COMPOSITIONAL VARIATION OF DEBRIS IN GLACIERS, BYLOT ISLAND, DISTRICT OF FRANKLIN

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Abstract


A pilot study to define variations in composition of glacial debris was carried out on outlet glaciers that flow from high-grade metamorphic terrane onto sedimentary terrane on the southwest side of Bylot Island. Preliminary observations indicate that 1) debris in lateral moraines of four of the five glaciers sampled has differing and distinct trace element geochemistry; 2) there are significant vertical compositional changes in debris bands in the glaciers; and 3) more than 98 per cent of the sand and coarser debris in the ice and moraines is derived from the metamorphic terrane.

Introduction

In 1977 reconnaissance and sampling of five glaciers and their end moraines were carried out on the southwest side of Bylot Island (Fig. 15.1). All glaciers drain basins within the central ice mass, which overlies rugged, highly metamorphosed Archean and/or Aplebian bedrock terrane (Jackson et al., 1973; Jackson and Davidson, 1975). Four of the glaciers studied extend as narrow, lobate bodies up to 15 km onto gently rolling terrain (Fig. 15.2) underlain by poorly consolidated Cretaceous and Tertiary sandstone and siltstone with some coal measures. The snout of the westernmost glacier studied overlies Helikian sandstone, shale, and dolostone. Major objectives of the study were to ascertain (1) at what distance down-ice from the gneiss-sedimentary rock contact the younger rock types became a significant part of the glacial load, (2) how the concentrations of various lithologic components varied vertically in the numerous debris bands in two of the five glaciers, and (3) how the composition of lateral moraines varied around the depositing glacier, as well as from one glacier to another, and how their composition and degree of weathering compared to those same properties of debris in transit in the ice of the two glaciers sampled in profile.

Preliminary Results

At present, trace element concentrations of clay sized (<4 μm diameter) particles have been determined by atomic absorption after a hot HNO₃-HCl leach.* for lateral moraines of five glaciers and for several profiles collected from the debris bands (Fig. 15.3) of Aktineq and "Camp" glaciers (Fig. 15.1). In addition, trace element contents of heavy mineral separates (s.g. >3.3) from fine sand (0.063-0.250 mm) have been determined as well as preliminary textural parameters and X-ray diffraction data for samples collected in profile.

On the southeast side of the snout of Aktineq Glacier, a gully exposes several layers of peaty material lying in growth position on till (?) and fluvial and eolian sand and gravel. Dates on the lower organic beds are 7860 ± 100 and 7450 ± 230 ¹⁴C years (GSC-2341, GSC-2377), and a date on the uppermost peaty layer, 2 m higher in the section, is 930 ± 70 ¹⁴C years (GSC-2397). Because large boulders from the lateral moraine of Aktineq Glacier lie on sediment covering this uppermost unit, it is concluded that the glacier snout is as far out onto the lowlands as it has been in the past 7000 years and that the till in the outer portion of the lateral moraine is very young.

From megascopic observations, all samples collected appear to be composed of more than 99 per cent Precambrian detritus, regardless of the distance of glacial flow over the younger bedrock. The debris bands on Aktineq and "Camp" glaciers show striking changes in colour and texture vertically; many debris bands contain clasts of highly deformed to virtually undeformed outwash, one piece of which was found more than 30 m above the base of "Camp" glacier. This clast of outwash was capped with fibrous peat which was dated at 120 ± 120 ¹⁴C years (GSC-2529, uncorrected).

Trace element contents of clay from lateral moraines indicate that two glaciers drain chemically similar bedrock terrane but that significant differences exist among the other three, suggesting that the five glaciers drain four geochemically different bedrock basins (Fig. 15.4). Trace element contents of clay from samples of englacial debris from the two glaciers profiled are similar to the contents in clay from their lateral moraines. Although the profiles sampled are from glaciers less than 10 km apart, they show trace element concentrations that are distinctly different, "Camp" glacier being markedly enriched in Cr, Fe, and Ni and to a lesser extent in Cu and Zn (Fig. 15.5). Preliminary

* Analyses by Bondar-Clegg & Co., Ltd., Ottawa.
analysis of X-ray diffraction data for the <4 μm fraction of these samples suggests that there may be an enrichment in the mixed layer or expandable clay minerals (typical of Cretaceous and Tertiary terranes) in samples from Aktineq Glacier, although both suites of samples are dominated by a chlorite-10Å mica (illite?) clay mineralogy. Thus, the generally lower metal values of Aktineq Glacier may be caused as much by dilution by metal-poor clays of local (Cretaceous-Tertiary) derivation as by basic differences in the geology of the Precambrian source areas. Eight samples of the Cretaceous to Tertiary rocks (collected by H.R. Balkwill) contain less than 30 ppm Cu, Pb, and Ni, 5 ppm Co, 85 ppm Cr, 100 ppm Zn, and 2.8 per cent Fe. The presence of numerous, rusty, weathering, sulphide-bearing gneissic boulders around "Camp" glacier, and the scarcity of these around Aktineq, however, tends to support the relationship of high metal levels to mineralization. Seventeen rusty boulders collected near "Camp" glacier contain up to 780 ppm Cu, 230 ppm Co, 240 ppm Cr, and 580 ppm Ni. Thirteen of the seventeen contain more than 300 ppm Cu.

