GS2017-17

Till sampling and ice-flow mapping between Leaf Rapids, Lynn Lake and Kinoosao, northwestern Manitoba (parts of NTS 64B12, 64C9, 11, 12, 14–16, 64F3, 4)

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In Brief:

- Purpose is to better-inform drift prospecting efforts in the Lynn Lake area
- Collected new till samples for analyses of till composition and kimberlite-indicator-minerals (KIM)
- Six phases of paleo-ice flow are reconstructed

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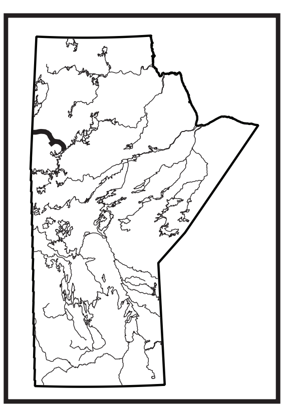

Summary

Quaternary geology fieldwork, including till sampling and ice-flow–indicator mapping, was conducted for 10 days in June 2017 along the road between Kinoosao (Saskatchewan), Lynn Lake and Leaf Rapids in northwestern Manitoba. Regional-scale (2.5–4 km spacing) till sampling was conducted along Provincial roads 391, 394 and 396 for characterization of the till composition. A total of 48 till samples (22.7 L each) were collected for kimberlite-indicator-mineral analysis. Additional 3 kg till samples were collected for trace-element geochemistry (<63 µm size-fraction) and clast lithology (2–30 mm size-fraction) analysis. Digitization of previous till-geochemistry sample results in the area is ongoing.

Paleo–ice-flow indicators were documented at 22 stations, and at least six ice-flow phases are recognized. Southerly paleo-ice flow (170–214°) is the dominant ice-flow phase. The till-sampling road-transect is aligned roughly perpendicular to this ice-flow orientation. Remnants of older ice-flow phases to the northwest, southwest and southeast were mapped, as were younger spatially restricted ice-flow phases to the southeast and southwest.

Esker ridges are the dominant glacial landforms, and a veneer of till drapes bedrock in most of the area. Preliminary results indicate the dominant till is a brown noncalcareous sand to silty sand till. Following the retreat of ice, shallow waters of glacial Lake Agassiz inundated the region. Wave-washing affected the till and bedrock highs between 330 and 435 m asl. Sand veneers were deposited between 280 and 435 m asl, and clay of variable thickness was deposited below 340 m asl.

From a mineral exploration point of view, results of this study will assist in evaluating the regional-scale diamond potential, and guide drift prospecting efforts in the Lynn Lake area.

Introduction

The Manitoba Geology Survey (MGS) conducted 10 days of road-based fieldwork in June 2017, along roads between Kinoosao, Lynn Lake and Leaf Rapids. A total of 109 stations were visited to log and sample exposed glacial sediments (till) and/or document the paleo–ice-flow history. The goals of this project were to

- conduct regional-scale (one sample every 2.5–4 km) kimberlite-indicator-mineral (KIM) sampling of till to assess the diamond potential of the study area along a transect roughly perpendicular to the dominant ice-flow orientation;
- conduct paleo–ice-flow mapping to assist reconstructions of the glacial dynamics of this area of Manitoba, which in turn guides drift exploration studies; and
- compile, digitize and update existing surficial mapping and till-geochemistry data (Figure GS2017-17-1).

Physiography

The study area is located in the northwestern part of Manitoba, northwest of Leaf Rapids along road access to the Saskatchewan boundary (Figure GS2017-17-1). Elevation varies mainly from 250 m asl (above sea level) in the east to 450 m asl in the west. Local relief is generally 5 to 30 m. Drift cover is generally thin, though up to 50 m of drift has been intersected in drillholes within the region. The area is part of the extensive discontinuous permafrost zone (Sladen, 2011), and permafrost was encountered beneath organic deposits at most sites.

The study area is characterized by moderately drained coniferous forests, underlain by both mineral and organic soils (Land Resource Group - Manitoba, 2003). Well drained silty sand soils on upland sites are dominated by closed stands of medium to tall black spruce, jack pine, trembling aspen, balsam poplar and some paper birch. On sandier upland sites, more open stands of jack pine are common. The vegetation on bedrock exposures is sparse, and limited to areas where pockets

