Current Research (1987) Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, pages 1-9

QUATERNARY MAPPING AND DRIFT EXPLORATION IN THE EASTERN PART OF THE CENTRAL MINERAL BELT, LABRADOR

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Quaternary Geology Section

ABSTRACT

Quaternary mapping was conducted over a 1850 km² area in the eastern Central Mineral Belt of Labrador (NTS map areas 13K/9 and 13J/12). Three distinct terrain types were identified: 1) below approximately 100 to 125 m a.s.l. in the Kaipokok River valley, red silt and clay of marine origin dominate; gravel ridges occur throughout the area; marine limit was 152 m a.s.l., as defined by a storm beach, 2) between 100 to 125 m and 300 m a.s.l., boulder-covered glacigenic sediments occur; cross-valley moraines of uncertain origin are common, and eskers occur in most valleys, and 3) above 300 m a.s.l. barren uplands occur and surficial sediments are rare; the most recent flow event is northeastward, although earlier flows were noted.

The terrain variation is interpreted to be a reflection of a regional ice-flow event toward the northeast followed by either a separate glacial advance or glacial retreat through the valleys. Marine inundation affected the area below 152 m a.s.l., although ice remained inland.

Drift-exploration programs in the area should recognize terrain changes and adjust programs accordingly to avoid reaching erroneous conclusions. Clast dispersal of up to 110 km was determined by indicator rock types.

INTRODUCTION

Quaternary mapping at the 1:50,000 scale in the eastern part of the Central Mineral Belt of Labrador marks a shift in emphasis in the approach to Quaternary exploration by the Newfoundland Department of Mines and Energy. Projects during the first two years of a five-year Canada–Newfoundland Mineral Development Agreement ranged from studies of dispersal patterns from a deposit of known extent and character (Batterson *et al.*, 1985), to tracing mineralized float to a previously unknown source (Batterson and LeGrow, 1986).

In 1986 this approach was superseded by one that considers a larger geographic area that has been the traditional focus of mineral exploration in Labrador. The need here is not for site-specific examination but for a regional appreciation of the Quaternary geology, the geochemical and sedimentological character of glacigenic sediments, and the transport of materials throughout the area. This combined approach is in direct support of a mineral exploration industry that traditionally has had limited perceptions of the effect of glacial processes on lithological and geochemical dispersal patterns.

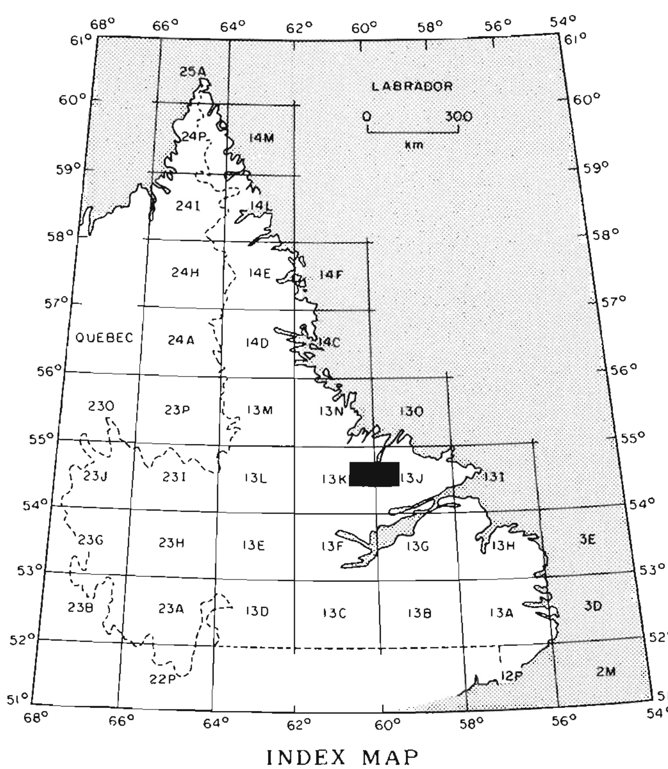

Figure 1: *Location of study area.*

Location, Access and Physiography

The study area is covered by 1:50,000 scale NTS map sheets 13K/9 and 13J/12 (Figure 1). It lies between 54°30'

This project is a contribution to the Canada–Newfoundland Mineral Development Agreement, 1984–1989

