ASPECTS OF GLACIAL HISTORY, SOUTHEASTERN ELLESMERE ISLAND, DISTRICT OF FRANKLIN

Project 750063

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Abstract

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Field work around Makinson Inlet, Ellesmere Island, has revealed that erratics, striated rock surfaces, and marginal drainage channels are widespread. These features, plus the glacial sculpture on Bowman Island, show that a major outlet glacier formerly flowed eastward in Makinson Inlet, draining a significant mass of ice that lay to the west of the present-day ice caps. A fossil peat deposit indicates an ice-free interval >44 000 years (GSC-140-2) ago with a climate more favourable than that of today. During Holocene time the sea penetrated to the head of the west arm of Makinson Inlet by 8930 ± 100 years B.P. (GSC-2519) and to the head of the north arm by 7330 ± 80 years B.P. (GSC-1972).

Introduction

During the summer of 1977 (June 23 to August 21) work on the project entitled "Quaternary Geochronology, Arctic Islands" was concentrated around Makinson Inlet, Ellesmere Island (Fig. 36.1). In addition, a three-day trip was made to the southeastern coast of the island and to Coburg Island, and four days were devoted to a re-examination of marine deposits at Cape Storm, southwestern Ellesmere Island. The second half of July was spent studying glacial deposits and landforms in the vicinity of Cape Herschel, north of the 78th parallel, and highlights of the work carried out there have been described previously (Blake, 1977). The present article will deal with various aspects of the investigations around Makinson Inlet.

As a complement to the writer's investigations of glacial history, R.A. Souchez and R.D. Lorrain of Université Libre de Bruxelles, Belgium, carried out a program of sampling basal ice from a number of outlet glaciers on the eastern side of the north arm of Makinson Inlet. Their work is intended to provide a better understanding of the chemical processes occurring at the ice/rock interface in polar glaciers as opposed to the temperate glaciers they have investigated previously in the Alps (Souchez and Lorrain, 1975).

Another component of the 1977 work involved coring of lake sediments from an ice platform. The lightweight nature of the coring equipment which was utilized (for ease of transport in the field) and an early thaw of the lakes, resulting from the exceptionally good weather throughout the early part of the summer, created problems in the coring program. R.J. Richardson is studying the short cores recovered from a lake to the west-southwest of the Swinnerton Peninsula base camp (Fig. 36.2).

A Hughes 500C turbine helicopter was used in the field, and the availability of this machine made it possible to visit a number of localities which otherwise would have been difficult to reach. In addition to helicopter support, two Honda ATC's (All-Terrain Cycles) were used for travel within a few kilometres of our base camp on Swinnerton Peninsula, near the head of the western arm of Makinson Inlet (Figs. 36.1, 36.2). These vehicles also were transported to more distant sites by Twin-Otter aircraft or were carried in a sling under the Hughes helicopter, and thus even greater mobility was achieved.

Geomorphology and Glaciation

Makinson Inlet is by far the largest fiord along the Ellesmere Island coast of northern Baffin Bay. The inlet extends for almost 100 km from its mouth in Smith Bay to the head of the north arm. The ice caps that dominate the east coast are localized over the Precambrian terrane – the Southeastern Highlands (Roots, 1963). In this part of Ellesmere Island nunataks and high domes on the ice caps attain elevations of more than 1100 m a.s.l., or, to the north of Makinson Inlet, more than 1500 m. Water depths in excess of 500 m are the rule in the middle reaches of the Inlet (Sadler, 1973). By contrast, elevations of the plateau surface developed on the Paleozoic rocks of Swinnerton Peninsula and elsewhere around inner Makinson Inlet rarely exceed 500 m a.s.l., and water depths are generally less than 200 m. Thus the total relief is significantly less in this region, which is part of the Southern Plateau as described by Roots (1963).

