GS2023-12

Current Quaternary geology investigations in southeastern Manitoba and implications for mineral exploration (parts of NTS 52L, 62P, 63A)

by T.J. Hodder and T. Martins

In Brief:
- Investigating the glacial dispersal of detritus from known Li-bearing pegmatites in the Bird River area using multiple parameters
- Collection of ice-flow data to reconstruct the glacial history and aid drift exploration
- Release of 2022 pilot study indicator mineral results

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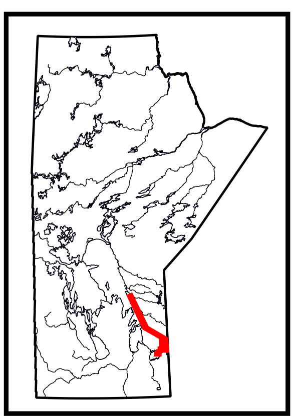

Summary
Quaternary geology investigations were conducted in southeastern Manitoba, to map paleo–ice-flow indicators, collect till samples and assess the suitability of current surficial geology mapping to guide drift exploration. Additionally, this study aims to characterize the dispersal of detritus from known lithium-bearing pegmatites in the Bird River area to better inform how drift prospecting methods can be used for critical minerals. Initial results from a pilot study conducted indicate that spodumene can be recovered from till that was collected down-ice of a known occurrence. Surprisingly, one sample from the road connecting Manigotagan and Berens River (east-side road) recovered two spodumene grains. This was an unexpected occurrence since there is no known lithium-bearing pegmatites in the region; however, the till-matrix geochemistry in this region has elevated lithium and cesium concentrations indicating that there is potential for lithium-mineralized systems in this underexplored region of Manitoba. The recovery of the rare-earth-element (REE) minerals euxenite and parisite from till along the east-side road indicate that there is also potential for uranium-thorium-REE–mineralized systems in the region. Elevated gold grain counts in till collected near Cat Lake is a significant occurrence and the source of these gold grains is unknown. The surficial geology mapping available for the Bird River area overrepresents the proportion of glacial-derived sediments (diamicton) in the area and underrepresents the proportion of glaciolacustrine sediments (sand). This characteristic of these surficial maps needs to be considered when planning any drift exploration in the Bird River area.

Introduction
The Manitoba Geological Survey (MGS) initiated a multidisciplinary Precambrian and Quaternary geology project focusing on the Bird River area of the Superior province of southeastern Manitoba (Figure GS2023-12-1). This report presents ongoing investigations regarding the Quaternary geology and the reader is referred to Martins et al. (2023) and Roush et al. (2023) for current bedrock mapping and compilation geology studies in the region. Quaternary geology fieldwork was conducted for one day in October 2022 and 14 days in June and August of 2023. A total of 139 field sites were visited to document the Quaternary sediments, collect till samples and measure the orientation of ice-flow indicators. As part of a pilot study, one till sample was analyzed over the winter of 2022 to assess if Li-bearing minerals could be recovered from till sampled down-ice of a known occurrence. Additionally, four samples were analyzed to assess if there is any potential for Li-mineralization along the road connecting Manigotagan and Berens River (east-side road).

The goals of this project are to
- map paleo–ice-flow indicators to assist reconstructions of the glacial history, which in turn guides drift exploration studies;
- assess the use of till-matrix geochemistry and indicator minerals to characterize the dispersal of detritus from Li-bearing pegmatites in the Bird River area; and
- assess the suitability of published surficial geology maps to guide drift exploration in this region of Manitoba.

Previous work

Surficial geology mapping
Southeastern Manitoba was mapped at a 1:100 000 scale during the National Geoscience Mapping Program (NATMAP; Southern Prairies and Greater Winnipeg projects; Matile and Fulton, 1994; Matile et al., 1998). An inventory of published surficial geology maps from this program is available through the MGS website (Manitoba Geological Survey, 2023). However, these series of maps were

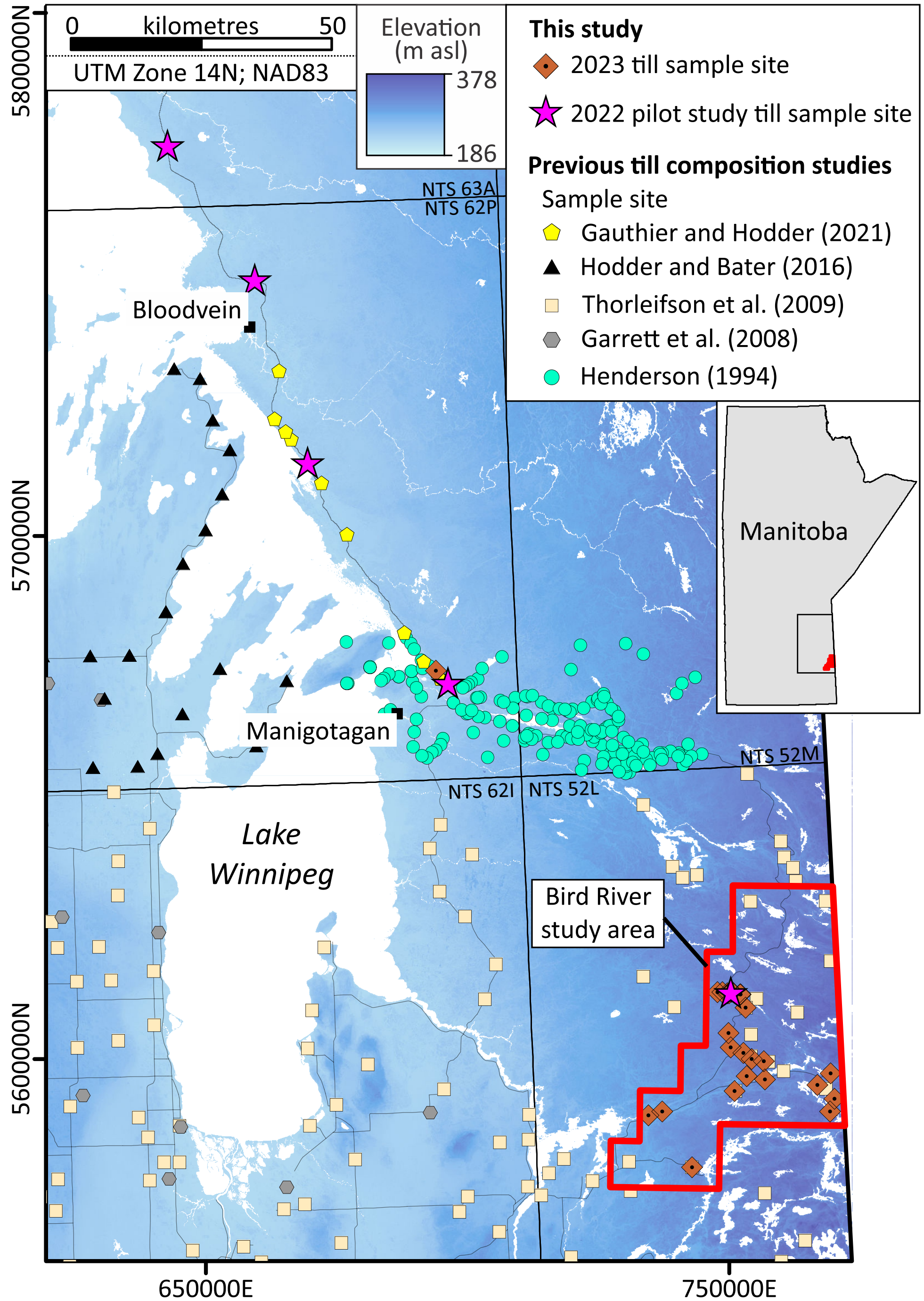

Figure GS2023-12-1: *Location of the Bird River study area (red polygon) in southeastern Manitoba. The locations of the five till samples analyzed as part of the 2022 pilot study are highlighted by pink stars. Sample locations from previous till-composition datasets for the region are plotted for reference. Background elevation data is provided by Earth Observation Research Center and Japanese Aerospace Exploration Agency (2022).*

published without any of the supporting field-based observations and station locations. This is useful information to understand where surficial geology mapping has been 'ground truthed', as a map is more accurate closest to those sites. Field-based data collected during the NATMAP projects were recovered from digital archives at the MGS and are published as Data Repository Items DRI2023009 (Matile et al., 2023b) and DRI2023010 (Matile et al., 2023c). Additionally, the published surficial geology maps from the NATMAP Greater Winnipeg project were missing collected field-based erosional ice-flow indicator measurements. This dataset was recovered from digital archives and also recently published (Matile et al., 2023a).

