A New 3-D Structural Model and Characterization of Basement-Rooted Faults of the Delaware Basin and Central Basin Platform for Application in Understanding Recent Seismicity

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Abstract

The Permian Basin of Texas and New Mexico is an important petroleum province with a complex tectonic history. The present-day architecture of the region has been shaped by several extensional and compressional deformation events since the Proterozoic. Each subsequent event was influenced by the accumulated tectonic fabric through fault reactivation and strain-transfer. These events have generated a network of regional faults whose footprints compartmentalize the basin spatially and impact the present-day stress state. Constraining the geologic controls that influence the region's stress state is vital when considering hazards related to seismicity, both induced and naturally occurring. We have constructed a 3D faulted framework model of the Delaware Basin (DB) and Central Basin Platform (CBP) using well, reflection seismic, and earthquake data; and prior publications and have characterized its deformation patterns and identified the controlling fabrics. To the first-order, the Delaware Basin is compartmentalized by an E-W trending oblique-slip fault zone, known as the Grisham Fault (GF). Deformation south of the GF is dominated by NW and SE-trending contractile faults with characteristic relays. Secondary features include fault-propagation folds and zones with oblique-slip faults. The oblique-slip zones have small vertical offsets and acted as transpressional foci. North of the GF, the spatial density of faults and attendant deformation decreases, with the larger features being broad fault-propagation folds laterally linked by smaller oblique-slip shear zones. Across the GF the faulted margin separating the DB and the CBP changes in morphology from high-angle reverse faults, with up to 4km of structural relief in the south, to reactivated fault-propagation folds and broad, low-relief monoclinal uplifts, which gradationally step onto the CBP in the north. The overall vergence direction of deformation oscillates from NW to SE across the DB and CBP. These changes are coincident with WSW-ENE trending oblique-slip fault zones and are observed every ~10km. Structural contour and isopach maps of key tectonostratigraphic intervals have been generated to investigate the spatial and temporal growth of these structures. Fault attribute interrelationships analyses such as: fault throw-length (T-L); throw-distance (T-x); throw-depth (T-z), as well as spatial distributions of fault throws from map and strike views provide evidence for linkage and growth histories. The results from this study have significant utility for understanding the earthquakes observed to date and for assessing the future evolution of seismogenic hazard in the region.

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