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EASTERN RED INDIAN LAKE BASIN, CENTRAL NEWFOUNDLAND: SURFICIAL AND ICE-FLOW MAPPING RESULTS

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ABSTRACT

The final year of a multi-year, till-geochemistry and regional surficial-geological mapping program in the Red Indian Lake Basin, focused on the eastern part of the basin. Field work in 2012 included mapping of ice-flow indicators, surficial geology and infill-till sampling, to enhance previous sampling programs. Regional till sampling was conducted at a spacing of 1 sample per 1 km along forest-resource roads and where helicopter support was required sample sites were pre-selected so that one sample was collected per 4 km^2.

Seventy-two ice-flow measurements were recorded. In conjunction with existing data, they indicate that there were at least 4 ice flows and, based on relative age relationships, have been assigned to 3 phases. The oldest (Phase 1) was a south-south-east to south-southwest flow identified in the south. Phase 2 consists of two flows separated by an ice divide near Costigan Lake; to the west of the divide, ice flow was west-southwest and to the east the flow was east-northeast. The youngest (Phase 3) is represented by a southward flow. A northwestward flow was also identified northeast of Shanadithit Brook and east of Red Indian Lake along the Exploits River; however its age relationship to the other ice flows is unclear.

The study area is covered by varying amounts of thick till (>2 m thick) and organic deposits, as well as thin till veneer (<2 m thick), glaciofluvial deposits and rare glaciolacustrine sediments.

INTRODUCTION

This paper presents results of 2012 field work from the eastern part of the Red Indian Lake Basin (RILB). This is the final year of a multi-year program designed to collect ice-flow and surficial geological data to provide a better understanding of the Quaternary geology of the RILB (Batterson and Taylor, 2008; Smith, 2009, 2010, 2012). The RILB has a long history of mineral exploration with the discovery of a Cu–Pb–Zn deposit in Buchans in the early 1900s, with the opening of a Cu–Zn mine at Duck Pond in 2007 and recent exploration of VMS deposits in the Tulks Volcanic Belt (Hinchey, 2007; Thurlow, 2010).

An understanding of the Quaternary geology provides support to current exploration and may stimulate future mineral exploration activity. There were three priority study areas in 2012. The primary study area was NTS map area 12A/09, east of the Duck Pond Mine; the secondary was 12A/07, /10, /11, and 16; and the third was 12H/01 and /08. With the exception of NTS map area 12A/09, these areas were sampled by the Geological Survey of Canada in the early 1990s (Klassen, 1994a; Davenport *et al.*, 1996); however, sampling was conducted at a wider spacing than currently practiced by the Geological Survey of Newfoundland and Labrador for regional 1:50 000 till sampling, as in-fill sampling was necessary.

LOCATION AND ACCESS

The study area includes all of NTS map area 12A/09, and parts of 12A/07, /10, /11, /16, and 12 H/01 and /08 (Figure 1). The area extends from Meelpaeg Lake in the south to Halls Bay in the north, and from Star Lake in the west to Badger in the east. It is accessible from the east by Route 370, which is off the Trans-Canada Highway, or by a forest-resource road that extends south of the Exploits River between Grand Falls-Windsor and Millertown. The northern part of the study area is reached *via* Dawes Pond or Southwest Brook forest-resource roads that are accessed from the Trans-Canada Highway. Extensive logging in the area has resulted in a dense network of forest-resource roads on NTS map areas 12 A/07, 16, and 12H/01. A helicopter was used to access much of NTS map areas 12 A/09, /11, where there was limited road access.

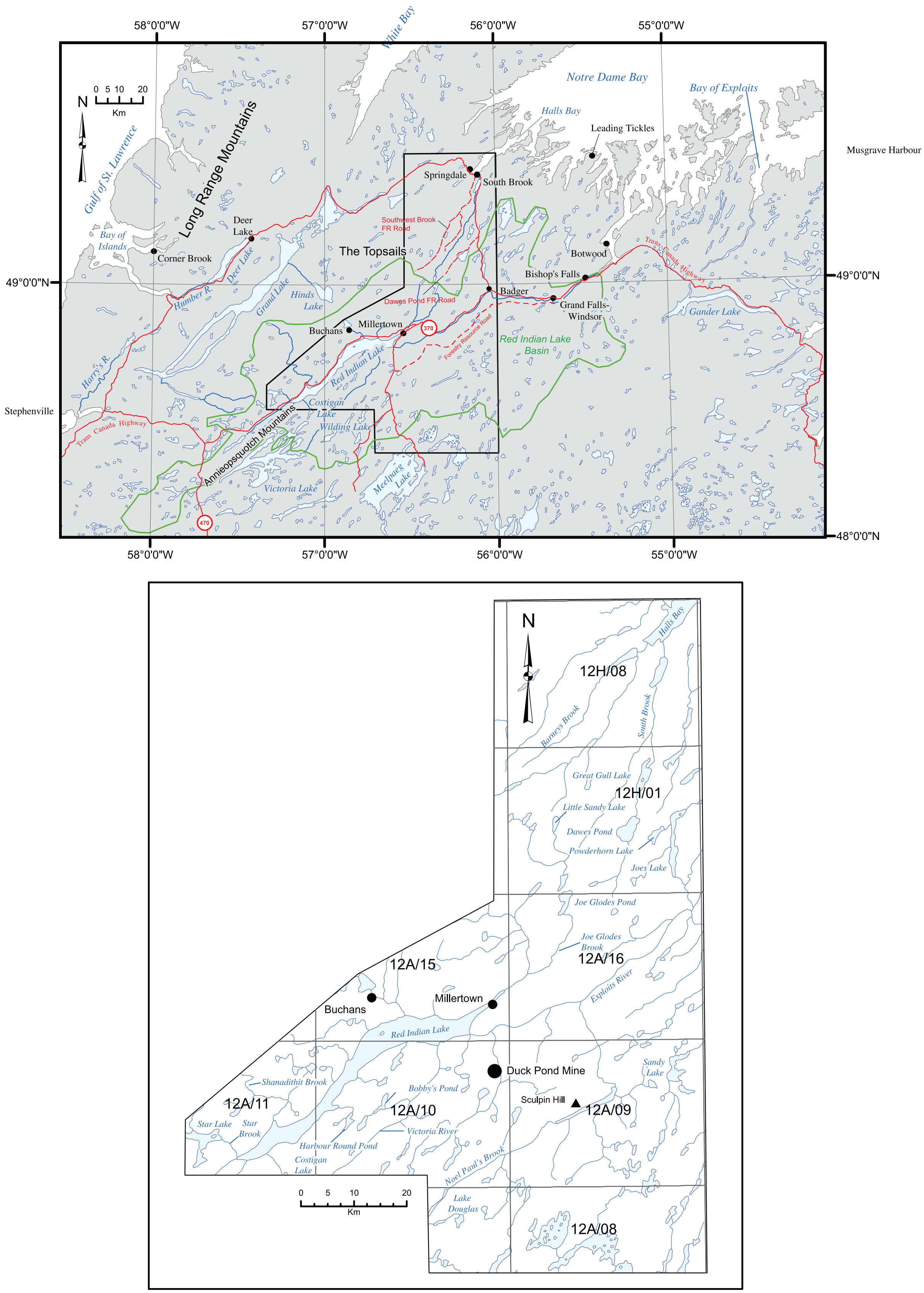

Figure 1. *Location of study area and place names used in the text.*

PHYSIOGRAPHY

The study area, with the exception of the northern and southern extremities, is within the eastern part of the RILB, which drains through the Exploits River into the Bay of Exploits. Bounded by the Topsails Plateau to the north and a 350-m-high plateau in the south, the elevation of the RILB decreases to the northeast. The largest water bodies in the study area are Red Indian Lake, Meelpaeg Lake, Sandy Lake, Joe Glodes Pond and Dawes Pond. North of Joe Glodes Pond, drainage of South Brook and Barneys Brook is to the north-northeast into Halls Bay. South of Meelpaeg Lake, drainage is into the Gulf of St. Lawrence.

