GEOLOGICAL CHARACTERIZATION

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- Ben Rostron, University of Alberta, Edmonton AB, Canada
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- Hairou Qing, University of Regina, Regina SK, Canada
- Lynden Penner, J. D. Mollard and Associates, Regina SK, Canada
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Natural Resources Canada Ressources naturelles Canada

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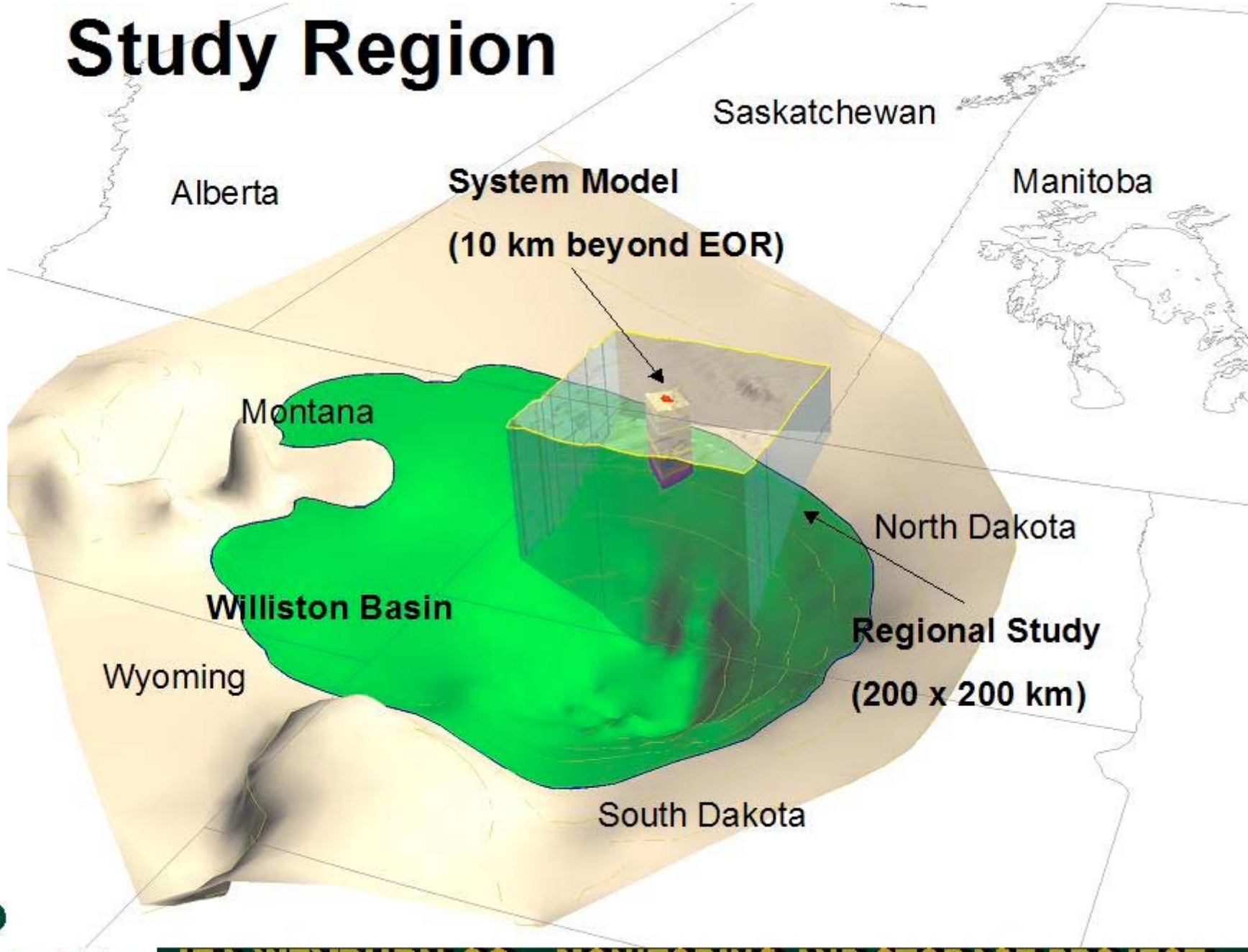
Research Groups and Sponsors

- **Research Participants**
- Saskatchewan Industry and Resources
- University of Alberta
- Mollard & Associates
- Saskatchewan Research Council
- University of Saskatchewan
- University of Regina
- North Dakota Geological Survey
- GEDCO
- British Geological Survey
- BRGM
- INGV

- **Sponsors**
- ***Industrial***
- EnCana Corporation
- SaskPower
- Nexen Canada Ltd
- TotalFinaElf
- BP
- Dakota Gasification Co.
- TransAlta Utilities
- ENAA (Japan)
- ***Governments***
- United States Department of Energy (USDOE)
- Natural Resources Canada (NRCan)
- European Community
- Saskatchewan Industry & Resources
- Alberta Energy Research Institute

Study Region



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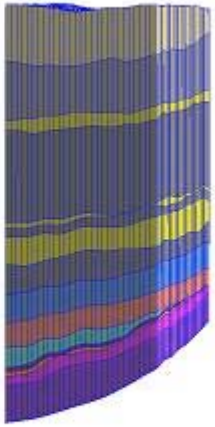
Objectives of Geoscience Characterization

- Assess integrity of geological container for storage of CO_2
- Provide input for performance and risk assessment and scenario analysis of the long-term fate of CO_2 in the subsurface (Geological Model)

Key Components to Assessment

- **Identify main traps (mechanisms)**
  - At and above reservoir level
- **Identify potential transport pathways**
  - Aquifers (and aquitards)
  - Preferential pathways
    - Depositional features
    - Discontinuities
  - At, above and below reservoir level
- **Identify associated transport properties**
  - Porosity, permeability, formation water flow velocity, etc.

Traps and seals at Weyburn



North

N-S Schematic Structural Section

South

Extent of Performance Assessment

10km — Weyburn Field — 10km

-650.0 ss

Lower Watrous

"Altered zone"

Sub-Mesozoic Unconformity

Frobisher Evaporite

Upper Midale (Marly)

Shoal

Intershoal

Midale Evaporite

Ratcliffe Beds

Poplar

Poplar

Green Point Anhydrite

Oungre Beds

Lower Midale

Oungre Evaporite

Frobisher 'Marly'

Frobisher 'Vuggy'