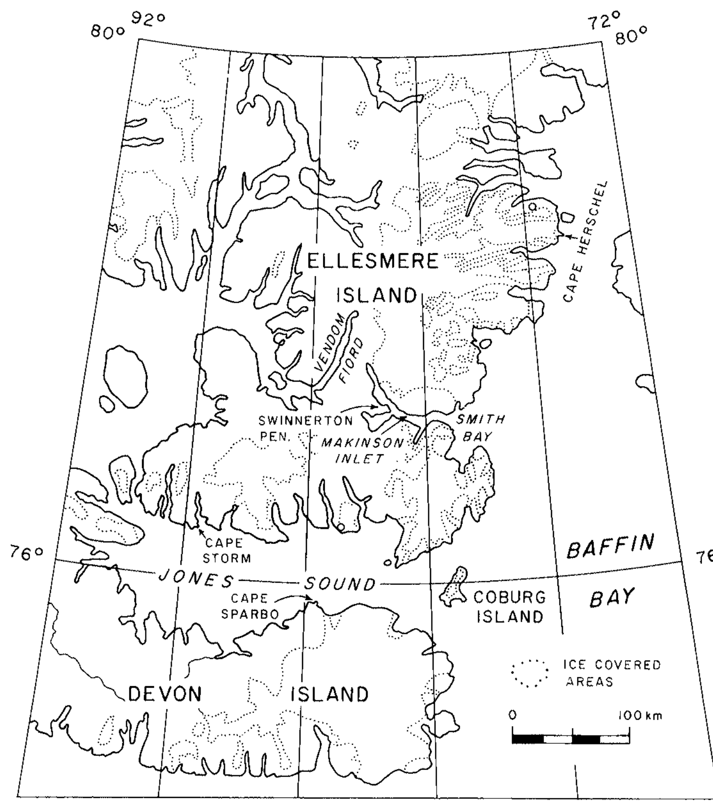

Figure 36.1. Location map, southeastern Ellesmere Island.

