HARTENERGY DENVER PREVIEW

E&P DAILY NEWS

2014 SEG Annual Meeting

OFFICIAL SHOW DAILY PUBLISHER OF THE SEG INTERNATIONAL EXPOSITION AND 84TH ANNUAL MEETING

Taking the Helm of a Strong Society

Chris Liner will become the latest to take on SEG's 'good problems.'

By Rhonda Duey, Executive Editor, *E&P*

There are bad problems, and there are good problems.

Bad problems include societies that are losing members, attracting fewer people to their conferences, losing the confidence of their exhibitors and generally dying on the vine.

SEG has none of those problems.

In fact, incoming President Christopher Liner, who holds the Maurice F. Storm chair of petroleum geology at the University of Arkansas, said the society has the kinds of "problems" that result from being robust, well run and growing. Membership numbers are strong, and the number of student members is growing, with more than 300 student chapters. The SEG staff numbers 100 people, who help manage a $25 million budget. A new SEG building is under construction at the Tulsa, Okla., headquarters campus and is scheduled for completion in mid-2015 to house growing SEG staff and provide lease income. The SEG Foundation, which funds society programs such as Geoscientists Without Borders, has an active board and excellent membership support. And the two international offices, in China and the Middle East, are meeting the needs of members in regions far away from Tulsa.

Christopher Liner is SEG's incoming president.

If there's a problem at all, it could be said that the society is almost too popular for its own good. Liner said that a typical annual meeting gets more than 1,000 abstracts and has to reject about 50% of them, even with a four-day conference. And many members find traveling to the U.S. for the annual meeting to be a challenge.

To that end, SEG and the American Association of Petroleum Geologists (AAPG) are drafting an agreement to jointly offer two international conferences per year, one operated by each organization. SEG will participate in next year's AAPG International Conference and Exhibition as well as evolve a new franchise in the other half of the year.

See SOCIETY continued on page 31 >>

2014 Meeting Boasts New Features

SEG welcomes delegates with a new look and feel to the event, registration kiosks, and a focus on technology advances.

By Mary Hogan, Associate Managing Editor, Special Projects

Known for its warm hospitality and with more than 300 days of sunshine a year, Denver will play host to the best and the brightest in the geophysics world during SEG's International Exposition and 84th Annual Meeting, taking place at the Colorado Convention Center. The show is already on track to surpass SEG's previous shows held in Denver, both in attendance and the number of technical program sessions. Between 8,000 and 9,000 attendees are expected as well as close to 400 exhibitors.

Bradley Birkelo is SEG's technical program chair.

"We hope everyone will be pleasantly surprised with the many new features we have added this year," said Melanie McGuire, SEG's senior manager of conventions and meetings operations. "There's a new look and feel to the entire annual meeting—from printed materials

See FEATURES continued on page 31 >>

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Isometric Sampling and the Pathway to Subsalt

Resolving the overburden will prove key to accessing the presalt.

Contributed by WesternGeco, a Schlumberger company

WesternGeco is showcasing several new applications for IsoMetrix marine isometric seismic technology at the SEG Annual Meeting. These demonstrate step changes in both imaging quality and acquisition efficiency using towed streamers. Since its launch, a continuous program of commercial projects has been successfully performed offshore four continents and in six petroleum basins, demonstrating suitability in a range of operating conditions and a variety of geological settings. Survey objectives have spanned the full range of applications, including reservoir characterization and E&P.

A typical IsoMetrix survey configuration means more than 250 million measurements are recorded each second, from both hydrophones and calibrated accelerometers. Each datapoint is individually transmitted from streamer to vessel for digital processing. This represents a huge increase in data volume, and consequently all IsoMetrix vessels are equipped with powerful computer systems to manage the data flow in an offshore environment. In fact, the *Western Trident*, the second IsoMetrix vessel, is now the third largest Schlumberger data processing center worldwide. This enables key elements of the processing to be performed onboard, along with fast-track products for initial geological interpretation. *Amazon Conqueror*, the second of a new class of vessels designed specifically for seismic operations, will be equipped with IsoMetrix upon launch in early 2015.

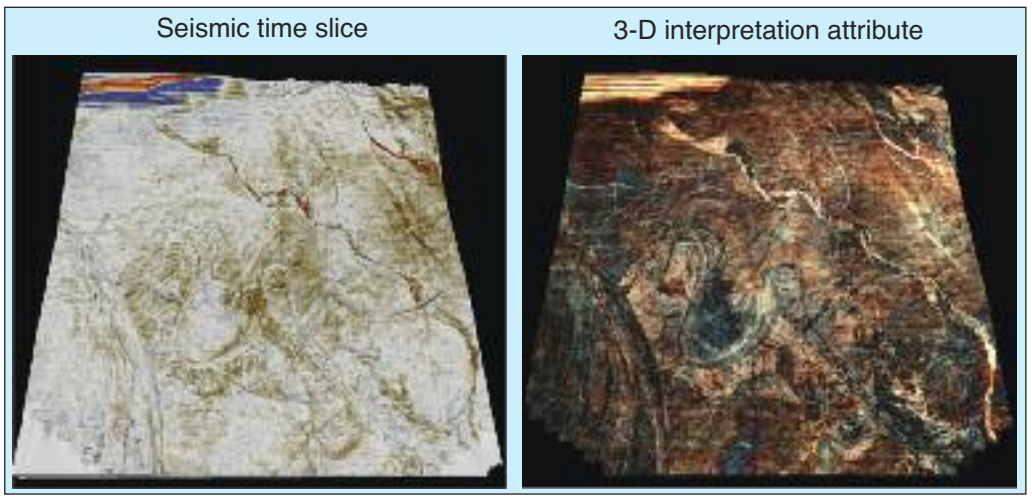
Subsalt plays, increasingly in deepwater environments, continue to attract considerable exploration interest in areas such as the Gulf of Mexico, West Africa and Brazil; however, accurate mapping of the hydrocarbon potential in these complex geological settings presents many technical challenges. Successfully navigating the pathway to the subsalt requires paying as much attention to both the overburden and morphology of the salt bodies as it does to the target itself. Subsalt imaging solutions require an integrated technology portfolio. WesternGeco has identified IsoMetrix as a core element in future subsalt workflows due to its capability to address aspects of wavefield sampling, 3-D deghosting and spatial resolution.

The system records separate data from each sensor in the streamers, providing independent measurements of acoustic pressure and both the vertical and crossline pressure gradient. While pressure and vertical pressure gradient measurements alone might be combined to deliver high-quality broadband data in the time domain, it is the extra crossline measurements that enable spatial wavefield reconstruction and full 3-D deghosting. This technology delivers records of the separated upgoing and downgoing notchless seismic wavefields sampled on a 6.25-m by 6.25-m (20.5-ft by 20.5-ft) point-receiver surface grid for every shot in a seismic survey.