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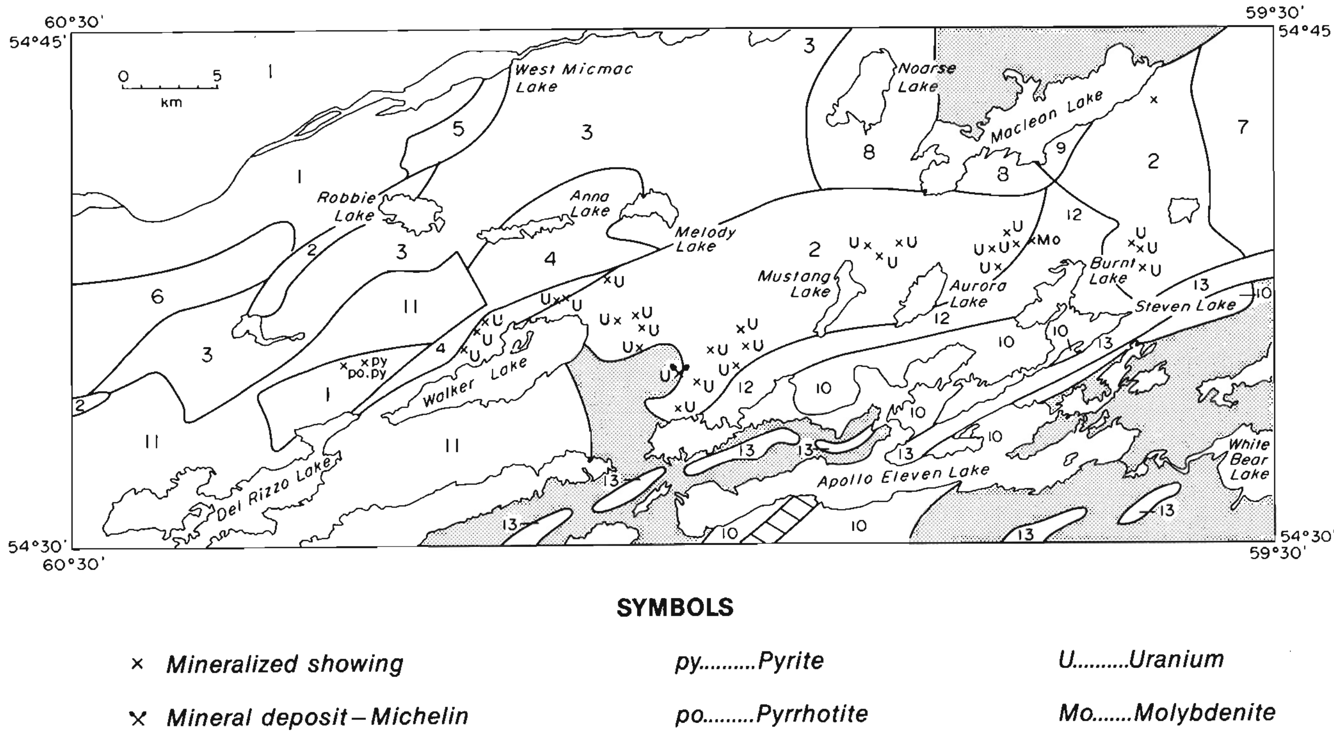


Figure 2: *Generalized geology map of the eastern part of the Central Mineral Belt (after Kerr, 1986).*

and 54°45' north latitude and 59°30' and 60°30' west longitude, and comprises a surface area of 1850 km². Access to the area is by float plane or helicopter, although the northern part of the field area can be reached by boat along Kaipokok Bay. Base camp was at the Brinco mining camp on Melody Lake, which is situated about 150 km north of Goose Bay and 40 km south-southwest of Postville.

Physiographically the area is diversified, ranging from wide valleys filled with marine sediments and extensive boreal forest to uplands reaching over 610 m above sea level (a.s.l.) that have a sparse vegetation coverage. This difference has been recognized by Lopoukhine *et al.* (1977), who contrasts the Benedict Mountain region, which stretches from White Bear Mountain through to Michelin ridge, with the Postville region, which essentially covers the remainder of the study area. Climatically, the area has an interior Labrador climatic regime (Banfield, 1981). Winters are long and severe, whereas summers are short and cool (12°C mean). Annual precipitation is 900 to 1100 cm with a summer maximum. Coastal fog is common and a hinderance to field work.

Previous Quaternary Research

This area of Labrador, like so many, has received relatively scant attention despite its long history of mineral exploration. Klassen (1983, 1984) has provided the most complete data, including striae in the Melody Lake area that trend generally northeastward. This trend is consistent with findings of others (e.g., Fulton *et al.*, 1980a,b; Vanderveer, 1982). Klassen (1983) suggests that the last regional flow event was superseded by a topographically controlled event that emplaced a series of ribbed or Rogen moraines within several of the major valleys that transect the area.

Bedrock Geology and Mineral Deposits

The Melody Lake area lies within the Central Mineral Belt (Greene, 1974) of Labrador, a zone of supracrustal and associated intrusive rocks that constitute the eastern part of the Churchill Province, the northern part of the Grenville Province and the Makkovik Province. The region has been the focus of numerous detailed geological mapping programs related to mineral exploration and to a number of more regional programs (Gower *et al.*, 1982; Ryan, 1985; Kerr, 1986). The following represents a brief summary of their work.

The study area is subdivided into four broad geological entities (Figure 2). The northwestern part of the area contains Archean basement rocks, which comprise layered quartzofeldspathic gneisses and amphibolites. Supracrustal rocks of Early Proterozoic age, defined as the Aillik Group, occur through the central part of the area between Walker Lake and Maclean Lake. The Aillik Group consists of felsic volcanic and volcaniclastic rocks, and minor metasedimentary and mafic volcanic rocks. North of the Aillik Group are pink, foliated, K-feldspar-porphyritic granites and equigranular leucogranites that form part of a suite of rocks called Makkovikian granitoids, intruded during the Makkovikian orogeny (Gower and Ryan, 1987). Granitoid rocks belonging to the Trans-Labrador batholith intrude the earlier rocks posttectonically and dominate in the study area. These rocks are generally undeformed to weakly foliated and contain a

