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GEOLOGY AND MORPHOLOGY OF THE "FJELLS"

INTRODUCTION TO THE ABISKO SYMPOSIUM, WITH COMMENTS ON SOME PROBLEMS

The words *high mountains* in the title of the Abisko-symposium are perhaps not quite adequate as a translation of the Scandinavian word *fjell* (Sw. *fjäll*) used as preliminary title during the preparation of the symposium. By this word, taken from popular language, is meant firstly areas above the timber line, secondly areas with a high and steep relief. A fjell is not necessarily really a high mountain.

The generally preferred way to delimit fjells by means of a botanical limit (the common Swedish topographical maps use contours above the timber line, hachures below it) gives of course a convenient unit for periglacial studies, but the method is just as suitable for morphological and geological studies — though one might not suppose so at first. The fjells (here = regions including areas above the timber line) in Sweden are generally not only areas high above sea level but also areas with greater relative relief than elsewhere. Slopes higher than 400 m occur only exceptionally outside the fjell region, where they are common as are also higher slopes (Rudberg 1960, map of relative relief). As a relief feature, the fjell region in Sweden is for the most part connected with the Caledonian rocks or the Caledonides, one of the two major geological units of the country.

The Norwegian part of the Scandinavian fjell region is much larger than the Swedish one, but the delimitation is sometimes more problematic. The timber line shows greater regional variations in Norway. In central southern Norway it reaches the highest levels in all Scandinavia, in the northern coastal areas it sinks to the sea level. The morphological contrast between the fjells and the regions outside them is not as striking as in Sweden, because the relief in these regions is much higher and more pronounced than in Sweden. As forests are also thin or lacking in many places below the timber line — because of scarceness of loose deposits —

this botanical limit has not always the same importance as in Sweden.

Fjell areas above the timber line represent in Sweden 8% of the total area.

GEOLOGY *

The most characteristic feature of the Swedish Caledonides is the series of flat-lying nappes of great horizontal extension. During the Caledonian orogenesis they were transported from the W towards E and SE over the Archaean basement, the lower ones only a rather short way, the higher ones from the very geosyncline. As a consequence metamorphism is generally shown to increase from the lower to the higher nappes. The sequence of the different units is from the bottom to the top as follows.

The Archaean basement — when observed in field — proves to be a base-levelled surface, the Sub-Cambrian peneplain, here along the front of the mountains only preserved in fragments, but of well established great extension in the Archaean middle and southern Fennoscandia. In most sections across the mountains (shown in the lake valleys) the peneplain is observed to dip W-wards below the Caledonian rock masses. The Archaean basement is in some places visible farther to the W in windows within the mountains proper. One of the greatest of these is the Sjangeli-Rombak window on both sides of the international boundary in the areas between Lake Torneträsk and Narvik.

Autochthonous Cambrian-Ordovician sediments (only Cambrian in the N) generally rest on the Archaean basement. The sediments are sandstones, shales, marly shales, alum shales and in the S also limestones. These rocks have N of Jämtland only a slight horizontal extension. They can be followed on maps as narrow bands along the eastern front and along the edges of the windows. In some places the Cambrian sediments are underlain by tillites, dating from Eocambrian glaciations of great regional extension.

The nappes generally rest on these autochthonous rocks.

The lowest nappes are built of overthrusted fossiliferous Cambrian-Ordovician sediments (also Silurian in Jämtland). They have their greater distribution in the S, only a single observation is reported from the Torneträsk area in the N.

Of greater importance is the next nappe, built of Eocambrian quartzites and arkoses, and of various igneous rocks, often cataclastic and

* Mainly after different papers by Kulling.

interpreted as parts of the Pre-Cambrian basement. These latter rocks dominate the northern frontal part of the range, the sediments the southern.

In the Middle Caledonian Nappes the main constituents are Eocambrian sparagmites (arkoses) with quartzites, conglomerates, schists and tillites of the same age and Archaean, mainly igneous rocks such as syenites. Also in this nappes the Archaean rocks predominate to the N, but the hard-schists N and S of Lake Torneträsk are regarded as former sediments.

The lower and middle nappes (local names in different places) belong to the eastern marginal parts of the Caledonides. To the W they thin out or disappear below the higher nappes, but are occasionally visible as inliers.

Among the upper nappes the Seve-Köli Nappe is by far the most important forming the main part of the Swedish Caledonides. The old geological terms Seve and Köli are used for high metamorphic mountain schists and lower metamorphic schists respectively. Characteristic of the former are mica-schists or garnet-mica-schists, of the latter phyllites. The great nappe is built of varying sediments with intercalated volcanics and intrusive igneous rocks. Among the latter different basic rocks are the most important, mainly as amphibolites in the Seve area. True Caledonian granites play a subordinate role in the Swedish Caledonides. Migmatite rocks occur locally.

In the Köli area it has proved possible to work out a stratigraphy by means of sparcely occurring fossils and some characteristic associations of strata (Kulling 1933). Most of the rocks are of Ordovician or Silurian origin. In the Seve area the geologists have so far no such stratigraphy. Some of the rocks ought to be of Köli age, others seem to be more connected with the rocks of the lower nappes.

Remnants of nappes above the Seve-Köli Nappe are traced in localities near the international boundary and on Norwegian territory. They are built up of high metamorphic schists, partly migmatites and late-Caledonian granites.

