Open File Report OF2000-5. Preliminary Exploration Database for Platinum-Group Elements in Manitoba

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Introduction and Disclaimers

This is a preliminary release of an exploration database for platinum-group elements in Manitoba. It provides a compilation of geological and geochemical data for many mafic and ultramafic intrusions in Manitoba that will aid in exploration for platinum-group elements (PGE). Although the database is focused on mafic and ultramafic intrusions, because all the currently identified major PGE deposits in the world are hosted by these types of intrusions, it also includes new PGE data for black shales in Manitoba. Over the past 20 years, shale-hosted polymetallic deposits have been gaining recognition in both the research and exploration communities as a potential, future source of economic PGE mineralization (e.g., Nick deposit, Yukon Territory; Hulbert et al., 1992).

We have provided information for most of the major (>100 m thick or 1 km long) mafic and ultramafic intrusions exposed at the surface. In addition, data are given for selected ultramafic intrusions (derived from Hulbert and Scoates, 2000) intersected by drilling but not exposed at the surface. For many of the ultramafic rock localities, individual locations are grouped geographically; for example, all the ultramafic rocks on Ponask Lake are given as a single record, as are all the ultramafic intrusions in the Thompson Nickel Belt. For a more detailed breakdown of ultramafic rock localities and Ni-Cu occurrences in the Province, the reader is referred to a database of Ni-Cu ± PGE occurrences and mafic and ultramafic intrusions in Manitoba that is concurrently being co-released by the Geological Survey of Canada and the Manitoba Geological Survey (Hulbert and Scoates, 2000). The Hulbert and Scoates (2000)

database provided an effective starting point for this report with most of our documentation for ultramafic occurrences in Manitoba based on records contained in their database. In effect, the two databases are complementary, with the current report focussed on providing data specifically supporting PGE exploration, and the Hulbert and Scoates (2000) database being focussed principally on magmatic Ni-Cu sulphide occurrences and related geological and exploration documentation.

Principal data sources for the occurrences contained in this report include Hulbert et al. (2000), Theyer (1980), Athayde (1989), Fedikow et. al. (1998), the Manitoba Mineral Inventory Cards, numerous Manitoba Mines Branch non-confidential assessment file records, selected Manitoba Geological Survey Mineral Deposit Series reports, and numerous Manitoba Geological Survey and Geological Survey of Canada maps and reports. Neither the bibliographic references nor the open assessment file numbers provided for most of the records are intended as a comprehensive reference list, but should give the reader a starting point when searching for relevant publications and exploration data. We have attempted to provide a thorough review of available assessment file records and mineral occurrence data for most of the intrusions falling in the northern part of the Superior Province. Given time constraints, it was not possible to complete a comprehensive survey for occurrences in the Trans-Hudson Orogen or in southeastern Manitoba. Some information contained in this report has not been previously published, including field records provided directly by geological staff of the Manitoba Geological Survey.

It is anticipated that this database product will be updated at regular intervals, with a final release of the current report in 2001. The final report will provide a more comprehensive review of assessment file and geological records and a thorough analysis of the available geochemical data contained in this preliminary release of the database.

This database is being released both on CD-ROM and on the Manitoba Industry, Trade and Mines website. The complete report contains the following files:

1) **ReadMe:** This file is provided as a .txt (text) file, a Microsoft Word® .doc file and .pdf (Adobe® Illustrator® format) file. To view the .pdf files contained in this report, use

(provided) Adobe® Acrobat Reader®. The ReadMe file contains an introduction to the report, including the title and authorship, an explanation of the contents and data sources, a description of the black shale samples listed in Table 4, and the acknowledgments.

2) **OF2000-5:** The main body of the report, as a .pdf file. Includes Figure 1a (first page of the file), a geological index map, given as a .pdf (Adobe® Illustrator® format) file and Figure 1b, a topographic map showing place names and occurrence dots. The index map shows the locations and reference identification number of all the occurrences contained in the main report database. The reference identification number (two or three-digit number given for each location) is a unique value for each occurrence that is also given in the upper right-hand corner on the first page of each occurrence description (Ref ID.) in the text portion of the database. Use the occurrence hyperlinks that are set-up on the index map to move between this map and the main report database. The map is modified from the Bedrock Geology of Manitoba file contained in Viljoen et al. (1999).

