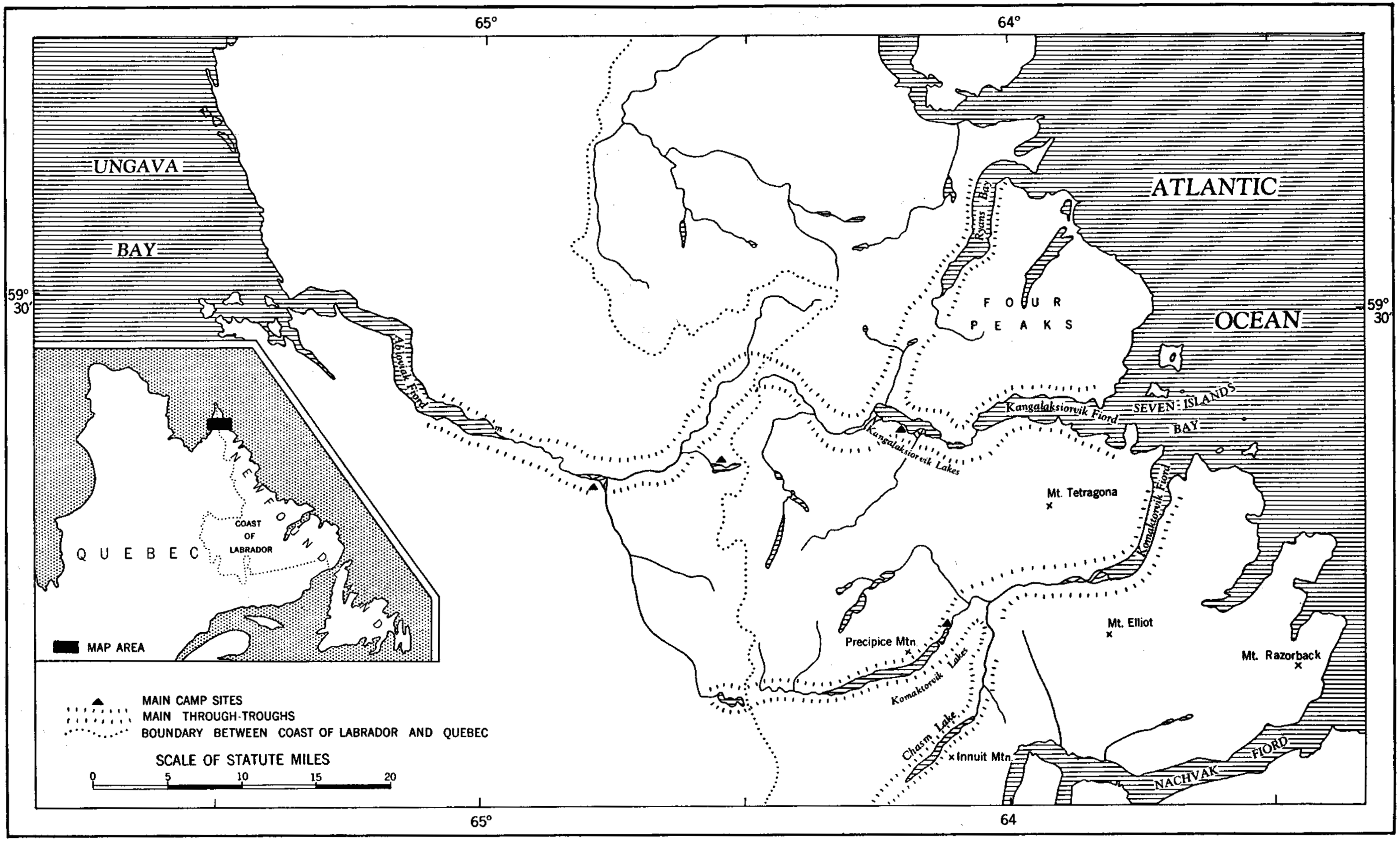

Sketch map of Torngat Mountains, Northern Labrador.

GLACIATION OF THE TORNGAT MOUNTAINS, NORTHERN LABRADOR

J. D. Ives*

THE writer, accompanied by his wife, Pauline Ives, as field assistant, worked in the Torngat Mountains of Northern Labrador between July 27 and September 16, 1956. The work was made possible by research grants from the Banting Fund, administered by the Arctic Institute of North America, and from the McGill-Carnegie Arctic Research Program. Transport from Goose Bay to and from the Torngats was generously provided by the British Newfoundland Corporation.

Upper Kangalaksiorvik Lake, some 15 miles west of Seven Islands Bay in latitude 59°22'N., was selected for the site of a base camp, and this was established with the aid of a Beaver aircraft on July 27. In addition, the Beaver was able to lay two food and fuel caches, one at the northeast end of Lower Komaktorvik Lake, and the other by the shore of a small lake on the Quebec side of the boundary, some 15 miles west of base camp. From these three centres an area of about 600 square miles, principally within the "Central Range" of the Torngats, was reconnoitred on foot.

Despite the short and relatively stormy season, it proved possible to complete a large part of the original program, although an investigation of the cirque glaciers was curtailed by the persistence throughout the summer of a considerable thickness of the 1955-56 snow cover on their surfaces. After August 20 this was augmented by frequent falls of fresh snow.

The following information is of a preliminary and reconnaissance nature, although it may be anticipated that future work will not greatly affect the general conclusions. The paper is based primarily upon a rapid review of the field notes and a cursory examination of the vertical air photographs from Saglek Bay northward to Cape Chidley. It is hoped that this work will be intensified and extended in the future. For information on the bedrock geology of the area the writer is indebted to Mr. Murray Piloski of the British Newfoundland Corporation.

Objectives of the field work

Two generally accepted, and yet untested, theories, which have played a fundamental part in the modern concept of the glaciations of Labrador-Ungava, and of northeastern North America as a whole, prompted the field investigations outlined below.