In Norway the nappes can be followed from the international boundary. They are of great importance in southern Norway. But in northern Caledonides they are difficult to trace because of steeper structures and more intense folding. The Caledonides represent here a deeper zone. In northern Norway the most important rocks are mica-schists, marbles, Caledonian granites and different igneous rocks of unknown age but structurally partly belonging to the Caledonian mountains (O. Holtedahl 1953).

MORPHOLOGY

In geomorphological studies in Sweden — which not only give a simple description — attention is usually paid to the influence of bedrock upon morphology and to forms caused by glacial erosion. Occasionally attemps are made to reconstruct the preglacial landscape, or — which is not quite the same — the glacial transformation of the preglacial landscape. This problem is difficult also for that reason that all sediments, with few exceptions, are lacking from the time between Silurian and Quaternary, corresponding sediments which could be used to check different reconstructions.

MORPHOLOGICAL DESCRIPTION

In all descriptions of the North-Swedish landscape stress is laid upon the relief type regions or zones stretching perpendicularly to the river systems and parallel to the general N—S extension of the country. Such zones are (Rudberg 1955) the coastal plain, a low, hilly transition region, the undulating hilly land, the monadnock plain (without real valleys), the premontane region (with plateaux or massifs and broad valleys), the mountains or fjells, with high mountains and low mountains.

According to some other principles another paper (Rudberg 1960) in the fjell region makes a distinction between (fig. 2): fjell in general, i.e. mountains with broad and rounded forms, with marked but not steep slopes and often rather flat crests, fjell with plateaux, where these flat crests have a greater extension and fjell with steep relief, reminding one of alpine relief. Within the latter group are in most places found the highest mountains. The plateaux of the second group often give the impression of peneplains. Smaller flat surfaces are also common on fjells of the first group, but too small to be shown on a small scale map. These fragmentary flat surfaces are often arranged like terraces or socles below the higher summits. Sometimes there are different socles in steplike arrangement. As is shown by the map (fig. 2) the mountain relief proper often starts with a marked eastern front, but in some areas there are swarms of small isolated fjells farther to the E. Examples are e.g. seen from the train between Gällivare and Torneträsk. Within the mountains there is often a striking contrast between a central zone with higher and steeper mountains and lower mountains on either side, often of plateau type to the E. Fjell types are illustrated by pls. 1—4.

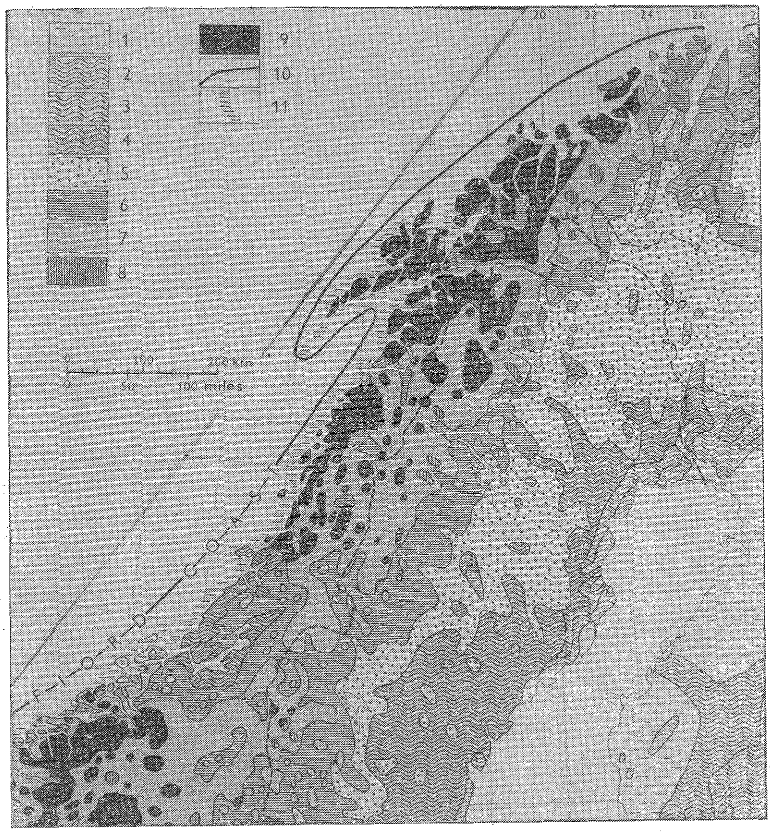

Fig. 2. Morphological type regions (from Rudberg 1960)

1. plain, relative height below 20 m; 2—4. undulating hilly land: 2. relative height 20—50 m, 3. relative height 50—100 m, 4. relative height above 100 m; 5. monadnock plain; 6. premontane region; mountain: 7. fjell in general; 8. fjell with plateaux; 9. fjell with alpine relief; 10. fiord coast; 11. strandflat

MORPHOGENESIS

Influence of the bedrock on morphology

Differences in petrographic composition is of far greater morphological importance in the Caledonides than in Archaean Fennoscandia, where in most cases only relief details are controlled by the bedrock.