3) **Table 1:** A text file (.csv) containing 1,484 Au, Pt and Pd, S and base-metal analyses of samples obtained from selected mafic and ultramafic intrusions in Manitoba. All of the tables included in the report are provided in .csv format and can be opened in most spreadsheet, database or word-processor programs.

4) **Table 2:** A text file (.csv) containing 854 major- and trace-element analyses of samples obtained from selected mafic and ultramafic intrusions in Manitoba.

5) **Table 3:** A text file containing total PGE analyses (Os, Ir, Ru, Rh, Pt, Pd and Au) of samples obtained from selected mafic and ultramafic intrusions in Manitoba.

6) **Table 4:** A text file (.csv) containing Au, Pt and Pd, base-metal and additional major- and trace-element data for samples obtained from selected black shale units in Manitoba.

7) **Figure 2:** A .pdf (Adobe® Illustrator® format) file showing the relative stratigraphic position of black-shale samples listed in Table 4.

The report can also be obtained from the Manitoba Industry, Trade and Mines website (www.gov.mb.ca/em/geoscience).

Geochemical Data Included in the Report

The report contains a compilation of both existing published and unpublished data as well as newly acquired whole-rock geochemical data for selected mafic and ultramafic intrusions and black-shale locations in Manitoba. The data are contained in the four tables that are included in the report. Although every effort was made to ensure that data contained in the report are both precise and accurate, by using appropriate certified reference materials and internal standards, it was not always possible to effectively monitor these parameters.

All the newly acquired analytical data (indicated by 'this study' in the source column) were obtained from Activation Laboratories Ltd., Ancaster, Ontario. Major-element data were determined by ICP-OES. Trace-element analyses were acquired by fusion ICP-MS. The elements Au, Pt and Pd were determined by PbS fire assay with an ICP-OES finish. Complete PGE analyses (Table 3) were performed by NiS fire assay with both INAA and ICP-MS finishes (Activation Laboratories Ltd.). Other laboratories that contributed data to this report include the Geoscience Laboratories, Ministry of Northern Development and Mines, Sudbury, Ontario (trace-element analyses by ICP-MS) and the Central Analytical Facility, Laurentian University, Sudbury, Ontario (major- and trace-element analyses by XRF). A few of the Au-Pt-Pd analyses were performed by XRAL Laboratories (Don Mills, Ontario), also using a PbS fire assay and ICP-OES finish. The previously published black-shale analyses were undertaken by ALS Chemex Ltd. (Vancouver, British Columbia) for Open File OF98-2 (Fedikow et al., 1995). The Au-Pt-Pd analyses for the black shale samples were completed by Activation Laboratories Ltd. Complete records of lab precision and accuracy associated with the newly acquired analytical data will be included in the final report. Average precision values, reported here as the relative standard deviation from the arithmetic mean, are as follows (Activation Laboratories data only): (1) Major elements (Actlabs package 4Litho): +/- 0.6% to +/- 4.7% (not including K and P, which are below or near the detection limit for the standards used to monitor precision); (2) Base metals and transition metals and S (Actlabs package 1F): +/- 3.7% to +/- 9.2%; (3) Rare-earth elements (Actlabs package 4Litho "standard"): +/- 4.2% to 5.9% (+/- 7.8% for Ce); (4) Pd, Pt and Au by PbS fire assay (Actlabs package 1C "Research"): +/- 9.9% for Pt, +/- 10.9% for Pd, +/- 26.4% for Au; (5) Semi-metals by ICP-MS (Actlabs package 1l): +/- 22.5 (average for Ge, Se, Bi and Te); (6) Total PGE using NiS fire assay (Table 3 data; Actlabs package 1B "combo"):

+/- 10% for all PGE and Re, and +/- 15% for Au (< +/- 3% for Pd and Pt). Based on replicate analyses of International PGE Standard SARM-7, the accuracy for the PGE-rich samples in Table 1 is estimated to be < +/- 10% for both Pt and Pd (Actlabs package 1C).

