Saskatchewan CO₂ Oilfield Use for Storage and EOR Research

(SaskCO₂USER)

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Petroleum Technology Research Centre

• Non-Profit Research & Development
• Collaborative partnerships with Industry, Government and Research Organizations
• Committed to improving oil recovery
• Research projects associated with CO2 management
  – IEAGHG Weyburn –Midale CO2 Monitoring & Storage Project
  – SaskCO2User
  – Aquistore
Objectives of the Program

- 2014 -2015 Research Program
- Applied research for commercial applications of CO₂-EOR operations and CO₂ storage.
- Focus on commercialization
  - CO₂ conformance
  - Wellbore Integrity
  - Monitoring
SaskCO$_2$USER Program

1. Evaluating minimum data sets
2. Storage integrity
3. Passive seismic monitoring
4. History-matched modelling
5. Wellbore design
6. Casing corrosion
7. Core assessment
Minimum Data Set Requirements

- How many wells needed to predict permeability field and model potential migration pathways (e.g., high permeability, faults)?
  - Analysis of variograms with various data set sizes
  - Analysis of realizations

- How many monitoring wells (producing well locations) needed to predict leakage / capture leakage event?
Monitoring of CO$_2$-EOR Sites for Storage Integrity

- Design an MMV Strategy
- 40 regulations and guidance documents reviewed (US, Canada, SK, AB, Texas, etc.).
- Automated workbook to allow for organization of the technology and rating
- Design technology deployment schedule
- Application of technology based on project risk and areas of concern for two leakage scenarios
- Ability to rank technology with equations based on rating categories
Monitoring of CO\textsubscript{2}-EOR Sites for Storage Integrity

- Historical events detected, located and reviewed using US Array, USGS, and GSC data
- Industrial activity reviewed and injection and production data for CO\textsubscript{2}-EOR field compiled
- 3 broadband stations installed. All observed events appear anthropogenic
- Ongoing work, tied in with monitoring network at Aquistore.
- World stress map data to be incorporated with anisotropy to determine stress conditions and pore pressure increases necessary to induce seismicity.
Stochastic inversion of Time Lapse Seismic Coupled with Flow Simulations for Reservoir Porosity-Permeability

• Iterative version of the Ensemble Kalman Filter (EnKF) applied to inversion/history matching experiments.
• Results indicate models improve when historical seismic data is included in the inversion model.
• Improved matches to seismic maps were obtained in all cases.
• The best match was obtained when seismic data was used for each formation.
Construction and Abandonment Design for Lifecycle Wellbore Integrity

- Wellbore design features to maintain wellbore integrity for long term abandonment
  - Enhanced cementing techniques
  - Positioning of downhole completion equipment
  - Material requirements for critical well sections such as the packer/tailpipe region
- Estimate additional costs for proposed designs compared to existing well designs
  - Wellhead upgrades, downhole completion tools and CRA casing
  - Estimated well construction cost differences for wells that require conversion to CO₂ EOR injection.
- Outline and procedure for abandoning horizontal well
  - CO₂ resistant cement plug in the horizontal section
  - Squeeze cementing option below the production packer
  - Cementing above the packer to a defined formation top.
Estimate in situ corrosion rates of casing/cement and contributing factors for wells located in the Weyburn–Midale Field

Database created of public and nonpublic log data (cement bond log, multi-finger caliper log and ultrasonic log)

Three wells from ~3100 chosen for the case study were producers, water injectors, and eventually CO$_2$ injectors

Evidence the rate of casing corrosion increases near the lower sections of the well, near the production perforations.
Core Assessment

- Investigate the influence of injected CO\(_2\) in the rock and pore framework.
- CO\(_2\) concentrations over 10 years established and 4 well locations chosen (3 cored wells and 1 observation).
- QEM scan completed and analysis of data vis-à-vis change in porosity and permeability completed.
- ~3-4% decrease in porosity – potentially CO\(_2\) injection related or variability in the reservoir.
- Two additional core samples being analyzed
2010 well: Lower Midale (Vuggy)
1957 well: Lower Midale (Vuggy)
1957 well: Lower Midale (Vuggy)
Summary of Accomplishments

- Project launch
- RFPs, contracts awarded, executed, March 2014
- Phase I Kick-Off Meeting held, July 2014
- Project Update 1 Meeting held, Nov 2014
- Project Update 2 Meeting held, June 2015
- Final Reports, September 2015
- (Forthcoming)Elsevier Supplement, IJGGC, 2016
QUESTIONS?

Thank you.

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