Current Research (1989) Newfoundland Department of Mines, Geological Survey of Newfoundland, Report 89-1, pages 249-257

QUATERNARY GEOLOGY OF SOUTHWESTERN NEWFOUNDLAND

Byron G. Sparkes
Terrain Sciences Section

ABSTRACT

A mapping survey was undertaken during the 1985 and 1986 field seasons in the La Poile (110/9), La Poile River (110/16), Peter Snout (11P/13) and King George IV Lake (12A/4) map areas. Eleven hundred and thirty-six samples were collected from shallow hand-dug pits, from the 'C' soil horizon in lodgement and melt-out till units. A representative pebble fraction was obtained at 450 sites and was matched to the bedrock map units. The Quaternary sediments have been divided into six units: these are: 1) colluvium, 2) alluvium, 3) glaciofluvial, 4) hummocky deposits, 5) till veneer, and 6) streamlined forms. The 63 micron fraction of the samples were analyzed for Cu, Pb, Zn, Co, Ni, Mn, Fe, V and Au. The 8 mm and finer fraction were analyzed for particle-size distribution. Ice flow in the area was predominantly to the south and extended to at least the coastline.

An analysis of till composition (pebble fraction) was done to determine the till dispersion. Analysis of some of the data for the fluted forms, suggest that about 60 percent of the clasts are locally derived. Pearson correlations between particle size and geochemistry indicate that Pb, Zn and Mo values are influenced by the matrix texture.

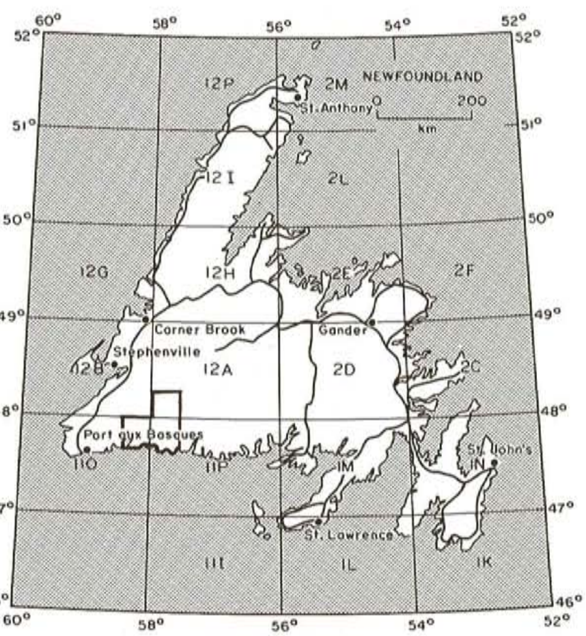

Figure 1. *Location of study area.*

INTRODUCTION

During the 1985 and 1986 field seasons, mapping of the Quaternary geology in the La Poile (110/9), La Poile River (110/16), Peter Snout (11P/13) and King George IV (12A/4) map areas (Figure 1) was undertaken. This project is a continuation of a provincially funded Quaternary mapping program, designed to provide information on the glacial dispersion, the distribution of glacigenic sediments and the geochemical and textural characteristics of till, as an aid to exploration in areas of mineral potential. There are no previously published reports on the Quaternary geology of southwestern Newfoundland, and the only map with any information is the Peter Snout area (11P/13) (Grant, 1974).

PHYSIOGRAPHY

King George IV Lake (12A/4)

Most of the King George IV Lake map area is a barren, hummocky upland at an elevation of 350 to 400 m, however, higher hills stand above this level, at a maximum height of 552 m. Three major river systems, the Lloyds, the Victoria and the Burnt Pond rivers drain toward the northeast. The topographic morphology and main drainage pattern reflect the bedrock structures, although many of the smaller lakes and ponds show no discernible geological control. Some ponds, particularly in the area east of Rocky Ridge Pond (Figure 2), appear to reflect southward ice flows.

Peter Snout (11P/13)

The Peter Snout map area is characterized by large areas of barren plateau at an average elevation of about 350 m. Numerous peaks over 500 m constitute part of the Blue Hills of Couteau, which are located to the northwest. Drainage is toward the south via the Grandy Brook system, and an unnamed brook that flows into Connoire Bay, west of Burgeo. The drainage pattern is transverse to the regional geological structure and therefore may be controlled by cross-faults.

