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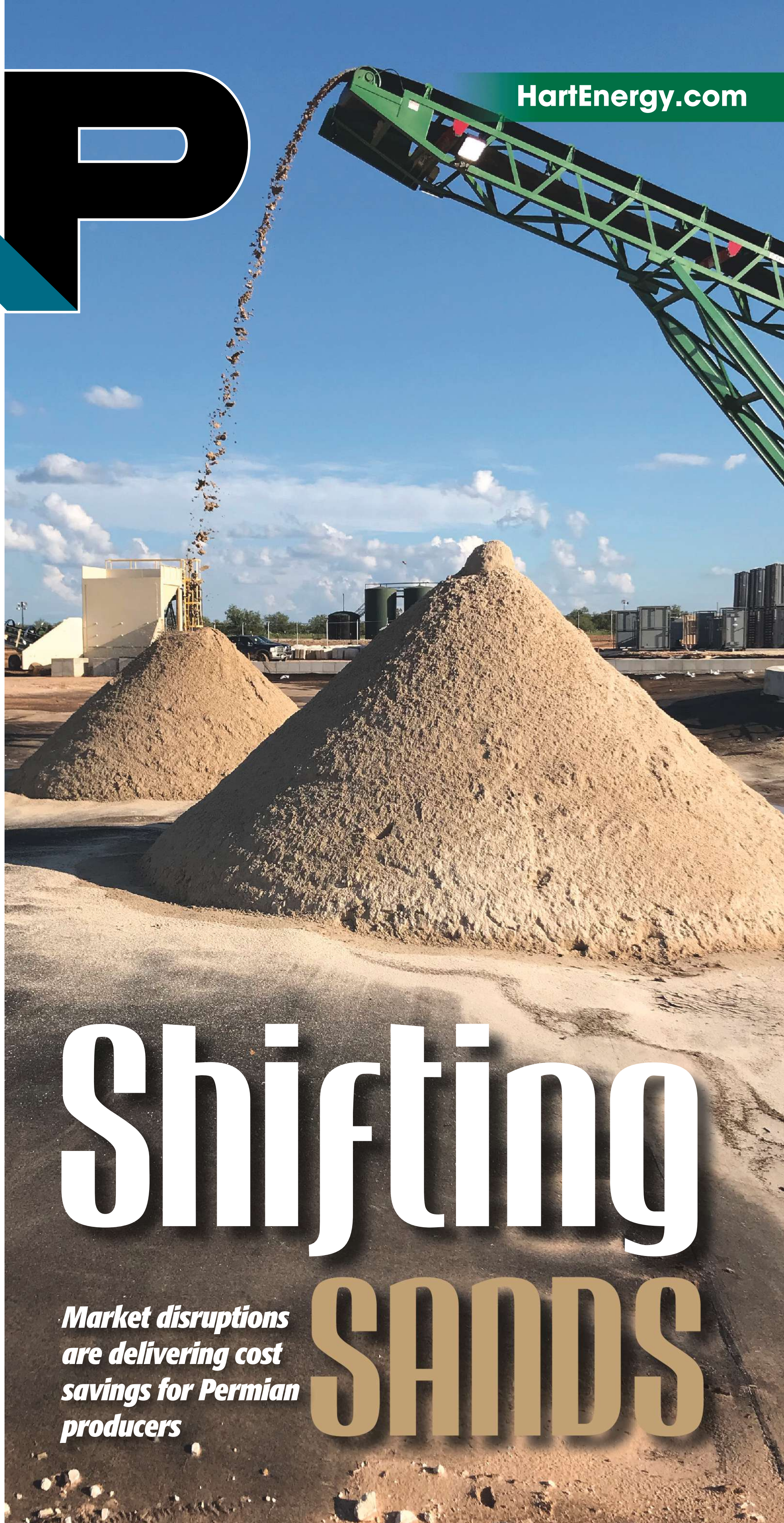
APRIL 2019



Drilling Fluids & Oilfield Chemicals

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Regional Report: **SOUTH AMERICA**

Shifting SANDS

Market disruptions are delivering cost savings for Permian producers

Decoding fluid movement to enhance production

Diagnostics system delivers economic value through an asset's life cycle.

