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Deepwater GoM challenges span full well process

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In the deepwater Gulf of Mexico (GoM), the most recent success is frequently followed by the next great challenge. Experience gained is quickly leveraged against ever-increasing extremes in this complex environment.

The Miocene and the Lower Tertiary trends, complicated by a salt canopy that overlies each, define the learning curve in the deepwater Gulf — a process that now extends from exploration to development. At every step, operating in these frontiers means confronting an immense array of challenges.

The answers are equally complex. They require a holistic approach that leverages every capability across all disciplines. Each step can be a technological hurdle, and success is often measured in incremental efficiencies. Advantage is achieved across the entire process and over the life of the well.

Subsalt trends

Activity in these deepwater trends is a driving force in the GoM. In 2007, for the first time in history, all 20 of the highest producing blocks were in deep water. Recent and pending lease sales targeting deep Miocene and Lower Tertiary trends look to perpetuate that dominance.

The statistics are impressive. Deepwater assets contribute about 72% of the oil and 38% of the gas to total GoM production. In the past eight years, the deepwater GoM has produced over 4 Bboe, and in 2009 is expected to produce about 2 MMb/d of oil.

There are now 125 proven deepwater fields. In 2008, there were nine discoveries and eight new producing projects with 15 more scheduled to begin production in 2009.

Moving forward

Partially masked by subsurface salt, subject to pressure extremes — faulted, fractured and compartmentalized — these deepwater trends place great demands on all aspects of well operations.

In the Miocene, the challenge is increasingly one of development where reducing costs and extending the life of the well predominate. While Miocene exploration is still a demanding environment, the new exploration frontier is the Lower Tertiary where extreme is being redefined by objectives in 10,000 ft (3,000 m) of water, reservoirs at 26,000 ft (7,930 m) and deeper, and pressures in excess of 20,000 psi.

Before the Phillips-operated Mahogany field was discovered in 1993, what lay under the salt was generally unknown. Salt so effectively masked seismic signals that most believed commercial hydrocarbons were not present, and penetration was usually unintended. But the success at Mahogany was soon followed by Shell's Enchilada discovery, which proved that a major play existed below the GoM salt canopy.

In the intervening decades, the movement from Miocene to Lower Tertiary has evolved to a broad scope of specific customized solutions for solving these extreme challenges. These challenges, along with useful information on the GoM's deepwater discoveries, are highlighted in the accompanying map.

Technology advances and a much better understanding of the subsalt environment have been key to reaching these deepwater discoveries. But experience has also shown that some of the greatest efficiencies and values in these projects are achieved through integrated solutions aimed at meeting long-term objectives. The following examples provide insight into the scope of capabilities this process can entail.

Miocene development

The Na Kika development southeast of New Orleans, La., in water depths ranging from 5,800 to 7,000, ft (1,769 to 2,135 m) involved a set of reservoirs and 10 subsea well completions. The Shell E&P project was "a model of technological innovation combined with an efficient execution process that set multiple records for well completions in any water depth," according to the authors of OTC 16228, Na Kika Completions Overview: Challenges and Accomplishments.

To accommodate the complex geology with the fewest wells, the 10 Na Kika wells were set up in six different types — three single-zone frac pack wells, two horizontal openhole gravel pack wells, one dual-zone commingled frac pack well, one dual-zone frac pack intelligent well, two triple-zone frac pack intelligent wells with lower zones commingled, and one triple-zone frac pack intelligent well with upper zones commingled.

The efficiency achieved in installing these completions was notable — they were finished in just 238 days versus the original estimate of 447 days. Credit for the achievement was largely given to the completion design and execution team and the processes designed to capture efficiencies and lessons learned.

The technical challenge was considerable. Field development, subsea well completion design, and completion installations in the Na Kika field required the integration of several new technologies and completion methods. While some had been implemented separately in other completion programs, the Na Kika completion program brought many of these solutions together for the first time.

Reservoir uncertainties such as compartmentalization, proximity, and connectivity between gas- and oil-bearing reservoirs led to installation of four intelligent systems in the multizone frac pack completions. Well requirements included competent sand control with low completion skin, remote zonal control, and continuous pressure/temperature monitoring capability for each zone. This functionality enabled producing reservoirs to be commingled or isolated as well as reservoir diagnosis to be performed remotely from the host facility, allowing optimal assessment of reservoir drainage and depletion management.

Complex fluid loss issues in the stacked completions required the development of new isolation devices. Described as one of most complex design issues, mechanical fluid loss devices addressed well control concerns caused by differences in pressure gradients or vertical separation between zones. Other issues involved device functionality and override capabilities, sizing, and non-interference with gravel packing operations.

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Other records achieved over the course of the Na Kika completions campaign include the highest rate frac pack in the world, the deepest setting of a tubing-retrievable surface controlled subsurface safety valve, the first use of a heave-compensated landing system for installation of subsea tree equipment, and the first application of interval control valves as a primary well suspension barrier in a subsea well.

Lower tertiary leverage

At even greater environmental extremes, Lower Tertiary wells are benefiting from many of the capabilities so recently acquired in the Miocene trend. A good example is the pressure limitation of fracture stimulation lines.

At depths below 20,000 ft (6,100 m) and pressures exceeding 20,000 psi, the wells have high fracture gradients and high friction pressure in the wellbore tubulars. Pumping conventional 1.00 to 1.04 specific gravity fracturing fluids requires surface treating pressures greater than 15,000 psi — which is the limit of nearly all of today's surface treatment lines between the treatment vessel and the wellhead.

To meet this challenge, high-density fluids have been developed that can reduce surface-treating pressures by nearly 40%, thus enabling the use of conventional pumping equipment.

Initially used in Chevron's Tahiti project, the high-density fluid technology was a key element in completing the operator's Jack No. 2, one of the pioneer wells in the Lower Tertiary.

The technology and experience from the Tahiti project became a strong leveraging factor in the success of the Jack application. Experience at Tahiti with the high-density fluid, in addition to related operations in production enhancement, coiled tubing, and completions, gave Halliburton engineers a significant advantage with the Jack well.

Deepwater opportunities

Few provinces offer the rewards or the challenges of the deepwater GoM. Success in this extreme environment requires a long-term perspective — one that systematically addresses return on investment over the life of the project, from exploration and prospect development to well planning and construction, completion, and production.

As exploration and development continue, many of today's challenges will be solved. But experience suggests that each step forward opens the door for new opportunities and new challenges to arise. Partnering with a service company that has proven technology, experience, and global reach can provide a fit-for-purpose solution, ensuring deepwater projects are executed with precision, while minimizing downtime and maximizing reservoir recovery. E&P

**See attached map*