LEGEND *(FIGURE 2)*

EARLY TO MIDDLE PROTEROZOIC

Obscured by drift

13. Michael Gabbro

Trans Labrador Batholith

12 *Fine grained quartz monzonite to granite*

Benedict Mountain Intrusive Suite

11 Otter Lake–Walker Lake granite

10 *Pink, equigranular, alkali-feldspar leucogranite*

9 *Pink to white biotite–hornblende granite*

8 *Gray to brown granodiorite to adamellite*

Adlavik Intrusive Suite

7 *Brown to gray K-feldspar-porphyritic syenite*

6 *Diorite and monzodiorite*

5 *Gabbro and leucogabbro*

EARLY PROTEROZOIC

Makkovikian Granitoids

4 *Foliated granodiorite*

3 *Pink, foliated, K-feldspar granite*

Supracrustals

2 Upper Aillik Group

ARCHEAN

1 *Quartzofeldspathic gneiss*

wide variety of rock types including gabbro, diorite, leucogranite and quartz monzonite. The youngest rock unit in the area is the Michael Gabbro, which postdates the Trans-Labrador batholith and was metamorphosed during the Grenvillian Orogeny. A discontinuous ridge of Michael Gabbro outcrops in the southern part of the study area.

The Central Mineral Belt contains deposits of uranium, beryllium, rare-earth elements and base metals. Within the study area uranium deposits are the most significant, and have been discovered largely as a result of exploration by BRINCO following the first pitchblende discovery in 1954. Of greatest significance within the map area is the Michelin deposit containing reserves of 6,213,000 tonnes at an average grade of 0.13 percent U_3O_8 (Gower *et al.*, 1982). The development of this deposit and the one at Kitts to the east of Kaipokok Bay, which has reserves of 207,150 tonnes at an average grade of 0.75 percent U_3O_8 (Brinex, 1979), has been stalled due to a poor market and environmental considerations. Numerous smaller uranium prospects occur throughout the Michelin–White Bear Mountain belt, which roughly corresponds to the configuration of the upper Aillik Group. These are summarized by Ghandi (1978). There are also minor occurrences of copper and molybdenite in the area.

QUATERNARY GEOLOGY

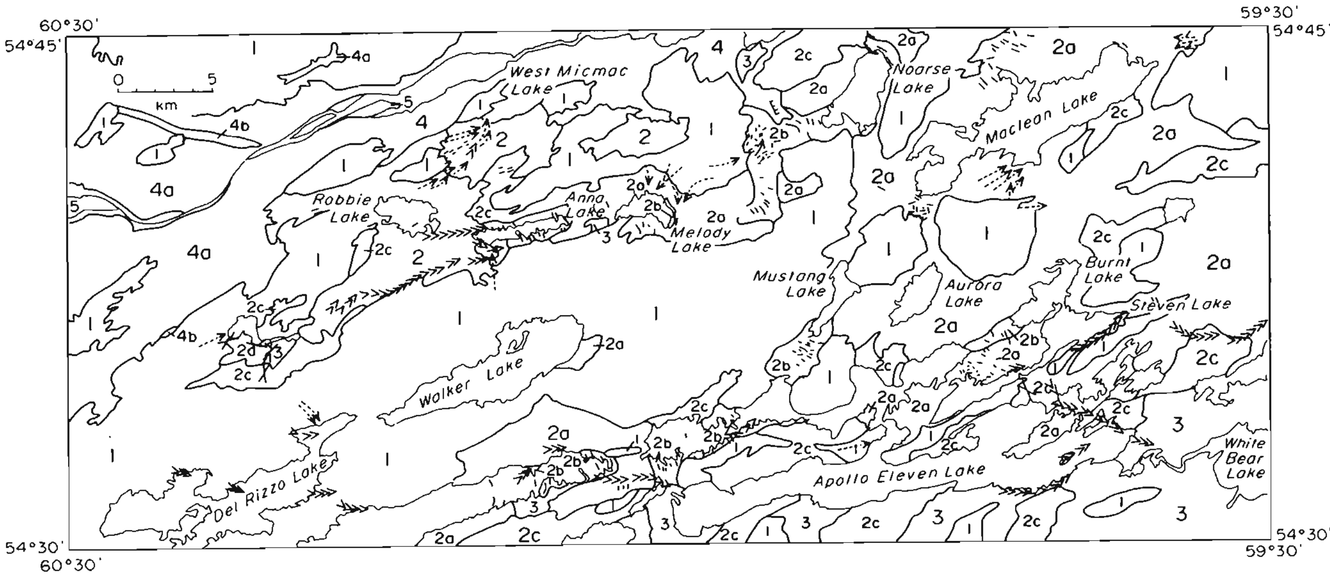
Terrain Units

Three major terrain units are identified within the Melody Lake area (Figure 3). These are discussed below.

Terrain 1 (Unit 1). The highland areas, i.e., those above approximately 300 m a.s.l., are dominated by barren rock having a discontinuous overburden cover up to 3 m thick. This terrain type dominates the Del Rizzio Lake–Walker Lake–Mustang Lake belt, and the area north of the Kaipokok River valley. The effects of glaciation are mainly erosional, and many bedrock surfaces show stossing.

Terrain 2 (Units 2 and 3). In the areas between 105 to 125 m and 300 m a.s.l., glacial sediments predominate. Characteristically these sediments have a fine sandy to silty matrix, and are slightly overconsolidated, with a clast content ranging from 10 to 30 percent. Clasts are usually subangular to subrounded, locally striated, and predominantly (90 to 95 percent) of local (less than 1 km transport) origin. Structurally the unit appears massive, although small (1 to 5 cm thick) fine to medium grained sand lenses occur locally. A more thorough investigation was hampered by the difficulty in digging pits because of a surface boulder cover, but initial interpretation suggests that the sediment is a till of subglacial origin (Unit 2). Boulders are commonly greater than 3 m diameter and in places cover 60 percent or more of the surface area. More than 98 percent of the boulders are less than 1 km from their bedrock source. Cross-valley moraine ridges are a common topographic feature. They have a 50 to 200 m spacing, are 5 to 15 m in height and are composed of diamicton similar to inter-ridge areas. No sections were available to provide an insight into the internal structure of these ridges. At several localities ridges were dissected by meltwater channels, and eskers occur at the up-ice side of the breach.