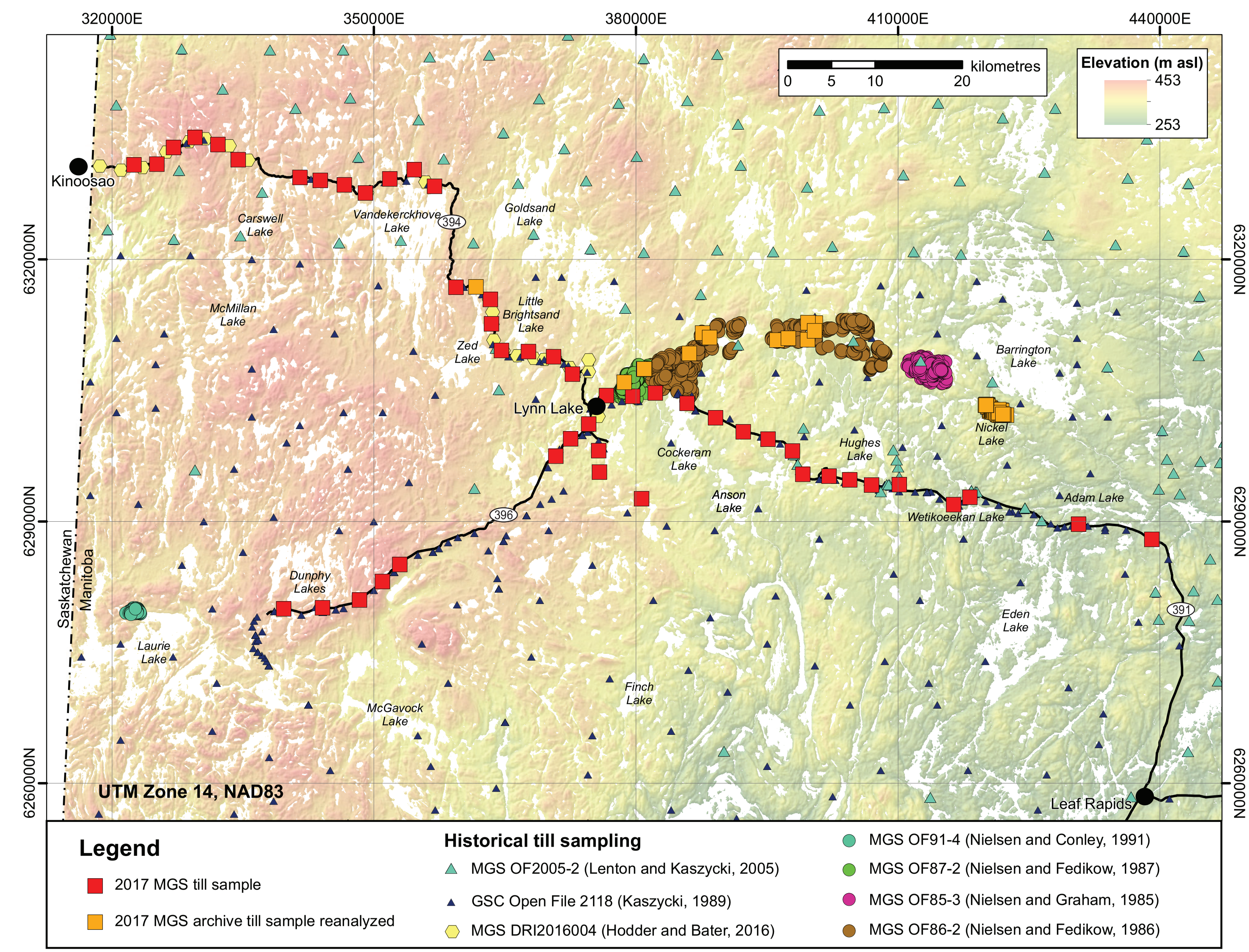

Figure GS2017-17-1: *The 2017 till sample sites and historical sample sites in the study area. Background hillshade was generated using a Canadian Digital Surface Model (Natural Resources Canada, 2012). Abbreviations: GSC, Geological Survey of Canada; MGS, Manitoba Geological Survey.*

of soil are present. Closed to open stands of black spruce, with Labrador tea and ground cover of mixed sphagnum moss and feathermoss, form the dominant vegetation on poorly drained mineral soils. On bog peatlands, the black spruce is more stunted and open, and in places is mixed with small quantities of tamarack.

Bedrock geology and diamond prospectivity

The study area is largely underlain by rocks belonging to the Lynn Lake greenstone belt, namely supracrustal rocks of the Wasekwan group (Gilbert et al., 1980), along with younger molasse-type sedimentary rocks of the Sickle group (Norman, 1934). These supracrustal rocks are intruded by granitoid plutons of different ages (Gilbert et al., 1980; Baldwin et al., 1987; Beaumont-Smith et al., 2006).

The diamond potential of the Lynn Lake area of Manitoba is unknown. There are currently no public KIM data available for the Lynn Lake region (Keller et al., 2004), hence this study will provide the first regional-scale insight into diamond potential from an indicator-mineral perspective. Results from the Lynn Lake area will be compared to recent KIM results in the Southern Indian Lake area (Hodder, 2017).

To the west, the Sask craton is known to host the Cretaceous Fort à la Corne diamondiferous kimberlites (Leckie et al., 1997). In addition, recent diamondiferous kimberlites have been discovered within the Sask craton at the Pikoo project (Armstrong and Kupsch, 2016), which is located approximately 100 km west of Flin Flon, Manitoba. The presence of Archean to earliest Proterozoic rocks in the west-central area of Southern Indian Lake, as well as the ubiquitous presence of zircons of Archean age in volcaniclastic rocks of the Southern Indian domain, suggests the potential existence for cratonic basement to the Trans-Hudson orogeny rocks in the area (Kremer et al., 2009). This may be analogous to the Archean crust of the Sask craton that is thought to underlie regions in east-central Saskatchewan. Ages consistent with that of the Sask craton were also observed in the Lynn Lake area in rocks from the Sickle group (Beaumont-Smith et al., 2006).

Surficial geology

Surficial geology between Kinoosao, Lynn Lake and Leaf Rapids (parts of NTS 64B12, 64C9, 11, 12, 14–16, 64F3, 4; Figure GS2017-17-2) has been mapped at a reconnaissance scale by DiLabio et al. (1986, 1:125 000 scale) and Kaszycki and Way Nee (1989a, 1:125 000 scale), and re-released as regional "A" series maps (Kaszycki and Way Nee, 1990a, b, 1:250 000 scale). The NTS map sheets 64C14 (Lynn Lake) and 15 (Cockeram Lake) were mapped in more detail, and produced as 1:50 000 scale black and white maps (O'Donnell, 1976a, b). A biophysical land classification has been published for a small portion of the study area (Land Resource Group - Manitoba, 2003). Most of the above mapping is not considered accurate enough for a detailed till-sampling program, but provides a guideline toward the regional surficial materials.

Till sample analyses

More information about the surficial geology of the field area can be gleaned from till-composition surveys conducted across the region. This includes a regional northwestern Manitoba study (Kaszycki, 1989), which included sampling and analyzing the <2 µm (clay) and <63 µm (silt and clay) size-fractions of till by standard atomic absorption spectroscopy (AAS) and instrumental neutron activation analysis (INAA), respectively. A report including this data was later released digitally (Kaszycki et al., 2008).

In 2003, MGS reanalyzed the <0.177 mm size-fraction of till samples from different locations that included sites between Lynn Lake and Kinoosao along PR 394 (Hodder, 2016). These samples were submitted for near-total digestion (four acid) followed by analysis with inductively coupled plasma–emission spectrometry (ICP-ES) and inductively coupled plasma–mass spectrometry (ICP-MS), as well as INAA. In 2005, MGS also reanalyzed the <0.177 mm size-fraction of a subset of till samples from the northwestern Manitoba project (Lenton and Kaszycki, 2005). These samples were submitted for near-total digestion followed by analysis with ICP-ES and ICP-MS (ultratrace 3), as well as INAA. For unknown reasons, only a few of those samples were actually within NTS areas 64C14, 15 or 16.

