LETTER

No geologic evidence that seismicity causes fault leakage that would render large-scale carbon capture and storage unsuccessful

In a recent Perspective (1), Zoback and Gorelick argued that carbon capture and storage (CCS) is likely not a viable strategy for reducing CO_2 emissions to the atmosphere. They argued that maps of earthquake epicenters portray earthquakes occurring almost everywhere, suggesting that Earth's crust is near a critical state, so that increments in fluid pressure from injecting CO_2 at 1 to 3 km depth will likely trigger earthquakes within the reservoir and caprock that would be expected to result in leakage of CO_2 from the reservoirs to the surface.

Vast Majority of Earthquakes Are Much Deeper Than CO_2 Storage Reservoirs

Zoback and Gorelick (1) articulated an important, albeit well-known, concern: CCS may induce seismicity (e.g., ref. 2), as can other subsurface technologies (3). However, their characterization of seismic activity misrepresented its relevance to CCS. What is important is not epicenters (2D location on a map), but hypocenters (3D location, including depth). In fact, most hypocenters in the continental crust are in basement rock at 8 to 16 km depth (e.g., ref. 4), with only a very small fraction of them occurring in sedimentary cover at depths shallower than 3 km, where CO_2 would be stored. The rheological properties of shallow sedimentary formations usually allow them to undergo substantial deformation without establishing leaking pathways or localized faults, in contrast with brittle basement rocks.

Hydrocarbon Reservoirs Have Existed for Millions of Years in Regions of Intense Seismic Activity

Zoback and Gorelick (1) stated that seismic activity would compromise containment of the CO_2, and result in CO_2 leakage to the surface. For justification, they referred to laboratory studies on granitic rocks—conditions that are not relevant for CCS. In reality, large volumes of buoyant fluids have remained stable in geologic traps over millennia in regions experiencing strong and frequent earthquakes, like southern California, even under substantial overpressures. If ubiquitous earthquake-induced leakage occurred, there would not be large quantities of natural gas still present in the subsurface.

Site Selection Is Key

Although there are geologic settings in which induced earthquakes and leakage risk could compromise a CCS project (they mention the Mountaineer project), this says nothing about the many geologic formations that exhibit excellent promise for storing CO_2. Zoback and Gorelick (1) presented their conclusion that CCS will likely be unsuccessful without an analysis of the many suitable geologic formations available. In contrast, a recent study suggests that deep saline aquifers exist throughout the United States that can accommodate the CO_2 migration and pressure increases associated with large-scale injection at the century time scale (5).

Summary

The facts that sedimentary cover rarely is the source region for earthquakes and that shallow overpressured hydrocarbon reservoirs coexist with deep basement seismicity do not support Zoback and Gorelick's conclusion that moderate-size earthquakes necessarily threaten seal integrity to the point of rendering CCS unsuccessful (1). We do not argue that the issues they raised are immaterial, but, rather, that more work on the physics of induced seismicity, fault activation, and geologic characterization in the context of CCS is needed.

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