POLISH POLAR RESEARCH	8	3	251—260	1987

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Vegetation of Calypsostranda in Wedel Jarlsberg Land, Spitsbergen

ABSTRACT: The paper presents plant communities from northern Wedel Jarlsberg Land. 55 species of vascular plants were described in this region. Differentiation of plant communities is discussed as controlled by habitat conditions. Plant succession in intramorainal zones of Renardbreen and Scottbreen has been also considered.

Key words: Arctic, Spitsbergen, vascular plants.

Introduction

The paper is based on observations collected during the expedition to Spitsbergen in 1986, organized by the Faculty of Biology and Earth Sciences, Maria Curie-Skłodowska University of Lublin. Botanical investigations were carried over Calypsostranda and adjacent intramorainal zones of Renardbreen and Scottbreen (Fig. 1). 55 species of vascular plants were described on the basis of field investigations from July, 1 to September, 10. Polunin (1959) and Rönning (1964) papers served as a basis for identification of plants. No *Draba* species have been distinguished because of their difficult determination.

Calypsostranda occupies an area of about 6 square kilometers and is composed of marine terraces (25 m to 120 m a.s.l.) cut by numerous erosive dissections. Terraces are built of marine sands and gravels with clay and till intercalations. There are also outcrops of metamorphic rocks of the Precambrian Hecla Hoek Formation (Flood, Nagy and Winsnes 1971). A recent glacial retreat in this region exposes considerable areas which can be subjected to plant succession. Terminal and lateral ice-cored moraines of Renardbreen are mantled with unstable rock debris. In intramorainal zone gravels, sands, muds and clays are accumulated. In the area adjacent to the glacier snout an extensive outwash occurs while a roche moutnnée

adjoins the ice. In Scottbreen forefield there are terminal and lateral ice-cored moraines and a different ground moraine if compared with the one of Renardbreen. It is covered with debris and gravels that form small hills and depressions. Patches of mud and clay are very rare. Unstability of substrate is the dominating feature.

A beach with a considerable supratidal zone accessible for vegetation occurs along a seashore. It is divided in few places by outwashes (Fig. 1).

Soils in the investigated area are characterized by strong skeletization, abundance of carbonates and neutral or weak alkalinity (pH from 6.8 to 7.3). Moreover, mineral soils have low contents of assimilable phosphorus and potassium but high of organic carbon (Klimowicz *unpubl.*). Initial soils, poorly developed, brown soils, peat and gley soils occur on terraces. Peaty and peat soils occupy scarce turf hills. Due to frost processes polygonal soils are formed, among others as assemblages of frost fissures (fissure polygons) or stone rings (stone polygons). Inside stone polygons (Pl. 1, Fig. 1) there are gley soils. Centers of stone rings are composed of silts, passing outwards and downwards into sands with clays. Centers of fissure polygons consist of brown soils while poorly developed soils or peat soils occur along fissures (Klimowicz *unpubl.*). A structure of polygonal soils is closely associated with settling by vegetation.

Meteorological observations carried out during the expedition provided data on climate of the region (Gluza *unpubl.*). Frequent cloudiness, high air humidity and high wind velocities reaching in blows 20 m/s are the most characteristic climatic features in summer (Table 1). In July eastern and

Table 1

Average and extreme values of some climatic parameters in Calypsostranda

Climatic parameters	Number of days	Mean for entire period	Daily maximum	Daily minimum
Insolation (hours)	41	3.8	15.6	–
Air temperature* (°C)	41	4.9	7.2	2.9
Relative humidity (%)	41	84.3	95.0	71.0
Wind velocity (m/s)	62	4.0	10.6	1.0
Atmospheric precipitation (mm)	44	0.6	11.0	–
Potential evaporation (mm)	41	1.2	2.6	–

* 2 m above a ground surface

northwestern winds predominated while southern and southwestern winds in August. The highest temperature was noted near a ground surface. It changed what depended on a type of substrate, its humidity and vegetation. The entire observation period had a mean insolation of 0.14 cal/cm^2/min whereas terraces covered with a deflation tundra absorbed over 70% of it. Permafrost occurred at depths of 20 to 30 cm in humid and wet areas,

and to 120—130 cm in areas with running water on a stony substrate (Pękala *unpubl.*).

Spitsbergen and Greenland form a separate province within the northern belt of arctic tundra (Aleksandrova 1971, 1980). Elvebakk (1985) divided the

