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Groundwater Protection
Groundwater Protection

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Gulf Coast Carbon Center

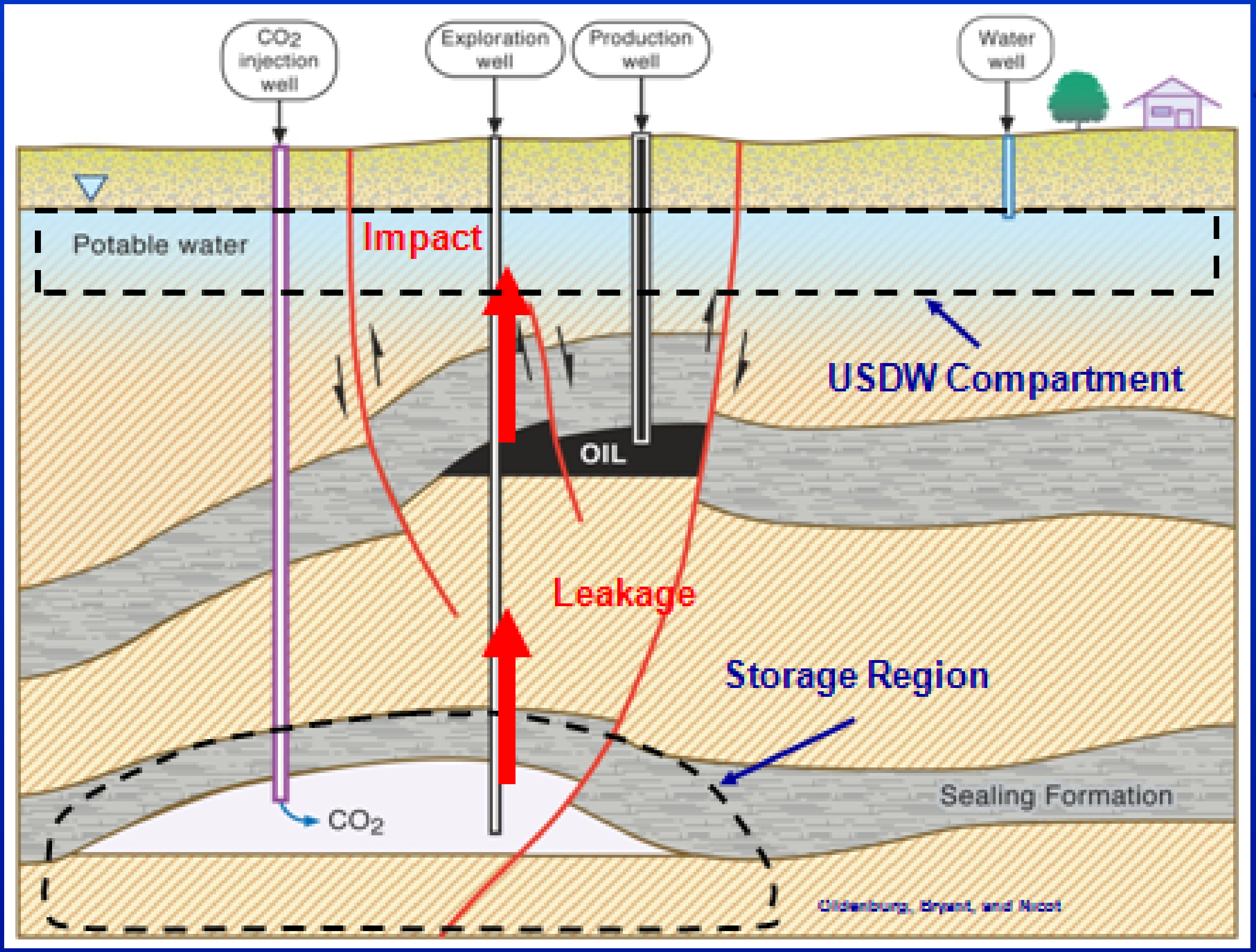
STORE

100 Years of Scientific Impact
1909 - 2009

Groundwater Protection