Fine-scale isometric sampling of the seismic wavefield in turn provides fine-scale characterization of the subsurface and means that 3-D interpretation attributes can be generated with confidence, independent of the orientation of viewing. This translates into more detailed representations of subsurface structures and stratigraphic variations.

Furthermore, IsoMetrix can be used to enable more efficient acquisition techniques and deeper tow depths, both of which enhance exploration efficiency. The combination of 3-D deghosting and fine wavefield sampling in all three dimensions represents the first-ever truly 3-D broadband measurement of the seismic wavefield using towed streamers.

IsoMetrix technology enables a new level of insight into subsurface geology from seabed to reservoir. First, understanding the overburden is important as the initial step to the subsalt. High-resolution characterization of shallower formations is critical for defining efficient well trajectories and is particularly crucial for helping to avoid drilling surprises in environments where the cost of sidetracking or abandonment can be extremely high. Knowledge of shallow geology also is important in developing detailed velocity models that benefit processes such as full waveform inversion and accurate prestack depth migration.



Example of IsoMetrix data aiding overburden resolution: A seismic time slice and equivalent slice from a colored 3-D interpretation volume extracted along a shallow dipping horizon show fine detail in channel systems. (Image courtesy of WesternGeco, a Schlumberger company)

Second, fine-scale sampling of the reconstructed seismic wavefield also benefits definition of the salt body geometry and

See PATHWAY continued on page 28 >>

E&P DAILY NEWS

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The *E&P Daily News* is produced for the 2014 SEG International Exposition and Annual Meeting. The publication is edited by the staff of Hart Energy. Opinions expressed herein do not necessarily reflect the opinions of Hart Energy or its affiliates.

SEG SCHEDULE OF EVENTS

Oct. 26 - 31 • Denver

All events will take place at the Colorado Convention Center, unless otherwise noted.

SUNDAY, OCT. 26

8 a.m. to 5 p.m.	Continuing Education Courses
8 a.m. to 5 p.m.	AAPG Fieldtrip Departing and returning from Denver
8 a.m. to 5 p.m.	SEG/Chevron Student Leadership Symposium Hyatt Regency
8 a.m. to 5 p.m.	SEG/ExxonMobil Student Education Program Hyatt Regency
8 a.m. to 12 p.m.	Committee Meetings Colorado Convention Center and Hyatt Regency
1 p.m. to 3 p.m.	Council Meeting
2 p.m. to 4 p.m.	Faculty Adviser Workshop Hyatt Regency Downtown, 3rd Floor, Agate
4:30 p.m. to 5:30 p.m.	Honors and Awards Ceremony
6 p.m. to 8 p.m.	Icebreaker and Exposition Preview Colorado Convention Center, Exhibition Hall
6 p.m. to 8 p.m.	Student Pavilion Colorado Convention Center, Hall E
6:30 p.m. to 7:30 p.m.	SEP/SLS Alumni Night Student Pavilion, Colorado Convention Center, Hall E

MONDAY, OCT. 27

7 a.m. to 8 a.m.	Speaker Orientation Breakfast
7 a.m. to 7 p.m.	Committee Meetings Colorado Convention Center and Hyatt Regency
9 a.m. to 4:30 p.m.	High Performance Computing Theater Colorado Convention Center, Booth 1582
9 a.m. to 9:45 a.m.	Guest/Spouse Program: Welcome by Visit Denver Guest/Spouse Hospitality Suite
9 a.m. to 10 a.m.	Résumé Writing Workshop Student Pavilion Colorado Convention Center, Hall E
9 a.m. to 11:30 a.m.	Opening Session and SEG Forum
9 a.m. to 6 p.m.	Student Pavilion Colorado Convention Center, Hall E
11 a.m. to 11:45 a.m.	Guest/Spouse Program: Glass Fusion Guest/Spouse Hospitality Suite
1 p.m. to 3 p.m.	Student Career Panel Hyatt Regency, 3rd floor, Centennial Ballroom H
1 p.m. to 5 p.m.	Guest/Spouse Program: Rock 'n' Brews Tour Meet at Hyatt Regency
1:30 p.m. to 4:30 p.m.	Technical Program e-Poster Sessions
1:30 p.m. to 4:30 p.m.	Technical Program Poster Sessions
1:30 p.m. to 5 p.m.	Technical Program Oral Sessions
1:30 p.m. to 4:30 p.m.	Guest/Spouse Program: High Tea Tour Meet at Hyatt Regency
2:30 p.m. to 3:30 p.m.	Guest/Spouse Program: Google Glass Presentation Guest/Spouse Hospitality Suite
3 p.m. to 6 p.m.	Challenge Bowl Finals Hyatt Regency
6 p.m. to 8 p.m.	Student Networking Event Hyatt Regency
8 p.m. to 9:30 p.m.	Open Mic Night Hyatt Regency

TUESDAY, OCT. 28

7 a.m. to 8 a.m.	Speaker Orientation Breakfast
7 a.m. to 6 p.m.	Committee Meetings Colorado Convention Center and Hyatt Regency
8:30 a.m. to 9:30 a.m.	Guest/Spouse Program: Yoga Seminar Guest/Spouse Hospitality Suite
8:30 a.m. to 5 p.m.	Technical Program Oral Sessions
9 a.m. to 5:30 p.m.	High Performance Computing Theater Colorado Convention Center, Booth 1582
9 a.m. to 6 p.m.	Student Pavilion Colorado Convention Center, Hall E
9:20 a.m. to 4:30 p.m.	Technical Program e-Poster Sessions
9:20 a.m. to 4:30 p.m.	Technical Program Poster Sessions
11:30 a.m. to 1:30 p.m.	Near-Surface Geophysics Luncheon
11:30 a.m. to 1:30 p.m.	GAC Latin America/ULG Luncheon
11:30 a.m. to 1:30 p.m.	GAC Europe/FSU Luncheon
11:30 a.m.	Guest/Spouse Program Luncheon Hyatt Regency
12 p.m. to 1:30 p.m.	Gravity and Magnetics Luncheon
2:30 p.m. to 4:30 p.m.	Guest/Spouse Program: Behind the Scenes Tour Meet at Hyatt Regency
3 p.m. to 4 p.m.	Guest/Spouse Program: Social Media Seminar Guest/Spouse Hospitality Suite
4 p.m. to 6 p.m.	Near-Surface Business Meeting Colorado Convention Center and Hyatt Regency
4:30 p.m. to 6 p.m.	International Reception Student Pavilion, Colorado Convention Center
7 p.m. to 11 p.m.	Near-Surface Evening Katie Mullen's Irish Restaurant and Pub
8 p.m. to 11 p.m.	Presidential Jam Hyatt Regency

