GS2020-7

Surficial geology mapping and till composition of the western Fox River greenstone belt area, northeastern Manitoba (NTS 53M15, 16)

by M.S. Gauthier and T.J. Hodder

Summary

Quaternary geology fieldwork, including till sampling and ice-flow–indicator mapping, was conducted over a portion of the buried Fox River greenstone belt in northeastern Manitoba (NTS 53M15, 16). Field sites were visited to ground-truth the surficial geology mapping, collect till samples and identify ice-flow indicators. Eighty-nine 2 kg till samples were collected for geochemical (<63 µm size-fraction) and clast-lithology (2–8 mm size-fraction) analyses. An additional 59 till samples (11.4 L each) were collected for kimberlite-indicator-mineral analysis. This work was completed during year one of a two-year project.

Paleo–ice-flow indicators were documented at 14 sites, from both erosional field-based ice-flow indicators and till fabrics. The till-fabric interpretations suggest young south- to south-southwest-trending ice flow (180–200°) and either a northwest- or southeast-trending ice-flow (300–320° or 120–140°). Older ice-flow phases were oriented to the northwest, northwest-southeast (bimodal, possibly twice), west (twice) and southwest. The study area is covered by erosional streamlined landforms, which trend toward the southwest (~245°) and were formed by the deglacial Hayes Lobe of the Laurentide Ice Sheet.

Parts of the study area are covered by a veneer of glaciolacustrine clay or silt (0.1 to ~1.0 m thick), though thicker glaciolacustrine deposits were observed (up to 1.5 m). Till varies in thickness from 0.1 to 14.0 m; thicker quaternary sediment packages are possible.

In Brief:

- Surficial mapping in NTS 53M15 and 53M16
- Collection of till samples to determine provenance and drift-exploration potential, including for diamonds
- Collection of ice-flow data to reconstruct the glacial history and aid drift exploration

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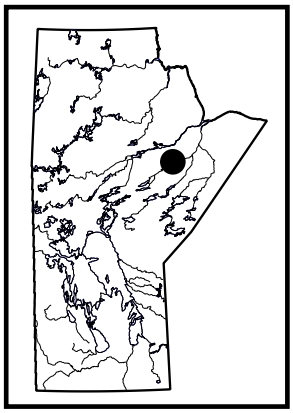
Introduction

Quaternary geology fieldwork, including till sampling and ice-flow–indicator mapping, was conducted for 24 days in August 2020, over a portion of the buried Fox River greenstone belt in northeastern Manitoba (NTS 53M15, 16). A total of 318 sites were visited to both document glacial sediments and measure the orientation of ice-flow indicators. The goals of this project are to

- conduct reconnaissance 1:50 000 scale mapping (sites spaced roughly 4 km apart), with in-fill mapping to be completed in 2021;
- sample till to assess the till composition of the area;
- sample till to analyze for kimberlite-indicator minerals (KIMs); and
- conduct paleo–ice-flow mapping to assist reconstructions of the glacial dynamics of the area, which in turn guide drift exploration studies in northeastern Manitoba.



Bedrock geology

The study area is underlain by rocks of the Fox River greenstone belt, which is part of the circum-Superior belt in northeastern Manitoba (Figure GS2020-7-1). The Fox River belt demonstrates potential to host nickel±copper and platinum-group-element (PGE) mineralization (Rinne, 2018). The belt consists of sedimentary rocks (mudstone, sandstone, minor iron formation and calcareous beds), mafic to ultramafic rocks (basalt to komatiitic basalt with minor interflow mudstones) and mafic to ultramafic intrusions (serpentinized peridotite, pyroxenite, gabbro and minor leucogabbro; Rinne, 2018, 2020). Archean granitoid rocks of the Superior province border the western and southern parts of the Fox River belt, whereas the area north of the belt is dominated by Paleoproterozoic metagreywacke and derived gneiss of the Churchill province.

