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Age and stability of bird-manured vegetation on Spitsbergen

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SUMMARY

The peaty sediments from a bird cliff (north-west Spitsbergen) and two skua-mounds (central and east Spitsbergen) have been studied palynologically. Results show that (1) the vegetation on the bird cliff has been stable and peat-forming for at least the last 5 centuries, and (2) there has been a succession of various dominant plant species on one of the skua-mounds for more than 4000 years and on the other for *c.* 4500 years. Peat formation on these mounds has probably been interrupted several times.

Key-words: bird cliff, palynology, peat formation, vegetation.

INTRODUCTION

It is well known that in the Arctic region luxurious vegetation develops around bird cliffs and other sites that are manured by birds (Salomonsen 1979). This type of vegetation often induces peat formation: peat growth in such areas actually depends on manuring, since manuring favours plant growth and organic material decays slowly in the Arctic climate. Two types of peat are distinguished: peat formed around bird cliffs, and the peat that forms the so-called bird mounds in the territory of solitary birds. But, although it is generally accepted that these bird colonies and bird mounds can be stable over ages (Salomonsen mentions a few historical records of bird cliffs observed for several hundred years), little research has been done on the sediments to investigate the matter. In this paper, the age and stability of bird-manured vegetation are investigated by means of palynological studies of peat sections from the two types of peat on Spitsbergen.

DESCRIPTION OF SITES

Søre Salatberget bird cliff

The bird cliff Søre Salatberget (Fig. 1) is situated on the south coast of Amsterdamøya, north-west Spitsbergen, 4 km west of the famous 17th century Dutch whaling settlement of Smeerenburg (Hacquebord 1984). A first report on the palynology is given by van der Knaap (1985). The bird cliff houses a colony of Little Auks (*Plotus alle* L.) and other bird species on a south-exposed rocky slope right above the sea. The peat sections A, B and C were collected *c.* 40 m above the sea from a densely vegetated patch of about 1 × 2 m between the rocks. The vegetation layer and some of the uppermost sediment was removed in the field. The vegetation belongs to the Oxyrio-Cochlearietum, as described by Eurola & Hakala (1977). Nomenclature of vascular plants follows Rønning (1979).

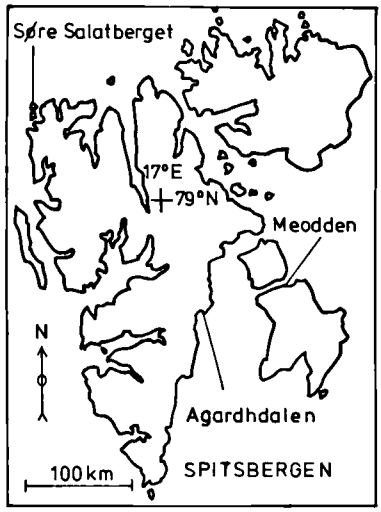

Fig. 1. The locations of the Søre Salatberget bird cliff and the Agardhdalen and Meodden skua-mounds on Spitsbergen.

Cochlearia officinalis, Saxifraga cernua and *Phippsia algida* are dominant, *Ranunculus pygmaeus, Poa arctica, Cerastium arcticum* and *Oxyria digyna* are frequent, *Saxifraga rivularis* and *Ranunculus sulphureus* are found occasionally.

Agardhdalen and Meodden skua-mounds

Skua-mounds are peat hummocks up to 70 cm high and 10 m across, which Arctic Skuas (*Stercorarius parasiticus* L.) use for resting or to survey their territory. The typical form is convex or somewhat flattened at the top, with sides that are concave only where they meet with the surrounding tundra.

