Monitoring, Safety and Stakeholder Engagement

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Developing a National CCS Program in Trinidad and Tobago
International Knowledge-Sharing Symposium

UTT, Energy Campus,
Brechin Castle, Couva

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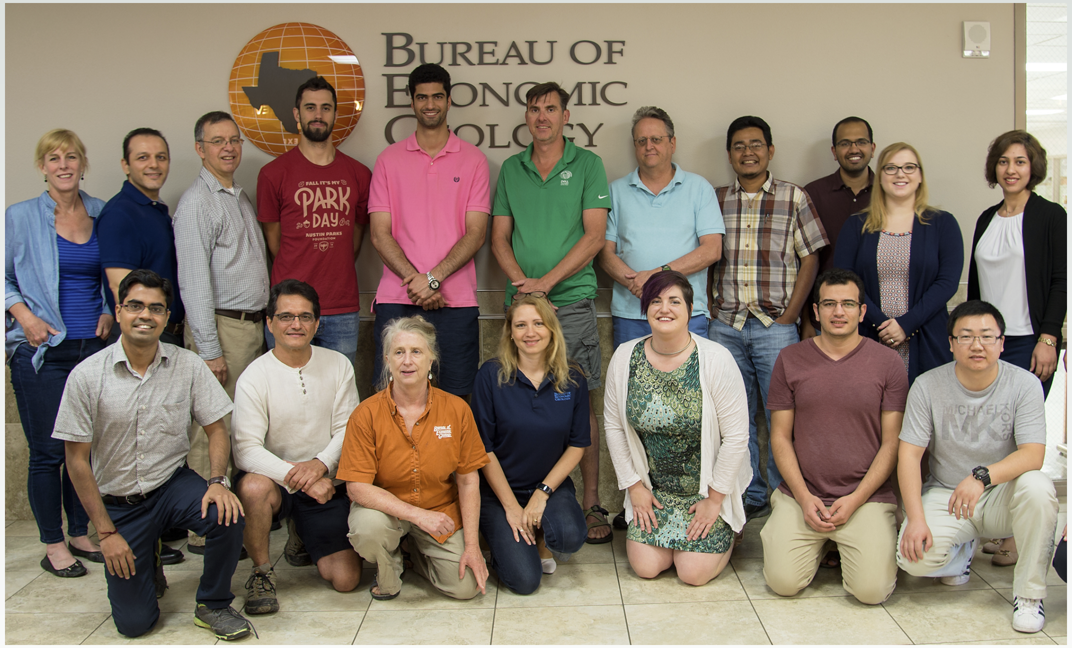
The University of Texas at Austin

- Multi-disciplinary group
- 20 years experience in CCS research and application
- Develop and implement monitoring programs for geological CO_2 storage sites
  - ✓ Site selection and permitting
  - ✓ Regulatory compliance
  - ✓ Conformance monitoring
  - ✓ Environmental monitoring
- Monitored >9 demonstration storage projects
- Actively monitored over 5 million tonnes of CO_2 in the ground



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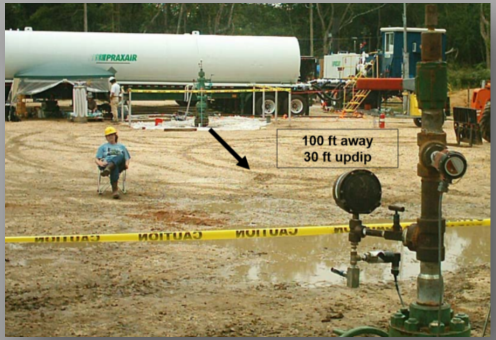
Evolution of Experience

Pilots ➡ Demonstrations ➡ Industrial

500 T



Frio Brine Storage Pilot 2004

SECARB Early Test- Cranfield Mississippi

Hastings Project

NRG Petranova Project

1.6 MMT/year

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Main Questions from Stakeholders

- Is it safe?
- Will it leak?
- What happens if it leaks?