The remaining terrain of intermediate elevation comprises sediments of glaciofluvial and glaciolacustrine origin (Unit 3). The largest area is south of Apollo XI Lake and around White Bear Lake. The sediment is commonly a stratified fine to coarse grained sand sequence exhibiting meltwater channel scars on its surface; the sequence is interpreted to be a product of proglacial sedimentation. However, there are exceptions. To the west of Apollo XI Lake there are several areas where compacted glaciofluvial sand is overlain by a boulder veneer that is similar to that overlying Unit 2 till. This sequence presumably reflects deposition of glaciofluvial sand in a subglacial environment, and subsequent deposition of a boulder veneer from a supraglacial position during deglaciation. Southwest of White Bear Lake, a sequence of ice-contact (kame) sand and gravel is overlain by glaciofluvial sand and gravel that coarsen upward and are interpreted to have been deposited near a rapidly retreating ice front. Throughout the area eskers are common. They are characteristically gravelly in texture and occur as more or less continuous ridges 3 to 10 m in height along the major valleys.



LEGEND

HOLOCENE

5 *Featureless fine grained sand to silt alluvial unit, deposited along the margins of modern fluvial systems; commonly overlies marine sediment*

4a *Silty to clayey plain of marine origin; sediment is red and commonly capped by a fine grained sand layer; surface cover of organic deposits is common*

4b *Gravel-rich ridges (2 to 5 m high) of marine origin*

3 *Low-relief (less than 3 m) sand and gravel plain of glaciofluvial origin; gravel-rich esker ridges (3 to 10 m high) are common; in places a cover of large (up to 5 m in diameter) boulders is evident*

PLEISTOCENE

2a *Hummocky moraine complex (3 to 8 m relief) consisting of till of subglacial origin; fine sand to silt matrix, 10 to 30 percent clast content, generally massive; usually covered by a veneer of boulders of probable supraglacial origin; boulders angular, local in origin and commonly greater than 3 m in diameter; eskers common throughout the area*

2b *Cross-valley moraine ridges (3 to 8 m relief), composed of similar material to the hummocky moraine complex; veneer of boulders common*

2c *Low-relief till complex, texturally similar to that in the hummocky moraine complex; occurs either as a veneer (less than 2 m) eroded by meltwater channels, or as a featureless surface*

PRE-PLEISTOCENE

1 *Upland areas dominated by bedrock outcrop; numerous pockets of glacigenic sediment present, usually less than 1 to 2 m thick; colluvium of Holocene age is common around steep slopes*

