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Vegetation Pattern and Ecology of Siliceous Boulder Snow Beds on Svalbard

By Arve Elvebakk*

Summary: The vegetation pattern of siliceous boulder snow beds (*Dicranoweision crispulae* all. nov. prov.) of Svalbard was investigated by using transect studies in several places on Spitsbergen. *Dicranoweisia crispula* is the best diagnostic species. It is found throughout the whole snow bed, is a good differential species against *Racomitrium lanuginosum* communities above the snow bed, and does not occur on basic rocks.
Three *Andreaea* spp. are also among the most important members of these communities. They are all acidophilous, but with different pH preferences. Eight weakly acidophilous species lacking both on basic and on gneissic/granitic rocks, are reported from Svalbard. Half of these are characteristic species of *Dicranoweision crispulae* on Svalbard.

Zusammenfassung: Die Vegetationsverhältnisse auf steinigen Silikat-Schneeböden (*Dicranoweision crispulae* all. nov. prov.) wurden an mehreren Orten Spitzbergens mit Hilfe von Vegetationstransekten untersucht. *Dicranoweisia crispula* ist die beste diagnostische Art: man findet sie im gesamten Schneebodenbereich, sie ist eine gut geeignete Trennart gegen die *Racomitrium lanuginosum*-Gesellschaften oberhalb der Schneeböden und kommt nicht auf alkalischen Steinböden vor.
Unter den wichtigsten Mitgliedern dieser Pflanzengesellschaft befinden sich zudem drei Andreaea-Arten. Sie sind sämtlich acidophil, wenn auch mit unterschiedlichen pH-Wert-Amplituden. Acht leicht acidophile Arten, die weder auf alkalischen noch auf Gneis-/Granitböden vorkommen, werden außerdem beschrieben. Die Hälfte dieser Arten ist charakteristisch für *Dicranoweision crispulae* auf Spitzbergen.

INTRODUCTION

Large areas of the Arctic are characterized by the prevalence of stones and boulders with only small areas of fine-textured soils. This is especially the case within the arctic polar desert zone. It is also characteristic of boulder slopes, certain snowbeds and alpine areas further to the south. Considering how important these areas are in the Arctic, they have received remarkably little botanical attention.

The present author worked in Spitsbergen, the major island of the Svalbard archipelago during the summers of 1975—1976 as a member of an expedition from the University of Trondheim/The Norwegian MAB (Man and the Biosphere) Programme. In 1979—1981 the author joined botanical expeditions from the University of Tromsø, Institute of Biology and Geology, to different parts of Spitsbergen.

During these expeditions vegetation studies (ELVEBAKK, 1979, 1981, 1985), studies on geological preferences (ELVEBAKK, 1980, 1982) and studies on the ecology and flora of lichens (ELVEBAKK, 1984) were made.

The present study was made mainly on the 1979—1981 expeditions. A synthesis of this is given below.

As to nomenclature the following works have been followed, HAWKSWORTH et al. (1981) (lichens), with some minor exceptions, DUELL (1983) (hepatics) and CORLEY et al. (1981) (mosses).

ANDREAEA SPECIES ON SVALBARD

A study of the boulder snow beds of Svalbard immediately reveals that the vegetation and flora on limestone and siliceous rocks are entirely different. The most striking aspect of the former is the dominance of *Schistidium* spp. The latter are first and foremost characterized by *Dicranoweisia crispula* and *Andreaea* spp.

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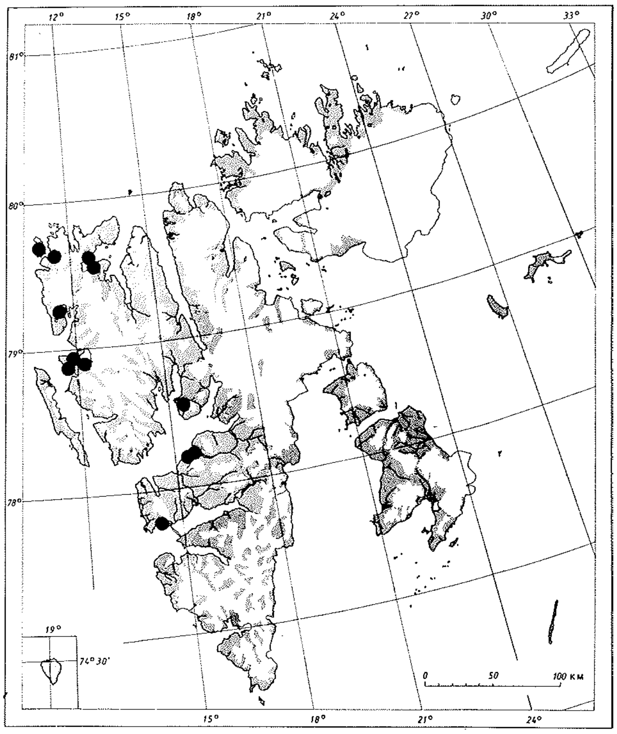


Fig. 1: Distribution of *Andreaea obovata* on Svalbard.

