Exploring Geologic CO_2 Storage in Arizona

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Arizona power companies are in a predicament. On one front, population growth has led to substantial rise in demand for electric power. If recent trends continue, this demand will increase about 3.6 percent per year in Arizona and electricity consumption will double in about 20 years (Western Resource Advocates, 2007). With abundant coal resources in Arizona's Black Mesa Basin and elsewhere in the western interior, utilities have turned to coal-fired generating plants as the dominant power source. Yet coal is the largest anthropogenic emitter of carbon dioxide (CO_2) globally, and pending legislation would regulate carbon emissions by imposing significant limits on conventional coal-power generation. Consequently, reliance on coal power may be viable in the future only if conventional or next-generation, advanced-technology coal plants can achieve carbon capture and geologic storage. Moreover, from an industry perspective, investment in costly capture technology would be considered only under reasonable assurance that production-scale CO_2 emissions could be safely and reliably stored underground. Thus, a critical first step is testing geologic sequestration of CO_2 at a very small scale where the process can be carefully studied.

The Starting Point

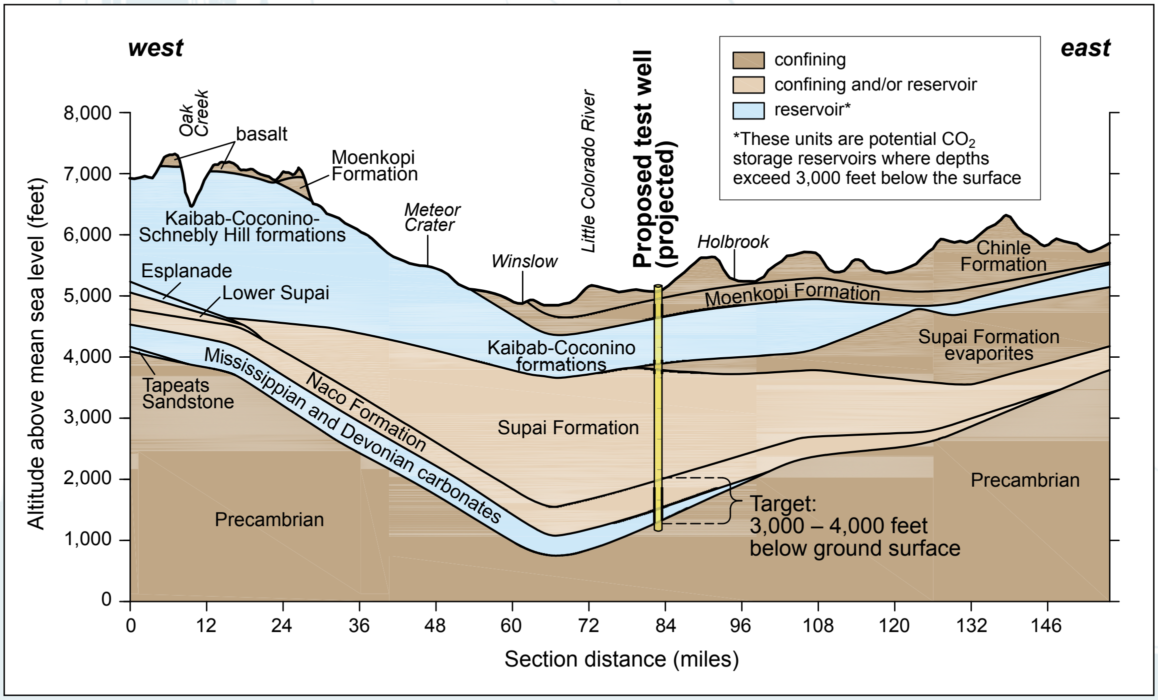
In Arizona, the Colorado Plateau Province is the obvious starting point to evaluate geologic storage of CO_2. According to the Department of Energy, six large coal-fired electrical generating stations operating in this region produce over 70 million tons of CO_2 annually, or roughly three percent of overall CO_2 emissions from the electric power sector. Over a billion tons of high-quality coal are found in shallow, mineable deposits in the Black Mesa area alone.

The Colorado Plateau in Arizona is underlain by a thick sequence of nearly flat-lying sedimentary strata with multiple potential reservoirs in the Paleozoic section that may be suitable for long-term CO_2 storage. The reservoirs range in depth from approximately 3,000 to 7,500 feet and are capped by thick and regionally extensive shale confining beds. However, hydrologic conditions and water quality in the plateau are poorly known in all but the uppermost aquifer.

