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EXCURSIONS AT THE ABISKO SYMPOSIUM, 1960

During the Abisko symposium four longer and two shorter excursions were arranged (fig. 1). The aim was to illustrate the different problems of the high mountains. Guides were written for the four longer excursions and distributed in stencil form to the participants[1]. The guides gave a general introduction concerning geology, morphology, periglacial features, slope developement etc. followed by a description of different localities, numberd as stop no. 1, stop no. 2 ... along a prepared route. The weather during the excursions was unusually warm and favourable. There was extremely little snow in the mountains as a consequence of a dry winter and a summer with high temperatures.

EXCURSION IN THE SURROUNDINGS OF THE ABISKO TOURIST STATION, 29TH OF JULY

The first locality visited was the Abisko canyon, situated just in front of the tourist station. The canyon, drained by the swiftly rushing stream Abiskojåkk, is abruptly incised in the gentle slope down to Lake Torneträsk. The vertical walls show instructive sections of the Abisko Nappe with ist hard-schists, intermingled with layers of whitish yellow dolomite. As to the formation of the canyon it is obvious that the rejuvenated fluvial erosion is caused by glacial overdeepening of the lake basin. The deepest part (depth 168 m) is situated just in front of the canyon. Concerning the time and the details of the formation, however, theories vary. The canyon has been supposed to be of interglacial origin (Wråk 1908), of postglacial origin (Sjögren 1909), of subglacial (Holdar 1957). Wråk

[1] The guides, written by the main leaders of the excursions were:

No 1 — Excursion to Luopakte and Kaisepakte (by K. G. Holdar, A. Rapp, S. Rudberg);

No 2 — Excursion to Narvik (by A. Rapp, S. Rudberg — with a general introduction by S. Rudberg);

No 3 — Excursion to Kärkevagge (by A. Rapp);

No 4 — Excursion to Låktavagge, Låktatjåkko and Rakkaslako (by S. Rudberg).

points to the great size of the canyon. Sjögren pays attention to the surroundings of the canyon, i.e. to the terraces of gacifluvial material separated from the canyon itself by broad shelfs of naked rock. Holdar emphazises the coincidence of direction of striae and canyon. It could also be noticed, that the canyon is situated in the lowest part of an open, broad valley. Thus concentration of running water and canyon erosion might occur in different periods; also in the presence of an ice sheet and with different relations to it.

From one of the glacifluvial terraces the excursion had a view over the delta of the present river. Long-shore drift from the W has resulted in an asymmetrical development of the delta.

The second part of the excursion was spent in studying periglacial features in the birch forest zone around the tourist station. Two localities were visited which had well developed „palses" (mounds of turf), about a metre high and some metres in length. Restricted in their distribution to northernmost Sweden these palses are developed in a local continental climate on open mires with a not very thick snow cover during winter. At the time of the excursion frozen ground was found at a depth of 50 cm (55 cm a week later). No layers of clear ice were seen. Other phenomena studied were series of well developed stone earth circles and terracettes — in typical development otherwise mostly only reported from the tundra zone. Their extra-zonal occurrence here is favoured by the special climatological conditions in open areas in the birch forest.

EXCURSION TO LUOPAKTE AND KAISEPAKTE, 30TH OF JULY

The aim of the excursion was to demonstrate a representative area in the eastern part of the mountain chain as a complement to the latter excursions in the western and the central parts. The main interests were geology, geomorphology, slope development, periglacial phenomena.

The excursion went by train eastwards from Abisko to Stenbacken station, made from this place a 12 km walk up in the mountain region along the foot of Mt. Luopakte and down again to the train at Kaisaniemi.

