Integration of Induced Seismicity with Subsurface Fault Interpretations at the Illinois Basin — Decatur Project

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Abstract

Observed seismicity at fluid injection sites has raised the awareness of the potential for felt and damaging seismicity with ongoing injection. Prior knowledge of the existence of faults that may be susceptible to earthquake-inducing slip and characterization of the reservoir stress state is crucial for assessing seismic hazard. Monitoring of CO2 injection at the US Department of Energy funded Illinois Basin - Decatur Project (IBDP) has shown that reservoir behavior can vary significantly at different injection locations within the same basin. Data acquired from this site allows identification of the factors controlling induced seismicity, leading to successful mitigation of any associated hazard. Interpretations of newly reprocessed 3D seismic illustrate the challenges related to identification of faults with induced seismicity potential in a region dominated by oblique and strike-slip failure. The vertical displacement on these faults is often near the limit or below the resolution of the seismic reflection data. Induced seismicity is fully in the microseismic range with event magnitudes lower than Mw 1.3. Using source mechanisms derived from the semi-sparse seismic monitoring network installed at the surface around the IBDP injection site, we have estimated the sizes of the failure planes along which failure has occurred. The maximum failure plane size is small (100s of square meters) in relation to the depth of the reservoir (>2000 meters), and likely represents only a small part of the entire fault surface on which failure occurred. Our modeling addresses the question of whether continued injection at high rates to sequester large volumes of CO2 could lead to larger slip surfaces or to growth of the existing fault planes, and in turn to much larger earthquakes. We integrate basin

history, possible deformation styles, and analyses of naturally occurring and induced seismicity to develop a structural model of faulting and induced or reactivated fracturing from which hazard scenarios can be built.