GLACIERS AND LAND FORMS IN THE CUMBERLAND PENINSULA OF BAFFIN ISLAND

BY

H. R. THOMPSON

DEPARTMENT OF GEOGRAPHY, McGILL UNIVERSITY

MONTREAL 2, QUEBEC, CANADA

Glacier 18; typical of the many hanging glaciers lining Pangnirtung Pass. The moraine has been partly destroyed by melt-water.

GLACIERS AND LAND FORMS IN THE CUMBERLAND PENINSULA OF BAFFIN ISLAND

by H. R. THOMPSON*

• This paper is a summary of the glaciological and geomorphological work of the Baffin Island Expedition, 1953, which was led by Colonel P. D. Baird, under the auspices of the Arctic Institute of North America. Only the section on Pangnirtung Pass is based on the author's own research: for the rest, the help of colleagues is gratefully acknowledged. All statements and figures are provisional, since the expedition's data are still being analyzed.

The largest island in the Canadian Arctic, Baffin Island has an area of 200,000 square miles and trends from northwest to southeast across the Arctic Circle (Fig. 1). The land is low and flat along the Foxe Basin coast but rises steadily to an elongated plateau beside Baffin Bay, in the northeast. This plateau – a Tertiary erosion surface cut across gneisses, gabbros, schists, granites, and similar rocks – reaches its greatest elevation of 5,000-7,000 feet in Cumberland Peninsula, the northernmost of the three peninsulas of eastern Baffin Island. The plateau was uplifted in the late Tertiary and is now trenched by deep and narrow valleys and pocked by innumerable cirques.

PENNY ICECAP

Upon the western down-slope of the plateau lies the Penny Icecap, which, with an area of 2,300 square miles, is one of the two large such features in Baffin Island. Roughly oval in plan-view, the Penny Icecap has a gently undulating surface, apparently controlled by the bedrock topography. Judging by the surface contours and by ice-cliff exposures around its margin, the Icecap is generally between 200 and 500 feet thick, though partially deglacierized outlet valleys suggest much greater thicknesses locally. Partly because of its position on the high "backbone" of Cumberland Peninsula, the Icecap is itself a major source and divide of both glacial and fluvial drainage. The original drainage pattern was probably dendritic, but differential erosion has since picked out lines of weakness, such as the two remarkable troughs which bound the Icecap on the north and on the south.

PLATE 1 — "Looking up Highway Glacier to Penny Icecap. Mountains are remnants of upland plateau." (Photo: J. A. Thomson.)

FIGURE 1 — "General location of Baffin Island, Cumberland Peninsula, and the two icecaps mentioned in the text." (Map drawn by The Shawinigan Water & Power Company.)

Camps A.1 and A.2 of the Baffin Island Expedition, 1953, were established on the Penny Icecap in mid-May by a "Norseman" ski-plane. At Camp A.1 (6,725 feet), W. H. Ward and S. Orvig made physical measurements of the surface layers of the Icecap and of the air above[4].

In contrast to their previous findings on the Barnes Icecap, 250 miles to the north[3], Ward and Orvig discovered in 1953 that the higher parts of the Penny Icecap lie above the firn line and that the feature does not owe its continued existence to the freezing of melt-water directly on to glacial ice. Indeed, no continuous mass of glacial ice was met until a depth of 43 feet had been reached in the course of hand-drilling down to 69 feet. The upper 43 feet of the borehole were composed of snow, new firn, old firn, cavities and ice bands, in a complicated succession.

Despite the contrast in their composition, the Barnes and Penny Icecaps have much the same equilibrium temperature (8.5°F) below the limit of the annual warm and cold waves[3, 4]. The equilibrium value must also be close to the mean annual temperature of the open air at each drilling site. On the Penny Icecap in the summer of 1953, temperatures above 32°F were recorded on only 14 days, with an absolute maximum of 38.5°F.

*Dept. of Geography, McGill University, Montreal 2.

