

## Annual review by E.C. Syme

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### Introduction

This 2008 *Report of Activities* marks the 40<sup>th</sup> anniversary of the first such report: *Summary of Geological Fieldwork 1968*, Geological Paper 68-3. We have come a long way from the 43 double-spaced typed pages in the 1968 version, but the intent remains the same—to bring the results of summer investigations to the geological community in as timely a fashion as possible. Manitoba is one of very few jurisdictions in Canada to publish its complete *Report of Activities* annually in November, and to make it available in hardcopy, CD-ROM and via download from the Web.

Staff of the Manitoba Geological Survey were saddened in 2008 by the loss of two of the founders of the modern Survey. Dr. Werner Weber, former Chief Geologist, passed away April 23, 2008 in Winnipeg and Dr. David McRitchie, former Director, passed away September 15, 2008 in Fernie, British Columbia. Both had long and productive careers in Manitoba, and an ‘in memoriam’ for each is included in this report.

This year, the Manitoba Geological Survey (MGS) continued multiyear programs in the Paleoproterozoic Flin Flon Belt, the eastern Kisseynew Domain and the Thompson Nickel Belt (TNB). Phanerozoic investigations focused on a study of the Devonian Three Forks Formation, investigation of shallow unconventional shale gas prospects, and the completion of products from the Williston Basin Targeted Geoscience Initiative.

The MGS initiated new field projects in

- the far north, in the Great Island Domain;
- Snow Lake (gold metallogeny);
- Paint Lake on the eastern margin of the Thompson Nickel Belt (TNB); and
- Southern Indian Lake, as a contribution to the Targeted Geoscience Initiative.

### Collaborative programs with the Geological Survey of Canada

#### *Targeted Geoscience Initiative*

As in previous years, a significant portion of MGS work in 2008 was conducted as part of the Targeted Geoscience Initiative (TGI). This initiative provides a vehicle to partner with the Geological Survey of Canada (GSC) on priority projects aimed at improving the economic sustainability of mining towns in northern Manitoba. The current TGI, announced in the February 2005 federal budget, is the third in a series of such initiatives since 2000. Federal funding for TGI-3 is \$25 million (nationally), to

be spent over a five-year period that started April 1, 2005. The TGI-3 Flin Flon project is an integrated, multidisciplinary geoscience study to aid in the discovery of new reserves of base metals in established mining communities of west-central Manitoba and east-central Saskatchewan. The project has been developed through joint provincial-federal-industry consultation and is delivered as a fully integrated partnership that includes the minerals industry, researchers from Canadian and American universities, and geologists from the MGS, the Saskatchewan Geological Survey (SGS) and the GSC.

The MGS is also in the process of completing products from the Williston Basin project (TGI-2). The primary objective of this project was to develop an integrated geoscience dataset that incorporates new stratigraphic data, seismic, gravity and aeromagnetic information, hydrogeological mapping, and remotely sensed data from a large area encompassing the Phanerozoic succession of the northeastern Williston Basin in Saskatchewan and Manitoba.

#### *Geomapping for Energy and Minerals (GEM)*

As announced in the 2008 federal budget, and subsequently by the Prime Minister in early August 2008, the Government of Canada is investing \$100 million over five years in its new Geomapping for Energy and Minerals (GEM) initiative to provide the geoscience information necessary to guide investment decisions leading to the discovery and development of new energy and mineral resources. The GEM initiative, delivered under two GSC Programs (GEM-Energy and GEM-Minerals), will focus mainly on northern Canada (north of 60° latitude) and will use modern geological methods and standards to identify the potential for energy and mineral resources. The GEM program will also fill critical information gaps in the knowledge base needed to increase exploration investment in the provinces, south of 60°. At least 75% of the federal funds will be allocated for public geoscience in the North, and up to 25% in the provinces, the latter on a cost-shared basis.

Manitoba and Canada completed planning for a GEM project in Manitoba’s far north in June 2008. The MGS initiated fieldwork in the region in July 2008 as the reconnaissance phase of a two-year, intensive, field-based program starting in 2009. The Geological Survey of Canada meanwhile funded two airborne radiometric and magnetic surveys in priority areas that will be the focus for coming fieldwork.

## **Precambrian mapping**

### ***Flin Flon–Snow Lake greenstone belt***

Geological Survey of Canada researchers led by S. Pehrsson, together with Laurentian University researchers H. Gibson and B. Lafrance, continued detailed mapping in the footwall and hangingwall rocks of the Flin Flon, Callinan and Triple 7 deposits. This work has been facilitated through excellent co-operation and collaboration with the exploration staff of Hudson Bay Exploration and Development Co. Ltd.

