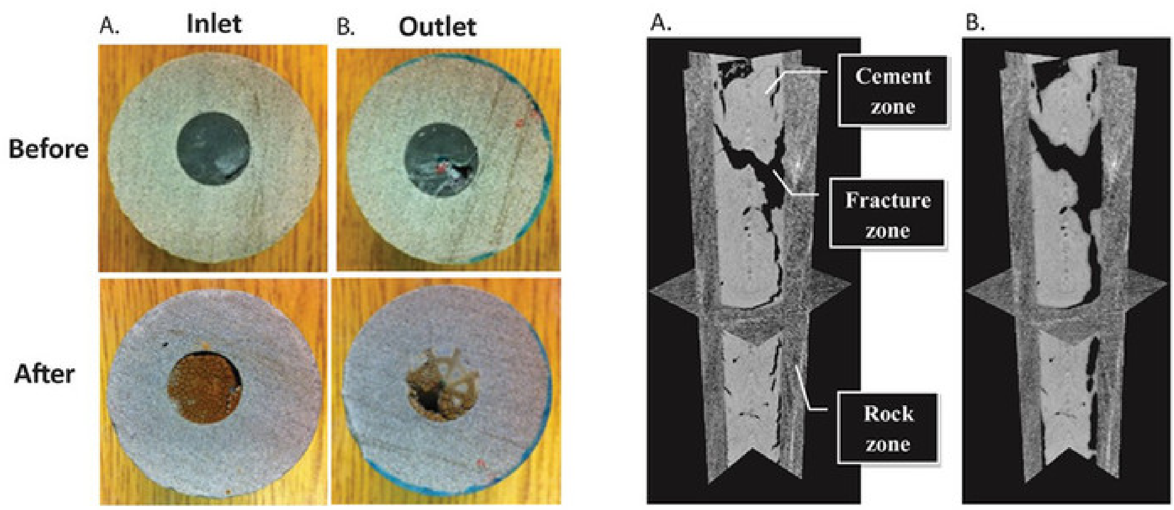
Cracks in abandoned wells could hinder carbon sequestration efforts

December 15 2015, by Liam Jackson



Penn State professors Zuleima Karpyn and Li Li are researching the impact of abandoned wells on underground carbon sequestration into saline aquifers. On the left is a piece of a cement well they recreated for laboratory testing; 'A' shows the well prior to sequestration, and 'B' shows the well eight days after sequestration. On the right are images of the cement created with a high-resolution scanner that allow the researchers to track whether cracks in the abandoned wells are worsening or healing during the sequestration process. Credit: Zuleima Karpyn and Li Li / Penn State

In search of ways to reduce greenhouse gas emissions, engineers are investigating the feasibility of sequestering carbon dioxide in saltwater aquifers deep underground. New Penn State research suggests that cracks in abandoned oil and gas wells, depending on their size and other factors, may impede sequestration efforts.

"Underground saline aquifers are one of the most promising destinations for sequestered carbon dioxide because they are abundant all over the world and they have very little use to society," said Zuleima Karpyn, associate professor of petroleum and natural gas engineering and Quentin E. and Louise L. Wood Faculty Fellow in Petroleum and Natural Gas Engineering.

"The general idea of sequestration into saline aquifers is to inject carbon dioxide deep into the Earth's subsurface to reduce emissions into the atmosphere. But if you inject it into the ground and it escapes, not only are your efforts in vain, but the carbon dioxide could also seep into groundwater or aquifers, making the water acidic and potentially causing other environmental issues," said Li Li, associate professor of petroleum and natural gas engineering.

To sequester carbon dioxide, the gas must be captured from power plants before it escapes into the atmosphere, and pressurized until it behaves like a liquid. The carbon dioxide is then injected into a saline formation underground—typically more than 1,000 meters deep, where the high pressure forces the carbon dioxide to maintain its liquid-like behavior.

"Carbon dioxide is highly soluble in saltwater, so some of it will dissolve. Over time, some will precipitate out as minerals such as calcium carbonate, and the minerals won't leak into the atmosphere. However, the dissolved carbon dioxide can create problems if it comes into contact with cement from abandoned wells," said Karpyn. Carbon dioxide dissolved in water often forms carbonic acid, which can dissolve cement and other hard structures.

Cement was used to form the walls of active wells, and to fill in many wells when they were abandoned. The cement in abandoned wells may be cracked, providing a potential escape route for carbon dioxide. There have been no definitive studies to count the number of abandoned wells existing in the U.S., but researchers estimate there are 200,000 in Pennsylvania alone.

Some past research has shown that injection of carbon dioxide into saline aquifers tends to heal cracks in abandoned wells while other studies suggest the practice makes cracks worse. The Penn State team set out to understand this discrepancy. They recreated the underground environment in a laboratory and, using X-ray microtomography, obtained high-resolution images of carbon-dioxide-rich saltwater interacting with the cement walls. The team then created a computer model to analyze hundreds of variations of their experiment.

Results of their studies, recently published in journals including *Water Resources Research*, suggest that the size of the cracks and the amount of time carbon dioxide is in contact with cement are predictors for whether a crack will self-heal or open up. When the contact time is long, meaning that slower-moving water flowed across long cracks, minerals were allowed to precipitate and adhere to and fill in gaps in the cement, leading to a self-healing crack. In contrast, fast-moving water in short cracks provided replenishment of carbonic acid in the solution, dissolving the cement and eventually opening up the cracks.

The researchers' findings could have implications for whether carbon sequestration in saline aquifers is a viable solution for reducing carbon dioxide emissions.

"As underground wells age, they are subject to geothermal heating and cooling from Earth's natural processes, which means they may crack over time. By observing and modeling what happens in in a laboratory under similar pressure and temperature conditions as in the deep subsurface, we're able to get a clearer picture of what actually happens deep underground," said Li.

More information: Peilin Cao et al. Self-healing of cement fractures under dynamic flow of CO -rich brine , *Water Resources Research* (2015). DOI: 10.1002/2014WR016162

Provided by Pennsylvania State University