ISSN 1916-6117 (online)
ISBN 978-1-4868-2715-2 (PDF)
(for entire OFR 6350)

ISSN 0826-9580 (print)
ISBN 978-1-4868-2714-5 (print)
(for entire OFR 6350)

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Marich, A.S. 2018. An update on multi-year Quaternary geological mapping along the Highway 11 corridor, northeastern Ontario: An update; *in* Summary of Field Work and Other Activities, 2018, Ontario Geological Survey, Open File Report 6350, p.19-1 to 19-10.

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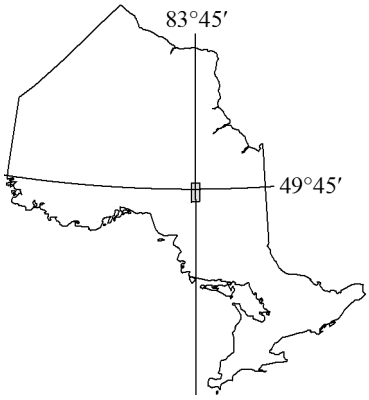
19. Project NE-18-001. An Update on Multi-Year Quaternary Geological Mapping Along the Highway 11 Corridor, Northeastern Ontario



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INTRODUCTION

Field work for an ongoing program aimed at updating the Quaternary geology maps of the Highway 11 corridor between Iroquois Falls and Hearst was conducted during the summer of 2018. This was the third season of data collection and, to date, ground-based field work for the areas represented by 8 1:50 000 scale National Topographic System (NTS) maps has been completed (Figure 19.1). These include the Iroquois Falls (42 A/15), Abitibi (42 H/2), Cochrane (42 H/3), Smooth Rock Falls (42 H/5), Kapuskasing (42 G/8), Opasatika (42 G/10), Val-Rita (42 G/7) and Mattice (42 G/11) NTS map areas. This report will focus on field work conducted in the Val-Rita and Mattice areas. The reader is referred to Marich (2016, 2017) for a brief overview of the first 2 years of field work.

This mapping program was initiated to gain a greater understanding of landforms and sediments along the Highway 11 corridor. Previous Quaternary geology mapping of the area was completed at a scale of 1:1 000 000 (Barnett, Henry and Babuin 1991) and 1:506 880 (Boissonneau 1965, 1966). Although Northern Ontario Engineering Geology Terrain studies were undertaken at a scale of 1:100 000 (Lee and Scott 1989a, 1989b, 1989c), there is still an increasing need for more detailed maps of surficial sediments in this area because land-use planning, aggregate resource assessment and other geoscience-related studies require more up-to-date, high-resolution, geoscience baseline information.

This program also supports continuing updates to Agricultural Soils Suitability mapping being conducted by the Ministry of Agriculture, Food, and Rural Affairs (OMAFRA). Highly detailed Quaternary geology mapping is essential for the classification of soils for various agricultural uses. To this end, OMAFRA and the Ministry of Natural Resources and Forestry (MNRF) acquired high-resolution digital elevation data (LiDAR) across most of the Highway 11 corridor. The resulting bare earth model (50 cm resolution) has proven to be extremely helpful for the Quaternary geology mapping by delineating landforms at a much higher resolution than has ever been mapped in this part of Ontario (Ministry of Natural Resources and Forestry and Ministry of Agriculture, Food and Rural Affairs 2017).

More than 2400 observations of the surface materials and landforms were made during the 2018 field season with 19 till and 4 esker sand samples collected. These samples will be analyzed for pebble lithology, heavy mineral content, including gold grains, kimberlite indicator minerals (KIM) and metamorphic/magmatic massive sulphide indicator minerals (MMSIM®[2]). In addition, fine-fraction geochemistry will also be completed on the silt and clay sized (−63 µm) fraction. These analyses are being performed to gain a greater understanding of the geochemical signature of these sediments, which,

[2]*MMSIM is a registered trademark of Overburden Drilling Management Limited, Nepean, Ontario.*