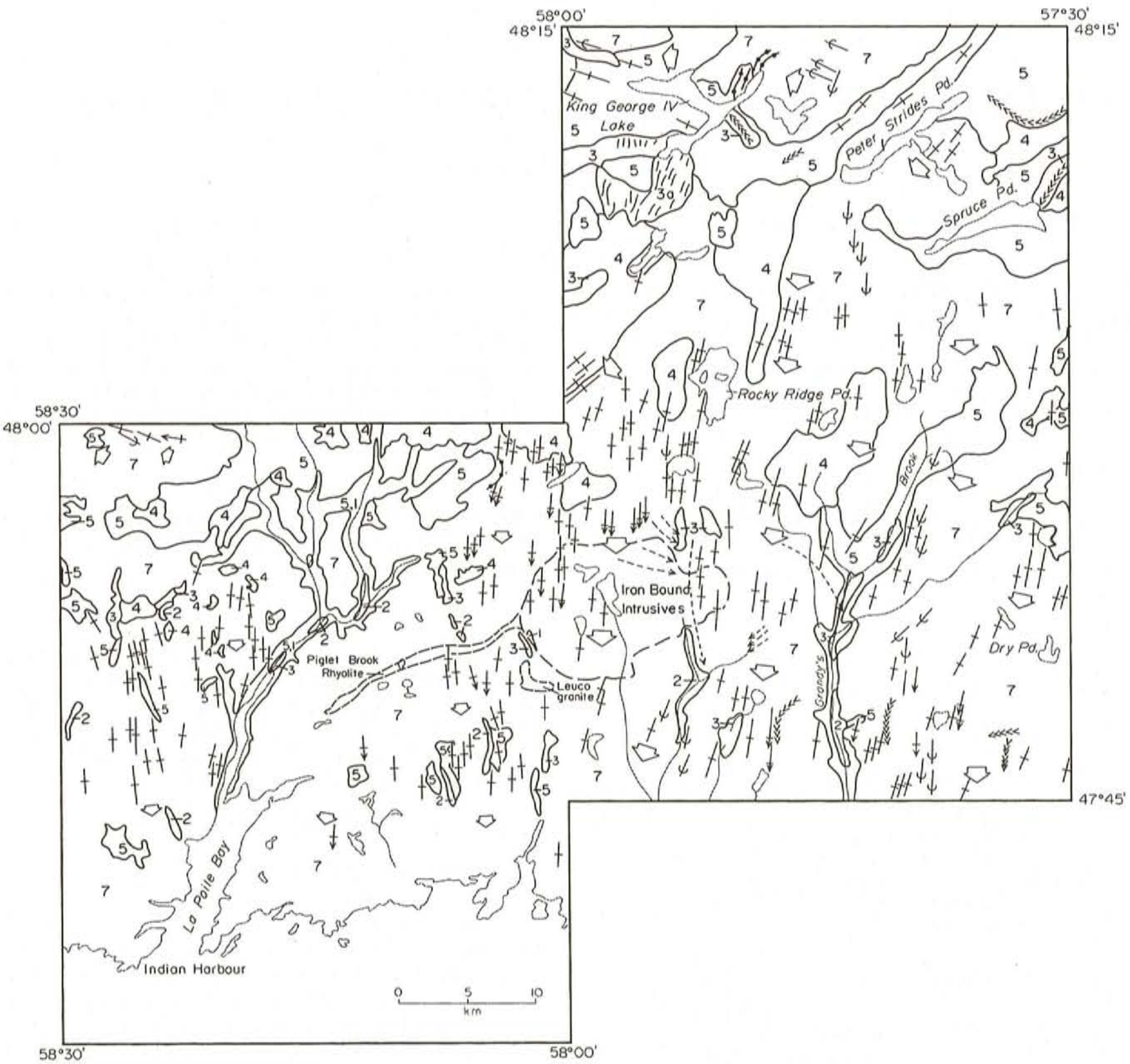

Figure 2. *Generalized Quaternary geology of map areas 11P/3, 12A/4, 11O/9 and 11O/6, southwestern Newfoundland.*

La Poile and La Poile River (11O/9–11O/16)

In this area, the topography is controlled, largely, by the relative resistance of bedrock type and the east-northeast-trending structural grain. The area west of La Poile River and Bunker Hill Brook is characterized by a gently rolling upland underlain mainly by the Rose Blanche Granite. This upland area has an elevation ranging from 520 m in the north to about 200 m, west of North Bay. East of La Poile River, the terrain is rugged and irregular, and the elevation ranges from 450 m in the northeast to about 250 m in the south. This area is underlain by metamorphosed felsic volcanic and sedimentary rocks, amphibolite, gabbro and granitoid intrusions. The Iron Bound intrusives (granite, diorite) at the eastern margin of the map area form the highest hills (593 m) and are a prominent landmark.