The Agardhdalen skua-mound (Fig. 1) is situated on a wet coastal terrace *c.* 10 m a.s.l., 500 m from the sea in the south and 500 m from the foot of the hills in the north. It measures *c.* 2 × 3 m and is 50 cm high. The top is flattened and 1 m across, and the hummocky sides are steepest near the top and level out lower down. The peat section had to be collected from the side of the mound below the edge of the top because permafrost was present in the wet central part when the mound was visited on 13 August 1984. Vascular plants cover 10% of the top and include *Stellaria crassipes, Cochlearia officinalis, Ranunculus sulphureus* and *Poa arctica.* Additional species on the slopes of the mound are: *Salix polaris, Alopecurus alpinus* and *Saxifraga cernua.*

The Meodden skua-mound (Fig. 1) is situated on a dry coastal terrace *c.* 15 m a.s.l., 300 m from the sea in the north and 50 m from the foot of the hills in the south. It measures *c.* 3 × 5 m and is 40 cm high. It is built up of many small hummocks of *c.* 30 cm across, which are highest in the centre of the mound and decrease towards the periphery. The peat section was collected on 12th August 1984 from the highest hummock in the centre; the peat was then rather dry and unfrozen. The vegetation of the skua-mound is dominated by the grasses *Poa arctica* and *Alopecurus alpinus. Stellaria crassipes* and *Cochlearia officinalis* are abundant; additional species growing on the mound are *Saxifraga cernua, Cerastium arcticum, Ranunculus sulphureus, Salix polaris* and *Luzula arctica.*

Some fresh bird excrements were observed on top of both skua-mounds.

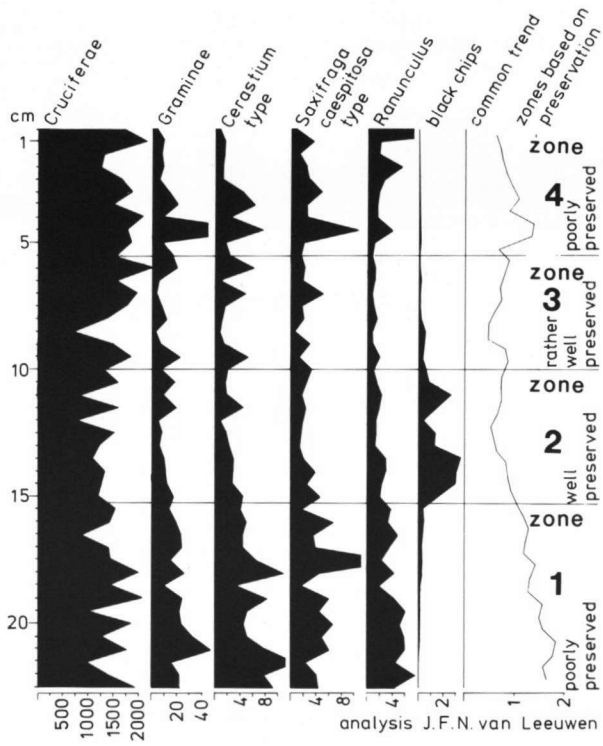

Fig. 2. Summary pollen diagram of the Søre Salatberget bird cliff, peat section C. Concentrations are numbers of grains in 1 mg dried sediment. Redrawn from van der Knaap (1985).

DIAGRAMS AND POLLEN TYPES

Pollen diagrams of the three peat sections from Søre Salatberget are presented in van der Knaap (1985). A summary diagram of one of the sections is presented in this paper (Fig. 2). The microscopic 'black chips' are presumed to be environmental pollution caused by the 17th century Dutch whalers of Smeerenburg. A common general trend can be observed in the curves of the five pollen types: high and low values of the curves coincide at many levels. This 'common trend' is presented in a separate curve in order to make it available for interpretation. The calculation procedure of the common-trend curve is given in van der Knaap (1985). Figure 3 gives the common-trend curves of the three peat sections.

The summary pollen diagrams of the Agardhdalen and Meodden skua-mounds (Figs 4 and 5) show percentage values for a few of the dominant pollen types only. Percentages are based on a pollen sum of local and regional types; long-distance types (i.e. pollen derived from outside Spitsbergen) are excluded.

The following discussion of pollen types and plant ecology forms the basis for the interpretation of the diagrams. The remarks on ecology are based on field observations by the author and on Eurola & Hakela (1977).

Cerastium type also includes *Stellaria* sp. *Cerastium arcticum* grows abundantly on moderately manured sites, *Stellaria crassipes* can also grow here but other species are unlikely to grow on manured sites.