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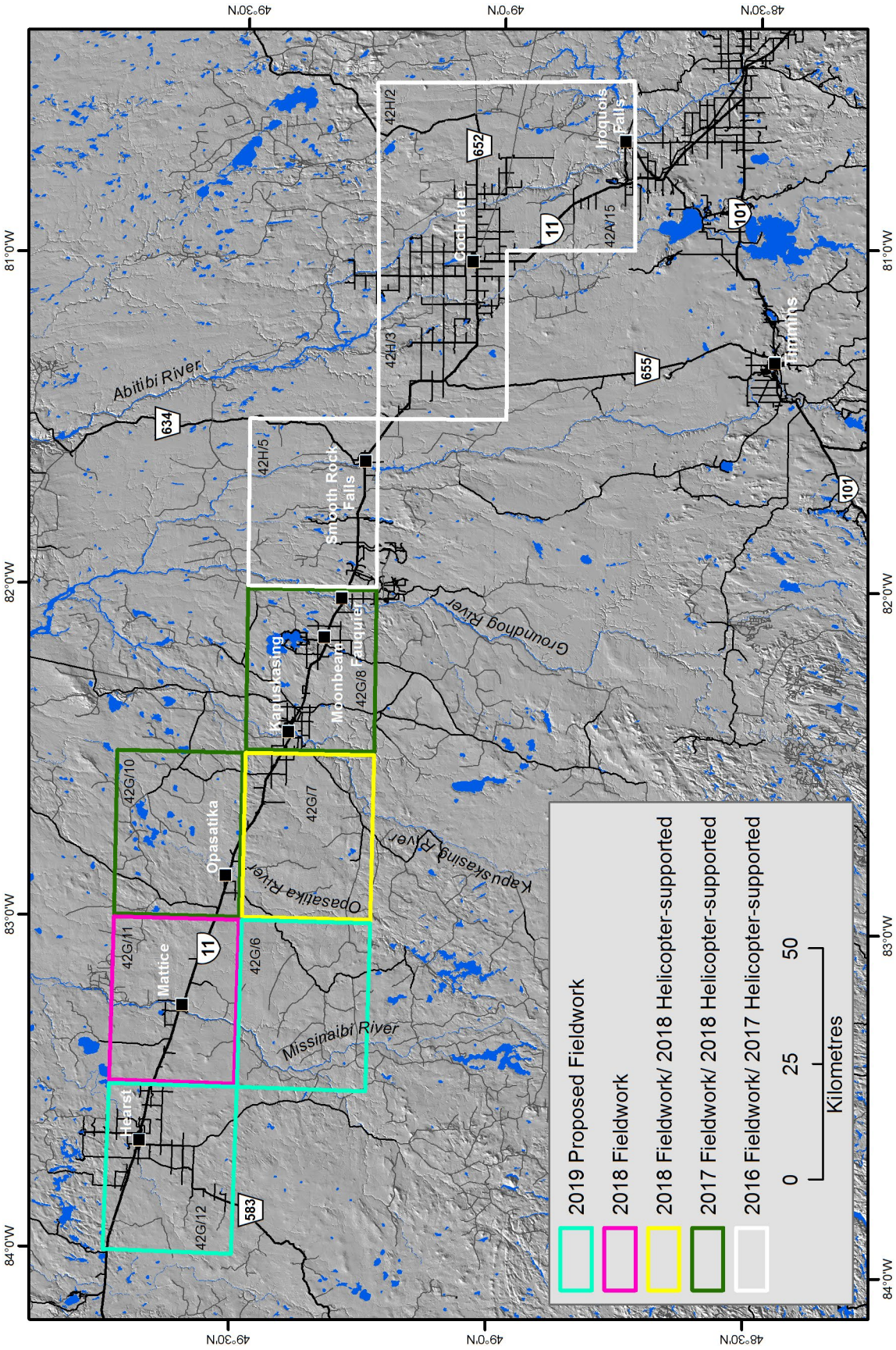

Figure 19.1. Study area map outlining the areas of field work for 2016, 2017, 2018 and 2019, as well as the area of helicopter-supported field work in 2017 and 2018. Lakes and drainage are shown in blue; roads are shown in black and dark grey. The high-resolution digital elevation surface is based on Provincial digital elevation model data *from* Ministry of Natural Resources (2013).

in turn, can aid in the assessment of resource potential in the area. To support OMAFRA's soil mapping initiative, peat and mineral soil samples were collected at 181 locations throughout the study area for their ongoing analyses of soil carbon and other nutrients.

BEDROCK GEOLOGY

Although bedrock outcrops are fairly common within certain parts of the area mapped in 2018, little work has been undertaken to assess the mineral resource potential. This is attributed primarily to the fact that bedrock outcrops are often widely spaced and host rock types that are not typically associated with base and precious metal mineralization. The area is underlain by Archean bedrock of the Quetico Subprovince (Ontario Geological Survey 2011) (Figure 19.2). Highly metamorphosed metasedimentary rocks (Photo 19.1A) are the dominant lithology and consist of paragneiss and migmatites, wacke, siltstone, arkose, slate, marble, chert and iron formation (Ontario Geological Survey 2011). In addition, massive granodiorite to granite, as well as gneissic tonalite and muscovite-bearing granitic intrusions, also occur within the study area (Photos 19.1B and 19.1C). The muscovite-bearing granitic rocks and associated pegmatites may have potential for hosting rare earth elements (REEs).

