Spontaneous Potential: Key to Understanding Continuous and Conventional Gas in Upper Cretaceous Sandstones, Deep Eastern Greater Green River Basin, Southwest Wyoming

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Spontaneous-potential (SP) log data from wells in the deep eastern Greater Green River Basin (GGRB) suggest that what appears to be overpressured pervasive gas at high saturations in Upper Cretaceous (primarily Lewis and Mesaverde) sandstones outside conventional fields is ‘gassy water’ with gas present at generally uneconomically low saturations.

Lewis and Mesaverde sandstones within conventional-trap fields in the deep eastern GGRB exhibit normal-SP deflections reflecting saline formation water with low formation-water resistivity (Rw) that yields calculated water saturations (Sw) less than 50 percent. In deep-basin areas outside conventional traps, however, Lewis, Mesaverde, and associated Upper Cretaceous sandstones generally exhibit reversed-SP signatures attributed to anomalously low-salinity formation water with anomalously high Rw resulting in calculated Sw greater than 60 percent. Uneconomically low gas saturations are confirmed by lack of commercial gas production from reversed-SP sandstones in numerous deep-basin wells despite mud-log gas shows, significant overpressure, neutron-density-porosity cross-over, and moderate to high resistivity, which can be deceptively high from low-salinity water.

Anomalously low-salinity water in deep-basin sandstones is thought to result from dilution of original saline formation water by water expelled from smectite clays during conversion to illite with increasing temperature (depth of burial). Low-permeability of deep-basin sandstones probably retards escape of expelled fresh water, which contributes to overpressure. Although the upward transition to more-saline formation water is gradational, mapped top of reversed SP clearly cuts across stratigraphy with relief exceeding 2,000 ft.

It is unclear whether regional continuous gas in Lewis and Mesaverde sandstones has been at low saturation since onset of gas migration or whether saturations once were higher and some gas was lost during influx of fresh water. What is reasonably certain is that subsequent to gas migration, fresh-water influx in the deep basin diluted original saline formation water regionally except in sandstones within conventional traps. Nearly identical low Rw of normal-SP Lewis and Mesaverde sandstones in deep-basin conventional traps suggests that saline formation water and associated high-saturation gas in these fields are ‘frozen-in’ accumulations emplaced during early gas migration and unaffected by fresh-water influx.