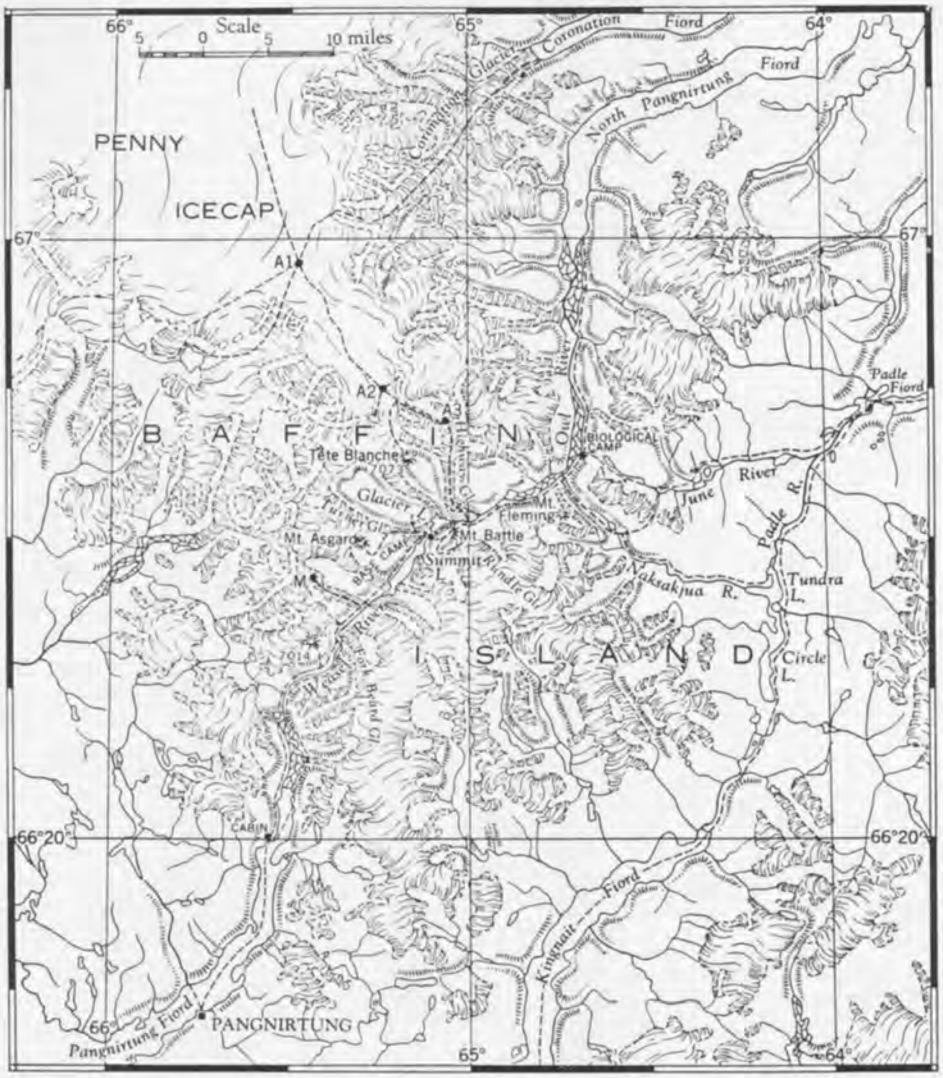

FIGURE 2 —"Area of operations of the Baffin Island Expedition, 1953, showing Penny Icecap, Highway Glacier, and the great trench of Pangnirtung Pass." (Map reproduced by courtesy of "Arctic".)

Orvig and Ward were particularly interested in the accumulation-ablation balance of the Penny Icecap surface. Seventeen inches of water were found to have accumulated as snow and ice in one year — *i.e.*, since the ablation season of 1952. Of this amount, 4-6 inches melted in the summer of 1953. But even this limited quantity of melting did not necessarily represent a loss to the Icecap, since most of the water percolated downwards and froze into ice bands. The chief cause of melting was occasional warm air (above 32°F), but solar radiation proved effective during some of the prolonged spells of fog that afflicted Camp A.1. Evaporation was negligible, because of the high humidity and low temperature of the air layer close to the ground.

