

Saskatchewan Phanerozoic Fluids and Petroleum Systems Assessment

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Abstract

The goal of this multi-year program is to improve understanding regarding how and where hydrocarbons in the Saskatchewan subsurface were generated, where and when they migrated over geological time, and where they are most likely to be trapped at present. This work will provide data for more accurate resource assessments for government and industry, for industry to formulate exploration and development strategies, and for further evaluation of Saskatchewan's capacity for safe, long-term geological storage of CO₂. This is a broad-scope program that involves several distinct geoscience disciplines including stratigraphy, hydrogeology, geothermics, and petroleum geochemistry.

Keywords: stratigraphy, hydrogeology, geothermics, petroleum geochemistry, geological modelling, migration, Saskatchewan, Western Canada Sedimentary Basin.

1. Program Description

This program is focussed toward performing an assessment of Saskatchewan's Phanerozoic fluids and petroleum systems (SPFPS). The work will address fundamental processes involved in the evolution of the Saskatchewan and selected neighbouring portions of the Western Canada Sedimentary Basin and its U.S.A. equivalent that resulted in generation, migration, and entrapment of hydrocarbons in Phanerozoic strata. This current review outlines the goals of the program and studies that will be carried out to achieve these results. Most research will begin in the summer of 2009 and all work is to be completed by March 2013.

2. Program Goals

The goal of this program is to improve our understanding regarding how and where hydrocarbons in the Saskatchewan subsurface were generated, and where and when they migrated over geological time to help determine where they are most likely to have been trapped at present time. This work will provide data that are helpful toward creating more accurate resource assessments for government and industry, formulating exploration and development strategies for industry, and screening and determining capacities of potential CO₂-storage sites.

3. Objectives

The study will complete gaps in hydrogeological mapping of portions of Saskatchewan's subsurface, most notably in the southwestern and northwestern parts of the province's Phanerozoic cover. These efforts will result in an integrated and complete suite of hydrogeological data and maps that will be consistent with the current work being performed by the Saskatchewan Ministry of Energy and Resources (ER) Petroleum Geology Branch to produce a set of isopach and structural geological maps which will serve as the foundation for this study. Existing organic geochemical and petrographic data will be culled from a variety of sources, and new geochemical and petrographic data will be generated to fill in identified gaps in data type and distribution. These data will be used to characterize and delineate areas of source-rock potential, source-rock 'kitchens', and migration 'fairways'. Geothermic research will also be performed to address a topic significantly lacking in data to produce a detailed thermal field of the Saskatchewan subsurface. Such organic geochemical and thermal parameters are essential for constraining basin-

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evolution models. State-of-the-art modelling packages will be used to generate 1-D, 2-D, and ultimately 3-D models describing the maturation, generation, and migration of petroleum into, and within, Saskatchewan.

4. Program Workflow

To achieve a reasonable result within this project, a broad-scope program is presented that involves several distinct geoscience disciplines including stratigraphy, hydrogeology, geothermics, and petroleum geochemistry. Our overall workflow includes the following overlapping phases of research: identifying data requirements to achieve a final product, compiling existing data, identifying gaps in available data, developing plans to obtain required data, ensuring integration among disciplines to provide suitable parameters for basin modelling, and performing simulations to provide realistic representations of the evolution of the petroleum system.

5. Individual Areas of Investigation

a) Regional Hydrogeology and Hydrochemistry of Saskatchewan (Combined University of Alberta M.Sc. and ER Project)

In this area of investigation, existing gaps in the hydrogeological mapping of Saskatchewan's subsurface will first be filled. These are most notably present in the southwestern (University of Alberta project) and northwestern (ER project) portions of the province's Phanerozoic cover. To achieve this, all Phanerozoic strata from the Precambrian to the uppermost mappable strata below surface casing will be studied in the two regions, with a final objective of generating a seamless hydrogeological provincial map series that gives a complete and integrated hydrostratigraphic picture of the subsurface of Saskatchewan.

b) Geothermics of the Williston Basin (University of Alberta M.Sc. Project)

