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PERIGLACIAL EXCURSION IN NORTHERN FINLAND AND NORWAY 1—8 SEPTEMBER 1979

1st of September: Excursion from Ivalo to Kevo Subarctic Research Station

Route: Ivalo—Inari—Kaamanen—Petsikko—Kevo (Fig. 1)

The bedrock along the excursion route in northernmost Finland consists of Precambrian metamorphic rocks mainly of granulites and gneisses.

During the last glaciation the ice sheet advanced NE and N in northernmost Finland. The excursion route lies north of the main ice divide which was approximately at 68°N. The retreat direction of ice margin during the deglaciation was to the SW.

On the way northwards we shall pass Lake Inari which is 1360 km^2 in area. The maximum depth is about 100 m. The lake basin is formed by several crossing fault lines. The drainage of the lake takes place to the NE into the Arctic Ocean via USSR and Norway. There are more than 3000 islands in the lake. The ice melts in early June and the widest open stretches are free of ice at the end of June. The lake begins to freeze in October. The ice cover is about one meter thick during a normal winter. On the shores we shall see ice-pushed phenomena.

In the Inari Lake basin the ice sheet formed a more or less stagnant ice cover with very blocky ablation moraines.

About halfway from Ivalo to Inari we shall visit Karhunpesäkivi (The Cave Stone of Bear) which is an example of tafoni, presumably formed during the preglacial times and then transported by the ice sheet.

In the region are found layers of weathered rocks *in situ* up to one hundred metres thick. They may have their origin in a subtropical climate of Tertiary time.

Inari is one of the main villages of the Lapps (called also Sami population) and during the summer time a lively tourist center where you find for example a museum of Sami culture (open air museum).

In Lemmenjoki River, draining into the Lake Inari, gold was found after the Second World War, and there are still some people digging and panning gold all the year round. The great dream of everyone is to find the gold vein in the bedrock.

On the way farther north we cross several esker ridges. One of the greatest

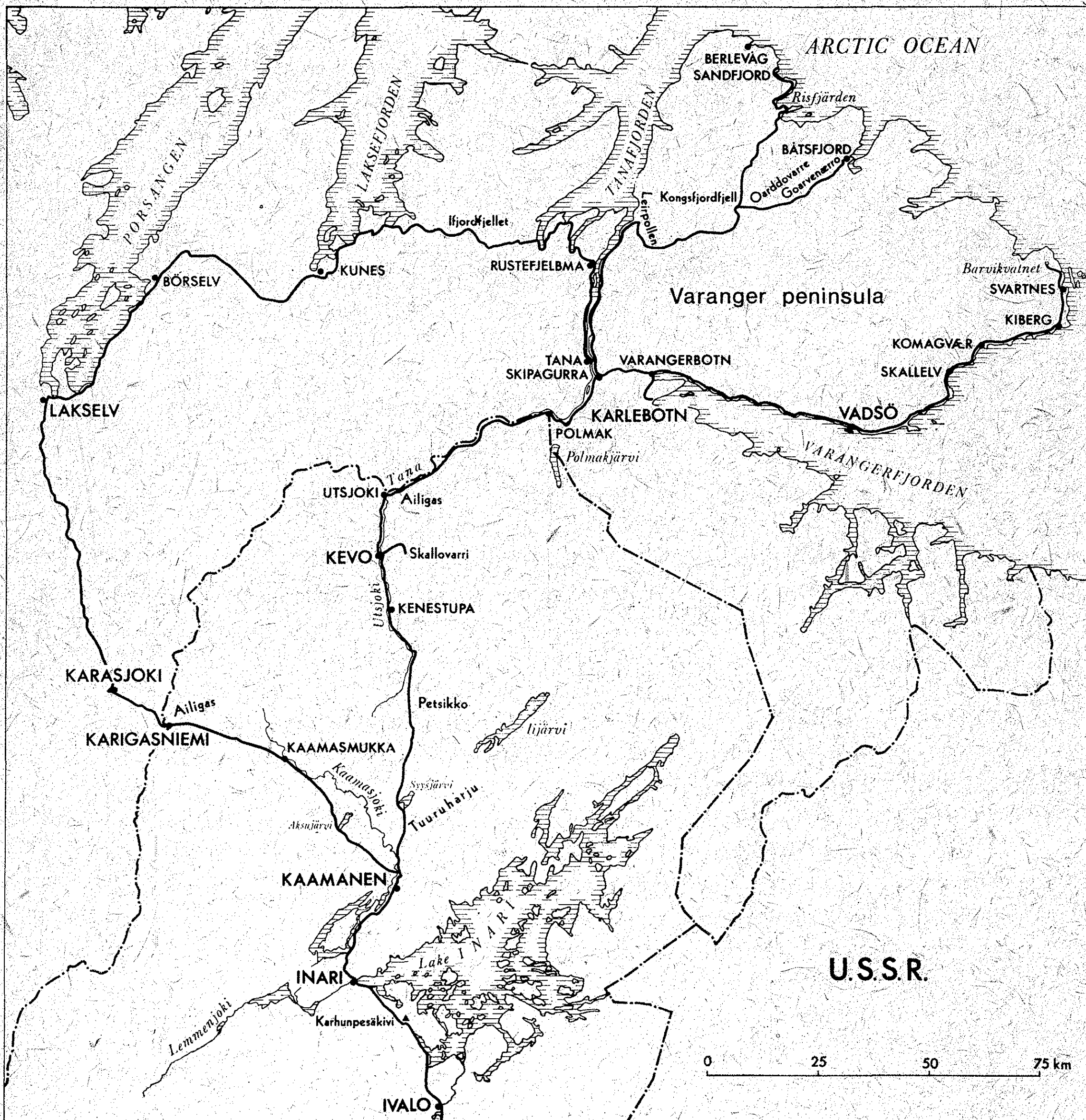


Fig. 1. The excursion route in northern Finland and Norway

and most typical is Tuuruharju esker (some 30 m high and 70 km long). The northernmost string bog is seen in a kettle of the esker.