The train-journey gives one a good first view of the landscape. The influence of bedrock upon morphology is clearly demonstrated by the contrast between the Abisko Alpes and the mountains farther to the E. The former are connected with the amphibolites of the Seve-Köli Nappe and characterized by steep slopes, scattered cirques and the ideally U-shaped "Lapporten" (the Lapp gateway), the latter are built of the mostly flat-lying rocks of the different, mostly lower nappes, producing gently rolling forms,

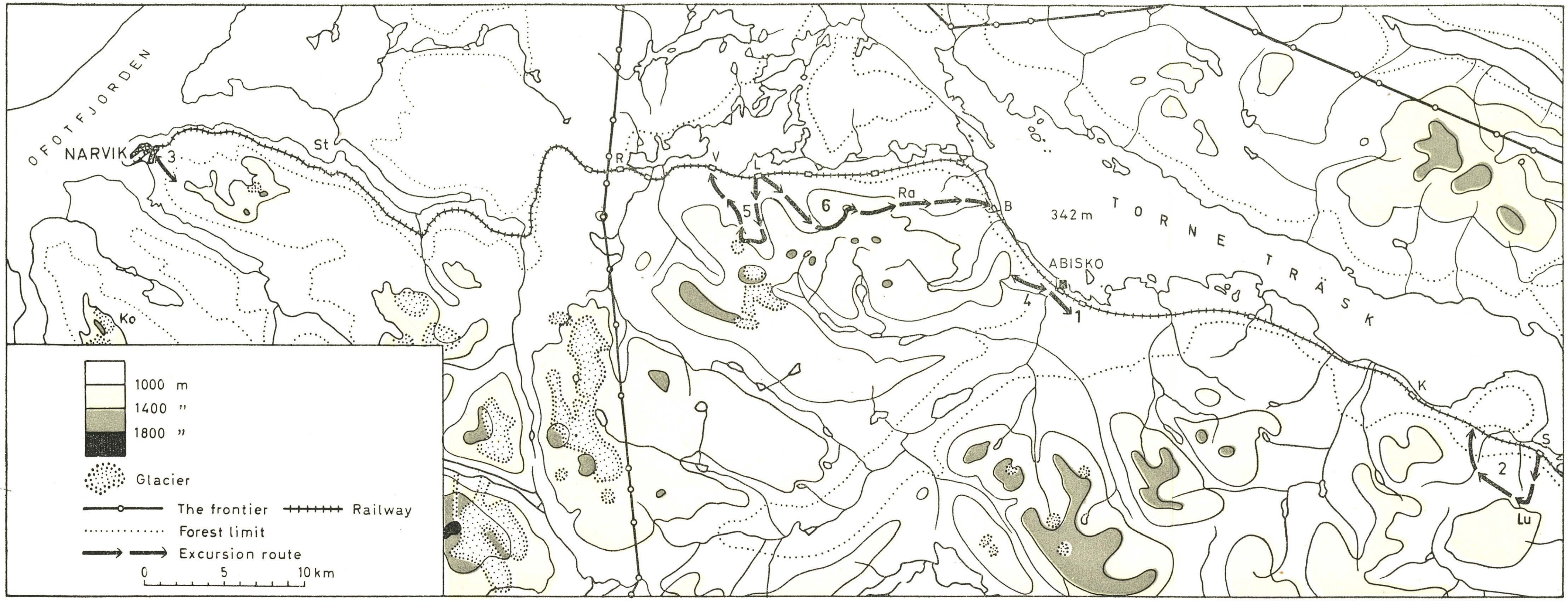

Fig. 1. Map of the Abisko — Narvik area

The excursion routes of the Abisko symposium are marked by arrows: 1. surroundings of the Abisko tourist station; 2. Luopakte and Kaisepakte; 3. Narvik; 4. Mt. Nuolja; 5. Kärkevagge; 6. Låktatjåkko and Björkliden. Some of the railway stations are marked by letters, for instance, R — Riksgränsen, V — Vassijaure, B — Björkliden occasionally interrupted by scarps or "glints" connected with the fronts of the nappes. An almost classical view of such a glint was passed at Kaisepakte station.

