Annual review
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Introduction

In 2005, the Manitoba Geological Survey (MGS) continued significant in-depth investigations in the Superior Boundary Zone and Thompson Nickel Belt, the Paleoproterozoic Flin Flon Belt, and the Bissett region of southeastern Manitoba. Phanerozoic investigations focused on completing the Williston Basin Targeted Geoscience Initiative (with partners Saskatchewan Geological Survey and Geological Survey of Canada).

New field projects were initiated in

- the Bird River Belt of southeastern Manitoba, where an innovative government-industry-university partnership is bringing combined resources to bear on the geology and mineral deposits of an area that has not been mapped for many decades; and
- the Nejanilini Lake area of Manitoba's far north, with a multidisciplinary approach spanning bedrock mapping, isotope geochemistry, mineral-deposit investigations and Quaternary mapping and sampling.

Partnerships continued to play an important role in 2005. Graduate students from a number of Canadian universities carried out directed field investigations that broadened the range of work that MGS is able to undertake with diminished staff resources. The Geological Survey of Canada's second Targeted Geoscience Initiative (TGI) ended in March 2005, but wrap-up work continued in the Williston Basin Architecture and Hydrocarbon Potential project and follow-up investigations continued in the Trans-Hudson–Superior Margin Metallotect project. A third, five-year TGI was announced in the February 2005 federal budget. Planning for a major TGI 3 project in the Flin Flon–Snow Lake–Leaf Rapids–Lynn Lake–La Ronge–Creighton area is in progress, with the first activities scheduled for late 2005.

Precambrian mapping

Projects that are dominantly mapping oriented in the Precambrian of Manitoba were undertaken in the Flin Flon Belt, within or adjacent to the Superior Boundary Zone (SBZ) including the Thompson Nickel Belt (TNB), and within the Hearne margin in Manitoba's far north. Most of the active projects in the SBZ are continuations of multiyear collaborative ventures with the Geological Survey of Canada and the universities of Alberta and Waterloo.

Flin Flon–Snow Lake belt

Researchers from Laurentian University, including Dr. Harold Gibson and Ph.D. candidate Michelle DeWolfe, continued work in hangingwall and footwall rocks of the volcanogenic massive sulphide deposits at Flin Flon (GS-1). Rapid facies and thickness variations within members of the hangingwall sequence suggest that these units were formed in a synvolcanic graben. The faults controlling the location of the graben may have controlled hydrothermal conduits and formation of massive sulphide mineralization. Additionally, the detailed stratigraphic subdivision and mapping of the hangingwall units show that they have been structurally repeated by low-angle faults, interpreted to be thrusts, that may also structurally repeat the stratigraphically underlying Flin Flon mine horizon. In September 2005, Laurentian Ph.D. candidate Brian Hartman started detailed work on the 777 project in Flin Flon.

Superior Province

Russell Hartlaub, a post-doctoral student at the University of Alberta, notes that the northwestern margin of the Superior Province represents a dynamic boundary zone with good potential for magmatic, sedimentary-hosted, and structurally controlled mineral deposits (GS-7). Examples of expected deposit types include volcanic-hosted massive sulphide (VHMS)–style mineralization in mafic granulite of the Split Lake Block, gold deposits along the Assean Lake and Aiken River shear zones, and titanium in a differentiated anorthosite igneous complex exposed on northwestern Split Lake. The Paleoproterozoic sedimentary rocks that overlie the northwestern margin of the Superior Province have reasonable potential for Pb-Zn sedimentary exhalitive (sedex)– and Carlin-type gold mineralization.

Superior Boundary Zone

The nature and age of granulite-grade rocks of the Pikwitonei Domain have been a matter of contention for decades. New mapping by Christian Böhm, supported by geochemical, isotopic and geochronological studies, focuses on resolving the origin of high-grade rocks at Wintering Lake (GS-5). The tectonic position of Wintering Lake at the western margin of the Pikwitonei Domain and east of the Thompson Nickel Belt suggests potential for a variety of commodities, such as base metals in mafic intrusive rocks and shear-hosted precious metals along late high-strain zones within the metasedimentary-dominated

supracrustal gneisses. The current study proposes that supracrustal rocks are present in the high-grade gneiss at Wintering Lake, in similar proportion to that in the lower grade granite–greenstone belt terranes to the east. In light of the extensive supracrustal rocks present at Wintering Lake, the mineral potential of the Archean 'high-grade rocks', including mafic and ultramafic gneisses, in the area should be reevaluated.