WEDNESDAY, OCT. 29

7 a.m. to 8 a.m.	Speaker Orientation Breakfast
7:45 a.m. to 6:30 p.m.	Committee Meetings Colorado Convention Center and Hyatt Regency
8 a.m. to 10:30 a.m.	Women's Networking Breakfast
8:30 a.m. to 9:30 a.m.	Guest/Spouse Program: Zumba Class Guest/Spouse Hospitality Suite
8:30 a.m. to 5 p.m.	Technical Program Oral Session
9 a.m. to 2 p.m.	Guest/Spouse Program: A Celestial Day in Boulder Meet at Hyatt Regency
9 a.m. to 3:30 p.m.	High Performance Computing Theater Colorado Convention Center, Booth 1582
9 a.m. to 4 p.m.	Student Pavilion Colorado Convention Center, Hall E
9:20 a.m. to 4 p.m.	Technical Program Poster Session
9:20 a.m. to 4 p.m.	Technical Program e-Poster Sessions
10 a.m. to 11 a.m.	Applied Science Education Program
10 a.m. to 12:30 p.m.	Guest/Spouse Program: Crochet Seminar Guest/Spouse Hospitality Suite
11:30 a.m. to 1:30 p.m.	GAC Pacific/Asia Luncheon
11:30 a.m. to 1:30 p.m.	GAC Middle East/Africa Luncheon
12 p.m. to 1:30 p.m.	Development & Production Luncheon
12 p.m. to 1:30 p.m.	Mining Luncheon
2 p.m. to 3 p.m.	Commencement (SLS and SEP) Student Pavilion, Colorado Convention Center
2 p.m. to 4:30 p.m.	Guest/Spouse Program: Crochet Seminar Guest/Spouse Hospitality Suite
6 p.m. to 9 p.m.	Wednesday Night Event Denver Museum of Nature and Science

THURSDAY, OCT. 30

7 a.m. to 8 a.m.	Speaker Orientation Breakfast
8:30 a.m. to 12 p.m.	Technical Program Oral Sessions
8:30 a.m. to 12 p.m.	Technical Program e-Poster Sessions
9 a.m. to 12 p.m.	Committee Meetings Colorado Convention Center and Hyatt Regency
1:30 p.m. to 5 p.m.	Post-Convention Workshops
7:30 p.m.	Research Committee Dinner Maggiano's Little Italy located in the Denver Pavilions

FRIDAY, OCT. 31

8:30 a.m. to 5 p.m.	Post-Convention Workshops

HPC Provides Real-Time Access to the Reservoir

HPC vastly expands the user's processing capabilities and the speed with which algorithms can be run.

Contributed by Schlumberger

From the oil field to the office, the E&P industry is driven by data. The ability to use the vast quantities of reservoir data to guide decision-making during all phases of field development—from shooting seismic to drilling and completing a well—has traditionally been limited by the computational power that users had at their fingertips.

The majority of petrotechnical computing is still done on laptops or desktop machines, meaning that any computation one runs is constrained by the hardware and processing power of local machines. To provide insight while the drillbit is still in the hole, these constraints meant that users could not wait hours for an algorithm to run. Instead, they had to make approximations and compromise on the quality of the answer provided to the driller, often with less-than-ideal results.

High-powered solution

The advent of high-performance computing (HPC) in the petrotechnical arena has now vastly expanded the user's processing capabilities and the speed at which algorithms can be run. By taking advantage of the parallel processing power of HPC, complex algorithms can be run up to 1,000 times faster than with a local machine without compromising on data quality.

As the industry continues to adopt more complex algorithms to better image complex geologies, relative compute effort has increased logarithmically to keep pace. This trend is expected to continue in the next decade, and HPC will likely provide the best computing solution.

Schlumberger has developed a strategy of advancing its petrotechnical software solutions to leverage the processing speeds afforded by HPC and to provide faster and more complete answers to guide better informed decisions. The company's petrotechnical cloud computing strategy combines advanced software application empowered by HPC and delivered in a cloud-computing infrastructure to support real-time workflows and improve the application of modeling and inversion as well as earth model building, among other disciplines.

This offering allows for real-time deep reservoir imaging and complex, fine-scale geosteering to keep pace with drilling. It also is a scalable and flexible processing solution, allowing users to easily transition from individual section to whole-trajectory modeling and run multiple scenarios in real time. The HPC-leveraged cloud computing solution permits prejob and post-job modeling and analysis and upgrades inversion capabilities from traditional 1-D to 2-D.

Compared to conventional desktop processing, HPC-enabled processing offers substantial performance gains. Depth-point inversion is available in 15 seconds vs. 4 minutes to 5 minutes. Peak processing demand requires only eight to10 nodes vs. the 250 nodes required for noncloud processing.

Proving its worth

Schlumberger has added capabilities to its petrotechnical software platforms Petrel E&P software platform, Techlog wellbore software platform and Omega geophysics data processing platform to take advantage of the processing speed and accuracy afforded by HPC in the cloud.

The GeoSphere reservoir mapping-while-drilling service, for example, has used cloud-based HPC to improve geosteering in narrow and complex formations. The deep directional electromagnetic measurements from the tool's array of multiple subs in the bottomhole assembly are used as inputs to refine structural and geological models for the reservoir. Updates to the model are available up to 25 times faster by HPC processing in the cloud, a significant reduction in turnaround time that allows the driller to make decisions on the fly to accurately land the well in the target zones and avoid structural dips and fluid boundaries.

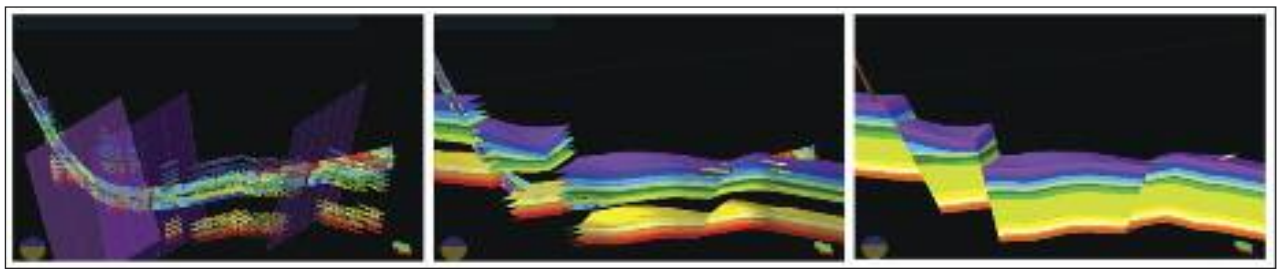


Figure 1. Enabled by HPC infrastructure, the inversion techniques of the GeoSphere reservoir mapping-while-drilling service provide the depth of investigation required for mapping the reservoir. (Image courtesy of Schlumberger)

The company's seismic-guided drilling (SGD) service also has benefited from HPC in a cloud environment. The service uses both surface seismic and LWD data to provide a 3-D look-ahead velocity model and predict formation pressures hundreds of meters ahead of the bit while drilling. By running this model via HPC, a clearer description of the geological and geomechanical properties of the reservoir is afforded in a much shorter turnaround time. The driller can then make proactive decisions that limit the risks of abnormal formation pressures and help ensure greater borehole stability.

