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TILL-GEOCHEMISTRY SAMPLING AND QUATERNARY MAPPING IN SOUTH-CENTRAL NEWFOUNDLAND, EASTERN POND (NTS 2D/11) AND MIQUEL'S LAKE (NTS 2D/12) MAP AREAS

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ABSTRACT

Surficial geological mapping and till-geochemistry sampling were completed in the Eastern Pond and Miquel's Lake map areas (NTS 2D/11 and 12) during the second year of a multiyear field program in south-central Newfoundland. The main field objectives were to collect samples for a regional till-geochemical survey, to complete surficial mapping, and to reconstruct the glacial history of the area to improve our understanding of the region's Quaternary geology and support mineral exploration activities. Samples were collected from the C- or BC-horizons of 569 hand-dug pits through a combination of road-, ATV-, and helicopter-supported field work. Thirteen previously unrecorded striation sites are reported; the striation record indicates that the area has a complex ice-flow history. An ice divide is suggested to have occurred in the central part of the area resulting in conflicting ice-flow and age relationships, and consequently complicated dispersal regimes. Outside of this central area, a north to northeastward ice-flow direction is the predominant ice-flow and direction of dispersal.

INTRODUCTION

This report is the first from a multiyear project initiated in south-central Newfoundland in 2013, consisting of sampling for till geochemistry, and mapping of ice flows and surficial geology. The project will provide an opportunity to further our understanding of the region's Quaternary history as it relates to mineral exploration, and to provide a basis for the evaluation of geochemical data. Determination of the ice-flow directions and clast provenance will aid in the interpretation of geochemical anomalies and also provide a better understanding of the regional ice-flow history. These results will supplement those from similar projects in central Newfoundland (Batterson and Taylor, 1998), southern Newfoundland (Proudfoot *et al.*, 1990), the Burin Peninsula (Batterson and Taylor, 2007) and the Red Indian Lake area (Organ, 2014).

Fieldwork in 2014 was conducted in the Eastern Pond and Miquel's Lake map areas (NTS 2 D/11 and 12; Figure 1).

LOCATION, ACCESS AND PHYSIOGRAPHY

Generally, the area has a rolling topography dissected by northeast–southwest-oriented valleys, including the Great Rattling Brook valley, Great Gull River valley, and the Northwest and Southwest Gander River valleys. The physiography is controlled mainly by bedrock. Hills are commonly oriented northeast, and areas underlain by the Botwood Group (*see* next section) are more rugged than those areas to the west and east. The highest elevations are at Miquel Hill and Pot Hill (400 and 308 m, respectively). Access to the area is mostly *via* the Trans-Canada (TCH Route 1) and Bay d'Espoir highways (Route 360) and a series of logging and hydro roads; much of the southwestern part of the study area is only accessible by helicopter.

BEDROCK GEOLOGY

The following details on the bedrock geology of the area are summarized from Blackwood (1981), Colman-Sadd and Russell (1982) and Dickson (1992, 1993).

The western part of the study area is predominantly underlain by Cambrian to Middle Ordovician mafic to felsic volcanic rocks (Unit COv) and marine siliclastic rocks (Unit Cos) of the Victoria Lake Supergroup (Figure 2). To the east are Middle Ordovician quartzitic sandstone, siltstone, shale, and schist (Spruce Brook Formation; Unit COsg) and Silurian felsic volcanic rocks (Stony Lake volcanic rocks; Unit Sv). Silurian marine (Indian Islands Group; Unit Ss) and non-marine siliciclastic sedimentary rocks of the Botwood Group (Unit Ss) underlie the Great Rattling Brook valley and the Northwest Gander River valley areas, respectively. The youngest rocks (Unit SDm) in the area are those of the

