An Overview of Some Key Factors Controlling Well Productivity in Core Areas of the Appalachian Basin Marcellus Shale Play

W. A. Zagorski[1], Douglas A. Bowman[1], Martin Emery[2], and Gregory R. Wrightstone[3]
[1]*Range Resources, Canonsburg, PA*
[2]*Range Resources, Southlake, TX*
[3]*Texas Keystone Inc., Pittsburgh, PA*

The Middle Devonian Marcellus Shale is one of the premier gas shale plays of North America in terms of total gas resource, extent, production rates, and economic potential. The organic-rich shale of the Marcellus was deposited in a foreland basin setting that was sediment starved and allowed for accumulation and preservation of the organic material. The Marcellus Shale Formation is positioned in the lower portion of the Hamilton Group which is bounded above by the Middle Devonian Tully Limestone and below by the Lower Devonian Onondaga Limestone. The Upper and Lower Marcellus Shale are divided by the Cherry Valley/Purcell Limestone.

Two major cores areas have developed in the 500 mi long, southwest-northeast trending Marcellus Shale play fairway. The two core areas display unique combinations of controlling geologic factors. Thickness, organic content, intra-organic matter porosity, overpressure, and maturity are some of the key Marcellus gas productivity factors. The Marcellus thickens from approximately 100 ft average gross thickness in southwestern Pennsylvania to over 300 ft average gross thickness in north-central Pennsylvania.

High organic content and the associate porosity and greater overpressure are key gas productivity factors for the Marcellus Shale. Organic content of the Marcellus can be inferred from GR and density log data calibrated with core measurements. The high organic content facies of the Marcellus is the key reservoir rock in terms of hydrocarbon storage. The organic content varies from approximately 2 to 15 wt% average in southwestern Pennsylvania to approximately 4 to 10 wt% average in north-central Pennsylvania and can be related to greater organic maturity to the north. The overpressure mechanism is conversion of liquid hydrocarbons to gas with increased organic maturity.

The key pore type in the Marcellus Shale is intra-organic porosity identified by FIB/SEM technology. The intra-organic porosity displays a degree of connectivity and is probably responsible for a significant portion of the Marcellus Shale productivity and gas in-place. Intra-organic pores range from <10 to 200+ nm. Other pore types include inter-particulate, inter-crystalline, and microcracks.

The major core areas of the Marcellus Shale play are examined and compared in terms of the regional thickness, structure, thermal maturity, over pressure trends. Within each core producing region we illustrate the various pore types within key reservoir units using various core, log, thin section, standard SEM, and Ion Milled SEM work.