SYMBOLS

»»»»» <><><> *Esker (direction known, direction unknown)*

Meltwater channel

Moraine, parallel to flow

Moraine, transverse to flow

Marine terrace

Figure 3: *Major terrain units and geomorphic features of the study area.*

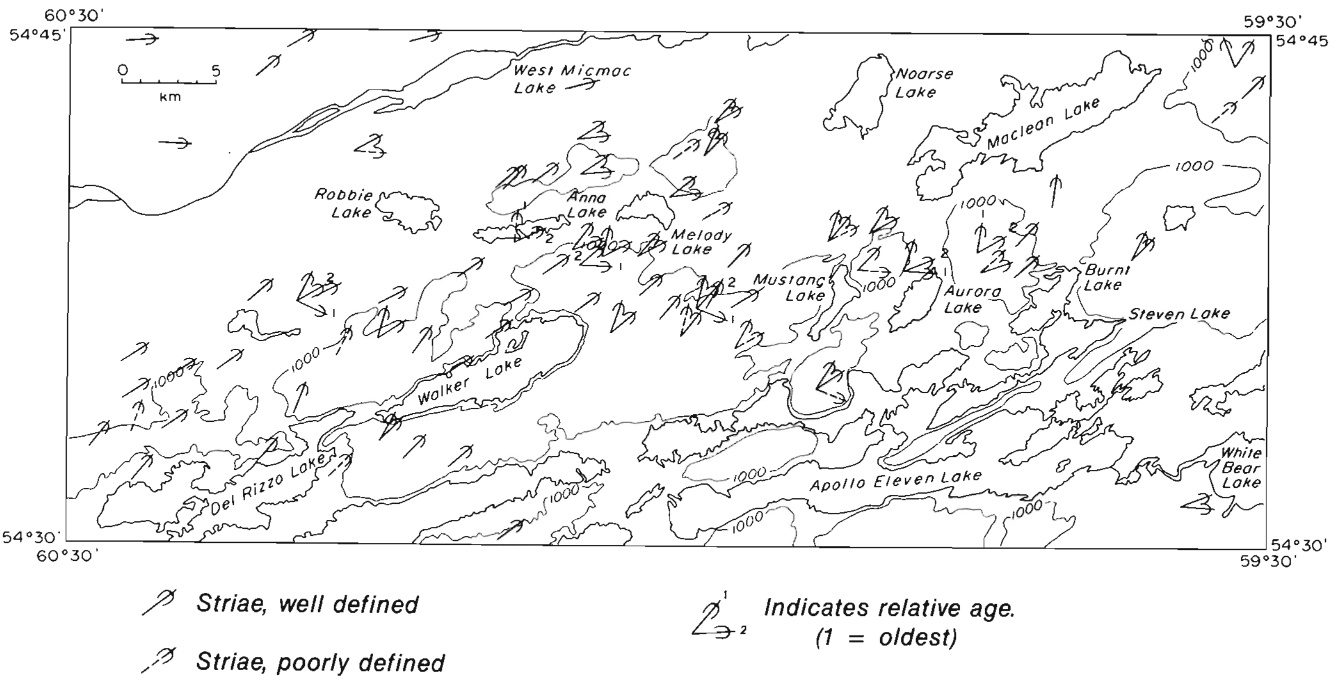


Figure 4: *Distribution map of glacial striae.*

Terrain 3 (Units 4 and 5). The northeastern part of the study area, within the Kaipokok River valley, contains thick sequences of marine silt and clay that commonly grade upward into fine grained sand. These sediments (Unit 4) are characteristically red, a reflection of their source in the Seal Lake Group mudstone, or in tills derived from these rock types (Thompson and Klassen, 1986). A series of linear or arcuate gravel ridges up to 15 m high occur to the west of West Micmac Lake and to the south of East Micmac Lake. No stratification of sediments within the ridges was observed. It is possible that these features represent storm beaches, although more evidence is needed to confirm the hypothesis. A marine storm beach on the south side of the Kaipokok River valley is of particular interest. It is a well sorted, 2-m-high cobble beach located at the base of steep-sided valley walls. The beach crest has an elevation of 152 m a.s.l., and records the highest marine limit in this area. Down slope of this beach, a series of marine terraces occur, each composed of successively smaller size fractions of sediment.

Holocene alluvial sediments (Unit 5) form a minor constituent within the Kaipokok River valley.

Directional Indicators

The direction of striae on bedrock surfaces in the Melody Lake area range from north to east-southeast (Figure 4). Striae sites are generally restricted to the highland areas (above 300 m a.s.l.), and are considered to represent the directions of regional glacial flow.

The last major regional ice flow across the study area was roughly northeast, in the range of 040 to 060°. This is indicated by the orientation of glacial flutes as well as striae. The striae are usually well developed and are commonly preserved on glacially polished surfaces. The trend of striations is across the regional topography and bedrock structure, suggesting a major flow event. It is likely that this flow event extended at least to the present coastline.

Several other flow directions predate the northeasterly flow. An eastward flow is interpreted at nine localities across the study area, and a northward to north-northeastward flow is indicated from at least five sites. An east-southeastward flow is shown at three sites. All these striae were well developed and unweathered, although not on glacially polished surfaces. Similarly, they were distributed across the map area rather than being confined to a small area, suggesting that they were formed by regional ice-flow events. These directional results are similar to those of Klassen (1983, 1984).

Dispersion of Clasts

The dispersal of clasts in the form of boulder trains has long been recognized as an important tool in the discovery of mineralized deposits. By examining the characteristics of dispersal trains from known mineralized bedrock (e.g., Batterson *et al.*, 1985), the possibilities of locating the bedrock source of other mineralized-float occurrences are increased. However, in many areas mineralized rock is an unsuitable choice, as it may occur in topographic areas having a small surface area available for erosion (e.g., a depression), the deposit itself may be small, and it may be indistinguishable from other nearby mineral prospects. The latter is the case in the Melody Lake area where numerous uranium prospects have been identified within similar host rocks. Indicator rock types, however, need not be mineralized. Within the Central Mineral Belt a series of useful indicators have been identified. Snegamook granite that outcrops to the north of Snegamook Lake, and highly crenulated quartzofeldspathic schist that occurs around Ballet Pond, were used to determine direct