Abb. 1: Verbreitung von *Andreaea obovata* auf Svalbard.

At least three *Andreaea* species are known from Svalbard. According to BERGGREN (1875), KUC (1973), and FRISVOLL (pers. comm.) *A. rupestris* spp. *papillosa* C. Jens. is by far the most common of these. This taxon has partly been regarded as a proper species, *A. papillosa* Lind. (BERGGREN, 1875; FRISVOLL et al., 1984), partly as a subspecies of *A. obovata* (NYHOLM, 1969), and partly as *A. rupestris* ssp. *papillosa* C. Jens. In this paper *A. rupestris* is treated collectively, but a taxonomic treatment of the northern taxa within this genus is greatly in need.

Andreaea obovata has been considered to be a "very rare" moss on Svalbard (KUC, 1973) with only three known localities from the northwestern part of Spitsbergen originating from LINDBERG (1867) and BERGGREN (1875). However, it was found scattered in most places visited by our expeditions, and seven other localities recorded by the author and two localities (Signehamna and Bjørndalen) recorded by A. A. FRISVOLL are shown in Fig. 1. Consequently *A. obovata* should not be regarded as a very rare species on Svalbard anymore.

Andreaea blyttii was considered as "rare" by KUC (1973) who documented seven localities. Two of these were sterile collections from Hornsund reported by KUC (1973), one on a nunatak, and one on a mountain 700 m a. s. l., both in rock crevices. The other localities were on the northwestern part of Spitsbergen and on northern Nordaustlandet. The species has also been recorded on Bjørnøya (BERGGREN, 1875). Three more localities have since been found by FRISVOLL (pers. comm.). One was on a siliceous summit near Ny-Ålesund, the others on the siliceous mountains Smørstabben and Trolltindane (1100 m a. s. l.) near Bockfjorden. In 1981 ELVEBAKK and SPJELKAVIK found *A. blyttii* on two mountains on the southern side of Liefdefjorden. In my opinion *A. blyttii* should still be regarded as a rare species on Svalbard, except in granitic areas where it is possibly more common, Fig. 2.

Very little has been published concerning the ecology of the *Andreaea* spp. on Svalbard except for the

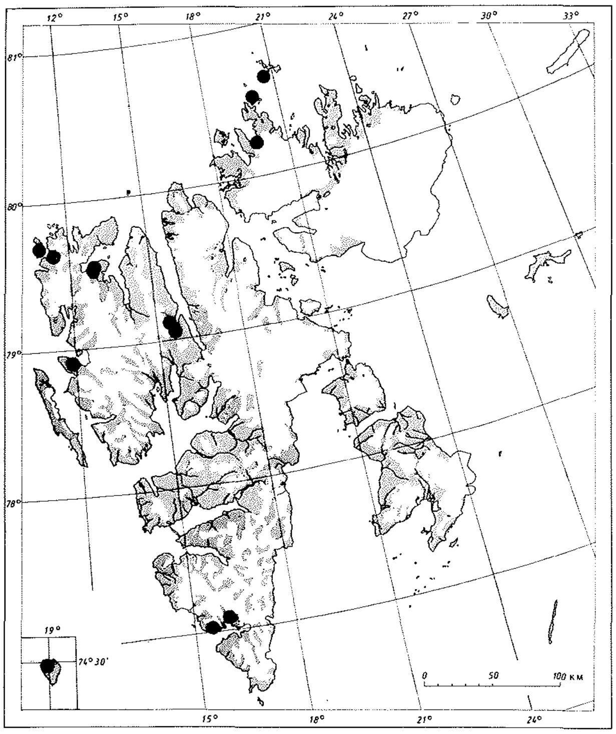


Fig. 2: Distribution of *Andreaea blyttii* on Svalbard.

Abb. 2: Verbreitung von *Andreaea blyttii* auf Svalbard.

classical work by BERGGREN (1875), where their acidophilous nature was underlined („Nicht auf Schieferboden noch weniger auf Kalk gefunden, . . .''). All species were found on stones and soils temporarily covered by mud. Only *A. blyttii* was stated as being found on rocks with a long-lasting snow cover, and only rarely together with other mosses (*Dicranoweisia crispula, Grimmia incurva*) and hepatics.

