Geologic Sequestration of CO$_2$
Four Topics (*Briefly*)

Mark D. Zoback
Benjamin M. Page Professor of Geophysics
Director, Stanford Natural Gas Initiative
Co-Director, Stanford Center for Carbon Storage
Co-Director, Stanford Center for Induced and Triggered Seismicity

Toward Carbon Management
November 8, 2019
Four Topics

Can Geologic Storage of CO$_2$ Help Meet the Goals of the Paris Accords?

- Acknowledging the Challenges of Scale (Volume, Time)
- Challenges of Saline Aquifers
- Utilization of Depleted Oil and Gas Formations
- CCUS and Unconventionals
Meeting Global Climate Goals (Limiting Global Warming to 2°C) Will Require The Oil and Gas Industry to be in the Business of Producing Oil and Gas and Sequestering Enormous Quantities of CO₂ in Depleted Oil and Gas Reservoirs
The red shaded areas are the chance of exceeding different temperatures above pre-industrial levels using the cumulative emissions concept.

- Source: Jackson et al 2015b; Global Carbon Budget 2015

To Limit Warming to ~2°C, About 4% per Year Reductions in Emissions Will be Needed
Oil and Gas Climate Initiative (IEA)

Current CCS - ~30 Mt CO₂/year
~15 Mt CO₂/year from anthropogenic sources
The scale of global change in Sky is unprecedented.

Energy System Global Emissions GT CO2/Year

-10 0 10 20 30 40

Global CCS 1 GT CO2

~1.5x Current GOP

Global CCS 5 GT CO2

~3x Current GOP

Global CCS 10.9 GT CO2

~3x Current GOP

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Challenges of Developing New Infrastructure:
• The time to develop (many decades)
• Enormous cost ($ trillions)
• Liability and the need for monitoring (and potential remediation)
• Difficulty of obtaining (and maintaining) a social license to operate…

Geologic Challenges
• Pore space is already occupied
• Required volumes will result in significant pressure increases at depth
What We Learned in Oklahoma

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Large Scale CO$_2$ Sequestration

- Modeling of a Large-Scale CCS Project - 100 Million Tonnes CO$_2$/Y for 50 years

The Mt. Simon Sandstone, Illinois Basin

(Zhou et al. GROUND WATER 48, no. 4: 494–514, 2010)
- Injection of 1 million tons of CO$_2$ over a 3 year period into the Mt. Simon (8 million barrels, 1.3 million m$^3$)
- Small earthquakes define faults in Precambrian basement
- Pressure change less than 1 MPa

Goertz-Allman et al., JGR
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AVOID PRESSURIZATION OF CRYSTALLINE BASEMENT (BOTTOM SEALS ARE IMPORTANT)
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Changing the Narrative
SPE – ATCE 2019 Meeting

Does CCUS have a Social License to Operate (SLO)?

An examination of the current state of Carbon Capture, Utilization, and Storage (CCUS), with specific focuses and discussions on incidental storage during EOR; On stakeholder engagement, acceptance, and awareness; On the critical relationship of the socioeconomic influences and political circumstances that are likely to shape the various stakeholders’ views in the near and long terms; and on why both carbon storage and incidental storage (utilization) of CO2 during enhanced oil recovery is important to SPE and SPE members.

Speakers
Richard Chalaturnyk
University of Alberta
Eddy Chui
Carnegie Mellon University
Steve Whittaker
Hawaii State Geological Survey

Moderator
Steven Carpenter
Enlightened Oil Recovery Institute
University of Wyoming

Dr. Steven Carpenter
U of Wyoming
Moderator

Dr. Rick Chalaturnyk, PE
U of Alberta
Expert

Dr. Sallie Greenberg
U of Illinois
Expert

Dr. Ben Rostron
U of Alberta
Expert

Dr. Steven Whittaker
U of Illinois
Expert
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- Significant resources devoted to SLO since 1990s
- SLO not consistently gained and broad-based community trust in industry is lacking
- Success at local levels
- SLO is no longer granted only by local communities
- SLO extends to “a potentially more powerful group of largely urban dwelling broader society, enabled by technology, especially social media.”
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Geologic Storage of CO$_2$ via EOR Projects

North American oil field distribution and calculated capacities

NETL (DOE), 2010
Only Realistic Pathway to Significantly Reduce Carbon Emissions in the Next 20 Years

The Oil and Gas Industry Brings Many Advantages:

- Existing Knowledge of the Subsurface
- Much Infrastructure is Already in Place
- Pore Space to Accommodate Enormous Volumes (3.4 Gtonne sc CO₂ is Equivalent to 1 Year of GOP)
- SLO in Existing O&G Fields Should be Easier
- But Can This Be a Viable Business?
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Unconventionals are World-Class Resources

After ~ 200,000 Wells
- RF Dry Gas ~25%
- RF Tight Oil 2-10%
- Many Uneconomic Wells

Courtesy Greg Leveille, ConocoPhillips
Why is Shear Stimulation Important?

The shear fracture network increases the area of contact between permeable planes and the low permeability matrix.

Would this be more effective if hydraulic fracturing was done with CO$_2$?
Compositional simulation of cyclic gas and CO$_2$ injection. The miscibility of CO$_2$ and oil is the primary recovery mechanism. A number of other mechanisms --including viscosity reduction, oil swelling, and repressuring-- contribute to enhanced production.
Thank you