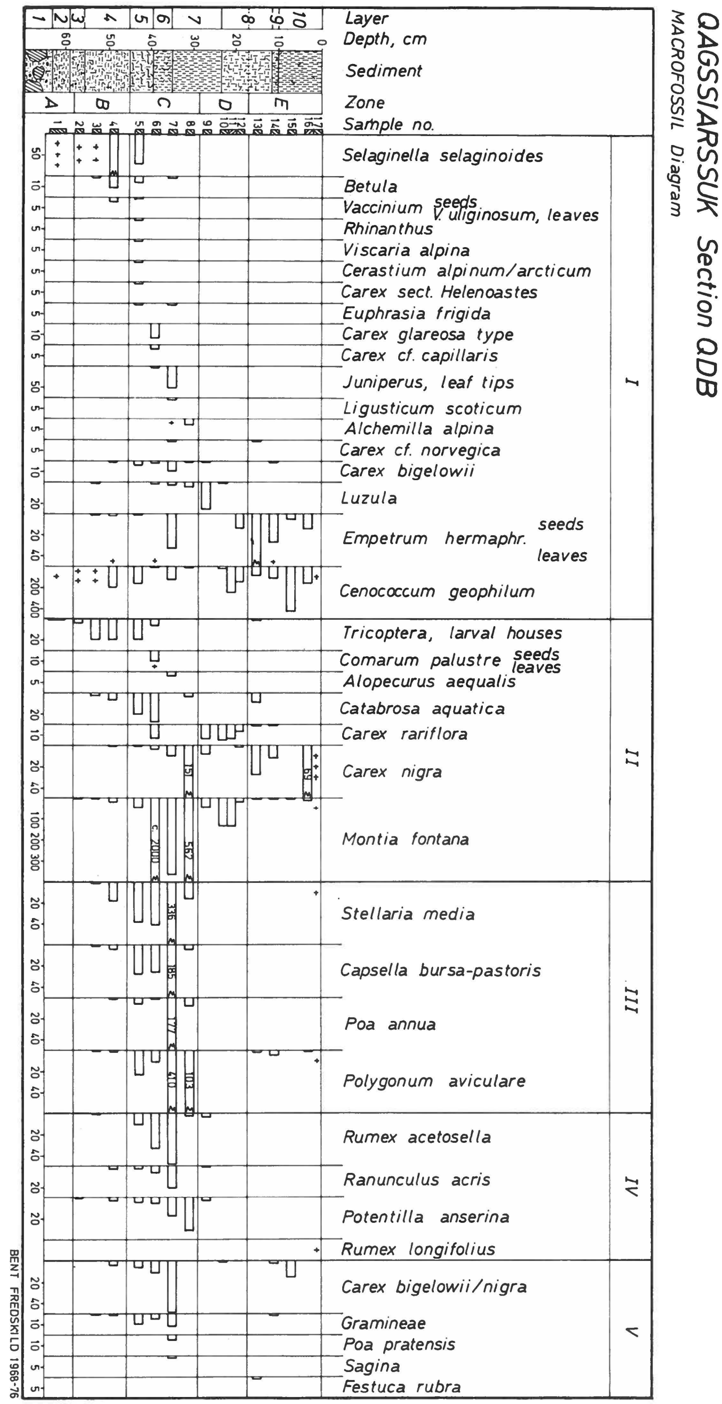

Fig. 14. Section QDB, macrofossil diagram.

