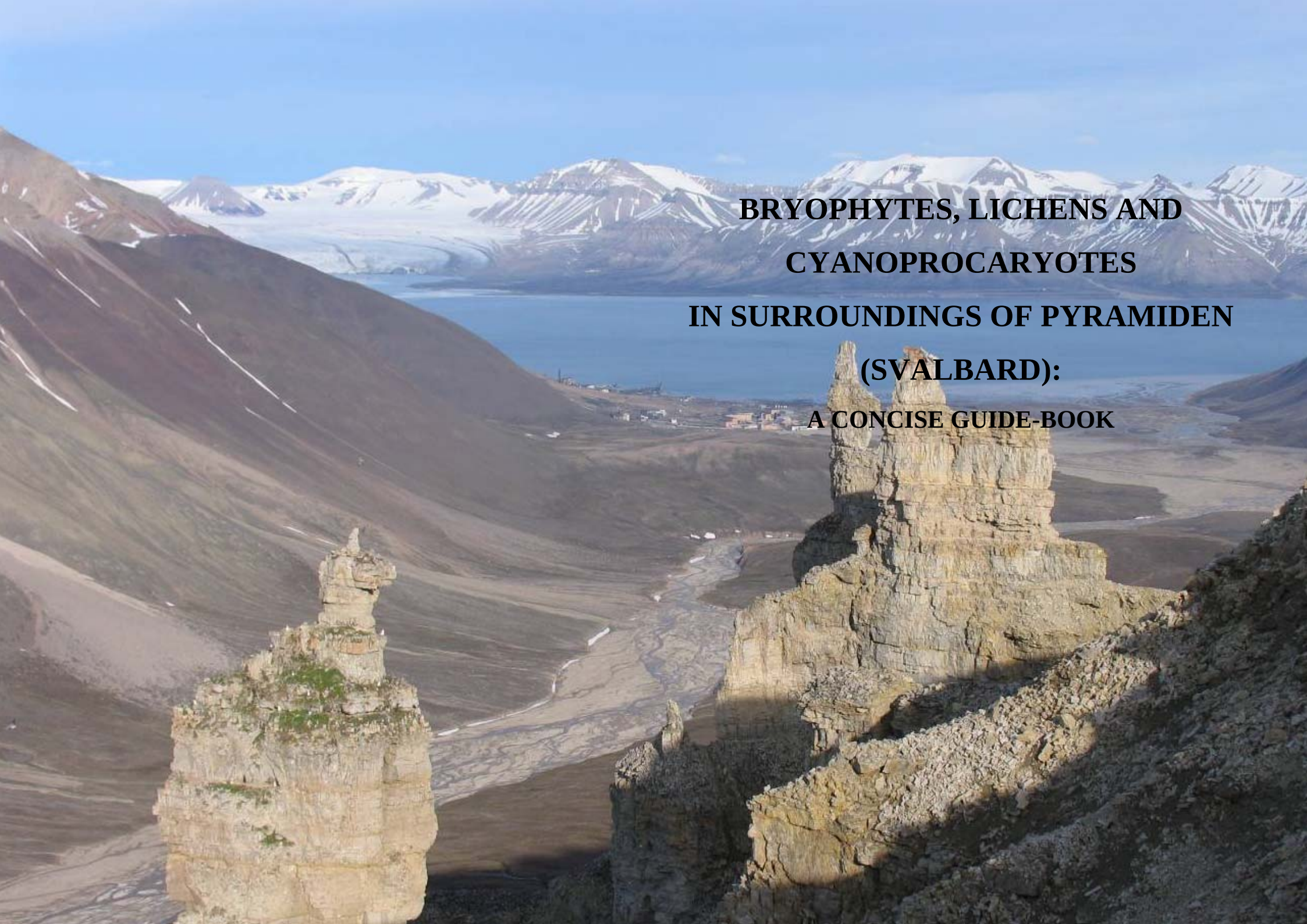
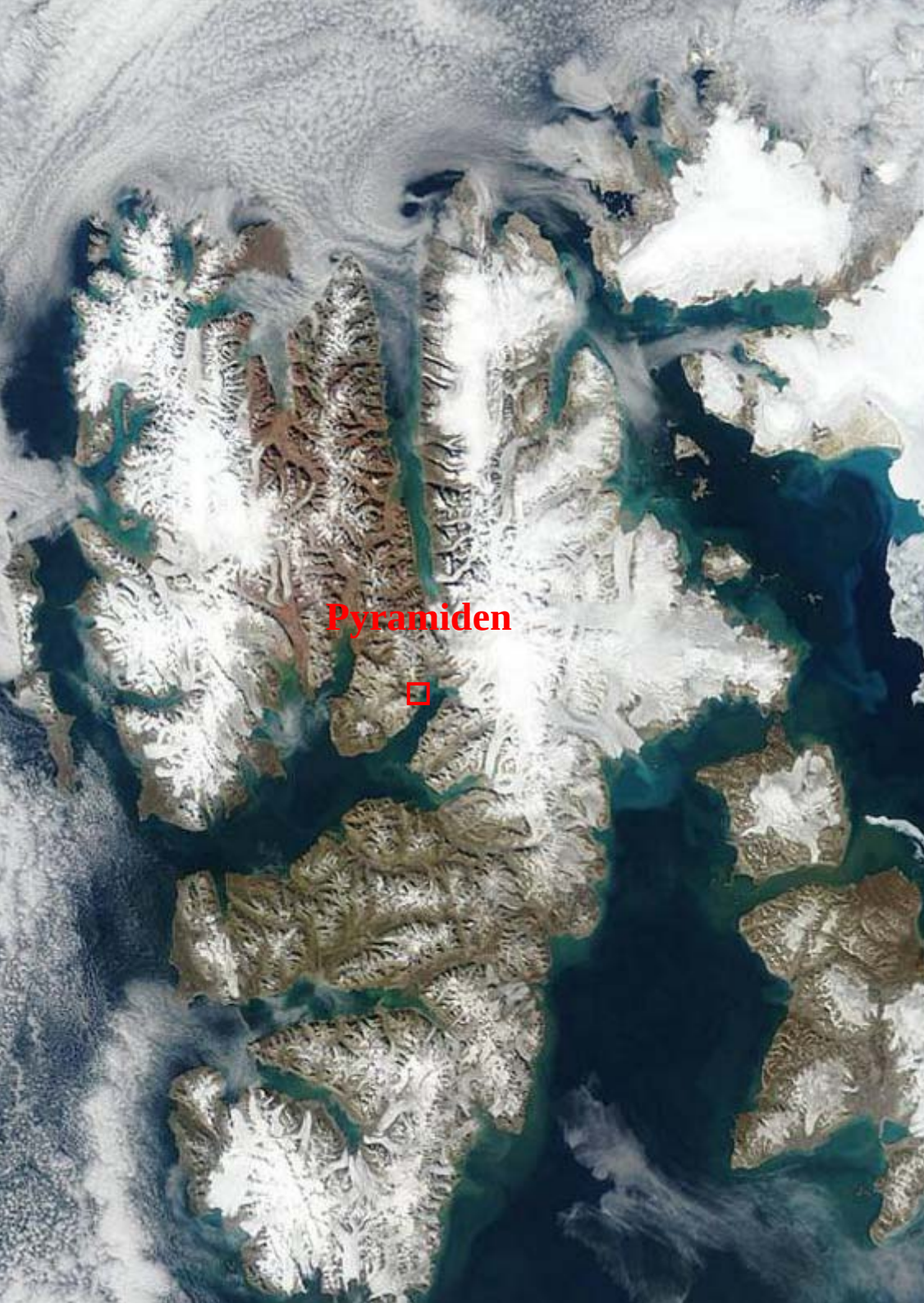


BRYOPHYTES, LICHENS AND CYANOPROCARYOTES IN SURROUNDINGS OF PYRAMIDEN (SVALBARD):

A CONCISE GUIDE-BOOK


Pyramiden

RUSSIAN ACADEMY OF SCIENCES
N.A. AVRORIN POLAR-ALPINE BOTANICAL GARDEN-INSTITUTE

SVALBARDS
MILJØVERNFOND

SVALBARD ENVIRONMENTAL PROTECTION FUND

O. Belkina, N. Konstantinova, N. Koroleva, L. Konoreva,
D. Davydov, A. Savchenko, A. Likhachev

BRYOPHYTES, LICHENS AND CYANOPROCARYOTES IN SURROUNDINGS OF PYRAMIDEN (SVALBARD): A CONCISE GUIDE-BOOK

2015

UDC 581.526.533(481-922.1) + 582.29(481-922.1) + 582.33:581.9 (481-922.1)
ISBN

O. Belkina, N. Konstantinova, N. Koroleva, L. Konoreva, D. Davydov, A. Savchenko, A. Likhachev. **Bryophytes, lichens and cyanoprocaryotes in surroundings of Pyramiden (Svalbard): a concise guide-book.** 2015. p. 254

This book presents some widespread and rare species of mosses, liverworts, lichens and cyanoprokaryotes in the surroundings of Pyramiden town on Svalbard archipelago, together with brief explanations of morphology, ecology and distribution of selected species. Five excursion routes in and around Pyramiden show the diversity of cryptogamic organisms and their habitats. The book contains more than 200 full-colored photographs and five maps of the excursion routes. To all who are interested in Arctic wildlife.

Fig. - 325, bibliogr. –33

Editors:

Dr. Sci (Biology) Michael Dodd, Dr. Sci (Biology) Irina Tatarenko, Dr. Sci (Biology) Natalia Koroleva

Reviewers:

Dr. Sci (Biology)

Layout: A. Savchenko

The book was published due to financial support of Environmental Protection Fund of Svalbard, № 13\12

CONTENTS

Introduction

Cryptogamic "plants" are plants of a previously recognized taxonomic group that included seedless plants such as ferns, mosses, liverworts (hepatics) and algae. Lichens and fungi also belonged to this group. The world ‘cryptogamic’ derives from two Greek words: “kryptos” that means “hidden” and “gameein” that means "to marry". Cryptogamic plants have no flowers and spread by spores and various kinds of propagules. For hepatics, propagules are one or two (rarely 3-4) celled gemmae. In lichens, groups of algal cells and fungal gyphae form soredia and isidia – specialized organs of vegetative reproduction. Most representatives of these groups can also disseminate by pieces of thallus or shoot breaking off.

In the arctic, cryptogamic plants play a very important role both in vegetation cover and diversity. In Svalbard,the known diversity of cryptogamic plants is very high. The number of taxa recorded so far, includes 208 cyanoprocaryota species, 757 species of lichens, 310 moss species and 108 species of liverworts. The number of species of cryptogams in Svalbard exceeds the number of vascular plants by almost eight times.

Different organisms adapt to the harsh arctic environments in different ways. A common adaptation is that of miniaturization. This allows some to escape from very low temperatures and wind desiccation by hiding in the numerous micro habitats that are provided both by various permafrost processes (e.g., solifluction) common in Svalbard. Cryptogams are mainly small to minute organisms from several microns in cyanoprocaryota to several millimeters or centimeters in mosses and lichens. Many of them form dense mats, turfs or cushions that represent a mixture of several species. Temperature and humidity in bryophyte mats, turfs or cushions are much higher than in surrounding environment because of dark color and high density of shoots. Diversity of species in the small patches can be very high. Sometimes in an area of about 5 x 5 cm, one can count up to 20 species of bryophytes.

Lichens’ adaptations to the harsh arctic climate are even more impressive.. They are the most numerous group of cryptogamic organisms in Svalbard. Lichens grow on all possible substrates that are not suitable for other organisms: bare rocks, shallow soil and even stones under water, as they obtain organic substances from the algae which are part of their thallus. Crustose lichens are the most common life form, they look like a crust firmly attached to the substrate. Crustose lichens comprise approximately 75% of the lichen diversity in Svalbard.

Lichens are able to enter a state of antibiosis that allows them to survive the extreme temperatures of the arctic. In addition, there are a number of other ecophysiological adaptations in lichens. These include a high content of protective pigments and thickening of cell walls in the upper cortex, and an areolated thallus structure which act as a protection against excessive solar radiation.

In 2008 and 2013, the authors sampled lichens, mosses, liverworts and cyanoprokaryotes on the territory of Pyramiden town and adjacent areas. We found 38 species of liverworts, 147 mosses, 168 lichens and 68 cyanoprokaryota taxa. For this atlas of cryptogamic organisms, 13 liverworts, 26 mosses, 40 lichens and 19 cyanoprokaryota species have been selected. The illustrated list includes both widespread and rare species each of which is annotated by brief descriptions of their morphology, ecology and range.

1. Overview

Geology, geomorphology, hydrology and soils

Pyramiden town is situated on West Spitsbergen Island in the eastern part of Dickson Land on the western shore of Billefjorden. The highest point is Pyramiden Mountain at 935 m. Our field excursion routes cover the mouth and valley of river Mimer and its tributary Torelva, the west coast of Petunia Bay and coast of Mimerbukta, as well as the territory of Pyramiden town situated at the foot of the southern slope of Pyramiden Mt. (fig.1.1).

Fig. 1.1 Pyramiden Mt.. Foto by N. Konctantinova

The relief of this part of Svalbard is sharply dissected with hills reaching 800–1000 m and valleys in between. The main geology is from the Paleogene period, rocks from the Lower Carboniferous are also widespread. The latter are represented by conglomerates, sandstones and limestones with local occurrence of coal. Also, there are Devonian rocks, composed of sandstones, siltstones, quartzitic sandstones and mudstones.

The river system of the area is quite extensive. It is represented by the river Mimer and its tributaries which occupy the central part of the Mimerelva valley. The river is supplied by melting glaciers and to a lesser extent, by precipitation. The river floods the valley in June and July, an annual? average water level is observed in August (fig.1.2).

Fig. 1.2 Pyramiden town is located at the mouth of the river Mimer
Foto by N. Konctantinova

Soil profile is shallow and typical for the high Arctic. Soil cover is patchy; the thickness and continuity of soil horizons are influenced by physical sorting of coarse and fine particles by frost resulting in the formation of sorted circles, polygons, and webs. Permafrost lies close to the ground surface.

Soils and vegetation are both influenced by a combination of cryogenic processes and solifluction. Cryogenic processes, such as cryoturbation, ground ice formation and freeze-thaw cycling are responsible for such landform as the polygon pattern. Repetitive alteration of freeze and thaw causes more fine soil particles to be drawn to the center of the polygon, and coarse rocky fragments are pushed towards the edges. This continuous process results in sorted circles and polygons, with a border of stones of various sizes surrounding a central area of fine earth. When material moves down a slope elongated polygons can be formed; even more often they are shaped as sorted stripes. The border of stones is almost completely barren, sometimes with occasional clumps of mosses and lichens. The central area of finer material can be carpeted by a variety of lichens, cyanoprocaryotes, liverworts and mosses, which form a so called ‘biological soil crust’.

Solifluction is the process of gravitational downslope movement of soaking wet soil horizons also sorted by repeated freeze and thaw activity. Solifluction

lobes are often bordered by turves of mosses and dwarf shrubs, and the patches of wet bare soil on lobes are occupied by fast-growing cryptogamic pioneer species".

Natural habitats in the area of Pyramiden town are united in following groups: 1. Arctic tundra, 2. Barrens, screes, young alluvia areas and glaciers, 4. Wetlands and marshes, 5. Meadows and grasslands, 6. Anthropogenic open plant communities.

Brief assessment of habitats and vegetation typology in Pyramiden area can be found at www.forskningsradet.no and www.sci.muni.cz/CPR/8cislo/Koroleva-web.pd.

Climate

Climate of the area is determined by the influence of several oceanic currents, one of them, - a branch of the Gulf Stream, is of particular importance. It is responsible for high air humidity and precipitation. Average annual temperature in the Pyramiden area is – 5.5° C, the warmest month is July, with an average temperature of +6.8° C. The coldest month is March, with an average temperature –15.8° C. The average annual precipitation is about 400 mm. In absolute terms, the quantity of water in the air is small, but due to constant low temperatures throughout the year, the relative humidity of the air is high (83% in winter and 87% in the summer).

History of Pyramiden

In 1910, the Swede Bertil Högbom got permission for coal mining in the Pyramiden, and in 1911 he started construction of a mine. In 1927, the Russian Trust "Severoles" bought the Pyramiden. In 1939-1941, the Trust "Arcticugol" continued mine construction and built or started building a range of facilities and accommodation in the area. A diesel station, warehouse, a dormitory and a bathhouse were built following by houses, canteen, radio station, boiler room; ventilation system and haulage drifts were started as well. The first shift of the workers spent the winter on the site in 1940-1941. However in August 1941, all people were evacuated from the island. Geological exploration rigs, vessels, fuel and, coal were burnt and site explosives detonated. The diesel station, vehicles and mining equipment were also destroyed. In August 1946, 609 workers returned to Pyramiden. That was considered as the beginning of the construction of modern mine. The first street in Pyramiden was built in March 1947. It stretched from the newly built port to the town. Houses were constructed along both sides of the street that is called in Finnish "Puukko knives". Later, two-storey houses started being built. The settlement was enlarging and its housing and living conditions were gradually improved. One of the unique botanical objects in Pyramiden is its lawns, which were planted with grass turfs imported from the mainland, and grasses acclimatized in Svalbard (fig. 1.3).

Fig. 1.3 Lawn grasses in Pyramiden. Foto by D. Davidov

In 1947-1950 extensive geological explorations were undertaken, and coal mining reached approximately 70 tons of coal per month. During exploitation of the mines; the power station, port, garage, three reservoirs for drinking water, a farm, greenhouse, and other industrial and social enterprises were built. At that time, up to thousand workers lived in Pyramiden. (fig. 1.4, 1.5).

Fig. 1.4 The hotel and bar in Pyramiden. Foto by D. Davidov

Fig. 1.5
The memorial to the last ton of ore mined in Pyramiden.
Foto by D. Davidov

Within the Conservation Program of cultural monuments in Svalbard, the Trust Arcticugol, in February 2011, reached an agreement with the Governor of Svalbard on joint implementation works for reparation and maintenance of the settlement's buildings.

2. Descriptions of some cryptogamic species

2.1. Bryophytes

Bryophytes are the most ancient group of higher plants. Despite the relatively primitive organization they are quite well adapted to various and often extreme environmental conditions. Their size is generally much smaller than the majority of higher plants also known as "vascular plants" or "tracheophytes". (Vascular plants include horsetails, club mosses, ferns, gymnosperms and angiosperms, or flowering plants). Bryophytes rarely exceed 10–20 cm in length and 1–2 cm in width. They can absorb water and solutes over their entire body surface; they have no roots or well developed conducting tissues that usually serve for the transportation of water and nutrients in other higher plants.

Bryophytes are subdivided into 3 divisions: mosses (Bryophyta), liverworts, or hepatics (Marchantiophyta) and hornworts (Anthocerotophyta). Mosses and the majority of liverworts have leafy shoots (fig. 2.1.1).

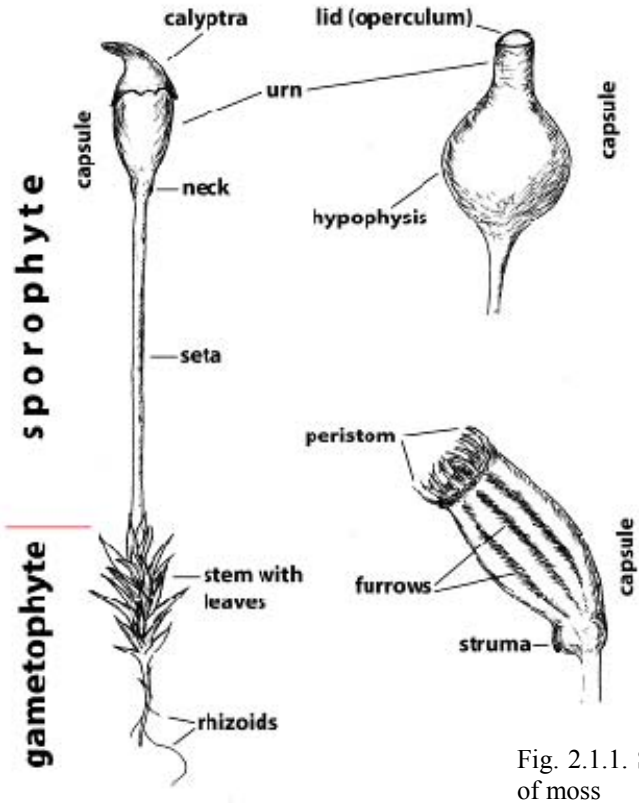


Fig. 2.1.1. Structure of moss

The leaves are formed predominantly of a single layer of cells. Unlike the most mosses, leaves of many liverworts are divided into lobes and usually have no costa. Leafy hepatics often have only two rows of leaves, while the leaves of the third row (on the ventral side) are smaller, can have a different shape or significantly reduced in size. Some liverworts and hornworts have a thallus that is not dissected into stem and leaves. Hornworts grow in areas with a warm and humid climate and do not occur in Svalbard.

Bryophytes differ from vascular plants in their life cycle which means the development of an individual plant "from spore to spore". Life cycle of bryophytes can be briefly described as follows. Unicellular haploid (i.e. with one set of chromosomes in a cell, n) spore germinates into small green thread-like or plate-like protonema (in liverworts it is usually reduced to 2–3 cells), which produces buds. Each bud develops into gametophyte – thallus or leafy plant. Gametophyte is the haploid (n) generation in bryophytes. It produces gametangia (archegonia and/or antheridia). Mobile spermatozoids leave the antheridia, but the ovum remains in the archegonium, wherein fertilization takes place. Resulting diploid (i.e. containing a double set of chromosomes, 2n) zygote develops into a sporophyte which is the diploid generation of mosses.

Gametangia in liverworts are protected by modified leaves (bract) and underleaves (bracteoles) or numerous specialized structures. Of these, the structure that occurs most often, is the perianth. It is derived from the fused leaf bases and forms(?) the tube surrounding the archegonia. The characters of these protective structures are often used for the identification of the species. In class Marchantiopsida, archegonia and antheridia are immersed in the thallus tissue or located in the so-called “receptacles”, which are peculiar outgrowths of the thallus. In mosses, gametangia are surrounded by special longer leaves that differ from the stem leaves.

The sporophyte consists of a foot, seta and capsule. The sporophyte’s foot is embedded in gametophyte providing a physical connection between two.. At the initial stage of development, the sporophyte is green, it contains chlorophyll and can synthetize the necessary organic substances on its own. when ripe, it loses this ability and uses nutrients supplied from the gametophyte. In the capsules, special cells undergo division (meiosis) whereby number of chromosomes halves, and daughter cells become haploid (n). Of them haploid spores originate and leave the capsule when mature. Then a new life cycle starts again. Thus, moss life cycle has two consecutive phases: haploid (gametophyte) and diploid (sporophyte) generations. In contrast to vascular plants with their long-lived sporophytes, the sporophyte of bryophytes is short-lived, attached to the gametophyte and is mostly dependent on it, whereas gametophyte is long-lived.

In addition to sexual reproduction, the majority of bryophytes can also disperse using special vegetative propaguls: gemmae or brood bodies, or can even regenerate into a whole plant from small fragments (such as a leaf or a part of the shoot).

Bryophytes are well adapted to life in high Arctic. In Svalbard they occupy extensive areas on banks of rivers and streams, on seepages, on rocks, in hollows and hummocks, and so on. They comprise an essential part of the vegetation, growing in swamps, tundra, cold polar deserts, on meadows, on cliffs and in waste places.

2.1.1. Mosses

The preliminary list of mosses includes 147 taxa, below we provide the descriptions and photos of some cryptogamic species found in Pyramiden vicinity.

***Aplodon wormskioldii* (Hornem.) R.Br. (fig. 2.1.1.1, 2.1.1.2)**

Tufts to 10 cm tall, light green. Leaves erect spreading, soft, rounded ovate, obtuse, uppermost ones with long apices. Margins of leaf lamina without teeth, cells large, hexagonal. Costa ending below the apex. Sporophyte with weak, colorless or yellowish seta 1–2 cm tall. Capsule brown or blackish, consisting of upper part (urn) and of more or less widened, rounded lower part (hypophysis). Occurs on decaying remains of animals, nesting places of skuas, dung in moist habitats, including sea coast. In mountains and Arctic.

Fig. 2.1.1.1. *Aplodon wormskioldii* (Hornem.) R.Br. Photo by O. Belkina.

Included in “The 2010 Norwegian Red List for species”, but not so rare on Svalbard.

Easily recognized by slender colorless or slightly yellowish seta, hardly widened hypophysis, rounded, obtuse or pointed leaves.

Fig. 2.1.1.2. *Aplodon wormskioldii* (Hornem.) R.Br. Photo by O. Belkina

***Aulacomnium palustre* (Hedw.) Schwägr. (fig. 2.1.1.3, 2.1.1.4)**

Tufts 2–5 cm tall, yellowish-green, with numerous brown rhizoids in lower part of stem. Leaves erect, spreading when wet and contorted when dry, oblong lanceolate, with serrulate or rarely almost entire margins, costa strong, ending below the leaf apex. Cells of lamina rounded, with thickened walls in the corners of cell, with one papilla in the center. Capsule inclined, usually asymmetric. Sometimes dense clusters of leaf-like structures are formed on the elongated leafless shoot tip; they are used for asexual reproduction. Grows in bogs, moss tundra, also near streams, puddles, and lakes. Very common on Svalbard, but rare in the Pyramiden area.

Fig. 2.1.1.3. *Aulacomnium palustre* (Hedw.) Schwägr.
Photo by O. Belkina

It can be identified by light green, yellowish color of turfs, oblong lanceolate serrulate leaves combined with growing of humid places.

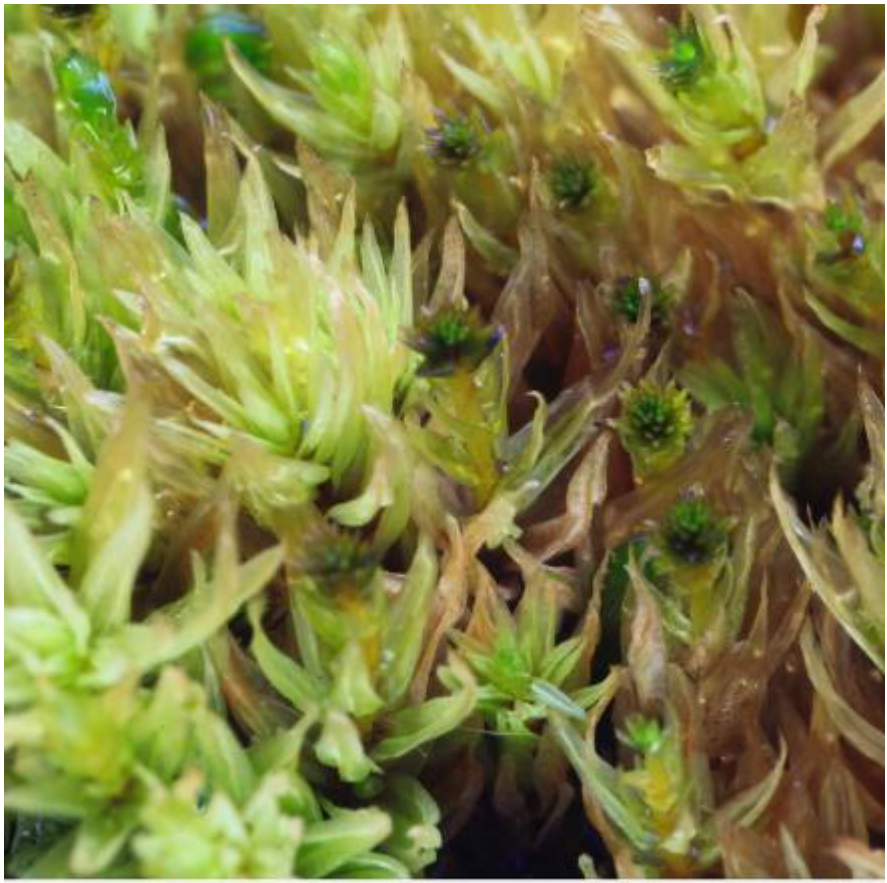


Fig. 2.1.1.4. *Aulacomnium palustre* (Hedw.) Schwägr.– plants with propagulas on the tips. Photo by D. Davydov

***Brachythecium turgidum* (Hartm.) Kindb. (fig. 2.1.1.5)**

Carpets or sometimes cushion-like tufts, whitish-green to golden, 3–10 cm tall. Stems creeping, ascending or erect, irregularly pinnate-branching. Stem leaves imbricate, concave, plicate, ovate-lanceolate, narrowed into long thin acute apex. Leaf margins narrowly recurved, entire or slightly denticulate. Costa ends above the middle of the leaf. Branch leaves are narrower and with longer costas. Leaf cells are long and narrow, square in the basal corners. Capsule inclined, oval-ovate, blended. The moss prefers moist and wet habitats: calcareous soils near streams, fens, bedrock outcrops, tundra. Widespread on Svalbard and in the Pyramiden area.

Can be distinguished by the yellowish-green or golden color, rounded or imbricate leafy shoots, straight leaves with narrowly pointed apex.

Fig. 2.1.1.5. *Brachythecium turgidum* (Hartm.) Kindb.
Photo by O. Belkina

***Campylium stellatum* (Hedw.) C.E.O. Jensen (fig. 2.1.1.6)**

Tufts loose, green, yellow-green, golden brown, glossy when dry, 3–10 cm high. Stems ascending or almost erect, irregularly branched. Leaves gradually narrowed from a rounded ovate base to squarrose (or more straight) fine long apex. Costa absent or very short and double. Leaf cells linear, in the basal angles are differentiated. Capsule inclined, elongate-cylindrical. Grows on moist and wet soil in fens, swampy meadows near springs and creeks, moss tundra, on river alluvium. Widespread on Svalbard and in the Pyramiden area.

Can be distinguished by recurved or squarrose leaves, wide, almost cordate leaf base in combination with reflexed long narrow acute apex, often yellow-green or golden-brown. From related species it differs by leaf features – lacking or short double costa, entire margins, gradual transition of the base to the narrow tip.

Fig. 2.1.1.6. *Campylium stellatum* (Hedw.) C.E.O. Jensen.
Photo by O. Belkina

***Cinclidium stygium* Sw (fig. 2.1.1.7)**

The plants form green or red-brownish turfs, 3–10 cm tall. Leaves are erect-spreading, not decurrent, from a narrow base rounded and obovate, with a short acute apex, entire margins, with red-brown border and the same colored costa, that protrudes from the leaf tip. Cells of leaf lamina are in the oblique rows, rounded-hexagonal. Seta 3–5 cm, capsule is pendent, oval, rusty-yellow when mature. Predominantly calcicole. It grows in tundra wetlands, rarely in damp gullies along waterways.

In the field, the *Cinclidium* species can be recognized by the broad-rounded leaves with clearly visible red-brown border. From other species of this genus *C. stygium* differs by non-decurrent, non-concave and abruptly pointed leaves.

Fig. 2.1.1.7. *Cinclidium stygium* Sw.
Photo by D. Davydov

***Distichium capillaceum* (Hedw.) Bruch et al. (fig. 2.1.1.8)**

Tufts green, 1–5 cm tall. Stem simple, erect. Leaves arranged in two rows. Leaf base whitish, shiny, with sheath, abruptly narrowed to squarrose, long green, denticulate, limb. Costa wide, excurrent. Seta 0,5–2 cm, capsule almost erect, symmetrical, cylindrical, light-brown. On calcareous bedrock outcrops and bare soil in tundra, on disturbed or ruderal places. Widespread in Svalbard and the Pyramiden area.

Can be distinguished by distichous long squarrose leaves with subula whitish oblong sheath. *D. capillaceum* differs from *D. inclinatum* by erect capsule vs. inclined, and less clear distichous leaves. From *D. hagenii* – by well-developed peristome.

Fig. 2.1.1.8. *Distichium capillaceum* (Hedw.) Bruch et al.
Photo by O. Belkina

***Ditrichum flexicaule* (Schwägr.) Hampe (fig. 2.1.1.9, 2.1.1.10)**

Tufts green to brownish-green, 1–5 cm tall, often forming 10–20 cm tussocks. Stem erect, mostly without branches. Leaves erect-spreading, lanceolate, gradually or abruptly narrowed to a long fine tip. Costa very wide, not clearly delimited from leaf blade. Cells thick-walled, in limb irregular, oval and square, at base – rectangular. In lower part of leaf margins bordered by transparent narrowly rhomboidal cells. Sporophytes very frequent. Capsule straight or slightly curved, narrowly elliptic, red-brown. On calcareous soil in different habitats. Widespread on Svalbard except in the region with acid bedrocks (e.g., granites). In the Pyramiden area it is common.

Fig. 2.1.1.9. *Ditrichum flexicaule* (Schwägr.) Hampe.
Photo by O. Belkina

Can be recognized by small size of plants, erect-spreading and not too narrow-pointed leaves, straight, almost cylindrical dark capsules. From other species of *Distichium* that are known on Svalbard, it differs by the characters which could be seen only under miscroscope.

Fig. 2.1.1.10. *Ditrichum flexicaule* (Schwägr.) Hampe.
Photo by D. Davydov

***Encalypta procera* Bruch (fig. 2.1.1.11)**

Tufts loose, glaucous or brownish-green, 1–2 cm tall, or solitary plants. The moss looks similar to rosette plant because of short, mostly simple stem and lingulate obtuse or shortly apiculate leaves. Cells in upper part of leaf lamina rounded-quadrate, densely papillose, whereas at the base they are almost smooth, elongate, colorless, with brownish thick cross walls and thin longitudinal walls. Capsules are covered by large cylindrical bell-like, fringed at base, calyptra. Capsule is elongated-cylindrical, striated, furrowed when dry and empty. Vegetative propagation by jointed filamentous brood bodies formed in axils of the upper leaves. On calcareous soil and fine earth, in dry and moist habitats: in tundra, polar desert, ruderal places. Sporadically distributed on Svalbard, in the Pyramiden area common.

