Basic Overview of Subsurface Geological Sequestration of CO_2

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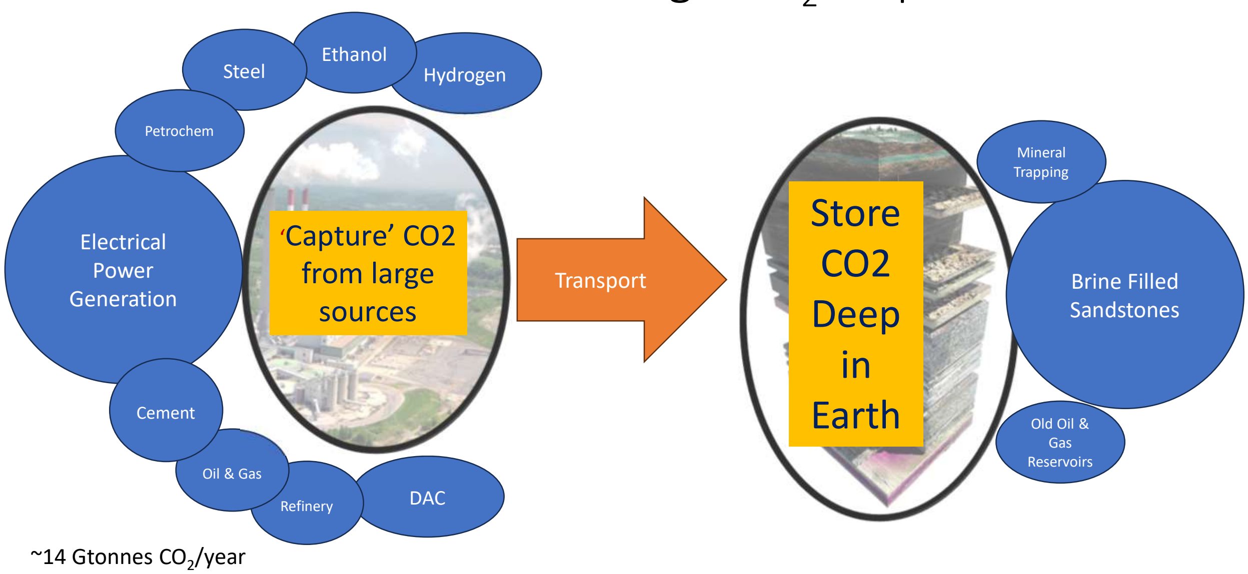
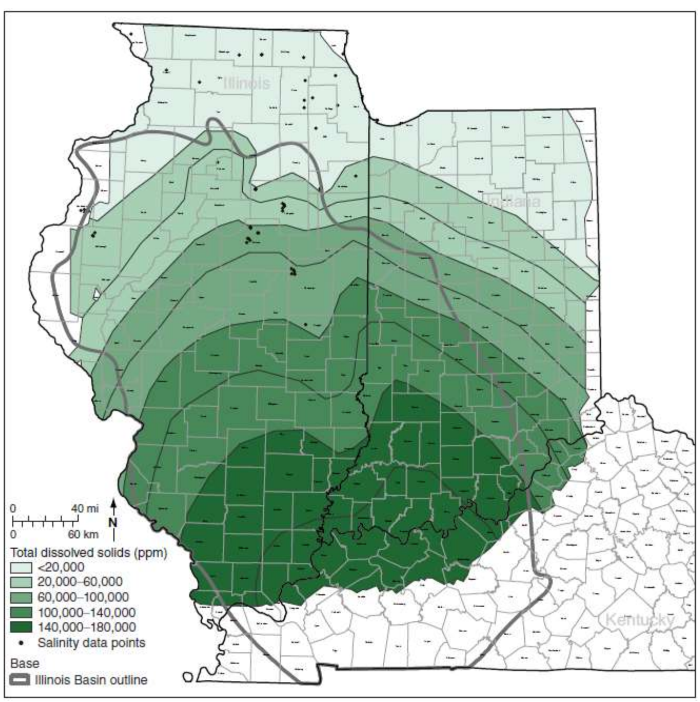
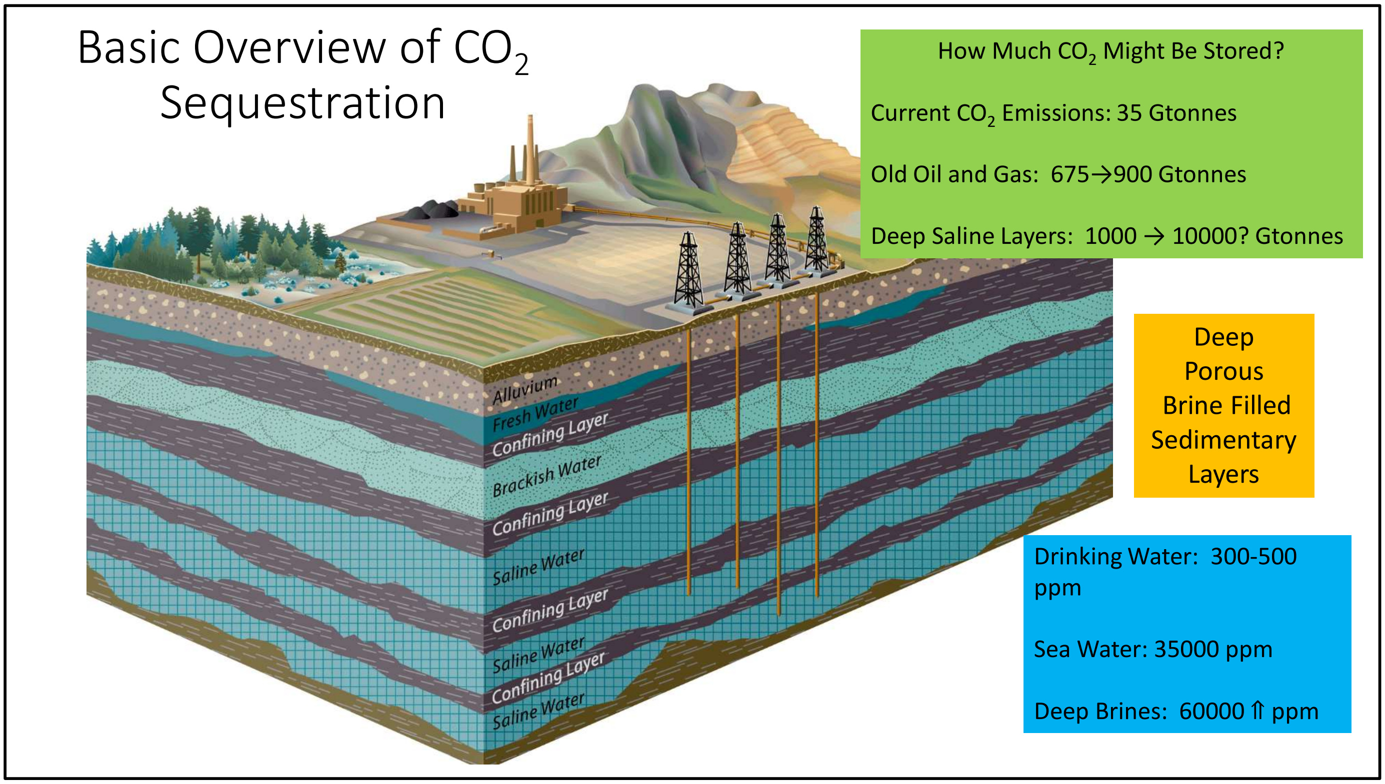
Basic Overview of Geologic CO_2 Sequestration



