

## **Fracture Patterns Associated with Tightly Folded Laramide Structures: The Example of Beer Mug Anticline, Wyoming**

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Beer Mug anticline, with a near-vertical forelimb and backlimb dip up to 50 degrees provides an ideal analogue for fracture systems that will have a significant effect on fluid flow in tightly folded Laramide reservoirs. Outcrop data collected over the 2009 field season indicate that the entire exposed sedimentary package, Tensleep Formation through the Alcova Limestone, is cut by numerous intersecting fractures. Fracture type and degree of development vary systematically with lithology and structural position. Fracturing is most intense towards the core of the anticline, which consists of brecciated, oil-stained rock with large-scale vuggy porosity. The age relationships of the fracture sets are commonly ambiguous since offset is minimal and most intersections are mutually crosscutting, but pre-fold and fold-related fracture sets can be recognized. Many of the early-formed fractures were reactivated in shear and/or extension.

Within the Tensleep Formation, bedding-parallel slip, commonly along the large dune cross-bed foresets, accommodated much of the pervasive strain. Small offsets were also documented on irregular calcite-mineralized planes oblique to bedding. The meter-scale dolomite beds interbedded within the thicker Tensleep sandstone units accommodated much of the larger-scale bed-parallel shear through brecciation, but brecciation is not always obvious due to cementation and weathering. In fact, at a gross scale, many of the dolomite beds give the appearance of being massive and completely unfractured. Granulation, brecciation, pressure solution, and cementation likely occurred nearly simultaneously with deformation. Natural hydraulic or injection fractures with random strikes occur within both sandstone and dolomite strata. Some injection fractures are parallel to the ESE-WNW striking early-strain extension fractures, suggesting an age and/or mechanical relationship. Many injection fractures contain not only dolomitic mudstone fill but also euhedral calcite crystals suggesting extension and open aperture at depth.

Shales overlying the Tensleep Formation accommodated strain by localized bedding-parallel shear faulting. Small thrust faults and shear fractures in the overlying Alcova Limestone provide additional evidence that the maximum stress was in the horizontal plane and approximately ESE-WNW prior to tilting of the beds. This suggests that the Beer Mug anticline was not passively draped over an underlying basement thrust.