GEOLOGICAL SETTING

The King George IV Lake (12A/4) and Peter Snout (11P/13) map areas lie within the southern end of the Paleozoic Central Mobile Belt (Kean, 1983). Both areas contain elements of the Dunnage Zone, and the Peter Snout area also has elements of the Gander Zone. The oldest units consist of ophiolite rocks overlain by an island-arc sequence. These are unconformably overlain by fluviatile sedimentary and subaerial volcanic rocks that have a northeast–southwest trend in the northern part of the area and an east–west trend

LEGEND

QUATERNARY

1 Colluvium deposits: *usually angular material of any particle size, accumulated on the lower parts or the base of slopes and transported by gravity through cliff failure and mass wasting*

Non-glacial environment

2 Sand to bouldery gravel alluvium: *up to 2 m thick, contains terraces and plains associated with stream channels and floodplains; commonly found in the larger valleys and may overlie glaciofluvial sediments*

Pro-glacial environment

3 Ice-contact or glaciofluvial deposits: *consists of gravel and sand in the form of hummocks, terraces and plains; commonly within valleys;* 3a, ribbed moraine: *bouldery diamicton with a sandy matrix, occurs as straight to sinuous ridges 2 to 25 m high and up to 1.5 km long, oriented transverse to flow; occur in valleys and areas of low relief.*

Glacial environment

4 Hummocky moraine (1 to 10 m thick): *commonly consisting of sandy till, but may be composed entirely of boulders, (appears to be of a complex origin, possibly the result of ice disintegration)*

5 Featureless till veneer: *commonly discontinuous and less than 2 m thick; in some areas it consists entirely of boulders and includes colluvium deposits in deeply incised valleys*

6 Linear forms consisting of silt–clay till; *commonly overlain by a thin (1 m) mantle of a more sandy melt-out till containing more boulders; long, flat-profiled flutes are the most common form—other forms include till ramps and ramped crag-and-tail hills*

PRE-QUATERNARY

7 *Bare rock exposed or obscured by vegetation, includes areas of boulder-strewn bedrock*

SYMBOLS

Direction of regional ice flow

Striation (ice direction known, unknown)

Cirque

Longitudinal ice-flow features

Drumlinoid, fluting

Crag-and-tail hill

Ramped hills

Ramped crag-and-tail hills

Transverse ice-flow features

Crestline of moraine

in the south. Intrusive rocks range from Silurian to Carboniferous; the older intrusives are concordant with structural trends and the younger ones cross-cut them. The faults trend northeast–southwest in the north and east–west in the south. The rocks vary from undeformed to polydeformed and the metamorphic grade varies from sub-greenschist facies to amphibolite (Kean, 1983; O'Brien, 1983).

The La Poile and La Poile River map areas are mainly underlain by three metavolcanic and metasedimentary units; the Bay du Nord Group, the La Poile Group, hosting the Hope Brook gold deposit, and the Keepings gneiss. These units are intruded by several generations of granitoid rocks, the most prominent being the Rose Blanche Granite, the La Poile batholith and the Chetwynd Granite. All units were affected by east-northeast-trending fault systems, such as the Cape Ray and Bay D'est faults (Chorlton, 1978, 1980).

FIELD PROGRAM

Eleven hundred and thirty-six samples were collected from shallow (50 to 75 cm) hand-dug pits, on an approximate 2- by 2-km grid spacing. Ninty-five percent of these samples are from the *'C'* soil horizon; the remainder are from either the *'B'* horizon or the *'B–C'* transitional zone, and were collected from drumlins and drumlinoid forms, crag and tail hills, ramps, hummocks, eskers and in areas covered by a thin veneer of featureless glacial sediment (commonly till). Where possible, a representative pebble fraction (16 to 60 mm) was obtained at approximately 450 sites. The pebble types were determined and referenced to a bedrock map unit. A landform classification map has been completed for all map areas (Sparkes, 1987) using 1:50,000 scale, black and white airphotos. This interpretation was extensively ground verified during the course of field work, and was used for determining ice-flow directions, possible ice margins, and the distribution of surficial sediment.

SEDIMENT ANALYSES

Geochemical

The 63 micron fraction (-250 mesh) of the matrix samples have been analyzed for Cu, Pb, Zn, Co, Ni, Mn and Fe by atomic-absorption spectroscopy, Au by fire assay and delayed counting neutron activation and U by neutron activation. The finer than 63 micron fraction was chosen for geochemical analyses because of the relative ease of sample preparation, in comparison to obtaining the clay fraction by centrifuging.

