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PRELIMINARY TILL-GEOCHEMICAL AND SURFICIAL MAPPING INVESTIGATIONS OF THE DEAD WOLF POND MAP AREA (NTS 2D/10)

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ABSTRACT

Commencing in 2019, a multi-year till-geochemical and regional surficial mapping program was initiated in the Dead Wolf Pond map area (NTS 2D/10) to encourage and facilitate mineral exploration in the area. Fieldwork focused on till-geochemical sampling, ice-flow mapping, and surficial mapping of the northern half of the map area. Regional till sampling was conducted at a spacing of 1 sample per 1 km^2 along forest-resource roads. A total of 123 samples were collected.

Six new striation sites were identified. The two main ice-flow events recorded reflect regional ice flow patterns: an east to east-northeastward flow, and a younger north-northeastward flow. Evidence of a previously undocumented east-southeastward flow was recorded at one location, but likely records the influence of local topographic control during deglaciation.

Till and organic deposits are the dominant surficial units within the study area. Till conceals much of the bedrock, creating a gentle undulating topography. It forms blankets, veneers, ridges and hummocks of varying thickness. There are sporadic organic deposits of limited extent, however, larger deposits are associated with flat-topped hills. Glaciofluvial deposits are generally confined to the valleys of Riverhead, Triton, Dead Wolf and Mint brooks.

INTRODUCTION

This paper presents preliminary findings from the first field season of a multi-year 1:50 000-scale regional surficial mapping and till sampling program in the Dead Wolf Pond map area (NTS 2D/10). The area surrounding the Dead Wolf Pond map area (NTS 2D/10) has been the focus of base metals, gold and tungsten exploration since the 1950's (Geological Survey of Newfoundland and Labrador (GSNL), 2019a). Similar bedrock geology within the study area indicates that there is potential to identify additional mineral occurrences (GSNL, 2019b). The Dead Wolf Pond map area (NTS 2D/10) was selected to promote mineral exploration by completing till sampling and surficial mapping to better understand the Quaternary history in order to comment on mineral exploration strategies for this area. This work will also complement similar projects completed to the west (Brushett, 2015; Campbell *et al.*, 2017), north (Batterson and Vatcher, 1991), and northeast (Brushett, 2010, 2011).

The objectives of the field program were to: 1) conduct surficial and ice-flow mapping; 2) reconstruct the pattern of glacial retreat; 3) sample till *via* truck and ATV along roads at a density of one sample per linear kilometre; and 4) provide data assistance for mineral exploration by delineating prospective areas using the pattern of glacial movement, surficial geology and till geochemistry.

LOCATION AND ACCESS

Fieldwork focused on the north half of the Dead Wolf Pond map area, located approximately 20 km south of Gander Lake and 20 km west of the community of Gambo (Figure 1). The eastern part of the map area is accessed from the Trans-Canada Highway (TCH) at the Gambo exit, *via* the Mint Brook forest-resource road. Access may also be gained from the northwest, *via* the Southwest Gander River forest-resource road and along the newly constructed power transmission corridor into an area that was previously difficult to access.

PHYSIOGRAPHY

The bedrock in the study area forms an undulating topography that is oriented east-northeast. Elevations typically range between 100 and 350 m asl (above sea level). The highest elevations are found southwest of Dead Wolf Pond and are marked by flat-topped hills covered by organic detritus (bogs). The lowest elevations of about 6 m asl are in the

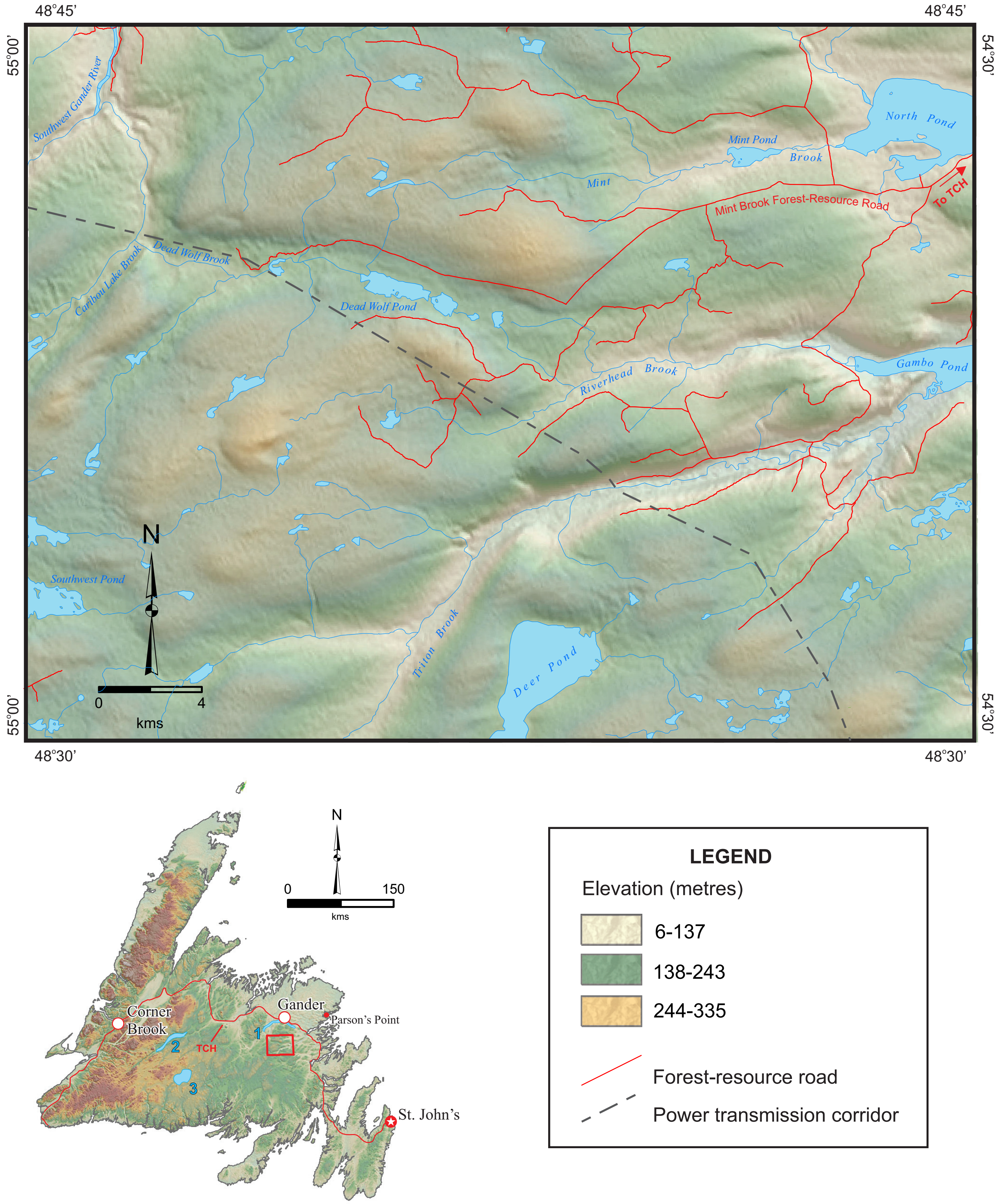

Figure 1. *Location of the study area (red box on inset) illustrating the physiography and place names used in the text. Numbers on inset map identifies the location of: 1) Gander Lake, 2) Red Indian Lake, and 3) Meelpaeg Lake.*

Gambo Pond area, and low elevations extend inland *via* the Riverhead Brook and Triton Brook valleys. Triton Brook forms an incised valley 200 m deep that extends over 20 km from the southwest end of Gambo Pond (*see* Figure 1).

