Wollaston Domain Surficial Geology Project: Investigations in the Janice – Burbidge Lakes Area, Saskatchewan

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This report is accompanied by the map separate entitled:
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Abstract

The Wollaston Domain Surficial Geology Project is designed to provide a framework for assessing the mineral potential of the Wollaston Domain. This project was initiated in the Janice and Burbidge lakes area (parts of NTS 74A/14 and /15) of northern Saskatchewan, in 2013. This year's project involves 1:50 000-scale surficial geological mapping; measurement of ice-flow indicators and determination of a relative ice-flow chronology; and a regional till-sampling program.

Spatial distribution and stratigraphic relationships among extensive (>90%) sediment cover suggests a complex geological history, mostly related to retreat of the Laurentide Ice Sheet during the Late Wisconsinan. Abundant late-deglacial meltwater associated with a slowly retreating and downwasting ice sheet significantly modified the landscape. This meltwater variably eroded till and deposited eskers and associated sediments. Stagnant-ice melt-out till is found adjacent to the glaciofluvial sediments and is also indicative of late-deglacial downwasting of the ice sheet. Antecedent subglacially deposited till makes up only a small component of the regional surficial material. Postglacial organic deposits are common in low-lying areas.

Two hundred and ninety-eight measurements of ice-flow indicators were made at 130 sites. Ice-flow directions range from 160° to 238°. Only 11 sites record multiple ice-flow directions, thus age relationships are preliminary. The youngest, late-deglacial, and most pervasive ice-flow phase was to the south-southwest (197° to 210°). Cross-cutting relationships indicate that this ice-flow phase is younger than a southward phase (170° to 188°) and a southwestward phase (232° to 238°). There may be an older, fourth ice-flow orientation to the south-southeast (160° to 166°).

Till and glaciofluvial samples were collected at 48 and 2 sites, respectively. Although till-matrix geochemical, grain-size, and indicator mineral analyses are in progress, some preliminary observations should impact the application of drift prospecting in the area. Subglacially deposited till should be preferentially targeted for drift samples as this till is likely locally derived. Problematically, this till is commonly overlain by stagnant-ice melt-out till or glaciofluvial veneer, or has been eroded by deglacial meltwater, making it difficult to locate and identify. Areas where ice-marginal sediments dominate, such as stagnant-ice melt-out till, or areas where meltwater has potentially eroded the surficial sediment exposing older sediment, are less suitable for drift prospecting and should be sampled with caution.

Keywords: *surficial geology, Quaternary geology, glacial history, ice-flow chronology, till sampling, drift prospecting, Late Wisconsinan, Janice Lake, Burbidge Lake, glaciofluvial.*

1. Introduction

The Wollaston Domain Surficial Geology Project is designed to provide a framework for assessing the mineral potential of the Wollaston Domain (Figure 1). This project was initiated in an area approximately 27 by 8 km around Janice Lake (parts of NTS 74A/14 and /15; Figure 1). During the field season, Quaternary geological investigations were undertaken in the Janice, Burbidge, and 'Stolen Boot' (unofficial name; Figure 1) lakes area to complement concurrent and previous bedrock mapping (Delaney *et al.*, 1995a, 1995b; Fetter, 2013). Rocks in the area are prospective for copper, uranium, and rare earth elements; the Fraser Lakes published NI 43-101–compliant resource (pegmatite- and granite-hosted U and REE; Saskatchewan Geological Survey, 2013b) is located approximately 6 km northwest of the study area. Conventional prospecting, however, is limited by extensive drift cover; consequently,

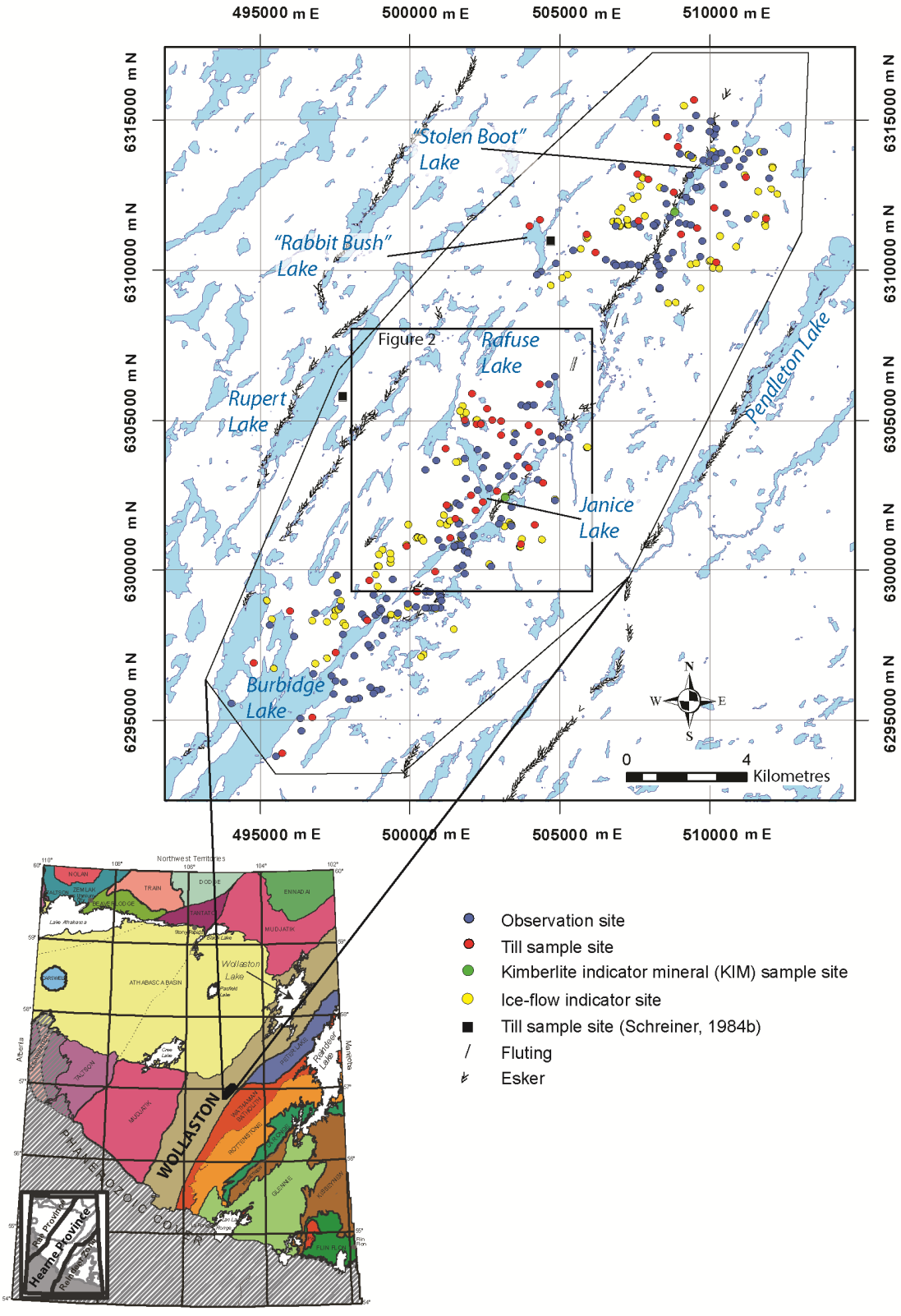


Figure 1 – Location of the 2013 map area with respect to the lithotectonic domainal map of northern Saskatchewan. Field sites are denoted and key locations are labelled.

