

Introduction to Geologic Sequestration of CO₂

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Introduction to Geologic Sequestration of CO₂

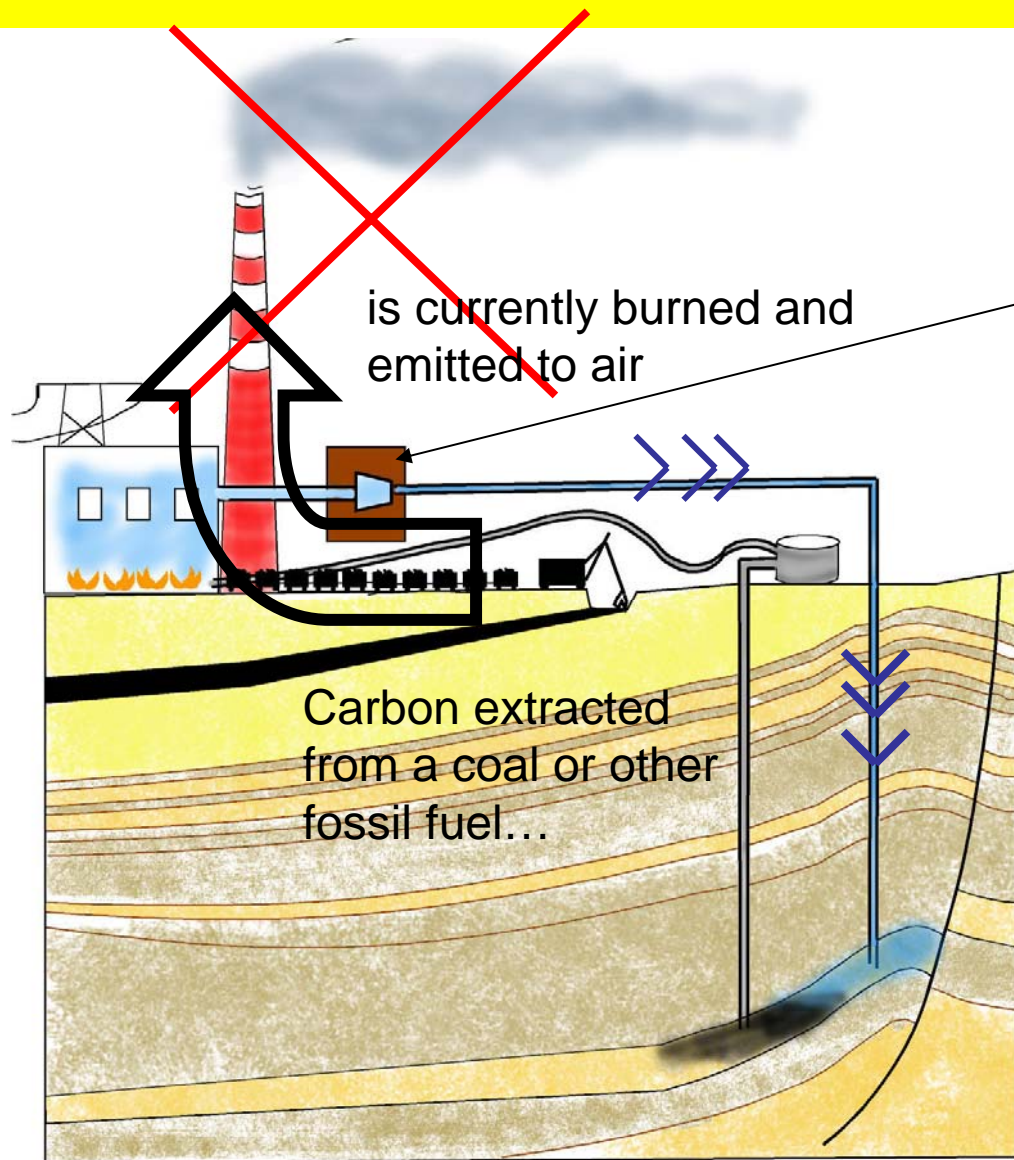


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What is Geologic Sequestration?



To reduce CO₂ emissions to air from point sources..

CO₂ is captured as concentrated high pressure fluid by one of several methods..

CO₂ is shipped as supercritical fluid via pipeline to a selected, permitted injection site

CO₂ injected at pressure into pore space at depths below and isolated (sequestered) from potable water.