A two-year research project to characterize and describe the Schist Lake–Mandy Road volcanogenic massive sulphide deposits and their hostrocks was continued in 2008 by a Laurentian University M.Sc. student (Cole et al., GS-2). The Schist Lake and Mandy deposits were the first to be mined in the Flin Flon area, but their stratigraphic relationship to the other Flin Flon Cu-Zn deposits is still not established. The deposit is hosted by a succession of bedded tuffs and mafic and felsic volcanoclastic rocks that share common interelement geochemical ratios. A preliminary alteration study illustrates that most of the samples have undergone the extensive alteration that is typical of volcanogenic massive sulphide deposits.

Geochronological results, acquired from a protoquartzite at Saw Lake, 40 km east of Snow Lake, shed new light on the origin and mineral potential of the region (Bailes and Böhm, GS-3). The Saw Lake protoquartzite occurs in the eastern part of the Paleoproterozoic Flin Flon Domain, but U-Pb detrital zircon data for the protoquartzite indicate a Neoproterozoic provenance, making it unrelated to the younger Burntwood and Missi groups of the Flin Flon and Kiseynew domains. The Saw Lake protoquartzite could be correlative with the Oswagan Group in the Thompson Nickel Belt, suggesting that the structural panel containing it will have potential as a nickel exploration target.

### ***Lynn Lake–Leaf Rapids***

Fieldwork conducted during the summer of 2008 at Southern Indian Lake was the first in a multiyear MGS project, in collaboration with the Geological Survey of Canada under the Flin Flon TGI-3 program (Kremer, GS-8). The primary focus of this project is to map supracrustal rocks along the northeastern extent of the Churchill River system in the Southern Indian Lake area (Pukat-awakan Bay, Pine Lake and Partridge Breast Lake). The work will provide information needed to assess the mineral potential of supracrustal rocks in the Southern Indian Lake area relative to similar and potentially related rocks in the Lynn Lake, La Ronge and Rottenstone domains.

### ***East Kiseynew–Superior Boundary Zone***

Work conducted by MGS and GSC in recent years has delineated lithotectonic assemblages on the margins

of the Kiseynew Domain. These include lithological units that extend up to hundreds of kilometres and define new tectonic subdomains with differing mineral potential (Zwanzig, GS-4). Tracing these assemblages in the high-grade metamorphic terrane depends on the distinctive field appearance, petrology, geochemistry, Nd isotope ratio and/or U-Pb age of the contained units. Areas examined in 2008 to better define such units were at Granville and Notigi lakes on the northern flank of the Kiseynew Domain and near Sherridon on the southern flank.

Recent work in the northeastern Kiseynew Domain has provided evidence that this area is underlain by or intercalated with Superior Province basement, which is exposed in structural culminations. This basement is mantled by paragneiss derived from metasedimentary rocks similar to the Oswagan Group, which hosts the magmatic nickel sulphide deposits of the TNB. Closely associated with the basement culminations is the ca. 1885 Ma K-feldspar–porphyritic Footprint Lake plutonic suite (Whalen et al., GS-6). The unusual and distinctive geochemical and isotopic characteristics of the Footprint Lake plutonic suite make it a relatively easily identified marker unit for the distribution of Superior Province basement within or beneath the Kiseynew Domain.

Mapping continued in 2008 at Notigi Lake, on the northern flank of the Kiseynew Domain northwest of Thompson (Murphy, GS-5). This second of two field seasons has added significant details to the structure, extent and composition of rocks from the Burntwood and Sickle groups. The structural style of deformation observed in the study area is similar to that in poorly exposed Archean orthogneiss with a sedimentary cover, found in several locations in the Kiseynew Domain south of Notigi Lake, that may host Thompson-type nickel deposits.

### ***Thompson Nickel Belt***

Geological mapping was undertaken on west-central Paint Lake in 2008, to improve understanding of the Archean basement to the TNB (Couëslan, GS-9). Previously identified packages on Paint Lake include multicomponent migmatitic gneisses, layered mafic rocks, retrogressed enderbitic gneisses and Proterozoic granitoid rocks. Results from this study also outline a package of Archean metasedimentary rocks that shares some similarities with the Paleoproterozoic Oswagan Group. This has major implications for exploration in the belt, because these Archean rocks could be mistakenly identified as Oswagan Group metasedimentary rocks. The recognition of an Archean metasedimentary sequence, including quartzite with garnet-bearing concretions, iron formations and olivine marbles, presents an additional complicating factor in an area already made challenging for mineral exploration by the intense deformation and high metamorphic grades.