BEDROCK GEOLOGY

The study area lies within the Dunnage and Gander zones of the Newfoundland Appalachians (Figure 2). Sedimentary and volcanic rocks within the Dunnage zone are remnants of continental and intra-oceanic areas and are composed of back-arcs and ophiolites deposited within the Iapetus Ocean during the Cambro-Ordovician (Evans and Kean, 2002; Hinchey, 2007, 2008). The Red Indian Line separates rocks of the Buchans and Robert Arm groups of the Notre Dame Subzone from the Victoria Lake Supergroup of the Exploits Subzone. These subzones formed on the North American continent side and the Gondwanan side of the Iapetus Ocean, respectively. The Red Indian Line lies along the south shore of Red Indian Lake and extends north-northeastward along Joes Lake and the eastern edge of Dawes Pond and continues northeast into Notre Dame Bay. A detailed description of the bedrock geology in the northern part of the study area is provided by Bostock *et al.* (1979) and Thurlow (2010); the bedrock geology of the southern part of the study area is described by Evans and Kean (2002) and Hinchey (2007, 2008).

Both the southern and northern parts of the study area are intruded by a number of granitic intrusions that range from Early Ordovician to Late Devonian; these include the Topsails Igneous Suite and the Hungry Mountain Complex in the north and the Snowshoe Pond, Meelpaeg Lake, Overflow Pond, and Great Burnt Lake granites in the south (Crisby-Whittle, 2012). Intrusions such as Snowshoe Pond and Great Burnt Lake granites, along with the siliclastic rocks of the Spruce Brook Formation, represent the Gondwanan margin of the Gander Zone (Crisby-Whittle, 2012). The discovery of mineralization within the RILB occurred over 100 years ago with the identification of zinc–lead–copper in the Buchans area (Thurlow, 2010) and high-grade chalocopyrite–pyrite at the Victoria Mine deposit on the south side of Red Indian Lake (Hinchey, 2008). Many more significant VMS deposits have been identified in the last 50 years, including the Tulks Hill, Tulks Hill East and Jacks Pond deposits, discovered during the 1960s to 1980s, and the Duck Pond and Boundary deposits discovered during exploration in the 1990s to early 2000s.

A further surge of exploration in the mid 2000s led to the discovery of the Lemarchant, Boomerang, Long Lake, Domino and Hurricane deposits (Crisby-Whittle, 2012). The Duck Pond deposit has been a producing copper–zinc mine since 2007 and is expected to keep producing until 2015 (Teck Resources Limited, 2013). The Leprechaun Gold deposit is the most recent discovery (Marathon Gold Corporation, 2013). It is likely that exploration in this area has not reached its full potential due to thick overburden.

QUATERNARY HISTORY

During the late Wisconsinan glacial maximum, Newfoundland was covered by a series of coalescent ice caps, which formed the Newfoundland Ice Cap (Grant, 1989; Shaw *et al.*, 2006). Ice divides extended down the Long Range Mountains through central Newfoundland and eastward to the Avalon Peninsula (Figure 3A; Shaw *et al.*, 2006). This configuration remained stable throughout much of the late Wisconsinan until sometime after 13Ka BP when deglaciation became terrestrial and the Newfoundland Ice Cap disintegrated into a number of small isolated ice caps (Figure 3B; Shaw *et al*., 2006). One of these was postulated to lie over Red Indian Lake (Grant, 1974). Remnant ice over the RILB disintegrated quickly as suggested by the paleogeographic reconstruction model for glacial Lake Shanadithit presented by Smith (2012). Isolated ice remnants existed on the highlands west of Buchans, northeast and south of Red Indian Lake (Figure 3B; Smith, 2012). South of the Exploits River, ice actively retreated to the south of Wilding Lake where it stagnated leaving a hummocky and boulder-covered surface (Smith, 2009). Radiocarbon dates of lake sediment from south of Millertown (GSC-4231) and on the road north of Meelpaeg Lake (GSC-4186) indicate that this area was ice free by 9300 BP (McNeely and McCuaig, 1991).

Quaternary investigations within the RILB began in the 1970s and continued through the mid 1990s with the work of Grant (1975), Grant and Tucker (1976), Vanderveer and Sparkes (1982), Sparkes (1985), Mihychuk (1985), Klassen (1994b) and Klassen and Murton (1996). These workers developed the ice-flow history for the RILB, and, in addition, Vanderveer and Sparkes (1982) along with Klassen and Murton (1996) conducted stratigraphic mapping around Buchans and the southwest end of Red Indian Lake. Further Quaternary investigations were initiated in 2008 with the start of the Red Indian Lake Project; its aim was to provide a better understanding of the Quaternary geology within the context of mineral exploration (Batterson and Taylor, 2008; Smith, 2009, 2010, 2012).