it is important to test the applicability of drift prospecting in the area. The objectives of the fieldwork were 1) to conduct surficial geological mapping at the 1:50 000 scale, to establish a geological framework for interpreting geochemical, mineralogical, and lithological dispersal patterns; 2) to document the glacial and ice-flow chronology; and 3) to conduct a till-sampling survey in order to establish regional background till compositional data. Highlights of the first two objectives are presented in this report and on the accompanying map separate; preliminary discussion of the third objective is also presented in this report.

2. Regional Setting

a) Bedrock Geology

The bedrock geology of the study area is discussed in detail by Delaney *et al.* (1995a, 1995b) and Fetter (2013). The study area lies within the Wollaston Domain of the Hearne Province (Figure 1) and is underlain by a thick sequence of northeast-trending, variably deformed and metamorphosed arkose, calc-silicate-bearing siliciclastic rocks, conglomerate, and wacke of the Janice Lake and Rafuse Lake formations. These two formations host copper mineralization in the area. Higher metamorphic-grade rocks on southwestern Burbidge Lake include psammopelite and minor pelite. A variety of granitoid to pegmatitic rocks have intruded the supracrustal rocks. The area was affected by five episodes of deformation and two Hudsonian metamorphic events.

b) Glacial Chronology

Saskatchewan has undergone multiple glaciations throughout the Quaternary Period but only the record of the latest – the Late Wisconsinan – has been well preserved in northern Saskatchewan. During the Last Glacial Maximum, 19 to 23 thousand calendar years before present (cal. ka BP; Mix *et al.*, 2001), most of Saskatchewan was covered by the Laurentide Ice Sheet (LIS). Ice advanced toward the southwest over Saskatchewan from a dispersal centre in the Keewatin Sector of the LIS located in Nunavut (Prest *et al.*, 1968; Prest, 1984; Dyke and Prest, 1987; Dyke *et al.*, 2002). At maximum ice extent, the ice sheet would have had a thickness of up to 3000 m over the study area (Dyke *et al.*, 2002). Widespread retreat of the LIS throughout North America was underway by 16.8 cal. ka BP (Dyke *et al.*, 2003; Dyke, 2004). In Saskatchewan, ice retreated to the northeast and the study area was completely ice-free by 9.0 cal. ka BP (Schreiner, 1984a; Dyke *et al.*, 2003; Dyke, 2004). During deglaciation, much of the area south and southeast of the study area was covered by proglacial lakes, such as glacial Lake Agassiz (*e.g.*, Schreiner, 1983; Schreiner, 1984a; Fisher and Smith, 1994); there is no evidence, however, of proglacial lakes in the study area. The terrain is instead dominated by several southwest-trending eskers and associated sediments, with minor amounts of stagnant-ice and subglacial ground moraine. Most of these landforms and sediments were deposited during the waning stages of ice retreat.

c) Physiography

The study area is part of the Foster Upland landscape area, which is part of the Churchill River Upland ecoregion within the Boreal Shield ecozone (Padbury and Acton, 1994; Acton *et al*., 1998). The terrain is characterized by moderate to steep bedrock ridges trending in a southwest direction, numerous lakes, and extensive lowland bogs and fens. The terrain is largely covered by glacial drift ranging from thin, discontinuous veneer to thick, hummocky deposits that mask the underlying topography. Maximum elevations reach 585 m above sea level between Burbidge and Janice lakes; maximum relief is ~100 m. Rivers drain northeastward toward Reindeer and Wollaston lakes (Figure 1).

The study area lies within a part of the Foster Upland that is dominated by coniferous forests. Open stands of black spruce are common on thin-soiled ridges, whereas closed stands of black spruce are common in areas of deeper soils with more moisture (Acton *et al.*, 1998). Jack pine is abundant in sandy areas where conditions are drier, and scattered stands of white birch are the result of recent fires or flowing water. In low-lying areas, open sedge fens and sparsely treed bogs are common (Acton *et al.*, 1998). On well-drained slopes, Brunisolic soils are common on sandy and gravelly deposits, and Gray Luvisols are common on clay deposits (Acton *et al.*, 1998). Gleysols and local Cryosols are common in the numerous, small, poorly drained flat or low-lying areas (Acton *et al.*, 1998). The area around Burbidge Lake was burned in 2010.

3. Previous Research

There has been very little geological work done in the study area in terms of surficial mapping, and/or drift prospecting, thus there is limited information on the extent and character of glacial drift in the area. Quaternary surficial deposits were previously mapped at the 1:250 000 scale as part of the Quaternary reconnaissance mapping program of the Precambrian Shield of Saskatchewan by the Saskatchewan Research Council (Schreiner, 1984a, 1984b). As part of a reconnaissance-scale till sampling program, samples were collected near Rupert Lake (sample BS-610; Figure 1; Schreiner, 1984a, 1984b) and ‘Rabbit Bush’ Lake (unofficial name; sample BS-604; Figure 1;

Schreiner, 1984a, 1984b). The samples were submitted for textural analysis but not geochemistry (Schreiner, 1984a). As part of the study of the geology of the Pendleton Lake area (Scott, 1973) (Figure 1), soil samples were collected south of the Janice showing (Figure 2) for geochemical analysis; some of these samples were collected from the C horizon, although the nature of the sediment (*e.g.*, till vs. glaciofluvial sediment) was not noted. In northeast Saskatchewan, Swanson (1996) conducted a reconnaissance-scale sampling program of eskers for kimberlite indicator minerals (KIM), for which data is accessible in the Kimberlite Indicator Minerals database on the Saskatchewan Ministry of the Economy website; however, no samples were collected from the mapped area.

