OF2009-13

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Winnipeg, 2009

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Thorleifson, L.H., Matile, G.L.D., Keller, G.R. and Hauck, S.A. 2009: Till geochemical and indicator mineral reconnaissance of southeastern Manitoba (west half of NTS 52E and 52L and all of 62H and 62I): final results; Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, Open File OF2009-13, 5 p.

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NTS grid: 52E3; 52E4; 52E5; 52E6; 52E11; 52E12; 52E13; 52E14; 52L3; 52L4; 52L5; 52L6; 52L11; 52L12; 52L13; 52L14; 62H; 62I

Keywords: Archean; chemical composition; clastic sediments; geochemical methods; gold ores; heavy minerals; igneous rocks; indicator minerals; kimberlite; major-element analyses; Manitoba; mass spectroscopy; metal ores; mineral composition; mineral exploration; plutonic rocks; Precambrian; sediments; Steinbach; till; trace-element analyses; ultramafics; Wabigoon Subprovince

Published by:
Manitoba Science, Technology, Energy and Mines
Manitoba Geological Survey
360-1395 Ellice Avenue
Winnipeg, Manitoba
R3G 3P2 Canada
Telephone: (800) 223-5215 (General Enquiry)
(204) 945-4154 (Publication Sales)
Fax: (204) 945-8427
E-mail: minesinfo@gov.mb.ca
Website: manitoba.ca/minerals

Cover photo: Sampling glacial till; the premier sample medium for this investigation.

Abstract

Till geochemical and indicator mineral reconnaissance to support mineral exploration and other applications was conducted by the Geological Survey of Canada and Manitoba Geological Survey in the 1990s. The project comprised one phase of overburden drilling and two phases of surface till sampling over southeastern Manitoba in the area south of 51°N and east of 98°W. Drilling was supported by the Canada-Manitoba Partnership Agreement on Mineral Development, while the two phases of surface till sampling were funded by the National Geoscience Mapping Program (NATMAP). Phase one drilling and surface till sampling data were released in 1993, including data for instrumental neutron activation analyses (INAA) and inductively coupled plasma (ICP) analyses of till matrix and heavy mineral concentrates, indicator minerals and lithology. The second phase of surface till sampling was completed in 1998, but data release awaited completion of mineral chemistry. With the completion of these analyses by the Natural Resources Research Institute of the University of Minnesota Duluth in cooperation with the University of Minnesota Twin Cities in early 2009, data from both phases were combined for release in this Open File.

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Introduction

This Open File presents data from one phase of overburden drilling and two phases of surface till sampling over southeastern Manitoba south of 51°N and east of 98°W. The data includes INAA and ICP analyses of till matrix and heavy mineral concentrates, indicator minerals, and lithological data.

Surficial geological mapping, drift sampling and Quaternary stratigraphic studies were conducted in southeastern Manitoba as contributions to two phases of work under the National Geoscience Mapping Program (NATMAP), and one phase under the Canada-Manitoba Partnership Agreement on Mineral Development.

The eastern half of the area is underlain by Precambrian rocks that are well exposed to the north of the Trans-Canada Highway and that are drift-covered to the south. These rocks are known to locally host mineralization. The western portion of the area is underlain by Paleozoic carbonates and sandstone as well as Mesozoic shale and evaporites.

The area west and south of Whiteshell Provincial Park is covered by glacial sediments that exceed 100 m in thickness in the Woodridge area. Near Winnipeg and Sprague, on either side of this zone of the thickest sediments, overburden thicknesses of 50 m are typical.

The glacial sediments tend to be divisible into an upper, carbonate-rich sequence deposited by late-glacial southeastward ice flow (Teller and Fenton, 1980; Bajc, 1991) and a lower sequence enriched in Precambrian shield debris, deposited by southwestward ice flow. Exceptions to this tendency would be carbonate-poor till deposited on shield rocks by southeastward ice flow and re-worked carbonate-rich till deposited by southwestward ice flow.

Methods

During the first phase, in 1991 and 1992, sediment samples were collected from 142 surface sites consisting in most cases of road cuts, 7 sections along the Roseau River and 23 rotasonic-drill holes cored down to and into bedrock. A total of 465 till samples were obtained from drillcore (297), surface sites (142) and river sections (26). A total of 195 sand samples, 248 clay samples and 86 rock and weathered rock samples were taken from drillcore. During the second phase, in 1997 and 1998, 178 till samples were collected from surface exposures in areas north of 50°N and west of 98°W.