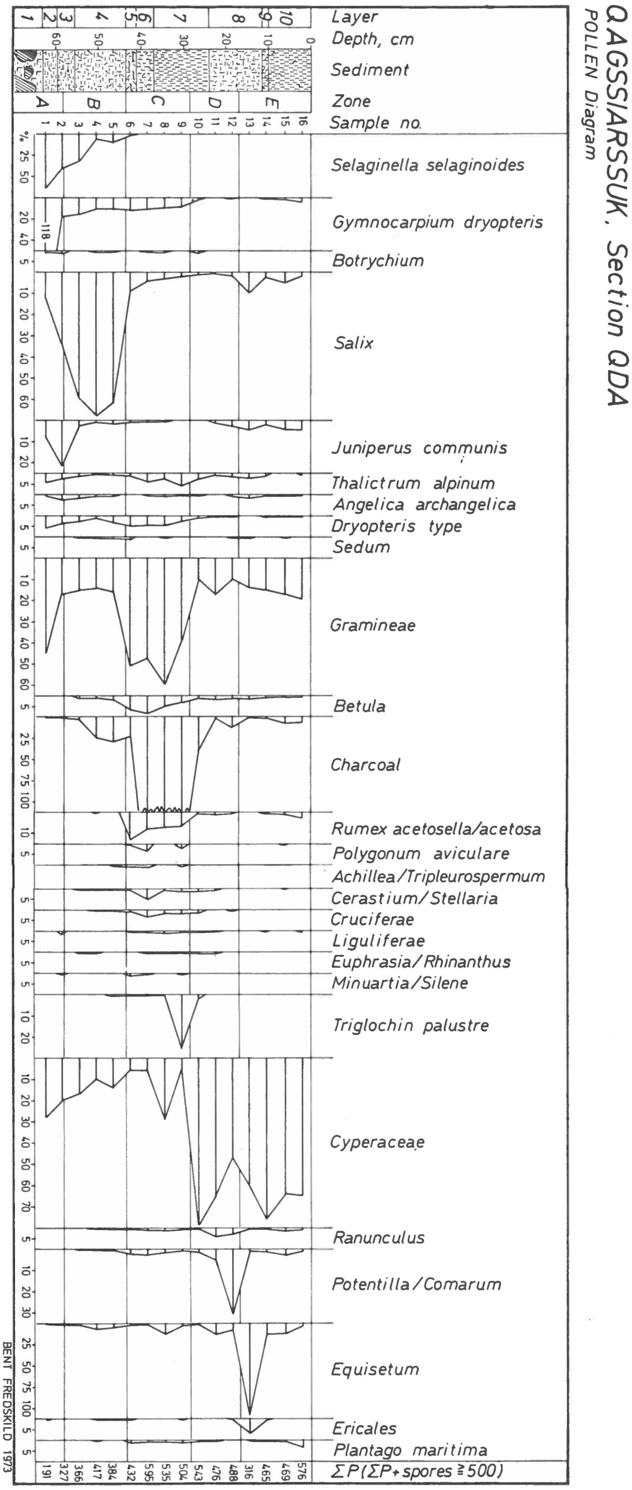

Fig. 15. Section QDA, pollen diagram.

sp., 7 (1), *Potentilla* sp., 6 (6), 7 (+), 8 (3). None of the samples were washed through the 0.2 mm sieve, and during the preparation of the macrofossil samples no seeds of *Juncus* were observed. However, all the pollen samples are inspected under a low power microscope after KOH treatment but before acetolysis, and in pollen sample no. 9 seven seeds of *Juncus bufonius/ranarius* were found. After this find 2 macrofossil samples, 16–18 and 58–60 cm below the surface, both from layers without cultural influence, were inspected with negative result, and it seems most likely that *Juncus* only occurs during zone C.

The macrofossils found have been arranged in five groups: I: species from heath, scrub, herb-slope and other dry or at least not too moist communities, II: species from moist to wet communities, III: annual weeds, IV: perennial weeds, V: varia.

The following pollen etc. not shown in the diagram (Fig. 15) were recorded: *Campanula*, sample 6 (2 pollen), 9 (1), 10 (2), 12 (2), 13 (1), 15 (1), *Caryophyllaceae*, 1 (2), 6 (1), *Erigeron* type, 4 (1), 7 (2), 11 (1), *Gentiana aurea*, 5 (1), *Juncaceae*, 10 (1), *Lathyrus japonicus*, 7 (1), *Montia*, 3 (1), 8 (1), *Polygonum viviparum*, 15 (2), *Streptopus amplexifolius*, 9 (1), *Thymus*, 7 (1), *Diphasium*, 1 (2), 7 (1), 12 (1), 13 (1), 14 (1), *Lycopodium annotinum*, 1 (2), 2 (1), 3 (1), 5 (1), 7 (1), 15 (1), 16 (1), *Huperzia selago*, 13 (1). Also present were: *Pediastrum*, 7 (1), 9 (2), *Microthyrium*, 5 (2), *Sphagnum*, 15 (1), and long distance transported pollen: *Alnus*, 8 (1), *Fagaceae*, 3 (1), *Coniferae*, 2 (0.5), 3 (1.5), 4 (1), 11 (1), 12 (2), 15 (1), 16 (0.5).

