Assuring Long-term Storage of Captured CO_2:Technical-Legal-Policy-Business Model

Presented by

Susan Hovorka Sahar Bakhshian
Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin

David Adelman
School of Law
The University of Texas at Austin

PURPOSE OF RESEARCH

- **Geologic storage in Deep Saline Formations (DSF) as part of Carbon Capture and Storage must be permanent**
  - Slow cumulative losses negate climate mitigation value
- **In our study, technical and policy approaches are united to provide this assurance.**
  - Leakage risk inventory
  - Leakage mechanism and limit modeling
  - Policy and perception

STAKEHOLDER NEEDS

Investment, policy and public acceptance requires confidence:

- **no reversals in storage**
- **normal liability profiles**

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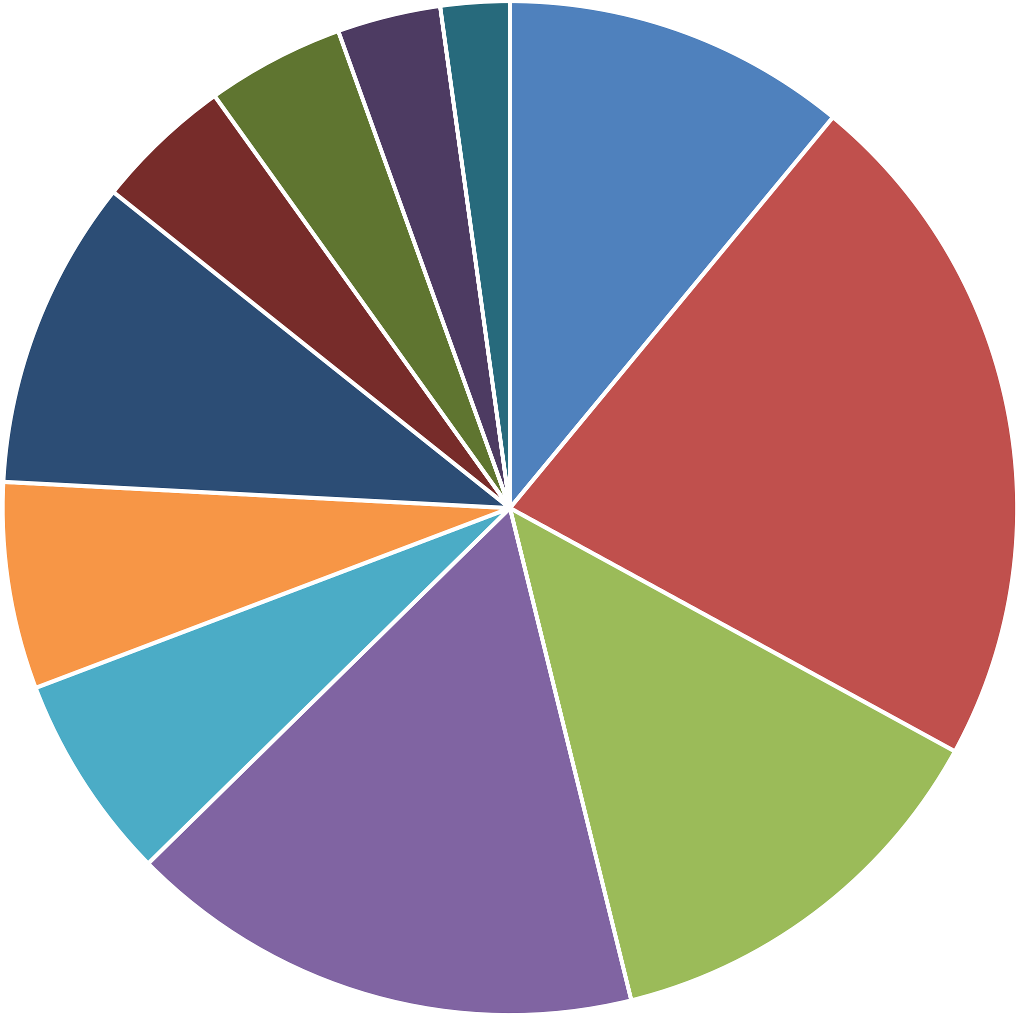
- **Normal liability profiles**

