GeoFile 7-2023 ReadMe

Manitoba till-matrix geochemistry compilation: total carbonate of the silt plus clay (<63 µm) size-fraction

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Abstract

This GeoFile provides a digital dataset for till-geochemistry surveys carried out in Manitoba, where the silt plus clay (<63 µm) size-fraction of the till matrix was analyzed for total carbonate (CO_3). This compilation of 46 projects includes 7844 till samples, and will be updated annually or bi-annually. This data can be brought into GIS software, and integrated with other geoscience data.

Calcareous till is present at surface across most of Manitoba. In northern Manitoba, carbonate detritus was glacially dispersed for distances up to 380 km beyond the limit of Paleozoic carbonate bedrock, which outcrops within the Hudson Bay Basin on the southwestern coast of Hudson Bay and along some river cuts. The net carbonate-dispersal pattern within the surface till is complex, though generally decreases in concentration to the west, southwest and south. The northwestern and western limit is patchy, with several remnant fragments of elevated carbonate in till. A second source of Paleozoic carbonate bedrock is the Williston Basin, which outcrops over the Precambrian shield, just south of Snow Lake and Flin Flon. There is only minor glacial dispersal of carbonate detritus north of this boundary, and almost immediate dominance of carbonate in the till south of the contact.

Résumé

Ce géodossier fournit un ensemble de données numériques provenant de levés géochimiques du till réalisés au Manitoba. La fraction granulométrique de silt et d'argile (<63 µm) de la matrice de till y a été analysée pour évaluer la teneur en carbonate total (CO_3). Cette compilation de 46 projets comprend 7 844 échantillons de till et sera mise à jour une fois par an ou tous les deux ans· Ces données peuvent être incorporées à un logiciel SIG et intégrées à d'autres données géoscientifiques.

Le till calcaire est présent en surface dans la majeure partie du Manitoba. Dans le nord de la province, les détritus carbonatés ont été dispersés par les glaciers sur des distances pouvant atteindre 380 km au-delà de la limite du substrat rocheux carbonaté du Paléozoïque, qui affleure dans le bassin de la baie d'Hudson, sur la côte sud-ouest de la baie d'Hudson et le long de certaines coupures de rivières. Le schéma global de dispersion des carbonates dans le till de surface est complexe, mais leur concentration diminue généralement vers l'ouest, le sud-ouest et le sud. La limite nord-ouest et ouest est inégale et comporte plusieurs fragments restants de till se caractérisant par une teneur élevée en carbonate. Le bassin de Williston, qui affleure sur le Bouclier précambrien, juste au sud de Snow Lake et de Flin Flon, constitue une deuxième source de roches carbonatées du Paléozoïque. Par rapport à cette limite, la dispersion glaciaire des détritus carbonatés au nord est minime et la dominance du carbonate dans le till au sud est presque immédiate.

DIGITAL DATA

Zip file geofile7.zip contains the following content:

- GeoFile_7-2023_ReadMe.pdf (this file)
- GeoFile_7-2023.xlsx:
  Table 1: Manitoba till-matrix total-carbonate data on the silt plus clay (<63 µm) size-fraction.
  Table 2: References.

Introduction

This dataset includes data from 7844 till samples collected between 1974 and 2022, where the silt plus clay (<63 µm) size-fraction of the till matrix was analyzed for total carbonate (CO_3) (Figure 1). This database will be updated as new data is released. Carbonate within the till is sourced from Paleozoic carbonate bedrock within the Hudson Bay Basin and the Williston Basin (Figure 1; Nicolas et al., 2010; Nicolas and Armstrong, 2017).

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.

Data captured includes all data immediately relevant to the till sample. This includes publication number, laboratory used, project name, spatial coordinates, depth of sample and other important information. Manitoba Geological Survey (MGS) project numbers are 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

The site location of till samples is a mix of GPS coordinates (post 2000) and cartographic estimates (pre-2000). Manitoba crosses three UTM zones (14 to 16). For ease of display in GIS, all coordinates in UTM zones 15 and 16 have been re-projected into UTM 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 for some sites whether the coordinates were collected in NAD27 or 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 (Table 1).

Analytical methods

The methods used to analyze for total carbonate in the till matrix has changed over time. Below are some of the methods used for various projects, as noted under the "Method" column of Table 2.

LECO induction furnace

Till samples were analyzed for total carbonate (CO_3) using a LECO induction furnace at the Geological Survey of Canada's (GSC) Sedimentology Laboratory (Ottawa, Ontario) for one older study (Kaszycki, 1989). No details were noted.

Atomic absorption spectroscopy

Till samples were analyzed for total carbonate (CO_3) using atomic absorption spectroscopy after a 1:1 hydrochloric acid leach for seven older studies at both the GSC Sedimentology Laboratory and the MGS Midland Sample and Core Library (Winnipeg, Manitoba). This method is designed to measure calcium and magnesium ions in the filtrate of acid-leached samples (McMartin et al., 1996). These ions are derived from the carbonate minerals of calcite and dolomite, and from any other soluble salts which may be present in the sample.