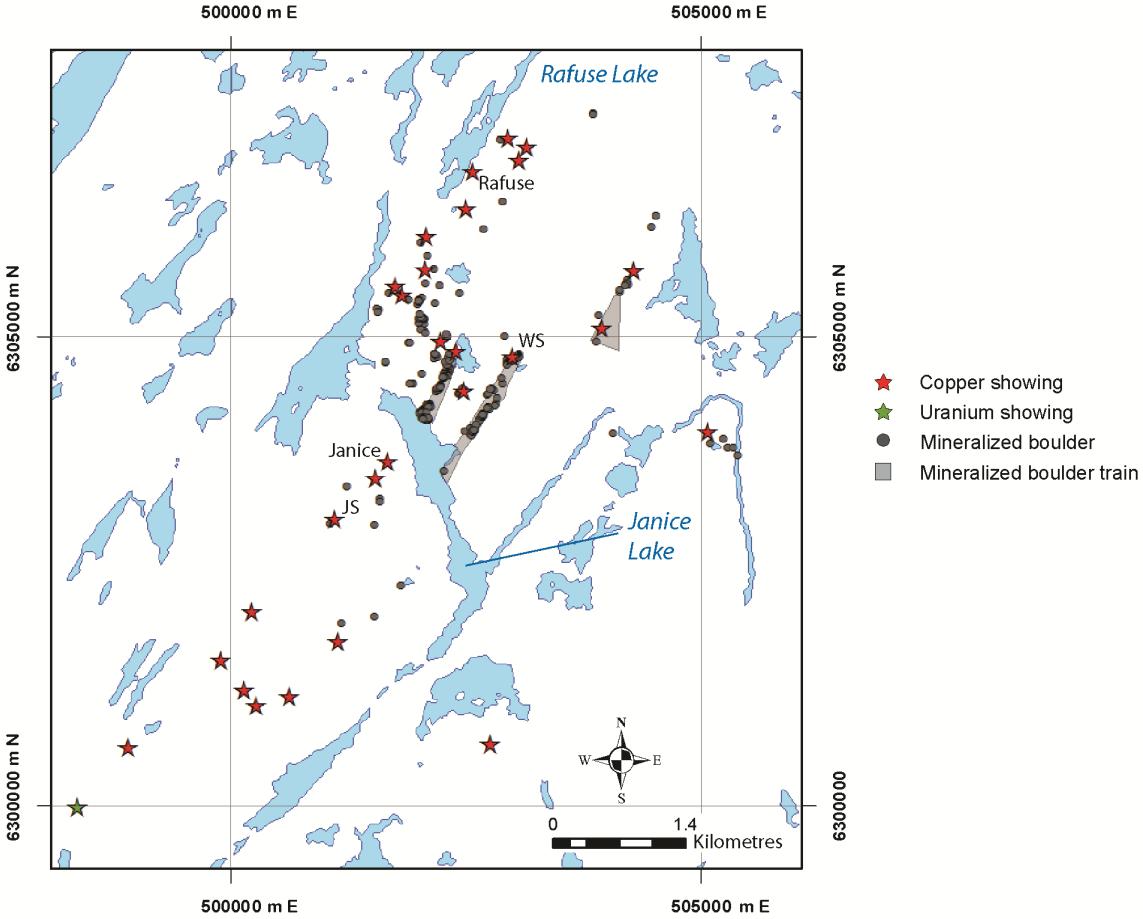


Figure 2 – Selected showings, mineralized boulders, and mineralized boulder trains (mostly copper mineralization) around Janice Lake.

Many exploration companies have worked in the study area over the past five decades, conducting soil geochemical surveys (Saskatchewan Ministry of the Economy (SME) assessment files 74A15-0009, 74A15-0023, 74A15-0031, 74A14-0036), boulder prospecting (SME assessment files 74A15-0006, 74A15-0007, 74A15-0008, 74A15-0014, 74A15-0020, 74A15-0021, 74A15-0022, 74A15-0023, 74A15-0031, 74A15-0034, 74A14-0036; Figure 2), and mapping of mineralized boulder trains (SME assessment files 74A15-0023, 74A15-0031, 74A15-0033, 7415-0034, 74A14-0036; Figure 2). Many of the mineral occurrences in the area are boulder trains or were discovered by tracing mineralized boulder trains to their sources (*e.g.*, JS occurrence and WS occurrence, respectively; Figure 2). In the early 1970s, both a detailed and a regional till sampling survey and subsequent geochemical analyses were conducted. The detailed survey was focussed around the Rafuse Cu showing (Figure 2), and the regional survey covered an area between central Burbidge and 'Stolen Boot' lakes, and between Pendleton Lake and west of Rupert Lake (Figure 1; SME assessment file 74A15-NE-0020). This study only analyzed for copper, lead, and zinc; the report noted contamination, accuracy, and precision problems, and no anomalous values. The current project updates this study with more accurate, precise, and extensive geochemical analyses, and an increased understanding of the glacial geology.

4. Current Research

a) Mapping of Quaternary Deposits

Surficial geological mapping is based on the interpretation of 1:60,000- and 1:70,000-scale aerial photographs taken in 1954 and 1952, respectively, combined with Landsat 7 imagery and Saskatchewan Geospatial Imagery Collaborative digital vertical aerial photographs with a 63 cm resolution, taken in 2008 and 2009. Fieldwork was focussed on ground-truthing air-photo and Landsat imagery interpretations through detailed examination of surficial sediments and characterization of various surficial deposits and problematic or complicated geological features. Fieldwork was restricted to areas accessible by boat and foot traverse (Figure 1). A total of 303 sites were examined.

b) Ice-flow Indicator Mapping and Chronology

An understanding of ice-flow chronology is essential to drift prospecting, enabling resolution of sediment transport directions and dispersal patterns. Two hundred and ninety-eight measurements of ice-flow indicators were made at 130 sites (Figure 1) and compiled with previously collected ice-flow indicator data (Figure 3). Large-scale ice-flow indicators, such as streamlined landforms, were identified from air photos. Small- to meso-scale ice-flow indicators were measured in the field and include microstriae, striae, sets of crescentic gouges, sets of crescentic fractures, grooves, and roches moutonnées (Figure 4). The sense of ice-flow direction was determined from the orientation of