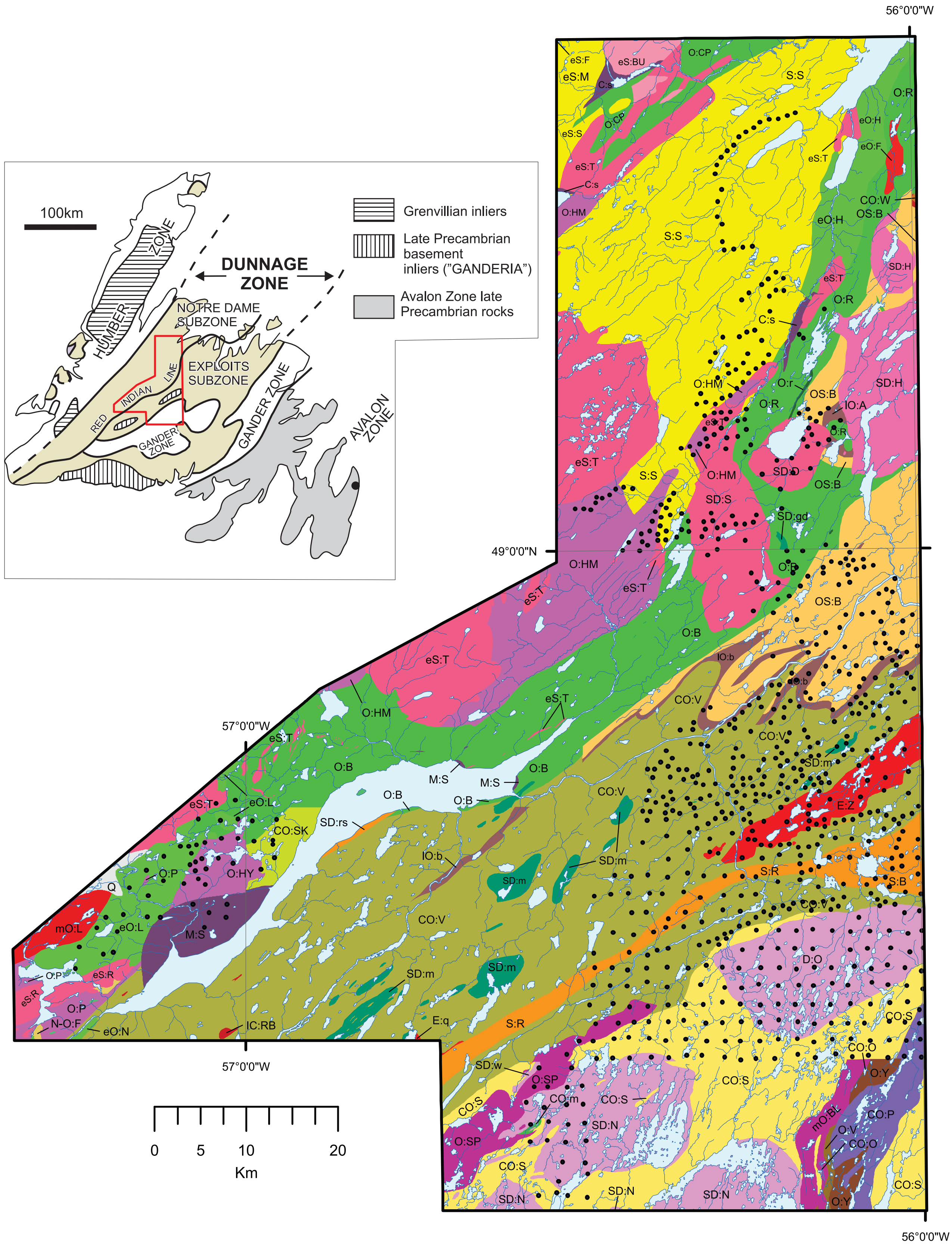

Figure 2. *Bedrock geology of the study area (taken from Crisby-Whittle, 2012). Black dots are locations from where samples were collected in 2012. Inset map shows location of study area outlined in red. Legend on the two following pages.*

LEGEND

PLEISTOCENE

SURFICIAL DEPOSITS

Q:u	Unconsolidated sediments

MISSISSIPPIAN TO PENNSYLVANIAN

B:se / Mi:S	**(B:se)** Red and grey conglomerate, sandstone, shale, siltstone and minor limestone; **Shanadithit Formation (Mi:S):** Poorly indurated sandstone and conglomerate; minor limestone and siltstone

EARLY SILURIAN TO LATE DEVONIAN

SD:	**(SD:gr)** Medium- to coarse-grained biotite granite; **Overflow Pond Granite (D:O):** Coarse-grained, garnetiferous, two-mica granite; **North Bay Granite Suite (SD:N)** biotite - muscovite granodiorite
SD:	**(ga):** Gabbro, diorite and quartz monzonite; **(gd):** Gabbro, Diorite and diabase
SD:rs	Red and grey, micaceous sandstone and conglomerate
SD:DP	**Dawes Pond Granite:** Grey to pink, medium- to fine-grained granite, quartz-monzonite and granodiorite

EARLY SILURIAN TO MIDDLE DEVONIAN

SD:RC	**Redcross Lake Intrusion:** grey gabbro and/or diorite
SD:	**(rg):** Medium-grained, biotite granite; **(wg):** White muscovite-biotite granite and quartz-feldspar porphyry; **Wilding Lake Granite (WL):** Grey, foliated, biotie granite

EARLY SILURIAN TO EARLY DEVONIAN

SD:S	**Skull Hill Quartz Syenite:** Quartz syenite, quartz monzonite, diorite and gabbro
SD:H	**Hodges Hill Intrusive Suite:** Massive, fine- to coarse-grained, equigranular to K-feldspar-porphyritic, biotite granite, granodiorite

EARLY TO LATE SILURIAN

S	**Botwood Group (B):** Subaerial mafic and felsic flows and pyroclastic rocks, **Rogerson Lake Conglomerate (R):** conglomerate and arkosic sandstone
S:S	Subaerial felsic, intermediate and mafic flows and pyroclastic rocks; fluviatile red sandstone, conglomerate and shale

EARLY SILURIAN

eS	**Sheffield Lake Complex (S):** Variably welded, fine-grained ash-flow tuffs. **Micmac Lake Group (M):** Felsic volcanic and volcaniclastic rocks, sandstone, conglomerate and mafic flows
eS:R	**Star Lake Intrusive Suite (R):** Foliated granite and minor granodiorite intrusions; **Topsails Igneous Suite (T):** granite, ganodiorite, syentie and gabbro
eS:F	**Flatwater Pond Group:** Pillow lava, pillow breccia, and diabase dykes and sills
eS:BU	**Burlington Granodiorite:** Light grey to greenish grey, hornblende-biotite granodiorite

LATE ORDOVICIAN TO MIDDLE DEVONIAN

O-D:W	**Windsor Point Complex:** Conglomerate, greywacke, siltstone and shale

LATE ORDOVICIAN TO EARLY SILURIAN

OS:S	**Southern Long Range Mafic Intrusions:** Mafic plutons, layered gabbro, hornblende and gabbro
OS:r	Fine- to medium-grained gabbro intrusive into Ordovician age rocks
OS:B	**Badger Goup:** Grey, well-bedded greywacke, including conglomerate layers

LATE ORDOVICIAN

lO:b	**(b)** Black shale and minor siliceous slate. **Shoal Arm Formation (A):** Chert, carbonacesous argilite and argillaceous siltstone

MIDDLE TO LATE ORDOVICIAN

O:gr	Massive to moderately foliated granodiorite and minor tonalite, with many small mafic to ultramafic fragments

MIDDLE ORDOVICIAN

mO:BL	**Great Burt Lake Granite:** Strongly foliated or mylonitic, pink to white, mostly megacrystic, biotite granite
mO:L	**Lewaseechjeech Brook Plutonic Suite:** Massive to foliated, equigranular or porphyritic, biotite-hornblende granodiorite and tonalite

EARLY ORDOVICIAN TO LATE SILURIAN

OS:m	Fine- to medium-grained gabbro and diorite with minor diabasic phases

LEGEND – Figure 2 continued

EARLY TO LATE ORDOVICIAN

O:HG — **Hinds Brook Granite:** White to pink, medium- to coarse-grained, biotite-amphibole

O:V — **Cold Spring Pond Formation:** Volcaniclastic arkose and greywacke; black, graphitic slate and polymictic conglomerate

O:Y — **Baie D'Espoir Group:** Marine clastic sedimentary rocks, felsic, intermediate and mafic volcanic rocks

O:SW — **Southwest Brook Complex:** Foliated and massive tonalite, biotite granite and granodiorite