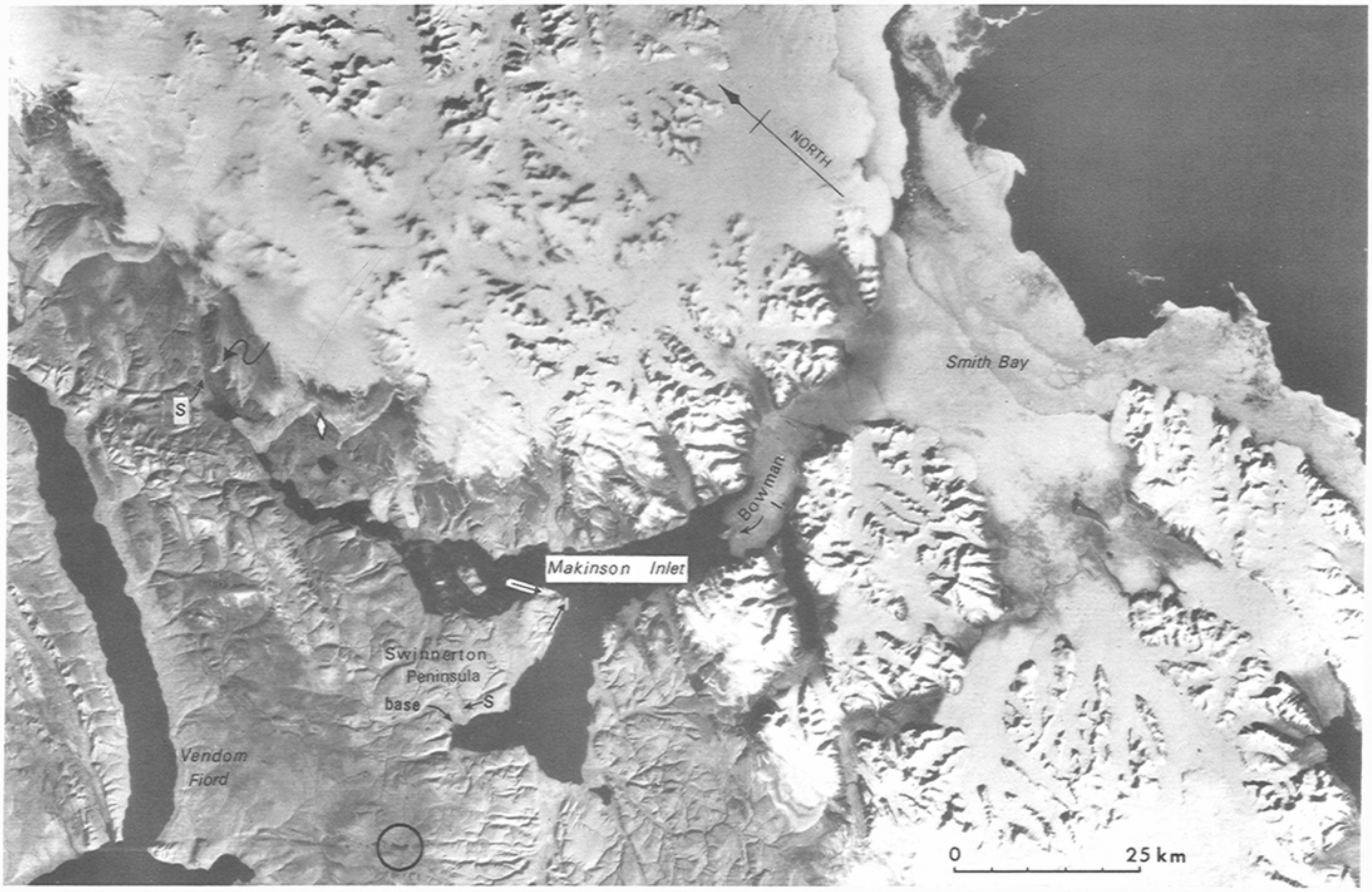

Figure 36.2. LANDSAT image of the Makinson Inlet area, Ellesmere Island. Arrows at the eastern end of Swinnerton Peninsula indicate the former direction of ice flow; the S-symbol refers to the two new sites with dated marine shells mentioned in the text; the diamond (south end) indicates where "old" peat occurs; the encircled lake is where coring was attempted; and the wavy arrow north of the head of the inlet indicates the glacier where in situ willows have been exposed by recent retreat of the ice (cf. Fig. 36.10). Image E-1758-17500, spectral band 7, August 20, 1974.

Evidence for much more extensive glacierization than at present is widespread in the form of innumerable erratic boulders, striated rock surfaces, and marginal drainage channels. Examination of the headlands at the eastern end of Swinnerton Peninsula revealed the presence of striated dolomite on the plateau surface at elevations between 300 and 345 m. These smoothed and polished surfaces indicate, as might be expected, converging flow within a significant mass of ice which was being channelled seaward via Makinson Inlet (Figs. 36.2, 36.3). Twenty-five kilometres east of Swinnerton Peninsula, the resistant Precambrian granitic and granulitic rocks of Bowman Island (Frisch, 1977), at approximately the same elevation (300 m), exhibit massive sculpturing and polishing by the outlet glacier that once filled Makinson Inlet. The amount of erosion that has taken place in order to carve Bowman Island into its present form provides additional evidence that the inner parts of this fiord system were buried deeply beneath ice during the last glaciation. This concept is in line with estimates of maximum ice thickness for the Innuitian Ice Sheet of 1900 m (Paterson, 1972), 2000 m (CLIMAP, 1976), and >2000 m (Sugden, 1977). Yet a marked contrast exists between the classic glacial landforms displayed on Bowman Island (Figs. 36.4 to 36.6) and certain parts of the plateau surface to the north, where incipient tors or tor-like landforms are present although erratics litter the surface (Figs. 36.7 to 36.9). Makinson Inlet and environs appear to represent an excellent example of what Sugden (1974) has described as a landscape of "selective linear erosion" (cf. also Sugden, 1968). This type of landscape is characterized by valleys in which tremendous amounts of scouring take place along pre-existing drainage lines or structural lineaments, whereas the adjacent "upland plateau remnants between the troughs generally show little or no sign of glacial erosion, and it is common to find the surface covered with regolith" (Sugden, 1974, p. 179-180).

