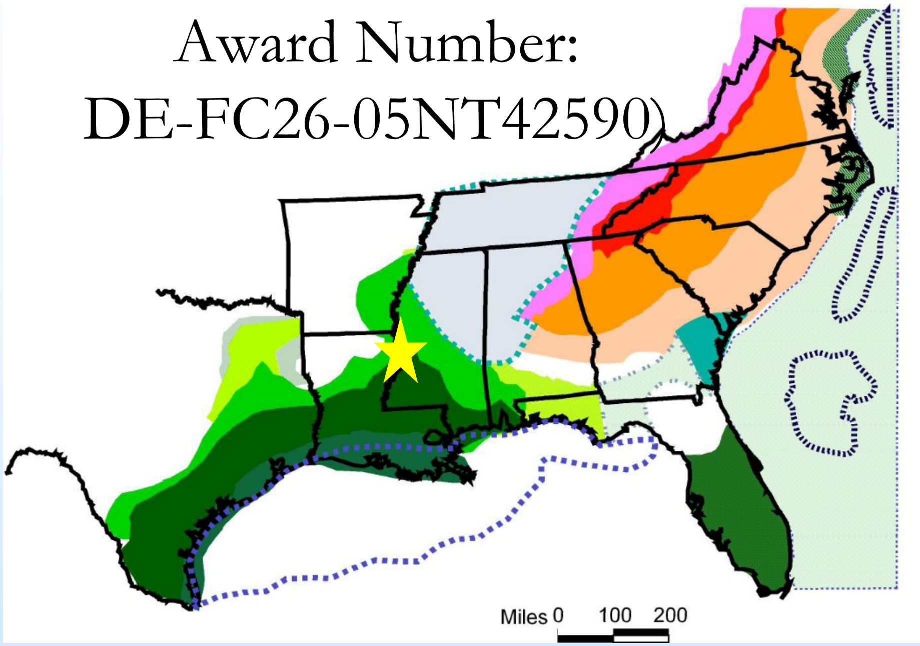
Southeast Regional Carbon Sequestration Partnership—Early Test at Cranfield

Award Number:
DE-FC26-05NT42590)



Susan Hovorka, Gulf Coast Carbon Center,

Bureau of Economic Geology Jackson School of Geosciences

T, he University of Texas at Austin

U.S. Department of Energy

National Energy Technology Laboratory

Addressing the Nation's Energy Needs Through Technology Innovation – 2019 Carbon Capture, Utilization, Storage, and Oil and Gas Technologies Integrated Review Meeting

August 26-30, 2019

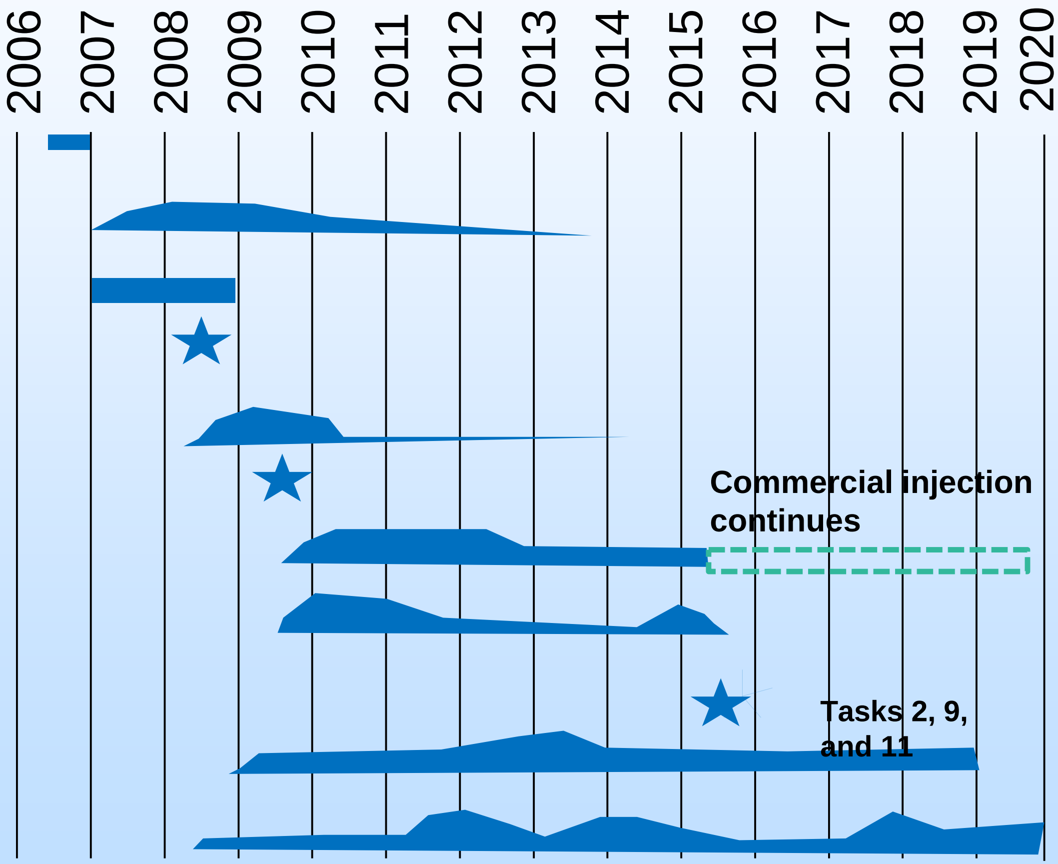
Presentation Outline

- Timeline of SECARB Early Test
- Team structure
- Early test goals
- Technical status- Commercializing the learnings
- Current activities
- Lessons learned – review publications

Real-time communication array

Timeline of SECARB Early Test

Site identification
Characterization
Planning monitoring
Start injection
Phase II monitoring
Phase III installation
Phase III injection
Phase III monitoring
End of monitoring
Data assessment
Technology transfer



Team Structure

SECARB
Southeast Regional Carbon Sequestration Partnership

Bureau of Economic Geology
Gulf Coast Carbon Center

Gulf Coast Carbon Center
Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin

Southern States Energy Board

SECARB Anthropogenic Test At Plant Barry/Citronelle

Denbury Resources
Field owner and injection system design, management, 4-D survey, HS&E

