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SPECIAL FOCUS: PERMIAN BASIN TECHNOLOGY

Grit, gigabytes, and tiny particles: What it takes to drill in West Texas today

For one West Texas operator, the combination of advanced nanoparticle-based additives and digital technology delivered cost savings and predictable results.

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Drilling operators have two core business drivers: reduce drilling costs and maximize reservoir production. These drivers are no different in the Permian and Delaware basins of West Texas and New Mexico.

What makes drilling in the Permian and Delaware unique is the advancements that operators and service companies design to push the technical limits of what is possible. In a period where depleted wells and unstable formations are more frequent, operators and service providers have joined forces to achieve efficiencies. The result: We now drill wells once thought to be unattainable.

The new age of West Texas oil and gas is fueled by grit, gigabytes, and tiny particles. For one West Texas operator, the combination of advanced nanoparticle-based additives and digital technology delivered cost savings and predictable results.

Change of routine. People in West Texas wake up every day with a routine: make coffee, take the kids to school, and make a white-knuckling trip down Interstate Highway 20, U.S. Highway 285, or another major artery that cuts through the heart of the region's oil and gas operations.

LEAD IMAGE: An arial view of an operator's drilling site in West Texas.

Since the advent of drilling for hydrocarbons in the mid-1800s, operators and service providers have conducted time-consuming, routine analysis of disparate and dispersed file systems to review operating and maintenance conditions. Service companies relied on paperwork to initiate execution, mitigation, restoration, and continuous improvement processes, and to offset information reviews for customers.

These routine practices took days and, in some cases, weeks to compile and understand. It was an effective but laborious process that relied on an individual's experience and knowledge. The routine process was gratifying, if you had been there and done that, but difficult for new and inexperienced workers.

The design of services was a common practice for fluid providers. Anyone who was at Halliburton Baroid was sure to follow each control point of the execution plan. The process was analogue and required massive amounts of daily paperwork and constant analysis to ensure alignment, execution, risk mitigation, improvement, and program communication.

Mass data and analytics changed this paradigm. The principles of execution are the same for fluid providers. However, the principles are now connected. The process is powered by a multitude of sources: databases that produce leading and lagging indicators; artificial intelligence and machine learning modules; and people. We accelerated the time it takes to carry out a fluid program, to reduce costs, and increase production.

Today, we open our laptops and phones to start our daily routines. Multiple historic and predictive data sources are used to inform our decisions faster and with more precision than ever. We use data analytics from wells in specific regions and the globe to inform decisions.

Throughout the process, we ask ourselves, *"Where is the well?"* If the well is nearby, or in a similar formation, we ask, *"What fluid systems are used?"* And the questions do not stop there.

We also ask:

- How did the operational and technical properties compare?
- Is the fluid program doing its job?
- Did the well(s) experience losses?
- How can we adjust the program to maximize the value of the wellbore?

This is Halliburton Baroid's digital universe, and at the center of it is the BaraLogix® Hub. The BaraLogix platform collects and dispenses drilling data from operations in West Texas and the world.

It enables Halliburton Baroid to deliver predictable drilling operations when certainty is buried beneath the surface. Multiple applications work within the platform and deliver value for our West Texas and global customers.

Model and simulate. The Drilling Fluid Graphics (DFG™) hydraulic modeling system allows Halliburton Baroid and operators to simulate hole cleaning under a variety of conditions, such as transient density, sweep equivalent circulation density profiles, and pressure effects of tripping schedules.

This modeling software can conduct hole cleaning simulations, predict fracture widths and perform geomechanical studies, based on the formation characteristics. The data include variables, such as minimum and maximum horizontal stress, Poisson's Ratio, overburden stress, pore pressure, and others.

With the modeling software, we can predict the most successful drilling fluid properties and lost circulation material (LCM). Inventory is available on location and can analyze all the micron particulate sizes while offering multi-modal solutions to determine the most effective option for curing the thief zone. The DFG software can run in the event of unexpected lost returns and saves customers time with pre-well and execution decisions.

