Shale Diagenesis and Permeability: Examples from the Barnett Shale and the Marcellus Formation

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Diagenetic style often exerts a controlling influence upon permeability. At deposition, the size and interconnectivity of the pore network is a function of the size, shape and packing of the constituent clasts. As the sediment is progressively buried, it dewaters and compacts, reducing the size of the pores, their interconnections, and the permeability. Cementation further s this process. While shale permeability is poorly understood and difficult to measure, we can assume that diagenesis exerts similar controls upon the pore network in shales. The following reports the results of an analysis of pore size and permeability in 43 core plugs from the Barnett shale and the Marcellus formation. The results clearly illustrate the effect of diagenetic style, an effect that accounts for a variation in permeability ranging over four orders of magnitude.

The Barnett Shale is a Mississippian argillaceous shale formation located in north-central Texas. It is described as a spent oil source rock that has surpassed the thermal transition from liquid to gas generation. With this transition, maturation-induced microfractures developed, enhancing both the porosity and permeability. The Marcellus formation is a highly fissile, black, argillaceous shale of Devonian age found throughout most of the Appalachian Basin. Unlike the Barnett, much of the Marcellus formation has not matured through liquid to dry gas generation and the formation contains varying amounts of interbedded limestones and calcite cement, both in the form of vein filling and matrix cements. In short, diagenesis within the Barnett shale served to expand the pore network, making it more efficient, while that within the Marcellus served to reduce the pore network, making it less efficient.

Permeability and throat size information were obtained from Hg capillary pressure testing while pore size information was obtained from NMR T2 spectra. A clear relationship between pore size and permeability was evident in each group of samples. However, given a specific pore size, the samples from the Barnett Shale will have permeabilities that are in micro-, not nano-Darcies.. When compared with similar results from high permeability sandstones, the results suggest that the efficiency of the pore network in the Barnet Shale approximates that found in sands, while that of the Marcellus samples is lower than that found in tight gas sands.