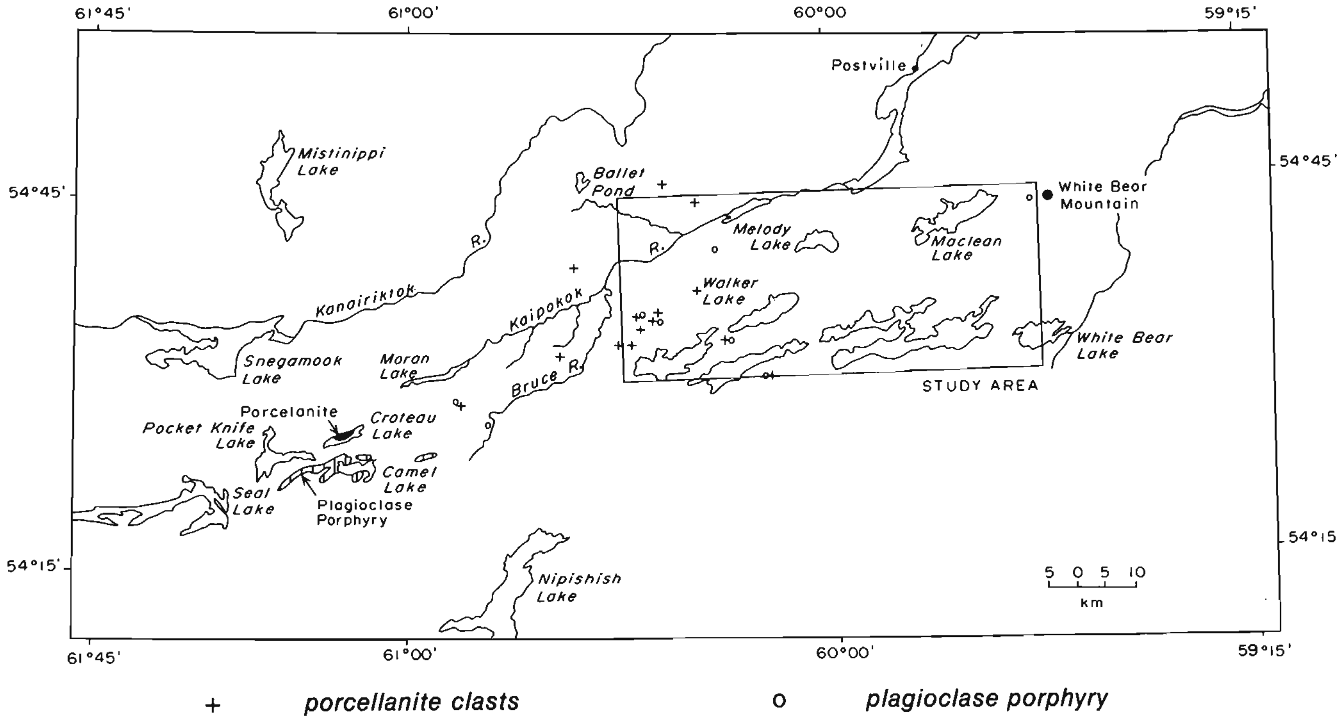


Figure 5: *Dispersal pattern of clasts from porcellanite bedrock around Croteau Lake and a plagioclase-porphyry unit from the Camel Lake area.*

eastward flow. Rock types that occur within the expected direction of transport include rocks of the Seal Lake Group (red–pink–purple quartzite), Bruce River Group volcanic rocks, sandstone and conglomerate, and on a smaller scale, porcellanite from the Croteau Lake area and a plagioclase porphyry from the Camel Lake area. For indicating long distance of transport, a green, aegirine gneiss from the Red Wine Alkaline Complex near Letitia Lake was also used.

The presence and subsequent identification of indicator rock types in the field is dependant on a series of factors, including the transportability of the rock (e.g., a friable rock will often not travel far without extensive comminution occurring) and the proportion of the indicator rock within a suite of clasts. Samples from test pits that may be 20 km or more down-ice of the source, and which yield 100 to 200 clasts, are unlikely to contain an indicator rock type, which probably constitutes less than 1 percent of the total clasts within an area. Sites that include mudboils generally present a better opportunity to identify indicator rock types, as a large number of clasts are revealed at the surface. Therefore, using our sampling techniques, an area containing few mudboils is not as likely to produce a good dispersal pattern as an area containing numerous mudboils or surface clasts.

Indicator dispersal patterns fall into three groups: those that were not identified; those that produced wide dispersal trains; and those that produced narrow trains. Snegamook granites, Ballet Pond schists, Crooked River granites and Red Wine gneisses were not identified in the Melody Lake area. Bruce River Group and Seal Lake Group rock types were ubiquitous across the area and consequently are of limited use in dispersal studies at the scales used by this project. Porcellanite and plagioclase porphyries produced the clearest patterns (Figure 5). Glacially dispersed plagioclase-porphyry clasts are restricted to a belt to the south of the Kaipokok valley, and were identified as far east as White Bear Mountain, a transport distance of 110 km. Porcellanite forms a narrower train and was not identified east of Walker Lake, although it had a more northerly distribution than the porphyry. Reconnaissance sampling indicated that the train is ribbon like within 20 to 30 km of the source, and increasing fanning of the train occurs in the down-ice direction. The general trend of the train is consistent with the most recent glacial flow event indicated by the striae data.

Glacial History–Some Preliminary Observations

The relationships between the various terrain units and their association with striae is not yet clear because grain-size and geochemical analyses are unfinished. Therefore, only a few preliminary observations are presented.

Two elements of the Quaternary history of the area are clear: 1) the last major regional glacial-flow event was toward the northeast and is the last event to have affected the area above approximately 300 m a.s.l., and 2) marine inundation reached about 150 m a.s.l., at least for a short period, and deposited thick silt and clay sequences below 90 to 105 m a.s.l. The terrain between 105 and 300 m elevation range is dominated by glacigenic sediments, and the sequence of events leading to their emplacement is open to speculation. In particular, the genesis of the cross-valley moraines is contentious. From their orientation (oblique to the northeast flow), they clearly postdate the regional glacial flow. However, two opposing possibilities as to their origin remain.

