Introduction

An increasing demand for hydrocarbons by the North American economy is widening the gap between supply and demand. Geoscience knowledge is an essential component of hydrocarbon- and mineral-exploration strategies. Over the past several decades, however, both industry and governments in Canada have generally reduced funding for geoscience investigations. As a result, Manitoba Science, Technology, Energy and Mines (STEM) and Saskatchewan Industry and Resources (SIR) has embarked on a collaborative investigation (April 1, 2003, to December 31, 2007), in partnership with Natural Resources Canada (NRCan), as part of NRCan's second round of Targeted Geoscience Initiatives (TGI). The resulting study, the Williston Basin Architecture and Hydrocarbon Potential Project (Phase 1), falls under a federal government program called "Consolidating Canada's Geoscience Knowledge". This project will build upon similar geoscience framework studies carried out originally within the Saskatchewan IEA Weyburn CO₂ Monitoring and Storage Project. Such projects have been developed in recognition that an in-depth understanding of the geological framework of the Williston Basin is fundamental to assessing the basin's mineral and

Objectives

The primary objective of the TGI project was to develop a seamless geological model of Paleozoic- and Mesozoic-aged rocks from basement to outcrop in an area that includes most of the Phanerozoic succession present in both eastern Saskatchewan and Manitoba. This model integrates stratigraphic, geophysical, and hydrogeological data to enhance our knowledge of subsurface mineral potential (e.g. brines, potash), and of hydrocarbon migration paths and entrapment mechanisms within and beyond traditional geographic areas of potash and hydrocarbon production.

Methods

Stratigraphic correlations between Manitoba and Saskatchewan were established. Manitoba and Saskatchewan researchers picked tops of these established stratigraphic horizons. A database was built that comprised geological picks derived from most of the drillholes penetrating Devonian and deeper horizons and from selected wells (averaging 5 wells per township in densely drilled areas) penetrating Mississippian- and Mesozoic-aged rocks. The final database contains information from a total of 9012 wells, which includes 2606 wells from Manitoba, 5046 wells from Saskatchewan, 771 wells from North Dakota, and 589 wells from Montana. A grid of regional cross-section were constructed to show these correlations and illustrate the architecture of the Williston Basin in the study area. Computer-generated structure and isopach maps for all major geological units were produced from this data. A compilation of public data through government reports and maps on source rock information, oil and gas shows, and oil reserves was formated into GIS-ready files. Through involvement with University of Saskatoon, the project has acquired seismic,

aeromagnetic, and gravity data, and has producted a comprehensive geophysical report. Through involvement of the University of Alberta, hydrogeological data was collected and a basin model developed, using the established stratigraphic horizons developed for the project.

Data Distribution

All the products of this project completed to date are available for free download at <u>www.WillistonTGI.com</u>. The final product of this project will be the integration of the stratigraphic data into an ArcView GIS product and a Gocad 3-D geological model that will be made publicly available on DVD. A written summaries or reports from the various tasks will accompany this release. An important component of the TGI project, part of the Consolidating Canada's Geoscience Knowledge program, was the compilation of a comprehensive bibliography of published geoscience information covering the study area, and is currently available on the website.

Project Participants

Geological Survey of Canada:

The project was initially led by Benoit Beauchamp (GSC-C), who has subsequently left the GSC and has been replaced by Martin Fowler (GSC-C).

Manitoba Science, Technology, Energy and Mines:

Ruth Bezys (Manitoba Geological Survey (MGS)) and Carol Martiniuk (Petroleum Branch; currently away on leave) are responsible for coordinating research work in Manitoba for the TGI project. Michelle Nicolas (MGS) is the chief researcher and worked on the Phanerozoic stratigraphy and hydrocarbon assessment. Gaywood Matile and Greg Keller (MGS) guided the development of a 3-D geological model for the project; Len Chackowsky (MGS) is involved in final map production; Glenn Conley and Greg Keller (MGS) are involved in database management; Craig Steffano and Paul Lenton (MGS) are involved in website design; and Derek Bogdan and Lori Janower (MGS) are involved with bibliography.

