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REPORT ON HYDROGRAPHIC INVESTIGATIONS OF NONGLACIATED PART OF NORTH-WESTERN SØRKAPP LAND (SPITSBERGEN)

ABSTRACT: On the base of the spatial distribution of the hydrographic phenomena the alimentation, transit and acumulation areas were distinguished. The alimentation area is divided into the mountain, wet subslope and wet terraces zones.

Key words: Arctic, Spitsbergen, unglaciated region, hydrographical areas and zones.

Introduction

Most of hydrographic researches in the nonglaciated regions were made in vicinity of the Polish Academy of Science Station, in Hornsund, and regions of Tsjebysjovfjellet and Hilmarfjellet (Krawczyk and Pulina 1982; Kuziemski 1958; Leszkiewicz; Wach, and Waga 1982; Pulina 1977). A scope of these investigations was that of hydrographic phenomena dynamics and chemical denudation dimension. On the base of variability of water levels and discharges, physico-chemical features of water and meteorological factors observed in the vicinity of the Station, following hydrological periods were distinguished: snow melting in June, permafrost and residual snowpack melting in the end of July, in August and in the beginning of September and water freezing in the end of September (Krawczyk and Pulina 1982).

The hydrographical problems of Spitsbergen nonglaciated areas were often analysed in connection with denudation activity of water. The periodicity of hydrographical phenomena was stated. A dispersed flow

dominates over the linear one, especially when the ground is still frozen (Czeppe 1965; Klimaszewski 1960; Szczepankiewicz 1960).

The hydrographical conditions of the Hornsund coast were also taken into consideration in mapping of geo-ecological units. The units of permanent and periodical lakes and streams and those of depressions permanently or periodically wet were distinguished (Czeppe and Ziaja 1985).

Field area

This paper presents the results of the hydrographical investigations carried out in Spitsbergen in August 1983. The hydrographical mapping covered basins of the Lisbetelva and small mountain streams (Liddalen, Sergeijevskardet, Hohenloheskardet, Savitsjdalen, at the foot of Wurmbrandegga) and on the coastal plains (fig. 1). The basic map scale was 1:100 000, enlarged then to 1:25 000.

The investigated area is built of Carboniferous and Triassic series (fig. 1). The Carboniferous one consists of light-grey, fin-grained, sometimes conglomeratic, thick-bedded quartzitic sandstones, mudstones and shales (Wendorff 1985). The Triassic measures contain the black or grey mudstones mixed with the sandstones, grey, fine-grained and laminated sandstones and the conglomerates with fine, white quartzitic pebbles. In the eastern part of the researched area there is a belt of Precambrian and old Paleozoic measures of a Hecla-Hoeck formation, represented mainly by the shales, conglomerates and dolomites. The Carboniferous and Triassic series are deformated by tectonic faults and dislocations.

The inner mountain valleys

The Lisbetelva basin is the vast valley surrounded from west, south and east by moutain massifs, with culminations exceedeing 600 m a.s.l. (fig. 1). The upper section of the valley forms an asymetric basin slopes of which exposed to south-west are covered by patches of perennial snow. The Lisbetelva begins at the very thick snow patch situated in the narrow and deep pass between the massifs of Lidfjellet and Kovalevskifjellet. It is probably that this patch conserves a small quantity of a relict ice. The river is supplied in its upper course by water originated from this snow patch ablation and