Alida Beds

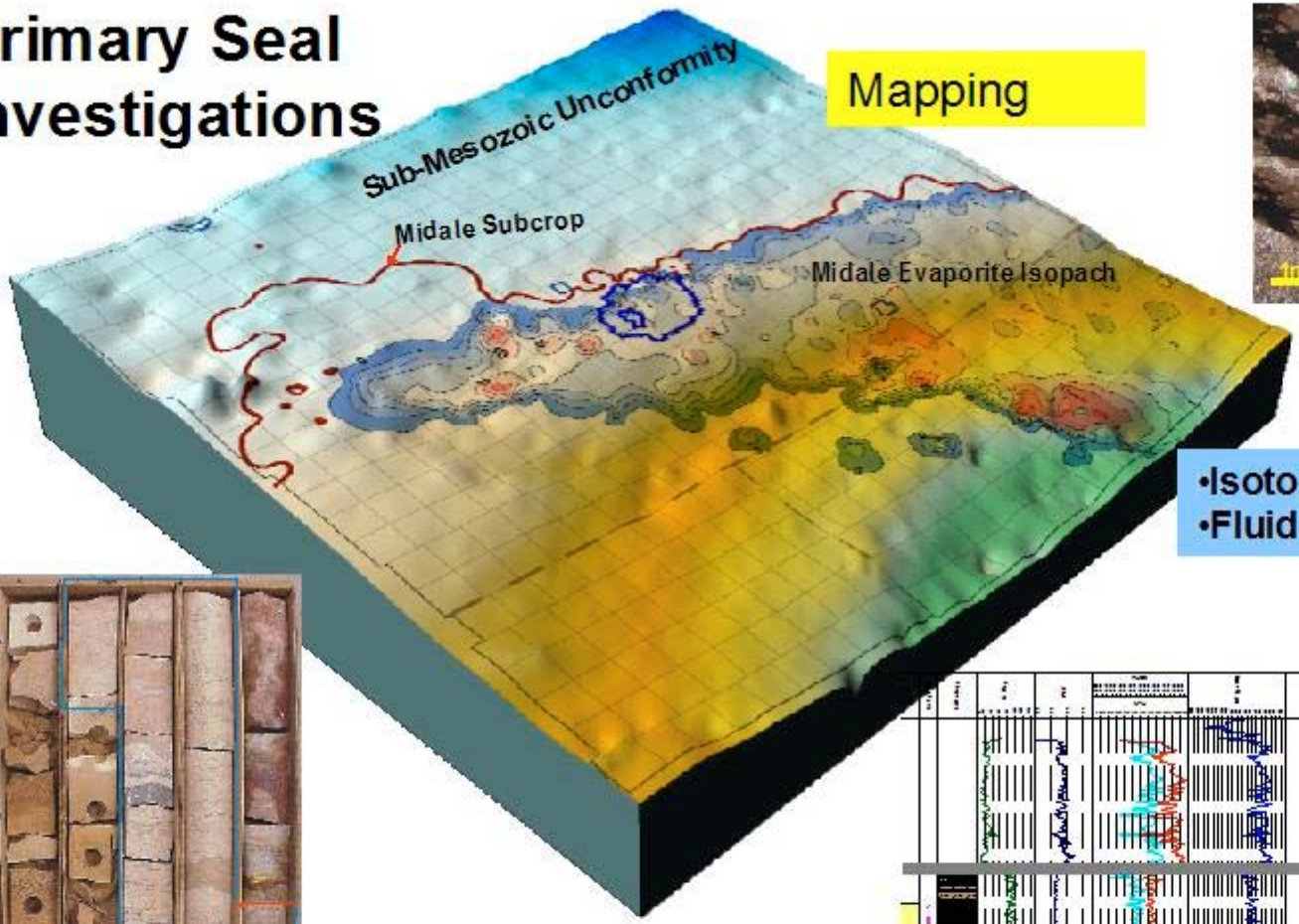
O/W

10km

1:1200

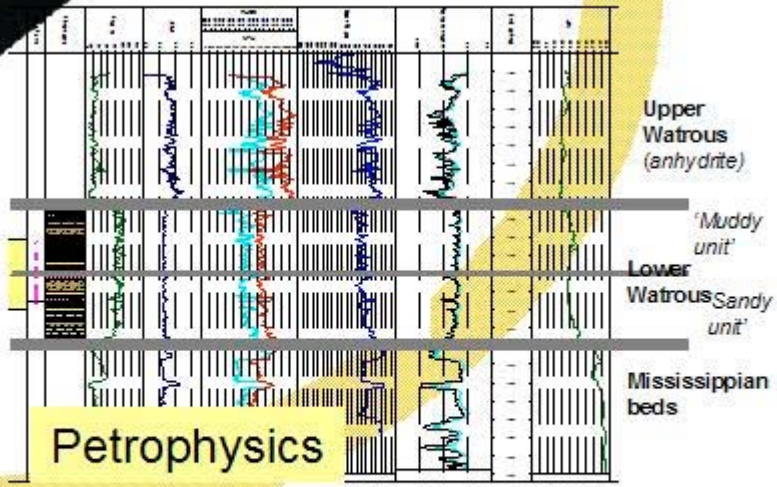
1:10,000

Primary Seal Investigations



Mapping

- Isotope geochemisty
- Fluid inclusion analyses



Core Analyses

Petrophysics

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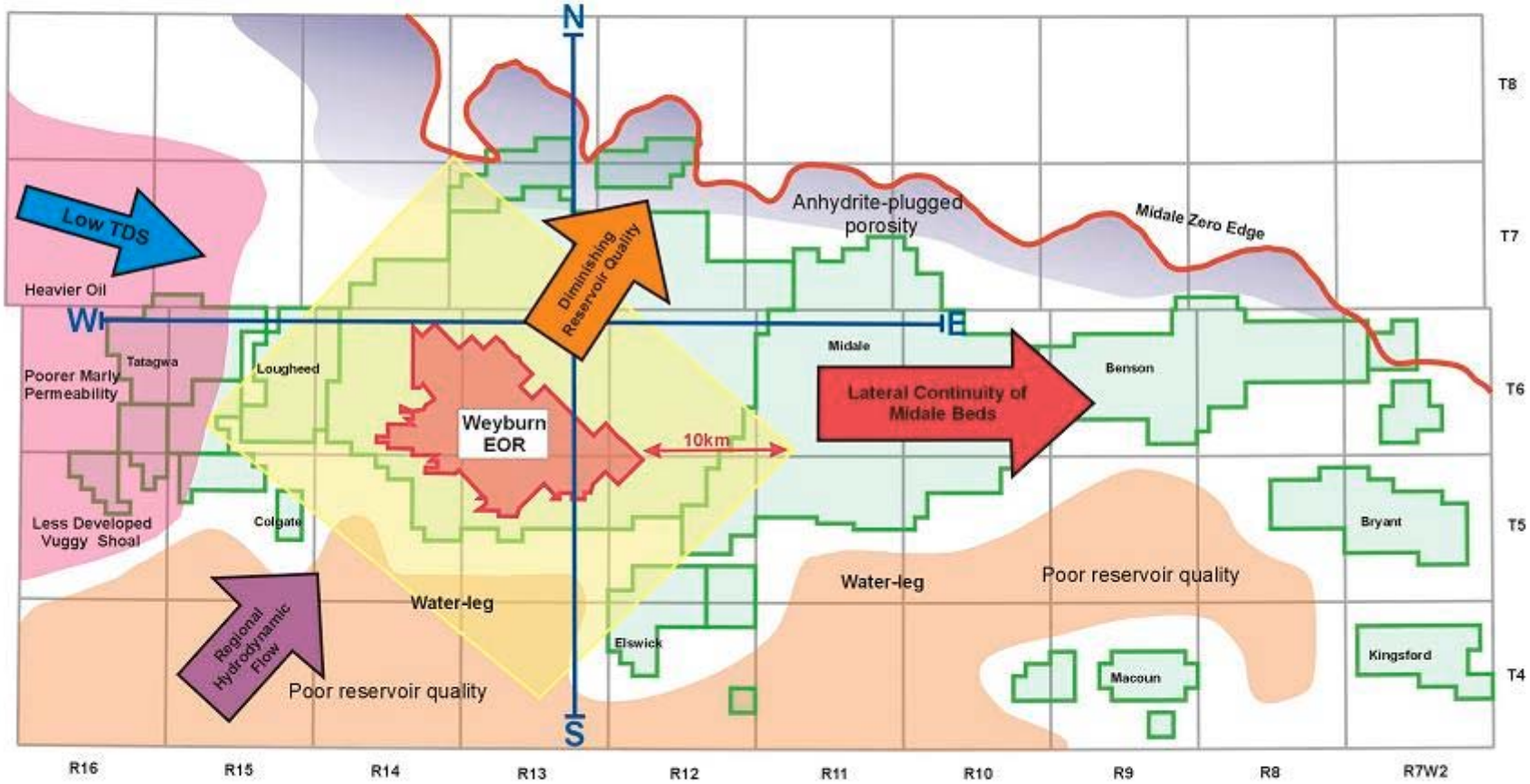
Bounding Conditions in Weyburn Area