The limit between the Caledonian and the Archaean rocks was crossed 10 kms from Abisko and the walk was made essentially within the Archaean area. The influence of the Archaean rocks could be seen from the train in the high frequency of block fields, often of the "boulder depression" type. The same phenomenon was studied during the walk from Stenbacken through the birch forest. The numerous small block concentrations have also been interpreted as indications of melt-water erosion during the deglaciation. The problem was discussed in one of the groups during the walk.

Above the timber line (here at 540 m) instructive views over the landscape were offered at different points. The Archaean basement, evenly and gently dipping westwards, could be discerned in the distant mountains north of Lake Torneträsk. The steep scarp of Mt. Tidnopakte in the same mountain region is a glint produced by the hard-schists of the Abisko Nappe, the already mentioned glint of Mt. Kaisepakte to the S of the lake, visible as a continous escarpment, is connected with schists of the Seve-Köli Nappe and the upper vertical slopes of Mt. Luopakte, immediately to the south, with the nappe of the same name as the mountain. The steep glints (most of them more or less E-facing) are as relief features probably to some degree renewed by glacial plucking below a great E-moving ice sheet. The asymmetrical profiles of the small Archaean mountains seen at the eastern end of Lake Torneträsk, with steep E-facing sides and gently W-facing ones, are probably due to the same glacial activity. These circumstances show that the W-moving ice from a later stage of the glaciation has not been able to re-model the hills and mountains, only to generate its own small size *roches moutonnées* (see below).

Higher up on the slopes of Mt. Luopakte the excursion passed the limit between the flat Archaean basement and the autochthonous Cambrian rocks, here beautifully exposed in a rivulet valley. The arcosic conglomerate of the basal layer, taken from another section in the neighbourhood, was demonstrated. The rocks in the rivulet are flat-lying, alternating beds of sandstone and shale. The break for lunch was made at this place, a classical locality of the International Geological Congress of 1910.

On the rolling plateau surfaces, passed before and after the break, the periglacial phenomena were studied in different localities. This eastern mountain region has a more continental type of climate with rather low precipitation, low winter temperature, strong snow drifting, weak snow protection. The periglacial features show no great variety. The characteristic ones are: block fields, particularly of the type *boulder depression*, wind-eroded surfaces, locally with mud flats, stone earth circles and low terracettes, systems of solifluction lobes higher up on the slope. The genesis of the terracettes and their connection with wind-eroded surfaces caused an animated discussion among the members of the excursion. The vegetation is also clearly influenced by the wind (no lichens on the wind--exposed side of the boulders) and by the snow distribution (the latter phenomenon demonstrated by Dr. G. Sandberg).

During the later part of the excursion the members had the opportunity to compare a picture more than 50 years old (presented in the guide) with the present landscape features. A steep rock wall with a talus slope below and a brook valley with steep sides, poorly protected by vegetation, proved to have undergone only extremely small changes in the 50-year period. The picture-comparison method, here demonstrated by Dr. Rapp, ought to be a useful method for the study of the recent slope development.

The last problem discussed was the deglaciation of the Torneträsk area. According to older theories a great ice-lake — the Torne ice-lake — was dammed by the inland ice margin as it receded E-wards. At the eastern part of Mt. Kaisepakte, however, there is a conspicuous series of lateral drainage channels (mapped 1950). They slope E-wards, thus proving that the last ice remnants were situated farther to the W. The great ice-lake has never existed (according to Holdar 1957); the valley was occupied by an almost isolated shrinking ice body. As long as the ice-margin receded down the slopes, accumulation and erosion continuously changed the surface forms of the till and of the glaci-fluvial deposits. An accumulation (esker, terrace) had hardly been built up before it was destroyed or completely removed by melt-water (cf. Holdar 1957).

The lateral drainage channels were seen in the distance. An accumulation landscape of the type last described was passed on the way down from the mountains.

EXCURSION TO NARVIK, 31TH OF JULY

The main purpose of the excursion was to show the strong contrast between the mostly open, softly undulating mountain relief on the Swedish side of the watershed and the steep relief on the Norwegian side with fiords and with keen peaks, a landscape more strongly influenced by glacial erosion.