Till sampling

Till composition studies over the Precambrian shield of southeastern Manitoba were initially completed in the 1990s. These studies include an ultra-low density till sampling study of the Canadian prairies (Thorleifson and Garrett, 1993; Garrett et al., 2008), a detailed regional-scale till sampling study of the Rice Lake belt (Henderson, 1994) and a reconnaissance-scale till-sampling study of southeastern Manitoba during the NATMAP projects (Thorleifson et al., 2009; Figure GS2023-12-1). A reconnaissance-scale till-sampling study of the newly established road between Manigotagan and Berens River was undertaken in 2020 (Gauthier and Hodder, 2020, 2021).

Methods

Field data

A total of 139 field sites were visited to ground-truth previous surficial geology mapping, collect till samples and map paleo–ice-flow indicators. The surficial materials at each field station were investigated by means of a hand-dug shovel hole, a Dutch auger (1.2 m long) hole, gravel pit or roadcut/trailcut exposures. Where encountered, till samples were collected from the hand-dug pits or cut exposures within the Bird River study area (e.g., Figure GS2023-12-2). At each site, a smaller ~2–3 kg sample and a larger ~14–16 kg sample were collected from C-horizon (n = 19 of 23) diamicton, interpreted as till, or in cases where C-horizon diamicton was in limited supply due to thin till cover, samples consisting of a mix of B- and C-horizon diamicton were collected (n = 4 of 23). The 2–3 kg till samples were split for archival purposes at the MGS Midland Sample and Core Library (Winnipeg, Manitoba) and will be analyzed for matrix grain size and geochemistry. This study will analyze the geochemistry of two different grain-size fractions and use similar digestion methods to work ongoing near the Brazil Lake pegmatite in Nova Scotia (McClenaghan et al., 2023). The 14–16 kg samples were submitted to Overburden Drilling Management Limited (ODM; Ottawa, Ontario) for indicator-mineral analyses and recovery of clasts for lithological classification.

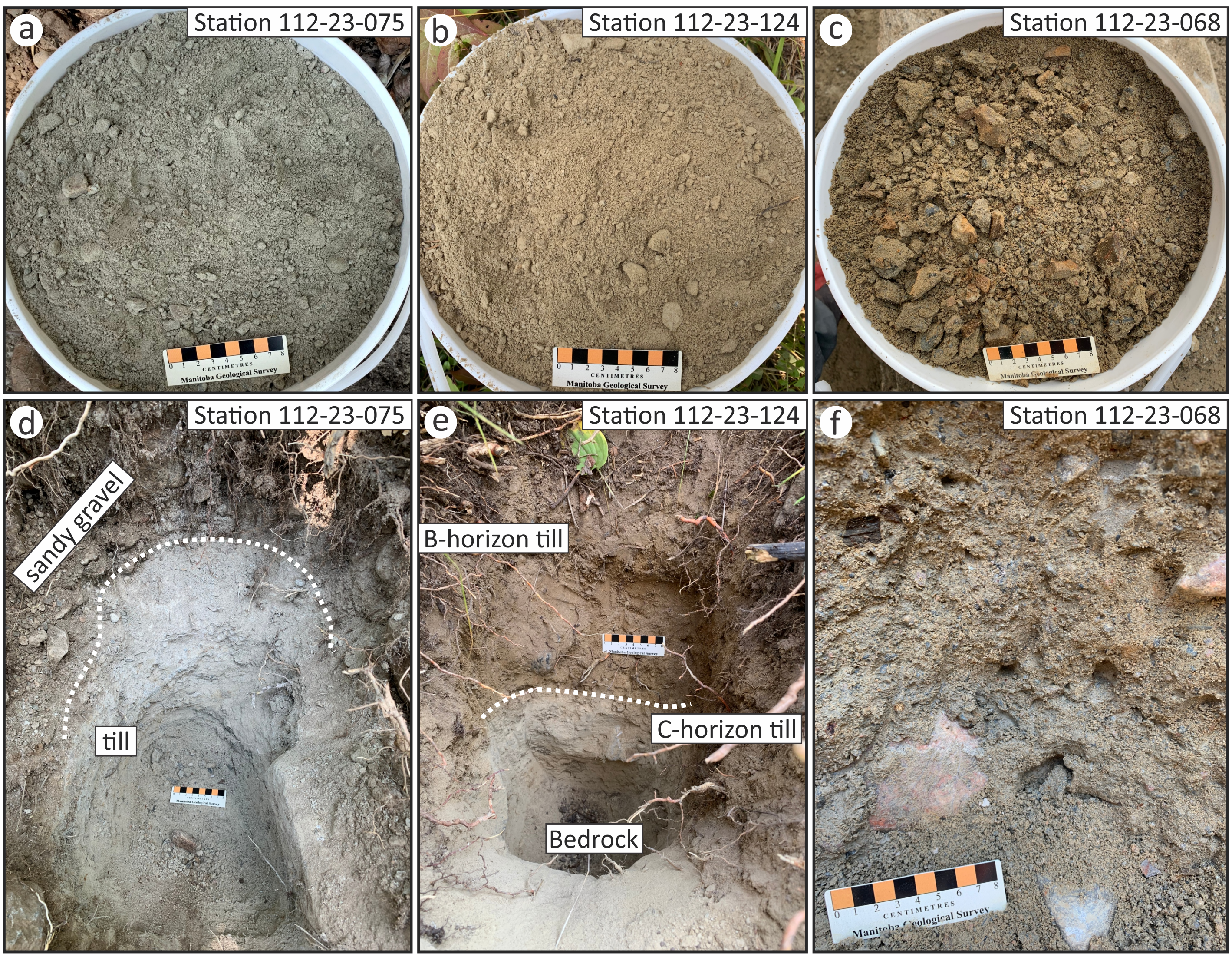

Figure GS2023-12-2: *Examples of till sampled and the hand-dug pits or exposures that they were obtained from:* ***a)*** *sandy-silt diamicton;* ***b)*** *sandy diamicton;* ***c)*** *sandy diamicton with a blocky appearance;* ***d)*** *overgrown trailcut exposure where till could be sampled underlying sandy gravel;* ***e)*** *hand-dug pit where C-horizon till could be sampled overlying bedrock;* ***f)*** *recently exposed site where till buried beneath postglacial sediments could be sampled, sediments which would not have been accessible in a hand-dug pit.*

Erosional paleo–ice-flow indicators, such as striae and grooves, were mapped at bedrock outcrops within the study area (e.g., Figure GS2023-12-3). The relative chronology at outcrops that exhibited multiple paleo–ice-flow indicators was deciphered using the crosscutting and outcrop relationships of facets and striae (McMartin and Paulen, 2009). Till-fabric measurements were completed at one site within the Bird River study area, where recently exposed sediments allowed access to a vertical face of till that was buried beneath postglacial sediments, and at one site near Manigotagan, which was initially visited in 2020 (Gauthier and Hodder, 2020). Each till-fabric measurement included the long-axes orientation of 30 elongated clasts, defined by a minimum 1.5:1.0 ratio of the a-axis (longest) to the b-axis (middle). These elongated clasts tend to rotate within the till matrix and orient parallel to the overlying glacier's shear stress direction (Holmes, 1941). Ice-flow data collected in 2023 is published in Data Repository Item DRI2023012 (Hodder and Gauthier, 2023)[1]. This ice-flow data will be combined with the forthcoming till-composition data to help interpret the till provenance and glacial history of the study area.

Indicator-mineral processing

The five till samples collected in 2022 were processed at ODM and results are presented in Data Repository Item DRI2023011 (Hodder, 2023)[2]. The <2 mm size fraction was passed across a shaker table to preconcentrate the mid- and heavy density mineral fractions. The preconcentrate was then micropanned to recover fine-grained gold, sulphide and other indicator minerals. The 0.25–2.0 mm concentrate was then processed using a heavy liquid separation to a specific gravity (SG) of 3.0 to produce a mid-density mineral concentrate (SG 2.8–3.0; MDMC) and at 3.2 to produce a heavy mineral concentrate (SG >3.2; HMC). Ferromagnetic minerals were removed from the MDMC and HMC fractions using a magnet. The nonferromagnetic MDMC and HMC fractions were then sieved into 0.25–0.5, 0.5–1.0 and 1.0–2.0 mm size fractions. The 0.25–0.5 HMC was then refined with a paramagnetic separation to assist counting of this fine fraction. These size fractions were then visually picked for metamorphic massive-sulphide–indicator minerals (MMSIMs®), lithium-indicator minerals (LIMs) and kimberlite-indicator minerals (KIMs). A select number of MMSIM, LIM and KIM grains were then verified using a scanning electron microscope (SEM) and these grains are noted in the remarks column for each table within Data Repository Item DRI2023011 (Hodder, 2023). Till samples collected in 2023 will be processed using the same methods.

