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High Performance/High Temperature Water Based Fluid Drills Wilcox Test

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Abstract

This case history examines the successful use of a specialized water based drilling fluid system to drill a demanding Wilcox well in Liberty County, Texas where environmental concerns made the traditional choice of a diesel based fluid undesirable.

The operator sought an alternative to a diesel based fluid for the 18,480' MD directional well to protect a nearby residential area from possible environmental harm. Cuttings disposal was accomplished via wellsite land farming. Design criteria for the water based system also included superior lubricity, penetration rates, a gauge wellbore, minimal wellbore gas solubility and entrapment, and high temperature rheological and filtration stability.

The mud system employed is a blend of methyl glucoside and polyglycerol, along with special additives to further enhance performance in critical design parameters.

The paper summarizes design and successful execution of the fluid system and drilling operation. Among performance objectives achieved were favorable mud cost and penetration rates as compared to offset diesel based wells (PDC bits were used), acceptable hole gauge, shale and temperature stability.

The paper is accompanied by a directional plot, graphical analysis of laboratory mud temperature stability results, hole caliper of subject well, and ROP and cost comparisons with diesel based offsets.

Introduction

High bottom hole temperatures and abnormal pressures encountered in deep "Wilcox" wells of Liberty County, Texas place unusual demands upon drilling fluids. Diesel based muds have traditionally been the system of choice for these wells, but environmental concerns on a recent Belco Energy Corp prospect prompted the operator to find a viable alternative which offered both high performance and environmental friendliness.

Belco's challenge on the Blackstone Minerals #1 was to drill an 18,480' (MD), 55-degree angle multiple target hole (Fig. 1) while protecting a nearby residential area from any environmental compromise the drilling operation may present. In terms of choosing a drilling fluid, an equally important consideration was to achieve performance characteristics comparable to those of oil based mud.

Performance Objectives

The operator set forth the following performance objectives, in addition to the environmental considerations, for choosing and designing a drilling fluid system:

- Improved lubricity to facilitate drilling and sliding in the high angle long tangent hole;
- Rates of penetration (ROP's) comparable to those obtainable with oil based fluids;
- Gauge wellbore to ensure successful logging and cementing of the production liner;
- Reduced wellbore gas solubility and entrapment.
- High temperature rheological and filtration stability.
- Geologic Sampling not affected by "masking" with OBM
- Reclamation costs minimized and Environmentally Friendly.

Specialized Drilling Fluid

DeepDrill™, a specialized water based system, was recommended by Newpark Drilling Fluids, LLC. This system, which contains a proprietary blend of methyl glucoside (MeG) and polyglycerol (PG), has been proven to provide superior lubricity, gauge wellbores and penetration rates similar to those seen with diesel based drilling fluids.

Since the system is comprised of water soluble, biodegradable organic additives, it satisfied environmental stipulations for local residents and allowed for land farming disposal of cuttings on site.

OGS Laboratory, Inc. in Houston developed a DeepDrill™ formulation containing the appropriate product mix to provide stability at temperatures up to 400°F *(Fig. 2).* A laboratory support plan was established in order to monitor and ensure performance of the system.

The required working volume was comprised of 60% new volume built on location and 40% fluid from a prior well.

Field Application/Operations Summary

The intermediate casing was displaced with 15.0 ppg DeepDrill™ fluid at 12,000' and an 8 ½" hole was drilled to 16,945' MD. An electric portable top drive was rigged up and the directional hole build section was begun just below the 9 5/8" shoe at 3 degrees/100' to a maximum angle of 55 degrees. Actual interval drilling time was 38 days(22 on bottom drilling), for an average of 130'/day.

Hole conditions in this interval were generally good as trips were accomplished without excessive torque, hole drag or fill.

Drilling progress was slow only when attempts to slide drill were first initiated. Reciprocating the drill string helped to restore acceptable penetration rates. Torque increases were noted when upper sand sections were encountered around 14,400', possibly motor and bottom hole assembly related. Backreaming stands and increasing the mud weight improved this situation.

Mud system performance was enhanced with regular sweeps of bridging materials for sealing porous zones and via the use of Newpark's LST-MD, a liquid Soltex™ in a proprietary carrier, to effectively reduce torque and drag. Short trips further helped to alleviate drag below 15,530'.