The HPC-enabled SGD service has been successfully proven in several blind-test studies. The results of these blind tests have led operators to implement the technology as a risk-mitigation measure in several deepwater HP/HT wells worldwide.

This cloud-based HPC offering allows Schlumberger to provide high-quality, efficient processing power to any oil and gas operation worldwide. And for the first time, operators have access to a complete HPC infrastructure that they can access and use as needed without having to invest in the infrastructure themselves. For more information, visit Schlumberger at booth 1319. ■

The Gateway to Libra

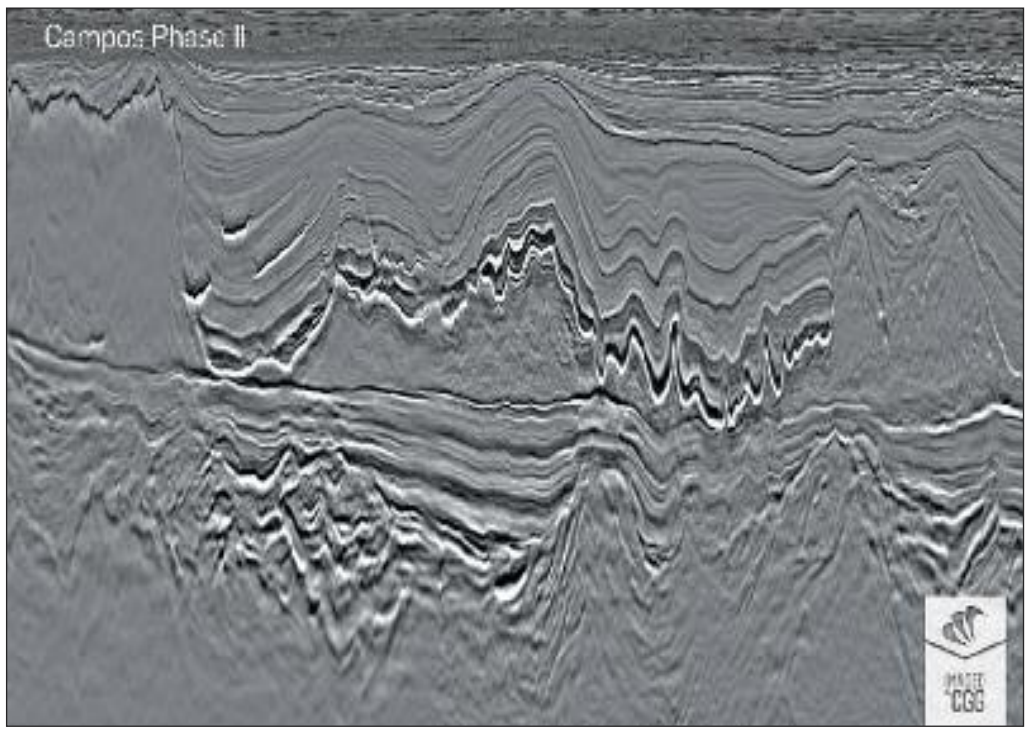
Experience, knowledge and new broadband coverage offshore Brazil bring insight to the potential of presalt acreage.

Contributed by CGG

In 2013, Brazil had a hat trick of licensing rounds after a five-year hiatus, which sparked a resurgence in marine seismic activity in the country. The excitement of this year's FIFA World Cup might have faded, but there is still plenty to get excited about in 11th licensing round acreage with extensive tracts of prospective presalt plays to explore.

With 50 years' experience of local operations and considerable knowledge of the geological and geophysical challenges in Brazil, CGG was poised to take advantage of this opportunity as operators committed to a significant seismic program. As a result, CGG was awarded four multiclient survey contracts in the Equatorial Margin and Espirito Santo and Campos basins totaling 43,130 sq km (16,653 sq miles).

These new surveys have been acquired with BroadSeis, CGG's benchmark broadband solution. BroadSeis is well suited for Round 11 license areas since its broad bandwidths can eliminate the need for compromise in targeting either high frequencies for shallow imaging or low frequencies (with good signal-to-noise down to 2.5 Hz) for deep imaging. BroadSeis' ghost-free data make it possible to deliver the best images throughout the section.



New BroadSeis coverage in the Campos Basin highlights presalt potential. (Image courtesy of CGG Data Library)

So what's in store for Round 11 acreage?

In the past, the main exploration targets in the Campos and Santos basins were within the shallow post-salt successions, but since the discovery of the Lula oil field, interest has turned toward the presalt. Significant finds have since been made, and the presence of Lower Cretaceous carbonate reservoirs has been established in the upper syn-rift and post-rift.

The new BroadSeis surveys have highlighted a number of megasequences in the presalt, with the oldest being highly-faulted basement that influenced the deposition of presalt reservoirs. Directly above the lacustrine shale and mudstone source rocks are thick syn-rift sequences that can be easily differentiated on the new images. The upper syn-rift is important for exploration in the northern Santos and Campos basins as it provides the main carbonate coquinas reservoirs for the Libra and Franco fields. In the post-rift sequences, nonmarine microbial carbonate potential reservoirs were deposited, as observed in the Lula Field. All presalt reservoirs are sealed by a thick sequence of evaporites.

The geology in these basins creates some interesting imaging challenges that have kept the geophysicists in CGG's Rio de Janeiro center on their toes. As well as deploying an advanced subsalt imaging toolbox including full-waveform inversion, they have been busy applying new internal multiple attenuation technology and using iterative velocity updates to image below the igneous intrusions.

In the new acreage of the Equatorial Margin, the westernmost Foz do Amazonas Basin experienced very high sedimentation rates, which led to the formation of a thick deltaic sequence. Basins in this region were affected by large gravity slides. Potential reservoirs in the Foz do Amazonas include Tertiary deltaic sands, turbidites, fractured carbonates and talus deposits, which are structurally and stratigraphically trapped. Paleo-canyons in this basin proved to be another imaging challenge that was ably tackled by CGG's geophysicists.