Reservoir Characteristics of Midale Beds in Weyburn Field Vicinity



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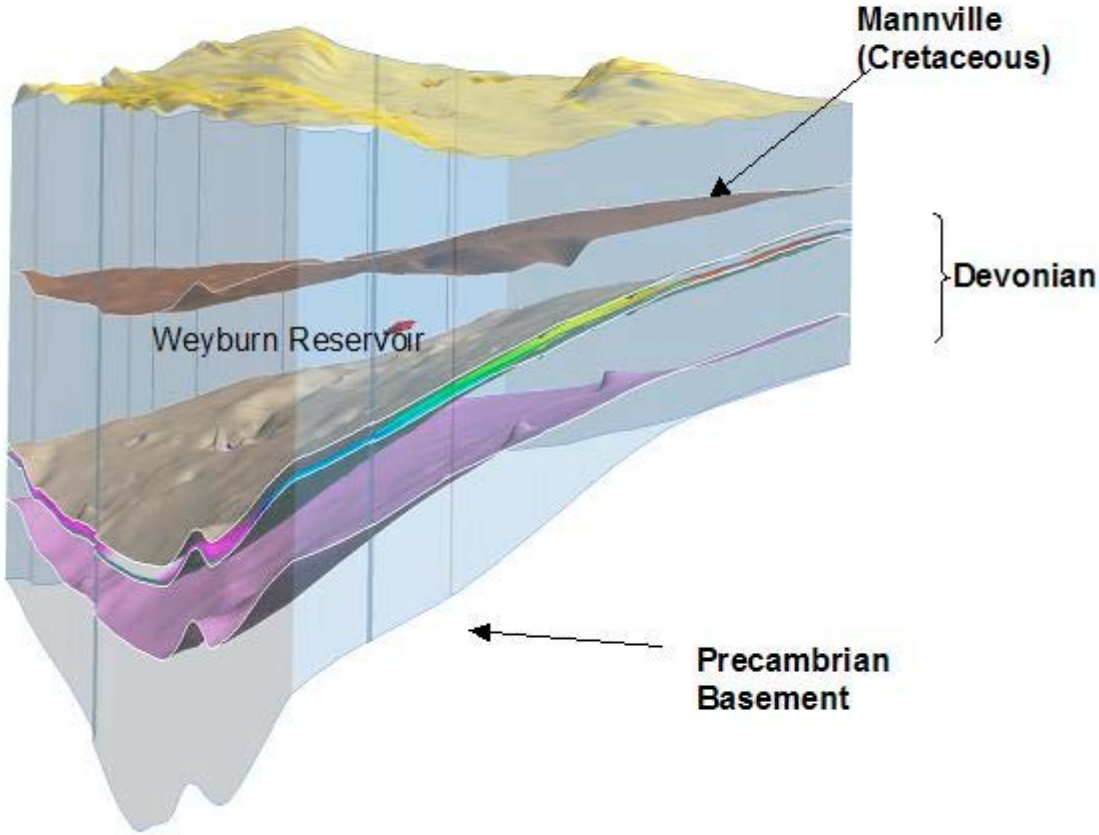
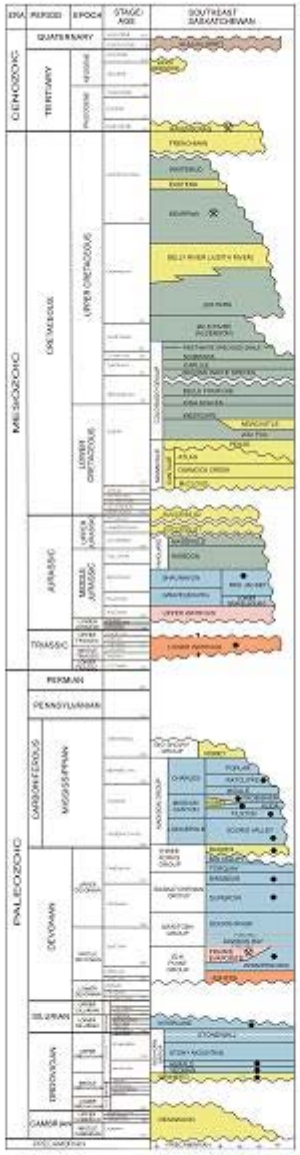
Regional Studies

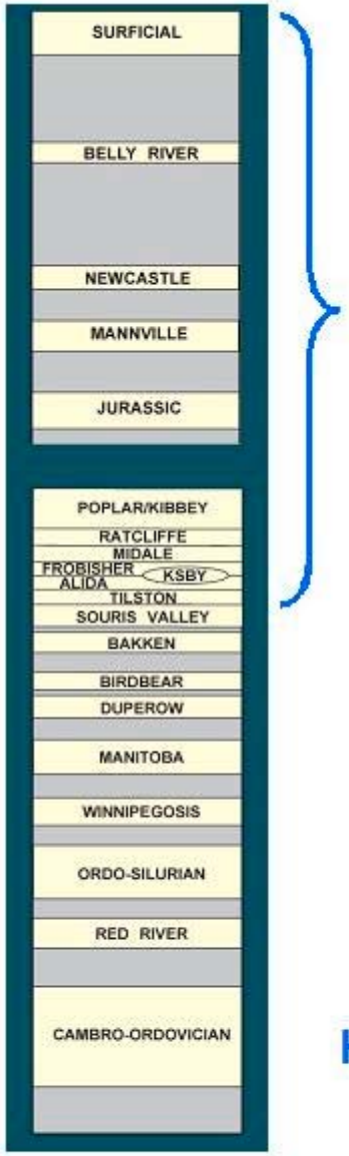
- International Effort
- Basement to surface
- Lithostratigraphy
- Hydrostratigraphy
- 2D-Seismic
- HRAM
- Surface Lineaments
- Data integration