Two instances of stuck pipe occurred (14,400' and 16,686'). In the first incident the top drive stalled out on bottom while drilling. The pipe was worked free with torque and pull. The interval was reamed several times and the mud weight raised 2-3 points. The BHA was changed out (laid down string stabilizer) and PDC bit and jars were picked up. Drilling continued while reaming out all sand stringers encountered at suitable intervals. LST-MD was added below 15,040' and conditions improved.

The second incident occurred after the well was logged at 16,681'. Bottoms up while drilling ahead in more of the objective sand required the well to be shut in and returns were lost. After staging in the hole to where the pipe was backed off in the 9 5/8" string, circulation was again established with suitable LCM pills, pipe was screwed back in to the fish, and the pipe was worked free using Newpark's Top Spot soaking solution after 20 minutes.

After freeing the pipe, drilling continued and full returns were maintained by incorporating up to 3 #/bbl LCM in the entire system and relying upon the inherent healing ability of a water based fluid.

A decision was made to run a protection 7" liner when the well reached 16,945'. Though the hole healed while drilling from 16,705' to 16945', and torque was running only 13,400 ft-lbs, the liner was run to protect uphole potential pay zones. The liner was run to a depth of 16,680', where it apparently became differentially stuck in the same interval where pipe had been stuck previously.

After a successful casing lap test to 19 ppg EMW, drilling continued in a 5 ¾" hole while allowing the hole angle to drop to 24 degrees at a total depth of 18,480'MD/16,870' TVD/4021' vertical section. Interval drilling time was 14 days (9 on bottom drilling), for an average of 110'/day. Rate of penetration was optimized in the Wilcox by employing a turbine (mud motor) with a natural diamond bit

Mud density at TD was 16.9 ppg with a 385°F BHT.

Logging the well to total depth was successfully accomplished despite several tool failures. The open hole was plugged and abandoned, and a 7" production tie-back string was installed. The DeepDrill™ system was displaced out and sent to a storage facility for use on future projects.

Performance Evaluation

Hole washout: The primary measure of hole gauge was determined with the one arm density tool *(Fig. 3).* This tool normally illustrates the most severe washout encountered.

Some hole enlargement was evidenced in the 8 ½" hole, however, the 7" liner cement job indicated that a more gauge wellbore may have been the case since excess cement was encountered above the liner top.The end result was a successful liner job that did not require remedial cementing.

The 5 ¾" hole was gauge with only a few minor areas of enlargement.

Lubricity/hole conditions: Lubricity and hole conditions were generally good on this well, especially when considering the area's demanding geology and the deviated nature of the hole. Directional work was successful and the multiple targets were hit. Mechanical procedures such as short trips and back reaming aided progress.

Several special lubricant products were tested, though LST-MD (Liquid Soltex™) proved most effective in supplementing the performance of the DeepDrill™ system. Superior hole stability was apparent when rig power failed several times and the drill string remained free with nil torque and drag problems. Shale stability was excellent and hole conditions allowed the well to be completed without any major fishing operations.

Temperature stability/gas entrapment: Adverse mud properties as a result of extreme temperatures were minimal. Bottom hole temperature was 385°F. A special resin based fluid loss product and a polyacrylate thinner were used in the system to help maintain stable properties.

No barite sag was observed at any time during the operation in this 16.9 ppg fluid.

Favorable bottoms up conditions minimized gas entrapment and reduced time staging in the hole to break circulation. An additional benefit of this system was realized when prolonged mud losses did not occur when circulation was lost, a common problem experienced with oil based fluids.

Penetration rates: Optimization of penetration rates was alternately affected by hydraulic limitations, bit selection, formation, hole angle and bottom hole assemblies. Actual drilling time was 52 days(31 on bottom drilling), excluding down time and liner job, for an overall average of 125'/day.

While motor failures can be a problem in diesel based fluids, elastomer components in the directional tools exhibited high durability in this water based system.

The DeepDrill™ system achieved 82-95% of drill rates seen with diesel based systems in 8 ½" holes on nearby offset wells*(Fig. 4)*. Note should be taken that all of these offsets were vertical or slightly deviated, therefore eliminating sliding, trips for new motors/BHA's, hole cleaning problems, friction, and other potentially time consuming factors associated with highly directional wellbores.

No offsets in the area involved a deviated 5 ¾" hole, so a comparison could not be made.

A deep Wilcox well was drilled in the area after this project. Diesel based fluid was used with good success in a vertical 6 ½" hole (*Offset 5, Fig. 4*).

Conclusions

Overall, the DeepDrill™ water based system met the performance and cost objectives set forth for the project.