Detailed till-geochemistry sampling projects were undertaken at targeted sites (Figure GS2017-17-1). These include studies at Farley Lake (NTS 64C16; Nielsen and Graham, 1985), between Minton and Nickel lakes (NTS 64C15 and 16; Nielsen and Fedikow, 1986), the Dot Lake to MacLellan mine area (NTS 64C15; Nielsen and Fedikow, 1987) and Laurie Lake area (Nielsen and Conley, 1991). All four studies analyzed the <2 µm (clay) size-fraction of till using standard AAS. Forty-seven samples from the Nickel Lake area have been pulled from archive and are currently being reanalyzed using modern analytical techniques to determine till-composition in this region.

Gold

Heavy mineral separates were analyzed for gold in three of the detailed till-geochemistry studies (Nielsen and Graham, 1985; Nielsen and Fedikow, 1986, 1987), and in the regional study (Kaszycki, 1989). The separates were concentrated from the 'fine sand fraction', which likely translates to between 0.125 and 0.25 mm on the Wentworth grain-size scale (Wentworth, 1922). Processing and grain counts for visible gold were carried out by Overburden Drilling Management Limited (Nepean, Ontario).

Methods

Road-based fieldwork was undertaken over 10 days in June 2017, based out of Lynn Lake (Figure GS2017-17-2). A total of 109 field sites were visited to ground-truth the surficial geology mapping, collect till samples and identify ice-flow indicators.

The surficial material at each field station was investigated by means of a hand-dug shovel hole and/or a Dutch auger (1.2 m long). Till samples were collected from the C-horizon

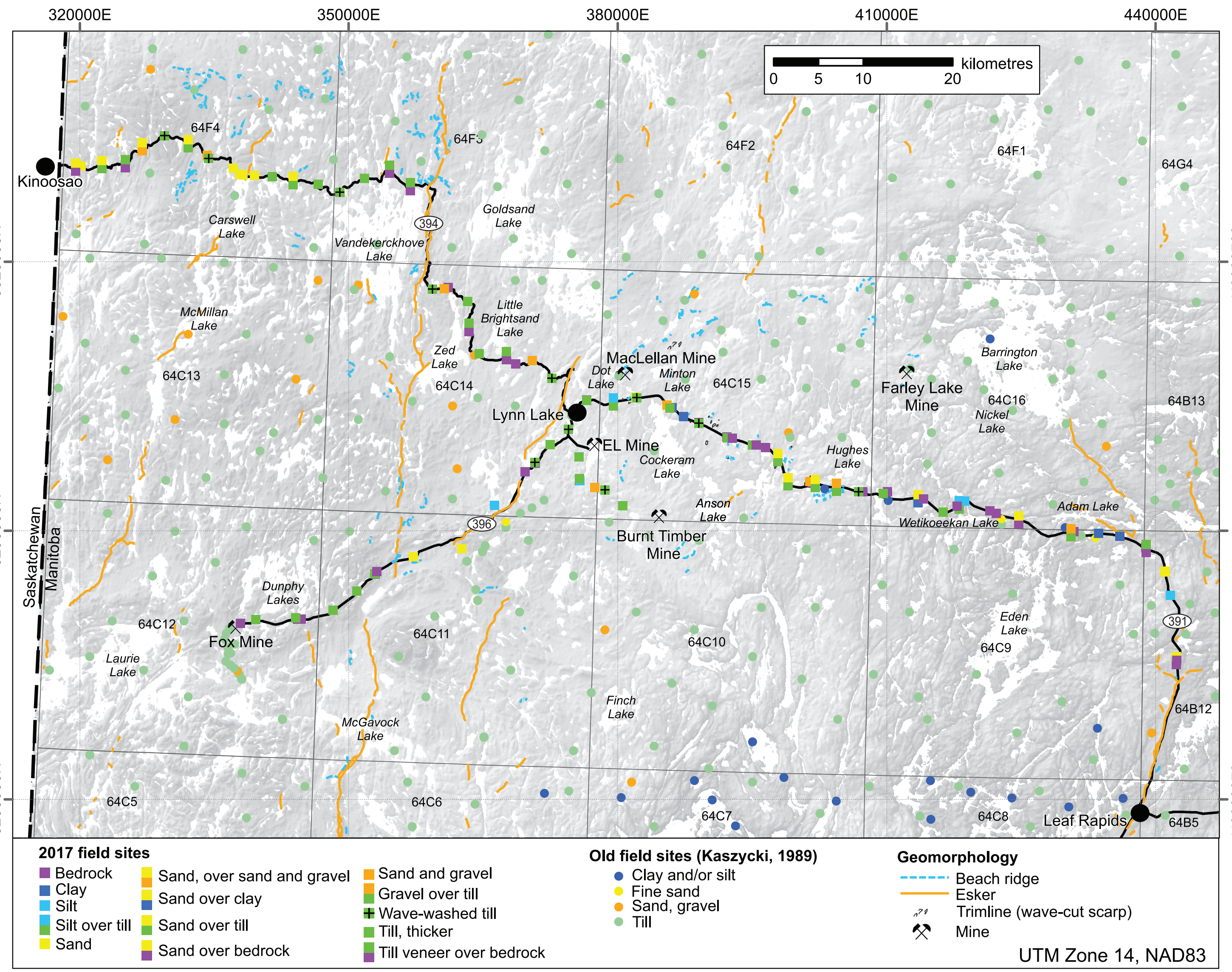

Figure GS2017-17-2: *Field sites visited during the 2017 field season, classified by surficial material. Field site data from Kaszycki (1989) is also shown, though the reader is cautioned that the upper first metre of sediment was not recorded at all locations; hence organic material, if present at surface, is not depicted and may be quite thick in places. Eskers, beach ridges and trimlines are digitized from existing surficial maps, orthophotos and light detection and ranging (LiDAR) imagery.*

soil, except where thin till draped bedrock and only the B horizon was present, or in poorly drained areas where the soil was gleyed. Permafrost was encountered at numerous sites during the late June fieldwork, which hampered till sampling at depth. Additionally, a surprising number of reforested (~70 years ago) sites, which were disturbed by the original road-building activities, were present along the road between Lynn Lake and Leaf Rapids. In these areas, careful attention was required when sampling and efforts were made to walk farther into the bush to find undisturbed till. Finally, it must be noted that previous work in this area (Kaszycki, 1989; Kaszycki et al., 2008) portrayed the majority of till sampled as surface samples. However, many of the samples were situated at depths of >1 m and sampled with the aid of borrow pits and backhoe trenches. Hence, any further till sampling in the area must take into consideration previous sample depth as part of the sample design plan.