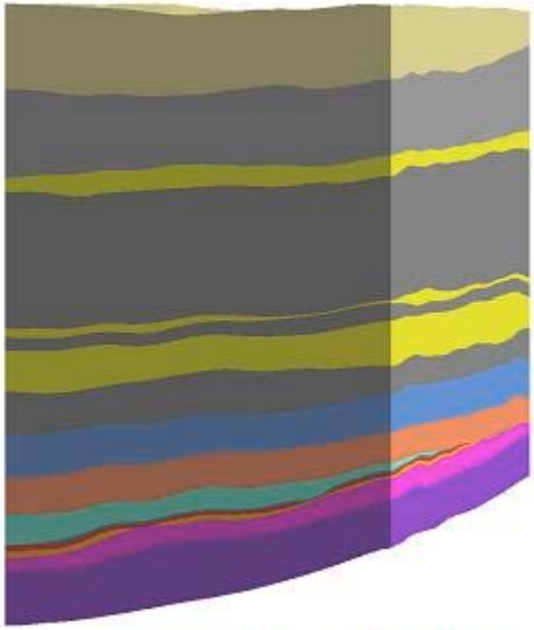


STRATIGRAPHY



HYDROSTRATIGRAPHY





Geology
Geophysics

System Model

Data Integration

Hydrogeology

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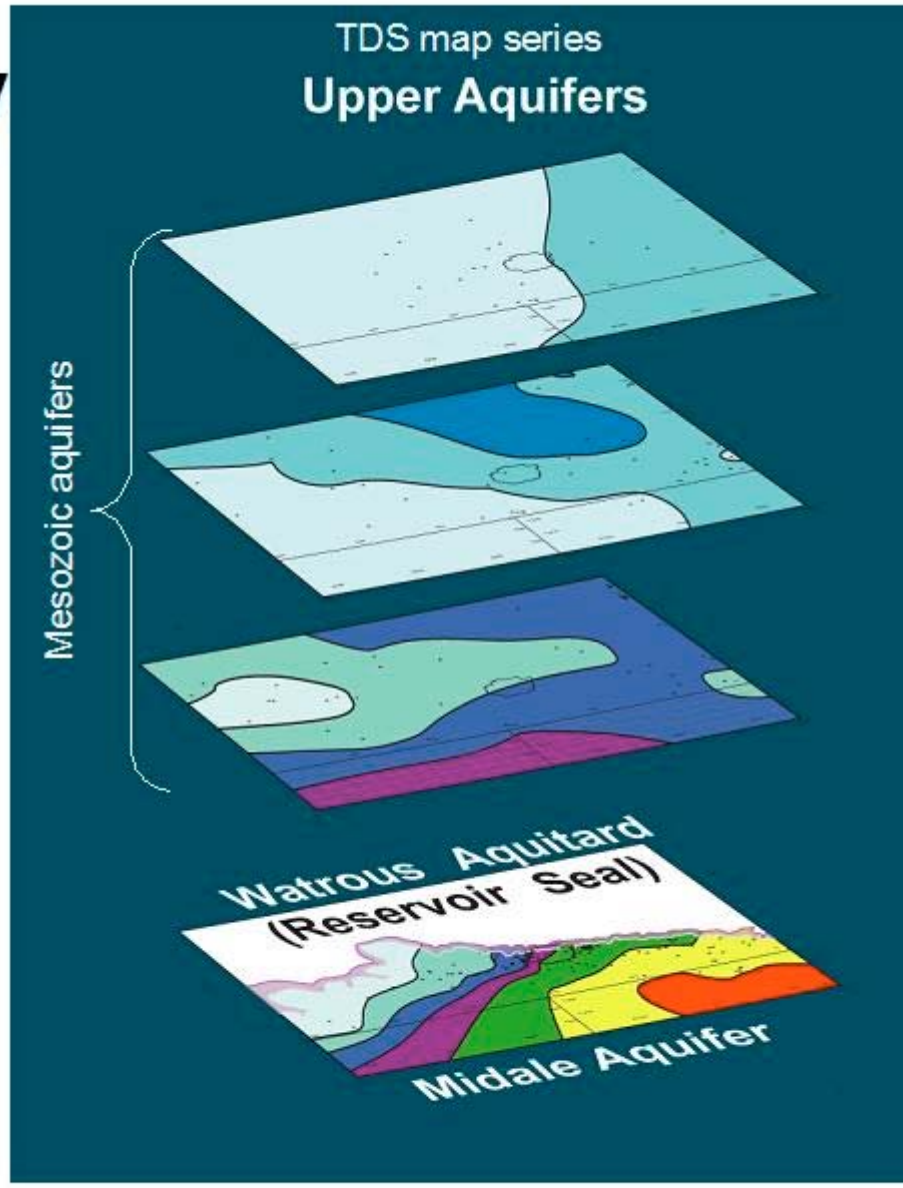
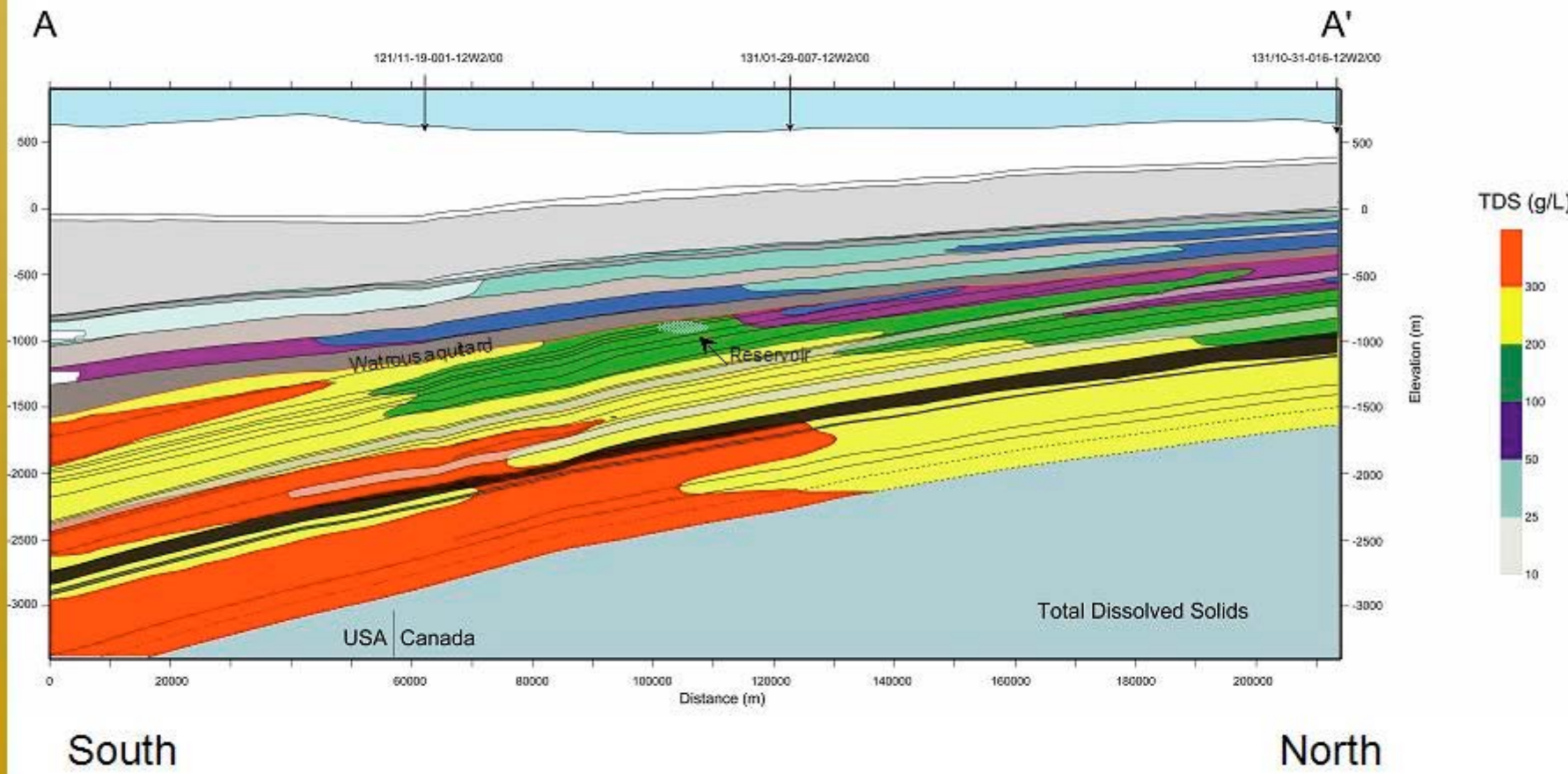
Basin Hydrogeology

- Hydraulic head maps from culled DST data
- TDS maps made for all aquifers
- Water Driving Force maps for all aquifers
- Hydraulic cross-sections of basin



