IEA GHG Weyburn-Midale CO_2 Storage and Monitoring Project

William Daniel Gunter
Alberta Research Council

CCS in the Power Sector
Delhi, India,
January 22-23, 2008

ptrc
Petroleum Technology Research Centre

Phase 1: 2000-2004

"To predict and verify the ability of an oil reservoir to securely and economically contain CO_2 (geologically) through a comprehensive analysis of various process factors as well as monitoring and modeling methods intended to address the long-term migration and fate of CO_2 in a specific environment (EnCana's Weyburn, Saskatchewan EOR operation)"

ptrc
Petroleum Technology Research Centre


Canada's Sedimentary Basins Most Suitable for CO_2 Storage
North Pole
Alpha Ridge
Canada Basin
Greenland
Beaufort Basin
Arctic Basins
Baffin West Basin
Foxe Basin
CORDILLERAN OROGEN
Mackenzie Basins
Intramontane Basins
Pacific Basins
Rocky Mountain
PRECAMBRIAN SHIELD
Alberta Basin
Athabasca Basin
Saskatchewan Arch
Bow Island Arch
Williston Basin
Hudson Bay
Labrador Basins
PRECAMBRIAN SHIELD
Moose River Basin
Transcontinental Arch
St. Lawrence Basins
Saguenay Arch
Frontenac Arch
Nova Scotia
Atlantic Basins
Algonquin Arch
APPALACHIAN OROGEN
U.S.A.
ALBERTA RESEARCH COUNCIL
EUB
AGS

Phase I Project Overview

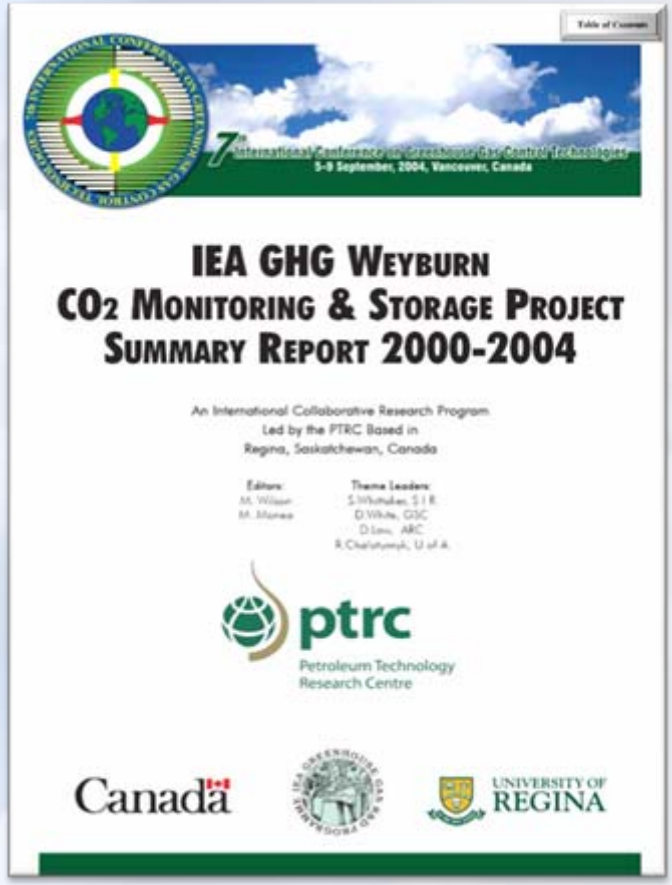
Launched in July 2000 by *PTRC in collaboration with EnCana*

Assess *technical and economic feasibility of CO2 geological storage*

The *CO2* is pipelined from Dakota Gasification Co. plant in Beulah, N. Dakota, USA and injected into the Weyburn oil field at an initial average rate of *5000 tons/day, for a total of approx. 20 million tones over the 20-year life of the project*