The till and sand samples, each about 12 litres, were disaggregated and processed for gravel fraction, a >3.3 specific gravity, and -10 mesh heavy mineral concentrate. The 4–16 mm portion of the gravel fraction from the first phase and the 8–16 mm from the second phase were classified with respect to lithology. Visible gold grains were counted, measured and classified. The >0.25 mm fraction of the heavy mineral concentrate was visually scanned and potential indicator minerals were selected for electron microprobe analysis. The entire heavy mineral concentrate was subsequently analyzed by INAA, and in the first phase only, a split of the concentrate was ceramic crushed and analyzed by nitric-aqua-regia-ICP.

A 1 litre split of the till samples was processed for recovery of the <0.063 mm fraction using a stainless steel 230 mesh screen. This fraction was analyzed geochemically using the same methods that were used for the heavy mineral concentrates. The <0.063 mm fraction was also analyzed using the Chittick method for carbonate content. A total of 86 bedrock samples from drillcore, including several occurrences of weathered rock, were also ceramic crushed and analyzed by the previously mentioned methods as well as XRF (X-ray fluorescence) whole rock analysis.

Results

The data from phase one, which were previously published by Thorleifson and Matile (1993), and phase two were combined for this report. The results of geochemical, lithological and indicator-mineral sample analyses are presented in tabular, mapped and shapefile formats.

Tabular data

The results of geochemical, lithological and indicator-mineral analyses are presented in Excel data tables. A description is provided for each data file. File names are linked to Excel tables.

1 Sites.xls: location of the sampling sites

The sites file provides UTM (NAD27, zone 14) and latitude/longitude coordinates for the 142 roadside sites, seven (143 to 149) Roseau River sections, 23 (A to W) rotasonic-drill hole sample sites, and 178 phase 2 (NATMAP II) roadside sites. The "UTM" column refers to the UTM zone that the site is located in, but the UTM coordinates have been standardized to zone 14 to simplify mapping the site data.

2 Samples.xls: sample depths

The sample file provides a link between site locations, sample numbers and sample depth. For each sample, the site and sample numbers and material type (till, sand, clay, rock, or weathered rock) are provided. Sampling depths are given as midpoint, upper limit and lower limit.

Surface sample sites 1 to 142 are roadside sites from which one till sample, numbered 2000 plus the site number, was taken. Sites 143 to 149 are Roseau River sections from which multiple samples with sample numbers from 2822 to 2847, were taken.

Sites A to W are overburden rotasonic-drill hole sample sites. Till samples from the rotasonic core have sample numbers in the 4000 series, sand samples have sample numbers in the 5000 series, clay samples in the 6000 series and rock samples in the 7000 series.

Finally, the 178 phase 2 (NATMAP II) surface sample sites are also roadside sites from which one till sample was taken per site. Site numbers and sample numbers remain the same.

3 Pebble lithology.xls: lithology of the pebble fraction

The lithology of the pebble fraction is used as an indicator of the source of the sediment and hence the transport history. Some rock types break down to smaller grain sizes and are therefore not represented in the pebbles. The entire 4–16 mm

fraction for the first phase and the 8–16 mm fraction for the second phase were classified and the classes weighed. The weight of the pebble fraction was about a half kg. The data are reported as weight percent Paleozoic carbonate and clastic sedimentary rocks, weight percent intrusive and high grade metamorphic (IHGM) (dominantly granite and similar rocks), and weight percent low grade metasedimentary and metavolcanic (LGMM) (dominantly greenstone and associated rocks).

4 Matrix carbonate.xls: carbonate content of the matrix

Calcite and dolomite contents and a total carbonate content are reported for till and clay as weight percent of the <63 micron fraction, as determined by the Chittick gasometric apparatus.