Saskatchewan Industry and Resources:

Under the direction of Kim Kreis (formerly of SIR) and Steve Whittaker, both of whom have since left SIR, are responsible for the coordination of all research tasks in Saskatchewan. Melinda Yurkowski directed Saskatchewan's compilation of a comprehensive geoscience bibliography and development of an ArcView GIS product for the geoscience knowledge inventory, preparared the regional cross-sections, and developed the Mesozoic tops database for Saskatchewan. Jeff Coolican provoded GIS assistance, as wellas compiled and prepared information for the hydrocarbon assessment. Arden Marsh was involved in the compilation and clean up of the tops into a useable database. Other SIR researchers include Andre Costa (has since left SIR), Stacey Spooner, Erik Nickel, and Andrew Nimegeers. SIR GIS assistance was from Megan Opseth and Tyler Music.

The University of Saskatchewan:

Dr. Igor Morozov will be responsible for regional geophysical investigations in the TGI project area. Dr. Jiakang Li, a Post Doctoral Fellow with the University of Saskatchewan, will work with Dr. Morozov on the compilation, integration, and interpretation of regional gravity and aeromagnetic datasets.

University of Alberta:

Under the leadership of Dr. Ben Rostron, Dan Palombi (M.Sc. student) will map existing hydrogeological and hydrochemical data for major deep aquifers (>250 m) to describe their flow in three dimensions.

Consultants:

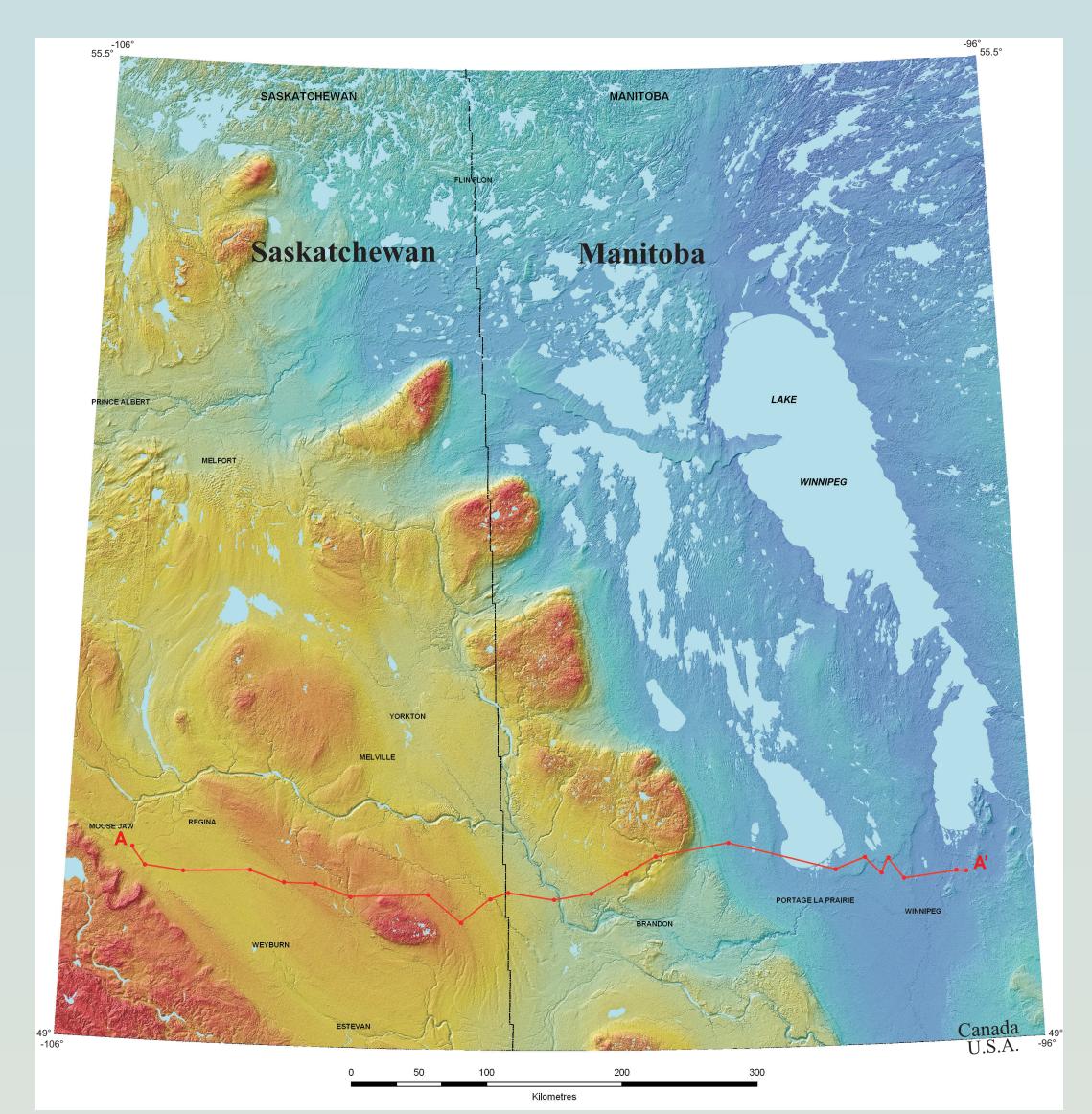
Consultants have been hired in support of the geoscience knowledge inventory and regional geological mapping. Dr. Don Kent and Patty Thomas will be working with SIR geologists, primarily in Saskatchewan, on Paleozoic stratigraphy, while Dr. Jim Christopher will focus on Mesozoic stratigraphy. Dan Barchyn will be working with Manitoba geological staff on Paleozoic stratigraphy in Manitoba.