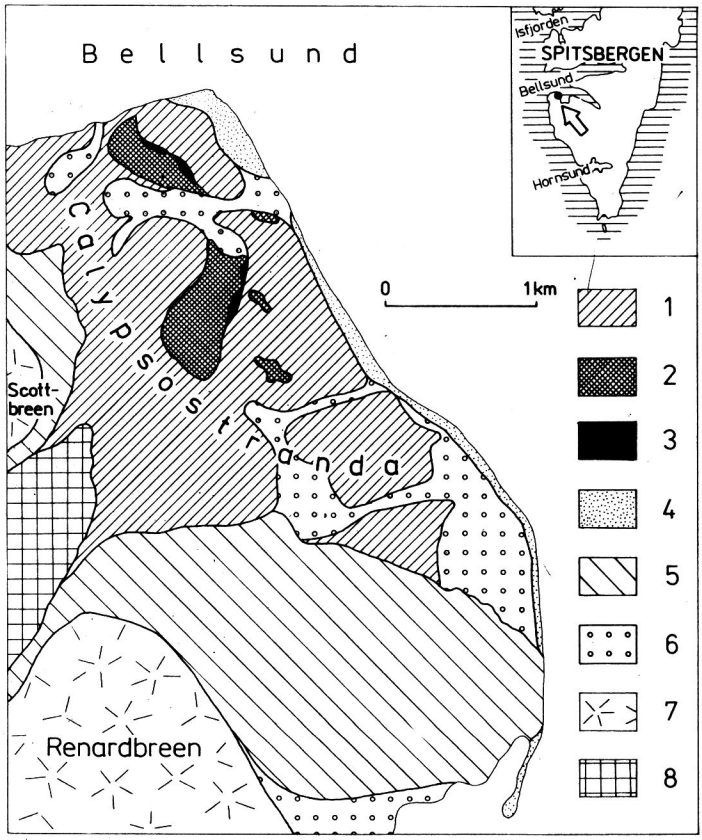

Fig. 1. Vegetation of Calypsostranda: 1 — communities of deflation tundra, 2 — wet communities of grasses and mosses, 3 — communities of snowbeds, 4 — beach vegetation, 5 — vegetation of intramorainal zones, 6 — outwashes, 7 — glaciers, 8 — mountain range

island into two zones: Northern Arctic Tundra Zone (NATZ) and Middle Arctic Tundra Zone (MATZ). The investigated area belongs, together with northern Greenland and Novaya Zemla to the NATZ.

Vegetation of marine terraces

Lichens form the dominant vegetation element of marine terraces in Calypsostranda (Pl. 3, Fig. 1). *Cetraria islandica* and *Cetraria delisei* are the most abundant. Among vascular plants *Salix polaris*, *Polygonum viviparum*,

Cerastium arcticum, *Silene acaulis*, *Saxifraga oppositifolia* and *Saxifraga caespitosa* are numerous. Vegetation of terraces has a characteristic spatial distribution preferring furrows and depressions. This trend may be also noted in settling the common polygonal structures (Pls. 1—2). Such growth pattern protects plants from destruction by strong winds. Scare vegetation cover, abundant species in dense pillows, location and large content of dry mossy tundra taxa are the typical features for a deflation tundra (*cf.* Eurola 1968, Gugnacka-Fiedor and Noryśkiewicz 1982).

Table 2

Vegetation of Calypsostranda

Vascular plants	Vegetation of marine terraces				
	Communities of deflation tundra	Communities of snow-beds	Wet communities of grasses and mosses	Beach vegetation	Vegetation of intramorainal zones
1	2	3	4	5	6
Equisetum scirpoides Michx.	+				
Equisetum variegatum Schleich.			+		
Salix polaris Wg.	+		+		+
Salix reticulata L.	+				
Koenigia islandica L.			+		
Oxyria digyna (L.) Hill.	+				+
Polygonum viviparum L.	+	+	+		+
Sagina intermedia Fenzl.	+				+
Sagina caespitosa (J. Vahl.) Lge.			+		
Minuartia biflora (L.) Sch. & Th. Tuearve	+				+
Minuartia rubella (Wbg) Hiern.	+				
Honckenya peploides (L.) Ehrh.				+	
Stellaria humifusa Rotth.	+				
Cerastium arcticum Lge.	+	+	+		+
Cerastium regelii Ostf.	+	+	+		+
Melandrium apetalum Fenzl.	+			+	
Silene acaulis (L.) Jacq.	+		+	+	+
Ranunculus hyperboreus Rottb.			+		
Ranunculus sulphureus Sol.			+		
Ranunculus pygmaeus Wahlenb.			+		
Papaver dahlianum Nordh.	+			+	
Cardamine nymani Gand.		+	+		
Cardamine bellidifolia L.		+	+		
Cochlearia officinalis L.	+	+	+	+	+
Braya purpurascens (R. Br.) Bge.				+	
Eutrema edwardsii R. Br.	+				
Saxifraga oppositifolia L.	+	+	+	+	+
Saxifraga hieraciifolia Waldst. & Kit.	+				

1	2	3	4	5	6
Saxifraga nivalis L.	+				
Saxifraga tenuis (Wahlenb.) H. Sm.	+				
Saxifraga aizoides L.	+		+		
Saxifraga hirculus L.	+		+		
Saxifraga cernua L.	+	+	+		+
Saxifraga hyperborea R. Br.			+		
Saxifraga caespitosa L.	+	+	+		+
Saxifraga flagellaris Willd.	+				
Chrysosplenium tetrandrum (N. Lund.) Th. Fr.			+		
Dryas octopetala L.	+				
Pedicularis hirsuta L.	+				
Juncus biglumis L.		+	+		+
Luzula arcuata (Wahlenb.) Sw.	+				
Luzula confusa (Hartm.) Lindeb.	+				
Luzula arctica Blytt.	+		+		
Alopecurus alpinus Sm.			+		
Phippsia concinna (Th. Fr.) Lindb.					+
Phippsia algida (Sol.) R. Br.		+	+		+
Deschampsia alpina (L.) R. & S.			+		
Poa alpigena var. *vivipara* (Malmg.) Schol.					+
Poa arctica var. *vivipara* (Malmg.) Schol.					+
Poa alpina var. *vivipara* L.					+
Arctophila fulva (Trin.) Rupr.			+		
Colpodium vahlianum (Liebm.) Nevski					+
Colpodium vacillans (Th. Fr.) Polunin	+				+
Dupontia fisheri R. Br.			+		
Festuca rubra L.	+				