5 Heavy mineral recovery and visible gold counts.xls: processing of till and sand

Sample weight is reported as total moist mass. The proportion of the sample coarser than 10 mesh (2 mm) is reported as percent gravel relative to total moist mass. The weight of -10 mesh, >3.3 specific gravity, ferromagnetic minerals (FM) (almost entirely magnetite), as well as the -10 mesh nonferromagnetic heavy mineral concentrate (NFM), are reported in grams. Visible gold grains are reported as number of reshaped (R), partially modified by transport (M), and pristine or little altered by transport (P). The total number of visible gold grains, which range from about 25 to 500 microns in size, is then reported as number per 10 kg of air dry -10 mesh for phase one, and as total count for the phase two samples. Moisture content for the phase one samples was determined by air dry weight loss of the split used to prepare the <63 micron fraction. The total moist weight was adjusted on the basis of gravel and moisture content to produce a weight for dry <2 mm or -10 mesh material. Moisture content averaged 10%. The size of the gold grains was then used by Overburden Drilling Management to produce an estimate of the contribution of each morphology class to the heavy mineral concentrate gold assay. The number of yellow, mostly zircon, and blue, mostly scheelite, grains is then reported as total per 10 g of nonferromagnetic heavy mineral concentrate, in the case of phase one samples only.

6 63 NA.xls: Geochemical analysis of the <0.063 mm fraction: INAA

A 25 to 30 gram split of the <63 micron fraction of till and clay samples was analyzed by instrumental neutron activation, while bedrock samples were ceramic crushed prior to this analysis. Values below the detection limit are reported as one-half of the detection limit. Detection limits are as follows: Au 5 ppb; Ag 5 ppm; As 2 ppm; Ba 100 ppm; Br 1 ppm; Ca 1%; Co 5 ppm; Cr 10 ppm; Cs 2 ppm; Fe 0.02%; Hf 0.5 ppm; Hg 1 ppm; Ir 5 ppb; Mo 5 ppm; Na 0.05%; Ni 50 ppm; Rb 30 ppm; Sb 0.2 ppm; Sc 0.1 ppm; Se 5 ppm; Sn 0.01%; Sr 0.05%; Ta 1 ppm; Th 0.5 ppm; U 0.5 ppm; W 4 ppm; Zn 50 ppm; La 1 ppm; Ce 3 ppm; Nd 5 ppm; Sm 0.1 ppm; Eu 0.2 ppm; Tb 0.5 ppm; Yb 0.2 ppm; Lu 0.05 ppm.

7 63 ICP.xls: Geochemical analysis of the <0.063 mm fraction: ICP

A 1 gram split of the <63 micron fraction was analyzed by nitric-aqua-regia-ICP. Bedrock samples were ceramic crushed prior to this analysis. Values below the detection limit are reported as one- half of the detection limit. Detection limits are as follows: Ag 0.2 ppm; Al 0.01%; As 2 ppm; Ba 10 ppm; Be 0.5 ppm; Bi 2 ppm; Ca 0.01%; Cd 0.5 ppm; Co 1 ppm; Cr 1 ppm; Cu 1 ppm; Fe 0.01%; Ga 10 ppm; Hg 1 ppm; K 0.01%; La 10 ppm; Mg 0.01%; Mn 5 ppm; Mo 1 ppm; Na 0.01%; Ni 1 ppm; P 10 ppm; Pb 2 ppm; Sb 2 ppm; Sc 1 ppm; Sr 1 ppm; Ti 0.01%; Tl 10 ppm; U 10 ppm; V 1 ppm; W 10 ppm; Zn 2 ppm. Bedrock samples were ceramic crushed.

8 HMC NA.xls: Geochemical analysis of heavy mineral concentrates: INAA

The entire nonferromagnetic heavy mineral concentrate was analyzed by instrumental neutron activation. Total sample mass is given in the last column. Values below the detection limit are reported as one-half of the detection limit. Detection limits are the same as those reported for the <63 micron fraction.

9 HMC ICP.xls: Geochemical analysis of heavy mineral concentrates: ICP

A 2 to 3 gram split of the nonferromagnetic heavy mineral concentrate was ceramic crushed and analyzed by nitric-aqua-regia-ICP. Detection limits are the same as those reported for the <63 micron fraction.

10a Bedrock XRF.xls: Geochemical analysis of bedrock from drillholes: XRF
10b Bedrock description.txt: Description of bedrock from drillholes

Both weathered and unweathered samples of bedrock from drillholes were analyzed by conventional whole rock analysis. All analyses were by XRF and/or ICP except FeO, H^2Ot, CO^2t, CO^2, C, S, and LOI (loss-on-ignition) by chemical methods. Fe^2O^3 is calculated using $Fe^2O^3 = Fe^2O^3t$ (ICP) - 1.11134(FeO volumetric). ICP-MJI data were obtained on 0.5 g of sample fused with lithium metaborate, dissolved in 5% HNO^3 and diluted to 250 ml. ICP-TR1 data were obtained on 1.0 g of sample (acid + fusion of residue) dissolved in 10% HCl and diluted to 100 ml. Bedrock core from the drillholes was described visually.