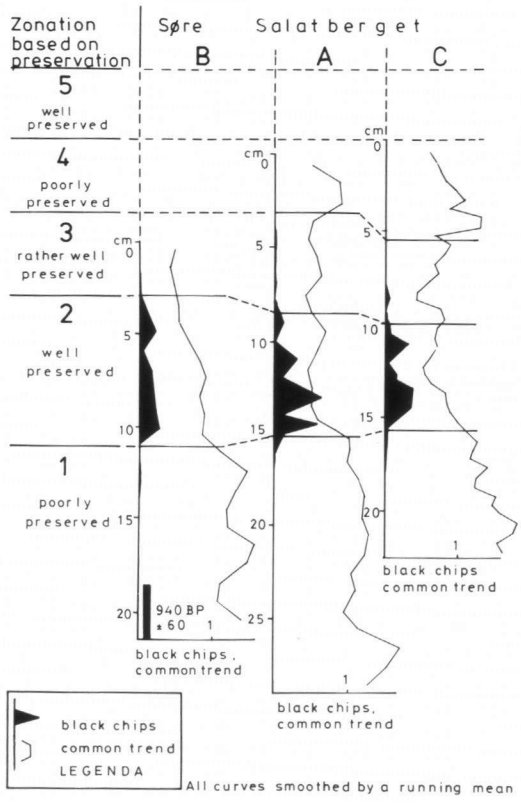

Fig. 3. Comparative diagram of the Søre Salatberget peat sections A, B and C. Redrawn from van der Knaap (1985).

Cruciferae pollen comprises many species but only *Cochlearia officinalis* on strongly manured sites has a high pollen production. Other Cruciferous species are not often encountered on manured sites.

Gramineae flower abundantly only on sites that are manured to varying degrees; most common species on these sites are *Poa arctica* and *Alopecurus alpinus*.

Saxifraga caespitosa type includes several species, of which *S. caespitosa*, *S. cernua* and *S. rivularis* are relevant here: these species become abundant under fairly strongly manured conditions.

Salix pollen most probably comes from *S. polaris* since other species are rare. *Salix* species tolerate moderate, but not strong, manuring.

Saxifraga oppositifolia type includes the very common *S. oppositifolia* and the rare *S. aizoides;* these species are rarely found on manured sites.

RESULTS

In the following discussion, years BP (before present) stand for radiocarbon years, and AD and BC indicate calendar years.

Søre Salatberget bird cliff

The three Søre Salatberget pollen diagrams have already been discussed in van der Knaap (1985). Relevant results are summarized here. (1) *Past vegetation:* it was concluded that

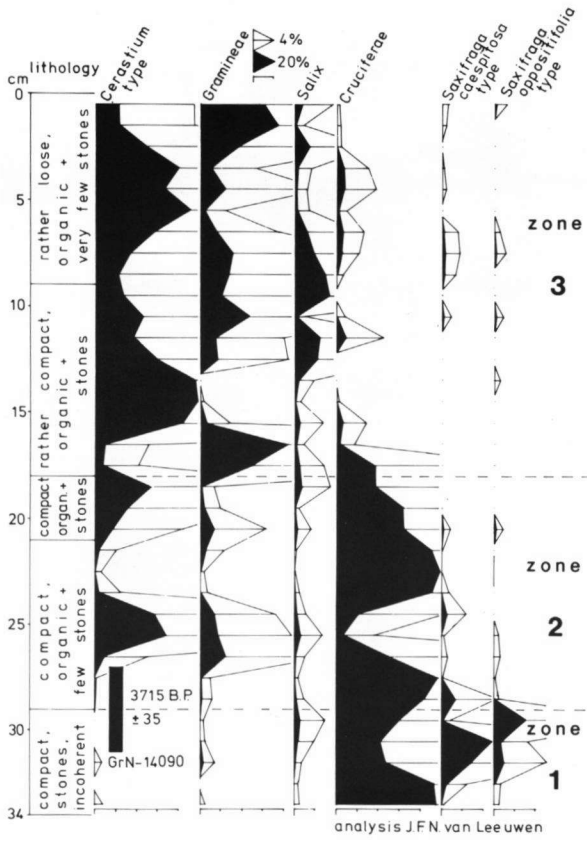

Fig. 4. Summary pollen diagram of the Agardhdalen skua-mound.