Particle-Size Distribution

The 8 mm and finer fraction of the samples have been analyzed for particle distribution from 8 mm to 0.00126 mm. The procedure involves both mechanical sieving through a bank of sieves, and an electronic size analysis using a fine particle analyzer (Coulter counter).

Glacial Flow

Ice flow in the area was predominantly to the south (180 to 210°), as indicated by numerous north–south oriented depositional forms such as flutes, drumlins, crag and tail hills, and till ramps. Glacial striae are not well preserved in the study area, but many bedrock stoss and lee forms indicate ice flow, parallel to the linear features. A diversion of southward-flowing ice in response to local topography is apparent in the vicinity of La Poile Bay and Grandy's Brook (Figure 2). This change is evidenced by a slight reorientation of the streamlined forms and it may also indicate a thinning of the ice near its margin.

In the northeastern part of the King George IV Lake map area, ice flow is more varied (Figure 2), having moved: a) to the southwest, parallel to Peter Strides Pond, b) south in the central part of the area between Spruce Pond and Rocky Ridge Pond, and c) west in the area of King George IV Lake. These divergent flows may be attributed to relatively thin ice conditions, which resulted in flow being controlled by topography and the direction of regional slope. The influence of regional slope upon ice flow is also evident in the northwestern corner of the study area, where linear forms indicate a northwest flow of ice into St. George's Bay.

REGIONAL QUATERNARY GEOLOGY

Figure 2 summarizes the distribution of glacial sediments within the field area. Units 1 and 2 consist of colluvium and alluvium respectively, and were not extensively sampled or studied in any detail. They are of very limited extent, and their occurrences were determined almost solely from airphoto interpretation. Unit 3 is a glaciofluvial sediment, consisting of sand and gravel associated with outwash systems, and is found within most valleys and broad linear depressions. Unit 3a consists of moraines, oriented transverse to glacial flow, which occur as straight to sinuous ridges 2- to 25-m high and up to 1.5-km long. These were formed either at or near the margin of the retreating ice.

The northern part of the study area, and in particular the area west of Rocky Ridge Pond, is characterized by widespread low-relief hummocky till deposits (Unit 4). These hummocks consist mainly of coarse till, which have many large boulders of predominantly local origin, that probably owe their present emplacement to both direct subglacial meltout and supraglacial meltout from stagnant ice. Basal deposition of material from a boulder-rich debris zone (due to stagnant ice conditions) can produce a low-relief hummocky terrain, since the debris load within this zone would not be uniform in its distribution.

Areas of featureless till veneer (Unit 5) occur throughout the study area, but are mainly found in the north. This unit is discontinuous, less than 3-m thick and commonly consists of a locally derived boulder lag. The form of this unit mimics the morphology of the underlying bedrock, and the mode of deposition may be similar to that of hummocks, i.e., meltout from stagnant ice.

The most widespread depositional features are linear forms that are parallel to regional ice flow (Unit 6, see symbols for Figure 2), and generally occur in areas lacking other sediment types. These features can be subdivided into three major types: flutes, till ramps, and ramped crag and tail hills. The fluted forms are up to 2-km long, 5- to 15-m high, have a relatively flat profile, and are most common in areas of low relief. Till ramps occur up-ice of bedrock knobs and are up to 1.5-km long, 400-m wide and 30-m high. Several of the ramped hills also have tails that are up to 1.3-km long, 200-m wide and 30-m high.

Many mechanisms of flute formation have been proposed (Galloway, 1956; Boulton, 1971; Smally and Unwin, 1968; Shaw and Freschauf, 1973; Jones, 1982) and all involve complex interactions between erosional and depositional processes. It is generally believed that these features develop in a subglacial environment and require an obstruction in the glacier's path to initiate deposition. This may be an embedded boulder, a bedrock knob, or a lodged block of frozen basal debris. Deposition of material down-ice of such an obstruction may be accomplished by lateral particle migration (plastic deformation) into a low-pressure zone within the lee-side cavity of the obstruction, or by subglacial meltout, if thawed-bed conditions occur. Lateral particle migration may explain the lack of any other sediment type in areas where the linear forms are most abundant and closely spaced, since the growth of the fluted forms would be at the expense of deposition in the intervening areas. Alternatively, these areas may be devoid of sediment due to net erosion.