O:M — **Sops Head Complex:** Tectonic melange containing of mafic and felsic volcanic rocks, limestone and conglomerate

O:P — **Pierre's Pond Plutonic Suite:** Biotite-hornblende granodiorite, and hornblende tonalite

O:in — Biotite granite and granodiorite

O:CL — **Cormacks Lake Complex:** Cordierite-gedrite gneiss, psammite, pelite calc-silicate gneiss, and amphibolite

EARLY TO MIDDLE ORDOVICIAN

O: — **Otter Pond Complex (OP):** Hornblende +/- biotite granodiorite to tonalite; gabbro to diorite; **Snow Shoe Pond Granite (SP):** biotite granite and granodiorite

O:ri — Intrusions into the Roberts Arm Group, including coarse-grained, pyroxene (hornblende) gabbro and equigranular, hornblende quartz diorite

O: — **Roberts Arm Gourp (R):** Mafic pillow lava, pillow breccia, agglomerate and tuff. **Buchans Group (B):** Mafic, intermediate and felsic flows, pyroclastic rocks, and iron formation; **Catchers Pond Group (CP):** mafic pillow lava and agglomerate, felsic aglomerat and tuff, chert and limestone

O: — **Halfway Mountain Granodiorite (HY):** Medium- to coarse-grained, biotite-amphibole subsolvus granodiorite to granite; **Hungry Mountain Complex (HM):** Tonalite, granodiorite, diorite, gabbro, amphibolite

EARLY ORDOVICIAN

eO:F — **Loon Pond - Woodfords Arm Plutons:** Quartz monzonite, granodiorite, granite, and quartz diorite

eO:H — **Hall Hill - Mansfield Cove Complex (H):** Mafic and intermediate intrusive rocks. **Star Lake Ophiolite Complex (L):** Pods and dykes of pegmatitic hornblende diorite and tonalite. **King George IV Lake Complex (K)**: mafic pillow lava and breccia, intercalated mafic tuffs. **Anniopsquotch Complex (N)** : Basaltic pillow lava and minor red chert

LATE CAMBRIAN TO MIDDLE ORDOVICIAN

CO:W — **Wild Bight Group:** Mafic lava and pyroclastic rocks, green bedded tuff, felsic lava and agglomerate

CO: — **Piperstone Pond Complex (P)** : Ophiolite complex consisting of ultramafic rocks. **Unnamed Ophiolite (Exploits Subzone) (O); Unnamed Ophiolite (Notre Dame Subzone) (ON):** Ultramafic rocks, gabbro, trondhjemite, diabase, volcanic rocks

LATE CAMBRIAN

lC:RB — **Roebucks Brook Intrusions:** Quartz monzonite, granodiorite, quartz diorite, diorite and gabbro

EARLY CAMBRIAN TO LATE ORDOVICIAN

CO:V — **Victoria Lake Supergroup:** Mafic to felsic flows and pyroclastic volcanic rocks, pillow lava, and epiclastic volcanic rocks

EARLY CAMBRIAN TO MIDDLE ORDOVICIAN

CO:m — Diabase and foliated amphibolite

EARLY CAMBRIAN TO EARLY ORDOVICIAN

CO:S — **Spruce Brook Formation:** Quartzitic sandstone, siltstone, shale and minor conglomerate

CO:SK — **Skidder Basalt:** Pillow lava, breccia, massive flows, minor mafic pyroclastic rocks, bedded chert

EDIACARAN

E:q — **(q):** Equigranular, medum-grained, chlorite granite, intruded by mafic dykes; **Valentine Lake Quartz Monzonite (V):** Quartz-porphyritic quartz monzonite, granodiorite. **Crippleback Lake Quartz Monzonite (Z):** Quartz monzonite and granodiorite, gabbro and diorite

E:m — Medium- to coarse-grained diorite

NEOPROTEROZOIC TO EARLY ORDOVICIAN

N-O: — **Fleur de lys Supergroup (F):** Metaclastic schists with interlayered amphibolite and greenschist; **Caribou Lakes Gneiss Complex (C):** Biotite-muscovite, migmatitic paragneiss

