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Water Resources and Natural Gas Production from the Marcellus Shale

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Introduction

The Marcellus Shale is a sedimentary rock formation deposited over 350 million years ago in a shallow inland sea located in the eastern United States where the present-day Appalachian Mountains now stand (de Witt and others, 1993). This shale contains significant quantities of natural gas. New developments in drilling technology, along with higher wellhead prices, have made the Marcellus Shale an important natural gas resource.

The Marcellus Shale extends from southern New York across Pennsylvania, and into western Maryland, West Virginia, and eastern Ohio (fig. 1). The production of commercial quantities of gas from this shale requires large volumes of water to drill and hydraulically fracture the rock. This water must be recovered from the well and disposed of before the gas can flow. Concerns about the availability of water supplies needed for gas production, and questions about wastewater disposal have been raised by water-resource agencies and citizens throughout the Marcellus Shale gas development region. This Fact Sheet explains the basics of Marcellus Shale gas production, with the intent of helping the reader better understand the framework of the water-resource questions and concerns.

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What is the Marcellus Shale?

The Marcellus Shale forms the bottom or basal part of a thick sequence of Devonian age, sedimentary rocks in the Appalachian Basin. This sediment was deposited by an ancient river delta, the remains of which now form the Catskill Mountains in New York (Schwietering, 1979). The basin floor subsided under the weight of the sediment, resulting in a wedge-shaped deposit (fig. 2) that is thicker in the east and thins to the west. The eastern, thicker part of the sediment wedge is composed of sandstone, siltstone, and shale (Potter and others, 1980), whereas the thinner sediments to the west consist of finer-grained, organic-rich black shale, interbedded with organic-lean gray shale. The Marcellus Shale was deposited as an organic-rich mud across the Appalachian Basin before the influx of the majority of the younger Devonian sediments, and was buried beneath them.

Why is the Marcellus Shale an Important Gas Resource?

Organic matter deposited with the Marcellus Shale was compressed and heated deep within the Earth over geologic time, forming hydrocarbons, including natural gas. The gas occurs in fractures, in the pore spaces

Figure 1. Distribution of the Marcellus Shale (modified from Milici and Swezey, 2006).

