Characterization of Natural Fractures and Laramide Deformational Styles across the Tertiary Uinta Basin from Image Logs and Whole Core Studies

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Abstract

Tertiary Uinta Basin strata record a tectonic cycle from deposition and burial, through at least one contractional event, and final extensional relaxation. We summarize a regional image log dataset to characterize natural fractures across the Uinta Basin, then draw from whole core studies to constrain relative timing relationships. More than 75 resistivity image logs that cover the Wasatch, Green River (GRRV), and Uinta Formations, constrain the types, failure modes, & orientations of natural fractures across the field. The most common variety are bed-bound, opening-mode, resistive traces, which are interpreted as calcite-healed. Additional populations of conductive (open) and mixed conductive/resistive fractures are typically also present, with sub-populations of shear fractures (microfaults). Significant faults are rarely observed. Conductive (open) fractures are more commonly observed in shallower intervals, while overall fracture intensity increases in the deeper intervals and is strongly associated with the mechanical stratigraphy. Significantly higher fracture intensity is seen in wells proximal to a regional structure. Considerable scatter of natural fracture orientations is observed on all image logs; nevertheless, the dominant orientations change across the basin. In the southeastern Uinta Basin, the dominant natural fracture population trends NW/SE, parallelling the deep margin of the Uncompahgre Uplift (as seen on seismic/gravity). From east to west, the dominant orientation changes systematically from NW/SE to W/E, remaining parallel to the Uncompahgre margin. The western & northern parts of the basin show a dominant NNW/SSE natural fracture orientation, although a prominent W/E set is also present. A study of selected GRRV and Wasatch whole cores reveals a protracted deformational history that occurred during and shortly after Eocene deposition. Deformation fabrics display a full range of failure modes, which record normal-faulting, strike-slip, and thrust-faulting stress regimes. Overprinting relationships, used to infer relative timings, suggest burial was followed by Laramide contraction that ultimately peaked and evolved back to a normal-faulting stress regime. These relationships help put the image log fracture populations into context. The dominant fracture population within the shallower Uinta and uppermost GRRV Formations is the NNW/SSE set, in contrast to the W/E set that dominates the deeper zones. In fact, W/E fractures are rare in the shallower strata, but both NNW/SSE and W/E sets are present in the deeper zones. Thus, we interpret the W/E set as being older, associated with initial ~E/W-directed Laramide contraction. The subsequent NNW/SSE set would most likely be associated with later, more N/S-directed shortening of the basinal region between the Uinta Mountain and Uncompahgre Uplifts. Successive natural fracture populations may record a maximum horizontal stress rotation from E/W to NNW/SSE during the Laramide.