NEAR-COASTAL AND INCIPIENT WEATHERING FEATURES IN THE CAPE HERSCHEL – ALEXANDRA FIORD AREA, ELLESMERE ISLAND, DISTRICT OF FRANKLIN

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Introduction

On Ellesmere Island along the south coasts of Alexandra Fiord and Buchanan Bay east of the Royal Canadian Mounted Police (RCMP) post are a number of intensely weathered bedrock features (Fig. 1). Included are examples of grus accumulations, spalled crusts, exfoliated joint blocks, differentially eroded dykes, and minor incipient weathering pits. Field studies were carried out during July 1979 to document the nature and occurrence of these features as part of a regional assessment of the influence of lithology and topographic position on the processes and products of subaerial weathering under arid arctic conditions.

Previous studies in this region have included reconnaissance mapping of the Precambrian-Paleozoic bedrock geology by Christie (1962, 1967) and, more recently, by Frisch et al. (1977). Preliminary evaluation of the glacial history has been undertaken by Blake (1977, 1978).

Acknowledgments

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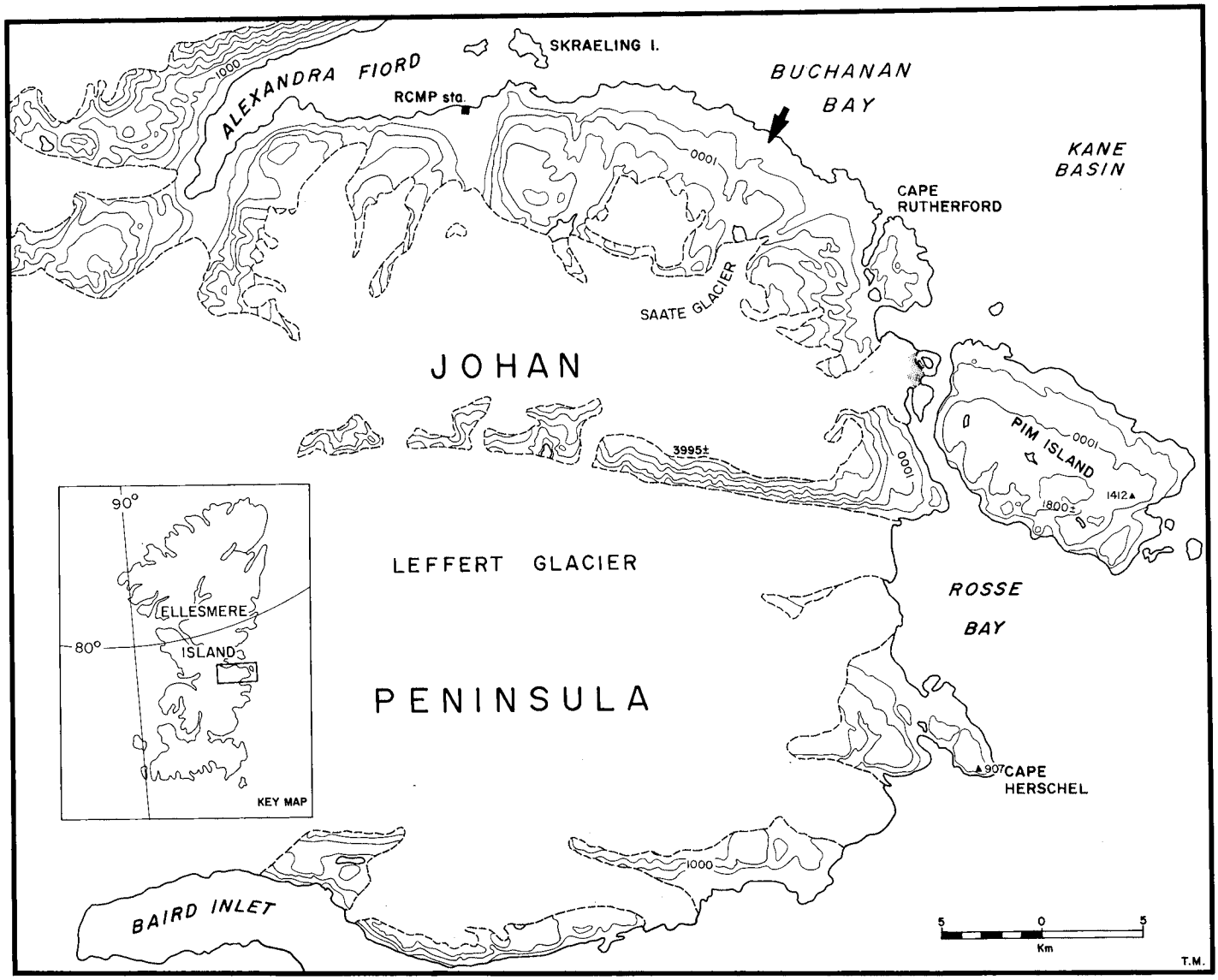

