Tectonic Evolution of the Paradox Basin with Insight from 3D Seismic Reflection Data

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Abstract

The Paradox Basin in southeastern Utah and southwestern Colorado has a complex geologic history that includes multiple deformational events with structural styles that were influenced heavily by the presence of extensive Pennsylvanian-aged Paradox Formation evaporite deposits within the basin. While some strata and structures have exceptional outcrop exposure, limited seismic and well data have given only a partial view of the subsurface constraints needed to fully characterize the geologic history and processes that have occurred in the basin. Because of this, open questions remain regarding the local expression of regional deformation events and their influence on local petroleum systems.

To better characterize the geometry and timing of basin deformation, we have interpreted a 40-mi2 3D seismic volume located in the northern Paradox Basin, acquired to image a hydrocarbon-rich clastic interbed of the lower Paradox Formation known as the Cane Creek interval. Significant economic resources on the order of ~10 MMBO have been produced in the central and southern sectors of the Cane Creek play while the unconventional resource potential in the northern sector is actively being characterized. The Cane Creek has a complex subsurface geometry that without seismic data would not be characterized in well planning. A tectonic evolution of the basin informed by subsurface data provides higher resolution insight into the timing and geometry of structural deformation that will aid in the ongoing and future economic exploration of the Paradox Basin.

We place these subsurface observations in the context of the geologic history of the basin and demonstrate their implications through a series of seismic images, cross sections, volume amplitude extractions, isopachs, horizons, and fault interpretations. Basement-involved faults in the pre-salt formations exhibit strike-slip geometries, indicative of a pre-Pennsylvanian deformational event. We define the Green River anticline as a detachment fold, with distributed shortening deformation in its core within the Paradox Formation. Deformation in the lower Paradox Formation accommodates shortening through a series of fault-related folds, duplexes, and wedges separated by three main detachment intervals, while the upper Paradox Formation is more fold-dominated. The shortening magnitude within the lower Paradox is variable and influenced by the position of basement faults, reflecting the influence of pre-salt paleotopography on deformation of the overlying section. By evaluating lateral thickness changes of stratigraphic packages in the post-salt section, we further characterize the geometry, magnitude, and timing of structural growth. With the added value of subsurface data integrated with regional well constraints and surface geology, we can validate and constrain the timing and manifestation of regional geologic events within the Paradox Basin and aid in well planning and drilling for future hydrocarbon exploration.

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