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MANITOBA TILL-MATRIX GEOCHEMISTRY COMPILATION 1: SILT PLUS CLAY (<63 µm) SIZE-FRACTION BY INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS

Manitoba Geological Survey

Manitoba

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Manitoba till-matrix geochemistry compilation 1: silt plus clay (<63 µm) size-fraction by instrumental neutron activation analysis

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Cover illustration:

Getting ready to take a till sample in the Gillam area, northeastern Manitoba.

Abstract

This Open File provides a digital dataset for till-geochemistry surveys carried out in Manitoba. Dataset 1 is a compilation of 32 projects that include almost 7000 till samples, with the silt plus clay (<63 µm) size-fraction of the till matrix analyzed by instrumental neutron activation analysis. This data can be brought into GIS software, and integrated with other geoscience data, to generate new exploration targets and design follow-up exploration programs.

Résumé

Ce dossier public comprend un ensemble de données numériques pour les levés de géochimie du till réalisés au Manitoba. L'ensemble de données numéro 1 consiste en la compilation de 32 projets renfermant près de 7 000 échantillons de till, pour lesquels la classe granulométrique du limon et de l'argile (<63 µm) de la matrice de till a été analysée au moyen d'une analyse par activation neutronique instrumentale. Ces données peuvent être téléversées dans un logiciel SIG et intégrées à d'autres données géoscientifiques pour produire de nouvelles cibles d'exploration et concevoir des programmes d'exploration de suivi.

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Introduction

This report captures till-matrix geochemistry data collected from surveys carried out in Manitoba since the 1980s. These surveys generally combine surficial mapping, paleo ice-flow mapping and sampling of till to be analyzed for geochemistry. Publication of the till-geochemistry data from these surveys have been successful in generating exploration activity, as well as providing 'background' baseline values. However, the current forms of data include paper, scanned PDF, diskettes and project-based Microsoft® Excel® spreadsheets, which limit its usefulness.

Moving forward in a digital age, all till-geochemistry data is compiled into databases that will allow users to quickly view, compile and interact with the data from different regions of Manitoba. Importantly, this release also includes graphs depicting the relative abundance of important elements across Manitoba, in both calcareous and non-calcareous till. This data will enable users to more quickly identify when an element concentration is atypical for an area.

This paper serves as a help file for compilation dataset 1. It includes analysis of the silt plus clay (<63 µm) size-fraction by instrumental neutron activation analysis (INAA), from almost 7000 till samples collected between 1987 and 2016 (Figure 1). This database will be updated as new data is released.

Methods

Collection methods

Till samples were collected from road cuts, borrow pits, ditches, natural exposures, hand-dug holes, Dutch-auger holes and boreholes across Manitoba. Wherever possible, till samples were collected from the C horizon in order to minimize potential weathering effects. To learn more about the characteristics of individual till samples, the reader is encouraged to view the original publication.

Till-geochemical surveys in Manitoba were first compiled to produce a till geochemistry index map (Manitoba Agriculture and Resource Development, 2020f). Following that, the data itself was manually compiled and separated according to size-fraction and analytical method. This is the first published compilation, and includes all data with the till matrix (<63 µm size-fraction) analyzed by INAA.

Data captured includes all data directly related to the till sample (Appendix 1). This includes publication number, laboratory used, project name, spatial coordinates, depth of sample and other important information. Depth of sample was transcribed from the original publications, and includes both depth ranges (e.g., 0.7–1.2 m) and single digits (e.g., 1.2 m). Manitoba Geological Survey project numbers were only assigned to some projects as this is a new internal initiative designed to better track projects from year to year. The user should note that the compilation includes samples taken at depth, in some cases by drilling and in others accessed by natural river sections.

Sample location

Sample location is provided for each till sample. Technically, Manitoba crosses three UTM zones (14 to 16). For ease of display in GIS, all data from zone 15 have been re-projected into Zone 14. Hence, all coordinates herein are reported as UTM Zone 14, NAD83. Some older samples may be misplaced by as much as 200 m, as it is unknown when recording methods switched from NAD27 to NAD83. While coordinates were compiled from the original reports, some projects were pre-GPS and the locations were digitized from hand-drawn field maps. Again, the coordinates of these older till samples are to be used as a guide instead of a precise location. This is why the data table includes the column 'Year_sampled' instead of the publication year (Appendix 1, Table 2).

