GS2024-24

Reconnaissance-scale Quaternary geology investigations to support lithium exploration in southeastern Manitoba (parts of NTS 52L, M, 62P, 63A)

by T.J. Hodder and O.B. Lian[1]

In Brief:

- Investigating the glacial dispersal of detritus from known Li-bearing pegmatites in the Bird River area using multiple parameters
- Reconnaissance-scale sampling of till from Bloodvein to Pointe du Bois

Citation:
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Summary

Quaternary geology investigations were conducted in southeastern Manitoba to map paleo–ice-flow indicators, collect till samples and document the surficial sediments. This study aims to document the till composition down-ice of known Li-bearing pegmatites in the Bird River area and investigate the potential for additional Li-bearing pegmatites in the region. The 2024 field season focused on completing a reconnaissance-scale sampling transect from the First Nation community of Bloodvein to Pointe Du Bois. Preliminary results from till samples collected in 2022–2023 indicate that spodumene recovery in till accurately reflects the location of known Li-bearing pegmatites in the Bird River area. There are at least six phases of paleo-ice flow, with the dominant ice-flow direction toward the southwest to west-southwest (230–250°). This study will provide guidance on till prospecting in Manitoba for Li-bearing pegmatites and a framework for understanding dispersal patterns in southeastern Manitoba.

Introduction

Geological surveys in Canada are conducting studies to better understand Li-bearing pegmatites and improve exploration methods to find new occurrences, including till prospecting best practices (Hagedorn and Beckett-Brown, 2023; Brushett et al., 2024; McClenaghan et al., 2024). As part of this initiative, the Manitoba Geological Survey (MGS) is conducting a multidisciplinary Precambrian and Quaternary geology project focusing on the Bird River area of the Superior province in southeastern Manitoba (Hodder and Martins, 2023; Martins et al., 2023). In 2024, the scope of the Quaternary geology-based fieldwork expanded to include a reconnaissance-scale study of the till composition between the First Nation community of Bloodvein and Pointe du Bois (Figure GS2024-24-1).

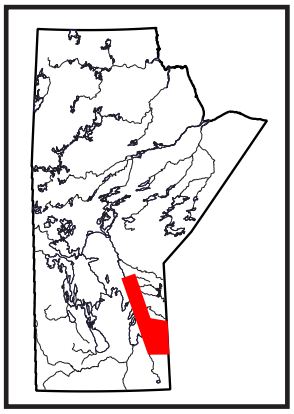
The goals of the Quaternary geology component of this study area are to

- map paleo–ice-flow indicators to assist reconstructions of the glacial history, which in turn guides till prospecting studies;
- assess the suitability of till-matrix geochemistry and indicator minerals to characterize the dispersal of detritus from known Li-bearing pegmatites in the Cat Lake area; and
- collect till samples at a reconnaissance-scale to gauge the prospectivity of the region for additional Li-bearing pegmatites.

Methods

A total of 140 field stations were visited over a 14-day period in 2024 to document the Quaternary sediments, collect till samples and measure the orientation of ice-flow indicators, bringing the total number of field stations visited from 2022–2024 to 279. 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 exposure.

The primary goal of till sampling in 2024 was to collect samples (where possible) at a reconnaissance-scale (approximately every 5–7 km) using road access, from the First Nation community of Bloodvein to Pointe Du Bois (Figure GS2024-24-1). In addition, further till sampling was conducted around the Eagle and F.D. No. 5 Li-bearing pegmatites in the Cat Lake area to better constrain dispersal patterns from these known Li occurrences and further investigate the elevated gold grain counts in till sampled in 2022 and 2023 (Hodder, 2024b). Lastly, till previously sampled along the east-side road contained two spodumene grains that were confirmed by Raman spectroscopy (Hod-