### ***Superior Province***

A detailed reinvestigation of alkaline igneous rocks from the southwestern part of Cinder Lake (Gods Lake Domain) was initiated as a joint project between the Manitoba Geological Survey and the Department of Geological Sciences, University of Manitoba (Chakhmouradian and Böhm, GS-10). At least three discrete intrusive phases were identified, as well as mineralogical and geochemical evidence for the presence of unexposed ultramafic and carbonatitic units genetically associated with the alkaline syenitic rocks. Geochronology and geochemistry of these rocks suggest they were emplaced in an arc setting ca. 2.7 Ga.

### ***Southeastern Manitoba***

Geological mapping of the Neoproterozoic Bird River greenstone belt of southeastern Manitoba, initiated by the Manitoba Geological Survey in 2005, was finalized by completion of coverage in the southwestern part of the belt in 2008 (Gilbert, GS-11). Detailed, 1:20 000 scale mapping and concurrent geochemical investigations have resulted in a new stratigraphic framework and revised interpretation of the crustal setting of the supracrustal rocks. Base-metal mineralization prospects in the Bird River Belt include both magmatic types and stratigraphically associated occurrences. The Bird River Sill hosts base-metal and platinum-group-element (PGE) mineralization; elsewhere, base-metal mineralization commonly occurs at lithological contacts within the volcano-sedimentary sequences. The Bird River Belt is also host to the TANCO mine at Bernic Lake, producing Ta, Li and Cs from rare-element pegmatite that accounts for approximately 80% of global reserves of Cs.

### ***Manitoba's far north***

In 2008, the Manitoba Geological Survey completed two weeks of reconnaissance bedrock mapping and sampling in the Great Island Domain on the southeastern margin of the Hearne craton in Manitoba's far north (Anderson and Böhm, GS-13). This work focused mainly on metavolcanic and metasedimentary rocks along the lower Seal and North Knife rivers, and included the collection of representative bedrock samples of all major rock types previously identified in the Great Island Domain. These samples will be submitted for litho-geochemical, Sm-Nd isotopic and/or U-Pb geochronological analysis, in preparation for a more concerted mapping program planned for the 2009 field season as part of the Manitoba Geological Survey's Far North mapping initiative.

### **Mineral deposit studies**

#### ***Kisseynew south flank***

A project in the Sherridon area was started in 2008, conducted by Laurentian University researchers (Tinkham and Karlapalem, GS-7). Alteration, litho-geochemical,

geochronological and metamorphic studies are in progress to constrain the environment in which volcanogenic massive sulphide deposits of the Sherridon structure formed and to elucidate the metamorphic evolution of the structure.

#### ***Snow Lake***

Fieldwork began in 2008 on a new MGS study of gold mineralization in the Snow Lake area (Beaumont-Smith and Lavigne, GS-1). Work to date demonstrates a strong spatial association of gold mineralization with the hangingwall of the McLeod Road Thrust. A more complete understanding of the relationship between gold mineralization and the tectonometamorphic history of the Snow Lake area will provide important constraints on gold exploration and development. Fieldwork undertaken this year represents the first stage in a multistage process of refining the geological model for gold genesis in the Snow Lake area.

#### ***Mineral deposits database***

The new digital mineral deposits and occurrences database for Manitoba has been completed. This first edition is slated for November 2008 release and will be accessed through the GIS Map Gallery. The newly designed database summarizes all of the information contained in the reports of the Mineral Deposit Series.

Work has started on the second phase, with the addition of recently released nonconfidential work that has been performed on specific properties. References included in the database allow users to find additional information for occurrences.

### **Phanerozoic investigations**

#### ***Phanerozoic stratigraphy***

Stratigraphic and petroleum investigations in the Phanerozoic of southwestern Manitoba focused on three major programs during this past year: 1) Williston Basin Targeted Geoscience Initiative (TGI), 2) Devonian Three Forks Formation stratigraphy and hydrocarbon potential, and 3) shallow unconventional shale gas prospects (Nicolas, GS-16).

The Williston Basin TGI Project is a multijurisdictional program focused on mapping the entire stratigraphy from the top of the Precambrian to the uppermost subsurface-mappable Cretaceous, which includes all potential hydrocarbon-bearing formations in Manitoba. All products derived from this project are available for free download from [www.WillistonTGI.com](http://www.WillistonTGI.com). Key components of the Williston Basin TGI project in 2008 include the release of the formation-tops database and the final stratigraphic map series.