Sandia Technologies
Monitoring Systems Design, Installation, HS&E

Vendors
e.g. well drilling, landmen

50 Vendors
e.g. Schlumberger

Core Lab
UT DoG
Anchor QEA

MSU & UMiss
Hydro & hydrochem

Curtin University
3-D Seismic processing

Federal collaborators
Via FWP

LBNL
Well-based geophysics, U-tube and lab design and fabrication

LLNL
ERT

USGS
Geochemistry

Separately funded

NRAP
VSP deployment & analysis

NETL
Rock-water interaction

Model comparisons
LBNL SIM SEQ study

IPARS Modeling
CFSES M. Wheeler

4-D Seismic analysis
K. Spikes UT DoGS

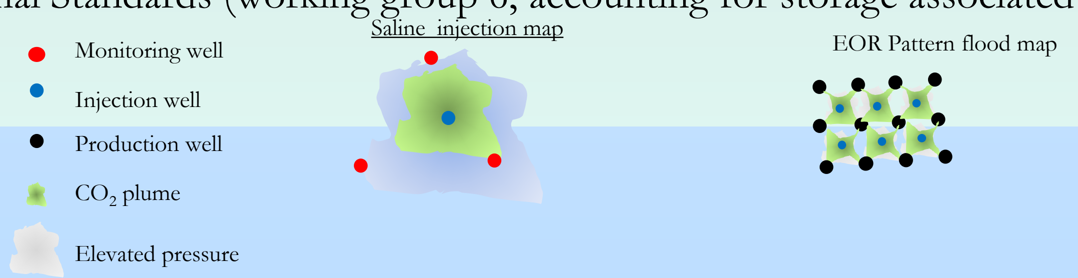
Rock Mechanics
CFSES Sandia NL

Microseismic deployment
RITE, Japan

Groundwater controlled release
AWWA

Technical Status - Moving information to commercial

- Injection scale-up – pushing the limit of injection
  - Assessing what is rate-limiting issue – overpressure or overfill?
- CCUS monitoring and accounting
  - Unique issues in a proven trap with production history – but complex fluids and many wells
- Maximize monitoring testing to minimize commercial monitoring
  - SECARB early test – extensive monitoring – many experiments
  - Commercial monitoring – focus on key issues –ALPMI method
  - Advising California Air Resources Board on their new Carbon Capture and Sequestration Protocol under the Low Carbon Fuel Standard
  - Advising International Standards (working group 6, accounting for storage associated with EOR.



Early Test Scope

- Monitoring saline and EOR in a commercial EOR project
- “Early” because project was nearly ready to start at time SECARB entered
- 10,000 ft deep Cretaceous Tuscaloosa Formation

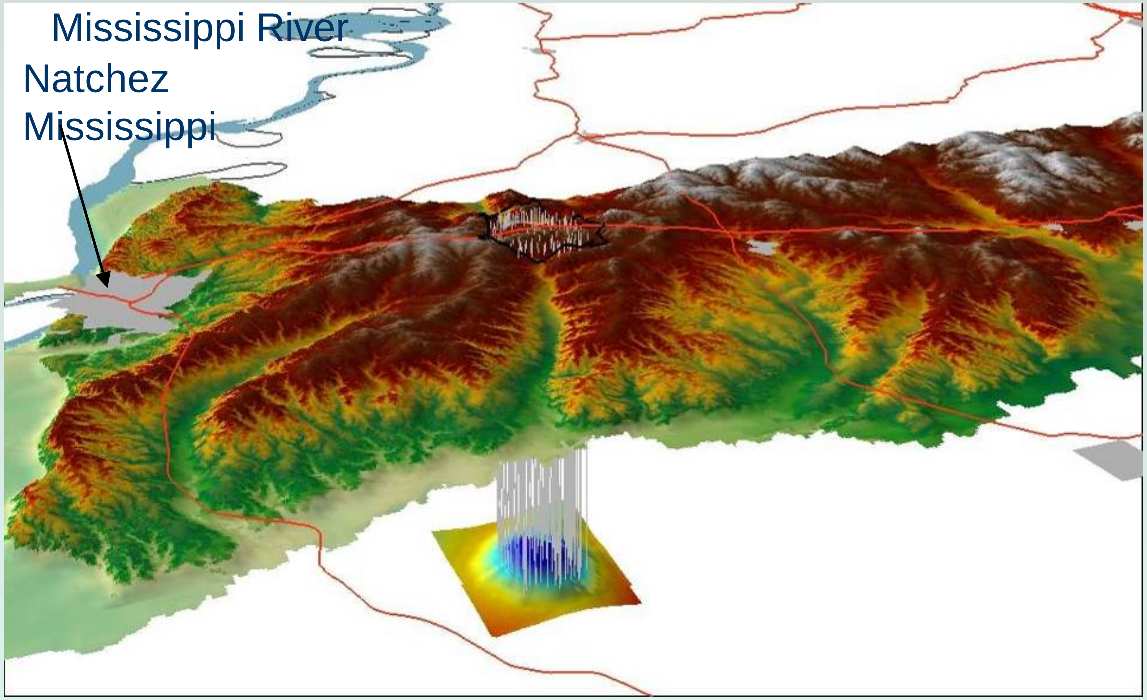
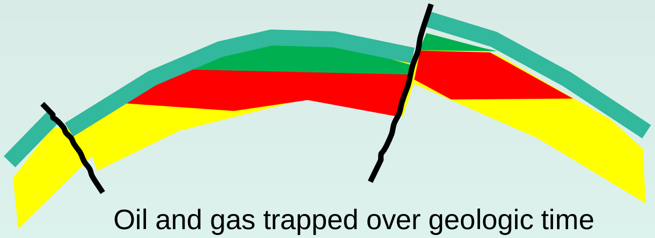


Figure Tip Meckel

Stacked storage EOR and Saline

- Characterization based on long production history
- Balanced flood
  - Fluid withdrawal (oil, water, gas CO_2) = Fluid injection (water, CO_2) during most of the operation
  - Area and magnitude of elevated pressure controlled by production
  - Area occupied by CO_2 controlled by production
- Controlled flood
  - Injection and production patterns
- Active surveillance
  - Production, pressure
  - Other techniques as needed
    - Wireline log, seismic, tracers,



Oil and gas trapped over geologic time

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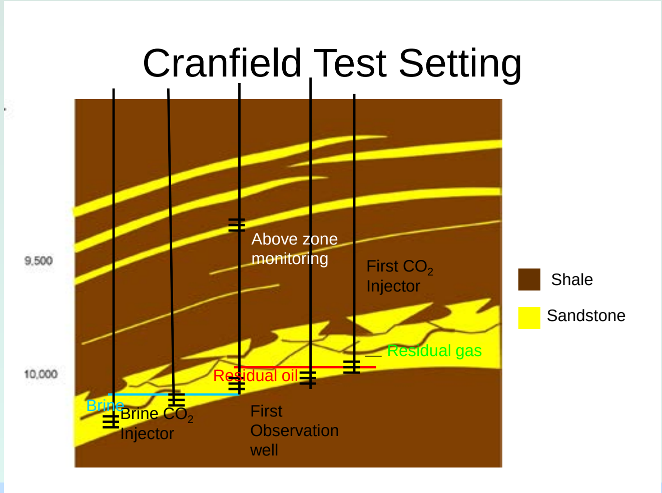
Major Contributions

- Early Test Developed monitoring approaches for later commercial projects
  - Process-based soil gas method
  - Effectiveness of groundwater surveillance
  - Pressure and fluid chemistry monitoring in Above-Zone Monitoring Interval (AZMI)
  - ERT for deep CO_2 plume
  - Limitations of 4-D seismic
- Published and propagated techniques for widespread application
- Advanced to commercialization