CO₂ stored in pore space over geologically significant time frames.

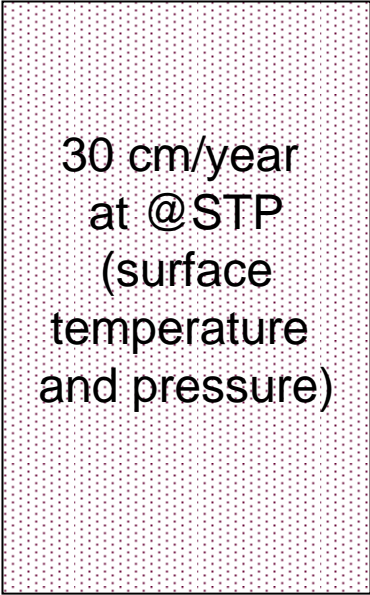
Is geologic sequestration ready to be used as part of a greenhouse gas emissions reduction program?

- Are subsurface volumes adequate to sequester the volumes needed to impact atmospheric concentrations?
- Is storage security adequate to avoid inducing hazards and to benefit atmospheric concentrations?
- Is the whole system (pipeline, well construction, permitting) mature enough to proceed forward?

Assessing Adequacy of Subsurface Volumes: the Value of Compression


- At depths >800 m CO_2 is stored as a dense phase (1 metric ton = about 1.6 cubic m)

Seven Gigatons ($7 \times 10^9 \text{T}$)
 CO_2 /year US emissions from
stationary sources:
if spread evenly over US:



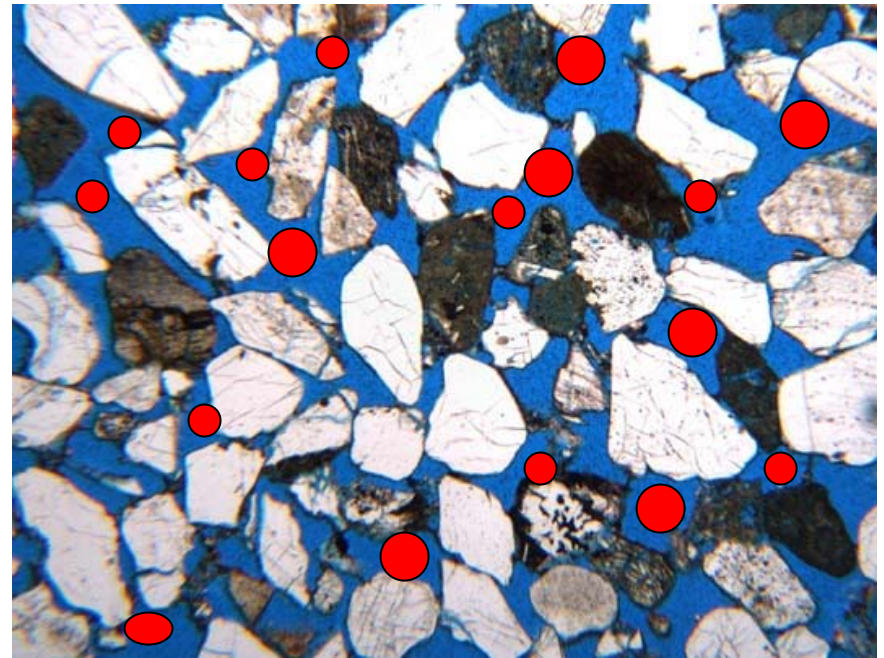
30 cm/year
at @STP
(surface
temperature
and pressure)

0.4 mm/year at
reservoir conditions



Assessing Adequacy of Subsurface Volumes: Microscope View

- Storage volume is in abundant microscopic spaces (pores) between grains in sedimentary rocks that are now filled with brine (or locally oil or gas)



