Integrated services yield efficiency in development

Success in Brazil will depend on a perspective that takes advantage of every step in the E&P process.

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Deep water and Brazil are nearly synonymous. For decades the two have meant innovation in some of the most difficult waters in the world. Lately that relationship has taken on even more vigor with the discovery of reserves in still greater subsea extremes. The recent emergence of impressive presalt reservoirs adds to the already robust postsalt play in driving activity offshore Brazil even higher. The scope and magnitude of these resources places a growing emphasis on identifying and bringing new discoveries to production as soon as possible.

Doing so takes a holistic approach that leverages every capability across all disciplines. Success in these deepwater provinces depends on efficiencies and advantages achieved through the entire process.

Just add salt

The significance of Brazil's deepwater assets is huge, and the pace of its development is growing. The plays in this frontier are described chiefly in terms of geologic deposition relative to its salt formations — presalt and postsalt.

The postsalt is where a great majority of Brazil's deepwater discoveries have been made. It describes a deposition in which reservoir sediments were laid down after the salt. In presalt, the deeper reservoir rock was laid down long before the salt was formed, and discoveries are buried under this autochthonous salt, which ranges from 656 to 6,800 ft (200 m to more than 2,000 m) thick.

In water depths of about 7,200 ft (2,200 m), the presalt is located south and southeast of Brazil over a 43,243-sq-mile (112,000-sq-km) area that includes the Espírito Santo, Campos, and Santos basins.

By 2020 Brazil plans to more than double its current oil and gas production of almost 2 MMb/d, with more than one third coming from presalt fields. Brazil's current reserves — which do not yet include new presalt discoveries — are about 14 Bboe. With presalt added, some experts believe Brazil's reserves may climb to 80 Bboe. If these estimates are realized, they will make Brazil the world's eighth largest oil and gas producer.

Growing complexity

The hydrocarbon-rich presalt play presents a multifaceted deepwater scenario that is bringing new challenges to Brazilian exploration and production. Reservoirs in this domain are complex heterogeneous layered carbonates, which makes reservoir characterization very difficult. These reservoir carbonates are very hard and cause low penetration rates. The tendency for borehole deviation while drilling in salt means directional control will be even more important in the massive presalt. Flow assurance related to paraffin deposition, hydrate, and scaling control is also a challenge.

In addition to these requirements, the presalt is a corrosive environment with significant amounts of carbon dioxide in associated gas (8% to 18%) and hydrogen sulfide (H_2S). This places a high demand on special cement and metallurgy throughout the process.

Developing the presalt will require a broad scope of technologies and capabilities to achieve economical and operational success. Based on experience gained over 25 years in Brazil's deepwater postsalt reservoirs, Halliburton believes the key capabilities in the coming years will include rapid identification of prospects, properly understanding the reservoir's potential, and efficiently and safely drilling the well.

Vision and understanding

In such a rich hydrocarbon environment, expediting prospect identification is a high priority. This involves accessing and understanding huge amounts of multidiscipline data to guide the large-scale exploration effort. Specialized volume interpretation and 3-D visualization systems are providing the means to manage and understand this data in a format that benefits a diverse, collaborative workplace.

The effort also requires a growth in skilled personnel resources to handle higher volumes of data. This potential training bottleneck is greatly eased by the availability of these software resources through standard desktop computers using intuitive, easy-to-learn interfaces.

The increasing exploratory success rate in Brazilian deepwater basins (already an impressive 60%) is due in part to the enormous inroads made over the past decade in seismic interpretation and visualization. Future achievements will depend on these exploration tools even more.

These systems promote integrated exploration teams, which expedites exploration by allowing geologists, geophysicists, and drilling engineers to easily share data and to work in a common earth model and collaborate with powerful 3-D visualization tools.

To address the high volumes of data in Brazil, the systems also speed the interpretation process by enabling junior staff to quickly screen broad sets of data for more detailed interpretation by senior analysts.

Advancements that provide resolution at the reservoir or basin scale are further improving exploration success. These innovations are the result of new image enhancement algorithms used in 3-D seismic reservoir characterization. According to a paper on reservoir characterization in Brazilian deepwater reservoirs, the algorithms enhance detection of the region's subtle stratigraphic and structural features. Some sedimentary features of

deepwater turbidites were analyzed that can be very difficult for visualization or even detection due to dimensions and seismic resolution requirements.