First stone polygons are found beside the road on the edges of peat bogs.

Soon after the Tuuruharju esker at Syysjärvi lake we leave the pine forests and birch forests become dominant with only single pine trees.

At the same time we have arrived in the zone of sporadic permafrost with real palsas. Already at the northern shore of Lake Inari perennial frost has been found, but the palsas are very small and low, like large strings.

At Petsikko, which is the highest point on the road to Kevo, we shall see the large mountain (*tunturi* in Finnish, *fjell* in Norwegian and *fjäll* in Swedish) massifs of Muotkatunturit and Paistunturit. When it happens to be a clear weather also some high, snow-covered fjells of Norway will be visible in the NW direction.

The road is following the deep fault valley of Utsjoki river on the left. In many places on the slopes you can see active talus formations. At Kenestupa and farther north the valley is partly filled by glaciofluvial valley trains and eskers with small lakes in between.

Some of the ponds dry up during summers with little precipitation and on the bottom of them can be seen sorted stone polygons.

Part of the river is called Kevo Lake which has a maximum depth of 40 m and on the peninsula in it is located the Subarctic Research Station of the University of Turku.

The lake level is 78 m above sea level, and just after the deglaciation the sea presumably penetrated into these narrow valleys. The isostatic land uplift in this region has raised also the valley bottoms above the sea level. Present land uplift is about 10—20 cm per 100 years (exact values are not available).

2nd September: Field trip from Kevo to a palsa bog at Skallovarri

When leaving the main road and Utsjoki valley about 3 km N of Kevo we follow a small truck road to the fence for separation of reindeers.

On the way we pass small pine forests in the valley. This is an evidence of the milder climate caused by the Arctic Ocean. Soon we arrive again to the birch zone. Over large areas, birches were killed in the years 1965—66 by larvae of the butterfly *Oporinia autumnata*. The totally damaged forest areas were more than 1000 km^2.

An experimental park (arboretum) for planting trees form different subarctic regions is passed on the way up.

Near the end of the road to the reindeer fence is a large palsa bog (Pl. 1) with a man-made palsa. This is an experimental study area of the formation of palsas. Several kinds of measurements have been carried out on these palsas. For example measurements of seasonal thawing, air temperature, humidity, wind speed and direction, thickness of snow cover and frozen peat layer, and penetration of frost into the peat.

Puonus and some frost uplifted stones and blocks (Pl. 2) will be seen on the walk to the palsa bog.

Stone polygons and some stone pits can be found in the surrounding of palsa bog and in the bottom of a very shallow pond filled with water only during the spring.

The topmost parts of the fjells have no forest cover and belong to *regio alpina* or alpine tundra.

3rd September

Paper session of the Symposium of the Co-ordinating Committee for Periglacial Research (I.G.U.) at the Kevo Subarctic Research Station. List of papers is presented in the foreword of this section.

4th September: in the morning — Transportation by bus from Kevo to Karlebotn (in the inner part of the Varangerfjord). In the afternoon — Field trip by foot to a palsa locality and visit to the Bigganjarga tillite

Route: Kevo—Utsjoki (Finland)—Polmak (Norway)—Skipagurra—Varangerbotn—Karlebotn.

From Kevo the road is following the lower course of the Utsjoki river, tributary to the Tana river.

In this area, the retreat of the ice sheet proceeded from N to S, and large amounts of ice were left in valleys causing the formation of kettle holes, eskers, and kames. During the deglaciation the sea entered the valleys. At the mouth of the Utsjoki river, the main late-glacial shoreline (about 10,300 B.P.) is situated in a height of 90 m above the present sea level.

At Utsjoki village the high mountain in the E is called Ailigas which was a holy mountain for the Lapps.

At the Utsjoki village we meet the Tana river constituting the border between Finland and Norway. The river, 330 km long, is one of the largest rivers in Norway and Finland. The spring flood is very dramatic in the Tana valley. The river is covered by ice that builds high dams and the water rises at the same time 4—5 m above the normal level. The break up may happen in one day and after one week the flood is over.

Travelling on the right bank of the Tana river it can be observed that the valley floor contains systems of river terraces and lateral ice marginal deltas. Aeolian activity and dune forms are present.

