What caused the induced seismicity at Castor?

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Abstract

The induced seismicity at the Castor Underground Gas Storage (UGS) project presents features that challenge the identification of the triggering mechanisms: (1) it includes the three largest earthquakes (two exceeding magnitude 4) ever induced in an UGS project, (2) the largest earthquakes occurred 20 days after the stop of gas injection, and (3) the earthquakes were induced in a critically stressed fault placed much deeper than the storage formation, away from the pore pressure perturbation region. It is evident that the typically assumed triggering mechanism of pore pressure buildup played a minor, or indirect, role in inducing the largest earthquakes. We have recently proposed a combination of triggering mechanisms that explain the observed induced seismicity at Castor (Vilarrasa et al., 2021). During cushion gas injection, both pore pressure buildup and buoyancy of the injected gas aseismically reactivated the critically stressed Amposta fault, which bounds the storage formation. After the stop of injection, buoyancy continued destabilizing the Amposta fault, accumulating aseismic slip due to creep. The slip of the Amposta fault caused stress redistribution that brought to failure conditions a critically stressed fault in the brittle crystalline basement. This deep fault induced the large earthquakes, with transient deformation-induced pore pressure changes controlling the delay between earthquakes. A thorough site characterization and monitoring could have anticipated the high risk of inducing seismicity at Castor.

Reference