Overview of USGS Carbon Sequestration – Geologic Research and Assessments Project

The National Academies of Sciences, Engineering, and Medicine
May 24, 2016

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Outline for Presentation

• U.S. Geological Survey (USGS) carbon sequestration Congressional mandate

• Why is geologic CO₂ sequestration important?

• What is the USGS geologic carbon sequestration project doing to address CO₂ storage?

• Summary of take-away points
Carbon Sequestration Mandate

• The USGS Carbon Sequestration Program is funded by the USGS Climate and Land Use Change (CLU) Mission Area.

• The Carbon Sequestration Program is responsive to The Energy Independence and Security Act (EISA) of 2007 (P.L. 110-140) which calls for the USGS to develop a methodology for, and then complete a national assessment of, the geologic storage capacity for CO₂, and to evaluate associated geologic risks.

• EISA also directed the USGS to conduct a national assessment to quantify the amount of carbon stored in ecosystems, the capacity of ecosystems to sequester carbon and the rate of greenhouse gas flux in and out of ecosystems (biologic carbon sequestration).
Why is geologic CO$_2$ sequestration important?

Geologic storage of CO$_2$ is essential to meet future CO$_2$ emission reduction scenarios$^1$

- By 2050, carbon capture and geologic storage (CCS) should contribute about 15% of total emission reductions through 2050 in the 2°C Scenario (International Energy Agency, 2013, 2016)

$^1$Intergovernmental Panel on Climate Change (2014); International Energy Agency (2015)
Carbon capture and storage (CCS) contributes 15% of total emission reductions through 2050 in 2°C Scenario (2DS) compared to 4°C Scenario (4DS).

The carbon intensity of the global economy can be cut by two-thirds through a diversified energy technology mix.

IEA (2013) Technology Roadmap Energy Technology Perspectives Carbon capture and storage
IEA (2016) Energy Technology Perspectives 2016
The regions with the largest technically accessible storage resources (circled) are the Coastal Plains (mostly in the U.S. Gulf Coast), Rocky Mountains and Northern Great Plains, and Alaska (mostly North Slope)

USGS National Assessment of Geologic Carbon Dioxide Storage Resources mean = 3,000 Gt CO₂ storage

USGS estimates of technically accessible storage resources for CO₂ in the United States by region

- Coastal Plains (1,900 Gt) 65%
- Alaska (270 Gt) 9%
- Pacific Northwest (14 Gt) <1%
- California (90 Gt) 3%
- Western Mid-Continent (150 Gt) 5%
- Eastern Mesozoic Rift Basins (0.44 Gt) <1%
- Rocky Mountains and Northern Great Plains (270 Gt) 9%
- Eastern Mid-Continent (230 Gt) 8%

Gt = metric gigaton
The following slides illustrate major focus areas for the USGS Carbon Sequestration – Geologic Research and Assessments Project
What happens when you pump carbon dioxide underground?

Major questions addressed by USGS research:
- How much CO₂ can be stored underground nationwide?
- How much oil can be produced by injecting CO₂ into reservoirs for enhanced oil recovery?
- What are the environmental risks of storing CO₂ in underground reservoirs? What is the potential for CO₂ leakage, impacts to drinking water, and induced seismicity?

The USGS is monitoring induced seismicity at the Arthur Daniels Midland industrial carbon dioxide injection project in Decatur, IL.

CO₂ injection well in Mississippi
The USGS has developed an assessment methodology for estimating the potential incremental technically recoverable oil resources resulting from CO₂-enhanced oil recovery (CO₂-EOR) in reservoirs with appropriate depth, pressure, and oil composition. The methodology also includes a procedure for estimating the CO₂ that remains in the reservoir after the CO₂-EOR process is complete (Warwick and others, in press).
Geological studies of reservoirs and seals in selected basins with high potential for CO$_2$ storage

- CO$_2$ density and geothermal gradient research
- Underpressure in the basins of the Great Plains

Michigan Basin (Buursink, 2014)