A total of 48 till samples, in 22.73 L pails, were collected for KIM analyses. Blind KIM samples were submitted to the De Beers Group of Companies (De Beers) to be analyzed through in-kind support. The KIM sample locations were withheld from De Beers, to allow equal opportunity for follow-up by all interested parties when the data is publicly released at a later date. Additional 3 kg till samples were collected for trace-element geochemistry (<63 µm size-fraction) and clast lithology (2–30 mm size-fraction) analysis.

The orientations of striations, grooves, chattermarks and roches moutonnées were measured at 22 sites and are contained in Data Repository Item DRI2017003[1] (Gauthier and Hodder, 2017).

Results

Surficial geology

Organics

Organic, treed bog peatlands are common on very poorly drained surfaces in the study area, and are usually underlain by permafrost. Organic cover is commonly thin (5–30 cm) where it overlies topographic highs, and thicker in low-lying areas or where the underlying surficial material is finer textured (Figure GS2017-17-3a). According to 1:250 000 scale mapping, organic deposits are thickest within NTS areas 64C14 and 15 (Kaszycki and Way Nee, 1990b).

Glaciofluvial

Ice-contact sediments

Esker ridges are the dominant glaciofluvial landform in the region. Four major esker systems cross the project area (Figure GS2017-17-2). Three eskers are used as road stretches—from the Lynn Lake airport south along PR 396, north of Leaf Rapids along PR 391 and along the east side of Vandekerckhove Lake. These eskers are a mix of ridged and hummocky landforms that can be up to 20 m high. Smaller (1–5 m high) and shorter esker ridges are scattered throughout the study area. At the few sites visited, these esker segments consisted of massive to weakly stratified fine- to coarse-grained sand with 5 to 15% subrounded to rounded granule- to cobble-sized clasts.

Glaciolacustrine sediments

The entire study area was inundated by glacial Lake Agassiz (Dredge, 1983), resulting in washing and erosion of the topographic highs and the deposition of clayey and silty glaciolacustrine sediments in the lows. Lake limits in the area, defined by beach ridges, trimlines, washed till and sand blankets, are between 440 and 340 m asl. This means that the lake levels lowered progressively throughout the study area after deglaciation.

Washed till

At sites between 435 and 330 m asl, till has been wave-washed. This means that fines have been removed from the upper 0.1 to 0.4 m of the till, and the concentration of fines increases with depth (Figure GS2017-17-4a, b). In some areas, wave-washing has left a lag of boulder- and cobble-sized clasts at surface (Figure GS2017-17-3b). Wave-washed till is preferentially situated on topographic highs, and may be more extensive than noted in Figure GS2017-17-2. Future analyses of till-sample grain-size distribution will help to determine the extent of wave-washing.

Sand and gravel beach deposits

A veneer (0.3–0.7 m) of poor- to well-sorted gravelly sand was found at seven sites throughout the study area, between 405 and 300 m asl (Figure GS2017-17-2). These sites are either beach ridges or areas where extensive wave-washing has created beach gravel (Figure GS2017-17-4c) that overlies till. Beach ridges are situated at 400–390 m asl between Kinoosao and Zed Lake, 370 m asl at MacLellan mine, and 345–330 m asl at Hughes Lake (Figure GS2017-17-5). Beach ridges have been mapped across the study area (DiLabio et al., 1986; Kaszycki and Way Nee, 1989a), but are likely far more extensive than depicted on Figure GS2017-17-2. For example, the beach ridges at Hughes Lake depicted on Figure GS2017-17-5 are small (0.2–0.7 km) features that are visible on light detection and ranging (LiDAR) imagery but likely hidden by forest cover on aerial photographs.

Sand

Moderate- to well-sorted sand (Figure GS2017-17-4d) and/or gravelly sand was found at surface between 435 and 280 m asl. In some areas, the landscape underlain by sand

[1] MGS Data Repository Item DRI2017003, containing the data or other information sources used to compile this report, is available online to download free of charge at http://www2.gov.mb.ca/itm-cat/web/freedownloads.html, or on request from minesinfo@gov.mb.ca or Mineral Resources Library, Manitoba Growth, Enterprise and Trade, 360–1395 Ellice Avenue, Winnipeg, Manitoba R3G 3P2, Canada.

Figure GS2017-17-3: *Examples of forested landscapes in the Lynn Lake area include* ***a)*** *organic bog peatlands with stunted spruce trees and sphagnum moss that overlies clay at 338 m asl,* ***b)*** *open spruce forest with wave-washed till surfaces resulting in cobble and boulder lags at 368 m asl,* ***c)*** *flat, well-drained, jack pine forest that overlies sand,* ***d)*** *moderately drained spruce forest that overlies till,* ***e)*** *recently burnt spruce forest exposes a till-derived boulder field that contains subrounded to subangular clasts of different lithologies, and* ***f)*** *open, unforested, bedrock-derived boulder field that contains subangular to angular clasts of the same lithology.*

Figure GS2017-17-4: *Examples of various sediment types encountered during fieldwork include* ***a)*** *washed till that has a sandy texture,* ***b)*** *unwashed till that has a silty sandy texture,* ***c)*** *poorly sorted beach gravel derived from till,* ***d)*** *moderately sorted fine- to medium-grained sand,* ***e)*** *massive clay sampled by an auger, and* ***f)*** *interbedded silt (dark) and sand (light).*