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In 1933, Odell, refuting the earlier work of Daly (1902), Bell (1882-84) and Coleman (1921), stated that the entire area of the Torngat Mountains had been completely inundated by continental ice at the Wisconsin maximum. Despite the slender evidence that Odell put forward, his concept, perpetuated by the writings of Tanner (1944) and Flint (1943 and 1947), has gained almost universal acceptance. Odell's main criticism of Coleman is based on the assumption that the felsenmeere so widely distributed above the 2,000- to 2,200-foot level were formed by frost action in post-glacial times.

Flint (1943, 1947, 1952 and 1953) has contributed extensively to the present understanding of the growth and disappearance of the Quaternary ice sheets. In considering the general climatic deterioration at the onset of glacial times, Flint envisaged the initial growth of vigorous glaciers in the coastal mountains of northeastern North America stretching from Labrador to Ellesmere Island. Flint states that the glaciers forming on these mountains would flow down their western flanks to accumulate as piedmont lobes and ultimately build up into an ice cap of continental proportions. During this growth the ice divide would move westwards from the mountains resulting in a reversal in the direction of flow across the mountains towards the east.

Flint pictured the reversal of these conditions towards the close of each glacial epoch, with the coastal mountains serving as the final centres of glacial outflow. This thesis apparently considers conditions in northeastern North America as the mirror image of those in northwestern Europe where the theory is based upon solid field evidence. Flint believed that the area west of the Torngats would prove of critical importance in the testing of this theory in the field, a belief which greatly influenced the general localization of this study.

The main objective of the present work was in general an attempt to establish the role of the Torngats in the glacierization of Labrador-Ungava, and in particular to assess the course of events in late-Wisconsin times with respect to the final disappearance of both continental and local ice masses.

Geological background

North of Nachvak Fiord the Labrador peninsula is composed of metamorphic and igneous rocks of Precambrian age. Between Nachvak Fiord and the Kangalaksiorvik lakes the main structural trend is north-northwest to south-southeast, roughly parallel with the coastline, and metamorphic zones of varying degrees of intensity follow this trend. Much of the bedrock is composed of various types of gneiss, a finely-banded garnetiferous gneiss and a granite-gneiss being particularly abundant. The rocks are predominantly coarse-grained and weather into a very rough surface upon which glacial markings are seldom clearly preserved, even on the lower ground which was cleared of ice most recently (Fig. 1). The entire area is cut by two series of basic dykes.

In the vicinity of the Kangalaksiorvik lakes the dominant structural trend swings round in a great arc and becomes roughly east-west on the Quebec side of the peninsula. Piloski has described this as a possible drag fold and

Fig. 1. Glacial striations and grooves in banded gneiss. The surface is relatively unweathered as it lies below high lake level. The glacial markings cross the lineation at right angles. Aug. 2, 1956.

it has an important influence upon the present relief. A major trough-like valley, passing inland from the head of Kangalaksiorvik Fiord, closely follows this trend, cutting through the height of land and passing westwards into Abloviak Fiord. Its highest point lies below 600 feet, although the surrounding mountains exceed 4,000 feet.

The major faults follow the dominant structural trend, although a second set, roughly at right angles to the first, is readily apparent in the topography.

Physiographic evolution

Until a more detailed examination of the available material has been made, the outline of the evolution of the Torngat Mountains given by Cooke (1930), and supported and extended by Odell (1933) and Tanner (1944), will be adopted as the most satisfactory. Very briefly this envisages the predominance of erosional processes over sedimentation since Precambrian times. In late Tertiary times the Labrador peneplain was uplifted to a considerable height and tilted so that a high escarpment bordered the Atlantic Ocean and the plateau surface sloped down gradually towards the west. This event has profoundly affected the subsequent evolution of the area, and in this connection it is emphasized that in general the Torngat Mountains are not a mountain range in the true sense of the word, and that in particular there is no western flank, but merely a gentle plateau slope, which passes gradually beneath the water of Ungava Bay. The terminology of "Coastal Range" and "Central Range" proposed by Odell (1933) is therefore misleading and extremely unfortunate. Throughout this report, however, Odell's terminology is retained for the purpose of clarity when referring to different localities.

It is assumed that prior to the onset of glacial times the uplifted peneplain had been subjected to the processes of a fluvial cycle of erosion for a sufficient length of time to allow a late youth to early mature stage of dissection to develop. This created a very rugged mountain country bordering the Atlantic Ocean, grading westwards into a slightly dissected plateau.

This is an over-simplification of the true pattern of development, but little more need be added for the present purpose other than to emphasize that the late Tertiary uplift was by no means uniform, and that warping and faulting occurred, the results of which are clearly visible in the landscape today.

The precise number of glacial periods which have affected the area is unknown, and so far no stratigraphic proof of more than one glacial period has been found in Labrador-Ungava. It is assumed, however, that the sequence of events in the Torngats closely paralleled the developments which are comparatively well known in southern Canada and northeastern United States. Morphological evidence, in the form of valley-in-valley cross sections and the floors of glacial valleys trenched by deep water-worn gorges of presumed pre-Wisconsin age, was found in the Torngats to support this assumption. The evidence indicates that the present landscape owes its appearance to two and possibly three glacial and inter-glacial cycles.

The actual amount of erosion attributable to glacial action is a matter of considerable controversy, especially when viewed in the light of recent work (Battle, 1952; McCall, 1952; Boyé, 1950; Cailleux, 1952; etc.) much of which tends more and more to question the effectiveness of glaciers as agents of erosion. It is assumed that little or no erosion of the open plateau surface was accomplished by the passage of the continental ice. Thus Odell's designation of "glacial peneplain" (1933, p. 209) is not accepted. A considerable amount of vertical and lateral erosion was probably accomplished in the great through-troughs and valleys, where the ice was thick and the speed of flow accentuated by the topographical restrictions.

Fluvial erosion in pre-glacial and inter-glacial times, together with frost action and mass movement, and sub-glacial fluvial erosion, has probably produced more important results by volume of material removed than have the glaciers. The presence of the glaciers, apart from their active participation, has been necessary for the production of the characteristic "glaciated" appearance of the Torngat Mountains today. It is not enough to state that the glaciers are ineffective as agents of erosion; an alternative method must be proposed which will adequately account for the U-shaped cross section with truncated spurs, the over-deepening and production of rock basins and valley steps, and the numerous other features so closely associated with "glaciated" mountains. Undoubtedly much more research is needed into the mechanisms of glacier flow and glacial erosion, but until conclusive evidence is forthcoming to the contrary the critical acceptance of the theory of glacial erosion seems advisable.

