# Nanometer-Scale Observations of Porosity in the Barnett Shale

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The nature and distribution of pores within the Mississippian Barnett Shale from the Fort Worth Basin (FWB) of north-central Texas has been examined. The Barnett Shale consists predominantly of dark-colored calcareous and siliceous mudstones which form a source, seal, and sink for hydrocarbons. Siliceous mudstones from a range of burial depths and thermal maturities have been studied with a scanning electron microscope (SEM) in order to characterize their pores, which are predominantly nanometer-scale. Arion-beam milling produces a low-relief surface free of both topography related to differential hardness and surface damage that occurs with mechanical polishing. SEM imaging of ion-milled surfaces allows unambiguous identification of pores as small as a few microns in diameter.

Samples examined thus far can be divided based on pore occurrence which corresponds to burial depth and to thermal maturity. Higher thermal maturity samples, those currently buried in the range of 1,500 to 2,200 m and having vitrinite reflectances of 0.9% to 1.6%, are one group. The other group is relatively low thermal maturity samples, those currently buried less than 500 m. Based on limited data and regional trends, vitrinite reflectance for these samples ranges from less than 0.5 to in the range of 0.7%.

More mature samples show well-developed nanopores concentrated in micron-scale organic-matter grains. Large numbers of sub-elliptical to rectangular nanopores are present, and porosities within individual grains of as much as 25% have been observed. In contrast, lower thermal maturity samples show few or no pores within organic-matter grains. Shallowly buried samples do show a wide vari-

ety of intergranular nanopores which are rare in higher thermal maturity samples.

Nanopore morphology and distribution is consistent with decomposition of organic matter during hydrocarbon maturation leading to intragranular nanopores found in higher maturity samples. As organic matter (kerogen) is converted to hydrocarbons, nanopores form to contain the liquids and gases. With continued thermal maturation, the pores grow larger and can coalesce to form irregular shapes or be joined by tubelike pore throats. The specific thermal maturity level at which nanopore development begins has not been precisely determined. However, current observations support nanopore formation being tied to the onset of kerogen conversion to hydrocarbons.

Preliminary work shows that pores in Barnett Shale samples from the Permian Basin differ somewhat from those found in the FWB. Samples examined have vitrinite reflectance in the range of 1.2 to 1.3%. Nanopores are present in organic matter from these samples, but are smaller and less thoroughly developed than those from the FWB. Intergranular pores are more common in the Permian Basin samples than in samples of corresponding thermal maturity from the FWB.