Marcellus

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Range Resources' (RRC) fourth quarter 2007 call announcing initial production rates (IP = 24 hour production tests) from five wells in Washington County, Pa., kicked off the Marcellus gas shale's breakout year. At the time, the "official" sources, including the U.S. Geological Survey (USGS) and the Energy Information Administration (EIA) gave no indication of the potential for gas production from the Marcellus. Thirty-year-old U.S. Department of Energy estimates for technically recoverable gas from Appalachian Basin black shales had mysteriously dropped out of sight. At a Petroleum Technology Transfer Council (PTTC) workshop in early January 2008, Gary Lash, Ph.D., and I pointed out that the Marcellus would become one of the world's top super giant gas fields, according to volumetric calculations. Dr. Lash is a professor in the Department of Geosciences at State University College in Fredonia, N.Y. The press got wind of this news and set off a land rush in the Appalachian Basin. More than a year later, enough Marcellus production data have leaked

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2008: Report card on the breakout year for gas production in the Appalachian Basin

to the public to allow a preliminary production-based assessment of the size of the Marcellus gas field. The purpose of this article is to describe what is known in early 2009 about the potential for the Marcellus after its breakout year.

Pennsylvania production data remains sketchy

Production data in Pennsylvania is currently, by state law, proprietary for five years. (However, a move is underway in the Pennsylvania Legislature to change this. On June 8, the Pennsylvania Senate unanimously passed SB297, which requires oil and gas companies operating in the state to disclose their production data twice a year. The bill has now been sent to the House for consideration). Inferences about production decline are then dependent solely on information that operators place in public documents, usually associated with investor and analyst workshops and in quarterly calls to shareholders. Public data are largely populated with initial production tests of the 24-hour variety, but choke specifications, back pressure, and other important assessment parameters are not revealed. Other important data such as lateral length, number of stimulation stages, and volume of proppant are also hidden from public view. There is no way of knowing how to compare the IP data from different operators and it seems unlikely that there is a common convention for measuring IP. Finally, there are virtually no public production data from private companies in the play.

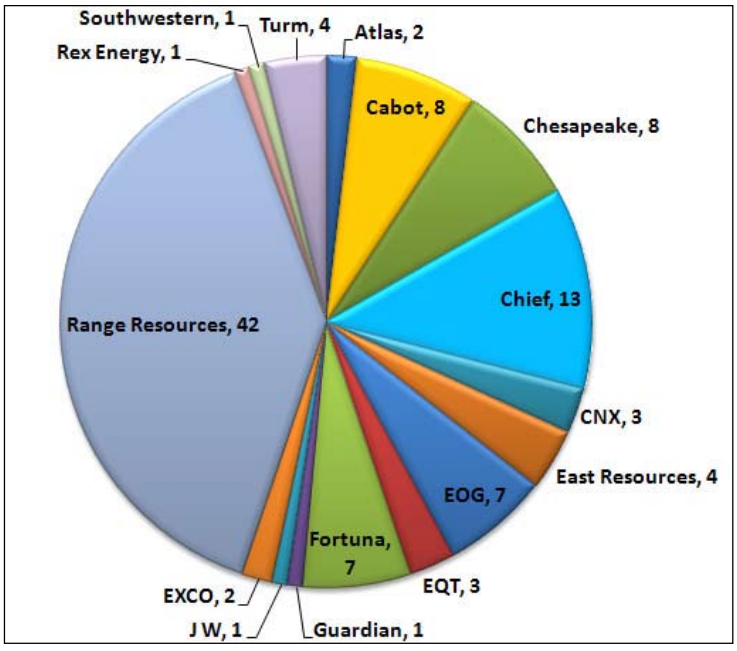
Decline curves with the most complete gas shale production data come from the Mississippian Barnett shale of the Fort Worth Basin. In a late 2008 investor and analyst report, Chesapeake Energy (CHK) published pro forma decline curves for both Barnett and Marcellus horizontal wells. Chesapeake has a premium acreage position in both plays. One would presume that both Chesapeake decline curves were based in large part on Chesapeake's experience in the Barnett shale, although Chesapeake announced six horizontal Marcellus wells in its late 2008 report, largely in West Virginia. The Department of Environmental Protection in the State of Pennsylvania (PA-DEP) keeps a reasonable but not complete record of spud dates for Marcellus wells with horizontal wells noted. Through Oct. 31, 2008, the PA-DEP's Web site for wells spudded in the Marcellus of Pennsylvania recorded few Chesapeake wells and no horizontal wells.