Can be recognized by the wide, lingulate or spathulate glaucous leaves, membranous campaniform yellow calyptra. From other species of *Encalypta* it differs by having a capsule with distinct strips and furrows , filamentose propagules, fringe at the bottom of the calyptra, obtuse leaves and some other features.

Fig. 2.1.1.11. *Encalypta procera* Bruch.
Photo by O. Belkina

***Hennediella heimii* var. *arctica* (Lindb.) R.H. Zander (fig. 2.1.1.12)**

Tufts loose, dark green or brownish, less then 2 cm tall. Leaves spreading when moist and imbricate and slightly twisted when dry, concave, ovate or rounded obovate, obtuse or shortly acute. Leaf margins often serrulate because of cells protruding along the edge. Costa strong, usually terminates below apex. Cells in upper part of leaf opaque, strongly papillose, at the base smooth and transparent. Capsule oblong, erect. Lid elongated, remaining and rising above urn by column attached to bottom of urn. Peristome is absent. On clay and calcareous soils, near the sea, often in ornithogenic habitats.

This variety may be recognized by capsules with lids on, elongated column even on mature plants. From the type species (*Hennediella heimii* (Hedw.) R.H.Zander), it differs by obtuse leaves.

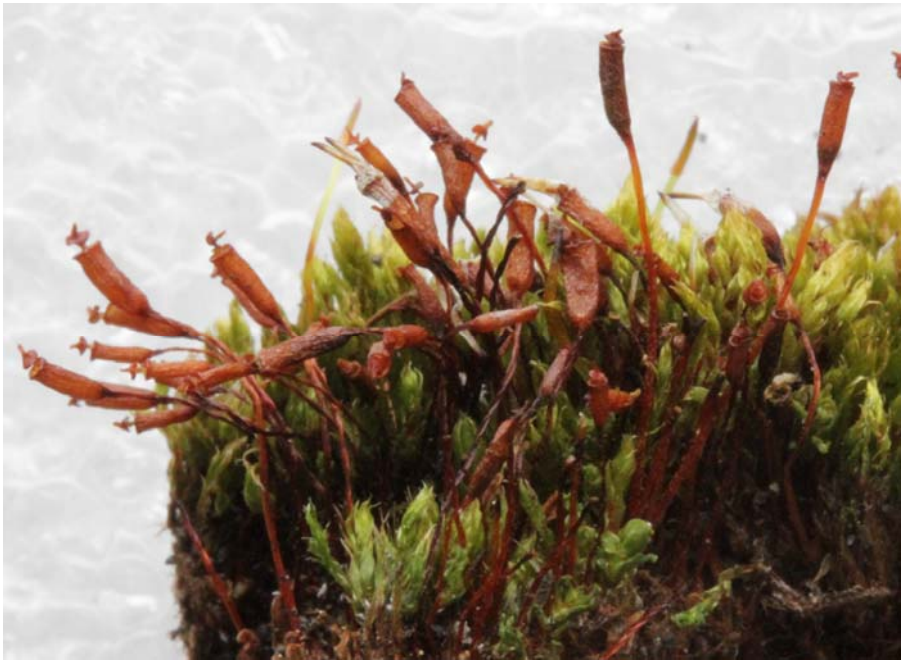


Fig. 2.1.1.12. *Hennediella heimii* var. *arctica* (Lindb.) R.H. Zander.
Photo by D. Davydov

***Hylocomium splendens* (Hedw.) Bruch et al. (fig. 2.1.1.13, 2.1.1.14)**

Carpets yellow-green, 2–10 cm tall. Stems ascending or almost erect, reddish brown, covered with dense, branched, thread-like structures – paraphyllia, bi- and tri-pinnately branched. Stem leaves concave, imbricate, from a narrow base rounded-ovate and narrowed into denticulate apex. Costa short and double or absent. Cells of lamina linear, in basal corners - short, with thick walls , orange or brown. Capsule elongate-ovate, inclined, slightly curved. On bare soils in tundra, bedrock outcrops, tussocks in bogs. Widespread on Svalbard, sporadically distributed in the Pyramiden area.

In southern regions *H. splendens* forms "annual floors". Youngest shoot initially rises vertically, but then branches in an almost horizontal plane. Next year main shoot begin to grow upward again, so every annual growth of individuals is visible. Stem leaves abruptly narrowed into tortuous denticulate apex. In Arctic, the variety of this species – *Hylocomium splendens* var. *obtusifolium* (Geh.) Paris is more frequent. It has wide ovate, not plicate obtuse stem leaves and dense pinnate or bipinnate branching without forming "annual floors".

Fig. 2.1.1.13. *Hylocomium splendens* (Hedw.) Bruch et al.
Photo by O. Belkina

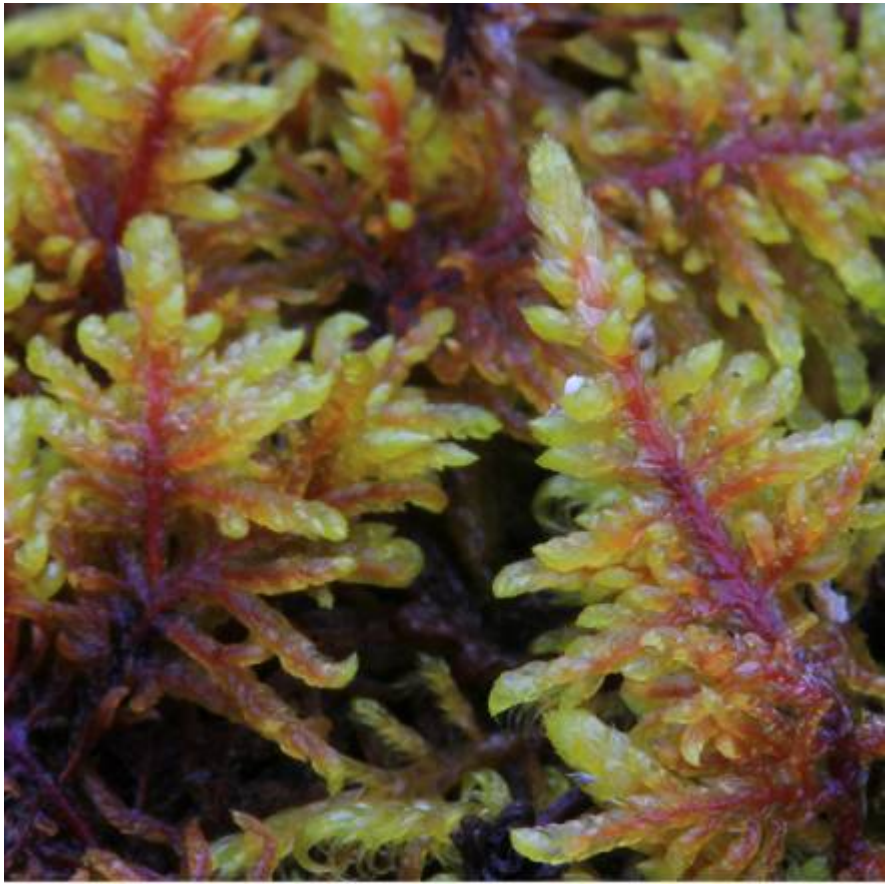


Fig. 2.1.1.14. *Hylocomium splendens* (Hedw.) Bruch et al.
Photo by D. Davydov

In Svalbard intermediate form is common: plants have leaves with abruptly narrowed, short, but almost smooth-edged tip and pinnate or bipinnate densely branching shoots.
Can be distinguished by regularly pinnate branching, red-brown stem with paraphyllia and imbricate leaves.

***Leptobryum pyriforme* (Hedw.) Wils (fig. 2.1.1.15)**

Plants form loose pale green turfs 1–3 cm tall. The leaves narrowed from the lanceolate base to the straight tip, with entire margins, with a broad, indistinctly delimited costa. Leaf laminal cells are linear. Sporophytes are very frequent. Apical leaves around gametangia are longer than others. Seta 1–4 cm, capsule horizontal or pendent, pear-shaped, yellowish-brown, later dark brown. Vegetative reproduction by rhizoidal threads, short axillary branches or oval reddish-purple gemmae formed in pairs in the leaf axils. Ruderal species. It occurs in damp or dry soil in a variety of plant communities, mostly in disturbed places, including anthropogenic habitats, for example in abandoned lawns, burnt patches, wasteland. One of the most common mosses in Pyramiden.

Fig. 2.1.1.15. *Leptobryum pyriforme* (Hedw.) Wils.
Photo by O. Belkina

In the field, *L. pyriforme* can be identified by glossy, tilted down, bulb-shaped (pyriform) capsules and narrow thread-like leaves.

***Meesia triquetra* (Richter) Engstr. (fig. 2.1.1.16, 2.1.1.17)**

Tufts 5–15 cm tall, green, rigid, dense. Stems erect. Leaves arranged in three rows, erect decurrent, oval-ovate base squarrose-recurved. Upper part of leaf narrow, keeled, with flat toothed margins. Cells shortly rectangular or rounded-polygonal, below elongate. Sporophyte with very long seta (8–10 cm), capsule curved, elongated pear-shaped, with long neck, yellow-brown. On seepages, fens, especially under slopes, often partly in water. Sporadically distributed on Svalbard, but rather rare in Pyramyden area.

Easily recognized by squarrose leaves arranged in three rows.

Fig. 2.1.1.16. *Meesia triquetra* (Richter) Engstr.
Photo by O. Belkina

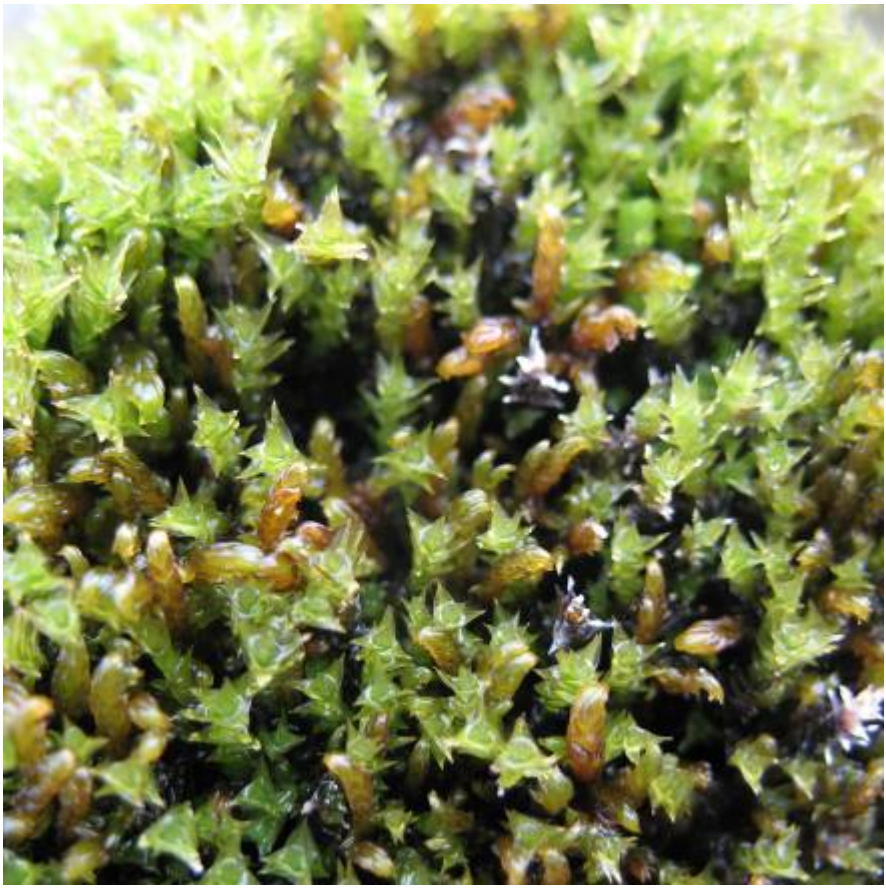


Fig. 2.1.1.17. *Meesia triquetra* (Richter) Engstr.
Photo by O. Belkina

***Niphotrichum canescens* (Hedw.) Bednarek-Ochyra & Ochyra** (=*Racomitrium canescens* (Hedw.) Brid.) **(fig. 2.1.1.18, 2.1.1.19)**

Cushions yellowish- or greyish-green, 2–10 cm tall. Stems creeping to erect, with regular and numerous short branches. Leaves erect and squarrose if moist, and appressed and flexuous if dry, from ovate base, lanceolate, acuminate or triangulate, keeled and canaliculate above, with hair at the top. Hyaline hairs straight, slightly serrulate and spinulose, papillose. Costa flattened, terminates at the middle of leaf, unclearly delimited at the top. Cells elongate-rectangular, square towards apex, strongly sinuous, densely papillose, angular cells shorter, enlarged, hyaline. Capsules straight, elliptical, reddish-brown. On stony soil, on siliceous as well as calcareous rocks covered with soil or fine earth. Widespread on Svalbard and sporadic in the Pyramiden area.

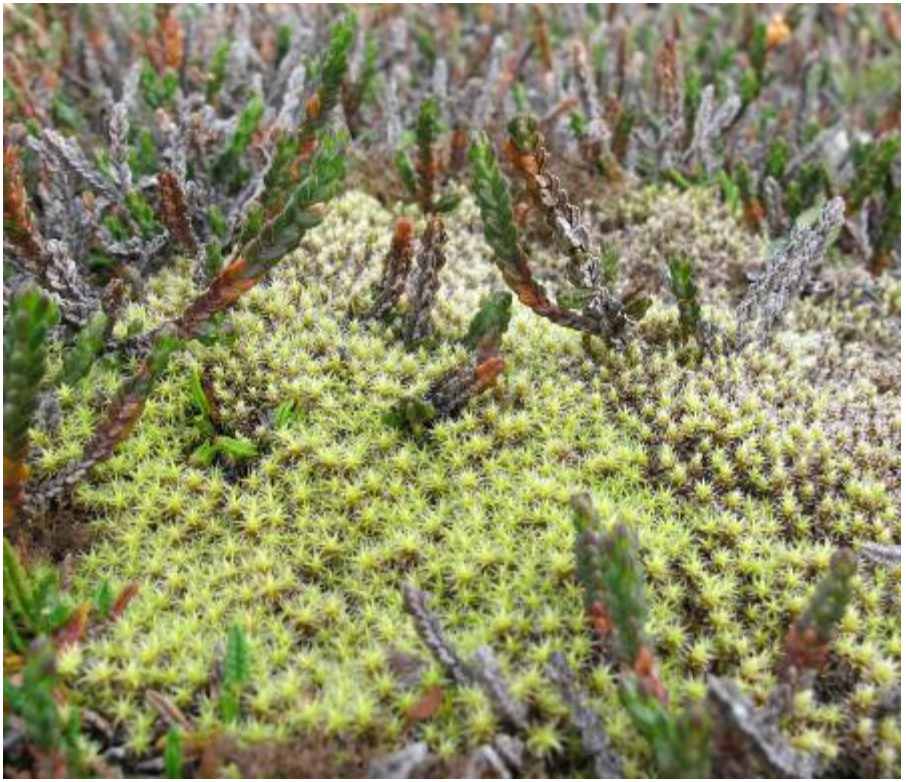


Fig. 2.1.1.18. *Niphotrichum canescens* (Hedw.) Bednarek-Ochyra & Ochyra. Photo by O. Belkina

As many Grimmiaceae, *N. canescens* can be distinguished by recurved leaves with hyaline hair-points, which gives to the cushions and tufts a hoary look. From other close species it differs by short costa, high conical papillae on the leaves, serrate and papillose hair, numerous short branches, often – grayish color.

Fig. 2.1.1.19. *Niphotrichum canescens* (Hedw.) Bednarek-Ochyra & Ochyra. Photo by O. Belkina

***Orthothecium chryseon* (Schwägr.) Bruch et al. (fig. 2.1.1.20)**

The plants form loose turfs/carpets, stems are prostrate along the substrate, ascending or erect, usually reddish, with acute, golden-yellow tips, sometimes greenish-yellow. Leaves are straight, adpressed when dry, oblong-ovate-triangular, costa short and double or absent. Leaf laminal cells are narrow, linear. Seta 2–3 cm, capsule is oblong-ovate, brownish. Sporophytes are rarely formed. Calcicole species, widespread in Svalbard. It occurs on moist soil in tundra, wetlands, along the banks of streams, on humus-covered bedrocks or on denudated stone surfaces. In the vicinity of Pyramiden, it is one of the most common mosses.

In the field, species of genus *Orthothecium* are well recognized by their reddish shoots with acute yellow tops, straight leaves and creeping tufts, sometimes forming moss hillocks. From other species *O. chryseon* differs by strongly longitudinally-plicate leaves with a short pointed tip.

Fig. 2.1.1.20. *Orthothecium chryseon* (Schwägr.) Bruch et al.
Photo by O. Belkina

***Plagiomnium ellipticum* (Brid.) T.J.Kop. (fig. 2.1.1.21, 2.1.1.22)**

Tufts green, 3–10 cm tall. Stems erect, covered with brown filamentous rhizoids, especially below. Leaves rounded-ovate or wide-elliptic, abruptly narrowed into short point, hardly decurrent. Leaf margins denticulate or rarely almost entire, bordered with 2–3 rows of narrow long green cells. Other leaf lamina cells rounded-hexagonal, arranged in oblique rows. In fertile plants, the upper leaves are larger, rhomboid, with a longer narrow apex. Capsules pendulous, oval. In moist and wet habitats: in fens, on stream banks, hollows in moss tundra. Sporadically on Svalbard. In the Pyramiden area *P. ellipticum* is rare, probably avoiding calcareous substrates there. This species was found near and under gull colonies on buildings and other constructions.

Fig. 2.1.1.21. *Plagiomnium ellipticum* (Brid.) T.J. Kop.
Photo by O. Belkina

Can be recognized by soft light green oval leaves with small tooth and little acute apiculus. Differs from genus *Cinclidium* by decurrent base and absence of reddish border.

Fig. 2.1.1.22. *Plagiomnium ellipticum* (Brid.) T.J. Kop.
Photo by O. Belkina

***Pohlia wahlenbergii* (F.Weber & D.Mohr) Andrews** (=*Mniobryum wahlenbergii* (F.Weber & D.Mohr) Jenn. **(fig. 2.1.1.23, 2.1.1.24)**

Tufts light glaucous or light-green, 2–10 cm tall. Stems erect, simple, reddish. Leaves distant, strongly cringe when dry, erect spreading when moist, acute, ovate-lanceolate to (rarely) lanceolate, decurrent along the stem. Costa strong reddish at the base, terminates below apex. Cells rhomboidal-hexagonal. Capsules inclined to pendulous, brown, ovate. Vegetative propagation by dark red brood buds or short branches formed in leaf axils. In or near running water: in springs and shallow creeks, river banks, flow-through swamps, late snow places. Apparently "dislikes" calcareous substrates. Sporadically on Svalbard and in the Pyramiden area.

Fig. 2.1.1.23. *Pohlia wahlenbergii* (F.Weber & D.Mohr) Andrews.
Photo by O. Belkina

Can be easily distinguished by light glaucous color in combination with suitable habitats, reddish weak simple stem, ovate-lanceolate leaves well-spread along the stem. The latter helps to differentiates *P. wahlenbergii* from *Philonotis* species, which often have similar color and reddish stem. But leaves of *Philonotis* spp. are more narrowly pointed, with recurved margins on both sides.

Fig. 2.1.1.24. *Pohlia wahlenbergii* (F.Weber & D.Mohr) Andrews.
Photo by O. Belkina

***Polytrichastrum alpinum* (Hedw.) G. L. Smith (fig. 2.1.1.25, 2.1.1.26)**

Tufts loose, green or brownish, 2–8cm tall, often growing as spaced plants. Stems erect, usually simple. Leaf has erect yellowish sheath at the base and spreading or recurved narrow denticulate upper portion. Lamina of the upper part is very rigid due to numerous longitudinally attached green lamellae. Lamellae cover almost entire ventral (upper) surface of lamina . They participate in photosynthesis. In cross section every lamella looks like one row of green l cells containing chlorophyll, the terminal cell is rounded and strongly incrassate, papillose at the top. Costa excurrent into a short brown toothed awn.

Fig. 2.1.1.25. *Polytrichastrum alpinum* (Hedw.) G. L. Smith.
Photo by O. Belkina

Male and female organs are formed on different individuals. Fertile male plants are easy to distinguish by a rosette of leaves around anteridia on the stem top. Few "floors" of the previous rosettes can be seen on the fertile male plants. Capsule mostly erect, cylindric, slightly asymmetric and curved, not ribbed. On soil, sand, turf, fine earth in different humid habitats and in different plant communities. Widespread on Svalbard and in the Pyramiden area.

Can be recognized by thick rigid needle-like leaves with brown awns at the top. Margins of leaves are toothed, not incurved on upper side and not membranous.

Fig. 2.1.1.26. *Polytrichastrum alpinum* (Hedw.) G. L. Smith.
Photo by O. Belkina

***Polytrichum hyperboreum* R.Br. (fig. 2.1.1.27, 2.1.1.28)**

Plants are similar to previous species. Leaf structure in general also looks similar to *Polytrichastrum* species. But uppermost cell larger than other, thin-walled , rounded conical or flask-like. Margins of leaf blade without teeth, membranous, incurved to about the middle of the leaf, overlapping, completely enclosing the lamellae. Costa excurrent into a bicolor awn: brown at the base and colorless distally. Fertile male plants with crown of leaves around anteridia similar to *Polytrichastrum alpinum*. Capsules erect, almost cubic shape, 4-angled, with distinct hypophyses under urn. On soil, fine earth, turfs in tundra and polar desert, on rocks, solifluction lobes, moraines and similar areas. This species more frequent in Extreme North. Widespread on Svalbard and in the Pyramiden area.

Fig. 2.1.1.27. *Polytrichum hyperboreum* R.Br.
Photo by O. Belkina

The habit of *P. hyperboreum* is similar to other species of *Polytrichum* and *Polytrichastrum,* but *P. hyperboreum* has incurved membranous margins and bicolor awn.

Fig. 2.1.1.28. *Polytrichum hyperboreum* R.Br.
Photo by O. Belkina

***Pseudocalliergon turgescens* (T.Jensen) Loeske (*Scorpidium turgescens* (T.Jensen) Loeske) (fig. 2.1.1.29, 2.1.1.30)**

Tufts golden-yellow, yellow-green or brownish-green, 6–10 cm tall. Stems prostrate, ascending or almost erect, irregularly branched. Leaves imbricate, concave, broadly ovate, obtuse, with short narrow recurved apiculus. Costa short, single or with branch. Cells narrow and long, incrassate, in basal corners - square or oval. Sporophytes rare. Vegetative reproduction is by fragile apical buds.

Fig. 2.1.1.29. *Pseudocalliergon turgescens* (T.Jensen) Loeske.
Photo by O. Belkina

On calcareous soils in wet habitats – on swampy tundra, seepages, especially at the bottom of slopes rarer in fens and coastal meadows. Widespread in some regions of Svalbard where calcareos bedrocks are present, including the Pyramiden area.
Can be recognized by rounded leafy, turgid plants often with pencil-like tips, as well as reflexed narrowed apexes of the leaves.

Fig. 2.1.1.30. *Pseudocalliergon turgescens* (T.Jensen) Loeske.
Photo by O. Belkina

***Psilopilum laevigatum* (Wahlenb.) Lindb. (fig. 2.1.1.31)**

Groups of spaced plants or tufts green, 0,5–2 cm tall. Leaves rigid, erect spreading when moist and appressed when dry, concave, slightly cucculate, elliptical, obtuse, in some places slightly bordered by rhomboidal cells, in upper part with irregularly denticulate margins. Costa strong, with tall wavy lamellae on upper (ventral) surface. The cells of lamellae are uniform, green , they substantially increase the photosynthesizing surface of leaf. Cells of leaf lamina short, towards the base more elongated. Capsule thick, curved, broadly oval. Occur on moist sandy, clayey or loamy bare soils, often along rivers and stream. Widespread in Svalbard, rarer in the Pyramiden area.

Psilopilum species can be recognized by lamellae in upper surface of costa, imbricate shoots, small size. *P. laevigatum* looks similar to *P. cavifolium* (Wilson) I.Hagen, which is also known from Svalbard. Differences between two can be seen only under the microscope.

Fig. 2.1.1.31. *Psilopilum laevigatum* (Wahlenb.) Lindb.
Photo by O. Belkina

***Sanionia uncinata* (Hedw.) Loeske (fig. 2.1.1.32, 2.1.1.33)**

Carpets or tufts green, yellow-green or golden-yellow. Stems 2–10 cm tall, creeping, ascending or erect, pinnately branched, with uncinate tops. Leaves sickle curved, one-sided facing plicate, ovate-lanceolate, finely pointed. Costa thin, long, terminates at the apex or lower. Cells of leaf lamina linear, vermiform; angular cells few, short. Sporophyte with curved inclined or horizontal capsule. On wet or dryer habitats: bogs, fens, tundra, bedrock outcrops, polar deserts. On various substrates: soils, fine earth, stones, decaying wood. Widespread on Svalbard and in the Pyramiden area.

Fig. 2.1.1.32. *Sanionia uncinata* (Hedw.) Loeske.
Photo by O. Belkina

Can be recognized by its yellowish color, pinnate branching, strongly uncinate shoots, falcate and secund leaves. From two other species of *Sanionia* (*S. georgicouncinata* (Müll.Hal.) Ochyra & Hedenäs and *S. orthothecioides* (Lindb.) Loeske) it differs in fine details of morphology and anatomy of leaves and of sporophyte structures.

Fig. 2.1.1.33. *Sanionia uncinata* (Hedw.) Loeske.
Photo by O. Belkina

***Splachnum vasculosum Hedw.* (fig. 2.1.1.34)**

The plants form compact green cushions or turfs 2–5 cm tall. Upper leaves are larger, from a narrow base broadly ovate, narrowed in an obtuse apex, margins entire or slightly denticulate. Leaf lamina cells are large. Seta 1–3 cm. Capsule consists of a very wide, spherical dark purple-bordeaux lower portion – hypophysis – and a narrow, short-cylindrical yellow-brown urn (fig. 2.1). It is confined to dung in wet places. It is believed, to be entomophilous like other *Splachnum*-species.

In the field, it clearly differs from the other species of the genus *Splachnum* by conspicuous reddish-purple capsules with a spherical inflated hypophysis and very wide leaves with blunt tips.

Fig. 2.1.1.34. *Splachnum vasculosum* Hedw.
Photo by D. Davydov

Stereodon revolutus **Mitt. (*Hypnum revolutum* (Mitt.) Lindb.) (fig. 2.1.1.35, 2.1.1.36)**

Carpets brownish green, golden-brown. Stems prostrate or ascending, pinnately branched. Leaves falcate or erect, plicate, concave, from narrowly ovate base elongate lanceolate, shortly acuminate. Leaf margins entire, revolute from base to apex. Costa short and double. Cells linear. slightly flexuose, incrassate, in angles of the leaf base - numerous, square, yellowish. Sporophytes very rare. On calcareous rocks covered with fine earth, in dry and exposed habitats, sometimes in moist places. Scarce on Svalbard, common on rocky places in the Pyramiden area.

Fig. 2.1.1.35. *Stereodon revolutus* Mitt.
Photo by O. Belkina

Can be recognized by the prostrate yellowish-brown carpets, pinnate stems, slightly falcate leaves, all these features in conjunction with occurrence on rocky substrate.

Fig. 2.1.1.36. *Stereodon revolutus* Mitt.
Photo by O. Belkina

***Syntrichia ruralis* (Hedw.) F.Weber & D.Mohr** (=*Tortula ruralis* (Hedw.) P.Gaertn., B.Mey. & Scherb.) **(fig. 2.1.1.37, 2.1.1.38)**

Tufts brownish-green, yellow-green, sometimes reddish-brown below, 1–10 cm tall. Leaves incurved, appressed when dry and squarrose when moist, keeled, oblong, narrow lingulate, with obtuse apex. Costa excurrent from the leaf top into a long toothed colorless hair. Cells of leaf rounded, square to hexagonal, densely papillose, opaque in upper part of lamina. At base, cells elongate, smooth and transparent, form a border. Sporophyte with erect, slightly bent, narrow ovate to cylindrical, brown capsule.

Fig. 2.1.1.37. *Syntrichia ruralis* (Hedw.) F.Weber & D. Mohr.
Photo by O. Belkina

Teeth of peristome long, very narrow, spirally twisted. In dry habitats: stony soils on slopes, bedrock outcrops, stable screens, in tundra, polar deserts as well as near sea birds colonies. Widespread on Svalbard and in the Pyramiden area.
Can be recognized by the long hyaline hairs and obtuse brownish squarrose leaves.

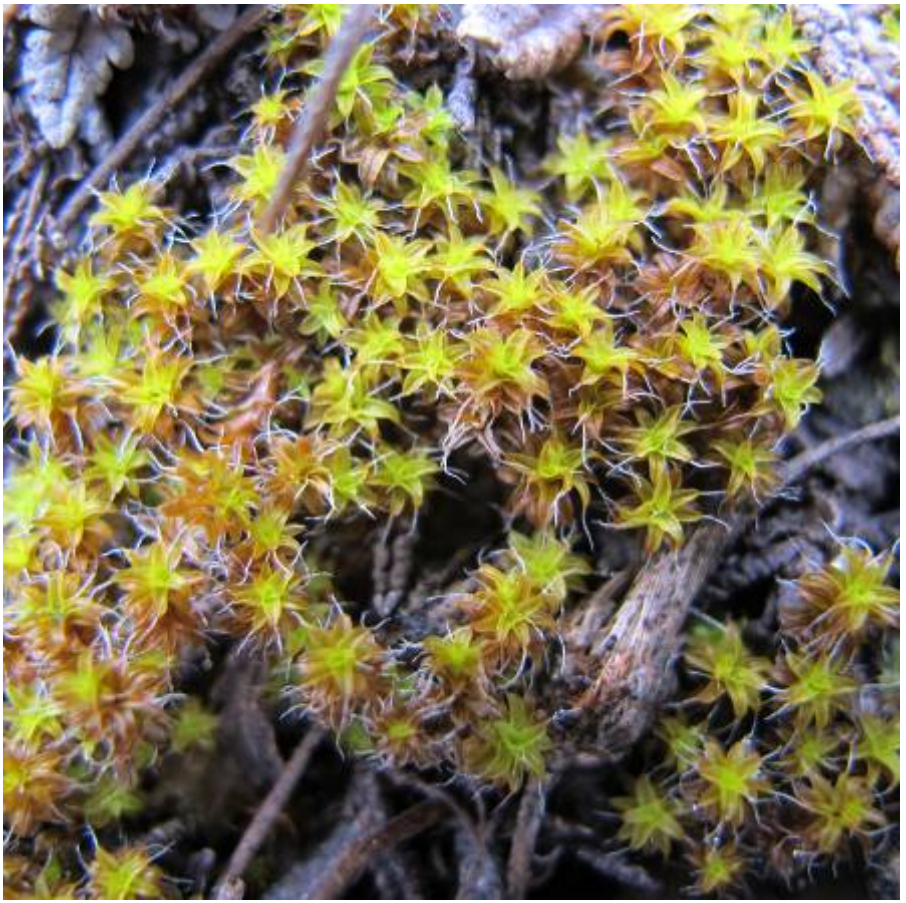


Fig. 2.1.1.38. *Syntrichia ruralis* (Hedw.) F.Weber & D. Mohr.
Photo by O. Belkina

***Timmia austriaca* Hedw. (fig. 2.1.1.39, 2.1.1.40)**

Tufts green, yellowish-green to olive-green, 5–10 cm tall. Leaves slightly curved when dry and spread when moist. Leaf elongate-lanceolate, differentiated in two parts: brownish-orange sheath and limb; limb–sheath transition abrupt, sharply angled. Leaf margins roughly serrate. Cells square or irregular in shape, with one conical mamilla on ventral (upper) surface and smooth on back) side. Sheath lamina cells smooth or with papillae on underside. Costa strong, reddish-brown.

Fig. 2.1.1.39. *Timmia austriaca* Hedw.
Photo by O. Belkina

Capsules oval, incline, furrowed when dry. On shale and limestone bedrocks covered with humus and fine earth, in tundra and polar deserts. Common on Svalbard and in the Pyramiden area.
Can be recognized by the spreading elongate serrate leaves with brownish-orange sheaths.

Fig. 2.1.1.40. *Timmia austriaca* Hedw.
Photo by O. Belkina

***Tomentypnum nitens* (Hedw.) Loeske (fig. 2.1.1.41)**

The plants form the yellow-green, often large tufts or tussocks. Stems erect, pinnately branched, up to 2–8 cm tall. Leaves upright, straight, triangular-lanceolate, long-pointed, longitudinally plicate, margins entire. Costa simple, terminates the top. Leaf cells are linear, shorter in the base of the leaf blade. Sporophytes are rare. *T. nitens* grows in moss tundra, bogs, and wetlands along streams. Usually in moist and damp habitats, but sometimes in a rather dry tundra with *Dryas octopetala*.

Fig. 2.1.1.41. *Tomentypnum nitens* (Hedw.) Loeske.
Photo by O. Belkina

One of the most common mosses in the Pyramiden area. Co-dominates in some plant communities.

In the field, it can be identified by a yellow-green color, acute straight triangular strongly longitudinally plicate leaves, pinnate branching.

Fig. 2.1.1.42. *Tomentypnum nitens* (Hedw.) Loeske.
Photo by O. Belkina

2.1.2. Liverworts

A preliminary list of liverworts in the surroundings of Pyramiden town includes 38 taxa. Thirteen of them are included in the Atlas.

Photos and descriptions of some liverwort species

***Aneura pinguis* (L.) Dumort. (fig. 2.1.2.1)**

Dark green liverwort with simple not or only sporadically furcated fleshy opaque thallus without any midrib ca. 2–7 mm wide and 10–15 homogeneous cells high. Cells of thallus contain numerous (up to 40–50 per cell) oil bodies. Male plants are smaller than female ones, androecia usually in groups of 3–4 pairs of antheridia. Female plants with clavate calyptra that are hairy or scaly, to 15 mm long. One of the commonest liverwort in Svalbard. In surroundings of Pyramiden town the species is also quite common. It is restricted to well moistened sites on slopes of brooks, banks of streams, and on walls of solifluction lobes . It occurs mainly as solitary thalli on bare soil or on bryophytes or mixed with mosses and lichens.