Eurola (1968) distinguished two "variants" fo deflation tundra in Spitsbergen: a "variant" of *Saxifraga oppositifolia* and a "variant" of *Dryas octopetala*. The former one occurs on the western seashore of Spitsbergen and its species composition corresponds with the community from Calypsostranda. Species of this "variant" include (*after* Eurola 1968): *Cetraria delisei*, *Cerastium regelii*, *Draba alpina*, *Minuartia rubella*, *Saxifraga nivalis*, *Saxifraga oppositifolia* and *Silene acaulis*. Hofmann (1968) described the association *Papaveretum dahliani* from Barentsöya and subdivided it into *Papaveretum dahliani typicum*, *Papaveretum dahliani saxifragetosum oppositifoliae* and *Papaveretum dahliani salicetosum polaris*. Communities from Calypsostranda correspond with the last two ones. The only difference is however in predominance of lichens in Calypsostranda while Hofmann's association is composed of flowering plant and occasional mosses.

Margins and slopes of terraces have unfavorable habitat conditions, resulting from unstable sandy-gravel substrate. *Saxifraga oppositifolia* is the only species that could accomodate to such conditions due to its numerous long and filamentous roots which penetrate deeper into a more compact

substrate. At the same time roots have much larger surface than covered by overground plant part. Trailing of bines plays also an important role. Moreover, this species is very drought resistant (Reznicek and Svoboda 1982).

Patches of vegetation with predominant mosses, accompanied by *Saxifraga oppositifolia*, occur in shallow ravines without rapid streams. An increased wetness of ground as indicated by mosses, is due to springs and a thick snow cover.

Southwestern edges of the lowest marine terrace in the northwestern part of investigated area are mantled at the foot by snow that does not disappear before the mid-July. After snow melting the communities of snowbeds are mainly overgrown by the alga *Nostoc commune*. Such forms as *Phippsia algida*, *Saxifraga cernua*, *Cerastium regelii*, *Cardamine nymani* and *Cochlearia officinalis* grow on the surface covered by this alga. Nearly all the specimens are however still in juvenile growth stages at the end of vegetation season. Thick and long-persisting snowbeds exert a good effect on vegetation unless they do not limit the vegetation season. When snow persists for a longer time then plants cannot fulfill the development cycle (Reznicek and Svoboda 1982, Aleksandrova 1983).

On lower altitudes there are polygonal and considerably flooded grounds. Wet communities of grasses and mosses are predominated by *Deschampsia alpina*, *Ranunculus hyperboreus*, *Phippsia algida* and *Arctophila fulva*. In flooded sites they are accompanied by *Nostoc commune*. Drier substrate zones are densely populated with numerous species common for the entire investigated region (Table 2). Mosses form scarce hummocks up to 30 cm high and are in turn overgrown with *Cerastium regelii*, *Cardamine nymani*, *Saxifraga hyperborea*, *Chrysosplenium tetrandrum* and *Juncus biglumis*. Phenological phases of plants are delayed there however if compared with dry communities what seems to result from cooling by meltwaters.

Such plant communities were previously noted in Ny Ålesund area, northern Spitsbergen (Elvebakk 1984). Two variants of snowbed communities were distinguished by Eurola (1968): the "variant" of *Saxifraga oppositifolia* occurs on the western seashore and has a relatively high species diversity. The second and the more inland "variant" of *Alopecurus alpinus* occurs further from the seashore. Regarding a geographic location of the investigated area and occurrence of numerous *Cetraria islandica*, *Cetraria delisei*, *Cochlearia officinalis*, *Saxifraga cernua* and *Saxifraga caespitosa*, the investigated snowbeds seem to be closely related to the "variant" of *Saxifraga oppositifolia*. Wet communities composed of grasses and mosses beneath such snowbeds were described by Hofmann (1968) from Barentsöya where he distinguished the association of *Calliergo-Bryetum cryophili* with *Chrysosplenium tetrandrum* and *Ranunculus hyperboreus* as well as *Cochlearia officinalis*, *Saxifraga hirculus*,

Saxifraga cernua and *Saxifraga caespitosa*. It is consistent with observations from Calypsostranda and absence of *Deschampsia alpina* on Barentsöya and its abundance in the investigated area is the only difference.

Elvebakk (1982) divided Spitsbergen plant species on the basis of their relation to substrate alkalinity. According to his scheme a vegetation of marine terraces from the investigated area is predominated by "circumneutral species" *i.e. Polygonum viviparum, Minuartia rubella, Silene acaulis, Saxifraga oppositifolia, Dryas octopetala, Pedicularis hirsuta* and *Luzula arctica*. Among "indifferent species" there are: *Salix polaris, Oxyria digyna, Papaver dahlianum, Cerastium arcticum, Ranunculus sulphureus, Saxifraga nivalis* and *Saxifraga caespitosa*, containing also lichens of *Cetraria delisei* and *Cetraria islandica*.

