The Geologic Storage Option

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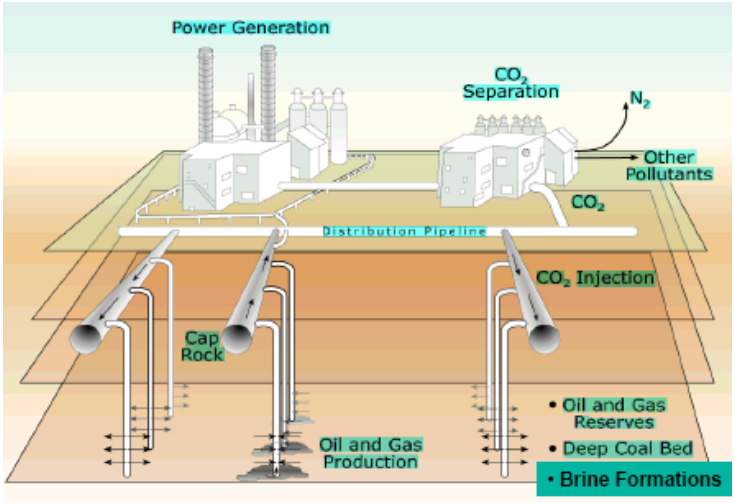
Topics

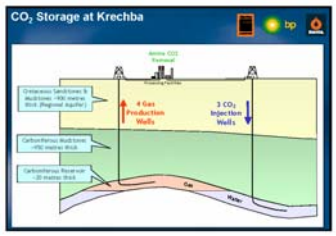
- Brief technology summary
- How is the CO_2 stored?
- Assessing storage capacity
- Cost
- Is geologic storage safe and secure?
- Need for monitoring
- Mitigation strategies
- The value of pilot studies
- What's next?

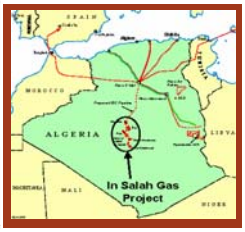
Geologic Sequestration Involves Capture, Compression and Injection

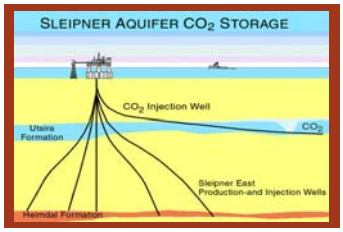


Geologic Storage Is Already Under Way

- Statoil injects 1x10^6 tons per year at Sleipner
- BP to inject 0.8x10^6 tons per year at In Salah

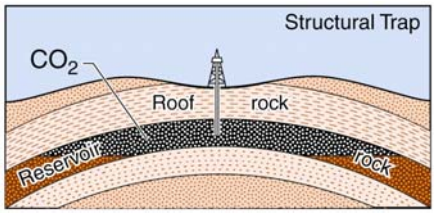


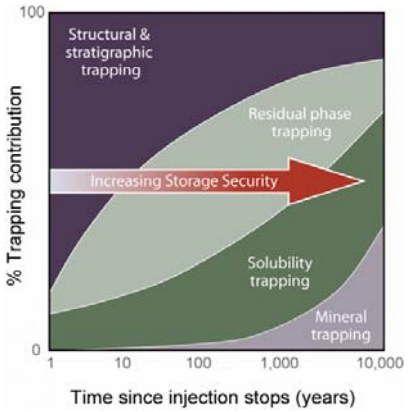




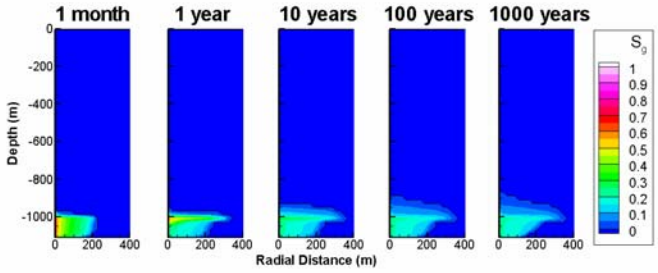
Geologic Storage Mechanisms

- Physical, hydrodynamic, trapping
- Dissolution
- Phase trapping
- Mineralization
- Surface adsorption