UNFCCC COP-21 Paris –
Official Side Event on CCS

Photos by IISD

Geologic CO_2 Storage - Safe By Design

1. Site Characterization – Permitting requires high level of assurance
2. Risk Assessment- Modeling identifies potential unwanted outcomes
3. Project Design - to minimize potential risk
4. **Monitoring Plan**

<u>Deep Subsurface – Verification</u>

Behavior conforms to predictions

<u>Shallow Subsurface - Assurance</u>

No unwanted outcomes to environment

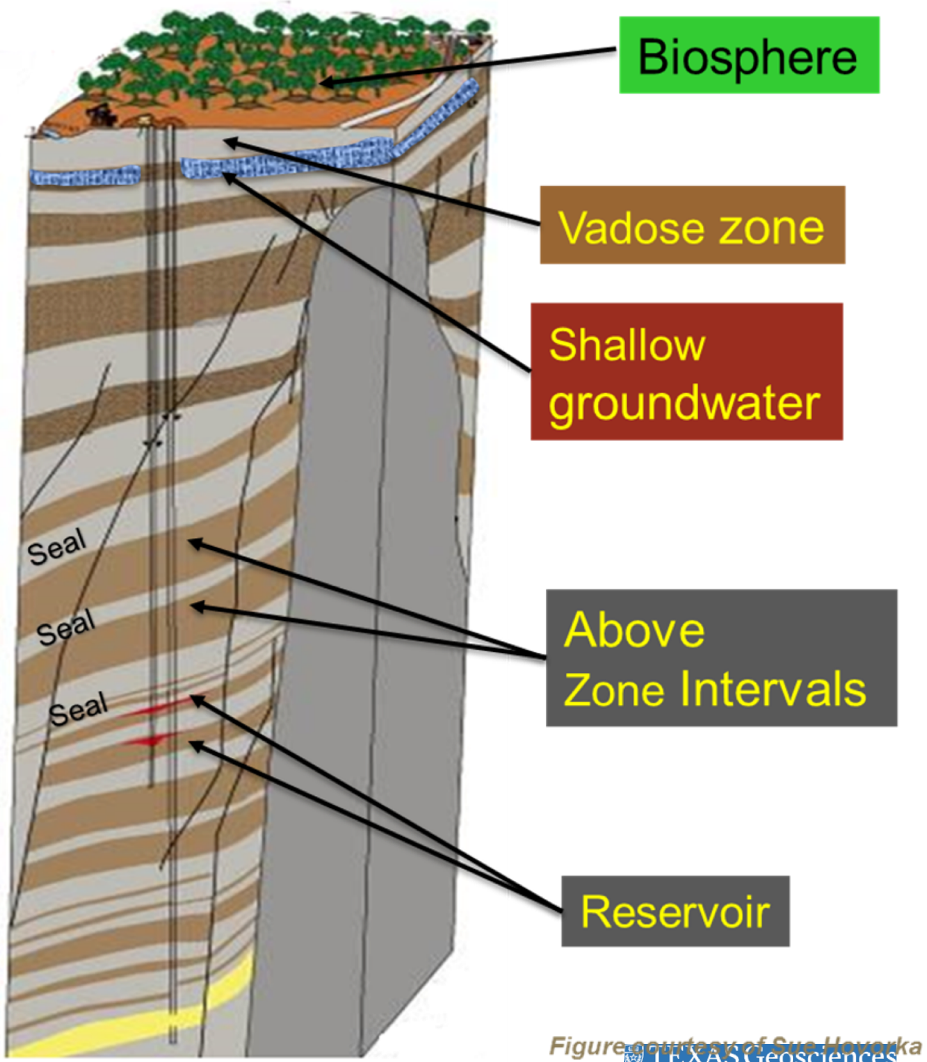
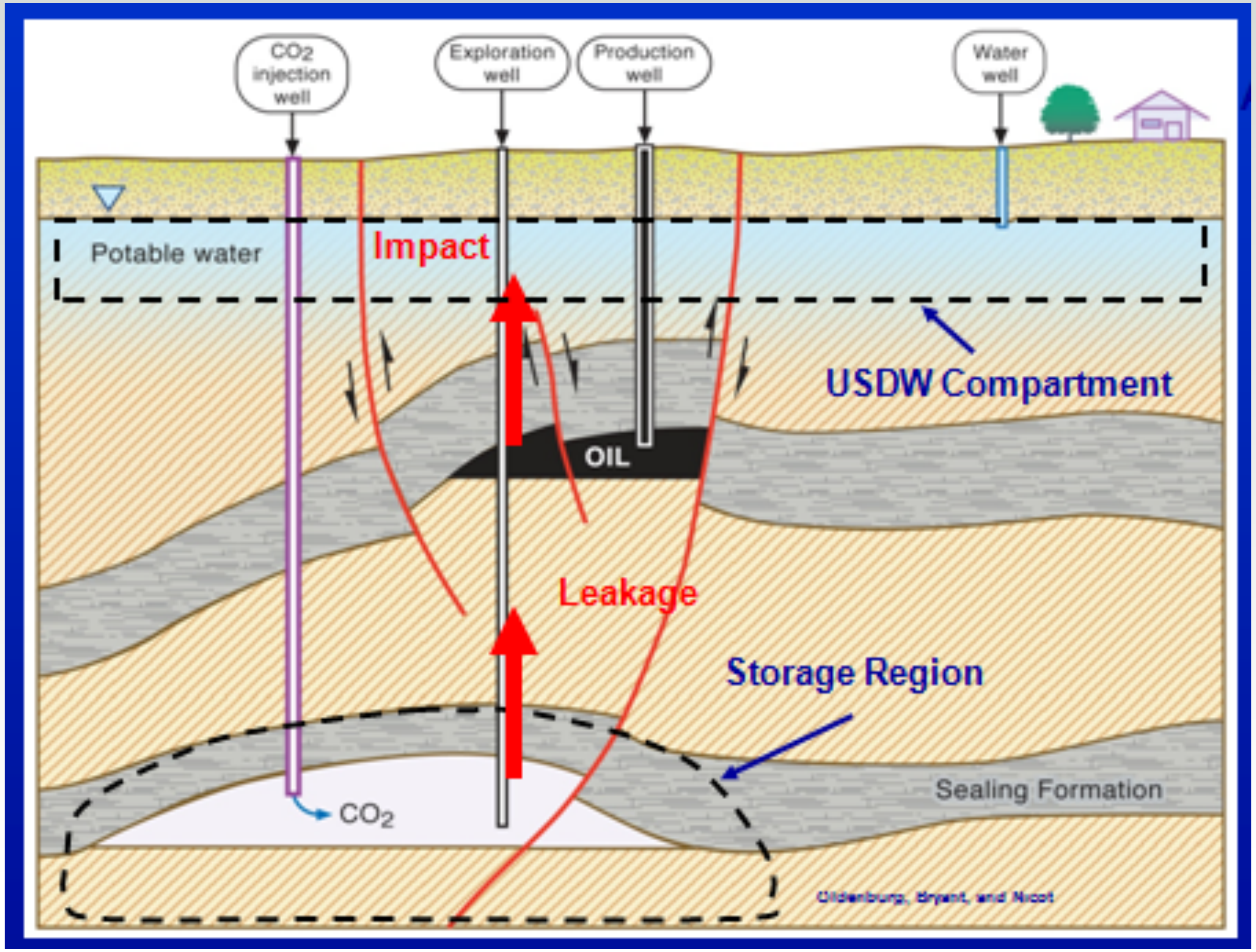


