

## GS-20 Summary of investigations for the Sedimentary and Industrial Minerals Section, Manitoba Geological Survey

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### Summary

The Sedimentary and Industrial Minerals Section of the Manitoba Geological Survey (MGS) conducted limited fieldwork in 2007 but many office-based projects were initiated or had new developments. The section is pleased to have hired a new stratigraphic and petroleum geologist this year. With the new hire, much progress was made on the Williston Basin Targeted Geoscience Initiative (TGI) project with all new content posted on the project's website. With the addition of a petroleum geologist to the section, the Devonian Three Forks Formation study is being expanded to improve understanding of the formation's oil-bearing capacity. Significant progress has been made with the Surficial Geology Compilation Map Series, which has been completed for the province and will be released in November 2007. Three stratigraphic coreholes were drilled in the summer of 2007, for a total depth of 166.1 m. Staff has also been responsible for responding to numerous requests for information on industrial minerals and aggregate deposits, as well as leading field trips. Some work has proceeded on the Phanerozoic lineament study and three-dimensional geological mapping of Manitoba. Support was also provided to the Manitoba Mineral Deposits Database and the Protected Areas Initiative Mining Sector Consultation.

### Introduction

The Sedimentary and Industrial Minerals Section has had some new and exciting developments this year. The section is very excited to have M. Nicolas hired as our newest geologist. Her speciality is petroleum geology and stratigraphy and her main target of study in the short term will be the Devonian Three Forks Formation, along with the completion of the Williston Basin TGI project.

Other developments in the section include

- Williston Basin TGI project;
- Devonian Three Forks Formation petroleum study;
- Phanerozoic lineament study;
- Surficial Geology Compilation Map Series;
- three-dimensional geological mapping;
- 2007 Stratigraphic Corehole Drilling Program; and
- miscellaneous studies

Significant progress was made on the Williston Basin TGI project, with developments toward a new stratigraphic correlation chart, database compilation, biostratigraphy, hydrocarbon assessment, regional cross-sections and regional maps. All new information, as it



comes available, has been posted on the TGI website (<http://www.willistonsgi.com>). With the hire of M. Nicolas, the Devonian

Three Forks Formation petroleum study will be expanded to include a detailed geoscientific study of the formation's oil-bearing capacity, as well as a reservoir analysis of the Sinclair Field (Nicolas, GS-17, this volume). The Phanerozoic lineament study, which is a co-operative study between the MGS, Saskatchewan Industry and Resources and the Alberta Geological Survey, has had some progress. The first phase of structural compilation is complete for Manitoba and the second phase of digitizing the lineaments will commence shortly. Considerable progress has been made on the Surficial Geology Compilation Map Series of Manitoba. The project is now completed and will be released on DVD (second edition) and as a 1:1 000 000 surficial geology map. Three-dimensional geological mapping of the province will continue into southwestern Manitoba in the upcoming year in support of the groundwater-related issues. Three coreholes were drilled in 2007 to assist in an understanding of Paleozoic stratigraphy and altered Mesozoic shale (Bamburak, GS-16, this volume). The section has been assisting with the compilation of the Manitoba Mineral Deposits Database (Heine, GS-21, this volume), as well as providing input to the Protected Areas Initiative Mining Sector Consultation in southeastern Manitoba. Aggregate studies were conducted in the Rural Municipality (R.M.) of Park as part of an ongoing project to update aggregate information in the province (Groom, GS-19, this volume).

### Williston Basin TGI project

The Williston Basin TGI project was originally a two-year project, and is now in its fourth year. Despite the completion delays, it has proven to be extremely useful and informative to all who work in the Canadian portion of the Williston Basin. With the creation of the project's own website (<http://www.willistonsgi.com>), all products from this project have been posted, as they come available, to ensure users are kept up to date. The high quality of science being conducted during the course of the project has not been compromised.

Below is a summary of the accomplishments for each task in the project.