The newly acquired data include approximately 400 samples selected from 1) Manitoba Geological Survey archives, 2) an existing sample collection from selected Flin Flon Belt intrusions (J. Young and L. Ayers, University of Manitoba), and 3) a sample collection for the Falcon Lake igneous complex (Tirschmann, 1992). In selecting archival samples for PGE +/- major- and trace-element analysis, we attempted to provide information on background PGE abundances for as many of the intrusions in our database as possible. The samples, for the most part, did not contain visible sulphide minerals and are therefore intended to establish whether the host intrusion has low, moderate or high background values. For several intrusions, we have provided data for samples collected across one or more lithostratigraphic sections. In the final version of this report, we intend to provide detailed sample-location data that can be used to plot the results against stratigraphic elevation, allowing the user to develop their own chemostratigraphic profiles for these intrusions. Detailed geological maps and type stratigraphic sections (unpublished) for selected intrusions will also be included in the final report. In addition to providing the first comprehensive PGE database for Manitoba (Tables 1, 3 and 4), this report also provides the first regional whole-rock lithogeochemical database (Table 2) for mafic and ultramafic intrusions in the Province. It is hoped that explorationists and academic researchers alike will find a wide range of applications for this new data.

Most of the pre-existing data contained in Tables 1 to 3 (indicated by the reference(s) given in the source column in the tables) is derived from unpublished studies of the metallogeny and petrogenesis of mafic and ultramafic intrusions in the Bird River Belt and the northwestern Superior Province undertaken by the Manitoba Geological Survey and researchers at the University of Manitoba.

With the following exceptions, all data presented herein are the property of the Manitoba Geological Survey, to the extent that sampling was completed by survey staff and the analyses were paid for by the survey. Exceptions include Au-Pt-Pd analyses for the Mayville intrusion,

Bird River Belt (provided here with the permission of Exploratus Limited, Winnipeg, Manitoba) and Au-Pt-Pd analyses for the Cuthbert Lake dyke (1999 sampling only; provided here with the permission of E. Chaboyer, Thompson, Manitoba).

The geochemical data in Tables 1 and 2 are linked to the main project database by the location name (unique value) and the analyses numbers (*see* fields labelled 'PGE Analyses Numbers' and 'Whole-rock Analyses Numbers,' respectively). For example, analysis number 4 in Table 1 would be listed in the main project database under the 'PGE Analyses Numbers' field as '1.0001' (5 digit reference number), whereas the same analysis number in Table 2 would be listed under the 'Whole-rock Analyses Numbers' field as '2.001' (4 digit reference number) The geochemical data contained in Tables 1 and 2 can be cross-referenced using the sample number as a unique identifier. For the most part, major- and trace-element data have been provided for the same samples that were analyzed for PGE. The data in Table 3 are not directly linked to the report, but can be indirectly linked using the 'Name of Intrusion' information. Data in Table 4 are linked to Figure 2 and the 'Black Shales' section of this file by the sample number.

Treatment of the Data

Owing to time constraints, a detailed analysis of the data contained in Tables 1 to 4 was not possible. It is recommended that anyone reviewing the intrusion database for anomalous PGE values (Table 1) keep in mind that: (1) the majority of the samples were collected during reconnaissance mapping programs or as part of systematic lithogeochemical studies, and are therefore intended to be used to establish background values for the host intrusions; and, (2) anomalously low values (e.g., <1 ppb combined Pd + Pt) may be as significant as anomalously high values (e.g., >100 ppb combined Pd + Pt). Based on many published, detailed studies of PGE contents in mafic-ultramafic intrusions, it is recommended that the 'typical' range of background PGE contents in mafic-ultramafic intrusions be taken as approximately 1 to 20 ppb combined Pd + Pt. Values significantly higher than this (i.e., >100 ppb combined Pd + Pt) indicate that the PGE were concentrated above typical mafic-ultramafic magma background values (e.g., by sulphide liquid or fluids) or that the parent magmas were enriched in PGE. Values significantly lower than this (i.e., <0.1 ppb combined Pd+Pt) may indicate depletion of PGE by the prior removal of PGE-rich sulphide minerals, through the action of magmatic or

hydrothermal fluids, or derivation from a PGE-depleted magma. Again, it is intended that the final version of the report will contain a comprehensive analysis of the geochemical data.

Geographic Co-ordinates

The location of the centroid (geographic centre of intrusion or suite of intrusions) for each occurrence has been given using UTM (Universal Transverse Mercator) co-ordinate values projected in Zone 14 (NAD 27).

How to View the Main Database

To review selected records in the database, simply open the index map (Figure 1.pdf) file with the Adobe® Acrobat Reader® and use a mouse to activate the hyperlink on a selected reference identification number (Ref. ID. in the database) for the occurrence you wish to view. The hyperlinks will call up the related database record for the selected occurrence. Use the "back" icon button (top of Acrobat Reader window) to return to the index map. It is intended that the final release of this report will include a fully-searchable database and a derived geographic information system (GIS) project file.