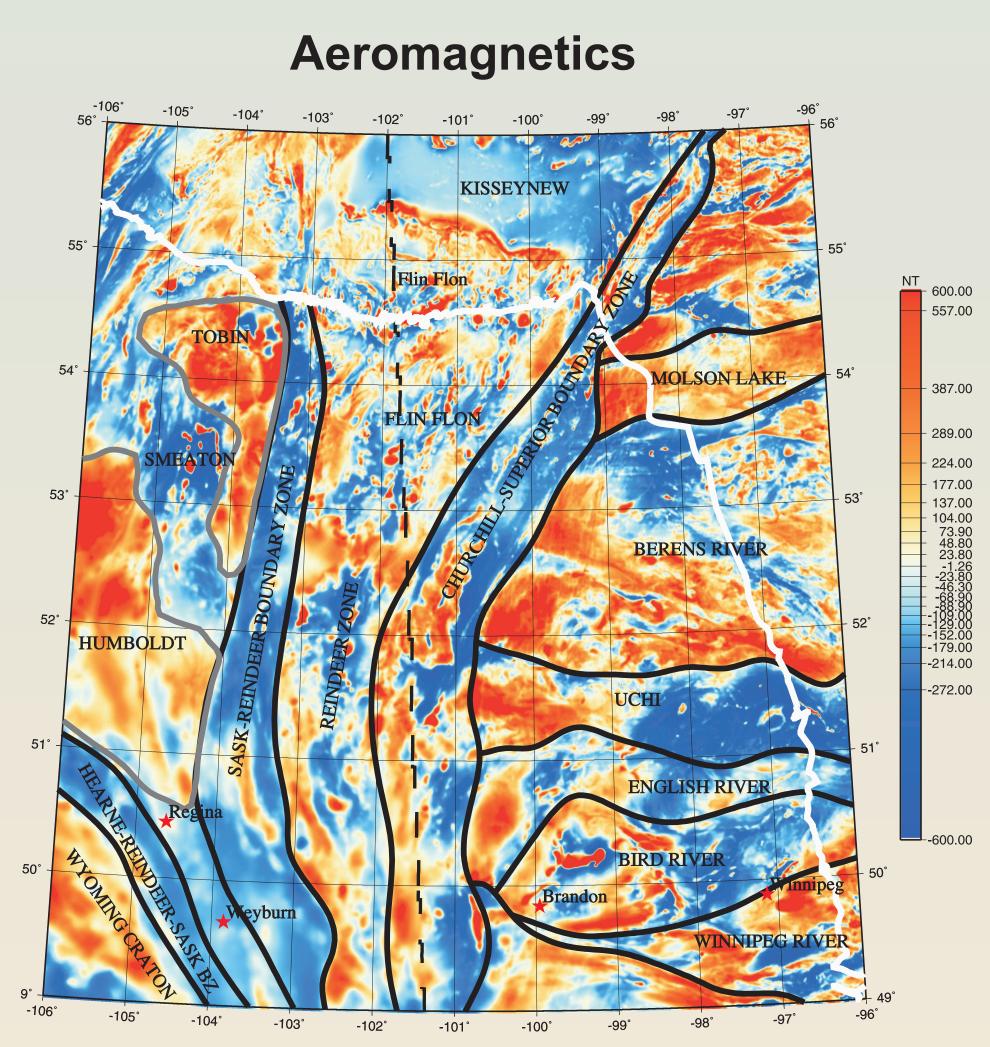
Manitoba Science, Technology, Energy and Mines **Petroleum Branch**



