Gas Generation and Transport in Shallow Organic-Matter-Rich Shales

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An understanding of both physical and biological processes of gas generation and movement in immature organic matter rich shales is essential to optimize long term gas production from this resource. As yet, there is no complete physical theory that includes gas generation together with the many gas transport modes in these systems. Typically, in field operations, the gas rate of these reservoirs declines initially and then levels off at a nearly uniform value. This long term rate is controlled by the interplay between biogenic gas generation, surface diffusion of gas, desorption of gas from kerogen, diffusion and transport of gas through nanometer to micron scale or larger pore systems to flow in microfractures and larger fractures (potentially created by hydraulic fracturing of the formation). Above and beyond the different transport modes, the connectivity of the different transport modes is critical.

Pedersen et al. (this conference) describe geological controls on the Colorado Group biogenic shale gas system in southern Alberta and Saskatchewan, Canada. There are many different transport subzones within the shale system: super low permeability marine shales, interbeds of thin laminae and thin beds of siltstones and very fine-grained sandstones, coarser grained facies, and microfractures. Given the time scales for surface, Knudsen, and bulk diffusion, Darcy flow in the shale, siltstones, and sandstones, and potentially pressure-driven flow in fractures, the tortuosity and complexity of gas migration from its generation point to the production well must be well understood to enhance rate and recovery from these resources.

Prior to production, with biogenic gas generation underway, to maintain constant pressure, gas must be leaking from the shale system to the surrounding formation and the overburden material (if the volume of consumed kerogen is relatively small and water mobility in the system is negligible). Before production, if the pressure is unchanged with time, this implies that the amount of leaked gas must equal the amount of biogenerated gas. This further implies that the flux of transported gas within the shale system must equal the gas generation rate which further implies that there is a natural driving mechanism for gas transport within the shale. Together with an estimate of the gas generation rate, the overall transport rate of gas through the shale can be estimated provided length scales for transport are available. After production, together with pressure and flow rate and geological data, estimates of the gas generation rate can be determined which permits an estimate of the gas transport rate through the reservoir. Here, we examine the time and length scales for different transport modes in shale systems and examine the requirements on connectivity between these transport modes to meet observed production from field operations.