Certainly a number of the small isolated mountains in the E are built up of Archaean rocks or of Proterozoic sandstone like the isolated plateau mountains farthest to the S, but the marked transition from the interior monadnock plains to the mountains proper (or in some regions to the premontane region) is to a very high degree associated with the front of the nappes. The greatest exception is found in some localities in the N, where the mountains of the margin are sculptured from the Archaean basement. Such is the case around Lake Torneträsk and in the northernmost end of Sweden. The front of the nappes often appears as steps or scarps in the landscape. These scarps from the well-known "glints" of the Swedish mountains, making a discontinuous E-facing "glint line". The glints may be produced by some of the lower nappes, e.g. the quartzite nappe in the S or overthrusted Archaean in numerous places in the N. Also the Seve--Köli nappe may show a marked eastern step, and in some regions there is more than one glint (e.g. the Ume river valley). In a restricted locality such as the Torneträsk area the glints may be connected with different nappes.

Asymmetrical profiles of the mountains with steep E-facing and gentle W-facing slopes is a common feature in a great part of the mountain region also without direct connection with nappes. The main reason is the general tendency to westerly dip of structures (see below).

Also the variations within the Caledonian rock masses causes conspicuous differences in morphology. The Seve rocks give compared with the lower metamorphic Köli rocks a high and steep relief — the above mentioned central high mountain zone. Notably the amphibolites and the migmatites are of importance in this respect. The highest mountains of Sweden are amphibolite mountains such as Kebnekaise, Sarek, Sulitelma, the Abisko Alpes, Helags.

The rivers which come from the low and open Köli areas pass the higher Seve region in deeply incised valleys. Valleys of the same sort are connected with the quartzite nappe in the southern mountain regions.

The relief of an Archaean window such as the Sjangeli-Rombak window may be very divergent from the softly undulating Caledonian surroundings as being very uneven in details, with numerous steep knobs and hollows. A relief contrast of the same type is shown in northern Norway S of Porsanger fjord, though the Archaean area is here not a real window, but only an Archaean lobe within the Caledonides.

It should be noticed that the correlation between rock type and morphology is not complete. The morphological limits are often pushed W-wards in comparison with the geological ones. It is also remarkable, that numerous important morphological features show no clear relations to structures. For example: the direction of most main valleys, the majority of wide plateaux, the numerous socles.

Glacial erosion

As the relief of the landscape before the glaciation (the initial surface) is unknown, it is necessary on the first approach to the problem to study well-known forms as cirques and trough valleys.

Scattered cirques occur in different mountain regions in Sweden. Some of them still have small glaciers. Most of them are empty and have not had active glaciers in postglacial time — to judge from the absence of true terminal moraines. Consequently they must date from the initial phases of the glaciations before the development of the great ice sheets (Enquist 1918; Mannerfelt 1945; Ljungner 1949; Rudberg 1954 and others). In spite of this circumstance they are often well preserved, with steep walls and with rock basins. The cirques are generally not densely spaced. Remnants of the initial surface are left between the cirque walls. Only locally in the highest mountains has the cirque erosion led to that stage where only sharp ridges remain, and the landscape has passed to the "fretted upland" type.

An attempt has been made (Rudberg 1954) to group observed cirques in the Västerbotten mountains as follows: A — cirques which open directly in the valley floor or to a plane socle surface, B — hanging cirques, C — cirques forming the end of trough valleys, D — asymmetrical cirques, E — open forms. The term *valley side cirque* is proposed for a type resembling the cirques in the B-group (H. Svensson 1959).

The dependence on preglacial relief features can be discerned in several cases, e.g. where small valleys have given shelter to the initial snow accumulation, or where the cirques are localized to steep slopes (generally E-facing) which are due to the inward dipping of rock structures and which probably for this reason have been more or less steep also in pre-glacial time. The asymmetry of cirques in group D is also caused by the dip of structures. Sometimes no kind of preglacial concave feature can be pointed to as responsible for cirque formation.

The lowest summits with empty cirques are in the Västerbotten mountains about 1000 m high or a little lower. This corresponds to a glaciation limit about 800 m lower than the present one. No lower cirques have been observed within the Västerbotten region, probably depending on the existence at an altitude of 800—900 m of plateau regions, that upon a lowering of the snow line would result in formation of plateau glaciers instead of cirque glaciers. A further lowering would lead to formation of waste ice-sheets in the interior plains. Ljungner (1949) reports a somewhat lower altitude for his lowest cirque observation (875 m) in Norrbotten. Somewhat lower values might be expected by further investigation in the same province. Most empty cirques open more or less E-wards, proving the existence of snow-drifting winds of the same direction as nowadays.

The back weathering of the cirque wall was in an examined case estimated to be 500—600 m at most, the deepening of the bottom 100—200 m (Rudberg 1954).

Trough valleys of perfect U-shape are not frequent in the Swedish mountains except for some of the highest mountains and the short so-called *dörrar* or *portar* (= doors or gates). One example is Lapporten at Abisko. In many sections of trough valleys only one flank has U-shape, while the other slopes are more gentle. These imperfect forms give information on trough valley formation. A selected case shows the following (fig. 3). The ice erosion is stronger in outer curves and upon the lee-side of spurs (if the ice in this case is supposed to move from the N). Truncation of spurs thus starts on the lee-side. A trough valley like that of fig. 3 can be explained almost completely by lateral erosion. The vertical erosion may be some tens of metres only. This assertion is proved by the fact that the tributary valleys open almost at the level of the bottom of the main valley in those places where the glacial flank erosion has been feeble. Another proof is that the main valley upstream of the section studied (not seen in fig. 3) is open with broad plains, inconsiderably higher than the valley floor downstream, and these plains cannot have been considerably lowered by glacial erosion, if current ideas of glacial erosion on plane surfaces are correct. The given example is no exception. Probably it illustrates a rather normal mode of trough valley formation in the Swedish mountains outside the highest mountain region.