Hydraulic Cross-Section



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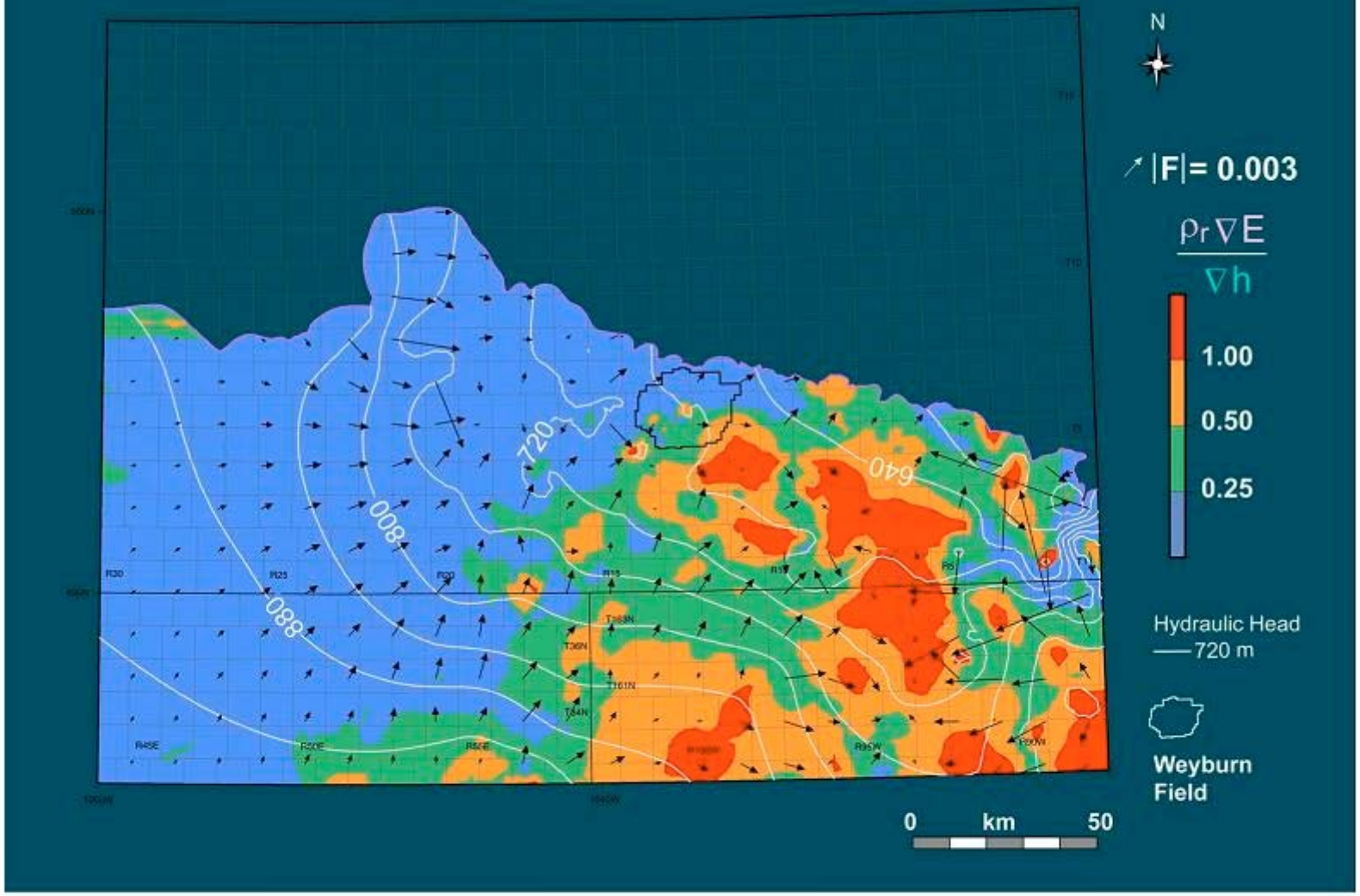
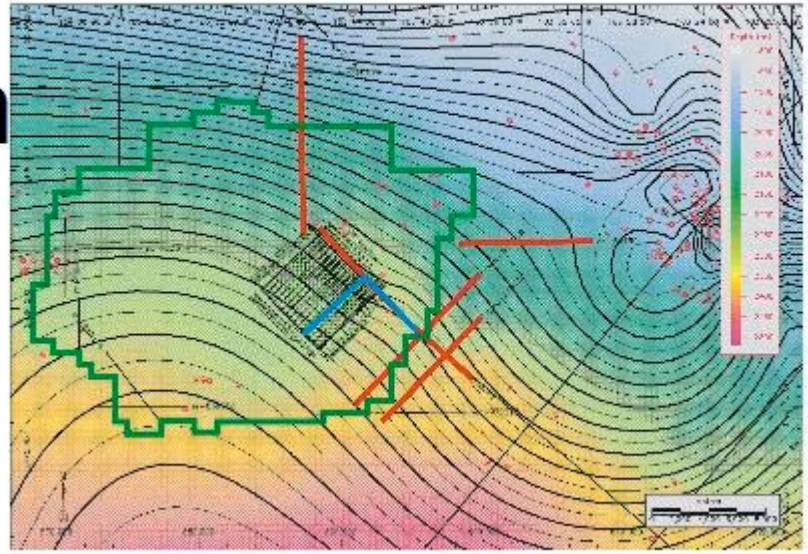
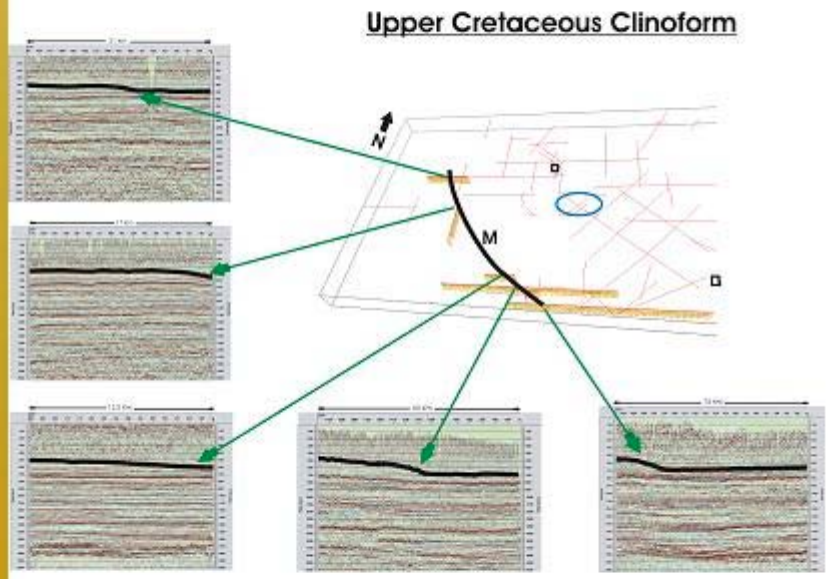
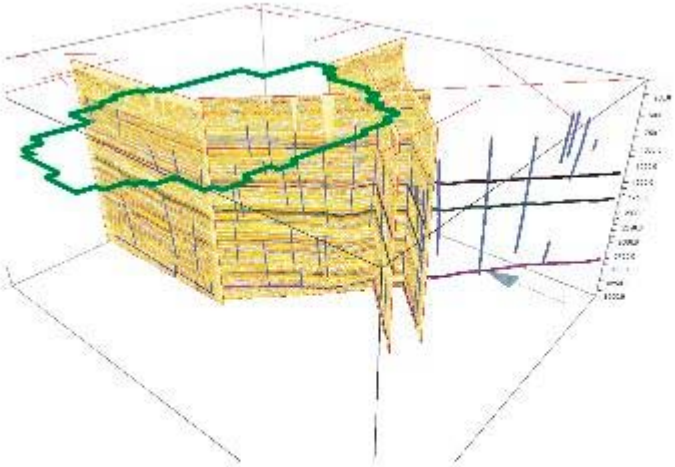
Water Driving Force: Midale Aquifer