Beach vegetation

In a beach zone a vegetation occupies a stone substrate near a terrace foot (Pl. 3, Fig. 2; Pl. 4, Fig. 1). It is mainly represented by *Saxifraga oppositifolia* and *Silene acaulis*. On the other hand a sandy substrate is overgrown by *Cochlearia officinalis*. *Honckenya peploides* is very rare and forms a single tuft. In sites which are extensively fertilized by birds there are large mossy patches. They occur either near small lakes where flocks of gulls (*Risa tridactyla*) are accumulated or around ancient miners' buildings which are nestling places for a sea swallow (*Sterna macrura*). Among vascular plants there are: *Saxifraga cernua, Saxifraga caespitosa* and *Cerastium arcticum*. Birds influence on development of vegetation is commonly noted in Spitsbergen. Their excrements enrich a substrate in nutrients and so, create a specific phytocenosis with abundant nitrophilic species (Eurola and Hakala 1977). Similar features occur in any place where animal remains were decayed (Pl. 4, Fig. 2).

Vegetation of intramorainal zones

Terminal and lateral ice-cored moraines of Renardbreen are steep and covered with unstable debris and so, they are unfavorable for vegetation (Pl. 5, Fig. 1). *Saxifraga oppositifolia* predominates there and is the only species on outer (north-eastern) morainic slopes. Gentler and longer inner slopes and a ground moraine are overgrown by communities composed of *Cerastium arcticum, Cerastium regelii, Melandrium apetalum, Saxifraga caespitosa* and *Colpodium vacillans*. There are also viviparous varieties of grasses as *Poa alpina* var. *vivipara, Poa arctica* var. *vivipara* and *Poa alpigena* var. *vivipara* (Pl. 5, Fig. 2). *Braya purpurascens* is also very common in this zone. Vegetation is limited there to sand and clay substrate and

occupies the most favorable conditions in monospecific patches as of *Saxifraga oppositifolia* (Pl. 6, Fig. 1) or in multispecies communities with mosses or algae that cover 80% of the surface (Pl. 6, Fig. 2).

Scottbreen forefield is less covered with vegetation either on ice-cored terminal and lateral moraines or on a ground moraine. *Cerastium arcticum*, *Cerastium regelii*, *Saxifraga oppositifolia*, *Saxifraga caespitosa*, *Poa alpina* var. *vivipara* and *Draba* sp. occur there. Dense vegetation patches occur near two small thaw lakes where algae predominate while vascular plants form small clusters only. Sandy wet till forms a substrate of this phytocenosis.

No influence of more severe microclimate (as expressed by a decreasing distance from the glacial ice) on vegetation, especially on higher plants, has been observed in forefields of both these glaciers. A relatively well developed patch of vegetation has been observed close to a glacier: on a lateral moraine of Scottbreen. Sandy till substrate was covered with mosses and vascular plant species, listed already for Scottbreen. Amongst other species there are: *Saxifraga nivalis* and *Saxifraga cernua*. A rich vegetation is also observed on a roche moutonnée just in front of Renardbreen. A patch of mosses with unique specimens of *Papaver dahlianum* and *Saxifraga caespitosa* has been found on its southwestern slopes (about 100 m from the ice).

Plant succession in glacier forefields seems to be dependent on substrate and especially, on presence or absence of clay and mud fraction that rules a substrate stability and humidity. In Renardbreen forefield, the areas uncovered earlier but composed of sandy-gravel sediments have a scarser vegetation cover than those which were uncovered later but composed of mud and clay. A stage of succession does not seem to be simply related to a time since a glacier retreat (*cf.* Fabiszewski 1975). In both investigated intramorainal zones no lichens have been found what is to be typical for areas with unstable substrate (Fabiszewski 1975, Gugnacka-Fiedor and Noryśkiewicz 1982).

Conclusions

1. Several plant communities have been distinguished in the investigated area:
   - vegetation of marine terraces, composed of communities of deflation tundra, communities of snowbeds and wet communities of grasses and mosses
   - beach vegetation
   - vegetation of intramorainal zones.

2. *Saxifraga oppositifolia* predominates or plays an important role in all investigated communities.

3. *Salix polaris, Polygonum viviparum, Cerastium arcticum, Cerastium regelii, Silene acaulis, Cochlearia officinalis, Saxifraga caespitosa* and *Saxifraga cernua* are the most common species in the investigated area.

4. Most plants from snowbed communities do not complete their development cycles due to a shorter vegetation period.

5. Phenological phases of plants from wet communities of grasses and mosses, influenced by cold meltwaters, are retarded if related to the other communities.

6. A type of substrate *i.e.* absence or presence of clay and mud fractions which decide about its stability and humidity, play an important role in plant succession of intramorainal zones.