Map of salinity in the Mount Simon formation. (Mehnert, E., & Weberling, P. H. (2014). Groundwater Salinity Within the Mt. Simon Sandstone in Illinois and Indiana. https://isgs.illinois.edu/publications/c582).





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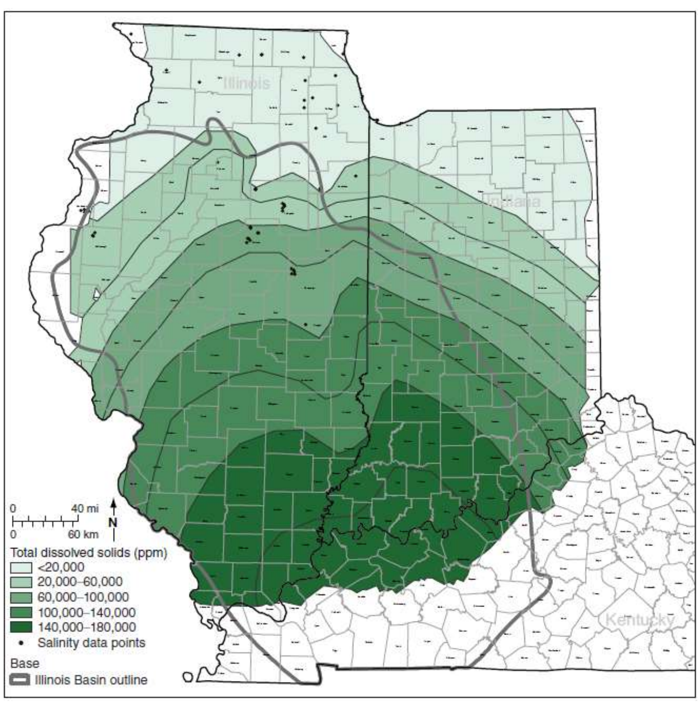


What happens to CO_2??