Raman spectroscopy analyses

Picked spodumene grains from the 0.25–0.5 mm size fraction of the MDMC of two samples (n = 4 grains) were selected for Raman spectroscopy for additional mineral confirmation. Analytical techniques such as SEM are unable to detect Li, meaning that mineral phases containing this light element can sometimes be misidentified using this technique alone. Raman spectroscopy can easily identify Li-bearing mineral phases, is nondestructive and requires minimal sample preparation. The analytical work was carried out at the University of Manitoba (Winnipeg, Manitoba) using a HORIBA Scientific LabRAM ARAMIS instrument equipped with a 460 mm focal length spectrometer, multichannel electronically cooled charge-coupled device detector, motorized x–y–z stage and solid-state 532 nm laser (mpc6000 by Laser Quantum) with a nominal output power of 50 megawatts (mW). The instrument was operated in confocal mode; an Olympus microscope coupled to the spectrometer was used to focus the laser beam on the sample surface and collect the generated Raman signal. The spectra were collected with a diffraction grating of 1800 g/mm; other instrumental parameters (data-collection times, slit width, etc.) were optimized by performing multiple measurements on the same area. Raman spectrum from spodumene reference material from the University of Manitoba collection was collected for comparison.

Preliminary results

Ice-flow reconstruction

Erosional ice-flow indicators were mapped at 38 field stations during the 2022 and 2023 field season in the Bird River study area (Hodder and Gauthier, 2023; Figure GS2023-12-4a). Striations and grooves account for the majority of documented erosional paleo–ice-flow indicators. Most of the outcrops visited were not glacially polished, due to postglacial subaerial weathering, and these outcrops generally only preserved the most recent ice-flow direction. The exception to this is at the Irgon pegmatite where the Quaternary sediments covering the bedrock were recently removed and glacially polished bedrock is now exposed, which provides an excellent opportunity to document the preserved ice-flow indicators (e.g., Figure GS2023-12-3a–d).

Four phases of ice flow are interpreted based on relative-age relationships observed in the study area (Figure GS2023-12-4b). The oldest ice-flow events preserved in the erosional record are toward the west-southwest to west (255–270°) and south to south-southwest (185–208°). There were no age relationships observed between these two ice-flow events in the study area. Following these older ice-flow events, east-southeast to

[1] MGS Data Repository Item DRI2023012, containing the data or other information sources used to compile this report, is available online to download free of charge at https://manitoba.ca/iem/info/library/downloads/index.html, or on request from minesinfo@gov.mb.ca, or by contacting the Resource Centre, Manitoba Economic Development, Investment, Trade and Natural Resources, 360-1395 Ellice Avenue, Winnipeg, Manitoba R3G 3P2, Canada.
[2] MGS Data Repository Item DRI2023011, containing the data or other information sources used to compile this report, is available online to download free of charge at https://manitoba.ca/iem/info/library/downloads/index.html, or on request from minesinfo@gov.mb.ca, or by contacting the Resource Centre, Manitoba Economic Development, Investment, Trade and Natural Resources, 360-1395 Ellice Avenue, Winnipeg, Manitoba R3G 3P2, Canada.

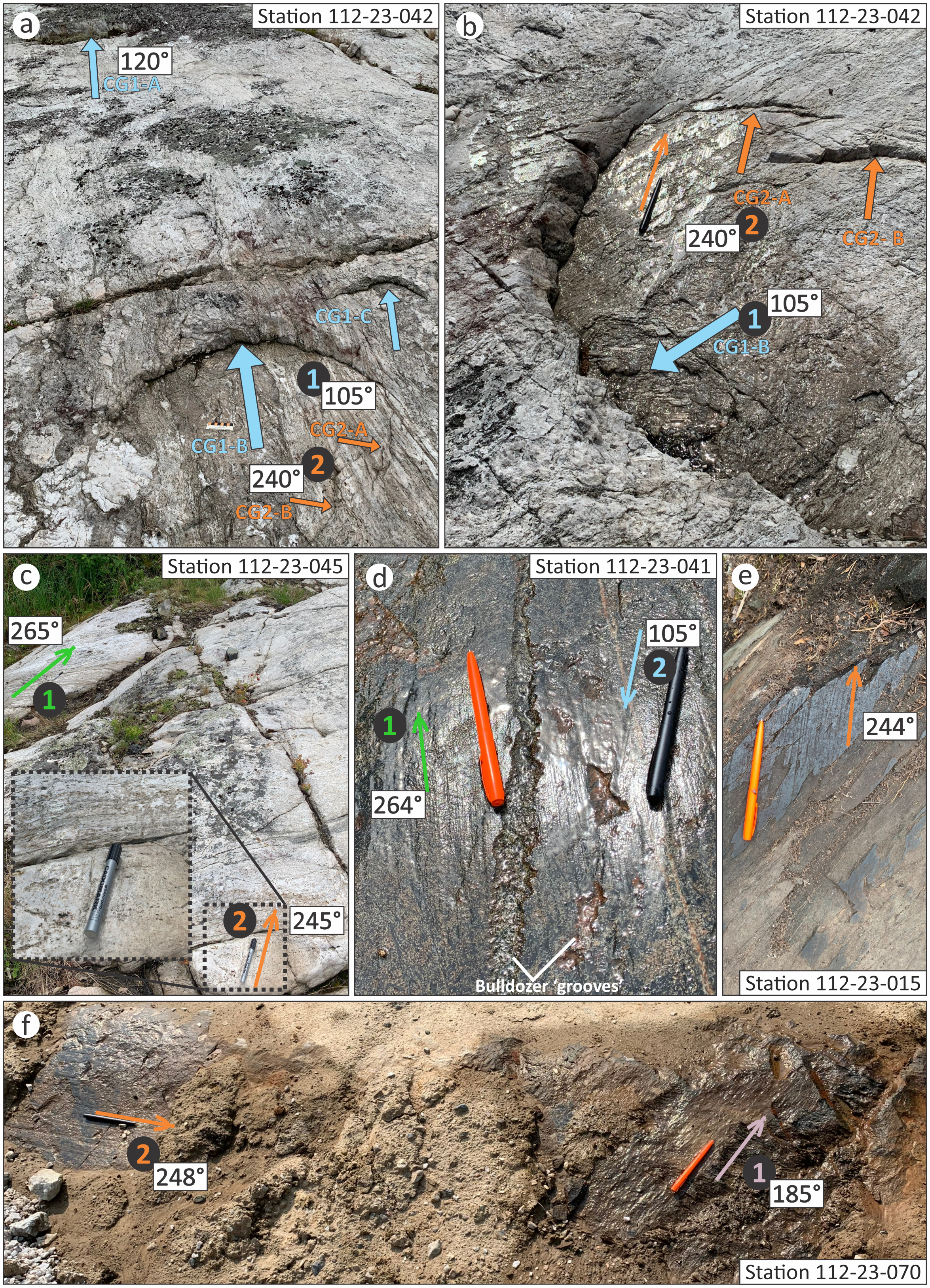

Figure GS2023-12-3: *Examples of field-based erosional ice-flow indicators observed:* ***a, b)*** *crescentic gouges and striations on the crest of the Irgon pegmatite. Note, specific crescentic gouges have been labelled (e.g., CG1-A, CG2-B) to help the reader orient themselves between photos. The right limb of the CG1-B crescentic gouge has been remoulded by the later 240° ice flow providing a relative age relationship at this site;* ***c)*** *striations oriented at 265° are situated on the down-ice side of the outcrop that was protected from the most recent 245° ice flow;* ***d)*** *striations oriented toward 264° are crosscut by a younger set of striations oriented at 105–285° on a surface of the Irgon pegmatite that is at a lower elevation than the crest of the pegmatite (protected);* ***e)*** *a more resistant part of the outcrop is striated at 244° on top;* ***f)*** *striations oriented at 185° are situated on a facet that was protected from a later 248° ice flow.*