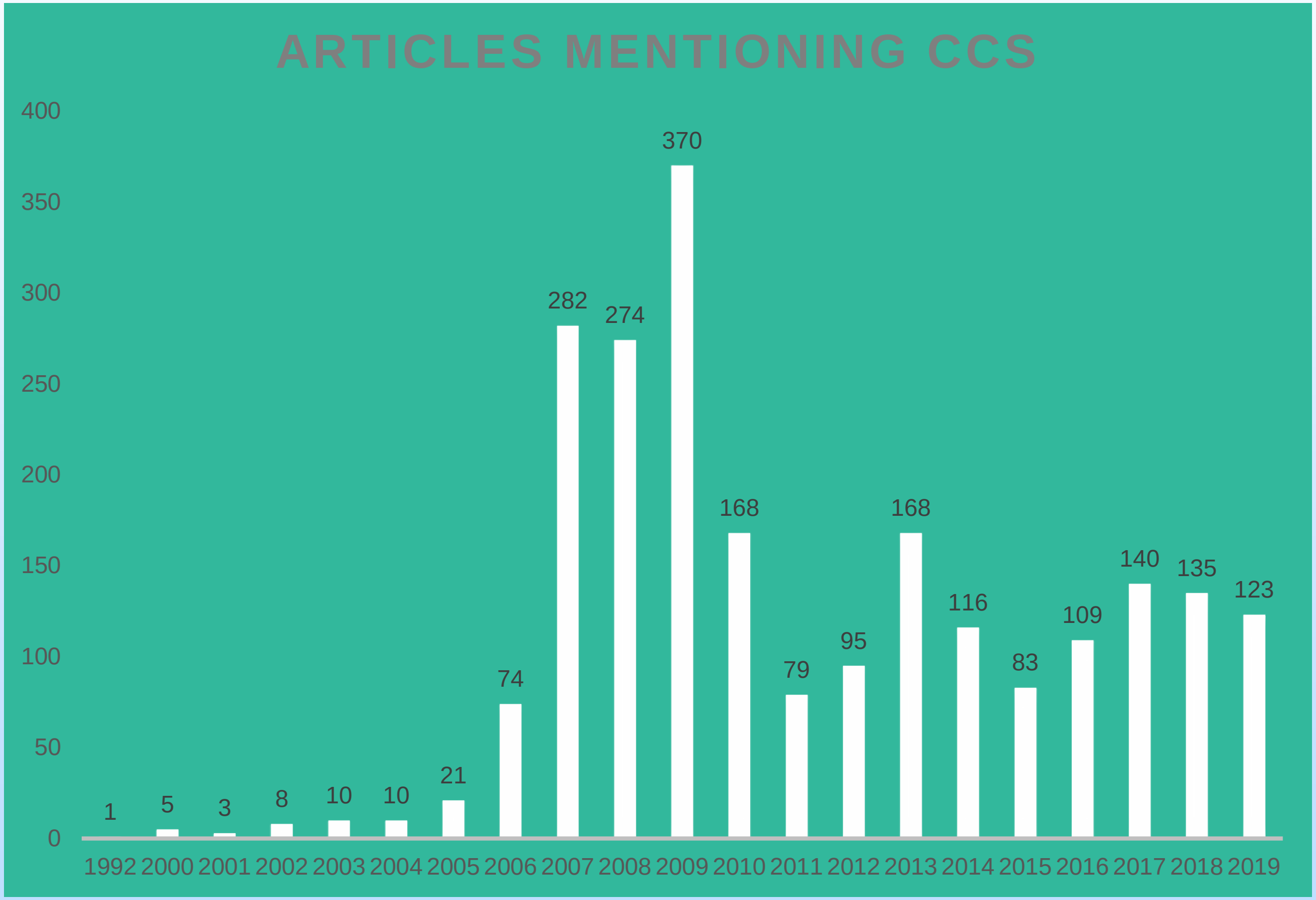
Early Test Goals

- Large-scale storage demonstration
  - 1 MMT/year over >1.5 years
    - Periods of high injection rates
    - Result >5 years monitoring with >5 MMT CO_2 stored
- Measurement, monitoring and verification
  - Tool testing and optimization approach
  - Deploy as many tools, analysis methods, and models as possible
- Stacked EOR and saline storage
- Commercial technology transfer ⇐ 2019 major effort
- Support Atlas, Maximize impact ⇐ 2020 major effort

Media Analysis

Emily Moskal

- What is limiting US press coverage of CCUS?



Statistics from more than 1000 US media outlets

Follow-up detailed interviews

- 1) freelance science journalists,
- 2) highly-engaged female science journalists
- 3) journalists who had covered the topic before.

Major media concerns per interviewees:

" there have been many failed projects"

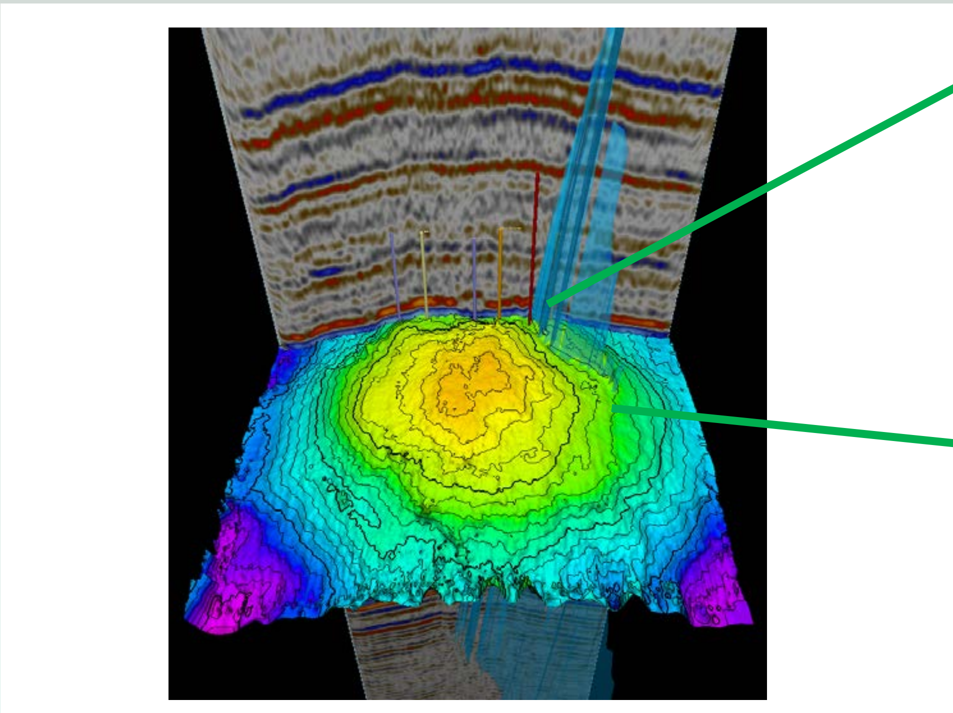
"the ones that exist are too expensive"

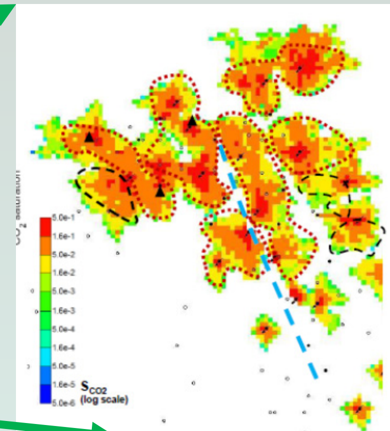
"we don't know if CO_2 will leak to the surface"

"environmental damage will be similar to those caused by fracking."

