Identifying at Risk Areas for Injection-Induced Seismicity Through Subsurface Analysis of Southern Kansas

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ABSTRACT

The U.S. mid-continent has experienced an unprecedented increase in seismicity linked to large-scale injection of wastewater. For stakeholders, poor resolution of subsurface faults and associated hazards has posed a challenge for siting and operating injection wells. This study focuses on using publicly available well data to map subsurface faults, lineaments, and present-day stresses in southern Kansas, with the ultimate goal of identifying specific structures and regions that may be at higher risk for injection-induced seismicity. A database of >500,000 stratigraphic well-tops from the Kansas Geological Survey was used to create new structure contour maps of 18 stratigraphic boundaries between the Precambrian basement and present-day surface. The tops data have varying spatial density, with counts per boundary ranging from 10,000 to 40,000 picks. The well tops were quality controlled for visual outliers and then interpolated using convergent interpolation, kriging, moving average, and minimum curvature methods. The maps were then compared against each other for spatial continuity and geologic accuracy to select the most reasonable data interpolation technique: convergent interpolation. Through a range of 3D surface analysis techniques, subsurface lineaments with two major trends were delineated across the study region. NNE-trending structures are likely related to the Nemaha Ridge-Humboldt fault zone and earlier Mid-continent Rift System, while NW-trending structures are probably associated with the Central Kansas Uplift. Subsurface stresses were examined using 13 image logs and approximately 201 caliper logs. In regions with lower data density, dipmeter logs and inversion of earthquake moment tensor solutions will be used, where available. Drilling induced fractures (DIFs) suggest a consistent an ENE maximum horizontal stress. Variability in orientations comes from logs with very low DIF counts (2-5 DIFs). Borehole breakout analysis indicates that the orientation of the minimum horizontal is NNW, orthogonal to the orientation of DIFs. These findings are being used to assess the reactivation potential of the mapped faults, and will be evaluated in conjunction with brine disposal data, to identify areas at risk for injection-induced seismicity.