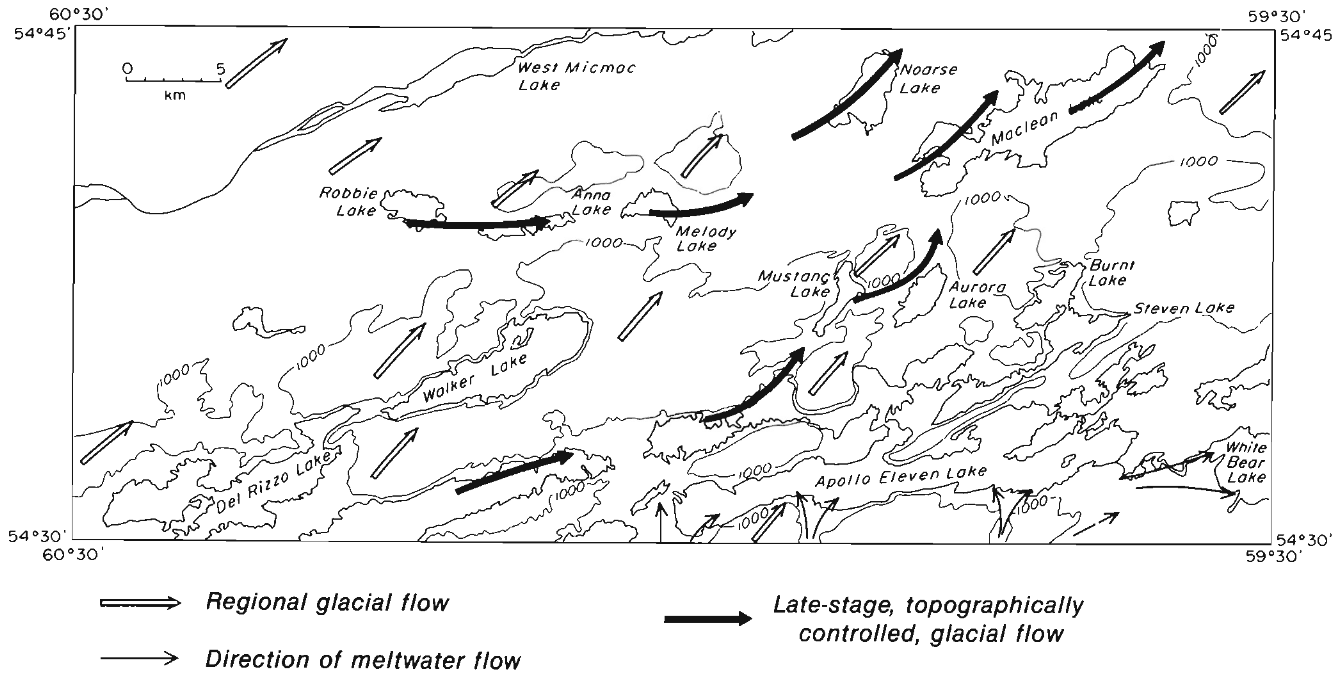


Figure 6: *A two-advance model as an explanation for the patterns of glaciated terrain in the eastern part of the Central Mineral Belt.*

In the first possibility the cross-valley moraines are subglacially or submarginally deposited during glacier advance, i.e., Rogen moraines (Figure 6). Although Cowan (1968) has adopted an ice-frontal approach to the development of Rogen moraines, many workers now consider these features to be subglacial features. Lundqvist (1969) suggests they form by the deposition of till onto ridges at the bedrock surface. These ridges are consistent with the development of transverse basal crevasses that result from tension within a compressive-flow environment. Shaw (1979), however, considers that Rogen moraines are the result of the melting out of folded and thrusted englacial debris planes developed within a compressive-flow regime. No sections exist within these moraines in the study area to test this hypothesis. However, the breaching of the moraines by eskers can be interpreted to be the result of englacial meltwater streams being let down onto, and consequently eroding, an existing subglacial surface. The Rogen-moraine hypothesis presupposes that deglaciation was by extensive stagnation, because active recession would probably destroy the moraines.

A subglacial origin would suggest advance of a thin ice mass or tongue through the Robbie Lake–Anna Lake–Melody Lake and the Witch Doctor Lake–Mustang Lake–Aurora Lake–Maclean Lake valleys. The distinct terrain change above the 300-m elevation level suggests that active ice was not thick. Retreat was by a down-wasting process with considerable amounts of outwash being drained, especially through the White Bear Lake area and the valleys to the south and west. Final wastage of the ice deposited a supraglacial boulder veneer, which in some areas overlies outwash deposits. Marine inundation affected the Kaipokok valley, although inland ice was still present. This is suggested by the lack of marine deposits in the Noarse Lake area, which lies below 90 m a.s.l. and is below the level of thick marine sediments in the Kaipokok River valley.

In the second possibility the moraines are recessional features formed by active, receding ice (Figure 7). Regional flow toward the northeast probably extended at least to the present coastline. Retreat of the ice would subsequently have been along major valleys, especially through Anna Lake and Witch Doctor Lake. Ice was still active during this phase and so annual reworking of glacial sediments occurred, forming a series of recessional moraines similar to those observed around modern glaciers. Glacial still-stands are reflected by hummocky moraine (e.g., between Noarse and Melody lakes). Eskers and outwash are intimately associated with these moraines, and are consistent with a receding ice mass. This could be related to an extension of the Québec North Shore moraine system proposed by Dubois and Dionne (1985). Within Labrador this system has been recognized in the Lake Melville area where it trends north–south. A continuation of this system would place it in the Melody Lake area. Furthermore, the moraines have been commonly described as a series of parallel ridges, associated with areas of outwash deltas and dead-ice hummocky moraine (Dubois and Dionne, 1985). A similar association of features is found within the study area.

The reconciliation of these divergent views is clearly significant to an establishment of glacial chronology. The fact that striae are rare on the coarse grained granitic bedrock in the valleys, and that no sections exist through the moraines exacerbate the problem. Discussion, therefore, centres solely on morphology. It is likely, however, that because northeasterly striae occur on glacially polished surfaces above 300 m a.s.l., no ice-free period existed between events within the valleys and those on surrounding highlands.