Yvette Kuiper, a post-doctoral student at Waterloo University, continued her work on the kinematics of major shear zones in the SBZ (GS-8). She interprets new structural data for the Mystery–Apussigamasi lakes area, together with data from other shear zones in the region, to indicate that various shear zones may have formed at different times, or that the northern SBZ is a zone of large-scale tectonic brecciation. If so, gold mineralization may be complexly distributed along major and minor shear and fault zones, as well as in local areas of brecciation.

Geological Survey of Canada geologists John Percival and Joe Whalen continued work in central Manitoba, following up previous work in the southernmost transect of the Trans-Hudson–Superior Margin Metallotect TGI project (GS-9). Their regional Nd isotopic study indicates that crust of Superior affinity extends at least 40 km west of the exposed Superior Province beneath the juvenile eastern Kisseynew Domain. Field observations and geochronology in the Wuskwatim Lake area suggest that a cover sequence, possibly equivalent to the Ospwagan Group, is exposed in structural culminations that are perhaps similar to those described for the Mel zone. Regardless of their detailed history, the mafic rocks associated with the Wuskwatim cover sequence warrant attention as possible equivalents of mafic-ultramafic intrusions of the Thompson Nickel Belt.

Thompson Nickel Belt

The Thompson Nickel Belt is one of the most richly mineralized segments of the SBZ. Work by MGS in the belt continues to focus on defining the nature and extent of the Ni-hosting Ospwagan Group supracrustal sequence.

Josef Macek and Cathy McGregor are finalizing a series of 1:20 000 and 1:50 000 geological maps of the exposed and sub-Phanerozoic TNB which, among other aspects, show the distribution of the Ospwagan Group rocks. These maps, developed by MGS and industry partners Inco Limited, Falconbridge Limited and HudBay Minerals Inc., are the product of a multiyear collaborative program designed to capture both company and government information on the TNB in a series of compilation maps. A geological report describing the Ospwagan Group from type localities is in preparation. This report will be a major advance toward distinguishing Ospwagan Group rocks elsewhere in the TNB, thereby providing key information needed for its recognition in newly explored areas, such as north and northeast of Thompson.

Herman Zwanzig used new and previously unpublished geochemical data, Nd-isotope data and recently published U-Pb zircon ages to characterize the mafic-ultramafic volcanic and intrusive rocks of the Bah Lake assemblage at the top of the Ospwagan Group in the TNB (GS-6). These data support an interpretation that involves four different episodes of crustal extension and mafic-ultramafic magmatism, and is consistent with an earlier conclusion that the Bah Lake magmatism was not directly related to the deposition of Ni ores. The high-Mg magmatism of the Bah Lake assemblage, however, may have provided the crustal and mantle conditions required for later emplacement of Thompson-type cumulate magmas with their high olivine (and Ni) contents and capacity to precipitate Ni sulphides.

Far north

In 2005, MGS geologists Scott Anderson, Christian Böhm, and Gaywood Matile conducted a field-based investigation of the Nejanilini Domain, one of Manitoba's last large tracts that is relatively unknown and unexplored in terms of its geological nature, evolution and mineral potential (GS-10). Archean high-grade rocks of the Nejanilini Domain form part of a stable cratonic crust that may have developed a deep lithospheric keel extending into the diamond-stability field. Deposition of the cover sequence is interpreted to record the onset of crustal subsidence in response to continental extension, and thus may have been accompanied by mafic-ultramafic magmatism, high heat flow and resultant hydrothermal circulation, which have the potential to produce significant hydrothermal sedex-type Zn-Pb-Ag and magmatic Ni-Cu sulphide ore deposits.

The Nejanilini Lake area contains a wide variety of spectacularly preserved Quaternary geological landforms, including drumlins, eskers and tunnel channels. Glacial erratics play a significant role in the appearance of the landscape, and their characteristics and distribution provide information contributing to a better understanding of the Quaternary geology of the region.