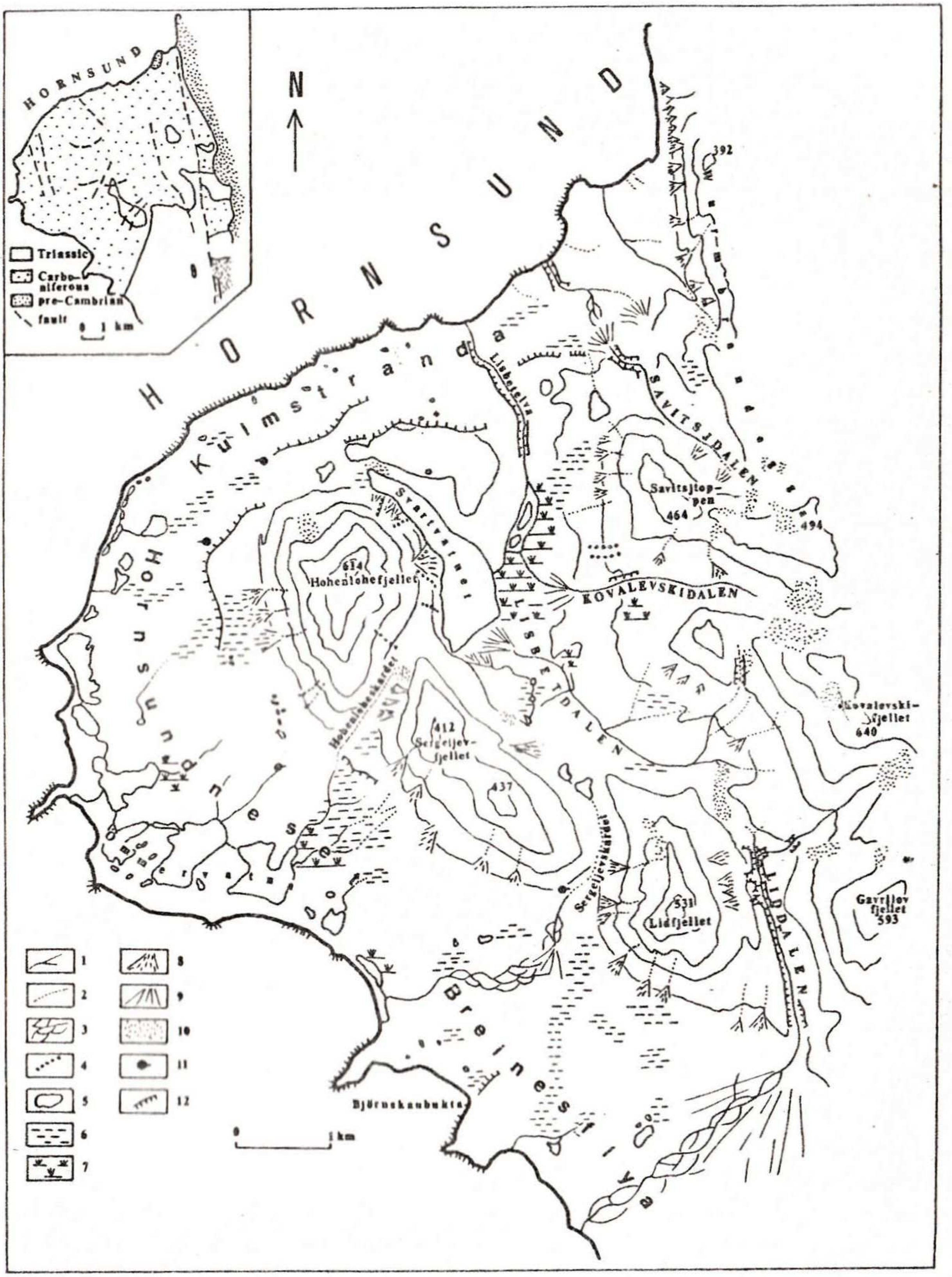

Fig 1. Geological sketch and hydrographic map of the north-western part of Sørkapp Land.

1 - permanent stream, 2 - periodic stream, 3 - braided streams, 4 - inteflow stream , 5 - lake, 6 - wetnesses, 7 - peatbogs, 8 - talus cone, 9 - alluvial cone, 10 - snow patch, 11 - spring, 12 - rocky scarps

that of the smaller snow-patches lying on the valley slopes and in gullies, and also by water coming from melting of permafrost. The central section of the valley is occupied by a vast depression, being probably a bottom of the previous Svartvatnet, in which the river divides into a net of the streams. In the eastern part of this depression there is the alluvial fan of the Kovalevskielva, supplied mainly by water from the ablation of the snow-patches lying in the upper part of the valley. In the central part the stream begins erode, but most of its energy is lost in snow tunnels and bridges observed in some section of its course. In the central part of the valley the Kovalevskielva, the stream at the foot of Sergeijevfjellet and the Lisbetelva divide into mumerous anastomosing streams. In summer, many beds of such the streams are not active because of retention in the ground. Water retention is great owing a thick moss cover in the Lisbetdalen bottom. In summer during the foehn winds when the ablation is considerable, meltwaters and precipitation not only soak the moss cover, but also concentrate under it in form of a layer of water. The western part of the basin is occupyied by Svartvatnet (0,8 km^2). Its extent is continually reduced: on the western side by material of talus fans and nival ridges, on southern - by the alluvial fans of of Lisbetelva and of Sergeijevfjellet stream and from north-east - by the waste transported by solifluction. Only northern shores of the lake are conserved by the snow-patches lying there during the whole summer. The tectonic dislocation line cuts the Svartvatnet area, thus its genesis can be the tectonic one. That of the small lake, in NW direction beyond the discussed catchment basin is unexplained and enigmatic. The water level of this lake is 20 m above that of the Svartvatnet one. It is filled with water during the whole summer, although the superficial feeding is not seen.

The Lisbetelva outlet to Hornsund forms a deep gorge cut in the Carboniferous sandstones.

The mountain section of the **Lidelva basin** contains the slopes of the massifs of Lidfjellet and Gavrilovfjellet. The stream begins by the confluence of two others - the smal one supplied by the permafrost meltwater and the second one coming from the snow patch lying between Gavrilovfjellet and Kovalevskifjellet. The most of the Lidelva course is situated in the bottom of a 30 m deep canyon. Down stream the canyon bottom becomes wider up to 25 m. On the coastal plains the stream forms a network of anastomosing beds Lidelva ends in a small lake separated from the sea by a contemporary storm ridge.

The Sergeijevskardet stream basin is an asymmetric valley. The highest part of its bottom is occupied by two small lakes (their total area amounts to 0.4 km^2), with the periodical surface outflow. In summer they are fed by the permafrost meltwater. A denivelation of these lakes amounts about 1 m, thus the water from the upper one flows to the lower one (142 m a.s.l.). The stream in Sergeijevskadet often disappears in the waste mantle covering the valley bottom. Before the coastal plain is reached the stream is supplied by the springs situated at the foot of a moraine, "attached" to the Sergeijevfjellet slopes. A total discharge of these springs amounts some 10 l/s, and temperature of the water is 1.8°C. These springs are active during the whole summer. On the coastal plain the anastomosing stream cut the outwash plain surface.