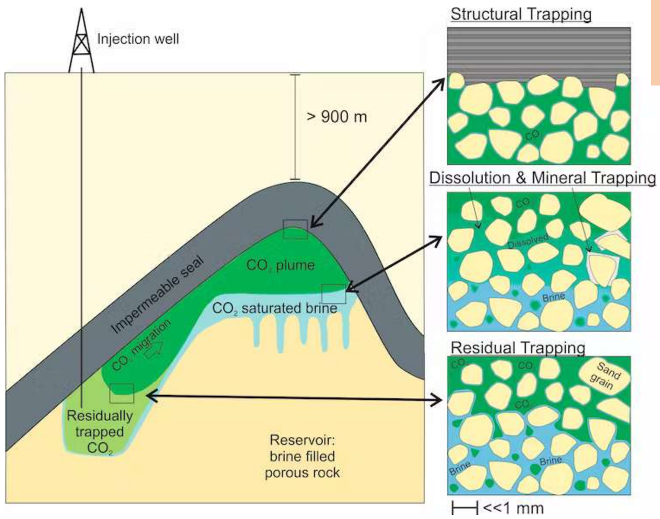
Pore Scale

Structural Trapping: 'trapped' by Eau Claire Shale

Residual Trapping: Bubbles caught in small pores

Dissolution: Dissolves into brine (which sinks)

Mineral Trapping: Reacts to form new minerals.



How Long Does This take?

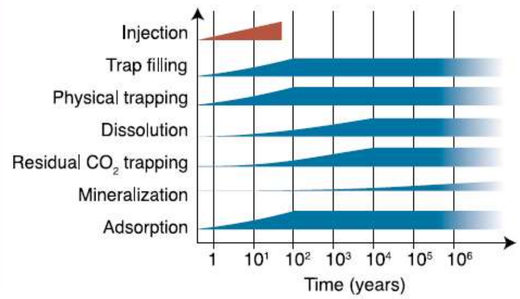
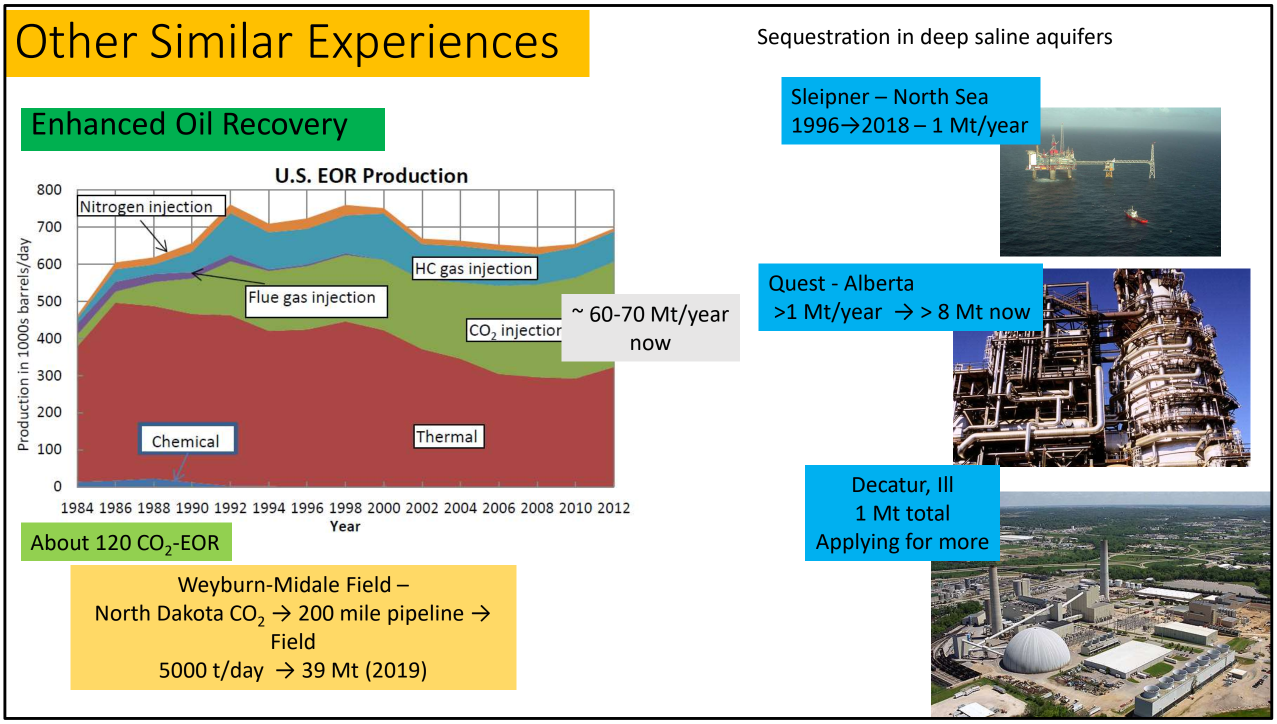