To the east of the delta, the Barreirinhas Basin is much less affected by the Amazon sediment load, but a steep margin led to megaslide complexes forming. This basin is the conjugate to Ghana and Togo, where large fields already are producing. Large en-echelon folds, rollovers and tilted fault blocks provide structural traps, and marine shales source Late Cretaceous reservoirs, which are stratigraphically sealed.

Visit CGG at booth 1339 to see its "Gateway to Libra" display and talk to its multiclient and new ventures team and Robertson geologists. The company's subsurface imaging group also will present some of the new technology applied in the SEG technical sessions. The company will host a Brazil happy hour presentation at 4 p.m. on Monday at its booth, discussing the subsurface imaging expertise behind these new displays. ■

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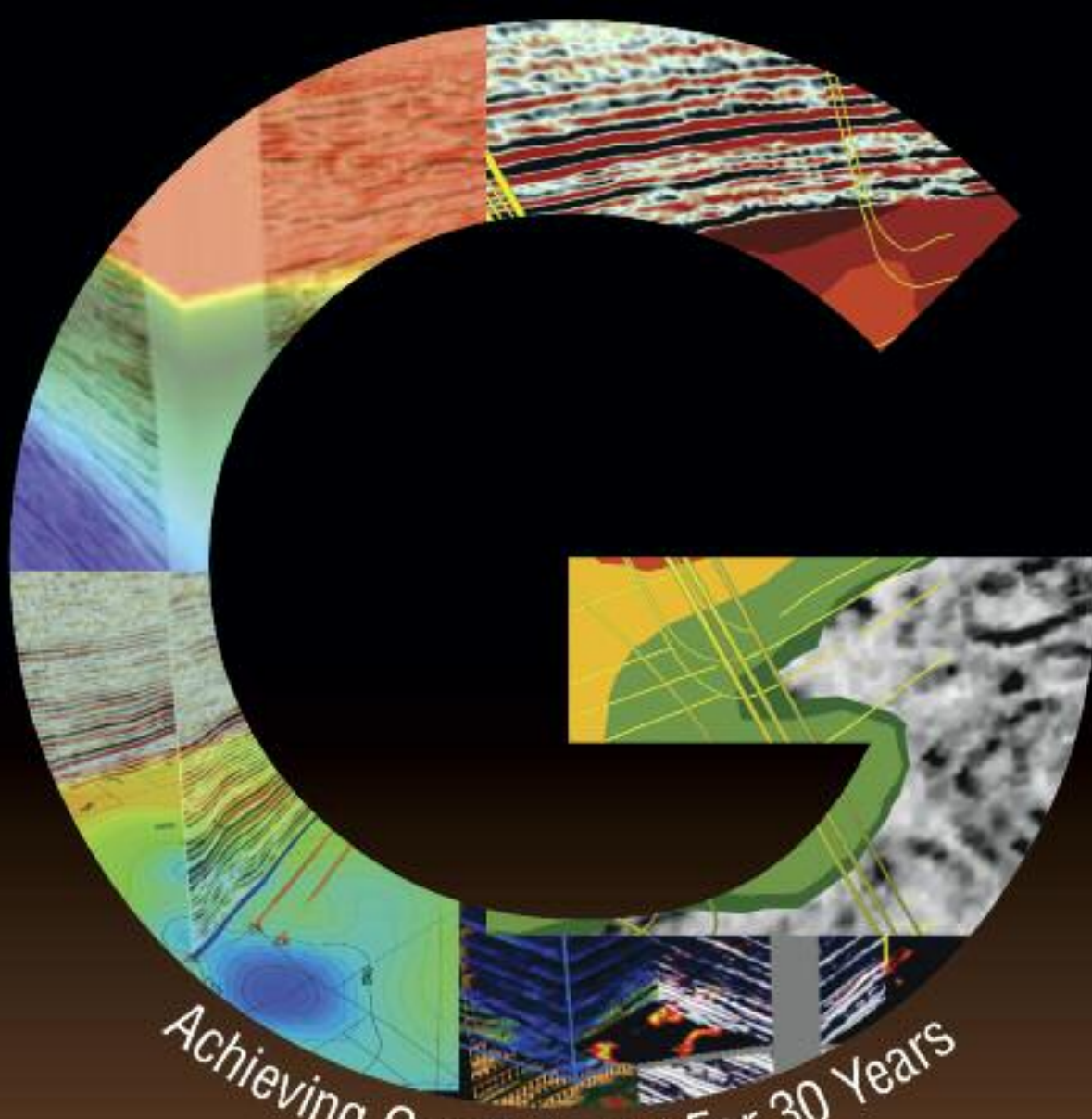

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Enabling RSS Hole Enlargement to Total Depth in a Single Run

At-bit reamer system leaves reduced-size rathole in hole-opening applications.

By John Evans, Halliburton

Halliburton's TDReam tool can significantly reduce the rathole length drilled in rotary steerable system (RSS) hole-enlargement operations while making it possible to reach section total depth (TD) in a single run.

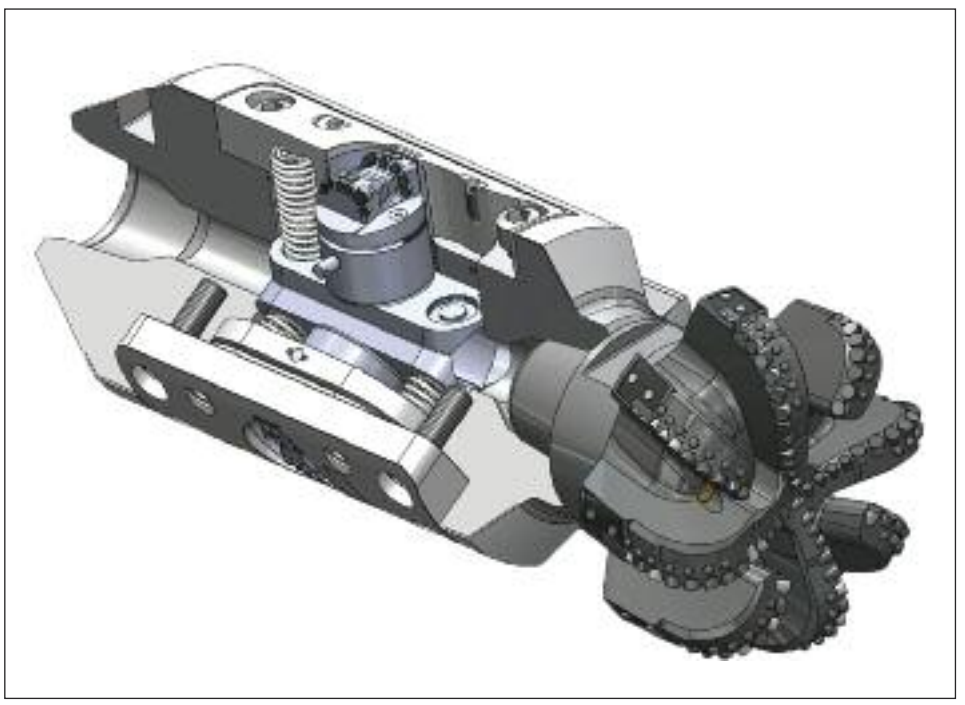
The tool was developed to meet a drilling tender requirement, which required a reaming-while-drilling tool that could be run on an RSS and that could deliver a rathole no longer than 6 m (20 ft). This saved the time and cost of an extra hole enlargement run for these sections.