The Hohenloheskardet stream flows from the snow-patches in front of which small ponds appear in the period of the increased air temperature. The stream bed is narrow, in some places sinuous in thick moss cover. The bed is periodically dry. On the coastal plain the valley bottom falls by a steep rocky threshold. The water from the valley flows on the plain and feeds the coastal mossy marshes and the Ømmervatna lakes. The thick moss cover in the valley and its foreground is connected with bird colonies, mainly those of little auks (Plautus Alle alle). The birds living on the Hohenlohefjellet slopes manure the ground. A development of vegetation is also favoured by sheltering this area by the mountain massifs from the strong eastern winds.

The Savitsjdalen stream basin contains the area lying between the massifs of Savitsjtoppen and Wurmbrandegga. The upper section of the valley forms a deep bowl. Its slopes exposed to north are covered by the perennial snow-patches. The other slopes are dissected by the network of the dendritic microbeds eroded in the waste cover of the Hecla-Hoek formation. Upper part of the valley is separated from the central one by the rocky threshold, beyond that the inclination of the valley bottom is reduced, and the water flows in the wide bed. In the lower section of the mountain part of the stream the bottom erosion is stronger. The final section, just before the coastal plain, is the young gorge. The water from the Savitsjdalen flows partially in the fan deposite, the rest - in their marginal zones, using a few of existing anastomosing beds. The mouth section is the flat-bottomed valley 25 m deep, to which the stream falls abruptly by a watefall, on the quartzitic conglomerates of the Hecla-Hoek formation. In summer this

flat-bottom valley is filled with snow, in which there are caves and corridors made by the water flowing under the snow.

The basin of the stream at the foot of Wurmbrandegga is situated on the contact of the rocks of various resistance - the weak slatestones of the Hecla-Hoek formation and the hard quartzitic Carboniferous sandstones. The water in the valley originates from the ablation of the snow-patches lying in the upper part of the valley, in the Wurmbrandegga gullies and also from the permafrost thawing.

The coastal plains

The investigated part of the **Breinesflya plain** is the area of the uplifted marine terraces, beach ridges and beaches composed of the gravel and sand. The hydrographic network of the area is shaped durnig the melting period. In summer, most of the beds is dry, because the waters coming to the plain from the slopes flow in the debris-alluvial fans and in the gravels, too. These waters are partially stored in the lakes. In their vicinity, the mossy vegetation appears, due to moisture and presence of soil. The discussed area has marshes mostly at the foot of the fans and old marine terraces.

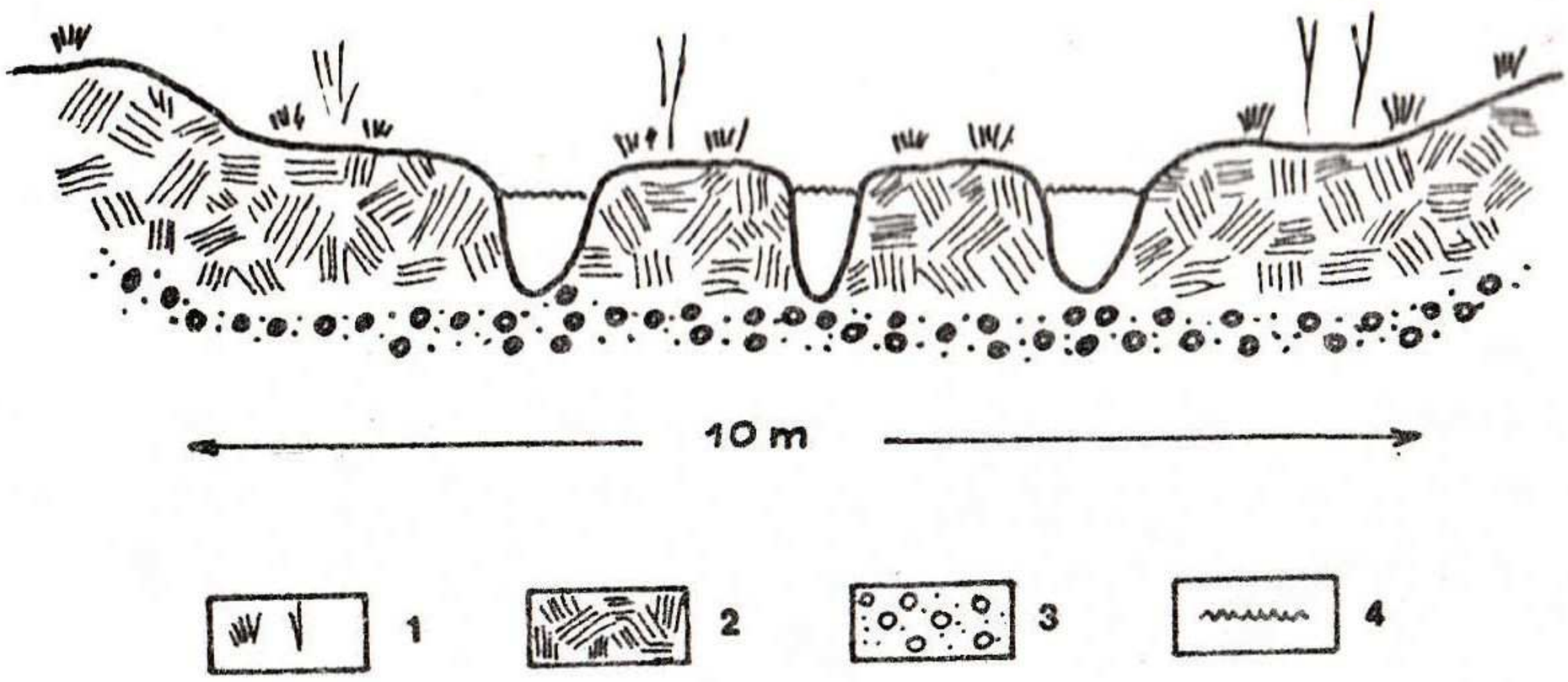

Fig. 2. Beds cut in turf at Hornsundneset.
1 - vegetation cover, 2 - turf, 3 - pebbles and sand, 4 - water level

