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QUATERNARY MAPPING AND SURFICIAL SAMPLING IN THE PARADISE RIVER AREA, SOUTHEASTERN LABRADOR (NTS MAP AREAS 13H/03, 04, 05 AND 06)

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ABSTRACT

A 6-week Quaternary mapping and surficial sampling (humus and till) survey was completed in the Paradise River area in southeastern Labrador (NTS map areas 13H/03, 04, 05 and 06) during the 2025 field season. The objectives of this project were to create 1:50 000-scale surficial geology maps and to carry out a till and humus sampling program to delineate regions with critical-mineral potential. In total, 71 humus and 83 till samples were collected and analyzed for precious metals (Au, PGEs and Ag) and critical metals (base metals, REEs) in areas affected by forest fires. Preliminary surficial mapping has identified 2 ice-flow movements in the region; a later northeastward flow in the Paradise River Valley and a southeastward flow in the Alexis River Valley. Till is the most dominant surficial sediment unit in the study area. It is mapped as a veneer in topographic highs and as a blanket in topographic lows. Glaciofluvial sand and gravel, associated with deglaciation is mapped within both the Alexis River and Paradise River valleys. Glaciofluvial sediment is mapped as terraces within the Paradise River Valley and as kettle and kame topography in the southwestern quadrant of the study area. The glaciofluvial deposits mapped are likely to be part of the Paradise Moraine, which has been identified both west, northwest and east, southeast of the study area.

INTRODUCTION

Labrador is well-endowed in critical minerals (*e.g.*, Cu, Ni, rare-earth elements (REEs) and U), and has significant potential for precious metals (*e.g.*, Au, platinum-group elements (PGEs)) (Gower, 2019; Magyarosi 2022; Natural Resources Canada, 2022). However, much of the bedrock is covered by surficial deposits associated with Quaternary glaciations (~2.6 Ma; Batterson and Liverman, 2001; Ullman *et al.*, 2016), thus making conventional mineral exploration limiting. The Paradise River area (NTS map areas 13H/03–06) has potential for critical metal (Cu, Ni and U) mineralization (Gower, 2010a, b). However, there is a lack of regional surficial geology maps, and the area has also been affected by forest fires that may affect geochemical signatures of surficial samples (humus and till). Therefore, a surficial mapping and sampling program was undertaken in the Paradise River area to address the lack of both surficial maps and surficial geochemical information for the region. The objectives of this surficial mapping and sampling project are:

1) complete 1:50 000-scale mapping for NTS map areas 13H/03–06, and reconstruct the glacial history,

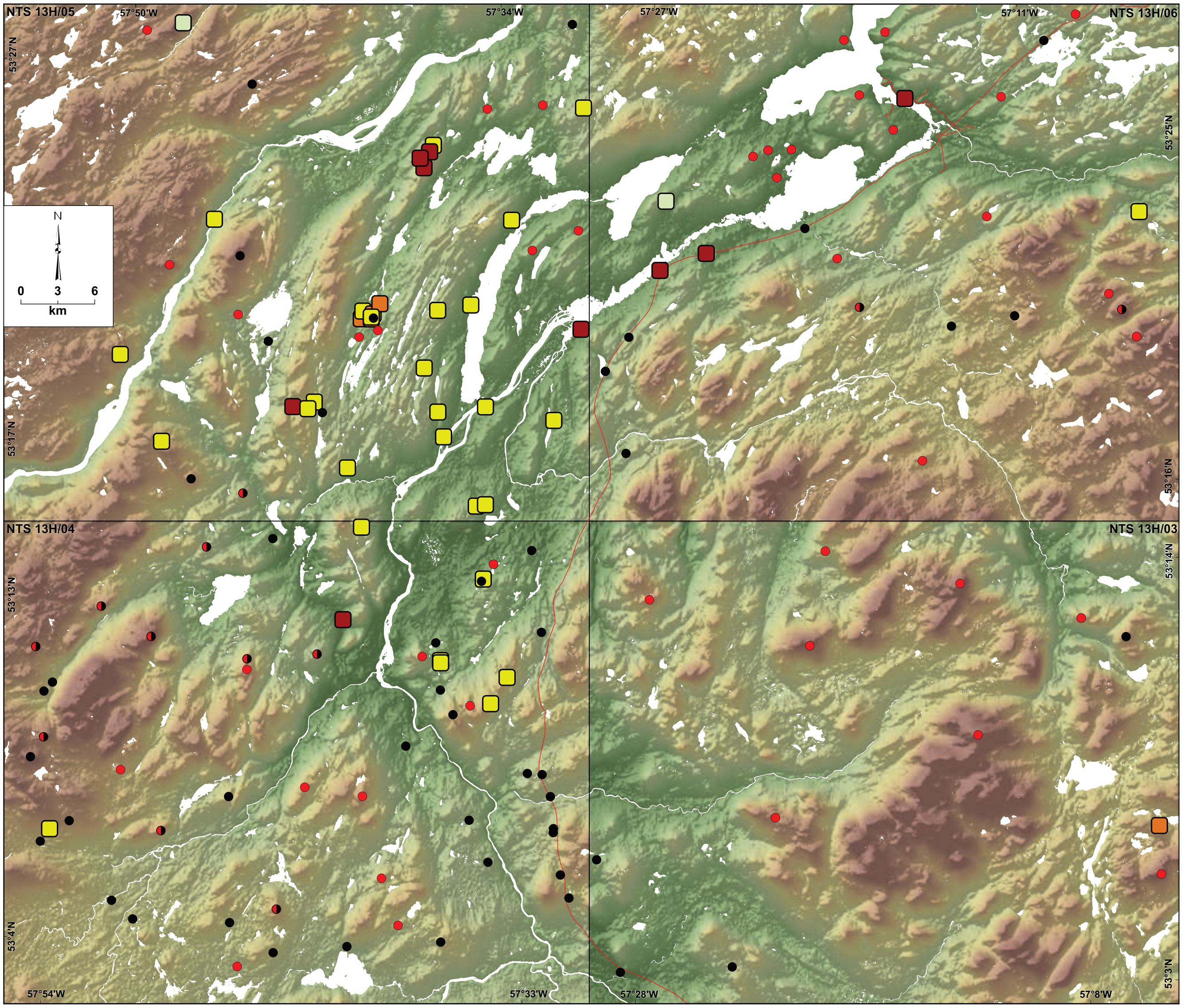
2) complete a surficial (till and humus) sampling survey to determine the geochemical signature of potential critical metal mineralization, and

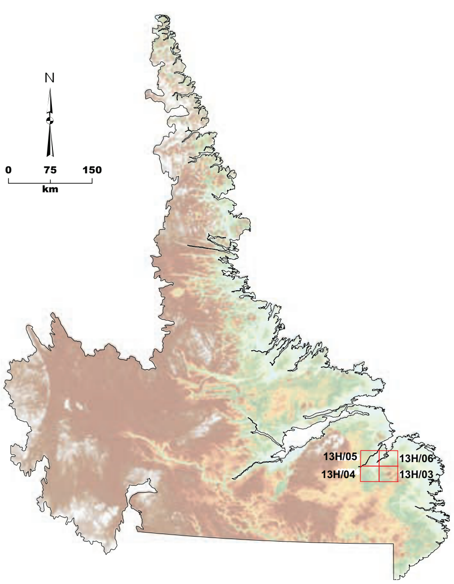
3) deduce whether forest fires in the region have influenced the geochemistry of surficial media (*i.e.*, humus and till).

This study is a continuation of the strategic surficial sampling and mapping program covering southeast Labrador, including the expansion of the humus sampling program (Hashmi, 2024a) targeting critical-metal mineralization (*see* Hashmi, 2024b–d). It provides an overview of the field and analytical work completed in 2025, as well as preliminary results of the surficial mapping component of the project.

STUDY AREA: LOCATION, ACCESS AND PHYSIOGRAPHY

The study area consists of four, 1:50 000 NTS map areas (13H/03–06; Figure 1). The Trans-Labrador Highway crosses through NTS 13H/03 and 04 and the regional highway (Salmon Cove Rd W) crosses NTS 13H/03, 04 and 06. The community of Paradise River lies in the northeastern





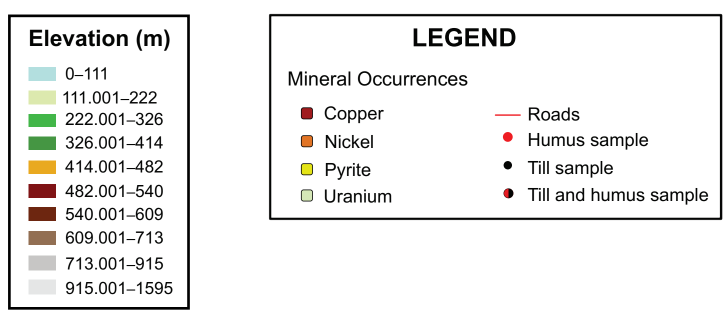


Figure 1. *Location, access, physiography and 2025 humus- and till-sample locations in the study area.*

tip of the study area. All other areas are accessible only by helicopter.

