

Lessons Learned from Drilling an Exploration CO₂ Injection Well Near the Cholla Power Plant, Holbrook, Arizona

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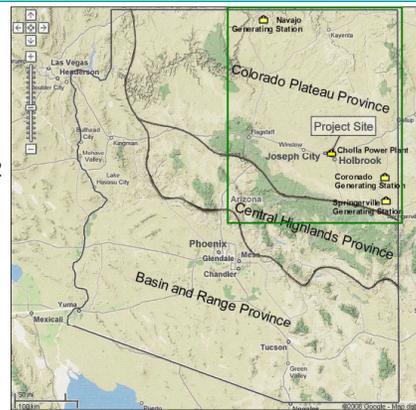
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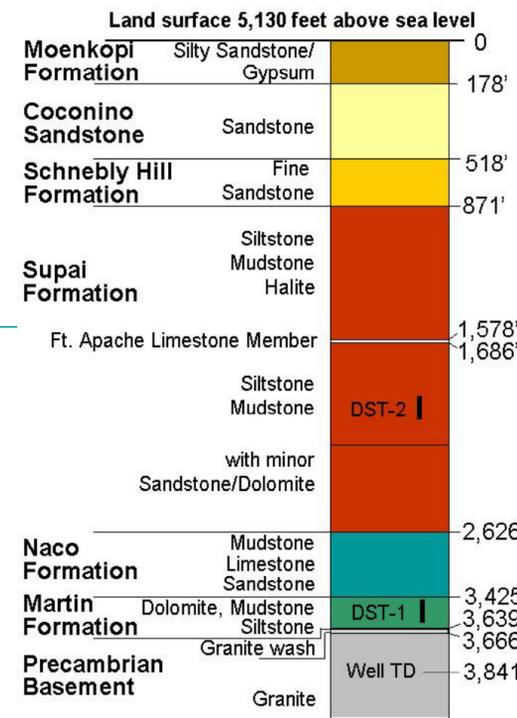
Background

- Within WESTCARB, Arizona (AZ) is the state with the 2nd largest CO₂ emissions after California
- 4 coal-fired power plants in NE AZ emit ~40 MM tons/yr of CO₂
- The Colorado Plateau in northeastern AZ is a stable geologic province with a thick sedimentary section
- WESTCARB drilled a Phase II exploratory well near the southern plateau margin on Arizona Public Service Co. land
- The target reservoir, the carbonate Martin Formation, had negligible permeability



Potential carbonate reservoirs present high permeability/porosity risk in the region

- Exploratory drilling in areas with few wells is always risky
- Observed stratigraphy was consistent with expectations, but porosity and permeability of the target formations were much lower than expected
- This suggests that carbonates in the region may have heterogeneous reservoir properties



Stratigraphic test wells without CO₂ injection may be a cost-effective exploration strategy

- Permitting for a small-scale CO₂ injection test was slow and expensive
- A stratigraphic test well could have been permitted quickly and would have provided core and fluid samples, logs, and permeability-thickness data from drillstem tests
- This approach may prove cost-effective in geologically risky areas with few existing wells and/or carbonate target reservoir formations

Two different injection permits required in Arizona

- EPA Underground Injection Control (UIC) permit required in AZ to protect aquifers with less than 10,000 mg/l total dissolved solids
- AZ also requires an Aquifer Protection Program (APP) permit from the Arizona Department of Environmental Quality (ADEQ). This program protects virtually *all* subsurface water, *regardless of salinity*
- Regulations tailored for CO₂ sequestration are needed for commercial-scale carbon capture and storage (CCS) in Arizona



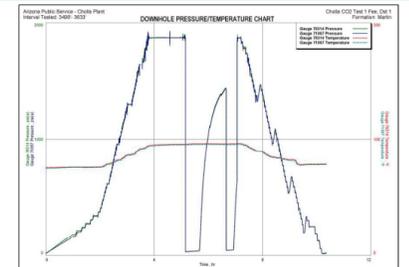
Drillers in Arizona need a state contractor's license

- Drilling contractors need an AZ contractor's license to operate independently; it is not trivial to get
- AZ has little oil and gas, so few big rig drillers operate there. Out-of-state drillers that bid on the WESTCARB well were unaware of the requirement
- This could be an issue in other states without hydrocarbon resources



Drillstem test (DST) shows reservoir permeability – before paying to case well

- A DST over 135 feet of the target Martin Formation produced negligible fluid returns (“no blow”)
- DST and log data showed no permeable reservoir options below supercritical CO₂ depth of 800 meters (2,600 feet)
- WESTCARB abandoned the project without paying to case the well, saving a major part of the budget



DST-1 over Martin Formation, 3,498–3,633 ft. Radial flow did not develop. Permeability too low to measure

A site access agreement can be difficult and slow to negotiate

- In spite of a cooperative land owner, indemnification clauses and liability insurance were difficult
- Particularly problematic for WESTCARB's self-insured governmental entities, LBNL and the USGS

Public acceptance based on local issues

- The primary concern was the impact of possible CO₂ regulations on local jobs related to the power plant
- With Arizona Public Service, a large local employer, providing a site for the well, there was no opposition to the project at public meetings, just curiosity
- Most people were not concerned about, or did not believe in, global warming



Drilling near the APS Cholla Power Plant fly ash pond, August 2009
Photo: R. Trautz

On a positive note

- EPRI developed a consortium of Arizona utilities and a coal supplier as WESTCARB industry partners
- EPA Region 9 and ADEQ worked cooperatively with WESTCARB on the Class V UIC and APP permits
- We resolved institutional and NEPA issues to site a CCS exploration well at the Cholla Power Plant, thanks to Arizona Public Service Company
- We successfully drilled and tested the first exploratory CCS well on the Colorado Plateau



Looking ahead to a geologic characterization well in the Black Mesa Basin

- Sedimentary section is 7,000 feet thick; primary target is the Tapeats Sandstone (not present at Cholla site)
- Site is on Hopi Land, 60 miles north of the Cholla site
- Data sources: cores, reservoir fluids, logs, DST, step-rate injection test (SRT), leak-off test
- UIC permit required for SRT; no ADEQ permit on Indian land

