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Spatial Variability of Fracture-Enhanced Shale-Gas Production: Insights from the Raton Basin, CO

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With matrix permeabilities in the micro- to nano-darcy range, gas shales are reliant on fractures for delivery of gas from the formation to the wellbore. These fracture networks may be natural, induced via hydraulic fracturing, or a combination of both. Here, we present a study of natural fractures and their impact on the gas producibility of the Cretaceous Pierre and Niobrara formations in the northern Raton Basin of southeast Colorado. The Raton Basin is positioned at the crossroads of Laramide mountain building, Rio Grande rifting, and Tertiary intrusions and volcanism. The resulting temporally variable stress regime (~70-110 deg. rotation of principal horizontal stress) has induced at least three identifiable fracture families with characteristic orientations and has led to present-day horizontal stress anisotropy.

The three distinct fracture families are consistent with mechanical models for the region proposed by Lorenz and Cooper (2004) and appear to be areally consistent between wells with image logs. However, localized fracture swarms identified from image logs exhibit fracture orientations that are inconsistent with the three fracture families. Intersection of these localized swarms appears to be a key driver in well performance, as inferred from production logs and well production histories. Given the potentially limiting effect of horizontal stress anisotropy on generating fracture complexity through stimulation, intersection of these swarms with completions is all the more important. Representation of regional fracture sets via assignment of characteristic spacing may be appropriate for some settings (e.g. Engelder et al., 2009). However, our results suggest that meaningful characterization of natural fractures and their impacts on production must go beyond this methodology to consider spatially variable fracture patterns, as they may be key to unlocking fractured reservoir plays.