In the transition from the Breinesflya plain to the Hornsundneset plain there are many wet depressions, situated parallel to the strike of beds. In these depressions there is a thick layer of moss dissected by streams conducting the fertile waters from the Sergeijevfjellet and Hohenlohefjellet slopes settled by the birds (fig. 2). The small, quaggy area close to the southern Ømmervatna, is probably the bottom of the old lake, as the traces of the previous shore line show.

The area situated on the Bjørnskaubukta Bay has the specific water conditions. The sandstone ridges reach 2 m of height and form characteristic landscape of the small rocks depressions without outflow containing water from the precipitation.

The **Hornsundneset plain** is a complex of the elevated marine terraces. The area falls to south. It is covered by the marine gravels and the rock debris from weathering of and sandstone ridges. In summer the plain is fed by the pronival waters and those of the permafrost flowing down the Hohenlohefjellet slopes. Those waters flow through the waste mantle and in the gullies. The outflows of that waters are observed on the terrace at the foot of the slopes. Most of the waters

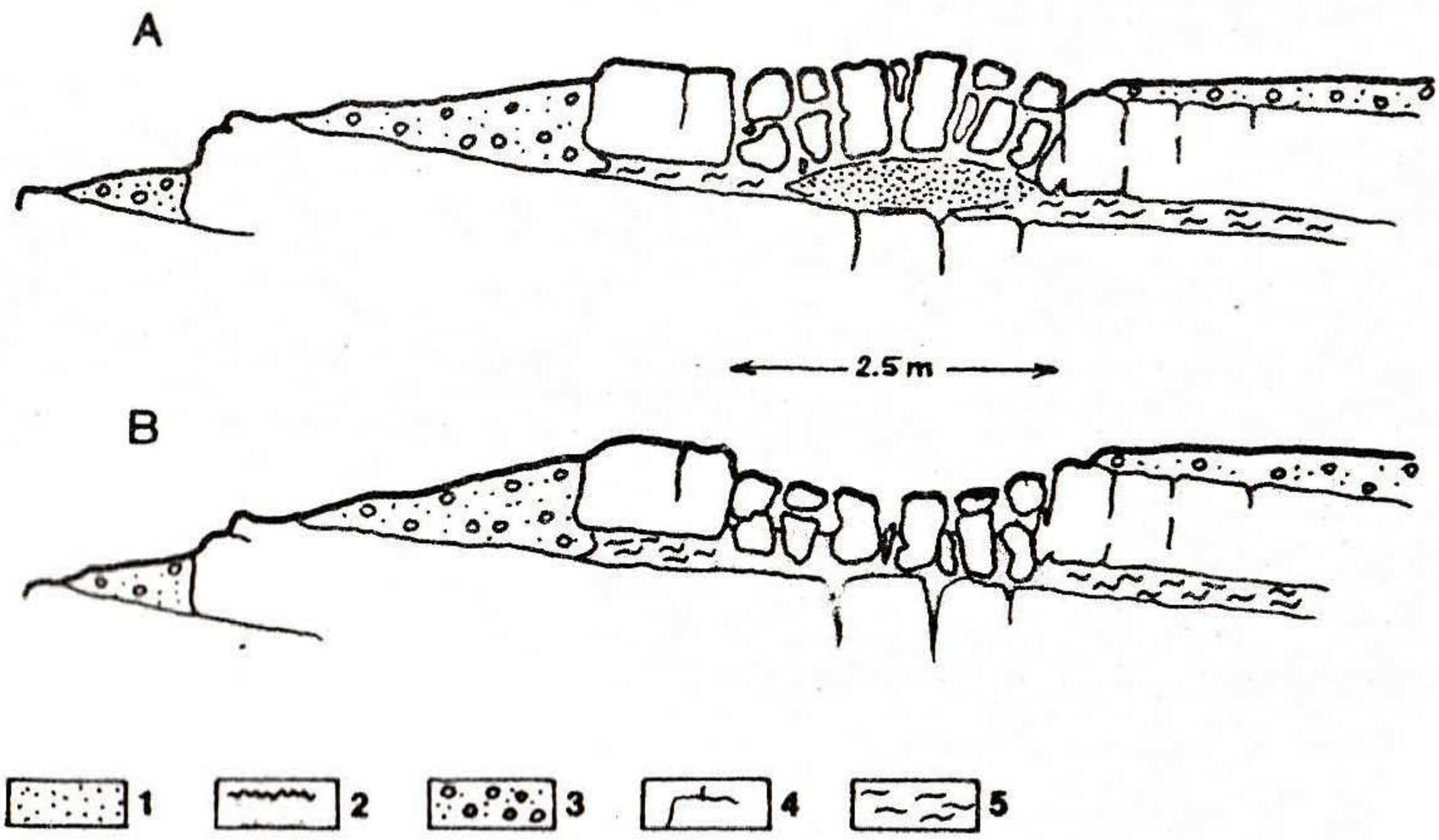

Fig. 3. Hydrolaccolit at Hornsundneset at the beginning (A) and in the end (B) of summer, 1 - ice, 2 - water level, 3 - pebbles and sand, 4 - quartzitic sandstones, 5 - shales