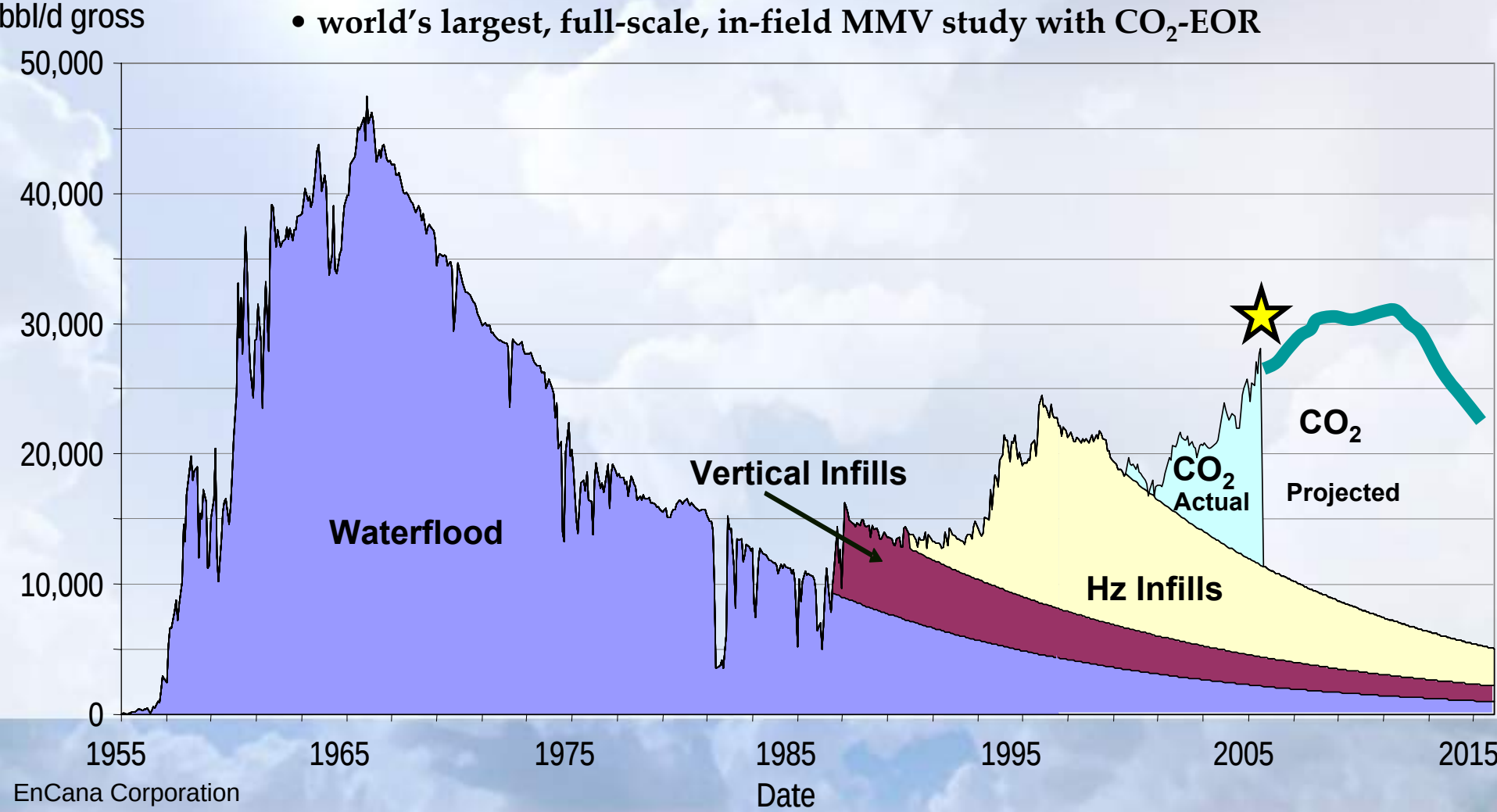
Funded by *15 industry and government sponsors* (Canada, USA, Japan, European Union)

Employed *22 technology organizations and some eighty specialists in six countries*

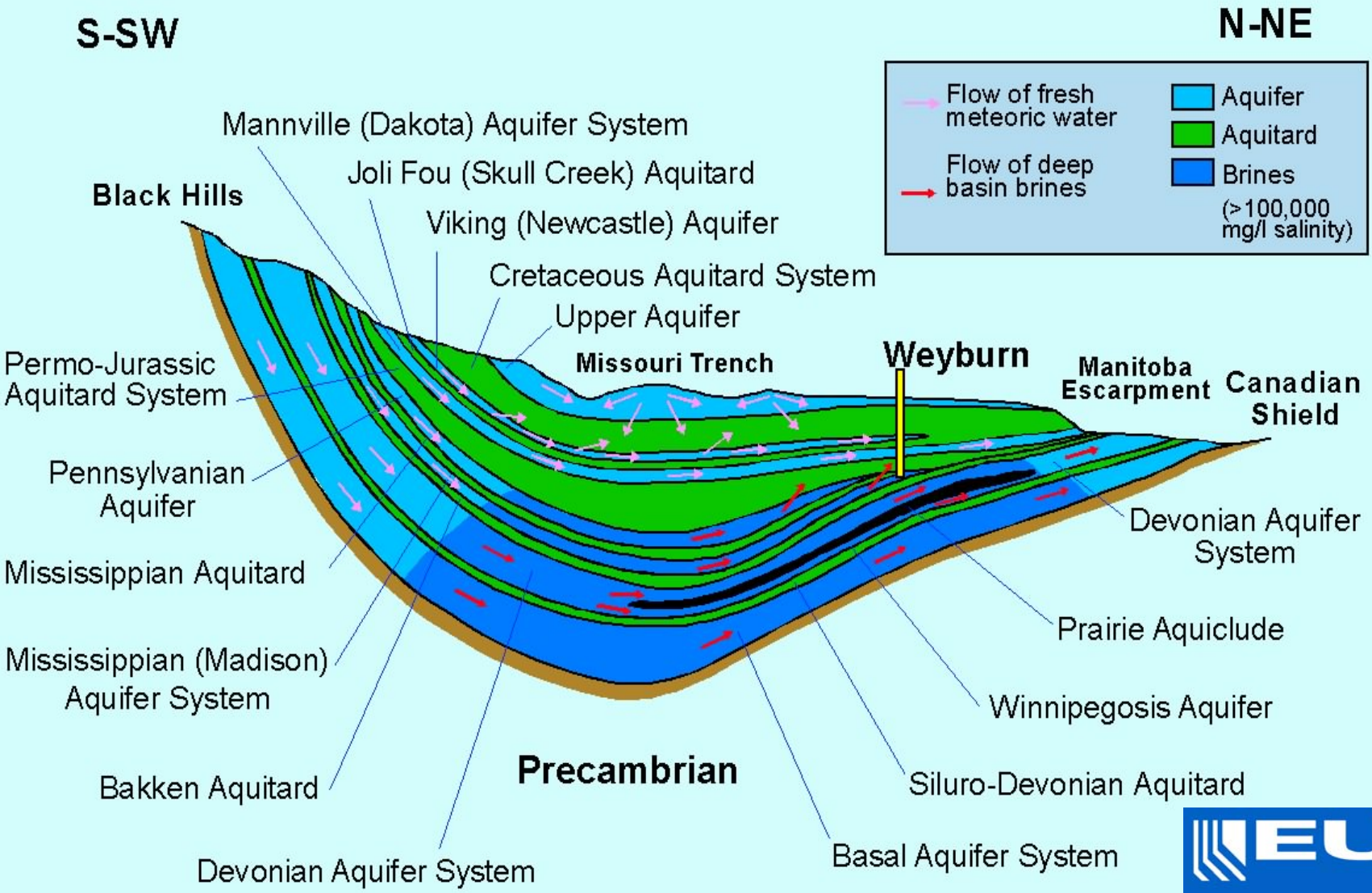


EnCana's Weyburn Unit Production Data

- 7 million tonnes (net) of CO_2 injected by end of 2005
- 26+ million tonnes (net) will be geologically stored by 2035
- 18,000 incremental bopd (30,000 bopd total unit prod'n)
- world's largest, full-scale, in-field MMV study with CO_2-EOR