the past vegetation of the bird cliff was identical to the present and did not change during the period covered by the pollen diagrams. (2) *Chronology:* the common trends reproduced in Fig. 3 were presumed to reflect changes in the sedimentation rate, and indirectly a climatic change, and could therefore be used for chronological correlation. The transition from zones 1 to 2 was dated *c.* AD 1615, on the basis of the black chips and certain types of pollen brought to Spitsbergen by the Dutch whalers (these types are not included in Fig. 2). The middle of zone 2 was dated *c.* AD 1635, on the basis of correlation with a radiocarbon-dated level in a peat section from a site about 100 km to the south. The radiocarbon date in Søre Salatberget section B might be a few hundred years too old because an unknown part of the radiocarbon in the sediment has a marine origin. There are probably no time gaps in the record, but the most recent deposits are absent at the top of the sections. The chronology is discussed here more fully.

From historical sources we know that the Søre Salatberget bird cliff existed in AD 1633 (L'Honoré Naber 1930). In the journals (log-books) of two wintering parties on Amsterdamøya (1633–1934 and 1634–1935) it is mentioned that the winterers collected the Scurvy herb (*Cochlearia officinalis*) several times on Søre Salatberget and on another bird cliff at the northern coast of the island. The conversion of the radiocarbon date in Fig. 3 gives AD 1000–1190 (Stuiver & Becker 1986). The correlation of the common trend curves shows that the base of section A is older than the radiocarbon date. It is therefore

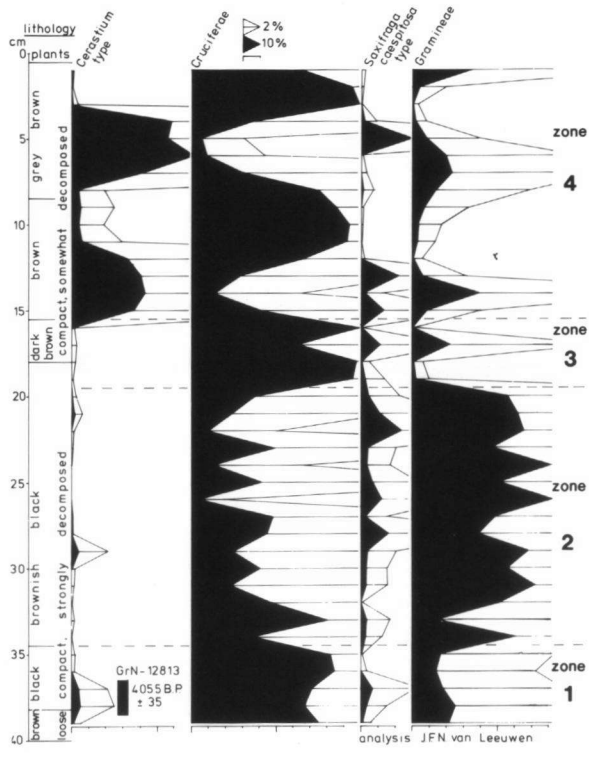

Fig. 5. Summary pollen diagram of the Meodden skua-mound.

concluded that the cliff was used by birds for several hundred years before the whalers arrived in AD 1614. The top of zone 5 is missing, probably not because the sediment has not been formed but because some material has been removed in the field. The bird cliff is still populated by Little Auks and other birds, and there has probably been uninterrupted habitation during the period from the beginning of the diagrams in Fig. 3 up to now. It is concluded that (1) the bird cliff Søre Salatberget has most probably been continuously inhabited by birds for the last 5 centuries, and (2) the bird-cliff vegetation has been constant throughout this period.

Agardhdalen skua-mound

The conversion of the radiocarbon date from the Agardhalen skua-mound (Fig. 4) into calendar years gives 2040–2200 BC (Stuiver & Becker 1986). The flattened top and the steep sides of the upper part of the skua-mound suggest that peat accumulation has ceased and that some erosion has taken place. Therefore, there is probably a time gap in the record at the top of the section. The reconstructed vegetation history on the skua-mound is as follows:

Zone 1. Cochlearia officinalis is dominant; this points to strong manuring of the site. Conversely, the former presence of *Saxifraga oppositifolia* points to a low nutrient level. The lithology points to a soil, and not to peat as in zones 2 and 3. Moreover, the section was taken from the side of the skua-mound. This leads to the following reconstruction: Zone 1 represents the only slightly manured soil with tundra vegetation (including

Saxifraga oppositifolia and *S.* vs. *caespitosa*) next to a manured skua-mound with abundant *Cochlearia officinalis.*

Zone 2. This represents the young and strongly manured skua-mound with abundant *Cochlearia officinalis,* together with some grasses and *Cerastium arcticum* and/or *Stellaria crassipes* in varying quantities.