Fig. 2.1.2.1. *Aneura pinguis* (L.) Dumort. (dark green thalli between mosses). Photo by N. Konstantinova

***Anthelia juratzkana* (Limpr.) Trevis (fig. 2.1.2.2)**

A very small liverwort, it does not exceed 1–3 mm wide and 7 mm long. It often forms quite characteristic thin bluish-grey or grey crust or whitish grey mats on exposed sites or occurs as scattered shoots among other bryophytes and then it can have yellow-brownish secondary pigmentation. Shoots are three-ranked, with 2 lobed lanceolate leaves divided up to 0.5–0.65 of their length and similar in shape and size to underleaves (the third row of leaves). Both leaves and underleaves are usually appressed and closely imbricate to the stem. The species has paroicous "inflorescens" (male gametangia are situated just below female) and is often fertile. Female bracts and bracteoles are larger than sterile leaves and underleaves. Perianth is wide ovoid and hidden in bracteoles. The species is very common on Svalbard but, it occurs in Pyramiden area rather sporadically because of a preference to acid substrates that are rather rare in this area. Restricted to snow bed communities, occurring as well on soil on spots in spotty tundra, on sides of hillocks, on dead mosses and in crevices and under crust of lichens.

Fig. 2.1.2.2. Gray carpet of *Anthelia juratzkana* (Limpr.) Trevis.
Photo by Konstantinova

***Clevea hyalina* (Sommerf.) Lindb. (fig. 2.1.2.3)**

Thalli (3)5–8 cm long and 1.5–6 mm wide, pale green to brownish, often with a reddish tinge, simple or dichotomously branched, occasionally with ventral innovations. Ventral scales are hyaline at least apically, in 2 rows, often numerous especially near apex and project over the sides of the thallus. The cells of scales have no oil bodies. Male and female plants intermixed, male plants are smaller and antheridia are scattered in the middle of thallus. Female plants are characterized by dorsal position of gynoecium. Arctic-alpine circumpolar species which was referred as a rare hepatic in Svalbard by Frisvoll & Elvebakk (1996). It seems to be not rare in calcareous areas in surroundings of Pyramiden. The species grows on moist clay, along the edges of bare soil in spotty tundra, on clay soils under rocks in rock fields, at the bottom of slopes of brooks, on bare soil at the bottom of hillocks. Besides the typical variety, var. *rufescens* is not rare in the area.

Fig. 2.1.2.3. *Clevea hyalina* (Sommerf.) Lindb. with female receptacles originated from the middle of thallus.
Photo by N. Konstantinova

***Gymnomitrion concinnatum* (Lightf) Corda (fig. 2.1.2.4)**

Small plants, usually 0.3– 0.5 mm wide and 5–20 mm long, worm-like, green or silver green in upper part and often light brown below. They often form dense turfs, carpets or cushions or occur as solitary individuals on the ground or among other bryophytes. Sterile plants are terete, bracts are larger than leaves and fertile plants look clavate. Fine papillose cuticle of leaves is characteristic for species. Leaves are divided up to 0.35 of their length with acute lobes and intact marginal cells. It grows on acid and neutral substrates, common on Svalbard (Frisvoll & Elvebakk, 1996). In the Pyramiden area it is rather rare and restricted to fine earth between calcareous rocks.

Fig. 2.1.2.4. *Gymnomitrion concinnatum* (Lightf) Corda.
Photo by N. Konstantinova

***Marchantia polymorpha* L. subsp. *montivagans* Bischl. & Boissel.-Dub. (fig. 2.1.2.5)**

Marchantia polymorpha L. subsp. ***montivagans*** Bischl. & Boissel.-Dub. (*M. alpestris* (Nees) Burgeff). Relatively large hepatic, up to 5–10 mm wide and 20–30 mm long. Plants are green to dark-green, often bearing vegetative propagules in so called baskets. This arctic-montane circumpolar species is not rare on Svalbard.

Fig. 2.1.2.5. *Marchantia polymorpha* L. subsp. *montivagans* Bischl. & Boissel.-Dub. with "baskets" in centrum of thalli.
Photo by N. Konstantinova

***Preissia quadrata* (Scop.) Nees (fig. 2.1.2.6)**

Large plants, grey-green with often purplish- brown or brownish margins. Thalli are 4–6 mm wide and 2–4 cm long, on the ventral side there are 2 rows of purple to blackish purple scales ending in a lanceolate appendage. The dorsal surface is obscurely reticulate, with one barrel-shaped pore in the center of polygons. Male and female receptacles are stalked, stalks with 2 rhizoid furrows, male disks are almost circular. This species occurs on bare clay soils, on loam at the bottom of rocks, on sides of hillocks, on slopes to brooks, on clay along small brooks, sometimes on moss remnants. The species is very common on Svalbard growing in areas with both calcareous and neutral rocks. In the surroundings of Pyramiden, it occurs rather sporadically, usually as single plants mixed with other thalloid hepatics, particularly *Sauteria alpina*.

Fig. 2.1.2.6. *Preissia quadrata* (Scop.) Nees.
Photo by D. Davydov

***Ptilidium ciliare* (L.) Hampe (fig. 2.1.2.7)**

Plants are olive green to brown and reddish brown, relatively large, up to 30–40 mm long and 1.5–2.0 mm wide. Underleaves are similar to leaves in size and shape, so the plants look like they have three rows of leaves. Leaves are asymmetrical, unequally bilobed, at 0.4–0.5 of the length thelobes are divided again so, as a result, leaves look like four-lobed. Dorsal lobe is largest, 11–30 cells wide. All lobes have numerous cilia which are shorter than the basal width of dorsal lobe. Male plants smaller than female ones, with bracts similar to the leaves. Gyneceum at apex of the main shoot, bracts concave and divided not more than 0.25–0.3 of their length, male bracts are the same size as leaves, female bracts are slightly larger. Sporophytes were not recorded on Svalbard. Very fine hepatic that

occurs mostly on soils in well moistened ground level in dwarf shrub-and-moss tundra, sometimes abundant. Accordingly Frisvoll and Elvebakk (1996) say the species is quite common on Svalbard however, in surroundings of Pyramiden, it is rare and never abundant. It is because of prevalence of calcareous rocks in the area.

Fig. 2.1.2.7. *Ptilidium ciliare* (L.) Hampe.
Photo by N. Konstantinova

***Sauteria alpina* (Nees) Nees (fig. 2.1.2.8)**

Fig. 2.1.2.8. *Sauteria alpina* (Nees) Nees with female receptacles.
Photo by N. Konstantinova

Plants are light to whitish- or yellowish-green, without any trace of secondary pigmentation, *thalli* (1)3–5 (8) mm wide, (6)9–14 mm long, rather fleshy to almost spongy or in basal parts almost flat, simple or sparingly dichotomously branched, sporadically with ventral branches, branches lingulate or ovate lingulate with rounded or notched apex, sometimes dorsal epidermis damaged with age and surface became lacunose. *Androecia* small, on both shortened ventral branches and lateral branches or dorsally situated on leading thallus behind the female receptacle. In most specimen collected on Svalbard, both paroicous and authoicous plants were present. Moreover, paroicous thalli occur much more seldom than authoicous ones. In some cases, several male branches were recorded nearby the female thalli. Close investigation showed that male and female branches were connected in rosettes but might look like pseudodiocous because of decayed basal parts. One of the commonest hepatic on Svalbard. In some places near Pyramiden, the species is particularly abundant.

***Scapania cuspiduligera* (Nees) Muell. Frib. (fig. 2.1.2.9)**

Green, rarely with older leaves brownish, small, only 1–2 mm wide and 8–15 mm long hepatic. A characteristic of the species is a crispate facies of the plants, combination of green color of the shoots with clusters of dark red to brown gemmae at the top of the shoot as well as subequally bilobed leaves. In surroundings of Pyramiden the species occurs usually as solitary plants as a pioneer on spots of bare soil and fine earth in spotty tundra, on calcareous ground, under *Cassiope tetragona* and *Dryas* cushions. It is probably not rare in the area but overlooked because of its small size and growth as solitary plants creeping on the ground.

Fig. 2.1.2.9. *Scapania gymnostomophila* Kaal. Photo by N. Konstantinova

***Schistochilopsis grandiretis* (Lindb.) Konstant. (*Lophozia grandiretis* (Kall. Schiffn.) (fig. 2.1.2.10)**

Middle size plants which form small cushions or mixed with other bryophytes. Shoots are usually up to15 mm long and 1–1.5 mm wide, mostly fleshy. Stems are light green in the upper parts, purplish-brown at the bases. Leaves are green to red-brown at the bases, 3–5 lobed, undulate, 1.5–2 times as wide as long, and divided by mostly rectangular sinuses up to 0.4 of their length. Microscopically, the species is characterized by very large thin-walled cells up to 40–50 μm wide and have numerous (up to 40–50 per cell) small oil bodies. In the surroundings of Pyramiden, we collected this species several times on peat soils under Cassiope cushions and on the sides of hillocks in plant communities dominated by *Dryas*, *Salix polaris*, *Cassiope tetragona,* lichens and mosses. Very rare on Svalbard, it was reported previously only from a single location near Longyerbyen and in Bockfjorden.

Fig. 2.1.2.10. *Schistochilopsis grandiretis* (Lindb.) Konstant.
Photo by N. Konstantinova

***Schljakovianthus quadrilobus* (Lindb.) Konstant. & Vilnen [*Barbilophozia quadriloba* (Lindb.) Loeske] (fig. 2.1.2.11)**

Plants are brown to blackish-brown or, rarely, olive green, 0.8–1.3 mm wide and to 20–30 mm long. Leaves are divided up to 0.5–0.7 of their length into 2–4 lobes, sinuses are gibbous, margins of leaves are characteristically reflexed and have thread-like teeth or appendages at ventral leaf bases. Underleaves are large, with lamina divided in two lobes, with numerous cilia at the base. Cuticule of leaves is strongly verruculose-papillose. Dioecious. Male bracts similar to the leaves, female bracts slightly larger than leaves and 4–5 lobed. Besides the typical variety, var. glareosa (Jørg.) Jørg. was collected. Species is common and often abundant in surroundings of Pyramiden where it occurs on the soil and rocks covered by soil, on edges of temporary streams from snow fields, near seepage, on slopes near melting snow and in snow beds.

Fig. 2.1.2.11. *Schljakovianthus quadrilobus* (Lindb.) Konstant. & Vilnen. Photo by D. Davydov

***Tritomaria quinquedentata* (Huds.) H.Buch (fig. 2.1.2.12)**

Relatively large plant, 2–4 mm wide and to 15–20 mm long. The species is characterized by asymmetric 3-lobed leaves with usually large concave ventral lobe, all three lobes end in cuspidate or apiculate one-celled apices, which are formed by not elongated cell. Male and female plants occur rarely, sporophytes were not recorded in this region whereas they are not rare on Svalbard. In the Pyramiden area the species grows on the soil among dwarf shrubs and mosses, on hillocks and along brooks. The species is one of the most widespread and abundant on Svalbard.

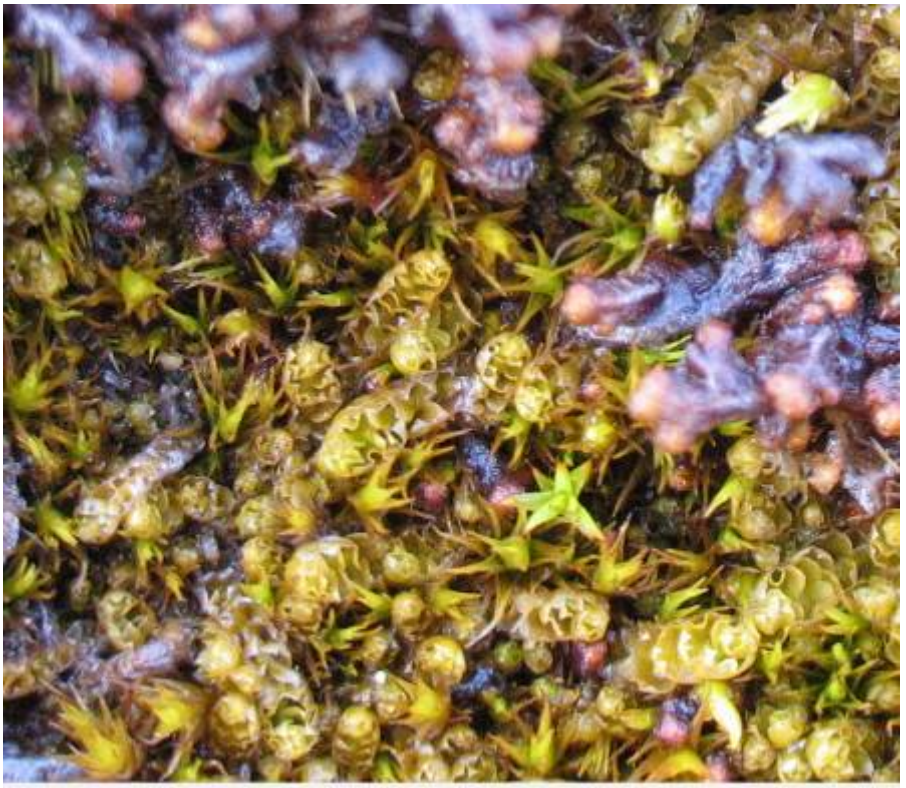


Fig. 2.1.2.12. *Tritomaria quinquedentata* (Huds.) H.Buch (gelb-green) and *Ptilidium ciliare* (L.) Hampe (red-brown from the right).
Photo by N. Konstantinova

2.2 Lichens

Lichens are the group of organisms whose thallus consists of two or more components. The first of them – a fungus (or mycobiont), and there can be several species of fungi in one lichen thallus. The body of fungus consists of mycelium, a set of thin branching filaments (hyphae), which represent chains of very long cells. Interweaving dense fungal hyphae form various lichen thalli. Singular cells, clusters or continuous layers of algae and (or) cyanoprokaryota are located in between hyphae. Those are the second component of lichen, so-called photobiont. The photobiont, or lichen photosynthetic system, can comprise several species of algae (or cyanoprokaryota). The latter are often collected in a special gall-like structure – cephalodia.

Algae contain photosynthetic pigments, by which they produce organic compounds used by the algae's and cyanoprokaryota's cells themselves as well as got consumed by mycobiont. The fungus of lichen thallus, in turn, absorbs water and other mineral substances from the environment, protects algae against mechanical destruction and environmental stress. Tiny hyphae easily go in between soil particles, into fine cracks of stones and wood, and firmly attach lichen thallus to the substrate. A certain species of fungus in combination with a certain species of algae (or/and cyanoprokaryota) forms a certain species of lichen.

Lichens reproduce vegetatively by soredia, isidia and pieces of thallus, which easily breaks off, its parts entrench to the suitable substrate and give rise to new lichens thalli. In most lichens, fungal component is able to reproduce independently, forming fruiting bodies (apothecia, perithecia, basidioma) with spores of sexual reproduction, or pycnidia (asexual spores). But such sporas must meet the algae (and/or Cyanoprocaryota) cells of the proper kind to provide growth of the lichen organism. The probability of this is not very high, that's why some lichens reproduce vegetative. Therefore, some fungal spores have "to catch" the algae cells from parent thallus, that allows them to arise new thallus without any additional "search" of partner-photobiont.

All various forms of lichen thalli however, belong to a few main types, or life forms: fruticose, foliose and crustose. Fruticose lichens include vertically orientated, more or less cylindrical or ribbon-like branched thalli attached to the substrate only by their lower part. Foliose lichens are flattened, horizontally oriented plates, often with lobes on the edges. They are attached to the substrate by rhizinae or special outgrowth of the lower surface of thallus (umbilicus). Crustose lichens represent crust on the substrate, and even partially within it. They are firmly attached to substrate, and it is not possible separate the thallus without damaging it.

Like mosses, lichens can dry out under dry conditions and stop their physiological processes and growth. They return to an active life again after being moistened.

Lichens grow on stones, on the wood; they are well-adapted to a variety of environmental conditions, including extreme cold. Currently, the list of lichens discovered in the surroundings of Pyramiden includes 168 species.

Photographs and descriptions of some lichens species

***Aspicilia nikrapensis* Darb. (fig. 2.2.1)**

Thallus 3−4 cm wide, along margins breaks up into discrete flat parts (areolae), therefore the edge looks like a fringe. Upper part is white, sometimes slightly pinkish, noncorticate, fluffy. Towards the center it becomes continuous, rimose. Apothecia are 0.4−0.7 mm wide, disc pruinose.

This lichen grows on sandstones. On Svalbard the species is common and widespread; outside the archipelago is known from arctic North America.

Fig. 2.2.1. Thallus of *Aspicilia nikrapensis* Darb., on the left – the thallus of *Rhizocarpon* sp. with apothecia.
Photo by L. Konoreva

***Baeomyces rufus* (Huds.) Rebent. (fig. 2.2.2)**

Thallus is dimorphic, consists of two parts. Horizontal part of thallus is greenish or pale white-grey, granular, sometimes verruculose, squamose, covers the surface of the substrate. Soredia are present. Podetia (the vertical part of the thallus, protuberances with apothecia) are bacilliform, 2–6 mm high, cylindrical or compressed. Apothecia are pink to reddish-brown, 1–4 mm wide.

This species grows on the stone and soil in the moist places. Frequently they inhabit the rocks (Devonian sandstones), rare – siliceous rocks. On Svalbard it is known from a few scattered locations. Species is widely distributed in both hemispheres.

Fig. 2.2.2. *Baeomyces rufus* (Huds.) Rebent. with dark brown apothecia.
Photo by L. Konoreva

***Brodoa oroarctica* (Krog) Goward (fig. 2.2.3)**

Thallus is foliose, irregularly spreading and loosely attached; lobes are solid, 0.5−0.8 mm broad, terete or flattened. Upper side is grey to brownish-grey to almost black; lower side is black, wrinkled, without rhizinae; lacking soredia or isidia. Apotecia were absent in Svalbard specimens.

This species grows on rocks protected by snow in winter. On Svalbard it is common and widespread. Overall range is circumpolar, in the Arctic and Alpine mountains.

Fig. 2.2.3. *Brodoa oroarctica* (Krog) Goward.
Photo by L. Konoreva

***Caloplaca tetraspora* (Nyl.) H. Olivier (fig. 2.2.4)**

Thallus is thin, presented by whitish or grayish crust, or inconspicuous. Apothecia up to 1.5 mm in diameter, initially are flat, become strongly convex when mature.

Disc is rusty red to reddish-brown, sometimes almost black; without thalline margin in the mature. The species can be easily distinguished by convex reddish-brown to rusty-red apothecia and 4-spored asci.

It grows on plant (mainly mosses) litter, is common species on Svalbard. Circumpolar range, in the Arctic and Alpine mountains.

Fig. 2.2.4. *Caloplaca tetraspora* (Nyl.) H. Olivier.
Photo by D. Davydov

Cetrariella delisei (Bory ex Schaer.) Kärnefelt & Thell (fig. 2.2.5)

Thallus is fruticose, consists of vertical lobes assembled together and forming small cushions ca. 3 cm tall. The lobes are extensively branched, especially near the tips. Upper and lower surfaces are of the same color, from light to dark brown. Soredia and isidia are absent; lobes matt or slightly shiny, with pseudocyphellae (bark breakages whereby the air penetrates into thallus). Margins with short visible cilia. The lobes at the thallus base are often dark, yellowish-black or yellow. Apothecia are frequent, the same color as the thallus, developed on the tips of lobes.

It grows in snow-bed communities in depressions which are wet for a long time. The species is widespread both in the vicinity of Pyramiden and on Svalbard. It is one of the forage components for reindeers, so called 'reindeer mosses'.

Fig. 2.2.5. *Cetrariella delisei* (Bory ex Schaer.) Kärnefelt & Thell.
Photo by L. Konoreva

***Cladonia gracilis* (L.) Willd. (fig. 2.2.6)**

Thallus is dimorphic, consists of two parts. Primary thallus is lobed, lobes 1–6 mm long and 1–3 mm wide, olive greenish on the upper surface and white on the lower. Podetia (vertical part) are 1–8 cm tall and 1–5 mm in diameter, greenish-brown to brown, cylindrical, subulate or hornlike, simple or divided into 2–3 branches in the upper part. Podetia cortex is smooth or sometimes divided in to the parts (areolated), blackish in the basal part, sometimes with leavf-like phyllocladia. Apothecia are brown.

The species occurs mainly on the soil or on the surface of boulders. In the vicinity of Pyramiden it is widespread, as well as on Svalbard in general.

Fig. 2.2.6. *Cladonia gracilis* (L.) Willd.
Photo by L. Konoreva

***Cladonia pocillum* (Ach.) O.J. Rich. (fig. 2.2.7)**

Thallus is dimorphic, consists of two parts. Primary thallus is lobed, lobes 3–10 mm long and 2–5 mm wide, thick, closely adpressed to the substrate, forming rosettes. The upper surface of rosettes is olive-green or brown whereas the lower surface is usually white. Podetia (vertical part of thallus) are short, 0.5–2 cm, greyish-green or brown, in the upper part look like tiny goblets (scyphi). Scyphi are regular, covered by cortex, the bottom is not perforated. Apothecia are brown, develop on the edges of scyphi, rare.

This lichens restricted mainly to the calcareous soil and is widespread both in the vicinity of Pyramiden and on Svalbard. It distinguishes from others specis of *Cladonia* genus by its rosette-like primary thallus.

Fig. 2.2.7. *Cladonia pocillum* (Ach.) O.J. Rich. Photo by L. Konoreva

***Flavocetraria cucullata* (Bellardi) Kärnefelt & Thell (fig. 2.2.8)**

Thallus is fruticose, with clustered lobes up to 5 cm tall. Lobes up to 2–10 mm wide, pale yellow or pale greenish, brownish at the base, smooth, cucullate, almost tubulate, with lip-shaped curved tips. Edges of the lobes area are irregularly undulate. Pseudocyphellae (cracks in the bark through which air penetrates into thallus) are situated on the lower side of the lobes. Apothecia have not been found in the Svalbard's specimens. Thallus contains usnic acid which determines yellowish color of thalli.

The species grows on the soil, is common on Svalbard and in Arctic and mountain regions. It is good forage for reindeers. This lichen distinguishes from other Flavocetraria species by the yellowish, coarse, cucullate, almost tubulate lobes.

Fig. 2.2.8. *Flavocetraria cucullata* (Bellardi) Kärnefelt & Thell.
Photo by O. Belkina

***Flavocetraria nivalis* (L.) Kärnefelt & Thell (fig. 2.2.9)**

Thallus is fruticose, pale yellow, with clustered lobes up to 5 cm tall. Lobes up to 3–10 mm wide, flat to slightly wrinkled, brownish at the base, reticulate-rugulose. Pseudocyphellae (cracks in the bark through which air penetrates into thallus) are dispersed on the lower side of the lobes. Apothecia on the tips of the lobes, with light brown disc, very rare in the specimens from Svalbard. Thallus contains usnic acid (yellowish).

It grows on the soil. On Svalbard this species is common and widespread, as well as in Arctic and mountain regions around the Globe. It is good forage for reindeers.

Fig. 2.2.9. *Flavocetraria nivalis* (L.) Kärnefelt & Thell.
Photo by L. Konoreva

***Fulgensia bracteata* (Hoffm.) Räsänen (fig. 2.2.10)**

Thallus placodioid, rounded to irregular, up to 1–2 cm wide, thin, pale yellow-orange to golden-yellow, lumpy, with pruina, consisting of scattered or aggregated convex parts – areoles. Marginal zone is not differentiated or poorly differentiated into lobes. The central part of the thallus consists of convex areola or verrucous-squamous, often with overlapping lobes, usually some parts get separated. Apothecia are frequent. Epithecium is red-brown, flat.

The species is restricted to calcareous habitats and is common both in the vicinity of Pyramiden and on Svalbard.

Fig. 2.2.10. *Fulgensia bracteata* (Hoffm.) Räsänen, golden-yellow thallus in the center. Photo by L. Konoreva

***Gowardia nigricans* (Ach.) P. Halonen, L. Myllys, S. Velmala & H. Hyvärinen** (=*Alectoria nigricans*) **(fig. 2.2.11)**

Thallus is fruticose, up to 7 cm tall, forming cushions, dull, pale greyish-brown, tips to brown blackish. Pseudocyphellae are white, fusiform, up to 1 mm long, clearly visible on the small old branches. Apothecia are rare. Color of the thallus helps to distinguish this species from the similar-looking tundra species from the genera *Alectoria* spp. and *Bryoria* spp.

The species occurs on soil, on exposed rocks, it is common on Svalbard. Species is widespread in both hemispheres, in the Arctic and in mountains.

Fig. 2.2.11. *Gowardia nigricans* (Ach.) P. Halonen, L. Myllys, S. Velmala & H. Hyvärinen. Photo by L. Konoreva

***Lecanora epybrion* (Ach.) Ach. (fig. 2.2.12)**

Thallus is thin, smooth, granular or verrucose, whitish. Apothecia up to 1.2 mm in diameter, constricted below. Disc of apothecia is flat, brown to dark brown, shiny. Thalline margins are thick, white, crenulate.

This species occurs on mosses, on the plant litter and soil. On Svalbard is common. Arctic montane species with wide geographical range.

Fig. 2.2.12. *Lecanora epybrion* (Ach.) Ach. with pale brown apothecia in the center. Photo by L. Konoreva

***Lecidea alpestris* Sommerf. (fig. 2.2.13)**

Thallus thick, warted-areolated, white to greyish, matt. Areolae often contain cyanoprokaryota, but cephalodia (special structures of the thalli, containing cyanoprokaryota) are not formed. Apothecia are up to 1 mm in diameter, black, strongly convex, emarginate, often grouped and confluent.

On Svalbard the species grows on soil. It is a widespread arctic montane Holarctic lichen.

Fig. 2.2.13. *Lecidea alpestris* Sommerf., pale thallus and dark disks of apothecia. Photo by L. Konoreva

***Lecidea atrobrunnea* (Ram. ex Lam. & DC) Schaer. (fig. 2.2.14)**

Thallus is large, up to 10 cm in diameter, divided into discrete sections (cracked-areolated). Areolae are convex, red-brown, shiny, sometimes accumbent, to verrucose-squamulose. Prothallus is brown, well developed. In extreme conditions, sparse separated areolae are formed on large prothallus. Apothecia have the distinct margins, black, up to 1.6 mm in diameter, becoming convex with age.

This saxicolous species is widespread on Svalbard but it is very rare in vicinities of Pyramiden. Arctic-mountain multiregional species.

Fig. 2.2.14. *Lecidea atrobrunnea* (Ram. ex Lam. & DC) Schaer.
Photo by L. Konoreva

***Lecidea ramulosa* Th. Fr. (fig. 2.2.15, 2.2.16)**

Thallus is thick, formed by nodular-verrucose isidia-like papillae, subfruticose, white to often bluish. Apothecia up to 1 mm in diameter, black, initially flat, with distinct proper margin, become convex without margin by age.

It grows on the soil and plant debris in snow-beds, on calcareous rocks. In the Svalbard the species occupies usually large areas forming thick bluish crusts on soil, ubiquitous. This lichens has circumpolar distribution. It distinguishes from others Lecidea species by its bluish thallus with protuberances.

Fig. 2.2.15. *Lecidea ramulosa* Th. Fr., thallus with dark apothecia. Photo by L. Konoreva

Fig. 2.2.16. *Lecidea ramulosa* Th. Fr forms the bluish crust on the soil and plants remnants in tundra. Photo by N. Koroleva

***Leptogium saturninum* (Dickson) Nyl. (fig. 2.2.17)**

Thallus is foliose, up to 5 cm wide, coriaceous. Lobes are rounded, with undivided slightly turned upwards margins, up to 10 mm wide. Upper surface is lead-grey or olive-grey to black, smooth or sometimes rugulose. Isidia are abundant, granular or branched, the same color with thallus or darker. Lower side is tomentose, with thick, short, whitish hairs made of elongated cylindrical cells. Apothecia have not been found in the Svalbard's samples.

This species grows on the stone, it is known on Svalbard from a few scattered localities. The distribution of this lichen is circumpolar, multizonal. It distinguishes from other lichens with Cyanoprokaryota as photobiont by the thick, short, whitish hairs on the lower side.

Fig. 2.2.17. *Leptogium saturninum* (Dickson) Nyl.
Photo by L. Konoreva

***Melanelia hepatizon* (Ach.) Thell (fig. 2.2.18, 2.2.19)**

Thallus is foliose, irregularly shaped, rarely rosette-like, 3–4 cm in diameter Lobes are concave to grooved, up to 2–3 cm long and 1–2 mm wide, branched, imbricated or entangled, with papillate pycnidia on the margins. Upper surface is dark brown, almost black, more or less shiny on the margins and matt in the center.

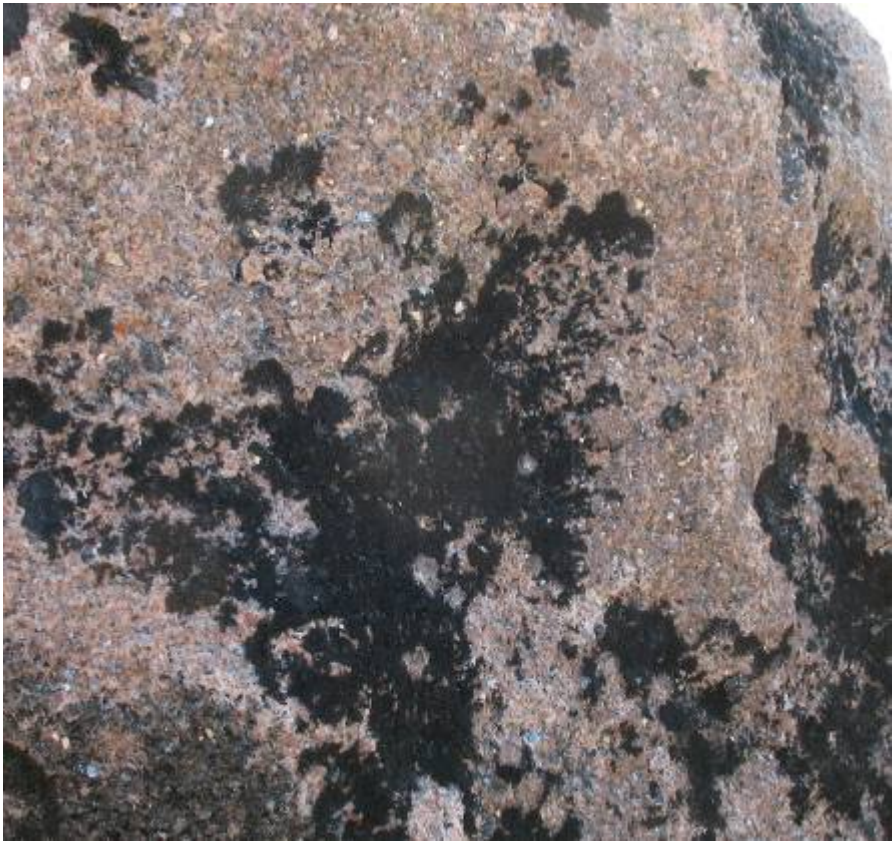


Fig. 2.2.18. Habitat of *Melanelia hepatizon* (Ach.) Thell., black thalli in center. Photo by L. Konoreva

Lower surface is dark, almost black, with a few rhizines. Apothecia and thallus are concolorate, margin of apothecia mostly with pycnidia. Apothecia are uncommon in the samples from Svalbard.

It grows on stones. This lichen is widespread on Svalbard and occurs in the Holarctic, from Arctic to the temperate zone, in the mountains.

Fig. 2.2.19. *Melanelia hepatizon* (Ach.) Thell.
Photo by D. Davydov

***Ochrolechia frigida* (Sw.) Lynge (fig. 2.2.20)**

Thallus is crustose, granular-verrucose, to coral-like, white or yellowish-white, with subulate outgrowths; often with soralia. The presence of spine-like outgrowths is one of the main species-specific features within the genus. Apothecia are large, up to 3 mm in diameter

This lichen inhabits soil, plant litter and rocks. On Svalbard is the most common and widespread species. Widely distributed in the Arctic and mountain regions.

Fig. 2.2.20. *Ochrolechia frigida* (Sw.) Lynge, with orange apothecia.
Photo by L. Konoreva

***Ochrolechia upsaliensis* (L.) Massal. (fig. 2.2.21)**

Thallus is thin, verrucose or verrucose-granular, white to greyish-white. Apothecia are very numerous, 1–2.5 mm in diameter, round. Apothecia disk is concave, then flat, pinkish to yellowish-red, with a thick white pruina. Thalline margin is thick, concolorous with thallus.

Species occurs on calcareous soil and rocks. It is tare on Svalbard and widely distributed in the Arctic and mountain regions.

Fig. 2.21. *Ochrolechia upsaliensis* (L.) Massal.
Photo by L. Konoreva

***Peltigera didactyla* (With.) J. Laundon (fig. 2.2.22)**

Thallus is foliose, up to 4 cm in diameter Lobes up to 1 cm wide, ascending on the margins. Upper surface is greyish to brownish, smooth, around the lobes margins with a very thin tomentum. Soralia are present, roundish. Lower surface is whitish to pinkish, with narrow, whitish to brownish veins. Rhizines are abundant, dense, pale grey to brownish. Apothecia up to 3–4 mm in diameter, are situated on narrowed vertical lobes. Disc is red brown or dark brown.

It grows on the soil among mosses. On Svalbard this species is found in a few scattered locations. However, it is ubiquitous near Pyramiden, and occurs even on anthropogenic meadows, lawns, the old stadium, etc. Probably it prefers slightly disturbed habitats. On the thallus of this species often inhabit lichenicolous fungi from genus *Illosporium* sp (orange-red patches on the lobes). Cosmopolite.