Updated pragmatic leakage risk assessment

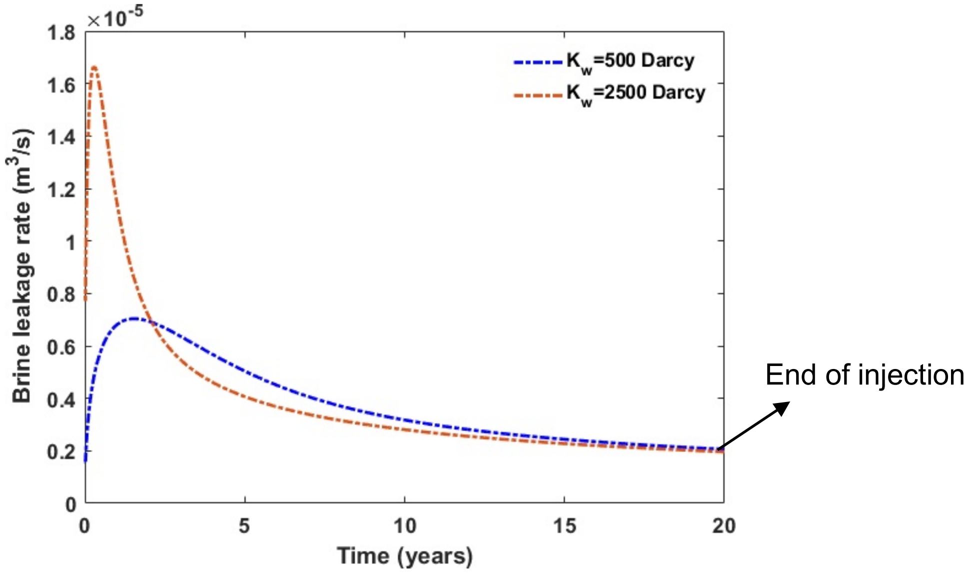


- Substantive subsurface brine leakage behind pipe through known well that infect has a poor cement job
- Substantive subsurface-surface CO_2 + methane + brine leakage behind pipe through known well that it turns out has a poor cement job
- Substantive subsurface brine leakage through unknown well that was not P&A
- Substantive subsurface CO_2 leakage through unknown well that was not P&A
- Elevated pressure in brine extends beyond AOR (e.g. energized zone thinner or more focused than modeled)
- Mobile CO_2 extents beyond modeled plume (e.g. energized zone thinner or more focused than modeled)
- Loss of injectivity because of boundary conditions
- Natural fractures and faults transmit brine out of zone
- Natural fractures and faults transmit CO_2 out of zone
- Loss of CO_2 injectivity because of near well-bore damage

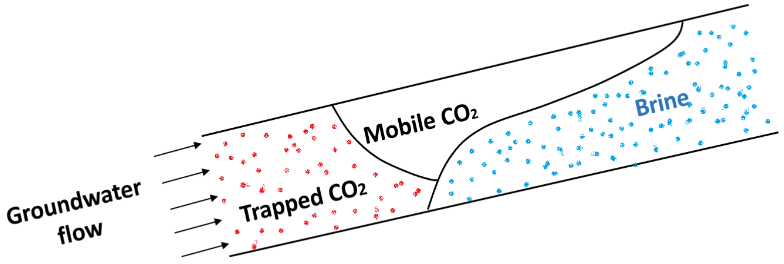
FSET PROGRAM REVIEW: KEY RESULTS

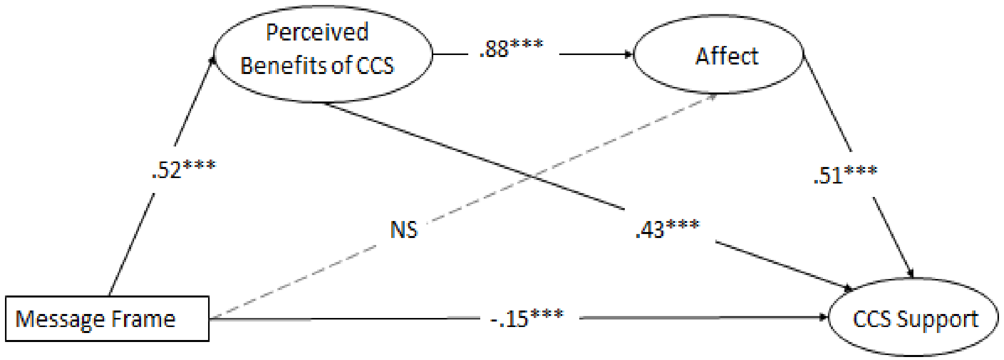
KEY RESULTS

- **New analytical plume stabilization approach – define CO_2 migration limits**
- **Pore-scale multiphase flow experiments**
- People tend to discount risks that are psychologically distant and focus more on risks that are psychologically closer. Psychological distance of *climate change* influences support for *CCS* through perceived local *climate change* impacts, perceived *CCS* benefits, and emotior