Missing or Blank Records

For many of the poorly-documented occurrences, several fields have been omitted from the database records in the interest of minimizing the size of the main database for printing purposes. Missing fields or blank records indicate that the information required was either not available or has not yet been compiled.

Errors or Omissions

Anyone finding errors or omissions in the report is asked to contact the senior author.

Black Shales

The initial black-shale geochemical database (Fedikow et. al., 1998) was developed for metallogenic and environmental/epidemiological studies of Phanerozoic black shales in Manitoba. The metallogenic potential for black shales has been demonstrated worldwide as 1)

host rocks to precious- and base-metal mineralization, 2) aquitards or ‘caprocks’ for focussing mineralizing fluids, and 3) metal-enriched source rocks (Bloomstein and Clark, 1989; Colman et al., 1989). Locally, their importance to mineral deposits has been demonstrated at Black Island in Lake Winnipeg (Fedikow et al., 1995), where the metal-enriched character of Ordovician black shales was interpreted to represent a link between mobilization of metals from a gold-enriched sulphide-facies iron-formation and the subsequent precipitation of these metals as variably coloured, metal-rich crusts on the shales. The chemical characteristics of these unique rocks will provide an opportunity to develop new metallogenic concepts relevant to mineral exploration in Phanerozoic sequences.

The project was designed to parallel and complement an environmental geochemistry study initiated by the Geological Survey of Canada (GSC) and described by Dunn (1990). The GSC study documents the chemistry of Cretaceous shales subcropping beneath glacial deposits, and seeks to address the apparent link between the high incidence of multiple sclerosis at Henribourg, Saskatchewan (Irvine et al., 1988, 1989) and the chemistry of soils and well waters. This association has been previously suggested by Gould and Warren (1980) and Hasanen et al. (1986).

The database has been established using a variety of analytical methods to generate a wide range of chemical elements, with the aim of providing baseline geochemical data to as wide a user group as possible. The geochemical data has been linked to Manitoba Phanerozoic stratigraphy, so that chemical characteristics of individual stratigraphic units can be determined and related to specific lithological units and associations. Based on observations on the Nick property by Hulbert et. al. (1992), it was decided to include a select suite of black-shale samples, from the larger sample population described in Fedikow et. al. (1998), for PGE analysis. The basis for black-shale sample selection was the association of highly enriched elements, such as Mo, As, rare-earth elements, base metals and precious metals, in previously analyzed black shales. Table 4 includes all geochemical data for the select suite of black-shale samples from Fedikow et al. (1998), as well as the new PGE data contained in this report.

Black-shale samples identified as geochemically anomalous and included with this report

represent a somewhat narrow range of units in the Phanerozoic stratigraphic time scale in Manitoba. The anomalous units include the Ordovician Winnipeg Formation, the Mississippian Bakken Formation and the Cretaceous Swan River, Morden Shale and Nibrara formations (Figure 2). New geochemical data for Au, Pt and Pd are included in this report and reported in Table 4. There is a narrow range of concentrations for each of these elements in the black shale samples selected for analysis. Gold ranges from <1 to 86 ppb, Pt from <0.1 to 14.8 ppb and Pd from 0.5 to 13.3 ppb. The highest Au analysis (86 ppb) is from a sample of Cretaceous shale and the highest Pt and Pd contents are documented from two samples representing the Gammon Ferruginous and Pembina members of the Pierre Shale (First White Specks). These two samples contain 11.6 ppb Pt and 13.3 ppb Pd and 14.8 ppb Pt and 12.5 ppb Pd, respectively. The multi-element analyses of black shales will focus further studies of these unique lithologies as well as provide stimulus for the assessment of mineral potential.

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River Belt); and Inco Limited, Falconbridge Limited, HBED and Cominco Ltd. (Thompson Nickel Belt and adjoining parts of the Superior Boundary Zone). Jeff Young and Lorne Ayers provided samples for selected intrusions in the Flin Flon Belt. Norman Halden and Patti Tirschmann provided samples for the Falcon Lake intrusive complex. John Lee provided detailed geological and geophysical data for the Moose Lake trend. We thank Christine Kaszycki, Ric Syme and Al Bailes for their strong support of this project.

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