Fig. 2. Roches moutonnées and perched blocks in the Abloviak-Kangalaksiorvik trough, looking east. Kangalaksiorvik River and terraces in middle distance. Aug. 4, 1956.

The extent of the Wisconsin Glaciation

The discussion is restricted to a consideration of the Wisconsin Glaciation, first, because the pre-Wisconsin evidence is so far indistinguishable, and second, because the Wisconsin was probably the least severe of all the glacial periods so that the conclusions reached here can be regarded as minimal for the greatest extent of continental ice in Quaternary times.

Coleman (1921), and all workers before him (Daly, 1902; Bell, 1882-84) believed that the Torngats maintained a local centre of glaciation throughout Wisconsin times, that the penetration of continental ice from the west was limited, and that the higher summits, above about 2,500 feet above present sea level, remained as nunataks even at the height of the ice flood.

Coleman's argument is based largely upon the sharp forms of the upper summits, which he believed would not have withstood inundation by continental ice, and upon the presence, on the higher surfaces, of a heavy mantle of frost-riven bedrock, or felsenmeere, which he considered to be of pre-Wisconsin age. Odell (1933), on the other hand, argued that the felsenmeere were formed in post-glacial times by vigorous frost-shattering, which thus invalidates Coleman's conclusion, and, despite the intensity of frost action, Odell found evidence of glacial polishing and grooving at an altitude of 4,700 feet.

Apart from the theoretical challenge by Dahl (1946 and 1947) who suggests that the coastal summits above 3,000 feet must have remained as nunataks on a consideration of the marginal surface slope of inland ice sheets, the conclusions of Odell have remained largely undisputed (see, however, Mercer, 1956). Work in Iceland, where it was possible to prove conclusively that the high coastal mountains remained as nunataks throughout the glacial epoch, induced the writer to consider carefully the objections of Dahl, and to attempt to re-assess the field evidence before making a final conclusion.

Thirteen of the major summits in the "central" Torngats, between Chasm Lake and Upper Kangalaksiorvik Lake, were ascended and their surfaces were subjected to minute examination. In addition uncounted spot examinations were made for evidence of glacial action throughout the area studied. From this two important generalisations can be made. First, in the eastern sector, between Mount Tetragona and the Quebec boundary, there is a marked contrast between surfaces above and below the 2,000- to 2,200-foot level. Below this level evidence of widespread glaciation, as noted by Coleman

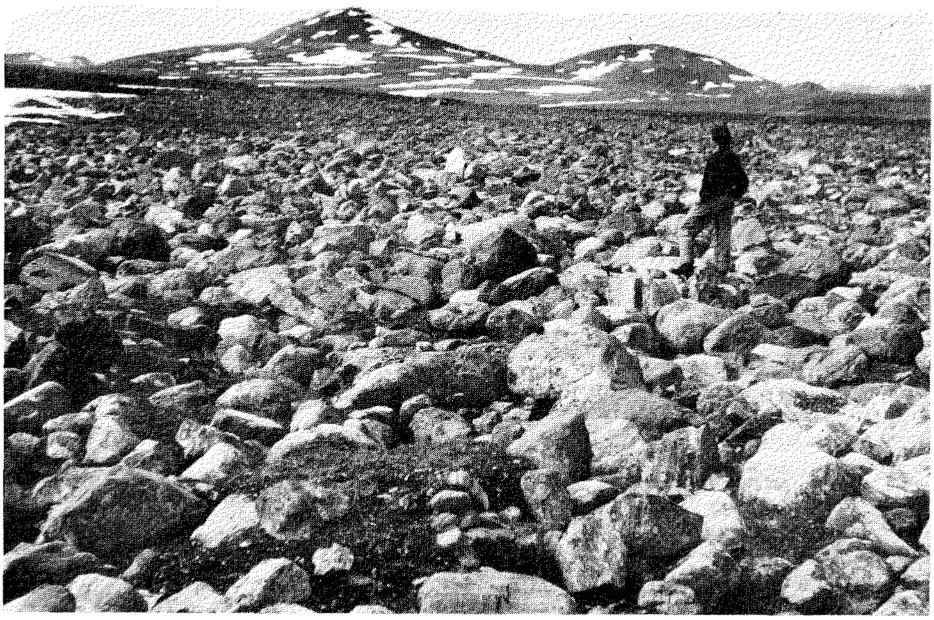

Fig. 3. Boulder fields of glacial moraine from which the fines have been washed by melt water. Altitude about 1,500 feet. Aug. 2, 1956.

Fig. 4. Frost-riven bedrock (felsenmeere) on summit of peak in "central" Torngat Mountains. Altitude about 4,000 feet. Aug. 2, 1956.

(1921), is abundant, mainly in the form of erratic and perched blocks, glacial striations (Fig. 1), ablation moraine (Fig. 3), roches moutonnées (Fig. 2), and fluvio-glacial deposits. Above this level evidence of glaciation is almost entirely lacking. Second, on the western side of the Labrador-Quebec boundary where the mountains merge imperceptibly with the "Ungava Bay Plateau" conclusive evidence of glaciation was found up to a height of 3,000 feet above present sea level. Superficially it appeared that Coleman's interpretation, with this modification, was generally correct. Nor would it be expected that Odell's poorly preserved striations could have survived the vigorous frost action which he himself invokes to explain the formation of the felsenmeere in post-glacial times. This is especially emphasized when it is pointed out that the bedrock upon which Odell found indications of glacial striations was a finely-banded coarse-grained gneiss which weathers to produce coarse, north-northwest to south-southeast ridges and furrows, and a similar set at right angles along the cross jointing, all of which closely resemble poorly preserved striations, and on which it is impossible to distinguish glacial markings when in a weathered state.