Erratics of granite and other shield rocks were observed to be widespread on the plateau surfaces cut in Paleozoic rocks of Swinnerton Peninsula, and they also are abundant to the west around Vendom Fiord (R.F. Roblesky, pers. comm. 1977). It is evident, therefore, that at some time, and in all probability on repeated occasions, boulders were carried westward by more extensive ice than exists at present, for the Paleozoic/Precambrian boundary is close to the western margin of the ice caps, both to the north and south of Makinson Inlet (Christie, 1962; Frisch, 1977). However, the erratics also document the eastward flow of ice out Makinson Inlet. Erratic cobbles and boulders of Paleozoic rocks are ubiquitous along the rim of the plateau on the north side of the inlet, and they are present in far greater numbers on Bowman Island. In addition marine shell fragments are present in the thin till which overlies the striated bedrock on the northeast corner of Swinnerton Peninsula and on Bowman Island, in both cases at elevations up to 300 m or more. On Bowman Island this is the same till in which Paleozoic rock fragments are so abundant. One limestone cobble contained a well preserved pygidium and an incomplete thorax of the Late Silurian trilobite Encrinurus (Frammia) arcticus (Haughton)[1] which is a characteristic faunal element of the Read Bay Formation (Bolton, 1965). The nearest locality to Bowman Island where rocks of the Allen Bay and Read Bay formations (undifferentiated) are known to occur is the north arm of Makinson Inlet, over 45 km distant (R.F. Roblesky, pers. comm., 1977; cf. also Kerr and Thorsteinsson, 1972; McGill, 1974; Kerr, 1976).

Marginal drainage channels occur throughout the inner Makinson Inlet region, and they provide valuable information as to the pattern of ice retreat. For the purposes of this preliminary report it is sufficient to note that they are particularly abundant and well developed to the west and northwest of Swinnerton Peninsula, and they are also abundant on either side of the north arm of Makinson Inlet.

Absolute Age Determinations

A long and complicated sequence of events is recorded in the deposits of the Makinson Inlet region, and more field and laboratory studies will be required before all the relationships between glacial, lacustrine, and marine environments are understood fully. Reconnaissance investigations in the early 1960's by J.G. Fyles and R.L. Christie provided the first materials on which radiocarbon age determinations could be carried out; thus some insight into chronology was gained at that time.

One of the most interesting discoveries made by Fyles in 1961 was a peat deposit exposed in a valley wall east of the north arm of Makinson Inlet (Fig. 36.2). This peat, at an elevation of approximately 365 m, was overlain by boulders on the floor of a large drainage channel. Its age was determined originally to be >36 400 years (GSC-140; Dyck and Fyles, 1964). A new determination on the remainder of the sample, however, gave a value of >44 000 years (GSC-140-2), and at the same time the predominant constituent was determined by M. Kuc to be the moss **Calliergon giganteum,** a species typical of moss bog tundra (Blake, 1974). The site was revisited in 1977, and new collections were made. Remains of beetles were found in the massive peat deposit, and a thorough study of them should provide valuable paleoenvironmental information. However, the very presence of beetles, including the ground beetle **Amara alpina** (Payk.)[2], indicates environmental conditions somewhat more favourable than those of today. At present **A. alpina** is not known to occur north of Cape Sparbo (Fig. 36.1) on the Jones Sound coast of Devon Island (Lindroth, 1963, 1968), approximately 240 km south of the Makinson Inlet site. It would appear that at least two episodes during which glacier ice occupied the north arm of Makinson Inlet are reflected in the peat bearing sequence here. One glacial episode is needed in order that the channel could be cut by meltwater, then an ice-free interval during which tundra bogs developed on the floor of the channel, followed in turn by another glacial episode during which the mass of boulders and finer materials overlying the peat were washed down the channel and deposited.

With regard to other "old" materials, a determination on fragments of **Hiatella arctica, Mya truncata,** and **Astarte** sp. collected by J.G. Fyles at 85 to 90 m a.s.l. in the south-central part of Swinnerton Peninsula gave values of 29 430 ± 680 years (GSC-134; standard preparation, with the outer 10% of shells removed by leaching) and 29 800 ± 220 years (GSC-134; second preparation, inner 37% of shells). Although Fyles (in Dyck and Fyles, 1964) suggested that, in view of the good agreement between the two determinations, they might represent the approximate absolute age rather than a minimum age, a case can also be made for the latter interpretation (cf. Olsson and Blake, 1962; Olsson, 1968; Blake, 1974).