7. There is no simple relation between a succession stage and time since a glacier retreat.

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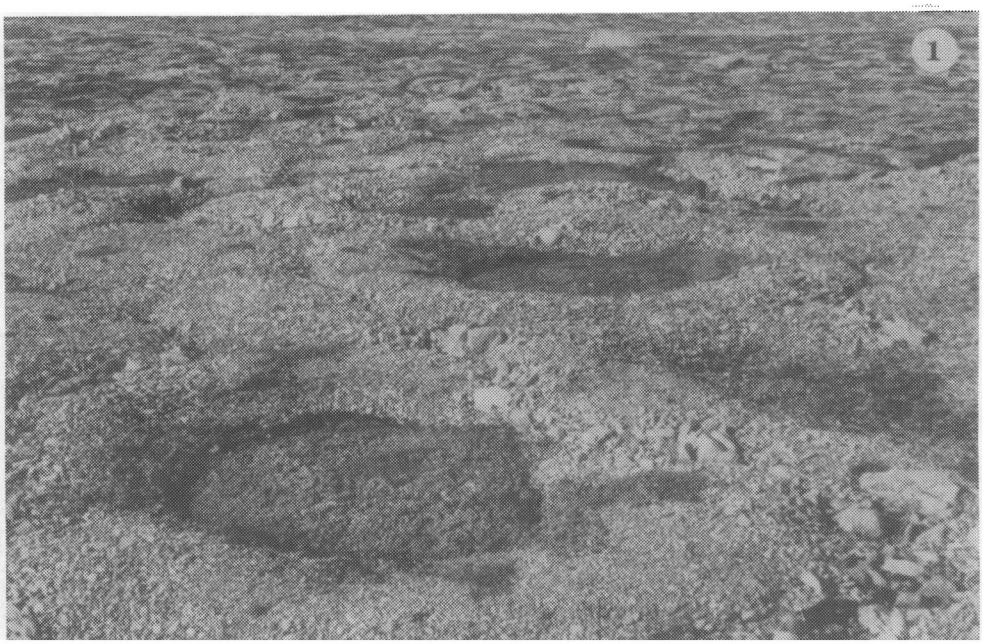
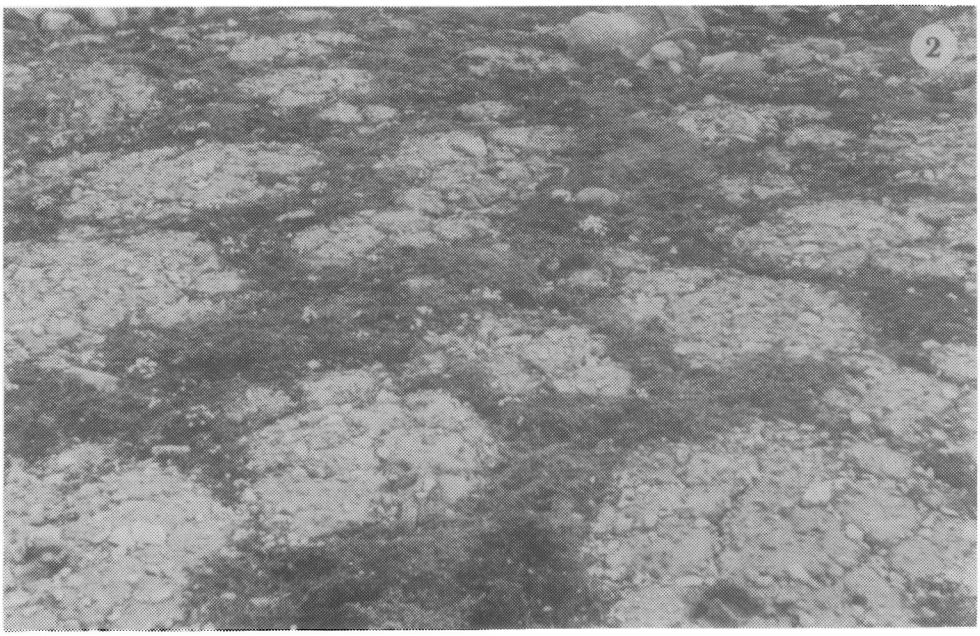
Received March 5, 1987
Revised and accepted April 22, 1987

