Pore Types, Capillary Pressure, and Diagenetic Controls on Reservoir Quality in the Upper Devonian Berea Sandstone, Eastern Kentucky

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ABSTRACT

The Upper Devonian Berea Sandstone is a low-permeability natural gas and oil reservoir in eastern Kentucky. Thin sections of Berea siltstones from five cored wells were examined as part of a larger study of the Berea petroleum system at the Kentucky Geological Survey. Cores span a range of depths, from +4 ft in Johnson County to -2,448 ft in Pike County (sea level datum). This petrographic work documents the pore types and diagenetic controls on reservoir quality in this very fine-grained unit. Though porosity is commonly greater than 10 percent, Berea reservoirs in Lawrence and Johnson Counties typically have low-permeability (less than 1 md). Pore types observed include primary intergranular and secondary moldic pores, and microporosity. Intergranular porosity is the most abundant pore type, but secondary porosity is important in the updip areas. These pores formed by dissolution of framework grains, such as plagioclase, rock fragments, glauconite and carbonate grains. Higher porosity samples have a significant contribution from secondary porosity. Microporosity occurs in partially dissolved framework grains and with clays. Capillary pressure analysis on six core plugs indicates median pore throat diameters of 0.07 to 2 microns. For the highest permeability samples, oil column heights of 100 ft are necessary to achieve oil saturations of 50 percent or greater. Since Berea pay zones are much less than 100 ft thick, down-dip continuity of the reservoir is needed to generate displacement pressures required for commercial oil saturations. Intergranular and fracture-fill cements that reduce porosity and permeability include quartz overgrowths, ferroan (Fe) dolomite, siderite, pyrite, and kaolinite. Quartz cements predate secondary porosity development and formation of Fe-dolomite, siderite, and pyrite cements. Fe-dolomite replaces grains and fills secondary pores and fractures, indicating its late timing. Siderite occurs in secondary pores, and replaces Fe-dolomite, making it one of the latest events. Berea reservoir samples from the single downdip well in Pike County lack secondary porosity and contain solid bitumen in intergranular pores. Though the well currently produces gas, the presence of bitumen indicates prior oil saturation. Since framework grain composition between the updip and downdip areas appears to be similar, differences in diagenesis likely reflect different burial and fluid flow histories.