Till ramps, unlike other streamlined forms, develop on the up-ice side of bedrock obstructions and are a common depositional feature in this part of the southwest coast. Boulton (1971) observed till deposition on both the up-ice and down-ice sides of a bedrock knob, underneath the margin of a glacier in Svalbard, Spitsbergen. He suggested that the up-ice deposition is partially the result of pressure melting of the glacier sole and the subsequent gradual accumulation of particles released from the ice. The deposition of materials down-ice of the knob (ramped crag and tail hills) was in a lee-side cavity, and occurred by squeezing and slumping of subglacial till into the cavity. Although this type of deposition was observed by Boulton (1971) on a relatively small scale (tens of metres), it may be applicable to these large-scale forms in the study area. The material in these ramps consists of a very compact, possibly lodgement till, exhibiting preferred pebble orientations parallel to the regional ice flow (Figure 3). These characteristics are consistent with those observed by Boulton (1971) for the subglacial material found up-ice of bedrock knob beneath the margin of modern glaciers. The absence of material down-ice of these forms in southwestern Newfoundland, may be the result of a relatively small sediment load and, therefore, not enough basal material is provided for much of any deposition by squeezing or slumping into a lee-side cavity.

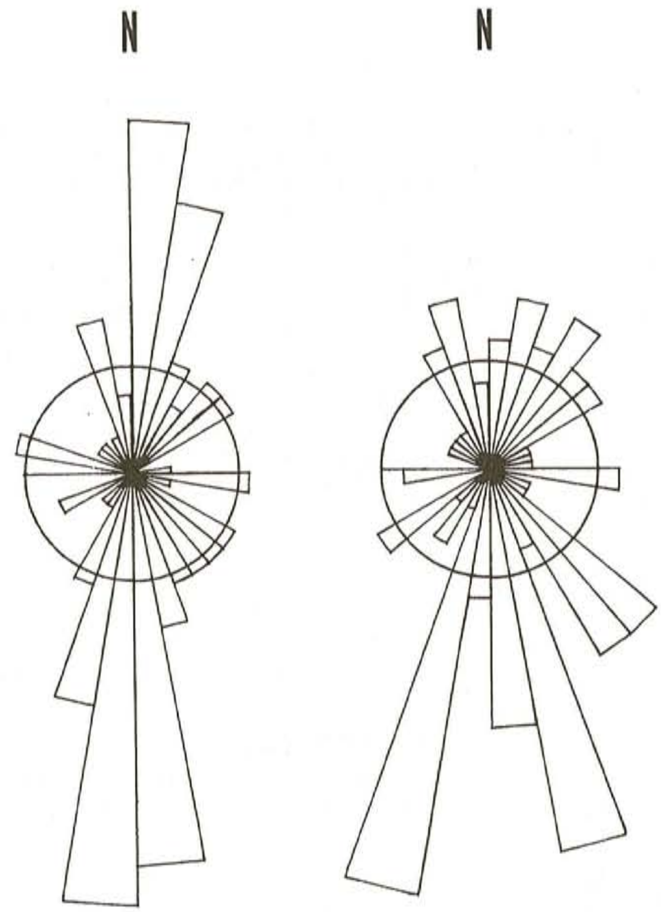

Figure 3. *Rose histograms for clast orientations on a typical till ramp.*

Glacial Dispersion

An analysis of till composition was undertaken as part of the study. A representative pebble fraction (16 to 64 mm) of the till was obtained at 300 sites, mostly from streamlined forms. Approximately 75 clasts were collected and identified from each hand-dug pit (75- to 100-cm deep), and where possible, the clasts were related to their bedrock source.

Analysis of some of the data for the fluted forms (Table 1) indicates that an average of 60 percent of the pebble-sized clasts in these forms are locally derived (up to 4 km up-ice), and the remainder have been transported as far as 10 km. Three bedrock units were selected and utilized as transport indicators on the basis of their position up-ice of many of the linear forms, and the degree to which they could be confidently identified in the pebble fraction. They are: 1) the Piglet Brook rhyolite, 2) a small leucogranite intrusion (Chorlton, 1980), and 3) the Iron Bound intrusives (Dunsworth, 1981) (Figure 2). The most useful of these units is the Iron Bound intrusives, consisting of porphyritic granite and syenodiorite, which are a distinctive bluish-green and greenish-brown, imparted by hornblende, actinolite and

