Glacial Morphology of the Kuvnilik Area

By

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Kuvnilik Fjord lies on the west coast of Greenland at about 62° 45′ N, north of the Frederikshåb Glacier (Frederikshåbs Isblink); it is about 30 km long, and extends in a SW-NE direction.

The two large islands, Ikatokø (120 m) and Kekertarssuak (533 m), lie in the outer half of the fjord. The sides of the fjord here slopes evenly, and the surrounding country only seldom reaches heights greater than 500 m. The inner half of the fjord is bounded by steep slopes, the country here having a very marked relief, with many peaks exceeding 1000 m. On the NW side of the fjord there is a lateral fjord, Tasiussarssuak, extending in a NNW direction; this is about 5 km long, and from 1–2 km wide.

The country SE of Kuvnilik, between the fjord and the inland ice (Indlandsis), is dominated by two big, steep-sided lakes, which are about 2 km wide, and respectively 15 km (Majorarisat) and 19 km long. Both of these lakes extend parallel to the fjord, and both are bounded to the SW by the Frederikshåb Glacier. The longer lake is separated from the inland ice by a narrow border across which a glacier about 2 km broad extends, occupying the whole of the middle part of the lake.

In 1878 A. Kornerup visited the district, and he describes it[1] as showing clear signs of an earlier glacial cover, with rounded topographic features, and striated bedrock surfaces strewn with subangular boulders, often of very great size; with deposits of clay, sand and gravel in depressions, and with terraced deposits in the valleys.

As a member of the Geological Survey of Greenland field party I had, in the summer of 1952, the opportunity of undertaking glaciomorphological investigations in the general area of Kuvnilik Fjord. The results of this work will be briefly presented here.

Glacial Deposits

Moraines

Numerous isolated boulders, which are found on all bedrock surfaces which do not slope steeply, form the most widely distributed and characteristic type of moraine (fig. 1). All the boulders, of which over 90 % are greater than 0,5 m in size, show signs of having been transported by ice.

[1]) Kornerup, A.: Geologiske Iagttagelser fra Vestkysten af Grønland. Meddelelser om Grønland, vol. 1, 2. ed., 1890.

However, only very few are much rounded and striated, while the great majority have sharp edges and some surfaces without any trace of glacial polish. These boulders have constituted the coarse fraction of the basal moraine of the inland ice.

The finer part of the basal moraine is only rarely to be observed, and it is supposed that is has been removed by post-glacial processes. This material has naturally been present, as is evidenced by the traces of it which

Fig. 1. Scattered moraine boulders.

remain in the supports beneath perched boulders (fig. 2), which can only be moraine material.

The bedrock is only completely covered by the ground moraine in very few places, and then only in smaller or larger depressions where the material has not been subject to any greater degree of post-glacial washing. There are, in particular, extensive moraine covered areas between 600 m and 900 m elevation north of the innermost part of Kuvnilik. Also the later valley glaciers have deposited ground moraines, as, for example, in the narrow valley east of the inner end of Kuvnilik, in the Majorarisat valley, and in a little valley on the west side of Kekertarssuak. Where the moraine is accessible for close examination, it is found that the material varies from sand to boulders several metres across, but finer material has doubtlessly also been present.

There have been no halts during the retreat of the inland ice, as shown by the absence of marginal moraines, so it must be supposed that melting has been continuous in this area. On the other hand, the valley glaciers which have occupied the fjord and most valleys after the inland ice stage, have here and there deposited terminal moraines.

On both sides of the southern arm of Kuvnilik, south of Kekertarssuak, are found the extremities of a terminal moraine which has traversed the fjord, and here the fjord is also quite shallow.

About one kilometer east from here, in a U-shaped valley which leads from the small un-named lake to the fjord, there is a small terminal moraine, which has been deposited by a glacier tongue from the south. Similarly, a small terminal moraine is found in the middle of the deep, narrow WNW-ESE valley east of the innermost end of Kuvnilik.