Analytical methods

Till samples were prepared for geochemistry analysis at the Saskatchewan Research Council Geoanalytical Laboratories (Saskatoon, Saskatchewan), the Geological Survey of Canada's Sedimentary Laboratory (Ottawa, Ontario), the Manitoba Geological Survey Midland Sample and Core Library (Winnipeg, Manitoba), and perhaps other undisclosed labs. This compilation includes data from 26 Manitoba till-sampling projects with the sample matrix (<63 µm size-fraction) analyzed by INAA between 1987 and 2016. The processing and analytical methods used vary according to the date of survey. Earlier surveys may have been analyzed for a restricted suite of elements, or at different detection limits (Appendix 1, Table 1). Samples were analyzed at Activation Laboratories Ltd. (Ancaster, Ontario), Bondar-Clegg and Company Ltd. (Ottawa, Ontario), and one at Becquerel Laboratories Inc. (Mississauga, Ontario). The full list of projects included and elements analyzed can be found in Appendix 1, Table 4.

Compilation methods

Included in this digital database is data from almost 7000 till samples collected from 32 different projects. Mass of the till-matrix analysis is included where reported. No effort was made to re-analyze, level or otherwise standardize these values. Some studies reported Sn as ppm and some as percent—all have been converted to percent in Appendix 1, Table 2. Some studies reported Ir as ppm and some as ppb—all have been converted to ppm in Appendix 1, Table 2.

Values below the detection limit are reported as one-half of the detection limit. The reader should know that detection limits may have changed over time (Appendix 1, Table 1), and assess the data accordingly.