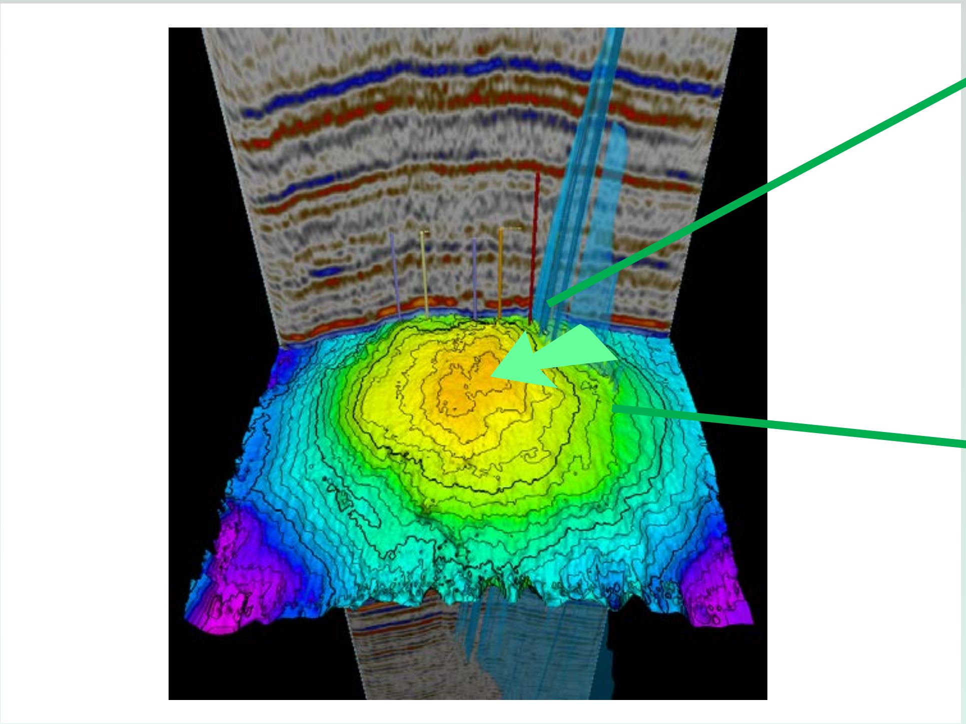
Outreach - reaching further

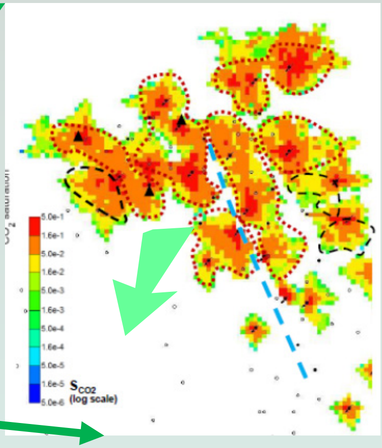
Physics of plume stabilization