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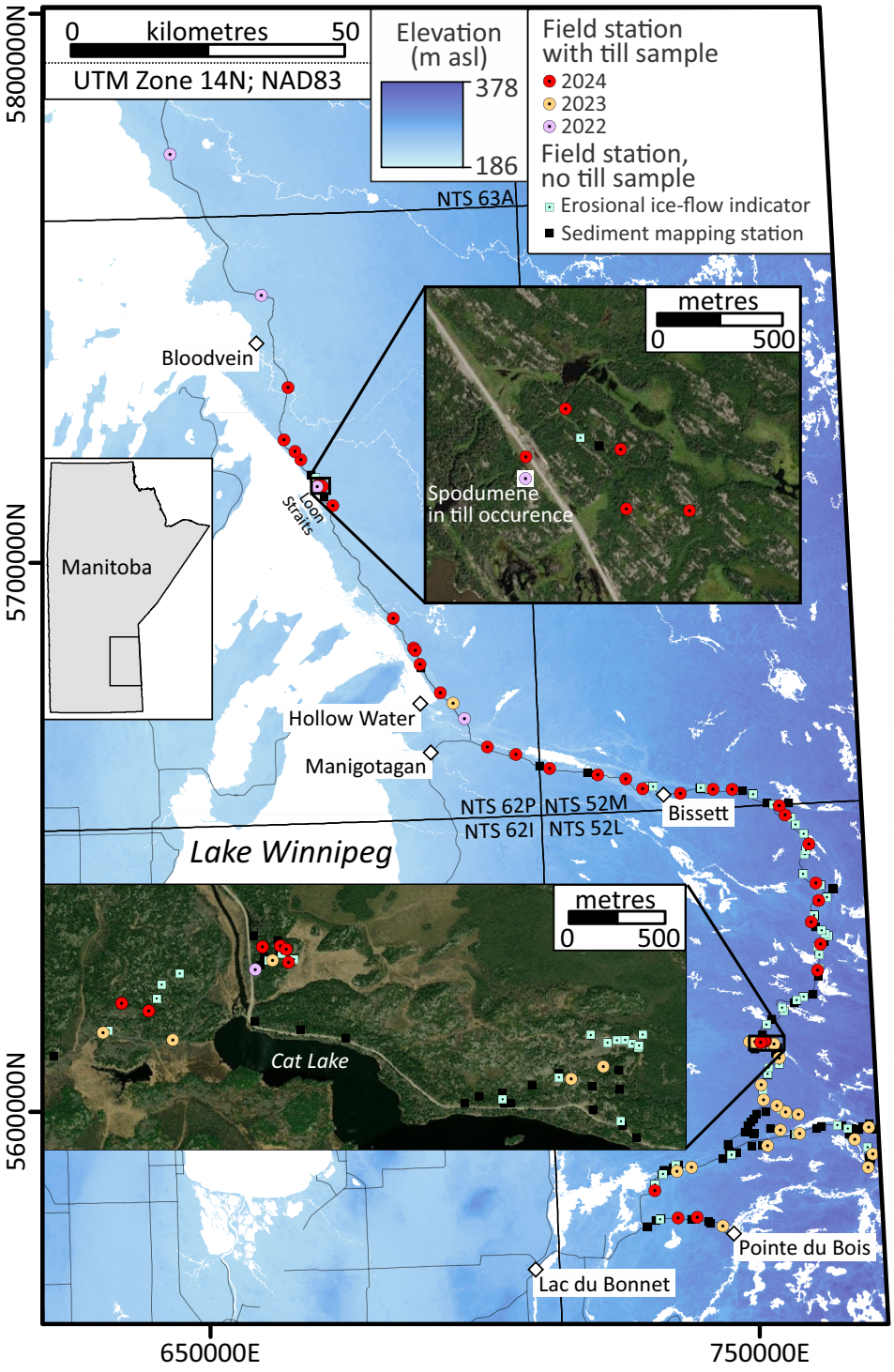

Figure GS2024-24-1: *Location of stations visited in southeastern Manitoba as part of this study. Background elevation data is provided by Earth Observation Research Center and Japanese Aerospace Exploration Agency (2022). Basemap imagery was created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ 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/>.*

der and Martins, 2023; Hodder, 2024b). This was unexpected since there are no known Li-bearing pegmatites in the area and the potential for Li mineralization is considered to be low with no known occurrences in the region (Rinne, 2023a, b); however, till-matrix Li and Cs values are elevated in the region (Hodder and Martins, 2023). To further assess the lithium potential of the region, follow-up till sampling was conducted in the vicinity of the spodumene in till occurrence east of Loon Straits (Figure GS2024-24-1).