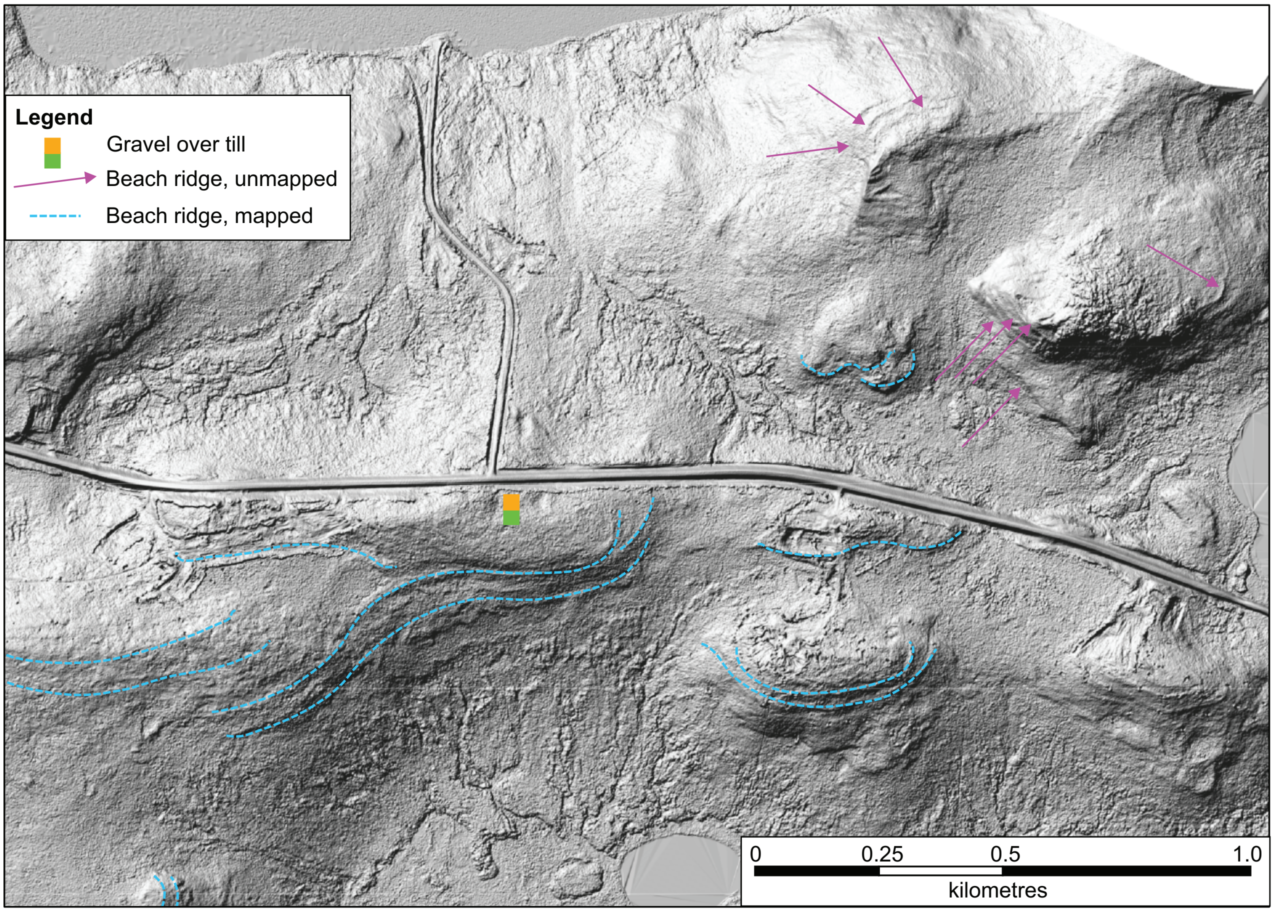

Figure GS2017-17-5: *Beach ridges surround most topographic highs in the area of Hughes Lake, and 0.3 m of gravel overlying till was dug from the topographic high at 344 m asl. The pink arrows point to some unmapped beach ridges, so the reader can more easily see these features. Background image is generated from light detection and ranging (LiDAR) data (imagery provided by Stantec Consulting Manitoba, 2017).*

is flat, well-drained and covered by jack pine forests (Figure GS2017-17-3c). Sand thickness was generally between 0.3 and 0.9 m overlying till, though at one site southeast of Adam Lake greater than 1.7 m of sand was mapped at 302 m asl. At another site southeast of Hughes Lake, sand overlies clay at 306 m asl.

Silt and clay

Dense, compact, milk-chocolate brown, generally massive silty clay to clay (Figure GS2017-17-4e) was encountered between Lynn Lake and Adam Lake (Figure GS2017-17-2), and is common at surface within NTS areas 64C7 and 8 (Kaszycki et al., 2008). This deepwater glaciolacustrine sediment was mapped between elevations of 340 and 270 m asl.

Less dense, brown, sandy silt was encountered at three sites in the study area, between 380 and 335 m asl. At one site along PR 396, silt was interbedded with sand (Figure GS2017-17-4f).

In some places, glaciolacustrine sedimentation occurred while the underlying till was still soft, resulting in flame structures from sediment loading (Figure GS2017-17-6). The thickness of these sediments is unpredictable at any one site, but generally varies from 0.3 to >2 m. It should be noted that glaciolacustrine sediments are probably more widespread than mapped by either this study or earlier studies, as these studies were targeting till sites for sampling purposes.

Till

Diamict, interpreted as till, was sampled at 48 sites in the study area (Figure GS2017-17-1). The matrix can be sandy, silty-sandy or sandy-silty, and the till typically contains 10 to 15% granule- to pebble-sized clasts (Figure GS2017-17-4a, b). Cobble- and boulder-sized clasts are rare, but present (Figure GS2017-17-3b, d, e). Till colours, determined by using the Munsell (Munsell Color–X-Rite, Incorporated, 2015) classification on wet till matrices, include light olive brown (47%), light to dark yellowish–brown (29%), gleyed grey (11%), grey brown (11%) and dark brown (2%). Colour distribution is random and not controlled by spatial patterns, with the exception of gleyed grey till, which was found in vegetated, wet lows. Preliminary field testing with 10% HCl acid suggests the till is noncalcareous, with the exception of one field station near Wetikoeekan Lake (Figure GS2017-17-2). Previous fieldwork (Kaszycki, 1989)