Assemblage zones

Zone A. Following the same argumentation as for section LM, the vegetation at QD was similar to that of LM prior to the landnam, i.e. an open *Salix* scrub rich in *Gymnocarpium* and other ferns, in *Selaginella*, and in *Angelica*, grasses, sedges and other herbs. *Juniperus* was growing on the drier parts of the raised beaches and on the nearby rocks.

Zone B. A willow scrub still persists. The increasing *Salix* pollen percentages may partly be ascribed to better preservation, which is also reflected in the findings of no macrofossils other than *Selaginella* and *Cenococcum* during zone A contrary to the many species recorded in zone B (Fig. 14). Small puddles occurred in the scrub, as indicated by the tricoptera larvel houses. The group of caddis fly species, to which the remains belong, are able to thrive in extremely small temporary puddles existing within the general vegetation cover. The cultural traces in the upper part of the zone, of whatever type they may be — seeds or pollen of weeds, charcoal, worked chips — have most likely been trampled down by man or his animals after the landnam.

Zone C. The landnam was initiated by cutting the scrub in the same manner as was employed in 1924 when the present habitation started (Verbal information from the late JEHU DAVIDSEN of Qagssiarssuk, who joined the settlers from the very first day). In these latitudes, whenever the natural vegetation of depressions within the settlements is disturbed and trampled the result is a moist, periodically wet or inundated area with a humic, clayey or sandy soil covered by *Montia*, weeds and some apophytic grasses and sedges and often mosses. It is worth mentioning that in this transect c. 4,000 *Montia* seeds were found, but only 2 (two) pollen. This type of vegetation covered the area at that time. For a while even *Comarum palustre* and *Catabrosa* grew here, indicating very moist conditions.

Macrofossil sample no. 7 seems to indicate a fairly dry vegetation: *Juniperus* leaf tips, *Empetrum* seeds, a maximum in *Rumex acetosella* nuts and only a few moisture demanding plants being recorded, but this impression is not corroborated by the pollen evidence. Towards the end of the zone a *Triglochin palustre-Carex nigra* meadow with *Potentilla anserina* and *Montia* covered the area.

Zone D. The sudden disappearance of the annual weeds and the drastic reduction in perennial weeds and other hemerophilous plants no doubt reflects the end of the Norse habitation. A *Carex rariflora* meadow, at first with *Luzula* sp. (presumably *L. multiflora* ssp. *frigida*) covered the area. Towards the end of the zone the more humified sediment and the different pollen spectra point towards drier conditions. The pollen does not indicate a spreading of willow scrub, but the numerous twigs, wood fragments and buds, especially in samples 11 and 12, seem to indicate that the scrub partly covered the area or at least sites in the immediate vicinity.

Zone E. The opening of the zone is marked by a variety of evidence indicating less moist conditions. The sediment is darker, i.e. more humified, *Carex rariflora* and *Montia* are replaced by *Carex nigra*, *Catabrosa* (sample 13), and *Empetrum*, the last mentioned presumably growing on top of the hummocks. The *Juniperus* curve, increasing from the end of zone D points in the same direction.

Layer 9, the bright brown swamp peat, was only 1.5 cm thick in the monolith used for sampling, whereas in one part of the measured section it was up to 15 cm thick. Neither the pollen sample nor the macrofossil sample from this layer differ markedly from the samples above and below.