The excursion was made by train. The views from the train are instructive and excellent all the way (except for the numerous tunnels and snow galleries).

The railway passes through the central part of the mountains, built of the higher Caledonian units, particularly the Seve-Köli Nappe. Outcrops with the typical rocks of this nappe are now and then visible close to the train (as the blue-black marbles west of Björkliden station). As concerns morphology the most interesting phenomenon is the strong morphological contrast between the Archaean window and the bordering Caledonian areas. The latter are of ordinary mountain relief type, or high mountain type. Broad crests, and steep-sided, U-shaped tributary valleys, more or less hanging above the main valley, are characteristic features. Such hanging valleys are the Låktavagge valley and the Kärkevagge valley on the southern side, both of them visible from the train. The steep slopes along the railroad often show small structure-controlled terraces.

The Archaean window (the Sjangeli-Rombak window) has a low relief. The landscape is produced by dissection of the arched Archaean basement, which probably had also here the shape of a Sub-Cambrian peneplain. In detail the area shows Archaean relief type: numerous hills and knobs, beautifully *moutonnée* by the W-mowing ice, with water-filled depressions between. The E—W running band of lakes near the boundary between the Archaean and the Caledonian rocks is seen from the train. As the Archaean rocks are generally thought to be the more resistant, the morphological contrast here is difficult to explain, as no faults have been revealed during the geological mapping of this well exposed area. The open valley of the Archaean window is structurally connected with an anticline. This sort of inverted topography — anticlines and low relief — is known from other parts of the Swedish mountains.

Well-preserved broad terraces, built in ice-lakes, are passed west of Vassijaure station. But a more striking impression gives the increasing scantiness of Quaternary deposits towards W. The Archaean window makes also an eastward stretching lobe of the great areas of naked rock in western Scandinavia.

The relief met with on Norwegian territory is quite a typical one for northern Norway. Close up to the international boundary is a softly rolling plateau relief — still belonging to the Archaean window — strongly contrasting with the higher mountains and abruptly dissected by the fjords and the young valleys. These valley systems show very typical alternations between glacially overdeepened sections and sections formed by renewed and strengthened stream erosion, initiated just by the foregoing overdeepening. The first beautiful view over the valley landscape is given from the lofty railway bridge over the deep valley of Norddalen, a second instructive view from the bridge over the river Sördalselva with its canyon.

The first characteristic Norwegian mountain peak, Mt. Nevertinn with its broad ice fields, is seen already from the Swedish side of the frontier. Farther to the west other sharply formed peaks come into sight, such as Mt. Rombakstötta.

During the descent to Narvik the railway follows the Rombaken fjord, at first on narrow, artificially built terraces high up in the steep southern slope. The Rombaken fjord has the typical open fjord form, slightly winding but without real spurs. Trough valley edges are sometimes seen, though not very clearly developed. The chart (presented in the guide and drawn by R. Dahl) shows that the floor of the fjord has two separated basins, 90 m and 342 m deep respectively. No thresholds exist at the transition to the broader and greater Ofotfjord. The sides of the fjord valley are steep, but smoothed by the ice. In some localities at the opposite side is seen a sort of "exfoliation" parallel to the steep slope. This is a rather common feature in many well-developed trough valleys, eroded in hard rocks in different parts of Norway, as in the Skjomenfjord, Tysfjord and Folla districts S of Narvik; in the Sjonafjord and Ranafjord districts a bit farther to the south; in Jölster, Olden and other areas around the Jostedals glacier in western Norway; by Lake Skjeggedalsvann and in the Setesdals valley in southern Norway (see also Rudberg 1954, p. 239).

