DEEP WATER

CASE STUDY

Integration Drives Performance and Accelerates Learning Curve in an Ultra-Deepwater Pre-Salt Exploration Drilling Project in Brazil

HALLIBURTON PROJECT MANAGEMENT ACHIEVES NEW BENCHMARKS IN POST-SALT AND SALT SECTIONS

SANTOS BASIN, PRE-SALT BRAZIL

CHALLENGES

- Provide accurate reservoir characterization
- Solve hole instability issues, and high torque and drag, in 28-inch riserless section
- Drill through hard rock intercalations in salt section and through hard carbonate formation in ultra-deepwater environment
- Mitigate severe fluid losses
- Avoid salt-creep and stuck-pipe issues
- Perform cementing in severe lost circulation scenarios
- Cement salt zones and carbonates with high CO_2 concentration

SOLUTIONS

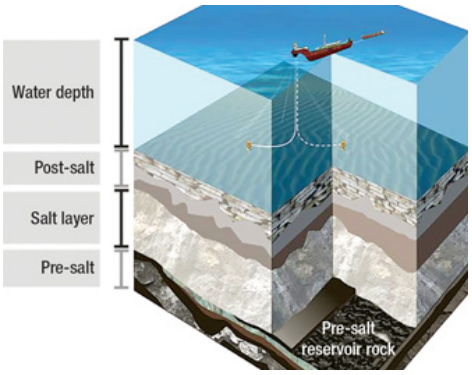
- Drilling Engineering Solutions (DES)
- Customized bits via DatCi℠ process
- GeoTech® PDC bits and EZ-Sleeve™ at-bit reamers
- Geo-Pilot® Duro™ RSS
- ADT® drilling optimization service
- Geomechanics services
- ENCORE® drilling fluid
- BaraBlend®-665 and BaraLock®-666 LCMs
- GeoBalance® MPD service
- LOGIQ® logging platform
- MRIL®-WD™ magnetic resonance imaging LWD tools

RESULTS

- Achieved record-breaking improvement in ROP in 28-inch riserless section
- Reduced torque and drag, eliminating need for back-reaming
- Provided better hole quality, with no spiraling
- Drilled riserless and salt sections in single runs per section
- Reduced drilling time by 60 percent in salt section
- Completed first well in four sections
- Improved productive drilling time by 56 percent
- Reduced total well construction costs

OVERVIEW

In Brazil, the Halliburton Project Management technical team is continuously collaborating to optimize well construction and evaluation services in a giant pre-salt field for a major consortium. A contract in a challenging offshore exploratory area with water depths of around 2200 meters (7,218 feet) included performance incentive on minimum required rates of penetration (ROP) per section. Integrating solutions from cementing, coring, wireline, well testing, and Baroid teams to increase project performance and flawless execution were key aspects for the project's success.



DRILLING IN ULTRA-DEEPWATER ENVIRONMENT

The operator faced many challenges to build exploratory wells in this ultra-deepwater environment, with the main objectives to minimize the significant drilling risks and costs, and to reduce the total cost of well construction and evaluation. Other challenges included the long 28-inch riserless section in the post-salt formations that were facing hole instability issues, high torque and drag, and vibration; the occurrence of hard rock intercalations in the salt and sometimes in the post-salt sections; very thick salt zones of around 2000 meters (6,562 feet); geo-stopping at the top of the carbonate reservoir; low rate of penetration (ROP) in hard and abrasive pre-salt carbonate reservoir with high carbon dioxide (CO_2) and hydrogen sulfide (H_2S) concentrations and severe fluid losses. Salt imaging, reservoir characterization, zonal isolation in salt zones and at the reservoir with high CO_2 concentrations, and remote locations up to 200 kilometers (124 miles) offshore also had to be addressed.

ENSURING A SMOOTH PROJECT IMPLEMENTATION

First, Halliburton Project Management (HPM) assigned a team of dedicated operational and cross-disciplinary subject matter experts leveraging Halliburton Formation and Reservoir Solutions (FRS) and Drilling Engineering Solutions (DES) organizations. Real-time monitoring services and the advanced DrillingXpert™ software package facilitated real-time visibility and operations management capability, as well as improved decision making, by providing access to all the required information in one location.