A faster, easier hole

In these extreme wells, the cost of drilling is a paramount concern. To reduce cost and risk, drilling optimization is used to mitigate wellbore stability issues and improve penetration rates in hard presalt carbonates and postsalt sandstones.

This is being achieved by integrating multiple datasets — from pore pressure to vibration — in real time. By understanding what's happening downhole as it is happening, engineers can make timely decisions to mitigate drilling hazards and improve drilling parameters.

Very narrow mud windows are a big concern for Brazil's deepwater wells because hole diameter lost by casing the well bore to isolate trouble zones can make it difficult to reach total depth at the optimal hole size. As a result, hydraulics issues typified by such events as lost circulation and kicks are prime sources of nonproductive time (NPT).

When drilling through the hard, abrasive formations, one of the greatest challenges is bit performance. Vibration is a common problem, and penetration rates are often low.

Drilling optimization is making significant inroads in mitigating many of these problems. A study of a Halliburton project in the difficult-to-drill Campos Basin provides a good example.

The study, described in a paper for SPE, examined 62 wells drilled in a three-year period using a cost-effective drilling optimization program that emphasized real-time pore-pressure evaluation, pressure-while-drilling (PWD) measurements, and vibration sensors.

The optimization program consisted of three main elements — hydraulic management, drillstring integrity, and well integrity. To maintain the hydrostatic and dynamic drilling mud pressures within the operating window, a rigorous hydraulic management process was applied along with real-time formation testing and collection of PWD data.

Drillstring integrity was addressed with proprietary anti-whirl software to predict critical RPM. In addition, real-time and recorded downhole vibration data were acquired.

Wellbore integrity in narrow mud windows was achieved with a suite of formation-pressure evaluation software. Downhole data were acquired with real-time and recorded PWD sensors (along with real-time formation testing).

PWD capabilities were particularly valuable in the Campos Basin due to their broad utility in monitoring equivalent circulating density, hole cleaning, and preventing stuck pipe and lost circulation. The pressure data also provided input to test hydraulics models, yielding a greater understanding of downhole pressure limits.

This drilling optimization program substantially reduced the overall drilling cost, significantly lowered NPT, and increased drilling efficiency. Most importantly, drilling optimization operations have added very little to the cost of the routine measurement-while-drilling services.

What's in the well?

Accurate fluid sampling and analysis are central to assessing well potential as rapidly as possible. In Brazil this is frequently done in hostile environments at depths that in many cases exceed wireline capabilities.

Innovative tubing-conveyed sampling systems are providing the best solution with highly accurate, customized sampling. In a recent Santos Basin well, Halliburton successfully addressed these concerns with a modular reservoir description tool that combines formation testing and fluid sampling with packer technology to seal and isolate the zone of interest.

The operation avoided a high-cost well completion and conventional formation testing. Using the system enabled reservoir decisions to be made sooner than with conventional methods. Sampling was completed after 30 hours — and just three days after the job was finished, the discovery was announced.

Tubing-conveyed sampling systems are also being adapted by Halliburton to capture data on low levels of H_2S. The data are used to support selection of the appropriate metallurgy for completion and production facilities, which can significantly affect project cost and performance.

Used in a group of Brazilian wells, the sampling system was exposed to a variety of well environments, including maximum temperatures of 314°F (157°C) and nearly 7,900 psi.

The success of the H_2S sampling system — which employs special ceramic coatings—improved the sample quality and enhanced operation in low-concentration sampling environments. In particular, the system demonstrated how critical proper characterization has been when considering H_2S concentrations below 15 ppm.

Advancements in fluid sampling technologies that will benefit Brazil deepwater operations also include a new logging-while-drilling fluid sampling and identification tool. By enabling acquisition of fluid samples while drilling, the Halliburton tool will help reduce reservoir uncertainty even in the most complex Brazilian environments and will eliminate the cost of flat time associated with wireline sampling.

Expediting the process

The answers to expediting exploration and development in Brazil's deepwater provinces are found in the long-term integration of a vast range of technology and expertise. Chief among these skills are exploration, reservoir identification, and drilling.

Leveraging service capabilities across multiple disciplines ensures the fit-for-purpose solutions required in Brazil's postsalt and emerging presalt plays. Success in these complex deepwater domains increasingly depends on a perspective that seeks advantage at every step in the E&P process.

Visit *www.halliburton.com* for more information on Brazil deep water. E&P

**See attached map*