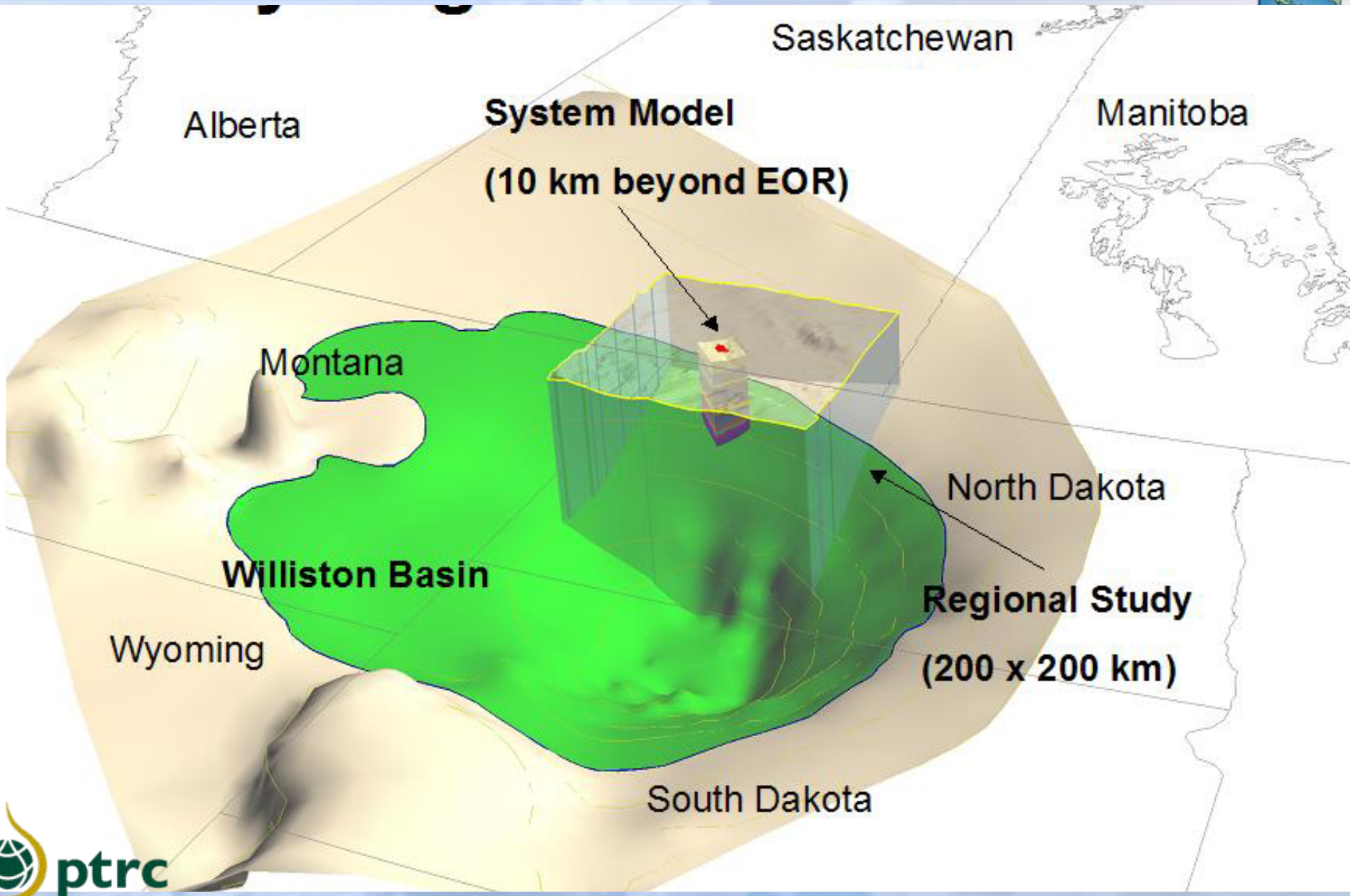


Cross-Sectional Diagram of Basin-Scale Flow of Formation Waters in the Williston Basin