HALLIBURTON | Project Management

28 15/16 inch
EZ Sleeve

28-inch GT85Cs
PDC Bit

HAL122889

Early engagement of the HPM team with the client, and the creation of a communication protocol and an integrated execution plan, were fundamental for a smooth project startup, helping to create:

- A collaborative environment for risk identification and management
- Engineering support during well planning
- Proper selection of technology tools to enhance project performance
- Fostering synergies among Halliburton and stakeholders

CUSTOMIZED SOLUTIONS AND NEW TECHNOLOGIES

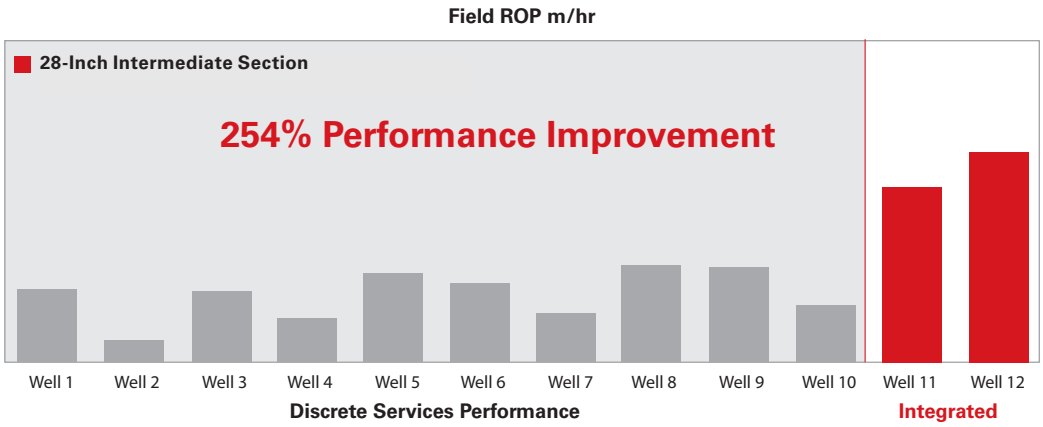
Next came the implementation of customized solutions and introduction of new technologies to boost project performance, thus reducing the total number of days to construct the well.

For the 28-inch riserless section, the Halliburton team designed new customized Geo Tech® PDC bits and an EZ- Sleeve™ at-bit reamer specific for the formation, and also used roller reamers, to reduce torque and drag, along with vibration – thereby increasing ROP by 254 percent on average in a single run, when compared to previous wells drilled in the field, using discrete service contracts. In one of the wells, Halliburton drilled 1151 meters (3,776 feet) in a single run, establishing a new record for the field in a 28-inch section, with excellent hole quality and hole cleaning; achieving double trip-out speed; and avoiding spiraling and drilling jar activations. Minimum bit wear was also observed. High viscous pills were important for hole cleaning.

The optimized bottomhole assembly (BHA) allowed an extension of the 28-inch section to be drilled with seawater, eliminating the 18⅛-inch x 22-inch hole enlargement section, thus saving around 17 days to the project, and reducing the number of sections and casings from five to four. This was the first well completed with four casings in the northwest area of the field.

A pump-and-dump drilling technique was available for the lower portion of 28-inch section in case of difficulties in advancing drilling. This involves mixing seawater with a very viscous and high-density fluid using a Mix on the Fly unit from Baroid, which creates a single, homogeneous, riserless drilling fluid stream. The equipment allows real-time adjustment of fluid weight, viscosity, flow rate, and cuttings carrying capacity. The homogeneous fluid is then pumped down the drillstring, and the returns (fluid and drill cuttings) are discharged at the seafloor. The riserless drilling fluid is usually supplemented with high-viscosity sweeps to clean out the hole.

A record-breaking achievement in the field, with 254 percent ROP improvement in a 28-inch riserless section



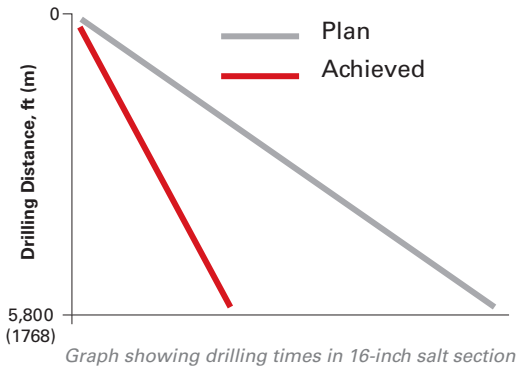
Graph showing ROP performance improvement in 28-inch riserless section of the Halliburton project, over that of previous wells in the field