The largest terminal moraines in the area lie between Kuvnilik and the lake immediately NE of the innermost end of the fjord. Two moraines

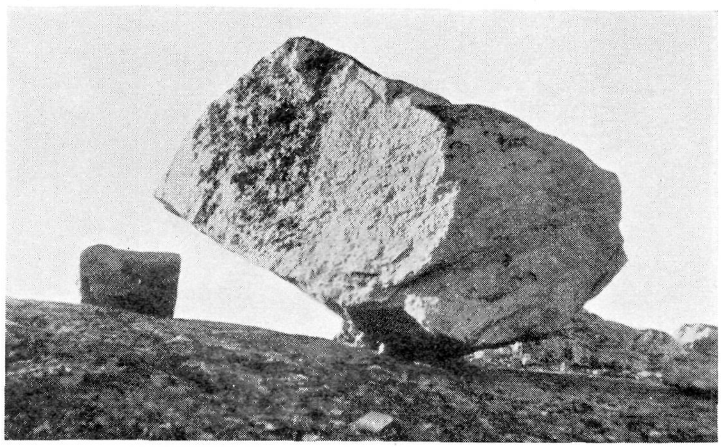

Fig. 2. Perched boulder. An angular moraine boulder resting on more fine-grained material. The notebook in the foreground indicates the size.

have been deposited here with an interval of about 100–200 m. The moraines are about 1 km long, and rise to about 50–60 m above the level of the fjord; they have been deposited by the glacier which filled the valley now occupied by the lake. The material varies greatly in grain-size; it is generally unsorted, but there are many parts which show a more or less clear bedding.

There are only a few occurrences of lateral moraines deposited by the valley glaciers, and here also, as in the terminal moraines described above, water-laid beds are to be seen here and there.

Lateral Meltwater Deposits.

The most widespread glacil deposits which are found in the region of Kuvnilik have been deposited by the lateral meltwaters of the glaciers which have occupied the valleys and the fjord. Stratified terraced deposits are often seen in small embayments in the valley sides; these are interpreted as kame terraces. Apart from these smaller occurrences there are three larger areas with notable amounts of lateral meltwater deposits.

On the east side of Kekertarssuak, between the shore and the steep rock side of the island, there is a 250–400 m wide belt of incoherent deposits, which are seen to be bedded in cliff sections along the shore and in the banks of many small streams. The material has been deposited by meltwater streams which have flowed between the rock side and the glacier in the fjord. The material does not extend above about 105 m, and it slopes evenly towards the fjord. There are no distinct terraces, but numerous small terrace-like niches occur quite irregularly. The reason for the big meltwater streams, which have deposited this material, not having formed marked terraces, must supposedly be that the glacier melted so

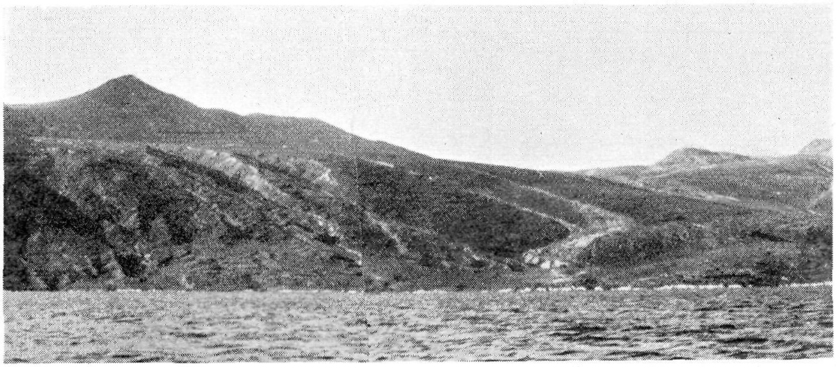

Fig. 3. The lateral meltwater deposits on the north side of Tasiussarssuak.

quickly that the lateral meltwater streams could not maintain a steady course for any length of time, but that they followed the relatively rapid retreat of the margin of the glacier away from the rock cliff.

Lateral meltwater deposits are found at two places around the lateral fjord, Tasiussarssuak: partly to the north and partly in a little valley on the west side, near Kuvnilik. The bottom of this valley is completely filled with incoherent material varying in size from sand to boulders up to half a metre large. Boulders larger than half a metre are uncommon, and only very few boulders larger than one metre were found. The cobbles and boulders are here, as at other places where there are meltwater deposits, completely rounded and smoothed, distinguishing them from the moraine material in the area, which is only rarely much worn. Stream sections in this deposit show clear signs of water sorting at several places. The supply of material must have come partly from the fjord glacier through three small lateral valleys, and partly from a branch of the fjord glacier which entered Tasiussarssuak.