Liz Percak-Dennett, Biota Technology

Oil and gas operations are faced with myriad complex scenarios in the ongoing demand to improve subsurface understanding and maximize reservoir economics and flow assurance along the production life cycle.

During the early life of an asset, capex decisions, such as well spacing and completion designs, are crucial to maximizing EUR and net present value per section. As development commences, continuous optimization is needed to minimize dollar per barrel economics, such as troubleshooting sharp increases in water cut or rapid drops in production volume.

Subsurface DNA Diagnostics is a noninvasive tool to elucidate fluid movement and has been deployed on more than 800 wells across 10 basins in the U.S. Rapid adoption by a majority of the top 20 U.S. onshore operators has resulted in a breadth of applications across the asset life cycle from appraisal and development through the production life cycle.

Subsurface DNA Diagnostics uniquely measure fluid movement in the subsurface by extracting and sequencing DNA originating from microbial communities that survive in temperatures and pressures common to reservoir systems. Microbes are ubiquitous in subsurface environments, residing in hydrocarbons and formation waters in rock-associated porosity, fractures and faults.

High-resolution studies into the subsurface DNA of the Delaware and Midland basins have returned millions of DNA sequences comprising thousands of unique DNA markers. Similar microbial diversity has been observed in all major onshore unconventional basins as well as in offshore regions in the Gulf of Mexico and Asia. These DNA markers capture subsurface heterogeneity at a higher resolution than current methods and serve as an "*in situ* tracer" as fluids are produced from reservoir intervals (Figure 1). This enables sub-formation, 4-D drainage height characterization, well communication and interference monitoring, and robust tracking of oil and water contributions across an asset.

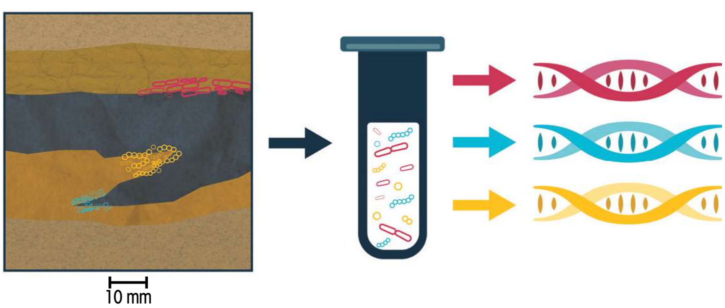

FIGURE 1. Production of fluids returns subsurface DNA to the surface along with hydrocarbons and/or water resulting in an *in situ* diagnostic to track fluid origination and movement. (Source: Biota Technology)

DNA diagnostics workflow

Samples to create a subsurface DNA baseline can be obtained through a low-risk, noninvasive workflow collecting well cuttings or reservoir fluids (oil, water and emulsions) during normal operations using collection procedures designed to preserve subsurface DNA.

Following collection, samples are processed at a central laboratory where DNA is extracted and sequenced using proprietary methods for oilfield samples. Biota's in-house extraction and quality control pipeline ensure sufficient extraction and quantification of subsurface DNA while eliminating environmental or human contaminants.

The high-resolution coverage of multiple sub-formations per well results in millions of DNA markers per project. Therefore, advanced software and data science are necessary to elucidate meaningful patterns. Biota incorporates field data to provide a comprehensive deliverable to the operator.

Exploration: Is this acreage economic?

During exploration, a critical activity for operators is determining the economic viability of the acreage position. Subsurface DNA Diagnostics can be used to identify and optimize well landings for new target formations or plays. By completing a subsurface DNA baseline with cuttings during drilling of the pilot well and production side track, produced fluid from an exploration well can be tied back to particular sub-formations and a high-resolution drainage height can be established over IP180-plus. This workflow has been applied to new acreage in the Permian Basin to establish drainage height of the pilot well and aid in value assessment. Additional work on this exploration well composed a lateral DNA profile at the stage level and was able to confirm that stages drilled out of zone had less production over IP180 than those within a target zone, thus helping to refine future candidate benches.

Development: What's the optimal field development plan?

The impacts of Subsurface DNA Diagnostics have been particularly noticeable during asset development, where the low risk, noninvasive workflow resolves a complex picture of the subsurface and detailed 4-D analysis of drainage height in stacked laterals.