#### 1. Geoscience knowledge inventory (bibliography)

- completed and ready to use on the website

## 2. Regional geological mapping

- a detailed stratigraphic column has been completed for the project (see section below) to assist in cross-border mapping
- biostratigraphy has been completed for several Mississippian and Cretaceous horizons (see section below)
- the stratigraphic database contains a total of 9012 wells and is available on the website for free download
- structure and isopach maps have been completed for 58 stratigraphic horizons, resulting in a total of 104 maps
- a grid of regional cross-sections with geophysical logs and TGI stratigraphic picks is in progress

## 3. Geophysical investigations

- regional gravity and high-resolution aeromagnetic maps were compiled for the Williston Basin within the study area, resulting in a seamless tectonic framework for the Precambrian basement rocks directly beneath the Phanerozoic cover
- eight seismic lines were acquired for the project

## 4. Regional hydrogeology

- a series of maps, consisting of total dissolved solids, freshwater head and water driving force for every hydrostratigraphic unit (19 in total from Precambrian to surface), have been completed, as well as the hydrochemical and hydraulic cross-sections

## 5. Remotely sensed imagery

- with the exception of using sensing methods to help draw the outcrop edges of some of the Lower Paleozoic and Cretaceous horizons, this task was cancelled

## 6. Hydrocarbon assessment

- oil and gas fields and pool boundaries, reserves information, oil and gas shows (outside producing zones), drill stem tests (DST), source rock information (total organic carbon [TOC] and Rock-Eval™) and vitrinite reflectance results have been compiled
- a GIS-based map will be created to view the data

## 7. Three-dimensional GoCad™ geological model

- the model will encompass the stratigraphy in southwestern Manitoba, including all units from the Quaternary to the Precambrian
- a preliminary version of this model is available on the website
- the final model is still in progress

## 8. Summary report

- As the project evolved, it was decided not to do one large report but to break it down into several reports, each discussing different aspects of the project, as outlined in the following:
  - a summary report on the results of the biostratigraphy for the Manitoba samples is in progress
  - a first draft of a detailed report on the Mesozoic sequence, covering the entire TGI area, has been

completed

- the geophysical report has been completed
- the final hydrogeological report is in progress
- first drafts of the summary reports on the hydrocarbon assessment for the Paleozoic and Mesozoic sections in Manitoba have been completed

## Stratigraphic correlation chart

With the staffing addition of M. Nicolas to the section, the TGI project has been moving towards completion. Presently the TGI stratigraphic correlation chart has been completed and is available for free download at <http://www.willstontgi.com> (Figure GS-20-1). This chart shows detailed crossborder correlations between eastern Saskatchewan and Manitoba of all formations and members within the Phanerozoic. The detail within the correlation chart (to member level) goes beyond the level of detail found in the published stratigraphic maps, which are also being produced for the TGI website. This chart is a state-of-the-art publication for this region of the Williston Basin, and will be the standard for future explorationists and researchers.

## Biostratigraphy

Samples of core from the Mesozoic and Mississippian intervals for the TGI project were sent to the Geological Survey of Canada's (GSC) paleontology laboratory in Calgary for biostratigraphic analysis (conodont, foraminiferal and palynological analyses). Preliminary review of the conodont analyses of the Mississippian intervals in Manitoba show interesting timelines. The Mississippian samples analyzed were from the Lodgepole Formation's Daly Member, Cruikshank Crinoidal facies, Basal Limestone facies and the Routledge Shale facies, as well as the Bakken Formation's Upper Member. All samples from the Mississippian indicate deep-water deposition. The conodont colour alteration index (CA) for all samples from the Mississippian had a value of CA = 1, indicating the rocks are thermally immature. A detailed report on the biostratigraphy results from the Williston Basin TGI project will be posted on <http://www.willstontgi.com> by the end of 2007. Results from the Mesozoic foraminiferal and palynological analyses are still being processed.