Nelson and others (2015)
Natural CO₂ reservoirs as analogues for CO₂ storage

• Use natural CO₂ reservoirs to investigate potential leakage risk and rates along faults and through breached seals
• Evaluate availability of natural CO₂ resources that will compete with anthropogenic CO₂ for use in enhanced oil recovery
  – Study natural gas isotope geochemistry (including noble gases)
  – Build geochemical database and characterize the size, timing and migration of natural accumulations within total CO₂ systems
  – Work with USGS Produced Waters Project by evaluating reservoir microbiology and water geochemistry
  – Establish multiple confidentiality and assistance agreements with natural gas producers
Economics of CO₂ Storage and Enhanced Oil Recovery (EOR)

Develop economic models:
• Representative economic/engineering cost models for saline formations
• Economic cost model for carbon dioxide extraction from natural sources

Describe/delineate costs of
• Site preparation and investment
• Pressure management
• Risk mitigation
• Monitoring

Petroleum engineering modeling tools that estimate injection capacities and pressure buildup for Mount Simon Sandstone

Work in coordination with the USGS Economics, Energy Resources, and Future Energy Supply project
The USGS also studies rock types that have the potential to store CO₂ through different mechanisms, including CO₂ mineralization in mafic basalts and ultramafic rocks, and CO₂ sorption onto organic-rich shales and coals.
Induced seismicity associated with CO$_2$ geologic storage

Background on Decatur & CCS

- Injection occurs right over crystalline basement into the lower Mount Simon Sandstone
- Extensive evidence of heterogeneous permeability structure (vertically, horizontally)
- Similar physics as wastewater injection sites except: buoyancy, compressibility, and mobility of super critical CO$_2$
- Same concerns: pore pressure change, mass added, poro-elastic strain changes
- Better opportunity to learn about physical mechanisms governing induced seismicity:
  - Seismic monitoring
  - In-situ stress analyses
  - Thermal, hydraulic, and mechanical models of injection & deformation

Strandli and others, 2014
Induced seismicity associated with CO₂ geologic storage

Locations of microseismic events and USGS monitoring stations

Double-difference relocated microseismicity using differential travel times from phase arrival times and waveform cross correlation (correlation coefficient ≥ 0.7). Focal mechanisms are from P-wave polarity for six events. Regional orientation of the maximum horizontal principal stress ($S_{Hmax}$) is indicated by opposing arrows.

Kaven and others (2015)
Cooperators and outreach

- State Geological Survey and university Co-ops
- Stanford and Univ. Texas at Austin CO₂ working groups
- Member of DOE National Risk Assessment Partnership Stakeholders Group
- Member of Interagency Carbon Capture and Storage working group
- Member of International Standards Organization working groups on Carbon Capture and Storage and CO₂-enhanced oil recovery
- Member of International Energy Agency working group on assessing CO₂ storage capacities
- Industry partners (Electric utilities, software developers, oil and gas operators)
Next steps

• Complete national CO$_2$-enhanced oil recovery assessment
• Continue induced seismicity research
• Better characterize potential geologic CO$_2$ storage formations
• Build in pressure, injection rate, time, and economics into future CO$_2$ storage assessments
• Conduct numerical modeling for hydrodynamic and geochemical interactions with CO$_2$ storage
Summary of take-away points

• Geologic storage of CO₂ is essential to meet future CO₂ emission reduction scenarios¹

The USGS is a recognized world leader in:
• The geology of CO₂ storage
• Resource assessments
  ▪ CO₂ storage
  ▪ Enhanced oil recovery
  ▪ Economics of CO₂ storage and energy-related resources
• Induced seismicity

¹Intergovernmental Panel on Climate Change (2014); International Energy Agency (2015)
References Cited


Global CCS Institute, 2015, website, www.globalccsinstitute.com/content/information-resource.


Carbon Sequestration—Geologic Research and Assessments Project

Project Website
http://go.usa.gov/8X8

Selected Publications
http://go.usa.gov/xZDpz

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