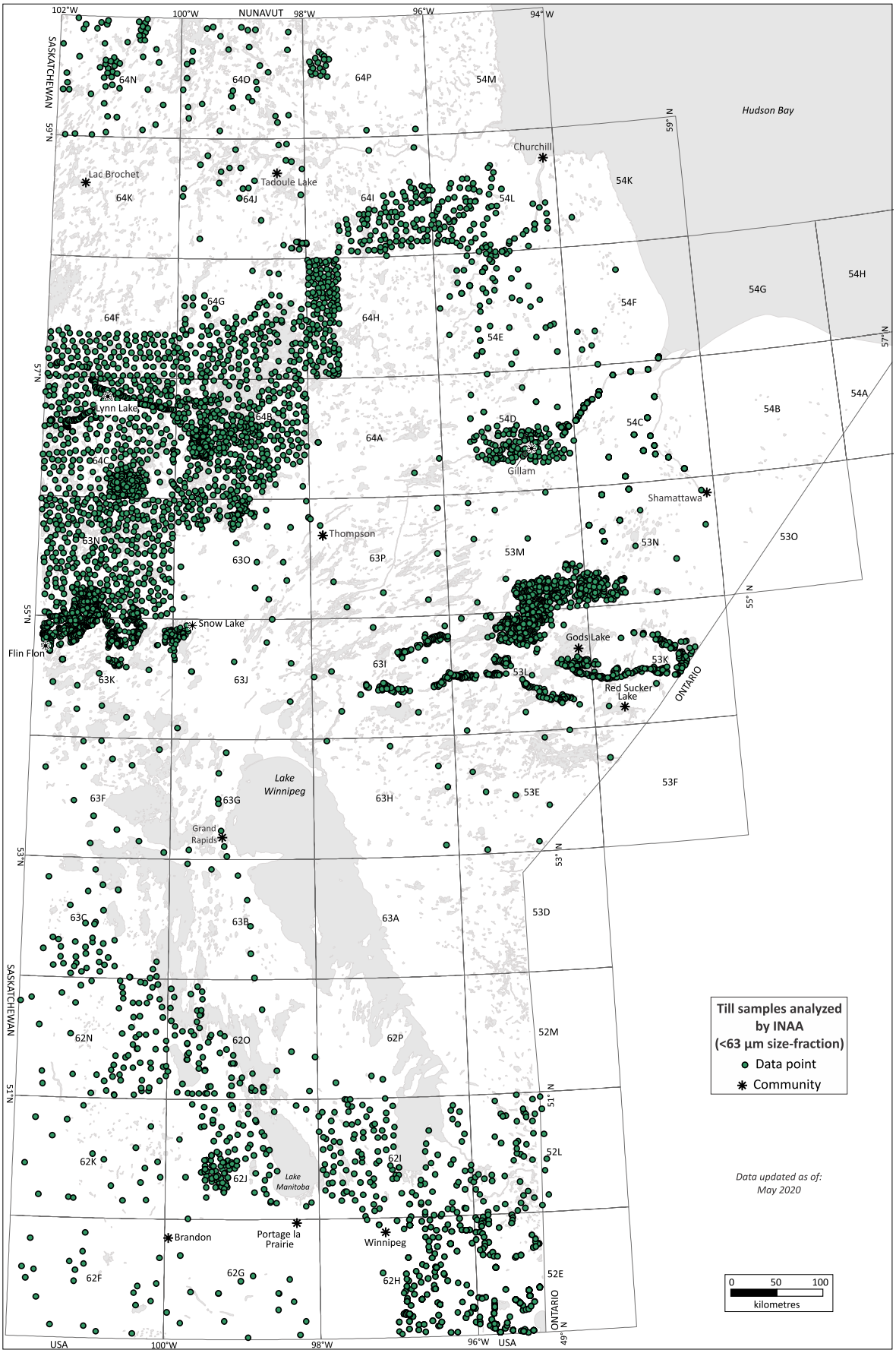

Figure 1: *Till-sample locations where the silt plus clay (<63 µm) size-fraction of the matrix was analyzed by instrumental neutron activation analysis in Manitoba.*

Preliminary results

Summary statistics

The summary statistics for all reported elements are depicted in Appendix 1, Table 1. Eight elements with 90th percentile values at or below detection limit are shown in grey. Most of these elements are not useful for exploration purposes using INAA. Diagrams showing probability plots for all 34 elements are in Appendix 2. The reader can use these plots to quickly understand the statistical distribution of each element, including elevated values and background concentrations. However, given that geology has spatial patterns, all data of interest should be analyzed spatially as well (Grunsky, 2010). For example, background values of iron are lower for tills derived from carbonate bedrock than from granitoid bedrock.

Carbonate till distribution

A significant portion of the till in Manitoba is calcareous (Figure 2). This carbonate has two sources: Paleozoic bedrock of the Hudson Bay Basin in the far northeast, and of the Western Canada Sedimentary Basin (WCSB) in the south (Wheeler et al., 1996), respectively. The net carbonate-dispersal pattern within the till is complex (Figure 2), and generally decreases in concentration to the west, southwest, and south of Hudson Bay. Then, the concentrations increase drastically within tills south of Flin Flon and Snow Lake, reflecting quick entrainment of calcareous detritus from the WCSB. Within this larger pattern, however, the calcareous surface tills locally contain a range of carbonate concentrations that relate to overprinting (dilution and/or reworking) and inheritance (preservation) during till transportation and deposition (e.g., Trommelen et al., 2013; Trommelen and Ross, 2014; Gauthier et al., 2019).

Prospective and background INAA concentrations

Because carbonate rocks are less resistant than most Precambrian shield rocks, they can mask, or dilute, the 'signature' of elements important to exploration. For example, there are no obvious glacial-dispersal patterns from any of the field sites with elevated till-matrix concentrations of multiple metals in the Knee Lake area (Trommelen, 2015). In large part, this is likely because the widespread regional calcareous till is partially masking the local bedrock signature. This masking effect is most obvious in the Knee Lake area, where the carbonate concentration of the surface tills is spatially variable. All carbonate in that area is far-travelled, having been transported at least 100 km from its source. High-density till sample analysis has mapped some 'holes', or 'sticky spots' (Trommelen and Ross, 2014) of lower concentration adjacent to spots where the carbonate concentration is higher (Figure 3). The greater than 75th percentile of rare-earth element concentration is restricted to the low-carbonate 'holes', regardless of the underlying bedrock. The till within these 'low-carbonate' windows contain more of other elements as they have not, or to a lesser degree, been diluted by carbonate.