But this does not say that vertical erosion in the mountain valleys is an exceptional feature. Very obvious results of such erosion are the numerous valley lakes, both in the fjell region and the premontane region — the latter a sort of piedmont lakes. A good example is given by the chart of Lake Torneträsk.

In the lower areas E of the mountains the most picturesque result of glacial sculpture is the "flyggberg" (term based upon a local dialect word from northern Sweden). These have more or less steepened lee-sides contrasting to the otherwise softly rounded form. The best developed types look like giant *roche moutonnée*. Flyggberg occur also in the mountains, where the formation can be facilitated by the W-wards dip of structures. The fresh-looking glint scarps may in the same way be the result of glacial rejuvenation.

Trough valleys with fragmentarily preserved spurs, the E-facing cliffs of flyggbergs and glints all demand an E-moving ice. The dominant direction of striae, however, is within the mountain region generally from the opposite direction, as are also the stoss sides of small *roche moutonnée*. The stage with the ice divide E of the mountains cannot have been of great importance for the major glacial features of the relief.

A survey of well known glacial forms and of scattered steep facettes (as on the flyggbergs) — which in the otherwise gently shaped landscape can be interpreted as true glacial forms — gives no complete picture of the total glacial erosion. So far there are no informations of the glacial influence upon the broad open valleys, lacking typical U-form, on rounded summits, on flat plâteau mountains and on socles below the summits. It should also be kept in mind that the lowering of the glaciation limit before the total glaciation must have lasted a rather long time, to judge from perfectly developed cirques. But this means also a long time for strengthened periglacial activity. If the glaciation limit was lowered e. g. 800 m, the tundra zone and frost shatter zone was lowered as much, i.e. in northern Sweden the lower limit of the former down to the sea-level. The results are unknown.

The total glacial influence of the preglacial landscape cannot be stated by means of the methods discussed. For that reason one may attempt to go the opposite way, to start with surface fragments which possibly can be regarded as preglacial. In the region of the large monadnock plains it is obvious that there are different plains, separated by steps. A step-like arrangement of flat surfaces is still more striking in the premontane region. As no structural base-levels for these flat surfaces are found they ought to be regarded as true peneplains, more or less perfectly developed. The different plains and fragmentary surfaces can according to altitude and mutual relations be grouped into a system of cycles of erosion. In the mountains the following relief features may be considered for a reconstruction: the plateaux, the socles below the summits, the valley floors, where the signs of vertical glacial erosion are feeble. It is the opinion of the author, that these fragmentary "cycles" in the investigated Västerbotten area can be grouped in the same system as is stated downstream, thus forming the upper parts, further from the base level, of the better developed cycles of erosion in the premontane region and the monadnock plains, and also remnants of higher systems (see further Rudberg 1954).

Whether such preglacial cycles of erosion can be followed in the whole mountain region is still an open question. However, such systems have been reported from different regions (e.g. Wråk 1908; J. Frödin 1914; Braun 1935), though some studies are based upon few field observations. In some regions such systems are difficult to discern, notably where the glacial erosion has been of obvious importance, as for instance around the greater valley lakes. The small canyons at different altitudes in the slopes above Lake Torneträsk are most easily interpreted as caused by rejuvenated stream erosion generated by glacial transformation of the main valley.

The systems of preglacial cycles of erosion are not the only indication of preglacial fluviatile activity. Other signs are the valleys breaching through the Seve area and the observed W-ward pushing of the morphological limits in comparison with the geological ones.

THE NORWEGIAN MOUNTAIN RELIEF

It is well-known that the Norwegian relief is high and steep and in these respects very divergent from the Swedish one. Certainly there are very wide plateau areas in the southern Norwegian mountains and occasionally in northern Norway, but on the whole the relief is strongly dissected by fiords and deep valleys penetrating far into the country. A strong rejuvenation of stream erosion originated from the important tectonic movement during Tertiary, according to general opinion (see notably O. Holtedahl 1935, 1940).

In this landscape, which already had strong relief before the glaciations the results of glacial erosion are more conspicuous than in Sweden.

Cirques are more numerous, more densely spaced, and occur on lower summits than in Sweden. An example: The amphibolite mountains S of Abisko (1600—1750 m) have well developed cirques but broad and rounded forms. The Mt. Kongsbaktinn (1576 m) SW of Narvik have cirques only separated by narrow ridges. Sharp alpine forms of the same kind are characteristic of the 700—900 m high mountains bordering the mouth of the Ofot fiord, and on the outer islands in the Lofoten-Vesterålen group such forms are occasionally found at still lower elevations. The present glaciation limit shows the same strong tendency to sink W-wards (Ahlman 1933).