Structural Characterization







Inclined view from South-West

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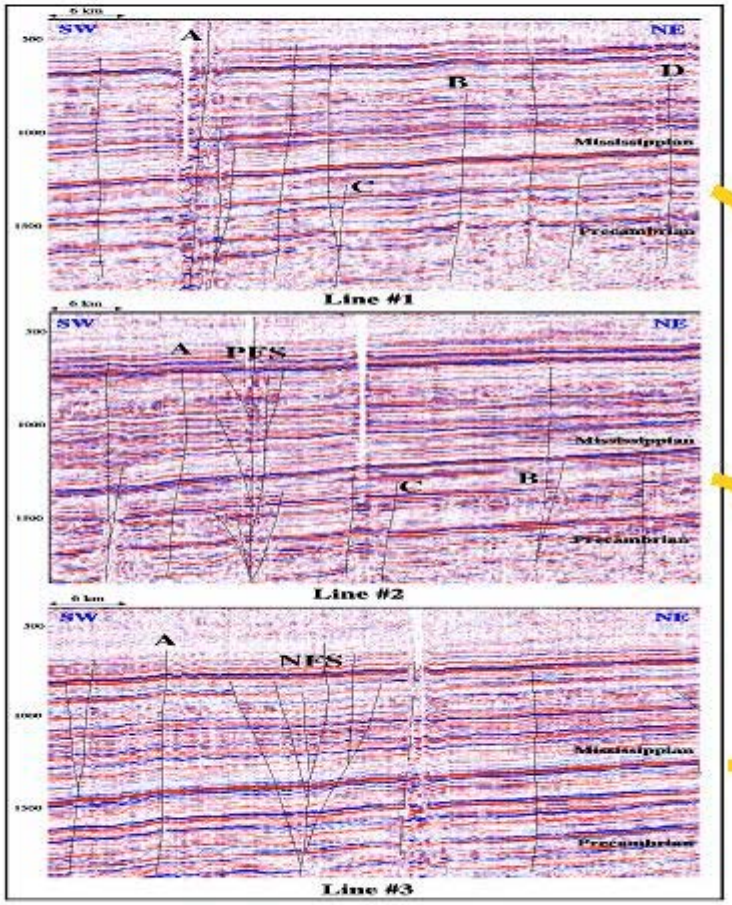
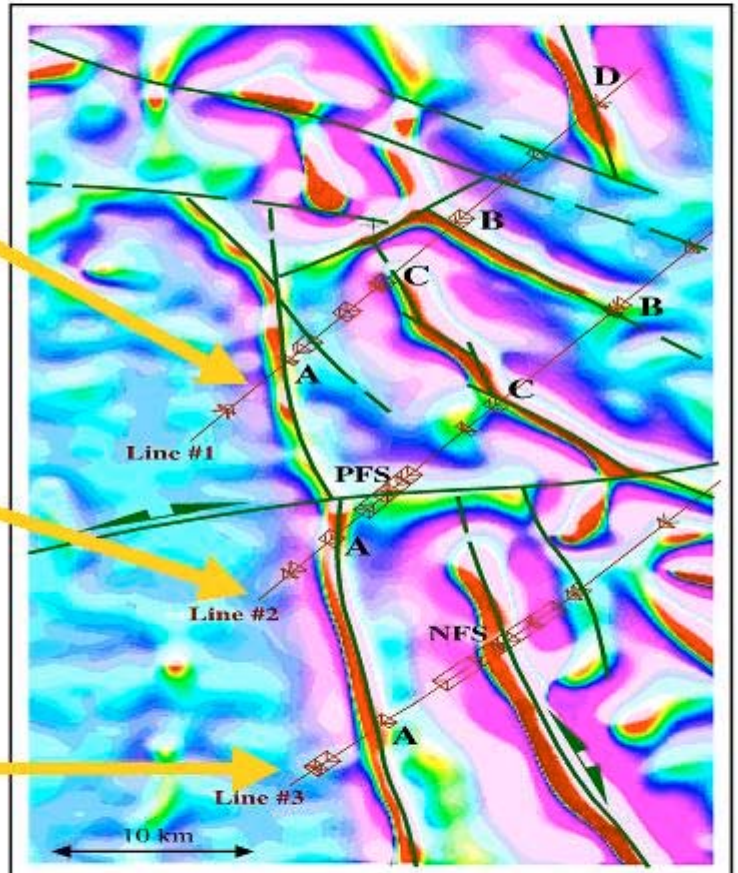
Seismic and Aeromagnetic Data Integration





2-D seismic lines, fault picks and interpreted faults on top of the filtered HRAM map

