Horizontal Drilling,
A Technology Update for the Appalachian Basin

Based on a workshop co-sponsored by PTTC's Appalachian Region, the Ohio Oil and Gas Association and Ohio Geological Society, May 27, 2004 in Cambridge, OH

Bottom Line

Horizontal drilling is being applied in many environments, including coalbed methane. One special process, CDX Gas LLC's pinnate drilling process, is **being** applied in coalbed methane projects in the Appalachian and some western coal basins. It is best suited for thick, low permeability coals with good lateral continuity. Where applied, production occurs more quickly, recovery increases and environmental impact is decreased. Although **initially** more costly, **when accelerated** production and higher recovery **rates are considered**, reserve unit development cost is actually lower than conventionally-drilled projects. Technology advances in horizontal drilling are being driven by producers, service providers and the federal government. Schlumberger described advances in its rotary steerable systems and coiled tubing applications, while Halliburton outlined an advanced hydraulic fracturing technique for horizontal wells. DOE's National Energy Technology Laboratory described its drilling R&D program, which includes a microhole drilling component.

Problem Addressed

Horizontal drilling technology and how it is applied within a particular geographic/geologic area continually evolves in both the reservoir situations where it is applied and the tools and techniques employed. Periodic reviews are helpful to **assist** busy independents understand changes relevant to their potential applications.

Key Words

Coiled Tubing
Horizontal Drilling
Pinnate Pattern
Rose Run
SurgiFrac^{SM}
Underbalanced Drilling

Speaker

Unconventional Drilling Methods for Unconventional Reservoirs, Doug Wight, CDX Gas, LLC

Horizontal and Directional Drilling in the Appalachian Basin, Jeff "Duff" Smith, Directional Drilling Contractors, LLC

Advanced Rotary Steerable Systems, Lars Halvorsen, Schlumberger Drilling and Measurement

Coiled Tubing Drilling Applications, Kirby Walker, Schlumberger Well Services

Drilling Technologies for Tomorrow's E&P Paradigms, John Rogers, DOE National Energy Technology Laboratory

SurgiFrac℠ Service—A Quick and Cost-Effective Method To Help Boost Production From Horizontal Completions, Daniel Mullins, Sr., Halliburton Energy Services

Rose Run Sandstone Horizontal Re-Drill Project, Mark Moody, Great Lakes Energy Partners, LLC

Reservoir Candidature, Capitalizing on the Benefits of Underbalanced Drilling, James Hardt, Weatherford International Ltd.

TECHNOLOGY OVERVIEW

CDX's "Pinnate" Drilling Process

Doug Wight, senior exploration geologist with CDX Gas, LLC, described their unconventional "pinnate" drilling process for unconventional reservoirs. Originally developed in southern West Virginia's coal beds, the process has been introduced in western basins. This "pinnate" drilling technique is best applied in thick, low permeable coals that have good lateral continuity.

CDX had multiple objectives when they set out to develop coal bed gas resources ahead of mining in southern West Virginia. First, they wanted a means to produce gas from unconventional reservoirs that was economic and would result in higher and quicker gas recovery. Also, they wanted to develop an underbalanced drilling technology that would maximize efficiency while creating a uniform drainage pattern. And finally, they wanted to optimize dewatering of the coals and minimize the environmental impact of water and gas production operations.

CDX achieved these goals by developing their dual well, horizontal drilling system that results in a pinnate drilling and drainage pattern. So-named because the final drilling pattern resembles the veins of a leaf, the system begins with two closely-spaced (within 20 ft) vertical wells: one well serves as an air injection well early in the project and then as a producing well; the second well serves as the horizontal and service well bore. In Wyoming County, WV, a horizontal well drilled from the service well intersected the first vertical well in the lower of two coal seam targets (Pocahontas 3, less than 100 ft below the Pocahontas 4), creating a cavity in the lower coal. Air injected into the cavity through the first well forces fluid and sediment up the second well to the surface. Once this is done, the first well becomes a producing well. The horizontal leg continues to be drilled from the second well, usually reaching a length of 4,800 feet before drilling stops and the drill bit begins to be retracted. As the drill bit is retracted along this main lateral, side laterals are drilled at 45 degree angles to the main and 90 degrees to each other. This drilling of side laterals continues as the drill bit is retracted all the way to the vertical

producing well. Each successive side lateral is longer than the previous hole, resulting in an essentially square drainage area.

After the first quad is drilled, second, third and fourth mains can be drilled from the horizontal service well, and side laterals can be drilled along each as the drill bit is retracted toward the dual well system. Early in the development stage of this technique, three additional vertical production wells were drilled, with each being intersected by a horizontal main. Now a 360-degree pattern can be drilled using only three vertical wells, not five or even eight as before. The final 360-degree pattern drains 1,280 acres and replaces 16 vertical wells, while providing uniform drainage and pressure depletion. The environmental impact is significantly reduced as well. These patterns can be expanded to drain more than 2,000 acres, and can be developed in more than one coal seam in the same area, using the same producing and service wells.