HIGHWAY GLACIER

From the eastern end of the Penny Icecap numerous deep and narrow valleys lead down to the sea or to the great northeast-southwest trench of Pangnirtung Pass. Many of the outlet glaciers occupying such valleys have very steep gradients and arouse speculation concerning their depths, their rates of flow, and the shapes of their bedrock floors. The 1953 expedition selected Highway Glacier as an example, since it was to be the routeway between Camps A.1 and A.2 on the Penny Icecap and Base Camp in Pangnirtung Pass (Fig. 2). H. Röthlisberger, J. R. Weber, J. Marmet and F. H. Schwarzenbach — all of the Swiss Foundation for Alpine Research — formed the expedition's seismic team, which made nearly 200 dynamite "shots" during the summer, to determine ice thickness[4].

At Camp A.2, lying at 6,300 feet in an ice valley near the edge of the Penny Icecap, they found 100 feet of snow and firn overlying 600 feet of glacial ice. The ice in turn was resting on a shallow bedrock valley of the rock tableland. The sides of such valleys were usually so steep as to be bare of ice, The Penny Icecap or local icecaps above the rock exposures being truncated by ice-cliffs about 200 feet high.

Farther down Highway Glacier, the vertical gap between the summit icecap remnants and the outlet glacier surface increased steadily to 3,500 feet, their former union proclaimed by hanging tongues of ice. The thickness of Highway Glacier likewise increased down-valley. Near Camp A.3, where the ice surface lay at 3,100 feet, the bedrock floor was already within 1,800 feet of sea level. At the snout of Highway Glacier, thirty miles from the sea, the rock bottom lay at an altitude of only 700 feet. Rôthlisberger believes that there was at this point a thick fill of loose rock debris between the bedrock floor and the glacial ice.†

Not only the thickness of Highway Glacier, but the topography of its bedrock floor, proved interesting. For here was no series of basins and steps such as are generally assumed to be characteristic of glaciated valleys. Even at Camp A.3, where several large outlet glaciers coalesced, there was no sign of such features.* Instead, the valley floor had smooth outlines and a steady down-glacier slope.

†Personal communication.

*Pangnirtung Pass itself also lacks a visible basin-and-riegel form.

Locally it was asymmetrical in cross-section, with its deepest axis close to the western margin. The only two major breaks of slope – neither of which had a basin on its up-valley side – occurred where Highway Glacier left its parent Icecap and where the lower part of its tongue "hung" slightly above Pangnirtung Pass.

PLATE 2 — "Snout of Turner Glacier. Lateral and medial moraines, delta on ice front, shrunken proglacial lake." (Photo: J. A. Thomson.)

The maximum rate of flow of Highway Glacier in its central section was measured by W. H. Ward as 52 feet in 38 summer days. Near the snout of the glacier, ablation removed 40 inches of snow plus seven feet of glacial ice, between mid-May and late-August. In this "zone of wastage" melt-water does not percolate, but flows away in torrents. It is again interesting to compare the volume of ablation with the ice equilibrium temperature (22°F)[4].

PANGNIRTUNG PASS

The great through-valley of Pangnirtung Pass, connecting Pangnirtung Fiord with North Pangnirtung Fiord, is sixty miles long and one to two miles wide. Its summit, near the 1953 Base Camp, has an altitude of only 1,285 feet, whereas the mountains on either side – remnants of the plateau erosion surface – rise to over 6,000 feet. It was in this spectacular trench that the writer made his own geomorphological studies in 1953[4].

PLATE 3 — "Looking south from Base Camp, down Pangnirtung Pass. Large new moraine protrudes into frozen Summit Lake." (Photo: J. A. Thomson.)