BEDROCK GEOLOGY

The bedrock geology was described by Jenness (1963), Blackwood (1981a, b), Blackwood and Green (1982), Blackwood *et al.* (1991) and O'Neill (1992; Figure 2).

Much of the study area lies within the Gander tectonostratigraphic zone of the Newfoundland Appalachians (Williams *et al.*, 1988), although rocks of the Dunnage Zone outcrop in the northwestern corner (Blackwood and Green, 1982; Blackwood *et al.*, 1991; O'Neill, 1992). The Gander Zone consists of five units including Early Cambrian to Late Ordovician siliciclastic marine sediments and Devonian to Mississippian granitic plutonic rocks. The Gander Group (Unit CO:G; Figure 2) consists of interbedded psammitic, semipelitic and pelitic rocks and minor volcanic rocks (Blackwood *et al.*, 1991). These rocks have been intruded by several Devonian plutons, the largest of which is the Middle Ridge Granite (eD:M) in the western half of the study area. It is composed of a garnetiferous muscovite–biotite granite that ranges from fine to coarse grained and exhibits equigranular and porphyritic textures (Blackwood *et al.*, 1991). Other plutonic rocks in the study area include a massive, medium- to coarse-grained megacrystic biotite granite (Maccles Lake Granite, DB:ML); a megacrystic medium- to coarse-grained biotite granite (Gander Lake Granite, DB:G); Blackwood *et al.*, 1991); and a grey, fine-grained psammitic and semipelitic paragneiss and schist (Square Pond Gneiss, CO:SQ; Meyer *et al.*, 1984).

The boundary between the Gander and Dunnage zones is located in the northwestern corner of the study area and is represented by the Gander River Complex (CO:X; previously known as the Gander River Ultramafic Belt (GRUB); O'Neill and Blackwood 1989). This is an ophiolitic complex of Late Cambrian to Middle Ordovician age, and contains amphibolite, serpentinite, gabbro, tremolite, and talc-magnesite schist along with mafic flows and voclaniclastic rocks (Blackwood *et al.*, 1991; GSNL, 2019b).

To the west of the Gander River Complex, rocks of the Davidsville Group (O:D) comprise fine- to coarse-grained conglomerate, grey to black shale, slate, minor siltstone and fine- to coarse-grained dark greywacke (Blackwood *et al.*, 1991).

MINERAL OCCURRENCES

Mineral exploration, both within and surrounding the study area has taken place since the 1950s and has resulted in the identification of 19 mineral occurrences (GSNL, 2019a; Table 1). The focus for mineral exploration was on gold and antimony, based on known occurrences associated with the Davidsville Group to the north in NTS map area 2D/15, as well as on gold and base metals associated with ultramafic rocks of the Gander River Complex to the west (NTS map area 2D/11). There are three active claims in the

Table 1. List of mineral occurrences in NTS map area 2D/10 (GSNL, 2019b)

MODS #	Name of Occurrence	Commodity; Secondary Commodity	Status	Associated Rock Unit	Latitute	Longitude
002D/10/Asb001	Watcher's Brook Road No 1	Asbestos; Copper	Indication	GRUB (Gander River Complex; CO:X)	48.6574	54.9374
002D/10/Be 001	Dead Wolf Brook North Ridge	Beryl	Indication	Middle Ridge Granite (eD:M)	48.6830	54.9007
002D/10/Be 002	Dead Wolf Brook Dam	Beryl	Indication	Middle Ridge Granite (eD:M)	48.6635	54.8824
002D/10/Be 003	Dead Wolf Pond	Beryl	Indication	Middle Ridge Granite (eD:M)	48.6554	54.8490
002D/10/Be 004	Riverhead Brook	Beryl	Indication	Middle Ridge Granite (eD:M)	48.6215	54.8275
002D/10/Be 005	Middle Ridge No 1	Beryl	Indication	Middle Ridge Granite (eD:M)	48.6104	54.8822
002D/10/Be 006	Middle Ridge No 2	Beryl	Indication	Middle Ridge Granite (eD:M)	48.6120	54.9125
002D/10/Be 007	Middle Ridge No 3	Beryl	Indication	Middle Ridge Granite (eD:M)	48.5977	54.9287
002D/10/Cly001	Triton Brook No 1	Clay	Indication		48.5787	54.5738
002D/10/Cly002	Triton Brook No 2	Clay	Indication		48.5857	54.5665
002D/10/Cu 001	Dead Wolf Brook Junction No 1	Copper; Zinc, Lead, Nickel	Showing	GRUB (Gander River Complex; CO:X)	48.6768	54.9431
002D/10/Fl 001	North Pond	Fluorine	Showing	Gander Lake Pluton (DB:G)	48.7444	54.5945
002D/10/Mg 001	Caribou River North	Magnesite; Talc	Prospect	GRUB (Gander River Complex; CO:X)	48.6750	54.9509
002D/10/Mo 001	Gambo Pond	Molybdenum	Indication	Maccles Lake Granite (DB:ML)	48.6233	54.5028
002D/10/Tlc001	Dead Wolf Brook Junction No 2	Talc	Indication	GRUB (Gander River Complex; CO:X)	48.6706	54.9344
002D/10/W 001	Caribou River Tungsten	Tungsten	Showing	Davidsville Group (O:D)	48.7196	54.9662
002D/10/Zn 001	Dead Wolf Brook No 1	Zinc; Copper, Lead, Tin Silver, Gold, Tungsten	Showing	Davidsville Group (O:D)	48.7130	54.9464
002D/10/Zn 002	Watcher's Brook Road No 2	Zinc, Lead	Showing	GRUB (Gander River Complex; CO:X)	48.6567	54.9374
002D/10/Zn 003	Dead Wolf Brook No 2	Zinc, Lead, Silver, Gold	Showing	Davidsville Group (O:D)	48.7268	54.9196