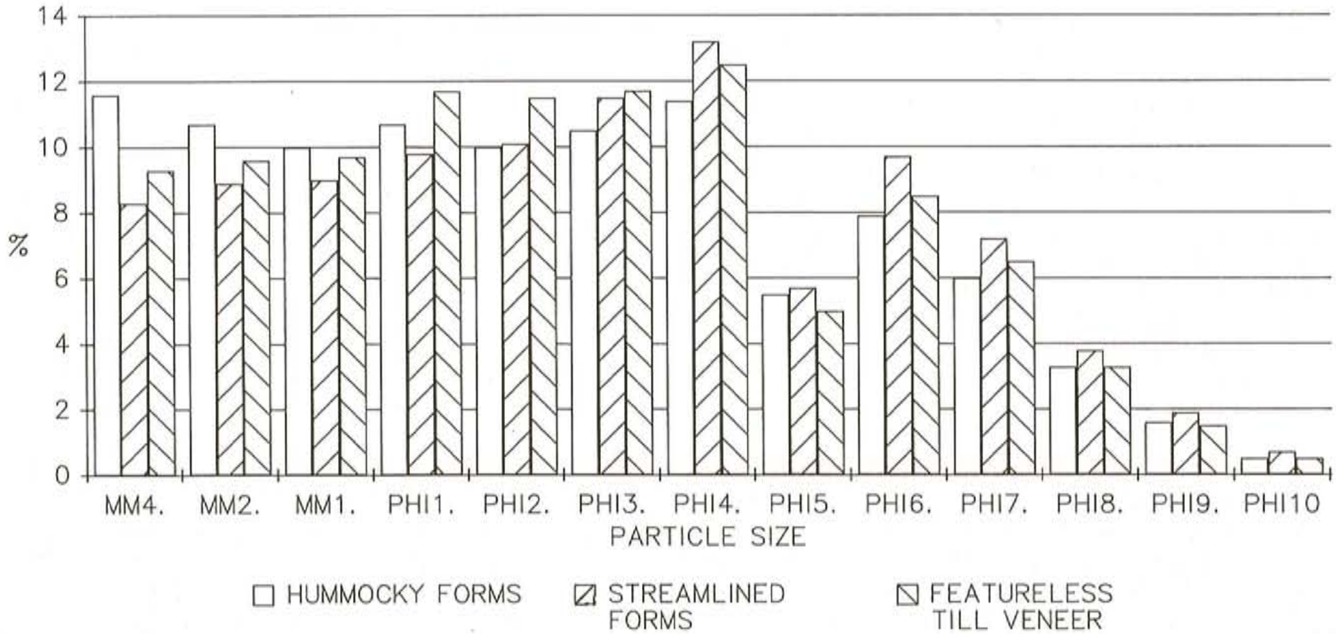

Figure 4. *Mean particle-size distribution by landform type.*

Table 1. Clast provenance in streamlined forms.

Sample	% Derived from up to 4 km up-ice	% More distal sources
1241	54.9	45.1
1242	78.8	21.2
1243	39.9	60.1
1244	48.8	51.2
1245	62	38
1246	64.1	35.9
1103	79.4	20.6
1104	65.6	34.4
1105	83.3	16.7
1107	62.5	37.5
1108	33.3	66.7
1110	50	50
1111	46.5	53.5
1117	45.1	44.9
1118	70	30

biotite. These rocks form a large contiguous area in the central part of the study area, and constitute the highest tills in the area.

Landform Geochemistry and Matrix Texture

The grain-size distributions of the three landforms types are presented in Figure 4. All three are very similar, except that the hummocky forms consist of more coarse to fine sand, and the streamlined forms consist of more fine silts and clay. This difference may simply be a function of the transport distance difference for both these forms.

Pearson correlation coefficients for matrix texture and geochemistry are presented in Table 2. The Pb and Zn geochemical values were regressed with Mn and Fe to remove the effects of co-precipitation, and the Mo values were log transformed (Kerr and Davenport, 1986). The correlation coefficients obtained are uniformly weak, but are statistically significant. A consistent correlation between Mo and the sand content of the matrix is evident in all landform types, and a similar correlation exists between sand and Pb, Zn and Mo in the hummocky forms. A conclusion to be drawn is that some of the variability in Pb, Zn and Mo geochemical values, obtained from regional soil sampling programs, may be explained by these correlations.

Table 2. Pearson correlations; geochemistry and matrix texture by landform type.