Alberta Energy and Utilities Board

Weyburn CO_2 Storage System



Geological Model

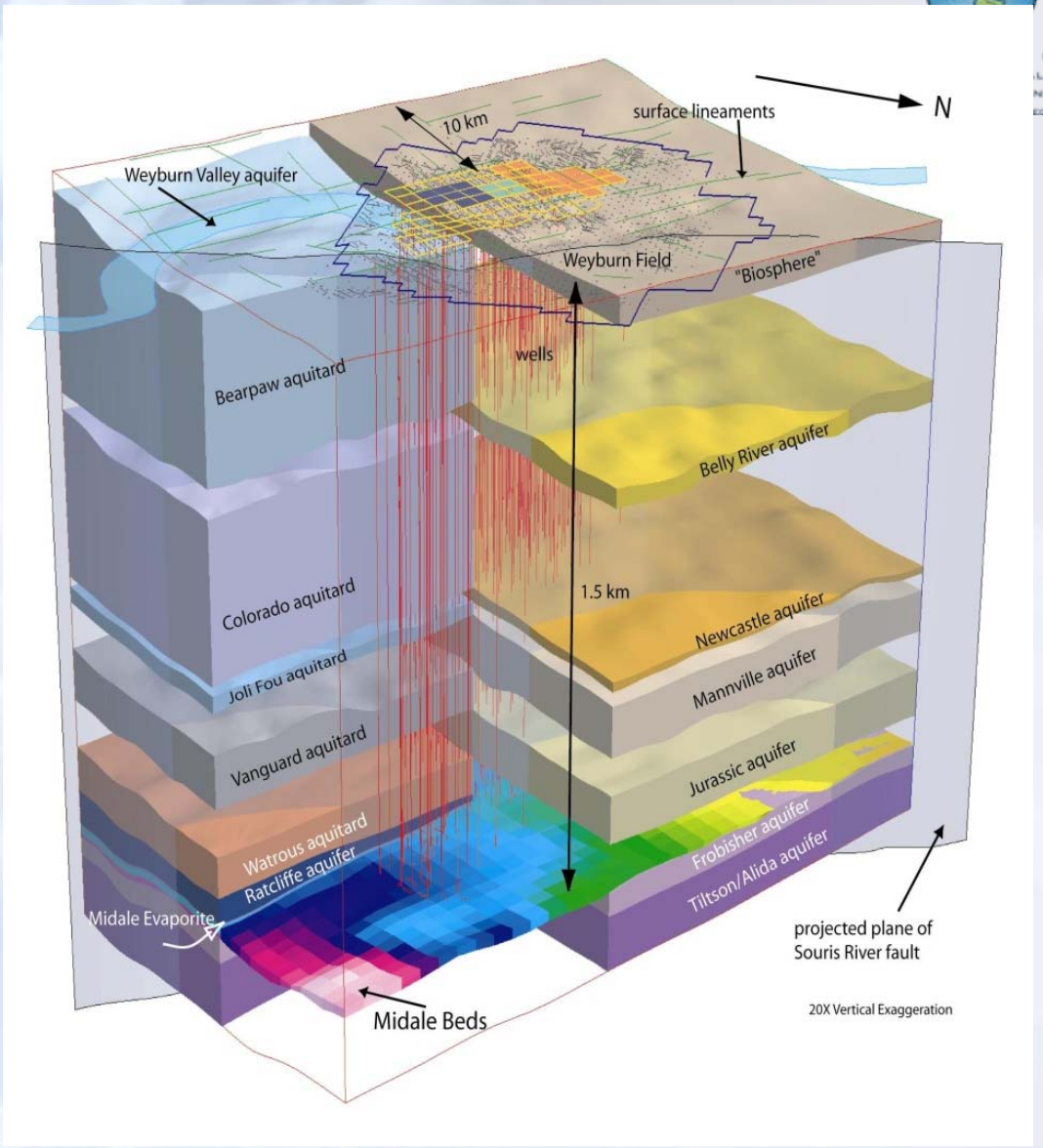
Areal extent 10 km beyond CO_2 flood limits