The present habitation is not reflected in the pollen diagram, although the macrofossils do provide some evidence e.g. the spreading of *Carex nigra* in samples 16 and 17 and of *Stellaria media* and *Rumex longifolius* in sample 17. *Rumex longifolius*, not found in Qagssiarssuk today, has been introduced in some Greenland settlements from Juliane-

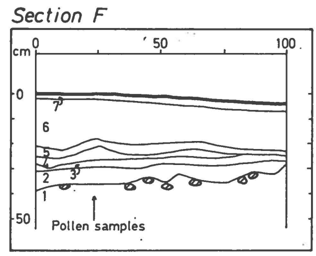

Fig. 16. Section F.

håb (60°43′N) in the south to Godthåb (64°11′N) in the north (PEDERSEN, 1972).

Section F

At the edge of the same depression from which section QD was cut, but at a slightly higher elevation (c. 11 m) a hole (Fig. 2 D) was dug through the peaty soil to the raised beach material. The site is 30 m from a Norse enclosure (Fig. 66 in NÖRLUND & STENBERGER, 1934). The mat-like vegetation, found within the enclosure, is dominated by *Carex nigra*, rich in *Ranunculus acris* and *Equisetum arvense*, with *Poa pratensis*, *Polygonum viviparum* and *Epilobium* sp. present. The following layers were distinguished (Fig. 16):

7. Recent herb mat.
6. Humus, brown, very felty (recent rootlets) upwards. The matrix a crumbling substance. Sh 3, Th^1 1, Ga ++, (Ag + As) +
5. Clayey humus, dark brown, slightly felted. Sh 3, Th^1 0.5, (Ag + As) 0.5, Ga +
4. Sandy-clayey humus, loose, crumbling. Brown with a reddish tone. Sh 3, Ga 0.5, (Ag + As) 0.5, Th^1 ++
3. Coarse sand, rusty yellow. Gs 2.5, Ga 1, Lf 0.5
2. Sandy clay, brownish grey. (Ag + As) 2.5, Ga 1.5
1. Sandy-clayey pebbles, rusty.

In addition to the pollen shown in the diagram (Fig. 17) the following were recorded: *Alnus*, sample 1 (1 pollen), 6 (1), 11 (1), *Ericaceae*, 4 (1), 9 (1), 12 (1), *Erigeron* type, 7 (1), *Gentianaceae*, 9 (1), *Minuartia-Silene*, 12 (1), together with *Pediastrum*, 2 (41), 6 (1), *Microthyrium*, 11 (1), *Sphagnum*, 8 (1), 12 (1), and long distance transported pollen of: *Ambrosia*, 12 (1), *Coniferae*, 4 (0.5), 9 (1), 10 (1), 11 (2.5), 12 (2).

A series of macrofossil samples were taken but all samples turned out to be humified beyond the preservation limit of macrofossils. Only in the present turf do seeds of *Carex nigra*, *Ranunculus acris*, *Montia* and others occur together with *Cenococcum*.

14–15 cm below the surface in layer 6 many bits of charcoal and a concentration of coarse sand up to 1.5 cm diameter were found.