The most extensive meltwater deposit is on a bedrock slope north of Tasiussarssuak, where the deposits reach an elevation of about 625 m in the east (fig. 3). Three terraces, all with a maximum width of about 300 m, are found between 450 m and 625 m; they slope gently towards the fjord, and rather strongly (about 1:25) to the SW. The terraces must actually be considered as kame terraces. The meltwater streams which formed these terraces flowed westwards through a pass at an elevation of 270 m between Tasiussarssuak and Bjørnesundet. The elevation of the pass has deter-

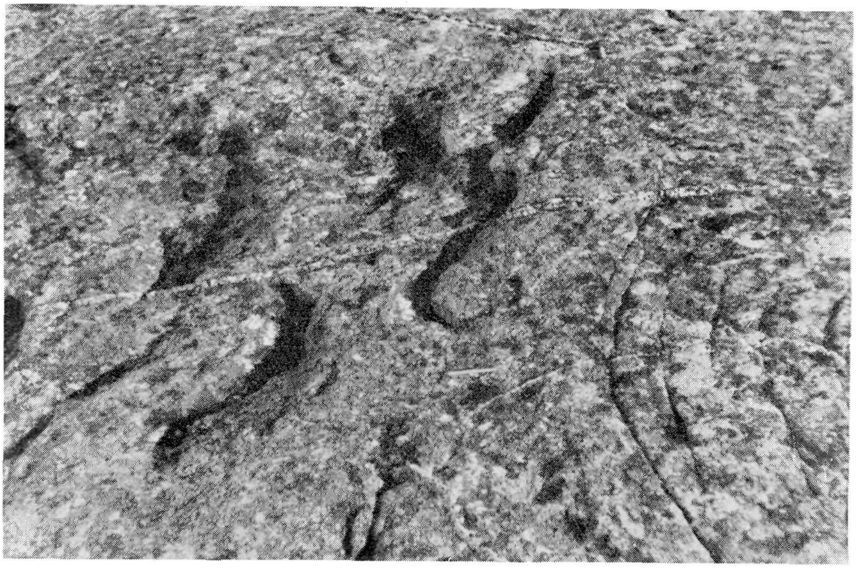

Fig. 4. Sichelbrüche (left) and parabelrisse (right). The direction of ice movement has been from left to right. Size is indicated by the pencil almost in the middle of the picture.

mined the level of the lowest terrace. After the surface of the ice had melted below the level of the pass, so that the meltwater could not escape this way, the character of the meltwater streams must have changed, for between the lowest terrace and the shore there is an even cover of glaciofluvial material up to 10 m thick. This material shows no clear signs of either terraces or bedding; this is supposedly because post-glacial earth flow, which still occurs on the slope, has obliterated the primary features.

Directions of Ice Movement.

The bedrock in the area is mostly coarse-grained gneiss, in which true glacial striae are only rarely to be observed. The directions of the movement are therefore largely determined by a study of the transverse fractures: parabelrisse and sichelbrüche (fig. 4), thoroughly treated and unequivocally named by E. LJUNGNER[1]. Examination of those localities where the topography cannot have influenced the directions of flow of the inland ice to any extent, shows that the last direction of movement, throughout the area, was from about N 75°–80° E. Since the break-up of the inland ice—during the valley glacier stage—ice movements have conformed completely to the underlaying topography.

[1]) LJUNGNER, E.: Spaltentektonik und Morphologie der schwedischen Skagerrak-Küste. part 3, Bull. Geol. Inst. Univ. Upsala, vol. 21, 1930.

Ice Erosion.

The country about Kuvnilik Fjord is characterized by rounded rock surfaces and U-shaped valleys. But areas with numerous roches moutonnées occur throughout the country. The question of the importance of glacial erosion in connection with the formation of these topographic features has been treated by O. D. VON ENGELN[1] and MAX DEMOREST[2] from widely different points of view. VON ENGELN'S opinion is that roches moutonnées represent the universal final stage of glacial erosion, being completely independent of the preglacial topography. DEMOREST, on the other hand, says that the form is due to differential erosion, very much dependent upon the pre-glacial topography and the structure of the bedrock: glacial erosion only removing the outer, very much fractured zone of rock, whereafter glacial erosion of the unaffected rock is restricted to grooving and polishing of the rock surface.

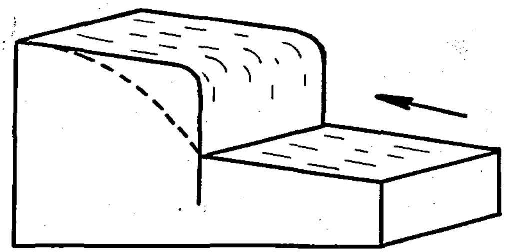

Fig. 5. Diagram of a fault with the scarp face directed towards the direction of the ice movement. The broken line indicates the presumed appearence if glacial erosion of the solid rock had been extensive.