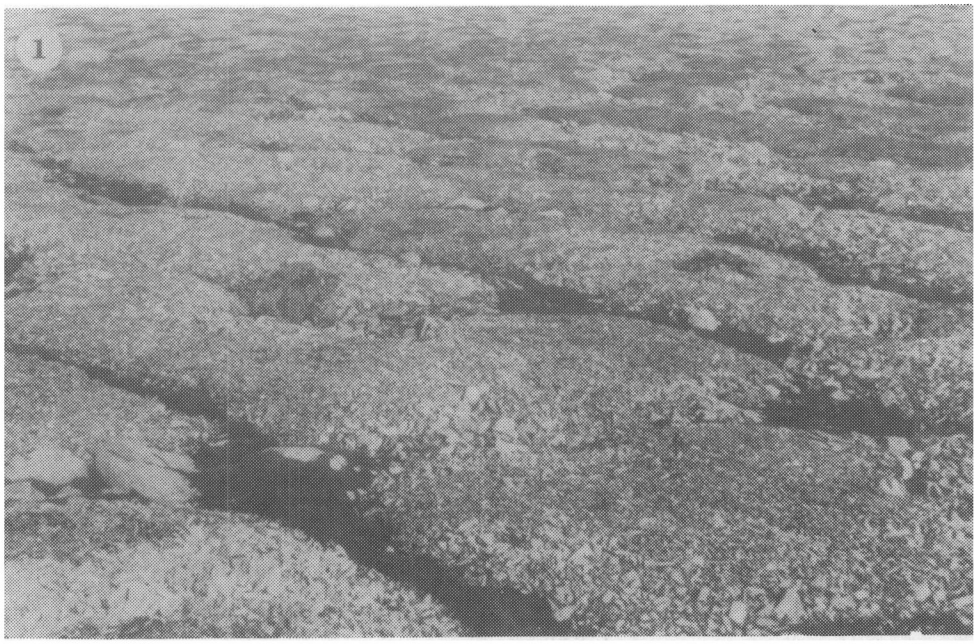
Streszczenie

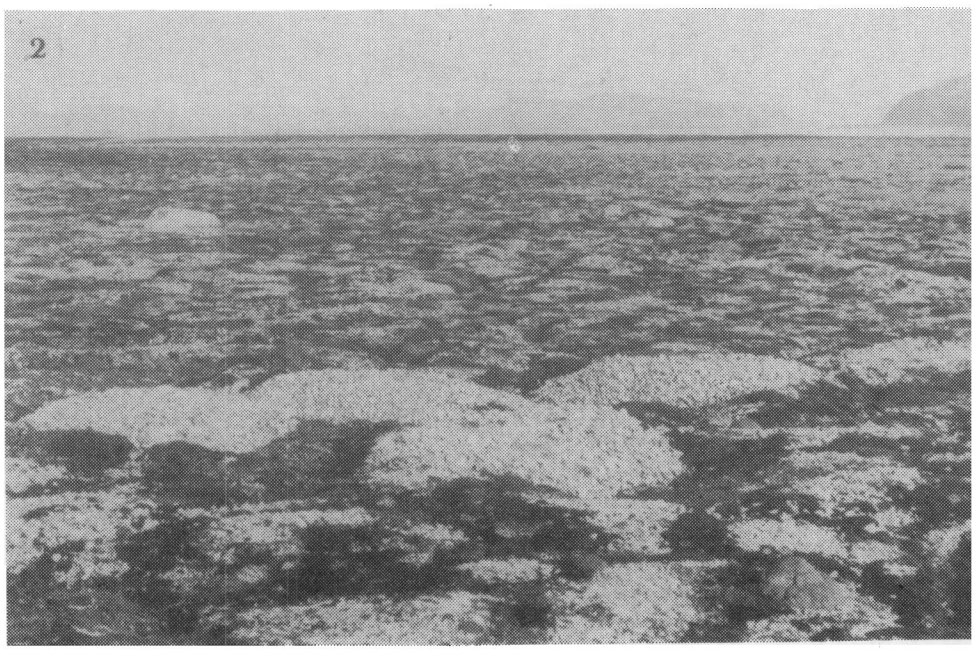
Podczas wyprawy naukowej na Spitsbergen zorganizowanej w 1986 r. przez Wydział Biologii i Nauk o Ziemi Uniwersytetu im. Marii Curie-Skłodowskiej w Lublinie przeprowadzono w ramach projektu CPBP 03.03. B.9. wstępną analizę botaniczną roślinności w rejonie Calypsostranda (Bellsund), Ziemia Wedel Jarlsberga (fig. 1). Uwzględniono specyficzne warunki geomorfologiczne, glebowe i klimatyczne (tab. 1) występujące na badanym obszarze. Stwierdzono obecność 55 gatunków roślin naczyniowych (tab. 2) oraz wyróżniono roślinność tarasów morskich (pl. 1—2; pl. 3, fig. 1), roślinność plaż (pl. 3, fig. 2; pl. 4) oraz roślinność stref intramarginalnych (pl. 5—6). Tarasy morskie są zróżnicowane pod względem siedliskowym co umożliwia rozwój różnych zbiorowisk roślinnych: tundry deflacyjnej, wyleżysk śniegowych oraz wilgotnych zbiorowisk trawiasto-mszystych. Głównym komponentem roślinnym tundry deflacyjnej są porosty, m.in. *Cetraria islandica* i *Cetraria delisei*. Z roślin naczyniowych najliczniej reprezentowane są: *Salix polaris*, *Polygonum viviparum*, *Cerastium arcticum*, *Silene acaulis*, *Saxifraga oppositifolia*, *Saxifraga caespitosa*. Rozmieszczenie roślinności jest determinowane przez działanie bardzo silnych wiatrów. W miejscach, w których pokrywa śniegowa zanika dopiero w połowie lipca, formują się zbiorowiska wyleżysk śniegowych z udziałem glonu *Nostoc commune*. Do roślin zasiedlających te tereny należą: *Saxifraga cernua*, *Cerastium regelii*, *Cardamine nymani*, *Cochlearia officinalis*, *Phippsia algida*. Późno ustępująca pokrywa śniegowa sprawia, że fazy rozwoju fenologicznego są tu znacznie opóźnione i prawie wszystkie osobniki do końca sezonu wegetacyjnego pozostają w stadium młodocianym. Poniżej wyleżysk śniegowych występują wilgotne zbiorowiska trawiasto-mszyste z udziałem takich gatunków, jak *Ranunculus hyperboreus*, *Phippsia algida*, *Deschampsia alpina*, *Arctophila fulva* oraz *Nostoc commune*. W skład roślinności plaży wchodzą głównie: *Saxifraga oppositifolia*, *Silene acaulis* i *Cochlearia officinalis*. Natomiast w miejscach intensywnie nawożonych przez ptaki tworzą się rozległe płaty mszyste z dużym udziałem azotolubnego gatunku, jakim jest *Saxifraga cernua*. W zasiedlaniu stref intramarginalnych lodowców Renarda i Scotta dominującą rolę odgrywa *Saxifraga oppositifolia*. Na uwagę zasługują również występujące tu żyworodne gatunki traw tj. *Poa alpina* var. *vivipara*, *Poa alpigena* var. *vivipara* oraz *Poa arctica* var. *vivipara*. Zaobserwowano, że decydującą rolę w rozwoju zbiorowisk roślinnych stref intramarginalnych odgrywa rodzaj podłoża odsłoniętego po ustąpieniu lodowca, a zwłaszcza obecność lub brak w warstwie powierzchniowej drobnoziarnistych frakcji ilastych i mułkowych. Jednocześnie wydaje się, że stopień zaawansowania sukcesji roślinnej nie tworzy prostej zależności z wiekiem podłoża, rozumianym w tym przypadku jako okres czasu, jaki upłynął od ustąpienia lodowca.