The study area lies within the ocean-influenced “Mecatina Plateau” ecoregion of the “Boreal Shield” terrestrial ecozone of Canada with a high boreal ecoclimate that is characterized by relatively high precipitation (~1000 mm average annual precipitation; Wiken, 1986). Vegetation is dominated by balsam fir, black and white spruce in the valleys, stunned vegetation such as krummholz spruce and caribou moss at high, exposed hilltops and sphagnum moss, cottongrass and sedges in poorly drained and wetland dominated regions. Podzol is the most dominant soil (Kauranne, 1992; Sanborn *et al.*, 2011), and permafrost is present in isolated patches in high elevation regions.

The topography is heavily influenced by the underlying bedrock. Higher elevation regions are steeply-sloping with crumbly bedrock and thin patches (<30 cm) of oxidized till, whereas lower elevation regions and valley bottoms are characterized by thicker (>1 m) till deposits and wetlands with little to no bedrock exposure. Forest fires (prior to 1983) have affected much of the study area, including, nearly all of NTS 13H/04, 05 and parts of 13H/03 and 06 (Foster, 1983).

GEOLOGY

BEDROCK GEOLOGY

The bedrock geology of the study area is summarized after Gower (2010a, 2019; Figures 2–5). It lies within the Grenville Province and encompasses the Hawke River, Lake Melville and the Mealy Mountains terranes. This region was affected by the Paleoproterozoic, Eagle River orogenesis and the late Paleoproterozoic Labradorian orogenesis. The oldest rocks are pre-Labradorian (~1.81–1.77 Ga) supracrustal rocks (of the Grenville Province), comprising mainly pelitic gneiss, psammitic gneiss, quartzite and some mafic volcanic rocks. These rocks are mapped in the northeastern to north-central part of the study area, as well as to the southwest. Rocks of the late Paleoproterozoic (~1.71–1.66 Ga) Labradorian orogenic event consist of early Labradorian anorthositic and mafic rocks (correlative to the Alexis River anorthosite to the southeast), as well as granitoid rocks including gneiss. These rocks dominate nearly all of NTS 13H/04 and 05 map areas. Late Labradorian (~1.66–1.60 Ga) rocks comprise granitoids (K-feldspar megacrystic quartz monzonite to quartz monzonite), anorthosites (leucogabbronorite, anorthosite and leucotroctolite) and mafic intrusive rocks (gabbronorites and metamorphic derivatives). These rocks are prevalent in NTS 13H/03 and 06. The youngest rocks in the region are Neoproterozoic (~0.90–0.54 Ga) Long Range dykes that crosscut early Labradorian rocks mapped in NTS 13H/04 and 05.

MINERAL OCCURRENCES

Copper, Ni and U occurrences discussed below are retrieved from the mineral occurrence database system (MODS) of the GSNL (*see* Geological Survey of Newfoundland and Labrador, 2021). Despite limited mineral exploration in the region, there are numerous Cu and Ni, and U indications (Gower, 2010b; Figures 2–5). Copper indications in the study area include the Paradise River Cu Indications #4 and #5, marked in the west-central part of NTS 13H/06 (Figure 5). These Cu indications are likely associated with the late Labradorian (~1.8–1.6 Ga) anorthositic and mafic intrusions, where Cu mineralization is likely hosted within weakly to strongly foliated mafic granulitic rocks. These anorthositic and mafic intrusive rocks are similar to the ones mapped in the southwest corner of NTS 13H/10 (outside the study area), where Ni, Cu, Co and V showings (with up to 5332 ppm Cu, 877 ppm Ni and 292 ppm Co; Martin, 2018) are identified within the White Hills area, ~15 km southeast of the town of Cartwright.

Copper indications named Crooked Lake Northwest #1, 2, 3 and 4, are present in the central-west part of the study area (southeastern corner of NTS 13H/05 and northeastern 13H/04; Figures 3 and 4) and associated with pre-Labradorian to early Labradorian rocks including pelitic to psammitic schist, gneiss and granitoids. A grab sample collected by J. Juilland *et al.* (1965) returned 0.044% Cu, 0.13% Ni and 0.06 g/t Ag (Kranck, 1966).

Crooked Lake #1 and Crooked Lake West #6, 8 and 9 Ni indications are marked in the southeast corner of NTS 13H/05 (Figure 4). These Ni indications are associated with ~1.6–1.8 Ga late Paleoproterozoic, Pre-Labradorian supracrustal rocks, and likely hosted within pelites, schist and gneiss.

The Southwest Brook Tributary U indication (determined by anomalous radioactivity; Figure 4) is present in ~1.6–1.8 Ga, early Labradorian granitoids, where U mineralization is likely hosted within foliated to gneissic granites and alkali-feldspar granite.

QUATERNARY GEOLOGY AND ICE-FLOW MOVEMENT

This summary of the regional Quaternary framework, *i.e.*, the glacial and deglacial events associated with the Late Wisconsinan Glaciation in southeastern Labrador, is based on work by Fulton and Hodgson (1979), King (1985),

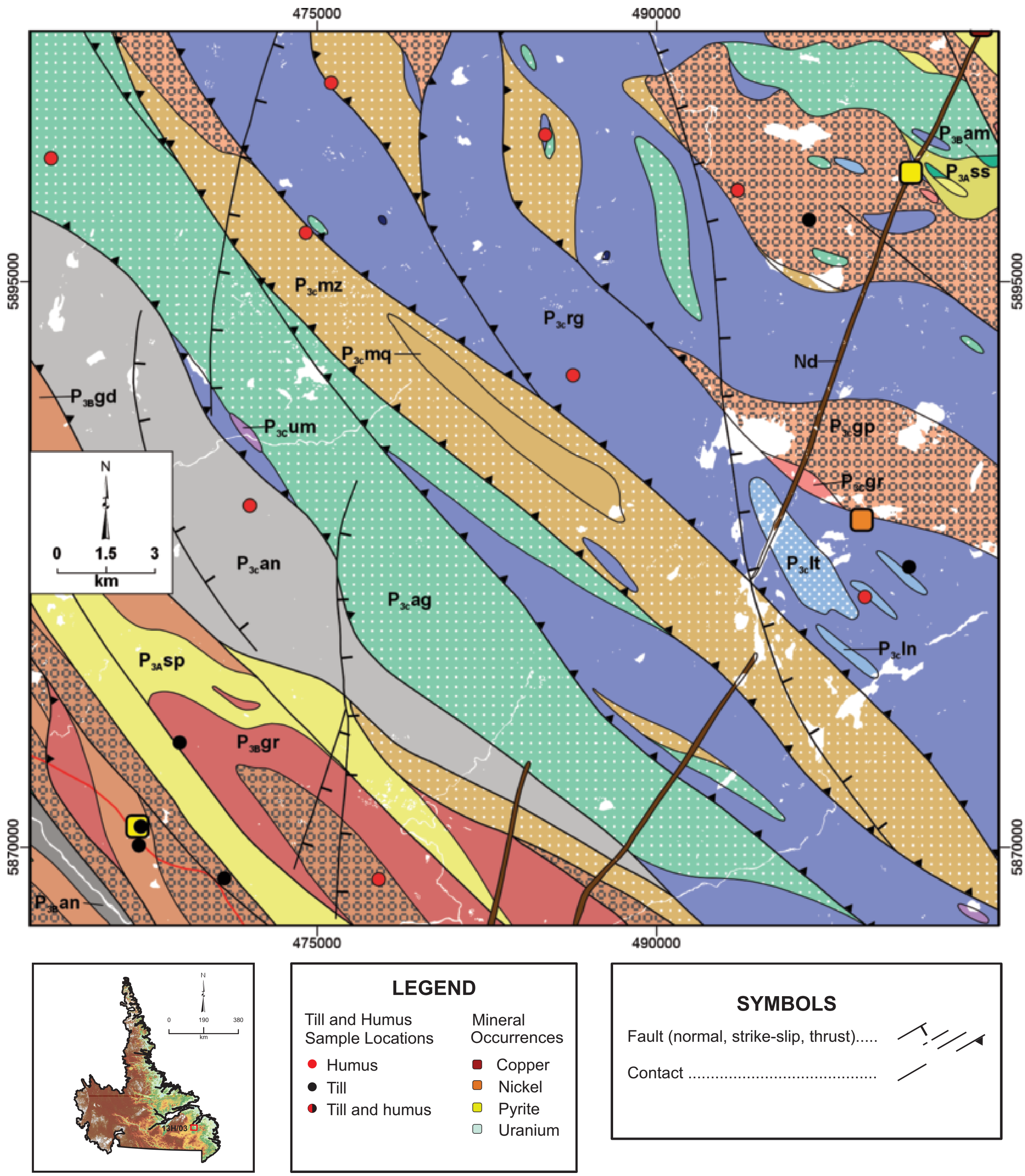


Figure 2. *Bedrock geology and mineral occurrences in NTS 13H/03. Bedrock geology and legend modified after Gower (2010a, b).*

LEGEND

NEOPROTEROZOIC

Nd	Long Range dykes

LATE PALEOPROTEROZOIC (P_3 1800–1600 Ma)

LATE LABRADORIAN GRANITOID, ANORTHOSITIC AND MAFIC INTRUSIONS (P_{3C} 1660–1600 Ma)

