Fig. 1. Looking down Adolf Hoels Gletscher, about 8 kilometres wide. Note the rough ice surface, partly cut by rivers. 23 August 1951.

JOURNEY ACROSS THE NUNATAKS OF CENTRAL EAST GREENLAND, 1951

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IN THE spring of 1951 plans were made by Lauge Koch's East Greenland Expedition for a summer crossing of the nunataks north of Petermanns Bjerg by a geological party. This region was chosen because large areas of ice-free country extend farther west than elsewhere in central east Greenland and, since the Caledonian mountain chain of the fjord zone trends northeastwards, it was hoped that new light would be thrown on the structure of the mountain belt. Between 72°N. and 74°N. this consists geologically of a crystalline band of gneisses and igneous rocks flanked to the east by non-metamorphic sediments of Late Precambrian and Early Paleozoic age and, nearer the coast, by younger sediments of Late Paleozoic and Mesozoic age. Early work in the Petermanns Bjerg region (Wordie, 1930) had shown that non-metamorphic sediments occur also in this area, and this had later been interpreted as indicating that a belt of these sediments extended to the west of the crystalline rocks and was therefore part of the foreland west of the belt of Caledonian folding (Wegmann, 1935; Koch, 1936).

Previous attempts at exploring the high mountain regions along the ice cap had shown that it would be exceedingly difficult to carry sufficient supplies for a journey lasting one month from a base in the fjords. In this region the large glaciers are heavily crevassed and cannot be used as routes by expeditions interested in other work than ice climbing. In 1948 W. Huber and I (Huber, 1950) had tried to travel westwards along the large Jætte Gletscher from a base camp near Gregorys Gletscher, northeast of Petermanns Bjerg, but we had failed. It became obvious that to make our planned journey across the inland nunataks we must either find a place where the first 1,700 metres above the sea could be climbed without difficulty, or arrange for supplies to be dropped by aircraft for a sledge party.

During the early spring of 1949 I had found that it was possible to reach a relatively flat glacier plain, only 1,000 metres above sea level, just north of the head of Geologfjord, Strindbergs Land, and that this appeared to lead westwards into the broad valley of Adolf Hoels Gletscher. In 1931 the Norwegians Høygaard and Mehren (1932) had followed part of this route in the opposite direction on their west to east crossing of the ice cap. They had travelled down Waltershausen Gletscher to Nordfjord, but from their reports they must have had unusually favourable conditions. Our first plan was to follow the route up Geologfjord westwards and cross northeast Strindbergs Land to the flat glacier plain, thus avoiding the highly crevassed surface

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Fig. 2. Weasel tracks on the ice cap after snowfall. 1 August 1951.

of Waltershausen Gletscher or of the even more difficult Nunatak Gletscher. This route would be much easier and shorter than that travelled by Høygaard and Mehren, moreover there was a large lake at an altitude of 750 metres where we hoped our Norseman aircraft would be able to land.

Fortunately, we were able to improve our plans very considerably as M. Paul-Emile Victor, whose expedition had worked for three successive years on the Greenland ice cap, and the Danish Government kindly offered to give us the most effective support they could. Victor had crossed the ice cap during 1950 with one of his mechanized groups using "weasels" and had reached Cecilia Nunatak, an easy journey from Ella Ø radio station on the east coast.

We therefore decided to make a combined expedition. A party from the French expedition would meet our group at Cecilia Nunatak to help us carry our heavy equipment which would be dropped, together with additional fuel for the weasels, near the French camp by a DC 4-Skymaster from Iceland. Our group would fly by Norseman aircraft to the head of Röhss Fjord, from where it was a comparatively easy climb to the top of Cecilia Nunatak, 1,600 metres high. From Cecilia Nunatak we would travel with the weasels of the French expedition westwards and northwards over the ice cap to the best place to start our way eastwards. Walking on skis and pulling light Nansen sledges we would then travel along the large glaciers coming down from the ice cap, thus crossing the nunataks and mountains, until we reached the area