The strict regimen of sampling, heat aging and pilot testing in the Newpark Technical Services Laboratory ensured the most cost effective treatments were made.

Total costs would compare favorably to a diesel based system for a project of this nature when all related costs are considered, including mud maintenance, transportation, waste disposal, downhole losses, site modifications, etc.

Meanwhile, the intangible value of environmental advantages for area residents, including goodwill, was immeasurable.

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4. Baker Hughes Inteq Directional
5. Smith International Bits

Nomenclature

MD=measured depth
OBM=oil based mud
LCM=lost circulation material

EMW= equivalent mud weight
TVD=true vertical depth
TD=total depth
BHT=bottom hole temperature
PDC=poly-diamond crystalline
F=Fahrenheit
PPG=pounds per gallon
BHA=bottom hole assembly
FT/LBS=foot/pounds
#/BBL=pounds per barrel

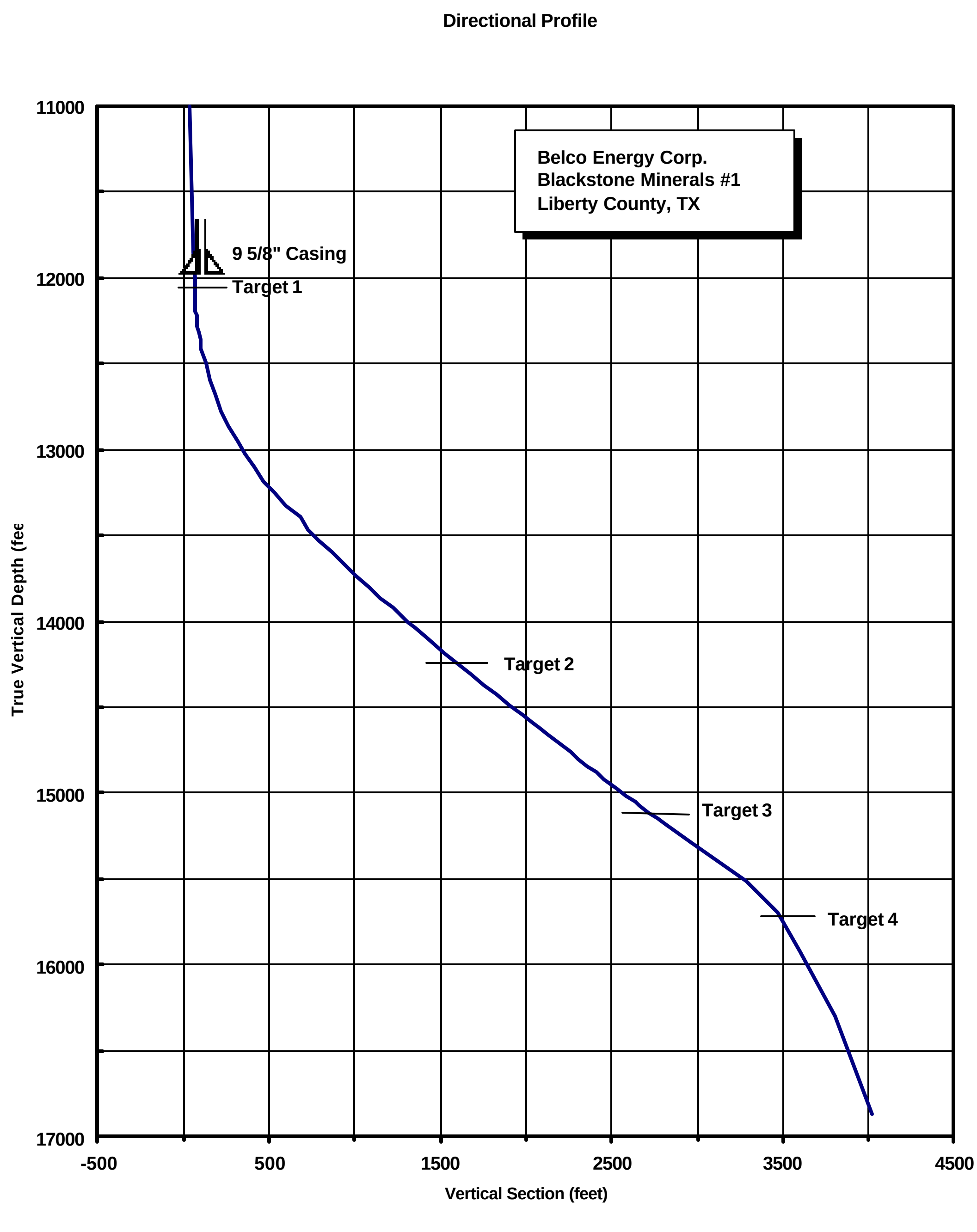

Figure 1: High angle, multiple target nature of well

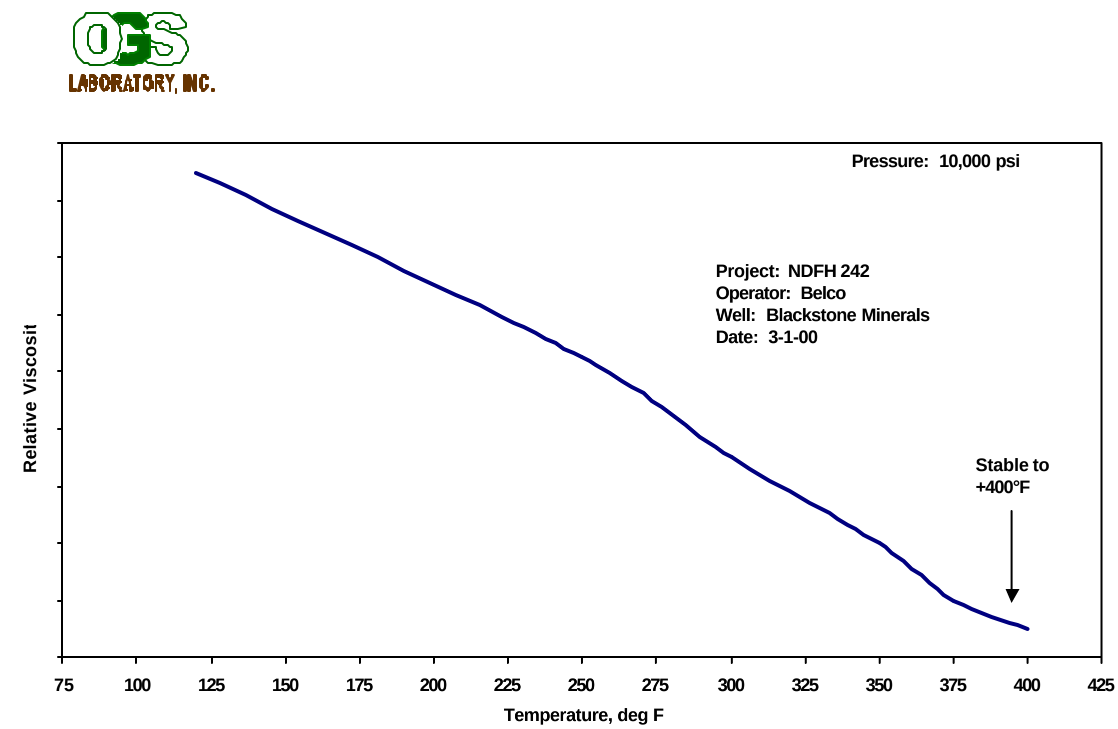

Figure 2: Temperature stability test of lab formulated mud (Fann Consistometer)