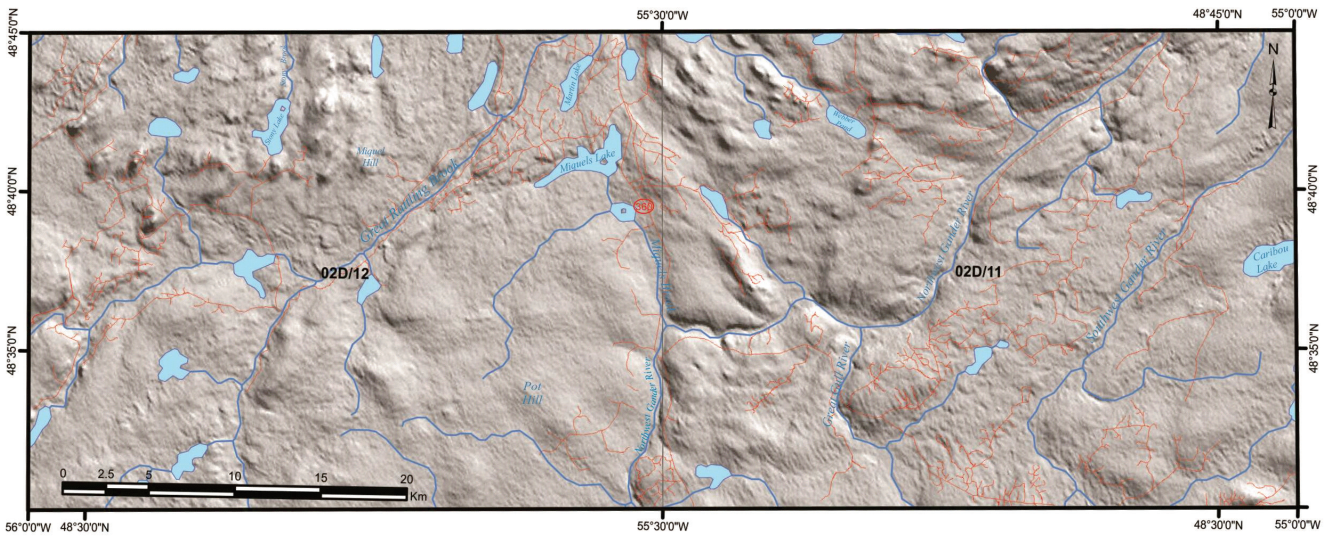

Figure 1. SRTM *image of study area showing physiography and place names mentioned in text.*

Silurian–Devonian Mount Peyton intrusive suite. The western and northern parts of the intrusive suite consist of a grey, fine- to medium-grained gabbro, and the eastern and southern parts of pink, biotite granite. Several small slivers of ultramafic rocks represent the easternmost portion of an extensive series of fragmented ophiolite complexes (Unit COu) that extends to and beyond the westernmost part of the study area, and includes the Great Bend Complex, the Coy Pond Complex, and the Pipestone Pond Complex. Several Devonian granitic intrusions occur throughout the study area (Unit SDg).

Within the study area, mineral exploration has been centred on areas underlain by volcanic and sedimentary rocks along the contact between the Botwood Group and Mount Peyton intrusive suite, where gold has been the main target of exploration, and in ultramafic rocks where magnesite (*e.g.,* Great Bend Magnesite Pit) and asbestos occurrences are present; there is also potential for precious metals. Antimony mineralization (*e.g.,* at the Beaver Brook mine) is hosted in Botwood Group sedimentary rocks. All documented mineral occurrences are shown in Figure 2 (Newfoundland and Labrador Geological Survey, 2014a).

ICE-FLOW HISTORY

Regional glacial histories for central Newfoundland have been compiled by a number of previous researchers including Grant (1974, 1989), Vanderveer and Sparkes (1982), Rogerson (1982), Proudfoot *et al.* (1990), St. Croix and Taylor (1990,1991), Batterson and Taylor (1998) and Shaw *et al*. (2006). Three separate phases of ice flow have been identified in the field area:

- The oldest phase was an extensive east to southeastward ice advance, recorded by striations across much of northeastern Newfoundland (bedrock outcrops were rarely stossed by this flow), with a likely source in the Topsails (Figure 3).
- The second phase was a north to northeastward flow, as shown by striations and bedrock stossing on outcrops. Striations from the earlier eastward flow are commonly preserved on the lee side of bedrock outcrops. Flow directions are generally more northward (and topographically controlled) where ice flowed into the Bay of Exploits. This was the dominant ice-flow phase in the region, responsible for sediment dispersal and moulding of bedrock outcrops (*e.g.*, Batterson and Taylor, 1998). It is speculated to have been sourced from an ice divide arching across south-central Newfoundland from Middle Ridge to Meelpaeg Lake (*e.g.*, St. Croix and Taylor, 1991, Figure 3). The dominant ice-flow direction in south-central Newfoundland is south to southeastward; Proudfoot *et al.* (1988, 1990) have suggested that this southward flow may have been contemporaneous with the north-northeast flow, as there is only evidence for one ice-flow event in the south, and that it would have flowed south from the proposed ice divide.
- The most recent phase consisted of a localized eastward flow, identified in the Badger–Grand Falls–Botwood area. This flow is recorded by fine striations overprinting those produced by the regional north to northeastward ice flow, and did not mould bedrock outcrops. Given the location of striations adjacent to the Exploits River valley, it is likely that there may have been topographic control on ice flow and drawdown into the Bay of Exploits. The source of this ice flow is uncertain.