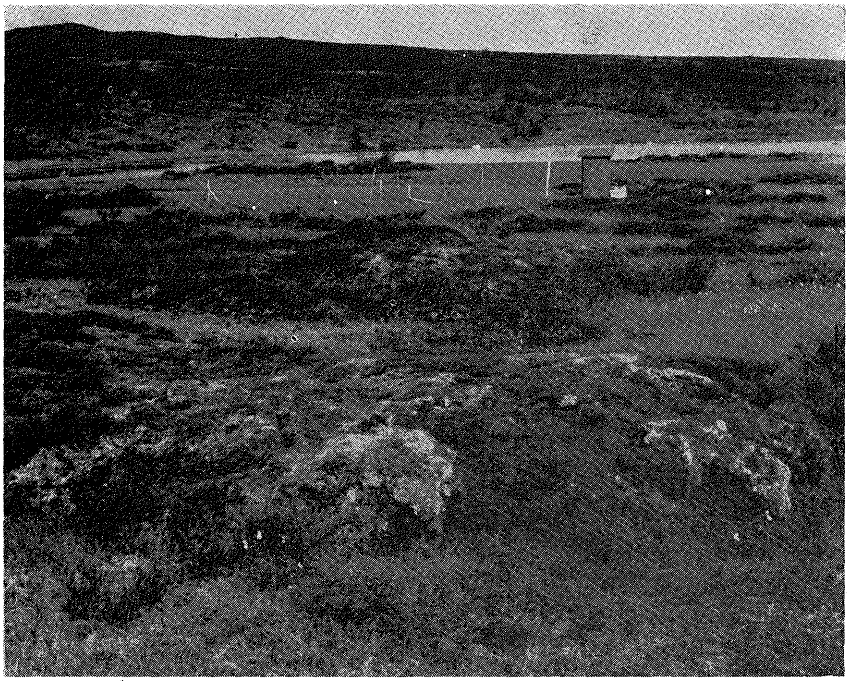
The Polmakjärvi south of our route was formerly part of the Tana fjord system but was isolated due to the isostatic uplift of the area.

From Skipagurra the road passes the inner part of the Varanger peninsula and leads down to the Varangerfjord.

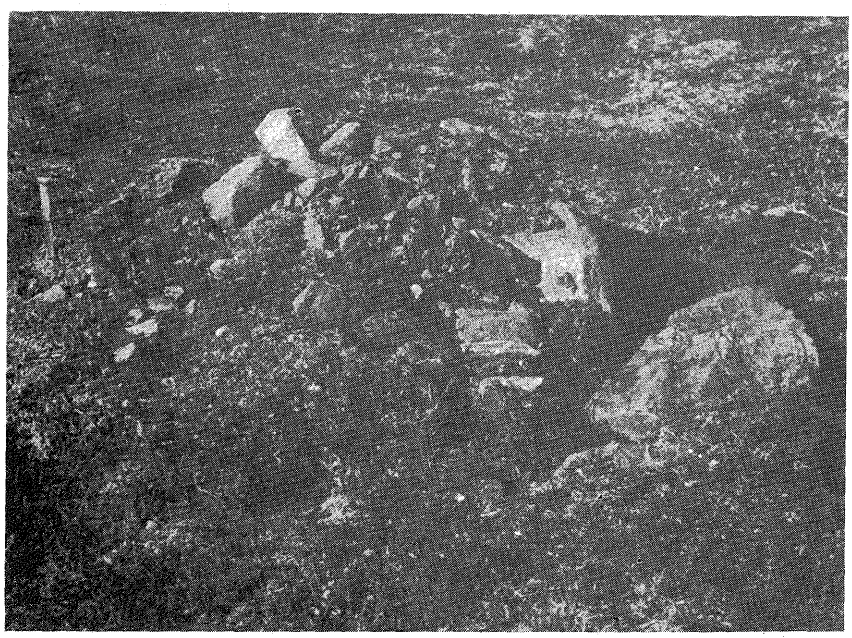
The northern side of the Varangerfjord is formed in Eocambrian sedimentary rocks. The southern side consists of Archaean crystalline rocks except in the innermost part of the fjord where Eocambrian sediments (shales, sandstone and quartzite) still occur. The difference in rock material is clearly reflected in the structures and morphology of both fjord sides.

A great number of palsa-bogs can be seen from the road and individual palsas in different stages of development are discernable before we reach Karlebotn.

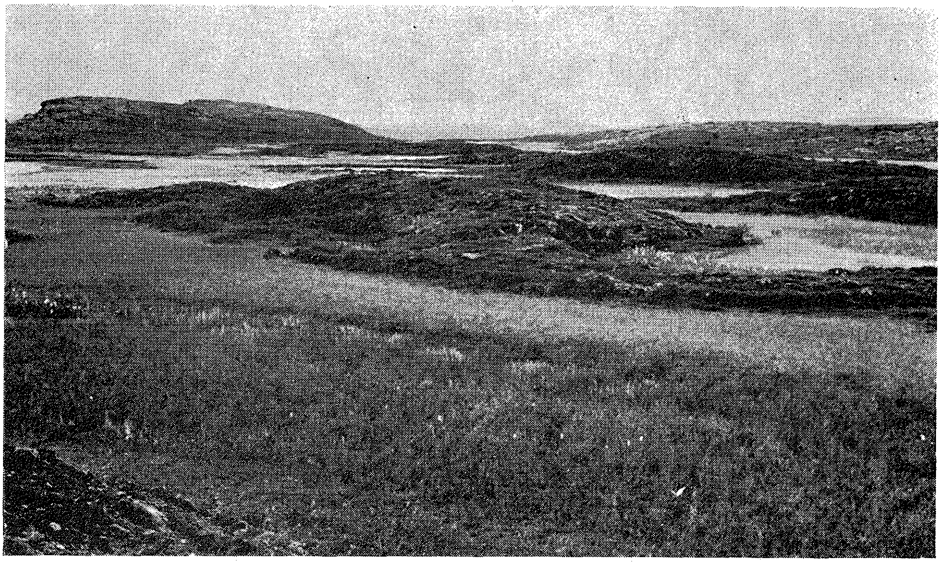
The afternoon program starts with a visit to a palsa bog, about 500 m to the north of the schoolhouse. The bog is situated 60 m above the present sea level,