Figure courtesy of Sue Hovorka

Environmental Concerns

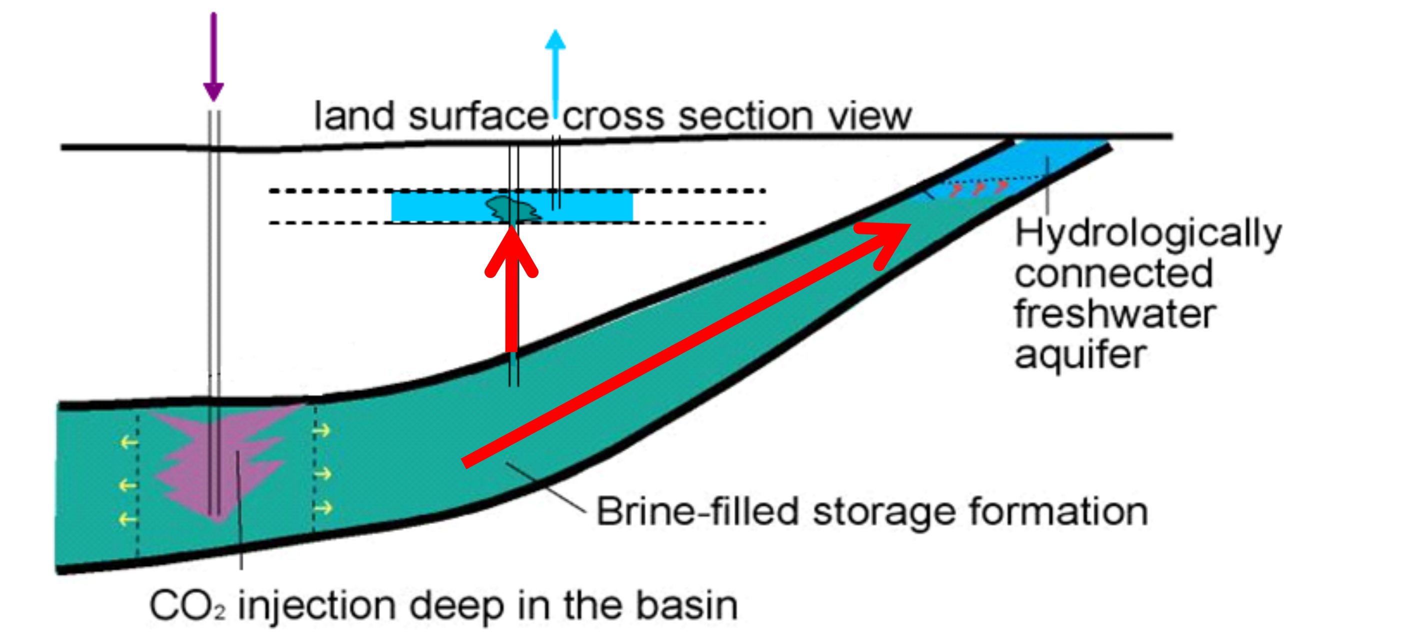
- Drinking water impacts
  - CO_2 or brine causing degradation of water quality
- Human health and safety
  - CO_2 reaching ground surface and displacing oxygen in low-lying areas
- Overall ecosystem health
  - Marine
  - Terrestrial

Potential CO_2 Migration Pathways



Brine Migration Pathways

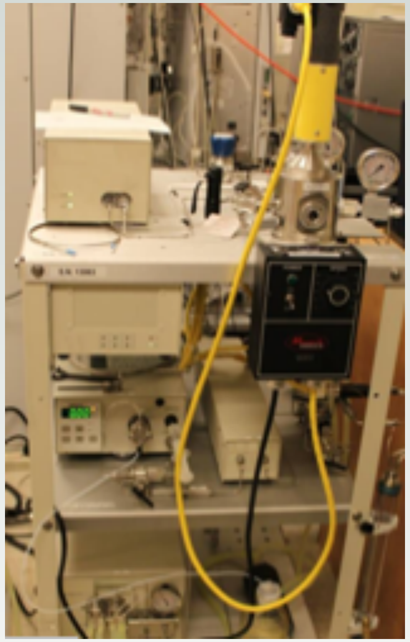
- Brine leakage through faults/wells to the shallow subsurface
- Along-dip water displacement



Nicot et. al, 200, 9GCCC Digital Publication Series #08-03g

Science Addressing Questions

- **Controlled Releases/Injections**
  - Deep Injection Projects
  - Shallow Controlled Releases
- **Natural Analogs**
- **Industrial Analogs**
- **Laboratory Simulations**
  - Geochemical and biological
- **Numerical Modeling**



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Potential Groundwater Impacts

$\underline{CO_2}$

- pH decrease
- Mobilization of heavy metals
  - Mineral dissolution
  - Detachment of metals from grain surfaces

<u>Brine</u>

- Organics, injection impurities, total dissolved solids

Evaluating Metal Mobilization

Laboratory:

- Rapid trace metal mobilization followed by decline. (Lu et. al, 2009)

Shallow Controlled Release (ZERT)