Determining the drainage height of stacked laterals on the same pad is key to optimize spacing decisions and rapidly close the cycle from spacing pilots to fieldwide best practices. During spacing trials, well cuttings are collected from the deepest wells on a pad and used to compose a pad-level vertical DNA baseline. This baseline is then compared to produced fluids from all wells on a pad through IP180 to rapidly monitor drainage height as wells transition out of early flowback and into production.

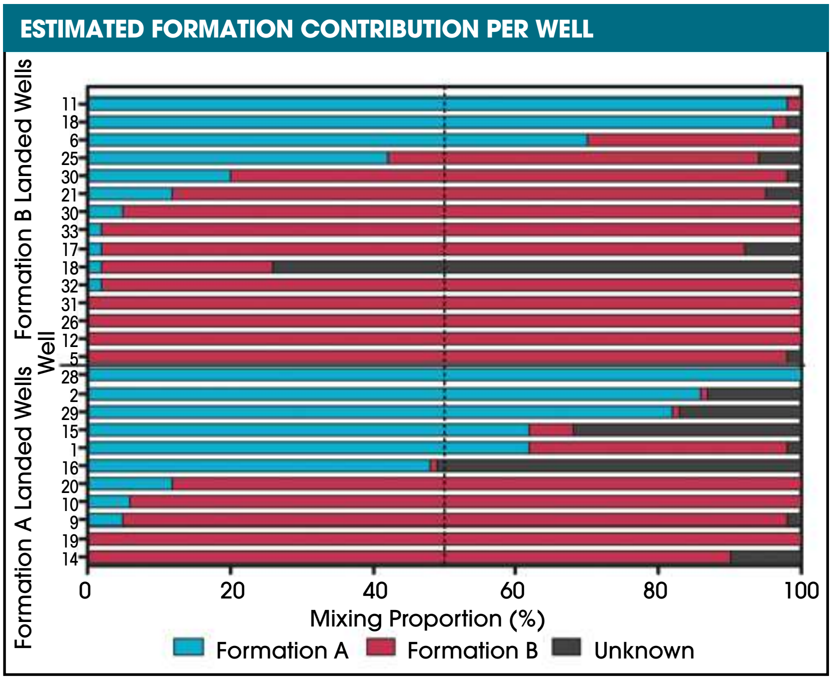

FIGURE 2. Estimates are depicted of the contribution from Formation A and Formation B (both within the Wolfcamp) to each well. Wells to the left and right of the black vertical bar landed in Formation A and Formation B. (Source: Biota Technology)

Work with operators in the Scoop/Stack identified several sub-formations that had extensive frac communication and were being drained by stacked wells, and also determined the role that frac order plays in closely stacked wells. These findings have led the operator to revisit some of its spacing decisions across undeveloped acreage to minimize wells draining adjacent sub-formations and reducing capital intensity.

Production: How to minimize decline?

As the asset matures in production, issues of parent/child communication and choke management play a central role in flow assurance well performance. These variables must be considered by operators as they minimize decline through the life cycle of the well. Four-dimensional production monitoring across an asset allows operations to monitor drainage heights to troubleshoot issues.

Recent work with Anadarko included determining sub-formation level 4-D drainage height in its acreage in the Delaware Basin through a fieldwide deployment of Subsurface DNA Diagnostics on several hundred samples from wells landed in various formations. Each well was analyzed to determine in- versus out-of-formation production (Figure 2) in Formation A and Formation B. The results identified out-of-formation production in each formation, and they were subsequently integrated with production data, reservoir properties and subsurface DNA to improve the learning rate for field development.

In shale gas production, rapid increases in water cut can signal pervasive operational and development problems; however, pinpointing the source of water influx is very challenging without downhole deployment. Subsurface DNA Diagnostics has been used in many gas-rich basins including the Cotton Valley, Appalachian (Utica/Marcellus) and Gulf Coast basins (Eagle Ford). In these cases, the same subsurface DNA baseline obtained from cuttings is compared to water collected during production and used to identify sources of contribution.

Conclusion

Subsurface DNA Diagnostics provide an independent workflow to improve reservoir economics by optimizing flow assurance and capex. Rapid adoption by a majority of the top domestic unconventional producers has resulted in analysis of more than 800 wells, illustrated a complex image of the subsurface with significant insights into out-of-formation contribution, a refined understanding of water contribution zones and improved production over the life of a field. E&P