Image from https://theconversation.com/carbon-capture-and-storage-has-stalled-needlessly-three-reasons-why-fears-of-co-leakage-are-overblown-130747

Times required figure from Fig. 5.8 of https://www.ipcc.ch/report/carbon-dioxide-capture-and-storage/



EOR figure from Verma, M. K. (2015). *Fundamentals of Carbon Dioxide-Enhanced Oil Recovery (CO2-EOR)—A Supporting Document of the Assessment Methodology for Hydrocarbon Recovery Using CO2-EOR Associated with Carbon Sequestration (Open-File Report 2015–1071).*

Numbers on CO2 for EOR from https://kleinmanenergy.upenn.edu/news-insights/exploring-direct-air-captures-role-in-enhanced-oil-recovery/
BUT it needs to be noted that most of this (70%) is sourced from natural underground sources.

Recent statistics on Weyburn-Midale from https://ccsknowledge.com/blog/crossing-borders-to-find-solutions-on-co2-storage

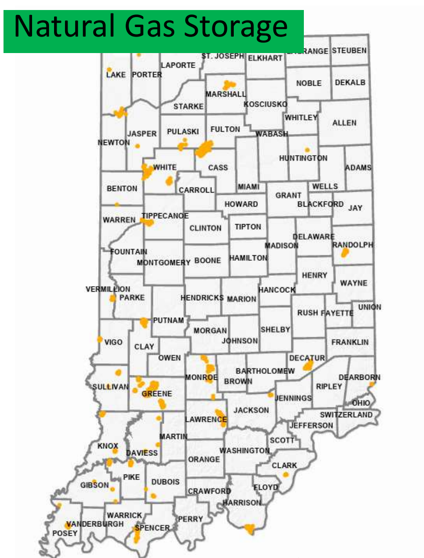
See https://www.natlawreview.com/article/enhanced-oil-recovery-energy-transition

Decatur https://netl.doe.gov/coal/carbon-storage/atlas/mgsc/phase-III/ibdp

Other Similar Experiences

Class I Wells – inject hazardous an non-hazardous fluid wastes into confined rock formations.

Natural Gas Storage



https://legacy.igws.indiana.edu/pdms/Map/

Active Class I Permits in Indiana

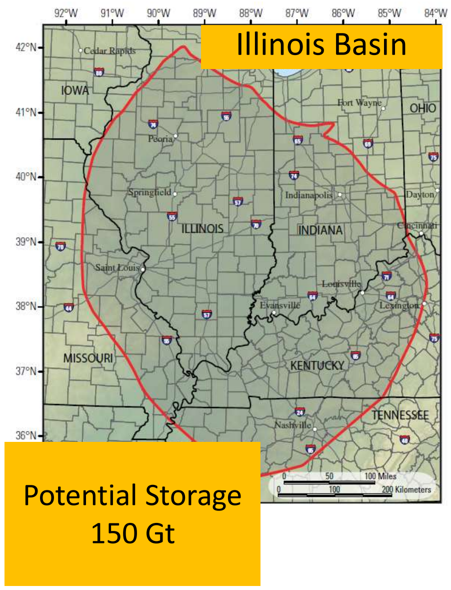
Facility	County	U.S. EPA Permit Number	Well Name	Hazardous or Non-Hazardous	Commercial
ArcelorMittal Burns Harbor, LLC	Porter	IN-127-1W-0001	Spent Pickle Liquor #1	Hazardous	No
		IN-127-1W-0003	Waste Ammonia Liquor (WAL) #1		
		IN-127-1W-0004	WAL #2		
		IN-127-1W-0007	WAL #3		
Duke Energy Indiana, Inc.	Gibson	IN-051-1I-0001	Waste Disposal Well (WDW) #1	Non-Hazardous	No
		IN-051-1I-0002	WDW #2		
		IN-051-1I-0003	WDW #3		
Shell Catalysts & Technologies	LaPorte	IN-091-1I-0001	Well #1	Non-Hazardous	No
		IN-091-1I-0002	Well #2		
		IN-091-1I-0006	Well #3		
Cathay Deep Well Disposal	Porter	IN-127-1I-C007	Well #1	Non-Hazardous	Yes
		IN-127-1I-C008	Well #2		