Hence, within areas of Manitoba covered by calcareous till, 'low' concentrations of desired elements may still be more prospective than the same concentration within noncalcareous till. The entire dataset of Manitoba tills is plotted in Figure 4 for both cobalt and zinc by INAA. Again, there is a negative correlation between both metals and the total carbonate concentration of Manitoba tills. This is why the total carbonate (wt. %) concentration is reported for most samples within Appendix 1, Table 2. In general, calcareous values should be noted and different populations should not necessarily be treated as one dataset.

Supporting data

The original files for each project can be found through the Bibliography of Manitoba Geology and Resource Centre Catalogue (Manitoba Agriculture and Resource Development, 2020b). To help with analysis, the following data is also available:

- Manitoba carbonate dispersal analyses in till (Manitoba Agriculture and Resource Development, 2020c);
- index of surficial geology maps in Manitoba (Manitoba Agriculture and Resource Development, 2020e);
- compiled surficial materials maps (Manitoba Agriculture and Resource Development, 2020d);
- digital compilation of surficial point and line features, including ice-flow data (striations, streamlined landforms) and bedrock outcrop locations (Gauthier and Keller, 2020; Manitoba Agriculture and Resource Development, 2020a; and
- current understanding of ice-flow history in northeastern Manitoba (Gauthier et al., 2019).

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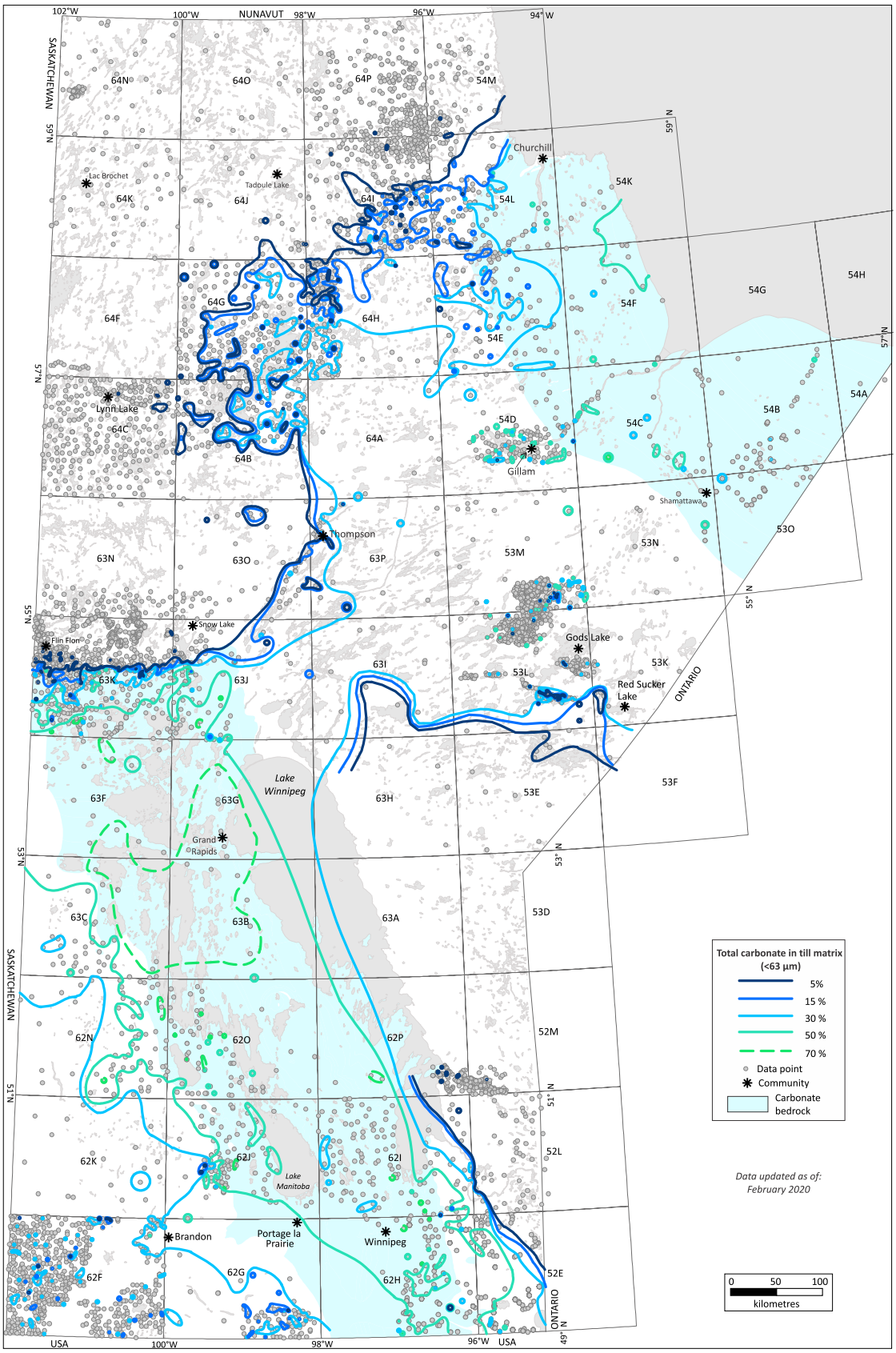