Till samples were collected at 41 stations during the 2024 field season at depths ranging from 0.3 to 3.7 m below the natural land surface, adding to the 29 till samples collected in

2022 and 2023 (Hodder and Martins, 2023; Hodder, 2024b, c). At each site, a smaller ~2–3 kg sample and a larger ~14–16 kg sample were collected from diamicton interpreted as till (Evans, 2018). Unmodified C-horizon till is the preferred sample material (n = 23 of 41), though in cases of thin till where C-horizon diamicton was not present or of limited thickness, samples collected consist of a mix of B- and C-horizon diamicton (n = 17 of 41) or B-horizon diamicton (n = 1 of 41). At one site, samples of both the B- and C-horizon till were taken to compare the matrix geochemistry. 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. The 14–16 kg samples were submitted to Overburden Drilling Management Limited (Ottawa, Ontario) for gold counts and indicator-mineral analyses (metamorphic massive-sulphide–indicator minerals [MMSIMs®] and lithium-indicator minerals), as well as the recovery of clasts for lithological classification.

Erosional paleo–ice-flow indicators, such as striae, grooves, crescentic gouges and chattermarks, were mapped at bedrock outcrops within the study area. The relative-age relationships at outcrops that exhibited multiple paleo–ice-flow indicators were deciphered using the crosscutting and outcrop relationships of facets and striae (McMartin and Paulen, 2009; e.g., Figure GS2024-24-2). A clast-fabric measurement in till was completed at one stratigraphic section along the east-side road, where the long-axes orientation (trend and plunge) of 32 elongated clasts, defined by a minimum 1.5:1.0 ratio of the a-axis (longest) to the b-axis (middle), were measured. These elongated clasts tend to rotate within the till matrix and orient parallel to the overlying glacier's shear stress direction (Holmes, 1941; Hicock et al., 1996).

Preliminary results

Till sampling in 2024

The entire study area was inundated by glacial Lake Agassiz following retreat of the Laurentide Ice Sheet from southeastern Manitoba (Fisher and Breckenridge, 2022; Gauthier et al., 2022). This large proglacial lake remobilized fine-grained material (clay, silt and sand) in till deposits, leaving a lag at the surface that consists of interlocked cobble- to boulder-sized clasts. To access unmodified till, the lag surface needs to be excavated and the proportion of silt and clay within the sediment needs to be assessed. In many areas with thin till cover, the extent of post-glacial modification was extensive, and the till was completely eroded, or entirely reworked leaving a clast lag and/or sandy gravel (~0.1–0.7 m thick). Where possible, roadcuts or trailcuts were used to sample till below the lag surface at depth and till was most commonly found encountered on the lee-side of bedrock outcrops (e.g., Figure GS2024-24-3a, b). At the station scale, there is significant spatial variability of till preservation and careful attention to elevation and vegetation, specifically investigating both the high and low terrains, is necessary to increase till sampling efficiency.

Spodumene and Li concentrations in till

In the Bird River area, spodumene {$LiAlSi_2O_6$} grains were recovered from till samples collected in 2022–2023 down-ice of known Li-bearing pegmatites (Figure GS2024-24-4a, b; Hodder, 2024b). The recovery of spodumene in glacial sediment provides a clear reflection of the known mineralization in the area. Problematically, the concentration of Li values in the till-matrix from the same samples is not elevated above background values (Figure GS2024-24-4a, b; Hodder, 2024c). The three highest values of Li in till matrix are all situated up-ice of known Li-related surface occurrences (Figure GS2024-24-4b). Following receipt of the 2024 analytical results, a more detailed analysis of the till composition will be conducted to further examine the relationships between spodumene grain recovery, different size fractions of till-matrix analyzed, analytical digestions used and pathfinder elements.