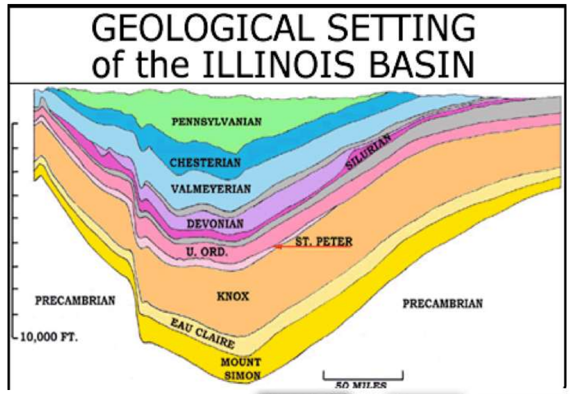
Indiana Figure publicly available at IGWS site.

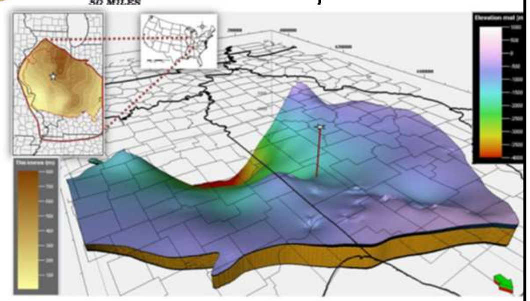
https://www.epa.gov/uic/class-i-industrial-and-municipal-waste-disposal-wells

Note also that the Potosi formation has taken 50 Mt equivalent of chemical waste fluids in Tuscola, Ill, close to the Border.

Why NW Indiana?







Illinois Basin outline from Swezey, C., Hatch, J., Brennan, S., East, J. A., Rowan, E., Repetski, J., Charpentier, R. R., Cook, T. A., Klett, T. R., Pollastro, R. M., & Schenk, C. J. (2007). Assessment of undiscovered oil and gas resources of the Illinois Basin, 2007. *U.S. Geological Survey Fact Sheet, 2007-3058, 1-2.*

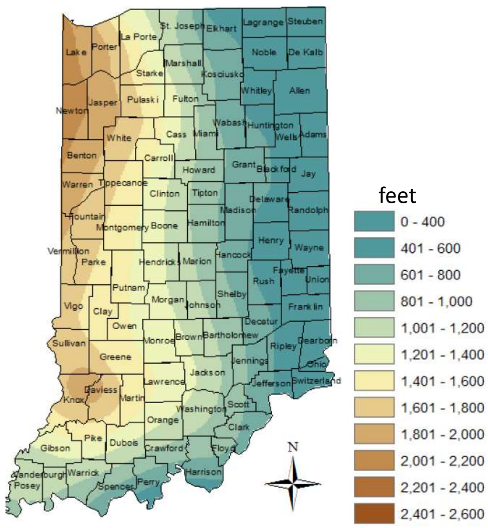
Estimate of the Potential technically accessible storage from the data for the Illinois Basin from Table 2 of Team, U. S. G. S. G. C. D. S. R. A. (2013). *National assessment of geologic carbon dioxide storage resources—Results (ver. 1.1, September 2013). https://pubs.usgs.gov/circ/1386/*
This estimate includes those formations

Simplified cross section of the Illinois Basin from
https://www.sharpeoilandgas.com/ILBGeo.html

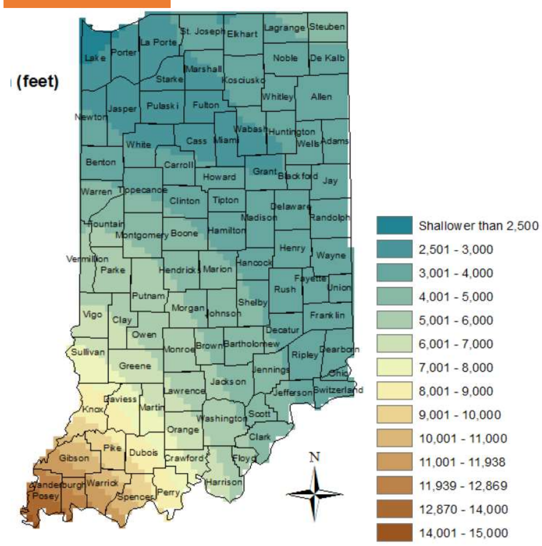
3D view from Ellett, K., Zhang, Q., Medina, C., Rupp, J., Wang, G., & Carr, T. (2013). Uncertainty in Regional-scale Evaluation of CO2 Geologic Storage Resources—comparison of the Illinois Basin (USA) and the Ordos Basin (China). *Energy Procedia, 37, 5151-5159. https://doi.org/10.1016/j.egypro.2013.06.430*