The Pass contains no trunk glacier today, but the evidence of roches moutonnées, groovings, polishing, facetting, and old lateral moraines, proves beyond doubt that ice formerly occupied the whole Pass, as well as Pangnirtung Fiord and probably North Pangnirtung Fiord. Many of the finer rock particles have disappeared from the old moraines, and the latters' vegetation cover is rich and well established, except on steep faces. On the twin basis of Eskimo legends and of ecological-dating studies by the botanist of the 1953 expedition, some of the old moraines are estimated to date back at least 900 years. It is impossible to say how long and how often the Pass and fiords were glacierized before that time. The fact that no undoubted raised beaches were seen around Pangnirtung Fiord suggests that glacierization may have lasted throughout the general post-Wisconsin marine transgression. Alternatively, the trunk glaciers of 900+ years ago may have represented an entirely fresh advance, which destroyed previously existing beaches.

Scores of "tributary" glaciers are still visible along the length of Pangnirtung Pass. All of them "hang" to some extent. The largest ones – such as Highway and Turner Glaciers – join the Pass at the lowest angles, but even these fall off quite abruptly when they reach the edge of the Pass. Some of the smaller glaciers hang in a spectacular manner at angles as high as 30°, but others do not protrude beyond the beds of their hanging valleys. There is a remarkable accordance in altitude of many such valleys, which may be related to a stage in the evolution of the Pass. Thereafter, their catchment basins were too restricted for their glaciers and rivers to cut down as rapidly as those in the larger tributary valleys.

Most of the glacier tongues are surrounded by moraine loops. That these have been quite recently formed is implied by the steepness and instability of their slopes; by the comparative abundance in them of small rock particles; by the occurrence of glacial ice as the chief constituent of each ridge; and by the almost complete absence of vegetation. In most cases there was a pronounced contrast in age between the inner and outer sections of the new moraines: the original moraine-building was followed by a short recession, a period of equilibrium, and finally the present rapid decay. In three cases the final recession is known to have taken place since 1925.

But even on the outermost slopes of the new moraines, lichen cover and willow growth-rings seldom testify to more than fifty years of colonization. It is not known how long the building of the moraines took, but in view of the rapidity of flow of the hanging glaciers, the ample quantities of debris still being transported, and the fact that most moraines consist largely of ice, it seems reasonable to suggest 1840-1860 as the period of the causative glacier advance.

The present decay of the tributary glacier tongues is betrayed not only by the occurrence of ice-cored moraine ridges far above the present glacier surfaces, but by the wholesale collapse of the roofs of englacial caverns and tunnels, by the very recent abandonment of melt-stream terraces and channels, and by the instability of every type of deposit. From a comparison of R.C.A.F. air photographs taken in 1948 and 1949 with the writer's own surveys and photographs of 1953, it is clear that the proportion of detritus to ice in the terminal zones has increased; that the ice cliffs where Turner Glacier reaches Glacier Lake have receded; and that the two large eskers of Turner and Highway Glaciers have emerged as much as fifty feet from the ice by differential down-wasting (Fig. 3).

The shapes of the morainic detritus are extraordinarily varied. Freshly broken, angular blocks, often of vast size, occur in medial and other moraines on the ice surface, on top of kames and eskers, and elsewhere in unpredictable positions. Some true englacial moraine, lying beneath englacial eskers, is also angular. By far the larger part of