Quaternary history

The study area was mapped using aerial photographs at 1:250 000 scale in the late 1970s, with limited to no ground-truthing (Klassen and Netterville, 1979). The Manitoba Geological Survey (MGS) conducted 1:50 000 scale mapping to the north (Trommelen, 2013; Trommelen et al., 2014; Kelley et al., 2015; Gauthier et al., 2016) and to the south of this area (Trommelen, 2015). These

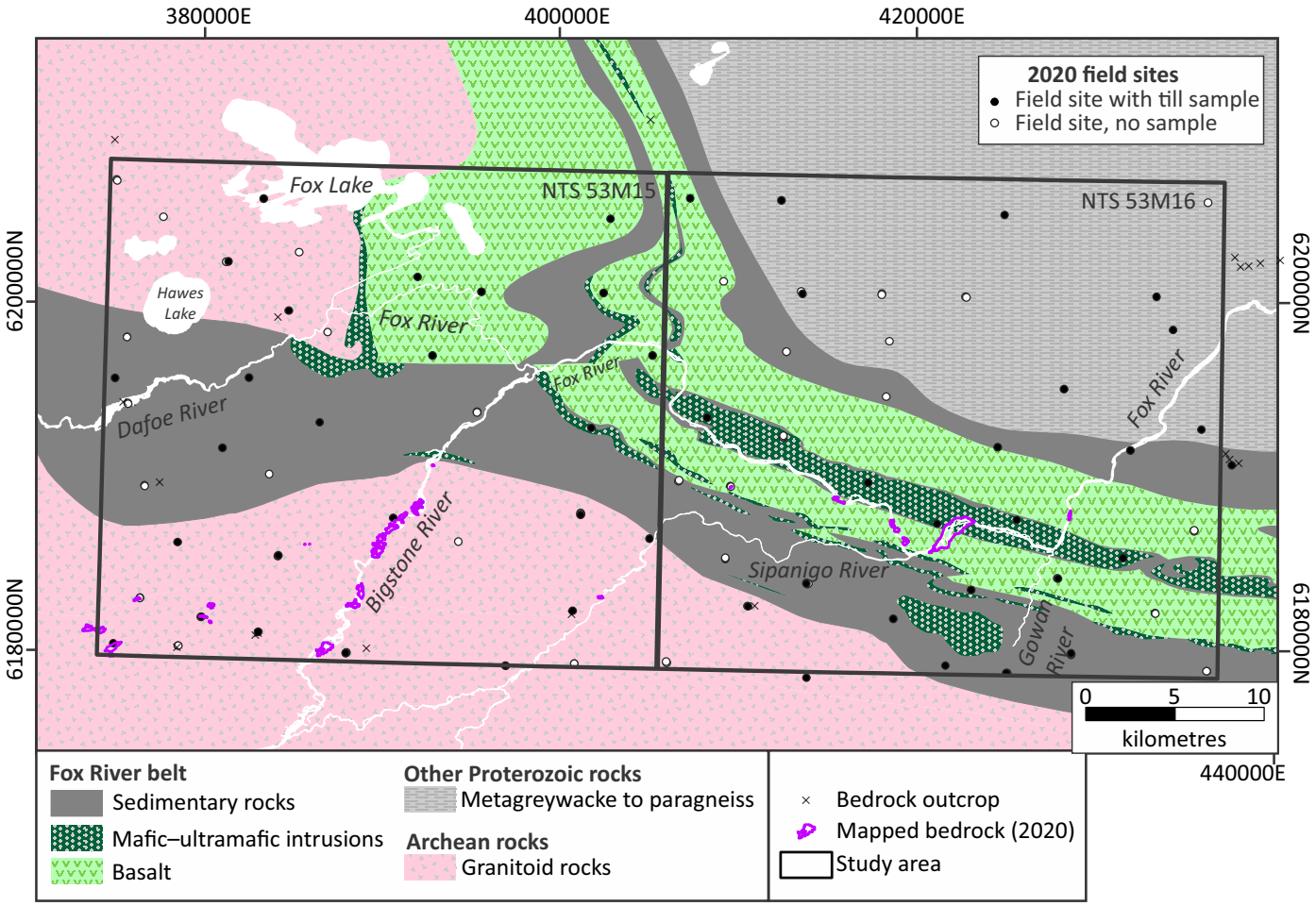


Figure GS2020-7-1: *Field sites and till sample sites overlying a portion of the Fox River greenstone belt, northeastern Manitoba. Bedrock geology is from Rinne (2018, 2020). UTM Zone 15, NAD83.*

areas are dominated by gently sloping, moderately to very poorly drained topography. Stunted spruce bogs and forests drape most areas and surface permafrost is common beneath organic deposits. Elevation varies between 68 and 198 metres above sea level (m asl). Local relief is generally 1 to 30 m, generated by smooth, bare to thinly drift-covered outcrops separated by low ground.

The study area was glaciated by ice flowing from multiple migratory domes of the Laurentide Ice Sheet during marine isotope stages (MISs) 2–4 (Klassen, 1986; Gauthier et al., 2019). At some point during MIS 2 a thick ice ridge, the Hudson Bay Ice Saddle, formed between two main domes (Dyke and Prest, 1987; Thorleifson et al., 1993). During deglaciation, the lobate Hayes Lobe flowed southwest from this saddle, and across the