Tectonic and Non-Tectonic Fractures in the Eocene Green River Formation, Piceance Basin, Colorado

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Natural fractures are prevalent in the Green River Formation oil shales of the Piceance Basin, northwest Colorado. When viewed at the whole-well scale, two fracture domains are apparent. The boundary between the fracture domains corresponds to the boundary between the so-called Leached Zone and Saline Zone. The Leached Zone refers to the upper portion of the Parachute Creek Member where past groundwater flow has dissolved salt beds and nodules to leave behind large vugs (Dyni, 1996). The Saline Zone refers to the lower portion of the Parachute Creek Member where connate waters are present, and thus no dissolution of salt has occurred. Fractures in the Leached Zone are abundant and exhibit a wide range in both strike direction and dip magnitude, with fracture dips measuring as low as 30°. Fractures in the Saline Zone are less abundant, are strongly clustered about a WNW strike direction, and have steep dip magnitudes that range between 70-90°. Broadly speaking, fracture density gradually increases from surface to a depth of approximately 1600 ft md and then abruptly decreases down to the top of the Saline Zone.

A conceptual model is proposed to explain observed fracture distributions whereby the initial fractures in the Green River Formation formed prior to contact with fresh groundwater (i.e. prior to establishment of the Leached and Saline Zones). These fractures occurred at or near maximum burial, were tectonically induced, and formed a single high-angle set oriented WNW. During uplift, erosion removed overburden layers and upper units of the Green River Formation were successively inundated by fresh groundwater, which led to leaching of salt beds and nodules. The leaching in turn caused widespread collapse of vugs and beds that resulted in formation of new joints and small faults in the Leached Zone. The Saline Zone did not experience leaching and collapse, thus fracture densities in this zone remain at the background level.