Plot no.	1	—	—	—	—	5	—	—	—	—	11
Slope (°)	10	15	30	30	20	15	15	10	10	10	15
Various cryptogams	5	5	1	2	5	10	20	20	20	20	20
Stellaria crassipes	20										
Luzula arcuata ssp. confusa	2										
Poa arctica	5										
Cladonia uncialis	3	3	3	1	1						
Cetraria nivalis	1	1	1	1	1	1		1			
Racomitrium lanuginosum	90	90	95	95	80	20	2	1			
Cladonia rangiferina		3	2	1	1						
Cetraria cucullata		1	1	1	1			1			
Cladonia mitis				1	3	7	1				
Cetraria hepatizon						2					
Parmelia sorediosa						1	1				
Sphaerophorus fragilis							1				
Umbilicaria cylindrica						1	1	1	1		·
Andreaea rupestris						10	10	7	5	5	20
Dicranoweisia crispula						2	3	5	10	10	7
Stereocaulon alpinum	1	1	1	1	1	1	3	10	3	2	2
Cladonia chlorophaea									1	1	
Vestergrenopsis elaeina											1

Tab. 1: Distribution of important species along a topographical transect in a siliceous boulder talus near Vårsolbukta, Bellsund.

Tab. 1: Verbreitung wichtiger Arten entlang eines Transekts in einer Silikat-Schutthalde nahe Vårsolbukta, Bellsund.

TRANSECT STUDIES

To study the ecology of characteristic snow bed species, transects were laid out in several places on Spitsbergen.

Tab. 1 shows a gradient analysed in 1980 at Vårsolbukta, Bellsund, western Spitsbergen. The transect was in a SW-faced dolerite boulder talus. Each plot measured 1x1 m. To concentrate on the most important species a number of lichens, mosses, and hepatics are treated collectively as 'various cryptogams'.

This locality was interesting for several reasons. The siliceous dolerite bordered on a limestone area with a similar topography. *Racomitrium lanuginosum, Andreaea rupestris,* and *Dicranoweisia crispula* were totally lacking there.

Generally the dolerite slope was covered with a more or less continuous cover of *Racomitrium lanuginosum.* However, the transect run along the side of a depression. Tab. 1 shows that five species are positively correlated with *R. lanuginosum:*

Cladonia uncialis
Cetraria nivalis
Cladonia rangiferina
Cetraria cucullata
Cladonia mitis

Slightly different correlations between these species could be observed. The *Racomitrium lanuginosum* carpet disappeared abruptly, and just as abruptly an increase in *Andreaea rupestris* and *Dicranoweisia crispula* in particular was observed. Other species included *Umbilicaria cylindrica* and *Stereocaulon alpinum,* the latter increasing in frequency.

The distributions of *Andreaea rupestris* and *Dicranoweisia crispula* were not totally sympatric, and an

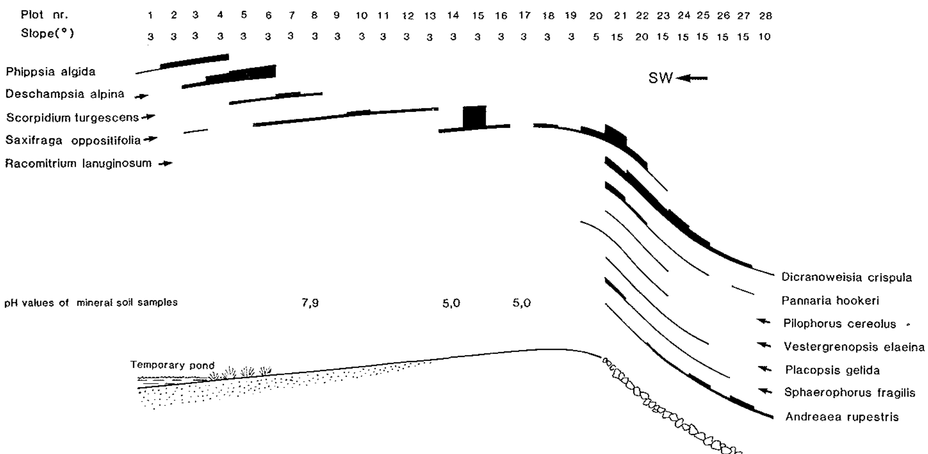


Fig. 3: Distribution of important species along a topographical transect near Ny-Ålesund.

Abb. 3: Verbreitung von wichtigen Arten entlang eines topographischen Transekts nahe Ny-Ålesund.

optimum of *D. crispula* was observed in the middle of the *A. rupestris* belt. As can be seen from the top of the table, however, the gradient was more moderate in the *D. crispula* section than in the neighbouring optimal *A. rupestris* areas. This indicates that snow lay longer over *A. rupestris.*

Fig. 3 illustrates a transect analysed near Ny-Ålesund. Although 28 plots (1x1 m) were analysed, only a small selection of the most interesting species is presented here. Some other species are included by ELVEBAKK (1980).

Most of the areas near Ny-Ålesund were limestone outcrops or limestone deposits. The SW part of the transect is typical of these substrates. First a *Phippsia algida,* then a *Deschampsia alpina* community were found along the margins of a temporary pond. After a transitional belt characterized by *Scorpidium turgescens* there was a moderate snowbed with *Saxifraga oppositifolia, Luzula arctica,* and *Cetraria delisei* belonging to the alliance *Luzulion arcticae* (Nordh. 1936) Gjærevoll 1952. This is the zonal vegetation of the area. pH values of the mineral soil of this section were 7.5.