Pl. 1. Skallovarri palsa bog in northern Finland with the experimental study site. Photo 1978

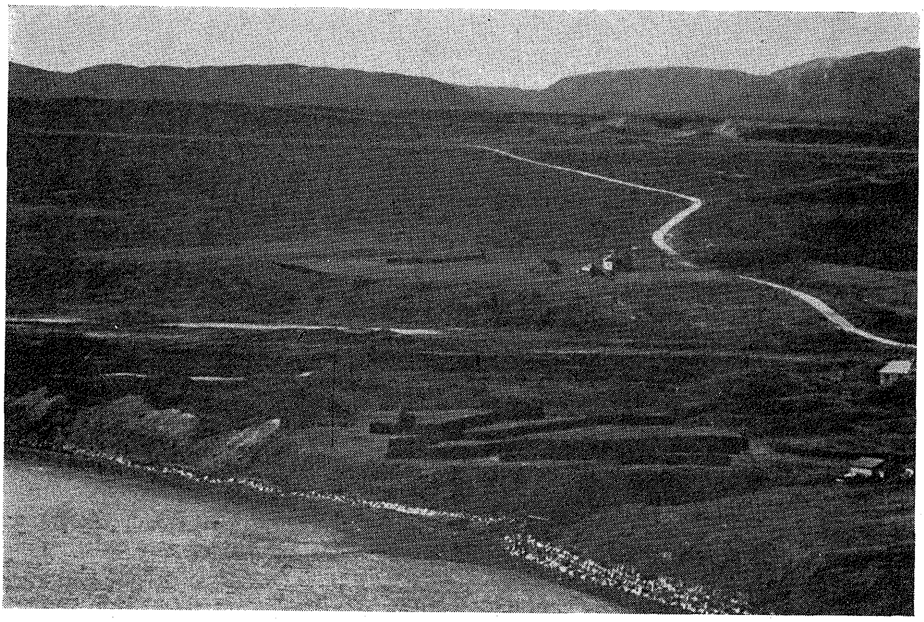


Pl. 2. Frost-uplifted blocks at the edge of the Skallovarri palsa bog



Pl. 3. Palsas in a bog area at Karlebotn, the Varangerfjord

Pl. 4. Scoured quartzite surface uncovered by marine erosion at Bigganjargga. To the left, part of the conglomerate and its contact with the quartzitic basement is seen



Pl. 5. Fluvioglacial delta in Karlebotn. During the isostatic upheaval of land the frontal part of the delta was reworked by the sea and outlined with terraces