	Streamlined forms			Till veneer	Hummocks
	Sand	Silt	Clay	Sand	Sand
Pb				.27	.23
Zn		.22	.22		.22
Mo	.28			.38	.26

Au Distribution in Till (11P/13, 12A/4)

Till samples (-250 mesh) from the Peter Snout (11P/13) and King George IV Lake (12A/4) map areas were analyzed for Au content by fire assay and delayed counting neutron activation. The distribution of Au values greater than 10 ppb, and the occurrence of Victoria Lake Group clasts is shown in Figure 5. Both distributions are spatially similar and thus

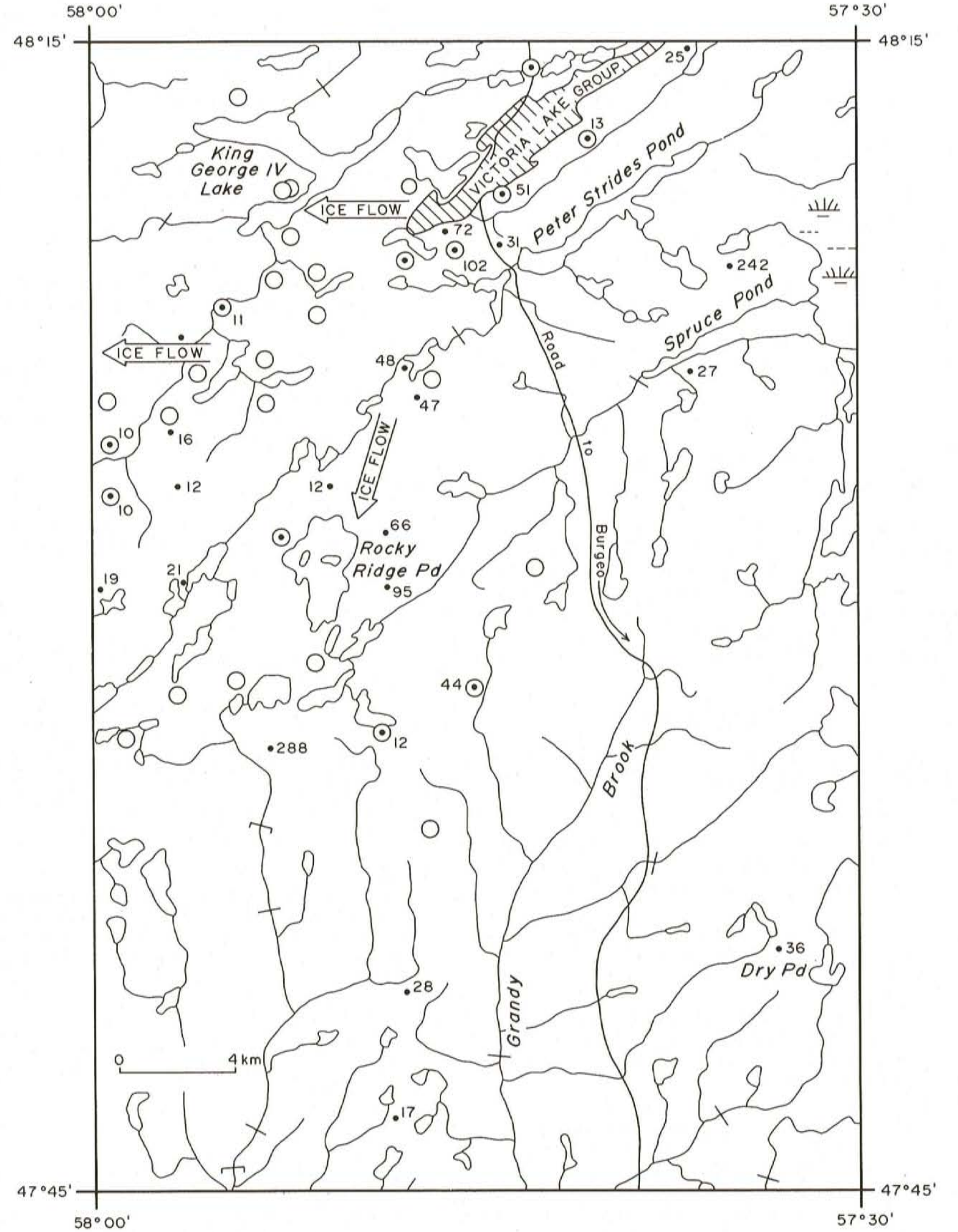

Figure 5. *Au in till (solid dot) and occurrence of Victoria Lake Group clasts (open circle) 11P/13 and 12A/4. Solid dot in open circle designates both Au in till and occurrence of Victoria Lake Group clasts.*