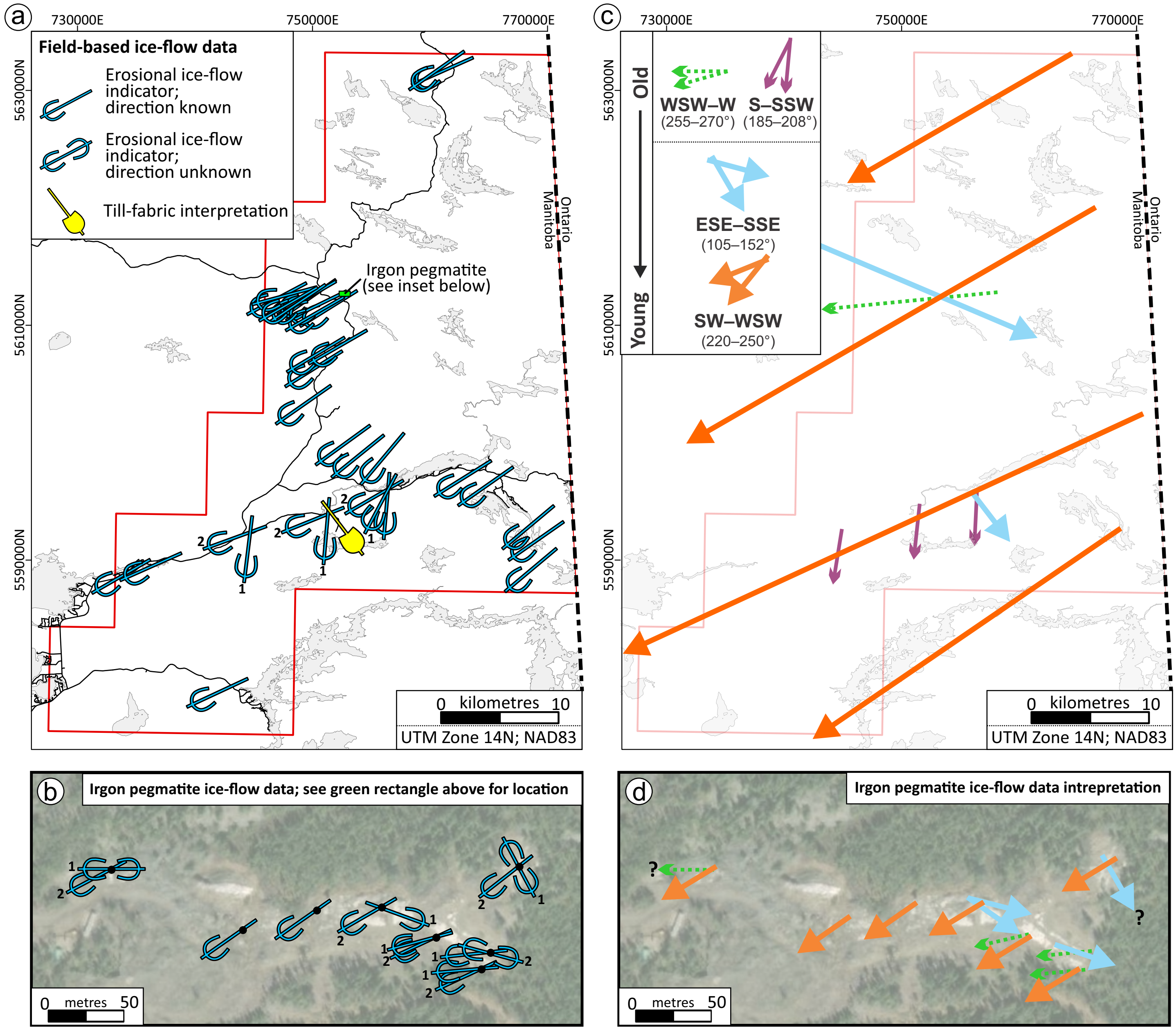

__Figure GS2023-12-4:__ Ice-flow indicator data and interpretation of the relative ice-flow history in the Bird River area: __a)__ field-based ice-flow indicator data measured in the study area; __b)__ aerial view of the area around the Irgon pegmatite and ice-flow indicators measured; __c)__ an interpretation of the relative ice-flow history; __d)__ aerial view of the area around the Irgon pegmatite and ice-flow data interpretation. Abbreviations: E, east; N, north; S, south; W, west. Basemap imagery in b) and c) was created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri software please visit <https://esri.ca/>.

southeast-trending (105–152°) ice overrode the study area. This ice-flow event is evidenced by large-scale crescentic gouges on the crest (Figure GS2023-12-3a, b) and as striations in relatively low-lying areas of the Irgon pegmatite (Figure GS2023-12-3d). A till fabric measured in a relatively denser till with a blocky soil structure (Figure GS2023-12-2c, f), which is qualitatively different than surficial till sampled in the study area, yielded a northwest-southeast (323-143°) fabric orientation and is tentatively correlated to this ice-flow event. This till is situated at 2.5 m below ground surface. The last ice-flow event that the region experienced trended southwest to west-southwest (220–250°). Erosional indicators associated with this ice-flow event are visible at most outcrops visited in the study area.

Indicator-mineral pilot study

Five till samples were submitted as part of a pilot study to determine if Li-bearing minerals could be recovered from till samples (Figure GS2023-12-1). This sampling consisted of a single sample collected ~150 m southwest of the spodumene-bearing F.D. No. 5 pegmatite in the Bird River study area (see Martins et al., 2023; Roush et al., 2023), which is down-ice of the dominant ice-flow direction in the region, and four samples extracted from MGS archives that were collected in 2020 from the east-side road reconnaissance study (Gauthier and Hodder, 2020, 2021).

F.D. No. 5 pegmatite

The till sample collected 150 m southwest of the F.D. No. 5 Li-bearing pegmatite recovered 35 spodumene [$LiAl(Si_2O_6)$] grains within the MDMC (sample 112-22-503-A01; Figure GS2023-12-5; e.g., Figure GS2023-12-6a). The recovery of spodumene from till using a mid-density mineral separation indicates that this novel technique developed at ODM is another tool that can be used in the exploration of Li-bearing pegmatites in the province. Additional till samples were collected in the vicinity of the Li-bearing pegmatites (F.D. No. 5 and Eagle) near Cat Lake (Martins et al., 2023; Roush et al., 2023) during the 2023 field season to gain further understanding of the till composition around these occurrences.

Surprisingly, within the HMC, seven quartz with gahnite ($ZnAl_2O_4$) grains (e.g., Figure GS2023-12-6b) and six scheelite ($CaWO_4$) grains (e.g., Figure GS2023-12-6c) were recovered. There are no known occurrences of zinc or tungsten to the northeast (which is the up-ice direction based on local ice-flow indicators; Figure GS2023-12-5b) of this sample site (Martins et al., 2023).

Importantly, there were also 63 gold grains recovered from this sample (e.g., Figure GS2023-12-6d), including 23 pristine grains (Figure GS2023-12-5). This is a significant amount of gold grains and is nearly double the previous high (n = 35 total grains) recovered from surficial till sampled during the NATMAP projects in southeastern Manitoba (n = 350 samples; Thorleifson et al., 2009). A comparison with visible gold concentrations in the province-wide till dataset (n = 6709 samples; Gauthier, 2020) indicates that this sample ranks in the >99th percentile. The bedrock source of these gold grains is unknown and the closest known gold occurrence is situated 10 km to the northeast (which is up-ice based on the dominant regional ice-flow direction) of this sample site (Martins et al., 2023). The till-matrix geochemistry of this sample is being analyzed alongside the 2023 samples and results are pending.

East-side road

Two till samples collected along the east-side road recovered REE minerals of interest from the HMC: euxenite [$(Y, Ca, Ce, U, Th)(Nb, Ta, Ti)_2O_6$] and parisite [$Ca(Ce, La)_2(CO_3)_3F_2$]. These two samples are situated 30.7 km apart (samples 112-20-011-A01 and 122-20-057-B01; Figure GS2023-12-5) and the bedrock source of the REE minerals recovered is uncertain. Euxenite can be found associated with U-Th-REE–rich granitic pegmatites as described by Bannatyne (1985) for dikes in the Shatford Lake area, Manitoba, or by Simmons et al. (2012) in north-central and southwestern United States. Euxenite is also found in other mineralized systems such as placer deposits (radioactive black sand deposits, Idaho, United States; Kiilsgaard and Hall, 1986), alkaline complexes (Strange Lake deposit, northern Labrador; Miller, 2021) or carbonatites (Aley complex, northeastern British Columbia; Chakhmouradian et al., 2015). Parisite has been described as a rare accessory mineral in the Strange Lake Main Zone deposit (McClenaghan et al., 2019), which hosts Zr-Nb-Y-REE mineralization, associated with a peralkaline granite intrusion in northern Labrador.