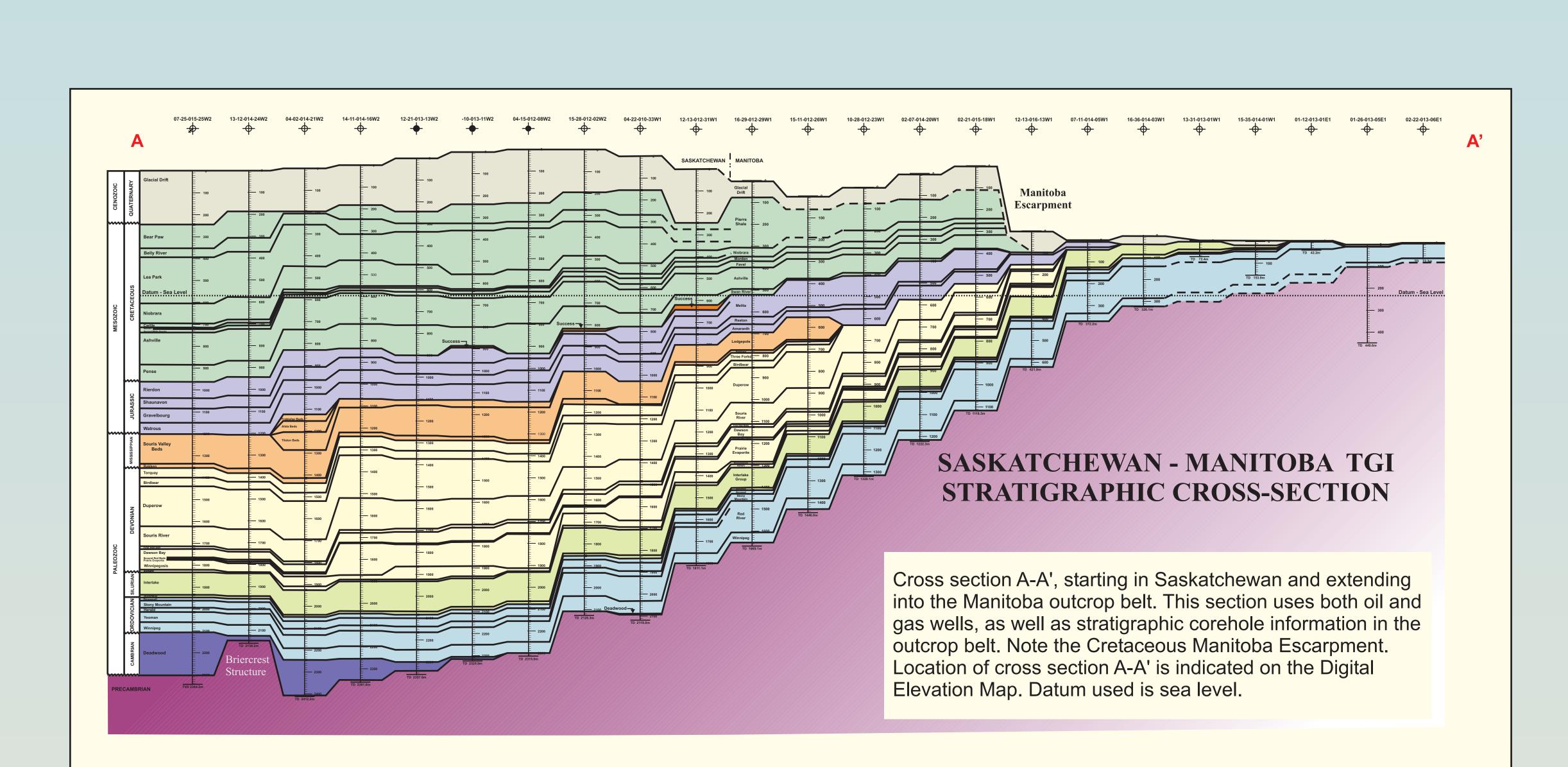
Canada



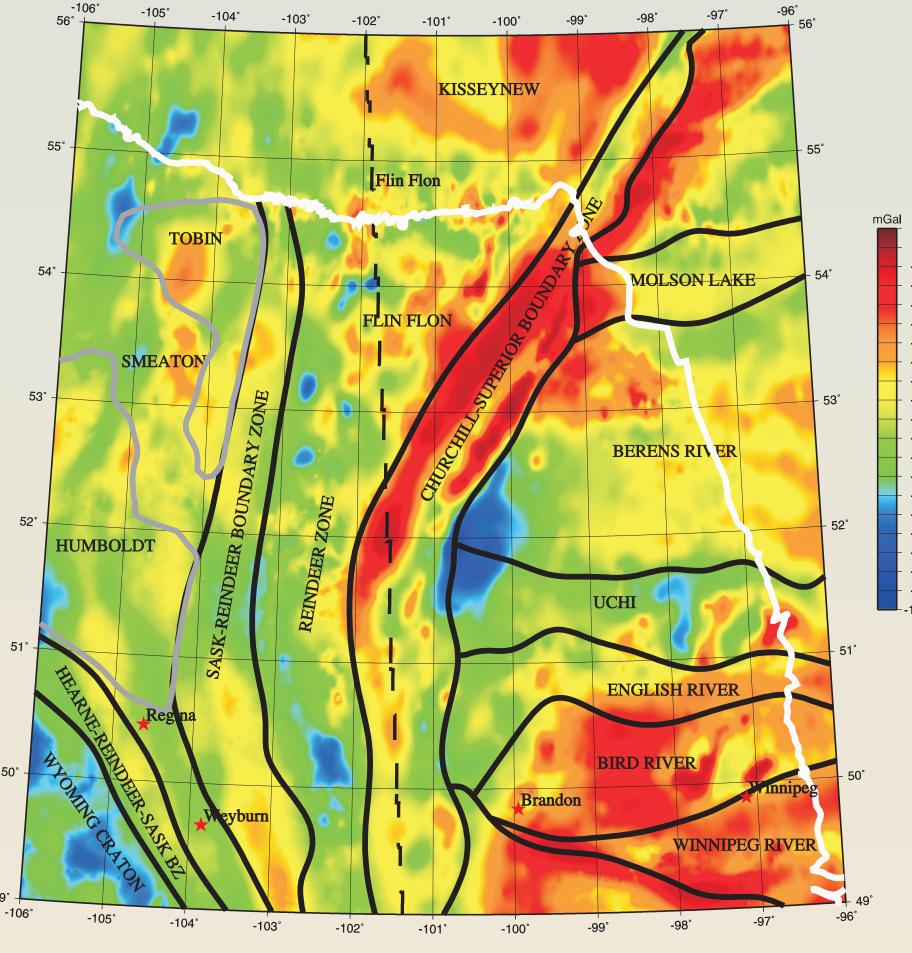
Digital Elevation Model of the TGI project area, showing crosssection line AA'.