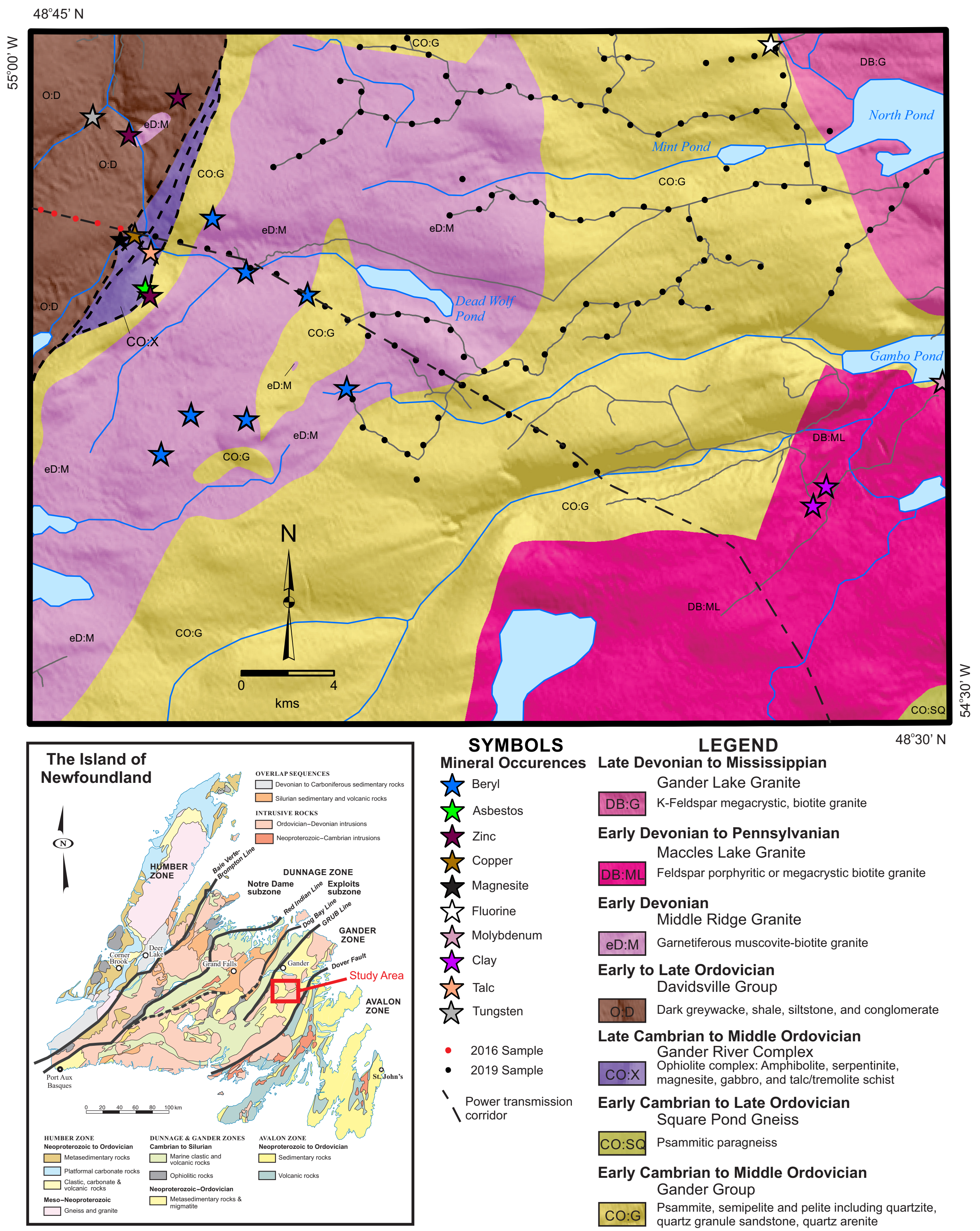

Figure 2. *General geology of the study area (GSNL, 2019b). Samples collected during the 2019 field season are shown as black dots. Mineral occurrence locations are identified by stars (GSNL, 2019a).*

study area, two are associated with the Davidsville Group in the northeast corner and the other in the southeast associated with the Maccles Lake Granite.

Most of the occurrences are located in the northwest part of the study area. The Gander River Complex hosts occurrences of asbestos, copper, magnesite, talc and zinc, whilst the Davidsville Group hosts tungsten and zinc mineralization (GSNL, 2019a). Beryl is reported within leucocratic phases of the Middle Ridge Granite (Blackwood and Green, 1982). Fluorite, molybdenum and clay deposits are located in the eastern part of the study area. Small patches of purple fluorite were observed by Dickson (1974) within megacrystic biotite granite close to the margin of the Gander Lake Granite. A molybdenum showing is located south of Gambo Pond within megacrystic biotite granite of the Maccles Lake Granite (GSNL, 2019a). Two occurrences of clay were identified southwest of Gambo Pond (Gibbons, 1966).

Elevated values of gold, nickel, scandium, vanadium, copper, and zinc have been identified in five till samples located in the northeast corner of the map area (*see* red dots on Figure 2; Campbell, 2019). These samples overlie the Davidsville Group suggesting this may be a promising area for identifying additional mineral occurrences in this area.

QUATERNARY HISTORY

During the late glacial maximum (LGM) at approximately 21 ka BP, Newfoundland was covered by multiple, local, ice-dispersal centres, collectively known as the Newfoundland Ice Cap that extended to the edge of the continental shelf (Grant, 1989; Shaw *et al.*, 2006). Major ice divides extended east from the Long Range Mountains through central Newfoundland where they bifurcated; one divide extending toward the northeast coast and the other southeastward onto the Avalon Peninsula (Shaw *et al.*, 2006). In northeastern Newfoundland, early ice retreat facilitated calving along deep channels, such as the Notre Dame Channel and the Trinity Trough (Shaw, 2003). As the result of calving embayments, the ice margin became land-based, and the configuration of ice divides shifted (Shaw *et al.*, 2006).

The Dead Wolf Pond map area was ice free between 12.0 and 10.5 ka based on dates from barnacle shells (GSC-4182) from Parson's Point to the east, and gyttja (GSC-5027) from 30 km west of the western edge of the map area (McNeely and McCuaig, 1991; Vardy, 1991). The generalized 12.0 ka ice margin modelled by Shaw *et al.* (2006) suggests that ice remained over much of the study area; however, the northwestern corner, and the area to the east around Gambo Pond, were likely ice free (Figure 3). The deglacial configuration was irregular and time-transgressive due to both ice thickness and topography. Jenness (1960) documented a discontinuous end moraine separating outer and inner drift zones (Figure 4A). The outer drift zone is found on the coastal side of the end moraine and is characterized by thin ground moraine (till) and sand and gravel outwash deposits (Jenness, 1960, 1963), whereas the inner drift zone generally includes thicker deposits of ground moraine, eskers and kames. While Jenness's (*op. cit.*) description of the inner and outer zones is accepted, the interpretation of a discontinuous end moraine has not been supported by subsequent work (Liverman and Taylor, 1990). In addition, Liverman and Taylor (1990) suggest that the boundary between the inner and outer drift zones is located farther east with the outer drift zone made up of exposed bedrock and marine sediments while the inner drift zone is made up of thin till, glaciofluvial gravel and sand, and bedrock (zones 3 and 4 respectfully on Figure 4B). The study area lies within Jenness's (1960) inner drift zone and Liverman and Taylor's (1990) zones 1 and 2, both representing thick till (blankets, ridged till and hummocky terrain and eskers and kames). During further ice retreat through ablation, the ice disintegrated into at least 15 isolated ice centres (Grant, 1974). Smith (2012) proposed that the ice center over Red Indian Lake was likely short lived due to the formation of glacial Lake Shanadithit and that remnant ice remained on the three topographic highs north of Red Indian Lake. The Meelpaeg, Middle Ridge and Gander ice caps had the potential to influence ice flow in the study area (Figure 5; Grant, 1974).