CDX developed this technique to drain coal beds of their natural gas prior to mining. Because the mining company's master plan includes a schedule for mine development, CDX knows how long they have to drain the coals completely; i.e., the date that the mine will begin to come through their operation. Knowing the length of time that they have to drain the coals, the gas content and thickness of the coal, and the volume of coal that has to be drained, CDX uses a computer program to determine the optimum spacing of the side laterals that will drain the coals in the amount of time available. By doing so, the drilling of unnecessary side laterals is avoided, and no gas is left in the coals that could have been drained prior to mining.

The pinnate drainage pattern in coal beds has improved recovery to more than 80% of the gas-in-place. Unique pattern design and underbalanced drilling also prevent wellbore damage and improved permeability performance. While this type of drilling and completion is costly (generally in the $million+ range), it has proven to be cost effective in the proper application environment.

New Horizontal Technologies in the Appalachian Basin

Jeff "Duff" Smith, Directional Drilling Contractors, LLC, presented a history of horizontal drilling in the Appalachian Basin, beginning with a chain at the end of a drill bit that whipped around to carve out a cavity in the rock, a "weed eater" approach, to the modern methods, like CDX Gas's pinnate operation. He also summarized the various applications for horizontal drilling and developments in other related technology, noting that when measurement-while-drilling (MWD) systems replaced the wire-line system, the technology developed more rapidly. A common barrier to applying newer technologies in the Appalachian Basin is that these technologies, often developed for the international market, are too costly or not physically available in the region.

Schlumberger provided information on its newer technologies, including advanced rotary steerable systems, particularly the PowerDrive series, and coiled tubing applications. The PowerV vertical control system was designed to drill a true vertical well while reducing drilling cost per foot by staying vertical. Recently, two 6,000-ft Pennsylvania wells were drilled with this system. Coiled tubing applications include drilling deeper to a new pay

or to produce a rat hole, adding a horizontal leg, removing well bore obstructions, etc. Other newer technologies include SlimPulse and Viper.

John Rogers, DOE National Energy Technology Lab, outlined their programs to develop drilling technologies for tomorrow's exploration and production paradigms. He began with a few givens: we need more gas, much of it will come from the same old places, but it will be harder to get. Therefore, we need new technology to develop deeper onshore and offshore gas resources and to produce oil from old fields. New technology can reduce drilling costs by reducing drilling time from 190 to 60 days in one example, and by improved drilling fluids, hydraulics, motors and rigs. Rogers provided a comprehensive overview of DOE's efforts to develop drilling fluids, microhole technology, coiled tubing technology – even ice roads and ice pads in Alaska – while presenting specific examples of each.

Another new fracturing process developed by Halliburton, termed SurgiFrac^{SM}, is intended to boost production from horizontal wells. Jets in the horizontal section cut the rock at any desired angle, thereby creating a preferred direction for induced fractures. Breakdown pressures are lower compared to vertical well fractures, with the inverse relationship between pressure and velocity during injection being the key. This technique should not be used in interbedded intervals where the two lithologies have different breakdown pressures. It is currently being tested in a Trenton-Black River project in New York.

Failed Rose Run Horizontal Re-Entry Project

Mark Moody, Great Lakes Energy Partners, LLC, summarized their experience in re-entering an old vertical Rose Run well in Ohio to drill a horizontal leg to enhance production. The original well at one time was capable of producing a million cubic feet a day with 2-3 barrels of condensate, but over time it began making salt. Fresh water was used to correct the salt damage problem, but because this well was on acreage that was included in a 3-D seismic survey, it was decided to drill a horizontal well "with a science project attitude."

The project became a series of disasters with drill bits and motors, one of which was created when a reaction between condensate and foam produced an explosion that killed the motor. The well had to be sidetracked around the problem, but after drilling only another 73 feet, the bit quit, the hole began taking the drilling fluid, Baroid came out, and so it continued. Conclusion was that too much fluid was put in the well while trying to make footage, and the well drank fluid as quickly as it could be pumped. While the project failed, it provides a framework of what one needs to consider in preplanning and design.

Connections

Lars Halvorsen
Schlumberger Drilling and Measurement
500 E. Lee St, Suite 550
Charleston, WV 25301
Phone: 304-353-9312 E-mail: lhalvorsen2@slb.com

James Hardt
Weatherford International Ltd.
515 Post Oak Blvd; Suite 600
Houston, TX 77027
Phone: 713-693- **E-mail:**

Mark Moody
Great Lakes Energy Partners, LLC
P.O. Box 550
Hartsville, OH 44632
Phone: 330-877-6747 E-mail: mmoody@gl-energy.com

Daniel Mullins, Sr.
Halliburton Energy Services
900 Pennsylvania Ave, #107
Charleston, WV 25302
Phone: 304-343-9054 E-mail: daniel.mullins@halliburton.com

John Rogers
DOE National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
Phone: 304-285-4880 E-mail: jrogers@netl.doe.gov

Jeff "Duff" Smith
Directional Drilling Contractors, LLC
2122 M-37 South
Traverse City, MI 49684
Phone: (231) 943-3000 E-mail: jeffsmith@ddcon.com

Kirby Walker
Schlumberger Well Services
500 Lee Street, Suite 550
Charleston, WV 25301
Phone: 304-353-9313 E-mail: walker26@slb.com

Doug Wight
CDX Gas, LLC
5485 Beltline Road, Suite 190
Dallas, TX 75254-7672
Phone: 972-852-0427 E-mail: info@cdxgas.com