Figure 1. *Field study area. The arrow indicates the position of the ridge whose weathering is illustrated in Figures 2 and 3.*

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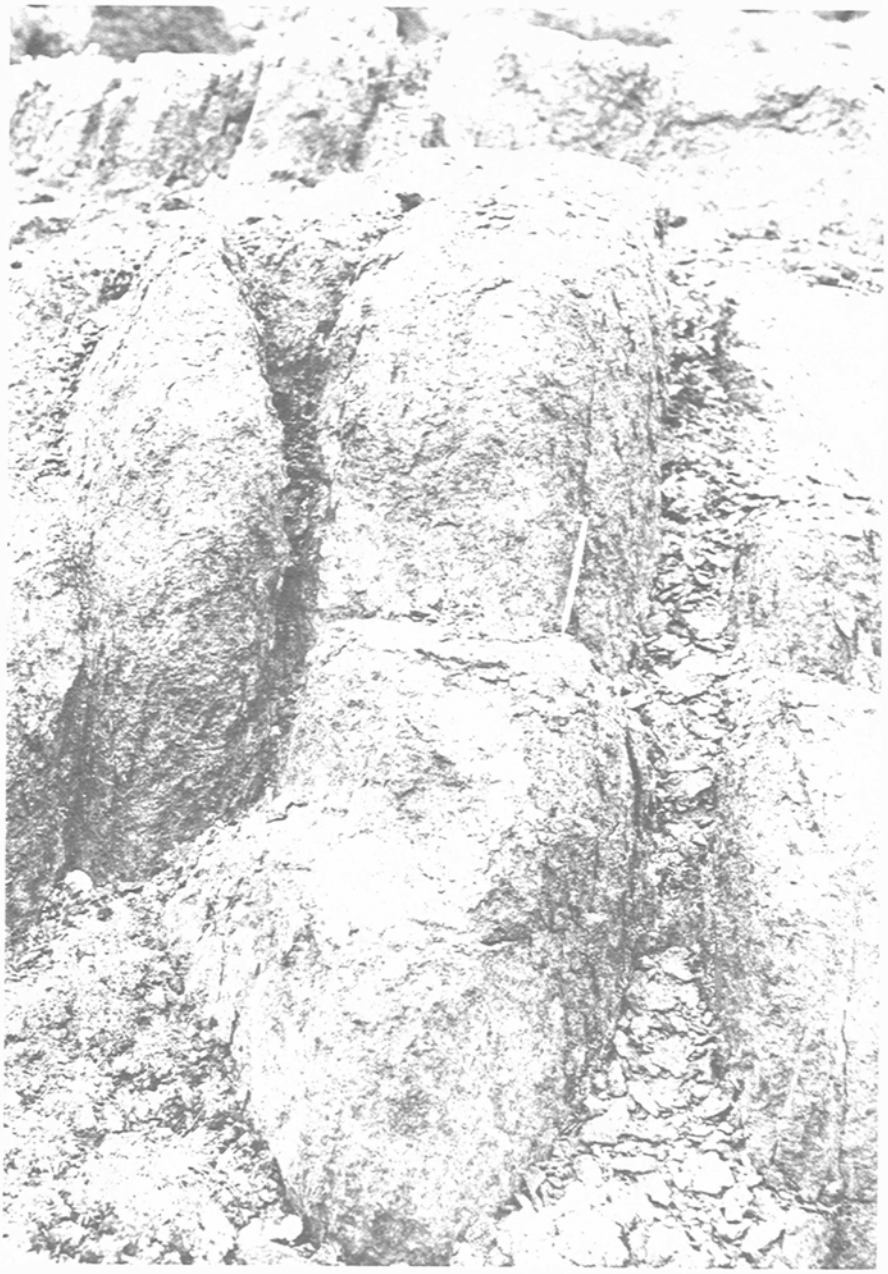