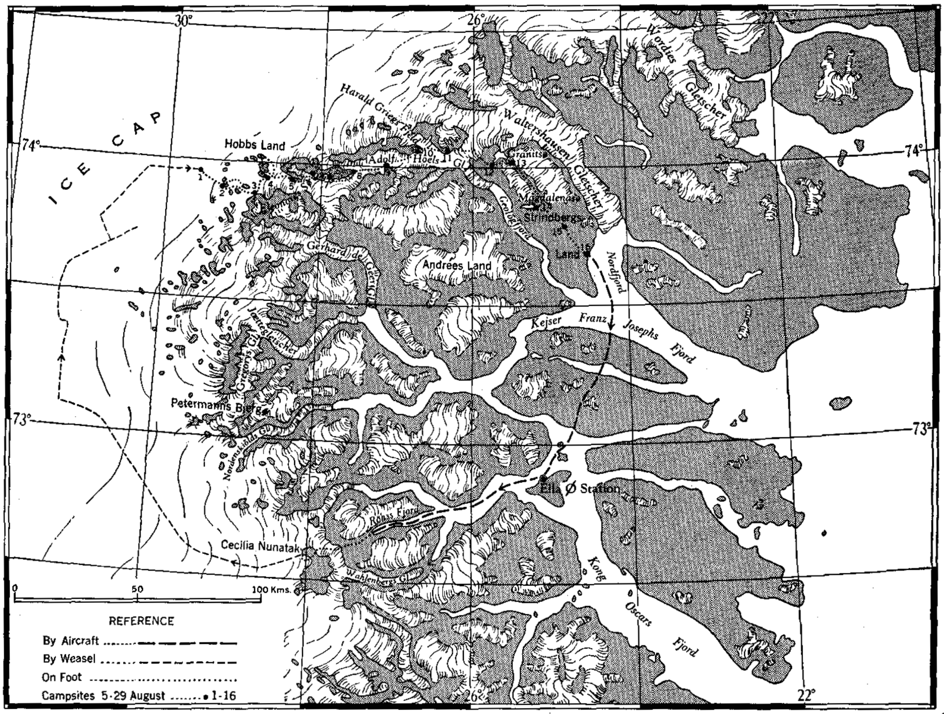

Fig. 3. Sketch-map of central east Greenland showing the route of the expedition.

north of Geologfjord, where we would be picked up by a Norseman aircraft from our expedition.

Compared with earlier journeys in east Greenland our combined party was an experiment and there was little experience to guide us. Our main purpose was to carry out as detailed geological investigations as possible, and we had to plan our crossing of the nunatak region accordingly. Our party consisted of W. Diehl, H. Röthlisberger, and myself as leader. Diehl and Röthlisberger are both most able mountaineers, and the latter had had some arctic experience as a member of the Arctic Institute's 1950 Baffin Island Expedition.[1]

Unfavourable weather and ice conditions delayed our start from Ella Ø until July 29. We reached Cecilia Nunatak two days later, where we met the weasel party according to plan. We found that the parachute drop had already taken place, and we were able to start westwards with them on the evening of August 1 (Fig. 2). During the following days we made several attempts to cross the broad border zone of the ice cap and to reach the lower region of the nunataks (towards the north we followed a route between 2,500 and 2,800 metres in altitude), but the weasels always broke through the snow bridges which covered the large crevasses. We were forced therefore to leave them behind on August 5, but we were now 300 kilometres on our way, though still 13 kilometres from the nearest nunatak, a small, rocky outcrop.

[1]See *Arctic*, Vol. 3 (1950) pp. 131–49.