Fig. 2.2.22. *Peltigera didactyla* (With.) J. Laundon, pink patches on lobes belong to lichenicolous fungus *Illosporium* sp. Photo by L. Konoreva

***Peltigera lyngei* Gyeln. (fig. 2.2.23)**

Thallus is foliose, up to 7 cm in diameter, more or less rigid. Lobes up to 1 cm wide, flat or with turned upwards margins. Upper side is scabrous, greyish-green to brownish. Lower side is veinless, light brown to brown, darkening towards the center, with a few white depressions and a few fasciculate rhizines 1–2 mm long. Photobiont (photosynthetic component of thallus) – cyanobacteria, *Nostoc*. Apothecia have not been found in specimens from Svalbard.

It grows on the soil. This species rarely occurs on Svalbard, and is known from scattered locations in the Arctic and mountain regions. Multiregional.

Fig. 2.2.23. *Peltigera lyngei* Gyeln.
Photo by L. Konoreva

***Peltigera rufescens* (Weiss.) Humb. (fig. 2.2.24)**

Thallus is foliose, rather large, up to 10–15 cm. Lobes are 3–7 cm long and 0.5–2 cm wide. The margins of the lobes are turned upwards. The upper surface is ash- or chestnut-brown, with a thin tomentum, lower – light or yellowish-brown with distinct brown veins, frequently confluents into a thick tomentose mass. Rhizines are dark brown. Apothecia are saddle-shaped, with dark discs.

This lichen grows mainly on the soil among mosses, often in places with available calcium, as well as among the rocks or on the surface of boulders. It is common in the vicinity of Pyramiden and on Svalbard.

Fig. 2.2.24. *Peltigera rufescens* (Weiss.) Humb., thallus among mosses and *Salix polaris*. Photo by L. Konoreva

***Phaeophyscia sciastra* (Ach.) Moberg (fig. 2.2.25)**

Thallus is foliose, rosette-like or irregular, up to 2 cm in diameter, closely adpressed to the substrate. Lobes up to 0.2–0.8 mm wide, flat or infrequently weakly convex. Upper side is smooth, grey-brown, dark brown to blackish, glabrate, patches with abundant isidia look darker. Isidia are on the lobe margins, sometimes in the older parts of the thallus, granular (rarely almost cylindrical) or soredia-like. Medulla is white. Lower side is black, with simple black rhizines, sometimes protruding from under the margins. Apothecia have not been found in specimens from Svalbard.

It grows on stones, and is widespread on Svalbard. Cosmopolite.

Fig. 2.25. *Phaeophyscia sciastra* (Ach.) Moberg.
Photo by L. Konoreva

***Physconia muscigena* (Ach.) Poelt (fig. 2.2.26)**

Thallus is foliose, irregularly rosette-like, up to 5 cm wide, pulvinate, loosely attached to the substrate, without soredia and isidia. Lobes up to 2 mm wide, usually raised at the tips. Upper side is grey brown to dark brown, pruinose. Medulla is white. Lower side varies from pale brown periphery to brownish black center. Rhizines are black, brush-like. Apothecia have not been found in specimens from Svalbard.

This species grows among mosses on soil, stones and rocks. On Svalbard is common. Species occurs in both Hemispheres from polar to temperate regions, in mountains.

Fig. 2.2.26. *Physconia muscigena* (Ach.) Poelt.
Photo by L. Konoreva

***Placopsis gelida* (L.) Lindsay (fig. 2.2.27)**

Thallus is whitish or yellowish grey to pinkish or cream-coloured, rosette-like, up to 4 cm in diameter, cracked-rimose in the center, with radiating lobes on the margin. Reddish-brown structure with blue-green algae (cephalodia) up to 2 mm diam, develop in the central part of the thallus. This species can be distinguished from other species of the genus by the pale, elongated or rounded soralia and placodioid cephalodia. Apothecia have not been found in specimens from Svalbard.

The species occurs on stones in nival habitats. On Svalbard a few scattered localities are know. Multiregional.

Fig. 2.2.27. *Placopsis gelida* (L.) Lindsay. Pale radial thallus with cephalodia in the center. Photo by L. Konoreva

***Placynthium asperellum* (Ach.) Trevisan (fig. 2.2.28)**

Thallus up to 1–2 cm, crustose, divided in to small parts (areolae) in central part, with radiating lobes on the margin, olive-black to black, matt. Lobes are narrow, up to 0.2 mm wide, almost rounded, obtuse at the margins. Prothallus is absent. Apothecia up to 1 mm wide, flat, immersed or semi sessile, olive-black. This species grows on the stone. On the archipelago is widespread. The distribution of this species is boreal to arctic-alpine, circumpolar.

Fig. 2.2.28. *Placynthium asperellum* (Ach.) Trevisan. Thallus as a black crust on stone. Photo by L. Konoreva

***Protoblastenia terricola* (Anzi) Lynge (fig. 2.2.29)**

Thallus is crustose, well developed, verrucose-areolate to almost squamulose, white or whitish-grey. Squamules are rounded, convex, up to 1 mm wide, darker at the margins. Apothecia up to 1.5 mm in diameter, strongly convex, orange to brown.

The species occurs on calcareous soil and is common in Svalbard. The distribution of this lichen is circumpolar arctic and mountain.

Fig. 2.2.29. *Protoblastenia terricola* (Anzi) Lynge.
Photo by L. Konoreva

***Protopannaria pezizoides* (Weber) P.M. Jørg. & S. Ekman (fig. 2.2.30)**

Thallus is squamulose to microlobular. Upper side is brown to greyish-brown, matt. Lower side is whitish. Lobes up to 0.6 mm wide, pale on the margins, serrated, overlapped. In the center of the thallus lobes diminish and form a granular crust. Prothallus is blackish or bluish-black, sometimes poorly developed. Photosynthetic part of thallus (photobiont) – Cyanoprocaryota *Nostoc*. Apothecia are acervate, more or less rounded, 2–3 mm in diameter, with reddish-brown, matt, concave or flat, then weakly convex disc. Thalline margin of apothecia is rather thick, serrated or granular.

This species grows on the soil among mosses. On Svalbard is widespread. Species is found within the Holarctic, in arctic and mountain regions. The similar species *Psoroma hypnorum* distinguished by the green-algal photobiont.

Fig. 2.2.30. *Protopannaria pezizoides* (Weber) P.M. Jørg. & S. Ekman. Greenish thallus with brown apothecia. Photo by L. Konoreva

***Psora decipiens* (Hedw.) Hoffm. (fig. 2.2.31)**

Thallus is squamulose, squamules up to 10 mm wide, appressed in the middle. The upper surface is bright red to reddish-brown, dull, sometimes pruinose, especially in the marginal zone, usually with cracks. Margin of squamules is white or the same color as the thallus, usually curved down. Apothecia up to 2 mm wide, black, flat, but soon become convex, on the margins of squamules. Photosynthetic part (photobiont) is green algae.

The species is restricted to calcareous soil. It occurs sparse in the vicinity of Pyramiden and on Svalbard.

Fig. 2.2.31. *Psora decipiens* (Hedw.) Hoffm. Brown thalline squamules with black apothecia between them. Photo by L. Konoreva

***Psora rubiformis* (Ach.) Hook. (fig. 2.2.32)**

Thallus is squamulose, squamules up to 4 mm in diameter, ascending and disorderly overlapping, thick, brownish to greenish-yellow. The upper surface is smooth or cracked-areolated, sometimes with a whitish or yellowish pruina on the squamule margins. The lower surface is almost white. Apothecia up to 2 mm in diameter, sessile, brownish-black or black, sometimes with yellowish pruina.

This species calcicole, grows on soil, and occurs in few scattered localities on Svalbard. Species is found in both Hemispheres.

Fig. 2.2.32. *Psora rubiformis* (Ach.) Hook. Pale thalline squamules with black apothecia between them. Photo by L. Konoreva

***Rhizocarpon geographicum* (L.) DC. (fig. 2.2.33)**

Thallus up to 0.5–10 cm in diameter, sometimes larger, areolated. Areolae are aggregated on black prothallus, 0.6–1.2 mm in diameter, convex, usually separated by small, multiple cracks. Areolae are smooth, greenish-yellow, sometimes bright yellow. Medulla is white. Prothallus is well developed, black. Apothecia are black, 0.6–1.5 mm in diameter, slightly concave. It grows on siliceous rocks. This species is common and widespread on Svalbard. In the world is cosmopolite.

Fig. 2.2.33. *Rhizocarpon geographicum* (L.) DC. greenish thallus with black apothecia. Photo by L. Konoreva

***Rhizoplaca melanophthalma* (Ram.) Leuckert & Poelt (fig. 2.2.34)**

Thallus is foliose, forming rosettes up to 1–3 cm in diameter It attached to the substrate only in the center by umbilicus. Lobes up to 0.3 mm wide, pale yellowish, yellowish-green to grey-green, often shiny. Apothecia are 1–3 mm in diameter, numerous. Disc colored from pale yellow or pale brown to black, concave, the old one becomes flat. Thalline margin of apothecia is thick, concolorate with disc, entire to crenulate.

This species grows on siliceous rock, and under nitrified conditions. It is common on Svalbard. This lichen is cosmopolite, occurs in the Arctic and mountain regions.

Fig. 2.2.34. *Rhizoplaca melanophthalma* (Ram.) Leuckert & Poelt.
Photo by L. Konoreva

***Solorina bispora* Nyl. (fig. 2.2.35)**

Thallus is foliose, closely adpressed to the soil, consists of scattered squamules, often presented by narrow rims around the apothecia. The squamules are rounded up to 10 mm wide, ash-greenish to light brown. Cephalodia are squamulose-verrucose, internal, with *Nostoc*. Apothecia are urceolate, concave, mainly solitary, in the center of thallus squamules. Disc is red-brown. Photobiont is the *Coccomyxa*. The species is restricted to calcareous soil, in areas with available calcium. It is common in the vicinity of Pyramiden and on Svalbard.

Fig. 2.2.35. *Solorina bispora* Nyl. with black "submerged" apothecia.
Photo by L. Konoreva

***Solorina saccata* (L.) Ach. (fig. 2.2.36)**

Thallus is foliose, rosette-like, up to 10 cm wide, in wet state can be greenish or greenish-grey, in dry − pale reddish to reddish-brown, matt. Lobes are small, rounded. Lower side is whitish-yellowish to brownish, with vesiculars protruded against apothecia pressed on the upper side. Apothecia are rounded, reddish-brown to black, immersed in the thallus, up to 5 mm in diameter

It grows on calcareous soil, and is quite common on Svalbard. Species ranges in the Holarctic from tundra to temperate zone, in the mountains.

Fig. 2.2.36. *Solorina saccata* (L.) Ach. Photo by L. Konoreva

***Sporastatia testudinea* (Ach.) A. Massal. (fig. 2.2.37)**

Thallus is brown, shiny, forming big patches, areolated. Marginal areolae are elongate, look like placodioid thallus margins. Areolae up to 0.4 mm in diameter, cracked. Prothallus is visible in between areolae, black. Apothecia are situated in the central part of the thallus, up to 0.3–0.4 mm in diameter, cracked. Disc is black, initially surrounded by its own margin, later convex.

This species can be found on stones. It is widespread on Svalbard, as well as in both Hemispheres.

Fig. 2.2.37. *Sporastatia testudinea* (Ach.) A. Massal.
Photo by L. Konoreva

***Stereocaulon alpinum* Laur. (fig. 2.2.38)**

Primary thallus absent. Pseudopodetia (vertical part of thallus) up to 3 cm tall, form loose tufts, cushions. Tomentum is well-developed, grey and usually lumpy on the ventral surface of the main branches. The leaflets on the surface of pseudopodetia (phyllocladia) are verrucose to squamulose, with short marginal cilia. Cephalodia are small, granulose to botryose, brownish to bluish, with *Nostoc*. Apothecia have not been found in specimens from Svalbard.

It grows on the soil among bryophytes. This lichen serves as a forage for reindeer or as nest-building material for the birds It is widespread on Svalbard. This species occurs in both Hemispheres, in polar and temperate latitudes, in the mountains.

Fig. 2.2.38. *Stereocaulon alpinum* Laur.
Photo by L. Konoreva

***Thamnolia vermicularis* (Sw.) Schaerer (fig. 2.2.39)**

Thallus is fruticose, consists of separate podetia-like tubules forming loose cushions. Tubules up to 4 cm long and 2 mm wide, whitish, whitish-grey, fistular, unbranched or weakly branched.

This species can be found on the soil among bryophytes, and is widely used by birds as nesting material because tubular, hollow structure of the lichen provides good insulation. It is widespread on Svalbard. This species is cosmopolite, distributed in Arctic and mountain regions.

Fig. 2.2.39. *Thamnolia vermicularis* (Sw.) Schaerer.
Photo by L. Konoreva

***Umbilicaria cylindrica* (L.) Delise (fig. 2.2.40)**

Thallus up to 8 cm in diameter, rigid, thick, with rounded lobes, often quite deeply dissected. Black cilia are situated at the margin, up to 2–4 mm long. The upper side of the thallus is grey to greyish-black, glabrate or with greyish pruina, smooth or wrinkled; in the moist state is turns brown. The lower side is pale, olive or brown-grey to the margin, covered with multiple branched or simple rhizinas. Apothecia are rugose.

It can be found on stones. This lichen is common on Svalbard. Species is known from both Hemispheres, from polar to temperate zones, in mountains.

Fig. 2.2.40. *Umbilicaria cylindrica* (L.) Delise.
Photo by L. Konoreva

***Usnea sphacelata* (R. Br.) (fig. 2.2.41)**

Thallus is fruticose, up to 5 cm high, erect, densely branched, yellowish in the lower part, black and shining on tips. Yellow and black stripes alternate each other in the central part. Soralia are strongly convex, blackened, mostly on the terminal branches. Apothecia have not been found.

It grows on the stones and only in mountains: It never occurs on plains. This species is widespread in Svalbard, in the world is distributed in polar regions and in high mountains, bipolar.

Fig. 2.2.41. *Usnea sphacelata* (R. Br.). Fruticose thalli on the lower edge of the stone and the upper left corner. Photo by L. Konoreva

***Xanthoria elegans* (Link) Th. Fr. (fig. 2.2.42)**

Thallus is foliose, orange, rosette-like up to 2–4 cm diameter, and apressed to the substrate. Upper side is orange to dark reddish-orange, lower side pale. Lobes 0.5–1 mm wide, up to 6–7 mm long, discrete, more or less overlapping in the center, plicate, convex to strongly swollen. Medulla contains the clear hollow. Apothecia are usually numerous, scattered throughout the central part of thallus, up to 1 mm in diameter

Species occurs on the stones or on the wood, often near bird colonies; nitrophilous. In Svalbard is widespread, in the world cosmopolite.

Fig. 2.2.42. *Xanthoria elegans* (Link) Th. Fr.
Photo by L. Konoreva

2.3 Cyanoprokaryota

Cyanoprokaryota (Cyanobacteria / Blue-green algae) is a group of microorganisms, the cells of which do not contain a nucleus. The strands of DNA, which carry the genetic information, form into a circular structure. Cyanoprokaryota perform photosynthesis in the same way as the plants do. They are an ancient group of living organisms, bacteria which carry out oxygenic photosynthesis and represent the first group of organisms to capture energy form the sun in this way. Cyanoprokaryota came to existence about 3.5 million years ago, and due to their strong emission of oxygen the composition of atmosphere gradually changed from reductive to oxidative 2.4 million years ago. According to the theory of endosymbiosis, ancestors of Cyanoprokaryota evolved into chloroplasts (cell in which photosynthesis takes place) of all groups of plants. A number of species of Cyanoprokaryota possess the ability to fix nitrogen and transfer it to a form available for animals and plants. Nitrogen-fixing capacity was important at the planetary scale, since nitrogen obtained by Cyanoprokaryota is included in the structure of amino acids.

Due to phototrophic metabolism, morphology and habitats, Cyanoprokaryota were previously referred to as blue-green algae, however, recently, they have been considered as a specific group of microorganisms, among which are unicellular (coccoid and rod-like) and more complex colonial and filamentous types. Sizes of their cells can be from about 1 to dozens of microns, and their macro colonies and thalli can be visible without the aid of a microscope. Shape of colonies can be both amorphous and spherical. Cells in colonies do not form plasmodesms (microscopic canals linking the neighboring cells) while the filamentous types have rows of cells with plasmodesms. Filamentous cyanoprokaryotes can develop true or false branching of filaments and special cells (heterocyst's) where nitrogen fixation occurs. Characteristic features of cyanoprokaryota cells are gelatinous envelopes (or sheaths) which consist of peptidoglycan. Some of the mucilaginous sheaths are visible only under microscope, others are large enough to be seen with the naked eye. They can be colorless or colored by pigments, homogeneous or lamellated (with parallel or cross-bedded layers).

Cyanoprokaryota are adapted to various environmental conditions as a result of their long evolution history. They occur in a variety of habitats, for instance, in sea water with high concentration of salt, in almost all freshwater ecosystems, thermal springs and in terrestrial habitats.

A total of 68 taxa were observed in various habitats of the area of Pyramiden. Their diversity is lower than in other parts of Svalbard. Cyanoprokaryotes communities are developed mostly in places with high humidity. The commonest species dominant in most of collected samples are *Nostoc commune, Calothrix parietina* and *Phormidium autumnale*. The highest diversity of species in the Pyramiden area was on moist soils and wet rocks.

Photographs and descriptions of some cyanoprokaryotes species

Calothrix parietina (Näg.) Thur. ex Born. et Flah. (fig. 2.3.1)

This species belongs to the filamentous group. Its cells are heterocystic, heteropolar, differentiated into basal (usually joined to the substrate) and apical parts. Sheaths present, firm, yellow-brownish coloured. The species is found everywhere, on different substrates. One of the most common species on Svalbard.

Fig. 2.3.1. *Calothrix parietina* (Näg.) Thur. ex Born. et Flah.
Photo by D. Davydov

***Chroococcus cohaerens* (Bréb.) Näg. (fig. 2.3.2)**

This species belongs to the cyanoprokaryotes forming microscopic colonies and occurring together with other species. Envelopes colourless. Cells spherical, pale blue-green. This species is typically subaerophytic. Can be found on banks of streams or seepage or on wet rocks. Four specimen were found near Pyramiden. It is also found in 5 other regions of Svalbard.

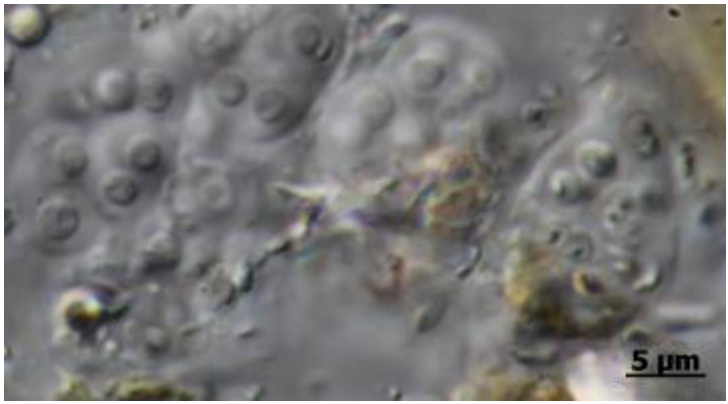


Fig. 2.3.2. *Chroococcus cohaerens* (Bréb.) Näg.
Photo by D. Davydov

***Chroococcus helveticus* Näg. – Хроококкус гельветский (fig. 2.3.3)**

This species belongs to the few-celled (2-8) microscopic colonial cyanoprokaryotes. Envelopes homogeneous and colourless. A single specimen was found in the vicinity of Pyramiden on snow-fed stream. It forms mats on rock. It was also found in the valley of glacier Aldegonda and in vicinity of Petunia Bay.

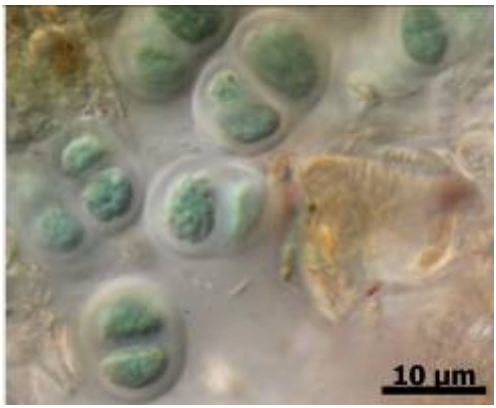


Fig. 2.3.3.
Chroococcus helveticus Näg.
Photo by D. Davydov

***Chroococcus subnudus* (Hansg.) Cronberg et Kom. (fig. 2.3.4)**

The species forms few-celled microscopic colonies. Envelopes thin, colourless. Cells oval-spherical or subspherical. We found two specimens in the vicinity of Pyramiden. New record for Svalbard.

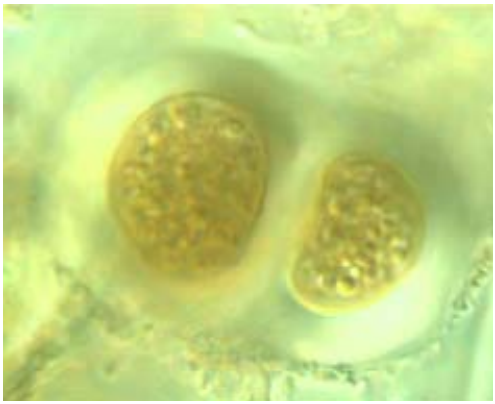


Fig. 2.3.4.
Chroococcus subnudus (Hansg.) Cronberg et Kom.
Photo by D. Davydov

***Chroococcus tenax* (Kirchn.) Hieron. (fig. 2.3.5)**

This species belongs to the colonial cyanoprokaryotes, it normally does not form macroscopic colonies, occurs together with other species. It forms small-celled colonies with transparent envelopes and clearly visible layers. Can be found in clean streams or on wet rocks. In the vicinity of Pyramiden was collected once on the Yggdrasilkampen mountain slope. Earlier it was found in the Ice-eye Lake Murchisonfjorden, on Nordaustlandet Island.

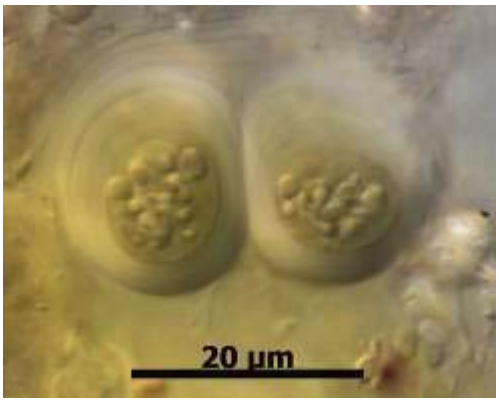


Fig. 2.3.5.
Chroococcus tenax (Kirchn.) Hieron.
Photo by D. Davydov

***Gloeocapsa alpina* (Näg.) Brand (fig. 2.3.6)**

This species forms microscopic colonies aggregated in macroscopic blackish masses. Envelopes blue to dark violet. Cells spherical. In the vicinity of Pyramiden it was found on the wet rocks and soils. Apart from these findings, the species is known on the coast at Murchisonfjorden, Rijpfjorden and on the Kaffiøra Plain (Oscar II Land).

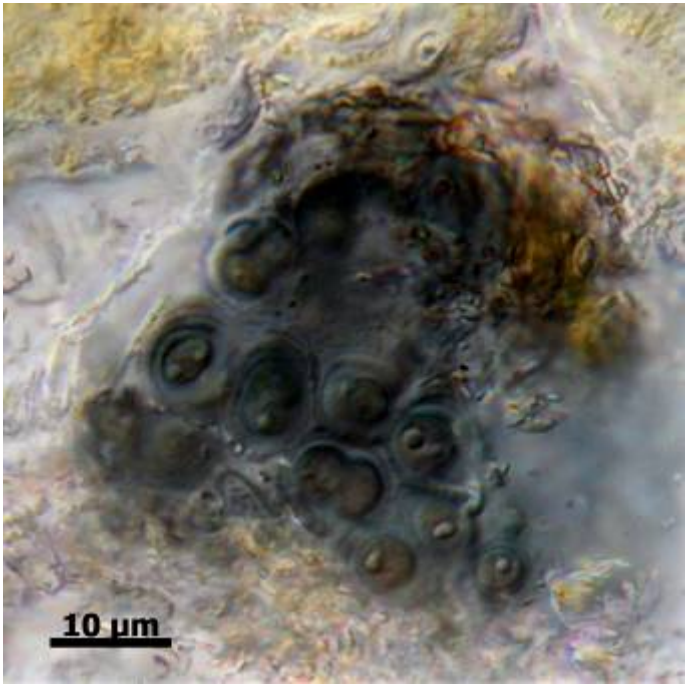


Fig. 2.3.6. *Gloeocapsa alpina* (Näg.) Brand.
Photo by D. Davydov

***Gloeocapsa kuetzingiana* Näg. (fig. 2.3.7)**

Colonies micro-, rarely macroscopic, usually amorphous, composed of subcolonies. Envelopes yellow-brown. Cells spherical, blue-green. The species was found in subaerophytic conditions, on wet rocks and soil, it is one of the most common species on Svalbard.

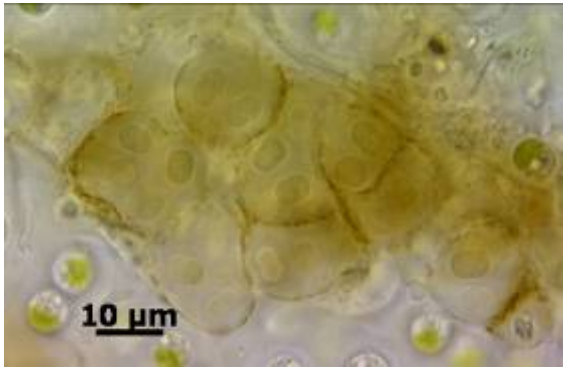


Fig. 2.3.7. *Gloeocapsa kuetzingiana* Näg. Foto by S.S. Shalygin.

***Gloeocapsa sanguinea* (C. Ag.) Kütz. (fig. 2.3.8)**

Colonies of the species are microscopic or macroscopic. Mucilaginous sheaths firm, envelopes close to the cells are intensely red, slightly reddish to almost colourless on outside. Subaerophytic, occurs on wet rocks and soils. Four specimens were found in the vicinity of Pyramiden. Species is also known from four localities on Svalbard.

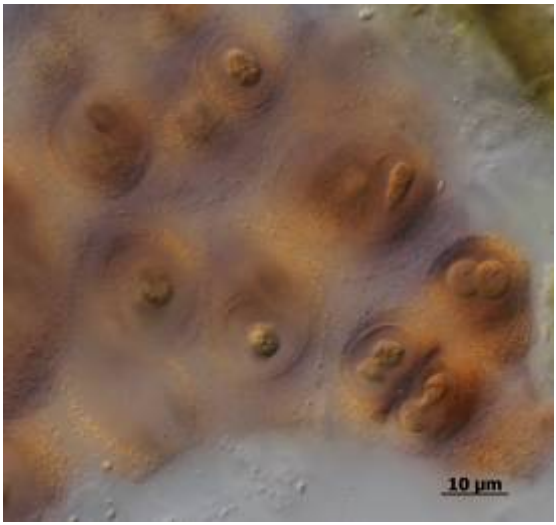


Fig. 2.3.8. *Gloeocapsa sanguinea* (C. Ag.) Kütz.
Photo by D. Davydov

***Gloeocapsa violascea* (Corda) Rabenh. (fig. 2.3.9, 2.3.10)**

This species belongs to the microscopic colonial cyanoprokaryotes occurring in between other species (for example, genus *Stigonema*). It is characterized by the formation of colonies with a mucosal purple or violet-red cover. Typical habitats are wet non-calcareous rocks. The species is common in the vicinity of Pyramiden, and was also found in three other sites on Svalbard.

Fig. 2.3.9.
Gloeocapsa violascea (Corda) Rabenh.
Photo by D. Davydov

Fig. 2.3.10. *Gloeocapsa violascea* (Corda) Rabenh. on the *Stigonema ocellatum* colonies.
Photo by D. Davydov

***Dichothrix gypsophila* (Kütz.) Born. et Flah. (fig. 2.3.11, 2.3.12)**

This is a filamentous cyanoprokaryote with heterocysts. Trichomes are bushy-branched. It forms macroscopic colonies, colony form hemispheres. These colonies are located on rocks in water. The widespread species on Svalbard.

Fig. 2.3.11. *Dichothrix gypsophila* (Kütz.) Born. et Flah.
Photo by D. Davydov

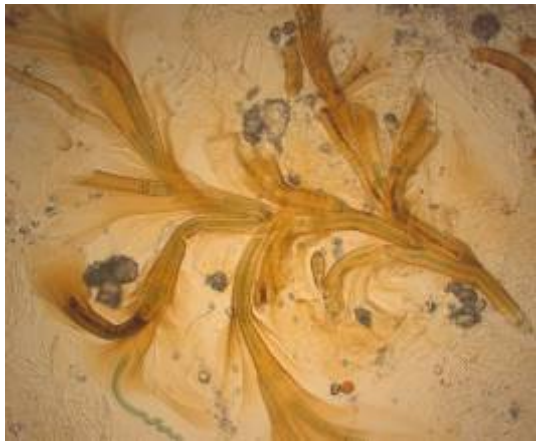


Fig. 2.3.12 *Dichothrix gypsophila* (Kütz.) Born. et Flah.
Photo by D. Davydov

***Gloeothece palea* (Kütz.) Rabenh. (fig. 2.3.13)**

This species forms few-celled colonies, aggregated in a blue-green mass. In the surroundings of Pyramiden it was found in two locations as new record for Svalbard.

Fig. 2.3.13.
Gloeothece palea (Kütz.) Rabenh.
Photo by D. Davydov

***Nostoc commune* Vauch. ex Born. et Flah. (fig. 2.3.14, 2.3.15)**

A filamentous, non-branching species with heterocysts.

Fig. 2.3.14. *Nostoc commune* Vauch. ex Born. et Flah.
Photo by D. Davydov

It forms macroscopic colonies, which are firstly spherical, yellow or olive green, then develop a dense prostrate thallus growing in to large (to a few decimeters) holed structures. The species occurs everywhere, on different substrates, primarily in moist habitat. The most widespread species in Svalbard.

Fig. 2.3.15. *Nostoc commune* Vauch. ex Born. et Flah.
Photo by D. Davydov

***Microcoleus vaginatus* Gom. ex Gom. (fig. 2.3.16)**

The species belongs to filamentous, non-branching, non-heterocystic cyanoprokaryotes. The filaments form pinkish mats. Sheaths colorless, homogeneous, contain several trichomes. Trichomes are cylindrical, with short cells. Subaerophytic, on wet soil and sand. The most widespread species on Svalbard.

Fig. 2.3.16. *Microcoleus vaginatus* Gom. ex Gom.
Photo by D. Davydov

***Phormidium uncinatum* Gom. ex Gom. (fig. 2.3.17, 2.3.18)**

A representative of the filamentous, non-branching, non-heterocystic cyanoprokaryotes.

Fig. 2.3.17. *Phormidium uncinatum* Gom. ex Gom.
Photo by D. Davydov

The interlacement of filaments form thick thalli – leathery mats. It grows mixed with species from genera *Pseudanabaena* or *Leptolyngbya*, thus occupies the upper surface mats and usually is colored in soft orange or bright red-orange colour.

Fig. 2.3.18.
Phormidium uncinatum Gom. ex Gom.
Photo by D. Davydov

It occurs in streams with different speed of flow, avoids muddy streams, grows on the lake shores and in the ephemeral ponds, frequently appears as a pioneering species. One of the most common species on Svalbard.

***Microcoleus autumnalis* (Trev. ex Gom.) Strunecky Komárek et J.R. Johansen (fig. 2.3.19, 2.3.20)**

The species belongs to the filamentous, non-branching, non-heterocystic cyanoprokaryotes.

Fig. 2.3.19.
Microcoleus autumnalis (Trev. ex Gom.) Strunecky Komárek et J.R. Johansen.
Photo by D. Davydov

The interlacement of filaments form dense thalli – leathery black mats. It occurs on soil under bird colonies, in lakes and rivers, on wet rocks, both on rocky substrates and on bryophytes. The species is resistant to an excess of nitrogen and can survive in sites with abundant bird droppings. One of the most common species on Svalbard.

Fig. 2.3.20. *Microcoleus autumnalis* (Trev. ex Gom.) Strunecky Komárek et J.R. Johansen. Photo by D. Davydov

***Pseudanabaena frigida* (Fritsch) Anagn. (fig. 2.3.21)**

This species belongs to the filamentous, non-heterocystic cyanoprokaryotes.

Fig. 2.3.21. *Pseudanabaena frigida* (Fritsch) Anagn. Photo by D. Davydov

Filaments are solitary or agglomerated in mats. Trichomes without firm sheaths, with slight constrictions at the distinct cross walls. This species frequently grow in mats in wetland and cold streams. It was found in four localitions on Svalbard.

***Rhabdoderma irregulare* (Naum.) Geitl. (fig. 2.3.22)**

This species belongs to the colonial cyanoprokaryotes normally not forming macroscopic colonies and occurring together with other species. Usually, the colonies contain a relatively small number of cells. Mucilage colourless. Cells cylindrical or curved. A new record from Svalbard.

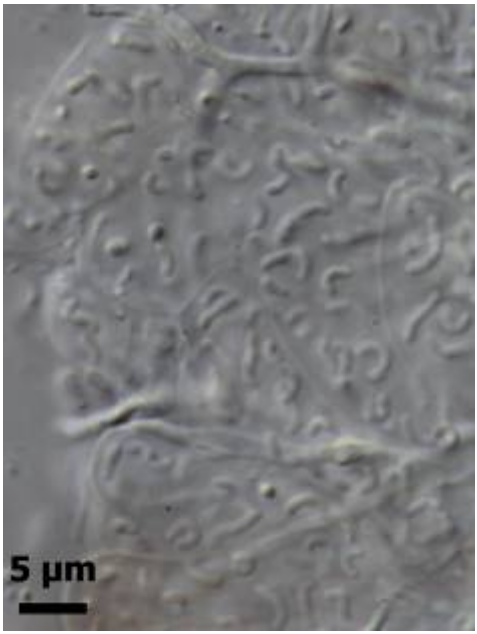


Fig. 2.3.22.
Rhabdoderma irregulare (Naum.) Geitl.
Photo by D. Davydov

***Scytonema ocellatum* Lyngb. ex Born. et Flah. (fig. 2.3.23)**

This species belongs to the filamentous, heterocystic cyanoprokaryotes. Filaments are free, commonly falsely branched, with one or two lateral branches. Sheaths firm, yellow-brown coloured. This species is aerophytic or subaerophytic, grows on wet rocks and soil. It was found in two localitions on Svalbard: Kaffiøra Plain (Oscar II Land) and on coast of the Innvika Bay (Fotherbyfjorden).