Figure 3. *Pattern of deglaciation on the Island of Newfoundland at 12 ka BP. Blue dashed lines show location of ice divides (*see *Shaw* et al.*, 2006). Red box shows location of study area.*

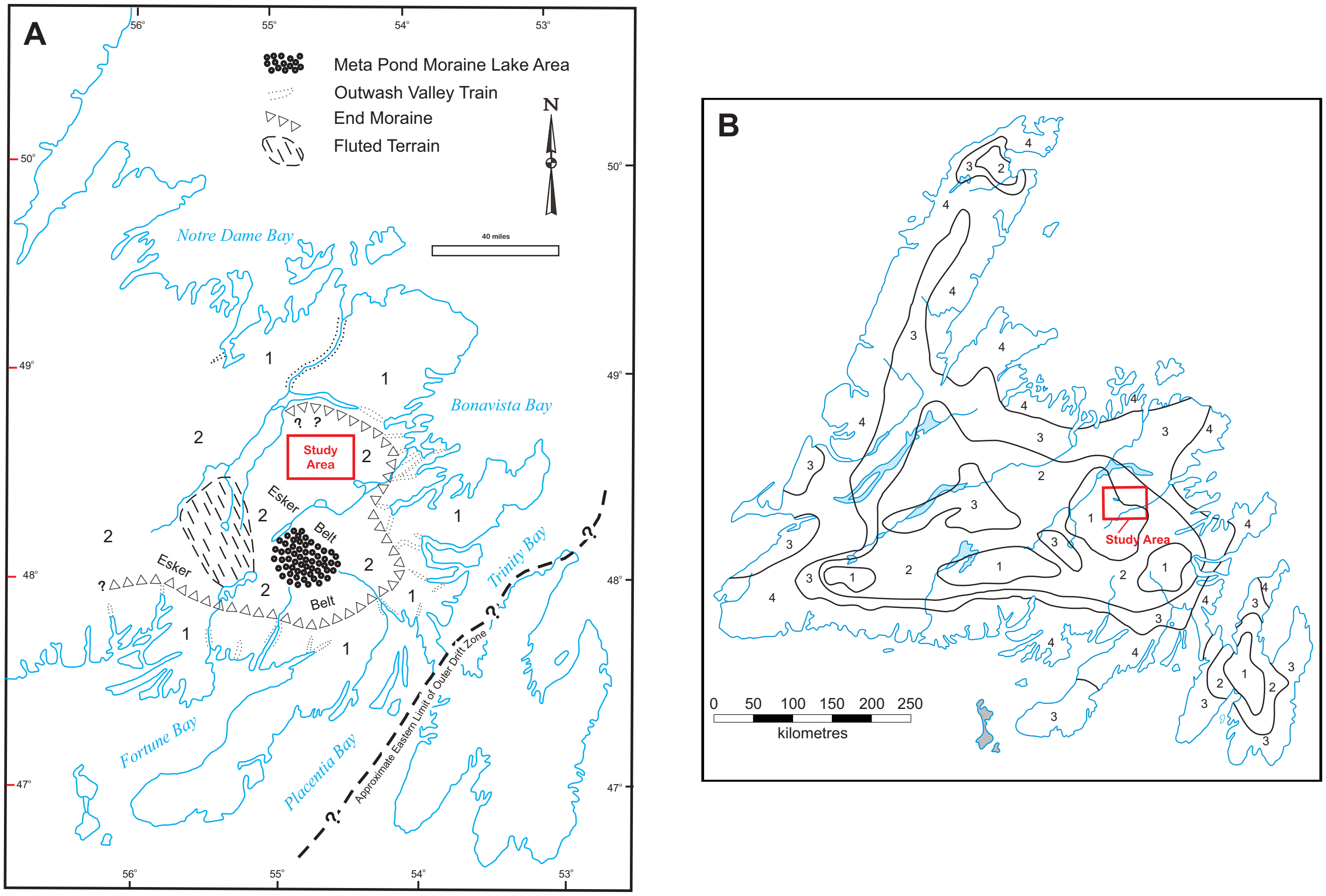

Figure 4. *A) Map showing the discontinuous end moraine separating the inner drift zone (2) from the outer drift zone (1) mapped by Jenness (1960); B) Landform zonation identified from surficial geology map of insular Newfoundland by Liverman and Taylor (1990). Zone 1 consists of hummocky terrain; Zone 2 is a mixture of till blanket, hummocky terrain, ridged till, kames and eskers; Zone 3 consists of till veneer, glaciofluvial gravel and sand, and bedrock; and Zone 4 is mainly exposed bedrock and marine sediments. The study area is outlined in red on both figures.*

A marine limit of 43 m asl was interpreted from a preserved marine delta east of Gambo by McCuaig (2006). Based on regional patterns, the sea-level history for the region likely follows a 'Type B' curve of emergence followed by submergence to present day sea level (Liverman, 1994). As a result of this sea level history, only a few raised marine features (and radiocarbon-dated marine shells relating to deglaciation) have been identified in Bonavista Bay (Liverman, 1994; GSNL, 2019c).

The study area is within Liverman and Taylor's (1994) 1:250 000-scale compiled surficial map of the Gander area. The dominant till units identified include till blanket and veneer, and hummocky terrain. In addition, till ridges are present south of the Southwest Gander River. Other minor units include glaciofluvial sand and gravel in the valleys of Mint Brook, Triton Brook and the Southwest Gander River, along with sporadic concealed bedrock. Two extensive clay deposits, up to 30 m long and 8 m thick, were identified south of Gambo Pond (Gibbons, 1966; GSNL, 2019a), but were not described in detail, and their depositional environment was not determined. No other detailed mapping has been conducted within the study area; however, detailed mapping was completed directly north in NTS map area 2D/15 by Batterson and Vatcher (1991) and Batterson (2000), and in adjacent map areas by Proudfoot *et al.* (2005), Taylor and Batterson (2003) and Brushett (2010).