Figure 2

Joint block revealing evidence of disintegration by surface spalling. Although not readily seen in black and white photographs, encrustations of both calcium carbonate and sodium chloride were noted along this ridge (cf. Fig. 1) an on equally intensely weathered outcrops along the south-western coast of Skraeling Island within 20 m of sea level. Salt wedging along joints was also noted at the latter locality. July 17, 1979

Field Observations

The area affords good exposures of quartz feldspar biotite paragneiss merging eastward into more massive, locally gneissic, potassic granite which is particularly well exposed on the plateau on Pim Island and on Cape Herschel (Christie, 1962). Numerous quartz-rich pegmatites are present. More mafic intrusions including granodiorite, diabase, and a rock resembling gabbro in appearance (on Skraeling Island) were noted within the gneiss. Gossan zones containing pyrite, magnetite, and copper sulphides were observed from the air on Skraeling Island and along the north shore of Alexandra Fiord. The study area lies along the northern flank of the Precambrian Shield with lower Paleozoic dolomites, limestones, and sandstones outcropping in steep slopes and vertical cliff faces up to 600 m high across Buchanan Bay to the north. Scattered outliers of Paleozoic strata are preserved at widely varying elevations ranging from within 20 m of high tide level to above 400 m a.s.l. southwest of the RCMP post. An ice cap extends over most of Johan Peninsula to within 2 km of the coast with permanent ice extending to below 750 m a.s.l. Valley glaciers reach to sea level. The broad nature of the valleys suggests that extensive glaciers flowed into Kane Basin via Buchanan Bay.

An interesting example of highly weathered coastal features is an outcrop ridge (Fig. 1-3) approximately 300 m long by 120 m wide by up to 45 m high situated east of a small stream delta draining an ice-dammed lake and part of Saate Glacier (78°52'N, 75°05'W).

During field studies observations also were compiled on the nature of granite exposures on Pim Island and particularly Cape Herschel (Fig. 1). The overridden and deeply sculptured upland surfaces typifying this area have been noted by Blake (1977). Textbook examples of glacial polish, striae, grooves, perched erratics, and roches moutonnées mark the exposures and provide evidence of glacial overriding by southward-flowing late Wisconsin ice (Blake, 1977).

Figure 3. *An exposure about half way up the same outcrop ridge as in Figure 2 (elevation approximately 28 m a.s.l.). Note the difference in degree of physical weathering of adjacent joint blocks. Laboratory data confirm that the unaltered block in the centre of the photograph is a granitic intrusion lacking hornblende but otherwise identical in both composition and texture to the host gneiss. July 17, 1979.*

The condition of the outcrop surfaces in this area immediately following glaciation to a large extent has determined the type of incipient weathering observed in the granite. Many features of glacial erosion on exposures remain intact with virtually no breakdown whatsoever. Preliminary breakdown of the outcrop surface has taken place primarily along joint systems (Fig. 4) and around original breaks in the glacially smoothed surface as, for example, around chattermarks. Localized grus development has resulted from continued flaking on outcrop surfaces. Although glacial polishing appears to hinder direct surface disintegration, flaking has resulted from rock breakdown undercutting surface areas.

That bedrock surface weathering has been limited is attested to by the presence of carbonate crusts up to 0.3 cm thick on both sheltered joint blocks and on exposed faces (Fig. 5; cf. Ford, 1970; Hallet, 1976). These crusts could not have survived intense glacial abrasion and would not likely form on such open, well drained – in places vertical – slopes by evaporation in postglacial time. They are thus believed to be late glacial in origin, formed perhaps during ice stagnation.