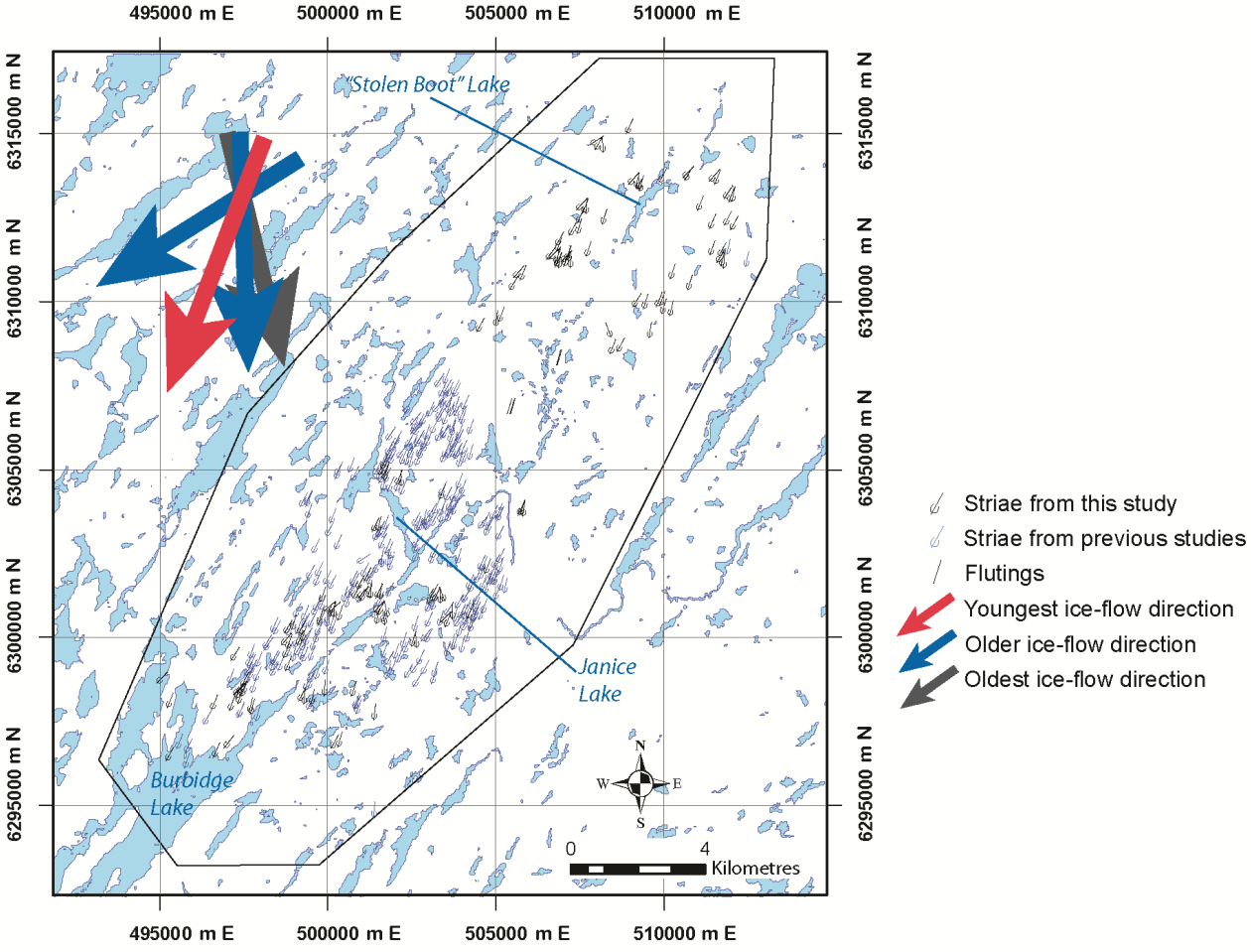


Figure 3 – Map of ice-flow indicators. Large arrows denote general ice-flow directions. References for previously measured ice-flow indicators are in the text.



Figure 4 – Some examples of small-scale ice-flow indicators. A) An outcrop showing microstriae is coloured in with marker (UTM 501154 m E, 6301892 m N[1]). B) Striae in five directions; pens and compass denote different directions (UTM 507281 m E, 6311496 m N). C) Crescentic gouges, denoted by yellow arrows; white arrow denotes ice-flow direction (UTM 505905 m E, 6311077 m N). D) A set of crescentic fractures, some denoted by yellow arrows; white arrow denotes ice-flow direction (UTM 503525 m E, 6304552 m N).

crescentic fractures and gouges sets, and roches moutonnées. Although opportunities were sparse, relative ages for multiple sets of diverging ice-flow indicators were determined, where possible, according to the following criteria (McMartin and Paulen, 2009, and references therein):

1) A set located in a lee position relative to another is older;
2) A set found only on top of an outcrop is considered to be youngest;
3) A set preserved only in a depression is older, and;
4) Deeper grooves and/or striae cross-cut by, or adjacent to, a finer set, including microstriae, are generally older.

[1] All coordinates are in UTM Zone 13V using datum NAD83.

Detailed ice-flow indicator measurements and descriptions will be added to the Saskatchewan ice-flow indicator database (Hanson *et al.*, 2011), which is available as a layer on the *Saskatchewan Geological Atlas* (Saskatchewan Geological Survey, 2013a). Three hundred and seventy-four previously measured ice-flow measurements for the area (Scott, 1973; Schreiner, 1984b; Delaney, 1995; Delaney *et al.*, 1995a, 1995b) were extracted from this database and added to this new dataset for interpretation. Thirteen ice-flow measurements were compiled from assessment file reports (SME assessment files 74A15-NW-0009 and 74A15-0031); these measurements were added to the new dataset and will be added to the Saskatchewan ice-flow indicator database.

c) Sampling and Analysis of Quaternary Deposits

Till samples were collected at 48 sites. Where possible, samples were distributed on a roughly 4 km^2 grid; a more detailed (~1 km^2) sampling grid was used, where possible, in the areas of the copper showings around Janice Lake (Figure 1). Sample pits were dug with a shovel to an average depth of 57 cm and most samples were collected from the C horizon (33 samples). Where the till was too thin, or where the till was too bouldery to dig to appropriate depths, samples were collected from the B/C horizon (15 samples). The paucity of acceptable sample media (*i.e.*, till, specifically C horizon subglacial till) was the main deterrent for sample collection over the majority of the area. An approximately 1 kg sample was collected from each pit to be submitted for grain-size, major and trace element, and gold analyses. This information will be used to define the composition of the till, which will aid in determining till provenance and glacial dispersal distances and patterns.

Two samples of esker sediment were collected for KIM analysis (Figure 1). At each site, approximately 25 kg of sand-sized sediment was collected from a pit ~110 cm deep on the crest of an esker. Both samples will be submitted for KIM analysis, gold grain counts, and magmatic or metamorphosed massive sulphide indicator minerals (MMSIM) analysis.

5. Results

a) Surficial Geology

Spatial distribution and stratigraphic relationships among extensive (>90%) sediment cover suggests a complex geological history, mostly related to retreat of the Laurentide Ice Sheet during the Late Wisconsinan. Based on drill-hole logs from the area between Burbidge and Rafuse lakes, drift thickness varies from negligible to 17 m thick, and averages 5.5 m. Much of the underlying bedrock structure is evident on air photos, indicating that much of the drift cover is thin. Two eskers and their associated sediments extend southwest through the area. Stagnant-ice melt-out till, eroded till terrain, and boulder fields are found adjacent to the glaciofluvial sediments. Subglacially deposited till makes up only a small component of the regional surficial material. Postglacial organic deposits are common in low-lying areas. No natural exposures of sediment were found in the study area, thus all sediment data is from pits dug up to 1.5 m deep.

Glaciofluvial Sediments: Distribution, Morphology, and Composition

The entire area was affected by subglacial meltwater. Erosional features such as eroded till terrain, boulder lags/boulder fields, escarpments cut into previously deposited sediment or bedrock, and exposed, scoured bedrock dominate the landscape. Depositional features are largely concentrated in two bedrock-controlled valleys, ≤2 km wide, approximately 5 km apart, that trend southwest through the area. These valleys are dominated by eskers, which are commonly flanked by plains, hummocks, and kettles. A glaciofluvial ice-contact veneer drapes a significant part of the landscape, overlying bedrock, and eroded and pristine till.