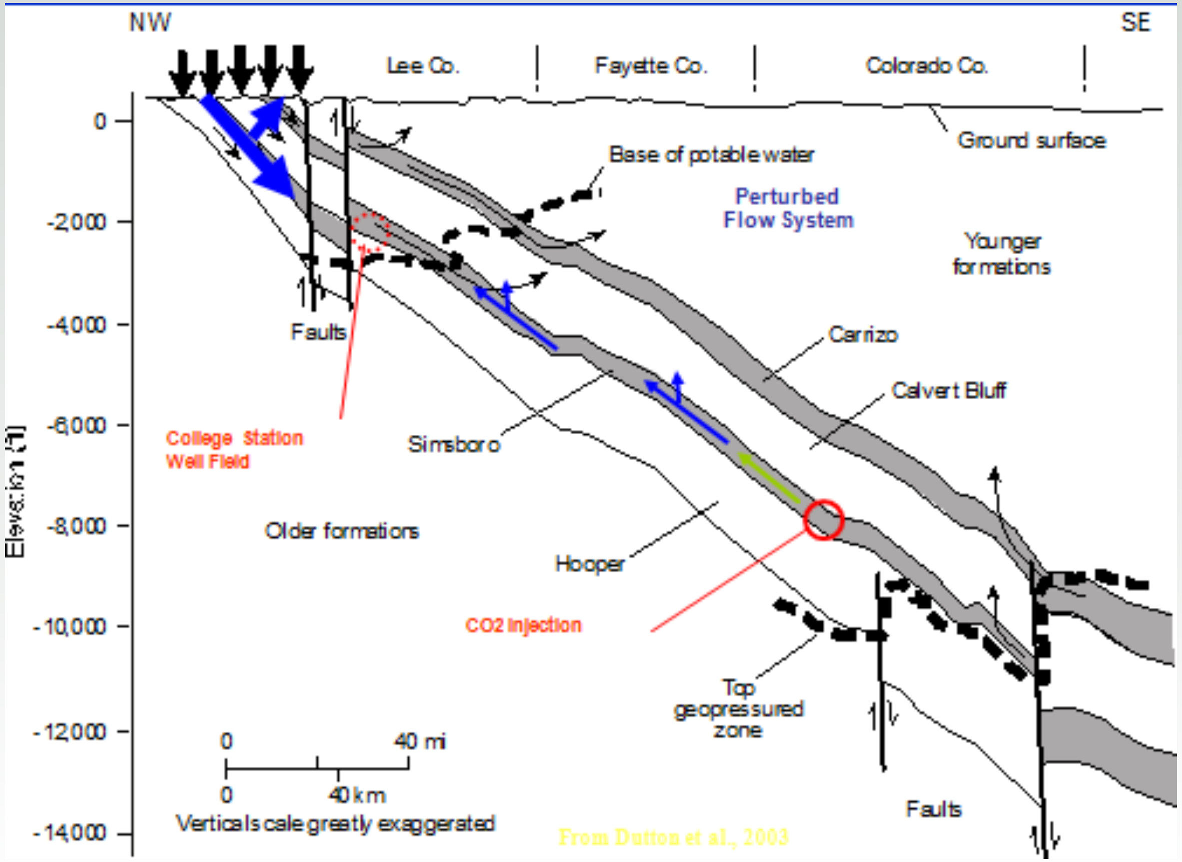
- Metals mobilized but were below drinking water standards and transient (Kharaka, 2010).

Natural Analogs (Mammoth Mt., Vesuvius)

- Metals not present in some high CO_2 environments. Some indication that metals are absorbed by mineral precipitation. (Stephens and Hering, 2004; Aiuppa et al., 1995)

Brine Migration

- Impacts are related to basin size and geometry
- Migration up well bores/faults.
- Abandoned wells should be properly plugged.
- Injection pressure management may be necessary in some instances.



Nicot et. al, 2008

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Outcrop Analogs

Hydrothermal Systems as Analogs for Breached Traps and Subsurface Healing: Outcrop and Subsurface Examples and Escape Mechanisms

David Bowen, David Lageson, Lee Spangler (Montana State University)
Bryan Devault, Herbert Mosca (Vecta Oil and Gas)
David Eby (Eby Petrography)

Hydrothermal fluids introduced along a fracture zone – Madison Fm. Gallatin Canyon Montana