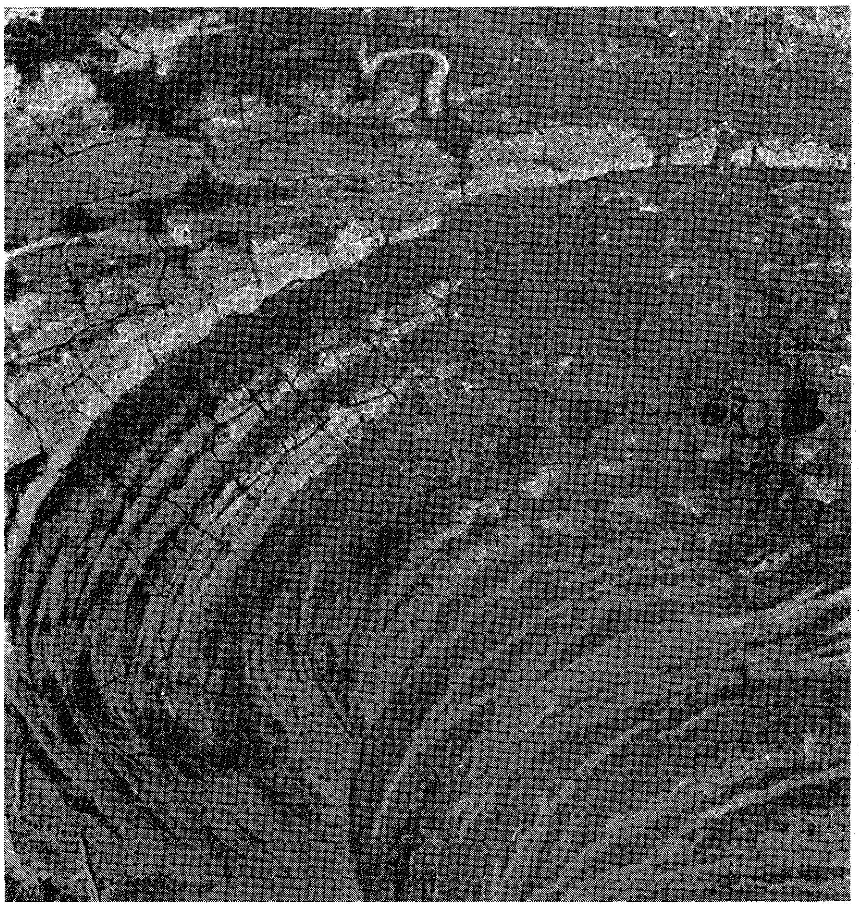


Photo Fjellanger-Wideröe, Oslo

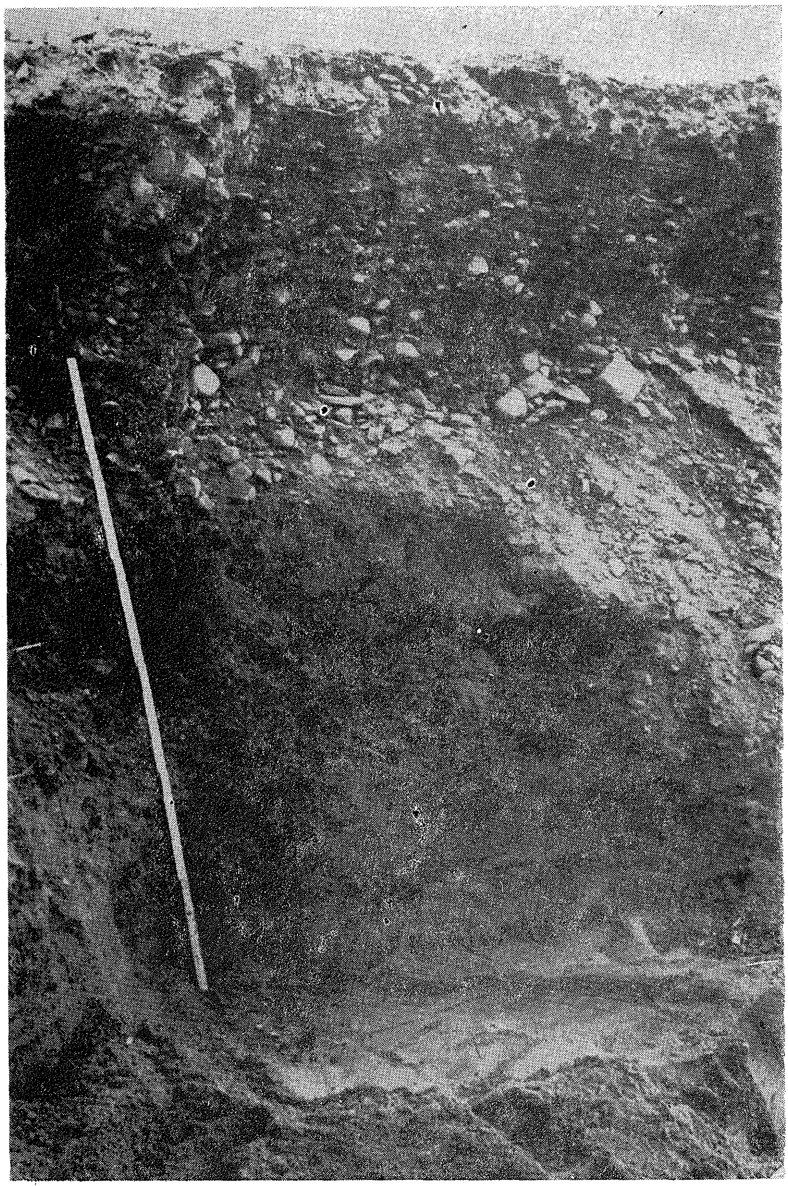
Pl. 6. Aerial photograph showing part of the terrace-beach ridge area of the Bussesund locality. Approx. scale 1 : 4500

Photo Fjellanger-Wideroe, Oslo

Pl. 7. Aerial photograph of circular mounds in a block-field environment on the Varangervidda. Approx. scale 1 : 7500.

Photo Fjellanger-Wideroe, Oslo

Pl. 8. Part of aerial photograph of the top surface of Mount Goarvencaerro (Bugtkjölen). Approx. scale 1 : 5000



Pl. 9. Polygonal pattern outlined by vegetation in the fluvioglacial surfaces at the river Gaednjajokka is underlain with infillings showing up as ice-wedge casts in vertical and horizontal sections

but raised shorelines indicate that the sea was once about 75 m above its present position.

The palsas in this bog are dome-shaped and 5.5—6.0 m high, 50—75 m long and have a width of 40—60 m (Pl. 3). The peat layer on the surface is about 1 m thick and below the peat there is a minerogenic core of mostly clay and silt intersected by ice lenses from 1 mm to 10 cm thick.

From the palsa locality it will take about half an hour to reach the Bigganjarga tillite locality. Though not being a feature of direct periglacial character, it is recommended to pay a visit to this, one of the most famous geological sites in Scandinavia.

The interest of this locality is that the moraine-like conglomerate lies directly on what seems to be an ice-scoured surface of quartzitic sandstone (Pl. 4). The conglomerate, which has the form of a large lense, is exposed by marine erosion. The block material is predominantly from the Precambrian and known in places southwards. The Norwegian geologist Reusch found the locality in 1890 and interpreted it as an evidence of an old glaciation (Eocambrian time); his interpretation was for a long time accepted and supported by other geologists.

Measurements of stone orientation in the conglomerate made in the 1940s did not show the expected concordance between the orientation maxima and the directions of scouring. This fact does, however, not exclude a glacial origin of the conglomerate as it may have been deposited on an earlier glaciated surface situated in a special environment, i.e. a submarine one outside an ice-sheet. There is no doubt that the Bigganjarga locality holds interesting problems suitable to tackle from the viewpoint of modern sedimentology.

During the last two decades there has been some general discussion about the formation of tillites and tillite-like rocks by slumping of marine sediments, mudflows and turbidity currents. If the glacial origin of the conglomerate of the Bigganjarga locality is denied, it is, however, necessary to find an explanation also for the scouring. Could it be formed in an unconsolidated (or frozen) sand surface by stones in the bottom part of material sliding or flowing on the surface? Before reaching a conclusion of a nonglacial origin, the deviation in the systems of scouring must be considered.

