LITHOLOGICAL SUITES AS GLACIAL 'TRACERS', EASTERN ELLESMERE ISLAND, ARCTIC ARCHIPELAGO

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Abstract

Morainic debris in the Cape Herschel area contains distinctive lithological suites, the distribution of which can be mapped. It appears that glacial ice from Kane Basin overrode the eastern capes of Ellesmere Island and that eastward-flowing glaciers of the island were deflected southward. The combined ice flows formed a large glacier that emptied southward through Smith Sound into northern Baffin Bay.

Introduction

Field studies of Pleistocene and Holocene features of the Smith Sound region have been carried out by W. Blake, Jr., of the Geological Survey of Canada, since 1977 (Blake, 1977, 1978, 1981). The field work has been based at the Cape Herschel station of the "North Water Project", established in 1973 by the late F. Müller (Müller et al., 1975). The author accepted an invitation to join Blake's field party during the spring of 1982 to study glacial erratic material in the Cape Herschel region; it was expected that at least some of the rock types in the glacially transported debris would be sufficiently distinctive to allow the assignment of 'probable source areas' to them. It was, indeed, soon apparent during field work that at least two contrasting 'suites' of debris can be identified. Mapping of the lithological composition of glacial debris in this region may allow the determination of the courses and limits of former glacial ice flows.

Lithological Suites

The morainic material in the Cape Herschel region is dominated, in most places, by angular and subangular debris from the local bedrock: mainly granitoid gneiss of various hues. This debris represents the exposed Precambrian crystalline 'basement' of the area and is of no diagnostic use at localities on or very near the outcrop. The granitoid debris at such localities will not be considered further here.

The non-granitoid debris contains a wide variety of rocks, mainly of sedimentary origin but including a few igneous rocks. The fragments of sedimentary rock are generally recognizable as representatives of the upper Precambrian and lower Paleozoic formations that are widely exposed in the Flagler Bay – Bache Peninsula region (noted by Blake, 1977, p. 114). The igneous rocks mainly resemble the diabase dykes or sills that are known to intrude both the Precambrian sedimentary rocks and probably derive from beds of the Precambrian Thule Group, which outcrops in the region. Dark grey, green-grey weathering impure limestone or limy greywacke fragments occur at certain places near sea level; outcrops of this distinctive rock are not known in the Bache Peninsula region and the debris may be exotic, transported by floating ice rather than by glacial ice streams.

Two lithological suites can be defined for the Cape Herschel region. 1. A suite, here named the 'Cape Suite', characterized by the presence of a variety of sedimentary rocks probably derived from both the lower Paleozoic beds of the region and the Precambrian Thule Group. 2. A suite, here called the 'Inland Suite', that represents the lower Paleozoic formations of the region and in which Thule Group rocks appear to be absent.

Cape Suite

The non-granitoid debris of the Cape Suite comprises, in addition to representatives of lower Paleozoic sedimentary formations (described later under 'Inland Suite'), an assortment of distinctive rocks that includes[1]:

1. White, fine grained quartzite with a pinkish cast.
2. Intraformational conglomerate: round red carbonate clasts in a lighter-coloured matrix; weathering reddish to purplish white.
3. Dark red shaly quartzite.
4. Platy, fine grained white sandstone with ripple marks; weathering yellow to white.
5. Pink, yellow, green and white weathering, domal-banded algal rock.
6. Light green ooidal-fragmental rock with white calcite matrix; weathering with a scoriaceous surface.
7. Green and red slaty shale.
8. Maroon slaty shale.
9. Oncolitic dolomite; weathering light green.
10. Dolomite with quartz and chert grains; weathering greenish grey.
11. Purple sandstone, poorly sorted but with well rounded grains and pink feldspar grains.
12. Dark, green-black, fine- to medium-grained diabase; weathering dark yellow-brown to green-brown.
13. Dark green-grey volcanic rock with green amygdules (mineral not identified).
14. Dark purplish volcanic? rock with green mineral patches (mineral not identified).

Rocks similar or identical to those listed above have been observed in the Rensselaer Bay Formation of the Thule Group (Christie, 1967; Dawes, 1976; Peel et al., 1982). Beds of this unit are well exposed in the south-coastal cliffs of Bache Peninsula (Christie, 1967).