The lower NE part of the transect was entirely different. It was composed of Tertiary sandstone with pH values in mineral soils of 5.0. The lichen and bryophyte flora in particular was almost totally different compared to the limestone area. *Cassiope tetragona* and *Racomitrium lanuginosum* grew along a very characteristic intermediate belt between the moderate snow bed and the ridge, and *Gymnomitrium corallioides* was typical of the ridge.

The boulder snow bed had a characteristic set of species dominated by *Dicranoweisia crispula* and *Andreaea rupestris.* It should be underlined that the ranges of these two species are not identical.

Some very interesting lichens were also found in this part of the transect:

Sphaerophorus fragilis
Placopsis gelida
Pannaria hookeri
Vestergrenopsis elaeina
Vestergrenopsis isidiata
Pilophorus cereolus

Most of these are regarded as rare on Svalbard. They seem to have a close preference for boulder snow bed communities primarily characterized by *Dicranoweisia crispula.*

Near Longyearbyen, Tertiary sandstones are among the most important bedrock types. A transect at Sverdruphammaren was briefly described by ELVEBAKK (1980). A survey of other boulder snow beds in the area confirmed the topographical preferences studied in the transect. An idealized distribution of the four most important species is shown in Fig. 4.

It should be noted that the distributions of *Racomitrium lanuginosum* and *Dicranoweisia crispula* were

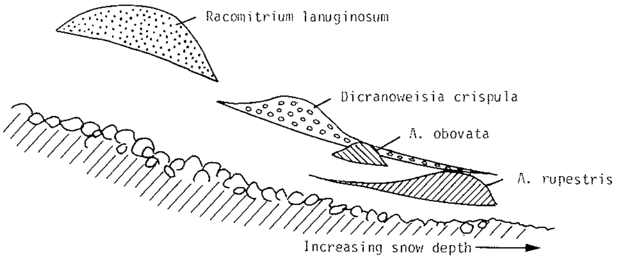


Fig. 4: Idealized distribution of four important species in siliceous boulder snow beds at Sverdruphammaren near Longyearbyen.

Abb. 4: Idealisierte Verbreitung von vier wichtigen Arten in Silikat-Schneeböden bei Sverdruphammaren nahe Longyearbyen.

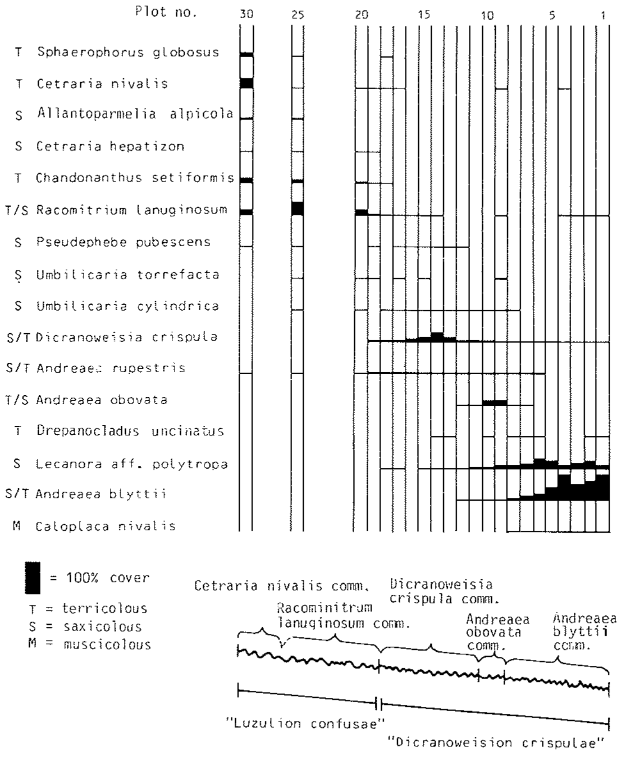
totally allopatric. Furthermore, the two *Andreaea* species had different topographical preferences, but both lay within the range of *Dicranoweisia crispula.* It is also important to note that there was an extreme zone in the lowermost part of the snowbed where *Andreaea rupestris* was absent. A species of the *Lecanora polytropa* complex was the most conspicuous lichen in this desolate zone.

Finally, a snow bed transect was analysed near one of the summits of the Keisar Wilhelm-høgdene mountains on the southern side of Liefdefjorden on northern Spitsbergen, 460 m a. s. l. This snow bed was situated in a migmatite area with pelitic schists (GJELSVIK, 1979). The snow bed area was dominated by rocks with about 20% boulders and very little finely grained soil. 22 plots (25x100 cm, the short side in the transect direction) were analysed in a 10—15° slope facing northwards (Fig. 5).

