

Integration of Structural Analysis and Gravity Modeling in the Permian Basin, West Texas

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Abstract

The Permian Basin of West Texas and southeast New Mexico is currently the most prolific oil-producing basins in the United States. This region experienced complex faulting and fracturing followed by extreme (30-42 m/my) subsidence in both the Midland and Delaware sub-basins. Based on regional well correlations, up to 1.3 km thick syn-tectonic sediment wedges were deposited into both sub-basins from Late Mississippian to Mid Permian (320-265 Ma) with an early Permian, angular unconformity within the Central Basin Platform that separates the two sub-basins. The present-day depth to the basement of the Delaware basin is approximately 5.7 km compared to 2.7 km in the Midland basin with mature source rock dominantly of early Permian age. Compilations from published seismic lines show that Late Paleozoic faults trend sub-parallel to preexisting northwest-southeast-striking faults in the underlying Precambrian basement, which were reactivated as thrust faults. The basement faults are also identical as elongate total horizontal gravity gradient highs. In order to investigate the larger-scale geometry of both sub-basins, their tectonic origin, and their relation to the most productive source rocks in both the Midland and Delaware basins, we created a regional 2D gravity model that incorporates density and lithological controls from industry well logs drilled to the Ellenburger formation and from published seismic refraction data and sediment thickness maps. Formation tops were correlated across the Permian Basin to incorporate layer density variations between formations: Ellenburger, Fusselman, Devonian, Wolfcamp, Bone Spring, Clear Fork, and Permian. A regional 650-km-long east-west-trending gravity low called the Abilene Gravity Minimum over the northern Permian Basin has been interpreted as a belt of Early Mesoproterozoic, metasedimentary

rocks. We propose that this belt of metasedimentary rocks sandwiched between parallel zones of stronger, plutonic rocks that may have acted as a zone of weakness that accommodates shortening at depth during Late Paleozoic collision and led to rapid, syn-collisional subsidence rates in the two sub-basins. We use the gravity map to compare with thermal maturity mapped from USGS vitrinite reflectance data to locate 166 km² of mature depocenters under the deeper area of the Delaware Basin. Most of these depocenters appear isolated and disconnected from one another. Thermal maturity increases with basement depth, especially in the western Delaware Basin.