Some small morphological features of the solid rock can be of great importance in judging the large-scale effects of glacial erosion, and in the Kuvnilik area there are two forms of importance in connection with the local erosion of the inland ice. On the NW side of the inner part of the fjord there are some N-S faults, of which the fault scarps face east: almost directly against the direction of movement of the inland ice. These fault scarps are exposed for distances greater than 1 km, and are up to 3–4 m in height. The faults cut surfaces which slope against the direction of ice movement, and therefore should have been exposed to particularly strong glacial erosion. These slopes show much glacial polish, but the fault scarps are only a little rounded, about the uppermost metre being affected. If the ice had removed an appreciable amount of the rock, the fault scarps would not appear as they do, but would be much more strongly bevelled (fig. 5), and it must therefore be supposed that only slight erosion of the solid rock has taken place.

An other, and lesser feature, is to be seen on the surfaces of the roches moutonnées which face the direction of the ice movement. Triangular pits and depressions are often to be seen in this evenly rounded surface (fig. 6 & 7); one side of the depression, which may be several metres long, is

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1) VON ENGELN, O. D.: Glacial Geomorphology and Glacier Motion. Am. Journ. Sci., vol. 35, 1938.

2) DEMOREST, MAX: Glacial Movement and Erosion: A Criticism. Am. Journ. Sci., vol. 237, 1939.

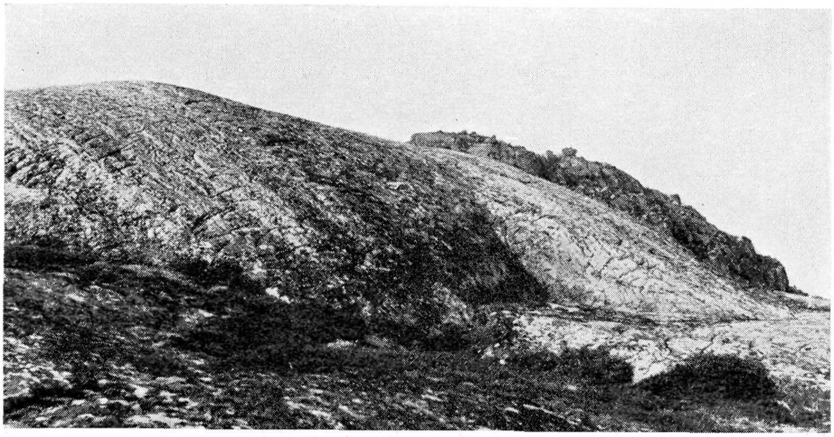
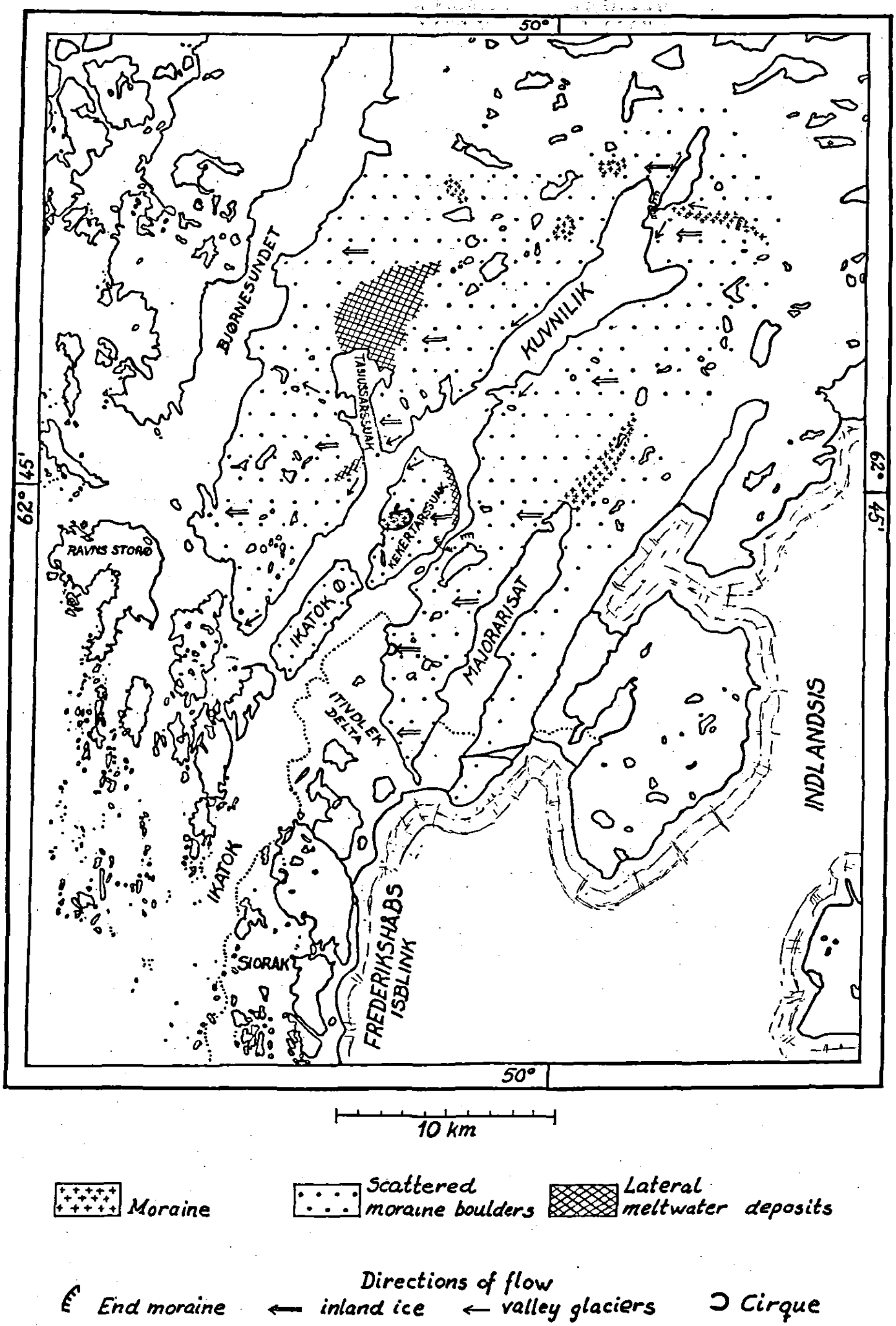