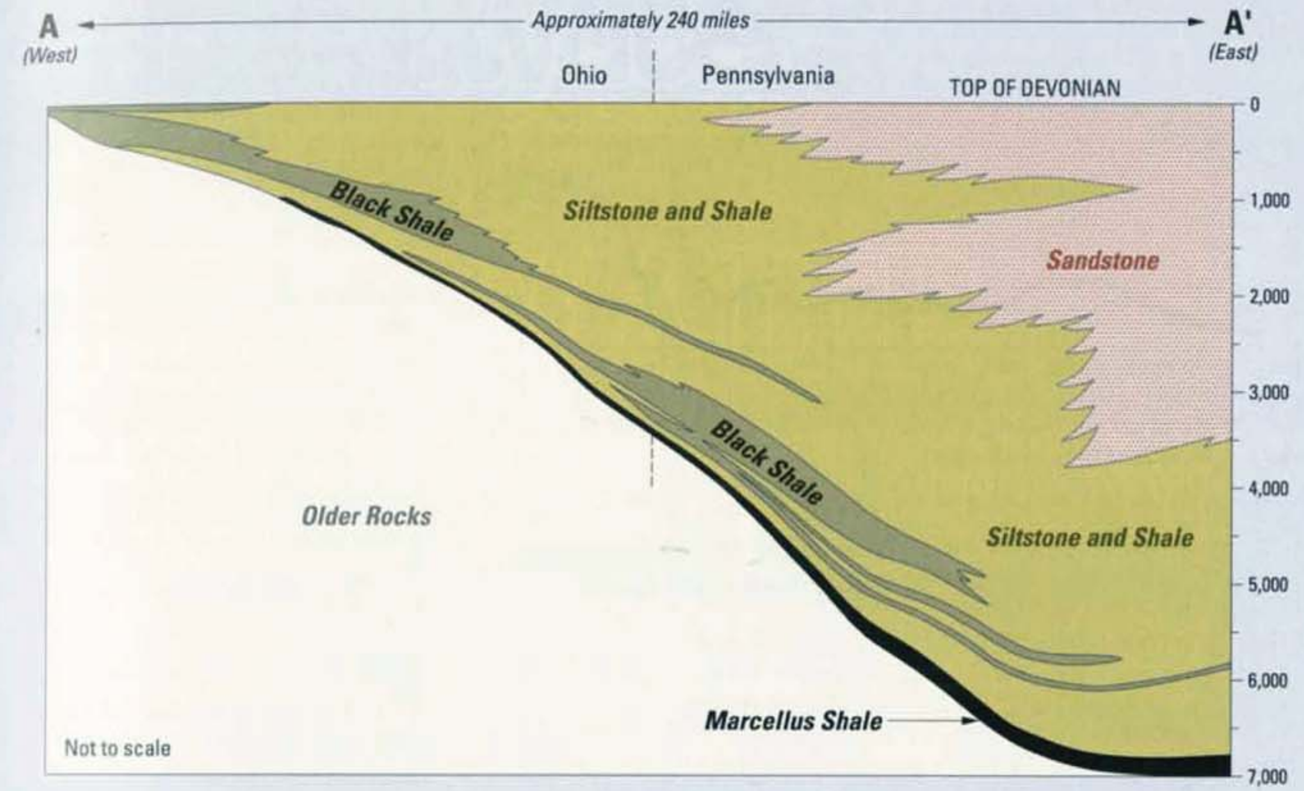

Figure 2. West to east line of section A-A' of Middle and Upper Devonian rocks in the Appalachian Basin. The Marcellus Shale is the lowest unit in the sequence (modified from Potter and others, 1980).

between individual mineral grains, and is chemically adsorbed onto organic matter within the shale (Soeder, 1988). To produce commercial amounts of natural gas from such fine-grained rock, higher permeability flowpaths must be intercepted or created in the formation. This is generally done using a technique called hydraulic fracturing or a *"hydrofrac,"* where water under high pressure forms fractures in the rock, which are propped open by sand or other materials to provide pathways for gas to move to the well. Petroleum engineers refer to this fracturing process as *"stimulation."*

From the mid-1970s to early 1980s, the U.S. Department of Energy (DOE) funded the Eastern Gas Shales Project (EGSP) to develop new technology in partnership with industry that would advance the commercial development of Devonian shale gas (Schrider and Wise, 1980). Goals of the project included assessing the size of the resource, estimating recoverable gas, and determining the most effective technology for gas extraction. The EGSP shale stimulation experiments tested a wide variety of hydrofracs and other techniques. Results were somewhat uneven, and DOE concluded that stimulation alone was generally insufficient to achieve commercial shale gas production (Horton, 1982). It was suggested that better success could be obtained by targeting specific formations in specific locations. The EGSP results did indicate that if the hydraulic fractures were able to intercept sets of existing, natural fractures within the shale (fig. 3), a network of flowpaths could be created.

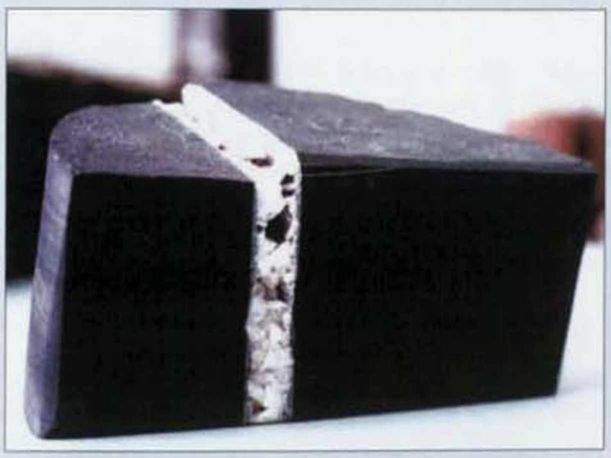

Figure 3. Marcellus Shale drill core from West Virginia, 3.5 inches in diameter, containing a calcite-filled vertical natural fracture. Photograph by Daniel Soeder, USGS.