Mount Simon Sandstone

Thickness



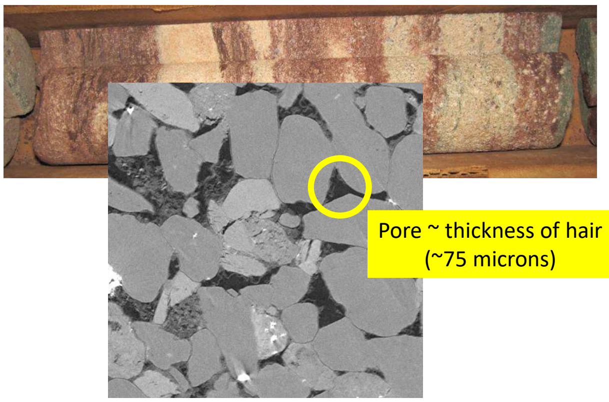
Depth



Figures from Medina, C., & Rupp, J. (2012). Reservoir characterization and lithostratigraphic division of the Mount Simon Sandstone (Cambrian): Implications for estimations of geologic sequestration storage capacity. *Environmental Geosciences, 19, 1-15. https://doi.org/10.1306/eg.07011111005*

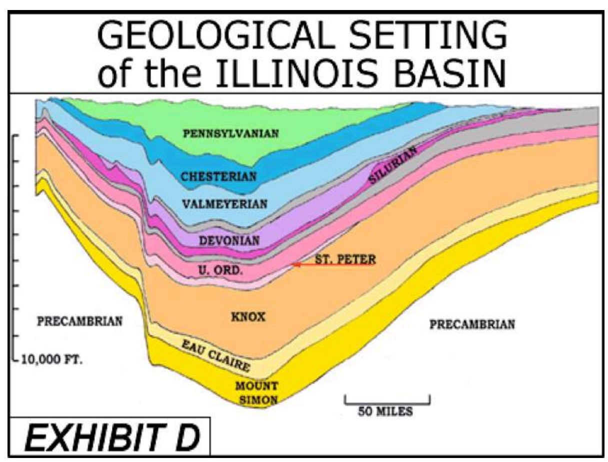
What do the Rocks Look Like?

Mount Simon Sandstone = Reservoir
- Cambrian Age (~500 Myr)
- Porosity – up to 30%
- Depth 2500’ → 3500’
- Thickness >2000’



Eau Claire Shale = Seal
- ‘Cap Rock’
- Low Permeability
- Thickness 700’ → 750’