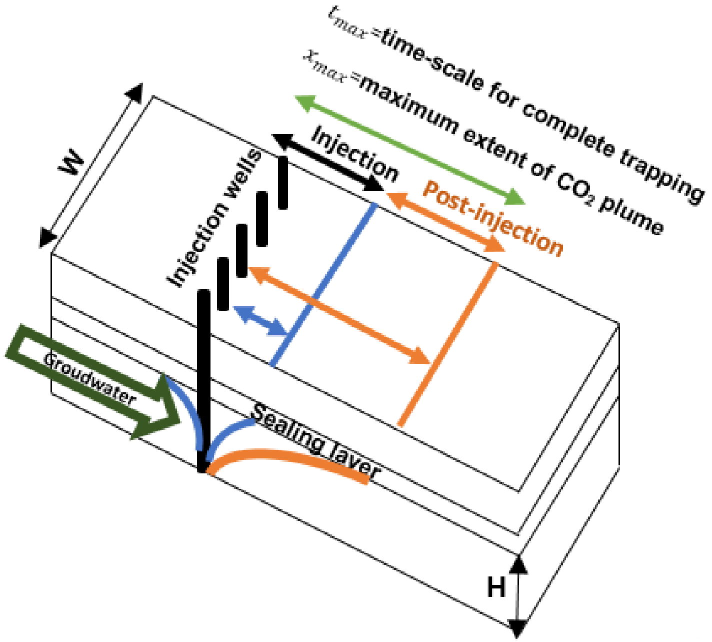
Brine leakage to the USDW through a wellbore (500 meter away from the injection well) during the CO_2 **injection** of 20 years in a **closed** reservoir. The radius of leaky well is 20 cm.

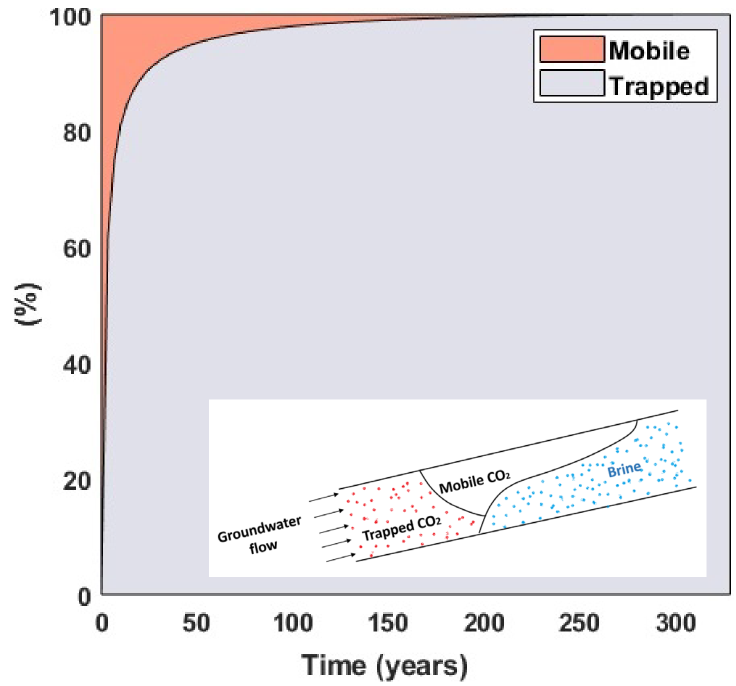




Incorporating subsurface CO_2 retention into risk assessments

- **Containment risk of CO_2 storage**
- **Developed a quantitative tool for predicting CO_2 plume stabilization**
- **Tool: A dynamic, multiphase flow analytical model for CO_2 migration and trapping in saline aquifers**