P_{3C}ag	Weakly to markedly foliated mafic granulite, plus leucocratic and melanocratic variants
P_{3C}am	Weakly to markedly foliated amphibolite, plus leucocratic and melanocratic variants
P_{3C}an	Massive- to strongly foliated anorthosite and leucogabbronorite
P_{3C}d	Unnamed mafic dykes
P_{3C}dr	Diorite, quartz diorite and tonalite; locally grading into leucogabbronorite
P_{3C}gd	Granite to granodiorite forming discrete unmigmatized plutons
P_{3C}gp	Megacrystic/porphyritic granite to granodiorite
P_{3C}gr	Granite and minor alkali-feldspar granite
P_{3C}ln	Primary textured to recrystallized leucogabbronorite and leucogabbro. Coronitic locally
P_{3C}lt	Primary textured to recrystallized leucotroctolite
P_{3C}mq	Quartz monzonite, including rare quartz syenite
P_{3C}mz	Monzonite, including minor syenite
P_{3C}rg	Massive- to strongly foliated gabbro and norite, commonly layered. Subophitic and locally coronitic
P_{3C}um	Massive-, weakly or strongly foliated ultramafic rocks, commonly layered and locally showing cumulate textures
p	Pegmatite

EARLY LABRADORIAN GRANITOID, MAFIC AND ASSOCIATED ROCKS (P_{3B} 1710–1660 Ma)

P_{3B}ag	Weakly foliated to gneissic amphibolite and mafic granulite, plus leucocratic and melanocratic variants
P_{3B}am	Amphibolite skialiths, lenses and layers (mainly remnants of former dykes)
P_{3B}an	Weakly foliated to gneissic anorthosite and leucogabbronorite
P_{3B}dr	Foliated to gneissic diorite to quartz diorite, and compositionally equivalent well-banded gneiss; in part derived from leucogabbronorite
P_{3B}gd	Foliated to gneissic granodiorite and compositionally equivalent well-banded gneiss
P_{3B}gp	Foliated to gneissic megacrystic/porphyritic granitoid rocks, augen gneiss
P_{3B}gr	Foliated to gneissic granite and alkali-feldspar granite, and compositionally equivalent well-banded gneiss
P_{3B}ln	Weakly foliated to gneissic leucogabbronorite and leucogabbro. Coronitic locally
P_{3B}mn	Weakly foliated to gneissic monzonorite and monzogabbro
P_{3B}mq	Foliated to gneissic quartz monzonite, grading into diorite or syenite, and compositionally equivalent well-banded gneiss
P_{3B}rg	Weakly foliated to gneissic gabbro and norite
P_{3B}um	Massive, weakly or strongly foliated ultramafic rocks, commonly layered and locally showing cumulate textures
P_{3B}ya	Foliated to gneissic syenite, alkali-feldspar syenite and alkali-feldspar granite, and compositionally equivalent well-banded gneiss

PRE-LABRADORIAN SUPRACRUSTAL ROCKS (P_{3A} 1800–1710 Ma)

P_{3A}am	Amphibolite skialiths, lenses and layers (mainly remnants of former dykes)
P_{3A}gp	Foliated to gneissic megacrystic/porphyritic granitoid rocks, augen gneiss
P_{3A}sc	Calc-silicate rocks, compositionally layered, medium grained
P_{3A}sp	Fine- to medium-grained pelitic schist and gneiss
P_{3A}sq	Quartzite, meta-arkose, thin to thick bedded
P_{3A}ss	Quartz-feldspar psammitic schist and gneiss; medium-grained and commonly rusty-weathering
P_{3A}sx	Metasedimentary diatexite; coarse-grained to pegmatitic and characteristically white-weathering
P_{3A}vm	Fine- to medium-grained, banded amphibolite containing quartz-feldspar layers and calc-silicate pods. Interpreted as mafic volcanic rocks

Figure 2. *Legend.*

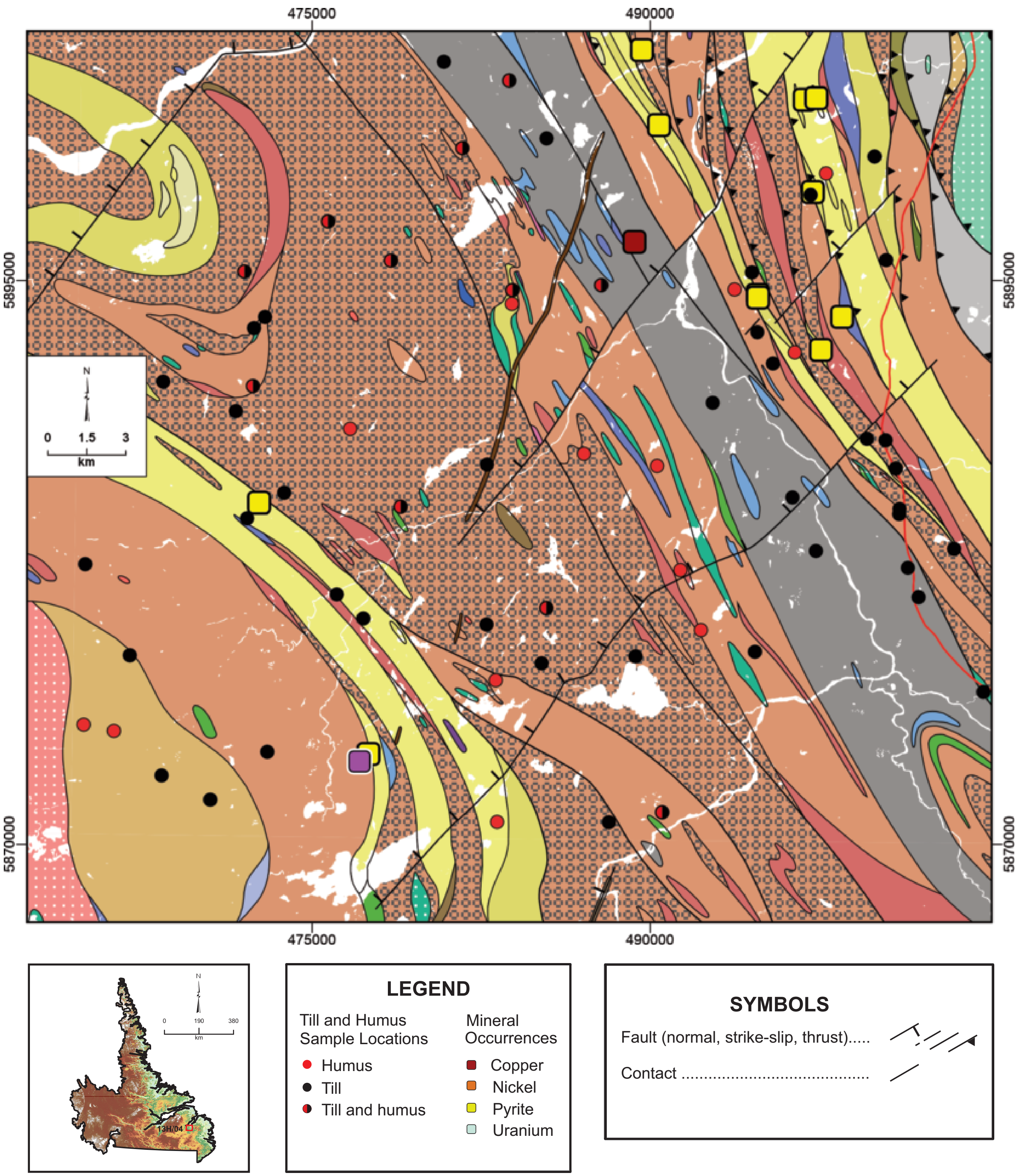


Figure 3. *Bedrock geology and mineral occurrences in NTS 13H/04. Bedrock geology and legend modified after Gower (2010a, b).* See *Figure 2 for bedrock geology legend.*