In Chesapeake's Marcellus v. Barnett comparison, its pro forma curves show an IP = 4.3 MMcfe/d v. 2.5 MMcfe/d, the PIP (practical initial production = 30-day production test) = 3.7 MMcfe/d v. 2.2 MMcfe/d, and a five-year cumulative production = 1.55 bcf v. 1.01 bcf. Does public production data through early 2009 support Chesapeake's upbeat prediction for well performance from the Marcellus relative to the Barnett? Publically-announced production data from horizontal wells of a collection of Appalachian operators seem to support Chesapeake's analysis.

Department of Environmental Protection records yield useful data

Through May 15, 2009, the PA-DEP records show 97 spud dates for horizontal Marcellus wells, although I can account for at least 10 more in Pennsylvania and West Virginia (Fig. 1). Undoubtedly others exist that have

Figure 1



not made their way into the PA-DEP records. Of these, a minimum of 53 were spudded through the end of 2008. The actual number might have been closer to 60. From this set of wells, one can explicitly identify over 40 wells with publicly released IP data, some stimulated after the turn of the year. Other data on production come from sources such as royalty payments and private companies. In all, 50 data are plotted on a log (IP)-probability graph with some data entered multiple times as an average number rather than an explicit IP (Fig. 2). It is immediately clear that the pro forma IP (= 4.3 MMcfe/d) for the Marcellus as published by Chesapeake during the Fall of 2008 is nearly identical to the P50 (= 4.2 MMdfe/d) for the production data available through the first 50 wells with reported IPs from the Marcellus. Even if a few poor performing horizontal wells have been hidden from public view, the P50 IP does not change appreciably.

Decline curve models predict rate of flow as a function of time, initial production rate, and a parameter that has the units of inverse time. Because there is not enough public data to define a Marcellus decline curve precisely, I rely on a pro forma decline curve and that curve published in the 2008 Chesapeake investor and analyst report serves well. Chesapeake has a very skilled technical staff and I have confidence in their ability to generate a reasonable decline curve for gas production from horizontal Marcellus wells. The best fit curve for the Chesapeake pro forma curve follows a power-law rate decline with a poor fit to initial production (Fig. 3A). The shape of the three most commonly used production-decline curves, depending on circumstances, are an exponential rate decline, a hyper-