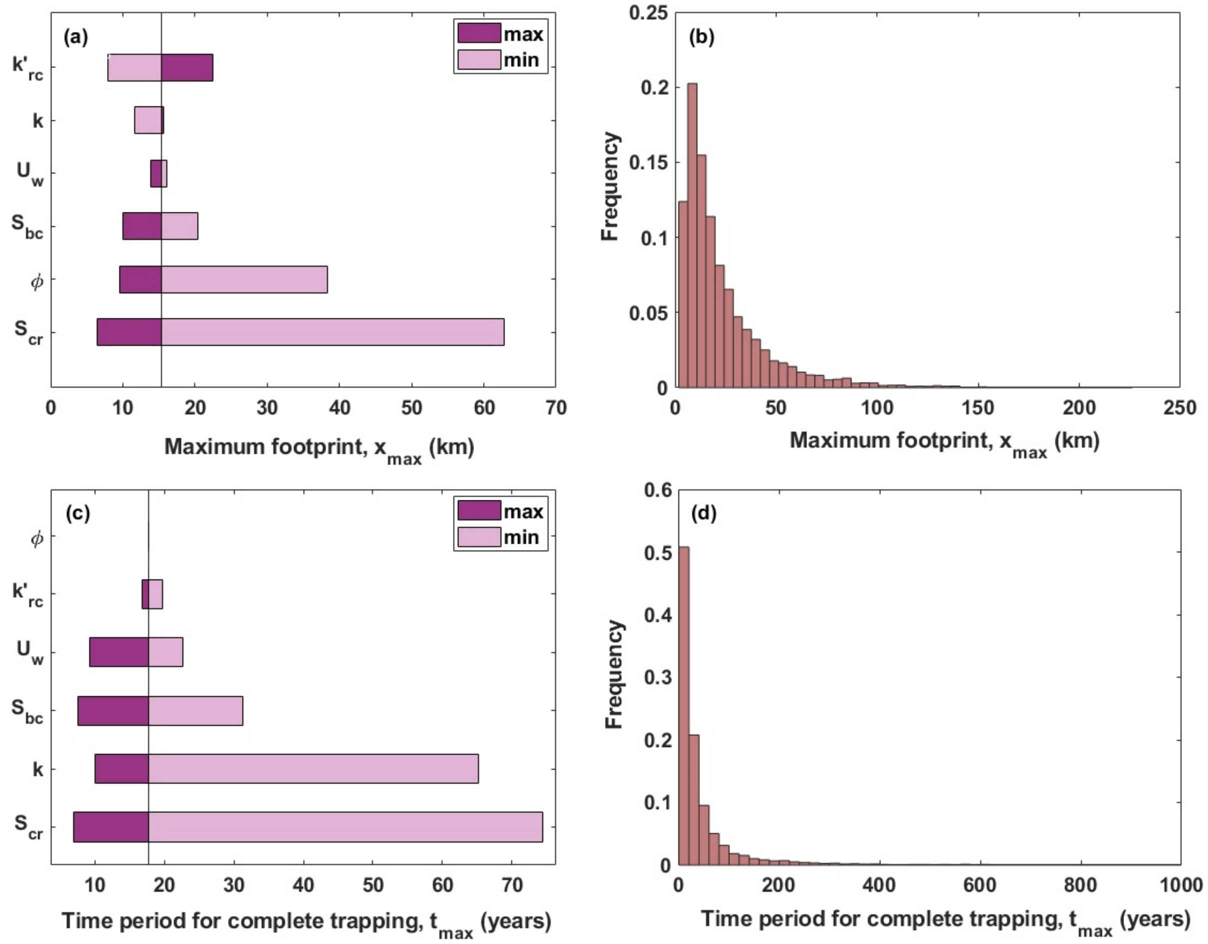
Time evolution of the percentage of **mobile** and **residually trapped** CO_2 during the post-injection stage

Uncertainty Quantification

- **Uncertainty quantification in the maximum footprint of CO_2 plume and the corresponding time-scale for its residual trapping using Monte Carlo simulations**

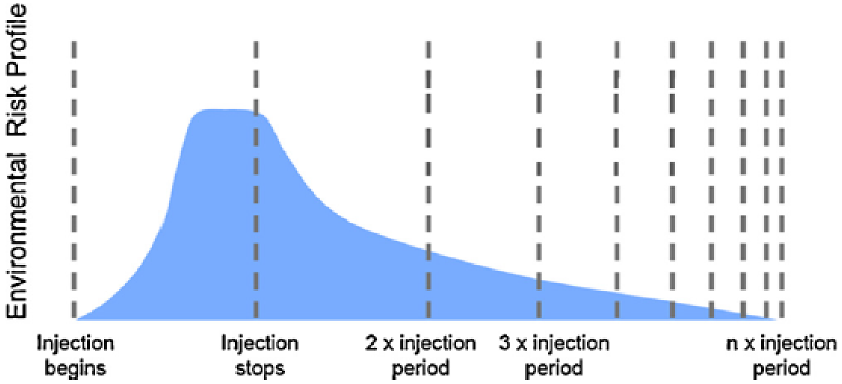
Range of geologic/fluid parameters used for the sensitivity analysis.