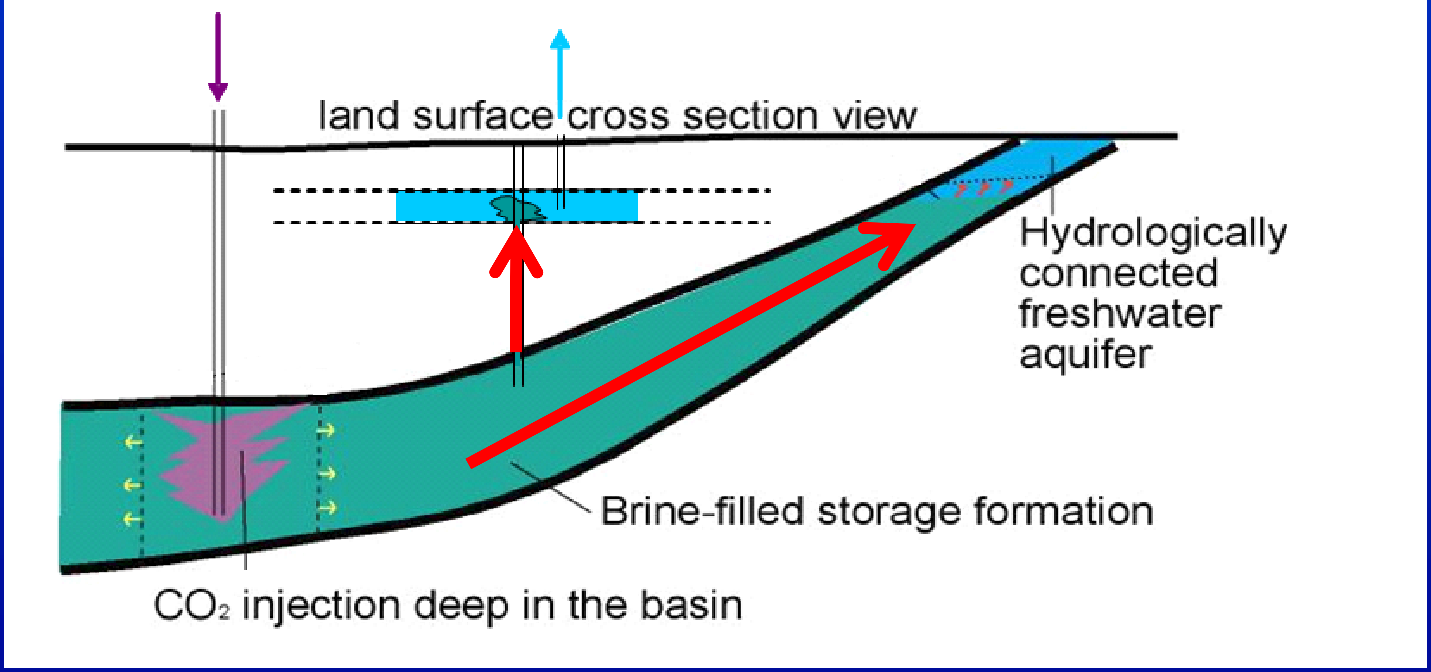
- Begins in the initial planning phase
  - Site characterization
  - Assess risks to groundwater
  - Criteria for choice of sites
  - Project engineering and management with regard to potential migration pathways
    - CO_2
    - Brine