study area (Dredge and Cowan, 1989; Gauthier et al., 2019, Flowset K). The Hayes Lobe is interpreted as a late-stage erosional event, which did not affect the composition of the underlying till(s) in an area 55 km to the south (Trommelen and Ross, 2014). This two-year project will determine whether that interpretation holds true for this study area as well.

Previous diamond exploration

Regional KIM results are compiled in the MGS KIM database (Keller, 2019). The majority of the study area has not been explored, though there are some till, glaciofluvial and alluvial sediment samples that have been analyzed for KIMs (Figure GS2020-7-2a). Garnets (G10D, G9 and G3; Assessment File 948565, Manitoba Agriculture and Resource Development, Winnipeg) were reported from two alluvial samples in the southwestern corner of the NTS 53M16 map area (Figure GS2020-7-2b).

The MGS KIM database only contains results from sources that have accompanying microprobe geochemistry data (Keller, 2019). This was necessary so that a standardized classification scheme could be applied to the KIM chemistry. There are additional KIM sampling projects that only reported visual kimberlite-indicator-mineral results. Visual KIM results are not as robust as microprobe-confirmed KIMs, but they still offer insight into diamond exploration potential.

Just east of the study area, a survey conducted by BHP World Exploration Inc. in 2000 reported anomalous visual KIM