Tab. 2 shows the distribution of most of the important species in this transect. Plot no. 30 represents a medium exposed ridge with 20% cover of *Cetraria nivalis.* A ridge with a more extreme expostion a short distance away was characterized by a greater cover of *Sphaerophorus globosus* and less *Cetraria nivalis.* Plots 25—20 represented an intermediate ridge — snow bed section dominated by *Racomitrium lanuginosum* and a high percentage of cover of *Chandonanthus setiformis.*

A few records of *Cetraria nivalis* and *Racomitrium lanuginosum* in the extreme part of the snow bed were due to small segments of plants being transported by wind and surviving for a certain period. Most of these specimens measured less than 1 cm.

Umbilicaria cylindrica seemed to be a typical species of the moderate snow bed and a good differential species against extreme snow bed communities.



Tab. 2: Distribution of important species and communities along a topographical transect in a snow bed at the Keisar Wilhelm-høgdene mountains.

Tab. 2: Verbreitung wichtiger Arten und Gesellschaften entlang eines Transekts auf einem Schneeboden im Keisar Wilhelm-høgdene-Gebirge.

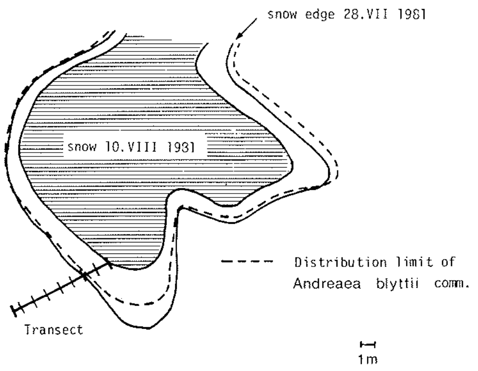


Fig. 5: Snow patch pattern on July 28 and August 10 and the position of the transect within the snow bed.

Abb. 5: Schneeflecken-Muster am 28. Juli und 10. August sowie Lage des Transekts im Schneeboden.6

The relationship between *Racomitrium lanuginosum, Dicranoweisia crispula, Andreaea rupestris,* and *Andreaea obovata* was largely the same as in the transect area near Longyearbyen. *Andreaea rupestris,* however, had no distinct optimal zone. A remarkable *Andreaea blyttii* zone was found in the most extreme part of the snow bed. *Andreaea blyttii* was closely correlated with *Lecanora polytropa* s. ampl. This is an interesting parallel to the most extreme section of the transect near Longyearbyen characterized by this lichen and by the absence of *Andreaea rupestris. Andreaea blyttii* was found abundantly fertile with a cover of up to 80%. It was heavily attacked by the muscicolous lichen *Caloplaca nivalis* (ELVEBAKK, 1984).

The snow bed was first visited on July 28th. A marginal zone of the *Andreaea blyttii* community not more than 1 m broad had appeared on the SW side of the snowpatch (Fig. 5). A few specimens of *A. blyttii* were visible on the SE side.

A couple days later there was a snow fall. At these altitudes this snow persisted for 4—5 days. The snow bed was again visited on Aug. 10th. when another 1—2.5 m broad zone of the *A. blyttii* community had melted on all sides of the snowpatch.

Fig. 5 shows that there was a certain lack of correlation between the location of the snowpatch and the *A. blyttii* community. ELVEBAKK (1979) observed a considerable difference from one year to another both as to the location of snowpatches and their date of melting. The distribution of an extremely snow-dependent community such as that of *A. blyttii* certainly indicates the general snowpatch distribution. The snow pattern in 1981 was anomalous, probably due to over-representation of SE winds.

Andreaea blyttii shows a preference for extreme habitats in three ways. It is an exclusive alpine species in Fennoscandia. Even in Svalbard it prefers mountains except in the north, e. g. the polar desert zone of Nordaustlandet. This pattern is shared with few other species.

Its extreme snow bed preference is also remarkable.

Aug. 10th. is generally not more than two weeks before a new winter snow cover is established at these altitudes while some parts of the *A. blyttii* community were still covered by snow. Consequently its growing season is extremely short although with a considerable annual variation.

It should, however, be stressed that climatic conditions might be favourable even at these altitudes. On Aug. 10th. a temperature of 7.8 °C was recorded and there was no wind. Being black and having a pulvinate growth form the moss is able to absorb a lot of energy. Its main threat is probably desiccation over some period. Longlasting snow cover, melting water, temporary snow falls, low temperatures, and

