Multidisciplinary Geomechanical and Geophysical Characterization of the Coupled Arbuckle Basement System, Payne County, Oklahoma

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ABSTRACT

Resource plays such as the Mississippian Limestone of Oklahoma and Kansas are characterized by 95% hypersaline water production. Although Oklahoma is currently covered by thousands of water disposal wells, it is only the north-central part of the State that has experienced a recent increase in seismicity. In addition to the Arbuckle-basement system of Oklahoma, type II water disposal wells have also been correlated with induced seismicity in California and Texas. The State of Oklahoma Underground Injection Control division recognizes three necessary components for significant injection-induced seismicity: sufficient pressure buildup from disposal activities, faults, and a pathway allowing the increased pressure to communicate with the faults.

This study integrates modern 3D seismic, well, and production data from Payne County, Oklahoma, to establish a stratigraphic and structural framework for Arbuckle-basement system as well as the overlying sedimentary section to the ground surface. We use seismic data conditioning and seismic attributes to better map structure, stratigraphy, and large-scale diagenetic features of the Arbuckle, such as collapse structures. Geostatistically derived 3D petrophysical models that are constrained to this framework and well data illustrate the spatial distribution of shear velocity, compressional velocity, bulk density, and porosity. The models are inputs for geomechanical analysis of the stress field and flow behavior. Well pressure and water-injection data provide estimates of ambient reservoir pressure showing some wells have been plugged, reducing injectivity. Such estimates also correlate with fault imaging seismic attributes, suggesting potential links with geological structures.