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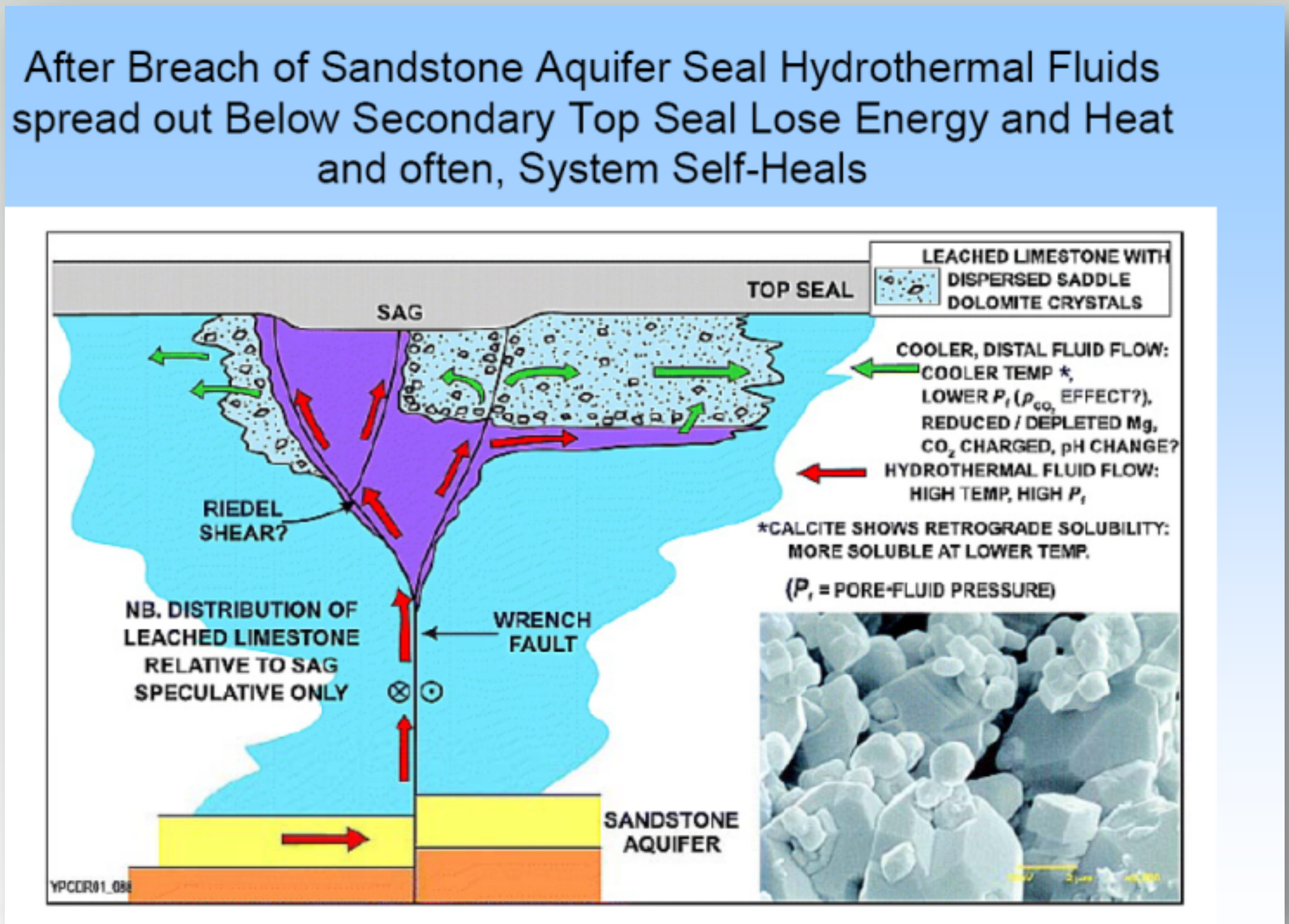
Migration Potential

- Correct environments trap CO_2
- Faults are most-likely natural avenues of transport out of traps.
- Faults can self heal
- Faults rarely reach the surface



Work by Dave Bowen, http://ieaghg.org/docs/General_Docs/Natr%20rel%20worksop/BOWEN_SEC.pdf

Industrial Analog: SACROC Oilfield

- Permian Basin, Texas
- 40 years CO_2 injection for CO_2 enhanced oil recovery
- CO_2 mined from natural subsurface deposit
- 150 Mt CO_2 injected (2012)
- 75 Mt recovered and recycled
- No evidence for CO_2 in the environment (Romanak et al., 2012)

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Research on Potential Environmental Impacts

International Journal of Greenhouse Gas Control 40 (2015) 350–377

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ELSEVIER

Developments since 2005 in understanding potential environmental impacts of CO_2 leakage from geological storage

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Terrestrial Ecosystem Effects