Parameter	Range
Residual CO_2 saturation (S_{cr})	$0.03 < S_{cr} < 0.3$
CO_2 end-point relative permeability (k'_{rc})	$0.3 < k'_{rc} < 1.0$
Connate brine saturation (S_{bc})	$0.05 < S_{bc} < 0.5$
Aquifer porosity ($\emptyset$)	$0.1 < \emptyset < 0.4$
Aquifer permeability (k), mD	$100 < k < 1000$
Groundwater velocity (U_w), m/s	$2.8 \times 10^{-9} < U_w < 9.4 \times 10^{-7}$

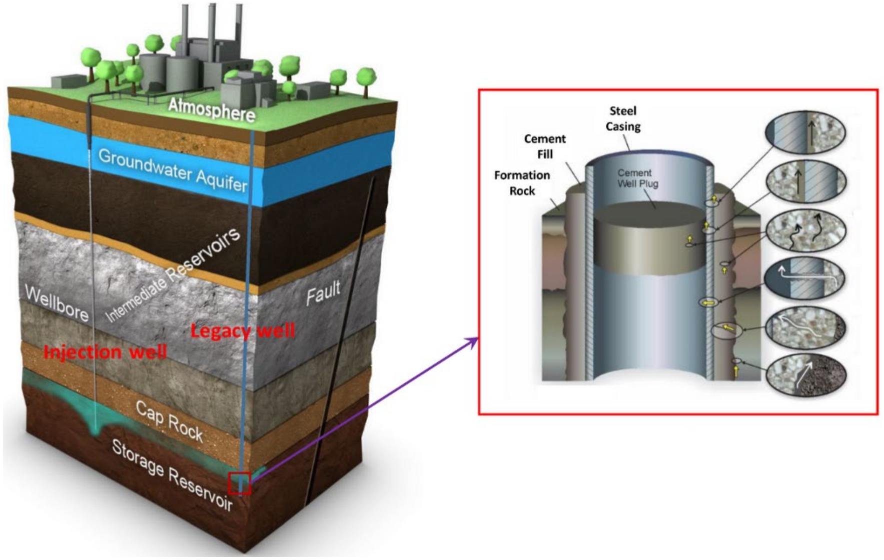


A quantitative tool for leakage rate estimation

- Estimating **leakage rate** from legacy wells located in the area-of-review (area of elevated pressure)
- Well integrity failure
- **Risk quantification**: a tool to enable the **insurers** to adjust their terms and premiums for insuring CCS projects



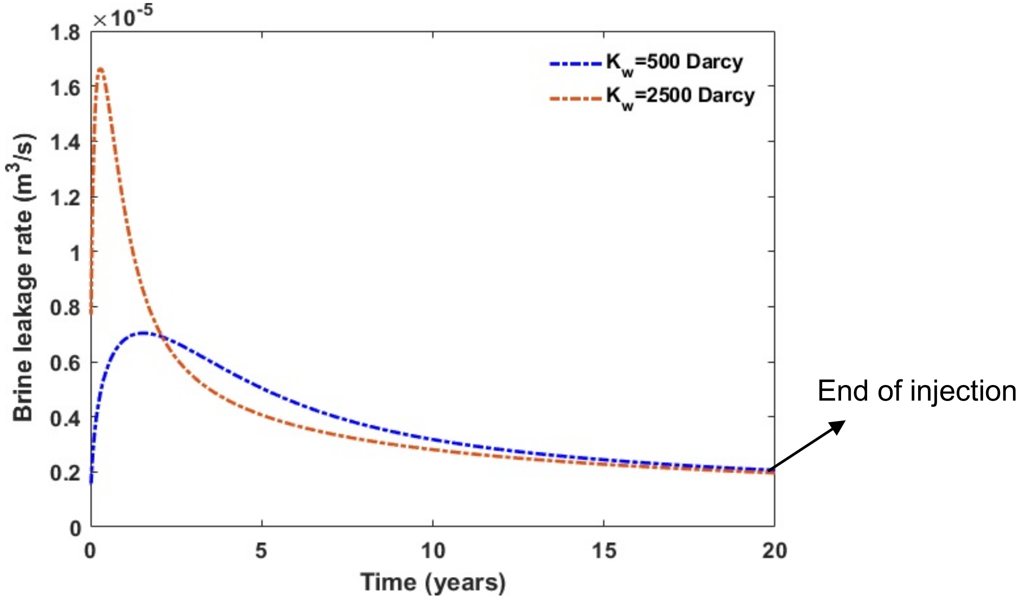
Conceptualized risk profile for a CO_2 storage project (Benson, 2007)



possible CO_2/brine leakage path (Islam et al. 2020)

Leakage rate estimation

- The reservoir pressure declines over time in response to the leakage.
- **Leakage is not sustainable**, it declines over time.