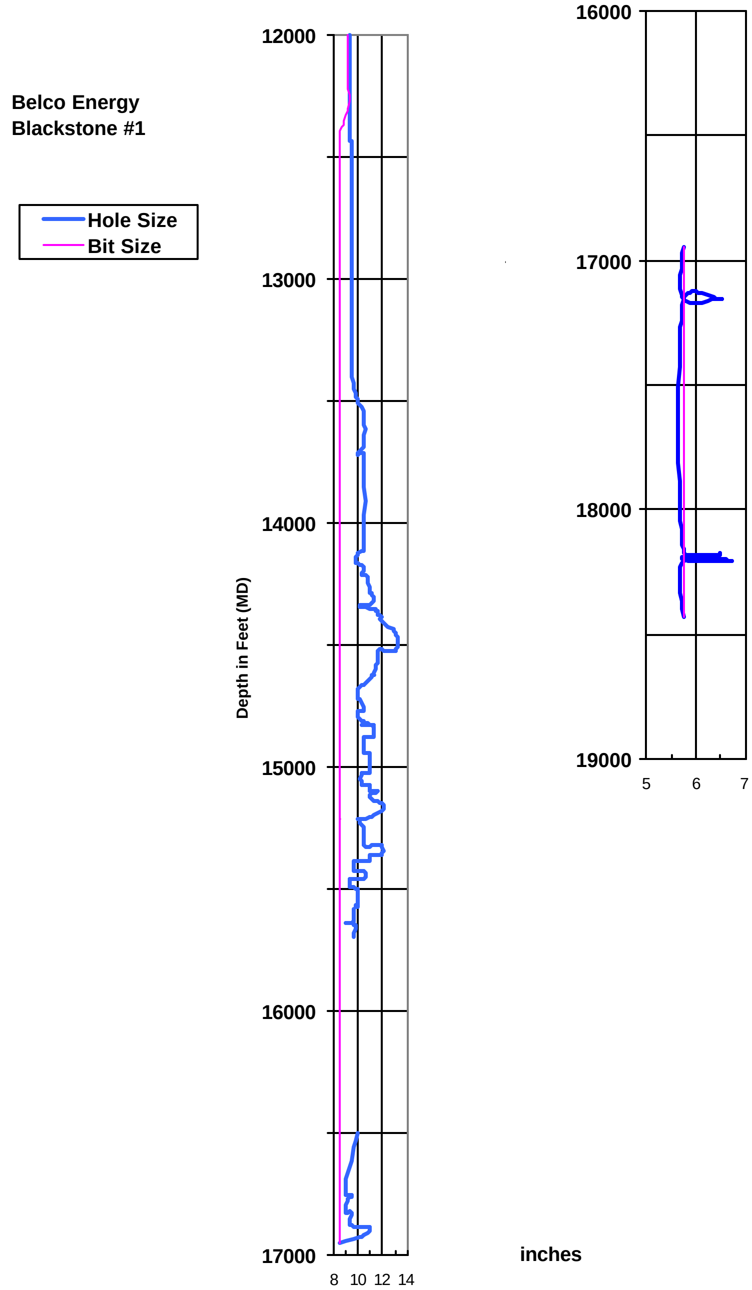

Figure 3: Hole gauge caliper from one arm density tool

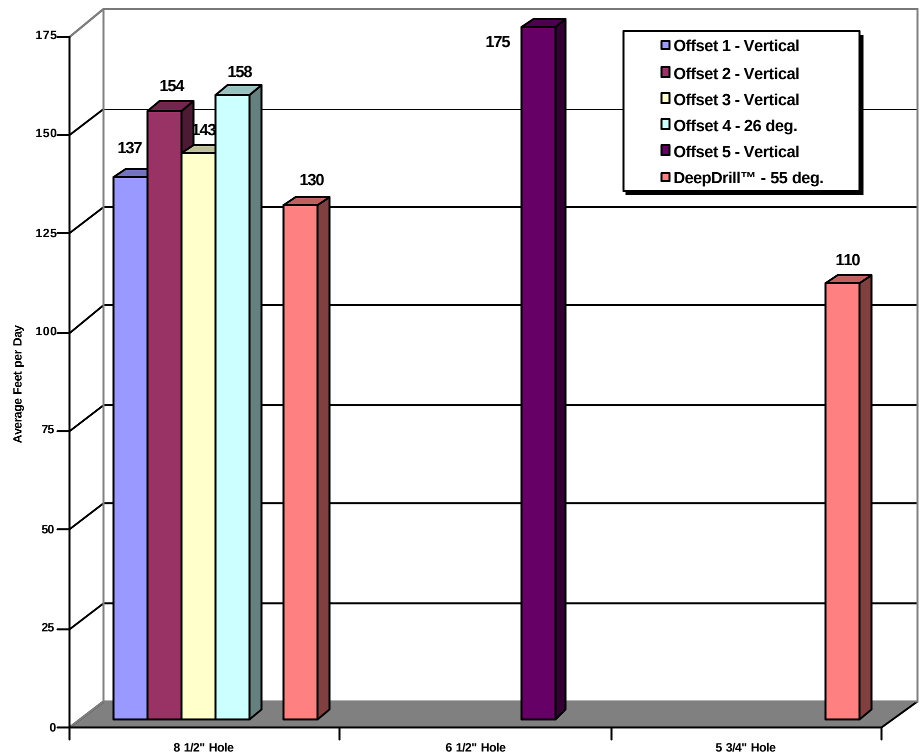

Figure 4: Average footage per day comparison of diesel based offsets versus DeepDrill fluid