In the salt section, Halliburton introduced the latest and more robust Geo-Pilot® Duro™ rotary steerable system (RSS). Another optimized BHA configured with a 16-inch MegaForce™ PDC bit, an EZ-Sleeve™ at-bit reamer, and a Geo-Pilot® DURO™ RSS successfully drilled a 1741 meters (5,712 feet) salt section in a single run. This represented a 60 percent drilling time reduction compared to plan, while reducing the risk of getting stuck in salt and controlling hole verticalization. This BHA configuration is a unique solution due to the "point-the-bit" RSS concept. In addition, real-time monitoring played a very important role in anticipating and quickly addressing any downhole issues during drilling. Halliburton also provided geomechanics with mechanical specific energy (MSE) and salt-creep control services and ADT® drilling optimization service in real time to observe wellbore stability, rock failure, and BHA integrity conditions.

60% drilling time reduction in salt section

In some wells, GeoBalance® managed pressure drilling (MPD) service was applied in the salt and carbonate reservoir zones. In salt, this service helped to control salt creep. In carbonate, it minimized fluid losses and allowed to operate in a very narrow mud window.

In the carbonate section, Halliburton used its Turbopower™ turbodrill with 12¼-inch impregnated bits and MRIL®-WD™ magnetic resonance imaging logging-while-drilling (LWD) tools for reservoir characterization and fluid identification.



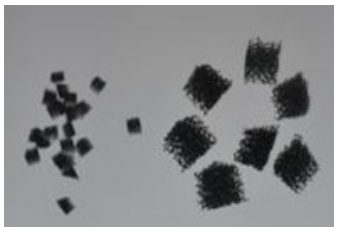
Graph showing drilling times in 16-inch salt section

Baroid deployed lost circulation material (LCM) technologies, such as BaraBlend-665 and BaraLock®-666 LCMs, to combat severe fluid losses. BaraBlend®-665 high-fluid-loss LCM, blended with fine and medium BaraLock®-666 reticulated foam, sealed the naturally fractured carbonate formation and helped save costs for the consortium by saving time related to cement plugs pumping and curing the losses of the expensive Encore® synthetic-oil-based fluid. The BaraLock reticulated foam LCM system is capable of extending the fracture sealing capacity of the BaraBlend single-sack solution up to 7,000 microns.

To characterize the reservoir, Halliburton deployed its LOGIQ® logging platform to acquire real-time data in an extensive logging program.

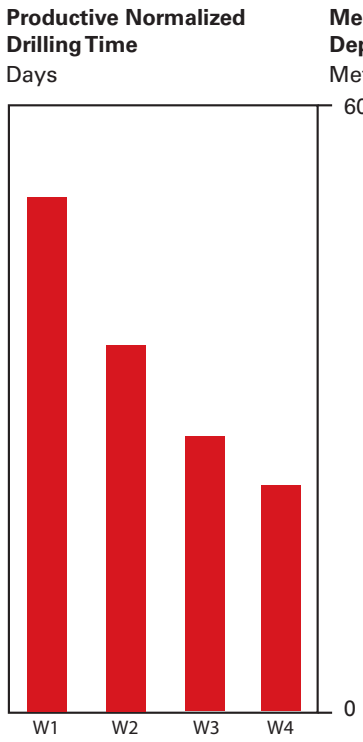

HAL122890
Severe fluid losses


HAL122891
BaraBlend®-665 LCM


HAL122896
BaraLock®-666 LCM

SETTING A NEW BENCHMARK

To streamline the delivery of services, Halliburton Project Management provided collaborative leadership to manage risks, integrate stakeholders, boost project performance, and reduce overall costs. This strategy ultimately delivered well construction services, setting drilling records in the post-salt and salt sections, adding a new benchmark for the field, and resulting in the following positive outcomes:



Graph showing fast learning curve

- A safer working environment with higher operating efficiency
- Integration among stakeholders/services and collaboration around risk management, well planning, and technology
- Acceleration of learning curve by leveraging global lessons learned from similar projects
- A record-breaking achievement in the field, with 254 percent ROP improvement in a 28-inch riserless section
- First well drilled in four sections in the northwest area of the field
- Up to 60 percent drilling time reduction in thick salt section
- Significantly reduced or stopped severe fluid losses through use of efficient LCMs
- Accelerated the project learning curve with integrated services
- 56 percent improvement in productive normalized drilling time per 3048 meters (10,000 feet)
- Fastest well drilled in the northwest area of the field
- Reduced total well construction costs

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