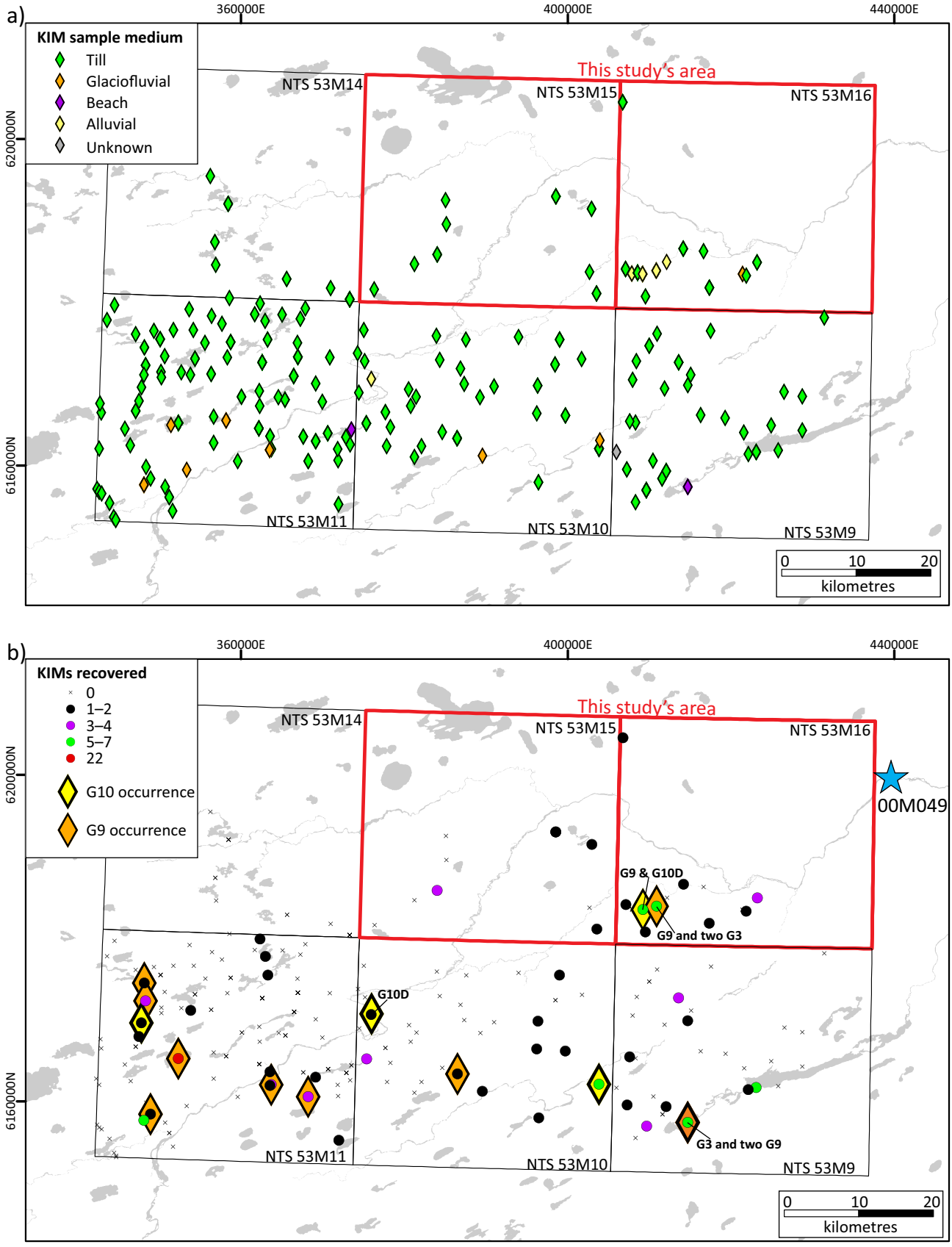


Figure GS2020-7-2: *Publicly available kimberlite-indicator-mineral (KIM) results in and around the study area including* ***a)*** *KIM samples classified according to the sample medium analyzed; and* ***b)*** *KIM recovery for each sample site. Sites that recovered G9 and G10 garnets are highlighted. Site 00M049 (blue star) recovered an anomalous quantity of visual KIMs that are not part of the Manitoba Geological Survey KIM database (Keller, 2019; see 'Previous diamond exploration' section). UTM Zone 15, NAD83.*

results (Assessment File 94830). This survey analyzed 54 samples across three separate permit areas and recovered between 0 and 23 KIMs in most samples. Interestingly, one stream-sediment sample recovered 1195 visual KIMs. The majority of grains are chromite (96%, n=1148/1195), but there were also 21 visually identified pyrope garnets (1.8%, n=21/1195). This sample was collected from a point bar on the Fox River (00M049, Figure GS2020-7-2b; Assessment File 94830). The origin of KIMs recovered from stream and river sediments are harder to trace to source, since these fluvial bodies are actively eroding both the local bedrock and sediment that has already been transported by glaciers. Regardless, this sample warrants follow-up.