2mm

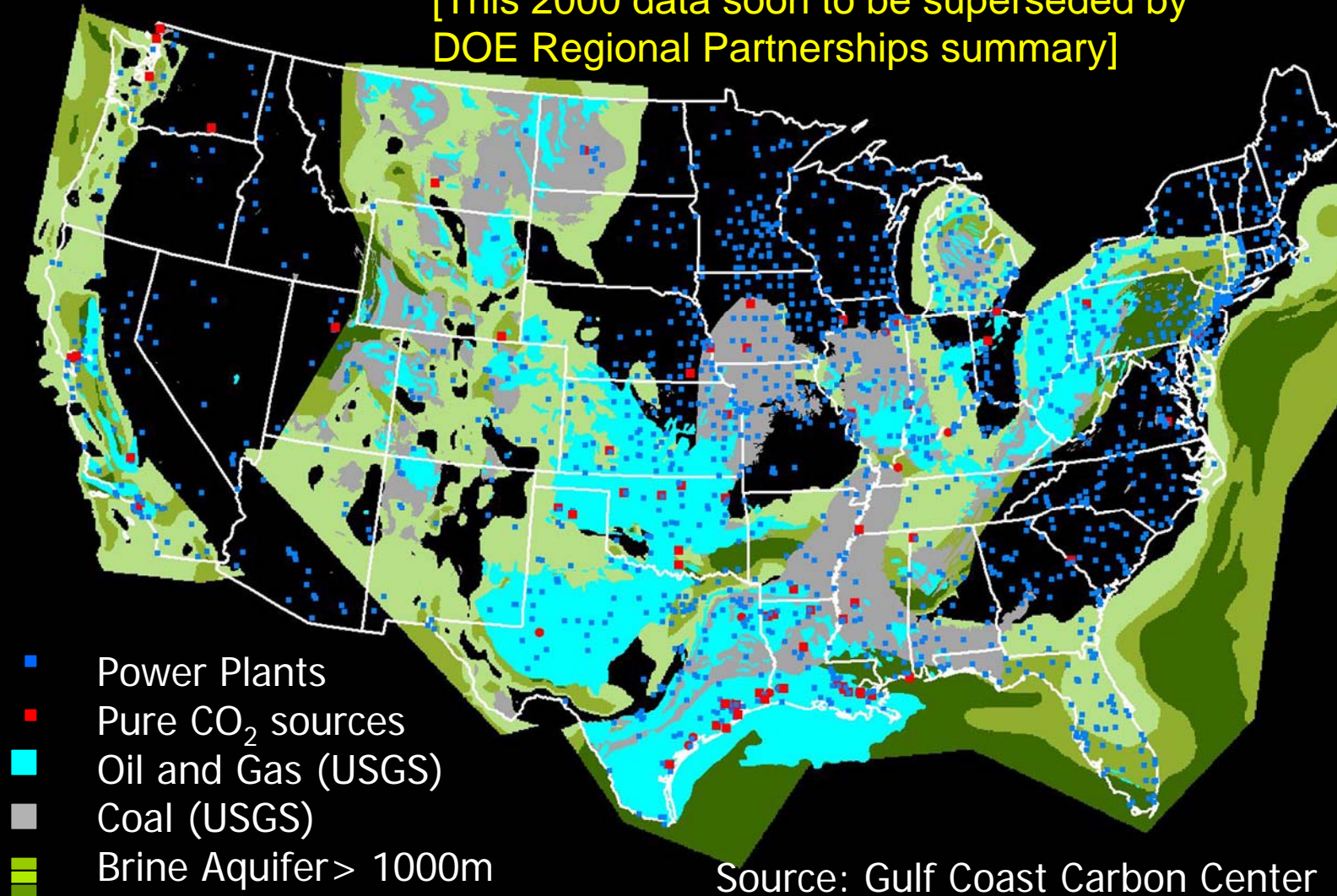
Sandstone thin section photomicrograph, Frio Fm.
Blue areas were filled with brine
now are 10-30% filled with CO₂

Assessing Adequacy of Subsurface Volumes: Distribution

- Pores to store and seals to prevent leakage upward are typical of sedimentary rocks found widely in the US and globally
 - Economically acceptable estimation of pore space commonly done for oil and gas reservoirs using available tools is adapted to brine-filled volumes
 - Not all sedimentary rocks are equally well known – confidence of estimates of storage volume is variable.