Evidence of glacial erosion, such as striae and grooves, indicates that northeastern Newfoundland was affected by two ice-flow phases during the last, late Wisconsinan glaciation (Figure 6). The timing of these ice-flow events is based on relative age relationships determined from crosscutting relationships and lee-side preservation (St. Croix and Taylor, 1990). The older, dominant phase is an eastward ice flow that has been identified from central to northeast Newfoundland (Vanderveer and Sparkes, 1982; Proudfoot *et al.*, 1988; Vanderveer and Taylor, 1987; St. Croix and

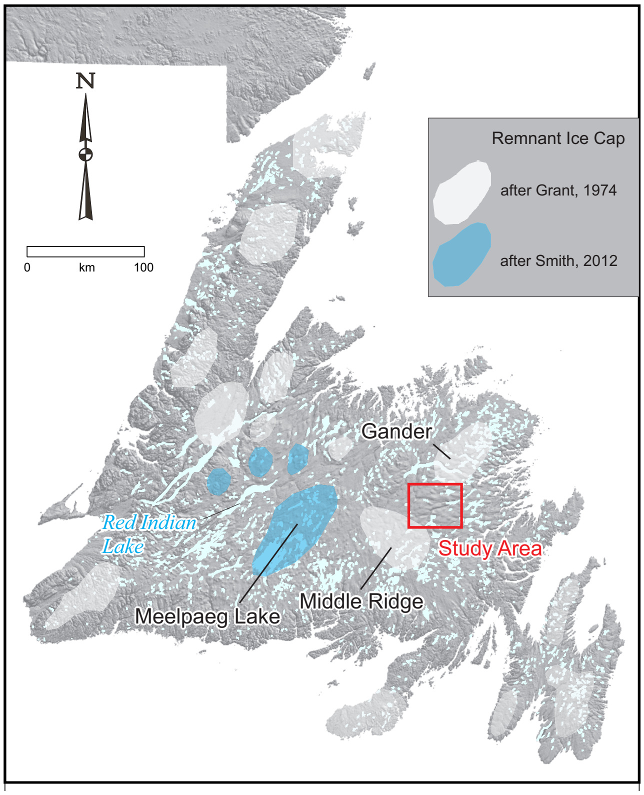

Figure 5. *Island of Newfoundland showing approximate locations of remnant ice caps as the Newfoundland Ice Cap disintegrated. Original interpretation is by Grant (1974), modifications were made by Smith (2012) over Red Indian Lake as a result of the formation of glacial Lake Shanadithit. Remnant ice caps are believed to have existed on the topographic highs north of Red Indian Lake. Detailed surficial mapping also indicated that Meelpaeg ice cap was larger than previously noted by Grant (1974).*

Taylor, 1990; Batterson and Taylor, 1998; GSNL, 2019d) and was mapped within the study area by Jenness (1960, 1963) and Taylor and Vatcher (1993). The source of this flow is likely an ice centre north of Red Indian Lake (Vanderveer and Sparkes, 1982; St. Croix and Taylor, 1991).

The younger phase consists of a north-northeast ice flow. Widespread evidence of this event is present in north-eastern Newfoundland (Vanderveer and Taylor, 1987; St. Croix and Taylor, 1990, 1991; Batterson and Vatcher, 1991; Batterson and Taylor, 1998). The source is likely from the Middle Ridge or Meelpaeg Lake ice centres (St. Croix and Taylor, 1990, 1991; Campbell *et al.*, 2017).

FIELD METHODS: OBSERVATION, SAMPLING AND ANALYSIS

Field observations pertaining to the surficial geology and ice-flow indicators were collected from 139 sites during the 2019 field season. At each site, GPS location, elevation, sediment type, matrix composition, clast information (size, composition, angularity, concentration of clasts) and striae measurements (where present) were recorded.

A total of 123 till samples were collected (Figure 2) along forest-resource roads at a spacing of one sample every linear kilometre. Samples of 1 kg were taken from the C or BC horizons in hand-dug pits or roadcuts, at an average depth of 73 cm, and placed in Kraft paper bags. Care was taken to clean sampling tools between sites, to avoid cross-contamination. To test site variability and reproducibility of results, duplicate samples were taken at a frequency of 1 in 20 from a second hand-dug pit 1–2 m away from the first.

Samples were processed and analyzed at the Geochemical Laboratory of the Geological Survey of Newfoundland and Labrador in St. John's, where they were air-dried to 60°C and dry-sieved through 63 µm (230 mesh) stainless-steel sieves to recover the silt and clay fraction for analysis. Minor- and trace-element content will be analyzed using ICP-OES analysis, whereas INAA analysis will be completed at Bureau Veritas (Mississauga). For further details of the preparation and analytical methods for till samples, *see* Finch *et al.* (2018).

RESULTS

ICE-FLOW INDICATORS

In total, 8 glacial striae were measured from 6 new sites along forest-resource roads within the map area (Figure 6). These striae record two dominant ice-flow phases that include an east to east-northeast and north-northeast ice flow as well as a less extensive east-southeast flow. The two dominant ice-flow events are consistent with regional ice-flow patterns described in (St. Croix and Taylor, 1990). One multidirectional site located northeast of Gambo Pond documents a north-northeast flow followed by an east-southeast flow. This is the first known evidence of an east-southeast flow within in the area, and is likely due to local topographic control during late stages of deglaciation. Until further evidence of this east-southeast flow is documented, the regional ice-flow pattern best represents the ice-flow history for the study area (Figure 6).

SURFICIAL GEOLOGY

A brief description of the surficial geology is provided, prior to a detailed aerial-photograph interpretation, presently under consideration. The current description is based on 1:50 000-scale, black and white imagery from the 1960s, field observations, and Shuttle Radar Topography Mission (SRTM).