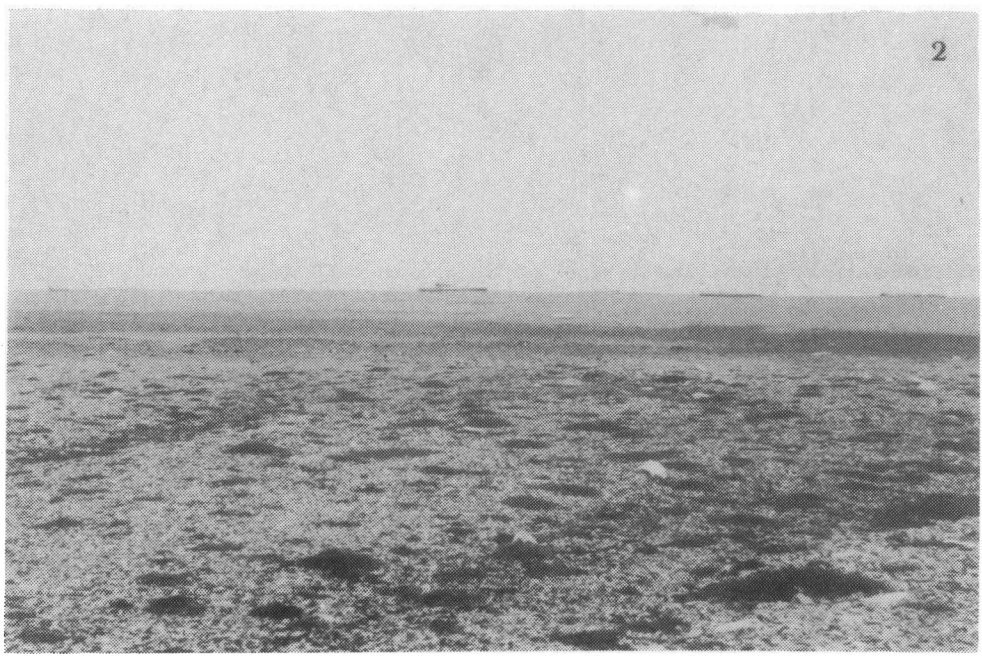


1. Calypsostranda. Settling of stone rings by vegetation
2. Calypsostranda. Spatial structure of vegetation on polygonal soil