Within the MDMC of sample 112-20-027-A01, two spodumene grains were recovered (Figure GS2023-12-5). This is interesting since there are no known Li-bearing pegmatites in this region. To verify this occurrence in till, picked spodumene grains were analyzed with Raman spectroscopy (Figure GS2023-12-7; Table GS2023-12-1) as a follow up from SEM analyses. This analysis looked at the Raman spectra of a spodumene reference material, two picked grains recovered from till sampled down-ice of the F.D. No. 5 pegmatite (sample 112-22-503-A01) and the two grains recovered from till sampled along the east-side road (sample 112-20-027-A01). This analysis confirmed that all four of the picked grains analyzed from till are spodumene and an example of the Raman spectra of one grain from sample 112-20-027-A01 is presented alongside the spodumene reference material in Figure GS2023-12-7 and Table GS2023-12-1.

Elevated Li and Cs concentrations in till matrix

The reconnaissance-scale survey of the east-side road was the first publicly available dataset of till composition for this region (Gauthier and Hodder, 2021). Given the surprising presence of spodumene grains, the Li and Cs partial digestion (aqua regia) concentrations were plotted alongside the province-wide dataset (Gauthier, 2022). Three till samples from the east-side road have >99th percentile Li concentrations and >95th percentile Cs concentrations (Figure GS2023-12-8a, b); these data are also plotted spatially on Figure GS2023-12-5. One of these sites is situated 10.7 km to the northwest of the site where two spodumene grains were recovered from the till sample, and the other two elevated Li-concentration samples are from sites situated 9 km to the north of Bloodvein (Figure GS2023-12-5). Again, there is no known source for Li or Cs in this area.

To the west of Lake Winnipeg, a till-sampling survey was conducted in 2003 within the Fisher Branch (NTS 62P) area. This data was resurrected from digital archives and published in 2016 (Hodder and Bater, 2016). The geochemical data cannot be directly compared with the east-side road data because a different size fraction of the till matrix was analyzed (<177 µm) using a different digestion (four-acid, near-total digestion). However, the Fisher Branch till samples (n = 46) were analyzed alongside the reanalysis of a large number of archived samples (n = 1509) from northwestern Manitoba (Lenton and Kaszycki, 2005). The dataset from the Fisher Branch area (NTS 62P) contains two samples with elevated Li values and two samples with elevated Cs values (Figure GS2023-12-8c, d). When compared to the larger dataset

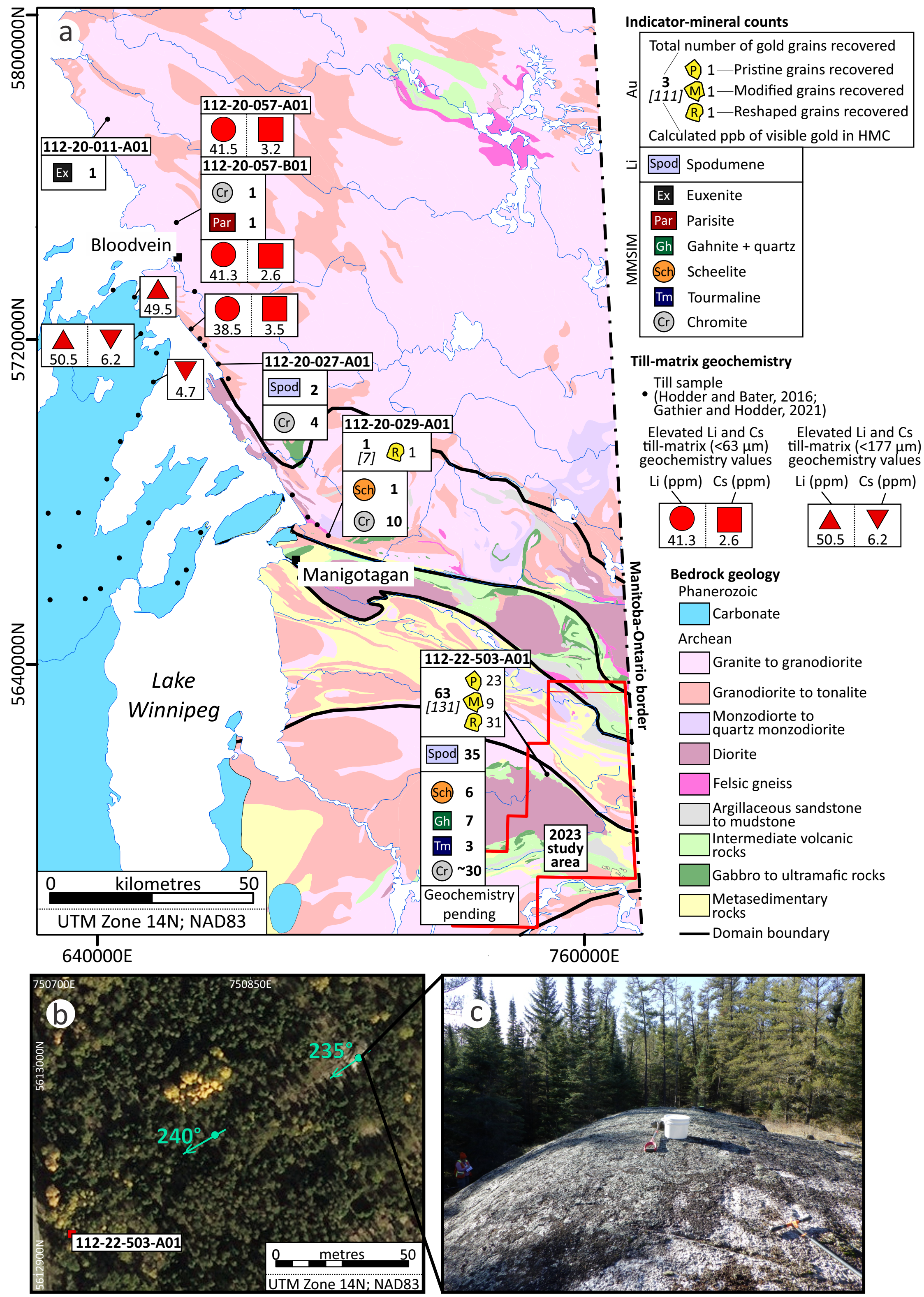

Figure GS2023-12-5: *Pilot study indicator-mineral results and till-matrix geochemistry data from the reconnaissance-scale east-side road (Gauthier and Hodder, 2021) and Fisher Branch area (Hodder and Bater, 2016) studies:* ***a)*** *till-matrix geochemistry values, gold grain counts and selected indicator minerals recovered from till sampled along the road connecting Manigotagan to Berens River (east-side road) and down-ice of the F.D. No. 5 pegmatite (sample 112-22-503-A01); Precambrian bedrock geology is modified from Manitoba Geological Survey (2022) and Phanerozoic bedrock geology is from Nicolas et al. (2010);* ***b)*** *aerial view of the area around the F.D. No. 5 pegmatite with the locations of till sample 112-22-503-A01 and ice-flow indicators measured;* ***c)*** *ground view of the outcropping F.D. No. 5 pegmatite looking down-ice (southwest) with visible ice-flow indicators (grooves) on top. Basemap imagery in b) was created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri software please visit <https://esri.ca/>. Abbreviations: HMC, heavy density mineral concentrate; MMSIM®, metamorphic massive-sulphide–indicator minerals.*