Ice-flow history

Erosional ice-flow indicators were mapped at 49 field stations during the 2024 field season (Hodder, 2024a[2]). Striations and grooves account for the majority of documented erosional paleo–ice-flow indicators, with minor observations of crescentic gouges and chattermarks. Six phases of ice flow are interpreted based on relative-age relationships observed in the study area (Figure GS2024-24-5). The erosional record is dominated by south-southwest to west-southwest trending paleo–ice-flow indicators that were formed during the final two phases of ice flow that the region experienced (phases e and f) and outcrops in the region are typically moulded toward the southwest. However, there are older ice-flow events that can be deciphered within the erosional record. These include ice-flow events toward the west to west-northwest (phase a, 260–285°), south to south-southwest (phase b, 180–196°), west-southwest (phase c, 252–260°) and east-southeast to south-southeast (phase d, 105–155°). Relative age-relationships indicate that phase a is older than phases c, d, e and f. In the field, no relative-age relationships were observed between phases a and b, or between phase b and phases c and d. This complicates resolving the relative-age relationship between some of these older ice-flow events. Future work will synthesize these observations with previous studies to provide a regional ice-flow reconstruction (Henderson, 1994; Gauthier and Hodder, 2020; Matile et al., 2023).

[2] MGS Data Repository Item DRI2024010, 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.