5th September: Excursion by bus on the northern side of the Varangerfjord

Route: Karlebotn (southwards to the fossil delta plain) —Varangerbotn—Vadsö —Skallelv—Komagvaer—Kiberg—Svartnes—Barvikvatnet.
Return by the same route.

The Karlebotn branch of innermost Varangerfjord is bordered by a raised glaciofluvial delta, modelled by marine terraces in its distal part (Pl. 5). Some of the former beach areas are rich in finds from settlements made after the withdrawal of the ice sheet. In North Scandinavian archeology the Karlebotn area has become a standard site.

In the heath vegetation of the frontal part of the preserved delta plain, about

70 m a. s. l., a polygonal pattern is visible, outlined by furrows. After snow melting thin fissures can be seen in the polygon furrows. Usually they can be traced also in summer as knife-sharp cuttings in the vegetation mat. In sections below the polygon furrows narrow, funnel-like forms with sandy soil, a few cm wide and 10—20 cm deep, are observed. Normal ice-wedge casts do not occur, and surface is not underlain with permafrost. The isotherm 0 °C of mean annual air temperature crosses the inner part of the Varangerfjord. The frontal part of the old delta is strongly windswept during wintertime and with no, or only a thin, snow cover. From the topographical and climatological points of view the locality is a typical one for frost fissuring in a non-permafrost environment. A more detailed description of the locality is given in SVENSSON's paper (1969).

The Karlebotn—Varangerbotn district is very rich in palsa bogs (Fig. 2). In some bogs many palsas are in a stage of disintegration; in other localities the palsas seem to be very stable. The map (Fig. 2) shows a clear difference in palsa frequency between the southern side of the Varangerfjord with its many palsa bogs and the northern side with only few palsa sites.

Via Varangerbotn the route goes on the northern side of the Varangerfjord. Except for a short passage (Domen) between Kiberg and Svartnes, the road is running below the highest shoreline of Late Glacial time. Raised beaches, glaciofluvial deltas and marine cliffs can be seen along the road. Among the shorelines especially the „Main line" is of interest as it corresponds to a period of climatic cooling in Late Glacial time, the Younger Dryas period, about 10,000—11,000 years ago.

At Skallelv and Komagvaer vast deflation surfaces are seen. By removal of sand, old beach ridges are exposed. The active wind direction is not from the sea but from the land (NW). An active direction belonging to the sector SW—NW is also observed on ventifacts and in strongly blasted surfaces of boulders in block fields in plateau areas of the peninsula.

In raised deltas and beach ridge areas preserved patterns of fossil ice-wedge polygons occur in many parts of the Varanger peninsula. Aerial photographs are a very useful tool for detecting the polygons as described in this journal (SVENSSON, 1964a). The locality in northern Scandinavia, where this feature was for the first time observed and described, is situated on the northeasternmost part of the peninsula (on the Bussesound). The Bussesound locality will be examined by means of aerial photographs and by observation in the field. A vast tetragonal pattern of fossil ice-wedge polygons outlined by the vegetation of linear furrows existed in this area (Pl. 6) starting on a terrace surface (78—81 m a. s. l.) close to the highest shoreline and continuing downwards in a beach ridge system to 64 m a. s. l. The pattern is not found in lower levels of the raised beach area. Much of the pattern is now destroyed by the excavation of gravel. In sections of the gravel pit distinct wedge casts can usually be observed with typical structures of infilling. The Bussesound locality will be discussed also from paleogeographical point of view (*cf.* the paper by H. SVENSSON in this volume, p. 245—252).

