Coalbed Reservoir Characterization of Coal Lithotypes and Cleat Spacing in the Powder River Basin, Wyoming

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The Powder River Basin, Wyoming, produced 536 billion cubic feet (BCF) of coalbed methane (CBM) in 2008, which is 27 percent of the total 1,966 BCF of CBM produced in the U.S. for that year. The basin has cumulative production of 2,400 BCF of biogenic gas mainly from the Wyodak-Anderson coal zone of the Fort Union Formation. The producing coals, 20 to 200 ft thick, include the Anderson (Big George), Canyon (Wyodak), and Smith. About 800 2-ft canisters of coal core, collected from the entire thickness of various coal beds, were studied for their lithotypes, apparent rank, gas content, cleat spacing, and quality.

Apparent rank of coal in the Powder River Basin ranges from subbituminous C (subC) in the shallow margin to subituminous B (subB) and A (subA) toward the deeper part. Average cleat spacing ranges from 1.06 in. (27mm) for subC to 0.9 in. (23mm) for subA, with the latter having greater permeability. Coal lithotypes and cleat spacing vary laterally and vertically across and within a coal bed. Coal lithotypes include attritus; fine, medium, and coarsely laminated vitrain; woody vitrain; and fusain. The Wyodak-Anderson coal beds, on average, contain 58 percent attritus, 40 percent vitrain, and 2 percent fusain. The amount of gas in the attritus and vitrain lithotypes varies within a coal bed and between coals. Basin wide, there is a relatively higher percentage of fine to coarse laminated and woody lithotypes in the southeast part of the basin and a higher percentage of attritus in the west-central part of the basin. Gas content increases with higher apparent coal rank, with depth, and smaller cleat spacing. Desorbed average gas contents for coals with apparent rank of subC and subA are 8.5 standard cubic feet per ton (scf/t) and 85 scf/t for attritus, 7.6 and 75 scf/t for finely laminated vitrain, 8.8 and 79 scf/t for medium to coarsely laminated vitrain, 4.2 and 79 scf/t for coarsely laminated vitrain, 7.4 and 79 scf/t for woody vitrain, and 2.1 and 96 scf/t for fusian. The good porosity and permeability of subA fusain is attributed to its ‘charcoal-like' properties, which contribute to the high gas content and potentially to high gas flow through the reservoir.

This study is an important tool in the prediction of gas volume and flow within a coal. Knowledge of the vertical variation of lithotypes and cleat spacing can assist in forecasting gas compartmentalization and migration and increases the success in targeting sweet spots for gas development.