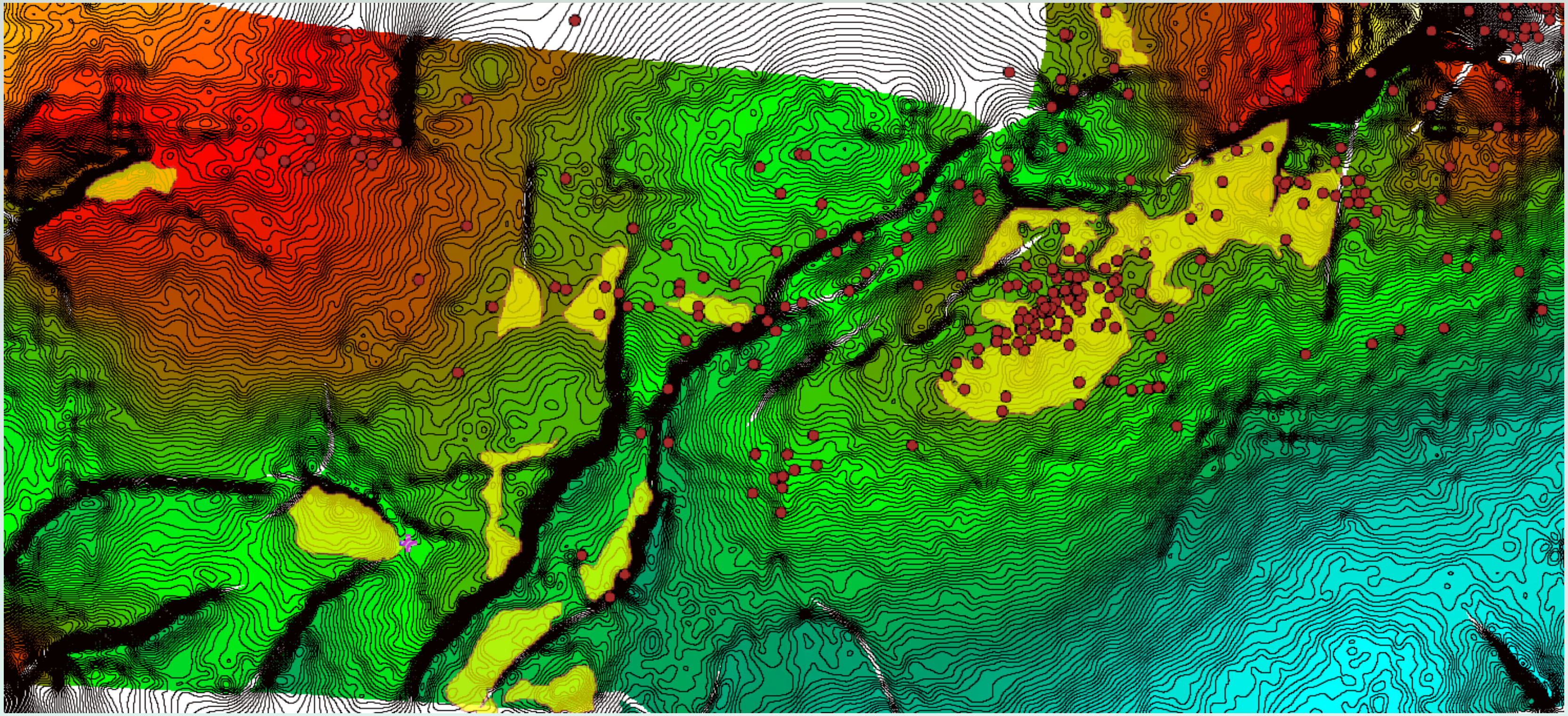
Physics of plume stabilization



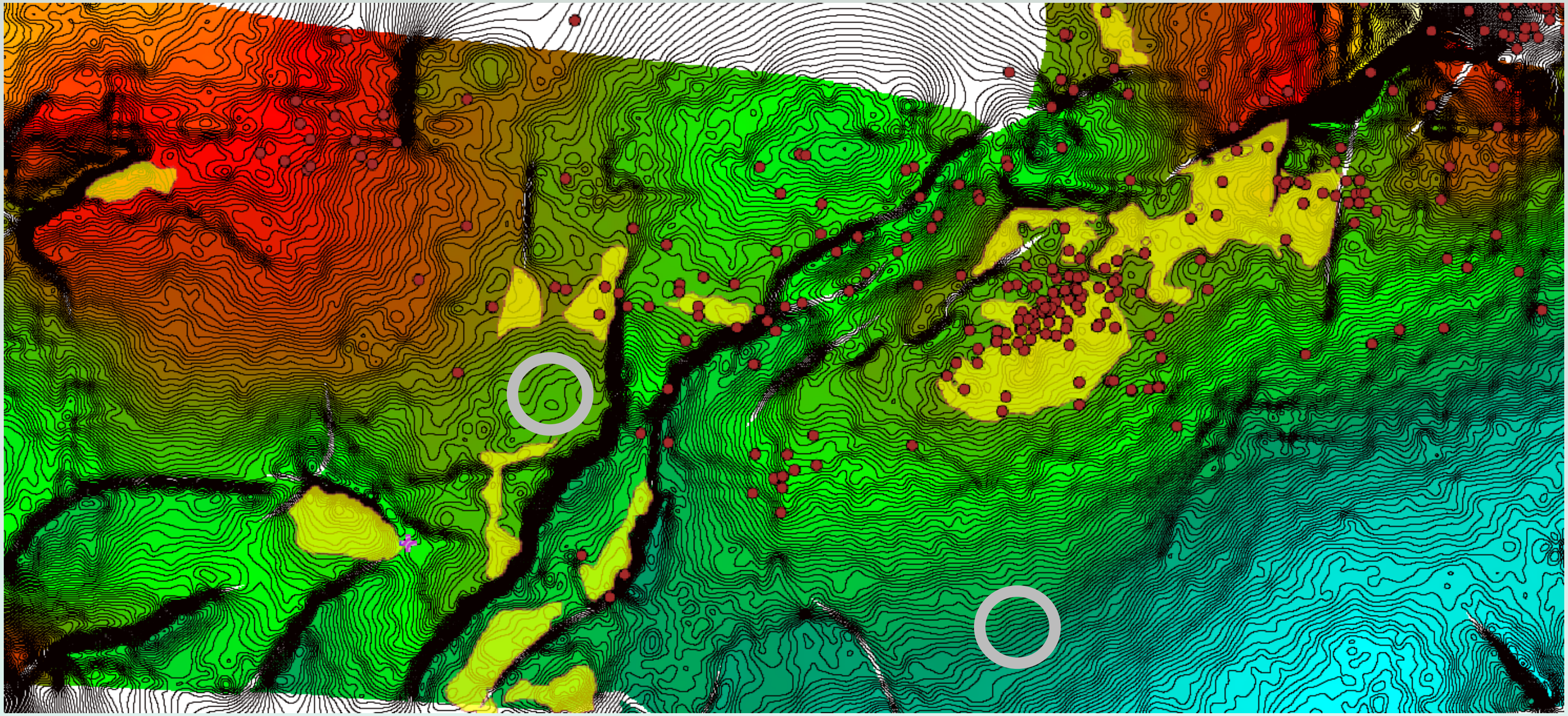


How fast and how far will CO2 migrate on dip before stabilizing?