Above the interior part of the Rombaken fjord there is a beautiful view from the railway over a broad delta. The submarine part of this delta, which is still being actively built, is clearly visible in calm weather. East of this recent delta there is a series of raised delta terraces, cut by the river and forest-covered. The highest of these terraces reaches about 100 m above sea level and probably corresponds to the upper marine limit of the locality (according to R. Dahl). In the outer part of the fjord, between Sillvik and Straumnes stations, is a conspicuous moraine ridge, stretching into the fjord from the northern side. On the southern side opposite this ridge is a projecting promontory of solid rock. The two peninsulas form the supramarine part of the threshold, which separates the two basins of the Rombaken fjord. Moraine ridges of the Straumnes type are common features in Norwegian fjord valleys. They are interpreted as a sort of terminal moraines, formed in one of two ways. They may be due to a local retardation of ice retreat at the transition from deep to more shallow water or dry land (sometimes a rock threshold). They may also, when connected to a greater system, reveal a general stagnation of ice retreat, caused by some change in the climate.

In front of this moraine ridge the railway crosses the boundary between the Archaean window or anticline and the Caledonian syncline of the Ofotfjord. According to the geological sections of Kulling (1960) different tectonic units can be discerned within the latter. The lower of them represent the continuation of the nappes found in the Torneträsk area; the upper ones represent higher nappes, not preserved on the Swedish side. The sequence has a marked westerly dip. Typical "Narvik schists", injection gneisses or migmatites, are seen at different places in Narvik.

From Narvik the excursion made a trip by cable-car to Mt. Fagernesfjell, where splendid views over the Ofotfjord and the surrounding mountains are to be seen. The glaciated Mt. Kongsbaktinn on the southern side of Beisfjord and the lofty peaks north of Ofotfjord received special attention. The first of them have been interpreted as a nunatak (Ahlmann 1919, p. 214). The latter, with frangible pinnacles near the summit and rising with steep walls above the even socle, exhibit also forms, by some scolars regarded as proofs of nunatak sculpture. A discussion of the nunatak problem came as a matter of course. Comparison was made with observations from other glaciated areas in the world, e.g. eastern Canada.

The landscape on the other side of the Ofotfjord gives a good example of structure-controlled relief. The broad socle with a straight-lined border towards the fjord is connected with a monocline structure, the steep peaks to areas more rich in late-Caledonian granites.

EXCURSION TO MT. NUOLJA, 1ST OF AUGUST

The excursion (led by Dr. G. Sandberg) made a walking tour up to the timber line to study different vegetation features. The connection between the brown lichens on the white trunks of the birches and the snow cover during the winter was discussed. The influence of climate amelioration during the last decades was demonstrated by comparing photographs some twenty or thirty years old with the present conditions on the same site. More luxuriant birch growth and a richer development of willow shrub at the forest limit were established.

EXCURSION TO KÄRKEVAGGE, 2ND OF AUGUST *

The excursion to Kärkevagge was especially devoted to deglaciation features and to recent slope development.

Kärkevagge is a trough valley (see above.), situated about 20 km WNW from Abisko. The walk started from Låktatjåkko station, located at 500 m altitude in the uppermost part of the birch forest. On the walk up to the

* The following chapter is mainly written after an outline by Dr. Rapp. For further details see paper by Rapp (Kärkevagge. Some recordings of mass-movements in the northern Scandinavian mountains) in this volume, p. 287.

valley mouth the excursion passed over *roches moutonnées* of Archaean gneisses with well preserved glacial sculpture and striae indicating a W-moving ice (cf. above Excursion to Luopakte . . .).

The valley bottom is characterized by enormous masses of big boulders apparently originating from the steep rock walls (mica-schists) on the western valley side. One boulder accumulation stretches parallel to the E-facing walls of Mt. Vassitjåkko (1 580 m) in the outer part of the valley, another ridge of boulders and finer debris dams up Lake Rissajaure (812 m) in the innermost valley end. The boulder accumulations in Kärkevagge are probably one of the largest of their kind in the Scandinavian mountains. They are interpreted as a type of late-glacial terminal moraines. These boulder trains and the rich variety of morainic and glacifluvial ridges in the valley were keenly discussed by the members and different interpretations were suggested.