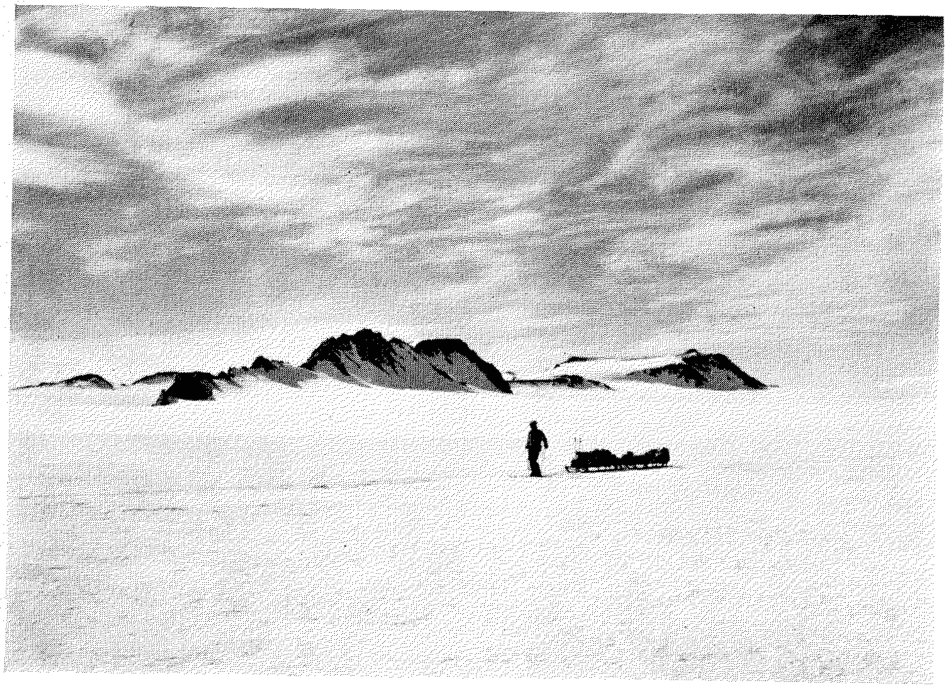

Fig. 4. Nunataks at the edge of the ice cap, passed when travelling on skis towards the main glaciers. 8 August 1951.

Thanks to the assistance of the French weasel party led by G. Rouillon, we had reached the westernmost point of our journey still well equipped and fully supplied. The French party then had to make its way back to the Central Station and the west coast, while we hoped to be able to walk through Hobbs Land, Harald Griegs Fjeld, and Adolf Hoels Gletscher to Strindbergs Land within the next three to four weeks.

We had planned to abandon our equipment as soon as it was of no further use. Thus we left our skis at Camp 6, at about 1,500 metres, as from there on we were travelling on bare ice, and on August 18 we left one of the two sledges, already badly damaged, as well as a tent, some clothes, and food at Camp 7, as every kilometre seemed to be getting more difficult. Two days later we had to abandon the remaining sledge and to carry our supplies, including many rock samples, as the extremely hummocky ice became too difficult for sledging.

We reached the northernmost part of Strindbergs Land on August 25, where we had to cross a rather large river draining Granitsø. We were disappointed to find that the lake was already covered with thin new ice, besides carrying some icebergs, as we had hoped that our aircraft might be able to land there. Fortunately we could live from hunting—a fact we had taken into account in our plans—as we had practically no food left. On the morning of August 27 we used the last of our fuel and so set out for Magdalenasø, about 25 kilometres away, where our Norseman aircraft should have

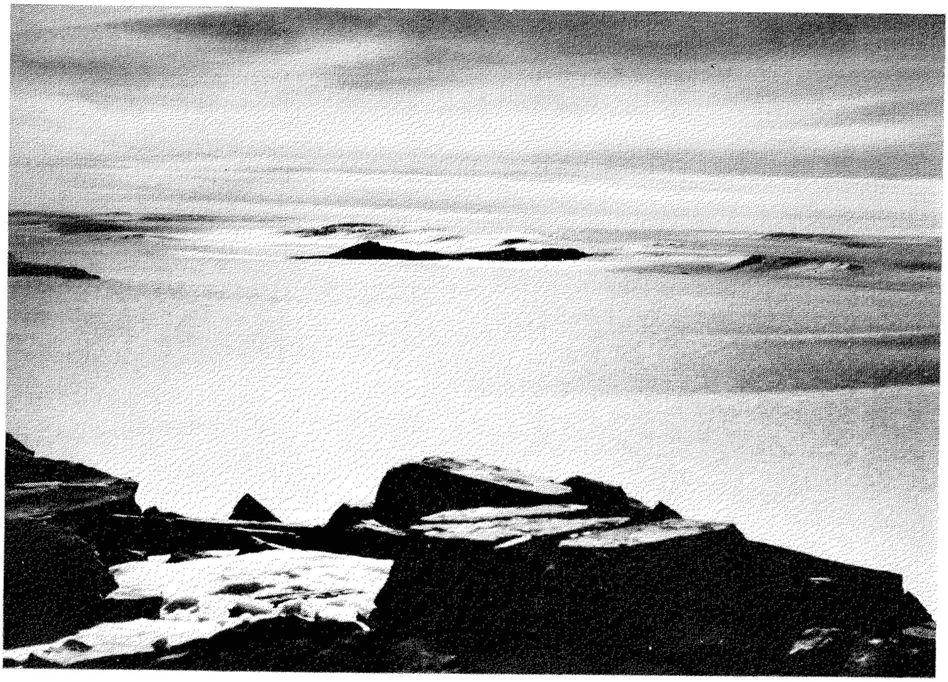

Fig. 5. Edge of the ice cap seen from the top of one of the nunataks. 6 August 1951.

left a cache for us some two weeks previously. However, finding no cache we waited for 24 hours and then, as we had no food left, we started to walk the remaining 30 kilometres to Nordfjord where we assumed that supplies, including coal, had been left in a small cabin which I had made my base during the winter of 1948–9. This proved a happy decision, and one of the expedition's Norseman aircraft found us in Nordfjord on the evening of August 29 and took us to Ella Ø.