Before proceeding further it is necessary to consider the weight of the evidence which is given to the presence of felsenmeere on the upper surfaces. Examination of the superficial cover throughout the Torngats revealed that,

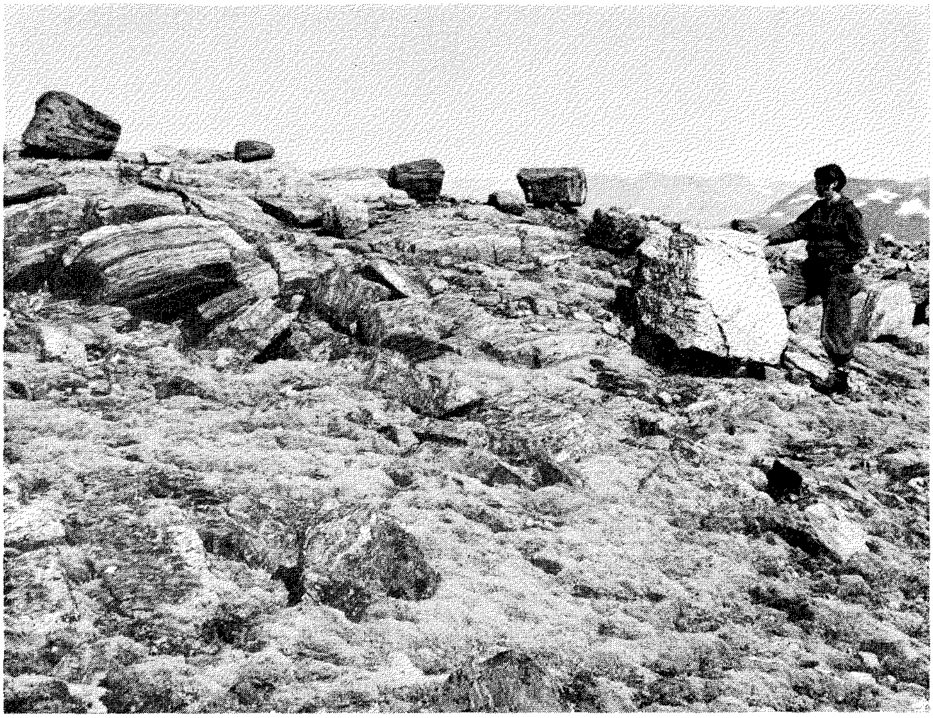

Fig. 5. Perched blocks on glaciated summit of ridge above the confluence of Abloviak River with south bank tributary. Note the absence of frost-riven blocks. Altitude about 2,800 feet. Aug. 7, 1956.

excluding obvious till and fluvio-glacial deposits, there are two distinct types of boulder fields (felsenmeere). Below the 2,000- to 2,200-foot level the mass of boulders is characterized by a sub-angular to sub-rounded form (Fig. 3), although occasional boulders have been split subsequent to the rounding process. Above this altitude and away from talus slopes the surface cover of rock debris is distinctly angular (Fig. 4). The latter is described as true felsenmeere, the product of frost-shattering of bedrock, the former is believed to be ablation moraine from which all the fine material has been washed away by running water.

A further examination of the felsenmeere takes the argument to its conclusion. The summit ridge overlooking the junction of the Abloviak River with its main south bank tributary has two summit areas separated by a slight saddle, each about 2,800 feet above sea level. The ridge follows the east-west structural trend so that the composition of the bedrock of which the two summits are composed is identical—a coarse-grained gneiss. The eastern summit is a ridge of bedrock, littered with perched blocks, which have undoubtedly been deposited by continental ice (Fig. 5). In contrast (Fig. 6) the western summit is broad and level, about 600 yards across, and is covered with a deep mantle of frost-riven bedrock. Erratics were found among the angular blocks. If the felsenmeere are truly of post-glacial age it is difficult to account for the relatively unweathered appearance of the eastern summit (Fig. 5). That this summit has been swept clean of superficial material, implies that, as the rock type is the same, its original cover of felsenmeere had been formed in pre-Wisconsin times and that it has been removed subsequently by the same agency that deposited the erratic blocks. The broader summit (Fig. 6), presumably because of a difference in local conditions, of which the areal extent is probably important, retained all or most of its cover of felsenmeere, which, however, may have been slightly reworked by the passage of ice.

The evidence already presented appears to invalidate the conclusions of both Coleman (1921) and Odell (1933), and the problem would have remained unsolved but for the eventual discovery of unmistakable erratic blocks (Fig. 7) on two of the major summits ascended, one at a little over 4,000 feet, and the other at the 5,000-foot level.

The general scarcity of erratic material on the higher summits must not be over-emphasized as, from a consideration of the morphology, the emplacement of erratics by continental ice flowing from lower land west of the Torngats would be a matter of some difficulty. Any erratic material found

Fig. 6. Felsenmeere on summit one-half mile west of summit in Fig. 5. Occasional large boulders probably emplaced from ice cover. "Ungava Bay Plateau" in background. Altitude about 2,800 feet. Aug. 7, 1956.

Fig. 7. Erratic block of granite-gneiss on summit in "central" Torngat Mountains. Altitude about 4,000 feet. Aug. 27, 1956.

at over 4,000 feet must have been dragged up in the bottom layers of the continental ice. This movement would need a vigorous flow of ice across the summits, which in turn implies that the summits in question were submerged beneath a considerable thickness of ice.

The morphology of the two mountains upon the summits of which the erratic blocks were found is interesting in this connection. Each summit is broad and level with a gently sloping west or southwest ridge. On one, which lies immediately north of Precipice Mountain in the Komaktorvik lakes area, the southwest ridge is broad and slopes gently from the summit, at a little over 4,000 feet, down to 2,700 feet. A trail of erratics was found from the 2,700-foot level all the way to the summit. The second summit is similar in form; it exceeds 5,000 feet, and lies immediately north of Chasm Lake. It is considered that such gentle slopes in the direction from which the ice came would be particularly favourable to the emplacement of erratic blocks, whereas it seems likely that steep onset faces would be inimical to this process.