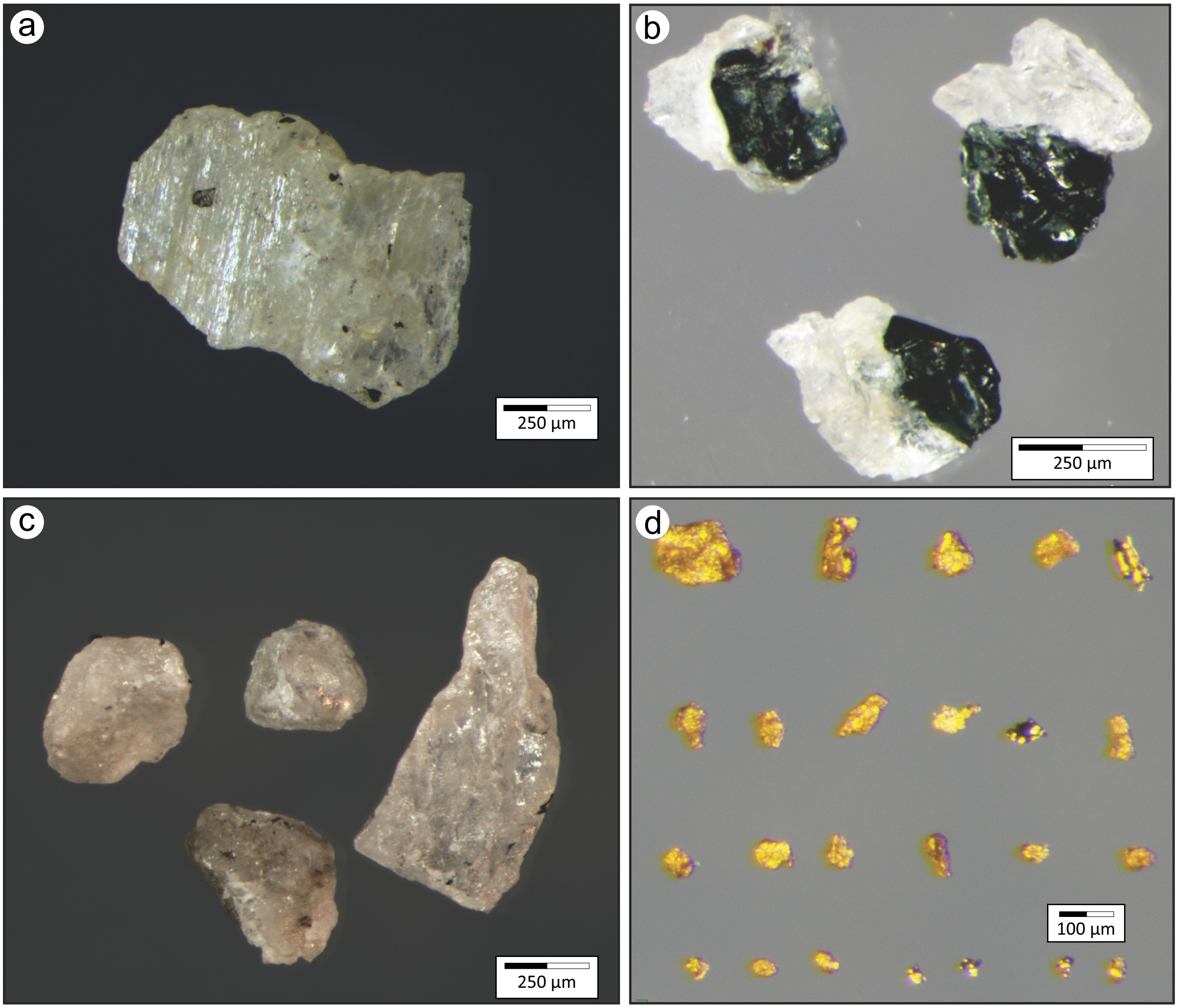

Figure GS2023-12-6: *Example of indicator minerals and gold recovered from sample 112-22-503-A01, which was sampled 150 m down-ice of the F.D. No. 5 Li-bearing pegmatite:* ***a)*** *spodumene grain;* ***b)*** *quartz and gahnite grains;* ***c)*** *scheelite grains;* ***d)*** *gold grains.*

from northwestern Manitoba, the Fisher Branch Li values are in the >98th percentile and the Cs values are in the >97th percentile. This indicates that these Li and Cs values are significant from a regional-scale perspective. These till samples with elevated concentrations are situated 13–30 km southwest of Bloodvein, in close proximity to the elevated Li and Cs samples from the east-side road reconnaissance survey (Figure GS2023-12-5).

The occurrence of elevated Li and Cs values from two different surveys that are spatially coincident, coupled with the recovery of spodumene grains from an indicator-mineral sample from this study, suggests that there is potential for Li-bearing pegamatite mineralization in the region. The dominant ice-flow direction in the region is toward the southwest (220–250°; Gauthier and Hodder, 2020), thus additional till sampling to the east and northeast of Bloodvein could help elucidate the bedrock source.

Suitability of published surficial mapping to guide drift prospecting

Successful drift-prospecting surveys using glacial sediments must use till and not other surficial sediments (McClenaghan et al., 2001, 2020). The Bird River study area is covered by two surficial geology maps that were published at a 1:100 000 scale (Mann, 2004a, b). It is important to note that the fieldwork component of this mapping was primarily restricted to road and trail access, with limited fixed-wing air support (Matile et al., 1998). As a result, there is not an equal distribution of field stations across the mapped area with large regions that have no field-based observations to verify the airphoto interpretations (Figure GS2023-12-9). The surficial geology maps indicate a landscape that is dominated by glacial-derived sediments and bedrock (Figure GS2023-12-9). For the glacial-derived sediments, it

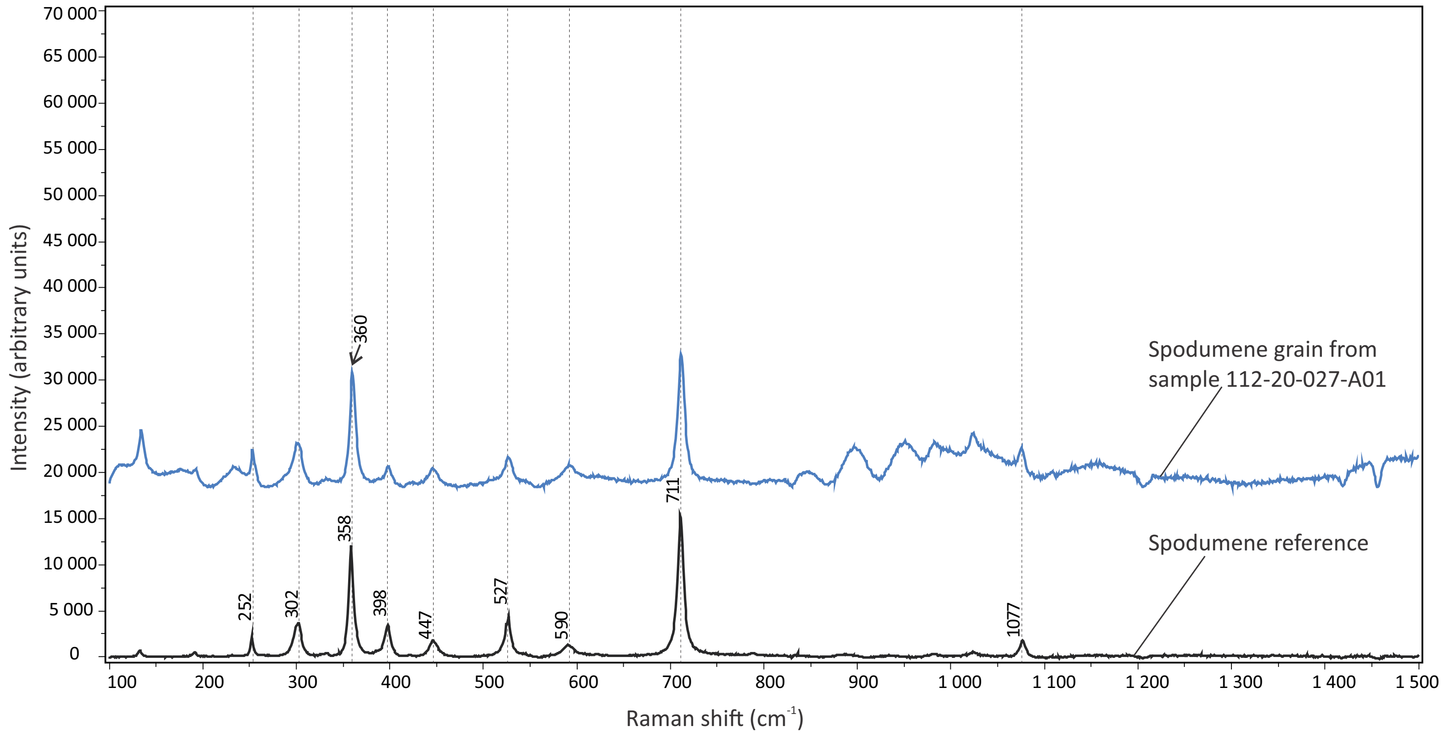

Figure GS2023-12-7: *Raman spectra of spodumene reference material (black) and from one of the spodumene grains recovered from sample 112-20-027-A01 (blue). Note the fluorescence effect after the 850 cm^{-1} range for the spodumene grain from sample 112-20-027-A01 not allowing for a clear match to the peak at approximately 1077 cm^{-1}.*

Table GS2023-12-1: Raman shift of spodumene (reference material and sample 112-20-027-A01) compared to the literature.

Spodumene reference material	Sample 112-20-027-A01	Sharma and Simons (1981)	Raman shift
		225	
252		247	
302	302	296	
		326	M-O stretch/bend
358	360	356	
398	398	389	
		412	
447	447	436	
527	527	512	
		542	O-Si-O bend
590	590	583	
		614	
711	711	707	
		782	$Si-O_{br}$ stretch
		884	
		973	
1077		1012	
		1066	$Si-O_{nbr}$ stretch
		1095	

Abbreviations: br, bridging stretching; nbr, nonbridging stretching; O, oxygen; Si, silicon.

