Shale gas to Three Forks: 
Manitoba Geological Survey’s 
petroleum and stratigraphic investigations

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Current Projects

• Shallow Unconventional Shale Gas Project
• Bakken-Three Forks Project
• GEM Energy: Hudson Bay and Foxe Basins Project
• 3-D Model of Southern Manitoba
• TGI 2: Williston Basin
• CO₂ Storage in the Basal Aquifer
• Cretaceous Gammon Ferruginous Chemostratigraphic Investigations
Shallow Unconventional Shale Gas Project

Project goals:

• To verify if the Cretaceous sequences of SW Manitoba have the right **geological conditions** for economic shale gas accumulations.

• Identify the best target formations.

• Determine type of gas (biogenic or thermogenic).
Cretaceous Gas Shows

1906-1933:

- Natural gas used for domestic lighting and cooking purposes at several sites in SW Manitoba.
- Historical documents indicate up to 12 gas wells drilled in SW Manitoba between 1906 and 1933.
  - At least two wells remain capped.
Project Target Formations & Documented Gas Shows

<table>
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<th>SOUTHWESTERN MANITOBA</th>
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<tr>
<td><strong>Pierre Shale</strong></td>
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<td>Coulter Member</td>
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<td>Odanah Member</td>
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<td>Millwood Member</td>
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<td>Pembina Member</td>
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<td>Gammon Ferruginous Member</td>
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<td><strong>Carlile Formation</strong></td>
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<td>Belle Fourche Member</td>
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<td>Westgate Member</td>
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<td>Newcastle Member</td>
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<td>Skull Creek Member</td>
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- Stratigraphic details:
  - West (T1 R29W1):
    - *620 m thick*
    - 100 m TVD to 720 m TVD
    - Pierre Shale (Odanah Mb) to Ashville Fm.
  - East (T2 R9W1):
    - *220 m thick*
    - 100 m TVD to 310 m TVD
    - Pierre Shale (Odanah Mb) to Ashville Fm.

Yellow highlight indicates units with documented gas shows
Isopach map:
Pembina Member to Belle Fourche Member

- Combined thickness from the top of the Pembina Member to the base of the Belle Fourche Member.
- Lack of data towards the north and along the outcrop belt.
  - **Orange** upper limit = 240 m
  - **blue** lower limit = 0 m
- Contour interval = 10 m
Outcrop, Core & Soil Sampling

• Geochemical and mineralogical analyses include:
  – Rock-Eval™ (TOC and T\textsubscript{max});
  – X-Ray Diffraction (XRD);
  – Major and minor trace element bulk geochemistry (chemostratigraphy).

• MMI - soil geochemistry profiling.

• SEM to characterize pores and estimate porosity.
Water and Gas Well Sampling

- Geochemical analyses include:
  - Dissolved gas composition;
  - Free gas composition;
  - Water chemistry:
    - cations, anions, alkalinity, sulphates;
  - Stable Isotopes:
    - Sulphur, carbon, oxygen.

- 5 free gas samples collected:
  - 2 gas wells;
  - 3 domestic water wells.

- 13 domestic water wells sampled.
Results

• Geochemistry:
  – High organic content in the shale in most of the formations.
  – Rocks thermally immature, so gas is still present in the rocks.
  – Methane present is present as free gas within the pores, fractures and adsorbed on particles.
  – Dry biogenic gas.

• Mineralogy is complex and variable, but some beds have high quartz content.

• Porosity and permeability is comparable to the other shale gas plays.

*SEM image of siltstone in the Carlile Formation showing pores.*
Conclusions

• Best shale gas target formations identified include up to 220 m thick of shale.

• Geochemistry and mineralogy of the rocks is similar to other shale gas basins.

• Geochemistry results indicate that this is an unconventional biogenic shallow gas play.

• Potential shale gas area covers over 50 000 km².

• Manitoba does have the right geological conditions for shale gas.
  – Question: Is it economic? ..... 

• Still more work to do...
Bakken-Three Forks Project

Project goals:

• Review, update and describe the stratigraphy of the Three Forks Fm.

• Describe the regional geology of the Three Forks Fm, and how it relates hydrocarbon accumulations.

• Update Bakken Formation stratigraphy and how it relates to the Three Forks Fm.

• Define the Big Valley Formation.

• Build a depositional, erosional and deformational model for the Three Forks, Big Valley and Bakken formations.
Three Forks Formation

- Maximum thickness of the Three Forks in Manitoba is 64 m.
- Three Forks is subdivided into four units;
  - Correlative to Christopher (1961) units in Saskatchewan.
  - Units 1, 2 and 4 are further subdivided into subunits.
- Isopach and subcrop trends of each unit are north-south.
- Three Forks and Middle Bakken are hydraulically linked, therefore oil production is reported as commingled.
- Best production comes from subunit 4c, and subunit 2c.
- Where there is production from Unit 4, the Middle Bakken is very thin (< 1m).
- Production from Unit 2 is economic when the Middle Bakken is thick (> 4 m) and acts as the dominant reservoir.
Three Forks Isopach

- Thin in Manitoba due to erosion
- Thickest in the west along the MB-SK border
Three Forks Isopach

- Thickest in the west along the MB-SK border
- Localized thickening in the east

Contour Interval = 2 m
Three Forks Isopach & Unit Edges

- The units within the Three Forks were individually mapped.

- North-south trend to subcrop edges; follows isopach trend.

- Localized isopach thicks in the east correspond to preservation of Units 3 and 4 east of the main subcrop edge for these units.
TF Unit Edges & Tectonics Controls

- Basement features:
  - Fault re-activation throughout the Paleozoic (SBZ);
  - Large scale effects of the Severn Arch.

- post-Prairie Evaporite structural deformation:
  - Localized and large scale salt collapse;
  - draping effects.

Superior Boundary Zone

basement hinge line

Birdtail-Waskada Zone

Three Forks edge
Bakken-Three Forks Producing Areas

Birdtail Field
Kirkella Field and Twp 13
Daly Sinclair Field
north of Pierson Field
Recent Bakken-Three Forks Exploration and Development

Northern expansion of the Birddtail Field

Twp 13

Northern expansion of the Daly Sinclair Field

Three Forks edge
Bakken-Three Forks Prospects

- Oil staining in Bakken
- Unit 4 preserved
- Low drilling density
- Virden structure
- Basement faulting
- Unit 4 preserved, low deep drilling density
- Birdbear-Lodgepole escarpment
3-D Model of Paleozoic

From the TGI 2 Williston Basin 3-D Model (available at www.WillistonTGI.com)
Coming Soon...

Geoscientific Report will include:

- New stratigraphic framework.
- Updated regional geological framework.
- Detailed description and mapping of the Three Forks, Big Valley and Bakken formations.
- Depositional, erosional and deformation model described.
- Economic discussion.
GEM Energy: Hudson Bay and Foxe Basins Project

Project goals:

• Develop a better understanding of the geological evolution of the basins;

• Provide a modern appraisal of their hydrocarbon potential.
GEM Energy: Hudson Bay and Foxe Basins

Results to date:

- Several oil shale horizons;
- Shale within the oil window.
- Bituminous residue found in several cores;
- Modern pockmarks identified on the basin floor.

Still more work to do...
For more info on MGS projects...

Click on

Geological Survey Activity Tracker

at

www.manitoba.ca/minerals