Potential CO_2 Migration Pathways



Brine Migration Pathways

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

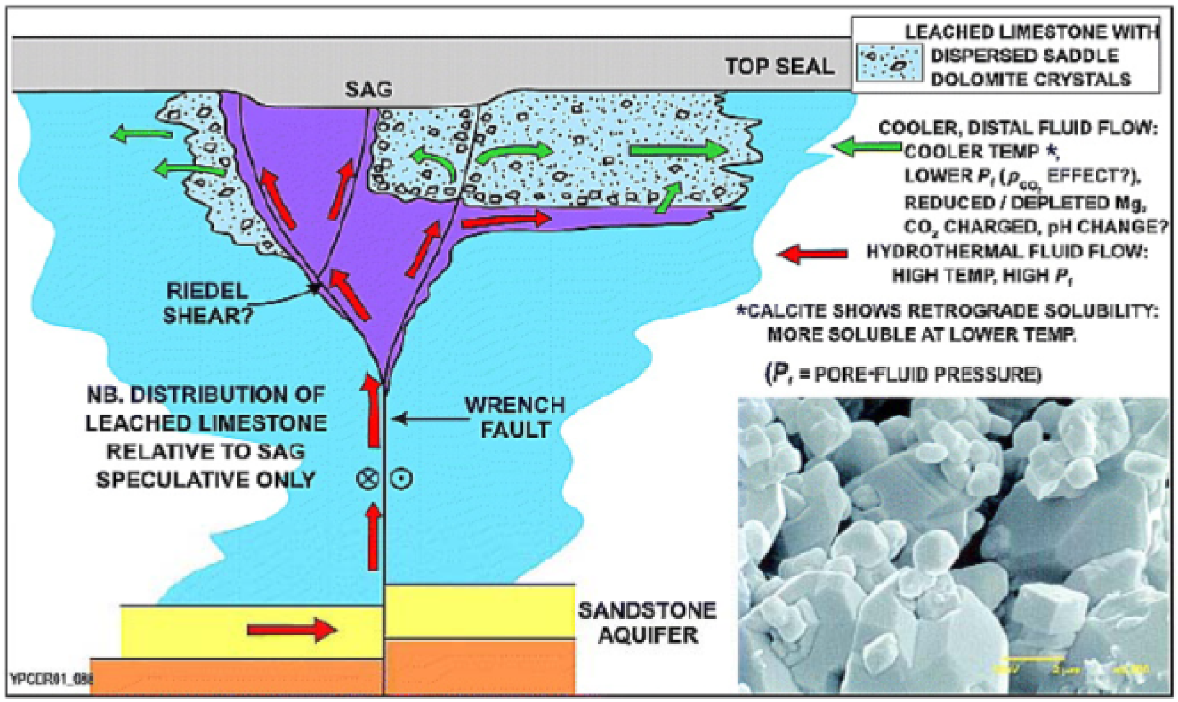


Nicot et. al, 200, 9GCCC Digital Publication Series #08-03g

Migration Potential

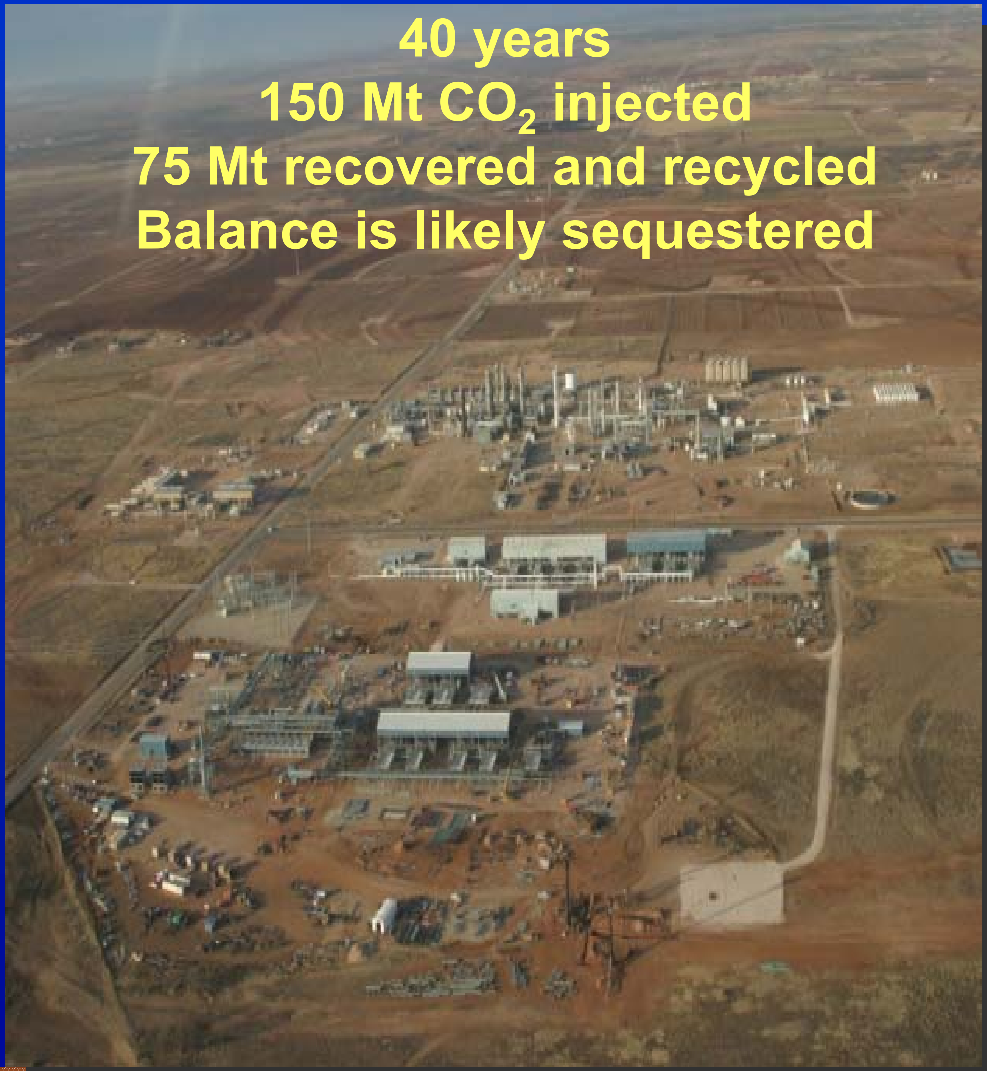
- Correct environments trap CO_2
- Faults are most-likely avenues of transport out of traps.
- Faults can self heal
- Faults don't always reach the surface