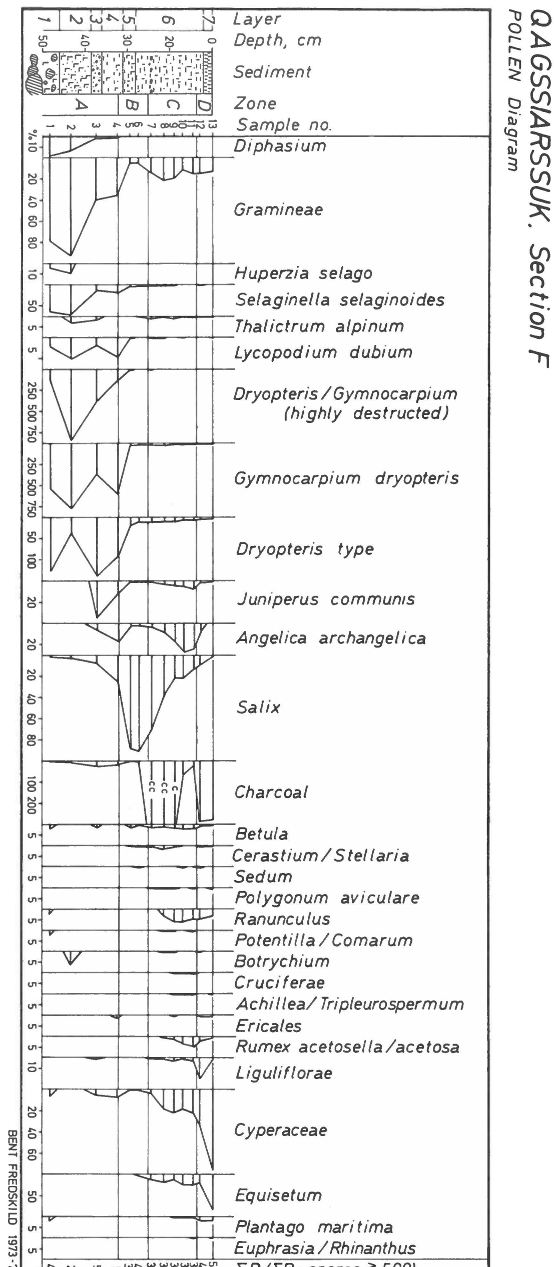

Fig. 17. Section F, pollen diagram.

Assemblage zones

Zone A. Pteridophyte spores, often so highly corroded that it was impossible even to distinguish between *Gymnocarpium* and *Dryopteris*, dominate the pollen spectra. Among the pollen *Graminaea* are dominant. Samples 1 and 2 are rich in spores indicating a heath-like or a low, open, scrubby vegetation with a good snow cover: *Huperzia*, *Diphasium*, *Selaginella* and the dominant *Gymnocarpium*. The relatively high number of Pediastrum in sample 2 also indicates moist conditions in the ground layer. *Juniperus* is common in samples 3 and 4 indicating drier conditions, but *Angelica* is most probably connected with a damp willow scrub. (The *Salix* pollen presumably underrepresented due to destruction). Without detailed investigations it is difficult to ascertain whether the different pollen spectra in the consecutive layers reflect continuous sedimentation under different environmental conditions or only a different degree of corrosion of pollen and spores, washed down through the more or less sandy layers from a surface persisting unchanged over a long period. However, it seems difficult to explain e.g. the large number of *Pediastrum* in sample 2 which is highly humified and their absence from the less humified sample 3 if the latter explanation is maintained.

Zone B. A dense willow scrub must have been growing on the spot at the time of the landnam.

Zone C. The scrub was gradually reduced contemporarily with a spreading of *Ranunculus* (? *acris)*, *Liguliflorae* (? *Taraxacum*), *Cerastium-Stellaria* (? *Stellaria media*), *Rumex acetosella*, *Cyperaceae* and, strangely enough, of *Angelica*. The relatively few pieces of charcoal found in the present section do not indicate a burning of the scrub by the landnam people, a method otherwise proved in a part of Vesterbygden (Godthåbsfjord) by IVERSEN (1934).

Presumably the decreasing charcoal content from sample 9 indicates the closing of the Norse period. *Angelica* and *Cyperaceae* continue to increase up until the boundary of the next zone.

Zone D. The present habitation favoured *Cyperaceae* (*Carex nigra*) but caused the extinction of *Angelica* and *Salix* from the spot.

THE INFLUENCE OF THE LANDNAM ON THE VEGETATION

South Greenland

The influence of the introduction of an animal-based agriculture (sheep, cow, goat and horse) upon the vegetation at Qagssiarssuk can be summarized as follows: Prior to the landnam the depressions between the raised beaches and slopes facing the fiord were covered by a low, open *Salix* scrub rich in ferns and herb-slope plants with *Juniperus* growing on the drier parts. The vegetation on these slopes, being exposed to frequent and violent foehns all the year round did not include *Betula*, not even *B. glandulosa*, which was otherwise common in the area (Fredskild, 1973) and is still very frequent in scrubs and heaths. At the landnam or soon after the scrub was cut down and grass-sedge communities rich in weeds covered the area. *Stellaria media*, *Capsella bursa-pastoris*, *Poa annua*, and *Polygonum aviculare* were beyond doubt immediately introduced and presumably also *Achillea millefolium* s.l. A number of species, favoured by the landnam but not obviously characterized as being either anthropochorous or apophytes deserve some comments.