Fig. 6 & 7. Triangular pits in roches *moutonnées*. Numerous sichelbrüche are to be seen in the rock surface on the upper picture. The scale on the lower picture has 20 cm divisions.

generally determined by a crevice. The rock which filled the depression has supposedly been broken up by frost action, and has thereafter been removed by the advancing inland ice. The sides of the depressions show signs of glacial smoothing, and the edges are rounded. These triangular pits and depressions supposedly represent the lowermost part of the pre-



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glacially shattered zone, since they are often of about the same size, and occur only a few metres apart. From this it may be concluded, as Demorest proposed, that the inland ice removes the outer shattered mantle, after which the glacial erosion in the hard, unweathered and little fractured rock is very much reduced, and has mainly a smoothing and polishing effect.

These erosional forms, and the judgement of the amount and nature of the erosion are only valid when applied to almost level surfaces or surfaces which slope towards the direction of ice movement. It is more difficult to determine the nature of the erosion which has taken place on steeper surfaces sloping in the same direction as the ice moved, as there is here no trace of glacial polish, and the rock surfaces are angular and fractured. In this case glacial erosion has supposedly been restricted to the removal of only some of the shattered outer mantle.

Earlier Glaciation.

It is impossible to say whether the area has been glaciated more than once, or to define the course of such possible glaciations. The only trace of a glaciation prior to the last total glaciation is to be seen in two cirques facing west. The one is situated on the west side of the tract of land between Majorarisat and the fjord, about 1 km south of the big bay. It is regularly semi-circular, with steep sides about 150 m high, the floor of the cirque being at an elevation of about 30 m, and the opening to the fjord about 200 m wide. The other cirque is the moraine filled valley on the west side of the Kekertarssuak; it is about 1.5 km long and almost 1 km wide. The steep sides are more than 250 m high, and the innermost part of the valley floor lies at about 100 m elevation, with an even slope out to the fjord. The upper parts of the steep walls of both cirques have been much rounded by the inland ice advancing from the east, and there is therefore no doubt that they were formed before the last advance of the inland ice. It is, however, impossible to say whether they were formed as an introductory phase of the last glaciation, or whether they were formed earlier.

There is every reason to believe that a generally similar glacio-morphological development to that presently described, will be found to apply to large parts of the west coast of Greenland. However, a wealth of smaller glacio-morphological elements will undoubtly be discovered, and by extensive investigation of the bedrock surface, which is nearly everywhere exposed, features of importance for the more exact understanding of glacial erosion under varied conditions should be found.