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Microseismicity monitoring at the Decatur, IL, CO_2 sequestration demonstration site

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Industrial-scale carbon capture and storage (CCS) will require the injection of large volumes of CO_2 into extensive undisturbed brine aquifers. Large-volume injection has the potential to induce earthquake activity (Zoback and Gorelick, 2012). To assess the seismic hazard posed by one such operation, the USGS has been monitoring seismic activity at a CCS demonstration site in Decatur, IL, where supercritical CO_2 is injected into the Mt. Simon Sandstone, a basal brine formation, at a depth of about 2 km, several 10s of meters above granitic basement. During the first phase of injection, supercritical CO_2 was injected at a rate of about 1000 metric tons/day from November 2011 until November 2014. The USGS monitored microseismicity using a seismic network that consists of 16 stations (4 in 500 ft boreholes). The USGS data set contains 179 locatable events and shows that the microseismicity occurs in the Mt Simon sandstone injection interval and, to a lesser degree, in the pre-Mt Simon and the Precambrian basement. Microseismicity occurs in distinct clusters at varying distances from the injection well and distance from the well does not increase systematically with time. Double difference relocations of these events reveal that these clusters tend to form linear features in both the Mt. Simon and the basement, suggesting that the microseismicity involves reactivation of preexisting fractures and faults. This finding is corroborated by composite focal mechanisms for individual clusters that are consistent with the regional horizontal principal stress orientations and right-lateral slip across the reactivated faults and fractures. Despite the injection of nearly one million tons of CO_2 the largest microearthquake magnitudes barely exceeded 1 and, thus, none of these events could be felt at the surface.

During the second phase, injection down a second borehole will be at a rate of about 3000 metric tons/day starting in early 2016 and continue for three years. To augment our monitoring capability, we have added three additional shallow borehole stations to the USGS network; additionally, the deep borehole network deployed by the Illinois State Geological Survey, Schlumberger Carbon Services and Archer Daniels Midland will be combined with the USGS network for a total of 51 individual sensors. We anticipate that the addition of the new stations will substantially improve our event detection and location capabilities.