NATURAL GAS PRODUCTION IN PA: DEEPER DRILLING? DEFINITELY!

This column is presented weekly by the Public Education sub-committee of the Clinton County Natural Gas Task Force in an effort to provide accurate, up-to-date information on activities surrounding the Marcellus Shale formation and the natural gas exploration industry.

Prior to 2000, the Devonian-age Marcellus Shale was a term used principally by geologists. Less than a decade later, "Marcellus" has become a household word in much of PA. This rapid rise to familiar status has been fueled by growing estimates of the huge commercial potential of this natural resource lying deep below the forest-carpeted expanses of the Commonwealth's plateaus. Gas industry experts tout the value of the Marcellus. They assert that production from this natural gas play will ensure cheap and plentiful natural gas resources for many years to come for homeowners, factories, and power plants.

The Marcellus has long been known as a gas-rich source rock among geologists. Yet, shale units were never considered as economically viable, gas reservoir targets. Now, with the capability of horizontal drilling and hydrofracing technology, the Marcellus has been redefined by the industry as a producible, source-reservoir play. Still in its infancy as a gas play, relatively few Marcellus wells have been drilled to date. However, trends indicate increasing numbers of wells per pad and the lengths of horizontal laterals. Thus, gas recovery volumes certainly will grow. Because of its large regional extent and high organic content, the Marcellus Shale is being promoted as a "world-class" natural gas field.

Natural gas exploration and production throughout our Commonwealth clearly will continue into the foreseeable future. It is also likely that it will not be long before the names of other geologic units become equally commonplace, including the Ordovician-age Trenton-Black River Groups and the Utica Shale. Once the production infrastructure is in-place, deeper drilling, applying newer, ever-evolving technology, beyond the Marcellus, appears inevitable. This conclusion is based upon an understanding of the geology of the Appalachian Basin and the data it yields. It also reflects the nation's drive to satisfy its seemingly unquenchable thirst for additional energy resources.

PA has a long history of extraction of its rich hydrocarbon resources, its coal, oil, and natural gas. The origin of our fossil fuels is intimately tied to the geologic history of the Appalachian Basin. Stretching almost unbroken over 1,500 miles from Alabama to Canada along the eastern margin of North America, this several-hundred-mile-wide belt comprises rounded mountains, plateaus, and interspersed lowlands. The ancient folded and faulted rock formations we see today represent some of the sedimentary layers deposited in that basin.

The geologic history of the Appalachian Basin is long and complex, lasting more than 250 million years. It involves several episodes of mountain building, when earth's massive crustal plates collided with the eastern edge of the North American plate. And, between those events, the basin experienced long periods of inactivity. Erosion of those mountains generated abundant

sediment and many river systems delivered that material to vast lowlands marginal to a large inland sea. Think in terms of all of the rivers contributing sediment to the Mississippi River, and, in turn, the river constructing its delta out into the Gulf of Mexico. Beyond the delta, the finest sediment moves farther offshore and spreads out into the marine basin.

Not all of the materials involved in these events were inorganic constituents. This was also a time when one-celled and multicellular plants and animals were expanding and flourishing in both the marine and non-marine realms. It was the carbon and hydrogen derived from the organisms that ultimately were transformed both onshore and in the deep marine basin into the complex molecules we call hydrocarbons or fossil fuels.

For example, our 300-million-year-old Pennsylvanian-age coal reflects an Everglades-like setting in which thick deposits of plant matter amassed in huge, lush lowland swamps near the basin's edge. The Pittsburgh coal, described as one of the largest and most valuable mineral deposits in the world, ranges upwards of 16 feet in thickness. In order to form those thicknesses, more than three times that much plant debris must accumulate and regional conditions would have had to have been stable for very long periods of time.

The much older Devonian and Ordovician oil and gas resources originated with a variety of one-celled microorganisms that flourished in the oxygenated surface waters of this marine basin. Upon death, literally zillions of these critter's bodies descended slowly into the oxygen-starved bottom waters of the basin along with abundant fine-grained sediment shed from the adjacent landmass. Over millennia, this organic matter was subjected to bacterial breakdown, migrating fluids, and heat and pressure from the overlying rock materials and crustal forces. As a result, it underwent chemical alterations that ultimately converted much of it into oil and natural gas.

Deep exploratory drill holes penetrate the thick sedimentary sequences throughout the Appalachian Plateaus. Geologists examine well logs and drill cuttings and identify intervals of coal, black shale, and oil and natural-gas-rich sandstone. Just as the blackness of coal represents its high organic content, so also does black shale demonstrate its organic richness. However, color alone is insufficient to appraise the gas potential of black shale units. Determining the viability of a rock unit to generate producible hydrocarbons involves increasingly sophisticated geochemical testing to evaluate properties such as total organic content as well as the type, maturity, and history of its organic matter.

Evolving technology in petroleum exploration is not limited to testing and drilling. Although valuable geologic information derives from careful examination of drilling cores and cuttings, detailed geophysical logging has become an indispensible industry tool. Probes, lowered into the boreholes, generate graphical and digital records of a long list of physical and chemical parameters of the rocks and their fluids as a function of depth. Geologists and geophysicists apply complex computer software to analyze, model, and interpret this output, all of which facilitates decision-making throughout all phases of the operation.

In addition, the seismic surveying currently underway throughout the region generates a wealth of very high quality data. These data will prove pivotal not only to Marcellus drilling, but they

will be invaluable as deeper targets come into focus. Rock samples and well logs, used in coordination with seismic surveys, provide vital ground truth in the interpretation of these data.

As a result of this technological evolution, exploration targets are being recalibrated. The Appalachian Basin's rock strata are being reevaluated in an attempt to identify other hydrocarbon systems in which the rock unit is both the source and reservoir. Based on extensive experience, targeted source-reservoir units need to be geographically extensive, rich in organics, and meet specific geochemical benchmarks to qualify as a viable play. Typically these shale plays generate natural gas, but they may include oil plays as well.

We need to look no further than to our north and across the border into Canada to glimpse into our future. Currently, both the Middle Ordovician Trenton-Black River Groups and the Upper Ordovician Utica Shale are producing natural gas in New York; and in Quebec, commercial production from the Utica Shale is expected in 2012. In addition to these units, Lower Silurian sandstone units and Lower and Middle Devonian carbonate and black shale units represent target reservoir zones for future oil and gas exploration and development within the Commonwealth.

Clearly, the geological and technical evidence supports the conclusion that much deeper drilling can and should be anticipated. Prudent measures should be considered to monitor and assess our natural systems where gas exploitation is currently active or anticipated. The quality and quantity of public and private water supplies, the health of our streams and wetlands, and the status of ecologic systems as vital resources of our Commonwealth need to be protected.

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