

Micropetrography Observations of the Texture, Fabric, TOC, and Pore Types of the Leonardian Third Bone Spring Slope Strata on the Eastern Side of the Delaware Basin

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Abstract

The Leonardian Third Bone Spring (TBS) siliciclastic mudstones are an unconventional resource in the Delaware Basin. To characterize, explore for, and develop this unconventional resource, it is important to understand the SEM level (microscale) attributes of these strata. A core from the Whiting No. 1201 Collier well in Reeves County, Texas allows this opportunity. The TBS mudstones were deposited on the deeper Delaware Basin slope. Depositional setting was below storm-wave base in aerobic to anaerobic setting. There are three major lithofacies. In the laminated siliciclastic mudstone peloids, clay, and siliciclastic silt compose the matrix. Agglutinated foraminifera and radiolarians are present. Depositional processes are suspension settling and turbidity currents followed by bottom-current reworking. Bottom conditions were anaerobic. The burrowed siliciclastic mudstone is similar to the laminated siliciclastic mudstone. Deposition was in an aerobic to slightly dysaerobic setting that allowed bioturbation. Argillaceous carbonate skeletal packstones are gravity flows composed of a mixture of coarse skeletal grains, derived from the upper slope to outer shelf, in a matrix of siliciclastic mud. Slumping was common suggesting an unstable slope setting. The section has undergone thermal maturation into the oil window (mean $R_o = 1.05\%$; by vitrinite reflection analysis) and the kerogen is predominantly Type II. The laminated lithofacies has the highest mean TOC (2.91%) and is good to excellent source rock and the burrowed lithofacies has a mean TOC of 1.44% and is fair source rock.

The carbonate-rich lithofacies has the lowest mean TOC (1.18%) and is poor to good source rock depending on the amount of siliciclastic matrix. The siliciclastic lithofacies are the best reservoirs where the nanopores are dominated by organic matter pores in solid bitumen (60% to 80% of the pore network), with lesser intraparticle nanopores. Porosity and permeability, based on crushed rock analysis, indicate reservoir quality is very low but generally relatively good for mudrocks. Geometric mean permeabilities are all higher than 0.001 md. The burrowed siliciclastic lithofacies has the best reservoir quality (porosity = 8.15% and permeability = 0.004 md). The burrow siliciclastic lithofacies has the second best reservoir quality (porosity = 7.75% and permeability = 0.003 md). The Third Bone Spring shale, as shown in this core, appears to be a high-quality unconventional resource.