A total of 130,000 pollen (excl. pollen of aquatics and of long distance origin) has been counted in diagrams from S. Greenland lake deposits for the period prior to the landnam (for a full assessment of this material see Fredskild, 1973). Of this total only two were *Rumex acetosella/acetosa* and both of these were from the lake with the highest amount of long distance pollen, generally 10–30 $^0/_0$ of ΣP. During the same period, 55 pollen of another prolific pollen producer, viz. *Ambrosia*, were blown in from N. America and deposited in the same lake. The present investigation does not contradict the assumption that the S. Greenland *Rumex*, both *acetosella* and *acetosa* was introduced by the Norse settlers. *Ranunculus acris* is distributed far outside the Norse area in Greenland, viz. as far north as 67° on the west and 66° on the east coast, but being highly favoured by agriculture it is not unlikely that some strains of this highly variable species were introduced. Unfortunately it is not possible to separate the pollen of *R. acris* from those of other *Ranunculus* species, and the sharp increase in *Ranunculus* pollen contemporary with the landnam in the diagrams from the lakes at Qagssiarssuk cannot be ascribed to *R. acris* alone. Thus e.g. *R. hyperboreus* which in Greenland settlements behaves like *Montia*, may be partly responsible, as indicated by the sudden occurrence of achenes in the nearby Galium Kær in the first part of the Norse era.

Today *Potentilla anserina* is found only in some S. and S. W. Greenland settlements (Pedersen, 1972). Its few occurrences on the beach at inhabited sites are presumably neophytic and it may well have been introduced by the Norsemen. *Catabrosa aquatica*, found only at five localities in S. and S. W. Greenland, grows in moist places in settlements but also in closed natural communities, in agreement with its occurrence in Iceland: "In wet places, along rivulets...... often along gutters or drains from inhabited places" (GRØNTVED, 1942). It may have spread to Greenland by natural means at an earlier date, its occurrence in the Norse layers thus being apophytic, but it could just as well have been introduced from Iceland and have spread from the settlements, or its history in Greenland may be similar to that of *Juncus bufonius/ranarius* (p. 25). *Rorippa islandica* spread to its only known W. Greenland locality by natural means although it seems tempting to refer its S. Greenland occurrence, all localities close to Qagssiarssuk, to the Norse landnam. It would be just as tempting to explain the occurrence of *Eleocharis palustris*, growing at only two, and *E. uniglumis* growing at only one place close to Norse ruins, to the landnam. However, the finding of many achenes of *Eleocharis palustris* s.l. at Qagssiarssuk in three subsequent samples, 6–7,000 years old, is a warning against drawing seemingly evident conclusions of a concordant distribution between a plant and the Norse settlements if the plant is not strictly hemerophilous. The same applies to another "Norse plant" (OSTENFELD, 1926): *Carex rostrata*, achenes of which occur in samples back to 5,000 B.P.

As seen from the diagrams and the present vegetation in the investigated areas, *Carex nigra*, with a distribution confined to S. Greenland south of 61°20′N., is highly favoured by culture, but the finding of a perfectly preserved achene of this species with a nerved perigynium in a sample more than 7,000 years old proves that it spread into S. Greenland long ago. As discussed above (p. 25) this was also the case with *Juncus bufonius/ranarius*, but today its S. Greenland occurrences are bound to habitation, and considering its highly weedy character it is likely that the landnam people brought it in. It should be pointed out, however, that the sieve used for macrofossil samples in my 1973 paper was too coarse to retain *J. bufonius* seeds. *Montia* is another highly hemerophilous plant whose citizenship since deglaciation in S. and W. Greenland has been repeatedly proved. The present investigation does not throw light on the remaining "Norse plants", the introduction of which was not questioned by OSTENFELD (1926) and PORSILD (1932): *Anthoxanthum odoratum* ssp. *alpinum*, *Carex lyngbyei*, *Vicia cracca* and *Leontodon*, whose pollen is indistinguishable from other *Liguliflorae*. Findings of *Anthoxanthum* outside the Norse area in S. E. Greenland as far north as Skjoldungen (DEVOLD & SCHOLANDER, 1933) show its spontaneous occurrence in Greenland, as stressed by PEDERSEN (1972), who also considers *Carex lyngbyei* indigenous.