After Breach of Sandstone Aquifer Seal Hydrothermal Fluids spread out Below Secondary Top Seal Lose Energy and Heat and often, System Self-Heals



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

Industrial Analog: SACROC Oilfield



Science Addressing Concerns

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

Potential Impacts of Concern

CO_2

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

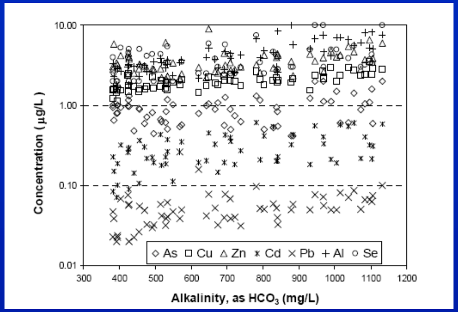
Brine

- Organics, injection impurities, total dissolved solids

Evaluating Metal Mobilization

Laboratory:

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



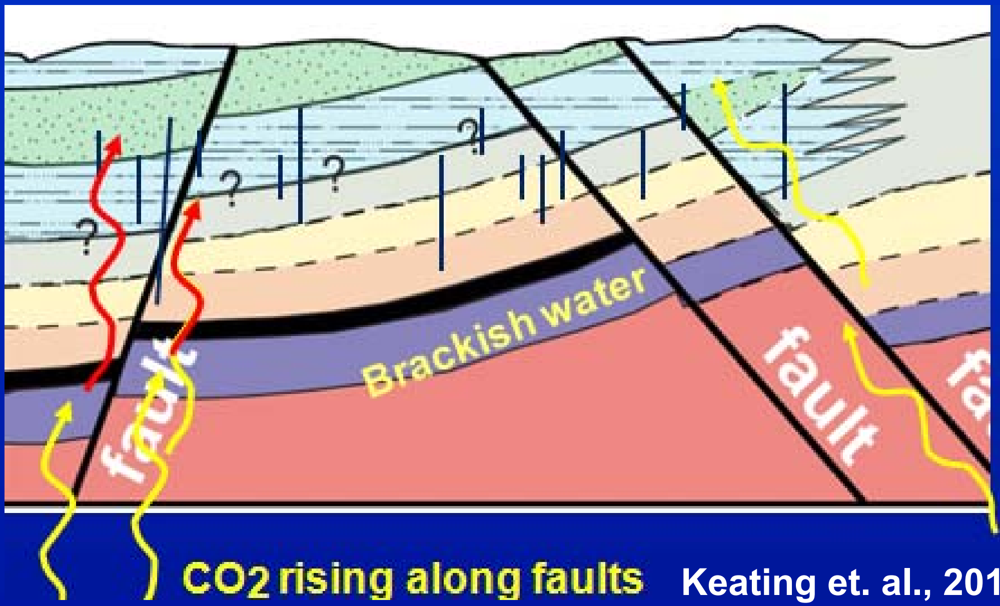
Shallow Controlled Release (ZERT)

- 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 Impacts: Natural Analog Chimayo, New Mexico, USA



Keating et. al., 2010

- Integrated field, lab and modeling.
- Trace elements are strongly associated with brackish water; in-situ mobilization is negligible
- Mineral precipitation decreases metal concentrations