Mineral deposit studies

Projects aimed at understanding the genesis and setting of specific mineral deposits range from regional mapping projects to deposit-specific thematic studies. In 2005, these studies were conducted in the Rice Lake and Bird River belts of southeastern Manitoba, and the eastern part of the Flin Flon Belt in northern Manitoba.

Bissett area

Scott Anderson continued his work in the Rice Lake belt, where his major contribution has been an improved

understanding of the regional setting of lode-gold deposits in the Bissett area. Significantly, however, the mapping has also identified in the Gem Lake area a bimodal suite of primary and variably reworked volcanic and volcaniclastic rocks up to 2 km thick (GS-11). These rocks exhibit many of the characteristics of oceanic or continental-arc volcanism in extensional tectonic regimes, and are interpreted to record the initiation of a ca. 2.72 Ga arc-rift basin(s) along the south margin of the Rice Lake Belt. These attributes indicate that, in addition to the demonstrated potential for orogenic lode-gold deposits, the Gem Lake area may be prospective for VHMS deposits.

Bird River belt

In 2005, MGS facilitated a unique tripartite (government-industry-university) partnership to study the setting of a variety of mineral deposits in the Bird River belt of southeastern Manitoba. The Bird River belt is host to the world-class Tanco pegmatite, a rare-element–enriched pegmatite mined for Li, Cs and Ta, as well as the Bird River Sill, a focus of Ni, Cu and/or PGE exploration since the 1920s.

Partners in the Bird River initiative include researchers and graduate students at the University of Waterloo, in part funded by Gossan Resources Limited, Mustang Minerals Corp. and Tantalum Mining Corporation of Canada Ltd., the University and the Natural Sciences and Engineering Research Council of Canada (NSERC). To capitalize on this new initiative, two MGS geologists and their students also began work on aspects of the geology of the region:

- Post-doctoral student Manuel Duguet conducted field investigations showing that the Bird River greenstone belt has experienced polyphase ductile deformation (GS-12). This regional work is expected to contribute to our understanding of the geological evolution of the belt and its contained deposits.
- M.Sc. student Paul Kremer initiated a study to examine the structural geology of the Bernic Lake Formation and provide constraints on the emplacement of REE-bearing pegmatites that occur within it (GS-14). Fieldwork in 2005 was focused on 1:10 000-scale geological mapping of the Bernic Lake Formation and the collection of an extensive sample set for oriented thin-section and geochemical analyses.
- M.Sc. student Caroline Mealin began an investigation that aims to determine the nature and distribution of sulphides and of Ni-Cu and PGE mineralization in the Bird River Sill (GS-15). The 2005 field season was devoted to geological mapping and sampling of the Chrome property.
- MGS geologist Paul Gilbert conducted both reconnaissance and detailed mapping at selected localities in the Bird River belt (GS-13). These investigations allowed a critical evaluation of existing geological maps and included remapping parts of the Bird River belt at a scale of 1:20 000. Future mapping will include an investigation of the possible extension of the mafic-ultramafic Bird River Sill, work to clarify the deformation history and possibly constrain the timing of economically important pegmatite intrusions, and a geochemical database needed to reassess the economic potential for VHMS mineralization.
- MGS geologist Peter Theyer collected humus samples in 2005 to complement the 2004 geochemical results in the area of the Mayville igneous complex (GS-16). All samples were analyzed for Pt, Pd and Au to investigate their usefulness as pathfinders to Ni-Cu-PGE sulphide mineralization, known to occur in rocks underlying this area. The results of this survey suggest that this method has some applicability; however, geochemical responses over known mineralization were erratic and may have been compromised by a number of variables inherent to this sampling environment. Selection of sample sites and the final interpretation of results are crucially dependent on a sound knowledge of the topography and drainage patterns.
- Honours B.Sc. student Armond Stansell (University of Manitoba) collected samples of sulphide-bearing fragments from the rock waste pile at the Maskwa open-pit mine (GS-18). Anomalous Ni:Cu ratios, combined with high Pt and Pd concentrations, were previously identified in rock samples collected from this locality. The samples are being analyzed in order to establish whether one or more chemically and mineralogically distinct sulphide-fragment population exist, to seek evidence of sulphide remobilization and possibly to identify the source rock of the sulphides.
- Honours B.Sc. student Linda Murphy (University of Manitoba) conducted a geological mapping and mineral-deposit research project with Peter Theyer, aimed at investigating the geology and mineralization in a deformed segment of the Bird River Sill (the Ore Fault property) and the role that deformation may have played in the mobilization and redistribution of Ni, Cu and PGE (GS-17).