flow under the surface and only locally there are the surface streams, then the water disappears in the moss, gravel deposits or in the waste, appearing again at the foot of the terraces. Thus there is a belt of the wetnesses and the small lakes, accompanied locally by hydrolaccolites (fig. 3). Waters from the wet zones flow to the coastal lakes in the depressions situated along exposures of sandstones. Those depressions are reduced by the cryoplanation and solifluction processes (fig. 4). In the central and northern parts of the plain water flows in depressions in the gravel terraces, where the flow in the cover prevails, and only locally there are the sections of narrow, flat-bottom beds, partially dry and covered by the moss in summer (fig. 2). In the discussed area such depressions are marked by a brightly green colour of the mosses.

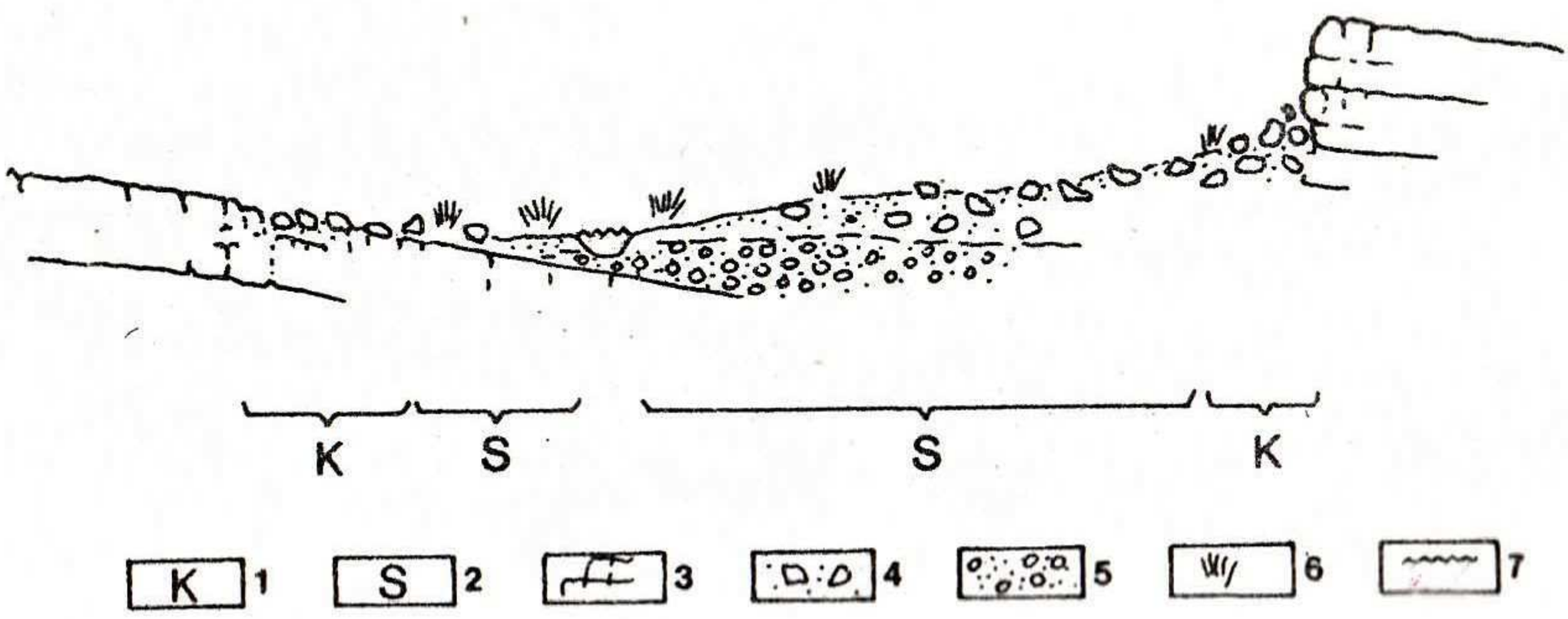

Fig. 4. Denudational valley nivelated by cryoplanation and solifluction at Hornsundneset.
1 - cryoplanation, 2 - solifluction, 3 - rocky scarp, 4 - debris, 5 - pebbles and sand, 6 - vegetation cover, 7 - water level

The Kulmstranda falls to Hornsund by a steep cliff, 10 m high, abraded by the sea. On the Kulmastranda, at the foot of the old cliffs, and in the small depressions, small lakes appear, but only a few of them are filled with water during the whole summer. The permafrost waters get to Hornsund along the tectonic zones running from north-west to south-east. These areas are covered by the waste mantle through which the water leaks. This water comes from the nival kettle on Hohenlohefjellet, from the ablation of snow-patches lying at the foot

of some of the old marine cliffs and from the permafrost thawing in the gravel deposits.

The Kulmstranda between the outlet of Lisbetelva and Wurmbrandegga is covered by the marine gravels and the alluvial fans deposits. The beds of two rivers flowing from inner mountain valleys are formed on the contact of the Carboniferous rocks and those of the Hecla-Hoek formation in the eastern part of the plain. On the plain there are the episodic streams.