## Hydrocarbon assessment

The hydrocarbon assessment of the TGI project area is nearing completion. A compilation of oil and gas shows, publicly available geochemistry results (TOC and Rock-Eval™), and vitrinite reflectance results from the GSC for the entire Phanerozoic section covering the TGI study area has been completed and converted into a GIS-ready format. Reservoir tables for the major fields, pools and units in Manitoba have been compiled and will also be converted into a GIS-ready format. Once all the hydrocarbon assessment data has been compiled into a GIS format, the information will be made

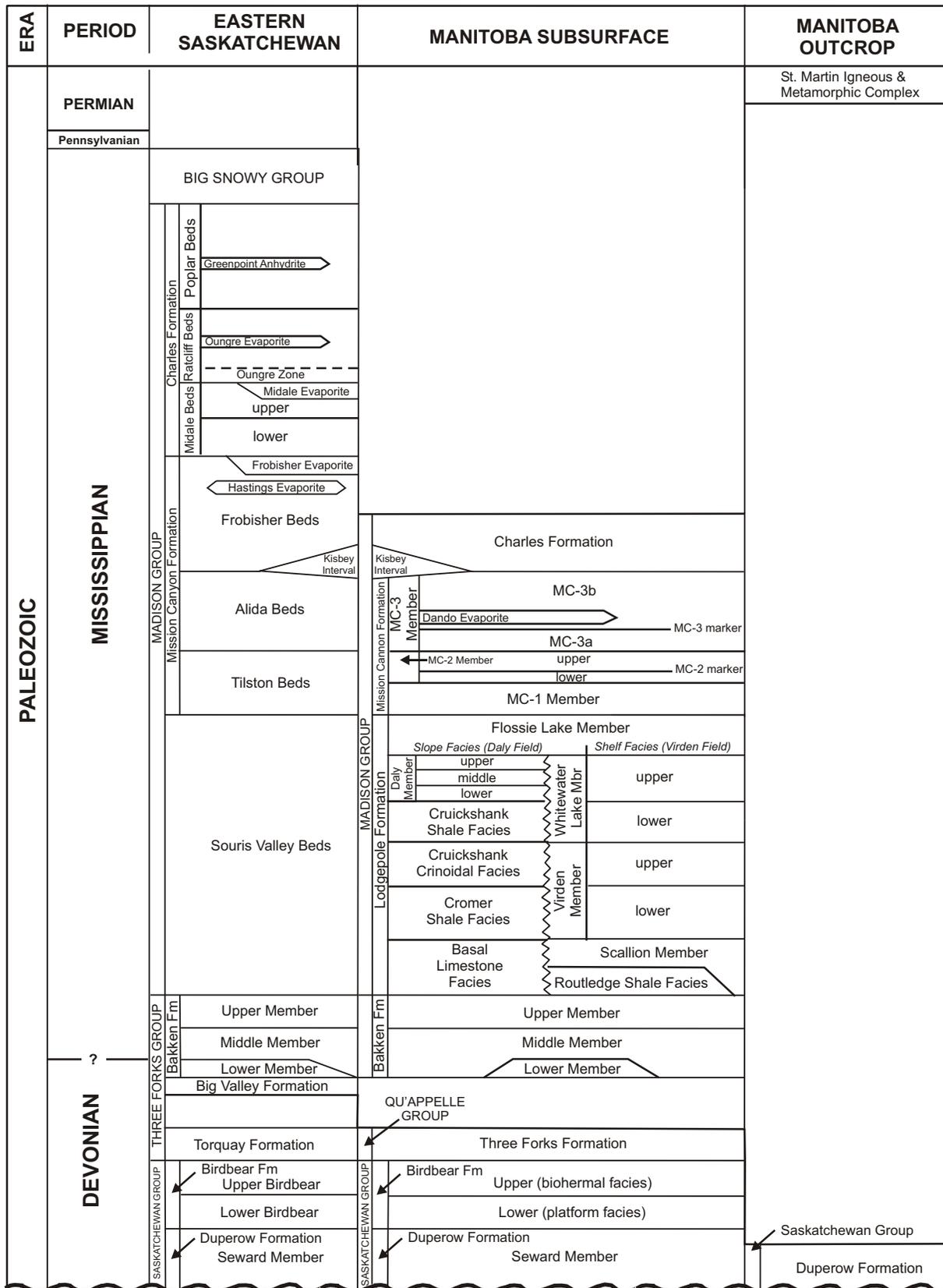


Figure GS-20-1: The central portion of the Williston Basin Targeted Geoscience Initiative (TGI) stratigraphic correlation chart. The entire section can be viewed at <http://www.willistontgi.com>.

available at <http://www.willistontgi.com> either as shapefiles or Excel® tables.