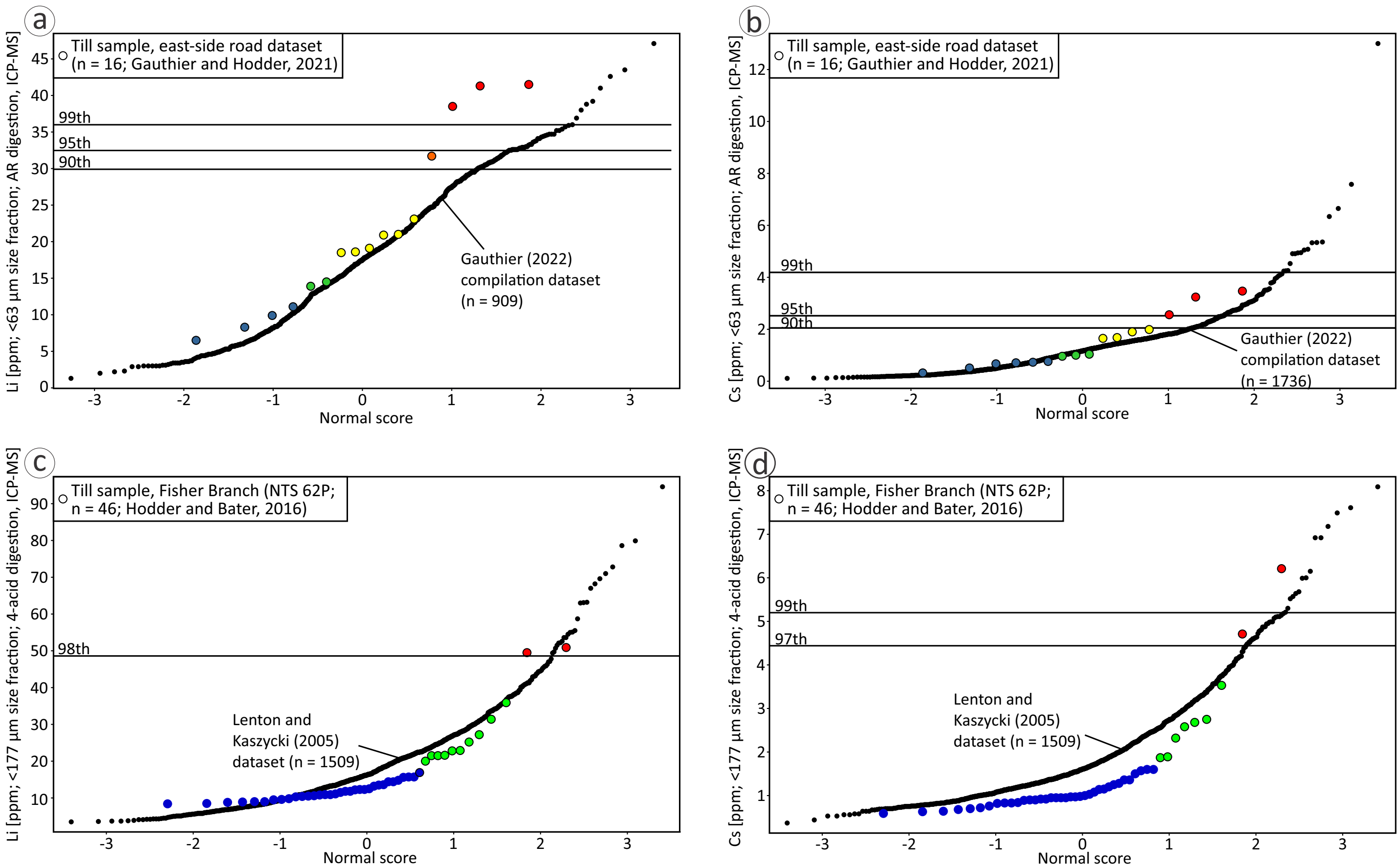

Figure GS2023-12-8: *Till-matrix geochemistry probability plots (Li and Cs) for east-side road and Fisher Branch till samples, compared to regional-scale datasets. Sample symbols have been coloured according to natural breaks, which have been qualitatively identified. Elevated values (red) are plotted spatially on Figure GS2023-12-5:* ***a, b)*** *Li and Cs values from the east-side road study (Gauthier and Hodder, 2021) are compared to values from the province-wide compilation dataset (Gauthier, 2022);* ***c, d)*** *Li and Cs values from the Fisher Branch area (Hodder and Bater, 2016) are compared to reanalyzed till samples from northwestern Manitoba (Lenton and Kaszycki, 2005), which were analyzed at the same time using similar analytical methodologies. Abbreviations: AR, aqua-regia; ICP-MS, inductively coupled plasma–mass spectrometry.*

is important to highlight that by definition these polygons can only be used as guide to where to look for till to sample for drift-prospecting. The legend states that these polygons comprise “gravelly silt to sandy diamicton, sand and gravel; 1–30 m thick; low-relief deposits between outcrops making up 25–75% of the area” (Mann, 2004a, b). Furthermore, these polygons comprise “sandy till interbedded and interspersed with nearly equal and often greater amounts of sandy glaciofluvial sediments, as well as minor glaciolacustrine sediments” (Mann, 2004a, b). These vague and all-encompassing descriptions were the best attempt at the time to acknowledge the scale of mapping, the boreal forest cover, the largely discontinuous sediment cover and the lack of regional field sites. Any future mapping efforts, by the MGS or mineral exploration companies looking for till, will require detailed digital elevation models, such as those derived from light detection and ranging (LiDAR) data, to better understand and map the surficial geology.

Map inaccuracies

The field-station data collected at the time these surficial geology maps were made is now published (Matile et al., 2023c). When comparing these field-based sediment interpretations with the mapped polygons, there are significant discrepancies. To highlight this, two areas are shown with the mapped polygons and field stations plotted together (Figure GS2023-12-10). In the first example (Figure GS2023-12-10a), the area is primarily mapped as discontinuous till and associated glaciofluvial sediments or organic deposits. Yet, the original field station observations indicate that this a bedrock-dominated terrain; confirmed in the field this year and clearly discernible from satellite imagery (Figure GS2023-12-10a). At the one station where till was observed in the field, the area was subsequently mapped as organics. The surficial materials at this location were confirmed as part of this study to be till with a prominent cobble and boulder lag at surface (Figure GS2023-12-10b). In the second example (Figure GS2023-12-10c), all of the field-based observations were of sorted sediments, organics or bedrock, but the subsequent mapping portrays a landscape dominated by discontinuous till and associated glaciofluvial sediments. Even though some of these sediments may have been deposited in a glaciofluvial environment, it is more likely that the majority of these sorted sediments were deposited within glacial Lake Agassiz, which cov-