To evaluate potential CO_2 storage in this area, Arizona industry partners have teamed with the West Coast Regional Carbon Sequestration Partnership (WESTCARB) to conduct the Arizona Utilities CO_2 Storage Pilot. The pilot project entails drilling, constructing, and testing one injection well for CO_2 storage. The proposed well is an experimental technology well to allow the WESTCARB consortium to gather information on the geology and suitability for CO_2 sequestration in the Holbrook Basin and in areas with similar geology in the southern Colorado Plateau. Sponsoring industry partners include Arizona Public Service Company (APS), Salt River Project, Tucson Electric Power, Arizona Electric Power Cooperative, and Peabody Investments. Project funding, in kind services, and/or technical contributions are provided by the California Energy Commission, U.S. Department of Energy, Lawrence Berkeley National Laboratory (LBNL), Electric Power Research Institute (EPRI), and the five industry partners. The total project budget is $5.5 million.

Site Selection

Based on regional geologic and hydrologic conditions (Montgomery & Associates, 2007), a site at the APS Cholla Power Plant near Joseph City, Arizona was selected for the pilot project. Two important factors were pivotal in selecting the site. First, of all land in the Colorado Plateau of northeastern Arizona outside the Navajo Nation and Hopi Indian Reservation, this area offers the best potential for CO_2 storage. Second, highly saline conditions present



East-west regional schematic geologic cross-section of the WESTCARB CO_2 sequestration pilot project.

in the uppermost aquifer suggest that underlying groundwater in potential CO_2 reservoirs will also be saline.

The well site selected for the demonstration project offers: 1) target reservoirs in the Pennsylvanian Naco Formation and the Devonian Martin Formation (a primary target; see diagram below left), which likely have saline groundwater conditions and possibly have permeability and porosity suitable for CO_2 storage; 2) sufficient depth of burial and hydrostatic head for CO_2 storage as a supercritical fluid; 3) extensive overlying fine-grained confining beds to prevent vertical leakage of CO_2; 4) access to or near the site on paved roads; and 5) an easement for land use and ease of permitting through the cooperation of APS.

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Drilling, Completion, and Testing

The test well will be drilled into Precambrian basement rock at a depth of approximately 4,000 feet using conventional mud-rotary drilling. LBNL and EPRI scientists have engaged Sandia Technologies of Houston, Texas, and Montgomery & Associates of Scottsdale, Arizona, to oversee and manage the well-drilling and testing program. As property owner, APS obtained a drilling permit from the Arizona Oil and Gas Conservation Commission (AOGCC), a temporary aquifer protection permit from the Arizona Department of Environmental Quality, and an underground injection control permit from the U.S. Environmental Protection Agency for the planned CO_2 injection pilot test. Well drilling began in July.

Well completion plans (Sandia Technologies and Montgomery & Associates, 2009) call for setting and cementing a conductor casing followed by drilling a 12¼-inch borehole into the upper Supai Formation to a depth of around 965 feet. A protective surface casing will be installed to isolate the wellbore and regional C-Aquifer from underlying saline groundwater. The surface casing will be equipped with a pressure-seal assembly for required pressure testing and subsequent blow-out prevention. The remaining borehole will be drilled with an 8½-inch drill bit using a salt-based mud.

Due to uncertainty regarding the adequacy of downhole conditions for CO_2 injection in the Naco and Martin formations, one or two drill-stem tests are planned to isolate each formation during drilling to obtain interval-specific information on formation pressures, water quality, and permeability. Upon reaching total depth, a full suite of geophysical logs will be obtained in the uncased borehole, and sidewall cores will be collected from selected intervals. If field data confirm adequacy of the injection intervals, a 5½-inch protective casing will be set and cemented in the borehole and zones will be selected for perforation of the casing.

And Finally, Injection

Field and laboratory data obtained from the test well, such as water quality and petrophysical properties, will be evaluated to determine if the pilot CO_2 injection test should proceed. If testing confirms saline groundwater exists in sufficiently permeable zones within the Martin and/or Naco formations, up to 2,000 metric tons of food-grade CO_2 will then be transported by truck to the site and injected into the completed well. Injection will occur in targeted zones between depths of 3,200 and 3,700 feet within the perforated casing. Vertical seismic profiling and formation fluid sampling of the injection well will be conducted prior to and for three to five months after the end of CO_2 injection.

The CO_2 used in this test is the amount generated by a typical 1,000-megawatt coal-fired power plant in approximately 2.2 hours. Although this amount is quite small, the pilot project will provide critical information about the injectivity of CO_2 into the geologic formation, test numerical modeling codes that estimate the extent and stabilization of the CO_2 plume, measure changes in water chemistry within the formation, test and demonstrate methods for monitoring the location of the CO_2 plume, and estimate the amount of the injected CO_2 that dissolves in the reservoir water or becomes immobilized in the formation. Upon completion of testing, the injection well will be plugged and abandoned, or preserved as a monitor well under APS ownership. ■

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References

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