### **Regional cross-sections**

An array of regional cross-sections, covering the TGI study area for the entire Phanerozoic section, is in the process of being completed. Preliminary cross-sections have been reviewed and will be posted on the website when completed.

### ***Devonian Three Forks Formation study***

A petroleum study of the Devonian Three Forks Formation, Qu'Appelle Group, in southwestern Manitoba is being expanded from a smaller study (Nicolas, 2006), originally undertaken as a core workshop at the Saskatchewan and Northern Plains Oil and Gas Symposium in October 2006. This expanded study includes the entire depositional area of the Three Forks Formation in Manitoba, from Twp. 1 to 23 and Rge. 13 to 29, W 1st Mer. A preliminary report discussing the early findings of this study is published in this volume (Nicolas, GS-17, this volume).

The expanded study includes core descriptions, isopach and structure maps of the formation, detailed maps of the units within the Three Forks Formation, tectonic environment, and controls on the formation's oil-bearing capacity. A reservoir analysis of the Sinclair Field and comparison of the Sinclair reservoir with other Three Forks Formation producing pools within the province will also be attempted. A final geoscientific report will be published in early 2008.

The discovery of the Sinclair Field in 2004 has sprouted a great interest in the Three Forks Formation in Manitoba – a formation overlooked for its petroleum potential in the past. The Sinclair Field has proven and probable reserves, estimated at 6.8 million m<sup>3</sup>, and has attracted much attention from the petroleum industry. New drilling techniques and a better understanding of the geology of the Three Forks Formation has many petroleum companies exploring elsewhere in Manitoba's wedge of the Williston Basin to hopefully find another hidden field as successful and profitable as the Sinclair Field.

### ***Phanerozoic lineament study***

The first phase of the Phanerozoic structural compilation project of Manitoba's portion of the Western Canada Sedimentary Basin has been started by the MGS (Bezys, 2006). This initial phase involved the inventory of published maps and figures of lineaments in Manitoba. As a result of this work, over sixty documents were identified, from published works between 1957 and 2006.

The second phase of digitizing the lineaments into ArcView layers (i.e., shapefiles) and tagging the lineaments with attribute data will commence shortly. This data will be merged with GIS digital shapefiles from published sources and contributed to the joint Alberta,

Saskatchewan and Manitoba database of Phanerozoic structural lineament information.

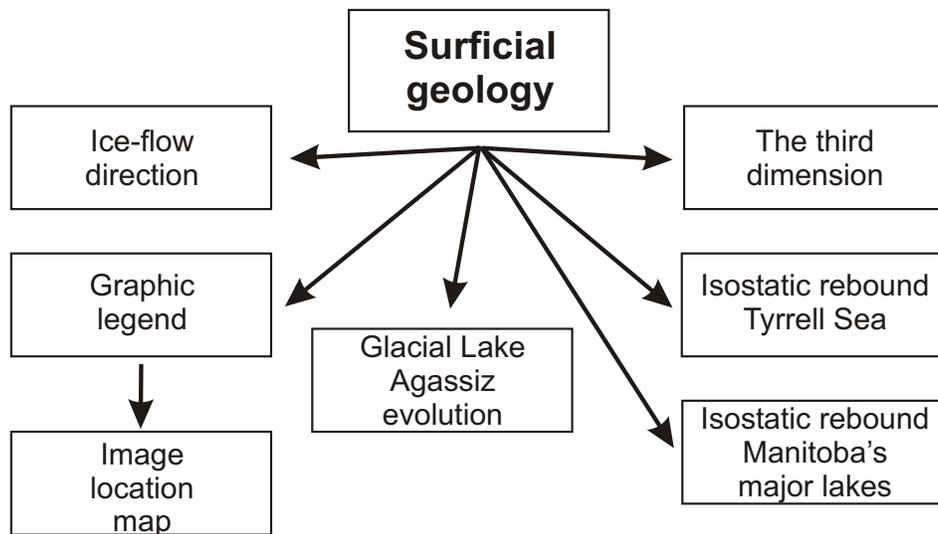
### ***Surficial Geology Compilation Map Series***

The Surficial Geology Compilation Map Series (SGCMS) in Manitoba, which addresses an increasing demand for consistent surficial geology information for applications such as groundwater protection, land management and mineral exploration, has been completed and will be released on DVD (second edition) and as a 1:1 000 000 surficial geology map at the annual mineral convention (Matile and Keller, 2007a, b). The final map compilation at 1:1 000 000 is being released as a two-sided hard copy map and will supersede the original surficial geology map that was released in 1981 (Nielsen et al., 1981). All SGCMS products are also available for download from <http://www.gov.mb.ca/iedm/mrd/geo/gis/surfgeomap.html>.