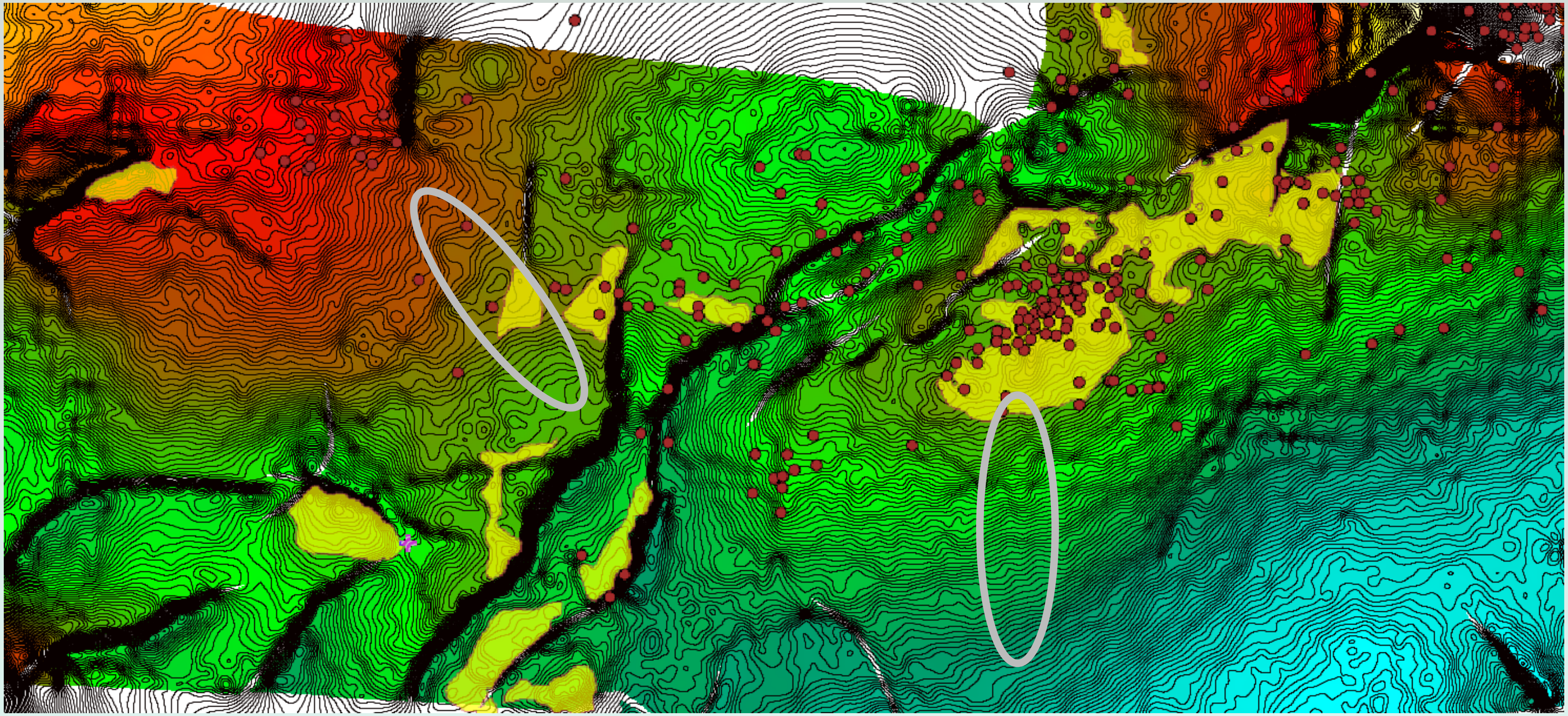
Upscaling to regional saline aquifers



Upscaling to regional saline aquifers



Upscaling to regional saline aquifers



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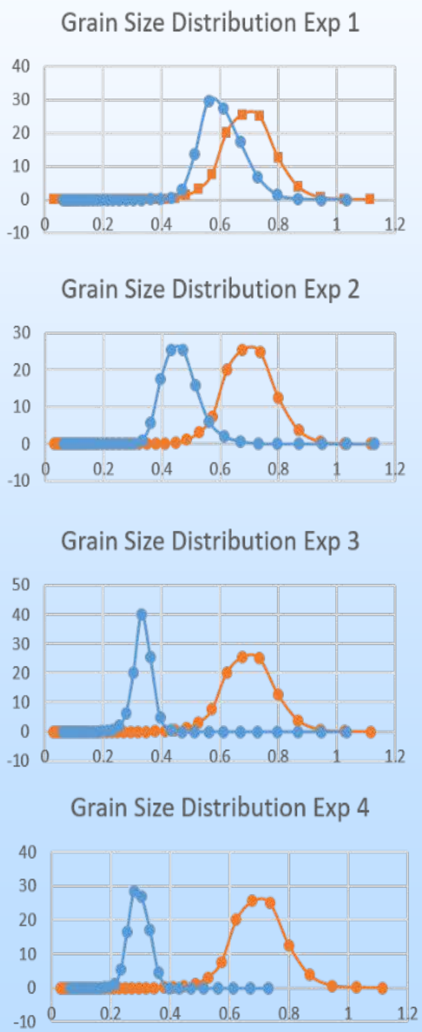
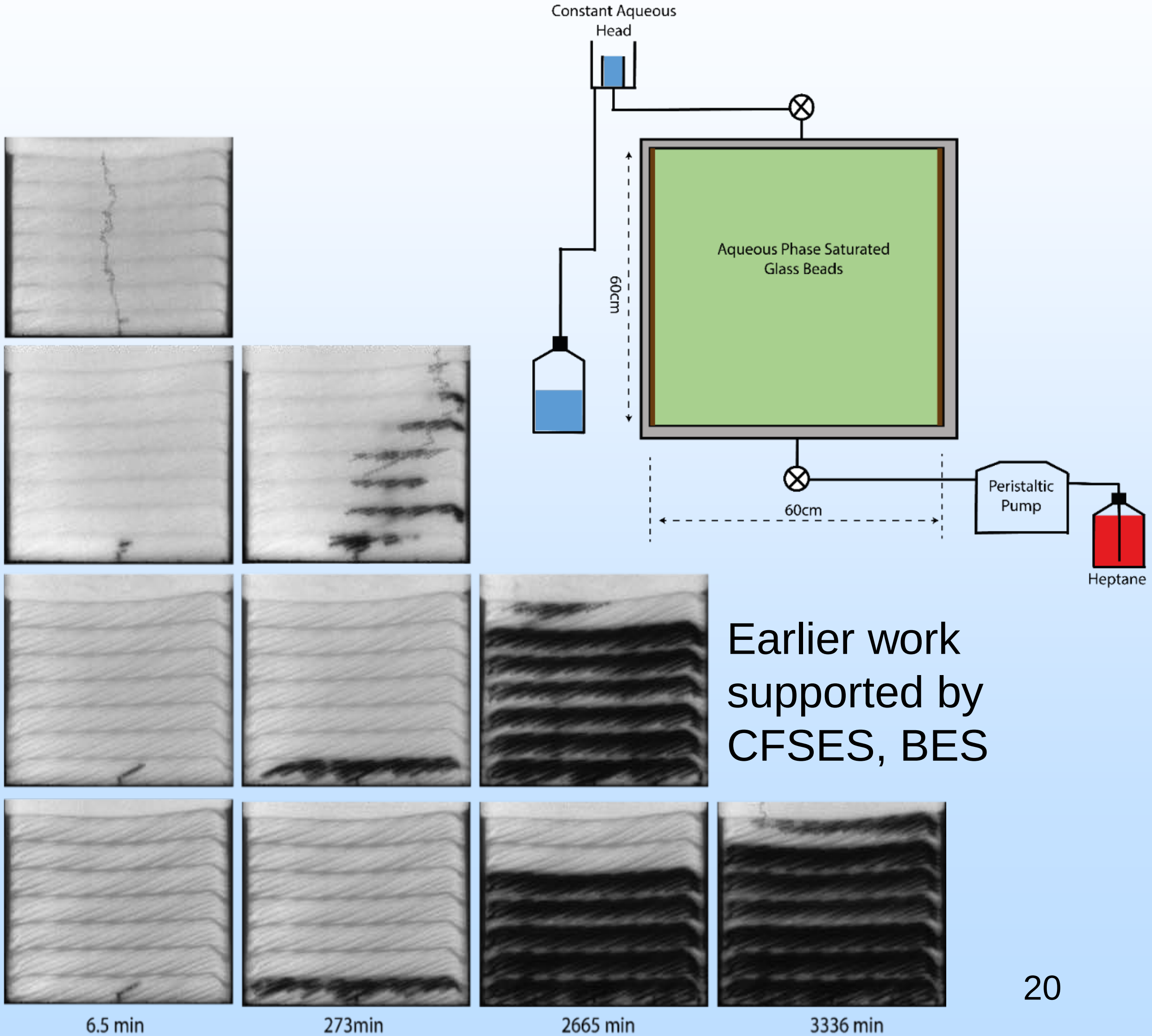
Physics of plume stabilization

- Dynamics of CO_2 capillary trapping and influence of factors on stability of trapped CO_2: A pore-scale study
- Convection-diffusion-reaction of CO_2-enriched brine in Tuscaloosa sample: A pore-scale study
- Mechanism of CO_2 dissolution trapping: Combined pore-scale and Darcy-scale study
- Influence of small scale geologic heterogeneities on CO_2 plume stabilization and trapping: An experimental study
- Visualization and analysis of CO_2 injection and oil production data in the Cranfield site

Small scale geologic heterogeneities influence CO_2 plume stabilization and trapping