The river system and the subsurface water

In summer many streams beds of investigated area are dry, some are drained periodically or episodically and only a few carry water during the whole summer, like the Lidelva and Lisbetelva, the streams from Savitsjdalen and Sergeijevskardet and from the valley at the foot of Wurmbrandegga. All the mentioned rivers are fed by the pronival and permafrost waters. Their beds are probably antecendent and were formed by the Pleistocene proglacial waters. The streams on the coastal plain begin usually in the wet areas, where water outflows mainly from bog--spring and sometimes from the rock springs.

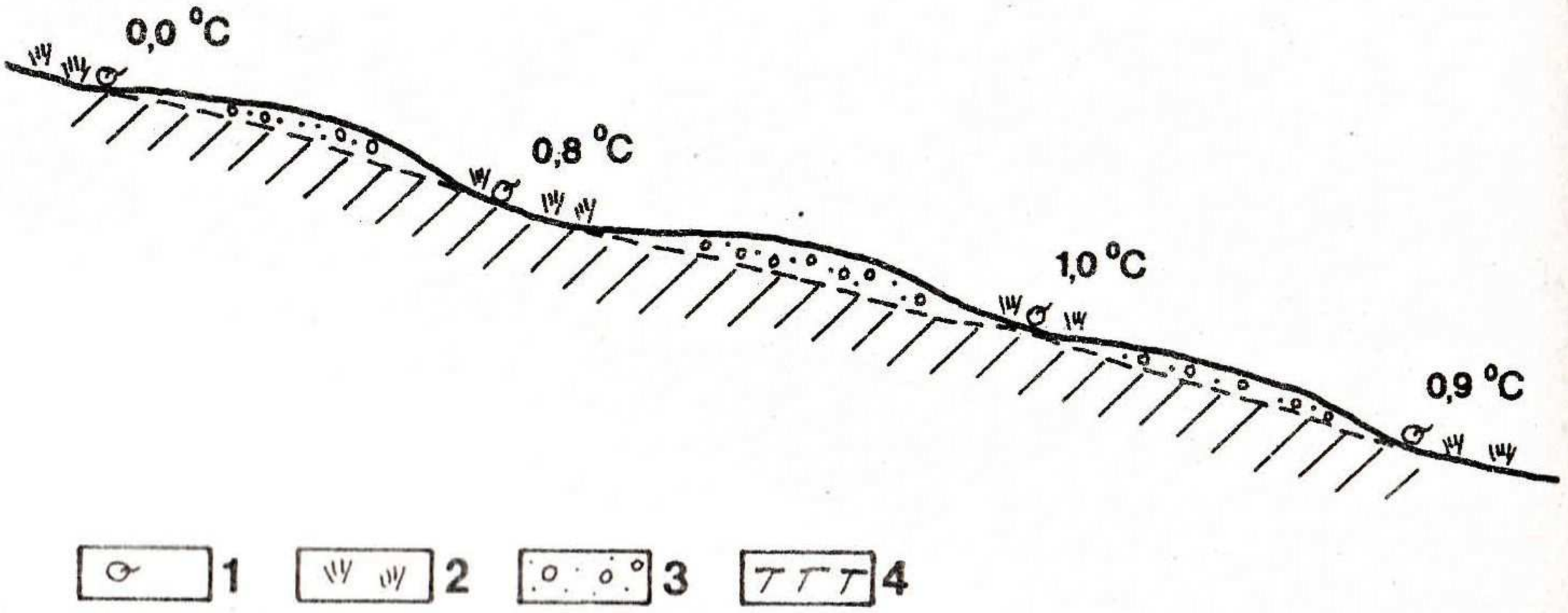

Fig. 5. Episodic springs at Kulmstranda,

1 - spring, 2 - mosses, 3 - pebbles and sand, 4 - permafrost level

Seasonal outflows are those which are active during the whole summer. Most of them exists at the foot of the slopes, the talus and alluvial fans, the nival ridges, the old beach ridges, the gravel terraces and the marine cliffs. Their temperature amounts to 1,2°- 5,8°C. The seasonal leakages connected with the rocky slopes built of the cracked, thin laminated mudstones and sandstones, have the temperature 0,1° - 0,6°C. The seasonal springs are scarce in the discussed area. Those springs are descending; their temperature amounts to 1,2° - 4,6°C. **Periodic outflows** are active a few days when the air temperature increases or rains. **Episodic springs** in the discussed area are active during several hours only. The temperature of those springs is varied. Flowing through the gravels, the waters are warmed - or cooled, if they have the contact with the permafrost (fig. 5). The springs on the slopes are often ascending if loamy material is transported by the water (fig. 6).