- Effects are spatially limited
- Plants and microbes can uptake substantial amounts of CO_2
- Plant and microbial communities may shift to acid tolerant species.
- Impacts occur at about 10% soil gas at shallow depth (20–30 cm).
- Plants with well-developed root systems are most resilient

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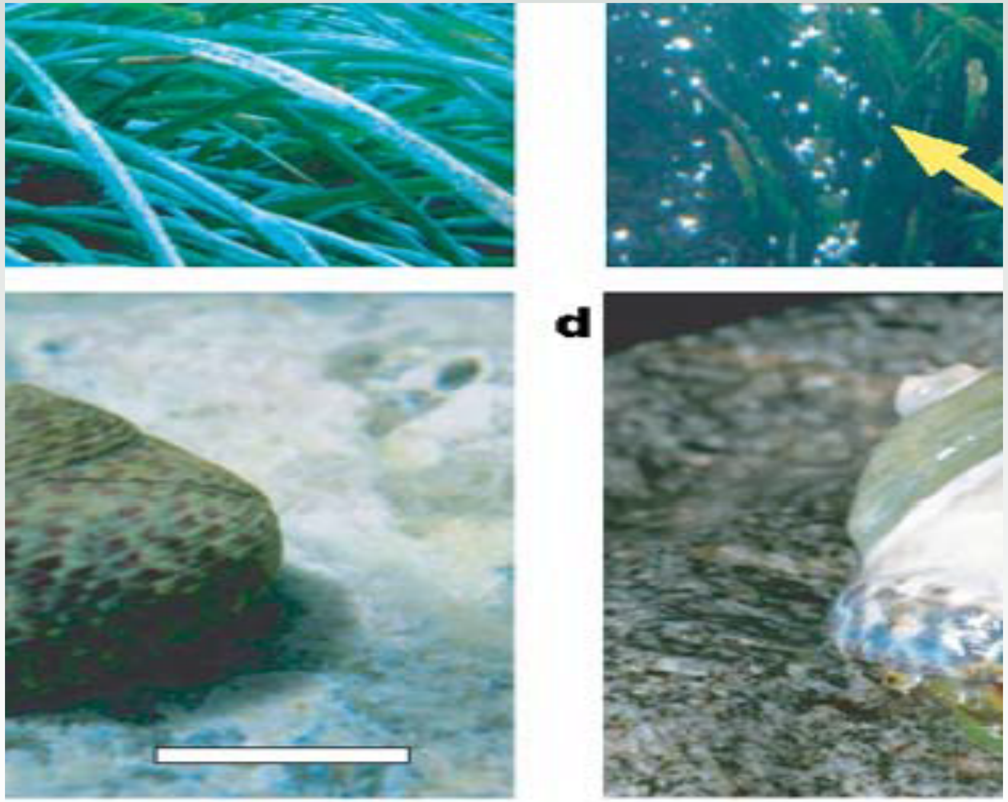
Marine Ecosystem Effects

- Most of the CO_2 is retained in the sediments
- When bubble plumes form they dissolve within 10 m of the sea floor.
- Dissolved CO_2 sinks to create a plume near the seabed
- Most impact is to bottom-dwelling immobile biota.
- Many species have mechanisms to protect from small fluctuations



Stakeholder Engagment

- Public outreach should begin early in project planning phase.
- Establish a strong outreach team
- Identify and know key stakeholders
- Establish an outreach program
- Develop key messages and materials tailored to stakeholders
- Have protocols in place for responding to stakeholder concerns before a project begins.

Scientific Evidence Base on Geological CO_2 Storage

- It works –
  - CO_2 is easily stored and trapped in deep geological formations
- It is safe –
  - Permitting and site selection ensure safety
  - No adverse outcomes have been seen
- It is ready for deployment now

Concluding Remarks

- Geological CO_2 storage is safe by design.
- Environmental protection begins before a project starts.
- Site selection, risk assessment, permitting and monitoring provide assurance.
- Many scientific approaches have been used to investigate the potential for environmental impact. The results have provided additional assurance.
- CO_2 is not likely to reach groundwater or ground surface
- In the unlikely event that CO_2 does reach the ground surface, impact will be transient and localized.
- Stakeholder engagement is vitally important and should be implemented early in the planning phases
- Protocols for responding to stakeholder concerns should be in place before a project begins.

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www.gulfcoastcarbon.org

Thank you

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