Figure 2

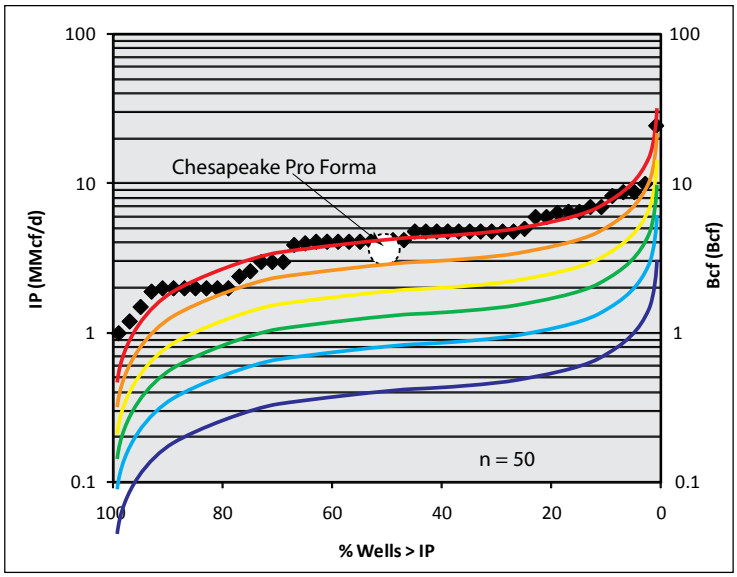
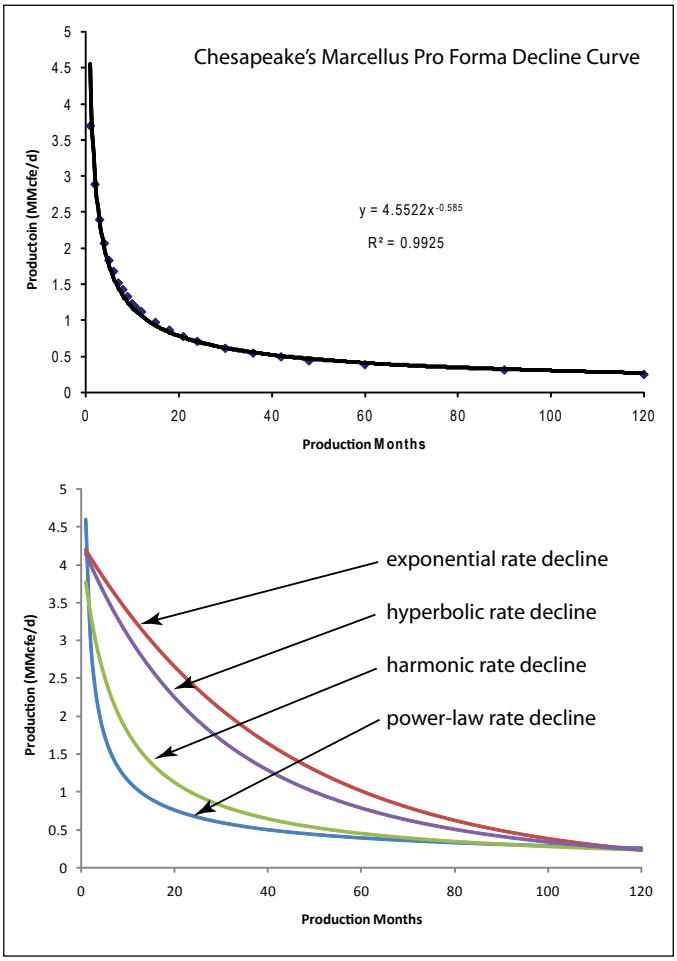


Figure 3



bolic rate decline, and a harmonic rate decline (Fig. 3B). A power-law rate decline is steeper than the three traditional rate decline curves.

So little public data is available on Marcellus decline that it is impossible to grade the Chesapeake pro forma curve with confidence but there are hints in the public domain. One of the most encouraging wells was drilled and completed by Cabot (COG) in Susquehanna County for which the IP was 8.8 MMcfe/d and after 60 days the well was still flowing at 91 percent of IP. Another well has declined to 67 percent of IP in 105 days. This is relative to the Chesapeake pro forma decline of 51 percent of IP over the same period. A third Cabot well has declined to 49 percent of IP over 60 days. which is a steeper decline than Chesapeake's pro forma rate decline curve. Chesapeake's data from the Stern wells of West Virginia are equally encouraging, with six wells through the 2008 investor and analyst report having a PIP averaging 3.7 MMcfe/d. The meager Cabot production data appear to suggest that a power-law rate decline curve is somewhat conservative as a tool for making longer range forecasts about gas production from the Marcellus.

