Progressive Deformation in the Arbuckle and Wichita Mountains: Implications for Exploration in the Anadarko Basin, Oklahoma

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Abstract

Ongoing exploration and production in the Anadarko Basin of western Oklahoma (e.g., STACK, SCOOP) focuses on Mississippian and Devonian strata that have experienced progressive deformation events (e.g., Ancestral Rockies, Ouachita). Here we examine outcrop-scale geologic structures in the Arbuckle and Wichita Mountains of southwestern Oklahoma to explore the stress and deformation history during Late Paleozoic tectonism. Structural features observed in the Wichita Mountains region include extension fractures/veins, faults, and tectonic stylolites. Extension fractures at high angles to bedding are abundant with a range of strikes. ENE and ESE striking strike-slip faults occur along with N to NE striking reverse faults. Sub-vertical tectonic stylolites, though not abundant, generally strike N. Structures in the Arbuckle Mountains include extension fractures/veins, faults, tectonic stylolites, and mesoscale folds. Extension fractures/veins are abundant and generally at high angles to bedding. Faults at high- and low-angles to bedding are abundant, exhibiting normal, strike-slip, reverse, and oblique slip. Patterns are simpler once fault orientations are rotated by removing fold axis plunge and local layer dip. In the rotated data, faults fall in two prominent populations: (i) steep conjugate strike-slip faults striking NE and NNW; and (ii) gentle to moderate-dip conjugate reverse faults striking NW and SE. Less common, tectonic stylolites were found in the Arbuckle anticline backlimb. Mesoscale folds are best developed in the Arbuckle Group limestones with fold axes similar to the Arbuckle anticline. Stress inversion from rotated fault data indicates NE-SW directed maximum principal stress, with minimum and intermediate

principal stresses either vertical, consistent with thrust faulting stress regime, or horizontal, consistent with a strike-slip faulting stress regime. We interpret that much of the mesoscale deformation occurred as layer-parallel shortening during Ancestral Rocky Mountain tectonism before macrostructural development. Similar mesoscale deformation is observed in subhorizontal reservoirs of the Anadarko Basin. The Wichita and Arbuckle uplifts provide opportunity to see reservoir-scale deformation in outcrop. Mesostructures like those described here can strongly influence hydrocarbon production, providing a mechanical fabric that, along with mechanical layering, strongly influences hydraulic fracturing in unconventional reservoirs.

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