Geological architecture of system

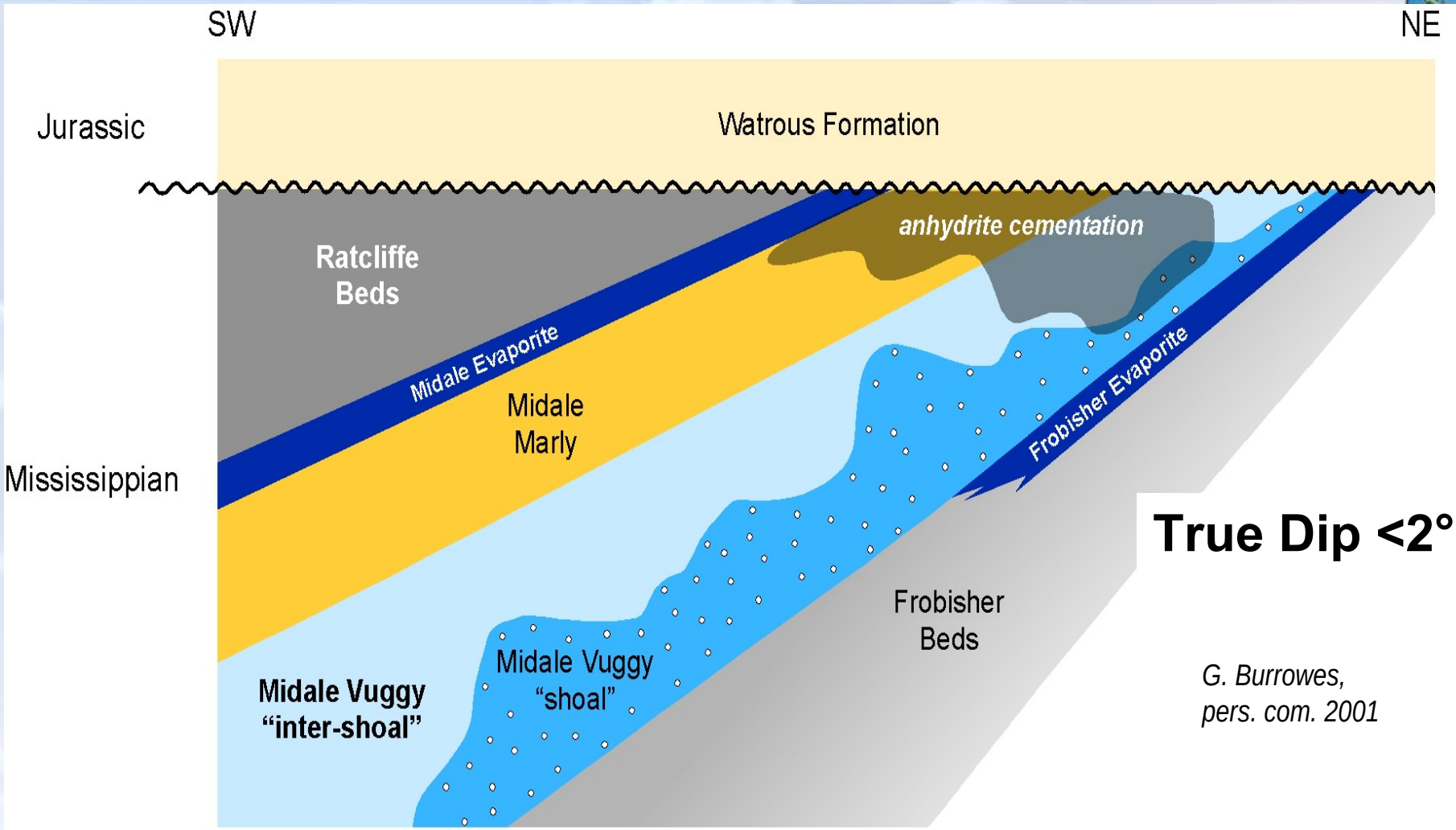
Properties of system

- lithology
- hydrogeological characteristics
- faults

Can be tailored for different RA methods and scenario analyses



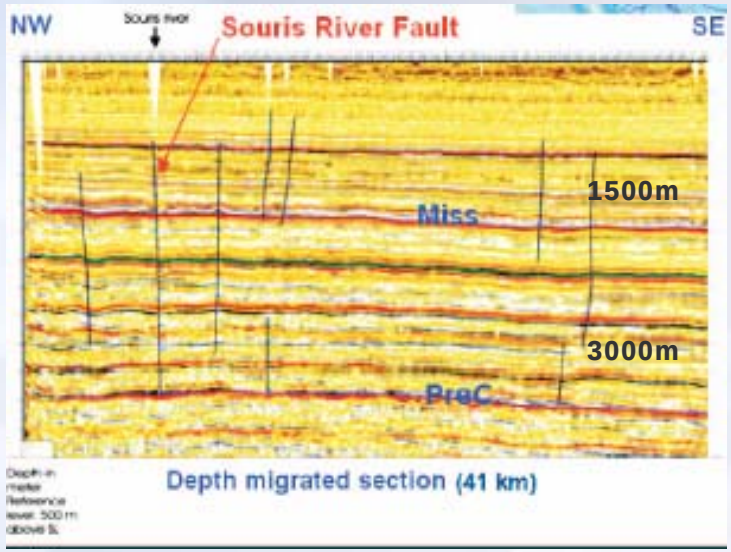
Petroleum Technology Research Centre



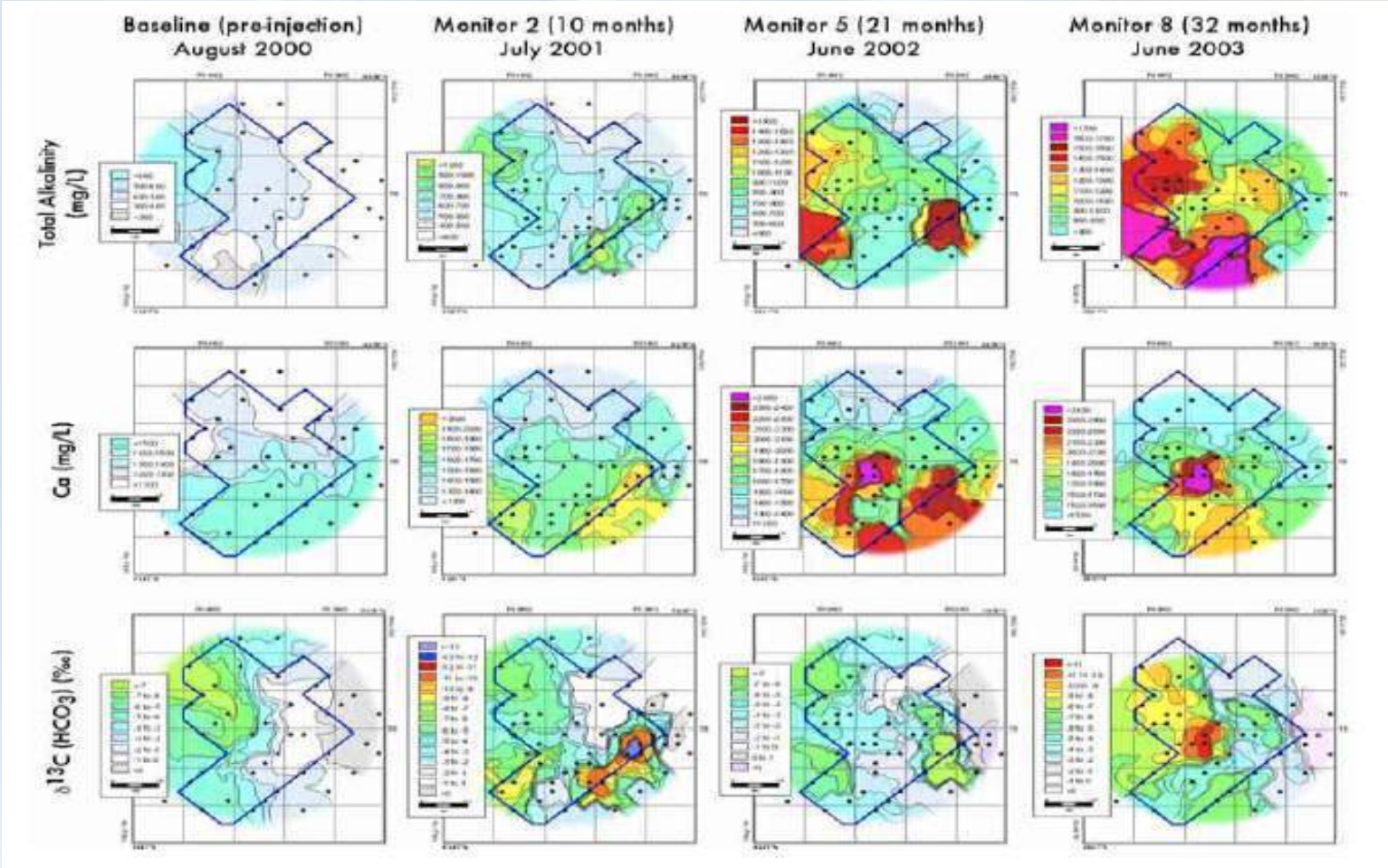
- Midale beds of the Mississippian Charles Fm. of the Williston basin
- Weyburn field lies near the Mississippian unconformity