Thus the round journey from Ella Ø and back was completed within thirty-one days. The travelling distance across the mountain range, that is from our camp 1 at the edge of the ice cap (August 5) eastwards to Nordfjord (August 29), was about 220 kilometres, while at the same time we covered about another 160 kilometres on geological and reconnaissance trips and the weasels had taken us 300 kilometres across the ice cap.

In general our journey was as successful as we could have hoped, and resulted in our getting a rather extensive knowledge of the geology of the innermost region near the ice cap. It was also shown that a small, experienced party of relatively little cost can move and work everywhere, even in the inland areas of mountains and ice, providing it is well organized and efficiently supplied. Besides geology, which was our main task, we made fairly detailed sketch-maps, and studied the glaciology, botany, and zoology of the area when time permitted. Most of the scientific results, including a map showing the principal glaciers between 72°N. and 74°30N. as well as a detailed geological map and profiles, have been published (in German) in *Meddelelser om Grønland* (Katz, 1952a). The following account briefly describes the main results of the expedition.

Climate and ice conditions

Compared with normal arctic practice, we appeared to be making a rather late start leaving in August. We had planned, however, to start approximately two weeks earlier, but weather conditions on the ice cap as well as ice conditions along the east coast had proved to be exceptionally bad during June to July, so that the progress of the French party (Victor, 1953) and our flight from Iceland were delayed. In fact, this proved to be most fortunate, because inland all lakes and streams formed by meltwater on the glaciers during the summer had refrozen. Only in the very last days, at an altitude of 1,100 metres or less, were we troubled by rivers still flowing under a thin sheet of ice, whereas as late as the end of July on our journey to Cecilia Nunatak we had been much hindered by melting effects when crossing Wahlenbergs Gletscher at 1,400 metres. Here we had to wade across deep rivers, partly in gorges, and continually broke through the rough ice surface into small holes filled with meltwater–each time with one leg only, which is extremely tiring on a long walk when carrying heavy loads. These holes, known as cryoconite holes, vary from a few centimetres up to half a metre in diameter and are as deep as a man's leg. They are produced by dark sand and stones melting down through the ice surface during the summer, and are a very common feature in this region.

On our journey over the ice cap with the French expedition we gained a good idea of the region to the west of the glacier system which produces most icebergs on the east coast north of Scoresby Sund. We found that the crevassed area at the edge of the ice cap extended much farther westwards than we had expected, and to an altitude of more than 2,600 metres. Throughout the entire distance from 72°30N. to 74°N. a large barrier of extensively crevassed terraces, icy slopes, and hills falling in steps towards the nunataks lay to the east of our route. On skis however, we found that we could cross it without too much difficulty.

On the ice cap the temperatures during the first days of August were mostly between –17° and –25°C (+1° and –13°F), sometimes as low as –30°C (–22°F). When approaching the nunataks it became noticeably warmer, which was mainly due to radiation from the bare rock; this warming effect was also apparent in the mountainous area at the same altitude as the ice cap (2,400 metres) if there was a sufficient area of exposed rock.

Later, in August, when travelling along the lower broad glacier valleys, the mean temperature was still well below freezing, –15° to –5°C. Although there were signs that a few weeks earlier there had been many lakes and flowing rivers on the glaciers as well as on the land, the larger lakes, mostly edging the glaciers, had never entirely thawed during the summer. At less than 1,500 metres altitude we found that on Eleonores Sø (Fig. 10), 1.5 to