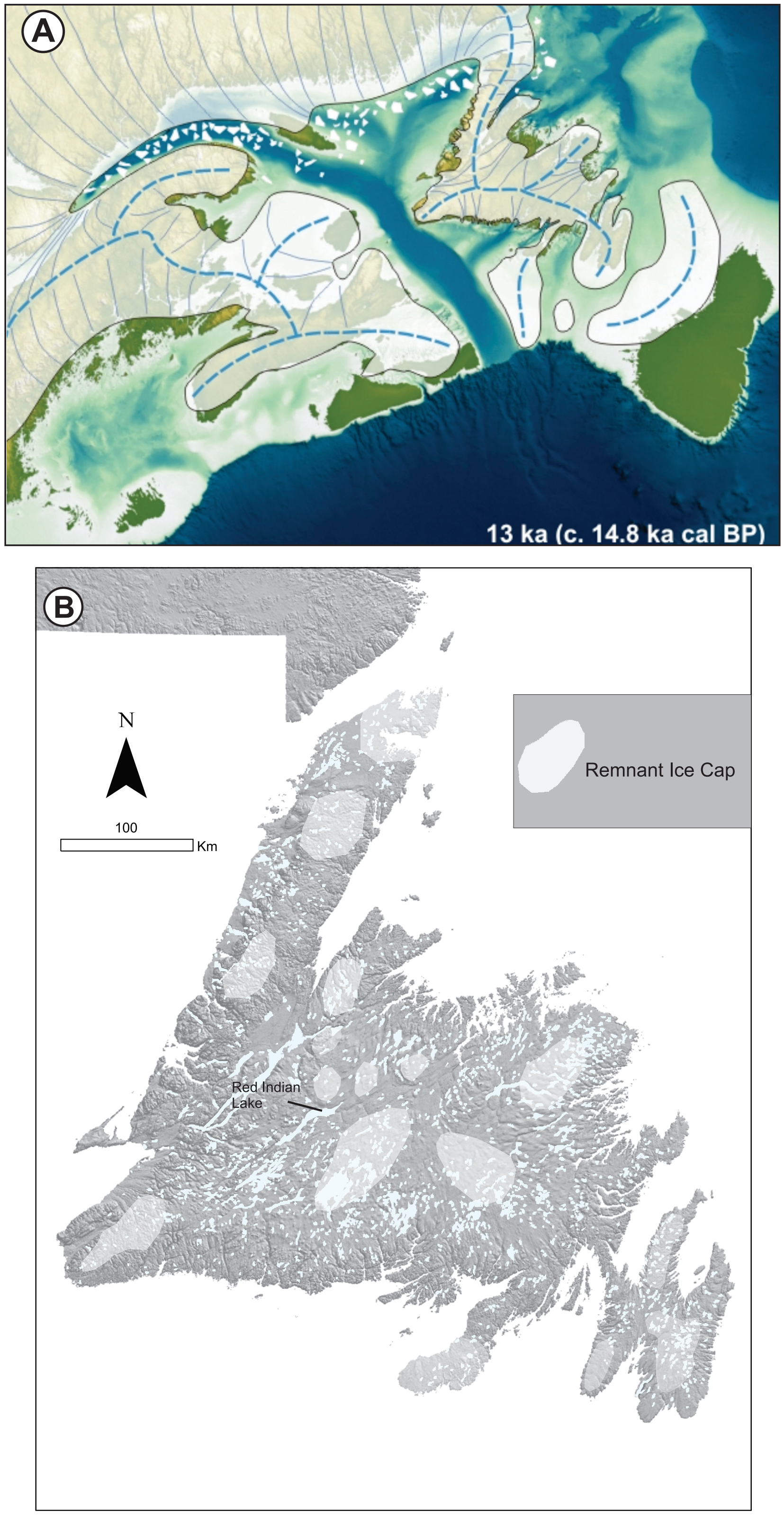

Figure 3. *Pattern of glaciation on the Island of Newfoundland. A) Shows the retreat of ice on to land and the location of ice divides at 13 ka radiocarbon years (~14.8 ka calendar years) (after Shaw* et al. *(2006)). B) Map of Newfoundland showing the approximate location of remnant ice caps as the Newfoundland ice cap disintegrated (modified after Grant, 1974).*

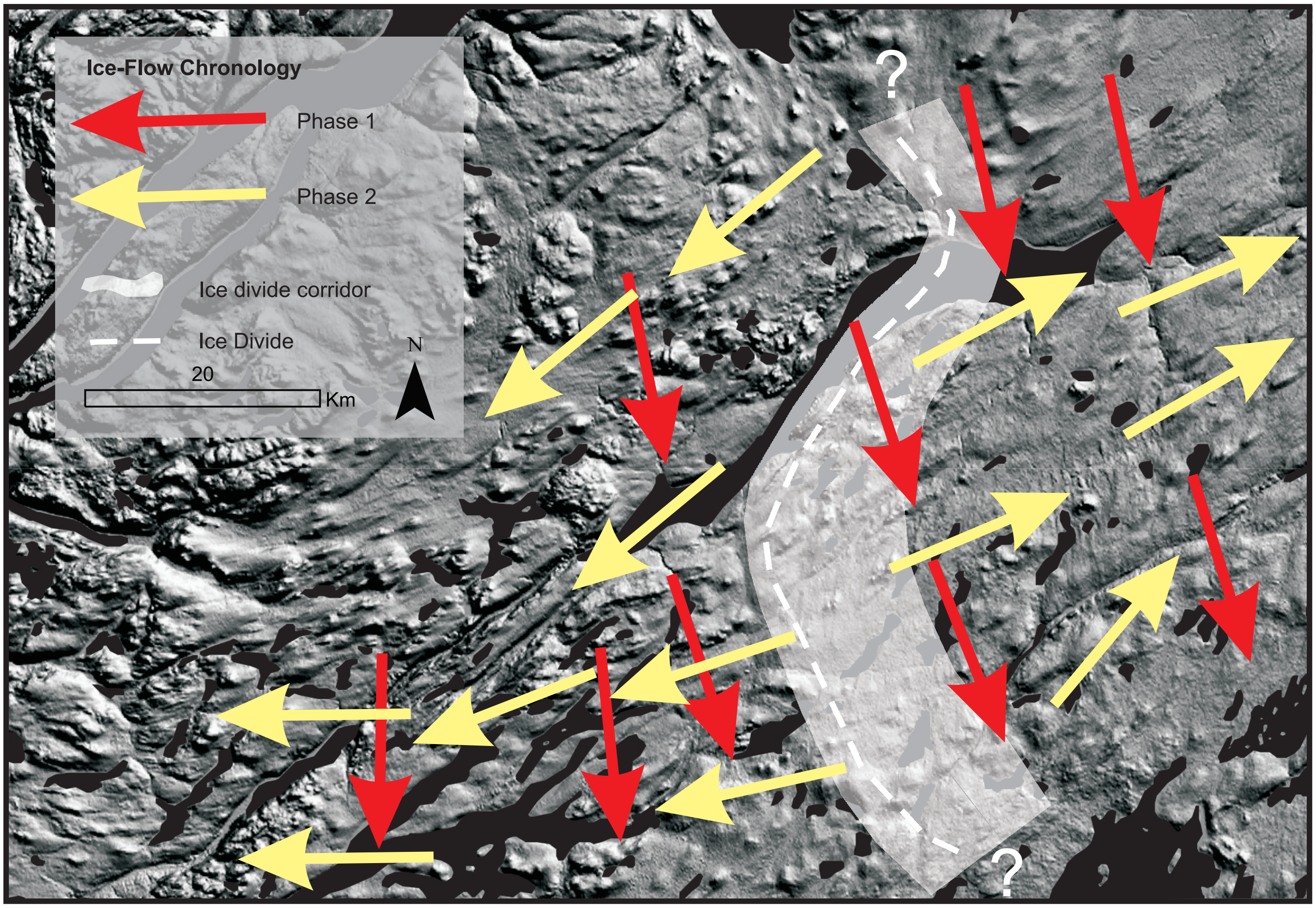

Figure 4. *Map showing the ice-flow chronology for the RILB (Smith, 2009).*

ICE-FLOW HISTORY

The ice-flow history of the RILB has been described by Smith (2009), and comprises two main late Wisconsinan ice-flow events (Figure 4). The earliest ice flow (Phase 1) was south to southeastward from a source in The Topsails (Figure 4, Phase 1); in the southwest, ice flow was predominantly southward, whereas in the northeast it was predominantly southeastward. Phase 1 was followed by the development of an ice divide (Figure 4; white dashed line) between Harbour Round Pond and Costigan Lake, where ice flow diverged toward the northeast and southwest (Figure 4, Phase 2). A younger south-southeast flow and a north-northwest flow were identified by Smith (2010), however, their rare distribution and uncertain relative age relationships resulted in them not being assigned a phase in Smith's (2009) ice-flow chronology.

METHODS

TILL SAMPLING

A total of 849 samples were collected from the BC–C horizons from hand-dug pits, road-cuts and mudboils and each 1-kg sample was placed in a bag. Depths of hand-dug pits averaged 55 cm, whereas sample depths from road-cuts averaged 220 cm. The spacing between samples varied depending on the mode of transportation. Along woods roads, samples were collected every 1 km, and in more remote areas, where helicopter support was required, sample collection sites were predetermined on a grid of 4 km^2. In-fill sampling on NTS map area 12A/16 was conducted *via* truck and ATV to provide an overall sampling density of 1 per 1 km^2. A duplicate sample was collected every 20 samples to check for field reproducibility of elemental concentrations as part of the quality assurance – quality control (QA/QC) process. Samples were submitted to the Geological Survey Laboratory for geochemical analysis by ICP-OES and ICP-MS. Samples will also be sent to an external laboratory to analyze for gold and other elements by INAA. Data will be released in 2013.

RESULTS

ICE-FLOW HISTORY

Seventy-two ice-flow measurements were recorded from 61 sites during the 2012 field season. Most of the striation data were collected along forest-resource roads where bedrock outcrops were plainly visible; 13 striation sites were identified on bedrock in remote locations. The relative ages of striations, where more than one set were identified at a site, were established from crosscutting relationships. Eight multi-directional sites were identified within the study area. All striations identified were fresh and unweathered, and are therefore, tentatively interpreted as late Wisconsinan.