Methods

Helicopter-supported fieldwork was undertaken over 24 days in August 2020, based out of the town of Gillam, which is located 40 km north of the study area. A total of 318 field sites were visited to ground-truth the surficial geology mapping, collect till samples and identify ice-flow indicators (Figure GS2020-7-1). The surficial material at each field station was investigated by means of a hand-dug shovel hole, a Dutch auger (1.2 m long) hole and/or a natural sediment exposure.

Eighty-nine 2 kg till samples were collected for geochemical analysis by partial and total digestion of the silt and clay size-fraction (<63 µm) and clast-lithology (2–8 mm size-fraction) analysis. Till samples were collected from the C-horizon soil, both at surface and at depths of up to 14 m. An additional 59 till samples (11.4 L each) were collected for KIM analysis. These samples were submitted to the De Beers Group to be analyzed through in-kind support. The KIM-sample locations are withheld, to allow equal opportunity for follow-up by all interested parties when the data is publicly released at a later date.

Results

Ice-flow history

Bedrock outcrops are rare in the study area, and new erosional ice-flow measurements were obtained from striations, grooves, chattermarks, crescentic gouges and fractures at just five field sites in the southwestern part of the study area, and one additional site along the Fox River (Figures GS2020-7-3, -4). Based on these erosional field-based ice-flow indicators, paleo ice flow was to the northwest, west, south and southwest.

Streamlined landforms were mapped across the study area, at a variety of resolutions from remotely sensed imagery (Figure GS2020-7-3). All streamlined landforms trend toward the southwest in the study area, at ~245° (Figure GS2020-7-5), and were formed by the regional Hayes Lobe (Dredge and Cowan, 1989; Gauthier et al., 2019).

Till-fabric analyses

Till-fabric analyses were conducted on the surface till at five sample sites, and on the subsurface till at an additional 11 sample sites (Figure GS2020-7-3). Preliminary interpretations suggest that the surface till was deposited and/or deformed by south- to south-southwest-trending ice flow (180–200°) and either a northwest- or southeast-trending ice-flow (300–320° or 120–140°). The till-fabric interpretations also suggest older ice-flow phases to the northwest-southeast (twice), west (twice) and southwest. Future work will reconcile these preliminary findings with the regional ice-flow history provided in Gauthier et al. (2019).

Till-fabric analyses are particularly useful in areas where bedrock outcrops are scarce. However, given that the orientations of the surface-till fabrics contradict the orientation of streamlined landforms, this study highlights the importance of conducting till-fabric analyses in all areas. The mismatch of orientations between different types of ice-flow indicators likely means that the streamlined landforms are erosional, and have exposed till(s) unrelated to the young southwest-trending ice-flow direction. Although forthcoming till-composition studies will assess this hypothesis, it should be noted that erosional streamlined-landform genesis is confirmed in the Knee Lake area, 55 km to the south (Trommelen and Ross, 2014).

Surficial geology

Preliminary comparison between the 2020 field sites and the existing reconnaissance mapping (Klassen and Netterville, 1979) shows that till at surface is more common than currently mapped (Figure GS2020-7-6). Generally though, a glaciolacustrine veneer of clay and/or silt, of variable thickness, drapes drumlinized till ridges across the study area. Wave-washed till was observed at elevations between 120 and 175 m asl, trimlines at 136 and 161 m asl and a beach at 134 m asl. Wave-washing was particularly strong in the southwestern portion of the study area, where low-lying bedrock is exposed between 170 and 185 m asl (Figure GS2020-7-1).

Future work

This report summarizes the work done during the first year of a two-year project. Ongoing surficial geology analyses will focus on 1:50 000 scale surficial mapping, as well as tracing lithological indicators from known bedrock source areas. The latter will be conducted by clast-lithology counts and analyzing the geochemical composition of the collected till samples. A second field season is planned for 2021, with similar methods to those in 2020.