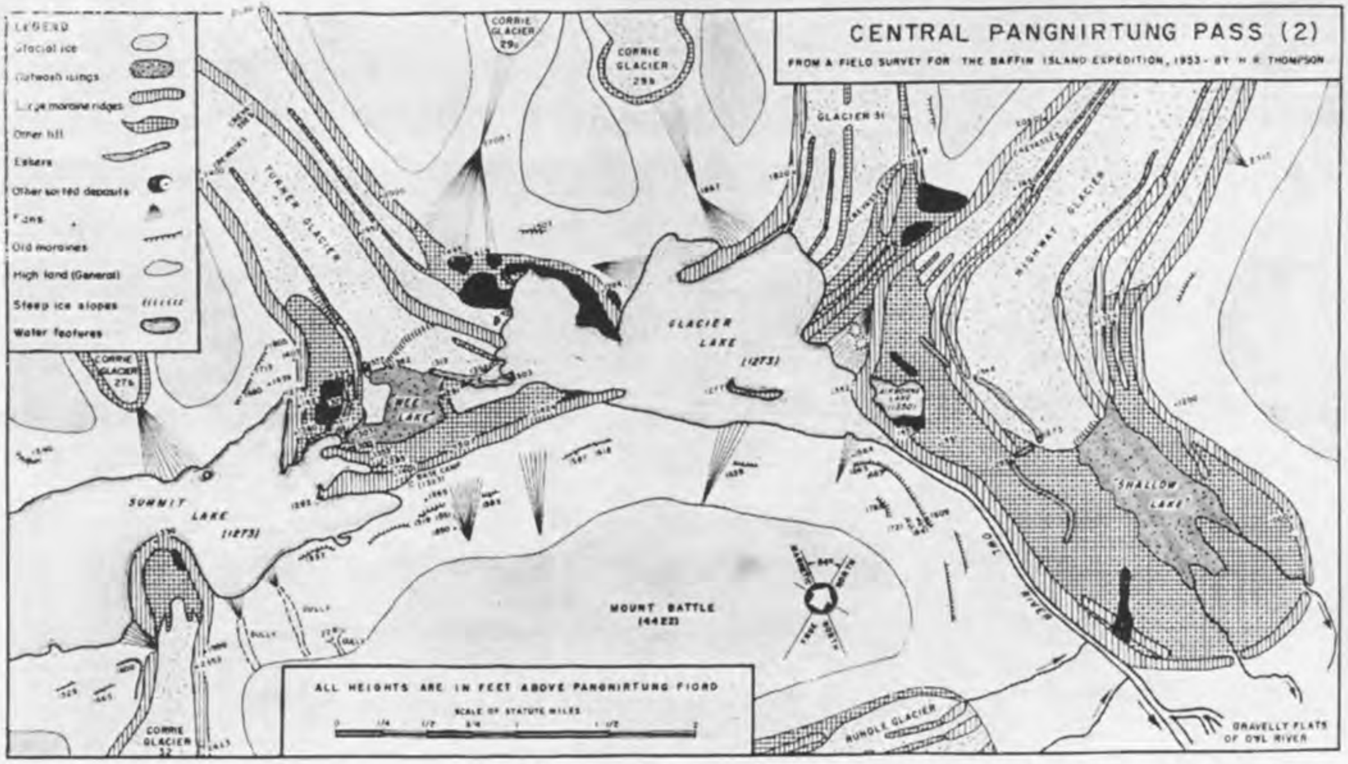

FIGURE 3 — "Land forms in Base Camp area, surveyed by plane table. The complex pattern on the map is greatly simplified from the true chaotic state of the glacier termini." (Map drawn by The Shawinigan Water and Power Company.)

every moraine deposit and all the basal load of each glacier is however composed of semi-rounded and sub-angular debris of all sizes. Very few such stones bear traces of facetting, polishing, groovings, or striations, whereas many have outlines partially attributable to water action. Often one found perfectly rounded cobbles and boulders scattered among the other morainic blocks and clearly laid down at the same time and in the same manner. All the evidence points strongly to water having been the principal agent in the shaping of most morainic debris except the superglacial angular blocks. The majority of stones however must have been subject to prolonged wearing by both streams and glaciers before their recent glacial transport.

PLATE 4 — "Summit of Pangnirtung Pass. Hanging glaciers, truncated spurs, new and old moraines." (Photo: J. A. Thomson.)