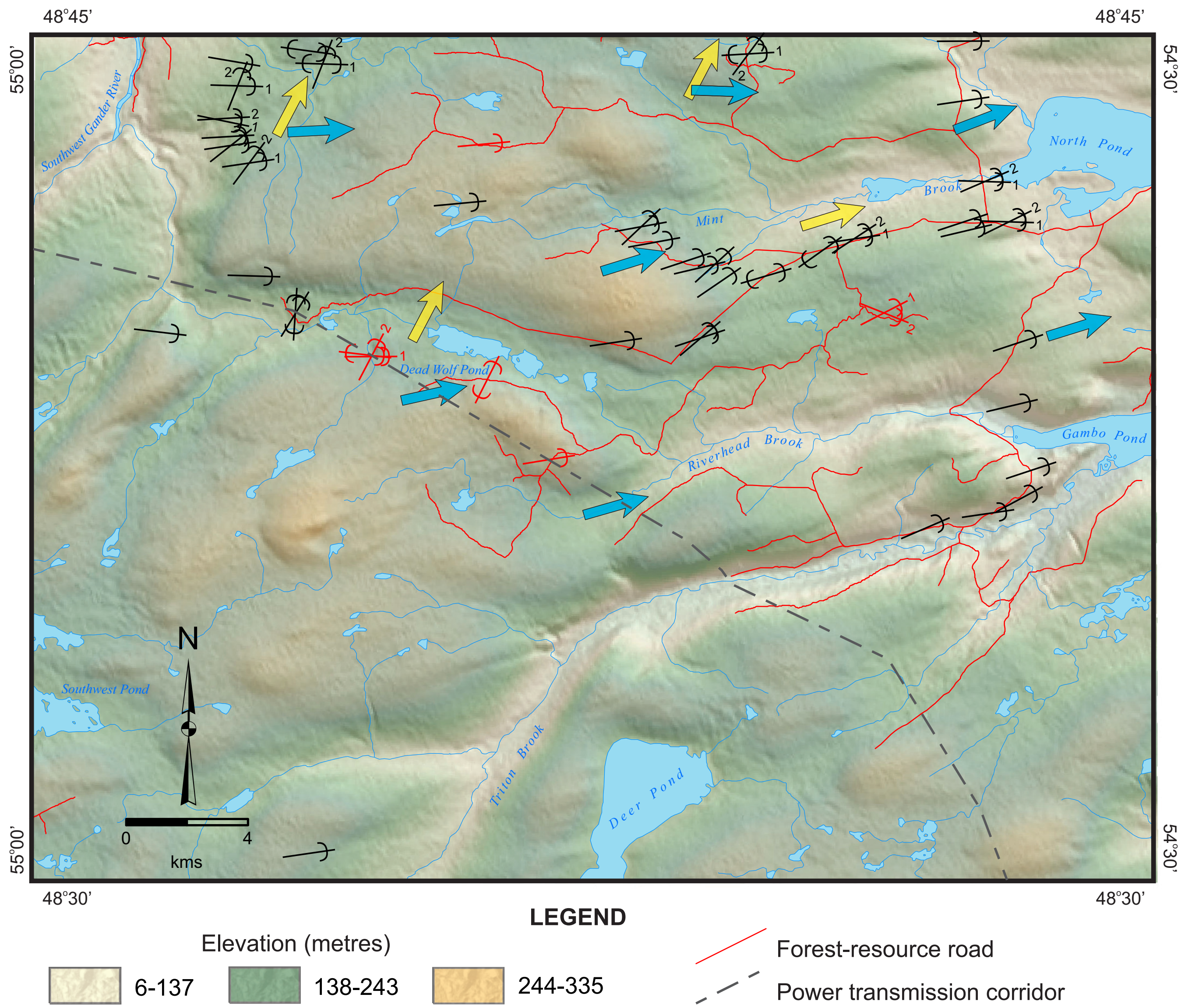

Figure 6. *Locations and orientations of striae identified during the 2019 fieldwork (shown in red). Previously collected striae are show in black. Relative ages are given by the numbers at the end of the striae symbols (1 = older; 2 = younger) Blue arrows show an older east to east-northeast flow, which was followed by a younger north-northeastward flow (yellow arrows).*

Bedrock is almost entirely obscured by overburden. The lack of exposed bedrock is shown by the smoothness seen on the SRTM image (Figure 7, Plate 1). Bedrock outcrops are typically visible in stream bottoms, and exposed along forest-resource roads and at topographic highs. The SRTM image shows a subtle east-northeast streamlined trend of bedrock exposures and intervening overburden. This represents the oldest ice flow identified in the area. Landforms such as till ridges are visible on the SRTM and are oriented transverse to ice flow.

The study area is dominated by sediment deposited under the influence of ice (glacial diamicton or till) and to a lesser extent, sediments deposited under the influence of flowing water (glaciofluvial sands and gravel). Till thickness ranges from a few centimetres, in areas adjacent to exposed bedrock, to tens of metres in areas where topography is flat or gently rolling. Glaciofluvial deposits may be up to tens of metres thick in larger valleys (*i.e.*, Triton Brook). Postglacial organic deposits, including bogs and string bogs, are a common feature.

Diamicton

As identified from airphoto interpretation, deposits of diamicton (till) form five main units that consist of till