Snow Lake

Simon Gagné, a Ph.D. student at McGill University, began a study in the eastern Flin Flon Belt to focus on the timing of gold emplacement in a number of gold deposits in the Snow Lake area and along the south margin of the Kisseynew Domain (GS-2). Preliminary observations from the North Star, Puffy Lake, Squall Lake and Nokomis Lake deposits support the suggestion that mineralization and alteration occurred during early to syn–peak metamorphic conditions.

Phanerozoic investigations

The Sedimentary and Industrial Minerals Section of MGS engaged in limited fieldwork in 2005, although numerous office-based projects continued or were initiated (GS-22). Some projects, such as the Williston Basin Targeted Geoscience Initiative (TGI) project, are in their final year, while others, such as the Phanerozoic lineament study, have just begun. Limited progress has been made on the 3-D coverage of the Quaternary geology of Manitoba and the surficial geology compilation of Manitoba. Municipal mapping of aggregate resources continues. Staff have also been responsible for numerous requests for information on industrial minerals and other deposits, as well as leading field trips. Staff also conducted field and office resource assessments in support of the Protected Areas Initiative.

Phanerozoic stratigraphy

The Williston Basin Architecture and Hydrocarbon Potential TGI project is a multidisciplinary, coordinated geoscientific study aimed at characterizing and understanding basin architecture and hydrocarbon potential in the Williston Basin. This two-year study involved new work that builds on established scientific leadership, cooperation and expertise amongst federal and provincial government agencies and universities. The result will be a seamless 3-D geological model of Paleozoic and Mesozoic rocks, from basement to outcrop, in Manitoba and Saskatchewan, in a geographic area extending from the northern and eastern outcrop edge to the International Boundary and west to 106°W. The first set of Lower Paleozoic maps was released on April 25, 2005 as a web release at the dedicated project website (www.willistontgi.com), which also hosts all other publications and guidebooks produced for the project. Subsequent maps sets (Devonian, Mississippian and Mesozoic) will be released throughout 2005–2006. The final report will be completed in 2006.

Aggregate

As part of a continuing program to update aggregate resource assessments in southern Manitoba, Heather Groom investigated the rural municipalities of Turtle Mountain and Riverside in 2005 (GS-21). Although both municipalities have enough aggregate reserves to meet their immediate needs, neither has abundant resources and municipal development plans should ensure that gravel deposits are protected from conflicting uses until they are depleted.

Other projects

Scott St. George continued work on a new tree-ring network for studying drought in southeastern Manitoba and northwestern Ontario (GS-19), as part of a Ph.D. study at the University of Arizona. Because the Winnipeg River provides 45% of the water flowing into Lake Winnipeg and the Nelson River, its watershed is the most important component of the hydrological system used to generate power by Manitoba Hydro. This project will lead to a better understanding of drought in the Winnipeg River basin — identifying how severe droughts can be, how often they can occur and what factors lead to their occurrence. Fieldwork in 2004 collected tree-ring samples at 11 locations within the Winnipeg River basin, with the oldest tree being 255 years old. An additional 14 tree-ring sites were established in 2005 within the northeastern and southern sectors of Lake of the Woods and near Quetico Provincial Park. Future analysis will determine if tree-ring data can be used to estimate the past occurrence and severity of drought in the Winnipeg River system, and place recent droughts within a longer-term context. This information will help us understand how and why droughts develop, and contribute to producing more realistic assessments of drought risks in the future.

The reestablishment of self-sustainable forest systems in mine tailings areas is a major environmental issue. A greenhouse experiment conducted by researchers at the University of Manitoba (lead by Dr. Sylvie Renault; GS-20) was designed to test the effects of paper-mill sludge on plants growing in mine tailings with and without fertilizer. The addition of paper-mill sludge without fertilizer to tailings increased shoot growth of the selected species. These preliminary results suggest that paper-mill sludge has potential as a tailings amendment for revegetation of the Central Manitoba minesite. The utilization of waste products from the pulp and paper industry for revegetation of abandoned mines would provide a relatively low cost reclamation technique.