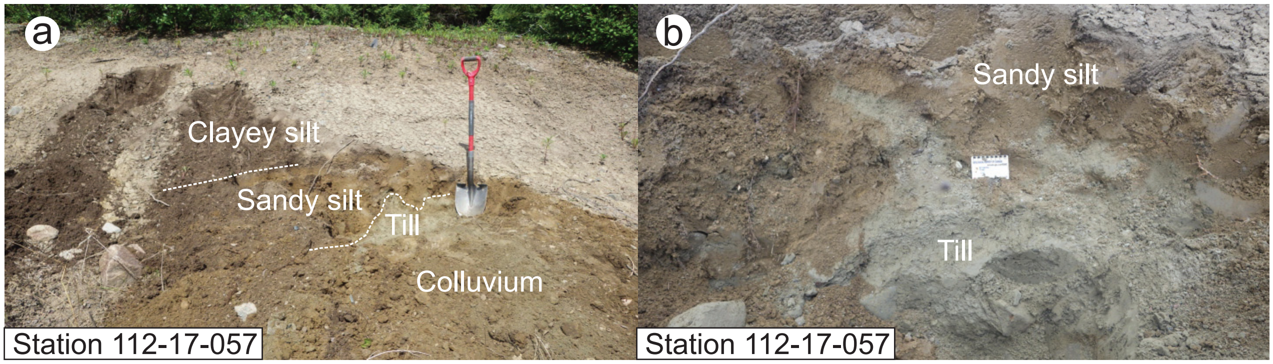

Figure GS2017-17-6: *Glaciolacustrine sedimentation at site 112-17-057 consists of dark brown clayey silt that drapes light brown sandy silt, overlying beige till **(a)**. A closer view of the glaciolacustrine-till contact shows water-escape structures **(b)**, which means that the till was still soft and water-saturated when glaciolacustrine sediments were deposited.*

suggests that patchy calcareous till is present at Wetikoeekan Lake, and becomes more predominant east of the community of South Indian Lake (Trommelen and McMartin, 2017).

Till is present at surface beneath most treed (spruce and/or jack pine), moderate- to well-drained, upland areas (Figure GS2017-17-3d) in the study area. Permafrost is usually present at depth near the crest of these uplands, and near the surface (20–30 cm) at the toe slopes. In some areas, the till forms crag-and-tail or drumlinoid ridges (0.13–2.1 km long with a mean length of 0.7 km) that trend between 195 and 210°. Throughout most of the study area, till is generally thin and drapes bedrock-controlled topography. Where till is thick, and permafrost is close to surface, rare vegetated permafrost mud boils are present in spruce bogs. Additionally, where till is thick but vegetation cover is thin, permafrost can form till-derived boulder fields (Figure GS2017-17-3e).

Bedrock

Bedrock outcrops are common throughout the study area (Figure GS2017-17-2), especially near the crest of most topographic rises. Along the roads, the majority of these bedrock surfaces are polished and striated, and the outcrops tend to form roches moutonnées that trend southward. In the forest, where vegetation cover is absent, permafrost can form bedrock-derived boulder fields (Figure GS2017-17-3f). These are distinguishable from till-derived boulder fields, because bedrock-derived boulder fields contain more angular clasts and are composed of only the local bedrock lithologies.

Ice flow

New ice-flow measurements were obtained from striations, grooves, chattermarks, crescentic gouges and fractures, and roches moutonnées at 22 field sites in the study area, and were combined with measurements from previous mapping in the area (Figure GS2017-17-7; Gauthier and Hodder, 2017).

Northwesterly ice-flow indicators were documented at just one road-cut along PR 391. At this site (Figure GS2017-17-8a, b), there are large outcrops with abundantly striated, steeply dipping, north-northeast–facing slopes. The shape of the outcrops (stoss and lee relationships), as well as plucking, confirm that ice flowed to the northwest between 308 and 314°. The steeply dipping faces were protected from the dominant southerly ice flow in the area, perhaps by a cover of till ('vanished protector', Veillette and Roy, 1995; Trommelen and Ross, 2011), as only the top and upper portions of the outcrops were later striated toward 174 and 180°.

Southwesterly ice-flow indicators were documented at four sites in 2017. At two sites, crescentic gouges were measured at or near the top of outcrops, trending toward 244 and 260°, where they were crosscut by striations trending toward 158 and 188°, respectively (Figure GS2017-17-8c). At the other two sites, striations trending toward 235 and 254° on east-southeast–sloping outcrop faces were crosscut by striations trending toward 174, 198 and 210° near the tops of the outcrops.

Southwesterly ice-flow indicators were also documented just east of Leaf Rapids (Kaszycki and Way Nee, 1989b; Figure GS2017-17-7). At this site, an ice-flow indicator toward 257° was recorded as being younger than another indicator toward 212°.

Southeasterly ice-flow indicators were documented at seven sites in 2017 (Figure GS2017-17-7). At site 112-17-060, three crescentic gouges on a southwest-sloping greenstone bedrock outcrop trend toward 100°. These crescentic gouges are crosscut near the top of the outcrop by fine, abundant striations that trend between 155 and 160°. On other outcrops at this site, there are a few low-lying spots that preserve fine striations between 205 and 208° (Figure GS2017-17-8d), which have been protected from the younger 160° flow. At three other sites, crescentic gouges or striations that trend between 125 and 150° are the only ice-flow indicators at that site, or are crosscut by other striations that trend toward 184 and 200° (Figure GS2017-17-8e). At three additional sites, fine striations that trend toward 158 and 172° dominate the surface of their respective outcrops (Figure GS2017-17-8f).