Monitoring Techniques

- 4D, 3C surface seismic
- 4D, 9C surface seismic
- 3D, 3C vertical seismic profile (VSP)
- Cross-well seismic
- Geochemical sampling analysis
- Tracer injection monitoring
- Conventional production data analysis
- Passive seismic
- Surface monitoring techniques



Tracking CO_2 Chemistry: Fluid Monitoring Surveys (Phase 1)

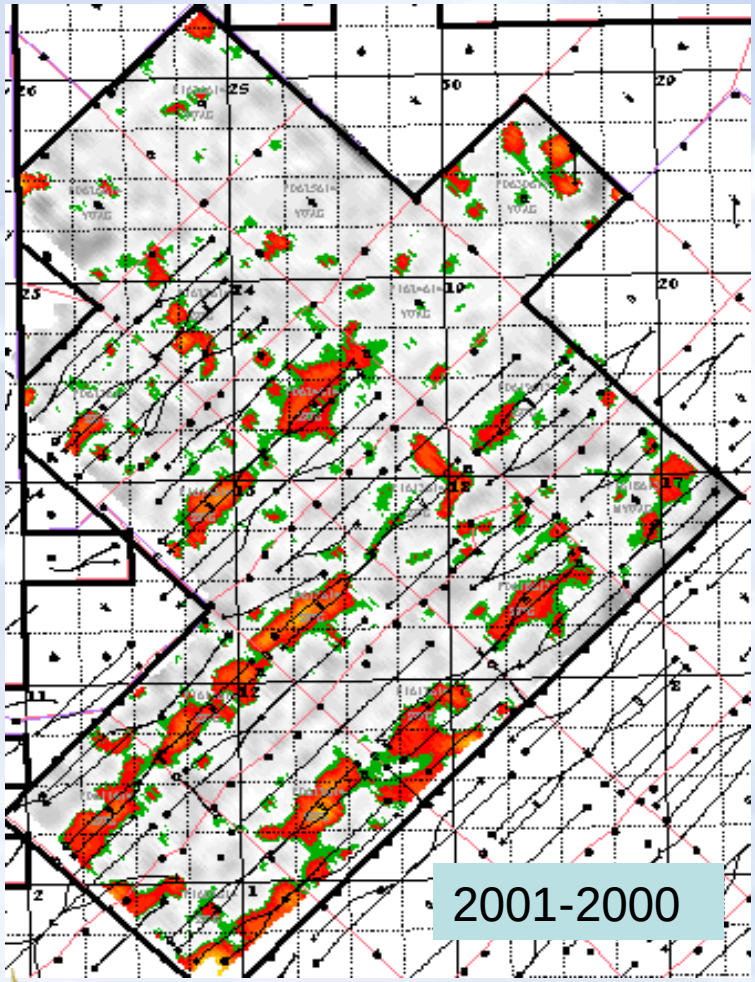


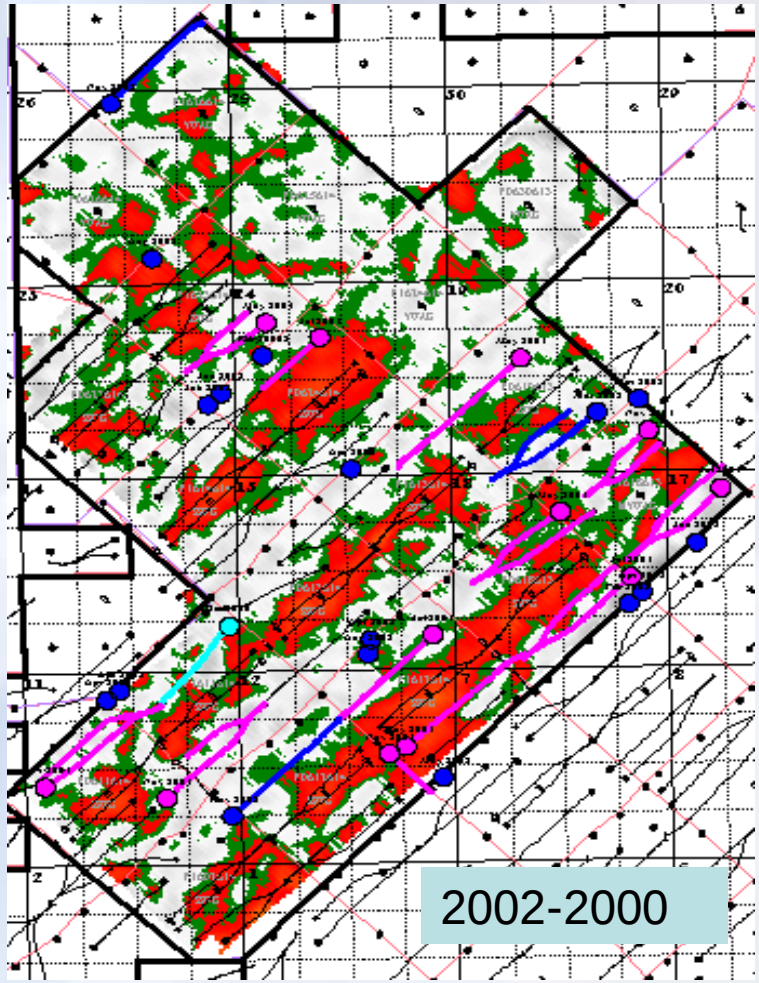
$$CO_2 + H_2O \leftrightarrow H_2CO_3 \quad \& \; H_2CO_3 + \text{Calcite} \leftrightarrow Ca^{2+} + 2HCO_3^-$$