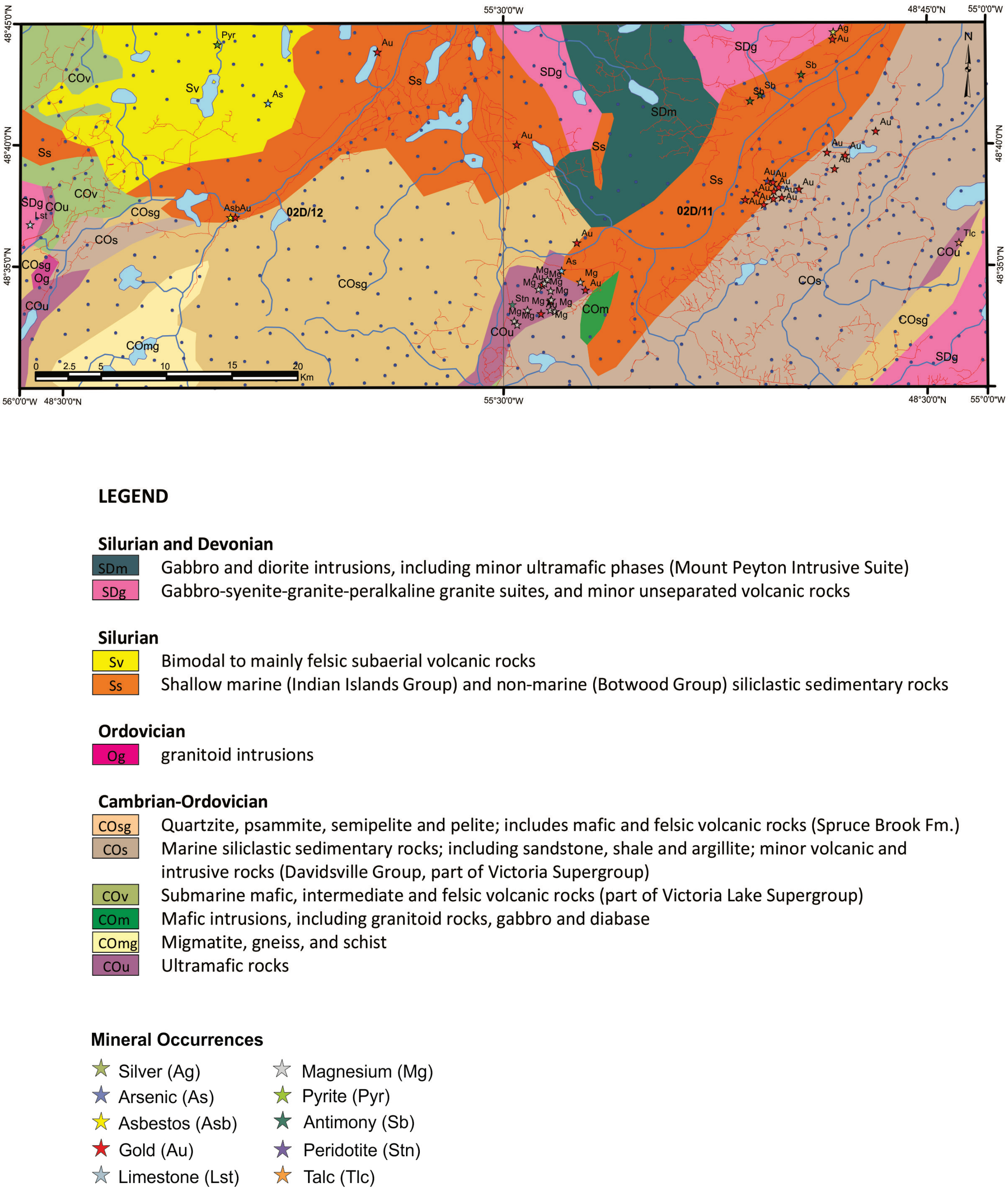

Figure 2. *Bedrock geology of the study area (Crisby-Whittle, 2012). Black dots show locations of samples collected in 2014.*

Figure 3. *Approximate location of remnant ice centres as the Newfoundland Ice Cap disintegrated (modified after Grant, 1974).*

GLACIAL DISPERSAL PATTERNS

Till geochemistry in the Grand Falls to Glenwood area (NTS map areas 2D/13 and 14) showed geochemical dispersal patterns that are commonly short, and diffuse (Batterson and Taylor, 1998). The pattern of dispersal suggests that it is controlled by the regional north to northeastward ice-flow event. Figure 4 shows glacial dispersal toward about 020°, suggested by relatively low chromium in the southern part of the suite, and higher values to the north. This is interpreted to reflect the dispersal of chromium-poor till derived from the adjacent Botwood Group sediments over the southwestern edge of the Mount Peyton intrusive suite (Unit SDm) and the dispersal of chromium-rich till from the gabbroic phase of this unit over Botwood Group sedimentary rocks in the north. In both cases, dispersal distances are less than 5 km. This dispersal pattern was also observed in the presence of clasts from the Botwood Group in till over the northwest margins of Unit SDm.

RESULTS

SURFICIAL GEOLOGY

Detailed surficial mapping (1:50 000 scale) for this area has not yet been completed, however preliminary observations based on field work and aerial photo interpretation are described below.

The surficial geology is dominated by varying thicknesses of diamicton, ranging from a thin veneer to blankets over 5 m thick. Topographic highs, such as Miquel and Pot hills, are characterized by thin and discontinuous sediment cover (Plate 1).

Only a single stratigraphic unit of diamicton was identified; its texture varies depending on the bedrock source, ranging from reddish, silty to sandy diamictons derived from red sedimentary rocks of the Botwood Group, to light brownish grey silty diamictons in areas derived from rocks of the Spruce Brook Formation and Davidsville Group, and brown to grey coarser sandier diamictons in areas derived by the Mount Peyton intrusive suite. Generally, diamictons are poorly sorted and slightly to moderately compacted, and have clasts ranging from granule to boulder size (up to 3 m