Aeromagnetic anomaly interpolated and reduced to pole. For clarity of the display, a non-uniform, histogram balanced blue-to-orange colour palette is used. With histogram balancing, every colour level occupies approximately the same area of the image. Main structural domains are indicated.



Geophysics (Li and Morozov, 2007) Gravity



Interpolated Bouguer gravity anomaly map of TGI II area. White contour indicates the edge of the Canadian Sheld; dashed black line is the Saskatchewan-Manitoba border. Major structural domains are indicated.

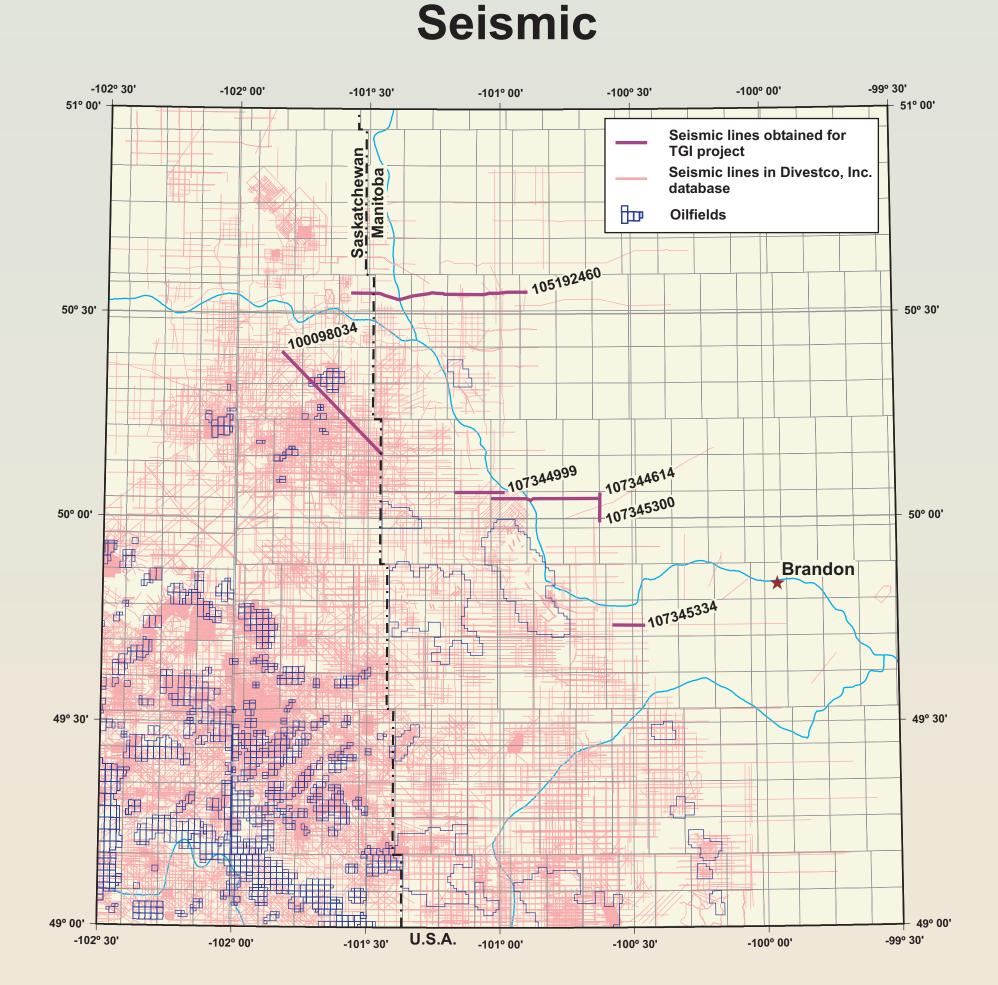






Saskatchewan Industry and Resources





Location map of seismic lines from part of the database provided by Divestco Inc. for the TGI project, showing seismic lines in SE Saskatchewan and SW Manitoba. The six lines shown in bold are being obtained and will be analyzed to calibrate the detailed structure of the Precambrian basement inferred from potential field data.