Nr.	Rock type	Geological epoch	Average pH
1.	Limestone marble	Hecla Hock/Carboniferous	7.61
2.	Red sandstone	Devonian	7.55
3.	Dolomite	Pre-Cambrian — Silurian (HH)	7.30
4.	Limestone with shale	Triassic or Permian	6.95
5.	Marble conglomerate	Devonian	6.94
6.	Basalt with dunite	Quarternary	6.88
7.	Chert with limestone	Upper Carboniferous/Permian	
8.	Green schist	Caledonized gabbroic intursion	6.81
9.	Mica schist	Pre-Cambrian — Silurian (HH)	6.74
10.	Grey sandstone	Triassic	6.55
11.	Dolomite with quartzite	Pre-Cambrian — Silurian (HH)	6.40
12.	Grey sandstone	Siktefjellet group. Devonian?	6.31
13.	Sandstone with dolomitic cement	Upper Carboniferous/Permian	6.30
14.	Grey sandstone	Devonian	6.17
15.	Dolerite	Intrusion. Probably Lower Cretaceous	6.13
16.	Chert	Permian	6.08
17.	Sandstone	Cretaceous	5.90
18.	Sandstone	Tertiary	5.87
19.	Shale with sandstone	Jurassic	5.75
20.	Green schist with phyllite	Instrusion	5.75
21.	Gneiss (with some deposits)	Pre-Cambrian — Silurian (HH)	5.55
22.	Quartzitic conglomerate	Devonian	5.55
23.	Pellitic schist (with some deposits)	Pre-Cambrian — Silurian (HH)	5.46
24.	Quartzitic siltstone	Permian	5.45
25.	Quartzitic sandstone	Culm	4.85
26.	Pellitic schist	Pre-Cambrian — Silurian (HH)	4.79

Tab. 3: Different rock types included in the study of geological preferences with mean pH values of their mineral soils.

Tab. 3: In der Untersuchung der geologischen Präferenzen berücksichtigte Gesteinsarten mit mittleren pH-Werten ihrer Mineralböden.

clouds prevailing at these altitudes are thought to be the main ecological factors preventing drought in an area with otherwise little precipitation.

GEOLOGICAL PREFERENCES

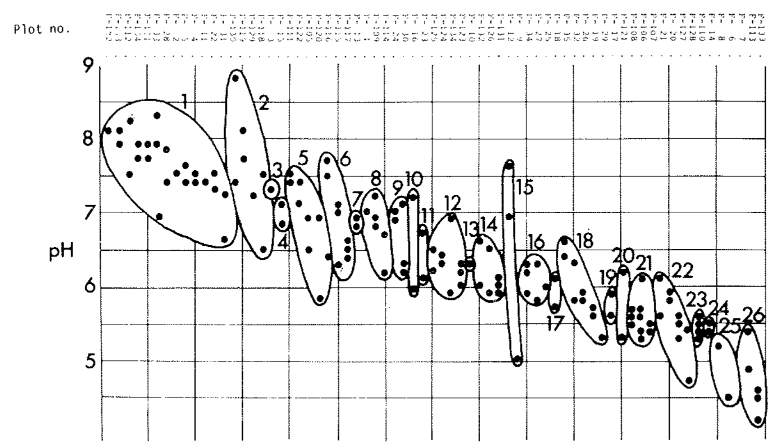
ELVEBAKK's (1982) study on geological preferences among Svalbard plants was based upon analyses from 35 plots (25x100 m). Later another 34 plots (F-101 to F-134) were analysed in the Liefdefjorden — Bockfjorden area using the same methods.

Tab. 3 lists all the rock types that have been included in the study and the pH values of their corresponding mineral soil.

Tab. 4 shows the distribution of selected species according to the pH values of the different soils. Their degree of occurence, field methods, and preference groups are described by ELVEBAKK (1982). The list of species includes a key species characteristic of each preference group in addition to species of particular interest to the present study.

None of the important siliceous snow bed species discussed here show a pattern similar to that of the basophilous *Fulgensia bracteata,* the circumneutral *Dryas octopetala,* or the indifferent *Salix polaris.* Although not being a snow bed species, *Racomitrium lanuginosum,* shares a preferentially acidophilous preference with *Luzula arcuata* spp. *confusa.*

The group of weakly acidophilous species contains four siliceous boulder snow bed species, *Placopsis gelida, Pannaria hookeri, Vestergrenopsis elaeina,* and *V. isidiata.* The latter two are treated collectively in Tab. 4. These were the only species included in this preference group by ELVEBAKK (1982). With the present additional data another four species (*Psora rubiformis, Peltigera lepidophora, Racomitrium ericoides,* and *Neuropogon sulphureus)* are classified as weakly acidophilous species. These eight species are