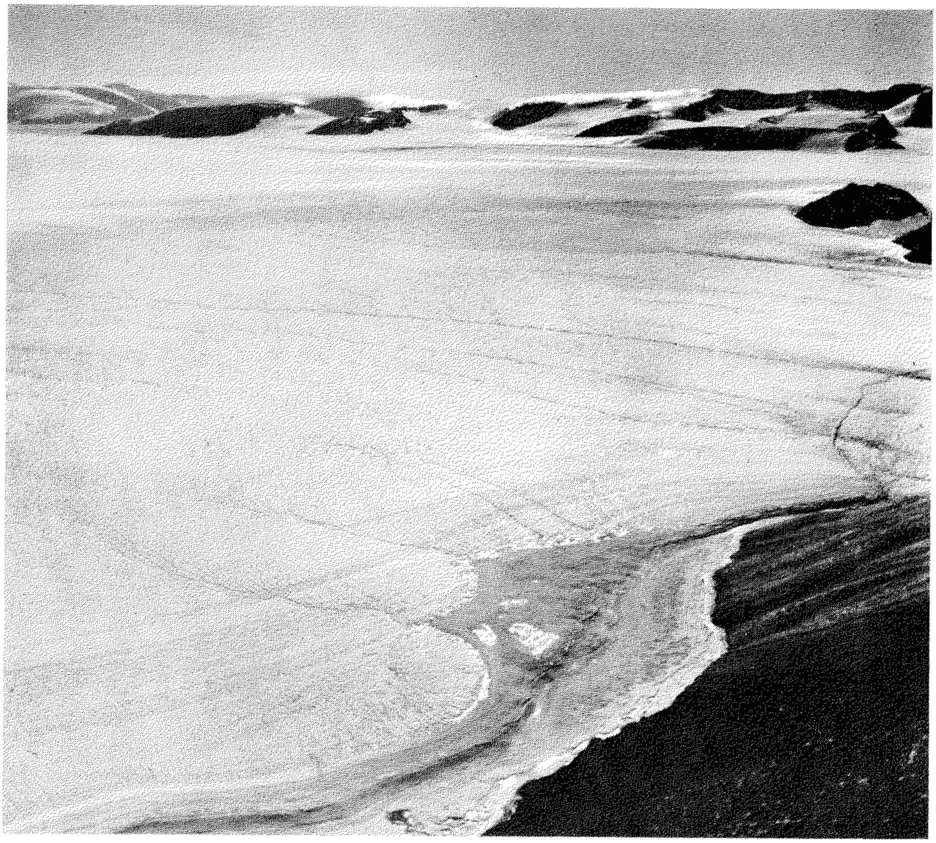

Fig. 6. Looking southwest from Harald Griegs Fjeld over one of the main glaciers which cuts the whole nunatak region. Ice surface in the centre is about 1,400 metres in altitude. Distance to the mountains in centre background is approximately 24 kilometres. 19 August 1951.

Fig. 7. Frozen river in gorge north of Strindbergs Land. 25 August 1951.

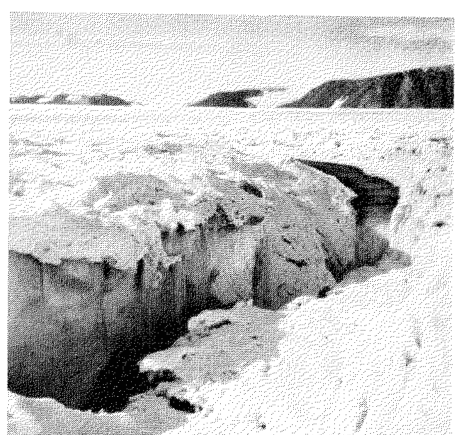

Fig. 8. River disappearing in 40-foot deep gorge, Adolf Hoels Gletscher after snowfall. 22 August 1951.

2 kilometres in diameter, only a strip 10 to 30 metres wide along the stony shore had thawed that year, and as early as August 12 this had refrozen to a depth of 20 centimetres.

We had expected to find a warmer climate, and the temperatures reported by Høygaard and Mehren in 1931 had been much higher than on our trip. The very low precipitation during the month of August was much the same as that found in all central and northern parts of east Greenland, which is almost a subdesert. We had some snow on August 1, cloudy and misty weather on the evening of August 4 and on August 7 and 15, and two further days of bad weather with snowfall and fog on August 20 and 21; on all other days there was bright sunshine, but generally with heavy winds from the west.

These winds are usual along the edge of the ice cap, because of the difference in pressure over the ice cap and off the coast, and their strength when funnelled in the fjords is well known; there they often cause a sudden and very large rise in temperature, especially during the winter. Because of the strong winds most of the snow was packed hard, dunes were formed, and quantities of drifting snow were transported eastwards, whitening the rocky slopes of the nunataks up to a height of 50 to 100 metres above the surrounding ice surface.

On the large glaciers the lower limit of permanent snow cover was about 1,700–1,800 metres, some 2–300 metres higher than on the local glaciers in the fjord zone. At the edge of the ice cap, however, steep slopes of pure, dense glacier ice were occasionally found at altitudes up to 2,300 metres.