Morphologically, eskers are the most distinguishing feature among the glaciofluvial landforms. Eskers are commonly undulatory, sinuous (Figure 5A), sometimes dendritic, and anabranching ridges that can be continuous up to 10 km in length. They are steep sided (25° to 30°), round crested (Figure 5B), and up to 20 m high and 40 m wide. Glaciofluvial plains are characterized by expansive, flat-lying sediments that are thick enough to mask the underlying topography (Figure 5C). Thick, ice-contact drift deposits (Figure 5D) commonly form hummocks or kames (hills), and kettles (depressions formed by the melting out of ice blocks from the ceilings of the tunnels). Stagnant-ice moraine is commonly found adjacent to, or draped by, glaciofluvial sediments.

The composition of esker ridges, plains, and hummocky terrain displays considerable lateral variability. These landforms are variably composed of loosely to moderately compacted, massive, imbricated, or stratified, poorly to well-sorted, silty, very fine sand to sandy pebble-cobble gravel (Figures 6A and 6B). Clast content ranges from 0 to 50%. Clasts are subangular to well rounded. The fact that none of the esker sediments were deformed, combined with the steep sides of the esker ridges, implies that they likely originated in subglacial valleys.

The glaciofluvial ice-contact veneer is commonly about 50 cm thick, but can exceed 1.5 m. The veneer commonly overlies bedrock or till (Figure 7A), and can be found interspersed with boulders from eroded till. The veneer is a

loosely to moderately compacted, moderately to very well-sorted, massive (Figure 7A) or irregularly bedded (Figure 7B), silty, very fine to fine sand. Clast content is commonly negligible and is granule- to boulder-sized. Clast roundness varies from angular to well rounded. This veneer was likely deposited over the landscape after large meltwater flows scoured the area.

A glaciofluvial diamicton is present in some locations. The diamicton exhibits various degrees of sorting (poorly to well sorted) and clast content (negligible to 45%) within tens of centimetres. The diamicton is loosely to moderately compacted, massive, and composed of silty, very fine sand to pebble-cobble gravel. Clast roundness ranges from angular to subrounded. The origins of this diamicton are difficult to determine; it could be from ice-contact slumping and/or the result of reworking of previously deposited till or glaciofluvial sediment.

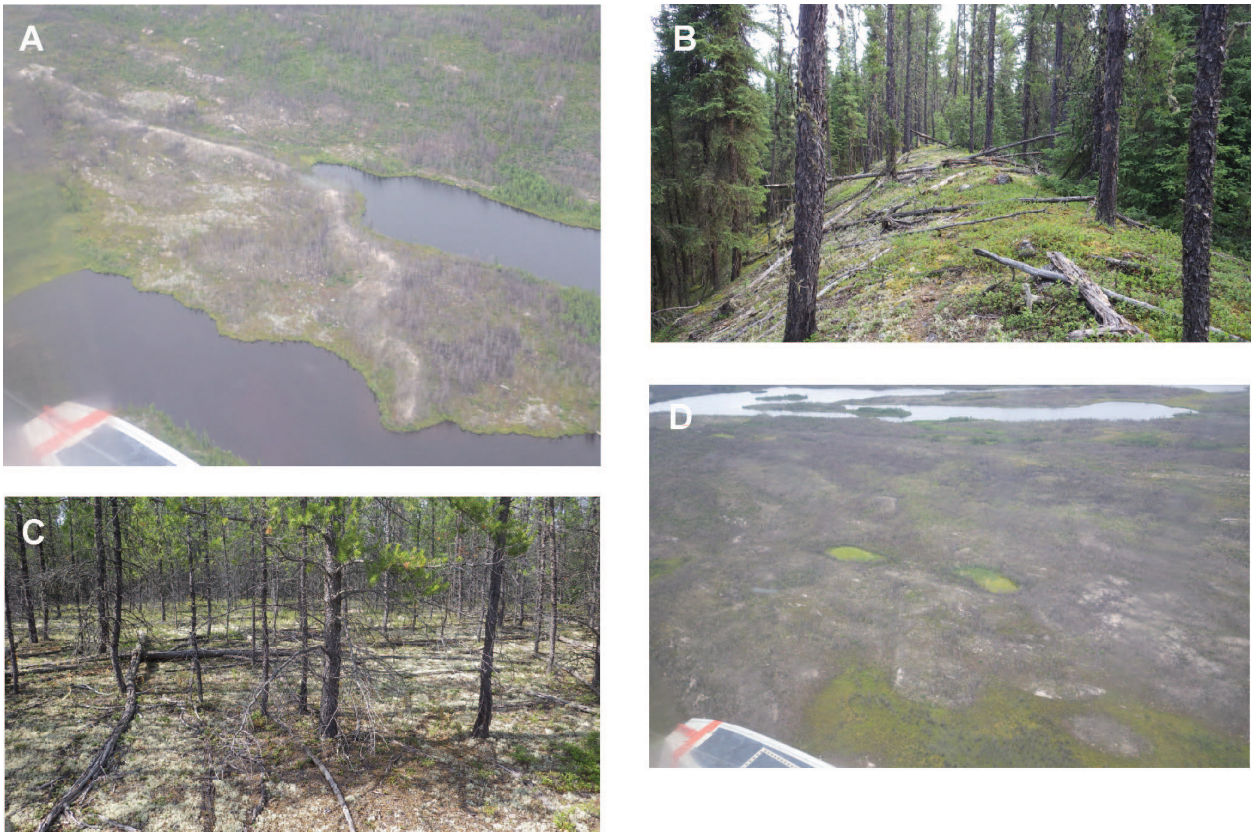


Figure 5 – Examples of glaciofluvial landforms. A) A sinuous esker ridge (UTM 498764 m E, 6300995 m N). B) A steep-sided, round-crested esker ridge (UTM 508819 m E, 6311976 m N). C) A glaciofluvial plain (UTM 508213 m E, 6311584 m N). D) A glaciofluvial hummocky terrain; note two kettles filled with organic material in the centre of the photo (UTM 498224 m E, 6300570 m N).

Till Deposits: Distribution, Morphology, and Composition

Till is a diamicton deposited directly by a glacier. In the study area, two till facies are present: a stagnant-ice melt-out till and a subglacially deposited till. The composition of these two tills is presented in Table 1 and examples are shown in Figure 8; an eroded till is also described below. All till deposits are found at or near the surface and are assumed to have been formed during the Late Wisconsinan glaciation; no older buried tills were noted.