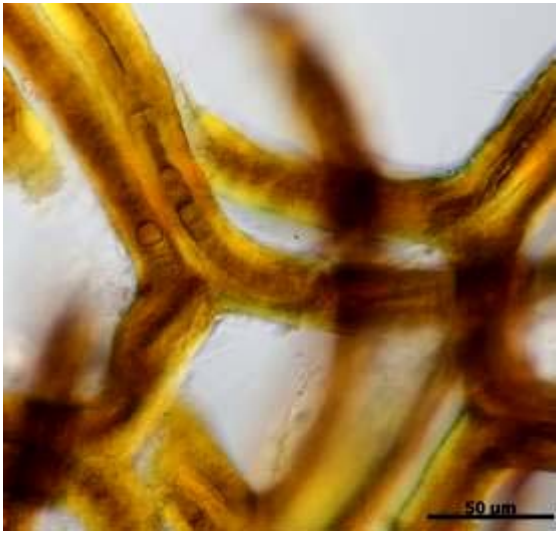


Fig. 2.3.23.
Scytonema ocellatum
Lyngb. ex Born. et Flah.
Photo by D. Davydov

***Stigonema ocellatum* (Dillw.) Thur. ex Born. et Flah. (fig. 2.3.24)**

The species belongs to the filamentous, heterocystic, branching cyanoprokaryotes. Thallus pillow-like composed of coiled, true branched filaments.

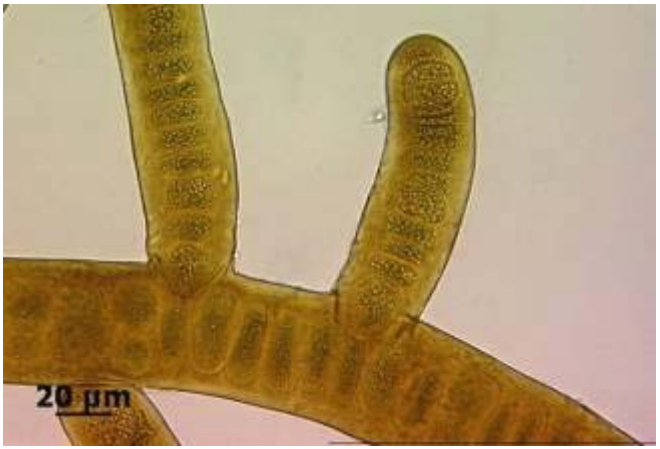


Fig. 2.3.24. *Stigonema ocellatum* (Dillw.) Thur. ex Born. et Flah.
Photo by D. Davydov

Sheaths thick, usually yellowish-brown. This species grows aerophytically on wet rocks or, rarely, on soil. In the vicinity of Pyramiden a specimen was found in valley Fiskekløfta. It is also known from two other locations on Svalbard (Prins Oscar Land and Kolsdalen).

***Schizothrix facilis* (Skuja) Anagn. (fig. 2.3.25)**

This species belongs to the filamentous, non-heterocystic cyanoprokaryotes. Filaments contain usually several more or less parallel trichomes. Sheaths firm, colourless. Trichomes cylindrical, grey blue-green. This species grows at the bottom of streams. It was found on the Kongsfjorden.

Fig. 2.3.25. *Schizothrix facilis* (Skuja) Anagn. Photo by D. Davydov

***Tolypothrix tenuis* Kütz. ex Born. et Flah. (fig. 2.3.26)**

This species belongs to the filamentous, heterocystic cyanoprokaryotes. Filaments heteropolar, basal parts with heterocystes and free apical ends, commonly falsely branched, usually with solitary lateral branches. Sheaths colourless. Near Pyramiden a single specimen was found in Mimer Valley, in a stream. It was found in five other locations on Svalbard.

Fig. 2.3.26. *Tolypothrix tenuis* Kütz. ex Born. et Flah. Photo by D. Davydov

Petunia bukta

3.1. Route “Western coast of Petunia bukta”

This route starts from a cabin on the north-eastern edge of Pyramiden (fig. 3.1.1). Length of the route is 10 km, altitude change 250 m.

Fig. 3.1.1. Position of the route and stops

Stop 1

The first marine terrace on the northern coast of Mimerbukta at the bottom of Mt. Pyramiden, altitude 20 m near triangulation point (fig. 3.1.2).

Fig. 3.1.2. Moss community near triangulation point on the northern coast of Mimerbukta. Photo by O. Belkina

Numerous turfs of the common moss *Sanionia uncinata* (fig. 3.1.3) look like a green “meadow” at the base of the triangulation point. Closely related and similarly-looking species *S. orthothecioides* occurs in some turfs. This species differs from *S. uncinata* mainly in traits of sporophyte. Several widespread vascular plants, the dwarf shrubs *Dryas octopetala* and *Salix polaris*, can be sporadically found here. Lichen species from genus *Peltigera* sp. also grow in these communities (fig. 3.1.4).

The triangulation point possibly attracts birds as bird droppings and feathers can be seen everywhere (fig. 3.1.3). Due to strong ornithogenic impact, vegetation around the triangulation mark is well developed and looks like a green oasis on generally gray slopes.

Fig. 3.1.3. Moss carpet covered with bird droppings.
Photo by O. Belkina

Fig. 3.1.4. Lichen *Peltigera* sp. among mosses.
Photo by L. Konoreva

Higher up the slope and northwards, the mossy tundra is replaced by patches of *Dryas octopetala*, *Saxifraga oppositifolia*, and *Cerastium arcticum* scattered among the scree (fig. 3.1.5, 3.1.6, 3.1.7).

Fig. 3.1.5. Patches of *Dryas octopetala* and *Saxifraga oppositifolia* on mountain slope. Photo by D. Davydov

Fig. 3.1.8. Flowering *Dryas octopetala.*
Photo by N. Konstantinova

Fig. 3.1.7.
Flower of *Saxifraga oppositifolia*.
Photo by D. Davydov

Nostoc commune, cyanoprokaryota species, also occurs there (fig. 3.1.8).

Fig. 3.1.8. A young colony of *Nostoc commune* on the soil.
Photo by D. Davydov

Along the road we pass open scree with various plant cushions. *Tomentypnum nitens, Ditrichum flexicaule, Orthothecium cryseum, Brachythecium turgidum, Stereodon* sp. are the most frequent mosses in the *Dryas-Cassiope* tundra. Sometimes *Trichostomum arcticum* and *Polytrichastrum alpinum* grow there as well. *Caloplaca cerina, Cladonia macroceras, Fulgensia bracteata, Ochrolechia frigida* (fig. 3.1.9) are among the most frequent lichens.

Fig. 3.1.9. Whitish coral-like thalli of lichen *Ochrolechia frigida* on soil and plant debris. Photo by L. Konoreva

Oncophorus wahlenbergii, Scorpidium cossonii, Cinclidium arcticum, Catoscopium nigritum occur along streams, on dry streambeds and in hollows (fig. 3.1.10).

Fig. 3.1.10. Parched streams with mosses alternating with cushions of *Dryas octopetala*. Photo by D. Davydov

Screes around patches of vascular plants seem lifeless. But with a closer look, there are a lot of turfs of small mosses hidden in between and under stones. *Tortula ruralis* is the most abundant moss here. *Encalypta rhaptocarpa* with narrow golden calyptras situated over urns, *Ditrichum flexicaule* and *Distichium capillaceum* with thread-like leaves and dark-green *Ceratodon purpureus* can be also seen in the area.

Lecidea lapicida, *Melanelia stygia*, *Rhizocarpon geographicum*, species from genus *Caloplaca*, *Lecanora*, *Miriquigica* are the common lichens on scree (fig. 3.1.11). *Lecidea lapicida* is a crustose lichen with its thallus often immersed in substrate, and only the black apothecia visible. *Melanelia stygia* has a foliose thallus with closely attached lobes. *Rhizocarpon geographicum* looks like a yellow crust on stone.

Fig. 3.1.11. Greenish-yellow thalli of *Rhizocarpon* sp., black thalli of *Miriquidica* sp., gray thalli of *Lecidea* sp. on the stone, white thalli of *Ochrolechia frigida* on soil near the stone. Photo by L. Konoreva

Further on, the road goes through screes along the high, abrupt terrace and ends on the eastern slope of Mt. Pyramiden (fig. 3.1.12). A panoramic view opens up towards the glacier Nordenskiöldbreen, ice-free mountain tops and medial moraines.

Dryas-Cassiope-lichen communities are found on relatively steep slopes of river banks and in depressions. There are also patches of vascular plants (*Cassiope tetragona* (fig. 3.1.13), *Dryas octopetala*, *Saxifraga oppositifolia*) mixed with mats and cushions of mosses and lichens. *Stereocaulon saxatile* (fig. 3.1.14), *Ochrolechia frigida*, *Cetrariella delisei* are the most abundant lichens here on solil; saxicolous lichens - *Protoblastenia rupestris* (fig. 3.1.15).

Fig. 3.1.12. Magnificent scenery from the slopes on the Nordenskiöldbreen.
Photo by O. Belkina

Fig. 3.1.13.
Flowers of *Cassiope tetragona*.
Photo by D. Davydov

Fig. 3.1.14. Grey cover on soil formed by fruticose thalli of the lichen *Stereocaulon saxatile*. Photo by N. Konstantinova

Fig. 3.1.15. *Protoblastenia rupestris* on the stone. Photo by D. Davydov

Liverworts are usually hidden under cushions of *Saixfraga* sp., *Cassiope* or *Dryas*, they also occur at the base and under rocks, on small patches of earth and debris. *Blepharostoma trichophyllum* is the most common thread-like liverwort

here. Its leaves are divided up to the base in to 3–4 one-cell wide segments; underleaves are similar in shape to leaves. This species is widespread in the arctic and subarctic. In Svalbard, it is represented mainly by the arctic variety *brevirete*. It differs from the type variety mostly in its short almost sub-quadrate leaf cells and underleaves. The liverwort *Leiocolea gillmanii* is rare in Svalbard but occurs frequently in such communities. This species is not rare in calcareous areas in the north and in mountains of holarctic, but in Svalbard it was previously known only from a few locations. It is relatively common and sometimes even abundant in the surroundings of Pyramiden.

Several gigantic rocks lie on the coast of Petunia Bay at the bottom of Mt. Pyramiden. A lot of calciphytic species can be found in their crevices and stone surfaces. Among them, there are calciphytic mosses *Stereodon bambergii*, *S. vaucheri*, *Pseudoleskeella tectorum*, *Schistidium platyphyllum*, and *Trichostomum arcticum* – all of them are widespread in Svalbard.

Stop 2

Mosses and lichens on the north-eastern slope of Mumien Mt., altitude about 35 m.

A conspicuous object on the way is a huge rock outlier splintered into blocks; it lays on the hill covered by dwarf shrubs-mosses tundra (fig. 3.1.16).

Fig. 3.1.16. A large rock outlier splintered into blocks.
Photo by O. Belkina

These blocks serve as a good observation point for seabirds. Bright orange spots of ornithophilous lichens *Xanthoria elegans* (fig. 3.1.17) cover the stone walls as a result from frequent bird visits. Also, *Stereodon revolutus*, *Distichium capillaceum*, and cushions of *Cynodontium strumiferum* grow on the uneven stone surface and in crevices. Leaves of the latter species are long and subulate when moist and curled when dry. The moss can be easily identified by its inclined, furrowed capsule with little struma. Large pure turfs of *Timmia austriaca* occur near the bases of these rock fragments.

Fig. 3.1.17. Ornithophilous lichen *Xanthoria elegans* on the stone.
Photo by D. Davydov

Snow patches stay on the shaded side of rocks even in late July. Some hygro- and hydrophytic mosses which are usually characteristic of wetlands, occupy these wet, snow-bed habitats. Among them, there are *Scorpidium cossonii* and *Loeskypnum badium* with falcate curved leaves, brownish-green and brownish-yellow *Pseudocalliergon turgescens* with imbricate leafy shoots, and *Campylium stellatum* with squarrose acute leaves.

Stop 3

Mosses and lichens at the base of the eastern slope of Svenbrehøgda, altitude 30 m.

Rich fens often occur at the base of mountain slopes. One of these is situated near a little lake and along a wide shallow stream on the right side of Hørbyedalen. Mosses and prostrate dwarf shrubs (*Salix polaris*) form tussocks on the banks and stream bed. Such habitats are common for *Meesia triquetra*, a distinctive moss with three rows of leaves on its shoots, and for *Scorpidium cossonii*. Species of *Cinclidium*, *Calliergon*, *Bryum pseudotriquetrum* and *Philonotis tomentella* also prefer wet depressions and grow partly in water. In addition, many mosses mentioned for the "Stop 2", can be found here.

Lichens from the genera *Peltigera* (fig. 3.1.18), *Solorina*, *Cetraria*, *Cetrariella*, and *Cladonia* grow in these moist habitats.

Fig. 3.1.18. Lichen *Peltigera didactyla* among mosses.
Photo by L. Konoreva

Fungi is not rare in the moist community. (fig. 3.1.19).

Fig. 3.1.19.
Small fungi among *Salix porais* and mosses.
Photo by D. Davydov

Cyanoprokaryotes grow here only on rocks. Among them, there are the widespread species *Aphanocapsa parietina*, *Calothrix parietina*, *Chroococcus cohaerens*, *C. spelaeus*, and *Gloeocapsa violascea*, which form cyanobacterial communities (fig. 3.1.20).

Fig. 3.1.20. Cyanoprokaryota community with dominance of *Gloeocapsa violascea* on rock. Photo by D. Davydov

Stop 4

Mosses and lichens near the mouth of Hørbyedalen (altitude ca. 10 m)

The lower part of the Hørbye Valley is a flat wide area with many streams flowing from the adjacent slopes and glaciers. Plains in between streams are occupied by fragments of moss and dwarf shrub-moss hummocky tundra (fig. 3.1.21), where mosses such as *Ditrichum flexicaule*, *Catoscopium nigritum*, *Philonotis tomentella* and *Orthothecium strictum* form numerous small hummocks. A pair of skuas is nesting here, and vegetation around the nest has whitish color and seems to degrade: crust of lichens and cushions of moss *Ceratodon purpureus* with sporophytes indicate a high level of disturbance. But diversity of mosses around the nest is rather high. It is worth noting, that you are liable to be severely attacked if you approach the nesting area, in such case you have to keep up a high stick. Skuas choose the highest target and hence attack the stick.

Fig. 3.1.21. Hummocky tundra, on the foreground flat hillock visited by seabirds. Whitish color marks disturbed tundra cover with prevalence of crusty lichens and *Ceratodon purpureus*. Photo by O. Belkina

Near this place, on bedrock outcrops (fig. 3.1.22), one can find mosses *Cyrtomnium hymenophylloides* and pale green or slightly bluish *Timmia comata* (fig. 3.1.23). Small worm-like moss *Myurella tenerrima* grows in crevices. A few stems of *Pleurozium schreberi* find suitable conditions for life on flat ledges. This species is widespread in the holarctic but rare on Svalbard. In the Pyramiden area it was found only in this location.

Fig. 3.1.22. Bedrock outcrops near the mouth of Hørbyedalen.
Photo by O. Belkina

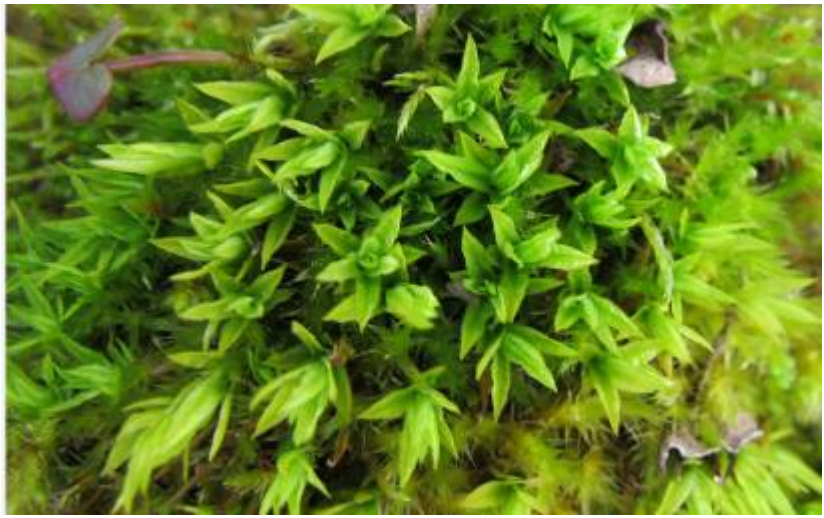


Fig. 3.1.23. *Timmia comata.* Photo by O. Belkina

Cyanoprokaryota *Nostoc commune* forms colonies on the fine earth among stones in the valley. Lichens *Placynthium asperellum* (fig. 3.1.24), *Phaeophyscia sciastra*, *Physcia dubia* and *Xanthoria elegans* were found on rocks.

Fig. 3.1.24. A blackish crustose thallus of *Placynthium asperellum* is in the center of this photo; right on stone are blue-gray thalli of *Physcia* sp., *Rhizocarpon* sp. (fig. 3.1.25) and *Phaeophyscia* sp. Photo by L. Konoreva

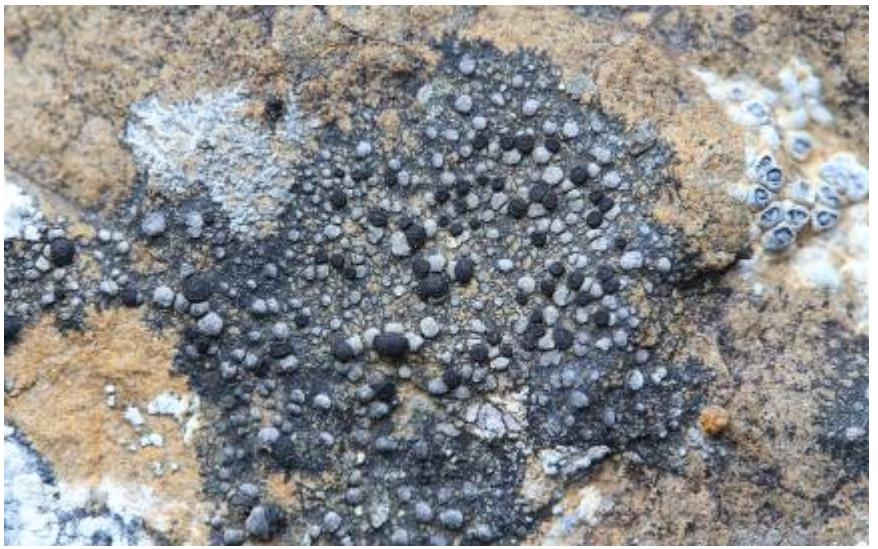


Fig. 3.1.25. *Rhizocarpon* sp. on the stone. Photo by D. Davydov

The way back goes on the upper road with a view of Pyramiden town from above (fig. 3.1.26).

Fig. 3.1.26. The way back by the upper road on the slope of Mt. Pyramiden. Photo by O.Belkina

Odinfjellet

3.2. Route "Odinfjellet"

The route starts at the base of Mt. Odinfjellet, where the dirt road from Pyramiden ends. The route goes from the Gousinoje (Goose) lake on the gentle south-eastern slope of Planteryggen (in Norwegian, a ridge of plants, named after finding Devonian plant fossils in the area) and ends on the Odinfjellet plateau (fig. 3.2.1).

Fig. 3.2.1. Position of the route and stops

The distance from Pyramiden to Gousinoje lake is 3.5 km, then up the slope for about 1 km with a rise in altitude from 80 to 580 m finally the mountain summit is at 813 m.

The picturesque rock buttresses looking like fantastic towers are one of the major attractions along the route. Some of rare moss species were found only on the Odinfjellet slope or also near a bird colony in Pyramiden.

The remains of the water supply system once carrying water from the Gousinoje lake to Pyramiden, can be seen on the lake's shore (fig. 3.2.2). After bypassing the second lake we head towards the south-eastern slope (fig. 3.2.3) where silhouettes of the rocky buttresses appear dramatically against the sky. On the way gentle inclines alternate with steep rocks.

Fig. 3.2.2. The Gusinoje lake (Goose lake) with remnants of water supply system. Photo by O. Belkina

Fig. 3.2.3. Start of the climb to Mt. Odinfjellet.
Photo by O. Belkina

Stop 1

Two types of Dryas-dominated tundra carpet the low slopes: one with co-dominance of lichens, and the other with *Cassiope tetragona* (fig. 3.2.4, 3.2.5).

Fig. 3.2.4. *Cassiope tetragona*-and-*Dryas* dominated tundra Photo by O. Belkina

Fig. 3.2.5. *Cassiope tetragona*-and-*Dryas* dominated tundra ,flowering *Dryas octopetala* and *Cassiope terragona* (on the right). Photo by O. Belkina

Here, the widespread mosses (*Ditrichum flexicaule*, *Distichium* spp., *Encalypta* spp., *Tortella* spp., *Schistidium* spp., *Stereodon* spp., *Syntrichia ruralis* etc.) occur along with some rare species. *Cassiope tetragona* grows in small hollows along with the small moss *Fissidens osmundoides* (fig. 3.2.6, 3.2.7).

Fig. 3.2.6
The moss *Fissidens osmundoides*:
Photo by O. Belkina

Fissidens species are indeed very distinctive from an overall view of their very flattened shoots even without examining them under the hand lens. But a good hand lens makes visible unusual structure of the leaf. At first glance, the leaf looks flat however, a closer view of a profile of the leaf reveal that it consists of two parts. Stem-orientated side of the leaf in its lower part forms a folded sheath which clasps the stem along a basal edge while upper part of the edge forms an open "pocket". On the opposite side of the nerve and at the tip of the leaf, lamina is flat, giving an overall impression as a "keel" if the sheath can be considered as a "boat".

Mosses of this genus occur in moist habitats such as river banks, moist rocks, tufts of sedges, in bogs and fen. In the Pyramiden area this species was found only on the south-eastern slope of Mt. Odinfjellet.

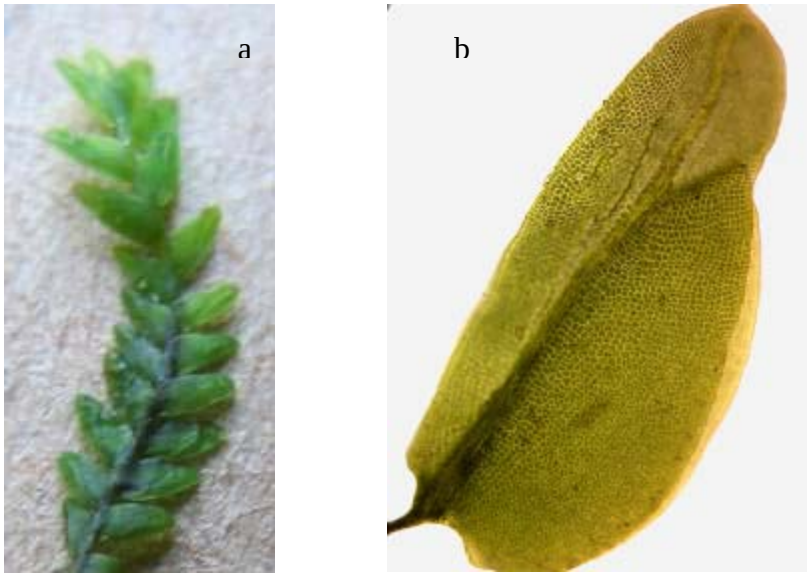


Fig. 3.2.7. The moss *Fissidens osmundoides*: a –stem with leaves, b – leaf. Photo by O. Belkina

Terrrestrial lichens such as *Ochrolechia frigida*, *Peltigera rufescens* (fig. 3.2.8) and *Cetrariella delisei* are common in lichens-and-*Dryas* dominated tundra; in some areas, the vegetation looks bluish because of the dominance of the lichen *Lecidea ramulosa* (fig. 3.2.9). Fungi can be found in such community (fig. 3.2.10).

Fig. 3.2.8. *Peltigera rufescens* on the soil. Photo by D. Davydov

Fig. 3.2.9. *Lecidea ramulosa* with blue-whitish thalli (below) and fruticose thallus of *Cetrariella delisei* (above). Photo by L. Konoreva

Fig. 3.2.10. Mushrooms in Dryas-dominated tundra.
Photo by D. Davydov

Algae and some lichens of genera *Stereocaulon* sp. and *Cladonia* sp. inhabit the frost scars in spotted tundra. *Petalonema incrustans* was found only in this particular habitat, together with common cyanoprocaryota *Aphanothece caldariorum, Chroococcus varius, Gloeocapsa alpina*and *Gloeocapsa violascea.*

In small, slow, shallow brooks on slopes, *Microcoleus autumnalis*, a very common typical blue-green algae of the Svalbard area can be found. It forms black shining mats, covering rocks and the soil surface. This nitrophytic species tolerates high concentrations of nitrates and grows under bird colonies. A species which is rare in the area, *Chroococcus helveticus* grows here on the rocks. *Stigonema ocellatum* is widely distributed on Svalbard but rare in the Pyramiden area. Under the magnifying glass it looks like a small brown “shrub”.

Stop 2

Flat area with ground water coming up to the surface.

A small seepage fen and wet grasslands occur on waterlogged soils on the gentle mountain slopes. Patches of *Salix polaris* and *Saxifraga hyperborea* (fig. 3.2.11) grow here and a green moss carpet lies along the branching brook on the south-eastern slope on the Mt. Odinfjellet.

Fig. 3.2.11. Flowering polar saxifrage *(Saxifraga hyperborea*).
Photo by O. Belkina

Philonotis tomentella (fig. 3.2.12) with reddish stem and green *Warnstorfia sarmentosa* with brownish-purple brunch tips, are water-loving (hygro- and hydrophytic) mosses and often occur in wet habitats. They are widely distributed in Svalbard in various habitats – on rocks, in wetlands, on river banks and in grasslands under bird colonies.

Several species of cyanoprocaryota grow near springs and overflow of brooks and rivulets. Colonies of *Gloeocapsa sanguinea* are well-defined and look like red dots on crust of lichens and mosses. The characteristic of the genus *Gloeocapsa* is that colonies have large transparent mucous cover recognizable under the microscope.

The moss *Aulacomnium turgidum* (fig. 3.2.13). forms tufts along rivulets in dwarf shrub-and-mosses dominated tundra. Occurring in hollows, *Cinclidium stygium* and *Polytrichum juniperinum* were found only on this mountain slope.

Fig. 3.2.12. *Philonotis tomentella*
Photo by O. Belkina

Fig. 3.2.13. *Aulacomnium turgidum.*
Photo by O. Belkina

Pseudocalliergon turgescens grows in habitats with available calcium in the substrata. Hygrophytic red-colored moss *Bryum cryophilum* is recognizable by obtuse oval leaves (fig. 3.2.14). In moss cushions grow lichens *Lobaria linita* and *Protopannaria pezizioides* (fig. 3.2.15).

Fig. 3.2.14. One of a few red-colored Bryum species, *Bryum cryophilum.* Photo by O.A. Belkina

Fig. 3.2.15. *Protopannaria pezizioides* with numerous and conspicuous chestnut brown apothecia in damp habitat. Photo by L. Konoreva

Drier parts of the slope are covered by grasslands, which contain the mesophytic herbs *Ranunculus sulphureus* (fig. 3.1.16) and *Potentilla hyparctica* (fig. 3.2.17), mosses *Ditrichum flexicaule, Polytrichastrum alpinum,*

Fig. 3.2.16. Flowering *Ranunculus sulphureus.*
Photo by O. Belkina

Fig. 3.2.17. Flowering *Potentilla hyparctica.*
Photo by O. Belkina

Stereodon revolutum, *Tomentypnum nitens*, and lichens of genus *Stereocaulon* sp. and *Thamnolia vermicularis* (fig. 3.2.18).

Fig. 3.2.18. *Thamnolia vermicularis*.
Photo by L. Konoreva

In rocky habitats with dominance of polar willow and moss *Sanionia*, *Niphotrichum canescens* and *Racomitrium lanuginosum* (fig. 3.2.19) form the carpets. In mossy sloping fen, there are the less common moss species *Meesia uliginosa* (fig. 3.2.20) and *Tayloria tenuis.*

Fig. 3.2.19. Tufts of moss *Racomitrium lanuginosum.*
Photo by O. Belkina

Fig. 3.2.20. Moss *Meesia uluginosa* with sporophytes. Photo by O. Belkina

Stop 3

Climbing on the slope and bypassing scree and rocks, we can look at inhabitants of rocks and stones; epilythic mosses and lichens. In Svalbard, some of them also readily grow on soil. *Andreaea rupestris* (fig. 3.2.21) with its brown tufts on rock surfaces and *Hymenoloma crispulum* with its narrow curling when dry leaves, are among the most typical epilythic mosses. *Hymenoloma crispulum* (fig. 3.2.22) often produces light-brown straight oval cylindrical capsules without furrows on the surface.

Fig. 3.2.21. Tuft of *Andreaea rupestris* on rock. Photo by O. Belkina

Fig. 3.2.22. *Hymenoloma crispulum* with well-developed sporophytes. Photo by O. Belkina

This trait helps to distinguish it from other narrow-leaved mosses.

Timmia austriaca and *Encalypta* species grow on soil patches between the stony areas.

Patches of snow remain on the mountain slopes throughout the summer. Snow-bed habitats in i.e. in Scandinavian mountains accommodate a specialist moss flora, but on Svalbard these habitats are inhabited by common tundra mosses (e.g., *Blindia acuta*, *Scorpidium cossonii*, *Catoscopium nigritum*). They form continuous mats along rivulets flowing from snow patches, and these dark-green stripes are well discernable against the background of grey rocks (fig. 3.2.23).

Fig. 3.2.23. Epilithic lichens on the stones (orange thallus in the center – *Porpidia* sp.). Photo by L. Konoreva

Numerous lichens cover the mountain rocks and stones. Almost two-thirds of lichens of Svalbard are epilythic species. Due to their morphology, anatomy and physiology, lichens readily occupy rocky habitats, which are often unsuitable for other living organisms. Lichens of genus *Cladonia* sp. and *Thamnolia vermicularis* form specific communities in snow-bed stony habitats on Mt. Odinfjellet's slopes.

The lichen community with *Flavocetraria nivalis* and *Cetraria* sp. (fig. 3.2.24) occur on stones.

Fig. 3.2.24. Lichen community with *Flavocetraria nivalis* and *Cetraria* sp.
Photo by L. Konoreva

Stop 4

At 450-500 m the hiker reaches the slope's terrace, which like giant steps goes upward to north-west, to the summit of Mt. Odinfjellet. The terrace is covered by rocky eluvia alternating with stony polygon fields (fig. 3.2.25) and rocky outcrops with small caves.

Fig. 3.2.25. Stones sorted by frost heave processes, polygon fields on Mt. Odinfjellet. Photo by O. Belkina

Polygons have a sandy or clayey center and a stony border, and only scattered mosses grow here: *Distichium* spp., *Ditrichum flexicaule* and *Tortella fragilis* (fig. 3.2.26). The latter species is identified by curled leaves with shining costa and broken leaf tips.

Fig. 3.2.26. Moss *Tortella fragilis.*
Photo by O. Belkina

The moss *Arctoa fulvella*, with capsules, was found only on this slope and nowhere else in the Pyramiden surroundings. *Encalypta procera* was collected on a shaded wall in a small cave. In rocky habitats, especially in damp hollows, more than 15 bryophytes were found. Among them, there were reddish-yellow *Orthothecium chryseon*, light-green *Brachythecium turgidum* and rather rare in Svalbard *Pseudoleskeella tectorum*.

Stop 5

After climbing to the second “step” of the plateau on Mt. Odinfjellet at 580 m, we find ourselves in an area of scree and stone fields like these at Stop 3. From this point, a magnificent view opens towards the towers and walls arising from cliffs on the south-eastern slope of Mt. Odinfjellet. These weathered outcrops are an integral part of the Mt. Odinfjellet summit (fig. 3.2.27). Fissures and steps of these towers are covered by bright-green meadows near nesting bird colonies. Only a skilled climber could obtain some mosses and lichens specimens from these habitats.

Fig. 3.2.27. Towers of Mt. Odinfjellet.
Photo by O. Belkina

From this point, weather permiting, we can have a look at the rapidly melting glacier Muninbreen and moraine deposits (fig. 3.2.28), as well as at the Muninelva river valley which joins the Mimerdalen valley further on.

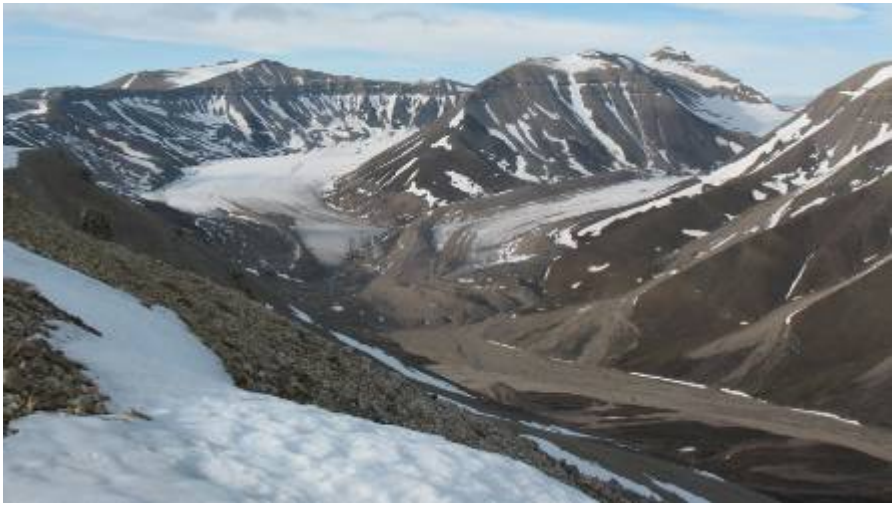


Fig. 3.2.28. Melting glacier Muninbreen and morane deposits.
Photo by O. Belkina

For less-trained walkers, this would be the final stop of the route. Only well-prepared and skilled mountaineers could reach the top of Mt. Odinfjellet and enjoy the views (fig. 3.2.29).