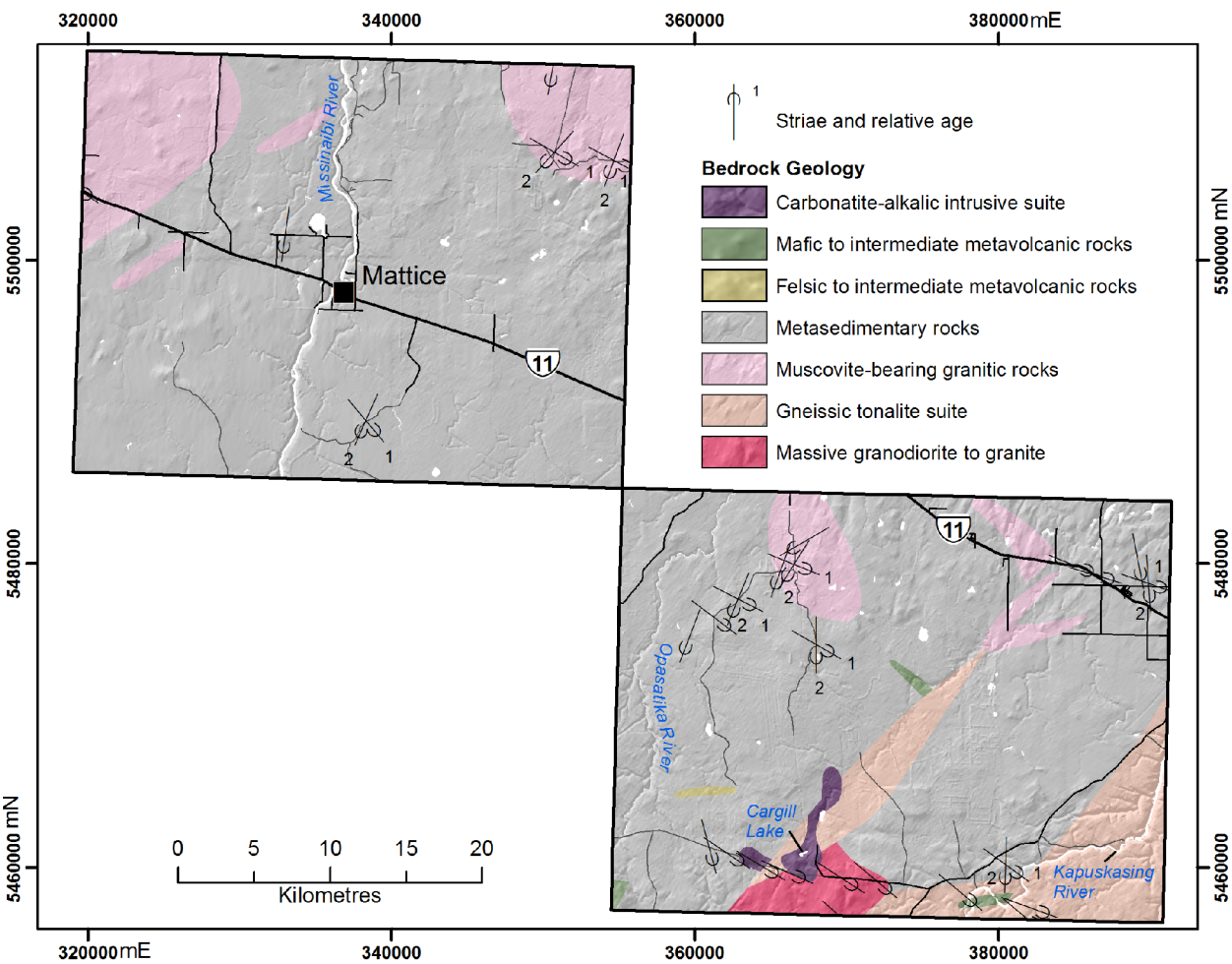

Figure 19.2. Simplified bedrock geology of the study area, specifically the Mattice and Val-Rita areas (*modified from* Ontario Geological Survey 2011), including glacial striae measurements collected in this study. The relative ages of the striae are indicated where crosscutting striae were observed. Earlier ice flows indicated by the number 1 and later ice flows by the number 2. Universal Transverse Mercator (UTM) co-ordinates are provided using North American Datum 1983 (NAD83) in Zone 17.

Thin slivers of felsic to intermediate metavolcanic and mafic to intermediate metavolcanic rocks (Photo 19.1D) are located within the Val-Rita area. A Paleoproterozoic carbonatite–alkalic intrusive suite is located in the south-central part of the Val-Rita map area. This suite consists of carbonatite complexes, nepheline syenite, alkali syenite, ijolite, fenite and associated mafic and ultramafic rocks. The past-producing Agrium Mine extracted phosphate from this unit and is currently being rehabilitated.

QUATERNARY GEOLOGY

All of Ontario was covered by the Laurentide Ice Sheet during the last glacial maximum, shaping the landscape and depositing various surficial sediments. The initial retreat of this ice sheet from the study area occurred approximately 8200 ^{14}C years ago (Dyke 2004). Situated within the James Bay drainage basin, the retreating ice sheet was fronted by a series of proglacial lakes (e.g., Hughes 1965; Veillette 1994; Veillette et al. 2017; Evans 2011; Roy et al. 2011; Breckenridge et al. 2012). Glacial Lake Barlow and, subsequently, glacial Lake Barlow–Ojibway, spanning 960 km from west to east and 240 km from north to south, occupied much of north-central Ontario and Quebec. The landforms and sediments of this lake dominate the regional landscape (Agterberg and Banerjee 1969, and others). It has been suggested by various authors that the Laurentide Ice Sheet advanced and retreated at least once, if not multiple times, into this proglacial lake basin (e.g., Hughes 1965; Veillette 1994). Glacial Lake Barlow–Ojibway existed for approximately 2000 years and its final drainage is thought to have been catastrophic, discharging northward during the final collapse of the Laurentide Ice Sheet into the Tyrrell Sea (Veillette 1994; Roy et al. 2011).