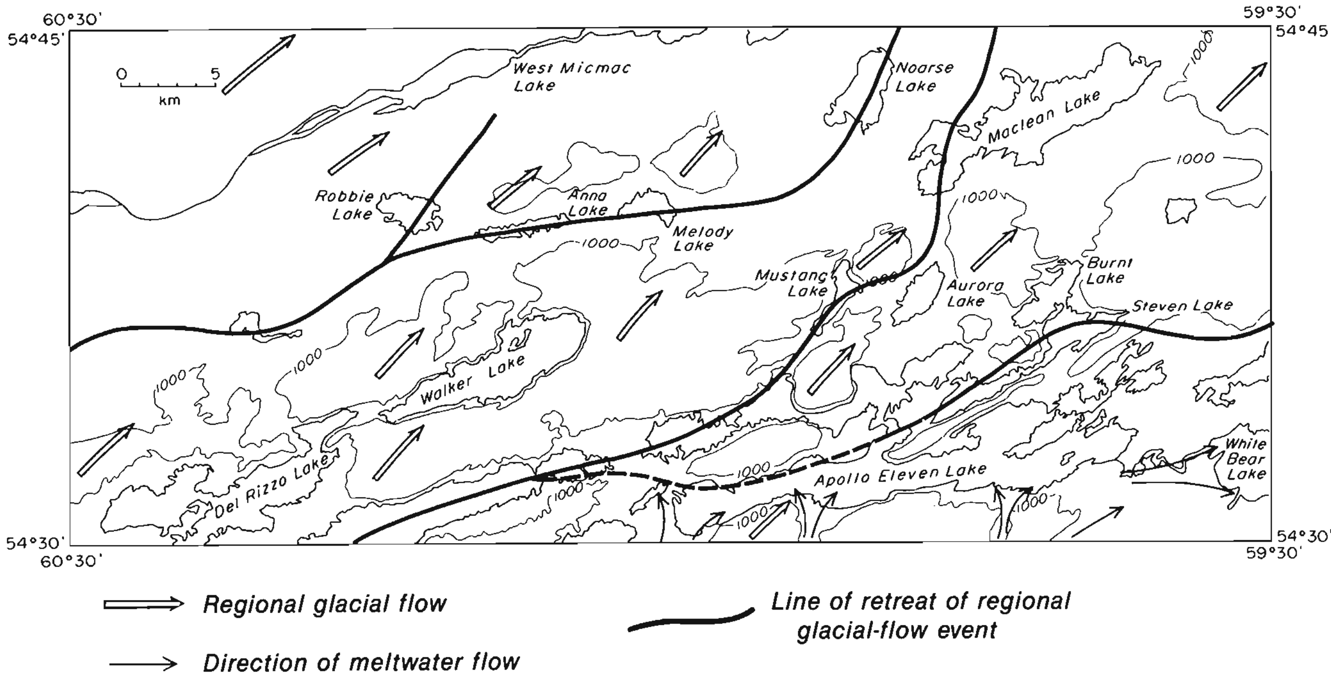


Figure 7: *A one-advance and active-recession model as an explanation for the patterns of glaciated terrain in the eastern part of the Central Mineral Belt.*

Mineral Exploration Implications

From an exploration viewpoint the debate between recessional and Rogen moraines is largely an academic one. What is significant is the contrast between glacial terrains on the uplands and those in the valleys. The uplands are essentially barren whereas the valleys contain reworked material. Similarly, the suggestion that the same flow pattern affected both areas can be negated, with the accompanying realization that different dispersal patterns are likely. Any exploration program in this area must take this terrain contrast into consideration, and adjust sampling patterns and interpretative techniques accordingly.

An understanding of the glacial dispersion of material is critical in Quaternary exploration programs. This project has documented the dispersal of indicator clasts across the study area. The patterns show that dispersion can be of considerable distances, and increased fanning occurs in the down-ice direction. It is suggested, however, that 90 to 95 percent of clasts are transported less than 1 km from their source, and that transport greater than 1 km is commonly reflected by less than 1 percent of the total clast content. The detailed documentation of pebble rock types should therefore be an integral part of any exploration program in a drift-covered area.

SUMMARY

Analysis of the effect of glaciation on the Melody Lake area is at a preliminary stage. Nevertheless, a three-fold subdivision of terrain in the area is possible. The area above approximately 300 m is bedrock dominated and records several periods of glacial activity, ranging from northward to east-southeastward; the most recent event was roughly toward the northeast. The area between approximately 100 to 300 m is dominated by glacigenic sediments that postdate material on the surrounding uplands, whereas the Kaipokok River valley is covered with thick marine silts and clays. This simple division points to contrasting sedimentological, geochemical and dispersal-pattern responses across the area.

Overall the program suggests the need for detailed Quaternary mapping in areas of mineral potential. An understanding of the glacial history and its effects on dispersal patterns would avoid costly over-generalizations and consequent misinterpretation of data.

ACKNOWLEDGEMENTS

The authors wish to thank John Gosse, who provided a high level of assistance, and Morley Thompson, who kept us well fed during the summer. Universal Helicopters Ltd. is thanked for its usual good service and, in particular, Roger Cassie, who is an excellent pilot and was a good member of the crew. Wayne Tuttle and Ken O'Quinn provided good expediting services. The manuscript was improved by reviews from David Proudfoot, Charlie Gower, Byron Sparkes and Doug Vanderveer.

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