These results support a suggestion made by E.B. Evenson (pers. comm., 1977) that englacial debris in alpine or outlet glaciers might be used to discover mineralization hidden beneath ice caps in their catchment areas, i.e. that till in moraines of present or past alpine glaciers or englacial sediment might be used in a fashion similar to stream sediments to map or discover the abnormal geochemical responses associated with mineralization within a drainage basin.

Heavy mineral (s.g. <3.3) content of the sand fraction from the lateral moraines of the five glaciers is very high in all samples (3 to 25 per cent by weight), and the heavy mineral suite is dominated by more than 90 per cent garnets and magnetic minerals with minor amounts of pyroxenes. Mineralogical and chemical analyses of these fractions are thus certain to reflect overwhelmingly the nature of the high-grade metamorphic Precambrian terrane from which these minerals predominantly were derived. Trace element analysis and visual scans of heavy mineral mounts of this fraction, however, suggest that sulphide or other labile components that may have been present in the lateral moraines have been destroyed in most samples by weathering. The variations in total contents (by weight) of heavy and magnetic minerals suggest that these, like the trace element values, vary in a systematic way from glacier to glacier.

Figure 15.2.
East side of "Camp" glacier where it leaves the mountains and flows onto the gently rolling lowlands. Glacial flow is from upper right to lower left. (GSC 203226-F)

Figure 15.3.
Ice cliff on west side of "Camp" glacier. Glacial flow is from left to right. (GSC 203226-G)
Figure 15.4. Frequency histograms of selected trace element distributions in the <2\mu m fraction of till from lateral moraines of five glaciers. Horizontal scales are in ppm, except Fe, which is in per cent.

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Figure 15.5. Frequency histograms of selected trace element distributions in the <4\mu m fraction of debris in transport in Aktineq and "Camp" glaciers. Horizontal scales are in ppm, except Fe, which is in per cent.

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Figure 15.6. Vertical variations in trace element content of <4\mu m fraction of debris in transport, east side of Aktineq Glacier. Vertical scale is true ice thickness above base of exposure. Horizontal scales are in ppm, except Fe, which is in per cent.
Analyses of clay from profile samples of "Camp" and Aktineq glaciers confirm what was evident from colour and textural contrasts in the field—that composition varies significantly vertically from debris band to debris band (Fig. 15.6). Similar variation has been noted by profile sampling of Wisconsinan till sections elsewhere in Canada (e.g. Shilts, 1976; Podolak and Shilts, 1978). It is probable that such regular vertical variations reflect stacking of debris bands of various thickness with minimal postdepositional disturbance. Furthermore, each debris band can represent the erosional tapping of some small part of the subglacial bed. This was illustrated strikingly by bright green debris bands located some 20 m above the base of "Camp" glacier and several kilometres down-ice from the nearest Precambrian source. The band was found to be markedly enriched in chlorite, Fe, and Mn relative to other debris bands above and below it.

Once formed, a debris band may persist for considerable distances downglacier with little or no addition of local material. In this connection it is of note that even the thick basal layers of debris-charged ice near the snout of Aktineq Glacier contain Precambrian detritus with no noticeable local component, even though exposures are more than 15 km from the nearest Precambrian outcrops. The expansible minerals found in the clay fraction of this debris indicate, however, that a local component is present and that provenance studies based on analysis of coarse debris (Boulton, 1970; Souchez, 1971) should be complemented by lithological analysis of fine fractions of the debris.

Conclusions

Because of the preliminary and incomplete nature of these data, conclusions from this phase of the glacier sedimentation study are general.

1) Bylot Island glaciers carry debris that can be related distinctly to their catchment areas in highly metamorphosed Precambrian terrane, despite the location of samples a few to 15 km onto chemically and lithologically dissimilar Cretaceous, Tertiary, and Helikian rocks.

2) Debris bands carry material that has been transported significant distances with little disturbance from adjacent bands or addition of debris from the base of the glacier.

3) The composition of debris bands varies vertically in a regular way, in much the same manner that previously deposited, apparently homogeneous till varies elsewhere in Canada. The variation within one glacier is, in this case, less than the significant compositional variation among glaciers.

4) Lateral moraines have compositional characteristics that are related closely to the debris in transit in adjacent glaciers. Some of the more labile minerals, such as sulphides, may have been removed from them by weathering.

5) Aktineq Glacier was as far advanced from the mountains during the past 500 years as at any time in the previous 7000 years.

References

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Podolak, W.E. and Shilts, W.W.

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