Assessing Adequacy of Subsurface Volumes – map view

[This 2000 data soon to be superseded by DOE Regional Partnerships summary]



Assessing Adequacy of Subsurface Volumes

- New study of capacity by DOE - NETL Regional Carbon Sequestration Partnerships to be released soon
- Major result: making conservative assumptions*: Space for 1000 Gigatons CO₂ at reservoir conditions - adequate space for >120 years of all CO₂ at current point source emission rates
 - * only fairly well known rock volumes assessed
 - * Assume that CO₂ fills 1% of the volume
- Uncertainty is risks incurred when very large volumes are injected

What are the risks?

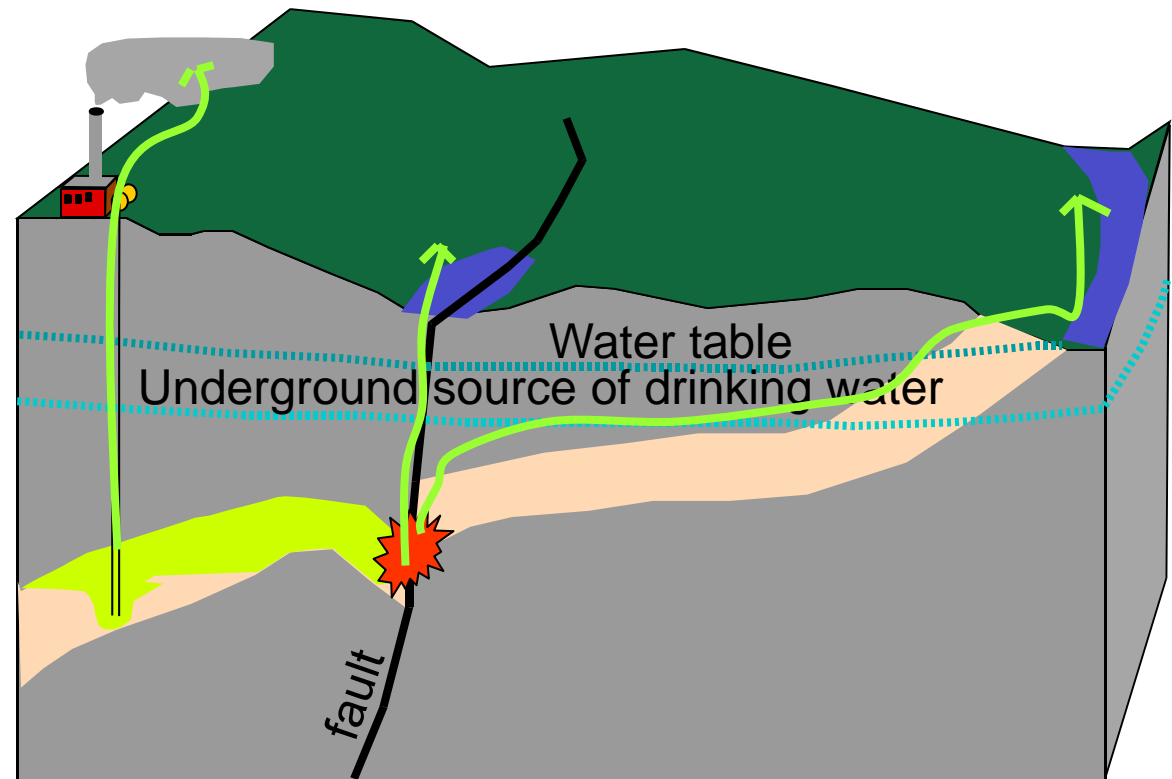
Substitute
underground
injection for air
release

Is storage security adequate?

Escape of brine
or CO₂ to
groundwater,
surface water,
or air via long
flowpath

Earthquake

Escape of CO₂
or brine to
groundwater,
surface water
or air through
flaws in the seal



Failure of well cement or
casing resulting in leakage

Is Security of Sequestered CO₂ Adequate? Types of Risks:

- Catastrophic or rapid escape of CO₂ or brine – death or damages
 - Well-known volcanogenic CO₂ outgassing: examples at Lake Nyos, Cameroon; Mammoth Lakes, CA,; industrial confined space risks
- Slow escape of CO₂ – storage becomes ineffective for atmospheric benefit, cost without benefit
 - Slow leakage of either CO₂ or brine within ranges of normal variability is probably acceptable in environmental and resource conservation context
 - However leakage rates < 0.1% of stored volume/year are required to benefit atmosphere

Is Security of Sequestered CO₂ Adequate?