The Devonian Three Forks Formation project is in its second phase of study, expanding the core and drill cuttings logging over the entire Three Forks depositional

area in Manitoba, examining producing pools outside the Sinclair Field, and evaluating the potential of less-explored areas. The Devonian Three Forks Formation oil play in Manitoba is a spin-off of the large Bakken Formation play of North Dakota, Montana and Saskatchewan.

The shallow unconventional shale gas project is in its first year of a four-year investigation of the shale gas potential in Manitoba's Mesozoic shale sequences, particularly the Ashville, Favel, Carlile and Pierre formations. Historical and new gas shows will be mapped, and geochemistry and mineralogical analysis will be conducted on samples from these horizons.

In 2008, MGS undertook work to document the chemostratigraphic signature of Upper Cretaceous shale sequences in the hope that this would lead to discovery of the provenance of the contained shallow unconventional shale gas (Bamburak, GS-17). The results of new geochemical analyses will be added to the historical geochemical results currently stored in the Survey's black shale database. The purpose of acquiring geochemical data for Upper Cretaceous rocks is to provide a complete package of information useful to companies considering exploration in the unconventional shallow gas plays in southwestern Manitoba.

### ***3-D model, North American Soil Geochemical Landscapes Project and OneGeology***

The Manitoba Geological Survey was active in 2008 on a number of international collaborative projects: 3-D modelling of southern Manitoba geology, collection of samples to support an international initiative, and provision of digital data to another international mapping project (Matile et al., GS-14).

The 3-D geological model for southern Manitoba will be expanded in a cross-border initiative with Minnesota and North Dakota. This initiative will unite disparate datasets and put them into a single standardized nomenclature, assisting in groundwater management on both sides of the Canada–United States border.

The North American Soil Geochemical Landscapes Project will provide continent-wide background soil geochemical data relevant to a variety of applications. The project will provide insight into the relationships between soil geochemistry, the environment and human health, as well as provide a framework and protocols for wide-scale geoscientific surveying of soils for health and environmental purposes.

OneGeology is an international initiative of the geological surveys of the world and a flagship project of the 'International Year of Planet Earth'. Its aim is to create dynamic geological map data of the world, available via the Web, to provide greater accessibility of geological map data worldwide. The Manitoba Geological Survey is the first non-national geological survey to have data available on the portal, and to offer it at a more detailed scale than is currently available for the rest of Canada.

### ***Aggregate resources***

The rural municipalities of Dauphin, Ethelbert, Gilbert Plains, Grandview and Mossey River were mapped in 2008 as part of an ongoing project to update a 30-year old regional aggregate inventory (Groom, GS-15). A pit inventory program resulted in updated information on aggregate resources for the five municipalities. Aggregate sources in the area are large and demand is relatively low, being mainly for highway and section road construction and maintenance.

### ***Other projects***

#### ***Revegetation of tailings***

University of Manitoba researchers continued with a program investigating the revegetation of mine tailings (Markham et al., GS-12). The Gunnar gold mine tailings pond has remained largely nonvegetated since the mine was closed 66 years ago. The Gunnar mine tailings site has missed a full timber rotation since it was abandoned and, without remediation, the site will be barren for another rotation. The site has also undergone a loss of carbon-holding capacity.

#### ***Compilation and partnerships***

The Manitoba Geological Survey is engaged in many partnered initiatives, including contributions from the federal government, the mineral industry and several Canadian universities. Partnerships added approximately \$1.1 million to geoscience programming in Manitoba for 2007–2008, and represent significant leverage of the MGS geoscience budget. The projects facilitate the training of future geoscience professionals, which in 2007–2008 included two postdoctoral fellows, two Ph.D. candidates, three M.Sc. candidates and two Honours B.Sc. thesis projects.

Primary focus for partnerships in 2007–2008 was the Flin Flon TGI-3 project. The Bird River suite of projects has been largely completed; theses and journal articles are in preparation. The new Federal-Provincial Far North program will form the core of partnered programs during the next 2–3 years.

#### ***Geoscience Information Services***

The Geoscience Information Services section supports the operation of the Geological Survey's research activities by providing data management, GIS and graphic production services.

The Williston Basin TGI-2 project is nearing completion, using a standardized database to combine Manitoba and Saskatchewan data. Work continued through 2008 on finalizing databases and producing new versions of maps for the entire stratigraphic section.

