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The Use of 3-D Strain in Outcrop to Predict Subsurface Reservoir Compartmentalization, Southern Bighorn Basin, Wyoming

Variations in 3-D strain within anticlinal folds have important implications for the development of fractures that affect subsurface reservoir permeability. This study quantified variations in 3-D strain that caused minor fault development at Thermopolis anticline in the southern Bighorn basin. Little Sand Draw field, a nearby subsurface analog field, exhibits distinct reservoir compartmentalization related to fracturing. Using the orientation, magnitudes and locations of the faults in outcrop, a reservoir model was developed that matched 50 years of production history.

A kinematic analysis was performed to determine the orientation of the strain axes for 628 faults (444 extensional, 184 reverse), including 189 faults with greater than 0.5-meters of separation. From these faults measurements, the average shortening direction was determined to be oriented NE-SW (perpendicular to the fold axis and bedding strike), whereas the elongation axes were oriented both NW-SE and NE-SW (parallel and perpendicular to the fold axis). Intensity of faulting was shown to be greatest along the forelimb of the anticline and significantly higher in faults oriented NW-SE.

3-D strain was measured parallel to the fold axis (Ssp), parallel to the bedding dip direction (Sdp), and perpendicular to the bedding dip direction (Sdn) using GPS-mapped fault offsets and bed thickness changes. Values of Ssp ranged from 0.96 to 1.27 (thinned to elongated), whereas Sdp values ranged from 1.04 to 2.0 (elongated) and Sdn values were 0.47 to 0.88 (thinned). The strain values were compared to geometric attributes of the structure. Ssp was most sensitive to structural position and the rate of dip change parallel to the fold axis. Sdn was most sensitive to bedding dips and the rate of dip change perpendicular to the fold axis. Sdp was highly variable and showed only moderate correlation to bedding dip and structural position.