Stagnant-ice Melt-out Till

The stagnant-ice melt-out till is deposited as a hummocky moraine that commonly forms a continuum with glaciofluvial ice-contact deposits. This moraine is generally characterized by irregular, low- to high-relief, undulating terrain of up to 30 m, variably including hummocks, irregular ridges, kettle holes, and boulder fields. Hummocks are commonly rounded and equi-dimensional hills (Figure 9) with steep or gentle slopes that range from 10 to 50 m in diameter, are up to 5 m high, and are commonly spatially associated with elongated ridges of similar dimensions. Kettle holes are shallow, generally equi-dimensional hollows up to 10 m in diameter and less than 2 m deep. Small, matrix-free boulder fields, or bogs, are situated in the low areas between hummocks and ridges. The thickness of the stagnant-ice moraine is difficult to determine. In many areas it is sufficient to mask some of the underlying bedrock

topography, which suggests that the thickness is greater than 2 m. In other areas, it forms a veneer only tens of centimetres thick on top of subglacial till or bedrock. The composition of this till is described in Table 1. Stagnant-ice melt-out moraine is interpreted to have been deposited by sub-, en-, and/or supraglacial melt-out and gravity flow of debris-rich stagnant ice near or at the ice margin.

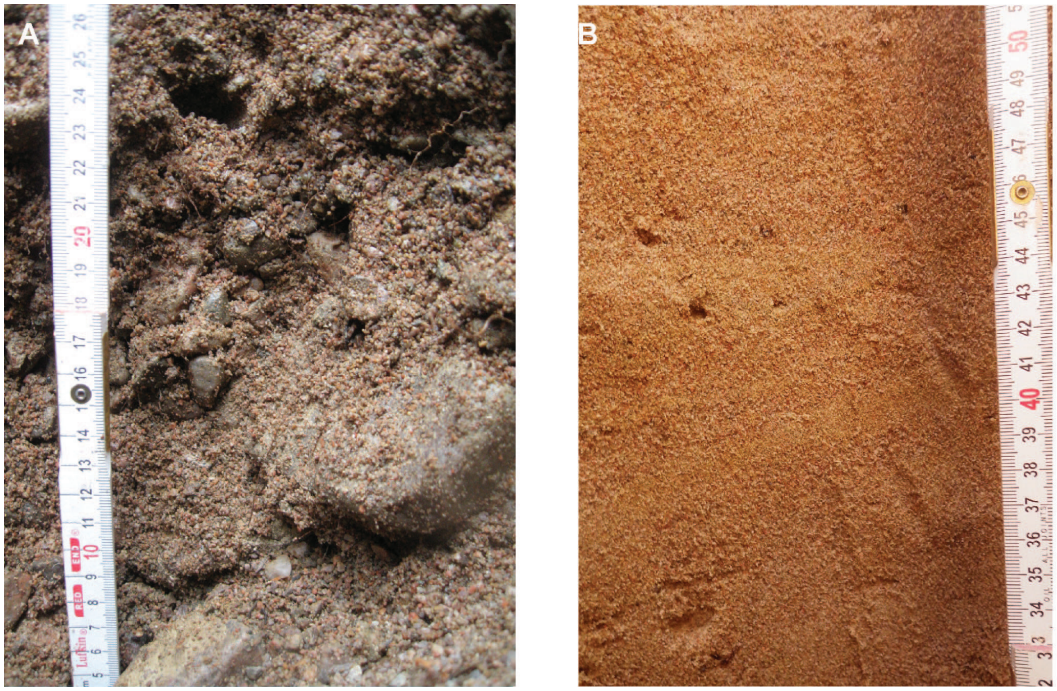


Figure 6 – Examples of the variable composition encountered within eskers, plains, and hummocky terrain. A) A sandy, pebble-cobble gravel from an esker (UTM 503156 m E, 6302450 m N). B) A fine to medium, horizontally bedded sand from a glaciofluvial plain (UTM 508213 m E, 6311584 m N).

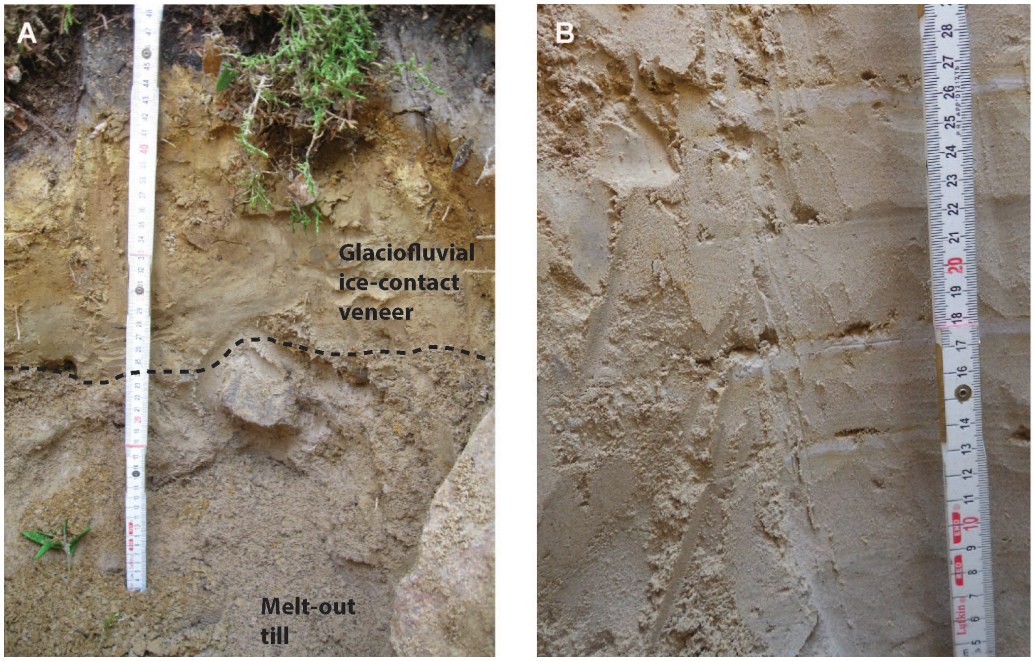


Figure 7 – Examples of the composition of the glaciofluvial ice-contact veneer. A) A massive, silty, very fine sand overlying melt-out till (UTM 504631 m E, 6306218 m N). B) A horizontally bedded, silty, very fine sand (UTM 510058 m E, 6313877 m N).

Table 1 – Field description of the composition of two till facies.

	Melt-out Till (Figure 8A)	**Subglacial Till** (Figure 8B)
Structure	massive	massive
Sorting	unsorted to poor; locally moderate to well with lenses due to the presence of interstitial meltwater	unsorted to poor; locally moderately sorted lenses indicating the presence of varying amounts of water during deposition
Compaction	loose to moderate	moderate to well
Framework	matrix supported	matrix supported
Matrix Colour (dry)	very pale brown (10YR 7/3)[1]; less commonly pink (7.5YR 7/3)	brown (10YR 4/3)
Clast Content (%)	5 to 50; commonly <35	10 to 35
Clast Size	granule to boulder	granule to boulder
Clast Roundness	angular to subrounded, dominantly subangular	angular to rounded, dominantly subangular
Clast Origin	mostly local	local
Other Features	commonly have silt/clay caps[2]	commonly have silt/clay caps; some pits contain till clasts[3], rotten clasts, and faceted clasts

[1]These codes refer to Munsell® soil colour classifications (Munsell, 1994).
[2]Silt or clay caps occur when meltwater percolates down through the sediment bringing fine grains with it; silt and clay becomes plastered on the upper clast surfaces.
[3]Till clasts are defined as pebble-sized (1 to 2 cm) highly compacted clumps of till that occur because of overburden pressures during deposition.