Inland Suite

The Inland Suite of glacial erratic debris contains variable amounts (rare to abundant) of sedimentary rock that can be ascribed to the lower Paleozoic formations of the region. The older (Rensselaer Bay Formation) rocks of the Cape Suite are not represented, although a few specimens

[1] The descriptions listed here are based on field notes. Limestone and dolomite were differentiated in the field by means of dilute HCl.

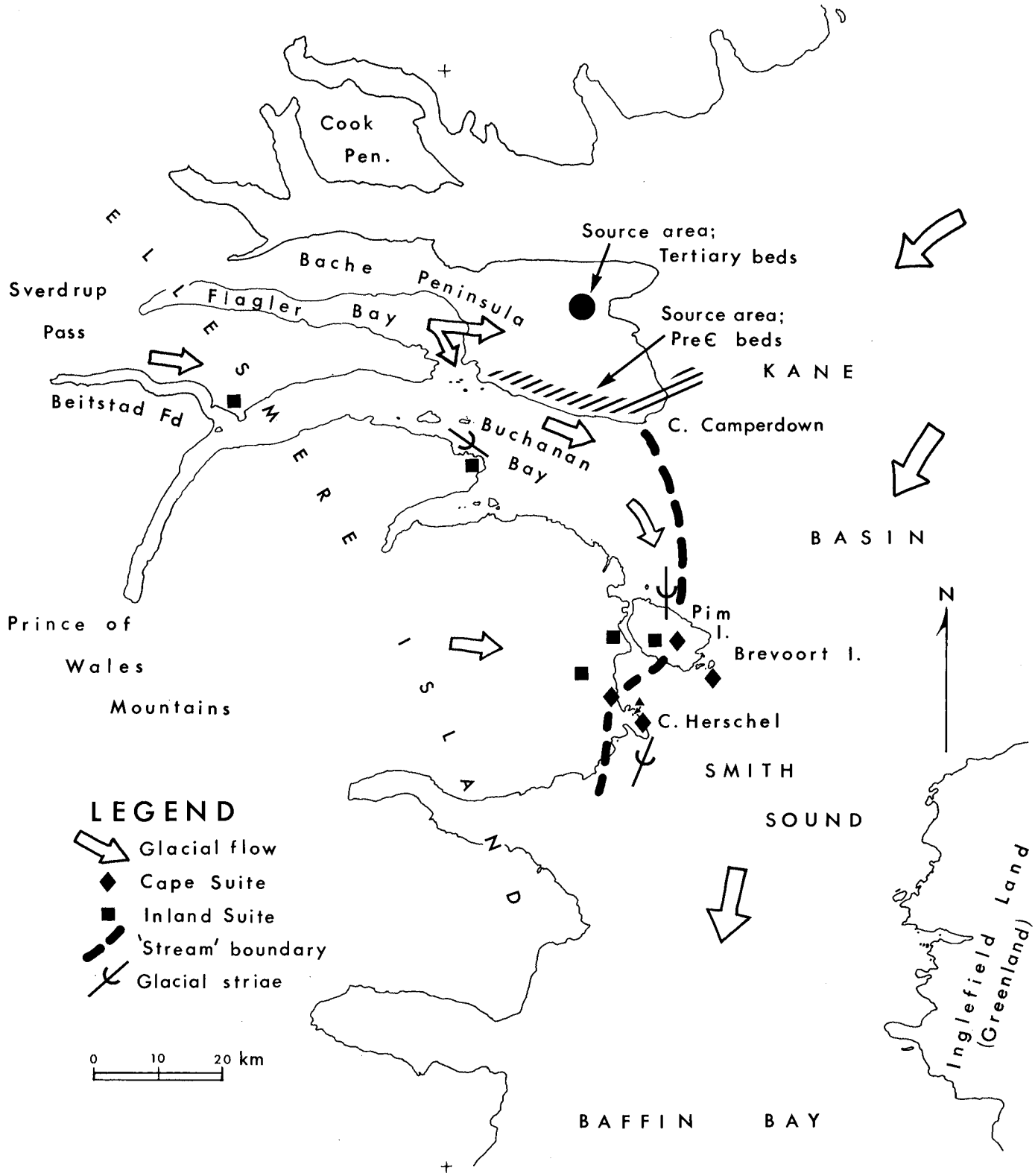

Figure 55.1. *Distribution of lithological suites in glacial debris, and some source areas, Cape Herschel region, Ellesmere Island.*

were found that may be assigned to the older unit. A partial list (based on field descriptions) of rocks typical of the Inland Suite follows:

1. Light violet-grey to grey, very fine grained limestone; weathering pale brown.
2. Grey, fine- to medium-grained limestone; weathering grey-black.
3. Grey, fine grained sandy limestone; weathering greenish grey.
4. Very pale yellow-white, medium crystalline dolomite; weathering orange.
5. Fine grained, grey limestone intraformational conglomerate with scattered round quartz grains; weathering green-grey.
6. Light grey to grey, fine grained dolomite with domal laminae; weathering pale yellow to pale green.
7. Light grey to grey-yellow, medium crystalline dolomite that breaks into flat plates; weathering pale yellow.
8. Grey, very fine grained limestone with dark grey partings and a silty? pattern standing out on weathered surface; weathering pale brown.
9. Grey, medium crystalline oolitic limestone with medium sized rounded quartz grains; weathering green-grey.
10. Dark grey, medium grained sandstone; weathering dark grey.

The suite of rocks listed above clearly represents the Cambrian to Ordovician formations of the Flagler Bay region (see Christie, 1967). The Cambrian and younger units are exposed over almost all of Bache Peninsula and over much of Knud Peninsula (south of Flagler Bay), and scattered outliers of these rocks occur in the rugged mountains south of the line of Beitstad Fiord and Buchanan Bay (Christie, 1962; Frisch et al., 1978).

Some confirmation of the usefulness of lithological suites as tracers for erratic trains became available from a reconnaissance visit by W. Blake, Jr., to Cook Peninsula, north of Bache Peninsula. A collection of glacial debris (the site was not visited by the writer) contained a suite of rocks markedly different from either the Cape or the Inland Suite. Sedimentary rocks exposed to the northwest, in the probable source area, are known to contrast with those of the Bache Peninsula region (Trettin, 1978, 1979).

Glacial Flow in the Cape Herschel Region

Glacial erratic 'trains' can be mapped in east-central Ellesmere Island, it appears, from the distribution of rock types in the surficial debris. The Cape Suite, described above, is here taken to be such an erratic train; rocks of the Inland Suite, although also present with the Cape Suite, can also be considered as a train. The distinctive lithological characteristics of the erratic trains, and of the probable source area of eastern Bache Peninsula, allow some tentative conclusions on the flow of ice in former glacial times.

Bache Peninsula and Other Source Areas

The lithologically distinctive beds of the Precambrian Rensselaer Bay Formation of Bache Peninsula and Inglefield Lands, with the limited areal extent of the unit (Fig. 55.1), make this formation useful in tracing glacial streams. The Paleozoic rocks, in contrast, are very widely distributed in outcrop and are more or less ubiquitous in the morainic debris of the coasts. Of very limited, almost 'point' distribution, are the Tertiary Eureka Sound beds of eastern Bache Peninsula (Christie, 1967, Map 1188A). This distinctive unit might be expected to provide good tracer debris, but the weakly lithified beds probably produced few large erratic fragments and the fragments almost certainly were short-lived, rapidly broken down to unrecognizable fines.

The Rensselaer Bay Formation, in addition to its outcrops on land as noted, must also form submarine outcrops in southwestern Kane Basin. This submarine source area may now be mantled by glacial and marine deposits.

Glacial Ice Flow

The source area for the Cape Suite probably lay along the south coast of Bache Peninsula or in southern Kane Basin, or in both places. A line extended northward from the western limit of the Cape Suite to the south-coastal outcrop area resembles or suggests a medial moraine trending southward from Cape Camperdown (Fig. 55.1). Such a moraine (or boundary between ice flows) would, presumably, lie between ice flowing southeastward through Buchanan Bay and ice flowing southward in southwestern Kane Basin. A polynya that can be seen off Cape Camperdown may be evidence of shallow water due to such a moraine ridge.