In this project, Saskatchewan's subsurface temperature fields will be mapped, building on earlier work conducted in the study area and using data from the many deep oil and gas wells drilled into the basin, particularly since deep rights reversion was introduced in Saskatchewan in 1997. Geothermic information is essential towards further understanding hydrocarbon generation in the region as well as in evaluating geothermal-energy and CO₂-storage potential, and for providing constraining parameters in basin modelling.

c) Petroleum Geochemistry (University of Regina M.Sc. Project)

RockEval, vitrinite reflectance, and petrographic studies will be performed on formations that have the potential for hydrocarbon generation to delineate mappable organofacies. Focus will therefore be directed toward the Shaunavon, Bakken, Dawson Bay, Ratner, Red River, and Winnipeg formations.

d) Petroleum Geochemistry (University of Regina Ph.D. Project)

Focusing on those same six formations that have potential for hydrocarbon generation mentioned above, this project will undertake Gas Chromatography – Mass Spectrometry (GC-MS) (biomarker), hydrous pyrolysis, and isotope typing; further delineating source-rock potential into mappable organofacies; and making oil-oil and oil-source correlations to identify migration fairways.

e) Quantitative Analysis of Petroleum Generation, Migration, and Entrapment in the Williston Basin (Combined Universities of Regina and Alberta Ph.D. Project)

After performing 1-D burial history analyses and calibrating the resulting model with data from other tasks, 2-D transects will be constructed across the entire Williston Basin from Montana to Winnipeg and from southwestern Saskatchewan to Rocanville. New data generated within the project will then be integrated into a dynamic 3-D model of the basin. Software used in this project will include IES Petromod (1D, 2D, 3D), Basin2 (water, heat, and solute transport code), and MPath (Permedia Group).

f) Examination of Novel Modelling Methods (ER Geologists/University of Alberta Hydrogeologist)

Using existing geological data, oil-generation and migration simulations in the Bakken of the Williston Basin will be made covering a large area that includes parts of North Dakota, Montana, Manitoba, Alberta, and Saskatchewan.

g) Integration of Existing Stratigraphic Data for Saskatchewan (ER Geologist)

Most currently available stratigraphic data have been generated by the ER Petroleum Geology Branch and the Petroleum Technology Research Centre (PTRC) during recent regional mapping projects. These existing data from western and eastern areas of the province will be meshed into a consistent, seamless stratigraphic database for the entire Phanerozoic basin in the province. This stratigraphic data and the resulting maps will serve as the foundation for the studies in this and many future projects.

6. Program Co-ordination

A Technical Steering Committee and the PTRC, as the managing agency, will monitor the program's progress, results, schedule, and products.

Integration and communication will be effected through semi-annual SPFPS meetings with researchers and sponsors, and ongoing technical interaction among all researchers.

7. Outputs and Products

Annual reporting will take place: a) in the Summary of Investigations, Volume 1, Saskatchewan Geological Survey, Saskatchewan Ministry of Energy and Resources; b) at the Williston Basin Petroleum Conference; and c) at other conference presentations as appropriate.

A useful outcome will be comprehensive datasets associated with: a) Saskatchewan's Phanerozoic stratigraphy and the related structure and isopach maps and cross-sections; b) the province's hydrogeological maps and cross-sections; c) the petroleum geochemistry organofacies maps; and d) the thermal field maps of Saskatchewan's subsurface.

Other main products highlighting final interpretations that result from the various individual areas of investigation and their overall integration will be a compendium CD/DVD/interactive Website, 3-D dynamic basin models, and peer-reviewed publications.

8. Sponsors and Partners

The current major sponsor is ER, but the PTRC is encouraging industry participation to help direct the program and potentially provide data that would be otherwise unavailable. The Universities of Regina and Alberta are, at present, the main research providers. Other institutes which carry out work in the basin, and with which additional research linkages – especially with regard to expertise and provision of data – will be sought throughout the course of the program, include the North Dakota Geological Survey, the Universities of Saskatchewan and North Dakota, and the Geological Survey of Canada, among others.

9. Summary

The SPFPS program will improve both the understanding of petroleum systems in Saskatchewan, particularly in the Williston Basin region, and selected datasets used by governments and industry to assess sedimentary-rock-hosted resources in the province, provide information that will help companies prepare their exploration and development strategies, enhance available data for screening potential CO₂-storage sites, and increase geoscience-training capacity at universities.