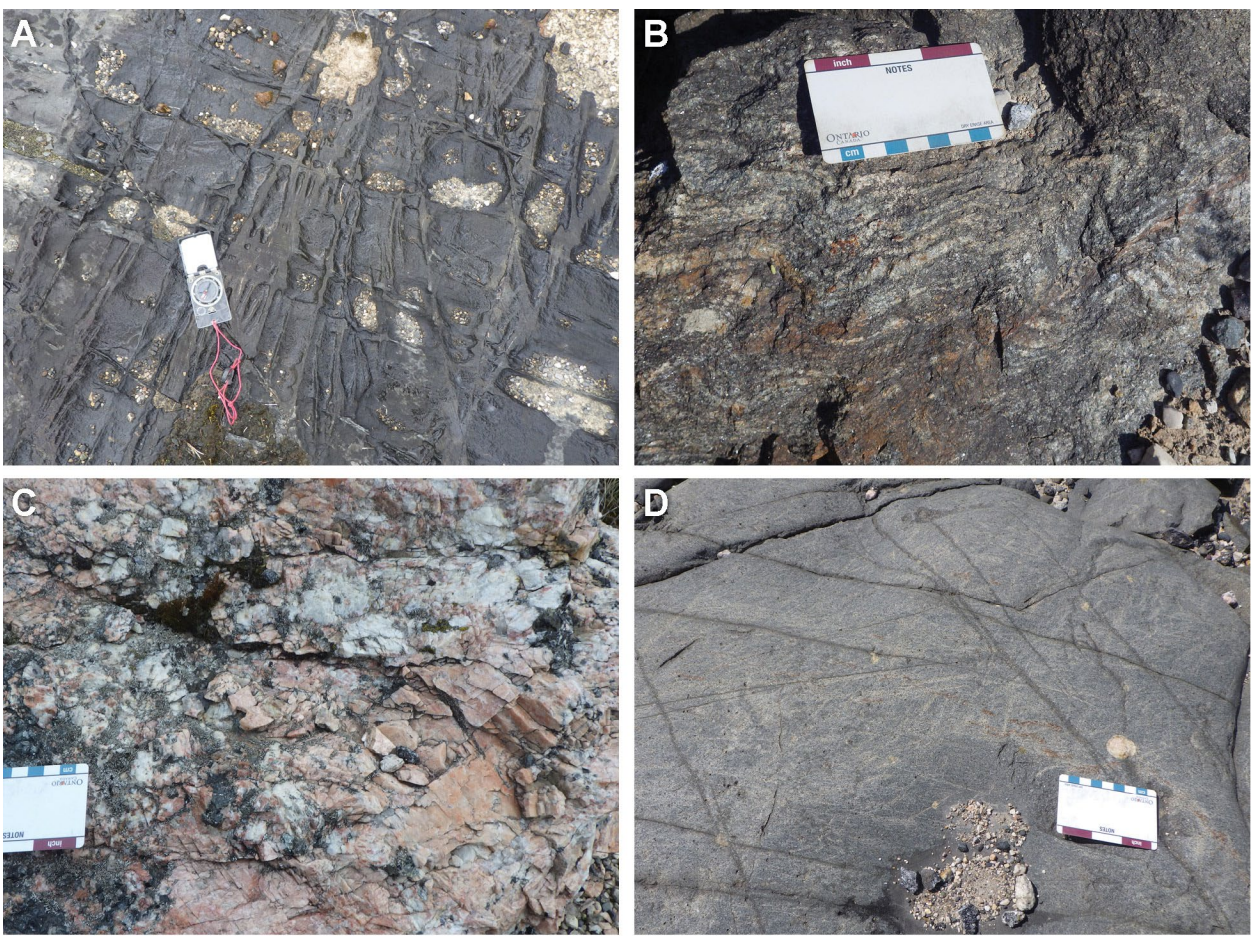

Photo 19.1. Examples of bedrock observed within the study area: **A**) metasedimentary rock, **B**) gneiss, **C**) an example of pegmatite within muscovite-bearing granitic rock and **D**) mafic metavolcanic rock.

The study area is located within the glacial Lake Barlow–Ojibway basin and, as such, has a landscape of very low relief dominated by wetlands. Drift thickness varies from a few centimetres near bedrock outcrops to approximately 40 m along esker ridges, based on limited water well records. The greatest relief was observed in areas occupied by eskers, large bedrock knobs, or gullies eroded by fluvial action. Iceberg keel marks are the dominant feature on the land surface. Thousands of these features cut into the surface materials in large swaths, primarily in areas of elevated topography, and sediment within the keels are highly disturbed. They vary in width and length, with widths ranging from a couple of metres to about half a kilometre and lengths from a couple of metres to several kilometres. The orientation of keel marks can appear to be random at first look, but, regionally, are oriented to the southeast, suggesting a dominant wind direction to the southeast. The following sections describe the sedimentary units from oldest to youngest.