Fig. 3.2.29. The top of Mt. Odinfjellet, the view from plateu, alt. 580 m. Photo by O. Belkina

On the summit, the lichen *Usnea sphacelata* can be found. This is one of few lichens famous for their bipolar distribution (i.e., it grows both in arctic and Antarctic). The species is relatively common on Svalbard, but grows only on mountain summits (fig. 3.2.30).

Fig. 3.2.30. Yellow-grey fruticose thalli of lichen *Usnea sphacelata* on stones. Photo by L. Konoreva

On the way back, it is recommended to follow the same route. Well-equipped experienced climbers can go on the ridge which looks like dragon backbone and tail (fig. 3.2.31). Fewer mosses grow there, among them *Syntrichia ruralis, Stereodon revolutus* and *Bryum* sp.

Fig. 3.2.31. Descent from Mt. Odinfjellet on a ridge divided by Plantekløfta crevice. Photo by O. Belkina

Southern coast of Mimerbukta

3.3. “Southern route”

The "Southern route" starts from the helicopter pad on the south-eastern edge of Pyramiden and goes to the south. It crosses the wide delta of Mimerelva river, with its numerous branches of the main river and separate streams, then passes along the lower part of north-eastern slope of Yggdrasilkampen. Then and the route descends to the sea beach before returning to the mouth of the river Mimerelva along the edge of the sea coast. The distance from the "Tulip" hotel to the end of the route is about 5 km. Altitude change is no more than 100 meters (fig. 3.3.1)

Among attractions along the route, there is an interesting moss flora in parts of the Mimerelva delta, and spectacular gypsum outcrops on the western shore of Billefjorden and southern part of Mimerbukta shore.

Fig. 3.3.1. Position of the route and stops

Stop 1

Helicopter pad (fig. 3.3.2)

The area around the heliport is divided into two parts: a damp eastern part and dry western part. In the more trampled western part, grasses such as *Poa alpigena* and *Deschampsia alpina* dominate the vegetation cover. Mosses are represented mainly by *Bryum* spp. and *Ceratodon purpureus,* so-called ruderal (weedy) species, settling in areas disturbed by human activities. The vegetation of the eastern part is more diverse. Attractive spikes of *Eriophorum scheuchzeri* look like pieces of cotton-wool (fig. 3.3.3, 3.3.4). There are cushions of loosely rooting *Dupontia psilosantha* and creeping *Puccinellia phryganodes*, both species occur also on marshes.

Fig. 3.3.2. Heliport Pyramiden. Photo by O. Belkina

Fig. 3.3.3. Damp eastern part of the helicopter pad. White spikes of *Eriophorum scheuchzeri* together with bright-green clumps of *Deschampsia alpina*, reddish-brown tussocks of *Bryum calophyllum* and green clumps of *Sanionia uncinata*, *Drepanocladus polygamus*, and *D. aduncus.* Photo by D. Davydov

Fig. 3.3.4. *Eriophorum scheuchzeri*. Photo by D. Davydov

Mosses here form a thick, solid cover, where tussocks of *Bryum calophyllum,* 15–25 cm in diameter with abundant sporophytes, are the most conspicuous. Its short broad-oval urns clearly differentiate this species from the other *Bryum* species which are widely distributed in Pyramiden town.

Drepanocladus polygamus takes a significant place in moss cover (fig. 3.3.5, 3.3.6). This species has squarrose acute leaves, which could be confused with the leaves of *Campylium* species. But the leaves of the latter have a short double vein, whereas veins of *D. polygamus* are long, single and unbranched. Mosses *Philonotis tomentella*, *Distichium inclinatum*, *Pseudocalliergon turgescens* can also be found in the eastern part of the helipad.

Fig. 3.3.5. A big tussock of *Drepanocladus polygamus* 20 cm in diameter, surrounded and pierced by ascending shoots of seashore grass *Puccinellia phryganodes* in the foreground. Bright-green clumps of *Deschampsia alpina* in the background. Photo by O. Belkina

Fig. 3.3.6. *Drepanocladus polygamus*, close-up. Photo by O. Belkina

Lichens cover is fragmentary in these plant communities. The ubiquitous foliose lichen *Peltigera didactyla* occurs among cushions of vascular plants and mosses (fig. 3.3.7) in the vicinity of Pyramiden. Other species are very tiny and can be found on bare soil or on plant litter only with a help of powerful lens.

Fig. 3.3.7. Foliose lichen *Peltigera didactyla* among mosses and *Cerastium arcticum*. Photo by L. Konoreva

Cyanoprokaryota communities on the eastern part of the helicopter pad are very diverse. Here grow small colonial forms of the widely distributed species *Aphanocapsa muscicola*, *Aphanothece castagnei*, *Chroococcus pallidus*, and large mats of filament forms of *Microcoleus autumnalis*. A a rare species, *Spirulina tenerrima,* was found here and in similar habitats in Petunia-bay.

Stop 2

Lowland to the south and south-east from the helicopter pad.

To the south-east of the helipad lies a wide, damp lowland covered by grasses and mosses (fig. 3.3.8).

Fig. 3.3.8. Damp lowland to the south-east of the road.
Photo by O. Belkina

Near the fence around the helipad, there are dense tufts of the hygrophilous mosses *Bryum pseudotriquetrum*, *B. calophyllum*. *Splachnum vasculosum* also grows here. It stands out with its bright green leaves and contrasting purple-colored large capsules (fig. 3.3.9).

Fig. 3.3.9. *Splachnum vasculosum* in wet habitat.
Photo by O. Belkina

Lichens generally avoid wet habitats and are absent from the damp lowland.

The territory adjacent to the seashore is littered with timber and pieces of rubbish (e.g., iron, plastic,), that provide additional habitats for bryophytes (fig. 3.3.10). Prostrate halophyte and hygrophyte grasses and herbs *Puccinellia phryganodes, Phippsia algida*, *Stellaria humifusa* and *Ranunculus hyperboreus* are the most common flowering plants. Birds, especially geese enrich the substrata with their droppings that affect the species composition of mosses.

Cushions of the moss *Distichium hagenii* occupy a humus layer formed on top of rubbish dumps made of burnt and decaying wood, pieces of metal and broken glass; the moss is quite rare on Svalbard. It differs from two other species in the genus *Distichium*, which are common on Svalbard, by the aborted teeth of the capsule peristome. Therefore, the identification of *Distichium* species is only possible using mature sporophytes which are not always present. *Hennediella heimii* var. *arctica* was also found here, but only on sea-bird droppings.

A typical inhabitant of the stony banks of mountain rivers and shallow rapid rivulets, *Ochyraea cochlearifolia* was found here and identified by its rounded broad-oval concave leaves.

Fig. 3.3.10. Cluttered lowland with logs.
Photo by O. Belkina

Lichens occupy wood debris, occasional rocks and soil. Wood is actively colonized by epilythic lichens, which normally prefer rocks. Among them, there are species in the genera *Lecanora*, *Candelariella* and *Caloplaca* (fig. 3.3.12). Crustose thalli of these species are often completely or partially submerged in the substrate and only apothecia are visible on the surface. The apothecia of *Lecanora* species are grey, brown or black; *Candelariella* species have yellow apothecia, and apothecia of *Caloplaca* species are yellow to orange-red.

Tortula cernua together with *Hennediella heimii* var. *arctica* (fig 3.3.11) were found on wet soil under wooden ducts among *Phippsia algida* and *Stellaria humifusa*.

Mats of the cyanoprokaryota *Pseudanabaena frigida* grow on open ground. *Anabaena inaequalis*, rare on Svalbard, can be also found in this habitat.

Clumps of *Deschampsia alpina* and *Saxifraga cespitosa* occupy a large area to the south of the helicopter pad. The moss *Aongstroemia longipes* often occurs there in disturbed habitats.

Continue along the road to the south up to the bridge to cross the river flowing from the Bertilbreen glacier. The Mimerelva delta spreads out with numerous streams and islets of pebble alluvium (river drifts) which get inundated during high water.

Fig. 3.3.11. Mixed cushion of mosses *Hennediella heimii* var. *arctica* (black capsules) and *Tortula cernua* (green capsules). Photo by O. Belkina

Fig. 3.3.12. Lichens on wooden debris. *Lecanora sp.* with grey thalli (at the edges); *Candelariella sp*. with yellow thalli (in the center).
Photo by L. Konoreva

Nice bright-yellow cushions of *Saxifraga aiziodes* grow over pebbles to the west of the road (fig. 3.3.13). Numerous inconspicuous small plants of *Saxifraga oppositifolia* are covered with large light-purple flowers in June and July (fig. 3.3.14).

Fig. 3.3.13. Cushions of *Saxifraga aiziodes* on river drifts. Photo by O. Belkina

Fig. 3.3.14. *Saxifraga oppositifolia* Photo by N. Konstantinova

Stop 3

Lowland between the road and the sea

Islets with grasses and dwarf shrubs are situated amidst clay and pebble alluvium to the east of the road (fig. 3.3.15).

Fig. 3.3.15. Islet with grasses and dwarf shrubs between road and sea.
Photo by O. Belkina

Occasional cushions of *Saxifraga oppositifolia, S. aizoides, Salix polaris*, *Dupontia psilosantha* (fig. 3.3.16)) were found on alluvium in depressions and in vehicle tracks together with a pinkish-reddish crust of the cyanoprocaryota *Pseudanabaena frigida*. (fig. 3.3.17, 3.3.18).

A small population of the moss *Bryobrittonia longipes* was found here in cushions of *Saxifraga oppositifolia*, this moss is very rare in Svalbard. It looks similar to species in the genus *Encalypta* and belongs to the same family Encalyptaceae, however, the plants are clearly differentiated by their leaf anatomy. Also, the moss *Distichium hagenii* occurs here.

Two ruderal mosses *Leptobryum pyriforme* and *Ceratodon purpureus* can be found on alluvial deposits as well as the uncommon moss *Warnstorfia fluitans* with its falcate leaves. Numerous cushions of *Splachnum vasculosum* occur on animal droppings. It has dark-violet globular capsules marking it out from other *Splachnum* species. A number of other mosses also thrive there, as well as all around Pyramiden, i.e. *Distichium capillaceum, Pohlia wahlenbergii*, *Campylium stellatum* and *Orthothecium intricatum*.

Fig. 3.3.16. Tundragrass *Dupontia psilosantha* forms extensive thickets in damp coastal lowlands. Photo by N. Koroleva

Fig. 3.3.17. Cyanobacterial mats with *Pseudanabaena frigida*.
Photo by D. Davydov

Fig. 3.3.18. Cyanobacterial mats with *Pseudanabaena frigida*. Photo by D. Davydov

Foliose and fruticose lichen species from genera *Peltigera*, *Cladonia*, *Cetraria*, and *Stereocaulon* are found in more or less dry habitats. Pioneer species from genus *Stereocaulon* inhabit open rocks, fine earth and shallow soil (fig. 3.3.19, 3.3.20).

Fig. 3.3.19. *Rhizocarpon sp.* on a stone. Photo by D. Davydov

Fig. 3.3.20. *Stereocaulon sp.* on a stone.
Photo by D. Davydov

Stop 4

North-eastern slope of Yggdrasilkampen

Having reached the southern bank of Mimerelva, the road gradually rises along the flat rocky north-eastern slope of Yggdrasilkampen mountain. Dryas-moss and Dryas-moss-lichen tundra alternates with scree and rocky beds of temporary streams. Widespread mosses occur in these habitats, for example species in genera *Distichium*, *Stereodon*, *Encalypta*, as well as *Orthothecium chryseon, O. intricatum*, *Cyrtomnium hymenophyllum* and *Ditrichum flexicaule*. On screes, there are *Schistidium* spp., *Timmia austriaca, T. comata*, *Syntrichia ruralis* and the rare species *Brachythecium cirrosum* (fig. 3.3.21); in streams there are *Scorpidium cossonii* and *Hygrohypnum luridum*.

Fig. 3.3.21. *Brachythecium cirrosum.*
Photo by O. Belkina

The liverwort *Blepharostoma trichophyllum* is common both on Svalbard and in the vicinity of Pyramiden town. This is the smallest (0.1-0.2 mm in width and 3.5 mm in length) thread-like liverwort with leaves split almost to the base on 3-4 hair-like segments and similar underleaves. It can be found on exposed soil in small depressions, as well as under clumps of vegetation. It forms a thin mats on the ground or grows scattered amidst mosses and other liverworts.

The common ubiquitous crustose lichen *Ochrolechia frigida*, fruticose *Cladonia gracilis* and *C. pocillum*, with rosette-like thallus and podetia with broad scyphi, and *Thamnolia vermicularis* with white tubular thalli grow here on the soil. Crustose lichens from genus *Rhizocarpon*, *Lecidea*, *Aspicilia* and others grow on stones and on pebbles (fig. 3.3.22, 3.3.23).

Fig. 3.3.22. *Diploschistes scruposus* on the stone. Photo by D. Davydov

Fig. 3.3.23. Lichens on the stone: *Melanelia hepatizon* (brown thalli) and *Rhizocarpon* sp. (yellow thalli). Photo by D. Davydov

Stop 5

The stream on the south-eastern slope of Yggdrasilkampen

On clayey soil on the mountain slope near a brook one can meet an elegant medium-sized liverwort *Tritomaria scitula,* it is widely distributed in Svalbard. It has light green three-bladed leaves, with bright red or reddish-brown brood buds located at the tips, sharply contrasting with the green color of leaves. Calciphylic liverworts *Leiocolea heterocolpos*, *L. gillmanii* and *Jungermannia polaris*, grow in mixture with mosses to form loose mats on the bank of a brook in its headwaters.

At the end of the road, continue towards the second large stream, then follow its course down to the sea (fig. 3.3.24).

Fig. 3.3.24. Beach and rocky outcrops at the foot of the eastern slope of Mt. Yggdrasilkampen on the west bank of Billefjorden, to the south of the mouth of Mimerelva river. Photo by O. Belkina

This part of the route to the Mimerelva river goes along the beach. The area is fascinating not because of plants but the gypsum exposures on the low steep cliff. Among them are attractive layered rocks, white-and-black 'marble floor', transparent crystals under a dark rock shelter and some bizarre rock formations (fig. 3.3.25, 3.3.26, 3.3.27, 3.3.28).

Fig. 3.3.25. Folded carbonate rocks with gypsum layer in rocky outcrops on the southern shore of the Mimerbuckta. Photo by A. Savchenko

Fig. 3.3.26. Gypsum crystals in the caves of rock exposures.
Photo by O. Belkina

Fig. 3.3.27. "Marble floor" on the beach.
Photo by O. Belkina

Fig. 3.3.28. Caves and niches in rock outcrops on the beach.
Photo by O. Belkina

Stop 6

Cemetery. (630 m from the road to the cemetery in a straight line)

Coming back to the road through Mimerelva and before passing coal storage facilities hikers can see three "islands" on the river delta far on left. (fig. 3.3.29). The old graveyard burials from 1950-60s, is located on one of the islands (fig. 3.3.30).

These islands result from melt water erosion of flat terraces. They are covered with dwarf shrub tundra and surrounded by *Dupontia psilosantha* wetlands on clayey alluvia. Diversity of mosses is low with mainly ruderal species linked to disturbed habitats. The light green moss with squarrose small leaves and long name, *Bryoerythrophyllum recurvirostrum*, can be found near the fence. Like many mosses in the Pyramiden area this species prefers calcareous substrata. It is unusual that the reddish color, normally a distinctive feature of this species, is almost not expressed in this population. There are also some rare mosses growing here, for example *Bryobrittonia longipes.*

Fig. 3.3.29. "Islands" - the remains of foothill terraces in the middle of the Mimerelva delta. The arrow shows the island on which the cemetery is located. Photo by D. Davydov a

Fig. 3.3.29. Cemetery on islands in the delta of Mimerelva river.
Photo by O. Belkina

The route ends in these isolated areas of piedmont terraces. On the way back one has to cross some water currents on the Mimerelva delta, and then take the road to Pyramiden.


Tordalen

3.4 Route "Mimerdalen and Tordalen"

The excursion to the valleys of Mimerdalen and Tordalen rivers is the longest of all excursions. The distance from Pyramiden to the most distant point of the route (stop 10) is 9 km. In total length of the route with the visits to waterfalls is about 20 km, and taking into account the topography is about 22 km. (fig. 3.4.1).

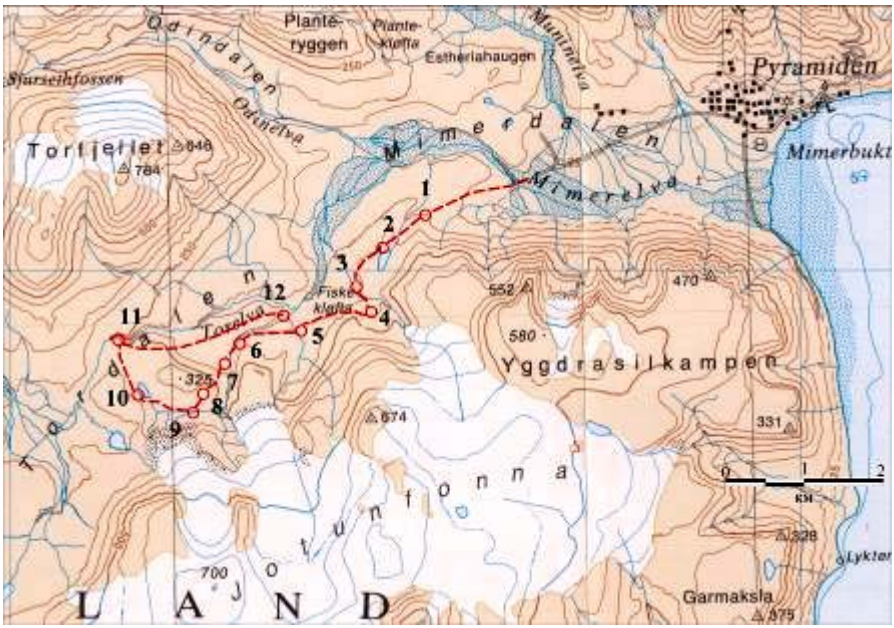


Fig. 3.4.1. Position of the route and stops

The route goes along the right banks of Mimerelva and Torelva rivers (fig. 3.4.1). This excursion gives an opportunity not only to search for cryptogamic organisms, but also enjoy a look at the glaciers, periglacial landforms and a variety of waterfalls (fig. xx). As we couldn't find official names of those waterfalls, we called them Nearest, Double, Far and Cascade falls for convenience. The walk will involve crossing relatively deep and rapid streams so high boots are strongly recommended.

The route starts at lower lakes with water intakes. From Pyramiden town to starting point, it is possible to drive about 2.2 km along the road up to the turn to the lower lakes with water intakes (Gousinoje and another) (see the map). From there, an old track goes to Goluboje Lake with a cabin on the shore (distance from the turn to this lake is about 2.5 km). (fig. 3.4.2).

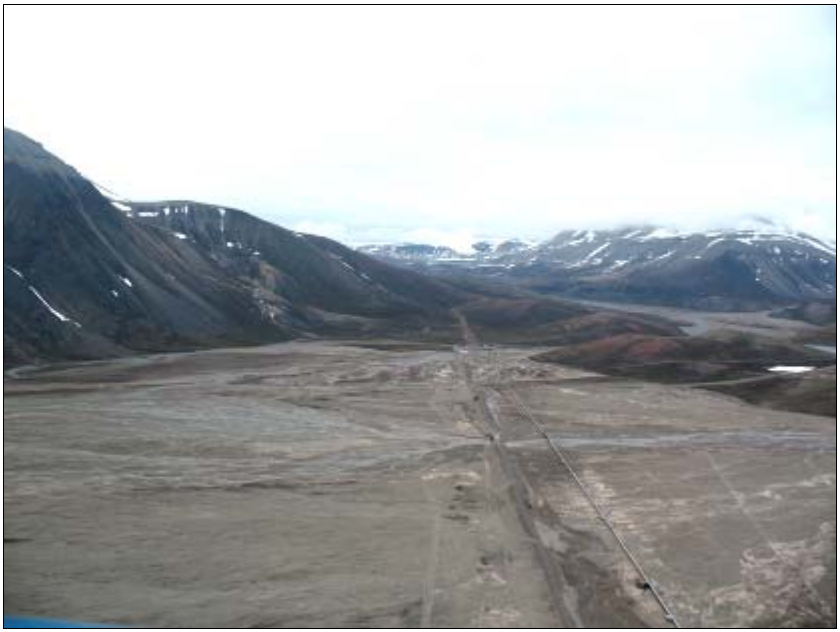


Fig. 3.4.2. The road through Mimerelva delta to Gousinoje Lake (turns right) and to Goluboje Lake (goes straight to north-western slope of Yggdrasilkampen). Photo by O. Belkina

Stop 1

The dirt road. (78º 38′ 36" N, 16º 9′ 2" E) (fig. 3.4.3)

Some rare bryophytes grow along the route. In a broad track which evidently forms the bed of a temporary brook, you can find some types of liverworts that are very rare in Svalbard. Small orange-brown spots or stripes in the tracks are formed by cushions of a very small liverwort *Oleolophozia perssonii* which is up to 3–5 mm tall and 0.5–1 mm wide. It has small light-green leaves and shoots that contrast in color with caps of numerous orange-red-brown gemmae on uppermost leaves. The species is easily recognized under the microscope thanks to one or two large persistent oil-bodies in the cells of 2-celled gemmae. The species also occurs in Petunia Bay near east-facing cliffs on the bank of a stream, under the Svenbreen Glacier. It is a rare species worldwide with a highly disjunctive arctic-montane distribution and was known previously on Svalbard from several localities in the Kongsfjorden area.

Fig. 3.4.3. Clumps of grass on sides of the dirt road.
Photo by D. Davydov

Moss *Orthotrichum* sp. grows on a transverse low rocky ridge to the south from the road. It has caps covered with long whitish hairs (fig. 3.4.4) which helps an easy identification of the species in a wild.

Fig. 3.4.4. The moss *Orthotrichum* sp. with caps covered by whitish hairs.
Photo by O. Belkina

Stop 2

(78º 38′ 23" N, 16º 7′ 32" E)

The cabin near the Goluboje Lake ("Goluboje" means "light-blue"). (fig. 3.4.5). The dirt road ends near the cabin on the shore.

Fig. 3.4.5. The cabin on the Goluboje Lake shore.
Photo by N. Konstantinova

Steep north-west facing shore of the lake is almost barren, while the gentle south-east facing shore is covered with cushions of bryophytes and vascular plants (fig. 3.4.6).

Fig. 3.4.6. South shore of the lake. Photo by D. Davydov

"Floating" islands of mosses are clearly visible in the shallow water of the lake. In fact, mosses are fixed to the clay and rocky bottom, with only their upper parts appearing above the water surface (fig. 3.4.7).

Fig. 3.4.7. Плавающие мхи варнсторфия (*Warnstorfia fluitans*) и скорпидиумы (*Scorpidium cossonii* и *S. scorpioides*). Photo by O. Belkina

Warnstorfia fluitans, *Scorpidium cossonii* and *S. scorpioides* form the base of these islands. The sizes of the mosses here are unusually large for Spitsbergen, 30 cm or more tall. Leaves of all three species look very similar, bent sickle like, making identification difficult for a non-specialist.

On the southern shore of the lake at the bottom of the hill, sides of numerous shallow streams are covered inhallose common liverworts. Here and there, relatively big patches (several square decimeters) of wet clay are covered by *Preissia quadrata* (fig. 3.4.8). It is a large, up to 4–6 mm wide and 2–4 cm long, leathery-thallose liverwort from the class Marchantiidae. The thalli are grey-green with often purplish brown or brownish margins and 2 rows of purple to blackish purple scales ending in a lanceolate appendage on the ventral (under) side. Dorsal (upper) surface of the thallus is obscure reticulate with one barrel-shaped pore in the center of polygons that can be seen with the powerful lens.

Fig. 3.4.8. Thalli of *Preissia quadrata*.
Photo by N. Konstantinova

This species often grows mixed with *Sauteria alpina*, one of the most common of Svalbard liverworts. Its light green thalli (fig. 3.4.9 , 3.4.10) are usually smaller than the dull green or red-green thalli of *Preissia quadrata*. *Sauteria alpina* also differs from the latter species by having rather fleshy to almost spongy thalli with an indistinct reticulate dorsal side, not having barrel-shaped pores that can be seen with lens and lack of any trace of secondary pigmentation. Both species differ clearly in female and male receptacles. In *Preissia* both male and female receptacles are stalked whereas in *Sauteria* the antheridia occur in raised groups along the midline of thallus

Fig. 3.4.9. Liverwort *Sauteria alpina*, thalli
Photo by N. Konstantinova

Fig. 3.4.10. Liverwort *Sauteria alpina*, sporogones.
Photo by N. Konstantinova

Dark green thalli of *Aneura pinguis* occur quite often on the sides of small hillocks (fig. 3.4.11). It represents another class of liverworts – Jungermanniopsida, and differs from those mentioned above, *Sauteria* and *Preissia,* by its dark green color and non reticulate dorsal side, types of rhizoids and male and female structures.. Most liverworts of this class have a stem, two rows of leaves, and often a single row of underleaves, which often differ from leaves. Under the microscope, the species of this class are easily distinguished from Marchantiidae by the shape of their rhizoids. They are smooth and have no protrusions, while Marchantiidae have two kinds of rhizoids: smooth and with appendages.

Mats of *Leiocolea gillmanii* are quite common at the bottom of rocks, in moist crevices on loam. This species belongs to the class Jungermaniopsida and occurs in this place mostly with numerous perianths and androecia under the perianths (fig. 3.4.12). Liverworts can form pure mats that cover up to 20% of the substrata. *Leiocolea gillmanii* was previously reported as rare in Svalbard but recently it was found in several places on the archipelago, where it was not rare and even abundant as in the Mimerdallen valley.

At the cabin the dirt road ends and a small path goes from the cabin to the southwest along the mountain slope.

Fig. 3.4.11. Thalli of *Aneura pinguis*.
Photo by N. Konstantinova

Fig. 3.4.12. *Leiocolea gilmanii*.
Photo by N. Konstantinova

Stop 3

Right tributary of the Mimerelva. (78º 38′ 8" N, 16º 6′ 36" E)

The large right tributary of the Mimerelva flows near the little lake in the area named Fiskekløfta, This name is composed of two Norwegian words which mean "fishing" and "canyon". Dwarf shrub-moss and moss-lichen tundra with the white bell-flowers of *Cassiope tetragona* and white-yellow flowers of *Dryas octopetala* carpet the banks of the stream. (fig. 3.4.13).

Fig. 3.4.13. Tundra with flowering *Cassiope tetragona* and lichens *Cetraria* spp. Photo by N. Konstantinova

Here you'll find common polar willow *Salix polaris* (fig. 3.4.14) and another species of mat-forming willows, *Salix reticulata* (fig. 3.4.15), with characteristic network of veins, as if pressed into the leaf surface.

The tundra mosses *Hylocomium splendens, Dicranum elongatum* and *D. spadiceum* form hummocks of various sizes. Occasionally, the mosses *Tomentypnum nitens* and *Sanionia uncinata* carpet the soil surface. If you're lucky, you can find here some myxomycetes (Myxogasteromycetes), slimy amorphous organisms with often brightly colored vegetative bodies (plasmodium) (fig. 3.4.16).

Fig. 3.4.14. Mat-forming willows –*Salix polaris*. Photo by O. Belkina

Fig. 3.4.15. Mat-forming willows –*Salix reticulata* (right). Photo by O. Belkina

Fig. 3.4.16. Brightly colored myxomycetes plasmodium among dwarf shrubs (*Dryas octopetala*) and lichens (*Cetrariella delisei* and *Cetraria islandica*). Photo by O. Belkina

A narrow path proceeds into a deep gorge formed by stream springing from the glacier Jotunfonna (fig. 3.4.17).

Fig. 3.4.17. A flock of geese crossing the stream from the Jotunfonna. Photo by N. Konstantinova

Stop 4

Solifluction slope. (78º 37′ 57" N, 16º 7′ 6" E)

Solifluction is a slow mass-wasting process related to freeze–thaw activity and typically occurring on slopes in periglacial regions. Small-scale solifluction influences vegetation structure and species composition. Patches of bare soil are readily occupied by fast-growing cryptogams occurring in association with cushions of tundra vegetation.

The moss *Stereodon bambergeri* forms hummocks near and on stones on a steep passage to the stream (fig. 3.4.18). A less common moss *Mnium thomsonii,* with a double row of teeth on the edge of a broad oval leaves, can also be found here but on soil (fig. 3.4.19).

Fig. 3.4.18. A hummock of *Stereodon bambergeri.*
Photo by O. Belkina

In the gorge, even in the middle of July there is still a lot of snow. After crossing the gorge, you'll find yourself on the north-west facing slope of the right tributary of Mimerelva River. The slope looks like a mixture of huge rocks and patches of bare soil as a result of substrata movement and permafrost processes (fig. 3.4.20). There are many shallow rivulets on the slope.

Fig. 3.4.19. The moss *Mnium thomsonii*. Photo by O. Belkina

Fig. 3.4.20. Substrata movement resulting from permafrost processes along the slope. Photo by N. Konstantinova

Both common and rare liverworts occur on clay under rocks. One of them, *Bucegia romanica* (fig. 3.4.21), is a worldwide rare species. It was described from Carpathian Mountains in Romania where it is not rare but later was collected in several localities of western North America and north-easternmost Asia (Chukotka and Yakutia). It was discovered recently in Svalbard. It is quite similar in appearance to a common species in Svalbard *Preissia quadrata* and can be easily confused.

Fig. 3.4.21. Thalli of *Bucegia romanica*. Photo by N. Konstantinova

A typical water moss *Ochyraea cochlearifolia* lives on the clay bottom of small streamlets. Its leaves are covered with a sheath of mucous clay (fig. 3.4.22). Small cushions of the moss *Catoscopium nigritum* occur on soil. The fruticose lichens, *Cetraria islandica* which is brown with a blood-red base and the slim and graceful *Gowardia nigricans*, occupy extensive areas (fig. 3.4.23).

After stop 4 we continue to move to south-west across hummocky moss tundra. An interesting arctic moss *Cyrtomnium hymenophyllum* can be found over there. This moss reminds one of species in the genus *Mnium* and belongs to the same family, but can be distinguished by its light greenish-bluish color.

The moss *Fissidens viridulus* looks like other species of this genus and has an unusual leaf structure with a double-layered base and a flat back wing (see the description of this moss in the excursion to Odinfjellet). The moss *Hymenoloma crispulum* is a typical inhabitant of rocky and stony substrates, but on Svalbard it often also settles on soil (fig. 3.4.22). Its narrow, pointed leaves are more or less

straight when wet, and become curly upon drying. This feature helps to distinguish it from other similar species in the family *Dicranaceae*.

Fig. 3.4.22. “Clay-like” cover of the moss *Ochyraea cochlearifolia* on a stone in the brook (left). *Hymenoloma crispulum* with curled dry leaves (right). Photo by O. Belkina

Fig. 3.4.23. Fruticose lichens *Cetraria islandica* and *Gowardia nigricans*. Photo by N. Konstantinova

Relatively dry spaces between tussocks are covered by the lichen *Lecidea ramulosa* that gives a bluish color to the tundra. (fig. 3.4.24).

Fig. 3.4.24. The bluish-gray thalli of lichen *Lecidea ramulosa* among brownish cushions of other lichens of genus *Cetraria*. Photo by N. Konstantinova

The bottom of the small streams flowing down the hillside is covered with brown and orange mats formed by cyanoprokaryota *Phormidium uncinatum*.

Approaching the next stream with its beautiful small waterfalls (fig. 3.4.25) we climb upstream, towards the first (Nearest Fall) waterfall on this route, it is easily seen from afar.

Fig. 3.4.25. Small waterfalls along the way to the Nearest Fall.
Photo by O. Belkina

Stop 5

Terrace at the Nearest Fall. (78º 37′ 50" N, 16º 4′ 40" E)

The brook forms numerous scenic waterfalls on the steep slope before cutting across the terrace. The streambed is flooded during snowmelt while in summer is almost completely barren (fig. 3.4.26). A shallow lake lies on the terrace, which is covered by cushions of plants and lichens.

Fig. 3.4.26. The Nearest Fall and terrace at the foot of a waterfall with cushions of tundra vegetation. Photo by O. Belkina

The mosses *Ditrichum flexicaule*, *Pseudocalliergon turgescens* and some *Bryum* species form small hummocks here, and *Philonotis tomentella* grows on waterlogged soil (fig. 3.4.27). The vegetation cover gets thicker on south-facing slopes.

A closed cover of crustose lichens is formed on more or less dry rocks. Numerous species of genera *Aspicilia*, *Placynthium*, and *Lecidea* often do not form thalli here, having only fruiting bodies scattered on the rock surface.

Fig. 3.4.27.
The moss *Philonotis tomentella* with brown antheridia on the tops of male plants.
Photo by O. Belkina

After leaving this picturesque corner, descend back into the valley and go further to the west (fig. 3.4.28).

