HARD ROCK DIRECTIONAL DRILLING PROVES SUCCESSFUL

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BOTTOM LINE

Directional drilling programs in the Appalachian Basin's highly-indurated reservoir rocks can be technically successful and economic. While case studies reveal some problems (such as increased drilling time, high fluid loss, very abrasive formations, and mechanical problems), reserves and production rates can be significantly increased.

PROBLEM ADDRESSED

Directional drilling in the Appalachian Basin's well-indurated reservoirs requires more equipment and increases drilling time. By understanding the process of evaluating reservoirs for directional drilling, operators can get accurate information about costs, potential advantages, and problems related to hard rock directional drilling, as well as new equipment. With this information, operators can profitably apply directional drilling technology.

KEY WORDS:
Directional Drilling
Horizontal Wells
Underbalanced Drilling
Indurated Reservoirs
Hard Rock Drilling

TECHNOLOGY OVERVIEW

Approximately 15 trillion cubic feet of gas (tcf) remain in the Appalachian Basin's common indurated reservoirs that include Tuscarora Sandstone, Clinton Sandstone, Oriskany Sandstone, Huntersville Chert, and Berea Sandstone. A significant problem with directional drilling in these formations is the slow rate of penetration, generally less than 6 ft per hour using air methods.

Among the new, or still-developing, directional drilling systems is a mud-activated down-hole hammer for water-mud applications, which is being developed by Novatek Engineering, Inc., and the US Department of Energy-Federal Energy Technology Center. This system promises a projected 80% increase in rate of penetration compared to conventional tri-cone drilling.

In addition to developing a well-designed engineering plan, operators must use proper surface equipment to ensure safe results. Depending on the specific application, some of the following equipment may be necessary: wellhead diverters, emergency shut-down valves, underbalanced drilling (UBD) equipment, choke manifold, pressurized sample catcher, chemical-injection pumps, UBD production separators, and flare systems to limit ground heating.

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SPEAKERS:
Appalachian Hard Rock Reservoirs:
Jim Ammer, US DOE-FETC

Oriskany Sandstone—West Virginia:
Paul Amick, Columbia Gas Transmission

Clinton Sandstone—Ohio:
Bill Murray, Belden & Blake Corp.

Recent Developments in Directional Drilling:
Al Yost, US DOE-FETC

FIELD RESULTS

1. A short-radius horizontal well was drilled and penetrated an 8-ft thick "sweet spot" in the Oriskany Sandstone, south central West Virginia. The Oriskany was completed open hole. Based on previous operator experience with the Oriskany, operators expected a high fluid loss and used a drilling fluid that was compatible with the very abrasive characteristics of the Oriskany. Although it took a while, the well continued to improve with time.

2. A case study of a deviated well drilled in the Clinton Sandstone in northeastern Ohio showed severe mechanical problems with motors, steering tools, and bits. These problems added nine days to the project. As a result, only 34% of the total time was spent drilling.

The well deviation exposed 1,400 ft of the Clinton, which subsequently was stimulated by fracturing. The fracturing process was successful, and there were no problems cementing and completing the well.

Eighty percent of the $1.55 million budget for this well was spent on drilling and stimulation. This did not

compare favorably with costs for vertically drilled wells in the Clinton that typically cost $170,000. The project did, however, increase the reserves by 2.5 times that of conventionally drilled wells in the Clinton.

3. A team approach was used to plan and drill nearly 80 short-radius underbalanced wells in the Niagaran Reef Trend, Michigan. The program's goal was to use horizontal drilling technology to re-enter existing wellbores.

A simple well design using production test data and minimal evaluation logging helped lower costs, while maximizing the number of candidate wells. The drilling program resulted in greater than a three-fold increase in production. There was also approximately a 10-fold reduction in the gas-oil ratio, and water production was decreased.

4. A successful horizontal drilling program in the Antrim Shale gas zone, Michigan, targeted improved production by increased contact with the pay zone and contact with more vertical fractures. Failed drill string connections were a major problem during this drilling program.

LESSONS LEARNED:

Economics of directional drilling in the highly indurated reservoir rocks of the Appalachian Basin should not be based on the cost of the first well. Typically the first well is the most expensive. After the steep learning curve, the cost of drilling horizontal wells can be competitive with conventional techniques.

New mud technologies, such as adding hollow glass spheres or using 7.5 lb muds, can decrease the cost of drilling with nitrogen. Compared to using air for drilling, nitrogen acts as a membrane gas which eliminates much of the problem associated with fines and corrosion.

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