http://www.sharpeenergyllc.com/ILBGeo.html



CO_2 Properties

Solid -109°F

Gas

Underground – Pressure & Temperature

Liquid

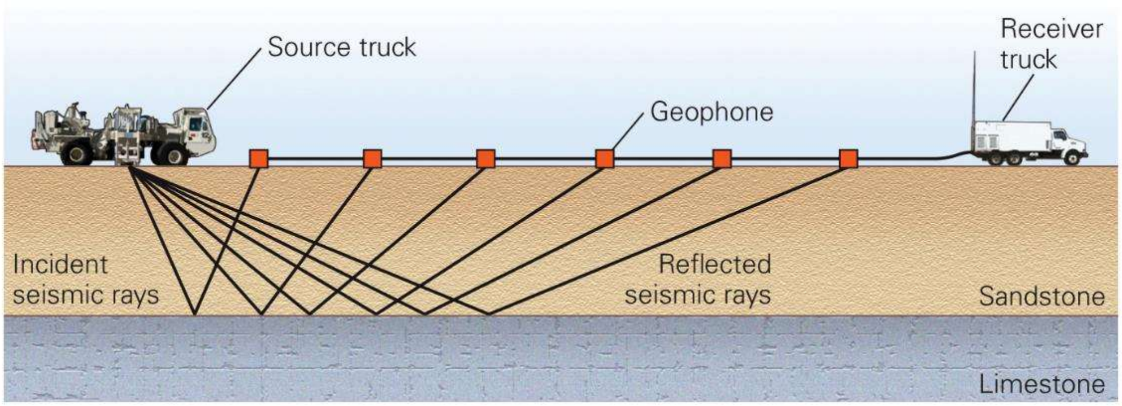
Supercritical Fluid

Properties of both gas and liquid

Density ~ 2/3 water

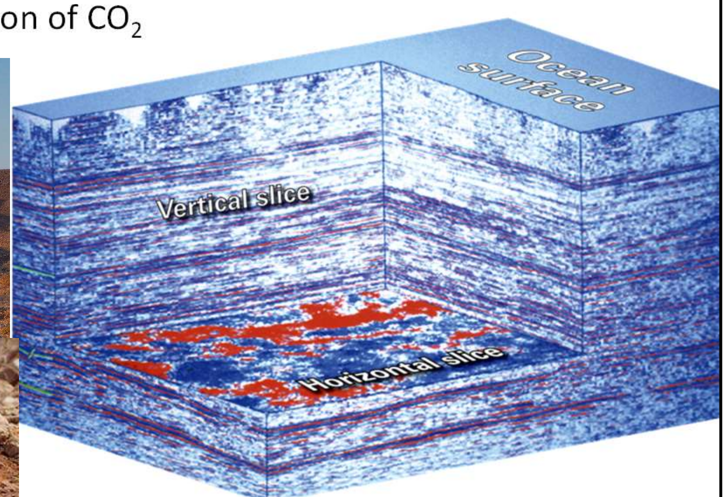
Seismic Investigations

- Active Source Reflection Seismology → Image the Subsurface



Seismic Investigations

- Active Source Reflection Seismology → Image the Subsurface
- Repeated Surveys → Track motion of CO_2



What are the Risks?

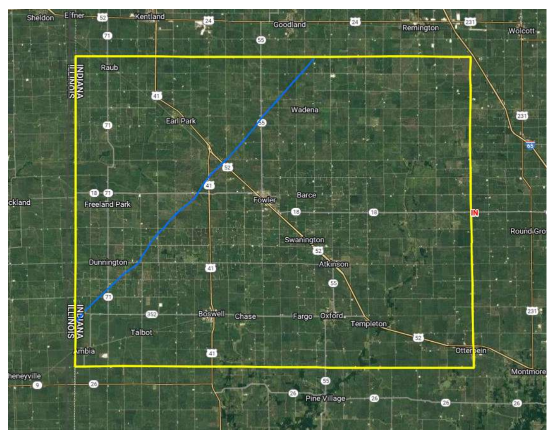
- CO_2 leaks from surface infrastructure
- CO_2 leaks from underground
  - Old boreholes poorly cemented
  - Undetected permeable faults in cap rock
- Seismicity?

What are the Benefits?

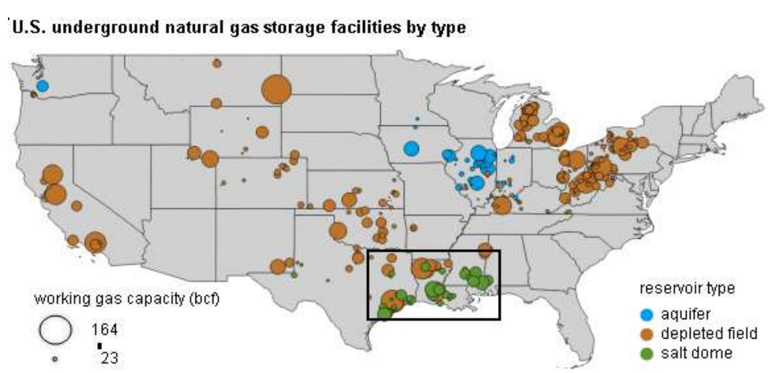
- CO_2 permanently removed from atmosphere
- 'Dependable'

Thanks for your attention!

Map from pipeline viewer at https://pvnpms.phmsa.dot.gov/PublicViewer/



Map of existing underground natural gas storage, https://www.eia.gov/todayinenergy/detail.php?id=22232



Paper on risks Anderson, S.T., 2017. Risk, Liability, and Economic Issues with Long-Term CO2 Storage—A Review. Natural Resources Research 26, 89–112.. https://doi.org/10.1007/s11053-016-9303-6

Infrastructure and Monitoring

- CO_2 pipelines (similar to existing pipelines)
- Drilling and completion
- Wellheads (+ access, plot size, etc.)
- Monitoring
  - Groundwater
  - Passive Seismic → microseisms
  - Active Seismic → movement of CO_2