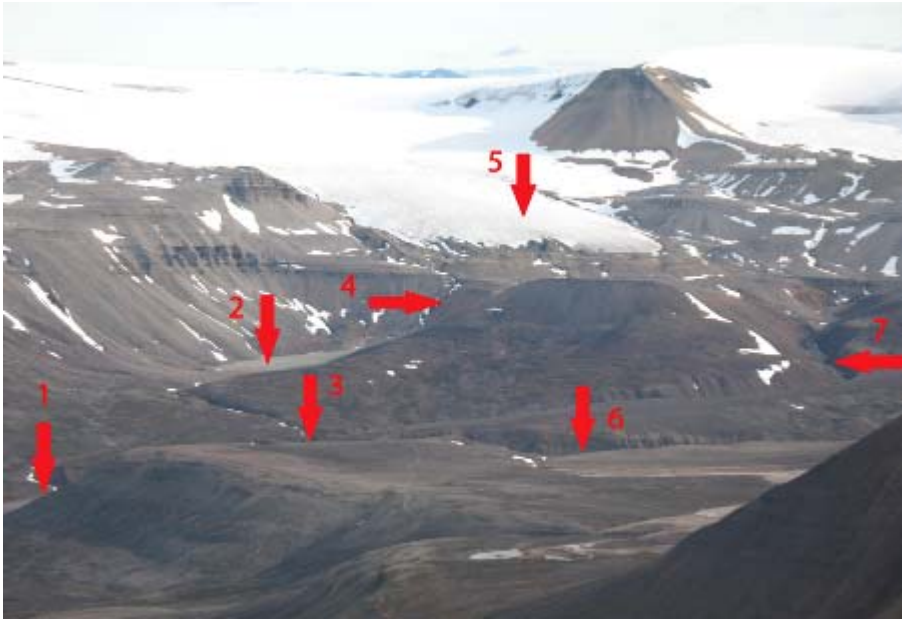


Fig. 3.4.28. The view from the slope of Mt. Odinfjellet to the Jotunfonna glacier, the valleys of Mimerdalen and Tordalen rivers:
1 – Mimerelva river, 2 – terrace front of the Nearest Fall, 3 – Cascade Fall (stop 11), 4 – the Nearest Fall, 5 – tongue of Jotunfonna glacier, 6 – Torelva river, 7 – stream with little waterfalls (stop 7).
Photo by O. Belkina

Stop 6 (78º 37′ 46"N, 16º 2′ 37"E)

Cyanoprokaryota community

An interesting extensive community with dominance of cyanoprokaryota occurs on the western part of the terrace and in the lower part of the valley (fig. xx). The most common species here are *Microcoleus vaginatus* (fig. 3.4.29), *Aphanocapsa muscicola*; *Gloeocapsa sanguinea* and *Stigonema ocellatum* can be also found here.

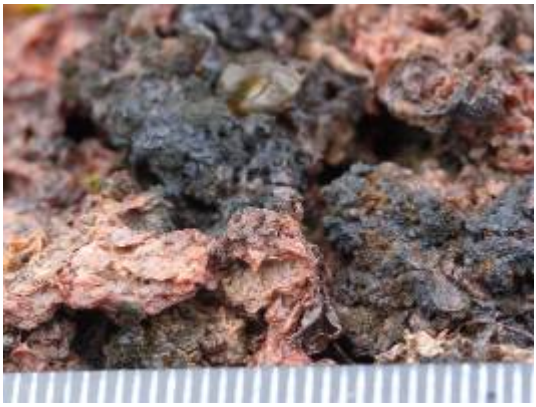


Fig. 3.4.29.
Dried red colored crust of cyanoprokaryota community dominated by *Gloeocapsa sanguinea*.
Photo by D. Davydov

From this stop the descending tongue of Jotunfonna glacier is visible in the distance (fig. 3.4.30). The Nearest Falls river flows from the glacier.

Fig. 3.4.30. The tongue of the Jotunfonna glacier and stony moist fields, inhabited by bryophytes. Photo by O. Belkina

Landforms such as non-sorted polygons, are formed on terraces as a result of ice wedge freezing (and growing) and thawing, which sorts the polygon border (fig. xxx). The more raised central areas of polygons are almost barren, while cracks and furrows between the polygons are colonized by mosses, liverworts and lichens. Among them, there are fast-growing species with 'ruderal' adaptive life strategy. These appear first on bare soil not yet occupied by other species. Among these pioneering species are mosses of genera *Pohlia*, *Bryum*, *Ditrichum*, and lichens of genera *Stereocaulon*, *Ochrolechia* and *Lepraria Lecidea*. The bluish crust thalli of *Lecidea* species prevail in polygon cracks on this terrace (fig. 3.4.31).

Fig. 3.4.31. Plants and lichens in polygon cracks, here the bluish crust of *Lecidea* prevails. Photo by O. Belkina

Hygrohypnella polare can be found in small streams and in moist habitats. This moss can grow not only on soil but also on the ice of glaciers, forming ball-shaped cushions.

Stop 7

Gravel screes at the entrance to Tordalen. (78º 37′ 37" N, 16º 2′ 1" E)

Third (on the way from the Goluboje lake) tributary also has some little waterfalls (fig. 3.4.32). Stream banks are covered by cushions of *Dryas octopetala*, *Saxifraga cespitosa*, *S. oppositifolia* and *Papaver dahlianum* (fig. 3.4.33).

Numerous mosses, such as *Encalypta alpina*, *Tortella fragilis*, *Timmia austriaca* occur on the soil and pebbles. The moss *Meesia uliginosa* can be found on the left bank of the stream. Fast-growing lichens of genus *Stereocaulon* occupy hollows and cracks between cushions of flowering plants and mosses.

Fig. 3.4.32. The little waterfall on the third tributary. Photo by O. Belkina

Fig. 3.4.33. *Papaver dahlianum* on the rocky stream bank. Photo by O. Belkina

Fast and turbulent water flow prevents plants settling on rocks and boulders in the streams. However, some cyanoprokaryota, e.g. *Schizothrix facilis,* manage to attach themselves to rocks and grow there.

Weather conditions become more severe with increasing altitude and distance from the sea. At high altitudes tundra with dominance of *Salix polaris* and *Dryas octopetala* occupy only small patches. Extensive areas are almost barren, with scattered plants and lichens.

Permafrost processes form a network pattern of stony polygons. Small stones remain in the polygon center, while larger material is pushed to the periphery (fig. 3.4.34). Cryptogams often form closed cover in the polygon center, so-called 'biological soil crusts'. In contrast to polygon centers, stony polygon rims are almost lifeless: only a few *Luzula* species can grow there.

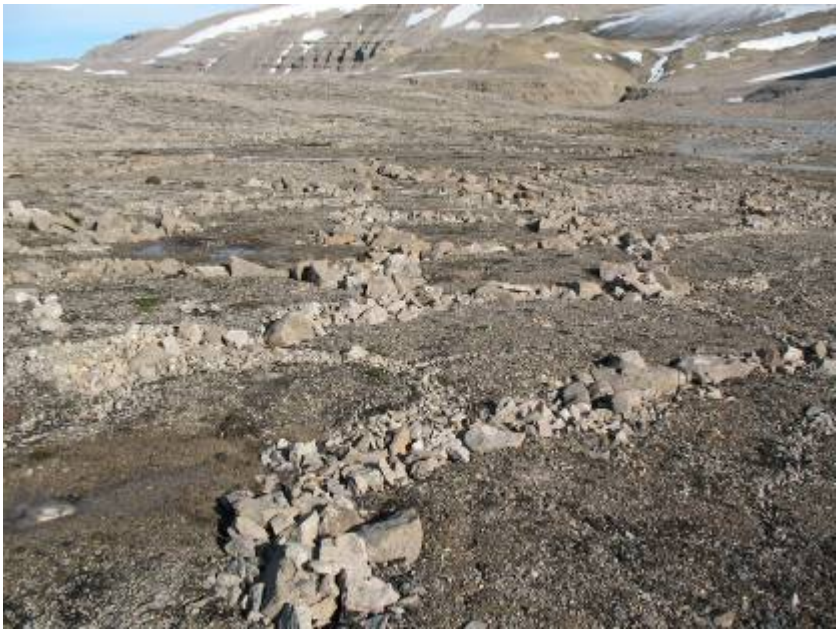


Fig. 3.4.34. Polygon network: stones on the rims and crusts of mosses, lichens and cyanoprokaryota in the polygon center.
Photo by O. Belkina

Numerous epilithic crustose lichens settle on the stones, for example, species of genera *Lecidea*, *Porpidea*, *Verrucaria* and some other species form their thalli inside or on the surface of stones. Sometimes thalli are almost absent and only fruiting bodies are visible on the rock surface (fig. 3.4.35).

Fig. 3.4.35.
Black apothecia of epilithic lichens from the genus *Porpidea*, which forms almost no thallus on the surface of stone.
Photo by L. Konoreva

Stop 8.

Moss communities in the snow-bed habitat. (78º 37′ 25" N, 16º 1′ 16" E)

Large part on mountain slopes and terraces is covered by snowfields, around which mosses are common plants. Species composition of moss communities there is similar to other wet habitats. Melt water moistens the soil and creates favorable conditions for plant life. A dense closed moss cover is formed with occasional moss cushions and a few vascular plants. These communities contrast with the grey and almost lifeless rock fields.

Pseudocalliergon turgescens, *Scorpidium cossonii*, and species of genus *Bryum* are common on snow-beds in the Pyramiden area. *Sanionia uncinata*, *Blindia acuta*, *Campylium stellatum*, *Oncophorus wahlenbergii* occur occasionally, while *Polytrichastrum alpinum* and *Ditrichum flexicaule* can be found in drier places (fig. 3.4.36).

Here you can find only a few specimens of *Tomentypnum nitens*. This moss is abundant in the lower part of Mimerdalen valley, and gradually disappears from the moss cover with altitude.

Rock outcrops above snowfields are actively colonized by lichens, where epilithic species of genus *Rhizocarpon* are most common (fig. 3.4.37).

Fig. 3.4.36. Snow-bed moss community on the slopes of Tordalen.
Photo by O. Belkina

Fig. 3.4.37.
Epilithic lichens of genus *Rhizocarpon* (yellow-green thalli) and *Melanelia hepatizon* (brown-black thallus in the center) cover rock outcrops.
Photo by L. Konoreva

Stop 9

The Double Fall. (78º 37′ 18" N, 16º 0′ 54" E)

Near Stop 8, the Double Fall forms two steps of about 1 and 1.5 m. Cushions of mosses grow on rocks along the edges and cracks above and below the water course. A common aquatic moss *Hygrohypnum luridum* was found in and near this fast-flowing mountain stream. Here you can also see numerous rounded capsules of *Schistidium platyphyllum* (fig. 3.4.38), immersed in the apical leaves. Reddish cushions of the moss *Orthothecium chryseon* and the brownish *Scopidium cossonii* (fig. 3.4.39) occur on rock ledges, together with cushions of *Timmia comata* and tiny rosettes of *Encalypta procera*.

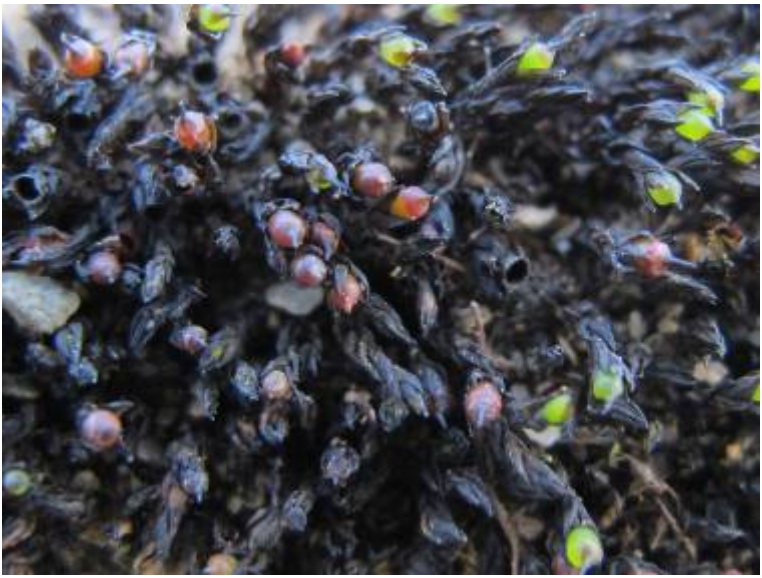


Fig. 3.4.38. *Schistidium platyphyllum* on a stone.
Photo by O. Belkina

Fig. 3.4.39. Water-loving moss *Scorpidium cossonii* is widespread in wet habitats. Photo by O. Belkina

From Stop 9, the route goes on fields of stony polygons. Here is a second northwestern tongue of the Jotunfonna glacier with its terminal moraines forming a hillocky landscape (fig. 3.4.40).

Bryum wrightii was collected on the gravel soil of one of the polygons. This moss has an unusually short round capsules, and can be identified in the field by this trait, unlike most of *Bryum* species. Small cushions of bryophytes, together with individual flowering plants, mainly *Luzula* spp., occur in wet habitats.

Fig. 3.4.40. The second northwestern tongue of glacier Jotunfonna and morainic hills. Photo by O. Belkina

Stop 10

The lake in Tordalen valley. (78º 37′ 25" N, 15º 59′ 1" E)

The route turns to the northwest, and goes down to the creek with a small lake, among stony polygonal fields (fig. 3.4.41). The number of bryophytes here is rather small. Scattered cushions of *Scopidium cossonii* and *Bryum* sp. occur in the central part of polygons, together with small cushions of *Orthothecium chryseon* and *Ditrichum flexicaule*. *Dicranella grevilleana*, a small moss with protruding threadlike leaves, was found on wet bare soil. Miniature moss *Platydictya jungermannioides* grows in rock crevices. Its species name is explained by the resemblance to a leafy liverwort, having a tiny stem and very small leaves. Colonial cyanoprokaryota *Chroococcus pallidus*, *C. varius* and *Gloeocapsa alpina* occur on banks of streams and lakes.

Fig. 3.4.41. The lake at the foot of the north-western tongue of Jotunfonna glacier and fields of stony polygons. Photo by O. Belkina

From Stop 10, follow to the west climbing up the slope to enjoy a striking wide panorama of the Torelva river valley (fig. 3.4.42). This could be the last point of the walk.

Fig. 3.4.42. Tordalen valley. Photo by O. Belkina

However, if you have not lost enthusiasm and want to carry on a little bit more walking, you can see a spectacular waterfall at **Stop 11 (**78º 37′ 48" N, 15º 58′ 21" E**).** This is the Far Fall, which is located near the mainstream of Torelva River (fig. 3.4.43).

Fig. 3.4.43. Far Fall in the rays of the midnight sun.
Photo by O. Belkina

Finally, beautiful Cascade Fall (**Stop 12 (**78º 37′ 56" N, 16º 4′ 4" E)) can be seen just above the junction point of Torelva and its largest right tributary (fig. 3.4.44, a, b).

a b

Fig. 3.4.44. Cascade Fall from different viewpoints (a, b). Photo by O. Belkina

To go back to the Mimerdalen and Pyramiden it is necessary to cross the tributary. However, one should take into account that the cross of the river at this point is very difficult because of the steep riverbanks, deep and very strong current. Therefore it is better to go 0.7–1 km backwards along the left bank upstream, and find there a suitable crossing.

On the way back one can take another look at the Tordalen and Mimerdalen valleys and surrounding slopes (fig. 3.4.45). The familiar pyramidal top of Pyramiden Mountain will guide the way home.

Fig. 3.4.45. The background: Tordalen and Pyramiden Mountains.
Photo by O. Belkina

Pyramiden town

3.5 Route “Pyramiden town”

Pyramiden town is situated on the western shore of Billefjorden, on Dickson land, at the foot of the southern slope of Pyramiden Mountain (935 m a. s. l.) at 78°39' N, 16°17'–16°24' E. Pyramiden is known as a far north ‘ghost town’ as it was abandoned in 1998, it is one of the most popular tourist destinations in Svalbard.

Stop 1

Anthropogenic meadow-grass grasslands in the center of Pyramiden

The Excursion starts at a major tourist attraction in Pyramiden, a square with the northmost monument to Lenin. It also has an abandoned sports center with swimming pool surrounded by two-storey wooden houses and a line of cobbled houses. Here we can find unique green lawns which were planted on fertile top-soil imported from the continent (fig. 3.5.1). Viviparous grasses (fig. 3.5.2) *Poa alpina*, *P. alpigena, Deschampsia alpina,* and herbs (*Saxifraga cernua*) form an dense carpet and colonize open patches with numerous seeds and propagules. Some alien species (*Achillea millefolium, Barbarea vulgaris*) are occasional here.

Fig.3.5.1. Anthropogenic grassland lawns in the center of Pyramiden. Photo by N. Koroleva.

Fig. 3.5.2. Embryos of viviparous grasses of *Poa* genus germinate before the fall of the seed, and while still connected to the parent plant. Photo by O. Belkina

These semi-natural grasslands are grazed by reindeer (*Rangifer tarandus*) and are visited by geese and seagulls. Among the grasses, mosses *Bryum* spp. (fig. 3.5.3), *Ceratodon purpureus* (fig. 3.5.4) and *Leptobryum pyriforme* form tufts with protruding sporophytes. These species are called "ruderal", i.e. plants often growing in disturbed habitats. Under the cover of grasses, spreadmosses such as *Sanionia uncinata, Distichium spp.,* and a variety of lichens: *Cetraria islandica* (fig. 3.5.5), *Cladonia pyxidata*, *Collema tenax*, *Lecidea alpestris*, *Peltigera didactyla, P. lyngei*, *P. rufescens*, *Xanthoia elegans* and *X. sorediata,* can be found.

Fig. 3.5.3.
Mosses of *Bryum* genus occur all over the Pyramiden, and produce plentiful sporophytes. Photo by O. Belkina

Fig. 3.5.4. Turf of *Ceratodon purpureus* parted due to destroying of reindeer or birds. Photo by O. Belkina

Fig.3.5.5. *Cetraria islandica* on soil in Pyramiden town.
Photo by L. Konoreva

Fig.3.5.6. *Rhizocarpon* sp. – the most common saxicolous genus on the Svalbard.
Photo by D. Davydov

Stop 2

Gull colony at an abandoned industrial building (‘brumberg’) and in the building construction and assembly management area.

Birds readily occupy abandoned construction sites in towns and villages in this polar region. In Pyramiden, black-legged kittiwakes (*Rissa tridactyla*) nest in a preserved dormitory building in the center of town. The big and easy to watch colony settled in the outskirts of Pyramiden (fig. 3.5.7, 3.5.8), where green algae cover and a luxurious meadow grow on 2–5 m wide strips enriched with bird’s droppings (fig..3.5.9). Among the dominating grasses in the meadows, there are *Cochlearia groenlandica* (fig. 3.5.10), *Trisetum spicatum* (fig. 3.5.11), *Poa alpigena* and *Puccinellia angustata*.

Moss cover includes *Ceratodon purpureus* with plentiful sporophytes, *Bryum* spp. *(B. pallescens, B. amblyodon, B. nitidulum*), *Sanionia uncinata*. (fig. 3.5.11). In the and nearby streams green mats of *Pohlia wahlenbergii, Philonotis tomentella, Bryum calophyllum, Orthothecium chryseon* cover the soil. Bird droppings enrich the soil with phosphates and nitrates. Mosses, which tend to avoid calcareous rocks, grow here, for example, *Aulacomnium palustre*(fig. 3.5.12) and *Plagiomnium ellipticum.*

Fig. 3.5.7. Colony of black-legged kittiwake in an abandoned building.
Photo by O. Belkina

Fig. 3.5.8. Kittiwake chicks. Photo by D.A. Davydov.

Fig. 3.5.9. Ornithogenic vegetation under a colony on an abandoned industrial building. Photo by N. Koroleva

Fig. 3.5.10. Cover with *Cochlearia groenlandica.* Photo by O. Belkina

Fig. 3.5.11. Moss tufts with cushions of *Trisetum spicatum*.
Photo by O. Belkina

Fig. 3.5.12. *Aulacomnium palustre* with more dark green brood bodies on the tips of shoots. Photo by D. Davydov

Lichens are relatively scarce; the orange-red thalloms of *Xanthoria sorediata* (fig. 3.5.13), are easily recognizable among more common species such as *Collema flaccidum, Lecidea alpestris, Peltigera didactyla, Physconia muscigena*. Cyanoprokaryota – *Nostoc commune, Microcoleus autumnalis, Pseudanabaena frigida*, cover the surfaces.

Fig. 3.5.13. Orange-red thallus of *Xanthoria sorediata*. Photo by L. Konoreva

Similar vegetation develops around abandoned farmhouses, on heaps of farm manure and even under swings on the former children's playground in the center of Pyramiden (fig. 3.5.14). Next to the coal power plant, there is an interesting area with small tufts of moss *Hennediella heimii* var. *arctica* (fig. 3.5.15), which have capsules with distinctive lids raised above urns.

Fig. 3.5.14. Ornithogenic meadow under the swings. Photo by O. Belkina

Fig. 3.5.15. *Hennediella heimii* var. *arctica*. Photo by D. Davydov

Aplodon wormskioldii (fig. 3.5.16) was found on the meadow nearby abandoned football pitch. Like many other mosses of *Splachnacea* family, this species grows on decaying organic substances, such as animal excrement and dead bodies. So the moss cushion exsists in this place during short period, and then its spores germinate only reaching the proper substratum. The species is included into the Norwegian Red List for Species, though occurs rather often on Svalbard.

Fig. 3.5.16. *Aplodon wormskioldii*. Photo by O. Belkina

Lichens are relatively scarce; the orange-red thalloms of *Xanthoria sorediata* are easily recognizable among more common species such as *Collema flaccidum, Lecidea alpestris, Peltigera didactyla, Physconia muscigena*. Cyanoprokaryota (*Nostoc commune, Microcoleus autumnalis* and *Pseudanabaena frigida*) are abundant in these habitats, received bird's excrements rich in phosphates and nitrates (fig. 3.5.17, 3.5.18).

Fig. 3.5.17. Nitrophilous community of Cyanoprocaryota *Microcoleus autumnalis*, forming shiny black mats under bird-colony in the center of the town.
Photo by D. Davydov

Fig. 3.5.18.
Microcoleus autumnalis.
Photo by D. Davydov

Stop 3

Weedy species on streets of the town and industrial zone

Pyramiden is an ideal place to observe succession or restoration of vegetation. It happens where the plant cover and soils were destroyed mechanically, eroded on roadsides and near buildings, on waste earth and coal mines Succession normally starts with the formation of moss and lichens cover and scattered tufts of grasses and herbs (fig. 3.5.19; 3.5.20). The species, which first occupy eroded surfaces, are called 'pioneer species'. Among them there are vascular plants *Taraxacum* spp., *Saxifraga cernua*, *Poa alpigena*, *P. alpina*, *Trisetum spicatum, Deschampsia alpina,* and mosses *Ceratodon purpureus*, *Leptobryum pyriforme*, *Bryum* spp. (often with sporophytes), *Sanionia uncinata, Distichium spp*. *Polytrichum hyperboreum,* and *Ditrichum flexicaule.* Moss *Psilopilum cavifolium* occurs on piles of coal, *Encalypta* spp. were found on the abandoned football pitch. Lichens *Cladonia pocillum*, *Peltigera didactyla*, *P. rufescens* and *Stereocaulon* spp. are among the most common species on lanes and in the industrial area of Pyramiden. Blackish-green colonies of *Nostoc commune* cover open soil.

Fig. 3.5.19. Cover of ruderal mosses on abandoned sport ground.
Photo by N. Koroleva

Fig. 3.5.20. Ruderal vegetation (*Taraxacum* sp. and *Cerastium alpinum* among *Bryum* sp. with its brownish capsules). Photo by N. Konstantinova

Stop 4

Seashore nearby Pyramiden town

A large part of the industrial area of Pyramiden (dock, warehouses, coal stocks, etc.) is situated on the seashore. Salt marsh vegetation develops here on fine-textured sediments (mud, clay). Prostrate halophytic herbs *Puccinellia phryganodes* and *Phippsia algida* are common here (fig. 3.5.21; 3.5.22). *Stellaria humifusa* and *Ranunculus hyperboreus* grow in shallow moist depressions, whereas *Poa alpigena* and *Deschampsia alpina* are abundant on higher elevations (Fig. 6). The mosses *Bryum* spp., *Sanionia uncinata*, *Drepanocladus aduncus, Bryum calophyllum, Campylium* sp*., Distichium hagenii* are occasionally found among mats of grasses and herbs. Lichens readily colonize pieces of wood, dry hummocks and litter. The terricolous (grows on the ground) lichen *Collema tenax* has a thick black or dark green gelatinous thallus, which swells up in presence of water. Widespread on Svalbard, crustose lichen *Lecidea alpestris* has contrasting white thalli and black apothecia. Foliose lichens, common species *Peltigera didactyla* and rare *P. lyngei* occur on soil and among mosses, whereas species from genus *Lecanora* and *Candelariella* grow on wood.

Fig. 3.5.21. Puccinellia and moss dominated plant communities with scattered tufts of *Deschampsia alpina* on the upper littoral on the seashore.
Photo by N. Koroleva

Fig. 3.5.22. Sprouting *Puccinellia phryganodes* on the seashore.
Photo by O. Belkina

Stop 5

Abandoned barn and stalls

In 1970's, Pyramiden was supposed to be 'the capital of Russian Svalbard'. Not only the apartments, Palace of Culture, swimming pool and indoor sport complex were built here, but also sheds for cows and pigs and a chicken farm (fig. 3.5.23). Manure was used as a fertilizer in the greenhouse for growing vegetables and ornamental plants. These days, anthropogenic grasslands dominated by *Poa alpina, P. alpigena*, *Puccinellia angustata*, *Trisetum spicatum*, *Cerastium arcticum* (fig. 3.5.24), and *Gastrolychnis involucrata* surround the abandoned barn and stalls. The moss *Ceratodon purpureus* forms a dense carpet, together with species of *Bryum* genera and *Sanionia uncinata* (fig. 3.5.25).

Fig. 3.5.23. Abandoned chicken farm.
Photo by N. Koroleva

Fig. 3.5.24. *Cerastium alpinum* flowering inside a jar, as in miniature glass-house. Photo by O. Belkina

Fig. 3.5.25. Mosses *Syntrichia ruralis*, *Stereodon revolutus* and *Sanionia uncinata* in the iron trough in the pen. Photo by O. Belkina

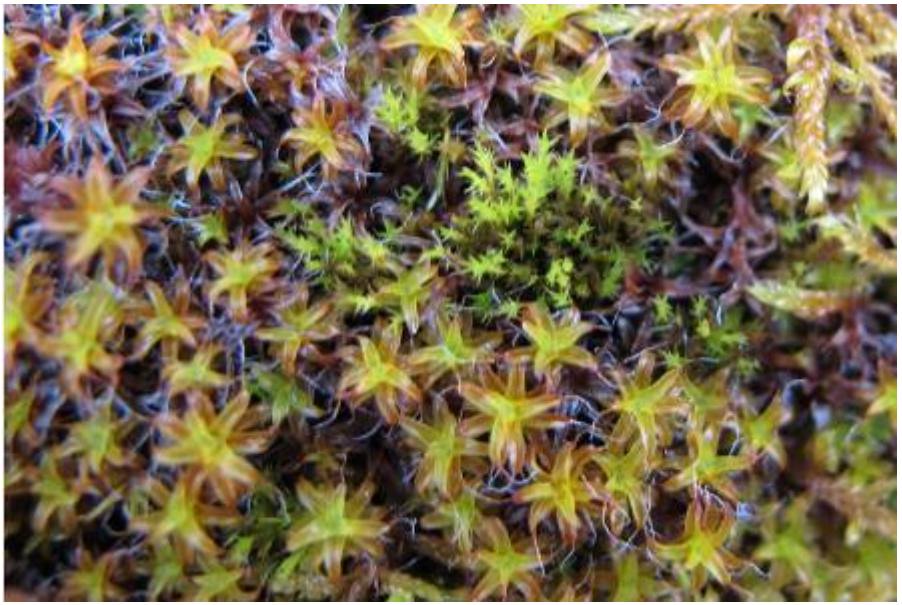


Fig. 3.5.26. Mosses *Syntrichia ruralis*, *Stereodon revolutus* and *Sanionia uncinata* in the iron trough in the pen. Photo by O. Belkina

Lichens *Peltigera didactyla, Xanthoria elegans* and *X. sorediata* were found on the grassland near the abandoned pigsty (fig. 3.5.27).

Fig. 3.5.27. Orange thalli of *Xanthoria elegans* on wood debris.
Photo by L. Konoreva

Cryptogamic organisms are the first to colonize destroyed habitats, bare soil and even artificial substrata; they start succession and open the way to flowering plants. Some mosses occupy artificial substrata in Pyramiden, *Bryum* species, *Sanionia uncinata* and also *Syntrichia ruralis* occupy boards and bottom of iron trough in the pen (fig. 3.5.25). Group of plants settled in a jar like in miniature glass-house was a funny finding near the pigsty (fig. 3.5.24).

In the farmyard, mushrooms grow on the remains of manure; they are collected by few present inhabitants of Pyramiden town (fig. 3.5.28, 3.5.29).

Plant communities in moist habitats near abandoned farms and stalls look similar to the vegetation found around bird cliffs, with dominance of *Cochlearia groenlandica, Poa alpigena*. *Puccinellia angustata* and *P. phryganodes, Ranunculus hyperboreus*, mosses of *Bryum* genera, and small *Encalypta* sp. etc. occur in moist habitats.

Fig. 3.5.28. Mushrooms on old manure pile, amidst *Poa alpigena* and *Cerastium* sp. Photo by O. Belkina

Fig. 3.5.29. Mushrooms on manure, amidst *Poa alpigena*. Photo by O. Belkina

Stop 6

Bottle house 78º39′34" N, 16º17′27"E.

Bottle house is situated on the north-western edge of Pyramiden and is among famous local attractions (fig. 3.5.30, 3.5.31). It was built in 1980-s of empty lemonade, vodka and champagne bottles. Tourists can use the house for short stay on permission of Arktikugol'.

Fig. 3.5.30. Bottle house general view.
Photo by O. Belkina

Fig. 3.5.31. Bottle house view inside. Photo by O. Belkina

Vegetation around the bottle house is common and characteristic of calcium-rich substrata in inner fjords areas of Svalbard. Closed plant communities with characteristic dark-green appearance due to dominance of *Cassiope tetragona* in combination with lichen *Cetrariella delisei* and mosses *Sanionia uncinata* and *Tomentypnum nitens* prevail in depressions. On wind-exposed and trampled hilltops are situated communities with xeromorphic appearance due to dominance of *Dryas octopetala*, rock sedge (*Carex rupestris*) and other xeric sedges (*C. hepburnii*, *C. misandra*). Mosses *Bryum amblyodon, Ceratodon purpureus, Sanionia uncinata, Distichium capillaceum, Niphotrichum canescens* often found on disturbed habitats.

On some distance from the bottle house there occur tundra mosses, which do not grow in Pyramiden, such as *Oncophorus wahlenbergii* (fig. 3.5.32)*, Tomentypnum nitens, Tortella fragilis*, etc.

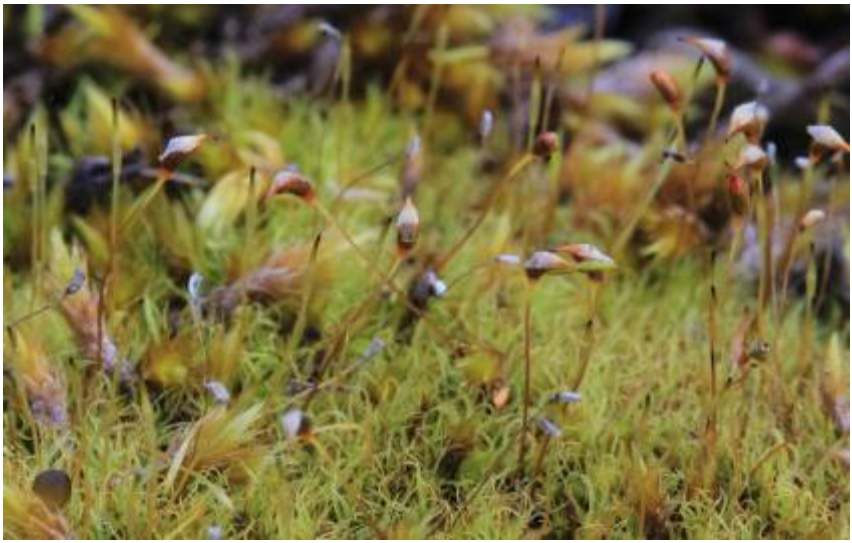


Fig. 3.5.32. *Oncophorus wahlenbergii*. Photo by D. Davydov

Calciphytic moss *Abietinella abietina* (fig. 3.5.33). was found on the left bank of the brook flowing from the glacier Bertilbreen. It looks like *Hylocomium splendens* when moist; difference between two species reveal, when they get dried out. (fig. 3.5.34, 3.5.35).

Fig. 3.5.33. *Abietinella abietina*. Photo by O. Belkina

Fig. 3.5.34.
Abietinella abietina single plant
Фото О. А. Белкиной

Fig. 3.5.35.
Hylocomium splendens single plant.
Фото О. А. Белкиной

Amphigastrium – see underleaf.

Androecium – all antheridia and surrounding leaves (“male house”).

Annulus – a part of capsule: one or few rows of cells located between urn and lid which promotes separation of lid. It is missing in some mosses.

Antheridium (pl. antheridia) – male gametangium where male sex cells, spermatozoids, develop.

Apical cells – terminal cells or rows of cells.

Apothecia – open fruit bodies of lichens (in fungi of Ascomycota group), in which spores are exposed at maturity.

Arachnoidally (thallus, medulla) – in lichens, tenderly thin branches, like a spider web

Archegonium (pl. archegonia) – female flask-shaped gametangium, where female sex cell (ovum) develops.

Arctomontane – species that occur in the Arctic and in the mountains

Areolae – a round to polygonal part of a surface mainly of crustose lichen, often integrated by general prothallus

Asci – a sac-like cells within which the products of meiosis, the ascospores, are produced (in lichens with fungal component of Ascomycota group).