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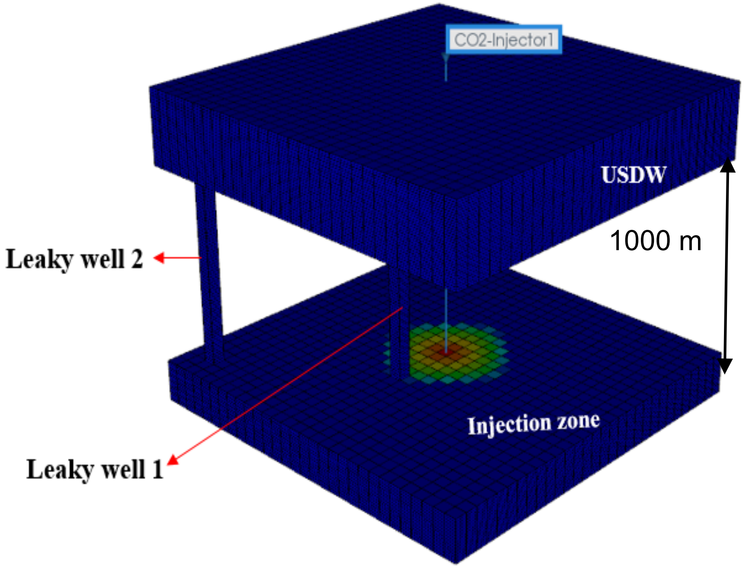
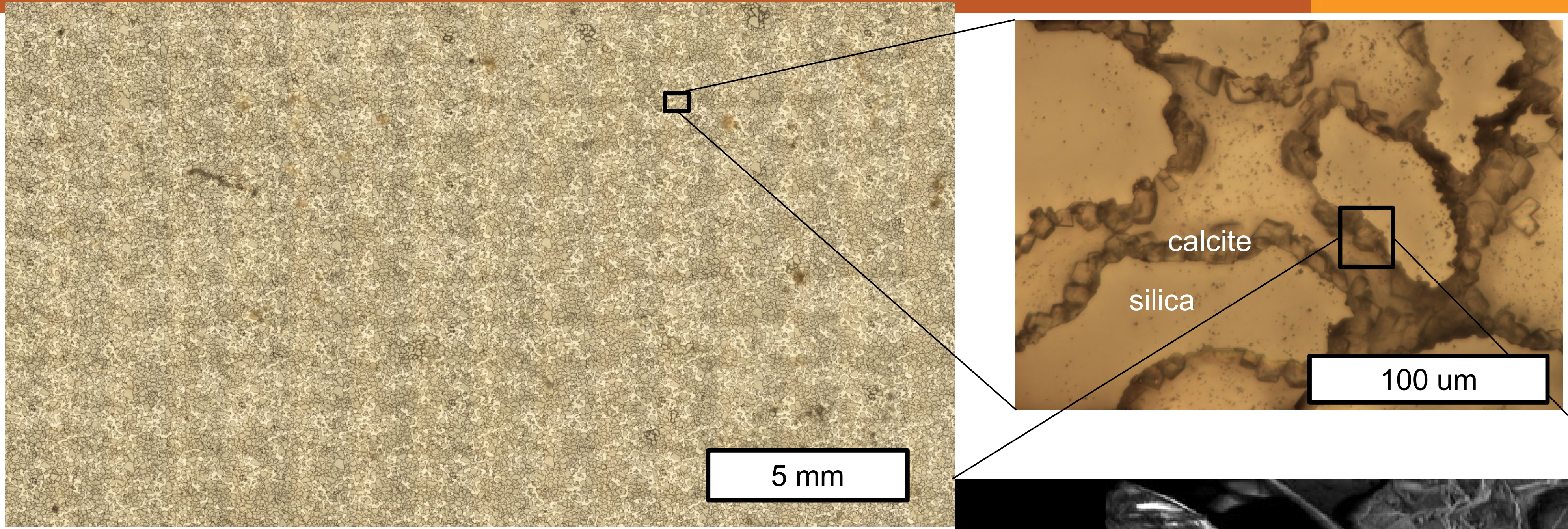


Leaky wells connecting the injection zone to underground source of drinking water (USDW).