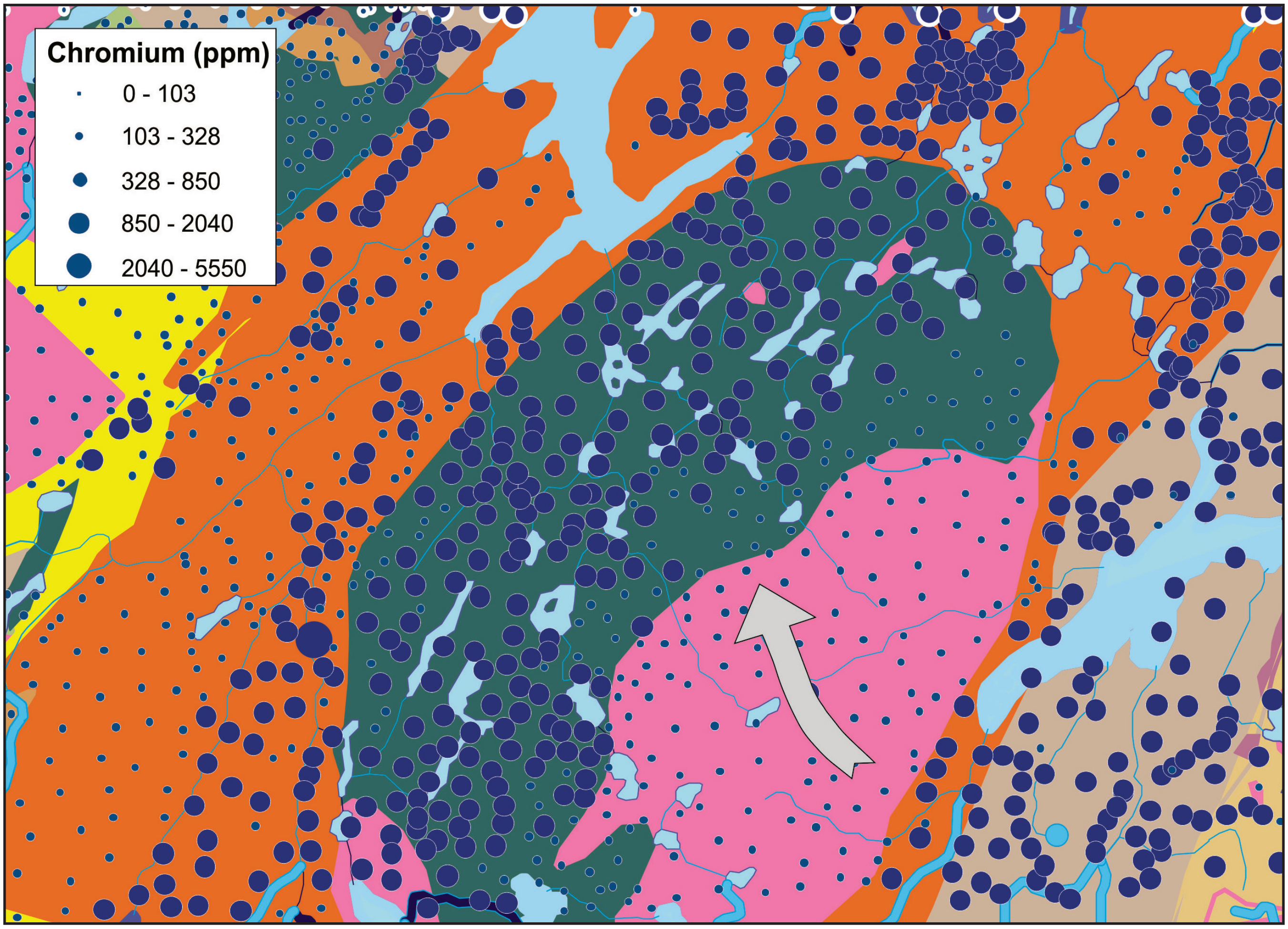

Figure 4. *Distribution of chromium in till, Grand Falls–Mount Peyton area. Low chromium in the southern part of the Mount Peyton intrusive suite, and high values above the northern edge are interpreted to reflect northward glacial dispersal of chromium-poor till (derived from Botwood Group sediments over the southwestern edge of Unit SDm) and dispersal of chromium-rich till from this unit over Botwood Group sedimentary rocks (*see *Figure 2 for bedrock geology legend; Batterson* et al.*, 1998).*

diameter), which are generally subrounded to angular. Clast content varies between 30 and 70 percent and averages around 45 percent.

In the northern and western parts of the study area, clasts are commonly striated, bullet-shaped and subround, which is indicative of basal transport and actively moving ice (lodgement processes). These diamictons are interpreted as basal or lodgement tills that are typically short-travelled.