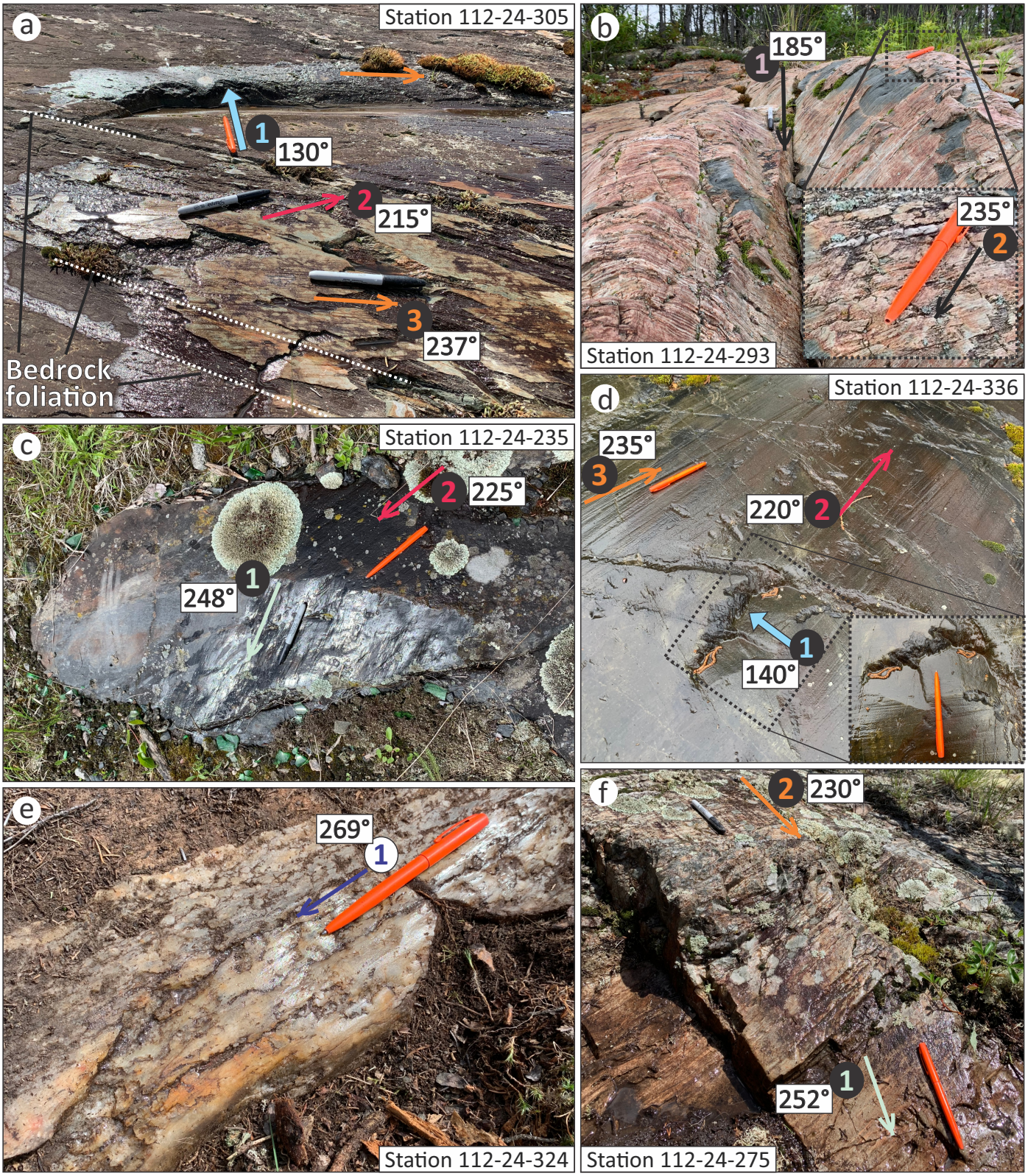

Figure GS2024-24-2: *Examples of erosional ice-flow indicators and the relative age-relationships observed in the study area:* ***a)*** *an older southeast-trending (130°) crescentic gouge is preserved on the upper surface of an outcrop where southwest-trending (215°) striations are crosscut by west-southwest-trending (237°) striations;* ***b)*** *south-trending (185°) striations and grooves are preserved on a protected trough from later southwest-trending (235°) striations and grooves;* ***c)*** *west-southwest-trending striations (248°) are preserved on a protected facet from later southwest-trending (225°) striations;* ***d)*** *an older southeast-trending (140°) crescentic gouge is preserved on the upper surface of an outcrop where southwest-trending striations and grooves (220°) are crosscut by southwest-trending (235°) striations and grooves;* ***e)*** *west-trending (269°) striations are preserved on a protected step from west-southwest-trending (239°) grooves on the uppermost surface of the outcrop (not shown);* ***f)*** *west-southwest-trending (252°) striations are preserved on a protected step from southwest-trending (230°) striations.*

Figure GS2024-24-3: *Examples of field stations where unmodified till was sampled:* ***a)*** *roadcut at station 112-24-249 where till below the clast lag was sampled at depth; the white arrows indicate boulders that form a lag surface over the till deposit;* ***b)*** *aerial and ground view of the roadcut at station 112-24-231 where till was sampled on the lee-side (southwest side, down-ice) of a prominent bedrock outcrop. 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/>. Abbreviation: R, bedrock.*