The erratic material was of granite-gneiss composition and was found to be resting upon finely-banded garnetiferous gneiss. As the bedrock geology west of the Labrador-Quebec boundary is little known, this material may have travelled only a short distance, especially since granite-gneiss is a very common rock in the Torngat area. However, its presence was sufficient to indicate that continental ice had passed over mountains exceeding 5,000 feet and it is considered that the thickness of ice above the summit must have been of the order of 1,000 feet in order to promote the vigorous movement necessary for the emplacement of the erratics. The erratics were relatively unweathered compared with the bedrock and felsenmeere upon which thy were resting, and it is assumed that they were deposited in post-Sangamon times.

From the evidence outlined above the following conclusions are put forward:—

1) The formation of felsenmeere pre-dates the Wisconsin Glaciation.
2) Fields of boulders of sub-angular to sub-rounded form below 2,000 to 2,200 feet are washed ablation moraines.
3) During the maximum of the Wisconsin, and hence during each preceding glacial period, the highest summits of the "central" Torngats were submerged beneath continental ice about 1,000 feet in thickness.
4) The maximum stage of inundation was relatively short-lived, and following this stage the higher summits stood as nunataks above the ice sheet for a considerable period.
5) A position of equilibrium was maintained for a long period when continental ice, which was flowing eastward through the great west-east troughs and diffluence passes, stood at the 2,000- to 2,200-foot level in the east, and up to 3,000 feet in the western slope of the "Ungava Bay Plateau" where the damming effect of the higher land caused the eastward-moving ice to be piled up to a greater height. During this period the local cirque glaciers would be very active, and the sharp, serrated ridges and peaks would receive their final etching.

The extent of the Wisconsin Glaciation on the coastal summits

So far the discussion has not included the so-called "coastal range" of Odell (1933) where summits of the Four Peaks group, Mount Tetragona, and southward, exceed 3,500 to 4,500 feet in close proximity to the present coastline. As no definite evidence of the glaciation of these summits was obtained, the discussion must follow the theoretical lines of Dahl (1946 and 1947).

Dahl objected to the conclusions of Odell (1933) and Tanner (1944) on the thickness of the Wisconsin ice sheet on theoretical grounds based on the measurement of the marginal slopes of present and past ice sheets. He suggested that the maximum slope of an ice sheet bordering a deep ocean would be 1:100, and upon this basis sharp coastal summits exceeding 1,000 meters within 100 kilometers of the margin of such an ice cap would remain as nunataks. Assuming the presence of a floating ice shelf, Dahl allows that the coastal summits could slightly exceed 1,000 meters and still fail to project as nunataks. Mercer (1956) has reiterated this argument and applied it to the southeast peninsula of Baffin Island as well as to the Torngat Mountains.

The first editions of the Canadian Hydrographic Charts, Nos. 4775 and 4776, published in 1955, clearly indicate that a broad continental shelf fringes the Northern Labrador coast, exceeding 100 miles in width in places. Eastward of the Torngats the shelf extends for 90 to 110 miles reaching a depth of 140-150 fathoms along its outer margin before dropping off steeply into very deep water. It is contended that the continental shelf would allow the accumulation of an enormous mass of ice, and if Dahl's marginal slope of 1:100

is applied to a continental ice sheet, the outer margin of which floats on the deep water bordering the shelf, such coastal summits as Mount Razorback would certainly be submerged, and it is most probable that the higher summits slightly farther inland would also be submerged, if only by a relatively thin cover of ice.

It is seen, therefore, that the evidence which supports the conclusion that the interior summits were covered by ice about 1,000 feet thick at the Wisconsin Maximum, suggests that the extreme coastal mountains were also submerged.

Directions of ice movements in the Torngats

The main movement of ice through and over the Torngat Mountains was from a westerly direction. As the bottom layers of the ice were strongly controlled by the topography, and as no striations were found on the summits examined, it has not been possible to give a more precise direction of movement than this. Although the trends of the striations in the valleys are, therefore, of limited value, they are instructive, as they provide, collectively with directional evidence gained from the examination of roches moutonnées, erratics, and fluvio-glacial deposits, a picture of conditions during the latter half of Wisconsin times.

As suggested above, it is envisaged that for a considerable period following the maximum extent of the Wisconsin ice sheet the higher summits projected as nunataks. During this time the pattern of movement clearly suggests that the Torngats were partially inundated by a great anastomosing system of glaciers flowing from an area to the west through every available trough, valley, pass and col, toward the Atlantic Ocean. This was slightly augmented by local ice supplied primarily from the numerous cirques.

Several interesting cirques were examined, and these showed every stage in the transition from a self-contained cirque with the backwall unbroken to an ice diffluence valley resulting from the progressive breaching of the backwall by a combination of cirque erosion and penetration by ice moving from the west.

It is emphasized that movement of ice from the west predominated except in the limited cases of local movement within the cirques. In no instance was there found any evidence of the reversal of flow toward the west from a theoretical local ice cap, and in only minor instances does the morphology of the western part of the Torngats coincide with westerly drainage. The three east bank tributaries of the main Abloviak tributary valley are broad and typical U-shaped valleys, which trend roughly east-southeast to west-northwest. The two largest valleys enter the main valley at grade, the third hangs some 800 feet above the floor of the main valley. Consideration of their morphology leads to the conclusion that at some period they contained westward flowing glaciers.

No moraines nor striations were found in these valleys, but even allowing the morphology of the valleys as evidence of local glacierization, and assuming that these valleys contained glaciers in late-Wisconsin times, the glacierization was of very limited extent and does not invalidate the general conclusion that no major reversal of flow occurred towards the close of Wisconsin times.

Examination of the movement of erratics was made in detail in certain limited areas. For example, all anorthosite erratics were found eastward of their parent outcrops. The same conclusion was drawn from an examination of the eastern margin of the north-south zone of garnetiferous gneiss which extends from Nachvak Fiord to the Kangalaksiorvik lakes. Lack of clear differentiation between the various rock types of the metamorphic zones did not allow further expansion of this method in the time available. Occasionally blocks of crystalline quartzite were found in the Kangalaksiorvik-Abloviak trough and below the Komaktorvik lakes; these may have been derived from the outcrop of crystalline quartzite shown on Piloski's map northwest of the head of Upper Komaktorvik Lake. If this is so it suggests a circuit movement of the bottom ice conditioned by the major topographic forms. Blocks of a pudding stone conglomerate were found along the floor of the main south bank tributary of the Abloviak River. This rock was not found in situ and it is possible that it may represent blocks of indurated moraine.