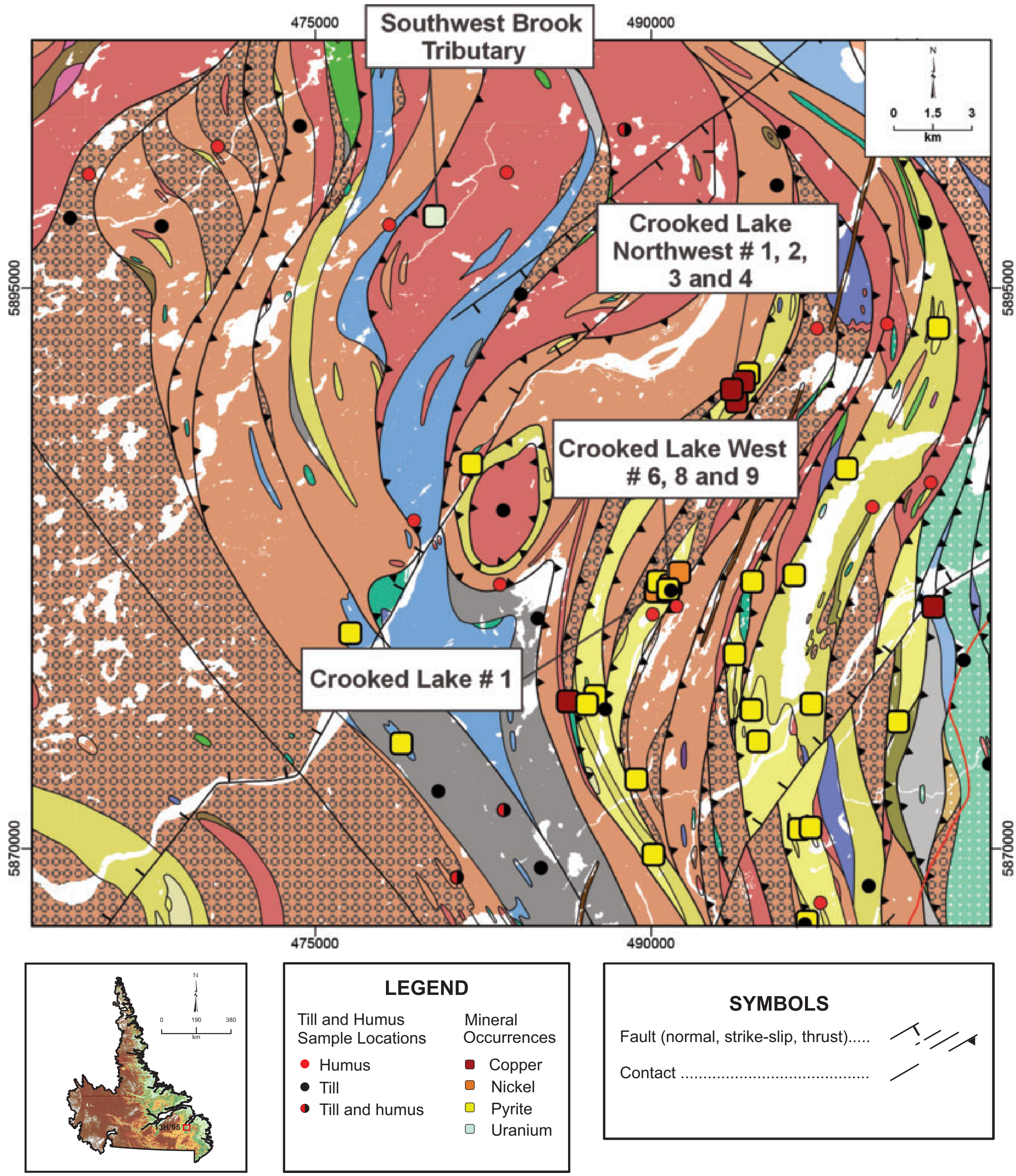


Figure 4. *Bedrock geology and mineral occurrences in NTS 13H/05. Bedrock geology and legend modified after Gower (2010a, b).* See *Figure 2 for bedrock geology legend.*

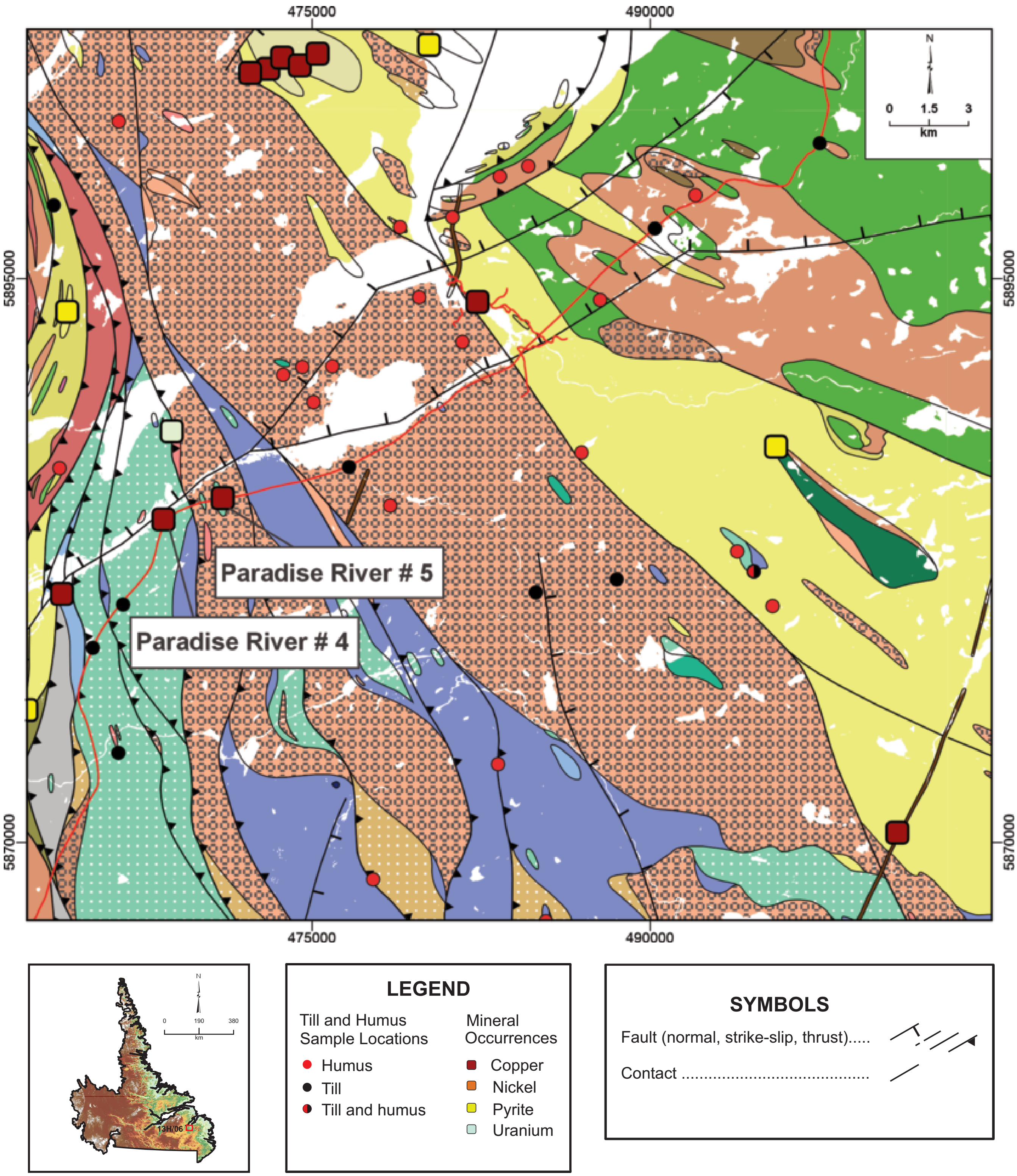


Figure 5. *Bedrock geology and mineral occurrences in NTS 13H/06. Bedrock geology and legend modified after Gower (2010a, b).* See *Figure 2 for bedrock geology legend.*

Josenhans *et al.* (1986), Grant (1992), Batterson and Liverman (2001), McCuaig (2002), Occhietti *et al.* (2004), Shaw *et al.* (2006), Ullman *et al.* (2016) and Couette *et al.* (2023). Ice build up was initiated in the uplands (*e.g.*, the Mealy Mountain Range) west, northwest of the study area. During glacial advance, ice-flow movement within southeastern Labrador (and within the study area) was topographically controlled (Figure 6).

During the last glacial maximum (LGM; ~22 ka before present, BP), the Laurentide Ice Sheet (LIS) covered all of Labrador, excluding the summit of the Mealy Mountains and nunataks in the Torngat Mountains in northern Labrador. The LIS extended across the Strait of Belle Isle onto the northern tip of the Northern Peninsula (Newfoundland) and coalesced with the Newfoundland Ice Cap (NIC; Grant 1992). Ice flowed northeastward in the northwestern quadrant (NTS 13H/05) and northeastern quadrant (western part of NTS 13H/06) and flowed into Sandwich Bay (to the northeast and just outside of the study area). In the southern part of the study area (quadrants NTS 13H/03 and 04), the ice-flow movement was to the southeast and northeast.

Deglaciation may have commenced as early as 17 ka BP and by 15 ka BP, the LIS had begun its northward recession (Barnett, 1992). Ice retreat was characterized by mechanical drawdown following a concentric thermo-latitudinal retreat pattern, ablation and ice-stagnation (Occietti *et al.*, 2004). Ice flow in southern Labrador continued to be topographically controlled (primarily by the ice centre in the Mealy Mountains). The LIS was disconnected from the Newfoundland Ice Cap by ~14.1 ka BP (Couette *et al.*, 2023) and based on radiocarbon ages of shells recovered along the Labrador coast, the area north of the Strait of Belle Isle was ice free by at least ~10.9 ± 140 ka BP (Grant, 1992). After disconnecting from the NIC, the LIS margin retreated to near the Québec–Labrador coast and deposited the Brador (~15 ka BP; calibrated years) and the Belles Amour moraines (~13 ka BP; calibrated year; Grant, 1992; Couette *et al.*, 2023). The LIS continued to retreat westward and deposited the Paradise Moraine. Radiocarbon dating of marine shells along a riverbank east of this moraine system were age-dated to ~9.2 ± 0.2 to ~9.6 ± 0.3 ka BP (calibrated years; Hodgson and Fulton, 1972), which is congruent with the formation of Paradise Moraine at ~9.4 ± 0.8 ka, recalculated from Ullman *et al.* (2016) and by Couette *et al.* (2023; ~^{10}Be: 12.1 ± 0.6 k). The retreating ice margin reached west of Lake Melville by 8.6 ± 0.6 ka BP and central Labrador by 7.0 ka BP (~7.8 ka BP; calibrated years; King, 1985; Ullman *et al.*, 2016). The last of the stagnating ice masses were likely located in the Labrador Trough and Nunavik. The LIS may have completely disintegrated by ~6.5–6.7 ka BP (Occietti *et al.*, 2004; Ullman *et al.*, 2016).