Matheson Till is the oldest sediment observed within the study area. It is a silty sand diamicton with approximately 5 to 10% granule to pebble-sized clasts predominantly of Precambrian rock types. The matrix is low in carbonate and does not effervesce when subjected to 10% HCl. The low carbonate content and dominance of local Precambrian rocks suggest that Matheson Till is a locally derived till. A thorough understanding of the provenance and geochemical signature of till can be useful when attempting to assess the mineral resource potential of the area. The ice flow associated with this oldest till unit was to the south or southeast, and has been recorded in the bedrock striation record which will be discussed below. It is important to distinguish between the various ice-flow directions, and their associated sedimentary deposits when undertaking drift prospecting in order to target the appropriate locations for potential mineral deposits. Matheson Till was identified only once during the 2018 field season, sandwiched between bedrock and overlying Cochrane Till (discussed in this section).

Minor deposits of glaciofluvial sediments were observed within the Mattice area and in the southern part of the Val-Rita area (Figure 19.3). These glaciofluvial sediments were observed in eskers and consisted predominantly of sands with minor gravel. Exposures cut into these eskers are commonly less than 5 m high with the exception of 1 excavation in the southwest quadrant of the Mattice area where pit faces were greater than 15 m high. Several metres of fine-textured glaciolacustrine sediments and/or Cochrane Till were observed capping most of the glaciofluvial deposits of the region. Because Cochrane Till drapes these eskers, their formation predates the Cochrane Till deposition. This, along with their continuity beyond the limit of Cochrane Till, suggests that the eskers are associated with the ice advance responsible for the deposition of Matheson Till (Barnett, Henry and Babuin 1991). The clast content within these deposits, albeit fairly low, consists of both local Precambrian rock types, as well as far-travelled Paleozoic rocks of the Hudson and James Bay lowlands. Of note, is the presence of cobbles from the Proterozoic Omarolluk Formation (omars); the source of these cobbles is likely the Belcher Islands in southeastern Hudson Bay. The dark grey greywacke cobbles contain deep circular cavities resulting from preferential dissolution of carbonate concretions (Prest, Donaldson and Mooers 2000). Many of these eskers and the associated glaciofluvial sediments were being extracted as a local source of aggregate, but currently, the pits remain mostly inactive.

The youngest sediments within the study area are associated with the Cochrane advance, the final advance of the Laurentide Ice Sheet into the study area and beyond (Hughes 1965; Evans 2011). Multiple layers of Cochrane Till interbedded with massive to laminated, sometimes varved, glaciolacustrine clays corroborates the idea that during the Holocene, the Laurentide Ice Sheet advanced into the glacial Lake Barlow–Ojibway basin at least once if not multiple times. The Cochrane Till is a clayey silt diamicton with minor (<5%) granules to pebble-sized clasts and the occasional cobble (Figure 19.3B). The till is variably compact, in some cases exhibits strong fissility, and is commonly capped by glaciolacustrine silts and clays. The Cochrane advance has been associated with ice flow to the southwest, based on the orientation of streamlined landforms and the youngest set of glacial striae (this study; Veillette 1994; Veillette et al. 2017). The Cochrane Till was observed primarily in thin drift areas, commonly associated with bedrock-controlled relief.