The S. Greenland sheep farmers today grow barley, rye and oats for hay or ensilage. According to the Norse saga, cereals were grown occasionally, but unsuccessfully. The finding of only one cereal pollen, viz. *Avena* in sample LM 7 (the determination kindly confirmed by dr. SVEND JØRGENSEN) proves the paucity.

Scandinavia, Faroe Islands and Iceland

The influence of agriculture on the original vegetation has been studied in other northern boreal-subarctic areas. HICKS (1975) reports from N. E. Finland that pollen of *Rumex acetosa* type (incl. *R. acetosella*) suddenly appears in the diagrams contemporarily with pollen of *Cerealea* and *Plantago lanceolata* at the landnam some centuries ago. *Rumex* pollen makes up 4–5 $^0/_0$ of the herb pollen. Prior to that, *Rumex* pollen was only found in two "late-glacial" samples. In another paper she mentions that *R. acetosa* as well as *R. acetosella* are introduced to the area and thus, together with i.a. *Vicia* type, are unambigous indicators of human interference (HICKS, 1976). By means of pollen influx diagrams the absolute, not only the relative increase in grass pollen is proved.

In Bjurselet, N. Sweden, KÖNIGSSON (1970) reports that one pollen of *Rumex acetosella* type and one of *Polygonum aviculare* (one *Rumex* pollen and none of *Polygonum* being found in earlier samples) occur contemporaneously with the first *Cerealea* pollen at the transition between the Neolithic and Bronze Age, but not until the Early Roman Iron Age habitation does *Rumex* pollen reappear, and then in great quantities. In several sites in Norrland, c. 200 km south of Bjurselet, HUTTUNEN & TOLONEN (1972) report similar events. They show that the first anthropochorous plants, including i.a. *Rumex* and *Polygonum aviculare*, occur with the first *Cerealea* in the middle of the Neolithic period. The real expansion phase, about A.D. 800–1000 is marked by a drastic increase in grasses, apophytes and anthropochores.

VORREN (1975) writes, that in Andøya, N. Norway, *Rumex acetosella*, *Achillea*, *Leontodon* and *Alchemilla alpina* together with some grasses which have spread from non-local communities are indicators of grazing. Among the local plants *Rumex acetosa*, *Ranunculus acris*, *Viola canina*, *Juniperus* and *Potentilla crantzii* are favoured, and this is confirmed by the pollen diagrams.

In a diagram from Tjørnuvik, Faroe Islands, JOHANSEN (1971) gives evidence for a Norse landnam c. A.D. 650. *Montia* appears contemporarily with *Cerelea*, *Rumex longifolius* and *R. obtusifolius*. *Rumex acetosa*, *Liguliflorae*, *Sedum*, and, as is usual, *Gramineae* increase. *Juniperus* decreases in accordance with the S. Greenland diagrams but contrary to the Scandinavian, where *Juniperus*, as demonstrated in many diagrams (e.g. BERGLUND, 1969), is considered an indicator of grazing.

In Iceland the Norse landnam is traceable in many diagrams (EINARSSON, 1961, 1962; VASARI, 1972 and BARTLEY, 1973). Common to all of these are an increase in *Gramineae*, *Caryophyllaceae* (presumably *Stellaria media* and *Cerastium caespitosum*, EINARSSON, 1963), *Rumex*, *Compositae*, *Ranunculaceae* and *Selaginella*, and a decrease in *Betula*, *Salix*, *Angelica* and *Dryopteris*. *Polygonum* cf. *aviculare* and *Cerealea* are introduced by the Norsemen. Unfortunately *Juniperus* pollen were not counted in EINARSSON's diagrams from the densely inhabited areas. ARI the WISE THORGILSSON says about A.D. 1120 that at the time of the landnam Iceland was covered by forest from the coast to the mountains (EINARSSON, 1963), but the pollen diagrams show that the birch forest was rapidly devastated, contemporarily with a sharp increase in aeolian sand deposited in the bogs due to soil deflation.