Large parts of the study area, particularly south of Great Rattling Brook (the southern part of NTS map area 2D/12), are dominated by hummocky moraine; bogs are commonly found in depressions between hummocks (Plate 2). The surface is commonly irregular and boulder-strewn, and diamicton containing sandy lenses or sorted layers are present beneath clasts and clasts that commonly have thin silt coatings on their upper surfaces. These areas may reflect supraglacial deposition from passive melt-out of diamicton under stagnant (non-flowing) ice that underwent downwasting *in situ*, without subsequent melt-out induced transport or deformation. If this is the case, diamictons may contain far-travelled material that does not reflect local glacial transport. Alternatively, they may be composed of subglacial till that is the product of pressing and squeezing of soft till substrate below stagnant portions of the ice margin. Given that the depositional environment is not always easy to ascertain, caution should be exercised when interpreting geochemical data collected from this material. Large river valleys, including those of the Northwest and Southwest Gander rivers, Great Gull River and Great Rattling Brook, contain extensive sand and gravel deposits (Plate 3). These deposits contain moderately to well-sorted, stratified sand and gravel that were deposited in glaciofluvial or fluvial environments

Plate 1. *This till veneer with exposed bedrock in the Miquel Hill area. Boulder-strewn terrain is also common in this area.*

Plate 2. *Hummocky terrain observed to the south of Great Rattling Brook. The surface is commonly irregular and boulder-strewn and bogs are commonly found in depressions between hummocks.*

and represent the routes of meltwater during deglaciation. Meltwater channels and eskers are commonly aligned with these river valleys.

A range of depositional landforms, including drumlins, flutes, ribbed moraine and crag-and-tail hills are present within the study area. Most of these are often commonly observed in areas of thick till, although crag-and-tail hills were also observed in areas of thin till and concealed bedrock. These features are typically composed of diamicton and likely reflect deposition under actively flowing ice. Drumlins, flutes, and crag-and-tail hills are predominantly oriented in a northeast direction, indicating that the northeastward ice flow was the dominant influence on the landscape. Areas of ribbed moraine are most common in the southern parts of the study area, in the Great Gull River area (Plate 4) and south of Pot Hill.

ICE-FLOW PATTERNS

A total of 13 striations were recorded and are generally consistent with previously recorded observations (Figure 5). They indicate:

- An early eastward flow across the northern part of the study area, which is likely part of the extensive east to southeastward ice flow recorded across much of northeastern Newfoundland. Evidence for this flow is not widespread in the study area. It is the oldest ice-flow event indicated in sites recording multiple directions, where age relationships could be determined.
- A second divergent ice-flow phase whose direction was north to northeastward and south to southeastward, as shown in Figure 5. In reviews of regional glacial history (*e.g.,* St. Croix and Taylor, 1991) a similar ice-flow pattern has been speculated to have originated from an ice divide in the Meelpaeg–Middle Ridge area (to the south of the study area; Figure 3). The presence of both north to northeastward and southward striations indicates that the location of this ice divide lies at least partially within the field area. In areas where both directions are present, there are no consistent age relationships between the two. It is suggested here that these striations may be explained by their proximity to a shifting ice divide, within which lies an area where conflicting observations reflect changes in ice dynamics.

REGIONAL SURFICIAL SEDIMENT SAMPLING

SAMPLING AND SAMPLE PREPARATION METHODS

The till-sampling component of the work resulted in 608 samples (including 39 duplicates) being collected from the C- and BC-horizons in test pits (average depth 55 cm), roadcuts (average depth 60 cm) and mudboils (average depth 25 cm). Sample locations are shown in Figure 2. Fluvial or glaciofluvial sediments were avoided during sampling, because of the possibility of reworking and the difficulty in defining distances and directions of transport. Sample spacing was controlled by access and surficial geology, but was generally 1 sample every 1 km along all primary and secondary roads and approximately 1 sample every 2 km in helicopter-supported areas. Samples were placed in Kraft-paper bags and sent to the Geological Survey's geochemical laboratory in St. John's, where they were air-dried in ovens at 60°C, and dry-sieved through 180 µm stainless-steel sieves in preparation for analysis.

