Spectrum of Pore Types in Siliceous Mudstones in Shale-Gas Systems

Robert G. Loucks, Robert M. Reed, Stephen C. Ruppel, and Ursula Hammes
Bureau of Economic Geology, Jackson School of Geosciences,
The University of Texas at Austin 78713-8924

Pore networks in siliceous mudstones of shale-gas systems are variable and complex. A spectrum of pore types has been identified on the basis of analysis of a number of shale-gas systems, including the Devonian Woodford Shale in the Permian Basin, Mississippian Barnett Shale in the Fort Worth Basin, Pennsylvanian Atoka Shale in the Permian Basin, Jurassic Haynesville and Bossier Shales in East Texas Basin, Lower Cretaceous Pearsall Shale in southwest Texas, and Upper Cretaceous Eagle Ford Shale in south Texas. Each shale-gas system has its own combination of pore types, depending on the mineralogy, texture, and fabric of the siliceous mudstone.

Pore sizes seen in the analyzed suite of siliceous mudstones range from approximately 5 nm to several microns. The pore types can be classified as (1) interparticle pores (between particles), (2) intraparticle pores (within discrete particle boundaries), and (3) organic-matter intraparticle pores (Figure 1; Loucks et al., 2010). Primary interparticle pores between grains are related to original mudstone pore space. These pores make up the primary pore system that is generally connected. Interparticle pores occurring between soft grains are commonly reduced in size by mechanical compaction and cementation. Intraparticle pores can be primary or secondary pores, but they occur within a discrete particle, such as a pyrite framboid or a porous phosphate particle, or as molds of fossils, crystals, or grains (i.e., feldspars). Organic-matter intraparticle pores are related to thermal maturation of organic matter during hydrocarbon generation.

Pores observed in siliceous mudstones suggest that a pore network may have one dominant pore type or a complex combination. Mudstones from the Barnett Shale in the gas-producing area of the Fort Worth Basin have a pore network dominated by organic-matter intraparticle pores (Figure 2A), whereas the Pearsall Shale appears to have a pore network dominated by intraparticle pores (Figure 2B). Figure 1 is a ternary diagram showing the relative number of pores in several shale-gas systems.

Many research questions remain regarding pore types and pore networks in siliceous mudrock shale-gas systems: (1) How do pores and pore networks evolve from initiation at the surface through burial? (2) Can porosity and permeability be predicted from mineralogy, temperature, pressure, and time as can be done with sandstones? (3) Is there a relationship between pore types and permeability, and how do we measure this relationship? (4) Do different types of organic matter produce different numbers of organic-matter intraparticle pores? (5) How accurate are our measurements of petrophysical properties of mudstones? (6) Does the preservation state (condition of the core sample) of the mudstone affect petrophysical measurements? Numerous other questions need to be addressed, and a wide range of mudrock samples from systems of different ages that are composed of different mineralogies, fabrics, and textures and that are subjected to a range of subsurface conditions need to be analyzed.

Loucks, R. G., Reed, R. M., Ruppel, S. C., and Hammes, I., 2010, Preliminary classification of matrix pores in mudstones: Gulf Coast Associations of Geological Societies Transactions, v. 60, (in press).

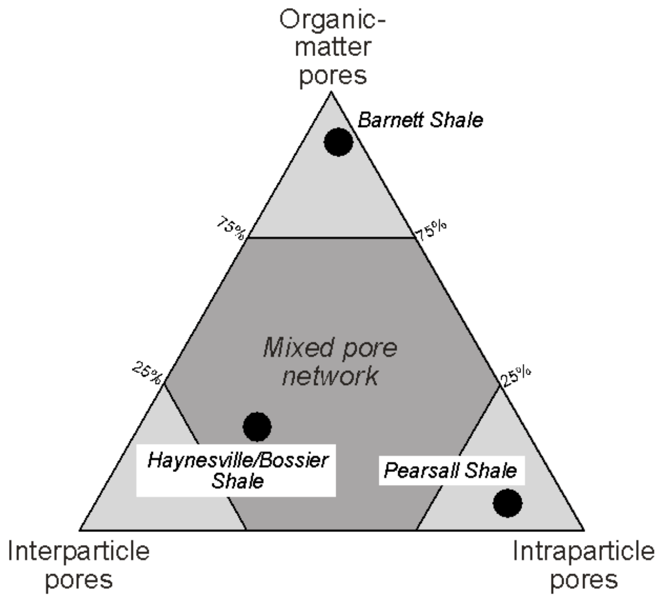

Figure 1. Classification of pores in siliceous mudrocks. Relative positions of pore-network types in several shale-gas systems. From Loucks et al. (2010).

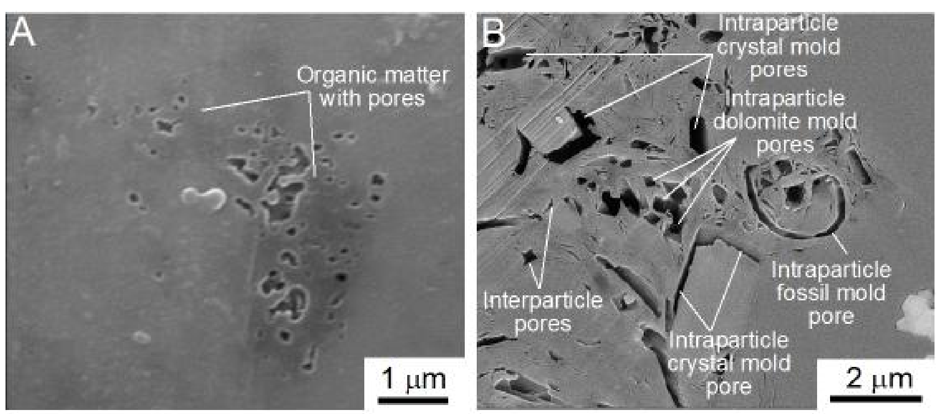

Figure 2. Mudstone pores in secondary electron images. (A) Ellipsoidal organic-matter pores. Darker material is organic matter. Ion-milled sample of Barnett Shale (7,111 ft) from the Fort Worth Basin. (B) Example of a complex pore network. Ion-milled sample of the Pearsall Shale (15,934 ft.) from the south Texas Lower Cretaceous shelf. From Loucks et al. (2010).

AAPG Search and Discovery Article #90122©2011 AAPG Hedberg Conference, December 5-10, 2010, Austin, Texas.