Porosity and Permeability of Berea Reservoirs (Upper Devonian) in Eastern Kentucky

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ABSTRACT

Historic porosity and permeability data in the Kentucky Geological Survey oil and gas database (n=583 from 18 wells) and a recent collection of new data contributed by industry (n=91 from four wells) were compared to improve our understanding of Berea reservoir characteristics in Kentucky. Although called a â€œsandstone,â€ the Berea is actually a siltstone in Kentucky, and is defined as a tight reservoir. Historic Berea porosity and permeability data show a weak relationship (R2=0.57), with mean porosity of 12.8 +2.7 percent, ranging from 2.8 to 19.5 percent, and mean permeability of 2.0 +3.4 md, ranging from 0.02 to 25.0 md. A significant number of data points are below measuring limits (impermeable, 0, < 0.1, < 0.2 md) and had to be excluded from analysis. New data collected by industry from four Berea cores stored at the Kentucky Geological Survey core library were derived from pulsed neutron permeability, which is capable of measuring much lower permeabilities than older techniques. The lowest permeability in the new Berea data set (excluding shale) is 0.00005 md. Mean permeability is 0.2 +0.4 md, ranging from 0.00005 to 2.5 md. Most of the new permeability values are between 1.0 and 0.01 md. Mean porosity is 8.9 +2.9 percent, ranging from 2.0 to 16.1 percent. Combining the new data set with the historic data (minus data below detection limits) yields a much better relationship between porosity and permeability (R2=0.81). Essentially, in tight siltstone reservoirs like the Berea, exclusion of low-permeability data (or data below old detection limits) can mask any porosity versus permeability relationship. For the combined data, mean porosity is 11.6 +3.3 percent, ranging from 2.0 to 19.5 percent. Mean permeability is 1.4 +2.9 md, ranging from 0.00005 to 25 md. For permeabilities greater than 0.1 md, porosities are generally greater than 10 percent. All porosity values above 12 percent have permeabilities greater than 0.1 md. Porosity and permeability data from four cores were also compared to bedding and XRD analysis for dolomite, pyrite, and clays. The best permeabilities and porosities from the four sample cores are in low-angle (likely hummocky) beds with some dolomite cement, but less than 5 percent dolomite, less than 8 percent illite and mica, and less than 15 percent total clays. Considerable variability and ranges were found for all of the comparisons, which highlights the complexity of reservoir permeability in tight Berea reservoirs.