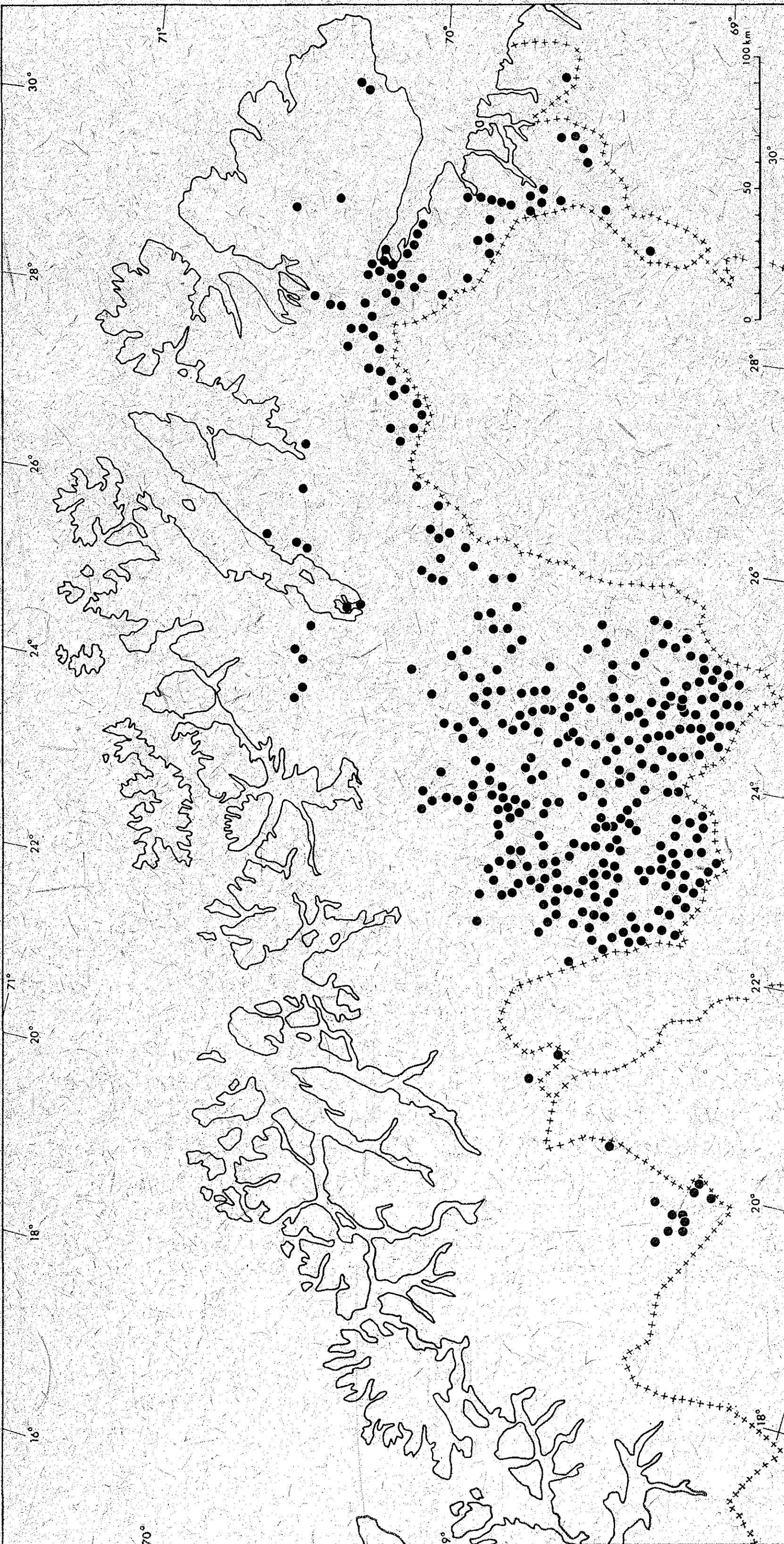


Fig. 2. The distribution of palsas in northern Norway

At the lake Barvikvatnet we shall return after having studied a type of short valleys (gullies), developed by thermokarst processes during the fossilization of a net of ice-wedge polygons. The problem is diceussed in a paper by H. SVENSSON in this volume, p. 139—142.

6 th September: Excursion by bus to the interior and northern part of the Varanger peninsula

Route: Karlebotn—Varangerbotn—Skipagurra—Leirpollen—Kongsfjord-fjellet —Oarddovarre—Goarvencaerro (direction Båtsfjord)—Gaednjajokka—Risfjord —Berlevåg. Return back to Karlebotn

From Skipagurra the route follows the lower course of the Tana river. The valley is here from 1.5—3.0 km wide and bordered by mountains up to 550 m high. On the E-side, almost vertical slopes rise to about 250 m exposing the Eocambrian sediments. The valley is floored by an unknown thickness of sediments, into which the river has cut down as a response to isostatic readjustments.

The Tana river is frozen for about seven months, from late October till late May when the ice break-up takes place in a few days. Blocks of ice may strand on the sandbanks in the channel causing severe floods and rapid discharges when the ice dams are broken. The maximum discharge in June is 1,750 m^3/sec. The highest recorded value is 3,550 m^3/sec. The minimum discharge in February/March is about 35 m^3/sec. In September the discharge is between 110—150 m^3/sec. The river carries enormous amounts of suspended material, some of which settles in ever shifting sandbars in the river course.

After the Leirpollen, the road ascends to 200—250 m a. s. l., passing the tree-limit at about 100 m. The low, undulating mountains have a height from 350 to 450 m with very sparse vegetation or barren land with block fields.

At lake Gaednjajavre we turn right and when climbing Mount Oarddovarre large block fields are passed. On this mountain a peculiar form of accumulated material will be studied. The form that occurs in the block fields on mountain plateaus stands out as circular, distinctly outlined hillocks (Pl. 7) up to 70 m in diameter and 1—4 m high. The material differs clearly from the block field due to its high content of finer fractions and somewhat rounded rock fragments. The morphogenesis is still under discussion. Probably the hillocks are not primarily formed by frost processes, but have a glaciofluvial origin. Later the forms have been modelled by periglacial processes, of which nowadays frost fissuring and solifluction can be observed.

At Mount Goarvencaerro (Bugtkjölen) we will make a stop to climb the mountain and by means of an aerial photograph (Pl. 8) try to find the regular, tetragonal pattern that — according to the photograph — occurs on the top surface. A field inspection shall show a vast block field with linear furrows constituting the network. The block mantle consists of sandstone and conglomerate of local origin, but also a few erratics are found. Fine material is lacking. An earlier hypothesis that the pattern is caused by frost wedging along structural lines of the bedrock, is now doubted after a section, 2.4 m deep, made in the block field, just reaching the bedrock. The section that will be demonstrated by Mr. MALMSTRÖM and Mr. PALMÉR, shows that below 0.8—1.0 m the block mantle is underlain by finer, till-like material, which may allow normal frost wedging. This process, acting in the bottom of the block field, may also cause movements in the upper part of the block mantle and affect the surface layer. Whether the process is active or the pattern is a fossil one is still under discussion. Some turned lichen-covered stones are observed and may indicate recent movements in the block surface.