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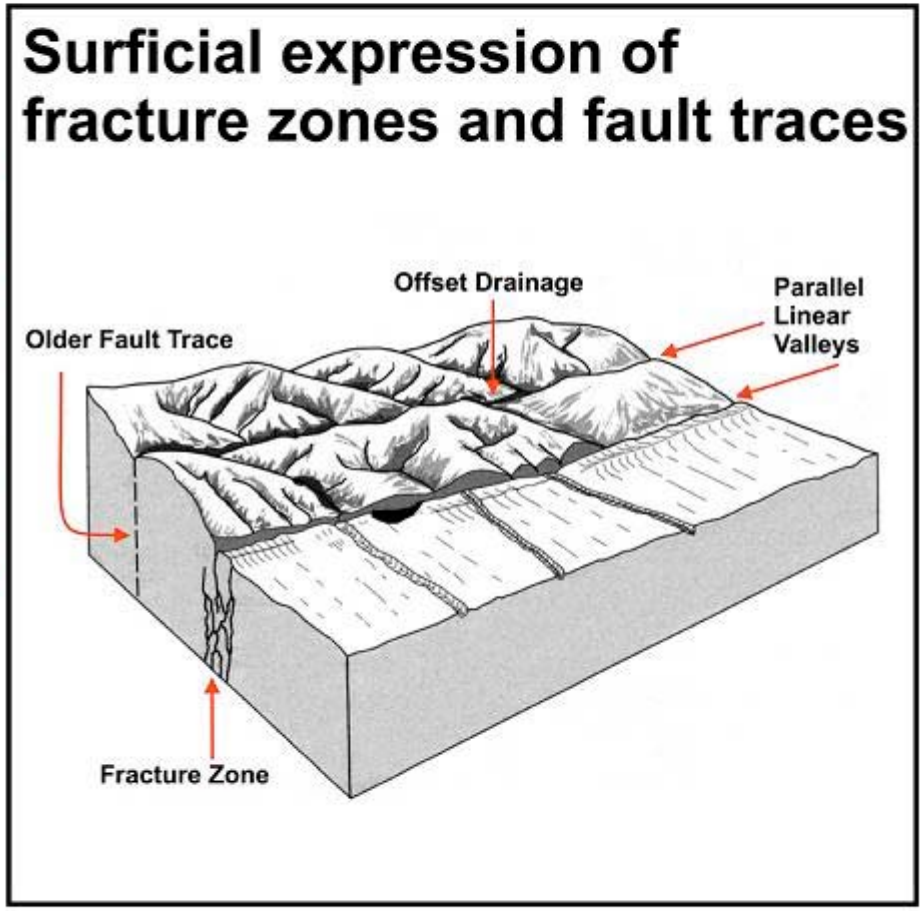
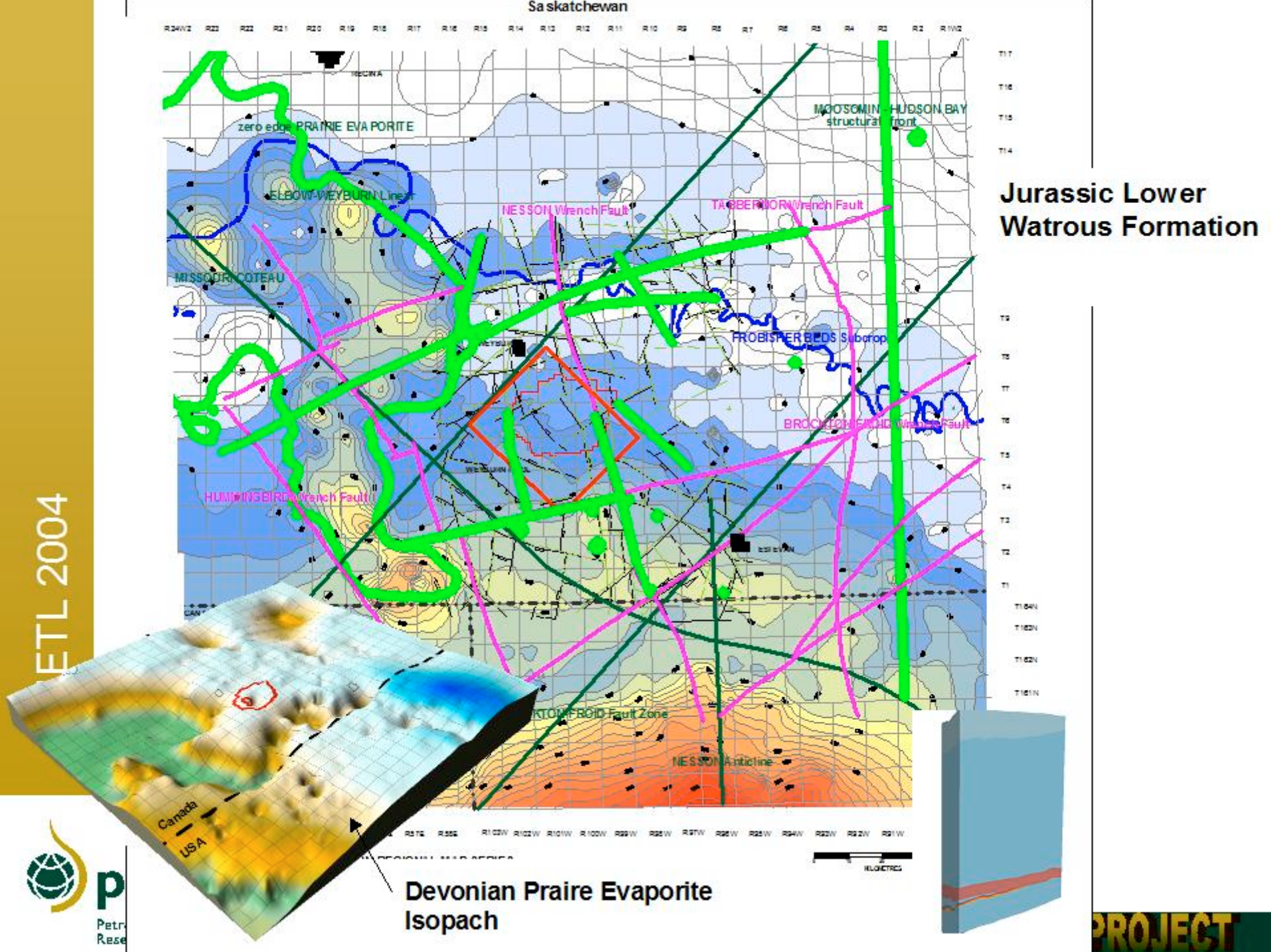
Relationship of lineaments to subsurface fracture zones and faults

Airphoto lineament map




Saskatchewan
zero edge PRAIRIE EVAPORITE
ELBOW-WEYBURN Linear
MISSOURI COTEAU
NESSON Wrench Fault
TABBERNOR Wrench Fault
MOOSOMIN - HUDSON BAY structural front
FROBISHER BEDS Subcrop
BROCKTON-FROID Wrench Fault
HUMMINGBIRD Wrench Fault
NESSON Anticline
Canada
USA
Devonian Praire Evaporite Isopach
Jurassic Lower Watrous Formation
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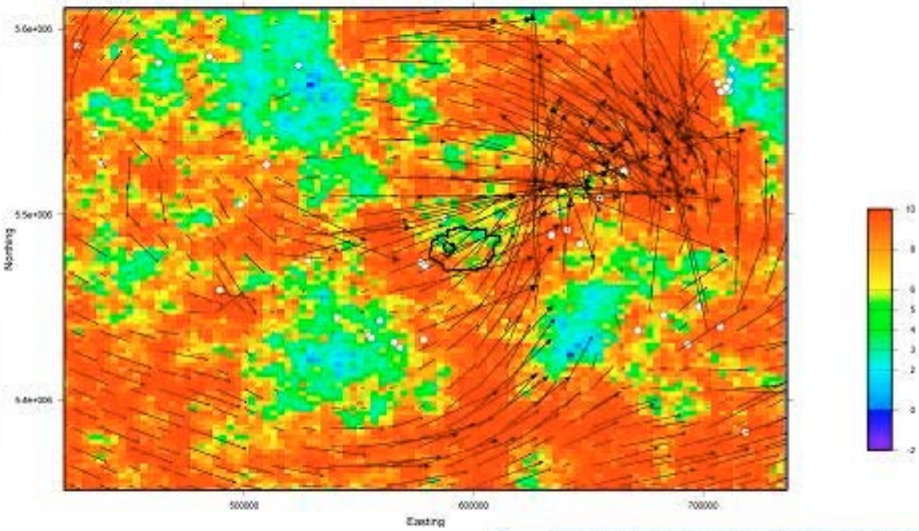
PROJECT

Property Characterization

Mannville Aquifer Simulated Permeability Field
Conditional Stochastic Simulation (SGS)