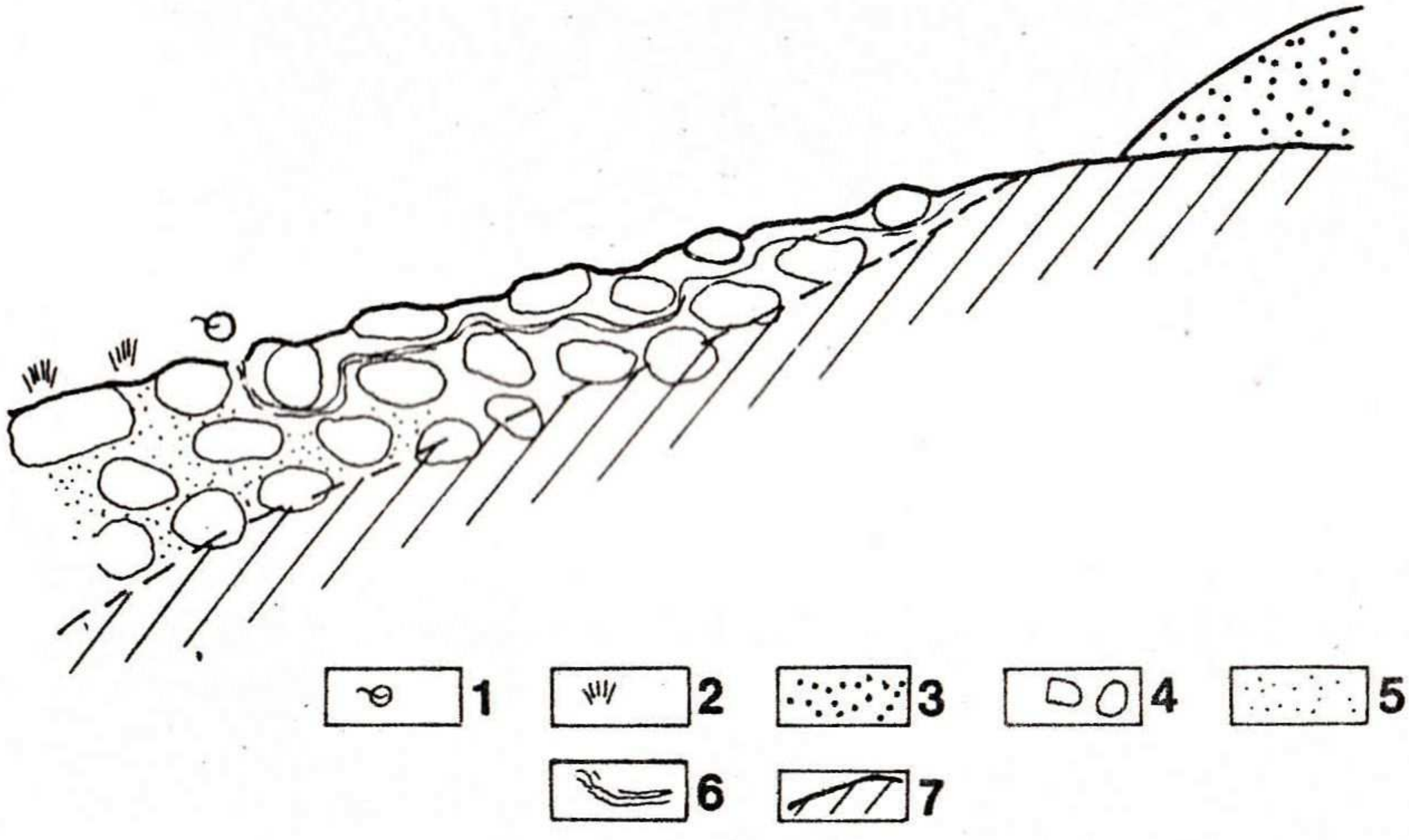

Fig. 6. Ascending springs in Lisbetdalen.

1 - ascending spring, 2 - mosses, 3 - snow patch, 4 - debris, 5 - clayish material, 6 - flowing water, 7 - permafrost level

Discharge of the seasonal and episodic outflows is small, amountin 0,1 - 1,5 l/s. Water cannot erode the bed and after several meter disappears in the moss or in the ground, and then sometimes it appear again on the surface. A small parts of investigated area are marshe some of them are dry in the end of summer.

Conclusions

On the base of the differentiation of the spatial distribution o the hydrographic phenomena in the investigated part of Sørkapp Land on can distinguish the following hydrographic areas and zones:

