Geologic History and Characteristics of the Northern Paradox Basin from Integrated Analysis of Subsurface Data

Amanda N. Hughes[1], Brook Runyon[2], Aubrey Bennett[1], Eugene Szymanski[3], Michael D. Vanden Berg[3], Elliot Jagniecki[3], and Dave F. List[4]

[1]University of Arizona
[2]Harvard University
[3]Utah Geological Survey
[4]Zephyr Energy Ltd.

Abstract

Unconventional petroleum resource exploration in the Paradox Basin requires a sophisticated understanding of the tectonic basin evolution and detailed characterization of the Paradox Formation clastic intervals that comprise primary exploration targets. While unconventional resources of approximately 10 MMBO have been produced in the southern and central portions of the basin, resource potential in the northern part of the basin is actively being assessed. A new 40 mi^2 3D seismic volume located in the northern Paradox Basin permits documentation of subsurface stratigraphic aspects and structural characteristics of the basin to provide context for future exploration and production activity and prospectivity in the region. Through a series of seismic images, geological cross sections, horizon and fault surface interpretations, stratigraphic isopach maps, and derived geophysical attributes, we present detailed observations that bear on several debated issues related to the geologic features and history of the region. We demonstrate that the Green River anticline is a detachment fold that formed primarily due to contractional deformation during the Laramide, with thin-skinned, complex internal shortening within the Paradox Formation accommodating deformation within its core. We show the nature and geometry of basement-involved faults, documenting two stages of predominantly strike-slip activity prior to deposition of the Paradox Formation, and the influence of those faults on localizing subsequent deformation within the Paradox Formation and on the local geometry of the thin-skinned Little Grand Wash normal fault. We further demonstrate through identification and mapping of stratigraphic features from geophysical attributes the orientation of paleochannels within the study area and relate these to more regional paleogeographic context through integration with other datasets. Finally, we characterize the detailed geometry of structural deformation internal to the layered clastic and halite intervals of the Paradox Formation, with particular focus on the Cane Creek interval of the Lower Paradox Formation, the primary exploration target. The Lower Paradox Formation is characterized by thicker clastic intervals, deformation predominantly accommodated by thin-skinned thrust faults, fault-related folds, imbricates, duplexes, and wedges that connect slip on 4 dominant detachment intervals that occur within the halite facies of the Paradox Formation. In contrast, deformation in the Upper Paradox Formation is folding-dominated, as a function of the thicker halite interbeds. This deformation pattern is consistent with mechanical modeling to lend confidence to our interpretations. Our work characterizing the structural complexity of this exploration target demonstrates the value of high-resolution seismic imaging in exploration and production targeting in this play.