The glaciers themselves are seemingly filling up the main valleys with a very thick mass of ice. Visible moraines are rather scarce and limited to small side tongues running into remarkable depressions, a common feature along our route. The surface of the main glaciers, which are some 5–7 kilometres broad and move rather fast, is often much higher than the neighbouring ice-free areas. As these areas are surrounded by mountains they form a kind of tributary basin with the narrow mouth towards the glacier-filled main valley (Fig. 9). In these depressions fairly large lakes are often dammed up by the side glacier tongues. We saw no streams leading from these lakes, and the equilibrium–if any exists–must be kept by evaporation, which would be quite possible as there is much evidence of the dryness of the local climate. The side glacier tongues running to the depressions are moving steadily, yet they melt away as fast as they move owing to the warmth from the great radiation from the surrounding bare rock slopes. Moraine hills burying dead ice and moraine lakes are characteristic of such depressions. Even at altitudes of 1,500 metres, where under normal circumstances the large glaciers are little affected by ablation and melting, a considerable loss of ice must result from such side tongues.

Geology

The route we followed from the westernmost nunataks to Strindbergs Land cut the trend of the mountain belt almost at right angles, thus providing us with an ideal geological cross-section. Moreover, the outcrops in general

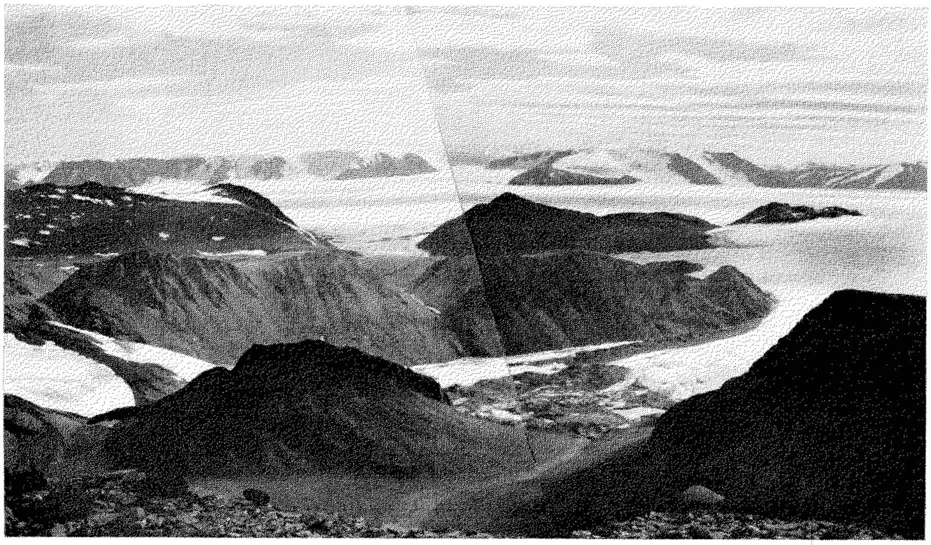

Fig. 9. Part of sedimentary area west of Harald Griegs Fjeld, looking south. Dead ice with moraines and lakes in depression, centre foreground. 17 August 1951.

