

From Radiolarian Ooze to Reservoir Rocks—Microporosity in Chert Beds in the Upper Devonian-Lower Mississippian Woodford Shale in Oklahoma and Implications for Gas Storage

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The mechanism of gas storage in shale-gas systems is a key element in characterizing these potentially prolific, low porosity/permeability reservoirs. This study integrates mineralogy, organic geochemistry, and porosity/permeability data of samples collected from the Upper Devonian-Lower Mississippian Woodford Shale, Arbuckle Mountains, Oklahoma, at locations previously described through detailed stratigraphic and spectral gamma surveys. The primary objective of this study was to characterize the rocks to further an understanding of gas storage in Woodford reservoirs in the adjacent Anadarko Basin.

Rock types of interest in the Woodford are broadly divided into chert and mudstone lithofacies that display different characteristics. Cherts (>90 wt% quartz, <5 wt% clays) have an average TOC content of 4.5%. Quartz occurs in cherts in a cryptocrystalline form (mosaic or granular chalcedony) that fills fossil radiolarian tests and composes much of the rock volume; the quartz formed diagenetically early from recrystallization of radiolarian skeletal parts (tests, spines, etc.). The organic matter is present as an amorphous organic material (AOM) in micropores (<10 μm across). Micropores occur 1) between minute quartz crystals within chalcedonic masses; or 2) between the colloform, bulbous masses of chalcedony. In contrast, mudstones (38-81 wt% quartz, 15-40 wt% clays), are more organic rich (avg. TOC 13.3%), with organic matter largely present as AOM and Tasmanites microfossils. Quartz in mudstones is largely detrital (subangular silt grains) but some are authigenic monocrystalline "grains" infilling Tasmanites. Limited mercury injection capillary pressure analyses (at 50% Hg saturation) reveal that 1) cherts have a) variable porosity (0.59 to 3.46%), b) low permeability (0.001 to 0.033 μD), and c) small pore mean apertures (6.4 to 7.9 nm); and 2) mudstones, compared to cherts, generally have a) greater porosity (2.3 to 11.9%), b) greater permeability (0.014 to 2.06 μD), and c) larger mean pore apertures (6.2 to 1.78 nm). Microfractures also contribute to rock porosity, but appear to be lithologically controlled and are best developed in cherts (brittle), but poorly developed or absent in adjacent clay-rich mudstones (ductile).

Owing to their microporosity, cherts of the Woodford may provide important, overlooked sites of gas storage in the formation, and upon artificial stimulation (fracing) may contribute a significant portion of the gas that is produced.