The W-facing valley side consists of a rock wall, 50—100 m high, talus slopes and gently sloping alluvium covered by a rich meadow vegetation. Some examples of momentary mass movements (rockfalls, earthslides, mudflows etc.) were demonstrated as well as more continuous mass movements (solifluction etc.). A new method of measuring the vertical velocity profile within a solif uction lobe was shown by Rudberg (cf. Excursion to Låktavagge . . . .).

During the lunch break at Lake Rissajaure most of the members enjoyed a short swim in the clear, cool water of the lake, which has a transparency of about 34 m. The water temperature on that day was about +12 °C, the air temperature about +22 °C, both extremely high values for this locality.

After the lunch break the excursion divided into two groupes. One of them studied the E-facing valley side with its well developed solifluction lobes in fine-grained mica-schist till. The other and larger group visited the cirque glacier Kärkereppe, situated in a hanging cirque high up in the eastern slope. Broad fields of fluted moraines in front of the shrinking glacier were demonstrated (by Hoppe and Schytt). The debris deposits after big snow avalanches, glacifluvial ridges and *roches moutonnées* in granite were studied on the way down to Vassijaure station.

EXCURSION TO LÅKTAVAGGE, LÅKTATJÅKKO AND RAKKASLAKO, 3RD OF AUGUST

The aim of this excursion was to show different periglacial features met with in a Swedish mountain area, from the tundra zone to the frost-shatter zone; features indicating assorting processes and features indicating downslope movement. The guides distributed to the members had a map, redrawn from the maps of two student teams, that worked in the area during the summer 1959 [2].

The excursion started from Låktatjåkka station. The total walking route to the terminal point at Björkliden station was 18 km. As regards geology and general relief features the area visited by the excursion is typical of the western part of the Torneträsk region. Dominating rocks are: mica-schists, garnet-mica-schists, marbles and black schists. The Låktavagge valley is a hanging tributary valley to the main valley west of Lake Torneträsk. The mouth of the valley lies at about 700 m above sea level. To the south the valley flattens at about 800 m and after a step at about 950 m. The western and (after a bend of the valley) the southern side show distinct trough valley edges, the eastern and northern only more occasionally. At the upper end of the valley a pass (where the Låktatjåkko hut is situated at 1 228 m) leads over to the valley of the river Rakkasjåkk, running eastwards to Björkliden. This valley is not a typical trough valley. It is broad and open, but has well developed steps; the lower one is the wide plain of Rakkaslako at 850—900 m. Låktavagge and the upper part of the Rakkasjåkk valley are surrounded by plateau-like mountains or mountains with broad crests: Mt. Låktatjåkko 1 412 m, Mt. Kåppasåive 1 412 m and Mt. Kärketjårro rising to about 1 400 m. In the slope of the latter is a small cirque with the bottom occupied by a lake. The floors of the Rakkasjåkk valley and the lower part of the Låktavagge valley are covered by till, partly rather thin and without characteristic forms (except for some lateral ridges below the mouth of the Låktavagge valley).

Concerning the periglacial features the area visited can as a whole be regarded as being of ordinary quality. In this respect there are, however, marked differences between the three main regions: the tundra zone of the Låktavagge valley, the frost-shatter zone of Mt. Låktatjåkko and the tundra zone of the Rakkasjåkk valley.

Steeper slopes with thin or discontinous drift cover are common in parts of the Låktavagge valley. The well developed periglacial features are found on the valley floor and the lower parts of the slopes.

On the slope between the Låktatjåkka station and the mouth of the Låktavagge valley different signs of movement in the solifluction lobes were studied by the excursion. In one case the result of measurements of the long axes of stones were given, showing a marked maximum in the

[2] The same map is reprinted in: "A report on some field observations concerning periglacial geomorphology and mass movement on slopes in Sweden" by the author in this volume, p. 311.

direction of slope in the surface layers but no clear orientation at a depth of 50 cm. In another place with solifluction tongues hanging over rock terraces a test pillar was demonstrated, proving that the top layer had moved 15 cm in 3 years, the bottom layer 5 cm[3]. A podsol profile is overridden in the section. Higher up in the Låktavagge valley proper a view towards the opposite side of the valley showed that one of the poles of the electric line has moved downslope. The pole has moved 108 cm during 21 years (cf. Malm & Nilsson 1959). It is situated in a solifluction lobe.