Late-Wisconsin conditions

The predominance of the west to east direction of ice movement is significant in a consideration of the process of deglacierization of the Torngats. A series of critical localities, such as the thresholds of north-facing cirques tributary to major west-east valleys, the confluence of tributary valleys and the main through-troughs, and several of the main ice diffluence cols, was selected and studied in an attempt to assess the extent of any late-Wisconsin resurgence of local movement once the main ice streams from the west had disappeared. All the evidence suggests that such a resurgence did not occur, and that the final movement of ice was from the west. This was illustrated by an examination of the threshold of the cirque on the north face of Mount Tetragona which contains Bryant's Glacier. The present snout stands at about 1,400 feet above sea level and below it three morainic arcs extend northwards; the terminal moraine, lying at about 1,100 feet above sea level, is situated almost one mile north of the snout. This moraine probably marks the historical maximum of the glacier, although it may possibly represent a late-Wisconsin stage.

The cirque opens out into a major U-shaped valley which cuts from southwest to northeast through the Tetragona mountain group. Clear evidence was found in this valley, in the form of erratics, roches moutonnées and striations, that the final movement of ice was towards the northeast, and striations were found within 100 yards of the terminal moraine of Bryant's Glacier. Thus it is apparent that in late-Wisconsin times the cirque glacier was not sufficiently vigorous to extend beyond the limit of its own cirque. Similar evidence was found throughout the area and indicates the insignificance of a late-Wisconsin outflow of ice from the Torngats.

This was further substantiated by the presence of lake shorelines in valleys tributary to the main through-troughs, indicating that ice-dammed lakes existed in the local valleys while continental ice still remained in the main valleys. A well formed shoreline was observed in the south bank tributary of the Abloviak Valley extending six miles upstream at an altitude of almost 600 feet above sea level. A series of perched deltas, subsequently dissected, were found on each side of the valley and coincided with the shoreline (Fig. 8). Subsequent lowering of the trunk glacier in the Abloviak Valley appears to have been gradual as no lower shorelines nor perched deltas were found. It is clear, however, that in the main valley, once the divide area had emerged from the ice, a second lake was formed to the west of the divide which spilled over eastwards into the Kangalaksiorvik River.

Fig. 8. Dissected perched delta and glacial lake shoreline in south bank tributary valley of the main Abloviak-Kangalaksiorvik trough. Aug. 10, 1956.

Examination of the aerial photographs reveals the presence of lake shorelines in other parts of the Torngats. Mr. Piloski and Dr. E. P. Wheeler 2nd have informed the writer that similar ice-dammed lakes were formed in the Saglek Fiord-Korok River area farther south.

Fig. 9. View towards the northeast from peak in "central" Torngats. Four Peaks group on the right, Ryans Bay in distance and Upper Kangalaksiorvik Lake to right of centre. Aug. 2, 1956.

For the present no definite chronological correlation between the lake shorelines, overflow channels and marginal drainage channels can be attempted. However, the main lines of the deglacierization can be envisaged.

Following the emergence of the summits as nunataks the Torngats remained in a stage of partial submergence for a considerable period. With the general climate amelioration that heralded the close of Wisconsin times the snowline in Labrador-Ungava gradually became higher. A critical height would be reached after which a relatively slight vertical movement would lift the snowline above a vast area of the ice cap, and in a very short time the entire ice cap would become climatically dead. Thus the early stages of thinning would be gradual but the final stage would result in rapid thinning of the glaciers and the ice sheet itself. At this stage it is believed that the main trunk glaciers were still of the order of 2,000 feet in thickness and continued their flow towards the east for some time. Progressively the supply of ice would diminish and they would eventually melt in situ, the floors of the deepest valleys being the last areas to be free of ice.

This condition is clearly seen in the Komaktorvik-Chasm lakes area where sub-parallel marginal drainage channels sloping gently down valley can be traced from an altitude of about 2,000 feet down to the valley floors. The average vertical interval between the channels is about 15 feet, and if, as maintained by Mannerfelt, they are annual features, the final wastage of the 2,000 feet thick Komaktorvik and Chasm glaciers appears to have been completed in less than 150 years, but this does not allow for temporary climatic fluctuations.

This phenomenal rate of disappearance of ice and the production of huge volumes of melt-water are in accordance with the evidence that below the 2,000- to 2,200-foot level the land has been thoroughly washed by strong melt-water torrents.

Fig. 10. Cirque with small glacier between Chasm and Komaktorvik lakes. Note that the backwall has been partially breached. Summits exceed 4,800 feet. Aug. 27, 1956.

Typical dead-ice topography in the floors of the main valleys indicates the location of the final ice remnants—at those places where the ice reached a maximum thickness in Wisconsin times and where the supply from the west was probably the most vigorous.

Finally, it is probable that when the deglacierization was complete the cirque glaciers also melted away, and that the present diminutive cirque glaciers have developed since the post-glacial Thermal Maximum, that they reached their maximum historic extension between 1600 and 1850 A.D., during the so-called "Little Ice Age", and at present are possibly just emerging from a period of rapid recession.

Following the emergence of the land from the Wisconsin ice masses a marine transgression occurred, reaching a minimum height of 205 to 225 feet above present sea level. The assumption that the original depression, due to the thickness of the ice load, and hence the subsequent recovery was greatest in the west is supported by scattered pieces of field evidence. Old river terraces in the Abloviak Valley were seen to be inclined gently towards the west, that is, in a down-valley direction. Mr. Piloski has also described a lake shoreline above Nakvak Brook, which drains into the northern arm of Saglek Bay, to be inclined towards the west.