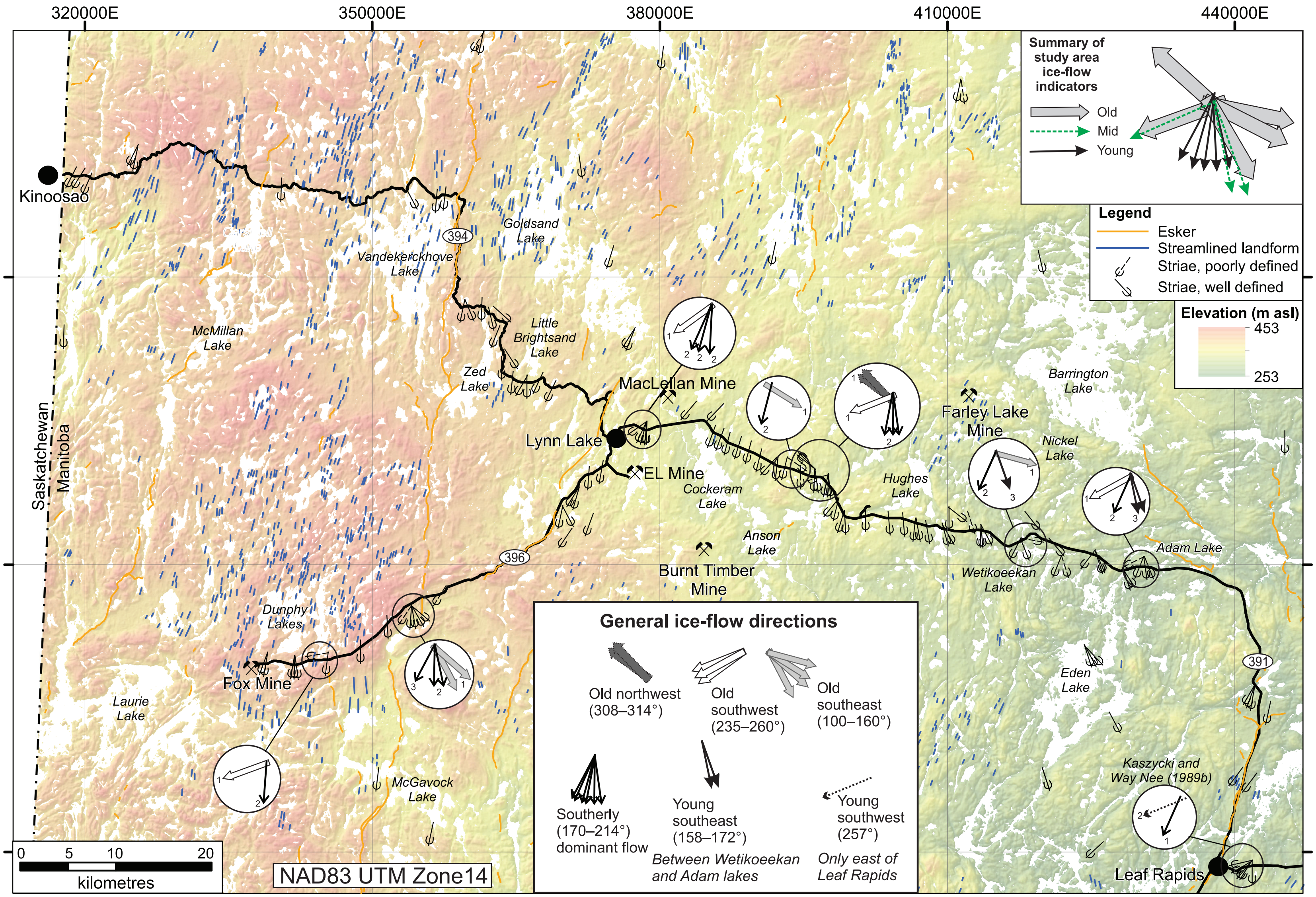

Figure GS2017-17-7: *Historical and recent field-based ice-flow–indicator data in the study area. Larger circles are a summary of the relative ages (1=oldest) and trends of ice-flow indicators for a single site or sites in close proximity to each other. The generalized ice-flow directions provide a key for differentiating between old and young ice flows of similar orientation. Background hillshade was generated using a Canadian Digital Surface Model (Natural Resources Canada, 2012).*