Border (leaf border) – one or more rows of cells located on the edge of leaf in mosses. They differ from other cells of lamina by the shape (usually longer and narrower) and sometimes by color.

Bracteole – modified underleaf in gynoecium of bryophytes.

Bracts – modified leaves surrounding archegonia or antheridia of bryophytes.

Brood bodies – specialized structures for vegetative (asexual) propagation of bryophytes. Usually they are formed in leaf axils or on top of the stem and are presented by gemmae, brood branches, bulbils etc.

Calciphyle, calcicole – species preferring substrates with a high content of available calcium, carbonate, limestone, dolomite etc.

Calyptra –usually membranous, rarely pilose cap or hood, covering the immature capsule of mosses and protecting it from adverse effects of environment (fig. 2.1.1). It is a remainder of archegonia.

Capsule – upper part of sporophyte, where spores are formed. In mosses consists of neck or hypophysis, urn, annulus and lids (operculum). In the early stages of development covered by calyptra (fig. 2.1.1).

Cephalodia – structures with cyanobacteria in the lichen thallus having as photobiont green algae.

Colony – microscopic or macroscopic aggregates of cells or filaments of Cyanoprokaryota, organized in a characteristic form; usually enveloped by clearly delimited or diffluent, distinct or fine mucilage of various consistency and color; cells or trichomes in colonies belong to several to many generations, sometimes with their own individual gelatinous envelopes.

Constrictions – narrowing of cross-walls in filamentous Cyanoprokaryota.

Costa, nerve – midrib; longitudinal strand in leaf lamina, providing substance to leaf cells and giving additional strength.

Crust (of lichen) – dense, variously pigmented fungal hyphae interweaving covering the upper layer (upper crust), and often lower (lower crust) of the thallus surface. Organs for attachment often are formed on the lower crust: rhizinae, umbilicus etc.

Crustose thallus– crust-like thallus, covering the surface of the substrate.

Cuticula – aggregation of outer walls of cells in direct contact with environments.

Decurrent leaf – extensions of the leaf base down the stem (in mosses), i.e. leaf attachment wherein a leaf base edges attached to the stem lower than the middle part of the base).

Dichotomous (branching) – dividing into two more or less equal branches while branching

Dimorphic thallus (of lichens) – consists of two parts, differently oriented: horizontally arranged crustose thallus and vertical podetium or pseudopodetium.

Disc of apothecia – the upper surface of apothecia, different colored protective layer for asci with spores.

Entire (leaf) – having edge of lamina without any teeth, projecting cell ends, notches etc.

Epilithic – organisms, growing on stony substrate.

Epithecium – in lichens, upper part of the discs of apothecia

Falcate (leaf) – having sickle form (sickle bended)

False branching (pseudobranching) – branching of thallus of Cyanoprokaryota, when cells are not connected physiologically; it appears in species in which the cells are arranged in rows, but not in trichomes where cells form a physiological entity.

Fertile plant – plant with sexual organs (gametangia)

Filamentous (cyanoprokaryotes) – species with thalli as chainlike series of cells (filaments).

Foliose thallus (of lichens) – leaf-like thallus, attached to the substrate by rhizine or umbilicus.

Fruticose thallus (of lichens) – shrub-, beard- or worm-like thallus.

Furcate (branching) – forked (dividing into two divergent branches while branching)

Gametangium (pl. gametangia) – organ, where sex cells (gametes) are formed. Gametangium can be male, i.e. antheridia, and female, i.e. archegonia.

Gametophyte – an individual producing gametangia (archegonia and/or antheridia). A plant with leaves that is called "moss" in common parlance (in daily use) is the gametophyte. After gamete maturation and fertilization, the sporophyte is formed. Gametophyte is the sexual generation in bryophytes (or mosses and liverworts) life cycle (fig. 2.1.1).

Gemma (pl. gemmae) – one or three, rare multi-celled structures aggregated mostly in groups on upper leaves or in their axils and used for reproducion. Thallose hepatics produce gemmae in special shallow cups on the upper side of the thallus.

Gynoecium (pl. gynoecia) – combination of archegonia and sterile threads (if present) and surrounding modified leaves of bryophytes.

Heterocytes (of Cyanoprokaryota) – special thick-walled cells where atmospheric nitrogen is fixed.

Heteropolarity – occurs in cells of Cyanoprokaryota, filaments of which are morphologically diversified into basal (usually attached to substrata) and apical (free) ends.

Holarctic species – species distributed throughout Holarctic – the large biogeographical region that includes arctic, boreal and temperate zones of continents in the northern hemisphere.

Hydrophytes – group of plants adapted to living in water (beds of streams, rivers and lakes, pools in the bogs etc.), i.e. aquatic plants.

Hygrophytes – group of plants adapted to living in moist sites (on edges of streams and swamps, on wet meadows etc.).

Hyphae – fungal cells, combined into filaments and forming the thallus of lichens.

Hypophysis (**apophysis**) – lower sterile portion of the moss capsule, which is located under the urn and usually is wider than urn, or inflated, and/or differently colored (fig. 2.1.1).

Imbricate (leaves) - pressed to stem overlapping each other (like roof tiles).

Isidia – structure for vegetative reproduction of lichens, variously shaped protuberances of thallus, covered, in contrast to **soredia**, by **crust**.

Keeled leaf – leaf having V-shaped cross-section, i.e. parts of lamina located on both sides of costa are oriented to each other at acute angle.

Lamella (pl. lamellae) – long flat one-cell thick structure located on upper side of leaf and stretched along leaf lamina perpendicularly to its surface. Lamellae are arranged in few or many rows and are presented in Polytrichaceae family of mosses. A cross section of such leaf looks like a comb whose teeth represent the rows of lamellae. Uppermost cells of lamella often differ from others in their size, shape and thickened papillose walls. Cells of lamella contain chlorophyll and enable photosynthesis.

Lamina (leaf lamina) – the part of the leaf, apart from the costa, formed by cells with chlorophyll and capable of photosynthesis

Lid (**operculum)** – part of capsule, closing the entrance to the urn when it has immature spores and usually falling away or rising over the urn after spores' maturation (fig. 2.1.1). It is absent in some mosses.

Limb – upper part of leaf lamina, usually contrasting with lower part (for instance, with sheat)

Mamilla (pl. mamillae) – bulge on the surface of an organ (usually of leaf), formed by protruding end of the cell. Unlike papillae, mamillae do not result from thickening of cell walls, they are formed by raised ends of elongated cells.

Mat – macroscopic colony of Cyanoprokaryota, covering substrate in form of gelatinous or crustaceous layer.

Medulla – loose interweaving of fungal hyphae in the central part of lichen thallus.

Neck – lower sterile part of capsule located between urn and seta (fig. 2.1.1).

Oil bodies – oil containing structures of different shape and size in the cells of many liverworts. It is one of the very important characteristics for classification and identification of species of liverworts.

Ornithogenic (habitat) – resulted from and affected by birds activity (such as nesting, feeding. settling, etc.). Usually recognizable by presence of droppings, feathers, regurgitates and special kind of vegetation.

Papilla (pl. papillae) – of different shape and size thickening of the cell wall; usually it looks like bulge on the surface of leaves.

Paraphyllia – small green filamentous, scale-like or leaf-like structures on stem and branches of mosses.

Pendent (capsule) – with the hole (mouth) of urn facing down due to steep bend (180º) in the top of seta (in contrast to erect capsule – with mouth oriented upward).

Perianth (in liverworts) – a tubular structure formed by coalescence of leaves for protection of the developing sporophyte.

Peristome – one or two rows of teeth along the edge of the hole in mature urn in mosses (fig. 2.1.1). Due to the special structure, under dry weather conditions, teeth are bent outward and spores are dispersed freely from the urn. In wet weather, teeth are bent inward, contact with each other and close the entrance to the urn, preventing the spore dissemination.

Photobiont – part of the lichen thalli, in which photosynthesis occurs. Represented by algae and (or) cyanobacteria.

Photosynthesis – process of creating organic substances from inorganic compounds with the participation of light and special green pigment, chlorophyll, contained in the chloroplasts of the cells.

Phyllocladia – squamule-like structures occurring in podetium and pseudopodetium of lichens.

Placodioid – lichen thallus with crustose central part and foliose periphery.

Podetium (pl Podetia) – vertical part of dimorphic thalli, which forms apothecia. Mostly in the genus Cladonia.

Prothallus – in crustose lichens the lower part of the thallus, located directly on the substrate.

Pruina – in lichens, the scurf, thin incrustation on the thalli or disc of apothecia

Pseudocyphellae – pale areas of the lichen thallus, looking like tiny pores, where medulla extends to the surface and respiration occurs.

Pseudopodetia – are similar in form and function to podetia, but differ in formation.

Pycnidia – structures, which form spores of asexual reproduction of lichens. A jar-like structures immersed into the thallus or disposed on the surface.

Receptacle – in liverworts of Marchantyophyta enlarged part of tissue (sessile or stalked) that contains antheridia or archegonia.

Receptacle stalk –stalk which bears receptacles.

Rhizine – a root-like hair or thread acting as an attachment organ.

Rhizoids – filamentary structure of one row of cells, which originates mostly from stem and serves to absorb water and other substances from the environment, to attach plant to the substrate, to unite shoots together into tuft, and sometimes to provide reproduction (fig. 2.1.1).

Saxicolous – growing on rocky substrata.

Scale – in liverworts a thin, flat appendage on ventral side of thallus

Scyphus – expansion of the upper part of podetia, a cups, on which are formed apothecia.

Seta – elongated part of sporophyte of bryophytes, raising the capsule above gametophyte for more effective spore dispersal (fig. 2.1.1).

Sheath (sheathing lamina) – in mosses, broad, embracing a stem lower part of leaf, differing from the upper, usually bent portion of the leaf by color, shape and structure.

Sheaths (envelopes) – in Cyanoprokaryota, morphologically distinct mucilaginous layers around cells and trichomes, excreted from cells (not parts of a cell wall). Often have a tube-shaped form (enveloping the trichome) open at both ends or closed (in several genera); can be lamellate and colored by sheath pigments. Presence, facultative presence, frequency, form and color of sheaths are among the taxonomic features used in species and to a lesser extent in generic taxonomy.

Soredia – structure of vegetative reproduction of lichens, consists of one or more cells of algae, surrounded by hyphae of the fungus. Form a powdery mass on thallus surface after its cracking.

Sporophyte – asexual generation, the main function of which is to form and disperse spores. It is located on the gametophyte and remains associated with it throughout its life. Consists of the foot, immersed in the tissue of the gametophyte, seta and capsule (fig. 2.1.1).

Struma – small protrusion on lower portion of capsule of mosses, on one side of neck (fig. 2.1.1).

Subaerophythic – Cyanoprokaryota living on the ground, on other plants, etc. (not in the water) but with sporadic water supply.

Subula – narrow long acute upper part of moss leaf

Terricolous – growing on the soil

Thallus (pl. thalli) – the vegetative body in cryptogamic organisms that is not divided into main organs (stems and leaves). Lichen thallus consists of fungal hyphae and algal cells and (or) cyanobacteria.

Trichome – elongate hair-like structure of Cyanoprokaryota, may be unsheathed or sheathed.

True branching – branching of thallus in filamentous cyanoprokaryotes, results from lengthwise or asymmetrical division of intercalar cells and further division of cells perpendicularly to the original trichome axis. True branches are physiologically connected with original trichome and occur mostly in certain more diversified and heterocytous cyanoprokaryotes.

Umbilicus – the central holdfast occurring in some foliose lichens.

Underleaf – in leafy liverworts, a leaf on the ventral side of stem, often differs in size and shape from leaves. Underleaves can give a third row of leaves on the ventral side.

Urn – upper part of capsule wherein spores are generated from special tissue, and mature. There are teeth of peristom along rim of urn ("mouth"), or they are missing in some species. Young urn with immature spores is closed by lid (fig. 2.1.1).

Ventral scale – a small leaf like structure of different color, shape and size occurring on ventral side of thallous liverworts.

References

Abramova, A.L., Savicz-Ljubitskaja L.I. & Z. N. Smirnova. 1961. Opredelitel Listostebelnich Mchov Arktiki SSSR. Moskva: Izdatelstvo Akademii Nauk SSSR: 1-716. [Handbook of mosses of Arctic of the USSR, Moscow-Leningrad, Isd. Akad. Nauk SSSR]. [in Russian].

Belkina O. A., Likhachev A.Yu. 2013. Mosses of the Prince Oscar Land (Nordaustlandet, Svalbard). *Arctoa*. V. 22. P. 27-34.

Belkina O., Likhachev A. 2014. Diversity of mosses in Pyramiden settlement (Billefjord, Svalbard) // Polar Ecology Conference, 2014.Abstracts. Polar Ecology Conference, České Budéjovice, Czech Republic, 21-25 Sept. P. 19-20. http://polar.prf.jcu.cz/data/PEC2014_abstract_book_final.pdf

Belkina O.A., Mavlyudov B.R. 2011. Mosses on glaciers of Spitsbergen. *Botanicheskij zhurnal* [Russian Botanical Journal] 96 (5): 582–596 [in Russian].

Davydov, D. 2013. Cyanoprokaryota in polar deserts of Rijpfjorden east coast, North-East Land (Nordaustlandet) Island, Spitsbergen. *Algological Studies* 142: 29–44.

Davydov, D. 2014. Diversity of the Cyanoprokaryota of the area of settlement Pyramiden, West Spitsbergen Island, Spitsbergen archipelago. *Folia Cryptogamica Estonica* 51: 13-23.

Davydov, D. A. 2010. Cyanoprokaryota of the Spitsbergen archipelago: the state of study. *Botanicheskij zhurnal* [Russian Botanical Journal] 95: 169–176 [in Russian].

Davydov, D. A. 2011. Diversity of the Cyanoprokaryota of the Grønfjord western coast (Spitsbergen, Svalbard). *Botanicheskiy zhurnal* [Russian Botanical Journal] 96: 1409–1420 [in Russian].

Fries, T.M. 1867. Lichenes Spitsbergenses. – K. svenska Vet.-Akad. Handl. 72: 1–53.

Frisvoll, A.A. & A. Elvebakk Part 2. Bryophytes. - In: Elvebakk, A. & P.Prestrund (eds.): A catalogue of Svalbard plants, fungi, algae and cyanobacteria // Norsk Polarinstitutt Skifter. 1996. V. 198. P. 57-172.

Glime J. M. Bryophyte Ecology. Vol. 1. Physiological Ecology. 2007 // Ebook sponsored by Michigan Technological University and the International Association of Bryologists. Accessed on 2009 at *http://www.bryoecol.mtu.edu/*.

Gollerbah M. M., Kosinskaya E. K., Polanskiy V. I. Cyanoprokaryota // Handbook of freshwater algae of the USSR. Moscow, 1953. Issue 2. 653 p. [in Russian].

Ignatov, M.S., O.M. Afonina & E.A. Ignatova. 2006. Check-list of mosses of East Europe and North Asia. *Arctoa.* 15: 1-130.

Kålås J.A., Viken Å, Henriksen S. og Skjelseth S. (red.) Nørsk rødliste for arter 2010. Artsdatabanken, Norge. 2010. 480 p.

Komárek, J. & Anagnostidis, K. 1998. Cyanoprokaryota, 1. Teil: Chroococcales. In: Ettl, H., Gärtner, G., Heynig, G. & Mollenhauer, D. (eds). *Süsswasserflora von Mitteleuropa* 19/1. G. Fischer Verlag, Jena, 548 pp.

Komárek, J. & Anagnostidis, K. 2005. Cyanoprokaryota, 1. Teil: Oscillatoriales. In: Büdel, B., Gärtner, G., Krienitz, L. & Schlager, M. (eds). Süsswasserflora von Mitteleuropa 19/2. Elsevier, München, 759 pp.

Komárek, J. 2005. Cyanoprokaryota, 3. Teil: Heterocytous genera. In: Büdel, B., Gärtner, G., Krienitz, L. & Schlager, M. (eds). Süsswasserflora von Mitteleuropa 19/3. Springer, Berlin Heidelberg, 1133 pp.

Komarek, J., Kovacik, L., Elster, J. & Komarek, O. (2012): Cyanobacterial diversity of Petuniabukta, Billefjorden, central Spitsbergen – Polish Polar Research. 33: 347–368.

Konoreva L. Five lichen species new to Svalbard // Graphis Scripta. 2011. V. 23. P. 24–26.

Konoreva L.A. To the lichen flora of the neighborhoods of former Pyramiden settlement, Svalbard archipelago // Nowitates Systematicae Plantarum Now Vascularium. V. 45. – St.-Petersburg: Nauka, 2011. P. 183-193. [in Russian].

Konstantinova N.A, Belkina O.A., Davydov, D.A., Konoreva L.A. Vilnet A.A. Modern stage and purposes of investigation of liverworts, mosses, lichens and cyanoprokariota in the Svalbard // Theoretical and Applied Ecology. 2014. № 1. P. 26–31. [in Russian].

Konstantinova N.A, Vilnet A.A., Ştefănuț S. 2014. On the distribution and variability of *Bucegia romanica* Radian // Arctoa. 23. 137-144.

Konstantinova N.A., Savchenko A.N. Distribution of liverworts, rare for the Svalbard Archipelago, around Piramida (Pyramiden) Settlement // Nature of the shelf and archipelagos of the European Arctic. Iss. 8 Proceedings of the International Scientific Conference (Murmansk, November 9-11, 2008). Moscow, GEOS. 2008: 177-181 [in Russian].

Konstantinova, N., Savchenko, A. (2008). Contributions to the hepatic flora of Svalbard. / Lindbergia 33: P. 13-22.

Konstantinova, N., Savchenko, A. Distribution of *Scapania ligulifolia* R. M. Schust. (Hepaticae) on Svalbard // Global Climatic Processes and their Effects on Ecosystems of Arctic and Subarctic Regions. 2011. Iss. 11. [in Russian].

Koroleva N. 2014. Phytosociological evaluation of terrestrial habitat types in Pyramiden area (Svalbard, Norway) // Czech polar reports 4 (2): 193-211. http://polar.prf.jcu.cz/data/PEC2014_abstract_book_final.pdf

Koroleva N.E., Konstantinova N.A., Belkina O.A., Davydov D.A., Likhachev A.Yu., Savchenko A.N., Urbanavichene I.N. (2008). Flora and vegetation on Grønfjord Area (Spitsbergen archipelago) // K&M, Apatity, 111p. [in Russian].

Matuła, J., Pietryka, M., Richter, D. & Wojtun, B. (2007): Cyanoprokaryota and algae of Arctic terrestrial ecosystems in the Hornsund area, Spitsbergen. – Pol. Polar Res. **28**: 283–315.

Øvstedal, D. O., Tønsberg, T. & Elvebakk, A. 2009. The lichen flora of Svalbard. – Sommerfeltia 33:1−393. ISBN 82-7420-029-2. ISSN 0800-6865.

Oxner A. N. Handbook of the lichens of the USSR. Iss. 2. The morphology, taxonomy and geographic distribution. Leningrad: Nauka, 1974. - 284 p. [in Russian].

Petchurov L.V. Spitsbergen. Moscow, 1983. 150 p. [in Russian].

Santesson R., Moberg R., Nordin A., Tønsberg T., Vitikainen O. Lichenforming and lichenicolous fungi of Fennoscandia. Uppsala, 2004. 359 p.

Skulberg, O. M. 1996. Terrestrial and limnic algae and cyanobacteria. In: Elvebakk, A. & Prestrud, P. (eds.). *A catalogue of Svalbard plants, fungi, algae and cyanobacteria*. Norsk Polarinstitutt, Skrifer, Oslo, pp. 383–395.

Index of species

Vascular plants

Cassiope tetragona (L.) D. Don.
Cerastium arcticum Lge
Cochlearia groenlandica L.
Deschampsia alpina (L.) Roem. et Schult.
Dryas octopetala L.
Dupontia psilosantha R. Br.
Eriophorum scheuchzeri Hoppe
Gastrolychnis involucrata (Cham. et Schltdl.) A. Love et D. Love
Papaver dahlianum Nordh.
Phippsia algida (Sol.) R.Br.
Poa alpigena (Blytt) Lindm.
Poa alpina L.
Potentilla hyparctica Malte
Puccinellia angustata (R. Br.) Rand & Redf.
Puccinellia phryganodes (Trin.) Scribn. & Merr.
Ranunculus hyperboreus Rottb.
Ranunculus sulphureus C.J. Phipps
Salix polaris Wahlenb.
Salix reticulata L.
Saxifraga aiziodes L.
Saxifraga cernua L.
Saxifraga cespitosa L.
Saxifraga hyperborea R. Br.
Saxifraga oppositifolia L.
Stellaris humifusa Rottb.
Taraxacum spp.
Trisetum spicatum (L.) K. Richt.

Mosses

Abietinella abietina (Hedw.) M.Fleisch.
Andreaea rupestris Hedw.
Aongstroemia longipes (Sommerf.) Bruch et al.
Aplodon wormskioldii (Hornem.) R.Br.
Arctoa fulvella (Dicks.) Bruch et al.
Aulacomnium palustre (Hedw.) Schwägr
Aulacomnium turgidum (Wahlenb.) Schwägr.
Blindia acuta (Hedw.) Bruch et al.
Brachythecium cirrosum (Schwägr.) Schimp. (=*Cirriphyllum cirrosum* (Schwägr.) Grout)
Brachythecium turgidum (Hartm.) Kindb.
Bryobrittonia longipes (Mitt.) D.G.Horton
Bryoerythrophyllum recurvirostrum (Hedw.) P.C.Chen.
Bryum amblyodon (Müll.) Hal.
Bryum calophyllum R.Br.
Bryum cryophilum Mårtensson
Bryum nitidulum Lindb.
Bryum pallescens Schleich. ex Schwägr.
Bryum pseudotriquetrum (Hedw.) P.Gaertn., B.Mey. & Schreb.
Bryum wrightii Sull.
Calliergon giganteum (Schimp.) Kindb.
Campylium stellatum (Hedw.) C.E.O.Jensen
Catoscopium nigritum (Hedw.) Brid.
Ceratodon purpureus (Hedw.) Brid.
Cinclidium arcticum (Bruch et al.) Schimp.
Cinclidium stygium Sw.
Cynodontium strumiferum (Hedw.) Lindb.
Cyrtomnium hymenophylloides (Huebener) T.J.Kop.
Cyrtomnium hymenophyllum (Bruch et al.) Holmen
Dicranella grevilleana (Brid.) Schimp. (=*Anisothecium grevilleanum* (Brid.) Lindb.)
Dicranum elongatum Schleich. ex Schwägr.
Dicranum spadiceum J.E.Zetterst.

Distichium capillaceum (Hedw.) Bruch et al.
Distichium hagenii Ryan ex H.Philib.
Distichium inclinatum (Hedw.) Bruch et al.
Ditrichum flexicaule (Schwägr.) Hampe
Drepanocladus aduncus (Hedw.) Warnst.
Drepanocladus polygamus (Bruch et al.) Hedenäs (= *Campylium polygamum* (Bruch et al.) Lange & C.E.O.Jensen, *Campyliadelphus polygamus* (Bruch et al.) Kanda)
Encalypta alpina Sm.
Encalypta procera Bruch
Encalypta rhaptocarpa Schwägr.
Fissidens osmundoides Hedw.
Fissidens viridulus (Sw.) Wahlenb.
Hennediella heimii (Hedw.) R.H.Zander (=*Desmatodon heimii* (Hedw.) Mitt., *Pottia heimii* (Hedw.) Hampe)
Hennediella heimii var. *arctica* (Lindb.) R.H.Zander
Hygrohypnella polare (Lindb.) Ignatov & Ignatova (= *Hygrohypnum polare* (Lindb.) Loeske)
Hygrohypnum luridum (Hedw.) Jenn.
Hylocomium splendens (Hedw.) Bruch et al.
Hylocomium splendens var. *obtusifolium* (Geh.) Paris (=*Hylocomium splendens* var. *alaskanum* (Lesq. & James) Austin
Hymenoloma crispulum (Hedw.) Ochyra (=*Dicranoweisia crispula* (Hedw.) Milde)
Leptobryum pyriforme (Hedw.) Wilson
Loeskypnum badium (Hartm.) Paul (=*Drepanocladus badius* (Hartm.) G.Roth)
Meesia triquetra (Jolucl.) Ångstr.
Meesia uliginosa Hedw.
Mnium thomsonii Schimp. – Мниум Томсона
Myurella tenerrima (Brid.) Lindb.
Niphotrichum canescens (Hedw.) Bednarek-Ochyra & Ochyra (=*Racomitrium canescens* (Hedw.) Brid.)
Ochyraea cochlearifolia (Venturi) Ignatov & Ignatova (=*Hygrohypnum cochlearifolium* (Venturi) Broth.)
Oncophorus wahlenbergii Brid.
Orthothecium chryseon (Schwägr.) Bruch et al.
Orthothecium intricatum (Hartm.) Bruch et al.
Ortotrichum sp.
Philonotis tomentella Molendo
Plagiomnium ellipticum (Brid.) T.J.Kop.
Pleurozium schreberi (Brid.) Mitt.
Pogonatum sp.
Pohlia wahlenbergii (F.Weber & D.Mohr) A.L.Andrews (=*Mniobryum wahlenbergii* (F.Weber & D.Mohr) Jenn.
Polytrichastrum alpinum (Hedw.) G.L.Smith (=*Polytrichum alpinum* Hedw.)
Polytrichum hyperboreum R.Br.
Polytrichum juniperinum Hedw.
Pseudocalliergon turgescens (T.Jensen) Loeske (=*Scorpidium turgescens* (T.Jensen) Loeske)
Pseudoleskeella tectorum (Funck ex Brid.) Kindb.
Psilopilum laevigatum (Wahlenb.) Lindb.
Racomitrium lanuginosum (Hedw.) Brid.
Sanionia orthothecioides (Lindb.) Loeske
Sanionia uncinata (Hedw.) Loeske

Schistidium platyphyllum(Mitt.) H.Perss.(=*S. rivulare* subsp. *latifolium* (J.E.Zetterst.) B.Bremer, *S. rivulare* var. *latifolium* (J.E.Zetterst.) H.A.Crum & L.E.Anderson)
Scorpidium cossonii (Schimp.) Heden□s
Scorpidium scorpioides (Hedw.) Limpr.
Splachnum vasculosum Hedw.
Stereodon bambergeri (Schimp.) Lindb. (= *Hypnum bambergeri* Schimp.)
Stereodon revolutus Mitt. (*Hypnum revolutum* (Mitt.) Lindb.)
Stereodon vaucheri (Lesq.) Lindb. ex Broth. (=*Hypnum vaucheri* Lesq.)
Syntrichia ruralis (Hedw.) F.Weber & D.Mohr (=*Tortula ruralis* (Hedw.) P.Gaertn., B.Mey. & Scherb.)
Tayloria tenuis (Dicks. ex With.) Schimp.
Timmia austriaca Hedw.
Timmia comata Lindb. & Arnell [=*T. norvegica* var. *excurren*s Bryhn]
Tomentypnum nitens (Hedw.) Loeske
Tortella fragilis (Hook. & Wils.) Limpr.
Tortula cernua Tortula cernua (Huebener) Lindb. (=*Desmatodon cernuus* (Huebener) Bruch et al.)
Trichostomum arcticum Kaal.
Warnstorfia fluitans (Hedw.) Loeske (=*Drepanocladus fluitans* (Hedw.) Warnst.)
Warnstorfia sarmentosa(Wahlenb.) Hedenäs (=*Calliergon sarmentosum* (Wahlenb.) Kindb., *Sarmentypnum sarmentosum* (Wahlenb.) Tuom. & T.J.Kop.)

Liverworts

Aneura pinguis (L.) Dumort.
Anthelia juratzkana (Limpr.) Trevis
Blepharostoma trichophyllum (L.) Dumort.
Bucegia romanica Radian
Clevea hyalina (Sommerf.) Lindb.
Gymnomitrion concinnatum (Lightf) Corda –
Marchantia polymorpha L. subsp. *montivagans* Bischl. & Boissel.-Dub.
Mesoptychia gillmanii (Austin) L.Söderstr. et Váňa (*Leiocolea gillmanii* (Austin) A.Evans)
Mesoptychia heterocolpos (Thed. ex C.Hartm.) H.Buch
Oleolophozia perssonii (H.Buch et S.W.Arnell) L.Söderstr., De Roo et Hedd. (*Lophozia perssonii* H.Buch & S.W.Arnell)
Preissia quadrata (Scop.) Nees
Ptilidium ciliare (L.) Hampe
Sauteria alpina (Nees) Nees
Scapania cuspiduligera (Nees) Müll.Frib.
Scapania gymnostomophila Kaal.
Schistochilopsis grandiretis (Lindb.) Konstant. (*Lophozia grandiretis* (Kall.) Schiffn.)
Schljakovianthus quadrilobus (Lindb.) Konstant. & Vilnen [*Barbilophozia quadriloba* (Lindb.) Loeske]
Trilophozia quinquedentata (Huds.) Bakalin (*Tritomaria quinquedentata* (Huds.) H.Buch)
Tritomaria scitula (Taylor) Jørg.

Lichens

Aspicilia nikrapensis Darb.
Aspicilia sp.
Baeomyces rufus (Huds.) Rebent.
Brodoa oroarctica (Krog) Goward
Caloplaca cerina (Hedw.) Th.Fr.
Caloplaca sp.
Caloplaca tetraspora (Nyl.) H. Olivier
Candelariella sp.

Cetraria islandica (L.) Ach.
Cetraria sp.
Cetrariella delisei (Bory ex Schaer.) Kärnefelt & Thell
Cladonia gracilis (L.) Willd.
Cladonia macroceras (Delise) Hav.
Cladonia pocillum (Ach.) O.J. Rich.
Cladonia pyxidata (L.) Hoffm.
Cladonia sp.
Collema flaccidum (Ach.) Ach.
Collema tenax (Sw.) Ach.
Diploschistes scruposus (Schreb.) Norman
Flavocetraria cucullata (Bellardi) Kärnefelt & Thel
Flavocetraria nivalis (L.) Kärnefelt & Thell
Fulgensia bracteata (Hoffm.) Räsänen
Gowardia nigricans (Ach.) P. Halonen, L. Myllys, S. Velmala & H. Hyvärinen (=*Alectoria nigricans*)
Lecanora epybrion (Ach.) Ach.
Lecanora sp.
Lecidea alpestris Sommerf.
Lecidea alpestris Sommerf.
Lecidea atrobrunnea (Ram. ex Lam. & DC) Schaer.
Lecidea lapicida (Ach.) Ach.
Lecidea ramulosa Th. Fr.
Lecidea sp.
Lepraria sp.
Leptogium saturninum (Dickson) Nyl.
Melanelia hepatizon (Ach.) Thell
Melanelia sp.
Melanelia stygia (L.) Essl.
Miriquigica sp.
Ochrolechia frigida (Sw.) Lynge
Ochrolechia upsaliensis (L.) Massal.
Peltigera didactyla (With.) J. Laundon
Peltigera lyngei Gyeln.
Peltigera rufescens (Weiss.) Humb.
Peltigera sp.
Phaeophyscia sciastra (Ach.) Moberg
Physcia dubia (Hoffm.) Lettau
Physconia muscigena (Ach.) Poelt
Placopsis gelida (L.) Lindsay
Placynthium asperellum (Ach.) Trevisan
Porpidia sp.
Protoblastenia rupestris (Scop.) J. Steiner
Protoblastenia terricola (Anzi) Lynge
Protopannaria pezizoides (Weber) P.M. Jørg. & S. Ekman
Psora decipiens (Hedw.) Hoffm.
Psora rubiformis (Ach.) Hook.
Rhizocarpon geographicum (L.) DC.
Rhizoplaca melanophthalma (Ram.) Leuckert & Poelt
Solorina bispora Nyl.
Solorina saccata (L.) Ach.
Sporastatia testudinea (Ach.) A. Massal.
Stereocaulon alpinum Laur.
Stereocaulon saxatile H. Magn.
Stereocaulon sp.
Thamnolia vermicularis (Sw.) Schaerer
Umbilicaria cylindrica (L.) Delise
Usnea sphacelata (R. Br.)
Verrucaria sp.
Vestergrenopsis elaeina (Wahlenb.) Gyelnik
Xanthoria candelaria (L.) Th. Fr.
Xanthoria elegans (Link) Th. Fr.
Xanthoria sorediata (Vainio) Poelt
Xanthoria sp.

Cyanoprokaryotes
Anabaena inaequalis (Kutz.) Born.
Aphanocapsa muscicola (Meneghini) Wille
Aphanocapsa parietina Nägeli
Aphanothece caldariorum P.G.Richter
Aphanothece castagnei (Brébisson) Rabenhorst
Calothrix parietina (Näg.) Thur. ex Born. et Flah.
Chroococcus cohaerens (Bréb.) Näg.

Chroococcus helveticus Näg.
Chroococcus pallidus Nägeli
Chroococcus spelaeus Ercegovic
Chroococcus subnudus (Hansg.) Cronberg et Kom.
Chroococcus tenax (Kirchn.) Hieron.
Chroococcus varius A.Braun
Dichothrix gypsophila (Kütz.) Born. et Flah.
Gloeocapsa alpina (Näg.) Brand
Gloeocapsa kuetzingiana Näg.
Gloeocapsa sanguinea (C. Ag.) Kütz.
Gloeocapsa violascea (Corda) Rabenh.
Gloeothece palea (Kütz.) Rabenh.
Microcoleus autumnalis (Trev. ex Gom.) Strunecky et al.
Microcoleus vaginatus Gom. ex Gom.
Nostoc commune Vauch. ex Born. et Flah.
*Petalonema incrustans [*Kütz.] Komárek
Phormidium uncinatum Gom. ex Gom.
Pseudanabaena frigida (Fritsch) Anagn.
Rhabdoderma irregulare (Naum.) Geitl.
Schizothrix facilis (Skuja) Anagn.
Scytonema ocellatum Lyngb. ex Born. et Flah.
Spirulina tenerrima Kützing ex Gomont
Stigonema ocellatum (Dillw.) Thur. ex Born. et Flah.
Tolypothrix tenuis Kütz. ex Born. et Flah.