Plate 3. *Glaciofluvial and fluvial sand and gravel deposits occupy large river valleys throughout the study area (Northwest Gander River shown here) and represent the routes of meltwater during deglaciation. Meltwater channels and eskers are commonly aligned with these river valleys.*

Plate 4. *Areas of ribbed moraine observed to the west of Great Gull River and common in the southern parts of the study area.*

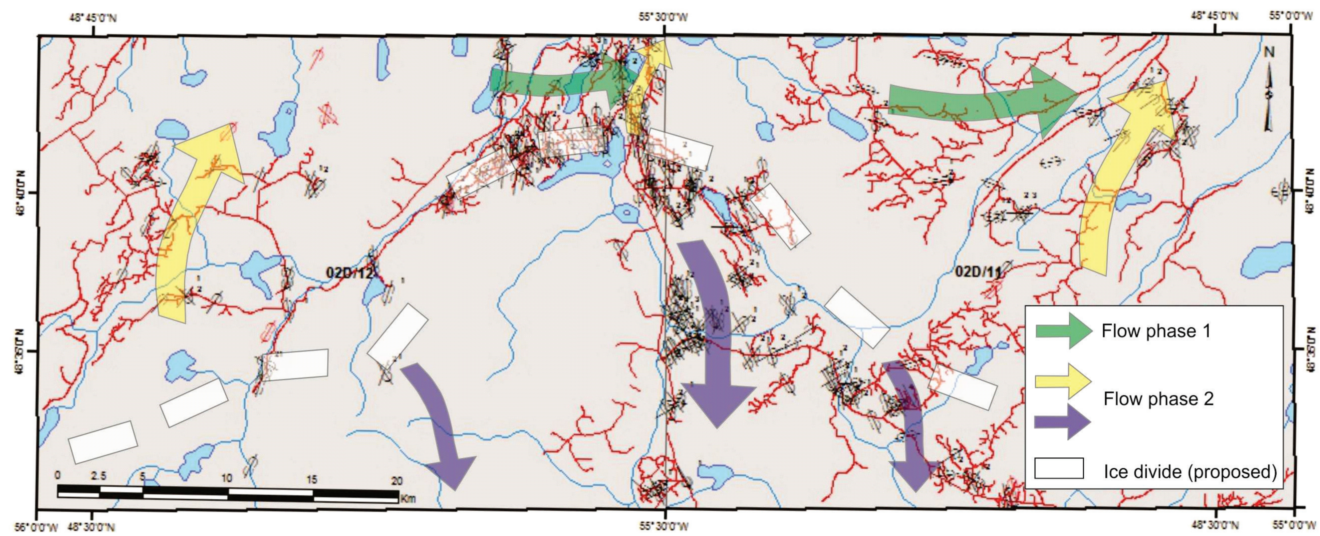

Figure 5. *Ice-flow patterns in the study area. At least 2 major ice-flow phases affected the area. The first (Flow phase 1) was a regionally extensive eastward flow with a likely source in the Topsails. This was followed by divergent flow (Flow phase 2) from an ice divide that produced north to northeastward flow over much of the study area and southward flow recorded in the central portion of the map area. Striations shown in red were recorded in 2014; those in black were recorded prior to 2014 (Newfoundland and Labrador Geological Survey, 2014b).*

IMPLICATIONS FOR EXPLORATION

Interpretations of till geochemistry and the development of mineral exploration strategies should consider the following:

- As evidenced by the conflicting directions and age relationships indicated by striation measurements, the study area has a complicated ice-flow history; this must be taken into consideration in any drift prospecting or geochemical exploration program. In the northeastern part of the study area, striations and landform orientations indicate that the ice flow is predominantly northeastward and that this is the direction most likely responsible for dispersal. Till geochemistry and clast-dispersal observations to the north support this interpretation (Batterson and Taylor, 1998). Striations in the western part of the study area also show a dominant northeastward ice-flow direction, and this is interpreted to be the main direction of dispersal. The interface between these two areas should be examined very carefully from the point of view of ice-movement directions; it is possible that either northward or southeastward dispersal may have taken place, as ice flowed in opposite directions away from the ice divide. The analyses of till samples collected during the 2014 field season should also help clarify dispersal patterns here; these are anticipated to be released in 2015.

- Sampling in glaciofluvial and fluvial settings should be avoided due to the possibility of sediment reworking, and the difficulty in defining distances and directions of transport. These areas include the valleys and areas surrounding the Northwest and Southwest Gander rivers, Great Gull River and Great Rattling Brook.

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