Brine Migration

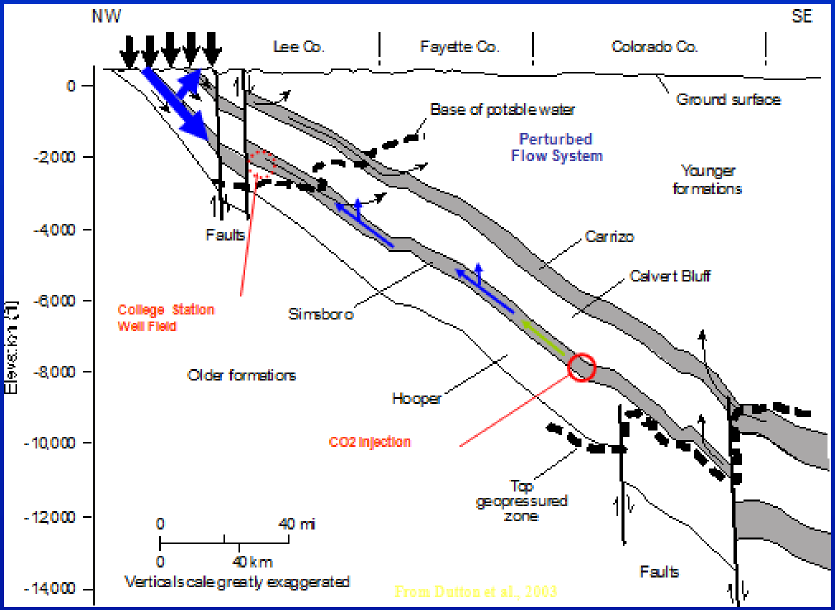
Impacts are related to basin size and geometry

Flow barriers could locally focus displaced water and provoke undesirable effects (migration up well bores/faults).

Abandoned wells should be properly plugged.

Injection pressure management may be necessary in some instances.