Prior to the collections made this past summer the oldest Holocene materials that had been dated were pelecypod shell fragments collected at the head of the south arm of Makinson Inlet by R.L. Christie in 1960; the result on the inner fraction of shells was 8200 ± 220 years (GSC-146; Dyck and Fyles, 1964; Craig and Fyles, 1965). A new determination on aragonitic shells of **Hiatella arctica,** collected at approximately 40 m a.s.l. from the basal unit of a sequence of marine sediments 2 km east of the base camp on Swinnerton Peninsula (Fig. 36.2), has given a value of 8930 ± 100 years (GSC-2519). This date indicates the time by which marine waters had penetrated close to the innermost part of the west arm of Makinson Inlet. The date also indicates that the glaciated surfaces on Bowman Island, more than 40 km to the east, have been free of ice for more than 9000 radiocarbon years, yet they retain their high polish and fresh-appearing striae (cf. Figs. 36.5, 36.6).

North of the ice-dammed lake that now exists at the head of the north arm of Makinson Inlet an important collection of marine shells was made in 1973 by S.B. McCann. In a fresh exposure which had been undercut recently by the river, a silt/clay unit was exposed at approximately 36 m a.s.l. (Fig. 36.2); aragonitic shells of **Hiatella arctica** from this unit were determined to be 7330 ± 80 years old (GSC-1972), a value only marginally older than shells of the same species collected 3 km east of the head of Vendom Fiord by D.A. Hodgson in 1972 (7010 ± 80 years; GSC-1858)[3]. There is thus a difference of roughly 1400 to 1800 radiocarbon years in the age of the earliest marine fauna between the site on Swinnerton Peninsula and the site north of the head of Makinson Inlet. This is a crude measure of the time it took for the lobe of ice occupying the north arm to disappear, although the exact position of the ice front in this arm at 9000 to 8800 years B.P. is unknown.

Not only did a marine fauna formerly penetrate north of what is now the head of the north arm of Makinson Inlet, but coniferous driftwood (**Picea** sp., identified by R.J. Mott) also floated in. At some point in time an ice-dammed lake, far larger than the present lake, existed in the area, but details of the chronology must await radiocarbon dating of organic materials collected from the lacustrine deposits preserved on the flanks of the valley (cf. Fig. 36.10).

One other aspect of chronological studies is worthy of mention. Many of the outlet glaciers that descend towards, and reach, the north arm of Makinson Inlet from the ice cap to the east appear to have retreated recently following a slight advance. In the case of the largest of these lobes in the valley under discussion (Fig. 36.2), numerous intact arctic willows, still rooted in place, are exposed through the thin and discontinuous layer of gravelly boulder till laid down by the glacier (Fig. 36.10). The ice also advanced over peat deposits, so a good chance exists to pin-point the age of this Neoglacial advance more precisely.

Pumice and Driftwood on Raised Beaches

At a site 1.5 km west of the base camp on Swinnerton Peninsula an expanse of raised beaches was found to contain a number of imbedded driftwood logs. In addition two pieces of dark brown pumice were discovered, and instrumental levelling showed them to be at an average elevation of 21.5 m. This is close to the elevation postulated for the 5000 year-old shoreline in this area on the basis of dated driftwood (**Picea** sp., identified by L.D. Gill) logs collected in 1972 at the same site by D.A. Hodgson and a few kilometres to the east by R.B. Taylor (Blake, 1975). At the time of writing no new age determinations are available, but eventually it should be possible to construct an emergence curve for Swinnerton Peninsula and to determine whether the pumice, which appears identical to the material found along the south coast of Ellesmere Island, did in fact reach Swinnerton Peninsula at approximately the same time.

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[1]Identified by T.E. Bolton

[2]Identified by J.V. Matthews, Jr. (Unpubl. GSC. Fossil Arthropod Rep. No. 77-11).

[3]The age of 6980 ± 80 years reported by Hodgson (1973) was prior to the $^{13}C/^{12}C$ ratio being determined, hence the slight change in age.