The importance of water action is visible on, in, and beneath every glacier. Torrential streams have washed away silt, sand, gravel and small cobbles, to form kames, eskers, deltas, lacustrine silts, outwash fans, shorelines and terraces of all kinds. Most of the glaciers have proglacial and superglacial lakes and ponds, each with its own land form association. Some moraine loops are composed of glaciofluvial deposits to the extent of one-third of their area. Only the eskers and the deltas are well bedded, but sorting and rounding are common.

Bedrock slabs beneath and immediately in front of the retreating glaciers invariably display signs of melt-stream abrasion, rather than those of glacial scour. Indeed, grooving and polishing are only found on valley sides, in locations where water flow is, and evidently has long been negligible.

One glacier tongue in Pangnirtung Pass has scarcely begun to decay and may even be advancing. Rundle Glacier, northeast of the Base Camp, has a steep front rising directly from a richly vegetated valley floor. Although no moraine loop has yet formed, its building has begun, with the accumulation of small boulder fans at the splayed-out end of one lateral moraine. A more even supply of debris is meanwhile melting out of the dirty basal layers of the glacier, tending to build a continuous apron resting against the ice front. But here, as elsewhere, melt-streams are innumerable and torrential, flushing all fine particles away as soon as they are liberated from the ice and inducing much attrition and movement of the coarse blocks as well.

CONCLUSION

The Penny Icecap, Highway Glacier, and the hanging glaciers of Pangnirtung Pass, offer classic examples of the zones of predominant supply, predominant movement, and predominant wastage, described by Wright and Priestley[5]. The Icecap may also be called a Sub-polar glacier cap, in Ahlmann's terminology, and its outlets, Sub-polar valley glaciers[1].

Each type of glacier has its own relation to the bedrock topography and each has formed its own deposits. Meltwater action during the short summer season is of great importance in the Cumberland Peninsula. Whereas it is at least 900 years since Pangnirtung Pass was occupied by trunk glaciers, an advance of the outlet glaciers of the Penny Icecap and many independent glaciers occurred only about 100 years ago.

The equilibrium temperature of 8.5°F in the Penny Icecap implies that a very marked warming up of the climate at 6,000-7,000 feet would be required to cause serious glacial shrinkage there. On the other hand a rise of a few degrees in the temperatures at *low* altitudes would greatly increase the ablation season in the zone of wastage. The present decay of the glacier tongues along Pangnirtung Pass may therefore be related to the recent climatic fluctuation around the North Atlantic Ocean[2].

REFERENCES

[1] Ahlmann, H. W. 1948. "Glaciological research on the North Atlantic coasts." Royal Geog. Soc. Research Ser., No. 1, 83 pp.

[2] Ahlmann, H. W. 1948. "The present climatic fluctuation." *Geog. Jour.*, Vol. 112, Nos. 4-6, pp. 165-195.

[3] Baird, P. D., W. H. Ward, and S. Orvig. 1952-3. "The glaciological studies of the Baffin Island Expedition, 1950." (Parts 1-5.) *Jour. of Glaciology*, Vol. 2, No. 11, pp. 2-23; Vol. 2, No. 12, pp. 115-121; Vol. 2, No. 13, pp. 158-168; Vol. 2, No. 14, pp. 242-248.

[4] Baird, P. D., and others. 1953. "Baffin Island Expedition, 1953: a preliminary field report." *Arctic*, Vol. 6, No. 4, pp. 227-251. (Includes *Introduction* by Baird. *Glacier Physics* by Ward, *Seismic Sounding* by Röthlisberger, *Meteorology* by Orvig, *Geomorphology* by Thompson, and six other sections.)

[5] Wright, C. S., and R. E. Priestley. 1922. "Glaciology. British (Terra Nova) Antarctic Expedition, 1910-13." London, 487 pp.

[6] Thompson, H. R. 1954. "Pangnirtung Pass, Baffin Island: an exploratory regional geomorphology." McGill University: unpublished Ph.D. thesis. 227 pp. (Includes 4 maps, 7 diagrams, 16 R.C.A.F. air photographs, and 90 ground photographs. Available at McGill's Redpath Library, Dept. of Geography, and Arctic Institute.)