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State of Stress in Southeastern Utah

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Abstract

The Paradox basin in southeastern Utah is an emerging play for carbon dioxide subsurface storage and hydrocarbon development. Knowledge of the principal stress directions and the relative stress magnitudes is important for predicting the slip potential of natural fractures during hydraulic fracturing stimulation. Similarly, at least qualitative knowledge of the stress tensor is required to forecast the potential of fault reactivation during continuous injection for water disposal or carbon storage. Previous studies showed that the Paradox basin's stress state varies from extension (normal faulting) in the west to mild compression in the east. The presence of outcropping salt structures and interbedding evaporites in the local stratigraphy adds complexity to the stress distribution mechanisms. However, stress state resources in this area are limited and excluding one point, the relative stress magnitudes were obtained from outside the basin's perimeter. Furthermore, the updated North America stress map does not include any stress orientation data within this basin. The lack of quantitative constraints on relative principal stress magnitudes and the large gaps in knowledge of horizontal principal stress orientations created challenges for predicting fault slip potential. In the current study, we integrate recent and legacy well data and continuous seismic records to identify critically stressed faults, characterize the SHmax orientation and estimate the local principal stress magnitudes. We identified two stress measurements/calculations in the mid-northern part of the basin. Petal fractures from core data analysis, breakouts from FMI interpretation and fast shear azimuth interpretation show an SHmax orientation of ~N50°-N70°. While these values require additional validation this directional trend aligns with previous measurements that show that west of the Wasatch fault zone and east, toward the Colorado Plateau, the SHmax orientation changes from N-S to E-W. These measurements also suggest that the northern part of the basin, where major faults are perpendicular to the maximum compressive stress orientation, could have relatively lower seismic risk for carbon storage. However, major faults in the central-eastern part of the basin are oriented parallel or with an angle of 30° to the SHmax orientation; this is a scenario which might favor triggered earthquakes depending on the relative principal stress magnitudes.

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