The trough valleys are far better developed than in Sweden, ideally shaped U-valleys are numerous, with steep sides and head walls, hanging tributary valleys, overdeepenings and blocking thresholds cut by interglacial and postglacial notches.

Attempts to reconstruct preglacial cycles of erosion are more dubious, at least in the valleys and along the fiords, where indisputable fragments are likely to be very infrequent. In the wider areas between the valleys a step-like arrangement of undulating surfaces has sometimes been reported, by Wråk (1908), Keindl (1936, 1939) and Evers (1941). A theory by Gjessing (1955) deserves special interest in this connection.

He discusses the backward moving of the trough valley end by combined glacial erosion during the glaciations and — because of lowered base level — strengthened stream erosion in interglacial times. The valley end is supposed to wander considerable distance and the result will be a sort of cycle of erosion — but of young origin.

An important problem is whether there existed ice-free areas or at least some peaks protruded as nunataks in the western and northern coastal areas of Norway during the glaciations.

Supporters of the theory are notably botanists, who point to some problems concerning the distribution and migration of the mountain flora. A number of species can hardly have reached Scandinavia after the deglaciation from E or S, as they are totally absent in continental Europe. They are however found in North America, in Greenland and in part on Spitsbergen and Novaya Zemlya. As a consequence ice-free refuges are postulated. Furthermore some species (unicentric) are restricted either to the northern part of the Scandinavian mountains or to the southern, others (bicentric) to the northern and the southern, but are absent in the areas between (see Nordhagen 1936). Refuges are sought for at the Norwegian coast and the best indications for occurrence of supposed refuges and nunataks have been found in the coastal areas next to the areas with specimens of discontinuous distribution. Most important of these areas are the Sunmøre region in western Norway and the Lofoten-Vesterålen islands in northern Norway. These are also localities, where the edge of the continental shelf is at the shortest distance from the coast, and for this reason intensified calving and lower ice-surfaces could be expected.

Geological field evidences of nunataks should be: absence of *roches moutonnées* and erratics and signs of rock weathering of long duration. Renewed examination, however, has proved the existence of erratics on many presumed nunataks (e.g. Grønlie 1940). *Roches moutonnées* are often poorly preserved on summits, which obviously have been covered by the inland-ice during the latest glaciation. Careful examination has so far showed no differences in weathering between supposed nunataks and adjacent areas (H. Holtedahl 1956). Another proof of true nunataks should be the nunatak form, i.e. the pointed form, the form of isolated peak or cone without standing in contact with cirques, peaks that "rise with wild and jagged forms, sharply distinguished from surrounding arched mountain surface" (Ahlman 1919, p. 213). Such forms may however be due to postglacial weathering, strengthened because of high altitude and great steepness (O. Holtedahl 1953). It has proved, that "so-called nunatak-topography" may be preserved and even accentuated under an ice-sheet (see review by Hoppe 1959). The problem of refuges and nunataks cannot yet be regarded as definitely solved. If the nunatak form is not due to intense weathering above an ice sheet, the striking contrast between the keen peaks and the rounded arched lower ridges another explanation is needed. Could it be due to strong lateral erosion by swiftly moving ice-streams? (See also papers by: Nordhagen 1940; E. Dahl 1948, 1954; Rudberg 1953; Nannfeldt 1958; Holtedahl & Rosenqvist 1958; Bergström 1959 and others).

At last a quite special problem concerning glacial erosion should be pointed out. The morphological contrast between the Swedish and Norwegian mountains is strengthened by the great differences in the thickness of the loose deposits. To the E the thickness may be 1—4 m or more, outcrops are certainly numerous but covered areas are by far greater than the uncovered ones. To the W the exposed bedrock dominates almost totally areas with strong relief but also different gently shaped landscapes. A small scale map is recently published for the countries of Norden (Rudberg 1960 — for Norway based upon an unpublished map by Feyling — Hansen). This map shows that areas with bare rock or thin moraine cover is located in the western part of the peninsula. It can be followed as a broad band from the Swedish Skagerack coast, along the southern, western and northern margins of Norway to the Varanger peninsula. Lobes from large Norwegian areas of exposed rock stretch over to Swedish mountain regions in some places. This important feature has only played a feeble role in the scientific discussions, but it is observed in some papers (i.e. Holdar 1957; H. Svensson 1959). The following explanations have been proposed: A former cover of loose deposits has been carried away by landslides, avalanches, solifluction, melt-water erosion, abrasion during higher stages of sea-level etc. The naked rock may be particularly connected with areas, where the stream-lines of the ice diverged. The naked rock may be connected with regions, where the iceflow was rapid, the erosion consequently intense, and where the total surface got a perfect glacial stamp, which by and by resulted in diminishing plucking and decreasing debris in the ice sheet during the continued glaciation. The first explanation cannot be of general importance, as no sufficiently great quantities of re-accumulated masses are known from valleys or depressions. The second explanation holds true only for parts of Norway. The third explanation ought to be proved in field.

It is evident that many problems still rest unsolved within the field of "fjell morphology". To summarize the most important ones are as follows.

Systems of cycles of erosion have been reported from some areas. We do not know if such reconstructions are possible within the greater part of the mountains — or expressed in another way if the main features of the preglacial landscape can be traced more generally behind the glacial transformation.