METHODS

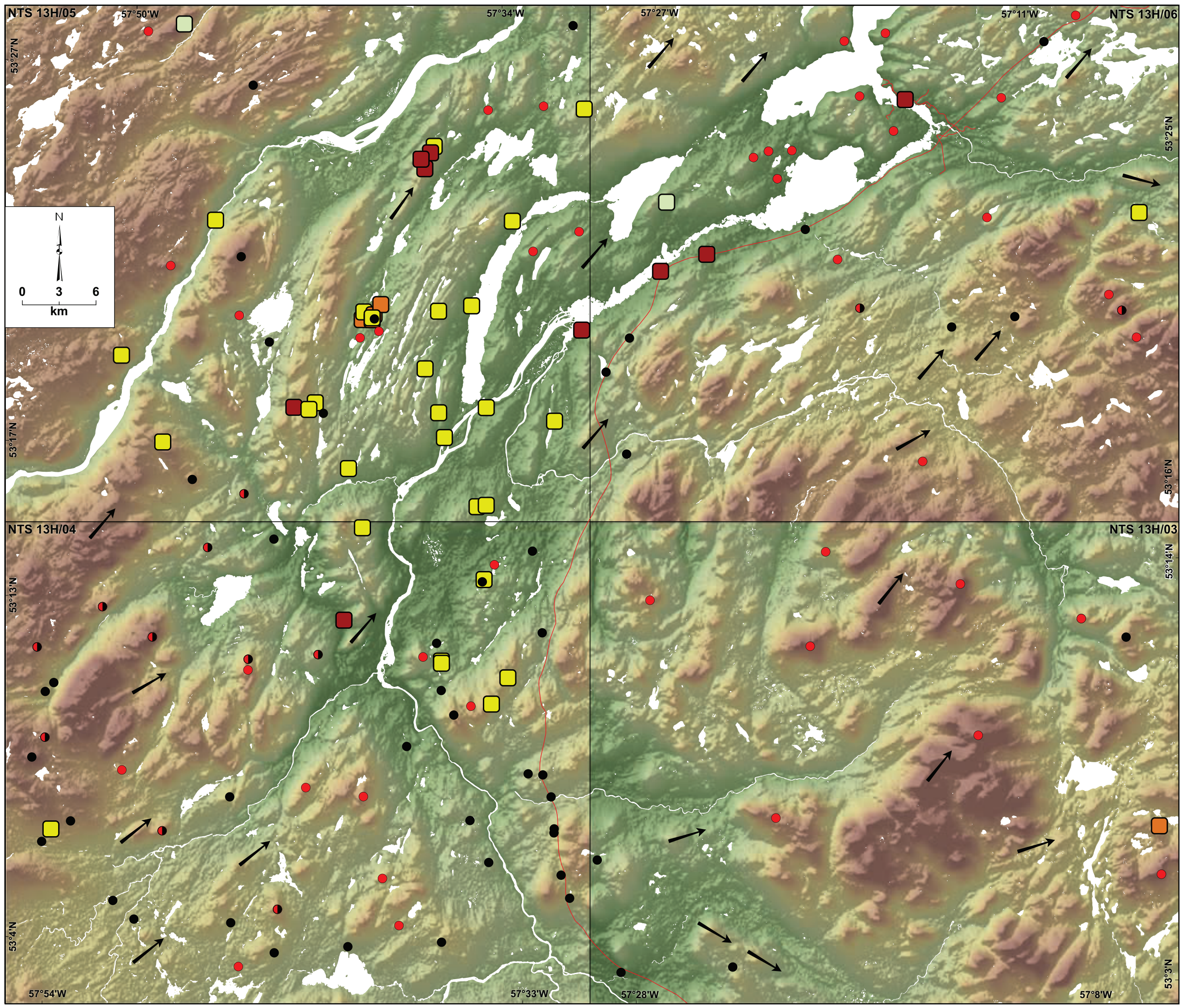
SURFICIAL MAPPING AND SAMPLING

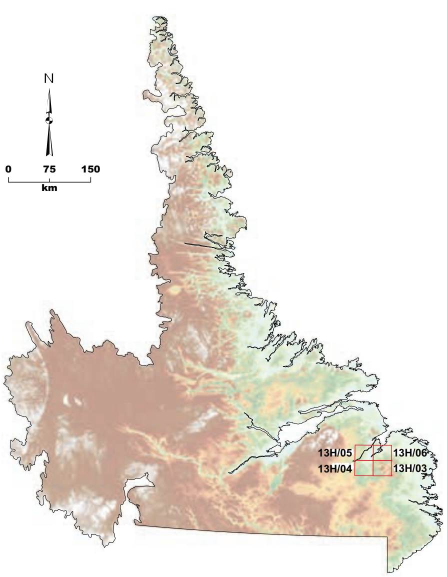
Surficial mapping and sampling were completed between June and July 2025 *via* truck, all-terrain vehicles (ATVs) and helicopter. Surficial mapping was completed in ESRI™ Survey 123 application with a custom-built form for the 2025 field project. At each mapping site (Plate 1), information such as GPS location, surficial material and characteristics, geomorphology, elevation, vegetation cover and orientation of micro-scale ice-flow indicators, such as striations, were noted.

A total of 71 humus and 83 till samples were collected for geochemical analyses and 14 till samples were collected for heavy-mineral separation. For humus, a 0.5–1 kg sample was collected, preferably near outcrop, to ensure that its geochemistry either reflected the till or bedrock composition (Plate 2A). For till, a 2–3 kg sample was collected of B-, BC- or C-horizon soil (developed in till; Plate 2B). Only 15 sites had a humus and till sample; collecting both at every site was not possible due to either a lack of humus development, or a lack of till at the site.

At each humus sampling site, a reciprocating saw was used to cut into the vegetation; the sample was then collected from a smaller hole within (*see* Hashmi 2024a). Sample depth was variable, ranging from a few centimetres to tens of centimetres and depended on factors such as the maturity and thickness of the organic layer. In areas where humus appeared to have been contaminated by mineral matter, *i.e.*, appeared "dusty", the sample was collected as deep as possible to reduce potential dust contamination. Each humus sample was collected using a stainless-steel knife that was thoroughly cleaned by hand (and water where available) to avoid cross contamination. Humus samples were collected in thick plastic bags and closed tightly with zip ties to ensure no outside material fell accidently into the bag; coarse roots, thick woody material and decomposing material were removed from the sample before the fully decomposed material was placed into a bag (Plate 2A).

At each till sampling site, a pit was dug to expose till. Sample equipment included a foldable shovel and a geological pick. Till samples were collected from a depth ranging from a few to tens of centimetres. Most of the till samples were collected from the BC- or B-horizon because the till is predominantly mapped as a veneer (*i.e.*, <1 m). Ideally, C-horizon till should be sampled because it is less affected by physical weathering processes such as surface washing, and/or chemical weathering processes such as hydromorphic dispersion (McClenaghan *et al.*, 2020). In some cases, till samples were collected from mud boils, where only the





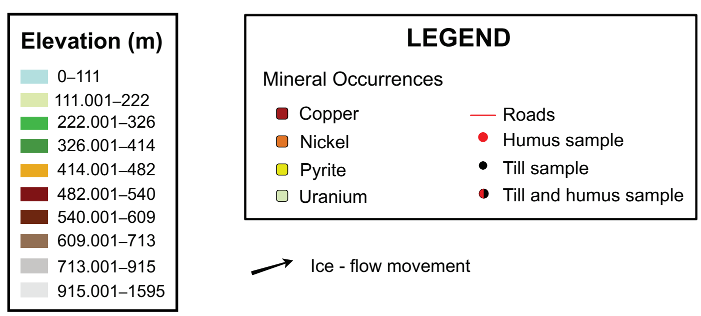


Figure 6. *Ice-flow movement in the region. Data retrieved from Geological Survey of Newfoundland and Labrador's striation database (2022).*

Plate 1. *Field photographs. A) Panoramic view overlooking the study area. The patches with fewer trees and exposed sediment are areas affected by forest fires (>50 years old). The yellow dotted lines encompass till blanket (*i.e.*, >1 m till; Tb); B) Bare rock with some tree cover and little to no topsoil; C) Low-lying region with exposed massive, sand and gravel is mapped as a glaciofluvial terrace (Gt). This area was affected by forest fire.*

top few centimetres of oxidized B-horizon material was available for sampling (Plate 2B).

Field data for both humus and till samples were collected using the ESRI Survey123 application with a custom form. Information collected at each sample site included location (GPS coordinates and elevation), site description, geomorphology and general site observations such as evidence of postglacial depositional disturbances such as forest fires. Additional information specific to humus samples included humus development, charcoal or evidence of forest fire and mineral matter present within the sample. Additional information specific to till samples included grain size (*i.e.*, field level estimate of the percentage of sand, silt and clay), clast content, unit thickness, and sedimentary structures. Photographs were also taken at each sampling site.

