Important Characteristics of Rocky Mountain Tight Gas Accumulations*

Stephen P. Cumella[1]

*Abstract from 2010-2011 AAPG Foundation Distinguished Lecture presentation.

[1]Bill Barrett Corporation, Denver, Colorado (scumella@billbarrettcorp.com)

Sandstones in tight gas accumulations in the Rocky Mountains commonly have permeabilities in the single digit microdarcy range and water saturations below 50%. If these sandstones had similar permeabilities at the time they were gas charged, capillary pressures required to reach these water saturations would have been hundreds to thousands of psi. Buoyancy can create these high capillary pressures, but gas columns must be hundreds to thousands of feet to reach these pressures. Many Rocky Mountain tight gas accumulations occur in discontinuous fluvial sandstone intervals where fluid columns of this magnitude aren't possible. An alternative explanation for this problem is that the gas charge occurred before the sandstones reached very low permeability when the capillary forces required to reach low water saturations were much lower (Shanley et al., 2004). This explanation proposes that gas charge occurs at shallower burial depths and compaction and cementation degrade permeability to the microdarcy range with continued burial.

Recent studies of the diagenesis of Mesaverde sandstones in the Piceance Basin indicate that permeabilities were reduced to near their current microdarcy levels prior to or during gas charge. Two mechanisms to provide the high capillary pressures required to charge the tight sandstones other than buoyancy are gas generation from in situ coals or other organic-rich intervals and gas migration up major fault and fracture zones from highly pressured organic-rich underlying units. These deeper units are probably also overpressured as a result of hydrocarbon generation. Significant in situ organic content is required to saturate the pore space of the sandstones in a tight gas accumulation. Some tight gas systems such as the southern Piceance may have sufficient in situ TOC to charge the sandstones within the system. Such systems have commercial production at high well density over large areas of the basin. Basins like the Piceance or the San Juan either have (San Juan) or will have (Piceance) continuous producing areas in most of the deeper parts of the basins.

Tight gas systems with low in situ TOC have a much more limited distribution of commercial gas production. Some tight gas accumulations may be conventional traps with gas/water contacts that are obscured by the very low relative permeability to gas or water (Shanley et al., 2004) Other tight gas accumulations may be controlled not by trap but by proximity to a major fault system that provides a conduit for highly pressured gas from deeper formations.

High heat flow may also be critical to creation of pervasive highly gas charged accumulations. The importance of high heat flow is indicated by significant differences between the Williams Fork gas accumulation in the north and south parts the Piceance Basin. In the southern Piceance, the gas accumulation has uniformly low water saturations, low water production, and a gas-saturated interval that gradually thickens into the deeper part of the basin, but the top of the gas interval shows little variation locally. In the northern part of the basin, the gas accumulation has variable water saturation, higher water production, and the top of the gas-saturated interval can vary significantly over relatively short distances. The higher heat flow in the southern Piceance may have created a pervasive fracture system that allowed all sandstones within the gas-saturated interval to be charged to high gas saturations. In the northern Piceance, gas migration may have occurred primarily along major fracture and fault zones; areas near the fault zones have better gas saturations and thicker gas-saturated intervals. Prolific tight gas accumulations in the San Juan Basin and in Wattenberg field in the DJ Basin are other examples in which high heat flow may have played a significant role in the creation of the accumulation.