Figure 36.3. Telephoto view north at the eastern tip of Swinnerton Peninsula and the north arm of Makinson Inlet. Two sites with striated bedrock at elevations between 300 and 345 m are indicated by arrows; at the northern locality shell fragments were abundant in the till overlying the striated bedrock. July 7, 1977. (GSC-203262-B).

Figure 36.4. Telephoto view southeast at Bowman Island from the plateau on the north side of Makinson Inlet. The top of the island is approximately 570 m a.s.l., whereas the ice-capped mountains beyond, on the south side of the inlet, rise to over 1000 m. The shoulder of the island, where Figures 36.5 and 36.6 were taken, is indicated by the arrow. July 9, 1977 (GSC-203262-D).

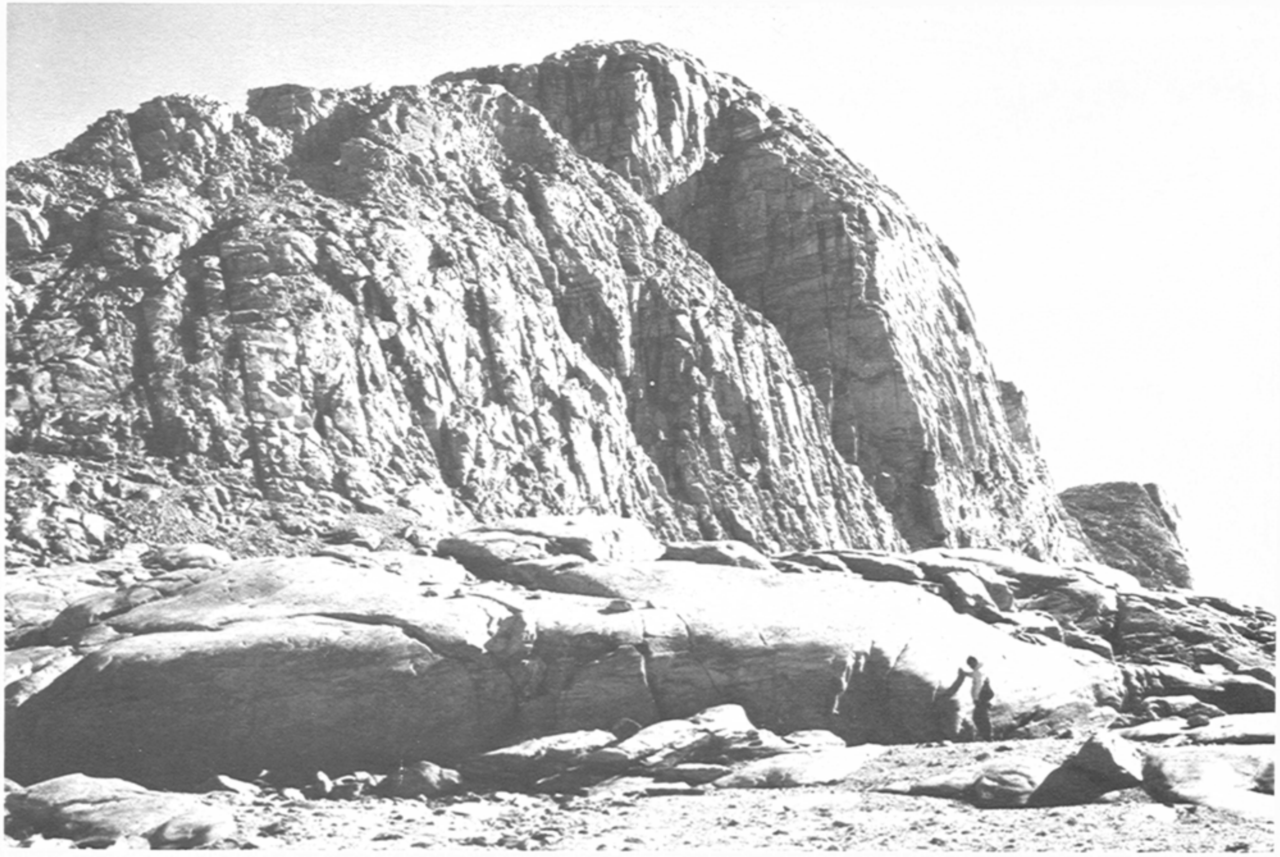

Figure 36.5. View eastward along the south side of Bowman Island, on shoulder at approximately 250 m a.s.l. Note the smoothed and polished granite in foreground. July 14, 1977 (GSC-203262-E).