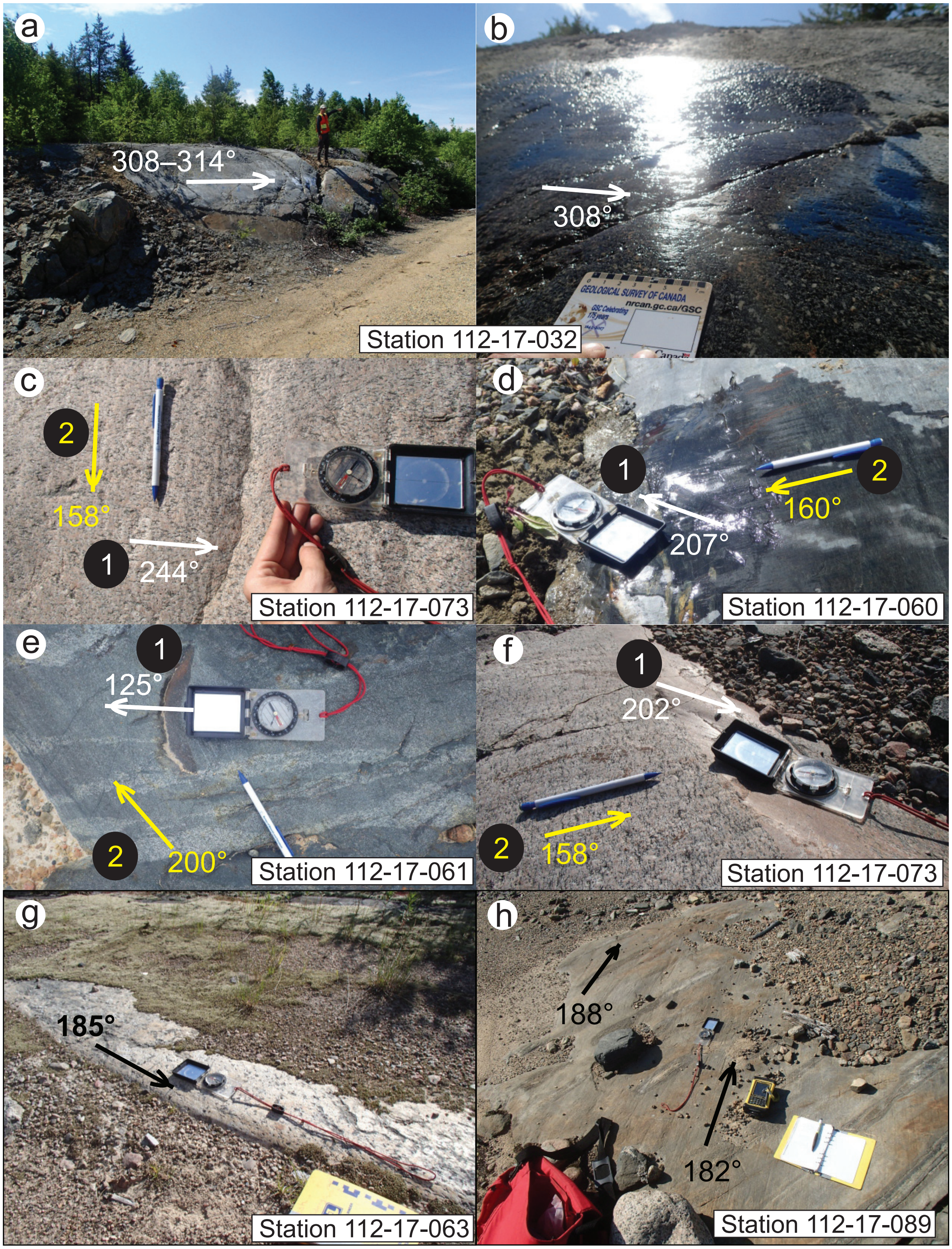

Figure GS2017-17-8: *Examples of ice-flow indicators in the study area include **a)** large roches moutonnées that trend northwest, **b)** abundant, fine striations toward 308° on the same outcrops; direction is interpreted from the shape and plucking relationships on the larger outcrop, **c)** a crescentic gouge toward 244° that is crosscut by striations toward 158°, **d)** fine striations toward 207° are protected in a low-lying area from younger fine striations toward 160°, **e)** a crescentic gouge toward 125° that is crosscut by striations toward 200°, **f)** striations toward 202° on a sloping face are protected from fine striations toward 158° on the top surface, **g)** abundant striations toward 185° on a low-lying bedrock outcrop, **h)** deep striations toward 182 and 188° on a low-lying, nearly flat, bedrock outcrop.*

Southerly ice-flow indicators were documented at most sites in 2017 (Figure GS2017-17-7), and are the most common trend of indicators mapped during previous work. The roches moutonnées, crescentic gouges and striations measured in 2017 trend between 170 and 214°. Southerly ice-flow indicators crosscut other indicators to the northwest, southwest and southeast (Figure GS2017-17-8e), and are crosscut by striations that trend toward the southeast (Figure GS2017-17-8d, f) in the area between Wetikoeekan and Adam lakes. Southerly striations dominate most outcrops and can be found on all surface slopes (Figure GS2017-17-8g, h).

Ice-flow history

Ice-flow measurements yielded at least six phases of ice flow in the study area. Northwest-, southwest- and southeast-trending ice-flow indicators are rare and probably old. Old southwesterly ice flow is regionally extensive (Dredge et al., 1986; Campbell, 2001, 2002; Smith, 2006; Smith and Kaczowka, 2007; Trommelen, 2011, 2013a, 2015a; Campbell et al., 2012) and is correlated to the pre-Late Wisconsinan. Old east-southeast ice flow is also regionally extensive (Dredge et al., 1986; Campbell, 2001, 2002; Smith, 2006; Smith and Kaczowka, 2007; Trommelen, 2011, 2015a, b; Campbell et al., 2012), though an age has not been assigned. Old northwesterly ice flow (270–300°) has been mapped in the Southern Indian Lake area (Hodder, 2015, 2016), approximately 145 km northeast of Leaf Rapids, as well as in parts of northeastern Manitoba (Campbell et al., 2012; Trommelen, 2015a). No relationships were documented in the field area between old southwesterly, southeasterly or northwesterly ice-flow indicators. Fieldwork within the Southern Indian Lake area (Hodder, 2015, 2016; Trommelen, 2015b), suggests that southeasterly ice flow is older than southwesterly ice flow. The relationships with old northwesterly ice flow remain uncertain, mainly because these ice-flow indicators are rare.

Dominant ice flow in the Lynn Lake area was to the south, between 170 and 214°. Southerly ice flow is regionally extensive across northern Manitoba, and is likely Wisconsinan in age. Most streamlined landforms in the region were also formed during this major southerly ice-flow phase. Young southeasterly ice flow (158–172°) crosscuts the southerly flows between Wetikoeekan and Adam lakes, and may relate to deposition of the Adam Lake esker ridge during late deglaciation (Figure GS2017-17-7). Young southwesterly ice flow (257°) crosscuts the southerly flows just east of Leaf Rapids, and is also documented further east along the road to South Indian Lake and at Karsakuwigamak Lake (Kaszycki and Way Nee, 1989b). This young southwest- to northwest-trending (260–280°) ice flow was also mapped near Thompson and Split Lake (McClenaghan et al., 2009; McMartin et al., 2010; Trommelen, 2013b), where it is correlated with late deglacial ice flow related to ice flowing from Hudson Bay.

Future work

Ongoing surficial geological analysis focuses on tracing lithological indicators from known bedrock source areas, using clast counts and the major- and trace-element geochemical composition of the collected till samples. Kimberlite-indicator-mineral analysis is also ongoing. Results of these analyses will

- identify favourable geochemical or mineralogical indicators within till to aid mineral exploration;
- establish compositional till characteristics and aid investigation of subglacial transport processes and distances;
- develop a framework to assist drift prospecting practises in the Kinoosao to Leaf Rapids corridor; and
- provide the first KIM results from the Kinoosao to Leaf Rapids corridor, to compare with those sampled at Southern Indian Lake and elsewhere.

Economic considerations

A thorough understanding of surficial geology is essential for drift prospecting in Manitoba's northern region. Till-sample analysis is commonly used in drift-covered regions to help determine the source area for mineralized erratics and boulder trains, as well as to narrow in on lake sediment sample results (Geological Survey of Canada, 1985; Schmitt, 1989). Interpretation of till composition depends on exactly what material was sampled, as well as detailed attention to the potential for palimpsest dispersal patterns in areas that have been modified by more than one ice advance and transport direction.

Forthcoming results will provide new constraints to drift exploration in the study area, applicable to exploration for a variety of commodity types, including gold and diamonds. Kimberlite-indicator-mineral analysis of till in the Lynn Lake area will provide the first insight into the diamond potential of the region from an indicator-mineral perspective. The outcomes of these studies are geared toward providing mineral exploration geologists with an up-to-date surficial geology knowledge base and the adequate tools to more accurately locate exploration targets in Manitoba's north.

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