Project Update

The TGI project was originally a two-year project, and is now extending into it's fourth year. Despite the delays, this project has already proven to be extremely useful and informative to all who work in the Canadian portion of the Williston Basin. With its own website, www.WillistonTGI.com, all products from this project have been posted as they are available to ensure the users of the information are kept up to date. The high quality of the science that is being conducted during the course of this project has not been compromised.

Below is summary of the accomplishments for each task of the project:

- (1) Geoscience knowledge inventory (bibliography) • Completed and ready for use on the website.
- (2) Regional geological mapping
 - A detailed stratigraphic column has been developed for the project to assist in the cross-border mapping. This column shows up-to-date stratigraphic correlations, many of them new, particularly in the Mesozoic.
 - Biostratigraphy was completed for several Mississippian and Cretaceous horizons, including conodont, foraminifera and palynological analyses.
 - The stratigraphic database contains a total of 9012 wells and will be available on the website for free download.
 - Structure and isopach mapping has been completed for 58 horizons, resulting in a total 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 of the Precambrian basement rocks buried beneath the Phaneroic 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 (18 in total from basement to surface) have been completed, as well as the hydrochemical and hydraulic crosssections.

(5) Remotely sensed imagery

• With the exception of using remote 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 of producing zones), DSTs, source rock information (TOC/Rock-Eval), and vitrinite reflectance results have been compiled.
- A GIS-based map will be created to view the data.

(7) 3-D Gocad geological model

- A preliminary version of the model is available on the website.
- The final model is in still in progress.

(8) Summary Report

- As the project evolved, it was decided not to do one large report, but to break it down to several reports, each discussing different aspects of the project. • A summary report on the results of the biostratigraphy for the Manitoba
 - samples has been completed.
 - The first draft of a detailed report on the Mesozoic sequence covering the entire TGI area has been completed.
 - The geophysical report is completed and published.
 - The hydrogeological report is nearing completion.
 - Summary reports on the stratigraphy and hydrocarbon assessment for the
 - Paleozoic and Mesozoic sections in Manitoba are nearing completion.

Economic Considerations

The total budget for this two-year TGI is \$768,500 with \$378,500 budgeted for fiscal year 2003-2004 and \$390,000 for 2004-2005. The break-down of total financial contribution to the project is \$720,000 from NRCan, \$28,500 from Manitoba, and \$20,000 from Saskatchewan. This represents a large amount of federal dollars being spent in both provinces on geoscience compilation and research in the Williston Basin. Exploration for prospective hydrocarbon reservoirs and mineral resources in the Williston Basin is usually led by small Canadian companies, which rely on government and universities for development of advanced modeling techniques of basins. These large regional syntheses are essentially the framework that all subsequent exploration will be based on, and it is hoped that further oil and gas exploration and mineral exploration will be conducted in southwestern Manitoba as a result of the new compilations and advancements.

References

Li, J., and Morozov, I., 2007. Geophysical Investigations of the Precambrian Basement of the Williston Basin in southeastern Saskatchewan and south-western Manitoba. University of Saskatchewan Final Project Report, http://seisweb.usask.ca/Reports/TGI2/.

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Whittaker, S., Rostron, B.J., Khan, D., Hajnal, Z., Qing, H., Penner, L., Maathuis, H., and Goussev, S., 2004. Theme 1: Geological Characterization; in Wilson, M. and Monea, M. (eds.), IEA GHG Weyburn CO2 Monitoring and Storage Project Summary Report 2000-2004; Seventh International Conference on Greenhouse Gas Control Technologies, Petroleum Technology Research Centre, Vol. 3, p.15-69.