Sheeting and exfoliation of bedrock, which would favour further surface weathering, were not widely encountered on the granite outcrop. Plucking has occurred along the distal side of individual outcrop ridges and limited block displacement has resulted. Where standing water occurs, as in upland basins excavated in bedrock or where snowbanks inhibit runoff, in situ frost heaved blocks are evident (cf. Potts, 1970).

Perhaps the most intensely weathered bedrock features in the Cape Herschel – Pim Island area are examples of micropitting covering outcrops in patches up to 10 m across (Fig. 6). A number were noted in the vicinity of Cape Herschel, where they are developed on the up-ice faces of glacially streamlined rock ridges of northerly aspect at various elevations up to 400 m a.s.l. Individual micropits are up to 5 cm across by 2 cm deep but average 2 cm wide by 1.2 cm deep on the basis of 62 examples. Lichens were noted in some micropits. The pits have enlarged through solution and adjacent examples have been joined by continued weathering. Evidence of surface flaking in areas adjacent to the pits was noted. The surfaces on which the pits developed typically slope at 15 to 30 degrees even though the pits commonly have a vertical orientation. Evaluation of aspect, slope, and other environmental conditions suggests that the micropitting has resulted from solution related to snowbank melting in the summer.

Discussion

An initial reaction to the occurrence of the coastal weathering features developed in paragneiss, not only at the site described but also on Skraeling Island and along the north coast of Alexandra Fiord, was that such features were produced over a long period of time and could even be pre-Wisconsin in age, having survived glaciation intact. Their position, however, would apparently preclude this. Any flowage of ice out of the Buchanan Bay area by valley glaciers merging with the main ice mass flowing south out of Kane Basin would have scoured the coastal lowlands along Alexandra Fiord, and particularly Skraeling Island, destroying these features had they predated the last ice advance of the Wisconsin.

Figure 4. *Typical outcrop surface in massive, medium grained granite on the Cape Herschel plateau. Note the smooth unaltered nature of the bedrock with incipient disintegration along joints due to gelifraction. Although not evident in this photograph, minor iron oxides have concentrated as stains along the joints. July 10, 1979. Pen (15 cm) provides scale.*