Regional offices

The Flin Flon office continues to provide regulatory and technical assistance to the mineral-exploration and mining communities in northwestern Manitoba (GS-4). This includes accepting applications and submissions that fall under the auspices of *The Mines and Minerals Act*. In addition, the office provides assistance and information to companies and individuals in obtaining information about the geology and mineral resources of the region.

Core-storage facilities

Manitoba's Mineral Resources Division has been storing Precambrian drillcore, obtained primarily from exploration drilling, since the early 1970s. Since that time, the Manitoba government has created a substantial repository of drillcore at five locations throughout the province. In 2005, Dave Prouse conducted inventory organization and updating work at the Thompson and Lynn Lake core libraries (GS-3).

Compilation and partnerships

Dorne Lindal and Tim Corkery continued work on the production of a seamless 1:250 000-scale bedrock geological map for the province. This map is based on the Bedrock Geology Compilation Map Series maps, which are converted to digital format and upgraded with more current content where necessary. When complete, this will be the main geological base for presenting data on the department's Internet Map Server.

Geoscience information services

In 2005, the Geoscience Information Services section devoted considerable time to the Williston Basin TGI project. Glen Conley was responsible for the assembly and verification of a large digital-data set and Len Chackowsky for the production of more than 40 structure and isopach maps for the northwestern portion of the Western Canada Sedimentary Basin in Manitoba and Saskatchewan.

Other major digital projects include

- updating the Manitoba Geochronology Database, last released in 1993, with data collected during the past 12 years; data already in the database have been checked for positional accuracy, and a user-friendly front end was developed by Greg Keller; the updated Geochronology Database will be released in November 2005;
- addition of digital geophysical data from the cancelled assessment files to the Internet Map Server by Paul Lenton, to enable clients to examine and download datasets.
- processing of a large till geochemistry data set, comprising more than 1500 sample locations covering five NTS sheets in the Lynn Lake area, for release in November 2005; and
- design of a new standardized GIS map symbol set, including geological symbols for point, line and polygon features, that will form the standard for all MGS maps in the future.

Client services and outreach

In 2004–2005, MGS published 6 geoscientific reports, 82 maps and the new Williston Basin TGI web pages. In addition, digital versions of 19 previously out-of-print or print-only publications were re-released; these are now available for free download from the web site.

The Mineral Resources Library staff, Lori Janower and Elaine Hunter, with contract employee Derek Bogdan, collaborated with Saskatchewan to create a new, online, searchable bibliographic database for the Williston Basin TGI project. The database can be accessed from the Williston Basin TGI website.

MGS mineral-education outreach initiatives included the Manitoba Mining and Minerals Convention Schools Program, National Engineering and Geoscience Week, and Provincial Mining Week. The latter, coordinated by Elaine Stevenson and delivered by many MGS staff, offered free, hands-on activities developed to complement the earth sciences curriculum and help increase public awareness of Manitoba's mineral resources and mining industry. The event drew more than 3700 visitors from the general public and the school tours program.

In June, Alan Bailes gave geoscience presentations to students of the Disbrowe and Red Sucker schools at Red Sucker Lake. The presentations developed some of the fundamental concepts used by geologists during their work and presented the end-uses of common rocks and minerals using Manitoba examples.

A number of MGS staff, including Vanessa James, Ruth Bezys, Elaine Stevenson and Peter Leskiw, contributed to the development of a new Prospector Training Program, now offered through Manitoba's University College of the North (UCN). The program was developed through a partnership between the province, the Government of Canada, UCN, the Assembly of Manitoba Chiefs and the minerals sector. The first eleven students to graduate from the course in September 2005 acquired new prospecting skills that included wilderness navigation and survival, mineral identification, regional geology, claim staking, prospecting, and exploration techniques and regulations.

Elaine Stevenson, the MGS outreach programs coordinator, also organized the first Aboriginal Mining Workshop, which was held as part of the November 2004 Manitoba Mining and Minerals Convention. The objective of the workshop, which drew 59 participants, was to increase awareness of exploration and mining in Manitoba and potential opportunities for community economic development, and to increase Aboriginal participation in the industry.

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