Prasanna G. Krishnamurthy

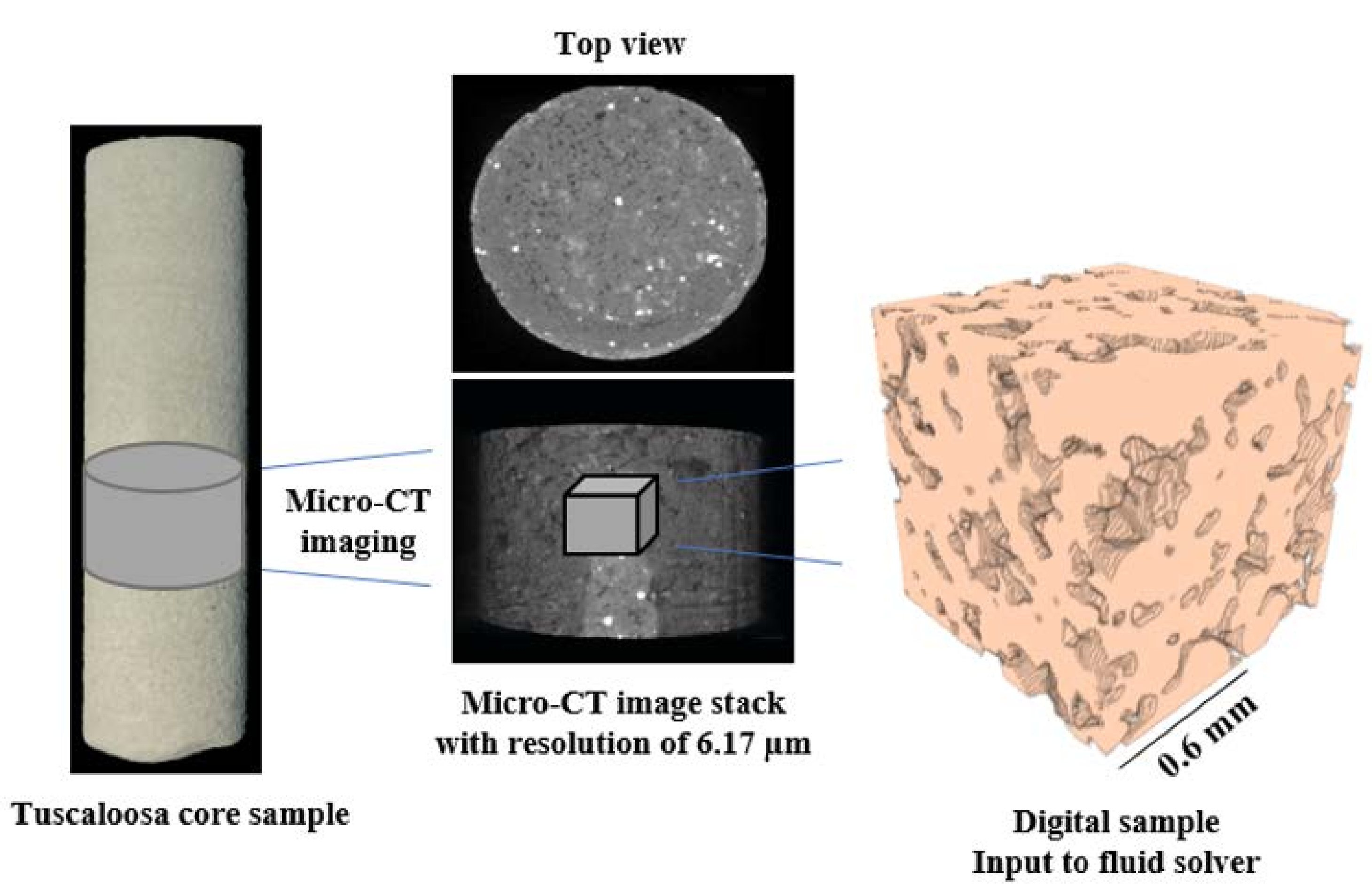




Earlier work supported by CFSES, BES

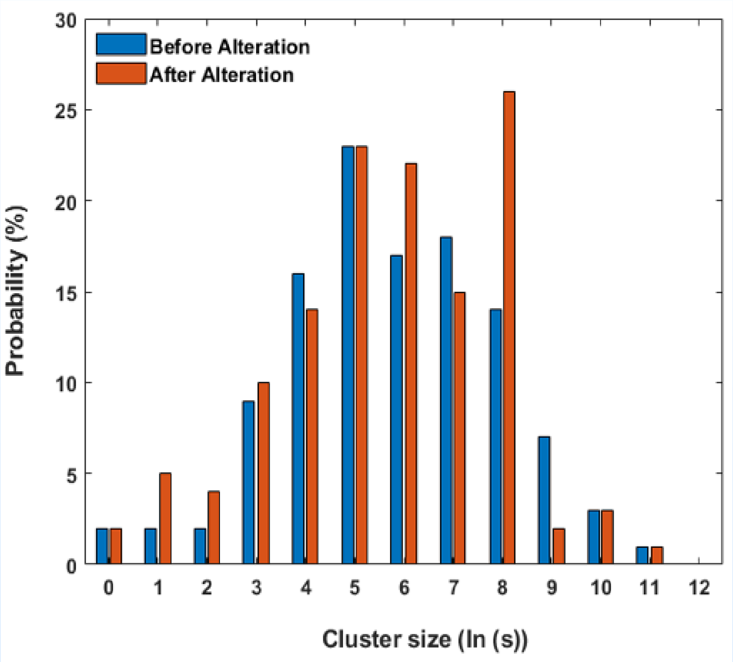
Pore scale flow in Tuscaloosa

Mehrdad Alfi

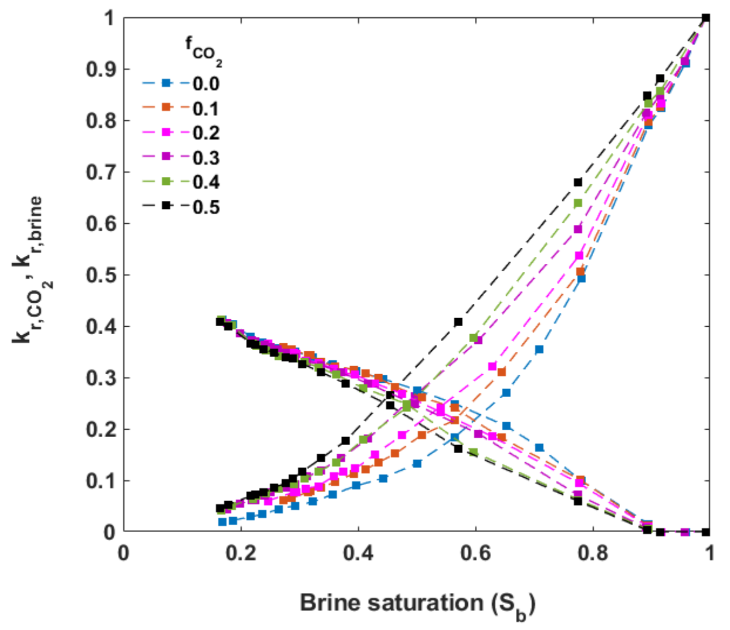


Effect of wettability alteration on CO_2 plume stabilization

Sahar Bakhshian



- Cluster-size distribution of CO_2 ganglia before and after wettability alteration



The relative permeability curves of $scCO_2$ and brine in samples with heterogeneous wettabilities fCO2 =fractional wettability

Value and methods for down-selection of monitoring tools

- Optimized tool selection (Assessment of low probability material impact: ALPMI)

Risk assessment method as usual

- Avoid subjective terms like safe and effective.
- E.g. : Specify mass of leakage at identified horizon or magnitude of seismicity.
- Specify certainty with which assurance is needed

Quantify risks to define material impact

Specify magnitude, duration, location, rate of material impact

Model material impact scenarios

Explicitly model unacceptable outcomes showing leakage cases.

ALPMI uses models differently than the typical history matching the expected performance

Identify signals in the earth system that indicate or preferably precede material impact

Method down selects only signals that indicate material impact may occur or may be occurring

Select monitoring tools that can detect these signals at required sensitivity

Approaches like those normally used for seismic survey design should be deployed for all modeling tools

Forward modeling tool response is essential to developing the expected negative finding: "No material impact was detected by a system that could detect this impact."

Deploy tools; collect and analyze data

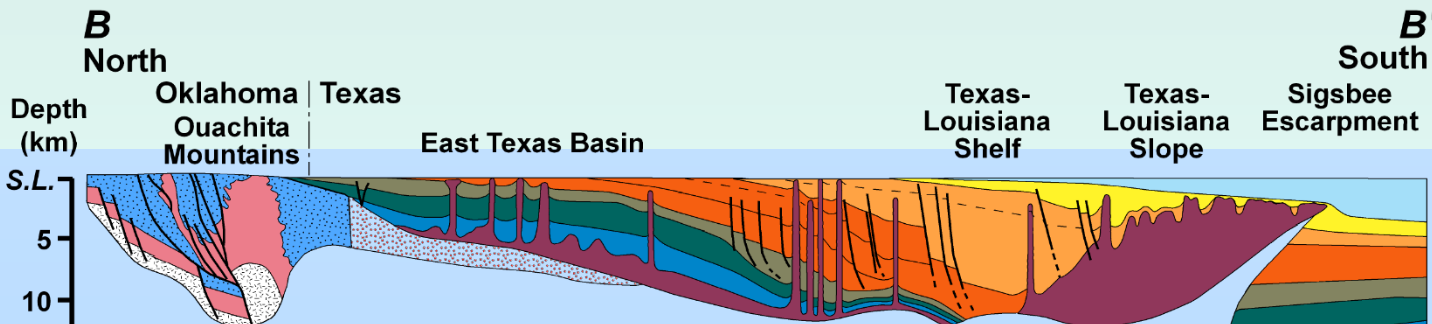
This activity as traditionally conducted. Include all the expected components, such as attribution, updating as needed, feedback , etc.