The following five ice-flow directions were identified. These are listed in no particular order:

- a west-southwest to southward flow on the north side of Red Indian Lake;
- a northward flow identified on the north side of Red Indian Lake, as well as one occurrence east of Red Indian Lake;
- a south-southeast to south-southwest flow in the southern part of the study area, immediately north of Meelpaeg Lake;
- an east-northeast flow east of Red Indian Lake, and
- a north-northeast flow in the northern part of the study area.

On the north shore of Red Indian Lake, the dominant ice flow was west-southwest and relative ages have been determined at two sites in this area (Figure 5). Site 373 records a north-northwest flow (330º) followed by a west-southwest flow (245º), whereas Site 713 records three ice-flow directions that show a progressive change in ice-flow direction from south-southwest (210º) to south (180º) to south-southeast (160º). Site 519 on the eastern shore of Red Indian Lake and Site 38 east of Noel Paul's Brook record an older north-northwest–south-southeast (345º), non-directional ice flow, followed by an east-northeast flow (60º). To the northeast, at Site 150, the opposite age relationship was identified, an east-northeast (52º) flow followed by a north-northwest–south-southeast (340–160º) non-directional flow. Site 113 records three ice-flow directions that indicate flow changed from east-northeast (56º) to north-northwest (328º) to north-northeast–south-southwest (17–197º). Northeast of Red Indian Lake, Site 187 records a northeast flow (39º) followed by a slight shift to east-northeast (60º). The most northerly striation site in the study area, Site 713, records a non-directional southeast–northwest (135º) flow followed by a northward (10º) flow.

The striation data is interpreted to represent at least 3 phases of ice flow in the eastern Red Indian Lake Basin. The south-southeast to south-southwest striations in the south, and the east-northeast to west-southwest striations on the east and west sides of Red Indian Lake, are consistent with Phase 1 and Phase 2, respectively, and previously described by Smith (2009; Figure 5). The north-northeast flow identified in the northern part of the study area shows a divergence of Phase 2 due to topography. Phase 3 is tentatively assigned to the younger southward flow. Whereas a site in the east records an orientation of this south–north flow, there is no landform evidence to suggest a northward flow. A younger southward flow was also described by Klassen (1994a) and Smith (2009), although the flow was not assigned to a specific phase of ice flow in Smith's (2009) ice-flow chronology.

Klassen (1994a) describes a west-northwest ice flow north of Buchans that is older than Phase 3. Smith (2009) identified a similar west-northwest flow on the south side of Red Indian Lake. A west-northwestward ice flow was identified at two sites in 2012 but record conflicting age relationships, *i.e.,* both older and younger than Phase 2 flow. As a result, the west-northwest flow is not assigned to a specific phase of ice flow.

SURFICIAL GEOLOGY

The surficial geology of the study area is complex and reflects sediment deposition under the influence of ice (till), flowing water (glaciofluvial) and standing water (glaciolacustrine). The thickness of these deposits may range from a few centimetres, in areas adjacent to exposed bedrock, to tens of metres in areas where the topography is flat or gently rolling. Postglacial organic deposits (bogs) are a dominant feature.

Diamicton Deposits

Diamicton is typically thick (2–15 m), forms a blanket over undulating terrain or is exposed as areas of hummocky terrain. Diamicton blankets are found north of the Exploits River and in most of the northern half of the study area. Hummocky terrain is characteristic of areas of glacial stagnation, and is located in the southern half of the Badger and Sandy Lake map areas (NTS map areas 12A/16 and 12A/09; Plate 1A and B). Thinner till deposits (<1.5 m) are associated with exposed bedrock north of Meelpaeg Lake and northwest of Red Indian Lake.

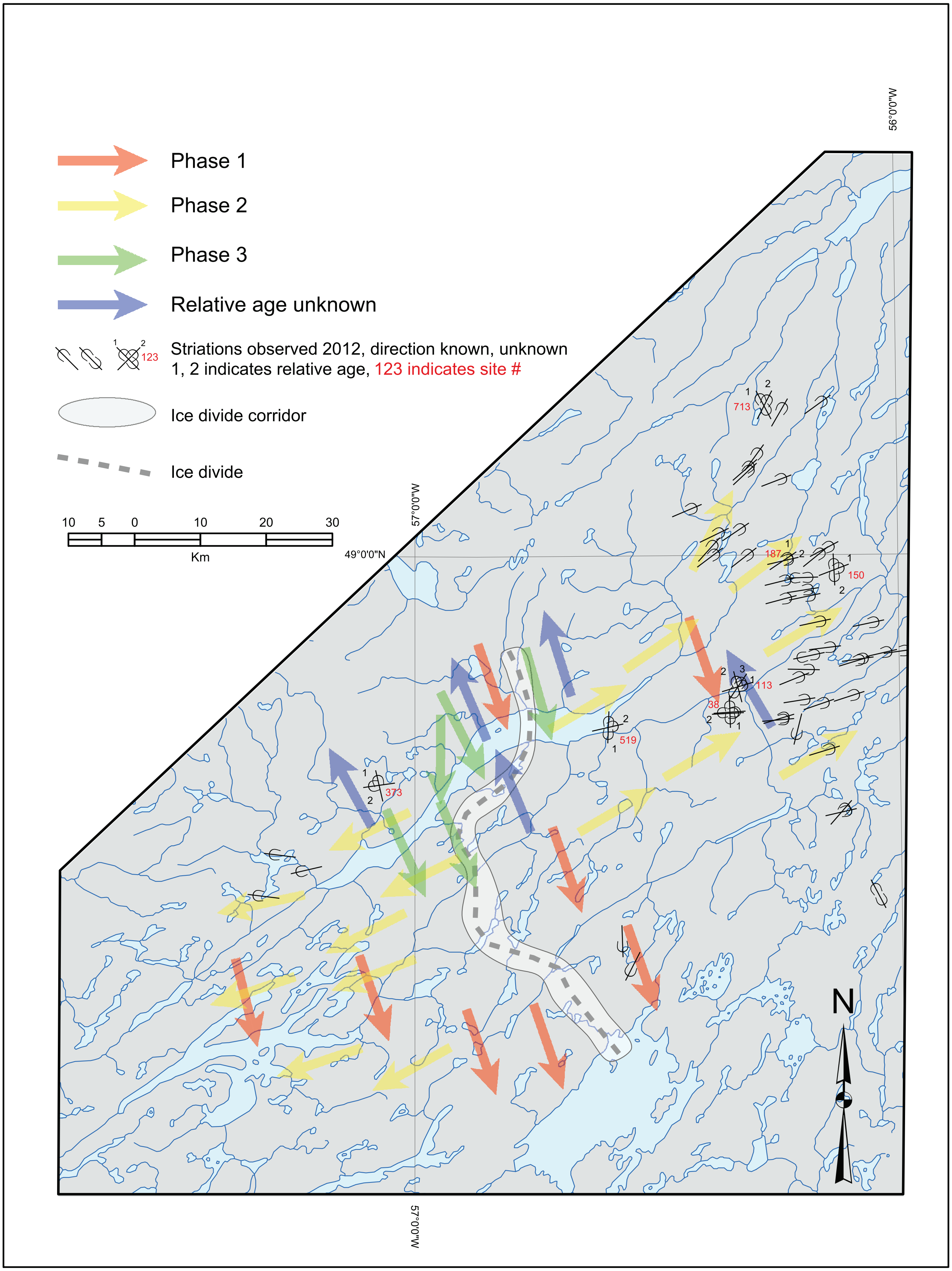

Figure 5. *Location of striations collected in 2012. Large arrows indicate the tentative ice-flow history for this area.*