Plate 2. *Representative photos of surficial sample media collected during this study. A) Well-decomposed, excellent quality humus having little to no mineral matter; B) Mud boil with an oxidized B-horizon till on the surface.*

SAMPLE PREPARATION AND ANALYTICAL TECHNIQUES

The humus samples were shipped directly to ALS Canada Ltd. Laboratory in North Vancouver, British Columbia for sample preparation and analysis. Here, the samples were dried (ALS code: DRY-22), milled in a Retsch mill (ALS code: VEG-MILL01) and passed through a <180 µm sieve (PREP-41) (Figure 7). The sieved humus sample underwent ashing, where a 100 g prepared humus aliquot is ashed (decomposed) at 475°C for 24 hours, with an ashed yield of approx. 2–4 g. Ashing of humus samples is useful because it concentrates the element content such that the back calculation to pre-ashed sample weight can reduce the detection limit by an order of magnitude. The ashed humus samples then underwent *aqua regia* digestion (1:3 nitric to hydrochloric acid) with an inductively coupled plasma mass spectrometry (ICP-MS) finish and inductively coupled plasma atomic emission spectroscopy (ICP-AES) finish (ALS code: ME-VEG41a). Additionally, a super trace detection package to determine REEs at parts per trillion (ppt) levels was also added to this procedure (ALS code: VEG41a-REE). A back calculation was also requested for the ashed samples to determine element concentrations in the original prepared aliquot, *i.e.*, the dried and separated humus sample (ALS Code: VEG41a-FAC and VEG41a-REE). These calculated values are the elemental concentrations of the ashed humus factored by the ratio of the weight of the sample before and after ashing. Lastly, loss on ignition (LOI) was also performed on a prepared 1 g humus sample to determine the percentage of organic matter present (ALS code: OA-GRA05).

The 2–3 kg till samples were shipped to the GSNL Laboratory in St. John's for pre-processing (Figure 8). At the GSNL laboratory, the till samples were dried at 55°C, crushed with a rubber mallet to disintegrate clumpy till and sieved to the <63 µm fraction. The <63 µm till fraction of till samples was also submitted to ALS Canada Ltd. for the following:

1) A multi-acid, near-total digestion with an ICP-MS and ICP-AES finish (ALS Code: ME-MS61L). This method includes ultra-trace detection for REEs (ALS Code: MS61L-REE).

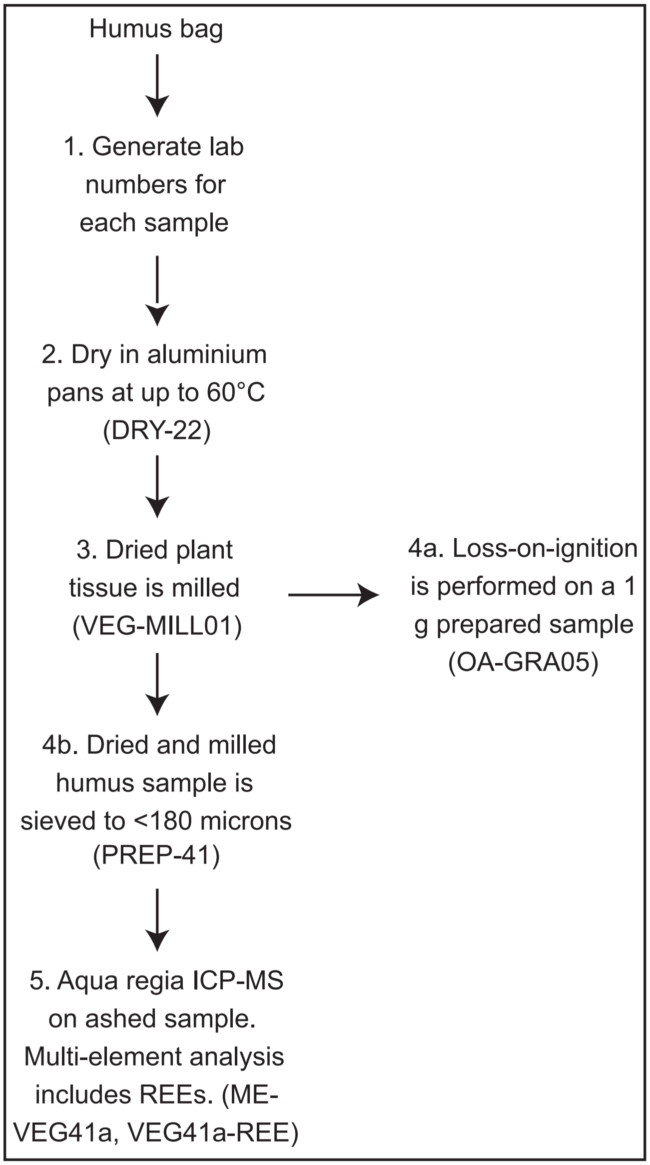


Figure 7. *Workflow outlining the processing and analytical techniques implemented for humus samples.*

2) Gold, Pt and Pd by *aqua regia* ICP-MS (ALS Code: AuME-NANO). This method detects Au and PGEs at parts per trillion (ppt) levels.

3) Clay separation (<10 µm; ALS Code: SCR-CLAY), followed by a multi-acid, near-total digestion with an ICP-MS and ICP-AES finish (ALS Code: ME-MS61L). This method includes ultra-trace detection for REEs (ALS Code: MS61L-REE).

Till samples collected during the 2025 field season were also submitted in-house (to the GSNL laboratory) for the following (*see* Finch *et al.*, 2018):

1) Loss-on-ignition (LOI) to determine organic content.

2) Four-acid (hydrochloric acid, hydrofluoric acid, nitric acid and perchloric acid) digestion followed by inductively coupled plasma-optical emission spectrometry (ICP-OES) to determine concentrations of major and trace elements (Ag, Al, As, Ba, Be, Ca, Cd, Ce, Co, Cr, Cu, Dy, Fe, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Rb, S, Sc, Sr, Ti, V, Y, Zn and Zr).

3) Lithium (metaborate) tetraborate fusion followed by ICP-OES and ICP-MS finish for the following: SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O, K_2O, TiO_2, MnO, P_2O_5, Cr, Ba, Be, Sc and Zr are analyzed by ICP-OES. Gallium, Ge, Rb, Sr, Y, Nb, Sn, Cs, La, Ce, Pr, Nd, Sm, Eu, Tb, Gd, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W, Tl, Bi, Th and U are analyzed by ICP-MS.

4) A 4-acid digest followed by ICP-MS to determine major and trace elements (Ag, As, Ba, Bi, Cd, Ce, Co, Cs, Cu, Dy, Er, Eu, Ga, Gd, Ge, Hf, Ho, La, Lu, Mo, Nb, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Sm, Sn, Sr, Tb, Th, Tl, Tm, U, V, W, Y, Yb and Zn).

Fourteen till samples, weighing 12–16 kg, were submitted to IOS Services Géoscientifique Inc. for indicator mineral processing. Here, the samples were wet sieved and screened to remove the pebble fraction (16–64 mm). The sample underwent fluidized bed processing and preconcentration on a shaking table followed by heavy liquid separation (specific gravity: 3.3), magnetic screening (to remove magnetic minerals), and fine screening to <63 µm. Indicator mineral counts were performed using IOS Services Géoscientifiques Inc.'s ARTmin™/ARTGold™ technology on the 63–150 µm and 150–250 µm grain fractions. Rare earth minerals (REMs), platinum group minerals (PGMs), base metal sulphide minerals (BMSMs; chalcopyrite, pentlandite, pyrrhotite, pyrite) and gold grains in these size fractions were identified and counted.

QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance measures in the field included cleaning of sampling tools with water (where available) and by hand before the collection of each new sample to reduce cross-contamination. A field duplicate was collected every 9 sites for till samples and 12 sites for humus samples to determine site variability. Quality control measures included insertion of field duplicates for humus samples and till samples to determine precision. Prepared laboratory duplicates were also inserted into till samples (OREAS-46) to determine accuracy before the samples were shipped to ALS Canada Ltd. for analyses.