Report if material impact did/did not occur

Via this ALPMI process can a finding that the material impact did not occur be robustly documented

Lessons Learned

- Need for reproducible method of determining how much monitoring is enough in a commercial setting.
- Need for improved physics-based models that correctly estimate process and rate of stabilization
- Need for improved and renewed dialog with the media
- Increasing confidence in site selection and monitoring
  - ISO standard released
  - California LCFS
  - 45Q tax Credit



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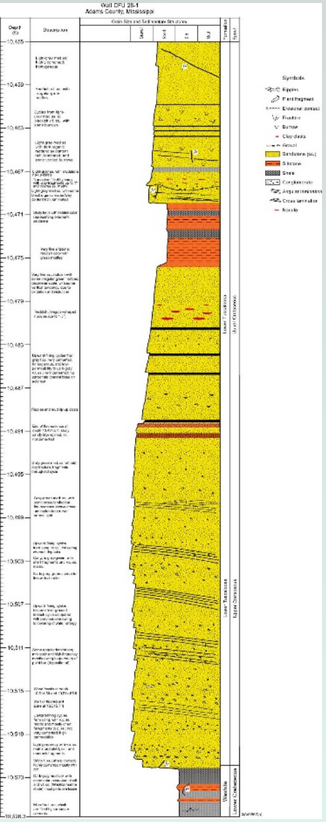
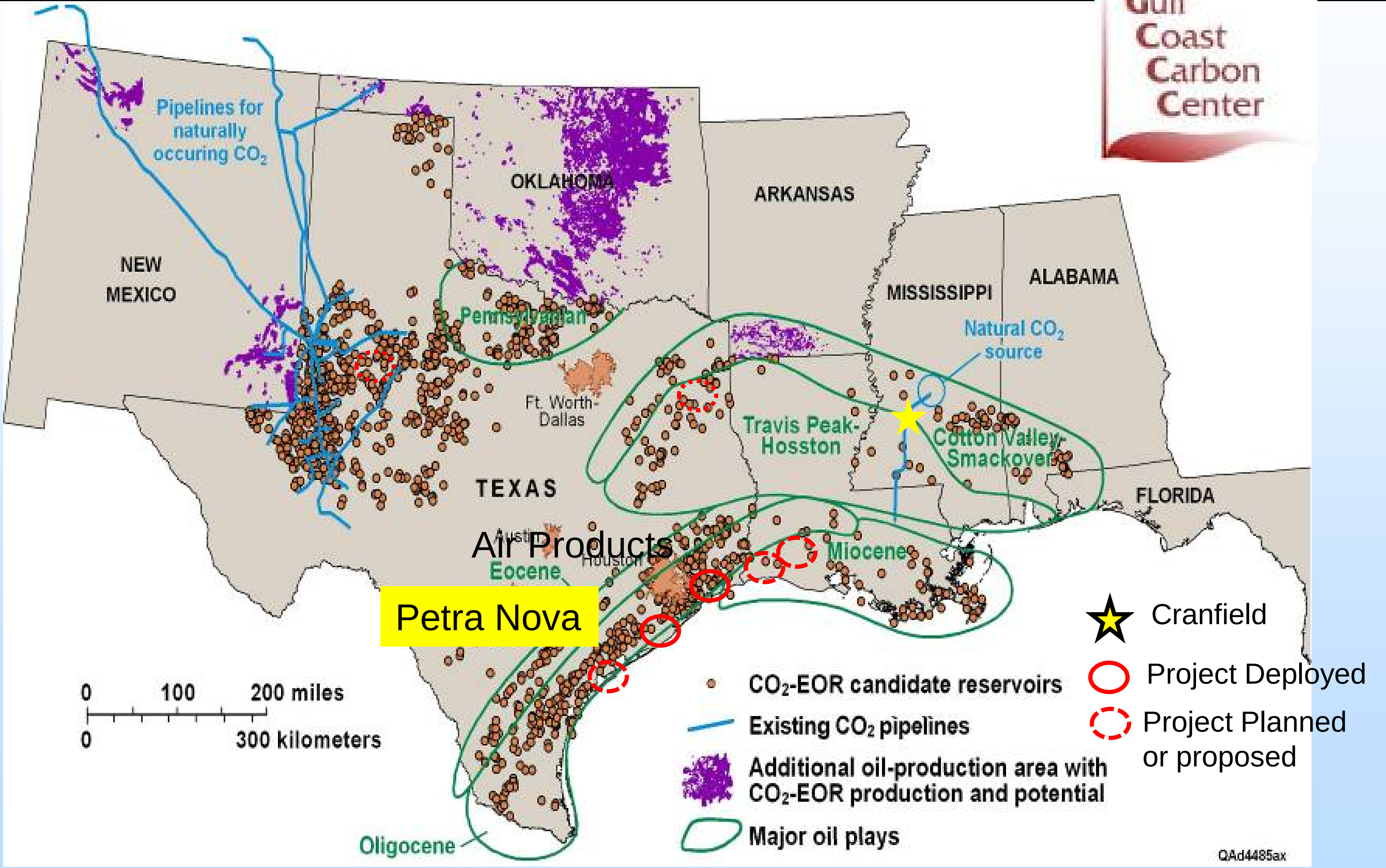
Synergy Opportunities



- Support technology transfer to commercial entities
  - Where can I inject?
  - What are first steps?
  - Explain retention and monitoring
- US – International collaboration of high value
  - ISO
  - IEAGHG

Looking for injectivity – core at Cranfield field, MS

Commercialization of learnings at SECARB Early Test Accomplishments to Date



Appendix

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Recent submissions and publications (108 total)

- Uploads to EDX (data) https://edx.netl.doe.gov
- Texas Scholar Works https://repositories.lib.utexas.edu
- Hovorka, S. D., Case study – testing geophysical methods for assessing CO_2 migration at the SECARB early test, Cranfield Mississippi "Geophysical Monitoring for Geologic Carbon Storage and Utilization" to be published by Wiley for the American Geophysical Union.
- D. W. Vasco, Masoud Alfi, Seyyed A. Hosseini, Rui Zhang, Thomas Daley, Jonathan B. Ajo-Franklin, and Susan D. Hovorka "The seismic response to injected carbon dioxide: Comparing observations to estimates based upon fluid flow modeling"
- Hosseini, S. A., Masoud Alfi, Donald Vasco, Susan Hovorka, Timothy Meckel, Validating compositional fluid flow simulations using 4D seismic interpretation and vice versa in the SECARB Early Test—A critical review
- Anderson, Jacob; Romanak, Katherine; Alfi, Masoud; Hovorka, Susan, Light Hydrocarbon and Noble Gas Migration as an Analog for Potential CO_2 leakage: Numerical Simulations and Field Data from Three Hydrocarbon Systems
- Fietz and Hovorka, Capturing the magic of carbon dioxide
- Hovorka, S.D. and Lu, J., Field observation of geochemical response to CO_2 injection at the reservoir scale, in Newel and Ilgen, Science of Carbon Storage in Deep Saline Formations , Elsevier

Benefit to the Program

Development of large-scale (>1 million tons of CO_2) Carbon Capture and Storage (CCS) projects, which will demonstrate that large volumes of CO_2 can be injected safely, permanently, and economically into geologic formations representative of large storage capacity.

Project Overview

Goals and Objectives

The Southeast Regional Carbon Sequestration Partnership's (SECARB) Phase III work focuses on the large scale demonstration of safe, long-term injection and storage of CO_2 in a saline reservoir that holds significant promise for future development within the SECARB region. The project will promote the building of experience necessary for the validation and deployment of carbon sequestration technologies in the region. Phase III will continue refining Phase II sequestration activities, sequestration demonstrations and will begin to validate sequestration technologies related to regulatory, permitting and outreach. The multi-partner collaborations that developed during Phase I and Phase II will continue in Phase III with additional support from resources necessary to implement strong and timely field projects.