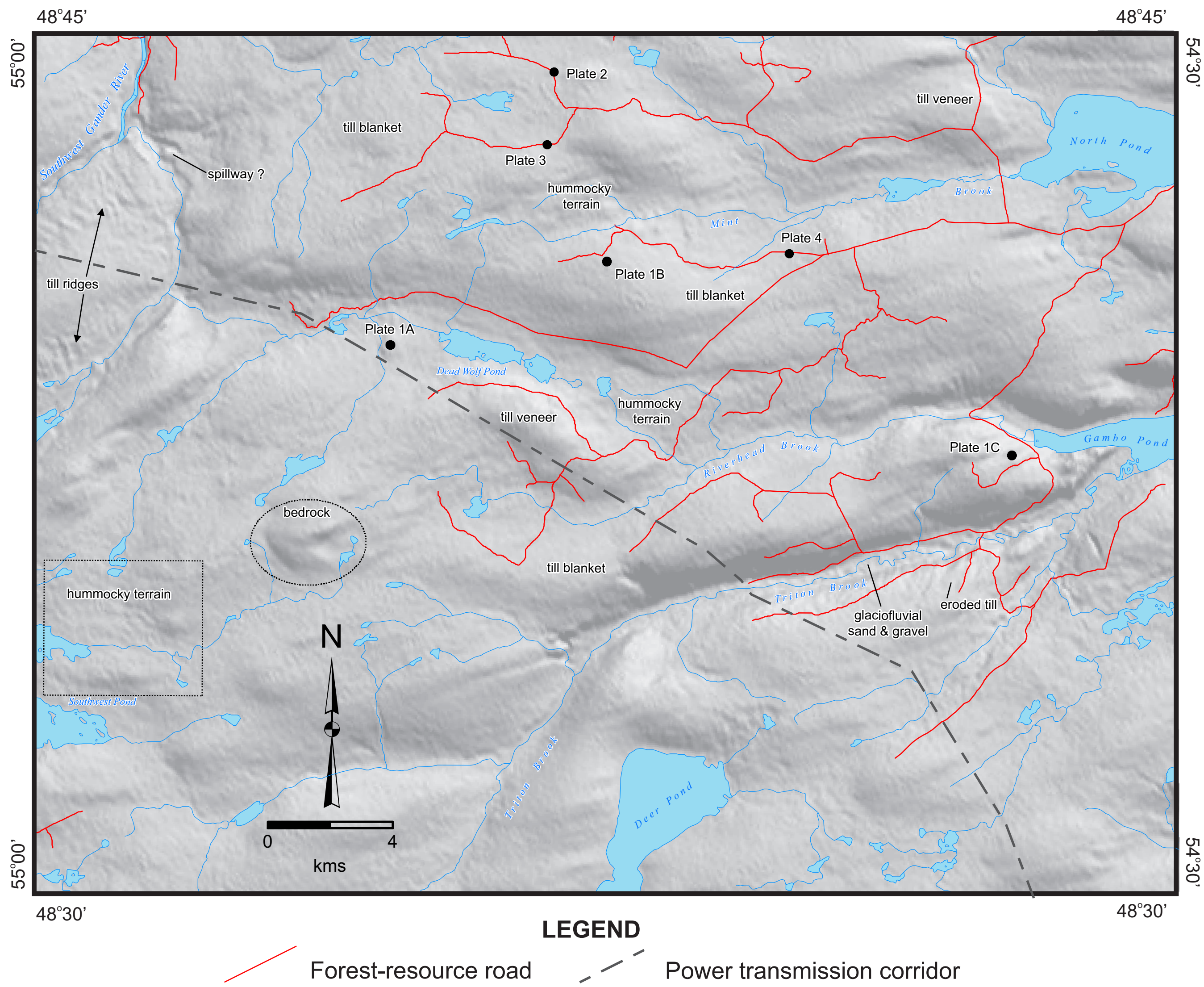

Figure 7. *Location of glacial landforms as interpreted from the SRTM image. Black dots identify location of plates mentioned in text. Thin drift is represented in areas where the underlying bedrock ridges show relief (*see *circle and Plate 1A).Thick till (blanket) is characterized by smooth textures, as can be seen in the area north of Dead Wolf Pond (Plate 1B). Hummocky terrain is identified by an irregular stippled surface, west of Dead Wolf Pond and north of Southwest Pond (*see *Square). Ridged moraine is noted southeast of Southwest Gander River. Eroded till is identified on the north-facing slope at the southwest end of Gambo Pond (Plate 1C) and on the north-facing slope of Triton Brook.*

veneer, till blanket, hummocky terrain, eroded till and till ridges. Till veneer is defined as having a thickness of less than 1.5 m; till of this type is associated with exposed bedrock in the centre of the study area (Plate 1A). The term till blanket is defined as having a thickness of greater than 1.5 m and masks minor topographic irregularities. Till blanket deposits are identified north of Dead Wolf Pond and Triton Brook (Plate 1B). Areas of hummocky terrain are located sporadically throughout the study area. Eroded till has been identified on the north-facing slopes at the southwestern end of Gambo Pond and Triton Brook valley (Plate 1C). Till ridges have been identified in the northwest corner of the study area (Figure 7) using the SRTM and are located in two north-northeast-trending valleys and oriented transverse to the most recent phase of ice flow (north-northeast). The ridges are slightly sinuous and are up to 1500 m long and 200 m wide.

Two types of diamicton are identified in the field in exposures in the northern part of the study area; however, their stratigraphic context remains unclear, due to the lack of exposed sections. Diamicton A is a poorly sorted, compact, boulder type having a silty to fine-grained sand matrix (Plate 2). The colour of the diamicton is variable ranging from

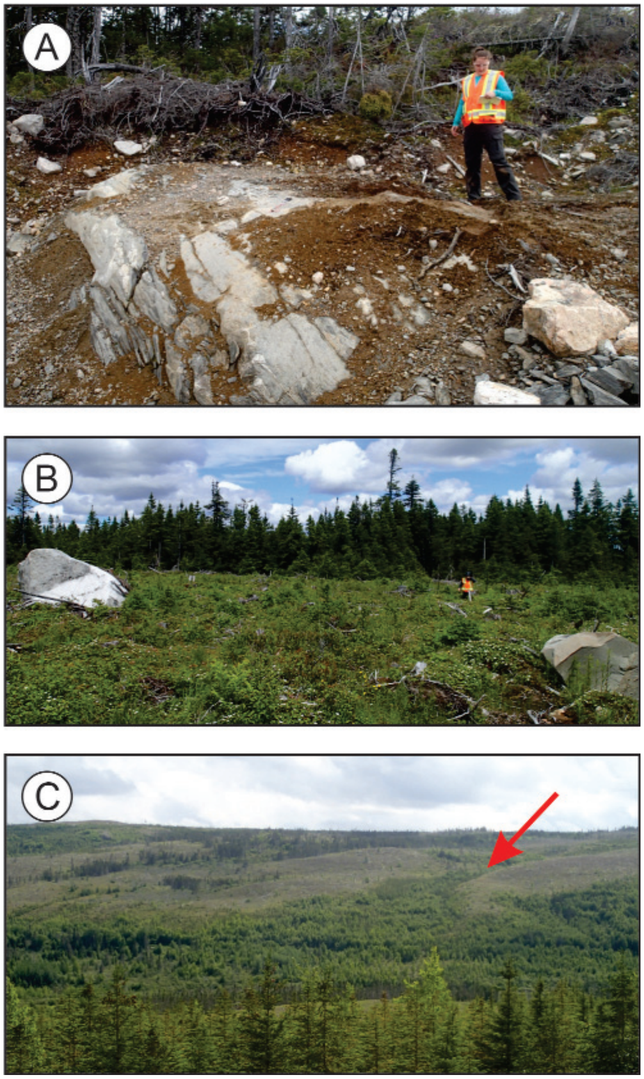

Plate 1. *A) An area of thin till (<1 m) overlying partially exposed bedrock located adjacent to the power transmission corridor; B) A flat area mapped as till blanket, with large angular boulders on the surface located north of Dead Wolf Pond; C) Meltwater channels (red arrow) eroded into till at the southwest end of Gambo Pond.*

light grey (Munsell colour 2.5Y 7/2) to pale yellow (2.5Y 7/4) to very pale brown (10YR 7/3). The variations in colour reflect changes in the composition of the underlying bedrock. It has a low (20%) clast content with clasts ranging from granule to boulder size (up to 1 m diameter) that are generally subrounded to angular. Clasts are striated and faceted and generally reflect the underlying bedrock. Diamicton B is similar to A but has a higher concentration of clasts and a sand-dominated matrix. It is associated with areas of hummocky terrain and has a high concentration (21–40% of the surface area) of angular cobbles to boulders (up to 3 m in diameter), on the surface (Plate 3).

Plate 2. *Test pit showing Diamicton A. It is a cobble–boulder diamicton, is light grey (10 YR 7/2 Munsell colour) having a silty to very fine-grained sand matrix. Clasts in this locality are angular to subrounded and are often striated and faceted. The average clast diameter is 2 cm, but clasts can be up to 100 cm in diameter.*

The characteristics of Diamicton A (*i.e.*, compactness, striated clasts, angularity and local clast lithology) indicate deposition by active ice, and thus interpreted as till (Benn and Evans, 1998). Additional studies consisting of clast-fabric analysis and examination of stratigraphy will provide further details on the depositional environment of the diamicton.

The morphology and characteristics of Diamicton B, the sandiness of the matrix material (less fine material) and the high concentration of large, angular clasts on the surface suggest that it formed by stagnating ice under a passive margin (Benn and Evans, 1998). Areas interpreted as showing similar effects of stagnating ice are present to the northeast of Gander Lake (Brushett, 2010) and to the west in the Meelpaeg Lake area (Campbell *et al.*, 2017).