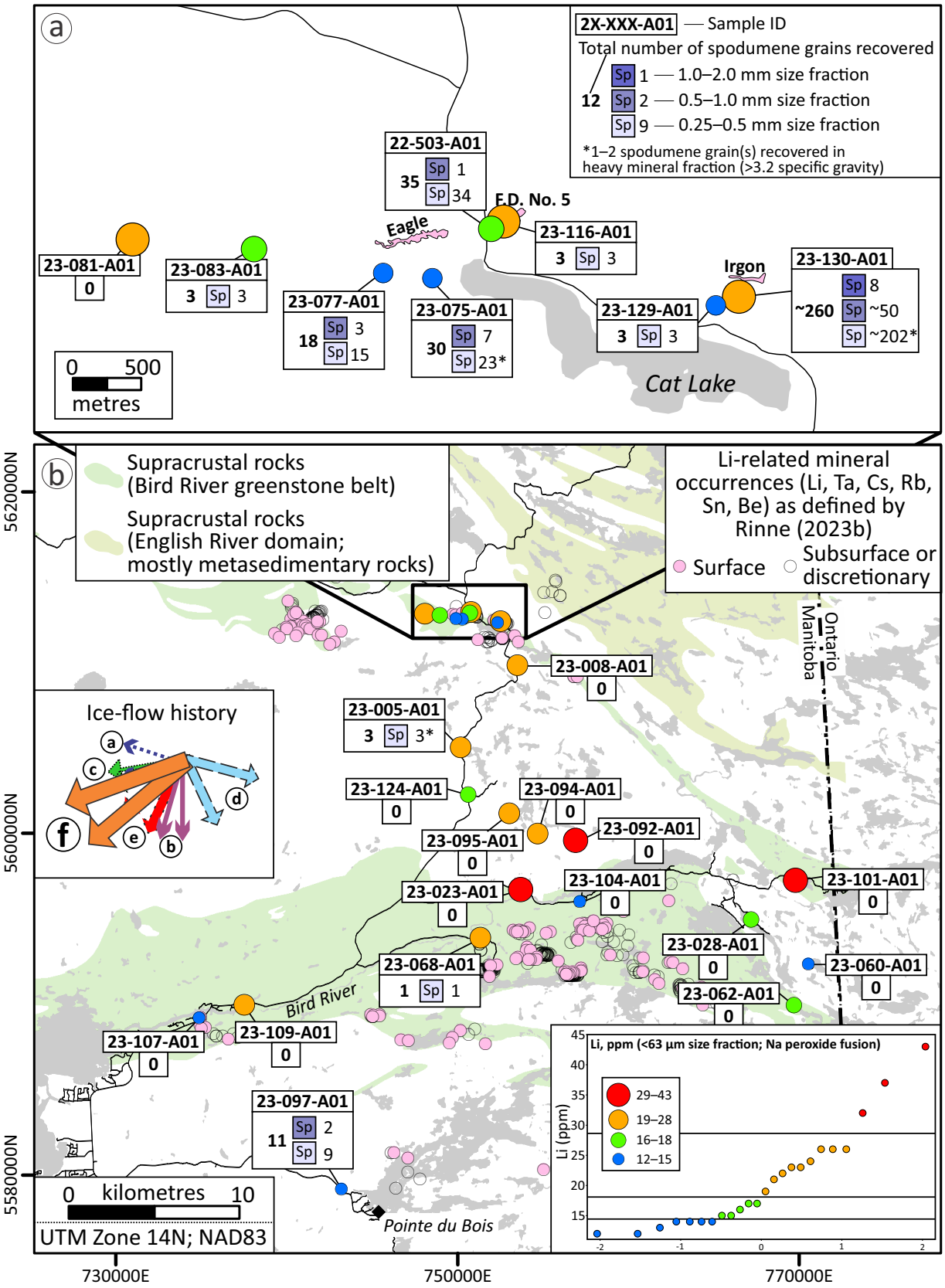

Figure GS2024-24-4: *Till-matrix spodumene counts (0.25–2.0 mm size fraction) and lithium concentrations (<63 µm size fraction) for samples analyzed in 2023 from the Bird River area:* ***a)*** *till samples around Li-bearing pegmatites (pink polygons) in the Cat Lake area, location shown in b);* ***b)*** *regional-scale till samples in the Bird River greenstone belt area. Till-composition data presented are available in Hodder (2024b, c). For clarity, the background geology (modified from Manitoba Geological Survey, 2022) has been simplified to show only supracrustal-dominant and mafic-intrusive units (i.e., approximate greenstone belt outlines).*