ptrc
Petroleum Technology Research Centre

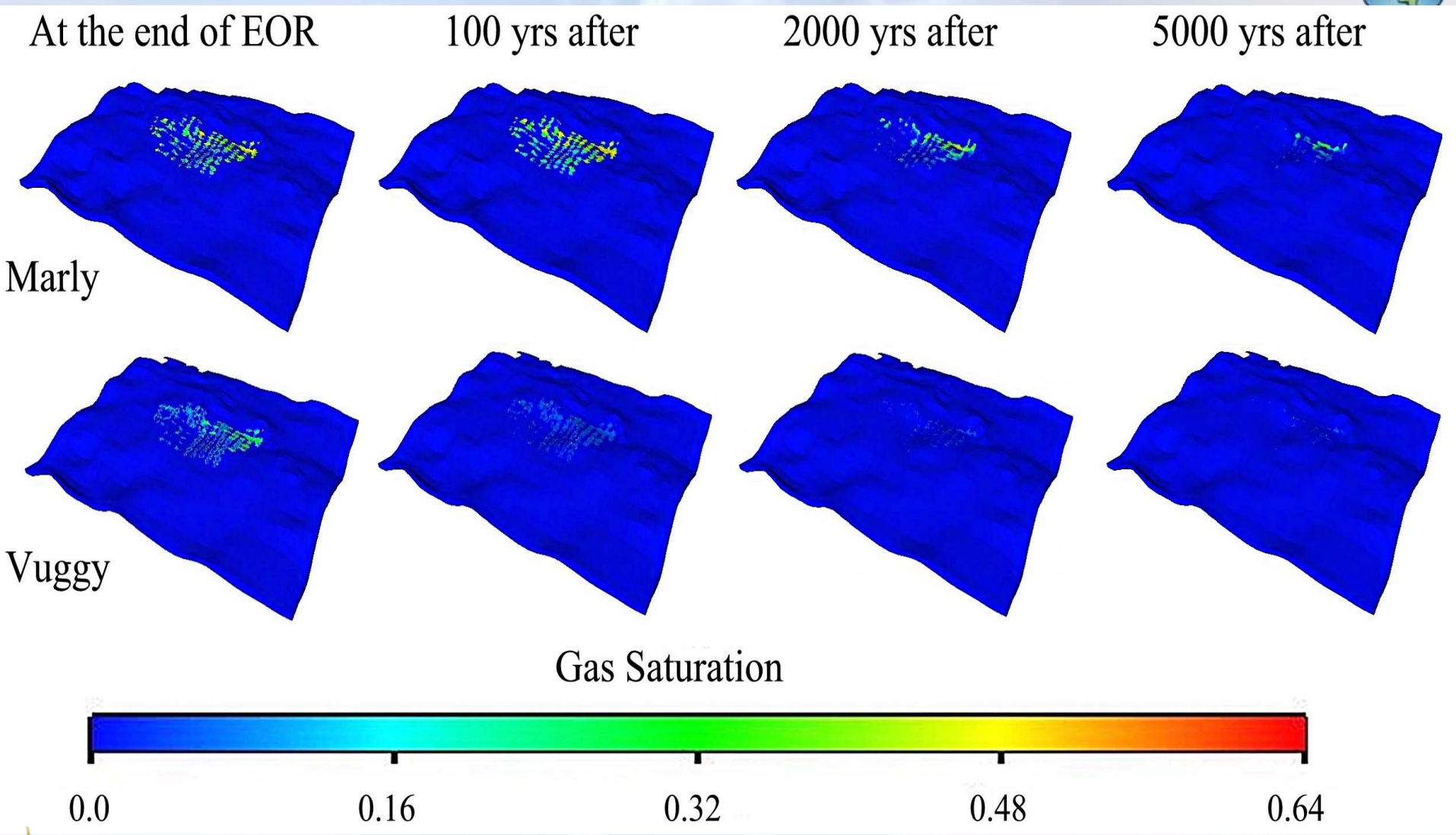
4D-3C Time-Lapse Seismic Surveys vs. Baseline survey (Sept. 2000)

