Uinta Basin Structure and In-Situ Stress Regimes from Whole Cores and Image Logs

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Abstract

Mechanical stratigraphy, in-situ stress, and natural deformation fabrics are important reservoir properties to characterize for improved development of Green River and Wasatch Formation targets in the Uinta Basin. Understanding impacts of these factors on hydraulic fracture (frac) geometry and resultant stimulated reservoir volumes requires careful characterization from available local and regional datasets. Lithofacies almost invariably control rock mechanical properties (strong vs weak) and stress, resulting in geomechanical variation at the bed scale. Faults and natural fractures influence frac cluster and stage efficiency, fluid deliverability, and operational interference between wells. Also, present-day principal stress magnitudes and orientations influence frac geometry (height, width, length) and determine "optimal" wellbore orientations. Whole cores of Uinta Basin Tertiary strata record fabrics from diverse failure modes developed in normal-faulting, strike-slip, and thrust-faulting stress regimes, often immediately adjacent to or overprinting one another. Overprinting/reactivated features are common and provide context for interpreting the tectonic history of the region. Normal-faulting regime structures in Uinta Basin cores include compactional stylolites, vertical tensile fractures, and normal faults. Thrust-faulting regime structures include tectonic stylolites, low-angle tensile fractures (beef), and thrust faults. Strike-slip regime fabrics include tectonic stylolites, vertical tensile fractures, and occasional small strike-slip faults. Overprinting relationships between regimes are complex and require detailed characterization to establish relative timing relationships and ultimately link to well performance, as most are below well log resolution. Overall, the core fabrics document a full basin cycle of initial extension, followed by contraction (basin closure), and relaxation. To better upscale and understand regional trends, we rely on borehole image logs and facies interpretations. These techniques benefit from the context that the core work provides, allowing detailed documentation of deformation sequences (including normal-faulting, strike-slip faulting, and thrust-faulting stress regimes) in the forelands of fold-thrust belts. Borehole image logs document that in-situ crustal stress orientation changes across the basin. Western parts of the basin are in an extensional regime related to the Basin-and-Range extension (SHmax is ~N/S), while eastern portions may preserve relict Laramide stresses (SHmax is ~E/W). Where the orientation of SHmax changes, the stress appears isotropic. These principal stresses may or may not be optimally oriented to drill and stimulate naturally fractured or, alternatively, homogeneous reservoir targets. Therefore, careful characterization of reservoir deformation fabrics and geomechanical properties is necessary.