Economic considerations

As bedrock outcrops are rare in much of Manitoba's northern region, a thorough understanding of surficial geology is essential for drift prospecting. Till-sample analysis is com-

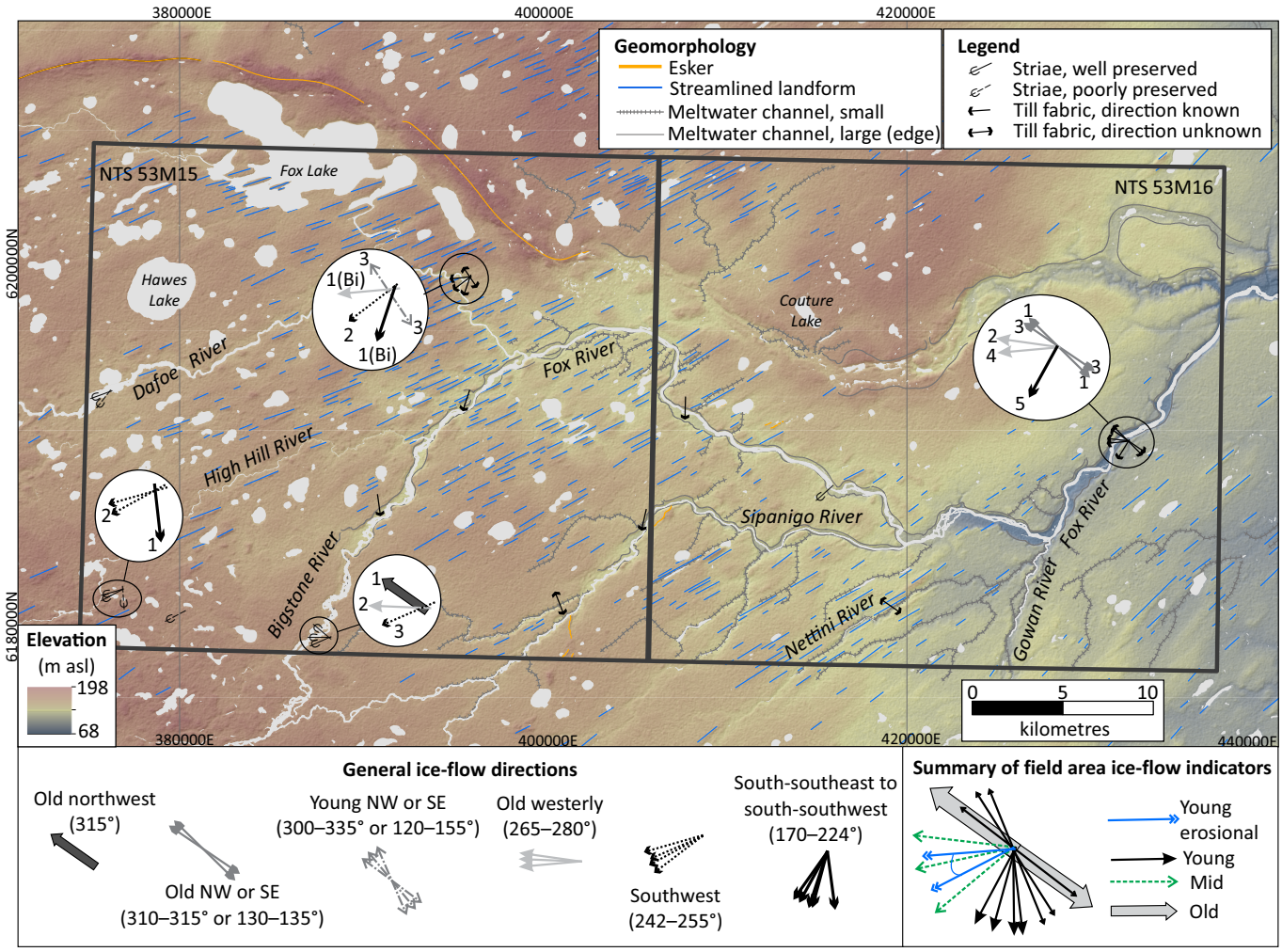


Figure GS2020-7-3: *Ice-flow–indicator data in the study area. Larger circles are a summary of the relative ages (1=oldest) and trends of ice-flow indicators for a single site or sites in close proximity to each other. The generalized ice-flow directions provide a key for differentiating between old and young ice flows of similar orientation. Background hillshade was generated using a 30 m resolution Shuttle Radar Topography Mission digital elevation model (United States Geological Survey, 2014). UTM Zone 15, NAD83.*

monly used in drift-covered regions to help determine the source area for mineralized erratics and boulder trains, but is more difficult to interpret in palimpsest terrains such as in this study area. Ongoing surficial geology studies aim to provide a detailed framework for the directions, timing and nature (e.g., erosive or depositional) of major and minor ice-flow events in the region. 