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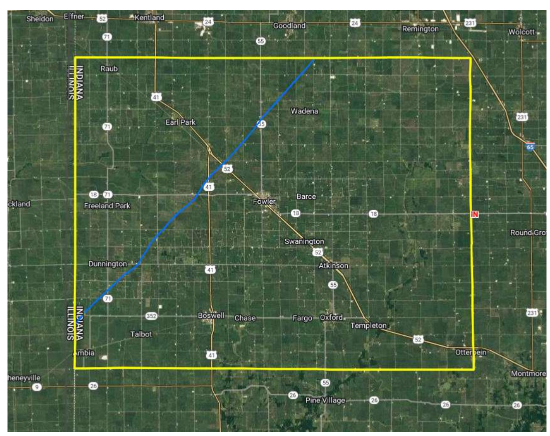
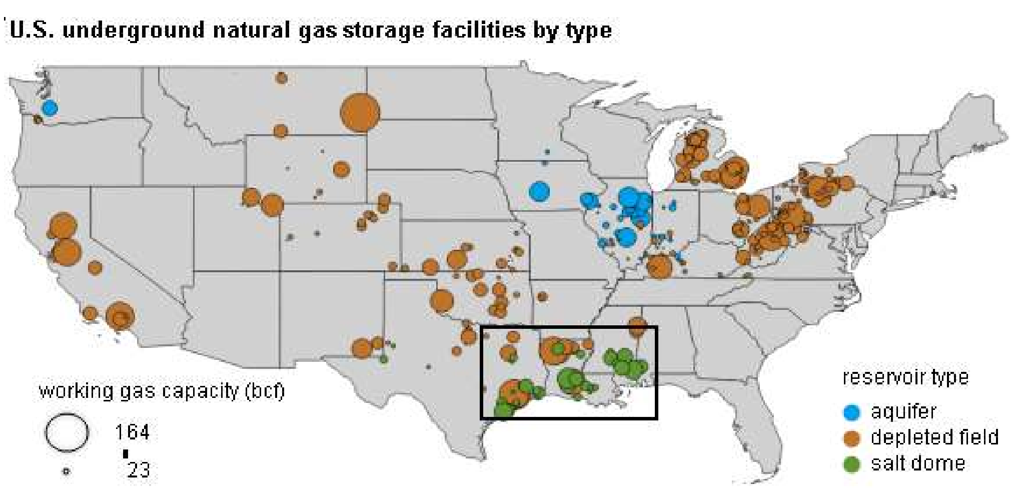
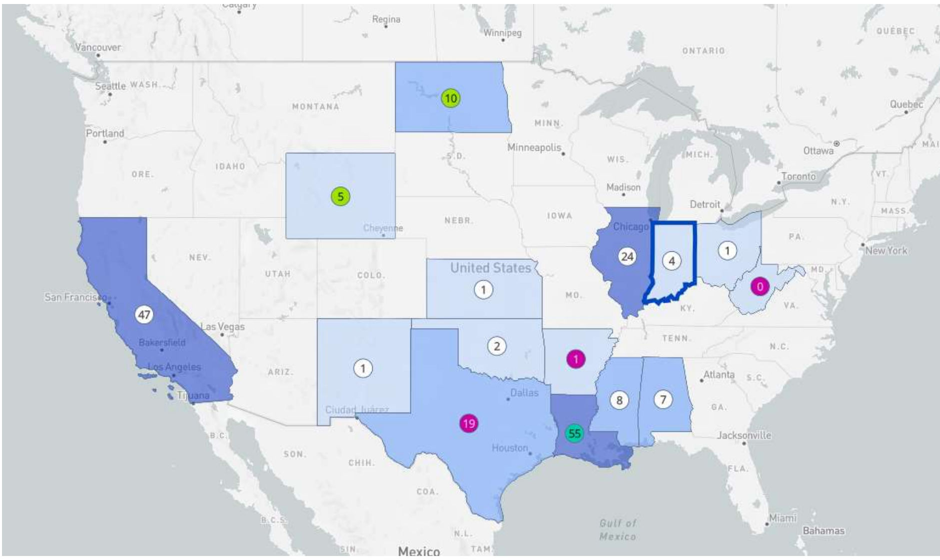
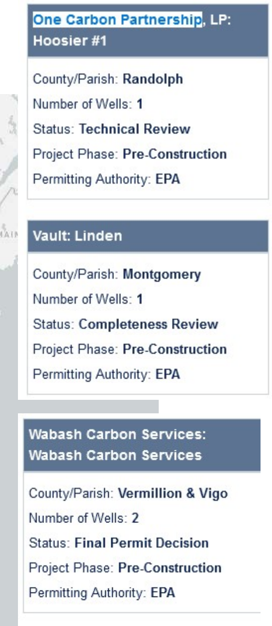




Indiana Class VI well applications





As at Nov 19, 2023

Map from website https://www.catf.us/classviwellsmap/ accessed Nov 19, 2023.
See also https://www.epa.gov/uic/current-class-vi-projects-under-review-epa