Glacial transport studies in the Gander area to the north concluded that, while the diamicton in the area is largely

Plate 3. *A high concentration of boulders in hummocky terrain.*

composed of locally derived material, it contains clasts that were transported up to 25 km east and 18 km north of the nearest potential source (Batterson and Vatcher, 1991). Source rocks of the collected pebbles will be identified and used in a clast-provenance study to determine transport distances.

Glaciofluvial Deposits

Glaciofluvial and fluvial sediments are confined to the valleys of Riverhead Brook, Triton Brook, Dead Wolf Brook and Mint Brook. Fieldwork identified two small sand and gravel deposits along the south side of both Mint Brook valley and North Pond.

A small sand and gravel pit is located west of Mint Pond (labelled Plate 4 on Figure 7). The forested area surrounding the pit is flat and appears to be undisturbed. The exposure is limited to a 0.5 m section and test pits. There is at least 1 m thickness of coarse-grained sand to granule gravel that contains angular to subrounded pebbles and cobbles (Plate 4). Test pits indicate up to 2 m of well-sorted fine- to medium-grained sand underlie the gravel. The contact between the gravel and sand was not observed. Dark coloured laminations and occasional subrounded pebbles up to 4 cm in diameter are exposed in the uppermost sand unit.

A small sand deposit is located 0.5 km south of North Pond. A test pit dug in a flat area devoid of boulders revealed 60 cm of clean medium-grained sand, containing pebbles and cobbles. Clasts are up to 10 cm in their longest dimension, and have an angular to subangular shape.

Organic Deposits

Organic deposits are common within the study area. Small, isolated bogs and string bogs are found in poorly drained areas or in topographic lows. Surprisingly, the largest organic deposits are associated with flat-topped hills and may be the result of impermeable finer grained till

Plate 4. *View of sand and gravel pit; the locations of insets A and B are labelled. Approximately 1 m of coarse sand and granule gravel (*see *inset A) overlies well-sorted fine- to medium-grained sand that is locally laminated (*see *inset B). The yellow line marks the approximate contact between the two units is known.*

(Diamicton A) derived from sedimentary rocks of the Davidsville Group to the west. Typically, the deposits are less than 1 m thick; however, thicker deposits occur locally.

DISCUSSION

The 43-m-asl marine limit at Parson's Point to the east of the study area indicates that a long narrow inlet, currently occupied by Gambo Pond and the Triton Brook valley (up to 20 km inland), would have formed as a result of inundation by the sea, immediately following deglaciation. Extensive clay deposits identified by Gibbons (1966) are located at, and above, this marine limit indicating the clays could have formed during the marine incursion following deglaciation. Confirming the location, elevation and the sedimentology of the clays, along with other depositional/erosional marine features, will help determine if these are of a marine origin. Another possibility is that these clays represent deposition in a glaciolacustrine environment. It is particularly important to delineate areas affected by marine incursion or glaciolacustrine sedimentation, as these areas are unfavourable for mineral exploration due to the reworking of sediment and the difficulty in defining transport directions and distances.

IMPLICATIONS FOR MINERAL EXPLORATION

Knowledge of the ice-flow history, type of retreat and the resulting morphology aid in the development of the following strategies for drift prospecting within the Dead Wolf Pond map area.

- The study area was affected by two ice-flow events. The older east to east-northeast flow is the dominant event identified within the surveyed area. However, a younger north-northeast flow affected the western part of the study area. A single flow event often creates a ribbon-type dispersal train with sharp straight edges which is outlined by high geochemical abundances inside and low abundances outside the dispersal train (McClenaghan and Paulen, 2018). However, when multiple flows are identified there are a number of glacial patterns that may result (McClenaghan and Paulen, 2018). A change in ice-flow direction can result in one of four palimpsest dispersal trains. These are: 1) the original ribbon pattern can be eroded entirely; 2) a fan shape is created by reworking the ribbon dispersal train between the two ice flows; 3) a new ribbon pattern in a different orientation forming a bi-lobate fan or 4) multiple ice flows having very different dispersal directions can rework glacial debris into an amoeboid-shaped train. As a result of the reworking of the dispersal train can result in diffuse geochemical abundances (McClenagahan and Paulen, 2018). Transport distances in Newfoundland are on the order of 10's of kilometres in the Gander area (*see* Batterson and Vatcher, 1991) and in the Baie Verte area (*see* Batterson and Liverman, 2000). This reflects the style of glaciation on the Island, of coalescing ice caps at the glacial maximum, and a smaller number of topographically controlled ice centres during deglaciation in comparison to continental style glaciation (Batterson and Liverman, 2000). Therefore, when conducting boulder tracing or following up on a till anomaly in an area affected by two ice-flow events it is important to consider both flows and the potential dispersal patterns that could result.

- Areas of poorly sorted sediment containing silt, deposited in contact with active ice (*i.e.*, till) are the best for conducting drift-prospecting surveys.

- The uppermost surface of areas of thicker till may not necessarily reflect the composition of the underlying bedrock due to directional shifts in actively moving ice.

- Sediments deposited from stagnating ice, such as that observed on hummocky terrains, are less suitable for drift prospecting, as there is a high portion of distally derived material (Proudfoot, 1988; Geological Survey of Canada, 2017). Due to varying amounts of associated meltwater, sediments forming hummocky terrain tend to contain less fine-grained matrix (*i.e.*, sandier, less silt) and to be better sorted than till deposited by active ice. In areas of hummocky terrain, till sampling programs should be designed so that hummocky areas as those found in the Mint Brook and Dead Wolf valleys are avoided, and if sampling is required, samples should be collected from between the hummocks (Proudfoot, 1988; Geological Survey of Canada, 2017). It should be noted that any exotic mineralized boulders identified within hummocky terrain may have experienced longer transport distances and thus have a more distant source.

- Sampling sediment that is moderately to well sorted, or lacking silt, such as glaciofluvial sands and gravels, or lacustrine and marine sediments, should be avoided due to sediment reworking, as well as the difficulty in defining transport directions and distances. Such sediment may be common below the marine limit (43 m asl), mainly in the Gambo Pond area, as well as in the valleys of Riverhead Brook, Triton Brook, Caribou Lake Brook, Dead Wolf Brook and Mint Brook.

FUTURE WORK

Geochemical analysis of the first years' results will be released during 2020. Surficial mapping will continue in 2020 with the surficial map of NTS map area 2D/10 to be released in 2021. The focus of field investigations in 2020 will include:

1) Completing till sampling, ice-flow mapping and surficial mapping of NTS map area 2D/10, with a focus on:

    a) determining the extent of marine inundation in the Gambo Pond area,
    b) examining the clay deposits south of Gambo Pond and determining their depositional environment, and

2) Determining dispersal distances and patterns by conducting clast-provenance and clast-fabric studies.

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