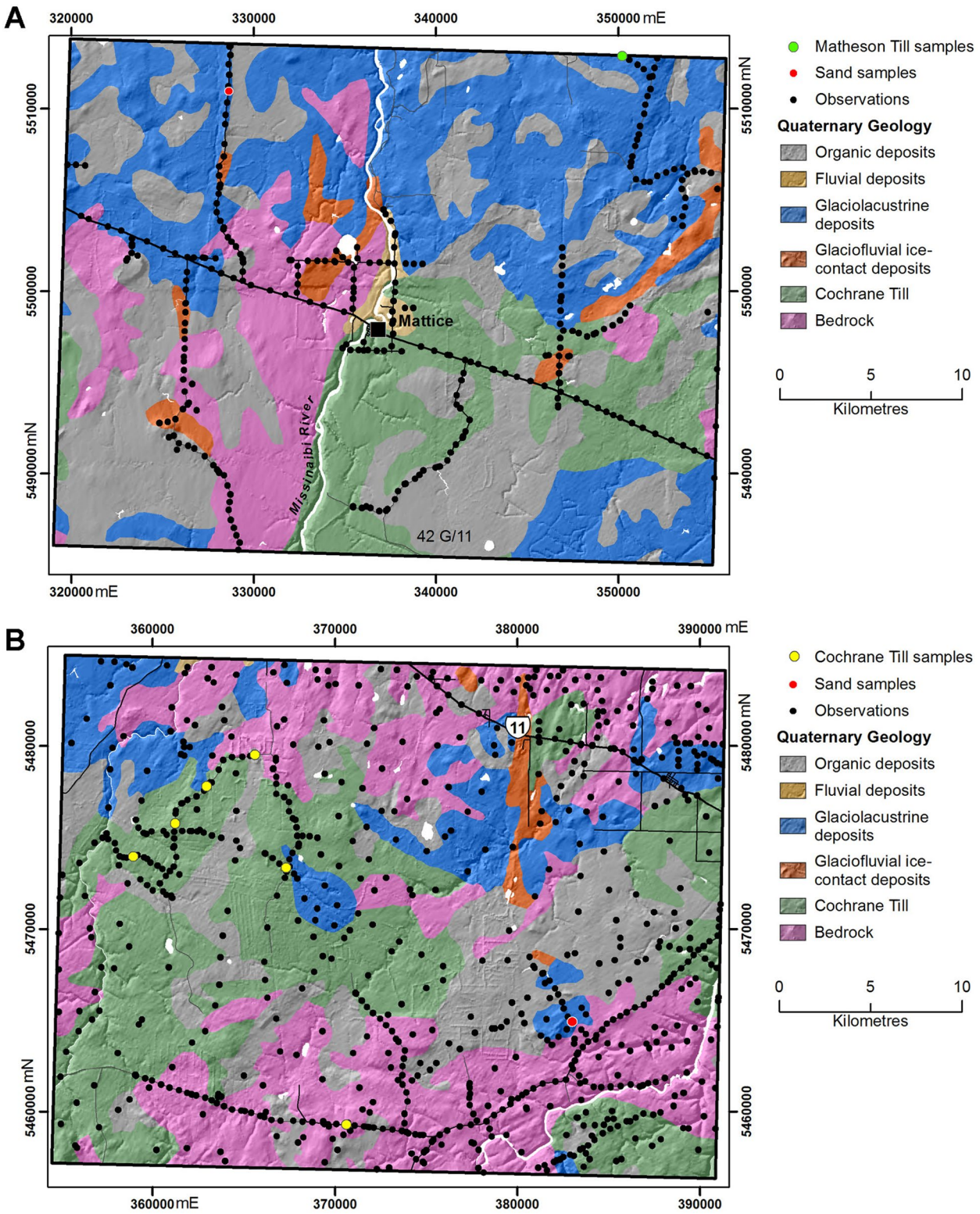

Figure 19.3. Simplified Quaternary geology of the **A**) Mattice and **B**) Val-Rita study areas (*modified from* Barnett, Henry and Babuin 1991); *see also* Figure 19.2 for the relative locations of the 2 study areas. Map includes field observation locations (black dots) and sample locations (yellow, red and green dots). The high-resolution digital elevation surface is based on Provincial digital elevation model data from Ministry of Natural Resources (2013). The UTM co-ordinates are provided using NAD83 in Zone 17.

Deep-water glaciolacustrine sediments consisting of massive to laminated silt and clay, as well as varved sediments, occupy much of the Highway 11 corridor. These silts and clays are commonly greater than 1 m thick and, in some places, are upward of 10 m thick. Varved silts and clays are observed throughout the study area and are often interbedded with massive clayey silt to silty clay. The varves consist of distinct dark grey clay (winter) beds and pale tan silt (summer) beds (Photos 19.2A, 19.2B and 19.2C). Thin beds containing ice-rafted debris were commonly observed. Within the ice-rafted debris, red granules, possibly derived from the Silurian Kenogami River Formation, a red mudstone that crops out to the north on the Albany River, were commonly observed (Bajc, Lee and Yeung 2014; Gao, Lee and Yeung 2015).

Ice-Flow Indicators

Ice-flow indicators were observed throughout the study area. Striae were commonly observed in areas of thin drift where polished bedrock was exposed (*see* Figure 19.3). The striae are well preserved on outcrops of fine-textured bedrock (e.g., metasedimentary rocks) or on fine-textured veins and/or dikes within coarse-textured rock types. Two main ice-flow directions are recorded in the current study area: an older southeasterly flow, associated with the deposition of Matheson Till, and a younger southwesterly flow that records the latest ice flow associated with the Cochrane Till. Crosscutting striae in these predominant directions were measured on many outcrops within the study area and agree well with observations made previously by Veillette and others (Veillette et al. 2017).