Carrizo-Wilcox system

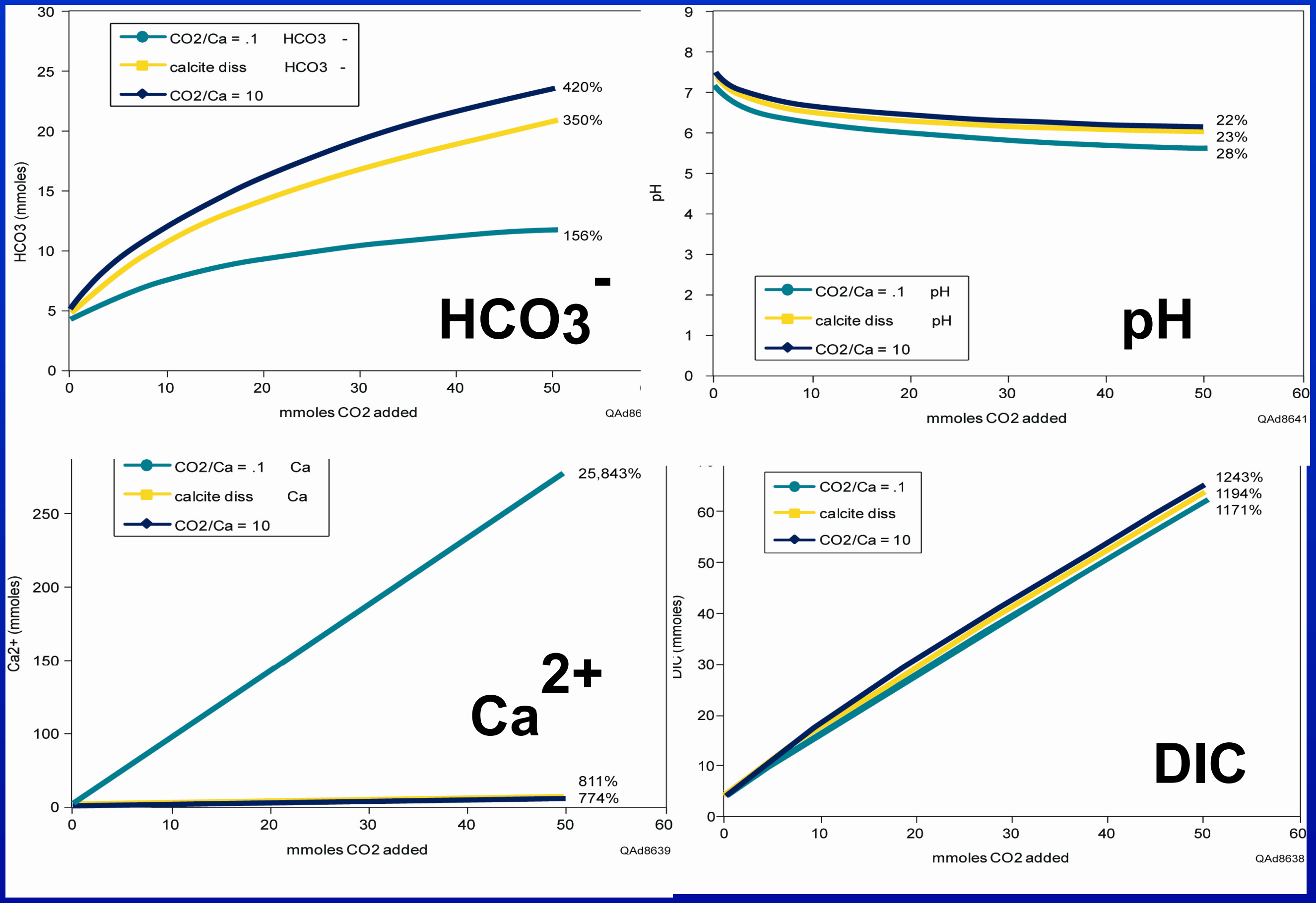


Nicot et. al, 2008

Groundwater Monitoring

- Not all research tools should be implemented for industry.
- Targeted in area and scope to reduce cost without reducing effectiveness.
  - Wells and faults
  - Selected parameters
- Main cost issue is geologic variability.
  - Sensitive parameters that behave similarly in any geologic environment.

Sensitivity of Groundwater Chemistry to CO_2



Romanak et. al., in review, International Journal of Greenhouse Gas Control

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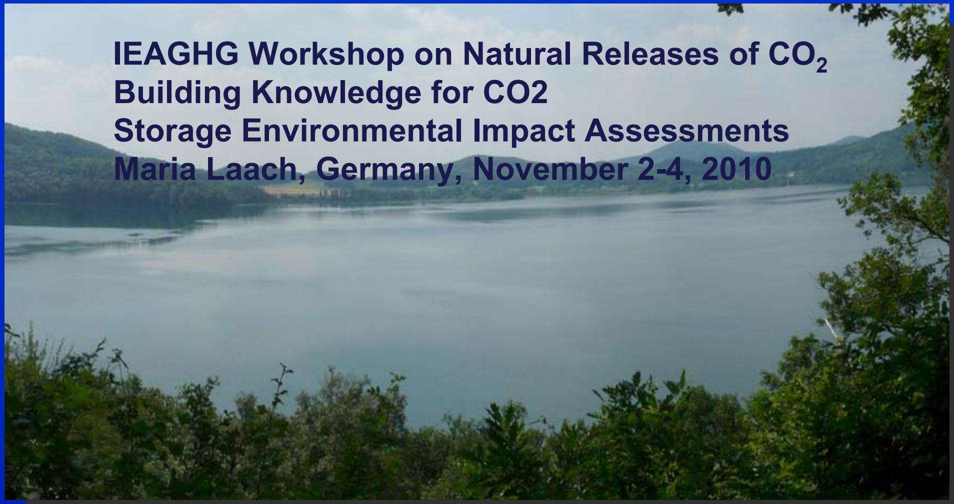
Natural Analogs for Public Perception



Dixon and Romanak, 2010, 2011

When used correctly, natural CO_2 releases provide a level of clarity for the public by giving tangible concrete examples of environmental impacts of CO_2.

Concluding Remarks

- Field tests, analog observations, laboratory experiments, and modeling increase confidence that CO_2 injected into geological formations can be permanently stored at depths below and isolated from underground sources of drinking water.
- CO_2 in aquifers is not problematic for groundwater quality.
- Brine displacement is not excessive and can be managed, especially in large basins.
- Monitoring can be targeted to potential migration pathways and should use global geochemical parameters that react the same in any environment.
- Natural releases of CO_2 can be used for communicating environmental impacts to the public.

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