Figure 36.6. View southward at shaped and plucked outcrop of granite on the shoulder of Bowman Island shown in Figure 36.5, at approximately 260 m a.s.l. Ice flowed from right to left in the photograph (west to east). The plateau (>600 m a.s.l.) in the distance is covered by a thin carapace of ice. July 14, 1977 (GSC-203262-F).

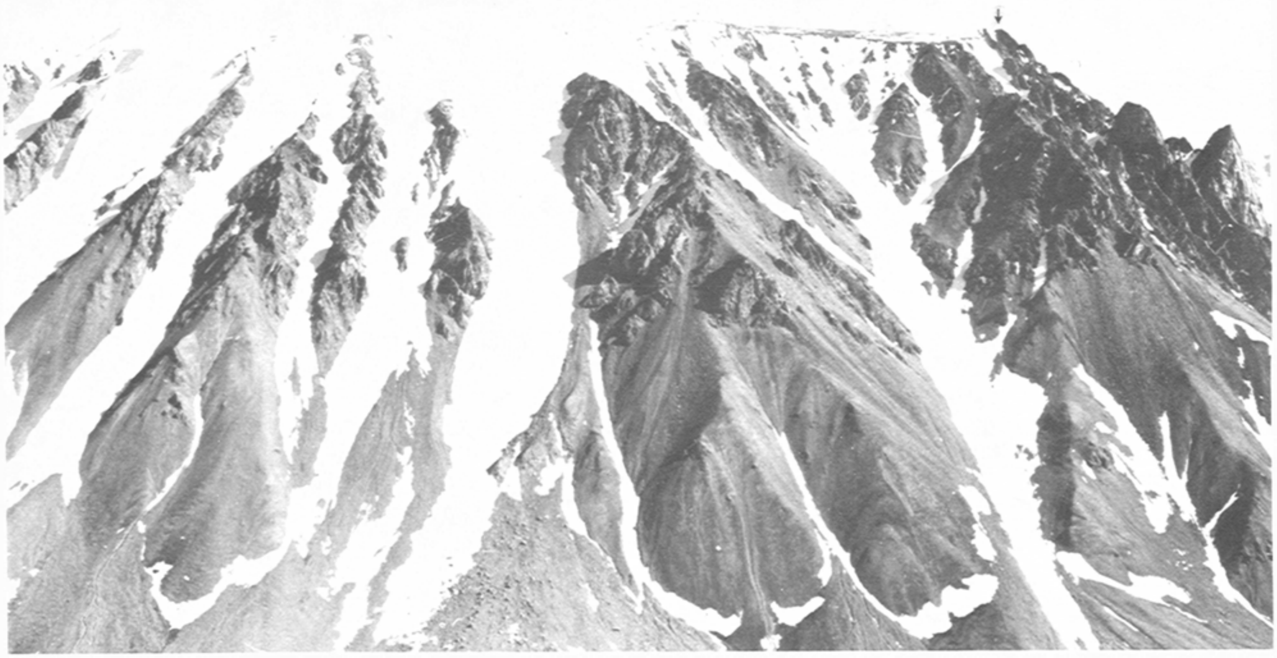

Figure 36.7. View eastward at a typical segment of the plateau along the north side of Makinson Inlet. The top of the small ice cap is more than 975 m a.s.l. The arrow indicates the point from which Figure 36.8 was taken. Numerous Paleozoic erratics are present on the Precambrian bedrock. July 9, 1977 (GSC-203262).