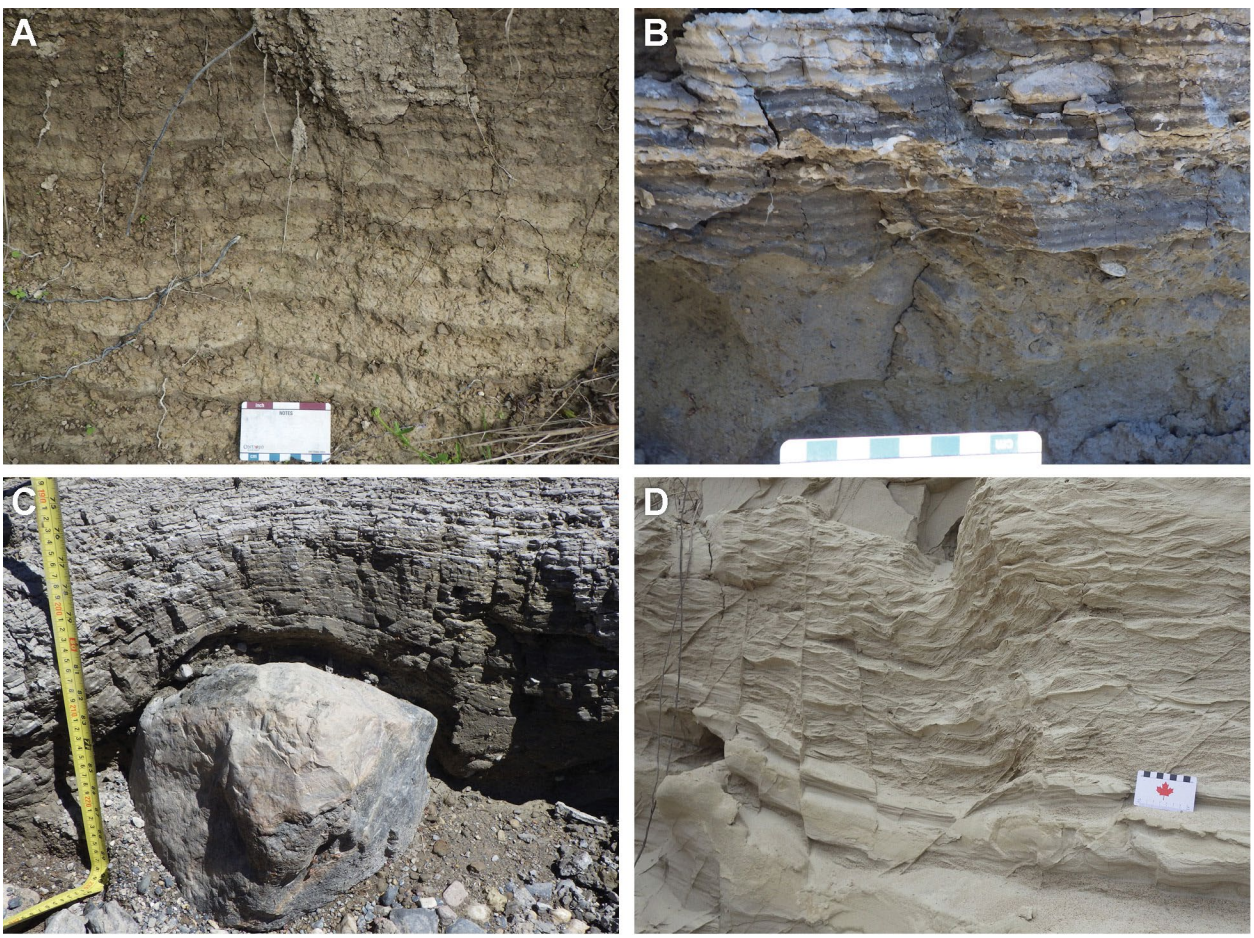

Photo 19.2. **A**) Ditch cut showing rhythmically laminated glaciolacustrine sediments (varves). **B**) Varves overlying Cochrane Till, a clayey silt and clast poor diamicton (each bar on the scale card is 1 cm). **C**) Varves draping a small boulder. **D**) Well-bedded and faulted sands within an esker deposit.

In addition to striae, glacial grooves, chatter marks and crescentic gouges were observed on outcrops and these, along with larger features, such as stoss-and-lee forms, as well as streamlined bedforms, were used to interpret ice-flow directions (Photos 19.3A to 19.3D).

HELICOPTER-SUPPORTED FIELD WORK

In early July, field work was conducted within the Kapuskasing, Opasatika and Val-Rita areas using a helicopter. The work targeted areas that were inaccessible using trucks and all-terrain vehicles. Landing sites included winter logging roads, old forest plots, river beds and any clearing where sediment was observed. More than 1000 aerial and ground observations were made during the helicopter-supported field work. Numerous photographs, which will aid in the landform and sediment interpretations were acquired as part of the survey. Photo 19.4 shows an example of intersecting iceberg keel marks as seen from the air.