In a traditional reaming-while-drilling bottomhole assembly (BHA), the reamer is placed above the RSS system and LWD tools, creating a long rathole up to 37 m (121 ft) long, which requires an extra trip to enlarge the hole to TD. By contrast, the TDReam tool is an integrated near-bit tool that immediately enlarges the rathole left by the RSS and eliminates the need for a dedicated reamer run.

In operation, the TDReam tool is placed between the bit and RSS, where it remains dormant as the section is drilled. With a length of just 1 m (3.3 ft), the one-piece, solid-body integrated reamer incorporates hydraulic shear pins that maintain the tool in dormant position during the drilling of the section. At depth, the BHA is pulled to position by the tool at the top of the rathole, where a flow increase activates the tool. The pressure drop through the bit maintains the tool in the open position as it enlarges the rathole.

The shear pin design prevents tool activation while drilling out the shoe track, and there are no locking devices that can inadvertently lock the activation pistons in the open position. When flow decreases, return springs close the reamer arms.

In the end, instead of 37 m of rathole that needs to be enlarged, a single trip results in a rathole less than 1 m long.



Halliburton's TDReam integrated near-bit reaming-while-drilling tool enables an RSS to reach TD in one run, leaving a rathole length of just 1 m. (Image courtesy of Halliburton)

TDReam tool technology includes an engineered design that seeks to optimize tool dimensions to help ensure satisfactory steerability and use of advanced proprietary software to model BHA behavior and steerability during drilling. Extensive computational fluid dynamics analysis was performed in the design phase to optimize hydraulics for improved tool-cleaning efficiency and to help ensure there is no hydraulic compromise from the internal workings of the tool.

Initial application in a hard rock directional well offshore Norway was a success. The operator required hole enlargement from 12¼ in. to 13½ in. using an RSS. The operator also required a solution that would save rig time and reduce the typical 37-m length of the rathole drilled.

Halliburton provided a drilling BHA that combined an advanced polycrystalline diamond compact bit with the TDReam1200 tool, run with a Geo-Pilot 7600 RSS and Wired XR Reamer. This assembly was run in-hole to drill while reaming to section TD, where the BHA was then pulled and positioned inside the enlarged wellbore. The TDReam tool was then activated to ream the last 15 m (49 ft) of hole, enlarging to 13½ in. The hole was then circulated clean and the BHA pulled to surface, after which the 10¾-in. liner was successfully run to TD and cemented.

The efficiency improvements afforded by the tool yield clear benefits in terms of substantial time and cost savings as well as providing additional well design flexibility and greater safety. Time savings alone in this case resulted in estimated savings to the operator of $300,000.

In addition, by allowing casing and cementing operations to be performed without the need for a dedicated rathole cleanout beforehand, reaming while drilling with the TDReam tool reduced the risks inherent with multiple trips downhole and pipehandling operations at the surface. At a spread rate of about $900 per minute, eliminating the cost of an extra trip by using the TDReam tool could save as much as $2 million compared to a traditional reamer. ■

The Evolution of Seabed Node Technology

Seismic system can provide improved data clarity and geophysical illumination.

Contributed by Seabed Geosolutions

Seabed Geosolutions' Manta seabed seismic technology can provide a single ocean-bottom node solution for water depths up to 3,000 m (9,843 ft). The technology can overcome challenging environments with complex geologies and deliver improved data clarity through versatility in survey design. The system was designed to deliver improved geophysical illumination with flexibility for dense source grid and full-azimuth and long-offset surveys.

Manta nodes are versatile, efficient and designed with maximum safety in mind. The flexibility of the system allows it to go where traditional streamer seismic often cannot. With a variety of deployment methods, the system can acquire high-resolution subsurface data in challenging, obstructed areas and from both shallow transition zones and deepwater.

The node is made up of a four-component sensor incorporating three geophones mounted in a Galperin orientation and one hydrophone. The integral inclinometer continually records the orientation of the node once it is positioned on the seafloor. This component configuration, which includes omnidirectional geophones, can provide a uniform azimuthal response and can capture the full wavefield. The technology records the compressional and converted waves' seismic attributes, which can enable better delineation of hydrocarbon zones and subsurface lithologies.

The compact and stackable Manta node goes where traditional streamer seismic often cannot, in depths up to 3,000 m. (Image courtesy of Seabed Geosolutions)

The system has been developed in unison with designed robotics to create a "no-touch" handling system, thereby seeking to reduce HSE exposure while achieving operational efficiency. The entire concept of the no-touch deployment and recovery system with automated node storage, data download and battery charging is founded on a transportable modular solution using available dynamic positioning vessels.

The company's R&D team has combined contemporary microcomponents with recent advances in rechargeable power-dense battery technology to create a compact, lightweight node for almost all survey locations and designs. The reduced node size and stackable shape help to make the most of deck space, allowing for flexibility and optimization of node counts. The no-touch handling system delivers the Manta node in either a traditional dense receiver configuration or by ROV. This makes the technology ideal during the production phase to understand, monitor and manage the reservoir across the life of the field.

Visit Seabed Geosolutions at booth 1124 for more information. ■

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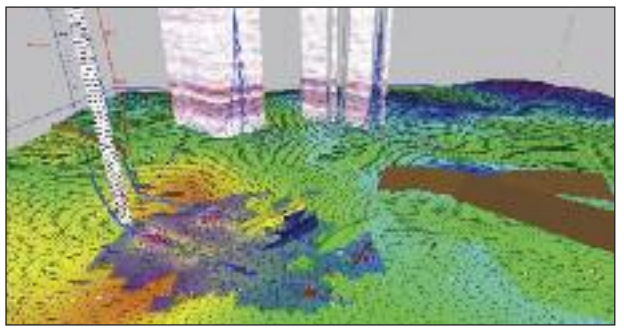
Microseismic data provide deeper reservoir understanding to enhance production and maximize field economics for the life of the well.