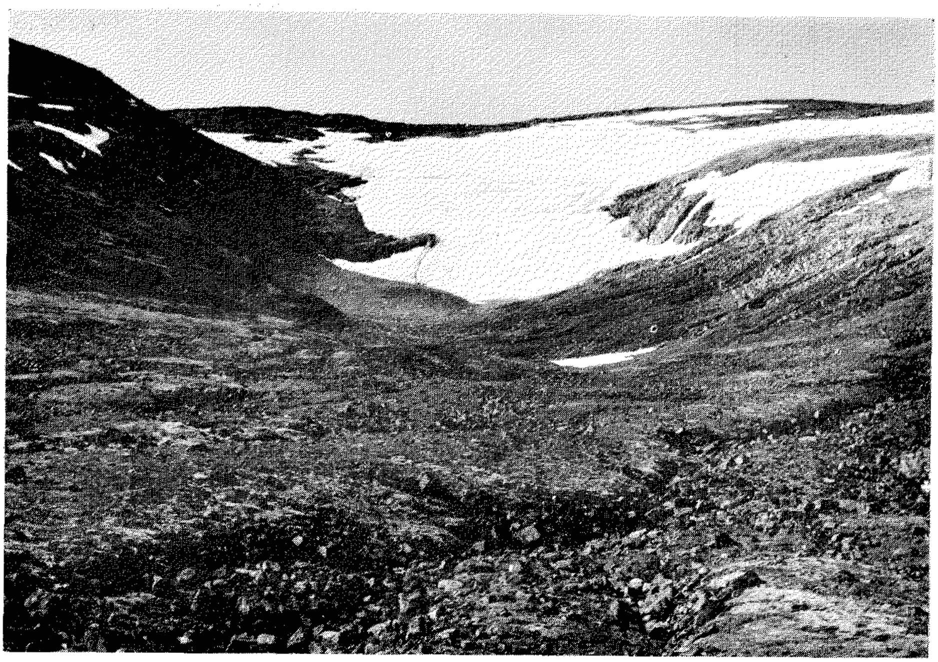

Fig. 11. Small cirque glacier, now stagnant, near head of Abloviak Fiord. Ridge above ice raises to 2,800 feet above sea level. Aug. 9, 1956.

The role of the Torngats as a possible centre of ice dispersal

From the evidence presented above it appears that in late-Wisconsin times no centre of ice dispersal existed in the Torngat Mountains. Before the possible role of the Torngats in the initiation of the Wisconsin ice sheets can be considered, the physical character of the area must be re-emphasized.

Flint (1943) tends to regard the Torngats as a mountain range, and if this were the case then his theory of the initial accumulation and dispersal from such a range would be logical. As has been stated above however, Odell's terminology of "Coastal" and "Central" *ranges* is especially unfortunate as the Torngats are merely the dissected eastern edge of an uplifted and tilted

Fig. 12. Cirque development in "central" Torngats. Aug. 27, 1956.

peneplain. Above all, the western slope is extremely gentle and any such description as "western flanks" is erroneous. Furthermore, a vast area of the Labrador-Ungava plateau exceeds 2,500 feet in altitude, which, when considering the areal extent and position in relation to the source of precipitation, is much more significant as an initial accumulation area than are the Torngats.

Preliminary investigations of the snowline in Labrador-Ungava, after the style outlined by Professor Gordon Manley in England (1949), also lend support to this concept. Semi-permanent snow beds in the Knob Lake area at an altitude of 2,000 feet above sea level allow a rough estimate to be made of the present height of the snowline above the land surface. This is approximately 2,000 feet, or 5,000 feet above sea level. In the Torngats the permanent snowline lies at about 3,500 feet. Widespread lowering of the snowline across Labrador-Ungava, resulting from progressive climatic deterioration at the onset of glacial times, would rapidly place an immense area of the plateau above the snowline, and hence form a huge reservoir of névé long before any significant accumulation could occur in the Torngats. Although many more data are needed, it is concluded that at the onset of Wisconsin times glacierization across a large area of the Labrador-Ungava plateau would have been instantaneous at the time of any significant lowering of the snowline. Furthermore, although small glaciers would develop concurrently in the Torngats, the build-up of an ice cap on the plateau to the southwest would starve them of precipitation and the first major glaciers would move from the west and southwest through the mountains to the Atlantic Ocean.