From Mount Goarvencaerro we return to lake Gaednjajavre and follow the valley of river Gaednjajokka northwards to the Kongsöyfjord. In the lower course of the valley, raised delta surfaces occur containing patterns of fossil ice-wedge polygons. In a gravel pit close to the road, sections with ice-wedge casts can usually be seen (Pl. 9).

In the terraced surfaces in the opposite side of the river Gaednjajokka, there occur gully forms developed from a former ice-wedge net.

In the inner part of Vestre Risfjorden a well developed system of beach ridges and river terraces occur. Fossil polygon patterns appear in the upper terraces, but are lacking in the lower ones (*cf.* Pl. 2 in a paper by SVENSSON in this volume, p. 245—252).

An intense marine erosion is working in the relatively soft rocks of the Varanger peninsula. This fact is evidenced by the present appearance of the northern coast, but also in the even, shallow sea bottom gently sloping from 30—80 m until reaching the slope of the Barents Sea shelf region.

Active talus formations can be seen in many slopes of the plateau mountains. An impressive locality is passed at Sandfjord.

Cirques are not frequent in the Varanger peninsula, but at Kjölnes the typical contours of some cirques can be observed. The rock structures stand out clearly after the later marine erosion of the walls. The cirque floor is covered by beach ridge systems.

7th September: Transportation by bus from Karlebotn to Lakselv (in the inner part of the Porsangerfjord)

Route: Karlebotn—Varangerbotn—Skipagurra—Tana Bridge—Rustefjelbma—Ifjord—Kunes—Börselv—Lakselv

The tour will give you a view of the large North-Norwegian fjords, the Tanafjord, the Laksefjord and the Porsangerfjord, passing the inner parts of the peninsulas that separate the fjords.

In this part of Norway, constituting a plateau land of moderate heights (300—400 m) with no high upland and made up of relatively soft rocks, the glaciers formed broad and not very deep depressions. Because of these facts the fjords clearly differ from the more typical West-Norwegian, branched, narrow and deep fjords.

On Mount Ifjordfjellet we shall reach the plateau and pass the highest point of the road, 370 m a. s. l. This part of the road is closed during the winter.

The mountain areas contain many interesting periglacial features. Unfortunately they are scattered and situated far from the road which makes it impossible to reach some of them by foot within a reasonable time. However, passing the innermost part of the Laksefjord a stop shall be made in the Kunes area to (by means of air photos and maps) discuss the distribution of palsas, some polygonal features and pingo-like forms in the „vidda" (the vast mountain plateau). The pingo-like forms ought to attract special attention. One type of them is characterized by a rampart with the central part occupied by a pond or a small lake. The diameter of the ring can be nearly 100 m and the height of the ring ridge 5—8 m. The material is till or fluvioglacial deposits. The forms look stable, but in some individual forms situated in shallow basins containing silty material the ramparts seem to be quite recently formed. In one of the localities a tabular mound in a stage of collapse can be observed, and probably it will end as a ring-ridged pond. Another type occurring in slightly sloping ground looks like hillocks in till material about 50 m in diameter with a depression in the top area. The depressions, 1—2 m deep, are covered by low vegetation and no erosional or collapse activity is seen.

The first type, especially the tabular mound, is interpreted as a transitional form between the palsa and the pingo. The second type is a collapse form of an ice-cored hillock, possibly a pingo. These hillocks are the most pingo-like features so far observed in Scandinavia (Svensson, 1964 b, 1969).

During the period of deglaciation large amounts of fluvioglacial material accumulated in the inner parts of the fjords and can be seen as fossil delta surfaces and gravel terraces, partly reworked by the sea during the isostatic upheaval of the land. The inner part of the Laksefjord makes a good example.

Passing along the eastern side of the Porsangerfjord, well developed systems of raised beaches can be observed from the road.

At Brennelv, before reaching Lakselv, the road passes a large bog area containing palsas. A project is started for removing the permafrost in order to cultivate part of the bog that is underlain with marine sediments (silt and clay).

8th September : Excursion by bus from Lakselv back to Ivalo

Route: Lakselv—Karasjok (Norway)—Kargasniemi (Finland)—Kaamasjoki—Aksujärvi—Kaamanen—Ivalo

From Lakselv we turn southwards to complete our field trip. The road enters the interior part of „Finnmarksvidda", an undulating mountain area built up of Precambrian rocks which is rich in lake basins and small rivers.

Palsa bogs are very frequent in vast areas of the Finnmarksvidda as can be seen in the map of the distribution of palsas (Fig. 2).

Karasjok is an important center of the Sami culture in Norway.

At Karigasniemi, on the northern side of the road, is another Ailigas mountain (holy mountain of Lapps); on the slopes, there are active solifluction lobes and terraces, and on the top of the mountain there are some tors. The problem is how they have survived during the glacial time.

On our way we shall cross large fields of periglacial sand dunes at the Kaamasjoki river. The dunes are parabolic in shape and formed by NW-winds just after the deglaciation.

Later, deflation deformed the dunes and — due to higher ground water level — many dune-dammed ponds have been formed among them.

Originally the wind-blown material accumulated in an ice-dammed lake during the deglaciation.

We are passing eskers, glaciofluvial deltas and drumlins. Just before we cross Kaktsajohka river it is possible to climb on a high delta on which can be seen sorted stone polygons and blow-outs.

Last palsas will be seen at Aksujärvi.

At Kaamanen, the circle will be closed and we shall now follow the only southgoing road to Ivalo.

ACKNOWLEDGEMENTS

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of the area visited during the excursion

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