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 drift-covered areas. More specifically, the results of this study may inform drift exploration for nickel, copper and platinum-group-element mineralization in the Fox River belt, and new KIM results will help assess the regional-scale diamond potential of the study area.

Acknowledgments

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Figure GS2020-7-4: *Examples of erosional ice-flow indicators in the study area include* ***a)*** *low-lying outcrop moulded and grooved toward 250°;* ***b)*** *a 2 m wide chattermark toward 176° that was partially protected from the younger 250° ice flow;* ***c)*** *0.2 m wide chattermarks toward 270° that are adjacent to, and cross-cut by striations toward 246°; the latter were mapped at the same site as* ***d)*** *an outcrop that has been moulded and plucked toward 310°.*

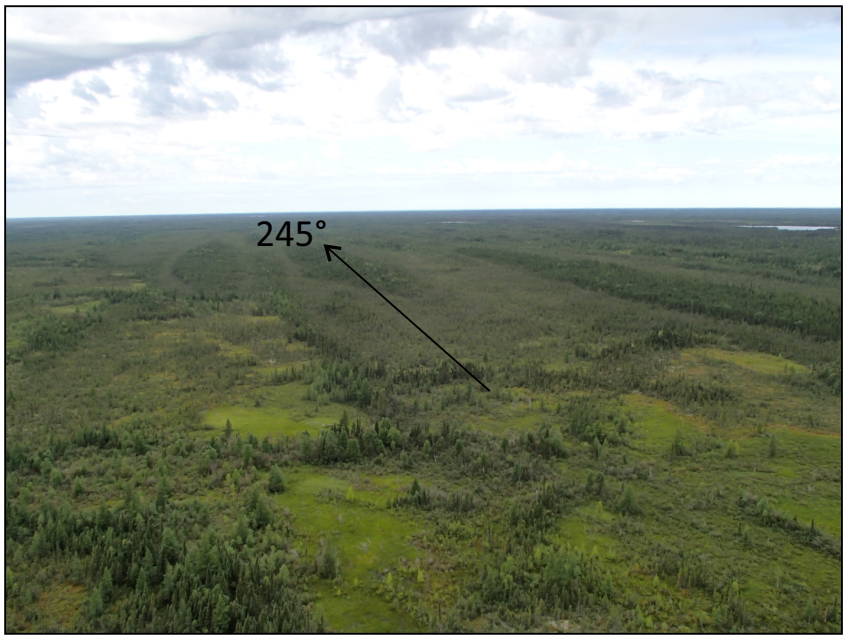

Figure GS2020-7-5: *Oblique aerial photograph of streamlined landforms in the study area.*