Zone 3. Cerastium arcticum and/or *Stellaria crassipes* and grasses become abundant, and *Cochlearia officinalis* nearly disappears. This points to less manuring; the use of the skua-mound by Arctic Skuas probably decreased at the transition from zones 2 to 3.

The diagram (Fig. 4) shows fluctuations of the dominant pollen types within the zones. The spectra around 25 cm in zone 2 show the dominance of *Cerastium* type and Gramineae over Cruciferae, and are therefore similar to spectra in zone 3. Alternating dominance of *Cerastium* type and Gramineae is observed in zone 3. These fluctuations suggest fluctuations in the dominant vascular-plant species and therefore point to fluctuating intensities of manuring by birds. Periods of very low manuring have possibly given rise to time gaps in the record (due to stagnation of peat growth), since peat formation on Spitsbergen depends largely on manuring. However, these gaps have not been traced.

In 1969 de Korte (1972) observed on the northern coast of Edgeøya (where Meodden is situated) that the breeding frequency of Arctic Skuas was lower along coasts where sea-ice is late in spring. The lower level of manuring in zone 3 is therefore a possible indication of late sea-ice, and indirectly of a cooler climate.

Meodden skua-mound

The conversion of the radiocarbon date from the Meodden skua-mound (Fig. 5) gives 2500–2650 BC (Pearson *et al.* 1986). The hummocky appearance of the skua-mound suggests that peat accumulation has ceased and erosion has taken place. Therefore there is probably a time gap in the record at the top of the section. The reconstructed vegetation history of the skua-mound is as follows:

Zone 1. This represents the initial phase of the skua-mound. *Cochlearia officinalis* and grasses are the dominant plant species, pointing to strong manuring.

Zone 2. Grasses are dominant. The importance of *Cochlearia officinalis* decreases and that of *Saxifraga caespitosa* and/or *cernua* increases. Manuring is strong, as in zone 1. The shift in the abundance of plants is possibly caused by gradual desiccation of the surface, which was connected with the elevation of the mound summit during peat growth.

Zone 3. Grasses are less important and *Cochlearia officinalis* becomes dominant, which points to strong manuring as before. The degree of peat decomposition drops abruptly. This can be explained by a cooling of the climate, which prevented the decomposition of plant material.

Zone 4. The appearance of *Cerastium arcticum* and/or *Stellaria crassipes* points to less strong manuring. The alternating dominance of these plants with *Cochlearia officinalis* points to fluctuating manuring. Time gaps in the records may well be present in periods with very low manuring.

Comparison of skua-mounds

The Agardhdalen and Meodden skua-mounds differ in their morphology, in the presence of permafrost, in past vegetation dominants, and in the past intensity of manuring. In spite of this, several similar trends are observed:

(1) fluctuating abundance of dominant plant species, interpreted in terms of fluctuating manuring intensities;
(2) a presumed time gap in the record at the top of both sections, and the possibility of additional gaps;
(3) a presumed cooling of the climate, recorded at about the middle of the two sections.

These events are not dated and need not be synchronous. A well-known general cooling on the northern hemisphere that falls within the studied period happened at the beginning of the Subatlantic period, *c.* 2400 BP.

DISCUSSION

The vegetation of the studied bird cliff has been constant over the last 5 centuries at least, but there have been frequent successions of dominant plant species on the studied skua-mounds. Periods of stagnation of peat growth are suspected in the skua-mounds, but not on the bird cliff. It is concluded that the constancy of vegetation and peat formation was greater on the bird cliff than on the skua-mounds. This could be expected because a bird cliff is a large system and is therefore better buffered against environmental changes than the small system of a skua-mound.

The bird cliff is at least 500 years old. One skua-mound is more than 4000 years old, the other is *c.* 4500 years old. The conclusion is that both types of high Arctic ecosystems are very stable, in spite of the high degree of environmental stress and the dependence of peat formation on manuring by birds.

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