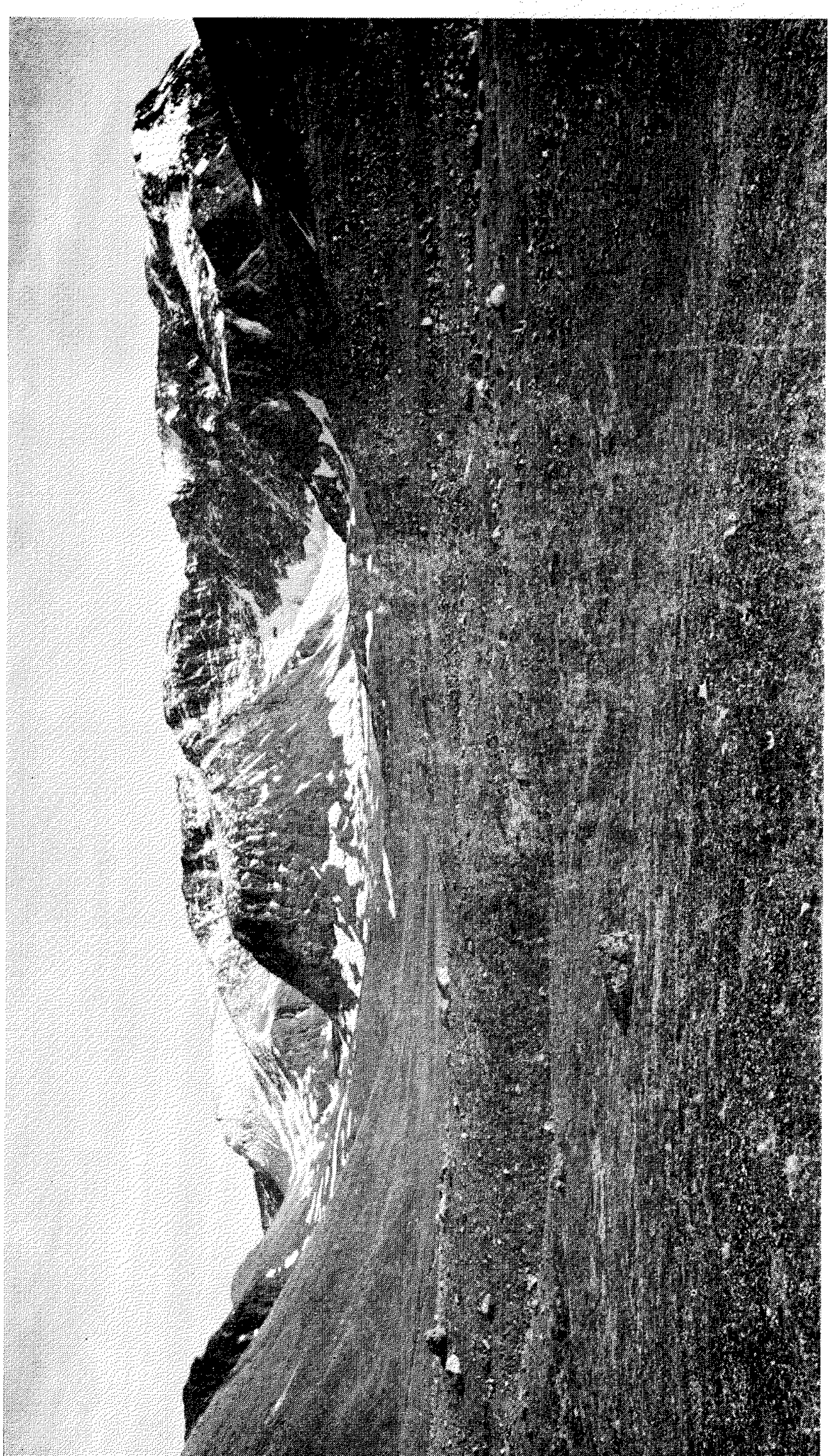

Fig. 13. The north face of Mount Tetragona, 4,500 feet, with the deep cirque that contains Bryants Glacier. Moraine with kettles in foreground. Sept. 1, 1956.

Conclusions

1. The highest summits of the Torngat Mountains were completely submerged by eastward moving continental ice at the height of the Wisconsin Glaciation. The ice reached a thickness of possibly 1,000 feet above the "central" summits and the highest coastal summits were probably covered by at least a thin cover when the ice margin reached the vicinity of the outer edge of the continental shelf, some 90 to 100 miles east of the present coastline.

2. Local glaciers in the Torngats never reached significant dimensions, and in late-Wisconsin times most cirque glaciers did not overspill the cirque thresholds.

3. The final movement of ice, excluding the local movement within the cirque, was from the west, and during the final stages of the Wisconsin Glaciation there occurred the rapid melting in situ of thick masses of ice.

4. Two, possibly three, separate glacial periods are recognized from the morphology of the area.

5. Instantaneous glacierization of a large area of the Labrador-Ungava plateau is considered the most likely method of initiation of a continental ice sheet in northeastern North America at the onset of each glacial period.

References

Battle, W. R. B. 1952. Corrie formation with particular reference to the importance of frost shatter at depth. Cambridge University: unpublished Ph.D. thesis.

Bell, R. 1884. Observations on geology, mineralogy, zoology and botany of the Labrador Coast, Hudson's Strait and Bay. Can. Geol. Surv. Rept. of Prog. 1882-83-84, Pt. DD.

Boyé, M. 1950. Glaciaire et périglaciaire de l'Atâ Sund nord-oriental Groenland. Paris: Herman, 176 pp.

Cailleux, A. 1952. Polissage et sucreusement glaciaires dans l'hypothèse de Boyé. Revue de géomorph. dynamique 3: 247-57.

Coleman, A. P. 1921. Northeastern part of Labrador and New Quebec. Can. Geol. Surv., Mem. 124.

Cooke, H. C. 1929. Studies of the physiography of the Canadian Shield I. Roy. Soc. Can. Trans., ser. 3, vol. 23, sect. 4: 91-120.

——— 1930. Studies of the physiography of the Canadian Shield II. Roy. Soc. Can. Trans., ser. 3, vol. 24, sect. 4: 51-87.

——— 1931. Studies of the physiography of the Canadian Shield III. Roy. Soc. Can. Trans., ser. 3, vol. 25, sect. 4: 127-80.

Dahl, E. 1946. On different types of unglaciated areas during the ice ages and their significance to phytogeography. New Phytologist 45: 225-42.

——— 1947. A reply to an address by V. Tanner. Norsk Geologist Tidssk. 26: 233-5.

Daly, R. A. 1902. The geology of the northeast coast of Labrador. Harvard Univ. Mus. Comp. Zool. Bull. 38: 205-70.

Flint, R. F. 1943. Growth of the North American ice sheet during the Wisconsin Age. Geol. Soc. Am. Bull. 54: 325-62.

——————— 1947. Glacial geology and the Pleistocene Epoch. New York: John Wiley and Sons. 589 pp.

——————— 1952. The Ice Age in the North American Arctic. Arctic 5: 135-53.

——————— 1953. Probable Wisconsin substages and late-Wisconsin events in northeastern United States and southeastern Canada. Geol. Soc. Am. Bull. 64: 897-920.

Manley, G. 1949. The snowline in Britain. Geog. Annaler 31: 179-93.

McCall, J. G. 1952. The internal structure of a cirque glacier. J. of Glaciology 2: 122-30.

Mercer, J. H. 1956. Geomorphology and glacial history in southernmost Baffin Island. Geol. Soc. Am. Bull. 67: 553-70.

Odell, N. 1933. The mountains of Northern Labrador. Geog. J. 82: 193-211, 315-26.

Piloski, M. J. 1956. Report on a reconnaissance of Northern Labrador. Unpublished report presented to the British Newfoundland Corporation, Montreal.

Tanner, V. 1944. Newfoundland-Labrador. Acta Geographica 8: 1-906.