To accomplish this compilation, all paper copies of the most current and detailed surficial geology maps of various scales published by the GSC and/or the MGS were digitized. Polygons for several areas, which had been mapped more recently, were derived from digital geological maps. Soil mapping was used to fill gaps in geological mapping. Edge-matching of adjoining map sheets, polygon gaps and inconsistencies were rectified based on data from the shuttle radar topography mission digital elevation model (United States Geological Survey, 2007) as interpreted by the MGS.

Map polygons are linked to a database containing the original maps' legends compiled from the source publications. These map legend items are parsed into seven lithological and morphological characteristics allowing legend standardization across the province. The database consists of two tables: a 'legend link' table containing the parsed categories and derived legend and a second table housing the originally published legend descriptions. These two tables are linked to the polygon attribute table via a 'link' field. The linked polygons can be queried based on the above characteristics.

The maps are being released on DVD in PDF and shapefile formats. The 1:250 000 and 1:500 000 scale maps are also available on a print-on-demand basis. The SGCMS provides seamless province-wide coverage at three scales. The 1:250 000 and 1:500 000 scale maps include 1) hill-shaded surficial geology polygons; 2) a brief description of the landscape; 3) major landforms including glacial ice-flow direction; and 4) a paleogeographic reconstruction of late glacial events. The 1:1 000 000 scale map includes all of the information above as well as 1) a graphic description of map units including photographs and diagrams to define each unit in lay terms; 2) an index map of these photographs; 3) the effect of isostatic rebound on the Tyrrell Sea and major lakes; and 4) a 3-D block diagram (Figure GS-20-2).



**Figure GS-20-2:** Flow chart diagram depicting the content of Manitoba's Surficial Geology Compilation Map Series, 1:1 000 000 scale maps.

### ***Three-dimensional geological mapping***

Three-dimensional (3-D) geological mapping of the province will continue into southwestern Manitoba in the upcoming year in support of groundwater-related issues. The priority level of groundwater-related issues will steadily rise as the demand for water increases and surface water sources become fully allocated. Water supply, wetland protection, water quality protection and the ability to predict groundwater responses to drought, climate change or land-use change require a sound 3-D geological understanding to be properly addressed. While information systems are well developed for surface water in rivers and lakes, recent technological progress now allows a much more comprehensive management capability with respect to groundwater, the source of drinking water for about a quarter of all Manitobans. The possible transfer of groundwater from large aquifers in

southeastern Manitoba to areas to the west has been the subject of recent discussions and is an example of a topic that requires optimal information to ensure good decision making. To that end, Manitoba Water Stewardship embarked on a drilling program in the fall of 2007 to help in the understanding of the aquifer systems in the Sandilands area of southeastern Manitoba (southeast of Steinbach; Figure GS-20-3). As well, the use of digital groundwater models by Manitoba Water Stewardship and consultants is increasing in response to the need for more quantitative groundwater assessments than have been carried out in the past. The likelihood that similar proposals will continue to arise on the U.S.A. side of the border, and the need to co-ordinate management of cross-border aquifers, indicate that these information systems need to be compatible across borders. Essential to this activity is 3-D geological mapping by MGS, which



**Figure GS-20-3:** Rotosonic drill set-up in the Sandilands area of Manitoba.

provides the framework or the 'geological vessel' for all wellwater management.

### **2007 Stratigraphic Corehole Drilling Program**

Three stratigraphic coreholes were drilled in the summer of 2007 by the MGS. Two of the coreholes were drilled in Paleozoic strata to obtain better recovery of coreholes originally drilled in 2006 near Duck Bay and along PR 271. A third corehole was drilled on the east bank of the Valley River, northwest of Dauphin, to test the areal extent of an altered Mesozoic shale. Details of the drill results (including the possible discovery of hydrothermally altered dolomite) are described elsewhere in this volume (Bamburak, GS-16, this volume). Three holes, totalling 166.1 m, were drilled this year.