- Pores to store and seals to prevent leakage upward are typical of sedimentary rocks found widely in the US and globally
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Techniques to Assure Safe Injection of CO₂ Used Currently

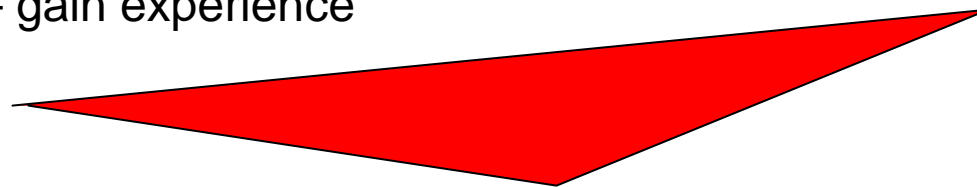
- Health and safety procedures for CO₂ pipelines, shipping, handling, and storing
- Pre-injection characterization and modeling
- Isolation of injectate from Underground Sources of Drinking Water (USDW)
- Maximum allowable surface injection pressure (MASIP) to prevent earthquakes.
- Mechanical integrity testing (MIT) of engineered system
- Standards for well completion and plug and abandonment in cone of influence and area of review around injection wells.
- Reservoir management; extensive experience in modeling and measuring location of fluids

How can Security of Sequestration be Better Assured?

- Rigorous site selection requirements
- Comprehensive monitoring requirements and mitigation plans
- Additional research
- Need for a balanced and phased approach

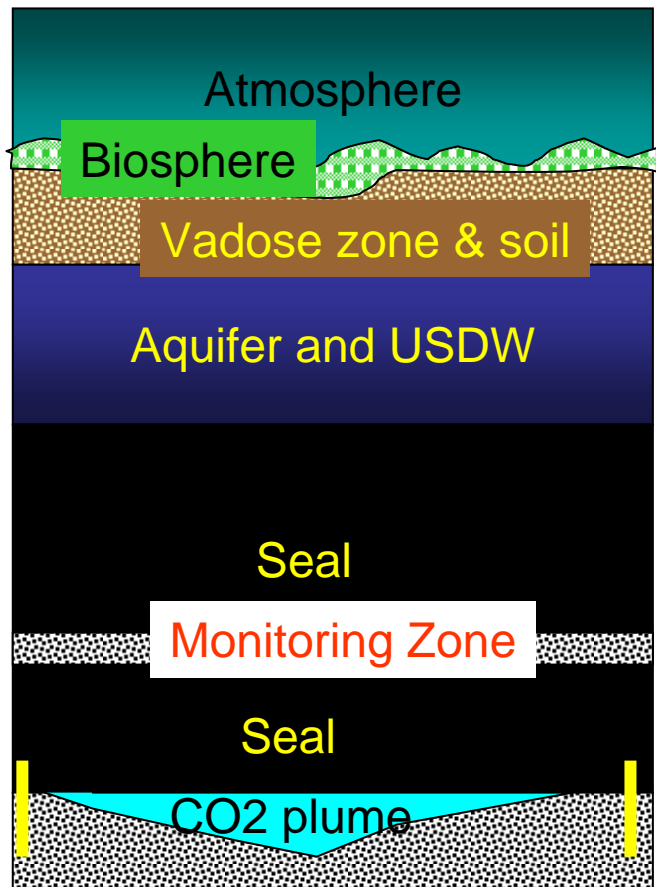
Not too restrictive:
encourage early entry into
CCS – gain experience