In late 2007, Steve Drake of Marsh Operating Company plotted initial potential (= IP) versus EUR for the Barnett shale and concluded that three orders of magnitude separate the two (IP = 0.5 to 5 MMcfe/d vs. EUR = 0.5 to 5 Bcf) for horizontal wells (**http://spemc.org/resources/presentation_120607.pdf**). Chesapeake used the same relationship in predicting that their average Marcellus well with a PIP of 3.7 MMcfe/d would eventually yield 3.75 Bcf. This linear relationship between PIP and EUR makes it straightforward to estimate the productivity for the Marcellus across the Appalachian Basin, assuming that the Marcellus depletes in the same manner as the Barnett. Forecasting requires that the Marcel-

Table 1

Counties ranked by tier based on both geology and gas production data from the Marcellus through May 15, 2009. *Tier 1 counties are those counties with proven horizontal wells producing with a P50 IP > 4 MMcfe/d or less than 10 miles from such wells. The other 109 counties are not adequately tested by production and thus graded downward between Tier two and Tier six depending on geological conditions.*

	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5	Tier 6	Total
Maryland			1				1
New York			3	4	4	6	17
Pennsylvania	5	6	8	6	6	11	42
Ohio		1	1	2	6	8	18
West Virginia	3	3	2	4	7	20	39

Table 2

Estimated Ultimate Recovery from Marcellus after a 50-year decline.
Power-law model assuming that 70% of the sections in each county are accessible and a well spacing of 80-acres.

	Counties	Sections	Total Risked Potential	Total Risked Potential	Total Risked Potential
			P90	P50	P10
			Bcf	Bcf	Bcf
Maryland	1	656	3,123	6,980	11,756
New York	17	13,906	30,955	71,859	126,176
Pennsylvania	42	32,622	133,240	291,648	521,406
Ohio	18	9,298	18,361	41,166	71,010
West Virginia	39	16,851	35,022	77,588	136,814
Totals	**117**	**73,333**	**220,701**	**489,241**	**867,162**

Table 3

Five-year production from core area of Marcellus
Power-law model assuming that 70% of the sections in each county produce with an 80-acre well spacing.

	Counties	Sections	Total Risked Potential	Total Risked Potential	Total Risked Potential
			P90	P50	P10
			Bcf	Bcf	Bcf
Maryland	1	656	1,061	2,371	3,993
New York	7	6,417	7,110	16,842	29,989
Pennsylvania	25	20,801	40,228	87,888	158,345
Ohio	4	1,804	2,679	6,077	10,749
West Virginia	12	3,430	6,436	14,222	25,512
Totals	**49**	**33,108**	**57,514**	**127,400**	**228,587**

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lus be subdivided into units no larger than the size of counties. With such a subdivision, the counties may be graded according to several geological parameters including thickness, depth, degree of overpressuring, thermal maturity, structural complexity, TOC profile, quartz/clay ratio and other geological parameters included in the Devon (DVN) tornado chart.

Marcellus may ultimately yield 489 Tcf

The Marcellus is prospective under at least 117 counties in five states of the Appalachian Basin. Using several geological parameters, I have graded each of these 117 counties according to a six-tier system (Fig. 2 & Table 1). Using the power-law rate decline of Chesapeake, an EUR for the Marcellus may be calculated assuming that 70 percent of the sections in each county are accessible, that wells have an 80-acre spacing and that decline is allowed to proceed for 50 years (Table 2). **This calculation yields a 50 percent probability (P50) that the Marcellus will ultimately yield 489 Tcf.** At present consumption rates in the United States, the Marcellus alone can meet the natural gas demands of our country for more than 20 years, if the gas could be produced fast enough, which, of course, it can't.

If the core of the Marcellus play is considered to include just those counties down to Tier 4, then the first five years of production from those 49 counties would yield 127 Tcf at P50 (Table 3). Obviously, such production would be distributed over a much longer period but, any way gas is produced from the Marcellus, it will become a super-giant gas field. Coupled with other gas shale plays in North America, the prospects for a reliable supply of natural gas for the next several decades are so substantial that national energy policy will eventually adapt to this gas shale bonanza that is American. ✯