Continuous improvement. The HindSight™ 20/20 continuous improvement and analytics application communicates with the onsite daily reporting software, WellSight® 20/20 – another module of the BaraLogix platform, **FIG. 1.**

HindSight 20/20 allows us to research any well in the world drilled by Halliburton Baroid with a couple of clicks. This system performs in-depth analysis on thousands of wells in minutes rather than 10s of wells reviewed in days, **FIG. 2.**

We can filter for wells that experienced losses and gather LCM pill formulations to identify the most successful strategy. With a selection of wells from a heat map of your surrounding area, we can analyze a variety of critical metrics and data trends, such as properties relative to consumption, mud weights versus depth curves, cost per foot drilled, cost versus hole section, product usage versus time, and a wide variety of other analytics.

HindSight 20/20 is customizable to meet the needs of the customer and how they want to interact with the data and analytics. Customers can run reports and view data updates in real-time with the secure, web-based system.

The result: Halliburton Baroid and its customers can use the shared platform to facilitate collaboration, alignment, strategic decisions, and continuous improvement.

Tiny particle of hope. Most land drilling applications intersect shale formations prone to instability when drilled with water-based fluids. The Permian and Delaware basins are no different. Inhibition with salt addresses most concerns with the wellbore face and drilled cuttings.

However, mechanical issues can occur as the filtrate penetrates the shale matrix and increases pore pressure in the near-wellbore. This pressure can build until shale breakout or sloughing occurs, and the deterioration of hole conditions often leads to non-productive time (NPT) and other high costs for operators.

Halliburton Baroid developed and implemented nanoparticle wellbore sealants to address this challenge. Tiny nanoparticles seal the microfractures that occur in the formation with drilling operations. They prevent fluids from reacting with unstable rock, which can cause wellbore instability.

These polymer particulates run through the bit, are sheared down to nanometer scale, and work their way into microfractures. In the past, this level of seal coverage seemed unattainable. However, as these particles are introduced to the mud system, they seal the cracks.

This intrusion can lead to significant wellbore stability risks, costing drilling operators millions of dollars in NPT or plugged-and-abandoned wells every year.

For the West Texas operator in search of a novel solution to their drilling challenges, this digital-chemical combination was exactly what they needed to achieve cost savings and predictable results.

Applying technology for impact. The operator's journey reached an apex in 2023. They could not justify the cost of a high-performance, water-based fluid system, built only to drill the curved section of the well.

FIG. 1. The world of BaraLogix: Five applications work together to deliver engineered solutions customized to maximize wellbore value.

FIG. 2. HindSight 20/20 taps into the BaraLogix® database and connects near real-time data from well operations.

Additionally, conventional oil-based muds were not economical because of the high rates of saltwater intrusion in the wellbore. The mud weight window – a description for the range between the pore pressure and fracture gradient – did not allow for a higher-density fluid without the risk of catastrophic and costly lost returns.

The drilling team began to look for a modified cut-brine fluid and discovered a clear brine system. However, it came with its own set of challenges: low rate of penetration, high torque, and the possibility of stuck pipe. The operator needed an advanced analytics software, HindSight, paired with modeling software, DFG, to help achieve their cost and performance goals.

Halliburton Baroid and the operator determined a water-based fluid (cut brine) with moderate suspension characteristics and low fluid-loss value was the right solution. The analysis indicated the addition of nanotechnology wellbore sealant was ideal, because it would stabilize the wellbore while drilling the curve.

Halliburton Baroid technical personnel combined offset data, pre-well modeling, and product knowledge to design a solution that included the new wellbore sealant, BaraSeal™-957.

The BaraSeal-957 wellbore sealant consists of a proprietary nanoparticle polymer technology that stabilizes microfractures in shale formations. The use of the wellbore sealant on a cut-brine drilling fluid enabled a low fluid loss system with an API fluid loss of <5 mL/30 min. and a thin and pliable filter cake. The redesigned fluid helped drill the curved section of the test well with improved performance (less hangups, reduced torque, better tool face angle, fewer hours drilling the curve to the landing point), as well as additional key performance indicators, such as absence of jarring while drilling or tripping, consistent tool face, and a smooth trip out after it reached total depth.

The wellbore sealant saved the customer mud product costs and valuable rig time. The curve was drilled to the landing point in 19 hrs with a final inclination of 81o. In the previous well, the customer did not use BaraSeal-957 and could not reach the final inclination.