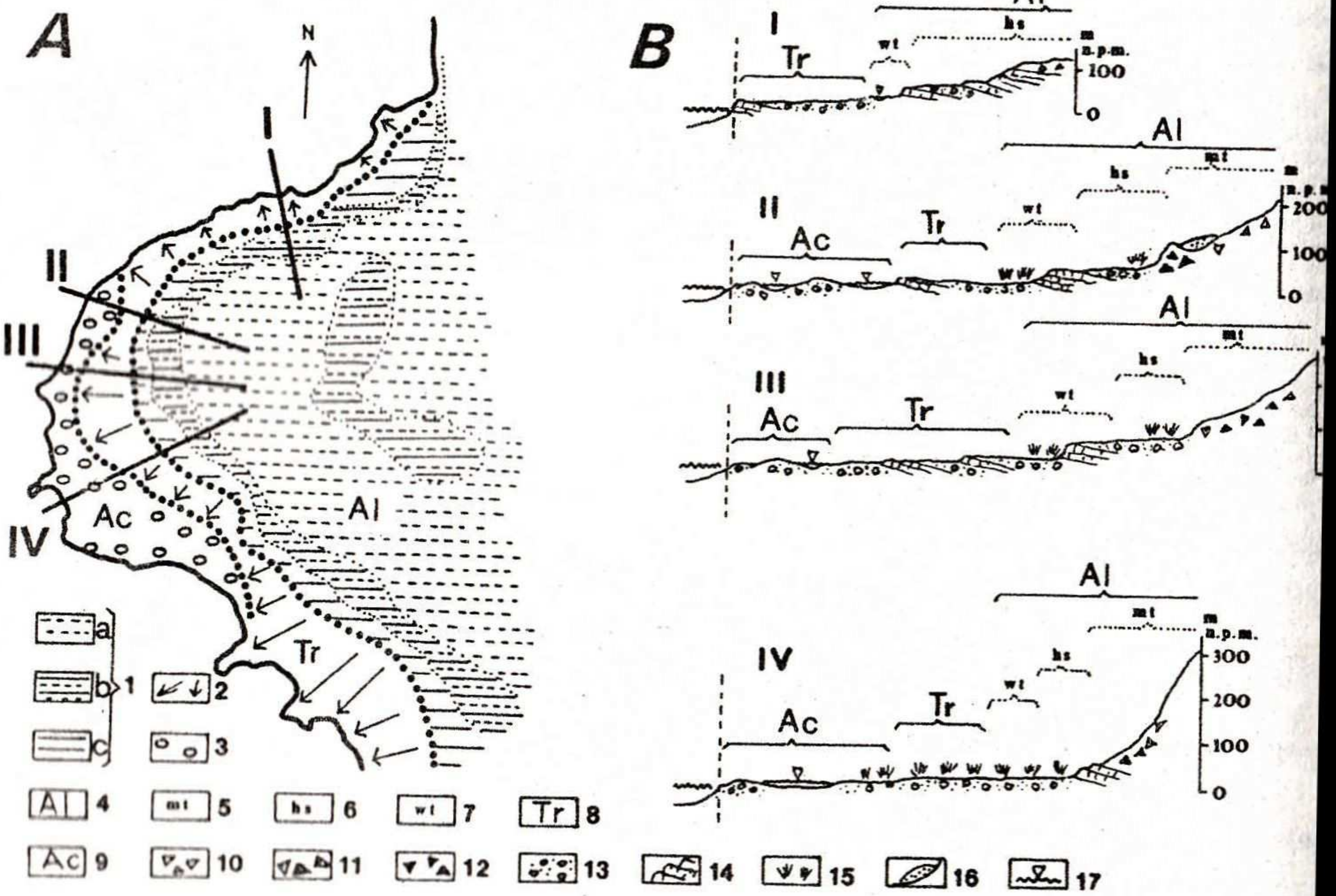

Fig. 7. Distribution of hydrographic areas and zones in north-western Sørkapp Land (A) and cross section of this area (B).

1 - alimentation area, 1a, 5 - mountain zone, 1b, 6 - wet subslope zone, 1c, 7 - wet terraces zone, 2,8 transit area, 3,9 - acumulation area, 10 - slope debris, 11 - talus-alluvial fan debris, 12 - nival ridg debris ,13 - pebbles and sand, 14 - rocky scarps, 15 - vegetation cover, 16 - snow patch, 17 - wate level

a) the alimentation area, divided into:
   - the mountain zone,
   - the wet subslope zone,
   - the wet terraces zone
b) the transit area,
c) the acumulation area.

This areas and zones are parallel to the mountain zone.

The alimentation area provides the remaining areas with most of the water in summer (fig. 7). The outflow of the waters from the snow-patches ablation and permafrost thawing in the mountain zone takes place during the whole summer. These waters flow through the waste mantle very often. In the wet sublope zone the bog-springs and marshes dominate. This zone is situated at the foot of the talus-aluvial fans, at the foot of the debris-waste slopes and of the nival ridges. The wet terraces zone is situated at the foot of the old high marine cliffs, old marine terraces, and alluvial fans of the outwash plain. There are many small lakes, most of which dry up in summer.

The transit area is sporadically dissected by the beds of the rivers carrying waters from the inner mountain valleys. The waters pass the plain also through the covers.

Along the coast stretches **the acumulation area**. Some of the lakes of this area are the old lagoons. Most of them are drained through the gorges cut in the old and contemporary beach ridges. The coastal lakes are fed with water coming from the remaining areas and zones.

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WYNIKI BADAN HYDROGRAFICZNYCH PRZEPROWADZONYCH W NIEZLODOWACONEJ CZĘSCI PÓŁNOCNO-ZACHODNIEGO SØRKAPP LANDU (SPITSBERGEN)

Streszczenie

Na podstawie kartowania hydrograficznego przeprowadzonego latem 1983 roku w niezlodowaconej części Sørkapp Landu stwierdzono prawidłowości w przestrzennym rozkładzie zjawisk wodnych na tym terenie. Wyróżniono następujące obszary i strefy hydrograficzne: obszar alimentacyjny, a w nim: strefę górską, strefę wilgotną podstokową, strefę podmokłych teras, oraz obszar tranzytowy i obszar akumulacyjny.

Obszar alimentacyjny dostarcza przeważającej ilości wód do pozostałych stref i obszarów. W strefie górskiej w czasie lata zachodzi ablacja płatów śnieżnych i wytapianie zmarzliny. Wody te wydostają się na powierzchnię w strefie wilgotnej podstokowej oaz w strefie podmokłych teras w postaci źródel i podmokłości. Wydajność tych źródeł nie przekracza 1,5 l/s. Następnie wody te spływają przez obszar tranzytowy w korytach lub spływem śródpokrywowym do obszaru akumulacyjnego, w obrębie którego znajdują się jeziora nadbrzeżne. Odpływ wód z większości jezior do morza lub fiordu odbywa się okresowo poprzez rozmycie wałów burzowych.

Obszary i strefy hydrograficzne rozprzestrzeniają się cenrtycznie wokół strefy górskiej.