In the "Eastern settlement" in S. Greenland tree birches were locally almost extinct but after the termination of the Norse era they spread again, yet presumably not covering as great an area as earlier. Only exceptionally were the introduced annual weeds able to stand their ground up to the present landnam, whereas at least some of the perennial weeds were naturalized. The 1924 landnam had a similar effect on the vegetation as had the Norse landnam. Soil deflation, evident in many places in today's S. Greenland sheep districts, also shows up in some lake profiles. In the "Western settlement" at the head of Godthåbsfjord *Alnus*, *Salix* and *Betula nana* were cut down or burnt (IVERSEN, 1934, 1954), and *Gramineae*, *Rumex acetosella* (which is native in this part of Greenland) and other herbs were favoured.

The effect of the introduction of agriculture on the vegetation at Qagssiarssuk traced in the investigated transects thus agrees well with the results of similar investigations from the subarctic-lowarctic boundary around the Atlantic.

The sections investigated are far from ideal for palaeoclimatological investigations as the introduction of agriculture including irrigation per se causes such radical changes in local conditions, that the effect of any climatic change is easily hidden or at best difficult to discover. Because of this only a few comments will be given.

The fact that irrigation was used at Qagssiarssuk is indicated i.a. by the drainage of Galium Kær immediately or shortly after the landnam, and recently KROGH (1974) has demonstrated the presence of large-scale irrigation channels bordered by walls of sod and supplied from a big lake dammed at the river, at the Norse episcopal residence Igaliko 20 km south of Qagssiarssuk. Unfortunately they have not yet been radiocarbon dated and we do not know when, during the Norse era, they were built. The investigation in Comarum Mose, 2 km from Qagssiarssuk shows that the landnam occurred in a very dry period. After some time a moist period was again followed by a drier period, again succeeded by a moist period which saw the disappearance of the Norsemen. These oscillations in moisture conditions seem to parallel the variations in the same period, revealed in the O^{18} concentration, and thereby in the temperature in the Greenland icecore (DANSGAARD et al., 1975).

The last mentioned moist period is also traced in sections LM and QD. Here the concordant spreading of *Triglochin palustre* communities gives evidence of very moist conditions. This may indicate a climatic change either directly in terms of higher precipitation and/or lower temperatures and thereby a lower evaporation, or indirectly in the formation of a permafrost layer, caused by a decrease in the yearly average temperature. (The insolation effect of a 20–30 cm thick peat layer overlying a gravelly raised beach seems insufficient to cause the formation of a permafrost layer without a lowering of the temperature). DANIEL BRUUN, who excavated the Norse ruins at Qagssiarssuk in the first half of July, 1893, writes (translated from Danish): "In spite of the warm weather the soil was frozen soon after we had dug just a little. This was the case even on July 31, when we passed the locality again. Because of this the work was very laborious" (BRUUN, 1896, p. 186). Furthermore, the more widespread occurrence of permafrost in the past centuries is indicated by the well preserved Norse clothes found in the churchyard at Herjolfsnæs (59°59′N) (NÖRLUND, 1924).

Today permafrost does not occur at Qagssiarssuk and is only sporadically found in S. Greenland (WEIDICK, 1968). I have met it only once in S. Greenland, viz. in a small, deep *Sphagnum* bog surrounded by a tall birch "forest" at Amitsuarssuk (60°46′N.) but the coring of several bogs with up to 4 m of peat elsewhere in the area between Kap Farvel and Qagssiarssuk was not prevented by permafrost. The frozen ground a century ago can be considered a relict from the world-wide climatic deterioration which began at the end of the Norse era and culminated some centuries later during the "Little Ice Age" (LAMB, 1966).

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