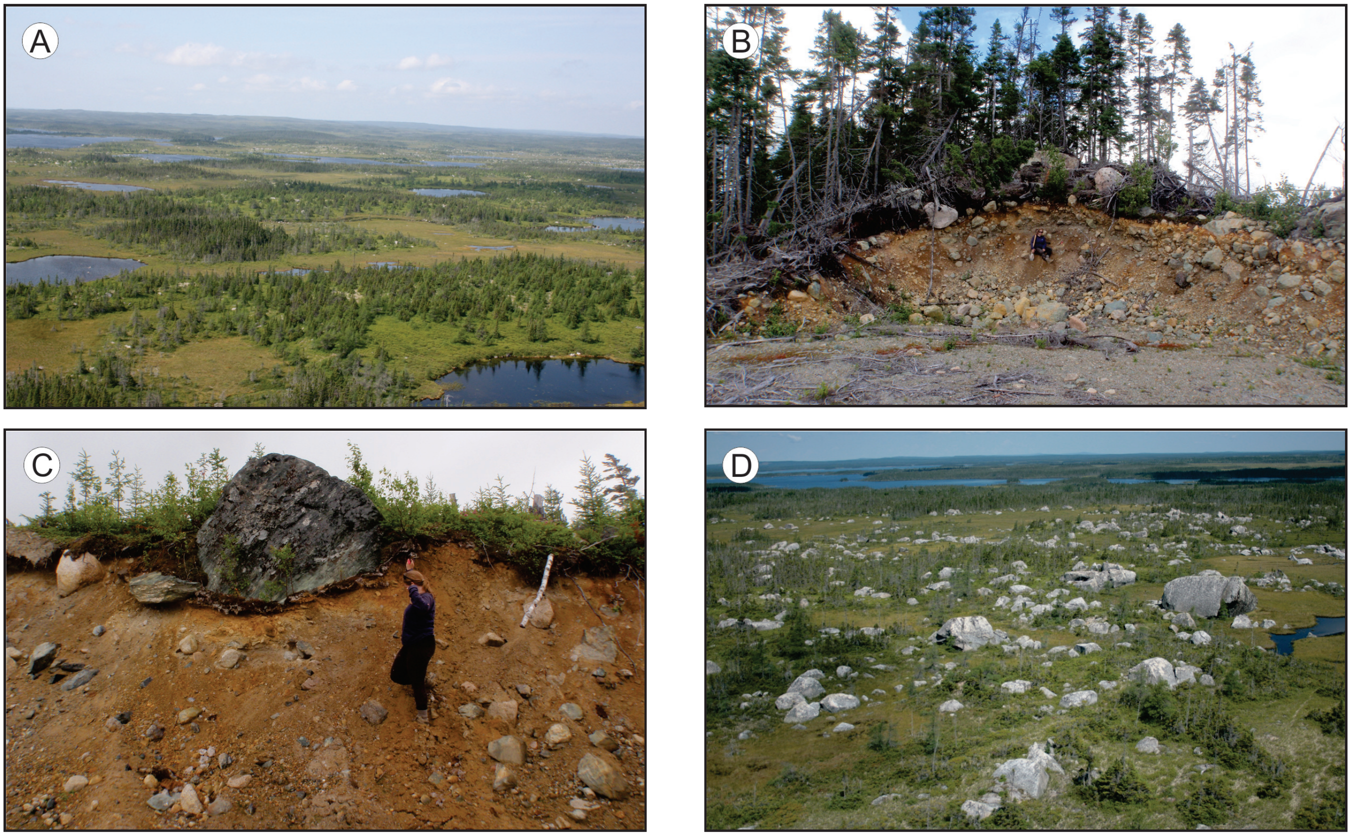

Plate 1. A*) Till hummocks interspersed between bogs and lakes. B) Cross-section through a hummock. Note the high concentration of clasts within the section and on the surface. C) Typical till matrix-supported section, with 20% clasts ranging from 0.2–2 m. D) High concentration of angular boulders on surface. Sizes range from 0.5–5 m.*

The diamicton is matrix-supported and generally has a silty sandy matrix. There is some variability in the colour of the diamicton, with light olive brown (munsell colour 2.5Y5/4) being the most dominant followed by dark yellowish brown (10YR4/4) and olive brown (2.5Y4/4). The variation in colour reflects changes in the colour of the underlying bedrock. The diamicton has a low clast percentage (20%) with an average clast size of 3 cm. Clasts are commonly striated, as well as faceted. Within the study area only one stratigraphic unit was identified. Clasts, on the surface, range from pebble to boulder in size (Plate 1C). Boulders are up to 3 m diameter. Clasts typically reflect the underlying bedrock geology and have likely been transported short distances. The morphology, composition and abundance of local clasts that are striated and faceted indicate that this diamicton was deposited by actively retreating ice and is interpreted as till. This till appears to be more uniform over the entire study area compared to areas to the west where multiple till units were identified (Smith, 2009, 2010). The uppermost till identified in the southwest end of Red Indian Lake by Smith (2010) is very similar to the till described above.

The diamicton south of Sandy Lake (NTS area 12A/09) is very similar in composition to the diamicton described to the north; the difference being the extremely high concentration of clasts on the surface in the south. Clasts in this area are up to 5 m diameter, and are very angular to angular (Plate 1D). The morphology of the diamicton in this area is typically hummocky. The increase in clast concentration, the angularity and the overall morphology suggest that this diamicton is a till that was deposited as the result of stagnating ice under a passive margin. Smith (2010) describes a similar stagnate ice area west of Meelpaeg Lake.

Glaciofluvial Sediments

Glaciofluvial deposits are confined to two segmented esker systems, as well as outwash deposits found in the bottom and sides of the South Brook and Exploits River valleys.

One segmented esker system is located east of Noel Paul's Brook; straddling NTS map areas 12A/09 and 16. The esker system is oriented east–west and extends approximately 14 km. It is discontinuous along its length and is between 5 and 20 m high. The esker ranges from a width of 5 m and has a sharp crest, to 15 m and where sand and gravel extend on either side of the ridge as hummocks and veneers. The second segmented esker system located east of Sculpin Hill, extending eastward to northeastward for 19 km, is flanked by glaciofluvial and till hummocks (Plate 2A). Sediments exposed in small roadside sections range from well-sorted sand to clast-supported cobbles. Both of these systems have roads built on their crests.