Chittick

Till samples were analyzed for total carbonate (CO_3) using the Chittick method after a hydrochloric leach for thirteen older studies at the GSC Sedimentology Laboratory. Samples are crushed and dissolved in HCl, and the released CO_2 is measured using a gasometric apparatus. The concentration of calcite, dolomite and total carbonate is then calculated.

CM5014 coulometer/acid evolution method

In two studies, till samples were analyzed for total carbonate (CO_3) using a two-step process with a CM5014 coulometer at the GSC Sedimentology Laboratory. Total CO_2 associated to the carbonate content is first measured, followed by the determination of the CO_2 associated to the calcite. The difference between the two measurements is used to characterize the amount of CO_2 associated to the presence of dolomite.

Total carbonate is then determined by decomposition of the carbonated minerals using hot dilute hydrochloric acid, evolving the carbonate carbon in the form of carbon dioxide. The gaseous carbon dioxide is bubbled to react with a solution of ethanolamine. The Faraday law is used for the calculation where each Faraday corresponds to one microgram of carbon dioxide.

The calcite fraction of the carbonate minerals is also determined by decomposition as described above. The quantification of dolomite requires the determination of total carbonate carbon. Dolomite is quantified by the difference.

Ca and Mg

Starting in 2012, most till samples were analyzed for total carbonate (CO_3) using the Ca and Mg method at Activation Laboratories Ltd. (Ancaster, Ontario) or the Saskatchewan Research Council Geoanalytical Laboratories (Saskatoon, Saskatchewan). This means that an aliquot of the till matrix (<63 µm size-fraction) was digested using hydrochloric acid and analyzed for Ca and Mg