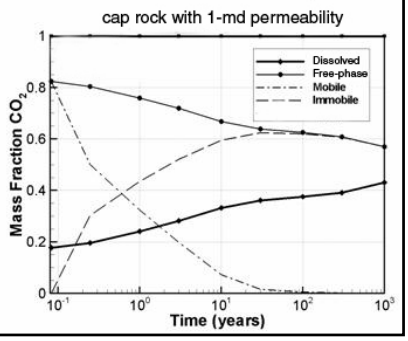




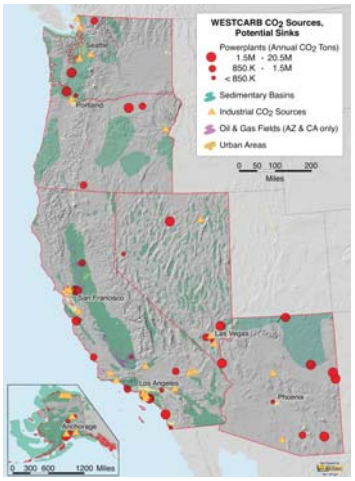
Simulations Show Fate of Geologically Stored CO_2

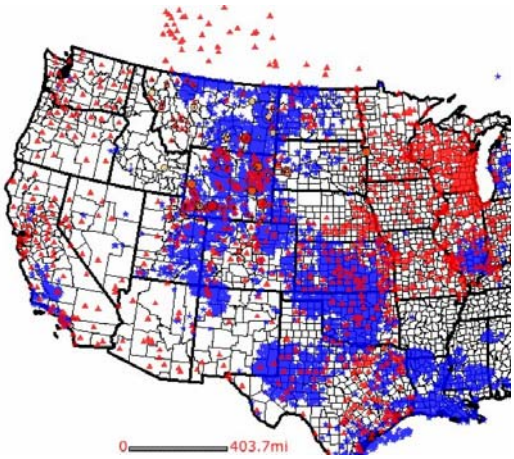


Results show fate of a plume of 900,000 tons of CO_2 injected beneath a poor quality cap rock (1-md permeability); S_g is the CO_2 saturation, where 1=100%; "mass fraction" means proportion of total, where 1=100%; mass of "mobile" plus "immobile" equals "free phase" CO_2



Potential Geologic Storage Formations are Broadly Distributed in Many States

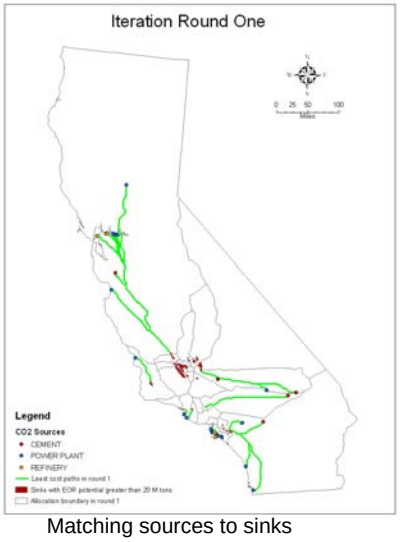




NATCARB database

Development of Supply Curves for Geologic Storage Improve Cost Estimates

- CO_2 source characterization
- Capture cost estimation
- CO_2 storage capacity estimation
- Transportation cost estimation
- Source-sink matching



Matching sources to sinks
(From H. Herzog, MIT)

IPCC Report Provides Context for Discussion of Storage Risks

"With appropriate site selection informed by available subsurface information, a monitoring program to detect problems, a regulatory system, and the appropriate use of remediation methods to stop or control CO_2 releases if they arise, the local health, safety and environmental risks of geological storage would be comparable to risks of current activities such as natural gas storage, EOR, and deep underground disposal of acid gas" (IPCC, 2006)

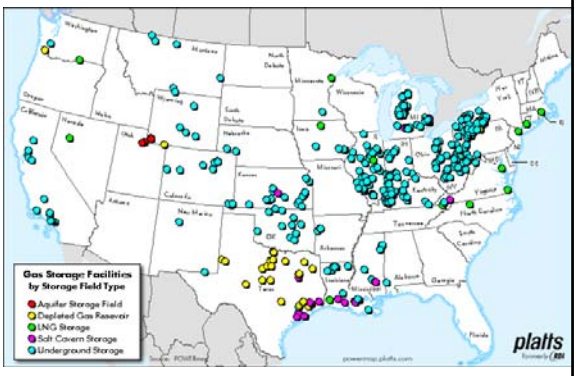
HSE Risks of Geologic Storage

- Impacts of unintended leakage
  - Health and safety of workers and general population
  - Environmental impacts
  - Unwanted intrusion into drinking water
- Earthquakes
- Unwanted intrusion of saline fluids