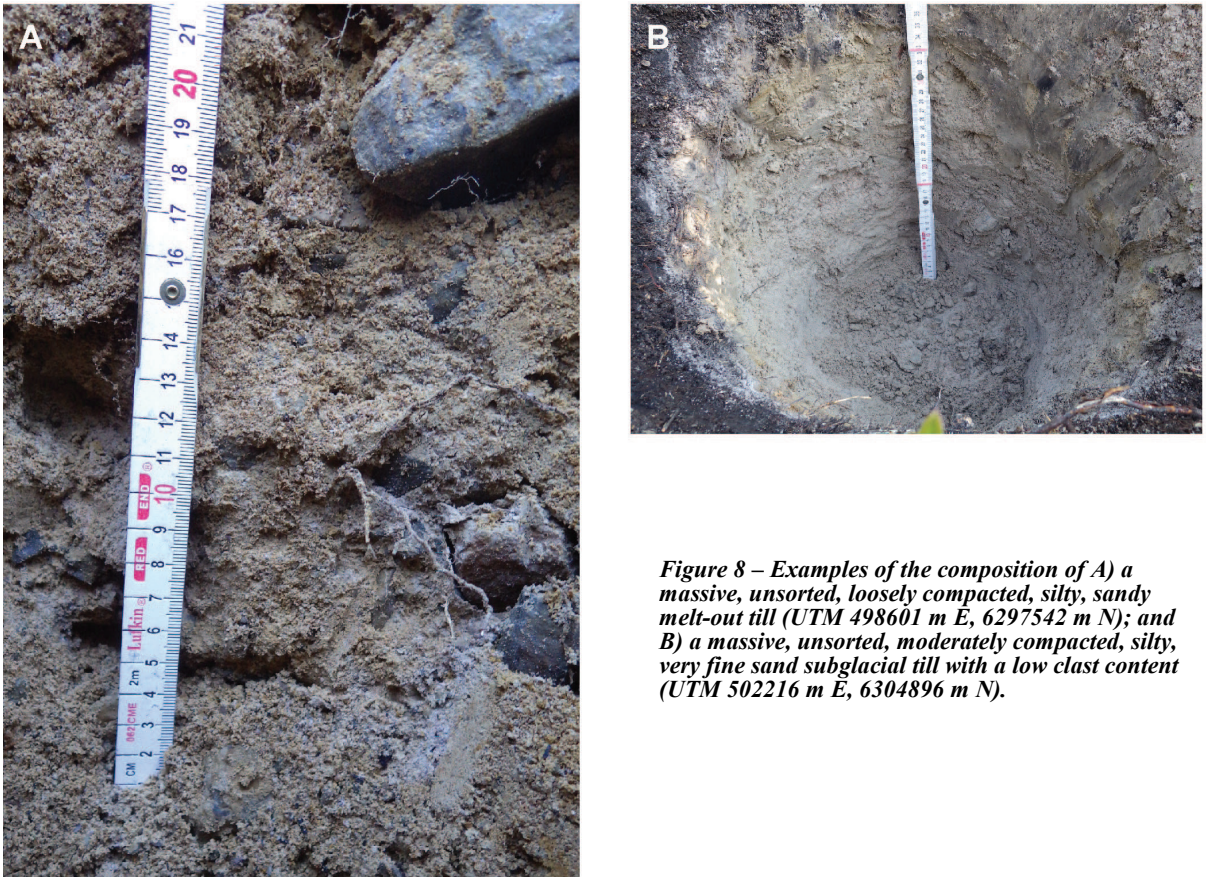


Figure 8 – Examples of the composition of A) a massive, unsorted, loosely compacted, silty, sandy melt-out till (UTM 498601 m E, 6297542 m N); and B) a massive, unsorted, moderately compacted, silty, very fine sand subglacial till with a low clast content (UTM 502216 m E, 6304896 m N).

Subglacial Till

The subglacially deposited till is discontinuous through the area, but is more commonly found on bedrock ridges than in valleys. It is not consistently found at surface, but may underlie the melt-out till or the glaciofluvial veneer. It is likely that much of this till has been eroded and/or covered by subsequent geomorphic processes associated with the glaciofluvial meltwater during retreat, especially in low-lying areas. The thickness of the till is generally difficult to determine due to a paucity of exposed sections; however, because the underlying topography is usually discernable on air photos, much of this till is thought to be present as a ground moraine veneer less than 2 m thick. The composition of this till is described in Table 1. Subglacial till is interpreted to have been deposited at the base of the ice sheet by a combination of lodgement and subglacial melt-out processes.

Eroded Till

Eroded till is situated in close proximity to glaciofluvial sediments and boulder fields. Eroded till is subglacial till in which the fines on the upper surface of the till have been washed away, leaving concentrations of boulders visible at the surface (boulder lag; Figure 10A). Erosion of till commonly produces clast-supported networks of boulders and cobbles in the upper 50 to 100 cm; these networks are infilled with the glaciofluvial veneer (Figure 10B). At some depth, pristine subglacial till may be found (Figure 10B). Eroded till is produced by post-depositional glacial meltwater that removes the fine material, leaving the larger clasts, and subsequently deposits fine sediment.



Figure 9 – Example of a hummock (roughly 3 m high and 15 m wide) that is rounded with gentle slopes (UTM 503879 m E, 6305169 m N).



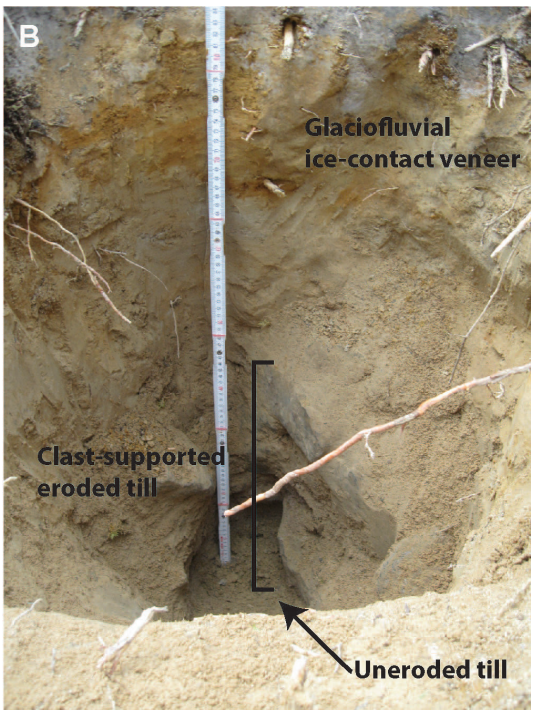


Figure 10 – Morphology and composition of eroded till. A) An example of a boulder-lag surface (UTM 496761 m E, 6296539 m N). B) An example of clast-supported eroded till that is infilled and overlain by the glaciofluvial ice-contact veneer. This eroded till overlies non-eroded till (UTM 504324 m E, 6306210 m N).