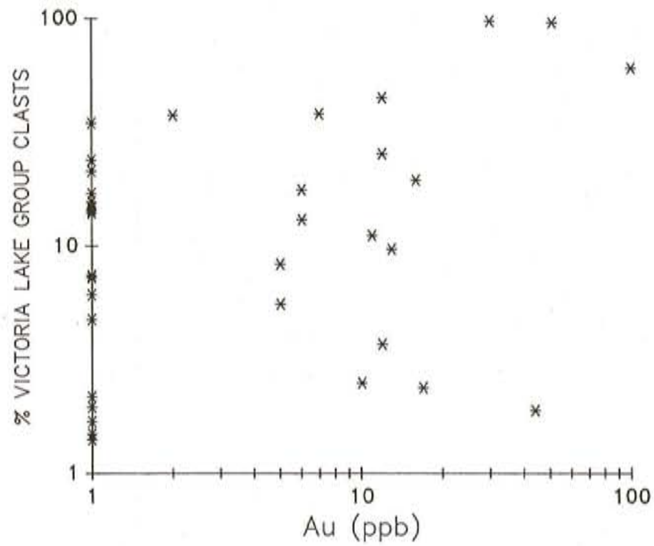

Figure 6. *Scatterplot; Au and percent of Victoria Lake Group clasts.*

indicate that Victoria Lake Group volcanics and sediments may have been the source for the elevated Au values. The Pearson correlation coefficient for Au and clasts in the till (.497) also indicate this source, although the correlation is influenced by several high values (Figure 6). The distribution patterns, which are primarily south and west of the Victoria Lake Group, agree with the known ice flows (south and west) in this area.

CONCLUSIONS

The summarized Quaternary geology and implications for mineral exploration in southwestern Newfoundland are as follows:

1) In much of the area, a southward ice flow dominated, therefore the interpretation of drift anomalies is unlikely to be complicated by complex glacial dispersion;

2) in the northern part of the area, multi-directional flow may have influenced the geochemical signature in the tills;

3) the differing geochemical characteristics of landforms should be considered in the interpretation of soil or till anomalies, where the sampling area includes several landform types;

4) some of the variability in geochemical values obtained in soil sampling programs can be explained by positive correlations between matrix texture and geochemistry;

5) areas of featureless till veneer (no constructional form) provide the best sampling media, and

6) till ramps (pre-crag streamlined forms) contain material from far up-ice and should be sampled only in regional soil surveys.

REFERENCES

Boulton, G.S.
1971: Till genesis and fabric is Svalbard, Spitzbergen. *In* Till: A Sympoisum. *Edited by* R.P. Goldthwait. Ohio State University Press, Columbus, Ohio, pages 41-72.

Chorlton, L.
1978: The geology of the La Poile map area (110/9), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 78-5, 14 pages.

1980: Geology of the La Poile River area (110/16), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 80-3, 86 pages.

Dunsworth, S.H.
1981: A petrographic and geochemical study of the Peter Snout granitoids, southwestern Newfoundland. B.Sc. (Hons) thesis, Memorial University of Newfoundland, St. John's, 80 pages.

Galloway, R.W.
1956: The structure of moraines in Lyngsdalen, North Norway. Journal of Glaciology, Volume 2, pages 730-733.

Grant, D.R.
1974: Surficial geology map series, 1:50,000 scale, Island of Newfoundland: 11P/11 Romeo, 11P/12 Burgeo, 11P/13 Peter Snout, 11P/14 White Bear River, 12G/8 Trout River. Geological Survey of Canada, Open File 244.

Jones, N.
1982: The formation of glacial fluting in east–central Alberta. *In* Reserach in Glacial, Glaciofluvial, and Glaciolacustrine Systems. Proceedings of the 6th Guelph Symposium on Geomorphology, 1980, pages 49-70.

Kean, B.F.
1983: Geology of the King George IV Lake map area (12A/4). Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-4, 34 pages.

Kerr, A. and Davenport, P.
1986: Regional geochemical patterns in the eastern central mineral belt of Labrador. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 86-1, pages 223-237.

O'Brien, S.J.
1983: Geology of the eastern half of the Peter Snout map area (11P/13E). *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-1, pages 57-67.

Shaw, J. and Freschauf, R.C.
1973: A kinematic discussion of the formation of glacial flutings. The Canadian Geographics, Volume 17, pages 19-35.

Smalley, I.J. and Unwin, D.J.
1968: The formation and shape of drumlins and their distribution and orientation in drumlin fields. Journal of Glaciology, Volume 7, pages 377-390.

Sparkes, B.G.
1987: Landform classification maps: La Poile; La Poile River; Peter Snout; and King George IV Lake map areas, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File NFLD 1574.