Figure 2: *Hand-contoured distribution of total carbonate concentration in the till matrix (silt plus clay, <63 µm size-fraction) of surface till samples in Manitoba. This till-matrix total carbonate compilation represents ongoing work and is sourced from a number of different studies with slightly different methods (Manitoba Agriculture and Resource Development, 2020c). Owing to the limited number of data points in most areas, the hand-contoured data are not accurate at a detailed scale but provide a general overview of the carbonate-dispersal pattern. Similarly, the contours are more detailed where local-scale fieldwork has been conducted. The area in white is underlain by Precambrian shield rocks (Manitoba Department of Mines, Natural Resources and Environment, 1979).*

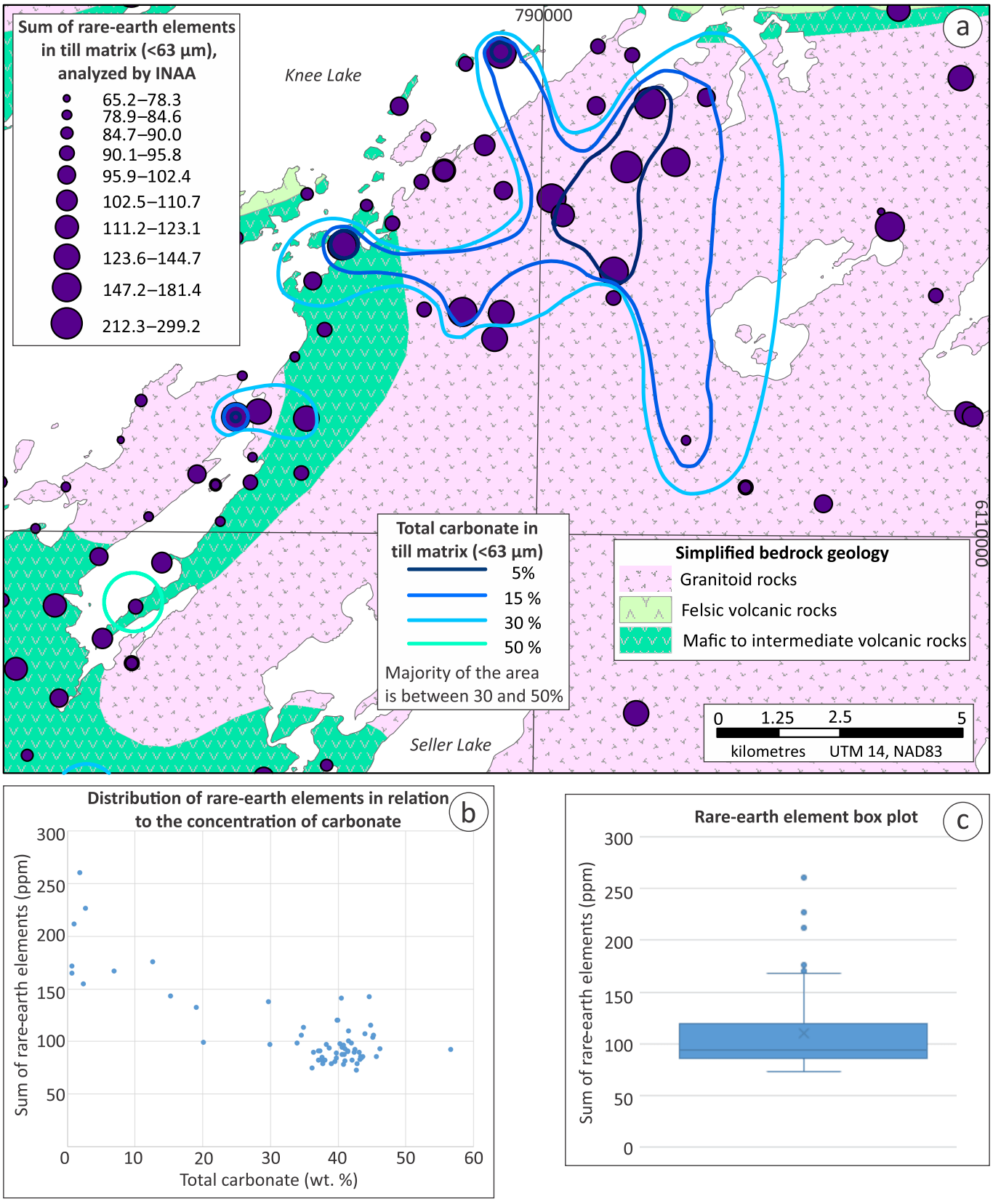

