Applications of Coupled Mechanical Deformation-Pore Pressure Diffusion Modules to Overpressure and Petroleum Systems in the Delaware Basin, west Texas

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Many of the world's important sedimentary basins are located in tectonically active regions. Implications range from the affects deformation has upon petroleum systems and basin-wide fluid migration to the potential for earthquakes to damage wells or production facilities. We demonstrate the use of two types of mechanical deformation-pore pressure diffusion models to investigate the response of pore fluids to transient dynamic strain.

This research models compaction-driven fluid flow in the Delaware Basin in conjunction with geochemical analysis and petrophysics data to examine overpressure conditions and its role on hydrocarbon migration. Initial overpressure conditions in the Delaware Basin were created by rapid sedimentation and disequilibrium compaction during the late Permian. Overpressure is still presently detected despite a lack of significant sedimentation over the past 250 million years. Numerical modeling suggests that continued hydrocarbon generation within shale source beds are most likely responsible for overpressure maintenance and furthermore, provide evidence that such large pressure gradients could drive long-distance hydrocarbon migration from deep source beds eastwards into the east Delaware Basin and westwards to the Central Basin Platform. Geochemical analyses of crude oil samples suggest a strong genetic correlation between oils from source rocks in the eastern Delaware Basin and those in reservoir rocks along the margins of the basin. In the second model application, we predict pore pressure changes associated with dynamic strain generated by strong earthquakes. The results demonstrate that overpressure induced by seismic faulting may affect regional fluid flow and hydrocarbon migration.