But even successful reconstructions of cycles of erosion would be hypothetical in many respects unless no special method to estimate the total amount of the glacial transformation could be found, particularly concerning areas lacking well defined glacial forms such as U-valleys etc.

The information given by the sharp contrast between areas rich in naked rock and till-covered areas have so far not been used for calculations of the glacial erosion.

To solve the morphological equation it is also necessary to estimate the total periglacial transformation of the landscape, i.e. the transformation in postglacial as well as in interglacial time and during the probably long periods of mountain glaciation and advancing glaciers. Well established knowledge of slope development within the periglacial cycle would be of highest value.

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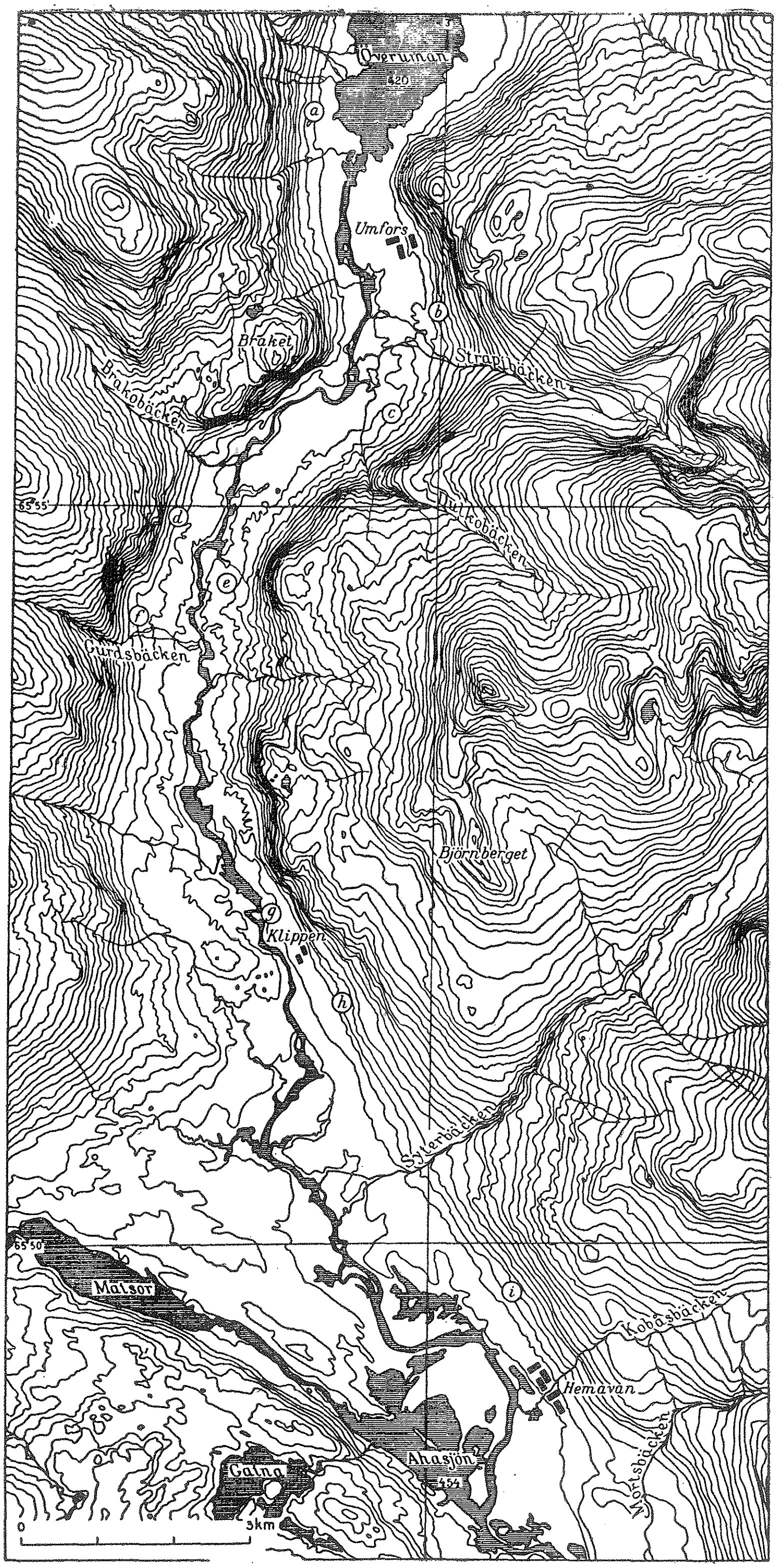
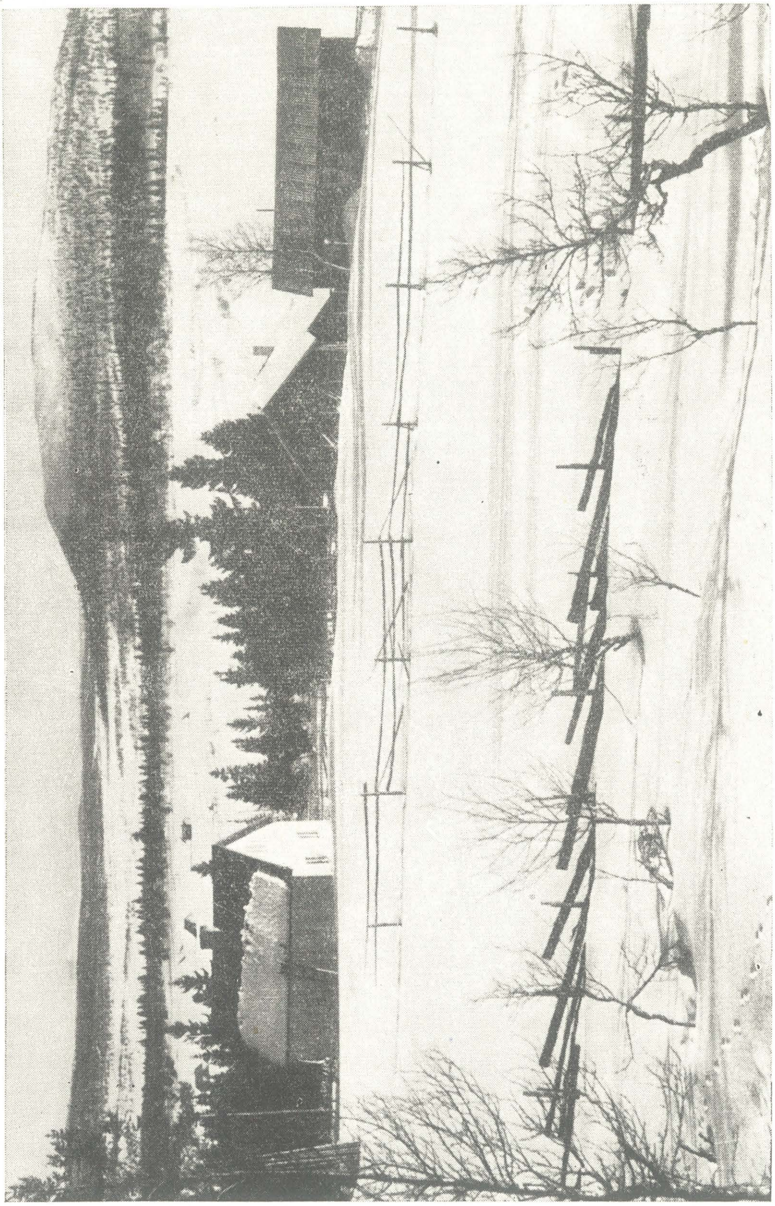
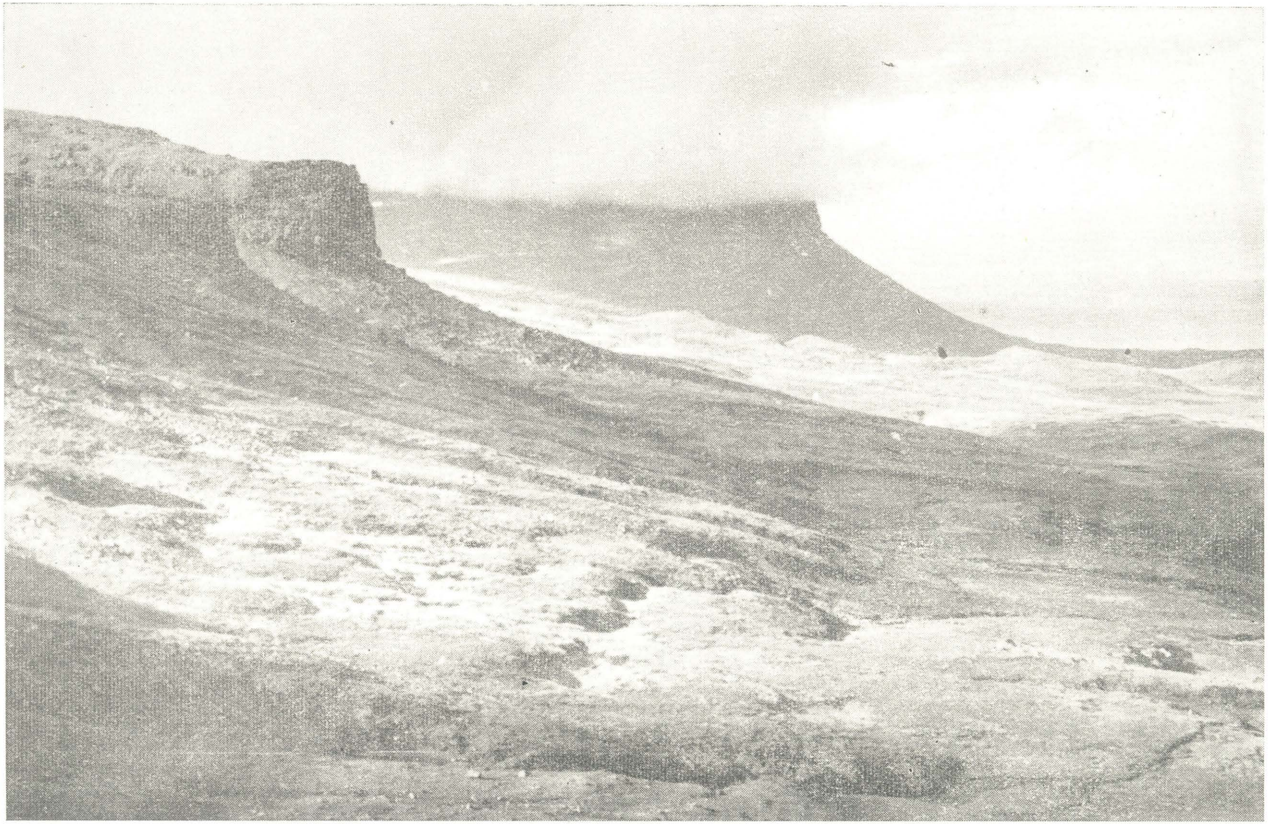