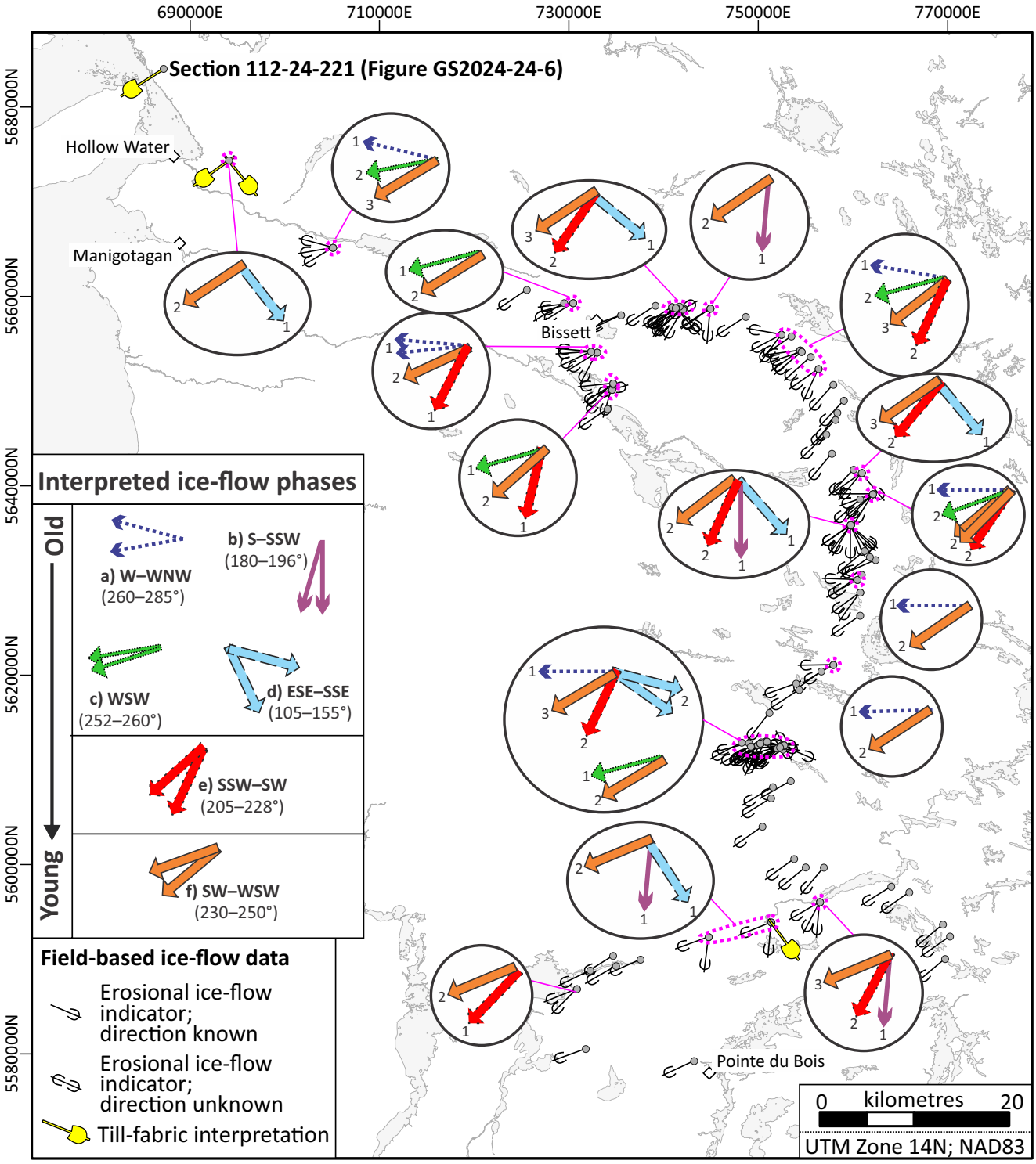

Figure GS2024-24-5: *Ice-flow–indicator data (relative-age relationships indicated) and an interpretation of the ice-flow phases in the study area.*

Importance of Quaternary stratigraphy

Erosional ice-flow indicators provide a relative-age relationship of ice-flow events but provide no indication of absolute timing. To assess the absolute timing of these ice-flow events, sorted sediments that were deposited during ice-free periods (underlying the glacial sediment) are an important stratigraphic constraint. These subtill stratigraphic beds can be dated using radiocarbon (if organics are present) or with optical dating of mineral grains. Understanding the timing of ice-flow events is important for improving spatiotemporal reconstructions of glacial dispersal, which in turn guides till prospecting.

Along the east-side road, two sites have subtill sorted sediments preserved on the lee-side (southwest side) of prominent bedrock outcrops. These sorted sediments are interpreted to

have been deposited during an ice-free period, possibly in a nearshore lacustrine depositional environment. At section 112-24-221 (Figure GS2024-24-6), there is ≥4.5 m of sand and gravel underlying till that drapes an undulating bedrock surface. Sand with crossbedding or horizontal bedding was sampled for optical dating to determine the timing of sediment deposition (Figure GS2024-24-6). The overlying till, qualitatively similar to the typical surficial till sampled across the study area, has a clast fabric that is interpreted to have formed by southwest-trending ice flow. As such, the southwest-trending clast fabric is tentatively correlated to the youngest mapped erosional ice-flow phase (phase f; Figure GS2024-24-5).

Economic considerations

Spodumene was successfully recovered from till sampled down-ice of known Li-bearing pegmatite occurrences in 2022