Adequate rigor to assure that early
programs do not fail



Mature = standardized, parsimonious but
adequate approach

Assuring Security: Monitoring Options



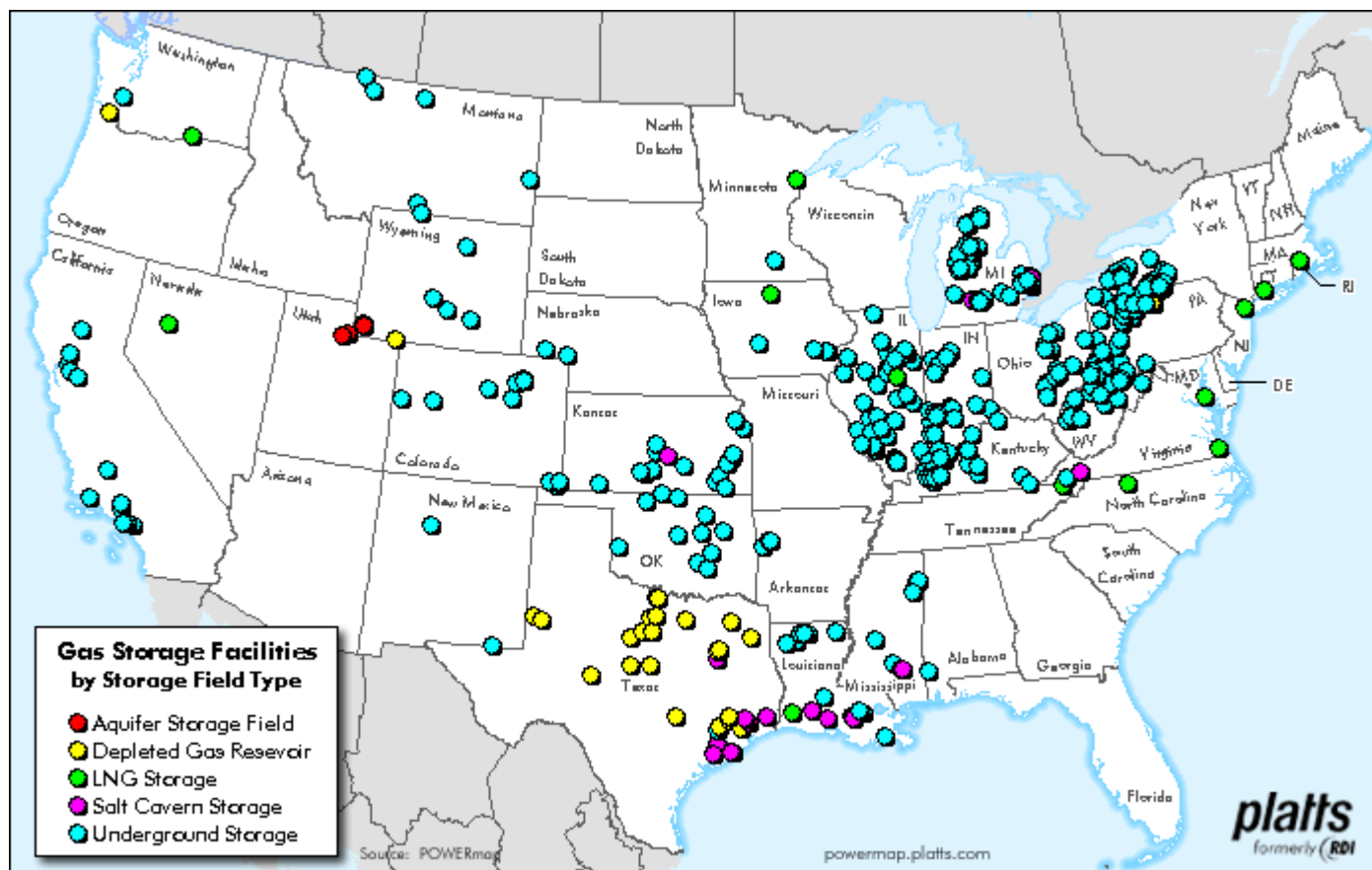
- Atmosphere
 - Ultimate integrator but dynamic
- Biosphere
 - Assurance of no damage but dynamic
- Soil and Vadose Zone
 - Integrator but dynamic
- Aquifer and USDW
 - Integrator, slightly isolated from ecological effects
- Above injection monitoring zone
 - First indicator, monitor small signals, more stable.
- In injection zone - plume
 - Oil-field type technologies. Will not find small leaks
- In injection zone - outside plume
 - Assure lateral migration of CO₂ and brine is acceptable

