

## **THE MARCELLUS SHALE PLAY IN PENNSYLVANIA – NEW PARADIGMS FOR AN OLD RESOURCE**

Submitted by Christopher D. Laughrey, Senior Geologic Scientist, Pennsylvania Geological Survey

The Devonian Marcellus shale of the Appalachian basin is a complete unconventional petroleum system in which the rock is the source, reservoir, and seal. The gas-bearing organic-rich Marcellus strata were deposited as a cyclic sequence of basal black mud, deep water and detrital carbonates, and medium-gray muds. These lithofacies reflect sedimentation in respective anaerobic, dysaerobic and aerobic environments in a stratified water column during earliest distal Catskill deposition. Both marine and terrestrial organic carbon is concentrated in the black shale facies. Present day total organic carbon (TOC) ranges from two to 10 percent.

The principal fairway for current and potential thermogenic gas-shale production from the Marcellus shale runs from southwestern Pennsylvania northeast through the central and eastern Appalachian Plateaus province and east into northeastern Pennsylvania. Organic-rich shale thicknesses here range from 50 to 200 feet. Drilling depths are 5,000 to 8,500 feet. The prospective shales were buried beyond the oil window and contain late mature to post mature organic matter ( $R_o = 1.0$  to  $> 2.5\%$ ). The average porosity is six percent. Estimates of the gas in place range from 70 to 150 Bcf, square mile<sup>-1</sup> and the recovery factor is expected to be 20 to 40 percent. The wells respond successfully to “slickwater fracs” with reported initial production rates of 2.6 to 5.8 MMcf, day<sup>-1</sup> and anticipated EUR’s of 3.5 Bcf per well. The typical well spacing is 80 to 160 acres per well. The average well cost is 3 to 4 million dollars.

The principal risks and challenges in the Marcellus play are topography, which complicates moving rigs and building infrastructure, rig shortages, transportation bottlenecks, permitting and other regulatory issues, and fragmented land ownership. Nevertheless, more than twenty active operators have leased a net area of 6,797,919 acres in the basin. All of this acreage probably will not be validated, but the play is clearly progressing towards commercial success. Prior to the current economic downturn, the Marcellus shale offered an attractive initial return of investment (72 to 100%) due to relatively lower royalties in the Appalachian region and premium natural gas pricing due to the play’s proximity to market. Demand is down for now, but with Marcellus breakeven economics estimated at \$3.17 per MMBtu the play is moving forward.