Formational-Scale Differences in Deformation and Implications for Petroleum Migration and Structural Evolution of the Pismo Basin, California

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Abstract

The Pismo-Huasna Basin is located in a Pliocene-Quaternary fold and thrust belt between the Coast Ranges and the Western Transverse Ranges, central California. Obispo, Monterey, and Pismo formations deformed with different styles and intensities due to distinct lithologies and mechanical layer thicknesses which had profound implications on the role of deformation in the petroleum system. Structures in the Obispo and Monterey Formations formed early in basin history and were subsequently tilted into favorable orientations to remain active during later stress regimes. Obispo Volcanics and the Edna Member of the Pismo contain abundant shear bands which, in the Edna, exhibit fault sealing characteristics in the active Arroyo Grande oil field. Edna shear bands formed during the current compressive stress regime, after hydrocarbon charging, and subparallel to bedding. Shear band kinematics are influenced by the regional tectonic stress field and local stress fields. Quantitative image analysis of the grain sizes within the deformation band and sandstone host rock finds up to a 33.2% decrease in average grain size and a reduction in porosity from 32-22% to 17-4%, due to cataclasis. Scanning Electron Microscope imagery shows that sand grains within the bands are sheared, fractured, spalled, and locally coated in smectite clay. In contrast to the sealing shear bands in the bituminous Edna Member of the Pismo Formation, faults and fractures in the underlying Monterey Formation and tar sand injectites in the Miguelito Member of the Pismo Formation provide conduits for migration of hydrocarbons through and out of otherwise low-permeability lithologies.