The plan included near-identical true vertical depth (TVD), directional profile, and hole size. However, wellbore instability issues only allowed for a maximum inclination of 60°, and the operator logged 44 hrs to drill the curve to that point.

Results. The addition of the BaraSeal-957 wellbore sealant in a pre-existing cut brine system, along with the treatment for water loss, allowed the operator to drill the curved section of the well 43% faster than the previous, near-identical hole section. Overall, the operator achieved a 50% total cost reduction for the project, FIG. 3.

SUMMARY

Halliburton Baroid has pushed the limits of technology for 105 years. Recent technological advancements in the digital space and pairing HindSight 20/20 with our daily reporting software allows operators to analyze their offset wells in a matter of minutes. Our Drilling Fluids Graphics hydraulic modeling system provides operators the ability to plan every aspect of the well, from geomechanics and hole cleaning to the mitigation of lost returns.

At Baroid, research and development never stop, and BaraSeal-957 is testament to what Halliburton can achieve. Nanoparticle technology paves the way for the industry to deliver wells once considered too risky to drill. Halliburton Baroid delivers engineered fluid solutions customized to maximize wellbore value.

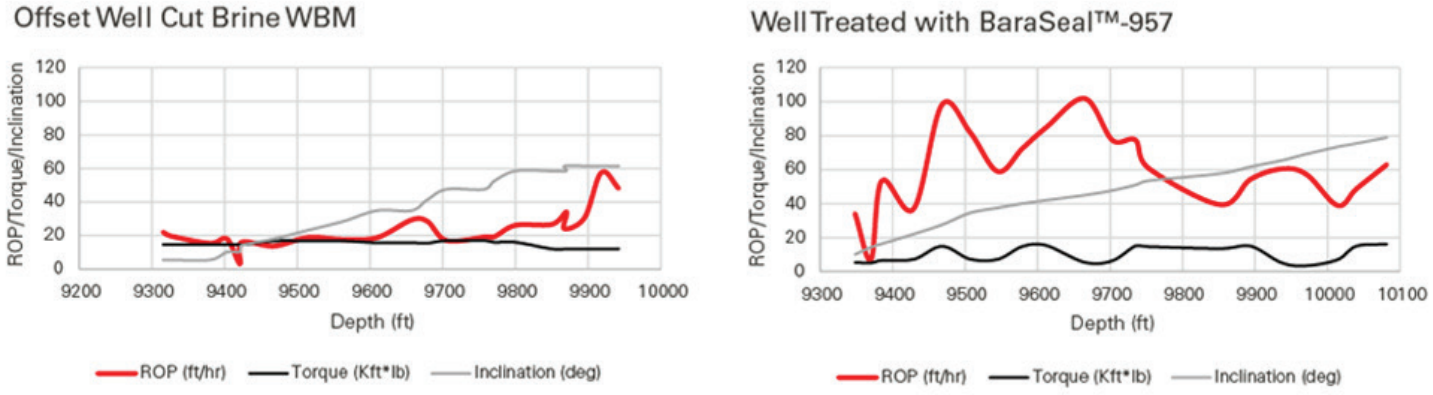

FIG. 3. Additional performance metrics and cost savings.

Challenge. Deliver performance and cost-effective solutions for problematic curve sections in the Delaware basin's Wolfcamp shale with the use of cut-brine fluids in lieu of conventional oil-based fluids.

Solution. Implemented HindSight 20/20 digital analytics and Drilling Fluids Graphics wellbore modeling with nanoparticle technology BaraSeal-957 wellbore sealant. This solution stabilizes microfractures, lowers fluid loss, and minimizes wellbore invasion of filtrate at low concentrations to save the customer time and money when drilling.

High concentrations of traditional filtration control additives achieve similar results. However, most combinations of starches and synthetic polymers contribute excessive viscosity to the fluid. BaraSeal-957 delivers tight filtration control with minor effects to the fluid's rheological profile.

Results can be summarized, as follows:

- Reduced time spent drilling a curved section from more than 44 hrs to 19 hrs.
- Improved wellbore conditions resulted in better tool face consistency and lower time drilling a curve.
- Eliminated the need for jarring during drilling and trips. **WO**

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