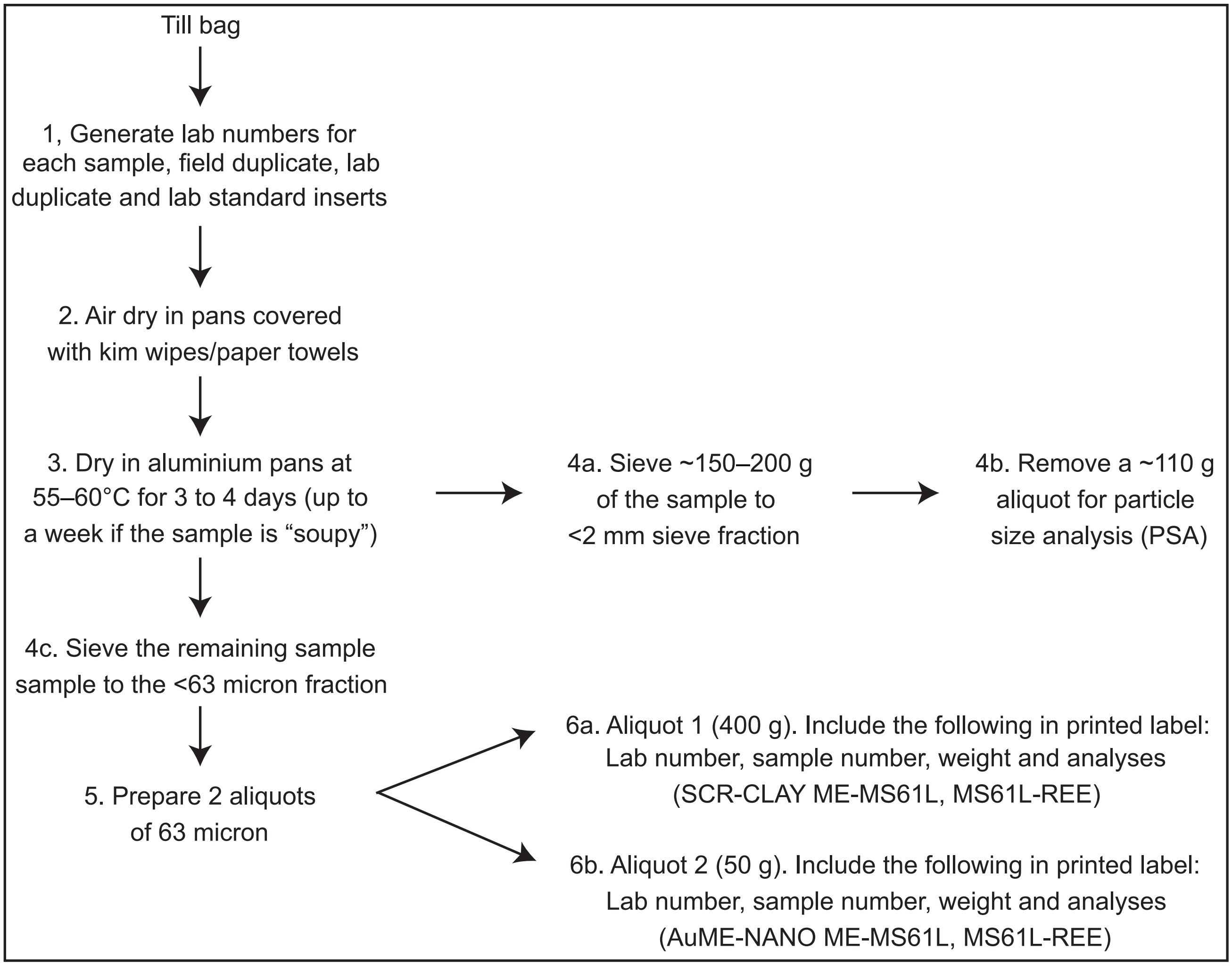


Figure 8. *Workflow outlining the processing and analytical techniques implemented for till samples.*

PRELIMINARY RESULTS

ICE-FLOW MOVEMENT

Two, distinct ice-flow movements have been mapped from macro- and micro-scale ice-flow indicators. Macro-scale ice-flow indicators include streamlined bedforms rôches moutonneés, stoss and lee relationships and crag and tail (Plate 3A). Micro-scale ice-flow indicators include features such as striations, grooves, and rat-tails. The two ice-flow movements in the regions are towards the: 1) northeastward, and 2) southeastward.

The northeastward movement is mapped on bedrock at high elevations along the Paradise River Valley; the Paradise River Valley is also oriented approximately northeastward, as well as at high elevations (hill tops).

The southeastward movement is mapped on bedrock within and at higher elevations along the Alexis River Valley. The Alexis River Valley is also oriented approximately southeastward). Preliminary ice-flow mapping suggests that both the northeastward and southeastward ice-flow movements are associated with the Wisconsinan Glaciation maximum in the region.

SURFICIAL MAPPING

The study area has been affected by the Late Wisconsinan Glaciation, evident by the presence of glacial sediments and several ice-flow indicator features. Below is a summary of the surficial units mapped.

Bare or concealed sculpted bedrock is mapped at higher elevations and in topographic lows (primarily within bog). Where bedrock is mapped as concealed (Rc), it is covered in vegetation (*i.e.*, trees, moss, shrubs).

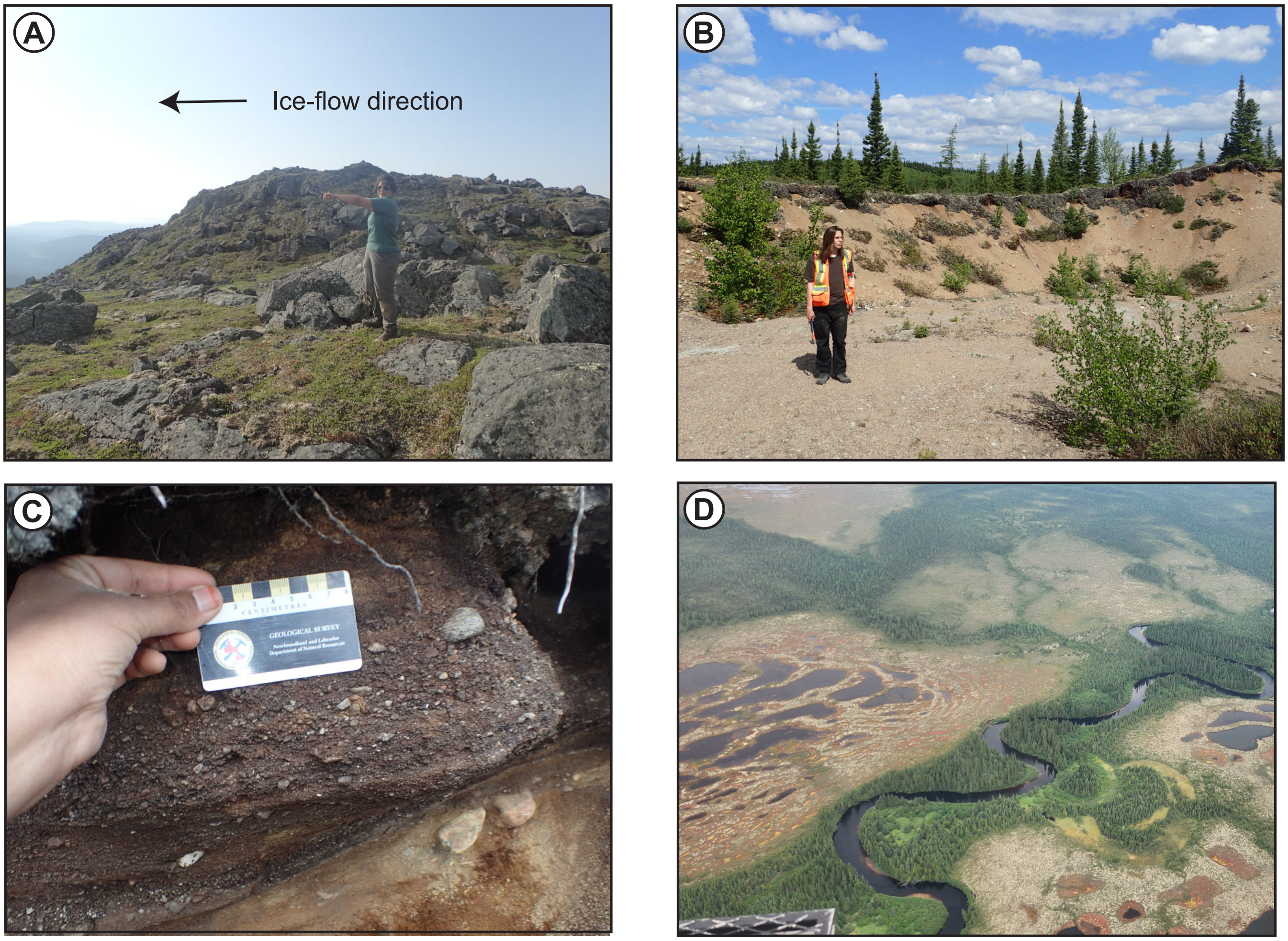


Plate 3. *Surficial mapping in the study area. A) Large roche moutonnée indicating ice flow to the north-northwest; B) Hummocky glaciofluvial medium–coarse sand and granule- to boulder-sized gravel; C) Cemented granule- (2–4 mm) to cobble- (4–64 mm) sized gravel associated with glaciofluvial outwash; D) String bog in topographic lows.*

Till is the oldest surficial unit mapped and is associated with glacial advance, glacial maximum and glacial retreat. The unit varies from brown, grey–brown to light to dark-grey. Till is mapped as a blanket (Tb; >1 m) at lower elevations and as a veneer (Tv; <1 m) at higher elevations.

Glaciofluvial sediments, comprising massive, to crudely to well stratified granule- (2–4 mm) to boulder- (>64 mm) sized gravel is mapped primarily within the Alexis River and Paradise River valleys. These sand and gravel deposits are variable in thickness and can range between 10–30 cm. These glaciofluvial deposits form terraces along the Paradise River Valley (cut by later meltwater flow), as well as hummocks, kettles, ridges and doughnut-shaped features in the southwestern quadrant (NTS 13H/06). Preliminary observations suggest that the glaciofluvial sediments mapped are associated with the Paradise Moraine, an ice-marginal deposit indicative of deglaciation by ablation and ice-stagnation. The Paradise Moraine is documented to the southeast (McCuaig, 2002) and to the west-northwest (Couette *et al.,* 2023) of the study area.

Organic deposits, consisting of muskeg, bog and fen are prevalent in topographic lows, along the river valleys, within bedrock depressions (Plate 3D).

FUTURE WORK

Analytical results are pending. Deliverables for this project will include the following:

1) Four, 1:50 000 surficial geology maps.