BASOPHILOUS SPECIES	
Fulgensia bracteata	33343313 3 3333333333 3 1
CIRCUMNEUTRAL SPECIES	
Dryas octopetala	55555555555555555554555554 5555 254454 545534143141 4 43 1 3
INDIFFERENT SPECIES	
Salix polaris	53453554435354535455453334545554545445555455554 55545 5454545545554445
PREFERENTIALLY ACIDOPHILOUS SPP.	
Luzula arcuata ssp.confusa	3 2 1 333 43335333335 344354535555555455554555545555555554
Racomitrium lanuginosum	2 233 2 1 5233253343553354354345555555554545555555 5555555
WEAKLY ACIDOPHILOUS SPECIES	
Psora rubiformis	41 23 22
Peltigera lepidophora	2 32 31 2 311 1
Racomitrium ericoides	34 2 3 3434 3 343433254433 33 4 434 33 4
Neuropogon sulphureus	433 X 3
Placopsis gelida	3 3 33 3 2 31 233
Vestergrenopsis spp.	3 3 1122 2233 2 331 1 211 3 1 22 1
Pannaria hookeri	44 3233 2 3 312233334 3 3
WIDELY ACIDOPHILOUS SPECIES	
Cetraria hepatizon	22 33432332 424433443354 2444343333323432233354433
Dicranoweisia crispula	3 53333 344433444433354354 334444 345 34334233333
Andreaea rupestris	3 53532 333 33 34433443544344441344333335433443
Sphaerophorus fragilis	1 1 2 2333222223 33342333333323 333243333 433 2
DISTINCTLY ACIDOPHILOUS SPP.	
Cladonia mitis	54 4 5 3355 3345243 443552 455 512
Andreaea obovata	2 1 1 3 55 355 1 3 331 353 3
EXTREMELY ACIDOPHILOUS SPECIES	
Pleurozium schreberi	555
Andreaea blyttii	X

Tab. 4: Distribution of selected species of preference groups according to pH values of mineral soils of different rock types.

Tab. 4: Verbreitung ausgewählter Arten nach pH-Werten der Mineralböden der verschiedenen Gesteinsarten.

particularly interesting as they avoid both limestone rocks/soils and extreme siliceous rocks/soils. It is also interesting that four of these often grow together in siliceous boulder snow beds.

The two most dominant species of these snow beds (*Dicranoweisia crispula* and *Andreaea rupestris*) are classified as widely acidophilous species. Because there is an abrupt decline in the occurence of these species when pH 7.0 is approached (Tab. 4), they are very good diagnostic species separating the acidophilous boulder snow bed communities from those on limestone. *Sphaerophorus fragilis* has the same pH range.

The other two *Andreaea* species, however, have different pH preferences. *Andreaea obovata* is concentrated below pH 6.2 with only a few occurences with low values within the 6.2—7.0 range. It is classified as a distinctly acidophilous species.

Andreaea blyttii was not represented in the lowland plots analysed in the preference studies. Both collections from Liefdefjorden, however, were found on a mountain not far from lowland plots with the same rock type and are therefore included in Tab. 4 under this rock type (pelitic schist). The two Frisvoll collections from the Bockfjorden area are also from the same rock type (GJELSVIK, 1979). This is a hard, acidic rock with a mean mineral soil pH of 4.8 (ELVEBAKK, 1982).

This extremely acidophilous tendency is confirmed also by the early records. All the five collections from northern Svalbard are from the relatively small granitic areas in the northwest (Kobbefjorden and Smeerenburgfjorden) and in the northeast (Parryøya, Nordkapp and Brennevinsfjorden). The remaining four localities from Svalbard are also from siliceous rocks, and *A. blyttii* is classified as an extremely acidophilous plant.

The conclusion is that the *Andreaea* species are acidophilous on Svalbard, but to different degrees.

CLASSIFICATION

A phytosociological classification of boulder snow beds presents some problems. The first is related to succession. Crustose lichens are overgrown by foliose lichens and mosses, mostly with pulvinate growth forms. As these pulvinate mosses grow, a small humic layer is produced. When these mosses attain a certain size, mineral soil is often deposited on their lower surfaces. A rich cryptogamic flora is then established on these pulvinate mosses, but only a small number of them are obligately musicolous. Most of them are also found in small rock fissures or on humic and mineral soil. These changes are cyclic. When too much humus and mineral soil is deposited, the pulvinate mosses loosen and die.

This system should be regarded as one community, as a thick humic layer with a different set of species is not established. Almost all species of this community are able to grow on rock surfaces (some obligately), on very thin layers of humus or mineral soil or on bryophytes and lichens.

There is, however, a certain mosaic pattern of communities. Small spots of wet soil beneath the boulders are often characterized by *Drepanocladus uncinatus, Saxifraga* spp., and *Poa* spp. These should be classified separately as fragments of totally different communities. Under overhanging surfaces separate communities characterized by *Acarospora chlorophana* and other crustose lichens can also be found.

In the most moderate parts of the snow bed successions lead to thick humic layers with mosses, fruticose lichens and sometimes vascular plants. These carpets should not be classified within the *Dicranoweisia crispula/Andreaea* communities.

In stable siliceous boulder areas, however, this transition area is rather small. Most often there is an abrupt change from the *Dicranoweisia* - *Andreaea* snow bed to a *Racomitrium lanuginosum* dominated community.

Svalbard communities with *Racomitrium lanuginosum* have been classified as *Racomitrio lanuginosi — Luzuletum arcuatae* belonging to *Luzulion arcuatae* (ELVEBAKK, 1985).