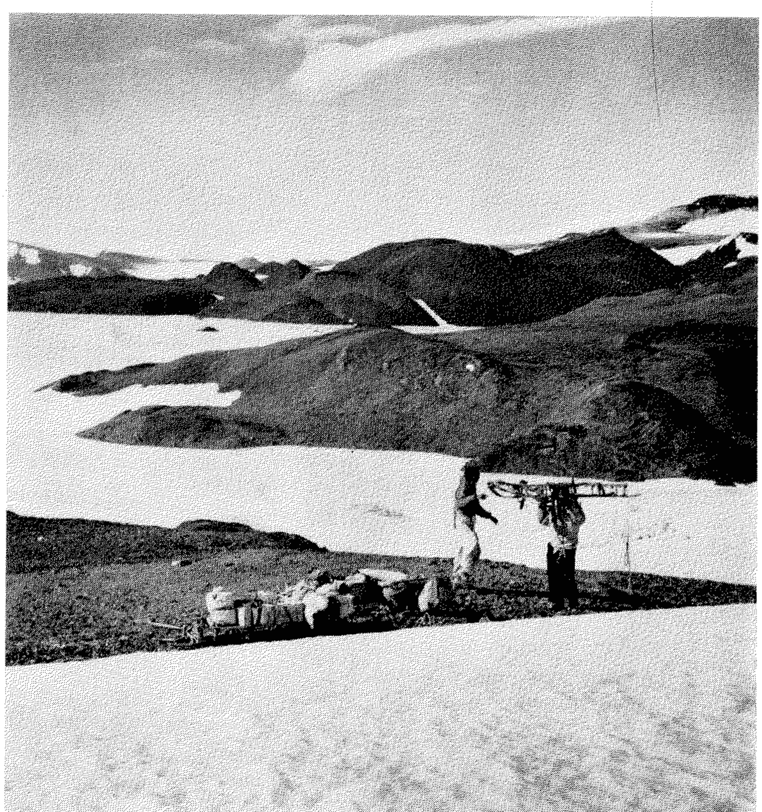

Fig. 10. Carrying sledges and supplies across a small, rocky pass to another glacier at Eleonores Sø. The lake is entirely surrounded by non-metamorphic sediments. A layer of black basalt may be seen in right background. 15 August 1951.

are well exposed and almost continuous, especially in the mountain chains to the north of our route, so that we could obtain a rather complete picture of the geological structure. As the structural trend is north–south to northeast–southwest we are dealing here, tectonically, with the westernmost exposed parts of the orogenic belt in central east Greenland; at least between 72°N. and 76°N. there are only some very fragmentary outcrops just south of our region which are as far west.

We found that the Caledonian orogenic belt extends westward, beyond the area examined. Tectonic disturbances were of even greater intensity in some parts of the area than in the fjord zone. Further, the effects of Caledonian metamorphism were observed almost everywhere; though small areas of less metamorphosed rocks and even of entirely unaltered sediments were found. Quartzites of various metamorphic grades predominate in the westernmost nunataks, whereas towards the east the rocks are mainly gneisses, mica-schists, amphibolites, and strongly altered quartzites. No continuation of the Petermann Peak Sedimentary Series (Wordie, 1930; Huber, 1950) was found, as some 50 kilometres north of the mountain the core of the folded belt is exposed again, and the effects of intense metamorphism can be observed as well as large granitic intrusions.

Another sedimentary area, however, was found on our journey in the region near Eleonores Sø, Arnold Eschers Land[1], about 74°N., 28°W. (Figs. 9, 10, and 11). It consists of sandy and limey slates, argillaceous shales, dolomites, and limestones with breccias. These rocks are of the same type as those of the Eleonore Bay Formation of the fjord zone, and were deposited in a similar lithological succession. They are therefore considered to be the same age, i.e. Late Precambrian. Tillites, found in the east, were not deposited on these strata; instead there is a thick mass of slightly altered greenstones (chlorite-albite-schists and actinolite-epidote-schists with actinolite-marbles) partly cut by porphyries. Contact phenomena against the underlying strata appear to exist, so that these rocks must have originated from a kind of ophiolitic intrusion (Katz, 1952a, p. 47). The tillites, laid down along the eastern shelf of the old trough, which are in the same stratigraphic position as the greenstones, are frequently intermingled with tuffitic material (Katz, 1952b). It is concluded therefore that not only great tectonic movements, but also strong magmatic activity occurred in some place during Late Precambrian times. Other parts of the trough, however, continued to be undisturbed areas of marine sedimentation until the Early Paleozoic. In these areas the Late Precambrian as well as the overlying Cambrian and Ordovician strata were affected as one single mass by the Caledonian orogeny.

In general it has been found in several places throughout the broad Caledonian belt of east Greenland, where the greater part of the rock formations are strongly metamorphosed, that bodies of non-metamorphic rocks exist. These represent remnants of the original sedimentary series deposited from Late Precambrian to Ordovician times. The best known and

[1]In a previous paper (Katz, 1952b) I erroneously referred to "Alfred Eschers Land". This area was named for the former Professor of Geology at Zürich (1952b, p. 28), and is correctly Arnold Eschers Land.