Using Weatherford's subsurface microseismic services, operators can see real-time hydraulic fracture monitoring and mapping to optimize well and fracture trajectories and avoid unanticipated subsurface complications. (Image courtesy of Weatherford)

Contributed by Weatherford

In today's environment of increasing hydrocarbon demand and growing reservoir complexity, operators are challenged more than ever to optimize recovery and improve economics by understanding the reservoir. Microseismic borehole or subsurface data that provide a detailed picture of the asset—including dynamics for both natural and pretreated fractures—enable operators to make more informed decisions regarding wellbore design and completion strategies for the life of the well.

The Weatherford Borehole Seismic Group has developed a suite of field-proven subsurface microseismic services that provide real-time hydraulic fracture monitoring and mapping and completion evaluation capabilities. Mapping services model and enhance stimulation programs with full geomechanical analysis along with designed pump pressures, injection rates and injection volumes to stay in the target zone in every stage. Operators can use the information to avoid unanticipated subsurface complications, optimize well and fracture trajectories and bypass nonproductive natural fractures.

Microseismic hydraulic fracture stimulation diagnostic services include microseismic monitoring that uses stimulation-induced microseismicity to map fractures. Wireline-deployed geophone arrays downhole record microseismicity, which provides data about the length, height, width and azimuth of a fractured zone; event sequence and magnitude; and the rock failure mechanism. Diagnostic tools can map a multistage treatment and measure overlapping fracture growth for multiple horizontal wells.

In a unique application in the Barnett Shale, a geophone array was placed in the cased horizontal leg of a wellbore to monitor the stimulation of a parallel cased horizontal well. Each zone of the adjacent well was stimulated, with the zones isolated by temporary packers set above the perforations after each stimulation. The operation revealed the preferred azimuth of fracturing along with the degree of overlap of the fracturing patterns created by each stage.

By mapping the stimulation results of two parallel horizontal wells, microseismic determined overlapping fracture patterns between stimulation stages in one well and between adjacent wells, which proved beneficial in improving production and recovery rates. This practice of simultaneously stimulating the perforated zones of two or more adjacent wells with overlapping fracture zones is now commonly used in most unconventional plays.

Continuously recording microseismicity

For remote wells less than 610 m (2,000 ft) from a treatment well, the Weatherford self-contained field unit facilitates deployment of a three-component geophone array on standard wireline to continuously record microseismicity before, during and after hydraulic stimulation. Microseismicity can be processed and mapped in real time or after stimulation. The seismic mapping data are streamed and displayed on site in the fracturing unit.

Among the new-generation technologies is the SlimWave with enhanced sensitivity for recording high-frequency signals and providing high-resolution vertical seismic profiles and microseismic monitoring. For treatment well operations, Weatherford is using methods based on Microseismic Spear technology developed by ExxonMobil Upstream Research Co. to record microseismicity when the absence of nearby observation wells prevents monitoring the stimulation.

The spear array records microseismicity during pretreatment pad and post-treatment shut-in stages and maps microseismicity in real time or after stimulation. In cases where wellhead pressure is too great to let the tool drop from the lubricator, a new e-coil pushes the tool into the well, increasing the breaking strain for the head and providing the ability to circulate fluid around the top of the tool should it become sanded in. The methodology will eventually make it possible to push the tool horizontally if necessary.

In an area of the Marcellus Shale where saltwater production has impeded drilling, the three-geophone seismic spear monitoring tool was used to verify that the fracture design in a vertical pilot well remained within the Marcellus prior to drilling horizontal wells. The spear was placed in the borehole during stimulation and recorded the fracturing emissions after the pumps stopped to show the extent of fracturing. The stimulation design fractured only the Marcellus, avoiding the underlying saltwater zone. The user was then able to develop a viable horizontal drilling and stimulation program.

Microseismic mapping is one of the key areas where the industry is pushing the envelope to maximize recovery and optimize economics in complex conventional and unconventional fields. ■

Taking Seismic Interpretation to New Levels

Software and plug-ins enable more accurate geological models and new ways of analyzing seismic data.

Contributed by dGB Earth Sciences

From denser sampling in space and time to sophisticated attributes and visualization technologies, the last few years have seen significant advances in seismic interpretation and its input to operators' drilling, well and reservoir management strategies.

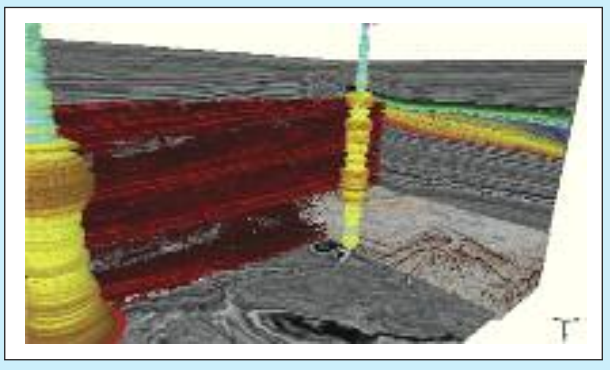
Major developments include the introduction of geologic age into the interpretation process, the fully interpreted seismic volumes that have resulted and the advanced workflows that have been built around them.

Fully interpreted seismic volumes have opened the way to the application of a number of advanced seismic interpretation workflows, from sequence stratigraphy, attribute generation and model building to geohazard interpretation. These workflows enable more geologic information to be extracted from seismic data and provide unprecedented value to operators.

Among these new developments is dGB Earth Sciences' open-source seismic interpretation software OpendTect—downloaded more than 150,000 times since September 2009—and its commercial plug-in, HorizonCube.

HorizonCube provides fully interpreted seismic volumes where horizons are automatically tracked between a given set of framework horizons and faults. The tracking is carried out through use of a seismic dip volume. The plug-in correlates time lines in this precalculated seismic dip field with the tracked surfaces stored as a dense set of mapped horizons called HorizonCubes.

In this way, the plug-in can provide improved quantitative rock property estimation, enhanced definitions of stratigraphic traps, more accurate and robust geological models, and the ability for interpreters to extract more from their high-resolution seismic data.



OpendTect open-source seismic interpretation software includes improved display capabilities. (Image courtesy of dGB Earth Sciences)

During the 2014 SEG Annual Meeting, dGB will be introducing the latest version of its OpendTect 5.0 software, which comes with significant advances to HorizonCube and stratigraphic interpretation capabilities, potentially leading to a better understanding of structural geologies.

Many of the new features within the software have emerged out of the dGB-led Sequence Stratigraphic Interpretation System (SSIS) consortium that includes sponsors Statoil, OMV, MOL and RocOil.