11a Indicator Mineral Chemistry.xls: mineral chemistry, phase 1
11b Indicator Mineral Chemistry.xls: mineral chemistry, phase 2
12a NATMAP I Indicator Counts.xls
12b NATMAP II Indicator Counts.xls

The >250 micron fraction of the nonferromagnetic heavy mineral concentrates was visually scanned for possible indicator minerals under a stereoscopic microscope. Selected grains were mounted and polished in 25 mm cylindrical epoxy mounts.

For the first phase, analysis of a total of 1195 grains was carried out at CANMET labs in Ottawa, using a JEOL 8900 electron microprobe operating at 20 kV and 40 nA. Peak

counting times of 10 seconds were used for Na^2O, K^2O, CaO, FeO, MgO, Al^2O^3, MnO, and SiO^2 and 40 seconds for TiO^2 and Cr^2O^3. Background determinations were made only on every 50th grain. Calibration was confirmed at the beginning and end of each batch. The analyses were completed in four automated runs which were driven by a set of x-y-z coordinates for one point per grain, selected to avoid inclusions, fractures or pits. At the end of each batch, every 28th grain, on average, was reanalyzed at another similar point to monitor precision related to grain heterogeneity, calibration drift, or unusual background measurements. These replicates indicate good reproducibility above 0.1% for all elements, with a few exceptions attributed to heterogeneity.

For the second phase, a similar electron microprobe routine with improved detection limits was utilized at the University of Minnesota, Twin Cities Campus, Department of Geology and Geophysics and the data were interpreted as part of ongoing activity at the University of Minnesota, Duluth.

Resulting data were used to select and classify minerals as indicator minerals. The phase one data are considered clearly adequate for the recognition of peridotitic garnets and kimberlitic oxides, adequate for the selection of chrome-bearing diopsides, and marginally adequate for the distinction of titanian almandines (>0.2% TiO^2). Garnets were classified using the Dawson and Stephens as well as the Gurney classifications. Diopsides with >~0.50% Cr^2O^3 were regarded as chrome diopsides. Magnesian ilmenites contain 3% MgO or more.

Processing of the NATMAP I samples was not optimized for indicator minerals other than gold. Despite this lack of optimization, a total of 55 kimberlite indicator minerals were recovered. The occurrences are well distributed but seem to be non-random, hence suggesting sources within the study area. In contrast, processing for oxide and silicate indicator minerals was optimized for the second phase, and this may be a principal explanation for higher indicator mineral counts in the second phase.

Mapped data

Results of the geochemical, lithological and indicator-mineral analyses are presented on bubble plot maps showing distribution and concentration. Bubble plot index maps show surface and drilling sample locations. File names are linked to maps.

Gold grains

- Modified Gold
- Pristine Gold
- Reshaped Gold
- Total Gold

Indicator minerals

- Andradite
- Chalcopyrite
- Chromite
- Corundum
- Cr-andradite
- Cr-diopside
- Cr-grossular
- Cr-pyrope
- Eclogitic Garnet
- Gahnite
- Mg-chromite
- Mg-ilmenite
- Monazite
- Olivine
- Spinel

Geochemistry

- Aluminum ICP
- Aluminum HMC ICP
- Antimony ICP
- Antimony INAA
- Antimony HMC ICP
- Antimony HMC INAA
- Arsenic ICP
- Arsenic INAA
- Arsenic HMC ICP
- Arsenic HMC INAA
- Barium ICP
- Barium INAA
- Barium HMC ICP
- Barium HMC INAA
- Beryllium ICP
- Beryllium HMC ICP
- Bismuth ICP
- Bismuth HMC ICP
- Boron ICP
- Bromine INAA
- Bromine HMC INAA
- Cadmium ICP
- Cadmium HMC ICP
- Calcium ICP
- Calcium INAA
- Calcium HMC ICP
- Calcium HMC INAA
- Cerium INAA
- Cerium HMC INAA
- Cesium INAA
- Cesium HMC INAA
- Chromium ICP
- Chromium INAA
- Chromium HMC ICP
- Chromium HMC INAA