Pore-scale multiphase flow experiments



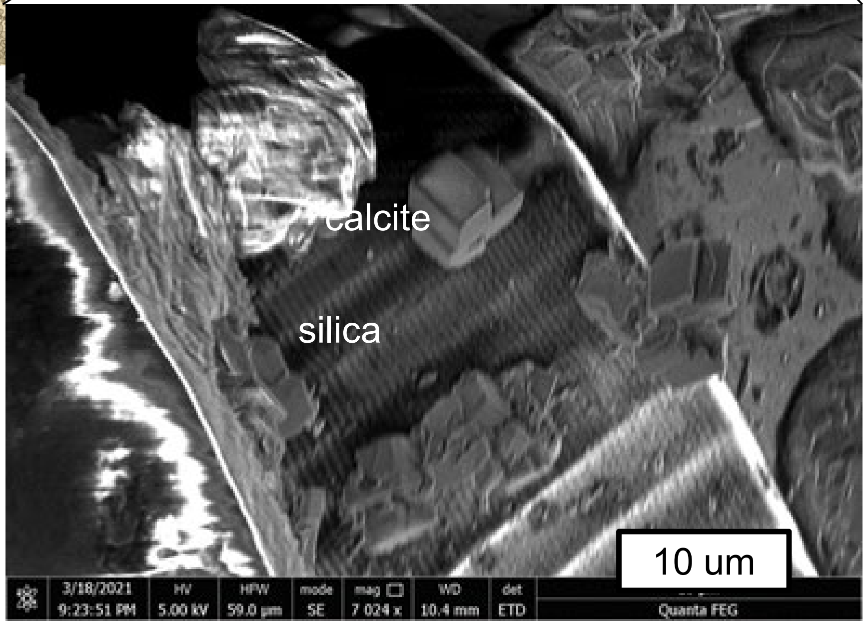
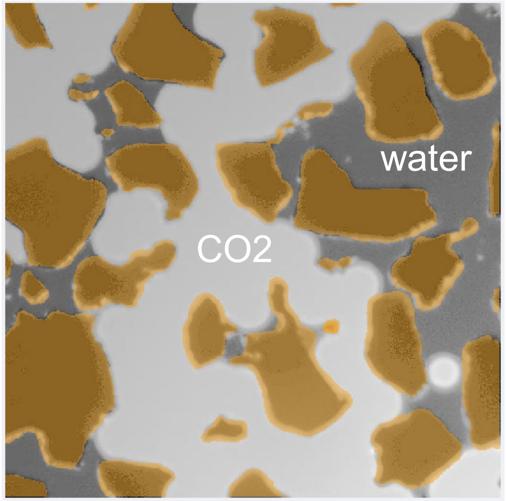


Image segmentation for residual saturation



CCS Social Science: Communication Research

Team led by Lee Ann Kahlor, College of Communication UT Austin, collaborating with scholars at University of Buffalo, Sam Houston State

Two papers in peer review:

"Psychological Distance, Risk Perception, and Affect: Texas Residents' Support for Carbon Capture and Storage" in review at *Journal of Risk Research;* being presented at International Communication Association annual conference, Paris.

Prerna Shah, University of Buffalo, Z. Janet Yang, University of Buffalo, Lee Ann Kahlor, University of Texas at Austin

"Framing Climate Change Mitigation Technology: The Impact of Risk Versus Benefit Frames on Acceptance of Carbon Capture and Storage" in review at *International Journal of Greenhouse Gas Control.*