Consequently the *Dicranoweisia — Andreaea* snow beds are well defined both as to topography and rock chemistry.

Phytosociologically these snow beds on Svalbard have a large number of characteristic species on alliance level, e. g.:

Dicranoweisia crispula
Andreaea rupestris s. ampl.
A. obovata
A. blyttii
Sphaerophorus fragilis
Placopsis gelida
Pannaria hookeri
Vestergrenopsis isidiata
V. elaeina

Tab. 2. illustrates the distribution of communities along the topographical transect near Liefdefjorden. The moderate part of the *Andreaea blyttii* community is characterized by dominance of *A. rupestris* in areas where *A. blyttii* is not found. *Dicranoweisia crispula* has the widest range in these snow beds, and is a good differential species against *Luzulion arcuatae*. A provisional *'Dicronweision crispulae'* alliance is therefore proposed to cover arctic and boreal alpine boulder snow beds at least in Svalbard and Fennoscandia. *Dicranoweisia crispula* and *Andreaea rupestris* s. l. are the most important species as to phytomass, but both are found rather far to the south, and they are both common e. g. in the lowlands of the middle boreal zone of northern Norway. In Fennoscandia *Pannaria hookeri, Andreaea blyttii, A. obovata,* and probably the northern taxon within the *A. rupestris* complex, are the most faithful species of *'Dicranoweision crispulae'*. A closer classification and comparison between Fennoscandian and Svalbard communities requires extensive phytosociological studies and a systematical treatment of northern *Andreaea* taxa.

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References

Berggren, S. (1875): Musci et Hepaticae Spitsbergenses. Bericht über die Untersuchung der Moosflora Spitzbergens und Beeren Eilands während der schwedischen Expeditionen 1864 und 1868, und Verzeichnis der dort gesammelten Arten. — K. svenska Vetensk. Akad. Handl. 1874, 13,7: 1—103.

Corley, M. F. V., Crundwell, A. C., Düll, R., Hill, M. O. & A. J. E. Smith (1981): Mosses of Europe and the Azores; an annoted list of species, with synonyms from the recent literature. — J. Bryol. 11: 609—189.

Duell, R. (1983): Distribution of the European and Macaronesian liverworts (Hepaticophytina). — Bryol. Beiträge 2: 1—115.

Elvebakk, A. (1979): Plantesosiologi of — fenologi i eit arktisk område: Stuphallet, Brøggerhalvøya, Svalbard. — Unpubl. cand. real. thesis, Univ. Trondheim, 1—233.

Elvebakk, A. (1980): Utskiljing av fattig og rik vegetasjon i vestlege delar av Spitsbergen, Svalbard. — In: K. Baadsvik, T. Klokk & O. I. Rønning, red., Fagmøte i vegetasjonsøkologi på Kongsvoll, 16.—18. 3. 1980, Rapp. Kgl. norske Vidensk. Selsk., bot. Ser., 1980, 5: 34—54.

Elvebakk, A. (1981): Indikerer torvakkumulering myrdanning i Arktis? — In: K. Baadsvik, T. Klokk & O. I. Rønning, red., Fagmøte i vegetasjonsøkologi på Kongsvoll, 15.—17. 3. 1981, Rapp. Kgl. norske Vidensk. Selsk., bot. Ser., 1981, 5: 144—154.

Elvebakk, A. (1982): Geological preferences among Svalbard plants. — Inter-Nord 16: 11—31.

Elvebakk, A. (1984): Contributions to the lichen flora and ecology of Svalbard, Arctic Norway. — Bryologist 87: 308—313.

Elvebakk, A. (1985): Higher phytosociological syntaxa on Svalbard and their use in the subdivision of the Arctic. — Nord. J. Bot. 5.

Frisvoll, A. A., Elvebakk, A., Flatberg, K. I., Halvorsen, R. & A. Skogen (1984): Norske navn på moser. — Polarflokken 8: 5—59.

Gjelsvik, T. (1979): The Hecla Hoek ridge of Devonian Graben between Liefdefjorden and Holtedalfonna, Spitsbergen. — Skr. norsk Polarinst. 167: 63—71.

Hawksworth, D. L., James, P. W., & B. J. Coppins (1980): Checklist of British lichen-forming, lichenicolous and allied fungi. — Lichenologist 12: 1—115.

Kuc, M. (1963): Flora of mosses and their distribution on the north coast of Hornsund (S. W.-Svalbard). — Fragm. flor. geobot. 9: 291—366.

Kuc, M. (1973): A review of the mosses of Svalbard. — Rev. bryol. lichénol. 39: 401—472.

Lindberg, S. O. (1867): Förteckning öfver mossor, insamlade under de svenska expeditionerna till Spitsbergen 1858 och 1801. — Öfvers. k. Sv. Vetensk. Akad. Förh. 1866, 23: 535—561.

Nyholm, E. (1969): Illustrated moss flora of Fennoscandia. — II. Musci. 6: 647—799, Stockholm.