### **Miscellaneous studies**

Numerous other studies and projects are carried out by the section.

#### **Manitoba Mineral Deposits Database**

The section is assisting with the compilation of the Manitoba Mineral Deposits Database, which will be based on the MGS Mineral Deposit Series (MDS). The design of the data input screens have been completed and work is progressing on populating the defined fields. To expedite the inclusion of this information, the MDS reports have been parsed and inserted into the appropriate database fields. This process is largely complete. Information from the Mineral Inventory Cards is also being incorporated. The fields that contain information from the MDS reports and Mineral Inventory Cards need to be edited to remove extraneous, non-acceptable characters and to confirm the accuracy of the entries. For further information on this project, please see Heine (GS-21, this volume).

#### **Aggregate studies and Protected Areas Initiative Mining Sector Consultation**

This summer, aggregate deposits in the R.M. of Park (adjacent to the south side of Riding Mountain National Park and encompassing six townships) were mapped due to increasing pressure for recreational subdivisions on prospective aggregate deposits (Groom, GS-19, this volume). The purpose of this study was to identify areas of best quality aggregate to be protected for extraction purposes. The last update of this municipality was done in 1980, as part of the South Riding Mountain project (Groom, 1980a, b; Young, 1983). Sites inspected include recently active pits and revisits to old extraction sites from the 1980 study.

The Protected Areas Initiative Mining Sector Consultation focused on site selection in natural region 5C (southeast Manitoba), with hopes of acquiring adequate representation for the region. Most sites were of organic material and the major concerns to industry were related to areas with the potential for peat extraction. Only

one site visited affected an active gravel deposit. A few sites had bedrock quarry potential for crushed stone. This set of sites is completed.

#### **Industrial minerals**

The industrial minerals potential for the rural municipalities of Miniota, Archie and Rosburn were investigated during the field season. This information will be used in municipal development plans, resource management studies, Protected Areas Initiative Mining Sector Consultation studies and for use by other government departments and clients. Results of these investigations are described elsewhere in this volume (Bamburak, GS-18, this volume).

#### **Field trips and presentations**

The Sedimentary and Industrial Minerals Section provided numerous field trips and presentations during 2007. Field trips were conducted for staff of the Canadian Fossil Discovery Centre, participants of the Manitoba Paleontology Seminar, and to staff of one petroleum company. Sites visited included Paleozoic limestone and dolomite outcrops of the Williston and Elk Point basins and Cretaceous shale exposures of the Manitoba Escarpment.

Presentations were made at two of the monthly meetings of the Mineral Society of Manitoba. Topics discussed included the Lake St. Martin cryptoexplosion crater and the Pemmican Island Mississippi Valley-type occurrence. Industrial and metallic minerals talks were presented to residents of the rural municipalities of Miniota, Archie and Rosburn.

#### **Economic considerations**

Large regional syntheses, such as the Williston Basin TGI and lineament compilation projects, are the framework upon which subsequent exploration will be based. The TGI project has shown that interprovincial subsurface correlations are invaluable and represent a significant accomplishment. This is best reflected in the new stratigraphic correlation chart and database of the study area that are now available for viewing on the website. This information, along with the detailed crossborder Mesozoic correlations, will be of assistance to the petroleum exploration industry in southwestern Manitoba.

The discovery of the new Sinclair Field (conventional oil) in southwestern Manitoba coincided with the crossborder correlations of the Bakken and Three Forks formations, which were part of last year's TGI project. Industry has benefited from the co-operative mapping project and discussions between Manitoba and Saskatchewan in understanding the dynamics of this exciting new play. Further study of the Devonian Three Forks Formation in Manitoba will hopefully see an expansion of the play beyond the boundaries of the Sinclair Field.

It is hoped that further hydrocarbon and mineral

exploration will be conducted in Manitoba as a result of the lineament compilation study, Manitoba Mineral Deposits Database and stratigraphic coreholes drilled. Surficial mapping and aggregate studies are important for effective land-use planning, and hydrocarbon, ground-water and industrial minerals development.

### Acknowledgments

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