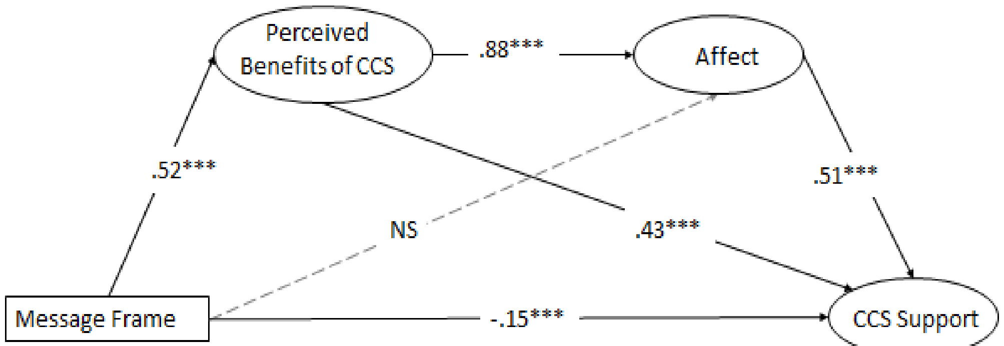
Wan Wang, Sam Houston State University, Prerna Shah, University of Buffalo, Z. Janet Yang, University of Buffalo, Lee Ann Kahlor, University of Texas at Austin

Study 1: Psychological Distance, Risk (Benefit) Perception, and Affect…

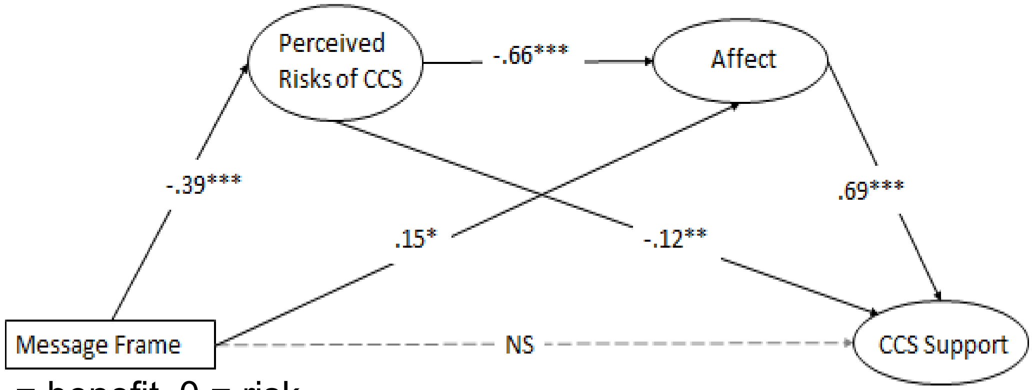
- Cross-sectional survey of East Texas communities where CCS is being developed.
- Background: People discount risks that are psychologically distant, focus more on risks that are psychologically closer.
  - Psychological distance = perceived distance between self and “other objects” (time, space, social relationship, and likelihood of occurrence).
- Findings: **Psychological distance of climate change** *currently* works through perceived Texas climate change impacts (fairly low level now), perceived *CCS* benefits, and positive emotion (e.g., hope) **in its relationship with support for *CCS*.**
- Takeaway: As the TEXAS impact from climate change becomes more known, psychological distance may shift, and this has implications for the mechanisms that impact current support for CCS.

Study 2: Framing Climate Change Mitigation Technology…

- Experimental survey study to see if messaging can move needle on support
- Respondents in East Texas randomly assigned to messages framed with benefit or risk.
- Serial mediation SEM shows message framing impacts support (as expected) *regardless of political leaning or pre-existing attitudes*.
  - Risk frame -> more risk perceived -> negative emotion -> less support
  - Benefit frame -> more perceived benefits -> positive emotion -> more support
- **Emotion is key for building support, benefits need to be clear**
- **A balanced message approach that includes risks and benefits is recommended, to build trust in the messages and their source**



*1 = benefit, 0 = risk



*1 = benefit, 0 = risk

Regulatory Implications

- Key Takeaways:
  - Greatest risks are relatively near-term and geographically delimited
  - Public support is quite sensitive to "perceived risks"
- Implications: minimize the potential for failures of high salience, as they are more likely to occur early in deployment and could seriously undermine public support
- Salient and Highest Risk: contamination of drinking-water aquifer with brine from a poorly constructed well

Regulatory Strategies

- Preclude siting of sequestration sites below major drinking-water aquifers
- Preclude or provide incentives for siting sequestration sites in areas with a history of significant oil or gas development
  - Bonding requirements
  - Tax Incentives
- Make site owners strictly liable for contamination of drinking-water aquifers (similar to Superfund)
- Insurance Premiums (private sector)

Conclusion

- FSET has provided a way to integrate across campus on growing issue of CCS
- Increase interaction across campus
  - UT-CCS – 6 January 2022
  - LBJS School Sloan project
  - Future Carbon management research and knowledge sharing –TBD
- Increase local to global impact