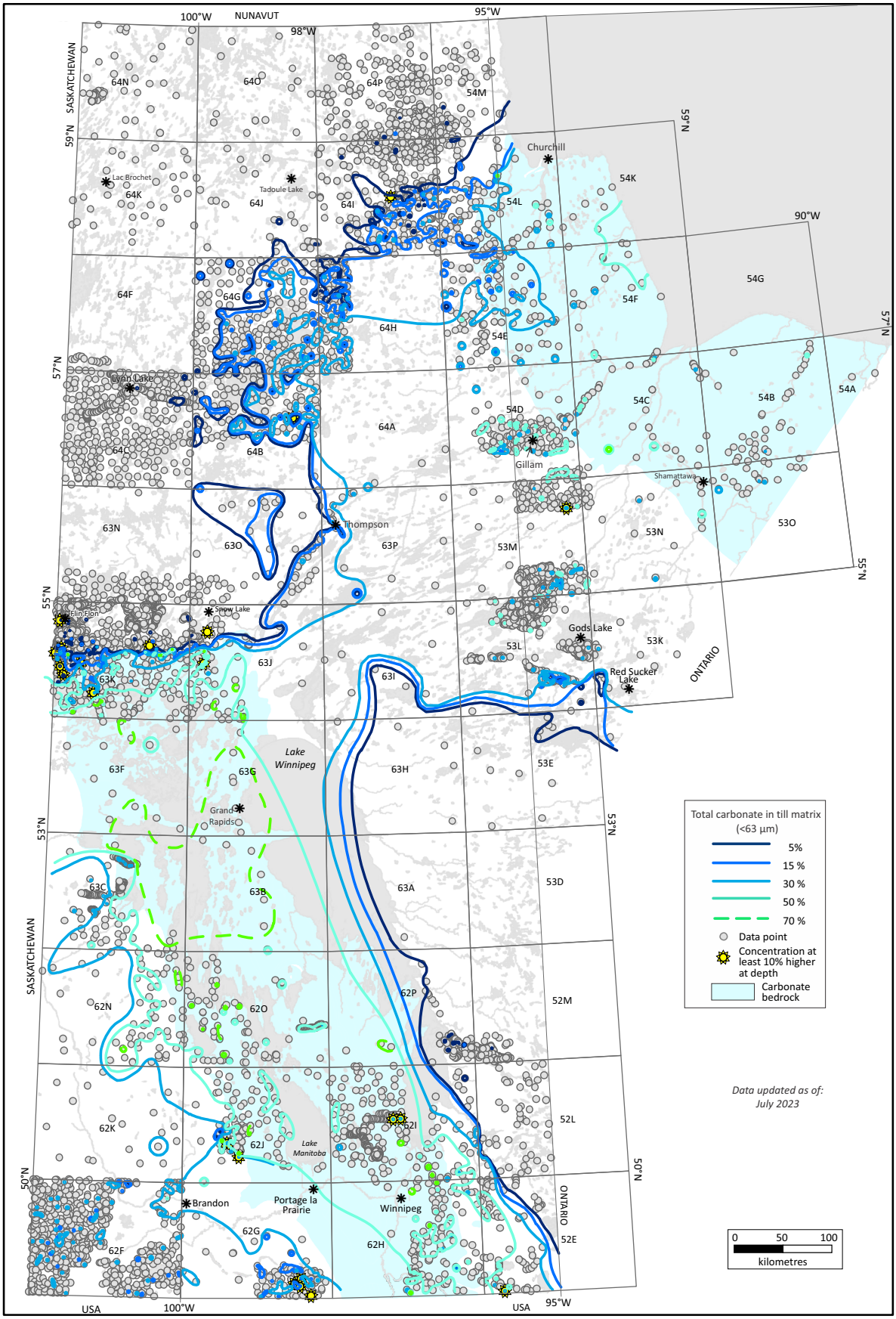

Figure 1: *Till-sample locations where the silt plus clay (<63 µm) size-fraction of the matrix was analyzed for total carbonate (CO_3) in Manitoba. The total carbonate distribution of till samples at surface is hand-contoured. The hand-contoured data is most accurate in areas of significant data points, and is to be used as a general overview in areas with few samples. Also shown is mapped Paleozoic carbonate within the Hudson Bay Basin (northeast) and Williston Basin (southwest; Manitoba Geological Survey, 2022a).*

by inductively coupled plasma–optical emission spectrometry or inductively coupled plasma–emission spectrometry. The proportion of calcite, dolomite and total carbonate (CO_3) were then calculated (weight percent).

Discussion

Carbonate dispersal in till

Calcareous till is present at surface across most of Manitoba. In northern Manitoba, carbonate detritus was glacially dispersed for distances up to 380 km beyond the limit of Paleozoic carbonate bedrock (Figure 1). The net carbonate-dispersal pattern within the surface till is complex, though generally decreases in concentration to the west, southwest and south. In central Manitoba, there is almost immediate dominance of carbonate in the till south of where Paleozoic carbonate bedrock outcrops. This indicates rapid incorporation of carbonate detritus during south- to southwest-trending ice flow (McMartin et al., 1996). When interpreting till-matrix and till-clast composition, it's important to remember that the surface patterns represent the palimpsest concentrations of overprinting and inheritance over multiple glaciations (Dredge, 1988; Trommelen et al., 2013). Older calcareous tills, buried beneath noncalcareous to less-calcareous tills, have been found at multiple sites (Figure 1), as have older noncalcareous to less-calcareous tills buried beneath calcareous tills (e.g., Dredge and Nixon, 1992; Thorleifson and Matile, 1993; Dredge and McMartin, 2011; Gauthier et al., 2019).

Dispersal limits

The northwestern and western limit is patchy, with several remnant fragments of elevated carbonate in till (e.g., Trommelen et al., 2013; McMartin et al., 2016). Along Annabel Creek near Flin Flon, a buried silty calcareous lower till overlain by an upper sandy noncalcareous till indicates that calcareous detritus was once transported at least 20 km north (~40 km northwest) of the Paleozoic outcrops (Figure 1; Table 1, site PJH940039; Nielsen, 1994). It is also possible that that buried calcareous till near Flin Flon may instead be a remnant of calcareous till transported from Hudson Bay. Near the Seal River, at the height of land on Great Island, 0.5 m of till with trace carbonate clasts (1.1 count percent) overlies buried till with 17.6 percent carbonate clasts (Trommelen et al., 2013). Though the total carbonate of these two till samples was zero (Table 1, site 10MT312), two nearby till samples contain trace carbonate (Table 1, sites 10MT296 and 10MT308, 2.88 and 2.36 wt. % respectively). Together with the surficial geology in the area, the site shows that calcareous detritus was once transported ~100 km west or northwest of the Paleozoic outcrops close to Hudson Bay.

Importantly, the limit of measured till-matrix carbonate may not be equal to the maximum limit of west and northwest dispersal. This is because calcareous detritus could be re-entrained and transported in a different direction by later ice, or sourced from local Precambrian marble or calcite-bearing minerals (Dredge, 1988; Dredge and McMartin, 2011; McMartin et al., 2016; Hodder and Gauthier, 2018). For this reason, we delimit the 5 wt. % contour and not a 0 wt. % contour on Figure 1. Alternatively though, postglacial soil leaching could remove some of the carbonate from the surface till (Dredge, 1988; Kaszycki et al., 2008) – leading to a false negative. Lastly, calcareous detritus deposited during older events could be later overprinted (comminuted and diluted) by Precambrian shield detritus to the point that it is no longer detectable (Dredge et al., 1986; Dredge, 1988). Using multi-parameter data is essential to untangle these conflicting possibilities.

Supporting data

The original files for most projects can be found through the Bibliography of Manitoba Geology and Resource Centre catalogue (Manitoba Geological Survey, 2020). To help with analysis, the following data is also available:

- index of Manitoba surficial geology maps (Manitoba Geological Survey, 2022b)
- digital compilation of surficial point and line features, including ice-flow data (striations, streamlined landforms) and bedrock outcrop locations (Gauthier et al., 2022a)
- the current understanding of ice flow in Manitoba during deglaciation (Gauthier et al., 2022b)

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