System mature enough to proceed: Global experience in CO₂ injection



From Peter Cook, CO2CRC

System mature enough to proceed: US experience in gas storage



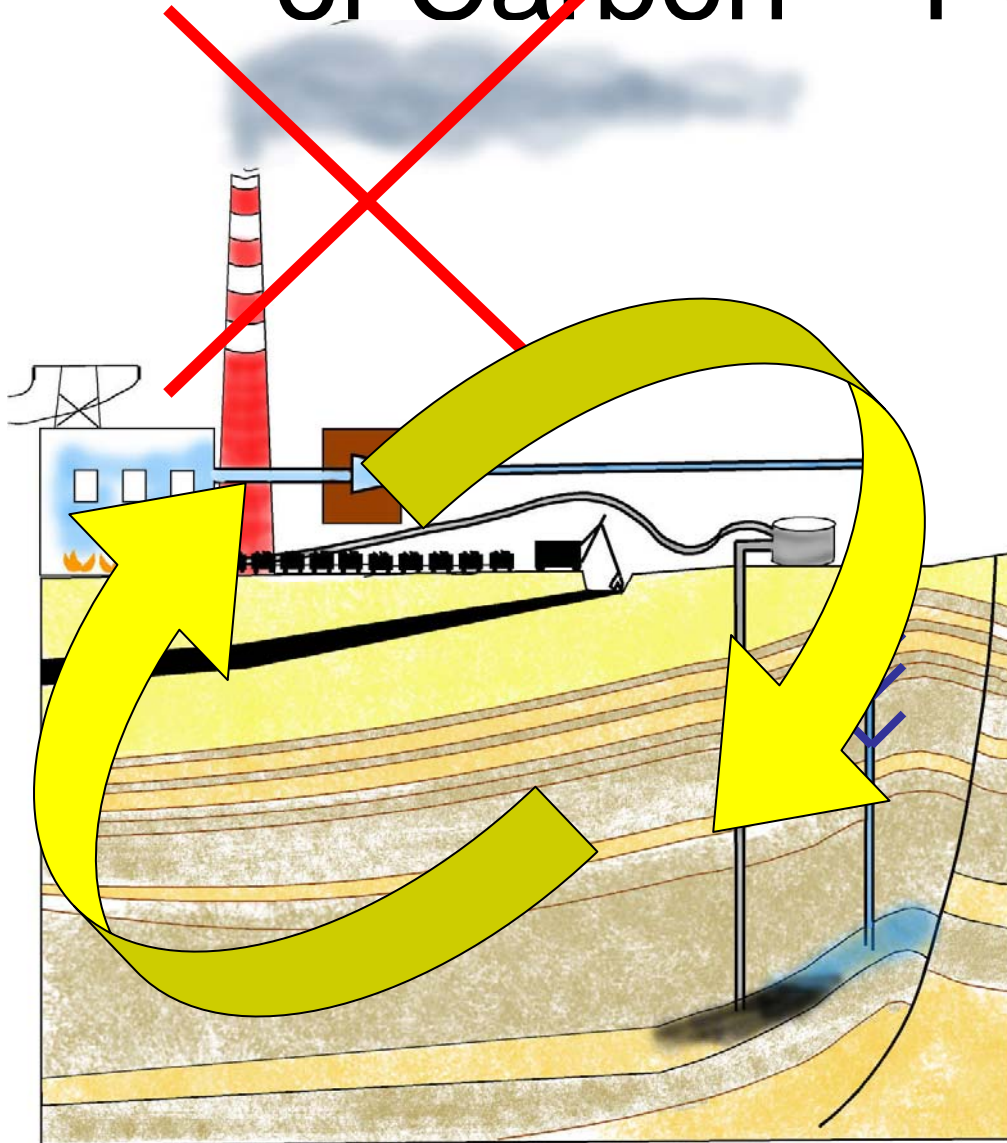
Geologic storage is ready to be used as part of a greenhouse gas emissions reduction program

- Subsurface volumes are adequate to sequester the volumes needed to impact atmospheric concentrations
- Using available technology, adequate storage security can be assured to avoid inducing hazards and to benefit atmospheric concentrations
- The whole system (pipeline, well construction, permitting) is mature enough to proceed forward-some work remaining

What needs to be done next?

- Prior to injection, CO₂ has to be captured at high concentration and compressed to about 2200 psi
 - Capture is major limit on utilization of geologic storage
- Assurance provided to industry on property rights and permitting
 - Legal precedents for large volume injection into brine in most states are inadequate
- Consensus on Best Practices for monitoring injection and post injection clarified
 - This should be a result of research in coming year – how much monitoring is adequate?

Geologic Sequestration of Carbon – Put it back



Carbon extracted from coal or other fossil fuel...

Returned into the earth where it came from