Boulder Fields: Distribution, Morphology, and Composition

Boulder fields are a common feature in parts of the study area (Figure 11). They generally occur in low-lying areas along lake shores, adjacent to peatlands, and at the base of slopes between till uplands or bedrock ridges; they are commonly found adjacent to glaciofluvial sediments and landforms. The boulder fields vary considerably in size, ranging from a few square metres to roughly 10 000 m^2. They commonly consist of moderately large (≤2.5 m diameter), subangular to subrounded, matrix-free blocks of rock that form a continuous, level surface veneer. Aside from lichen, they are normally devoid of most vegetation. Most are of heterolithologic composition and derived from local bedrock sources (≤25 km). Boulder fields are interpreted as the lag remnants of till or ice-contact deposits formed by the post-depositional erosion and removal of fine material by glacial meltwater.

Organic Terrain

Organic deposits, which include bogs and fens, are commonly found in low-lying areas, such as adjacent to lakes and streams, between bedrock ridges, and in valleys (Figure 12). They are flat to gently sloping, thick deposits that form plains that obscure underlying morphology. They can be several metres thick and cover up to several square kilometres.



Figure 11 – An example of a boulder field that is clast supported, matrix free, and consists of subangular to subrounded boulders, 0.25 to 1.0 m in diameter (UTM 501472 m E, 6300830 m N).

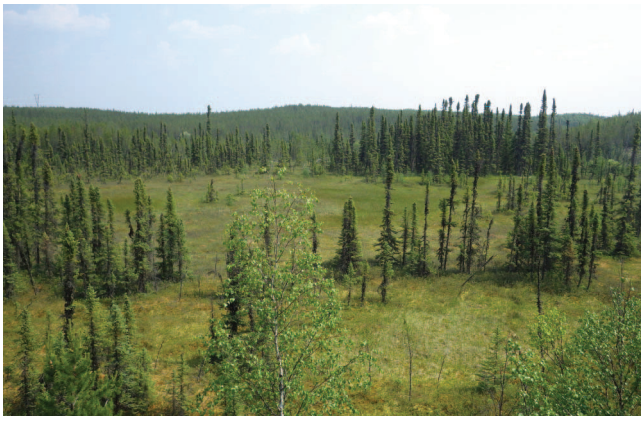


Figure 12 – Example of extensive organic plain (UTM 501844 m E, 6305530 m N).

b) Ice-Flow Orientation

Multiple ice-flow orientations were recorded by erosional features and a few depositional features. Bedrock surfaces were polished, striated, grooved, gouged, and fractured by glacial action (Figure 4); bedrock outcrops were carved into roches moutonnées; and sediment was molded into flutings. Ice-flow directions range from 160° to 238° and it is likely that most result from the Late Wisconsinan glaciation. Relative ages were determined at only 11 sites, hence ice-flow relationships are preliminary (Figure 3). The most pervasive ice-flow phase was to the south-southwest,

between 197° and 210°, with a modal direction of 202° (Figure 3). There were two older ice-flow phases: southerly (170° to 188°; Figure 3) and southwesterly (232° to 238°; Figure 3). No age relationships were noted between the south and southwest phases. Based on sparseness, two ice-flow measurements at 160° and one at 166° could represent a fourth, old ice-flow phase to the south-southeast. No ice-flow indicators were noted flowing in toward the eskers, as is common in many areas (*e.g.*, Veillette, 1986).

6. Implications for Drift Prospecting

In areas where bedrock outcrop is rare, a thorough understanding of the surficial geology is essential for drift prospecting. In the study area, late-deglacial meltwater significantly modified the landscape, variably eroding till and covering the landscape with glaciofluvial sediments, making drift prospecting difficult. Till-matrix geochemistry is the most commonly used drift prospecting method to help establish till composition patterns and determine subglacial transport directions and distances. For this project, till geochemistry and grain-size results are not yet available, however, some preliminary observations should impact drift prospecting methods. Typical drift prospecting of surface till is complicated by changing ice-flow orientations over time, late-deglacial glaciofluvial activity that has variably eroded and/or covered subglacial till, and the relative dominance of stagnant-ice till, which may be less suitable for till geochemistry analysis than the subglacial till.

The most favourable medium for drift prospecting is a veneer of the subglacial till. This till is dominantly composed of locally derived clasts (<5 km). Veneers are ideal because, when the till is local, mineral concentration is a function of sample height above the bedrock-till interface; the closer the till is to this interface, the more closely it reflects the local bedrock. The subglacial till, however, is not found continuously through the area. There are remnants of subglacial till on bedrock ridges, but within the valleys, this till has been largely removed, eroded or buried. Subglacial till affected by secondary meltwater flow (*i.e.*, eroded till) will have the majority of the silt and clay removed, which could lead to higher heavy mineral concentrations than non-eroded tills. Where it remains, however, its thinness, due to meltwater erosion, might make it a better drift prospecting medium than thicker subglacial till, because the eroded till is closer to the bedrock-till interface (Cummings *et al.*, 2011). Care must be taken, however, because it is possible that older tills with a different provenance associated with a different ice-flow phase have been exposed by the meltwater erosion. Determining whether an overlying till has been eroded and removed can be difficult. Overall, this till is difficult to find and sample because of variable meltwater erosion and/or masking by the glaciofluvial veneer.

Stagnant-ice melt-out till is less suitable than subglacial till for drift prospecting purposes. This till can contain higher amounts of distally derived material, and thus may not reflect the local geology. Meltwater present during deposition of stagnant-ice melt-out till removes significant amounts of silt and clay, resulting in an anomalously higher proportion of heavy minerals. The potential for the use of the stagnant-ice melt-out till cannot be determined until till geochemistry results are received, and the characteristics and depositional environment should be kept in mind when comparing results between the two types of till.

7. Summary

The area was glaciated multiple times, but the Quaternary geology of the Janice, Burbidge, and 'Stolen Boot' lakes area is largely the product of erosion and deposition during the last ice-sheet retreat. A thin mantle of subglacial till exists sporadically at surface and at depth; however, deglaciation was dominated by periods of stagnation and downwasting that supplied abundant meltwater to the area. Erosion by meltwater initially resulted in winnowing, removal, and reworking of till, bedrock scouring, and production of boulder lags. Subsequent glaciofluvial deposition led to the draping of the glaciofluvial veneer and the formation of eskers, hummocks, kettles, and plains. There is no evidence of re-advance over these glaciofluvial sediments. This late-deglacial glaciofluvial modification of the landscape makes traditional drift prospecting methods challenging to use in the area.

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