The production of a seamless 1:250 000 scale digital geological base map for Manitoba is nearing completion. The entire Precambrian compilation is complete and a new legend structure has been designed and implemented.



The geophysical dataset compilation project involves geophysical data in the nonconfidential assessment files. The project has focused on expanding the number of datasets and converting the data presentations to standard format, with particular emphasis on converting data to standard projection and datum. These data presentations are available for download from the GIS Map Gallery.

Geoscience Information Services has devoted considerable effort supporting ongoing compilation at 1:5 000 and 1:2 000 scales in the Flin Flon Belt. The final 1:10 000 compilation map is nearing completion, with release anticipated for March 2009.

### Client services and outreach

In 2007–2008, MGS published the annual *Report of Activities*, 2 open file reports, 16 open file maps, 2 geoscientific maps, the 2<sup>nd</sup> edition of the Surficial Geology Compilation Map Series on DVD, the 1:1 000 000 *Surficial Geology Map of Manitoba*, 6 preliminary maps, 62 stratigraphic maps and 4 data repository items. To meet client needs, MGS continued to offer the majority of the publications in hard copy, on CD-ROM or DVD for purchase through Publication Sales, and in electronic format for free download via the Web.

New Web content published by MGS in 2007–2008 included

- the Exploration Activity Tracker site, which provides the tools to quickly and easily track mineral exploration projects and mining activity in Manitoba; the “Companies” list and interactive “Exploration Activity Map” link to the most current public-domain information available on Manitoba-based exploration projects;
- the “Stratigraphic Map Series” page, featuring digital maps produced under this series, including 30 maps released on CD-ROM in 1998 as part of Open File Report OF98-7: *Manitoba Stratigraphic Database and the Manitoba Stratigraphic Map Series*, and 98 maps from the Williston Basin TGI 2 Project; all maps are available for free download from the new page; and
- “Manitoba Mining Thru the Centuries”, developed by the MGS Mineral Resources Library, which presents a chronology of Manitoba’s mining history; a clickable timeline or mine location map lists mining operations, companies and commodities mined, and a photo gallery offers a visual history.

Manitoba Geological Survey mineral-education outreach initiatives included the “Manitoba Rocks!” program, which was delivered at the Manitoba Mining and Minerals Convention, the Children’s Hospital, the Children’s Museum and during Provincial Mining Week. “Manitoba Rocks!” offers free hands-on activities developed to complement the Earth-sciences curriculum and increase public awareness of the importance of Manitoba’s mineral resources and mining industry. At the Provincial

Mining Week activities, a warm and sunny weekend helped to draw more than 3700 visitors. For the first time, MGS partnered with the Children’s Hospital to deliver a modified version of “Manitoba Rocks!” to 15 children at the hospital in November 2007 and in May 2008. In July 2008, MGS partnered with the Children’s Museum to offer gold panning as part of their “From Crystals to Gems” exhibit, which attracted over 800 visitors.

Other events organized or assisted by Elaine Stevenson, the MGS outreach programs co-ordinator, included

- the 4<sup>th</sup> Annual Aboriginal Mining Workshop (AMW), held as part of the 2007 Manitoba Mining and Minerals Convention. The AMW drew the highest attendance to date, with more than 100 participants. The workshop focused on the successes and challenges of developing and implementing partnerships for the socio-economic well being of Aboriginal communities.
- the 3<sup>rd</sup> Annual Learning Together Conference (LTC) in April 2008. The two-day conference focused on the opportunities and challenges faced by the mining industry and Aboriginal communities. More than 150 delegates from across Canada attended, including 25 Manitoba Métis youth who attended a special two-day mining workshop for youth and the conference plenary sessions.
- the two-day Mine Environment Neutral Drainage (MEND) Workshop on “Challenges in Acidic Drainage for Operating, Closed or Abandoned Mines”, held in June 2008. More than 100 people attended, representing provincial and federal governments, consultants, the mining industry, academia, Aboriginal Canadians, community members and environmental nongovernmental organizations.
- the Cross Lake Mining Conference, “Building Relationships and Creating Partnerships between First Nations and the Mining Industry”, held in July 2008. It is the first mining conference to be held in a northern Manitoba First Nation community. The conference was successful in attracting more than 140 delegates from First Nations, the mining industry and government.

Survey staff delivered mining and geology presentations to Aboriginal communities at Nelson House First Nation, at Granville Lake and at Wolseley School in Winnipeg. In addition, staff attended Aboriginal conferences, such as Vision Quest, and the Canadian Aboriginal Minerals Association Conference.

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