Tree kill at Mammoth Mountain, CA
http://quake.wr.usgs.gov/prepare/factsheets/CO2/

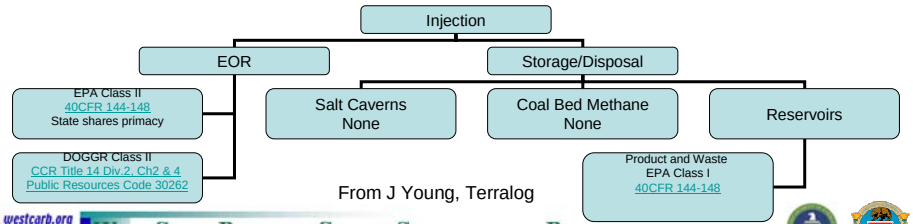
Many Lines of Evidence Indicate Storage Can Be Safe and Secure

- Natural analogues
  - Oil and gas
  - CO_2 formations
- Industrial analogues
  - Natural gas storage
  - CO_2 EOR
  - Liquid waste disposal
- Monitoring existing projects
  - Sleipner
  - Weyburn



Results of Review of Current Regulatory Framework in WESTCARB Region

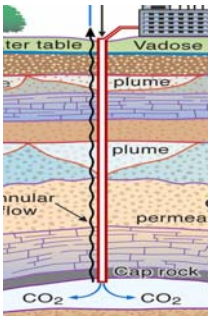
- Regulatory agencies actively participated in process
- Comparative assessment of regulations for enhanced oil recovery, natural gas storage, and underground waste injection
- Various unresolved issues remain



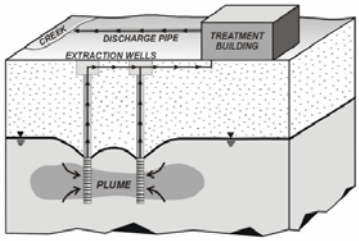
From J Young, Terralog

Remediation Options are Available if Something Does Go Wrong

- Leaking wells



- Lakes



- Groundwater

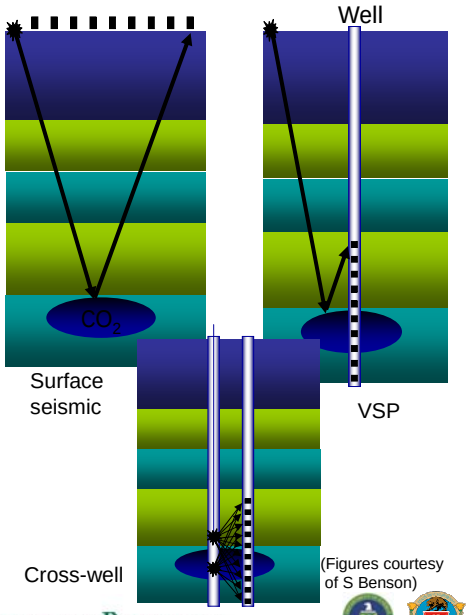
Picture taken from
http://www.clu-in.org/download/remed/542r01021b.pdf

Why Monitor?

- Confirm storage efficiency and processes
- Ensure effective injection controls
- Detect plume location and leakage from storage formation
- Ensure worker and public safety
- Design and evaluate remediation efforts
- Detect and quantify surface leakage
- Provide assurance and accounting for monetary transactions
- Settle legal disputes

A Substantial Portfolio of Monitoring Techniques are Available

- Seismic and electrical geophysics
- Well logging
- Hydrologic pressure and tracer measurements
- Geochemical sampling
- Remote sensing
- CO_2 sensors
- Surface flux measurements
- Estimated cost: ~$0.20/ton CO_2



(Figures courtesy of S Benson)

Pilots Provide Regional Knowledge Base Essential for Large Scale Implementation

- Pilots demonstrate best sequestration options, unique technologies and approaches, in region
- Pilots involve site-specific focus for
  - Testing technologies
  - Defining costs
  - Assessing leakage risks
  - Gauging public acceptance
  - Exercising regulatory requirements
  - Validating monitoring methods

What's Next?

- Reconciling and revising capacity estimates
- Criteria for site selection
- Best practices for well construction and injection control
- Monitoring and verification protocols
- Mitigation strategies
- Field testing to build the experience needed for full scale deployment