2) Data release for humus and till geochemistry, as well as indicator mineral separation.

3) An updated report on the interpretation of the humus and till geochemistry results. The report will also

include recommendations for analytical methods and best practices suited to targeting selected critical metal mineralization using till and humus for grassroots exploration programs in Newfoundland and Labrador.

SUMMARY

A 6-week humus- and till-sampling survey was conducted in the Alexis River Valley region in southeast Labrador (NTS map areas 13H/03–06). The objectives of this survey were to determine whether decomposed vegetation (*i.e.*, humus) overlying bedrock mineralization and mineralized-till dispersal can be used to fingerprint the geochemical signature of critical metals such as REEs, PGEs, U and base metals. Preliminary surficial mapping has identified only one till unit. This till unit (mapped as both a blanket and a veneer) is the oldest and most prevalent surficial unit mapped in the study area, and is associated with glacial advance, maximum and retreat. Also mapped is glaciofluvial sand and gravel associated with deglaciation in the region and mapped at lower elevations, and within the Paradise River and Alexis River valleys. Further, two distinct ice-flow movements are identified in the study area. These are oriented: 1) to the northeast, and 2) to the southeast. Both ice-flow movements to the northeast and southeast are associated with glacial maximum. The mapping and sampling survey completed for this study will facilitate the mineral exploration industry by providing the following: 1) 4, 1:50 000 surficial geology maps (NTS 13H/03, 04, 05 and 06), 2) surficial (till and humus) geochemical data for the region as well as an update on recommended analytical techniques that can better detect critical metal mineralization in surficial media, and 3) a comprehensive report on the best practises surficial sampling for critical metals, and the potential affects of forest fires on surficial geochemistry.

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REFERENCES

Barnett, P.J.
1992: Quaternary geology of Ontario, Geology of Ontario. Ontario Geological Survey, Special Volume 4, pages 1011-1088.

Batterson, M.J. and Liverman, D.G.
2001: Contrasting styles of glacial dispersal in Newfoundland and Labrador: Methods and case studies. *In* Prospecting in Areas of Glaciated Terrain. *Edited by* M.B. McClenaghan, B.T. Bobrowsky and N.J. Cook. The Geological Society, Special Volume 185, pages 267-285.

Couette, P.-O., Ghienne, J.-F., Lajeunesse, P. and Van der Woerd, J.
2023: Climatic control on the retreat of the Laurentide Ice Sheet margin in easternmost Québec–Labrador (Canada) revealed by cosmogenic nuclide exposure dating. Journal of Quaternary Science, Volume 38, pages 1044-1061.

Foster, D.R.
1983: The history and pattern of fire in the boreal forest of southeastern Labrador. Canadian Journal of Botany, Volume 61, Issue 9, pages 2459-2471.

Fulton, R.J. and Hodgeson, D.A.
1979: Wisconsin glacial retreat, Southern Labrador. *In* Current Research, Part C, Geological Survey of Canada. Paper 79-1C.

Geological Survey of Newfoundland and Labrador
2021: Mineral Occurrence Database System (MODS). Newfoundland and Labrador GeoScience Atlas OnLine. Last update: December 2021. http://geoatlas.gov.nl.ca/ [retrieved October 2025].

2022: "Striation Database" Newfoundland and Labrador GeoScience Atlas OnLine. Last update: November 2022. http://geoatlas.gov.nl.ca/ [retrieved October 2025].

Gower, C.F.
2010a: Geology of the Paradise River area (NTS sheets 13H/03, 04, 05 and 06), southeastern Labrador. Map 2010-15. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Open File 013H/0066.

2010b: Mineral Occurrences and metallogenesis in eastern Labrador. Government of Newfoundland and

Labrador, Department of Natural Resources, Geological Survey, Open File LAB/1571, 155 pages.

2019: Regional geology of eastern Labrador (eastern Makkovik and Grenville provinces). Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, St. John's, Memoir 4, 654 pages. [Geofile # LAB/1752]

Grant, D.R.
1992: Quaternary geology of St. Anthony-Blanc Sablon area, Newfoundland and Quebec. Geological Survey of Canada, Memoir 427, 60 pages.

Hashmi, S.
2024a: Humus and till geochemistry in the vicinity of Au mineralization in Newfoundland: Results from Glover Island (NTS 12A/12 and 13), Jackson's Arm (NTS 12H/15) and Nippers Harbour (NTS 2E/13) map areas. Government of Newfoundland and Labrador, Department of Industry, Energy and Technology, Geological Survey, Open File NFLD/3458, 55 pages.

2024b: New surficial geochemistry and indicator-mineral survey to target critical metals (base metals, PGEs, REEs, U): Revisiting the Alexis River Valley region (NTS map areas 13A/10, 14 and 15) southeastern Labrador. *In* Current Research. Government of Newfoundland and Labrador, Department of Industry, Energy and Technology, Geological Survey, Report 24-1, pages 127-138.

2024c: Till-geochemistry data targeting critical metals (base metals, PGEs, REEs, U) in the Alexis River Valley region (NTS map areas 13A/10, 14 and 15), southeastern Labrador. Government of Newfoundland and Labrador, Department of Industry, Energy and Technology, Geological Survey, Open File 013A/0126, 12 pages.

2024d: Humus-geochemistry data targeting critical metals (base metals, PGEs, REEs, U) in the Alexis River Valley region (NTS map areas 13A/10, 14 and 15), southeastern Labrador. Government of Newfoundland and Labrador, Department of Industry, Energy and Technology, Geological Survey, Open File 013A/0125, 9 pages.

Josenhans, H.W., Zevenhuizen, J. and Klassen, R.A.
1986: The Quaternary geology of the Labrador Shelf. Canadian Journal of Earth Sciences, Volume 23, pages 1190-1213.

Kauranne, L.K.
1992: Regolith exploration geochemistry in arctic and temperate terrains. *In* Handbook of Exploration and Environmental Geochemistry. *Edited by* L.K. Kauranne, K. Eriksson and Salminen. Handbook of Exploration and Environmental Geochemistry, Volume 5, 1st Edition, 443 pages.

Juilland, J.S., Meyer, W.T., Staub, W.P., Sutton, W.R., Bradley, D.A. and Donohoe, H.V.
1965: Report on exploration for the joint venture in the Sandwich Bay-Square Island area of southwest Labrador. British Newfoundland Exploration Limited Unpublished report. [Geofile # LAB/0200]

King, G.A.
1985: A standard method for evaluating radiocarbon dates of local deglaciation: Application to the deglaciation history of southern Labrador and adjacent Québec. Géographie physique et Quaternaire, Volume 39, pages 163-182.

Kranck, S.H.
1966: Appendix II. Report on geology of northern part of Sandwich Bay - Square Island joint venture area. In Summary Report of Exploration during 1966. Brinex Limited. Newfoundland and Labrador Geological Survey, Assessment Files LAB/0199 and 013H/0011, 13 pages.

Magyarosi, Z.
2022: Preliminary investigation of rare-Earth-element mineralization, Fox Harbour volcanic belt, southeastern Labrador. *In* Current Research. Government of Newfoundland and Labrador, Department of Industry, Energy and Technology, Geological Survey, Report 22-1, pages 57-83.

McClenaghan, M.B., Spirito, W.A., Plouffe, A., McMartin, I., Campbell, J.E., Paulen, R., Garrett, R.G., Hall, G.E.M., Pelchat, P. and Gauthier, M.S.
2020: Geological Survey of Canada till sampling and analytical protocols: From field to archive, 2020 update. Geological Survey of Canada, Open File 8591, 73 pages.

McCuaig, S.J.
2002: Quaternary geology of the Alexis River area, and the Blanc-Sablon to Mary's Harbour road corridor, southwestern Labrador. *In* Current Research. Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 02-1, pages 1-20.

Natural Resources Canada
2022: The Canadian Critical Minerals Strategy: From exploration to recycling: Powering the green and digital economy for Canada and the world. Government of Canada. https://www.canada.ca/content/dam/nrcan-rncan/site/critical-minerals/Critical-minerals-strategy Dec09.pdf

Occhietti, A., Govare, É., Klassen R., Parent, M. Vincent, J.-S.
2004: Late Wisconsinan–Early Holocene deglaciation of Québec-Labrador. Developments in Quaternary Sciences, Volume 2, Part B, pages 243-273.

Sanborn, P., Lamontagne, L. and Hendershot, W.
2011: Podzolic soils of Canada: Genesis, distribution, and classification. Canadian Journal of Soil Science, Volume 91, Issue 5, pages 843-880.

Shaw, J., Piper, D.J.W., Fader, G.B.J., King, E.L., Todd, B.J., Bell, T., Batterson, M.J. and Liverman, D.G.E.
2006: A conceptual model of the deglaciation of Atlantic Canada. Quaternary Science Reviews, Volume 25, pages 2059-2081.

Ullman, D.J., Carlson, A.E., Hostetler, S.W., Clark, P.U., Cuzzone, J., Milne, G.A., Winsor, K. and Caffee, M.
2016: Final Laurentide ice-sheet deglaciation and Holocene climate-sea level change. Quaternary Science Reviews, Volume 152, pages 49-59.

Wiken, E.B.
1986: Terrestrial Ecozones of Canada. Ecological Land Classification, Series No. 19. Environment Canada, 26 pages.