Fig. 3. Glacial transformation of the Ume valley, Västerbotten. By "Braket" lee-side plucking of a spur. At "c" erosion in the outer curve of the valley etc. Small cirques in the mountains to the right (after S. Rudberg 1954)



Pl. 1. Högvalen, Häjedalen. Isolated low mountain from the easternmost zone of the fjell-region



Pl. 2. Torneträsk area. Mt. Luopakte to the left, Mt.Kaisepakte in the background. Solifluction lobes in the foreground

Pl. 3. Fjell with cirques and remnants of "preglacial" plateau surface at the summit. From. Mt. Maskokaise, northernmost Sweden. Heights of the summits 1400—1500 m

Pl. 4. The Lofoten islands. Fjells with alpine forms without remnants of preglacial surface and cirque bottoms slightly above sea level. Heights of the summits 600—700 m

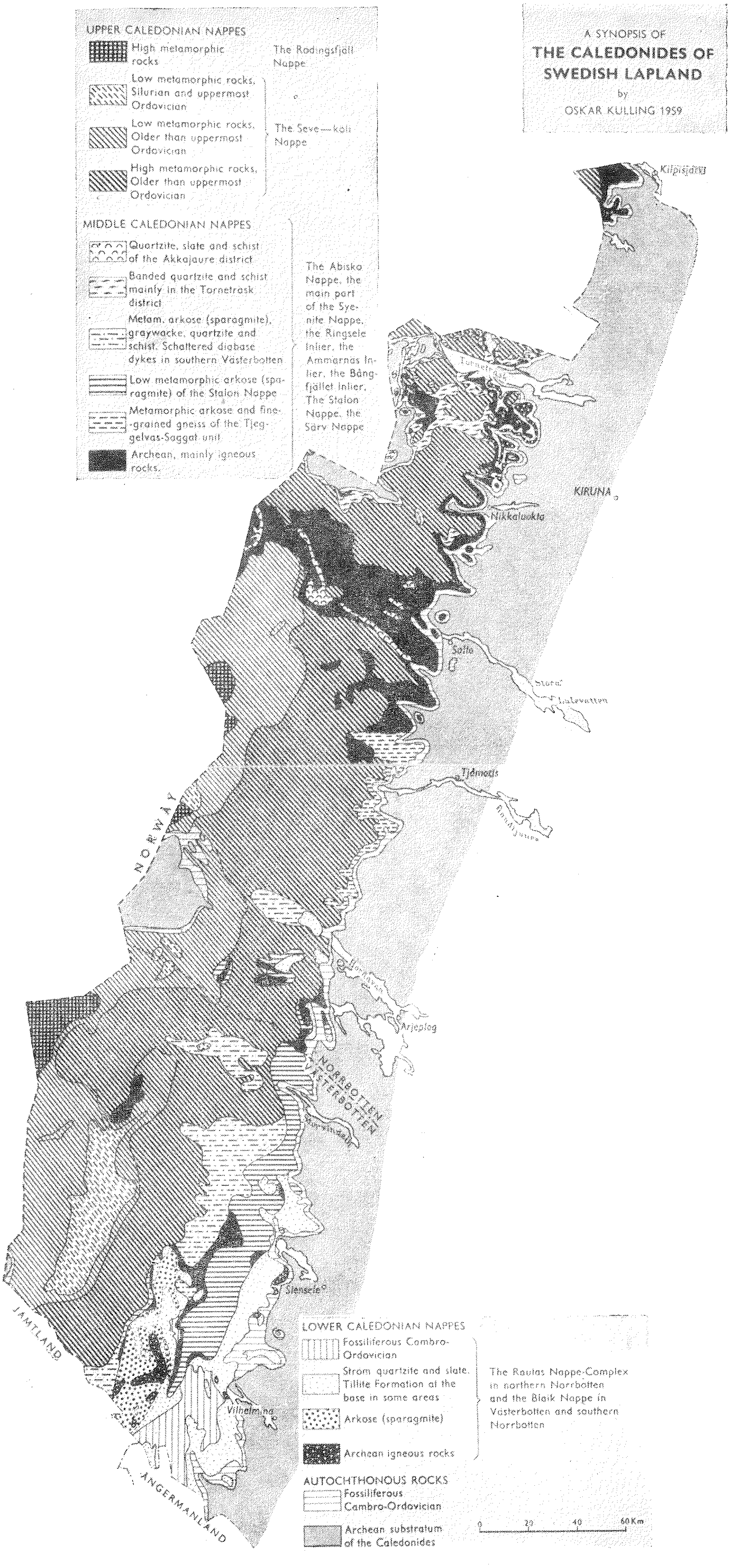


Fig. 1. Geological map (from Kulling 1960) of the Swedish Caledonides N of the province of Jämtland