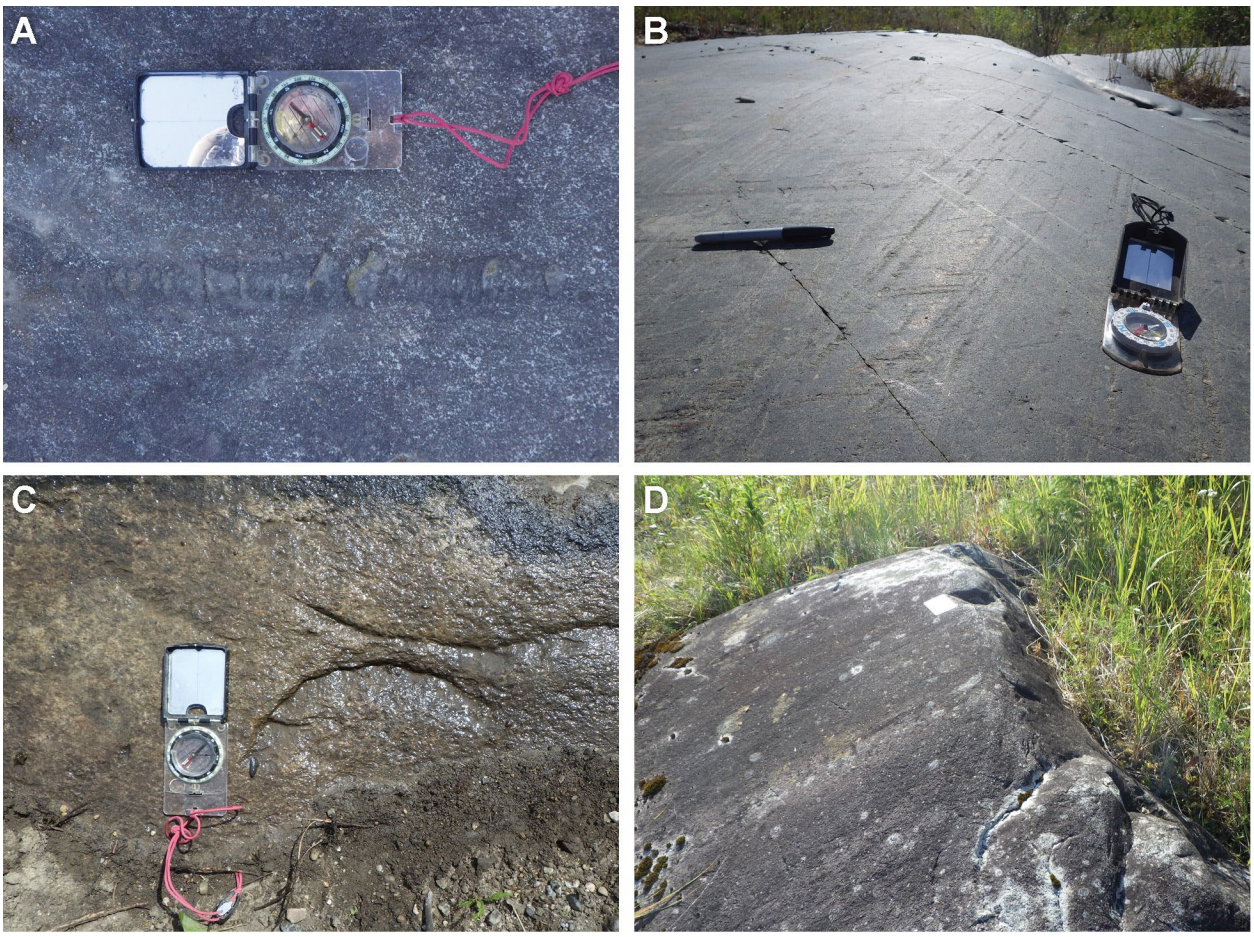

Photo 19.3. Ice-flow indicators. **A**) Chatter marks produced by clasts within glacial ice chipping the underlying bedrock as it flows over the surface. Ice flow was from northwest to southeast (i.e., from right to left in this example). **B**) Crosscutting sets of glacial striae. An older set, oriented to the southeast is shown by the marker and flowed from north-northeast to south-southwest (i.e., from left to right in this photograph). A younger set, parallel to the long axis of the compass, is oriented to the southwest. **C**) Crescentic gouges are a result of glacial erosion similar to that of chatter marks. In this case, ice flow was approximately toward the east-southeast (i.e., from bottom to top of this photograph). **D**) Bedrock outcrop showing classic stoss-and-lee form. In this case, ice flow would have been from northwest to southeast (i.e., from left to right in this photograph). (Note, scale card in centre of photograph is 9 cm long).

Photo 19.4. Photograph showing intersecting iceberg keel marks currently occupied by a meandering stream.

FUTURE WORK

Field work is proposed continue to the west within the Rock River (42 G/6) and Hearst (42 G/12) NTS map areas in 2019. If time and resources allow, areas with limited access within the Rock River, Mattice and Hearst areas will be visited by helicopter.

ACKNOWLEDGMENTS

The author would like to acknowledge Colin Roth, Aidan Buyers, Alex Hegel and Aaron Bustard for their exceptional assistance in the field. Thanks also goes to helicopter pilot, Dan Steckly with the Ministry of Natural Resources and Forestry. Drafting of figures was completed by Julien Bonin, and this manuscript benefited from a technical review by Andy Bajc, both at the Ontario Geological Survey. Finally, thanks goes to local landowners and aggregate pit operators for allowing access to their properties.

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