Syndepositional Fault and Fracture Control on Diagenetic Fluid-Flow, Tansil Carbonates (Permian), Dark Canyon, Guadalupe Mountains, New Mexico

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Syndepositional faults and fractures play an important role in the evolution of platform-scale diagenetic fluid-flow networks in carbonate systems. In the subsurface, the link between fluid flow along fractures and the spatial distribution of reservoir properties is elusive at best, and outcrop analogues are needed. The Tansil-age (Permian) outcrops of Dark Canyon, Guadalupe Mountains, New Mexico, are crosscut by closely spaced syndepositional faults and fractures, making it an ideal locality to characterize the influence of early deformation features on the diagenetic patterns and reservoir properties in surrounding host strata. This study utilizes traditional (measured sections, surface walking) and digital (RTK GPS, ground-based and airborne LIDAR) mapping techniques plus petrographic, isotopic, and fluid-inclusion data to address these issues.

Syndepositional fractures are common in Dark Canyon, typically oriented parallel to the platform margin trend, with subvertical traces. Fracture apertures range from millimeter- to meter-scale with sediment, microbialite, breccia, and cement infills. Syndepositional normal faults are less frequent and are often clustered, filled with breccia, and flanked by damage zones. Syndepositional offsets range from tens of centimeters to several meters, with some offsets large enough to have altered sedimentation and stratal architecture along the Tansil shelf.

Evidence for extensive flow of reflux brines along syndepositional fractures and faults is observed in the form of dolomite halos and reaction fronts surrounding early deformation features. These features are most common in shoreface and outer-shelf strata, and facies that were not completely occluded by early-calcite cements. When syndepositional deformation features intersect permeable strata, dolomite bodies can extend laterally into the surrounding host-rock for some distance creating complex and spatially heterogeneous porosity/permeability distributions. Porosity and permeability values in Dark Canyon's dolomitized strata are on average 3 times higher and two orders of magnitude higher respectively than in their unaltered counterparts. Calcite cements in early fractures include both syndepositional and burial phases. Isotopic, cathodoluminescent, and fluid inclusion characteristics of the cements indicate fractures were frequently reactivated and served as long-lived fluid conduits, from deposition through burial, hydrocarbon migration, and Tertiary uplift.