Figure 3: *The relationship between hand-contoured total carbonate concentration and rare-earth element concentrations (summed, INAA) in the south Knee Lake area of east-central Manitoba, sourced from Trommelen (2015). This data is plotted spatially on a bedrock map* ***(a)*** *as well as graphed* ***(b)****. A box-plot of total rare-earth element concentration for this local data is also shown* ***(c)****.*

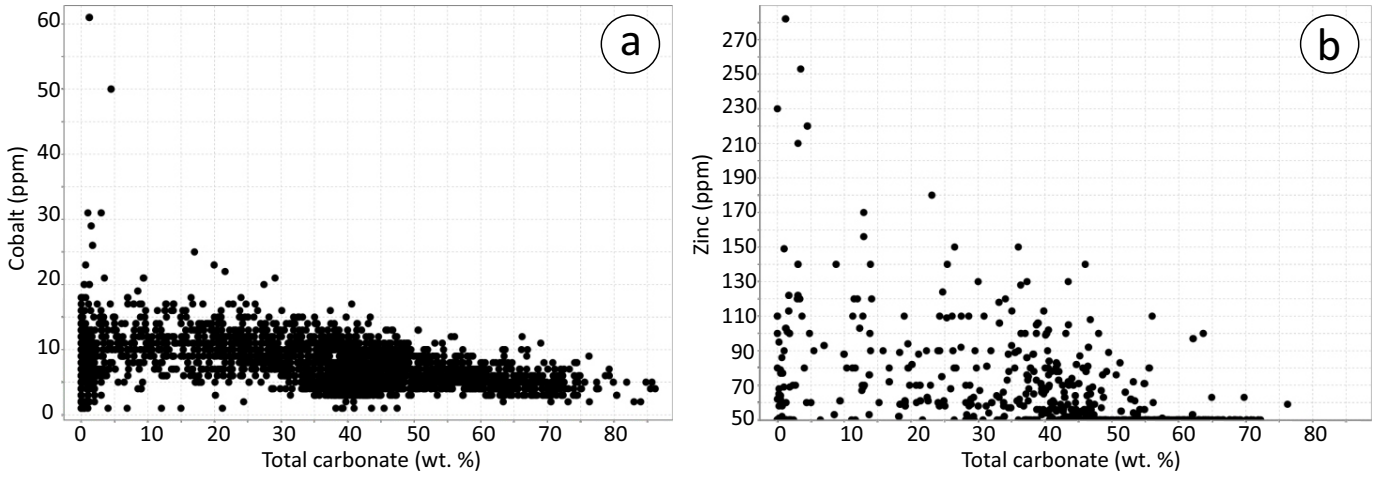

Figure 4: *Plots of cobalt* ***(a)*** *and zinc* ***(b)*** *concentration versus total carbonate concentration—for the entire dataset—show that there is a negative correlation between the amount of metals and the amount of carbonate in the tills in Manitoba.*

Manitoba Agriculture and Resource Development 2020c: Manitoba carbonate dispersal analyses in till; Manitoba Agriculture and Resource Development, URL <http://www.manitoba.ca/iem/geo/surficial/carbonate.html> [February, 2020].

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