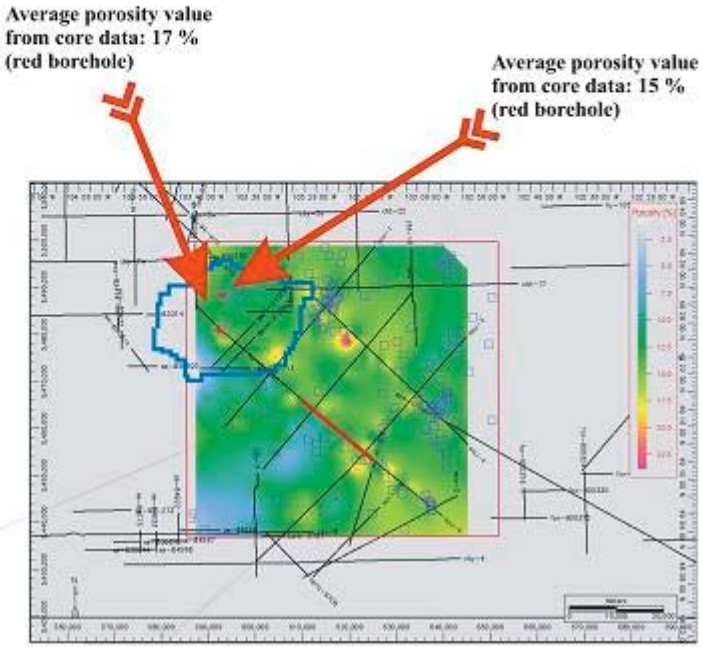
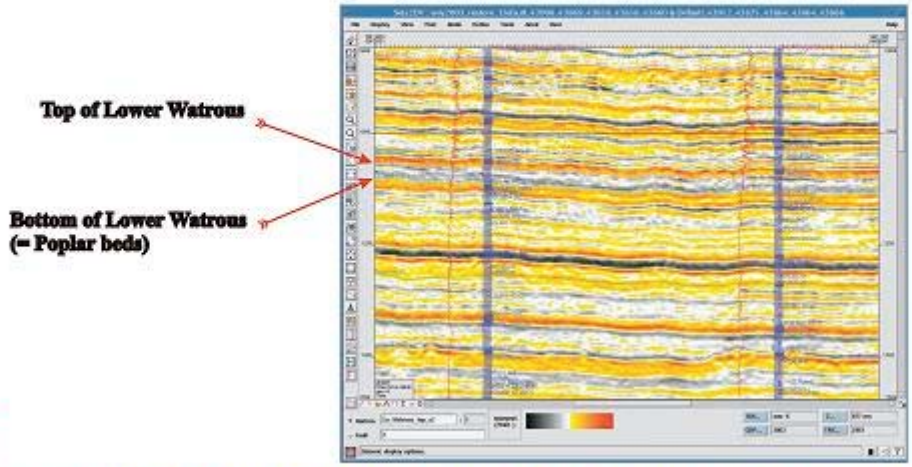


Fig. 14



Seismic attribute mapping (integrated reflection strength)

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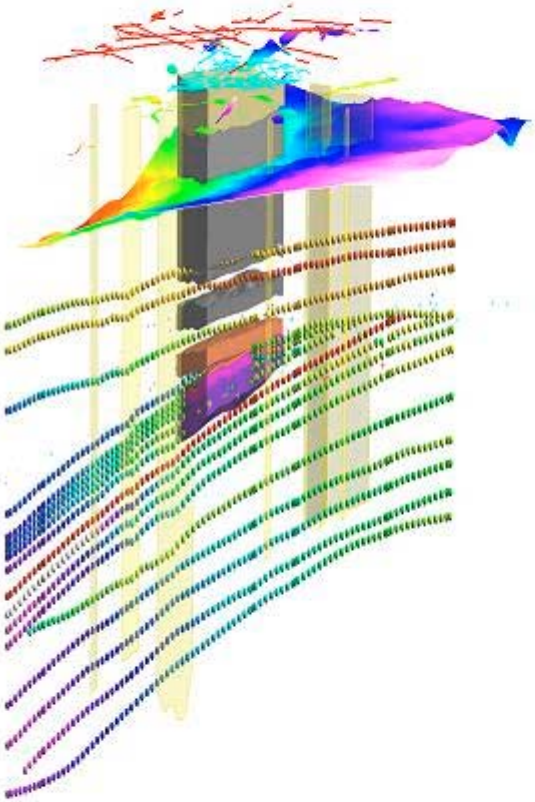
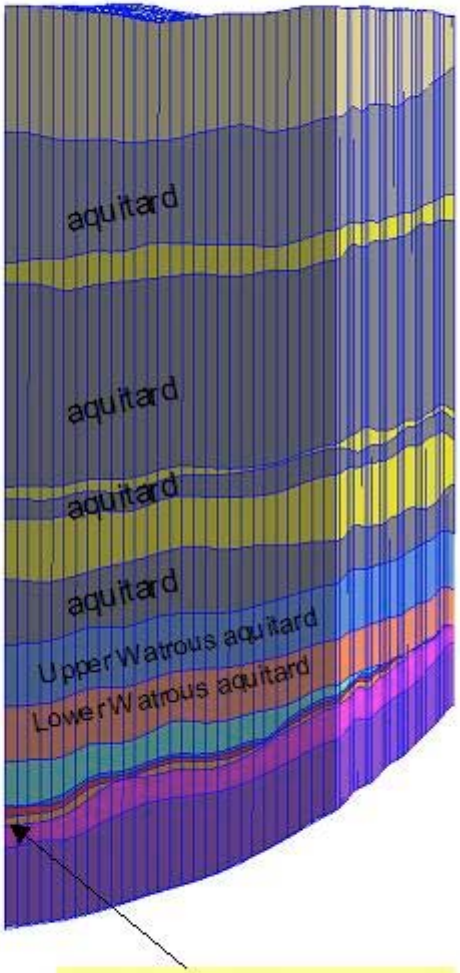
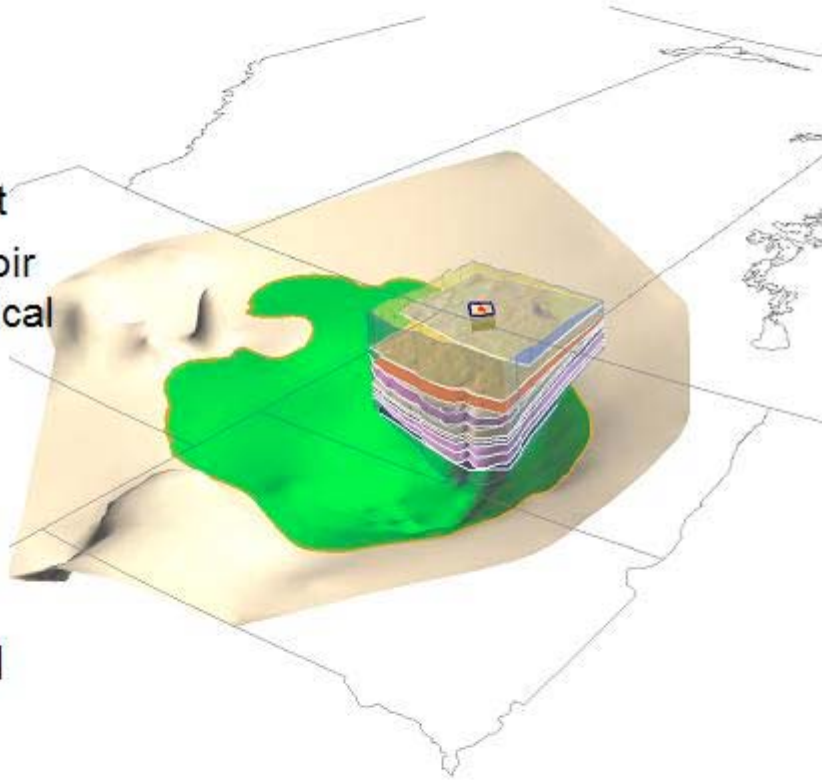
Geological Model



- Areal extent 10 km beyond CO_2 flood limits
- Geological architecture of system
- Properties of system
  - lithology
  - hydrogeological characteristics
  - faults
- Can be tailored for different RA methods and scenario analyses



Midale Reservoir

Summary

- **Geological Container at Weyburn is Effective**
  - Effective trapping setting
    - Primary seals are highly competent
    - Thick shale units above the reservoir serve as significant barriers to vertical flow (secondary seals)
  - Basin Hydrogeology
    - hydraulic separation between Paleozoic and Mesozoic aquifers
    - sluggish flow in Midale Beds
  - Tectonic elements have infuenced all levels of stratigraphy (deposition, erosion, dissolution)
    - No hydraulic evidence of fluid movement