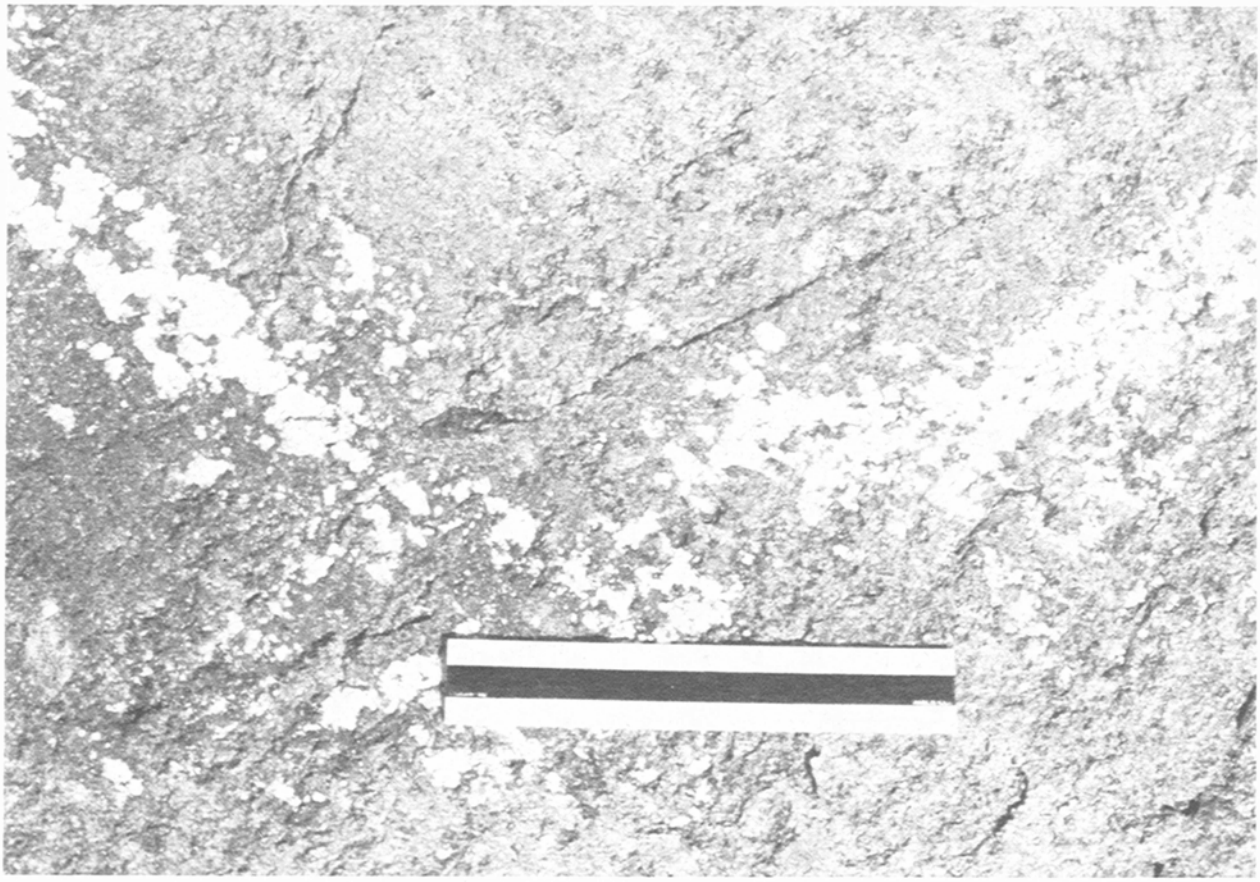

Figure 5. *Carbonate coating on exposed unweathered granite outcrop on west side of upland at 250 m a.s.l. near Cape Herschel station. Photograph was taken on July 10, 1979. Ruler is 15 cm long.*