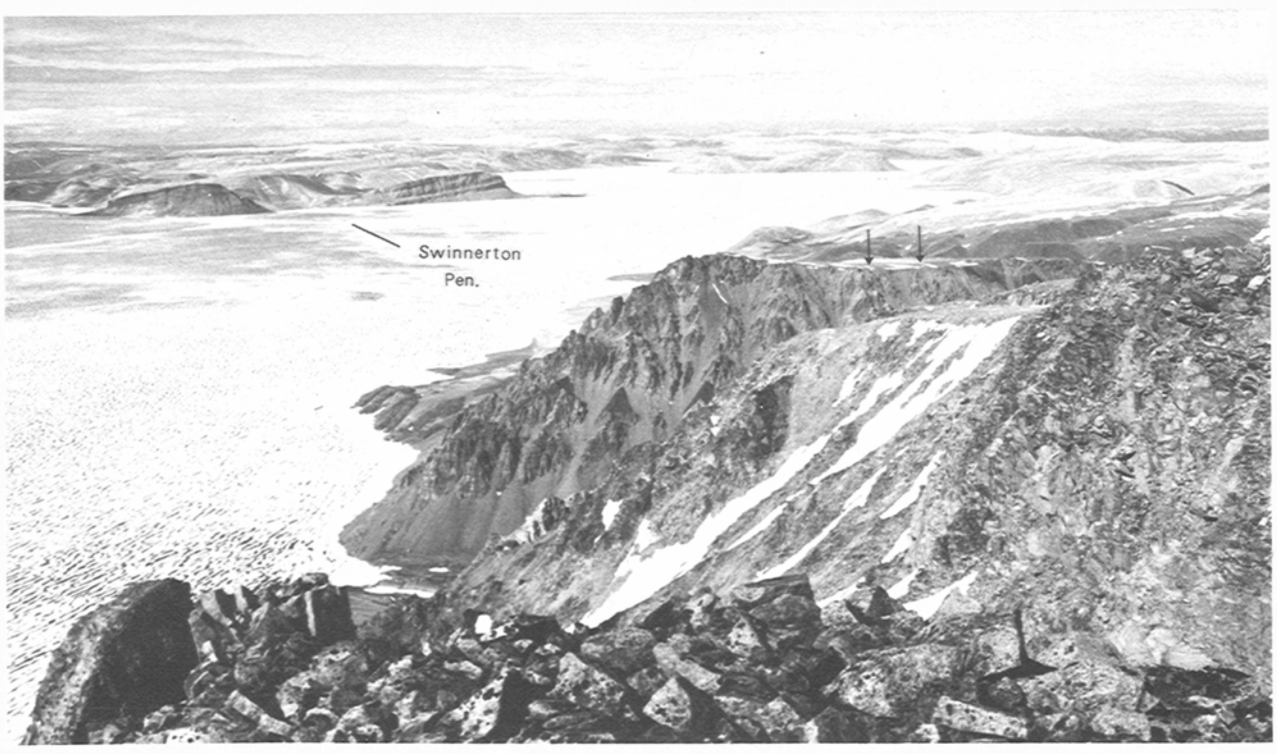

Figure 36.8. View northwest at the eastern tip of Swinnerton Peninsula and the north arm of Makinson Inlet from the point on the plateau indicated in Figure 36.7. The lower segment of the plateau in the foreground (arrows) is characterized by incipient tors or tor-like landforms (cf. Fig. 36.9). July 9, 1977 (GSC-203262-C).

Figure 36.9. View north-northwest at an incipient tor developed in garnetiferous metasediments on the plateau illustrated in Figure 36.8. The elevation of the top of the tor is approximately 525 m. Erratics of granite and Paleozoic rocks (limestone, dolomite, sandstone) are common on the plateau surface and on the tor itself. July 6, 1977 (GSC-203262-A)

Figure 36.10. Telephoto view eastward across the valley north of the head of Makinson Inlet (cf. Fig. 36.2) at terrain dissected by meltwater channels. The outer edge of the area covered by bouldery debris (circles) marks the limit of a Neoglacial advance of this outlet glacier. Between this limit and the ice, numerous in situ, rooted willows have been exposed by recent recession of the glacier. A former ice marginal position of a lobe flowing southward into Makinson Inlet is marked by a concentration of boulders along the hillside (black arrows); lacustrine silt deposits, in which large ice wedges have developed, are exposed lower on the slope (white arrow). August 15, 1977 (GSC-203262-G).

Acknowledgments

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