Sand and gravel along the west side of South Brook is also interpreted as glaciofluvial and has a hummocky morphology. The matrix is composed of moderately to well-sorted medium- to coarse-grained sand with granules (Plate 2B). Clast concentration ranges from low (≤20%) to high (≥40%), and some sites have a clast-supported matrix. Clasts range in diameter from 0.5 to 45 cm and are angular to subround.

Extensive sand and gravel deposits are located along the Exploits River valley. Deposits range from thin veneers to a maximum of 12 m (Environmental Geological Section, 1983; D. Taylor, written communication, 1985; F. Kirby, written communication, 1989) and are made up of sandy pebble to cobble gravel. In places, the gravel is poorly-sorted to well-sorted deposits of cobble gravel, as well as deposits of well-sorted sand. Some sites contain stratified sand and gravel (Environmental Geological Section, 1983; D. Taylor, written communication, 1985; F. Kirby, written communication, 1989). Clasts range from 0.5 to1 m and are typically subround.

Plate 2. *A) A steep-sided esker along the south side of Noel Paul's Brook. It is flanked by glaciofluvial and till hummocks. B) Well-sorted medium- to coarse-grained sand and granule gravel located in the South Brook valley.*

Glaciolacustrine Sediments

Glaciolacustine sediments are rare; their only occurrence was documented south of Dawe's Pond, where 1.5 m of mottled, very fine-grained sand and silt is overlain by 10 cm of fine to very fine-grained sand, which in turn is overlain by 10 cm of medium to coarse sand with pebbles. The silt forms irregularly shaped inclusions that are randomly dispersed within the very fine-grained sand unit (Plate 3). Contacts between the very fine-grained sand and silt are sharp. Within the silt to very fine-grained sand unit there are rare, randomly distributed clasts that range from 0.5 to 4 cm diameter. These clasts are interpreted as dropstones and their presence suggests that this is an ice-contact glaciolacustrine environment. The site was interpreted to be distal to the sediment source as evidenced by the very well-sorted fine-grained sand and silt.

Kirby *et al*. (2011) identified glaciolacustrine deposits at the south end of Powderhorn Lake and Little Sandy Lake on NTS map area 12H/01. Surficial mapping has not determined if these deposits are connected or the result of isolated localized ponding.

There is no evidence that glacial Lake Shanadithit extended into the south part of NTS map areas 12A/16 or 12A/09. In the northwest corner of NTS map area 12A/16 glacial Lake Shanadithit drained *via* South Brook valley and its lowest phase was controlled by the elevation of Joe Glodes Pond (Smith, 2012).

Organic Deposits

Organics are found throughout, most commonly south of Sandy Lake interspersed between till hummocks and north of Millertown on the west side of NTS map area 12A/16. Organics are commonly located in poorly drained areas, or in depressions between hummocks. Those found in the north part of the field area form raised string bogs (Plate 4). Typically, organic deposits are less than 1 m thick, however thicker deposits occur locally.

Plate 3. *Very fine-grained sand with irregularly shaped silt inclusions (the lighter colour). Note the random dispersion pattern of the silt inclusions. Rare clasts, 0.5–4 cm, are present and are interpreted as dropstones.*

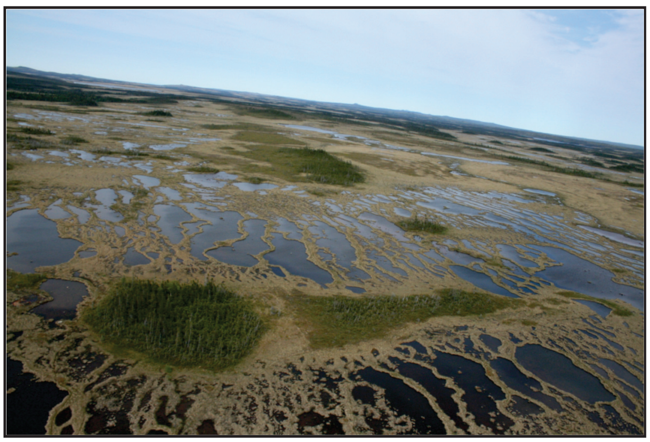

Plate 4. *Raised string bog in the north part of the study area.*

CONCLUSIONS

GLACIAL HISTORY AND DRIFT PROSPECTING

The morphology and type of sediments, along with glacial striations, provide insight into the pattern of deglaciation within this region, which is helpful in determining the best drift-prospecting and exploration techniques.

Glacial retreat occurred to the north, northeast, south and southwest. Meltwater generated during this retreat was confined to valleys, such as the Exploits River and South Brook, resulting in deposition of glaciofluvial sediments on the valley sides and bottoms. Active retreat is seen in the north and east of the study area as indicated by the presence of till blankets and veneers, the formation of striation hills and landforms, such as roche moutonnée and crag and tail, and the development of glacial Lake Shanadithit in the west part of the study area. The hummocky terrain identified south of Sandy Lake represents an area of ice stagnation. This type of terrain is very easily distinguishable due to its morphology and is commonly characterized by a high concentration of boulders on the surface. Glaciolacustrine sediments may be formed in active glacial environments and are the result of sediment being deposited in standing water. The only radiocarbon dates within this region are of lake sediment from south of Millertown (GSC-4231) and on the road north of Meelpaeg Lake (GSC-4186), which indicate that this area was ice free by 9300 BP (McNeely and McCuaig, 1991).

The ice-flow history, type of retreat and the resulting morphology aids in the development of strategies for drift prospecting within the RILB:

- This study area has a complex ice-flow history, reflecting fluctuations in ice flow during the last glacial advance and retreat. Therefore, care must be taken when inferring the direction of mineralized dispersal trains.
- Areas where poorly sorted sediment containing silt was deposited in contact with the ice (*i.e.,* till) as the result of active retreat are the best areas to conduct drift-prospecting surveys.
- Areas of thin veneer with local boulders are favourable for conducting drift-prospecting studies because the till was likely deposited by the last ice-flow event. The relationship between till and the direction of the last ice-flow event allows for mineralization in the till and boulders to be more accurately sourced.
- Areas of thicker till may be the result of shifts in the ice and the uppermost surface may not necessarily reflect the underlying bedrock. Geochemical and textural samples taken at regular interval throughout a section of thick till will help determine if there are multiple till units.
- Areas that were deposited under stagnating ice, such as hummocky terrain, are less suitable for drift prospecting as there is commonly a high proportion of distally derived material. Due to varying amounts of associated meltwater, sediments forming hummocky moraine tend to contain less fines (*i.e.*, sandier, less silt) and be better sorted than till found in the same area.
- Recognition of glaciolacustrine sediments is crucial because they were either deposited by water or modified by water. These sediments must be considered separately from tills when interpreting geochemical data because any identified dispersal patterns are unrelated to ice movement.
- Glaciolacustrine deposits tend to be small in areal extent and may not be represented on a 1:50 000-scale

surficial map. Within the areas identified as having been covered by glacial Lake Shanadithit, it is therefore important to consider the maximum elevation at which the glaciolacustrine sediments are potentially located.

- Caution needs to be exercised when working in areas occupied by former glacial lakes as the upper parts of the diamicton units may be washed or winnowed.

FUTURE WORK

Future work includes the release of a till-geochemistry Open File report along with a surficial map for NTS map area 12A/09. These will be released in 2013.

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