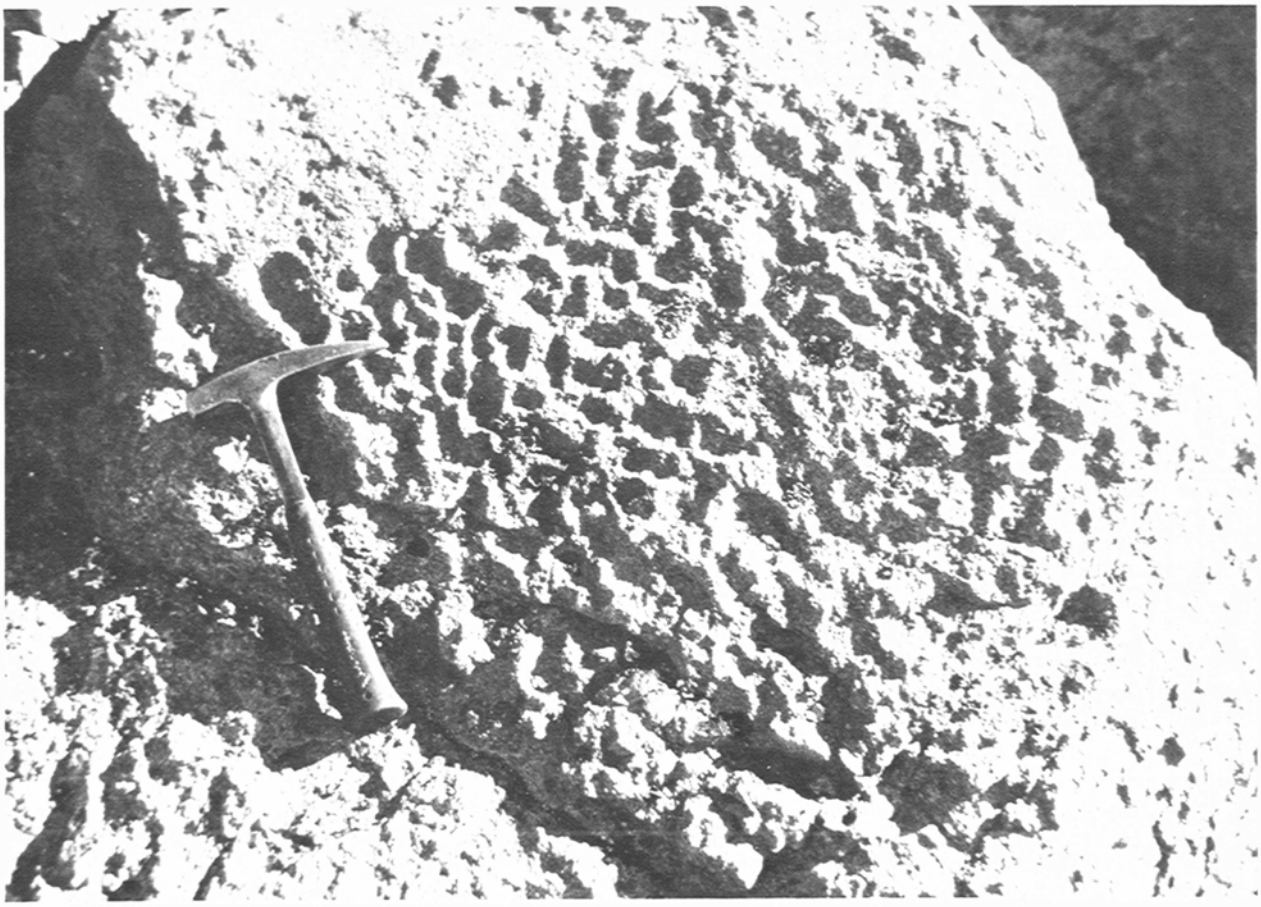

Figure 6. *Close-up view of micropitting developed in a north-facing exposure of granite near the north shore of Cape Herschel peninsula at 55 m a.s.l. This site was beneath the sea 7500 years ago. July 15, 1979.*

Figure 7. *Crusts of sodium sulphate coating till and clay at the edge of a small evaporitic pond located about 10 m a.s.l. on the north shore of Knud Peninsula about 30 km north of the study area. July 26, 1979.*

Marine shells, including single valves and intact pairs of **Mya truncata** (6260 ± 140 years old, GSC-1348), have been collected from sands along a stream immediately east of the RCMP post at about 30 m a.s.l. (Lowdon and Blake, 1973). Shells of the same species collected at 52 m a.s.l. on the north side of Cape Herschel Peninsula are 7210 ± 90 years old (GSC-2525; Blake, 1978). These dates indicate that the bedrock ridge along the coast north of Saate Glacier was beneath the sea in Holocene time (Fig. 1).

In a similar near-coastal position at 10 m a.s.l. efflorescences of sodium salts, including thenardite, were noted in a salt pond several metres across on the north side of the Knud Peninsula 30 km north of the study area (Fig. 7 cf. Nichols, 1969; Tedrow, 1969). It has not been established whether the salts originated from sea spray, from earlier marine incursion, or from Paleozoic evaporite sequences exposed upslope to the south of the site. Davies (1974) has reported similar highly saline lakes in marine silt terraces near sea level in northern Greenland. The mineral mirabilite ($Na_2SO_4.10H_2O$) is the low temperature stable form of sodium sulphate but under drying conditions, as in an arid basin, or in the lab, the mineral readily yields its water, reverting to thenardite (Reeves, 1968). Thenardite also has been identified by X-ray diffraction analysis from material collected in the Lake Hazen area of northern Ellesmere Island (Traill, 1969, p. 560). Elsewhere, in upland areas above both Alexandra Fiord and Cape Herschel, salt encrustations, primarily calcium carbonate and sodium chloride, appear to be mainly concentrated on mafic erratics and may indeed have been derived from leaching of hornblende within the rocks (Bradley et al., 1978). It is thought that intense weathering by salt crystallization at or near – and in some cases initially below – sea level has been largely responsible for the intense weathering of certain lithologies here and elsewhere in postglacial time (cf. Evans, 1970; Goudie, 1974; Birkeland, 1978; Watts, 1979).

Laboratory analyses on water chemistry, bedrock composition, and textural and physical changes accompanying bedrock weathering in the Alexandra Fiord area are currently being completed. An examination of the influence of bedrock lithology and outcrop position, with respect to sea level and to glacial ice, on rates of outcrop weathering under arctic conditions is found in Watts (in press). Incipient weathering features common to coastal granites as reported in this paper no doubt typify exposures of large areas of the Precambrian Shield in Holocene time.

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