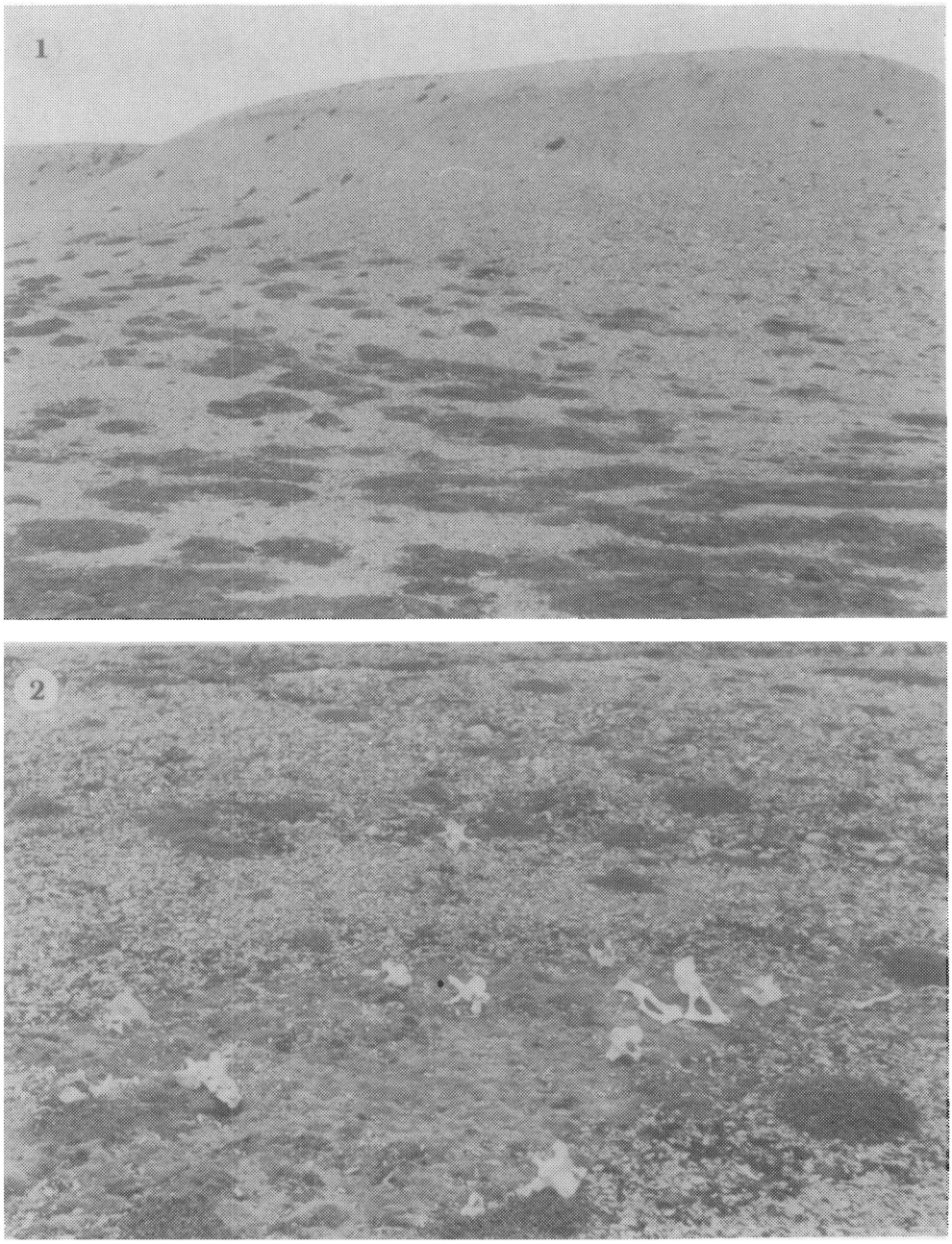




1. Calypsostranda. Spatial distribution of vegetation on marine terrace
2. Calypsostranda. Communities of deflation tundra

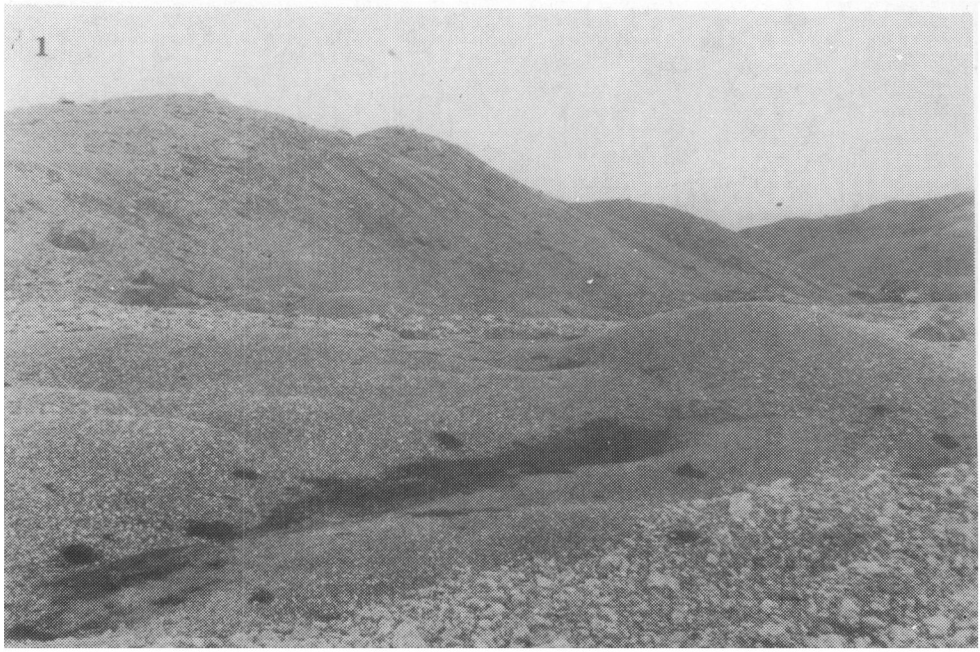


1. Calypsostranda. *Cetraria* sp. and *Saxifraga caespitosa* from deflation tundra community
2. Calypsostranda. Beach vegetation



1. Calypsostranda. *Saxifraga oppositifolia* on a beach at foot of marine terrace
2. Calypsostranda. Concentration of vegetation on a beach around remains of animal

1. Ice-cored moraine of Renardbreen with *Cerastium arcticum*
2. Ice-cored moraine of Renardbreen with *Poa alpina* var. *vivipara*



1. Intramorainal zone of Renardbreen with a monospecific patch of vegetation composed of *Saxifraga oppositifolia*
2. Intramorainal zone of Renardbreen with a multispecific patch of vegetation