- Cobalt ICP
- Cobalt INAA
- Cobalt HMC ICP
- Cobalt HMC INAA
- Copper ICP
- Copper HMC ICP
- Europium INAA
- Europium HMC INAA
- Gallium ICP
- Gallium HMC ICP
- Gold INAA
- Gold HMC INAA
- Hafnium INAA
- Hafnium HMC INAA
- Iridium INAA
- Iridium HMC INAA
- Iron ICP
- Iron INAA
- Iron HMC ICP
- Iron HMC INAA
- Mercury ICP
- Mercury INAA
- Mercury HMC ICP
- Mercury HMC INAA
- Lanthanum ICP
- Lanthanum INAA
- Lanthanum HMC ICP
- Lanthanum HMC INAA
- Lead ICP
- Lead HMC ICP
- Lutetium INAA
- Lutetium HMC INAA
- Magnesium ICP
- Magnesium HMC ICP
- Manganese ICP
- Manganese HMC ICP
- Molybdenum ICP
- Molybdenum INAA
- Molybdenum HMC ICP
- Molybdenum HMC INAA
- Neodymium INAA
- Neodymium HMC INAA
- Nickel ICP
- Nickel INAA
- Nickel HMC ICP
- Nickel HMC INAA
- Phosphorus ICP
- Phosphorus HMC ICP
- Potassium ICP
- Potassium HMC ICP
- Rubidium INAA
- Rubidium HMC INAA
- Samarium INAA
- Samarium HMC INAA
- Scandium ICP
- Scandium INAA
- Scandium HMC ICP
- Scandium HMC INAA
- Selenium INAA
- Selenium HMC INAA
- Silver ICP
- Silver INAA
- Silver HMC ICP
- Silver HMC INAA
- Sodium ICP
- Sodium INAA
- Sodium HMC ICP
- Sodium HMC INAA
- Strontium ICP
- Strontium INAA
- Strontium HMC ICP
- Strontium HMC INAA
- Sulfur ICP
- Tantalum INAA
- Tantalum HMC INAA
- Terbium INAA
- Terbium HMC INAA
- Thallium ICP
- Thallium HMC ICP
- Thorium INAA
- Thorium HMC INAA
- Tin INAA
- Tin HMC INAA
- Titanium ICP
- Titanium HMC ICP
- Tungsten ICP
- Tungsten INAA
- Tungsten HMC ICP
- Tungsten HMC INAA
- Uranium ICP
- Uranium INAA
- Uranium HMC ICP
- Uranium HMC INAA
- Vanadium ICP

- Vanadium HMC ICP
- Ytterbium INAA
- Ytterbium HMC INAA
- Zinc ICP
- Zinc INAA
- Zinc HMC ICP
- Zinc HMC INAA

Lithology

- Matrix Calcite
- Matrix Carbonate
- Matrix Dolomite
- Pebble IHGM
- Pebble LGMM
- Pebble Paleozoic

Index maps

- Drill Section Samples
- Surface Samples

GIS data

ArcGIS shapefiles are provided for mapped data in the "ArcGIS Shapefiles" folder.

Acknowledgments

Surface sampling was completed by L. H. Thorleifson, G. Matile, G. Gobert, A. Dunlop and D. Roberts in the first phase and by G. Matile, N. Grant, A. Burt and J. Mann in the second phase. For the rotasonic drilling, on-site geologists were G. Gobert and G. Olsen, drilling was done by Midwest Drilling, snow-clearing was completed by Stan Barta of Hadashville, and core storage was supported by Border Shell in Sprague. Description and sampling of drillcore were managed by G. Matile, G. Olsen, D. Roberts, G. Gobert H. Thorleifson and C. McGregor. Heavy mineral preparation, visible gold analyses, lamping, and indicator mineral selection were completed by Overburden Drilling Management Ltd. of Nepean, Ontario. INAA analyses were completed by Activation Laboratories Ltd., Ancaster, Ontario and ICP analyses by Chemex Labs of Vancouver. Electron microprobe analyses were completed by G. Laflamme and L. Cabris of CANMET in Ottawa for phase 1 and by E. Frahm of the University of Minnesota for phase 2. Carbonate and whole rock analyses were completed by Geological Survey of Canada staff. The excellent efforts of all who contributed are acknowledged with appreciation.

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