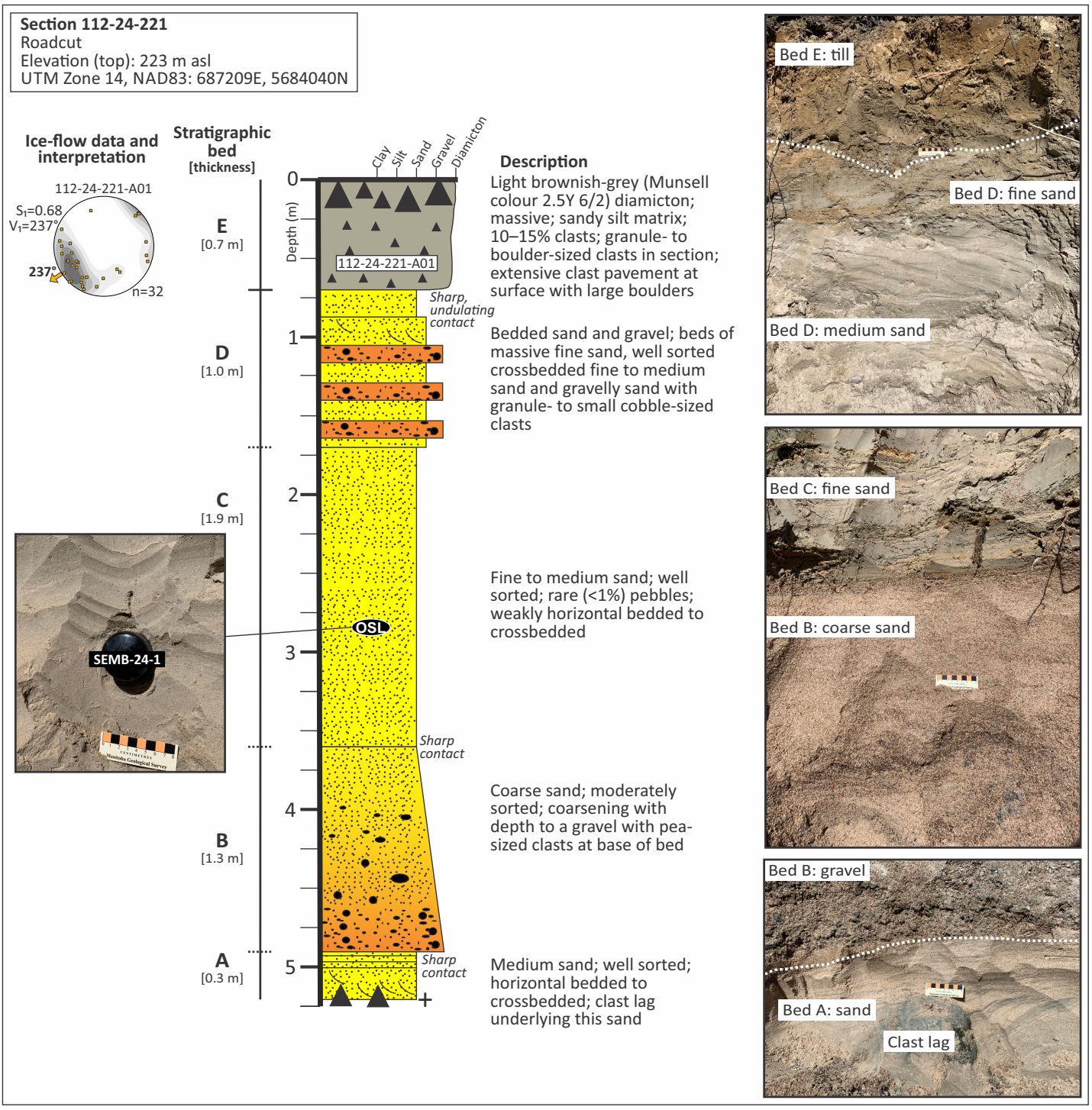

Figure GS2024-24-6: *Quaternary stratigraphy at section 112-24-221. See Figure GS2024-24-5 for location in the study area. Abbreviations: OSL, optically stimulated luminescence sample site; S_1, principal eigenvalue; SEMB-24-1, sample number; V_1, principal eigenvector.*

and 2023 (Hodder et al., 2024b). This highlights the effectiveness of indicator-mineral counts for identifying regions with Li-bearing pegmatites, which can be applied elsewhere in the province. Fieldwork in 2024 sampled till for lithium-indicator minerals at a reconnaissance-scale between the First Nation community of Bloodvein and Pointe du Bois, which will provide insight into the potential for lithium mineralization across this region. Furthermore, the 2022–2023 recovery of gold, euxenite, parisite, scheelite, molybdenite, chromitite and gahnite from till samples (Hodder et al., 2024b) reflects the region's diverse mineral potential, including critical minerals, that is being further evaluated with the analyses of the 2024 till samples.

Acknowledgments

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