From a small hut at 825 m the excursion had a view down the valley behind, showing large fields of thufurs on the flat valley floor and solifluction tongues on the somewhat steeper eastern valley side. From other points higher up series of solifluction tongues could be seen, covering a greater part of the slope. Wind-eroded surfaces, often connected with terracettes, were observed.

At the step in the valley bottom a sequence of well preserved — only partially frost-bursten — *roches moutonnées* were studied. Two systems of striae could be discerned, the older one coming from a more easterly direction and being less dependent on topography.

At 950 m in the upper part of the tundra zone the first good example of stone polygons was found. From this altitude the vegetation grows more and more sparse. Broad stone pavements are developed around the river, particularly in an area where the snow cover in some years is rather heavy.

The transition to the frost-shatter zone is not sharp along the route followed by the excursion. The weathering material and the till of the mica-schists in this area are rather rich in finer grain sizes, permitting a sparse vegetation cover. The black schists produce a small-sized stony debris. Stone stripes are however present, sometimes covering broad areas. Three localities with painted markings on stone-stripes were demonstrated. The mean movement during three years has been 2,2 cm, 2,8 cm and 0,7 cm respectively [4].

Before the last locality lunch break was taken at the tourist hut of Låktatjåkko. During drilling for water some years ago at just this place the permafrost was found to have a depth of 70 m, the greatest depth so far known in Sweden (Ekman 1957). As the weather was extremely clear most of the participants paid a visit to the top of Mt. Låktatjåkko. In the S Mt. Kebnekaise, the highest point of Sweden (2 117 m) was seen, to the W different keen Norwegian peaks.

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[3] cf. "A report on some field observations concerning periglacial geomorphology and mass movement on slopes in Sweden" by the author in this volume, p. 311.

[4] cf. "A report on some field observations concerning periglacial geomorphology and mass movement on slopes in Sweden" by the author in this volume, p. 311.

The descent along the floor of the Rakkasjåkk valley revealed a greater variety of different periglacial features than in the Låktavagge valley. In the upper part of the valley the following features were studied in different localities: micro stone-stripes on a wind-eroded surface with adjacent micro stone-polygons (probably in this case originating from dessication cracks); stone-polygons of ordinary size but with a tendency to formation of micro stone-polygons within the greater ones; systems of terracettes etc. It was of a special interest for the leaders of the excursion to show one of the localities to collegues with experience from other parts of the world. Here — very near to the Rakkasjåkk river — there is a small (12 m wide) rounded lake, surrounded by a bank of earth (1—2 m high). The long axes of stones are partially orientated parallel to the outer edge of the bank. The top of the bank has fissures and dessication cracks. A few days before the visit of the excursion frozen ground was found at a depth of 85 cm. In the guide the question was put to the members whether it is a collapsed pingo or not. According to some of them it was very like features described as pingos in other places. According to one of the members (professor Black) [5] another term, e.g. ice laccolith would be preferable, as the true pingos are connected with permafrost regions. Concerning the occurrence of true permafrost there are, as in the case with most Swedish mountain areas, no observations available from this locality.

In the great plains of Rakkaslako there are a great variety of well-developed periglacial features such as other collapsed "pingos", stone-polygons and well developed stone pits and palses. The two last phenomena were studied.

In the various discussions during the walking route two phenomena were particularly looked upon as remarkable: the great development of solifluction tongues and the low amount of annual movement. At least within the tundra zone it is only a question of displacement within the superficial layers of the drift cover and only to a slight degree of displacement within a debris cover produced by weathering of the solid rock (opinion in this case specially stressed by professor Birot).

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