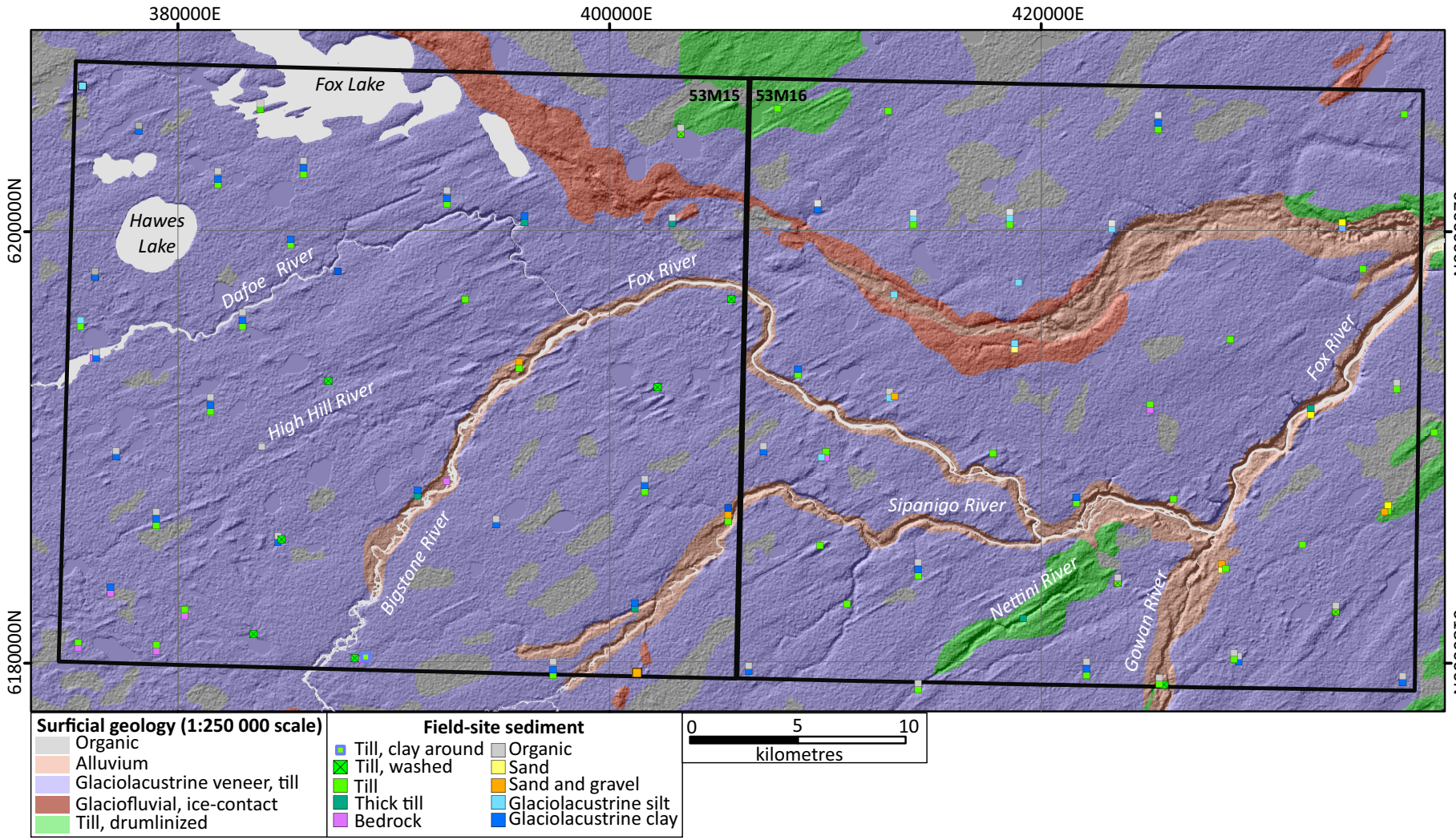

Figure GS2020-7-6: *The interpretation of sediments at the field sites are displayed overlying reconnaissance-level surficial geology mapping (Klassen and Netterville, 1979) of the study area. A hillshaded digital elevation model has been added to the background to show the regional topography (United States Geological Survey, 2014). UTM Zone 15, NAD83.*

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