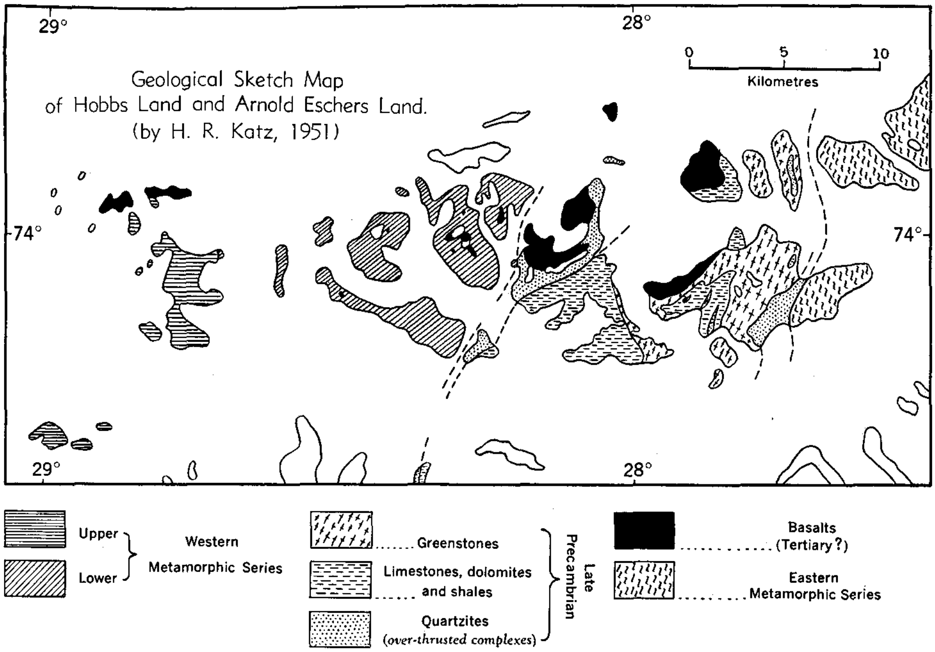

Fig. 11.

probably most extensive of these areas, where the effects of the orogeny have been comparatively slight–mainly some folding and faulting–is in the fjord region. As the greater part of Strindbergs Land falls within this region the geological cross-section made along our route shows the relationship between the western sedimentary areas and the fjord region.

Thus, the local non-metamorphosed area found on our journey shows that during the Late Precambrian the trough must have been much deeper in the west than in the shallow shelf zone of the fjords. The quartzites of Petermanns Bjerg do not therefore mark the western border of the geosyncline, as has formerly been assumed (Wegmann, 1935); neither are they of any regional importance, nor do they extend from far south to far north along the crystalline complex of the inner fjords of the region (Koch, 1936). They are a very local feature, and are merely one more remnant of the original sedimentary sequence. It is assumed that all this remnant series has been deposited in the same geosynclinal trough, and that it may all be correlated with the well-known Eleonore Bay Formation of the fjord region, or with parts of the Formation.

Superimposed on some tectonic features which are regarded here as Caledonian, are structures resulting from strong movements of later date. Especially west of Harald Griegs Fjeld, at about 28°W., some zones of complex overthrusting are believed to be of Devonian age; this movement is indicated both by the Upper Devonian tectonics in Strindbergs Land (Katz, 1952b) and farther east (Bütler, 1940), and also by the lithology of the thick Devonian Old Red sediments in the fjord region (Bütler, 1935).

At a later date our nunatak region was extensively eroded and was subsequently covered by a horizontal layer of basalt (partly nephelinites). This now lies at an altitude of more than 2,000 metres, and caps all mountains of that height for about 1,000 square kilometres. Its extension is probably much greater, as the basalt layer appears to continue northwards underneath the ice cap. Several basic and ultrabasic dykes and sills found in Hobbs Land (28°45W.) were apparently connected with the release of the large flow of lava, and they are very similar petrographically, as both contain phlogopite and nepheline. The basalt is tentatively assumed to be of Tertiary age.

In conclusion, our journey showed that in the westernmost parts of central east Greenland the geological features are also very complex, and that crustal movements must have occurred even up to the latest epochs. But the most important discovery was the knowledge that the Caledonian belt extends westward even beyond any outcrop that can be found; also, that during the Late Precambrian the geosynclinal trough had its central parts west of the present fjord region. Therefore it is unlikely that the western foreland of the Caledonian Geosyncline will be reached anywhere along the central part of the exposed mountain range, not even in Dronning Louises Land. Only in the northernmost area, towards Danmarks Fjord and Independence Fjord (80°N. to 82°N.), might this feature be found. Yet, although the orogenic belt in that region is probably very narrow and confined to the eastern part of Kronprins Christians Land, it is still possible that the undisturbed, horizontally-bedded sediments west of it (Koch, 1936; Troelsen, 1949) are not sediments formed on a western borderland but in the same geosynclinal trough. This is a question of great importance, but is far from being solved, and more detailed investigations are needed in that region. These investigations should also be of much assistance when a new survey is being made of north Greenland and of north Ellesmere Island.

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