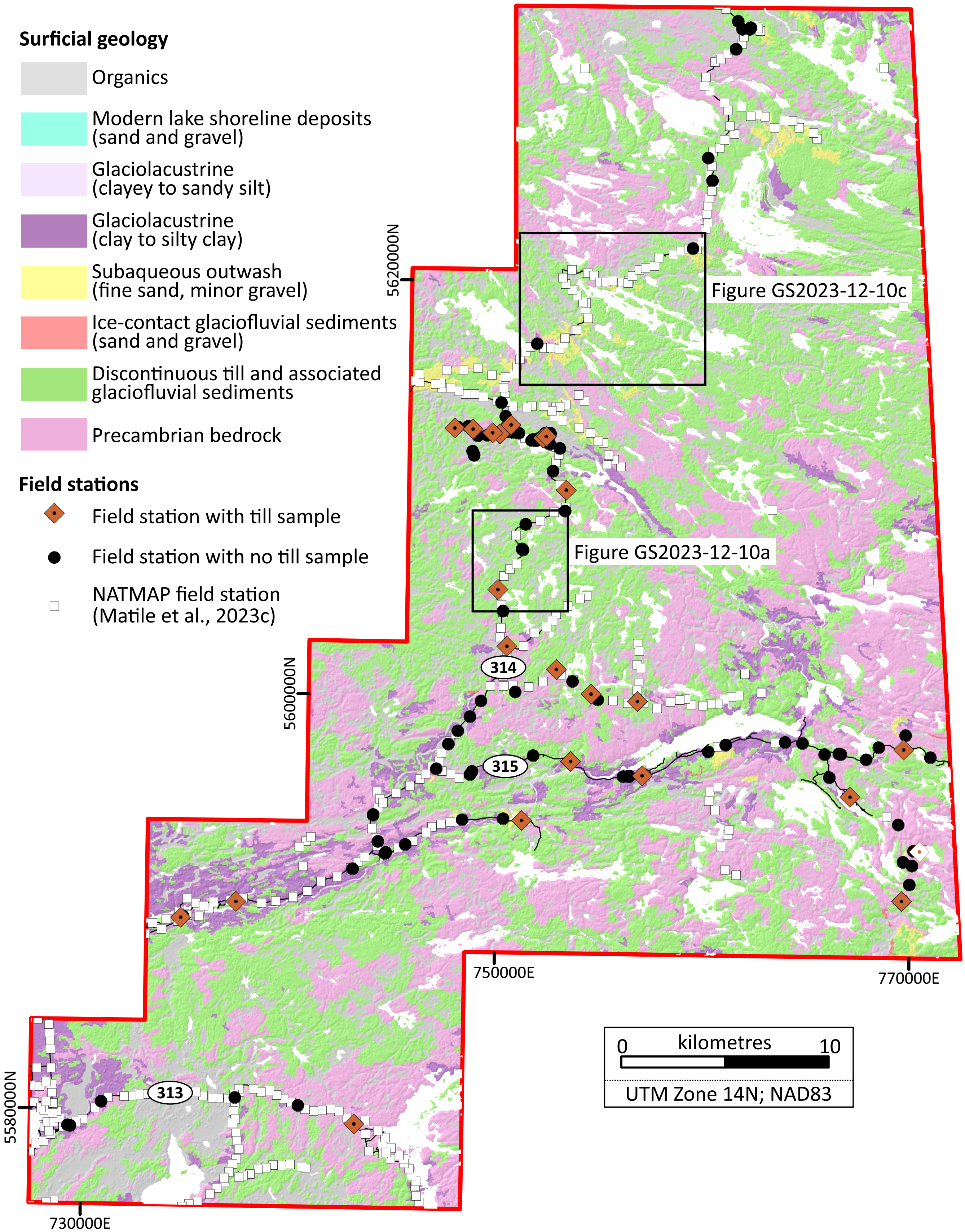

Figure GS2023-12-9: *Surficial geology of the Bird River study area (Mann, 2004a, b). The locations of the field stations, observations from which were used to produce these surficial maps, are displayed alongside 2022 and 2023 field stations. Abbreviation: NATMAP, National Geoscience Mapping Program.*

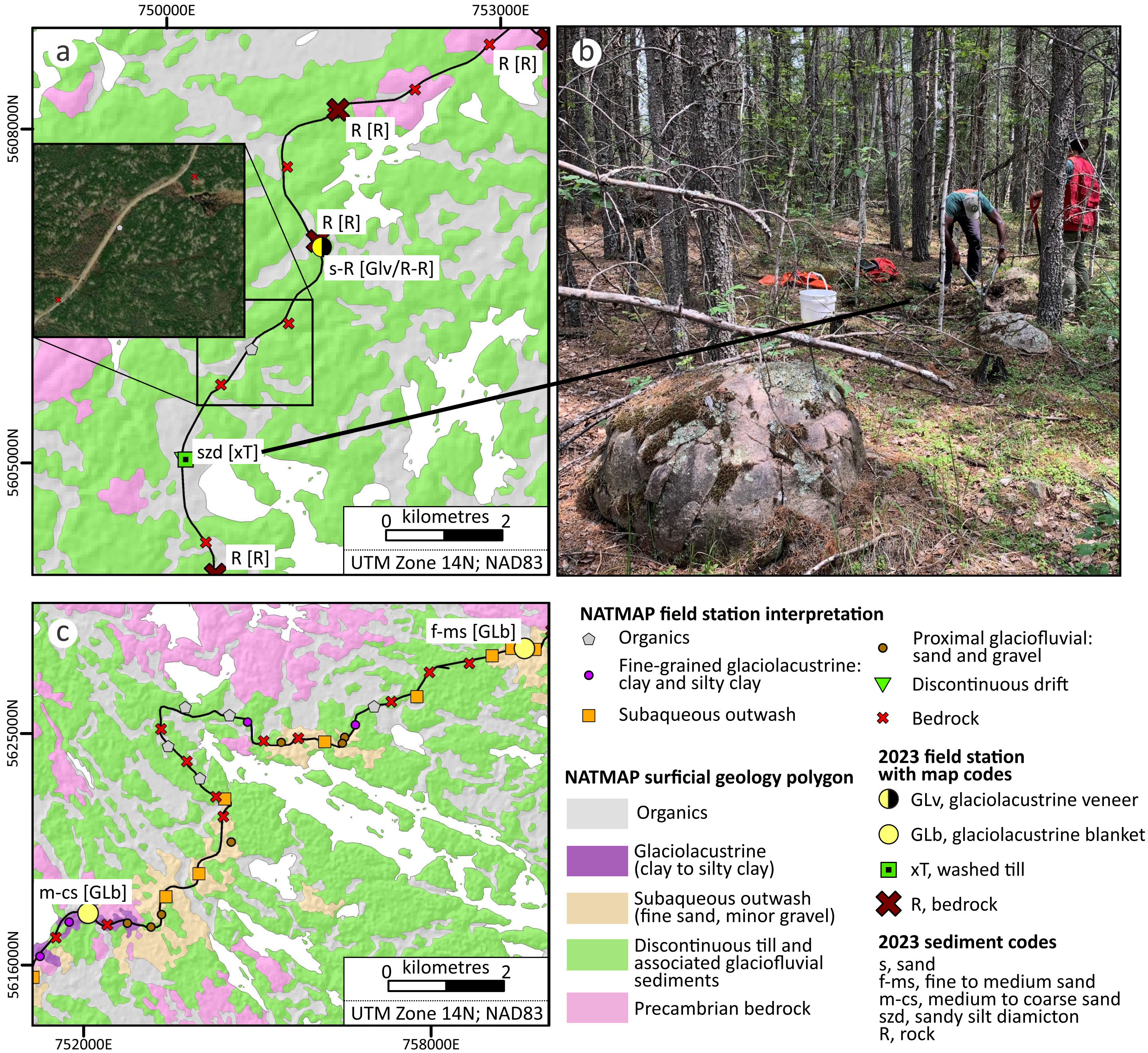

Figure GS2023-12-10: *A comparison between the surficial geology polygons and field-station data from the National Geoscience Mapping Program (NATMAP; Mann, 2004b; Matile et al., 2023c) for two areas in the Bird River study area. Stations from 2023 are presented and labelled with their sediment code and interpreted map code:* ***a)*** *an example of mismatched field-station observations and map polygons and misinterpretation of imagery (see inset);* ***b)*** *ground view of station 112-23-005, location shown in a);* ***c)*** *an example where the field-station data indicated only sorted sediments, organics or bedrock but the area has been mapped primarily as discontinuous till and associated glaciofluvial sediments. Basemap imagery in a) was created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri software please visit <https://esri.ca/>.*

ered this area during several phases of the lake (e.g., Thorleifson, 1996; Fisher and Breckenridge, 2022). Surficial geology maps are typically made using field-station data as 'true', and then interpreting the sediment cover beyond that. The two examples shown here, in addition to many others, highlight that the surficial geology maps are not a reflection of the field-based observations in places.

The published surficial geology maps for the Bird River area overrepresent the proportion of glacial-derived sediments in the area (e.g., diamicton), and underrepresent the proportion of glaciolacustrine sediments (e.g., sand). Furthermore, the mapped polygons do not accurately reflect field-based observations. These issues need to be considered when planning a drift-prospecting survey. To find and sample till in the Bird River area, it is recommended to use the field-based observations in combination with detailed digital elevation models and orthophotography, and not the published surficial geology maps.

Economic considerations

Spodumene was successfully recovered from till sampled 150 m down-ice of the outcropping F.D. No. 5 Li-bearing pegmatite. Till sampled along the east-side road recovered euxenite, parisite and spodumene grains, which highlights the potential for unrecognized U-Th-REE and Li mineralized systems in the area. Nearby where the two spodumene grains were recovered, till samples have regionally elevated values of Li and Cs in the till matrix, which supports the potential for Li-bearing mineralization in this largely unexplored area. These preliminary results indicate that the use of a MDMC to recover spodumene grains can be a useful exploration tool for Li-bearing pegmatites in Manitoba, especially when coupled with till-matrix geochemistry analysis. These methods are being further tested on till samples collected in the summer of 2023. The recovery of elevated gold grain counts, spodumene, scheelite and gahnite from a single till sample in the Bird River study area is a reflection of the region's diverse mineral potential, including critical minerals.

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