The delineation of the ice flow boundary in Figure 55.1 is based on data from rather few points and is therefore tentative and subject to modification. A question arises concerning the reason for an apparent westward bulge of the boundary near Cape Herschel. A possible explanation is that Pim Island may have acted as a barrier, behind which Kane Basin ice pushed westward at some stage.

Field confirmation of a southward flow of ice from Bache Peninsula to Cape Herschel was found in a small col atop the cape: fragments of brown sandy shale with black, carbonaceous markings. These fragments probably derive from the Eureka Sound beds of the peninsula. It is here suggested that Flagler Bay ice at some stage overrode the broad head of Bache Peninsula and swept Tertiary rock debris eastward onto south-flowing Kane Basin ice. Such a flow direction was earlier suggested (Christie, 1967, p. 7) to account for red granite erratics and 'old' shell debris on the uplands of eastern Bache Peninsula.

The probable Eureka Sound erratic debris was found, however, at about the local limit of marine submergence (somewhat above 100 m, W. Blake, Jr., personal communication) and the possibility that it was floated into place by sea ice must also be considered.

The hypothesis of a southwestward flowing Kane Basin ice stream meeting an eastward-flowing Ellesmere Island stream and the two combining to flow southwestward through Smith Sound has some interesting corollaries:

a. Greenland and Ellesmere Island glacial ice met, probably during a 'young' (just prior to deglaciation about 9000 years B.P., Blake, 1981) glacial stage.
b. The glacial junction crossed Pim Island and Cape Herschel so that the Kane Basin stream must have dominated. The filling of Kane Basin by glacial ice and the deflection southward of Ellesmere Island ice was earlier deduced by Blake (1977, p. 114) from the directions of glacial striae on Pim Island and Cape Herschel.

The southward flow of glacier ice through Smith Sound and the modification of an older, now drowned, drainage system was proposed by Pelletier (1966) from a study of submarine topography.

The domination of Kane Basin ice over that from south of Bache Peninsula could be expected for the following reasons. Firstly, Kane Basin is a large (over 200 km in length) inland sea into which the enormous Humboldt Glacier empties and, during glacial times, glaciers from a large area

of Ellesmere Island north of Bache Peninsula must also have flowed into the basin. Secondly, the greater 'cryodynamic head' available to Kane Basin ice, with much of its large drainage basin lying at the high elevations of interior Greenland, could be expected to result in Kane Basin ice overwhelming the ice flow from the relatively small area of the Prince of Wales Mountains and Sverdrup Pass.

The question of the age of the glaciation that produced the prominent and fresh-appearing glacial features of the Cape Herschel region is under active study (Blake, 1977, 1981).

Postglacial Drift

A distinctive rock type was noted among erratic debris at low elevations: dark green-grey weathering, medium grained, limy greywacke or impure arenaceous limestone. This rock was observed in beach deposits at the Cape Herschel camp and on Brevoort Island, always in small amounts and occasionally as large (about 20 cm) slabs. Beds of this rock type are found in the Silurian and younger Imina Formation, a unit exposed east of Cañon Fiord (Trettin, 1978, 1979) and on Judge Daly Promontory (Christie, 1974; Kerr, 1976), parts of Ellesmere Island northwest and north, respectively, of Bache Peninsula. The debris may have been carried southward along Nares Strait by floating ice in postglacial times. Sea ice drifts southward in the strait today (Ito and Müller, 1982).

It would also be reasonable to suppose that some debris from east of Cañon Fiord could be carried into Kane Basin by glacial ice flowing through such channels as Princess Marie Bay or Dobbin Bay (north and northeast of Bache Peninsula). Glaciers in these channels lie to the south of the 'drowned watershed' of Pelletier (1966) and would tend to join south-flowing ice.

Conclusions

The mapping of lithological suites in the glacial debris of east-central Ellesmere Island can be useful in determining the glacial history of the region. The distribution of the suites of erratics and the directions of striae in the Cape Herschel area can be accounted for by supposing that two major ice flows were present, one flowing eastward from the Prince of Wales Mountains and Sverdrup Pass region, and the other southwestward from Kane Basin. The southward deflection of the Ellesmere Island ice suggested by Blake is confirmed by the glacial erratic trains, and the boundary between the two glacial ice flows at some stage lay along the east coast of Ellesmere Island. The combined ice evidently moved southward through Smith Sound into northern Baffin Bay.

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