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# Natural Gas From Unconventional Geologic Sources

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## CHAPTER 8

## CURRENT INVESTIGATION OF DEVONIAN SHALE BY THE U.S. GEOLOGICAL SURVEY

Wallace DeWitt

JODRY: I have some information to add from Dr. Frank Stead of the USGS. His estimates for total gas in place in the Devonian black shales of the eastern United States is somewhere between 500 and 600 Tcf. That estimate of gas in place is close to the 600 Tcf estimate to be in place in the tight sands in the three principal basins in the western United States.

Mr. DeWitt will summarize the current USGS investigations of the Devonian shale.

DEWITT: When people expound great figures that run into the quadrillions of cubic feet, such as we have seen quoted in the newspapers, particularly in Ohio, they are talking about the gas that is recoverable only by pyrolysis. In other words, you would have to ignite shale and retort it. I don't think the people in the Appalachian Basin would be happy to have that happen, so the recoverable resource that we can expect by normal drilling and production methods would be much smaller, as indicated by the previous speakers. A very small part of that total amount of gas that is held in the rock can be recovered by present techniques.

The intriguing question is how to unlock the large volume of gas that is adsorbed in the black or brown shales. It appears from scanty data that most of the gas in the Devonian Shale comes out of the black or brown shales and is not found in the grey shales. We took a look at the whole Appalachian Basin, because the USGS is charged with the responsiblity of resource appraisal, and the first thing we found was that there was not much information to work with.

In the program that the USGS is engaged in with ERDA, our part is to characterize the shale and to come up with some appraisal of the resource. It is going to take many months to generate enough data to do this.

You would think that after poking around the Appalachian Basin for about 140 years, people would have some idea of what the shale looks like, but very little is known in the subsurface because of the manner in which the drilling progressed. We have to find the geometry of the black shale body itself. The question comes up of how the kerogenaceous material in the black shale matures. As the kerogen matures, how much oil is released and how is the oil broken down into gas; and, probably more importantly, how much of the gas that is generated is occluded within the shale and does not escape?

We know a few facts about the Basin. It is about 160,000 square miles in area. The black shale is richest in Tennessee and Kentucky, with a thickness of about 50 feet, where it is known as the Chatanooga Shale, and contains an average of about 15 to 18 gallons per ton of oil recoverable by pyrolysis. North and east along the Basin, the individual shale beds thicken. At the same time, the recoverable oil tends to diminish, and in southern Ohio, the oil content is about 7 gallons per ton. In western New York State, it is down around 3 gallons per ton, and over on the Allegheny front and in southern Pennsylvania, the oil content is less than a gallon a ton.

I don't believe there is any direct correlation between the amount of gas and the amount of oil to be recovered by pyrolysis, but I think it is an indication of the degree of maturation that has occurred, and may give us a clue to the amount of gas that we can expect to obtain by pyrolysis and also the smaller amount that would be available from natural fractures or by artifically induced fractures. There are other factors to consider, because part of this change in the amount of kerogenaceous material within the shale is due to differences in original deposition. The Upper Devonian sediments, of which the black shale is just a part, were deposited in a large and very complex delta. The source lay to the east, and from the areas where the maximum amounts of black shale were deposited, up onto this delta wedge, the material changes from a typical black shale with bituminous matter into a more coaly shale, having a less bituminous character.

Another factor that is going to cause trouble in the development of natural gas is splitting of the black shale sequence and interfingering with turbidite beds. Studies in New York State show that there are individual lenses extending 60 or 70 miles in an east-west direction. Their configuration in the subsurface is not yet known, but we will find out in our characterization study.

The geometry of the individual lenses must be worked out before planning any sort of development program in this area. Part of the characterization study is to delineate a framework, that is, determine the geometry and make structural analyses so the areas where the shales are thick and maturation has not proceeded too far can be correlated with known structures. We hope that we will find areas where dilation has occurred, and a fracture system exists.

We are going to carry on a series of geochemical analyses to determine the types of hydrocarbons and to link these with the maturation study.

The black shale, in addition to containing a great deal of hydrocarbon, also contains a considerable amount of uranium. We are also interested in the trace elements available within the black shale. If we go into more sophisticated treatment methods, such as heating the material in situ, we may be able to recover trace elements and deal with them as a resource.

For example, there is a great deal of pyrite in the shale. We might be able to recover appreciable quantities of sulfur from it. On the other hand, there are environmental considerations because there may be some easily volatilized metals which will have to be removed from the gas train before discharge or use.

We plan to make a thorough study of the trace element content of the material. At the same time, we hope to improve the understanding of the clay minerology of the shale, which will certainly be important for understanding the compatibility of fluids in different types of fracturing. We also want to know the framework of the general depositional areas of the shale so we can develop techniques in one area that may possibly be applied in another. It is important to save people money by identifying unfavorable areas as well as pointing out areas suitable for the application of one or more of the stimulation techniques.

JODRY: Recognizing that you have already said you don't really know the extent of the shale, would you have difficulty in accepting 500 or 600 trillion feet as the amount of gas that might be in place?

DEWITT: One thing that comes to mind--you mentioned the Big Sandy Field as having the best production, but there were wells scattered all through the basin drilled in the 1820s, 1830s, up to 1860. There was a large field developed right along Lake Erie. The drilling started in Fredonia, New York, and spread westward across northwestern Pennsylvania and eventually tailed out around Cleveland, Ohio. The wells in this field were low pressure wells (just a few pounds or a few ounces above atmospheric pressure) and produced small volumes of gas. They were used by local industries, by people who had a cookstove, furnace, and so on. But scant production history from those wells indicates more or less the same type of production as the Big Sandy Field--very long life. Two gas wells at Fredonia were drilled in the 1820s. Their total production was 6 mcf per year, which is not very much, I admit, but 77 years later when they were plugged they were still making 6 Mcf per year. We probably have the same general characteristics throughout much of the area we are now considering. There might be 500 or 600 Tcf in place.