Marly Zone

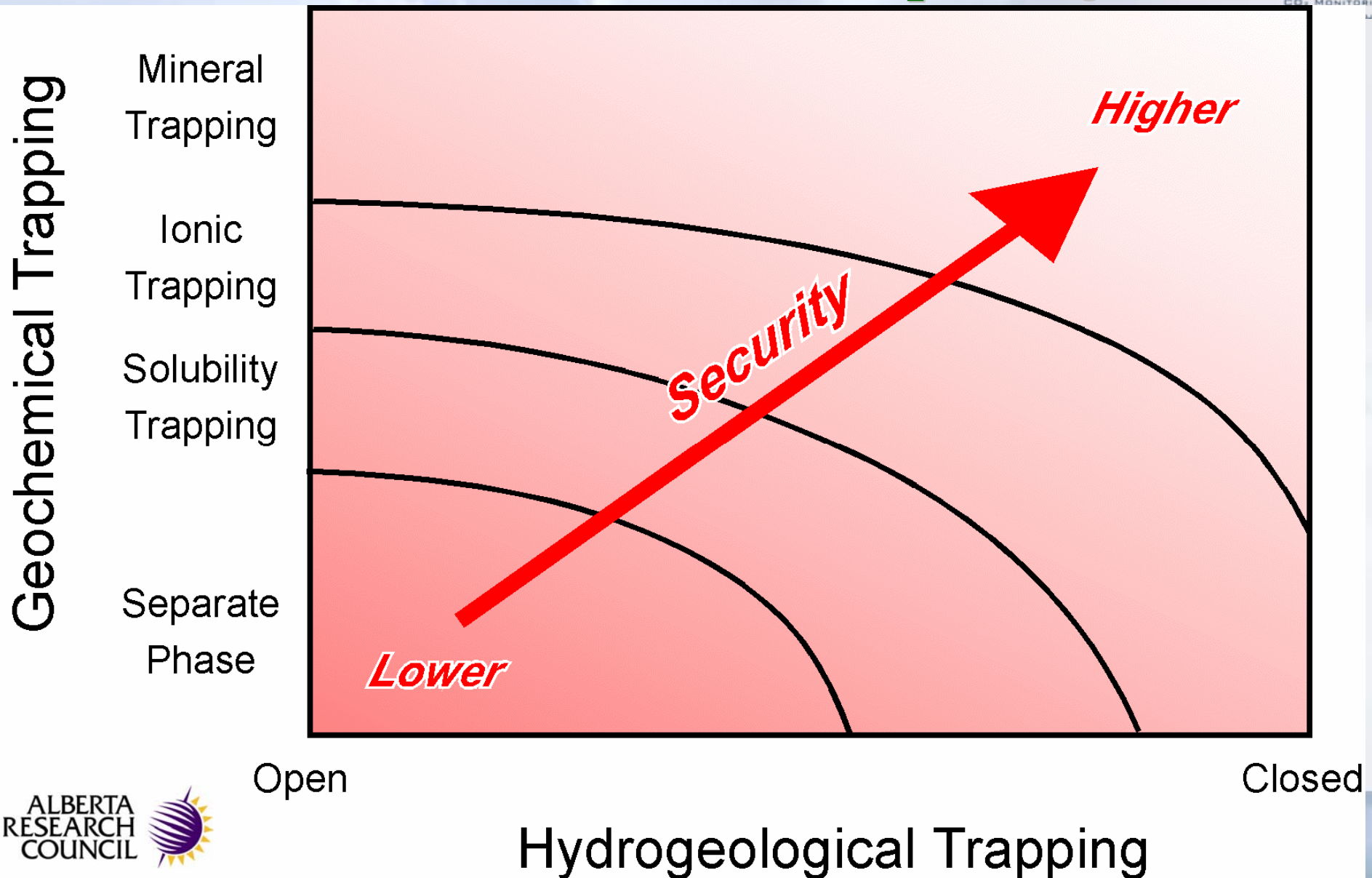




Gas Saturation with Time



Prediction & Risk Assessment of CO_2 Storage over time



ALBERTA RESEARCH COUNCIL

Final Phase of IEA GHG Weyburn-Midale CO_2 Storage and Monitoring Project

Non-Technical Component

- **REGULATORY**
  - **Clear, Workable and Science-based Regulations for CO_2 Geologic Storage**
- **PUBLIC COMMUNICATIONS**
  - **Public Awareness**
  - **Driven by the need for better public awareness of CO2 geological storage, especially on the issue of safety.**
- **FISCAL POLICY**

ptrc
Petroleum Technology Research Centre

Final Phase of IEA GHG Weyburn-Midale CO_2 Storage and Monitoring Project

Technical Components

- **GEOLOGICAL INTEGRITY**
- **WELLBORE INTEGRITY**
- **STORAGE MONITORING METHODS** (Geophysics & Geochemistry)
- **RISK ASSESSMENT;** Storage and Trapping Mechanisms; Remediation Measures; Environment, Health and Safety

ptrc
Petroleum Technology Research Centre

IEA GHG Weyburn-Midale CO_2 Monitoring and Storage Project

Best Practices Manual – Final Phase

Protocols for:

- ***Storage site selection***
- ***Monitoring and verification of stored CO_2***
- ***Well-bore integrity monitoring and remediation***
- ***Long-term risk assessment and risk management***
- ***Maximizing economic CO_2 storage capacity***

Overarching Principles: Address gaps in IPCC CCS Report and facilitate good public policy development to ensure widespread deployment of long-term CCS

ptrc
Petroleum Technology Research Centre

Final Phase: Partners to Date

Industry Sponsors

- Apache
- EnCana
- Chevron
- OMV Austria
- Aramco Services Co
- SaskPower.
- Schlumberger
- Shell

ptrc
Petroleum Technology Research Centre

Government Sponsors

- Natural Resources Canada
- United States Dept. of Energy
- IEA GHG R&D Programme
- Sask Industry and Resources
- Alberta Energy Research Institute
- RITE (Research Institute of Innovative Technology for the Earth)

Research Organizations

- Alberta Research Council (ARC)
- Canadian Light Source – Synchrotron
- ECOMatters (ECOM)
- Geological Survey of Canada (GSC)
- Permedia Group
- Saskatchewan Research Council (SRC)

- T.L. Watson & Associates
- University of Regina (U of R)
- University of Sask. (U of S)
- University of Alberta (U of A)
- University of Calgary (U of C)
- URS Canada Inc.

- Fugro Seismic Imaging
- Lawrence Livermore National Laboratories

- University of Bristol UK
- International Energy Agency

Project Contacts

Dr. Carolyn Preston, Executive Director PTRC
Email: Carolyn.Preston@ptrc.ca

Ray Knudsen, Project Director
Email: Ray.Knudsen@ptrc.ca

Dr. Frank Mourits, Project Integrator
Email: fmourits@nrcan.gc.ca

ptrc
Petroleum Technology Research Centre