The software includes a new interactive HorizonCube tracker workflow for 2-D seismic that can be used to track single horizons and create 2-D HorizonCubes through a dip-steered tracker where the user picks horizons at multiple seed positions in both the structural and Wheeler domains.

The resulting correlated geologic time lines provide interpreters with new ways of analyzing seismic data, help interpreters better understand their depositional histories and improve the ability to find stratigraphic traps and build accurate geologic models.

OpendTect 5.0 includes a graphics library with multitouch interaction capabilities and closer integration with MATLAB, the high-level language and interactive environment for numerical computation, visualization and programming. This will open up a huge potential database of easily accessible research code.

The software also includes significant enhancements like the SynthRock plug-in. With SynthRock, interpreters can combine forward modeling, rock physics and inversion to create and use forward models in qualitative and quantitative seismic interpretation studies. New SynthRock features within OpendTect 5.0 will include the ability to generate synthetic gathers from input volumes of density and P- and S-wave velocities.

Meanwhile, post-OpendTect 5.0 developments already have started. The interactive 2-D HorizonCube workflow developed within the SSIS consortium will be the basis of OpendTect's next-generation 3-D HorizonCube algorithm. The same workflow also will form the basis of an overhaul of dGB's conventional amplitude and similarity-based horizon trackers. This new development is being funded by BG Group and will be released within the open-source part of OpendTect, enabling all seismic interpreters to benefit.

Visit dGB at booth 1852 for more information. ■

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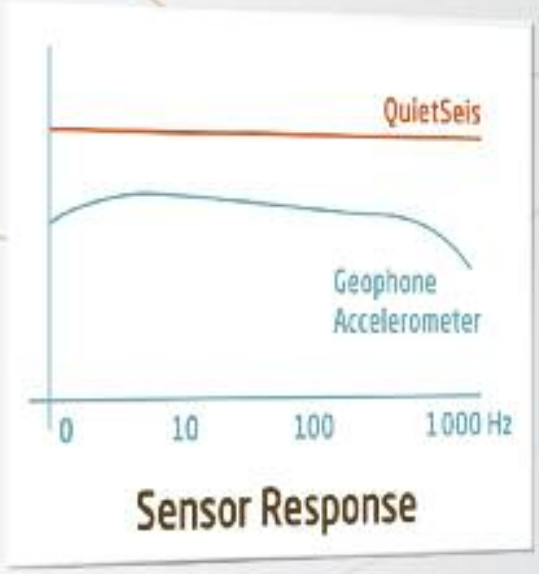

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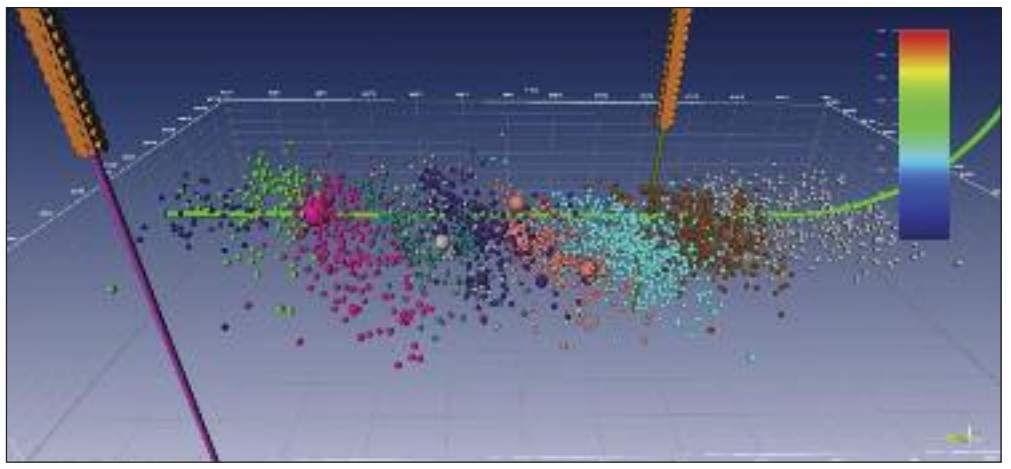
5% to 8% Recovery? Understand and Account for Variability and Watch EUR Climb

Workflows connect reservoir characterization and engineering to production with validation through microseismic mapping.

Contributed by SIGMA³

The only thing constant is change. If we've learned anything from that cliché over the past several years, it's that unconventional reservoirs seem to delight in challenging us in an equally paradoxical way. From Texas to China, Argentina to Kuwait, and North Dakota to Poland, shale reservoirs remind us that variability is the constant we have to deal with— whether by reservoir properties, completion, stimulation strategies, microseismic response, IP or EUR.

Some U.S. operators estimate recovery rates of 5% to 8% due to this challenge, but thanks to step changes in reservoir characterization modeling, horizontal drilling, new completion techniques and stimulation processes, and accurate microseismic data, operators can now do more than just scratch the surface of these resource-rich shale reservoirs. Above all, it is the integration of these discrete technologies that adds the most value.



Integrated reservoir characterization workflows that enable real-time frack data and microseismic events to be processed, interpreted and visualized in tandem with the earth models, well geometries and geomechanical properties help operators know where to drill, where to frack and how to frack. (Image courtesy of SIGMA³)

Manage reservoir variability through integration

Successful shale development requires a level of subsurface understanding that can only be achieved through an integrated workflow that turns key reservoir properties into a predictive model that precisely targets the areas that will yield maximum EUR when effective completion and stimulation campaigns are applied. This identifies where the bit needs to go and is the framework from which all key decisions—well placement, hazard avoidance, wellbore azimuth and inclination, well spacing to completion technique, fracture spacing, and treatment type—are made.

Since most of the effective permeability in a shale well is created during hydraulic frack stimulation, which is an engineering activity, integrated technology that addresses geology, geophysics and geomechanical rock properties and the role of natural fractures is the key to targeting sweet spots before the fracture spread arrives at the wellbore.

"Integrated GeoEngineering provides a direct link between geoscience and engineering needs, including the ability to predict well performance with a high degree of confidence and pinpoint the richest targets before drilling begins and then validate the findings in real time," said Jorge Machnizh, SIGMA³ CEO. "This helps operators optimize costs and improve the outcome of each well."

Identify sweet spots, estimate horizontal well production

Using the proprietary CRYSTAL platform, SIGMA³ has delivered integrated 3-D reservoir models to identify sweet spots and predict production of blind wells. By leveraging reflection seismic with geologic well data, production data and any available reservoir information, SIGMA³ delivers Shale Capacity models created from key reservoir properties, including natural fractures, brittleness, total organic carbon content and porosity, to demonstrate reservoir heterogeneity and variable well performance. This workflow allows GeoEngineers to build models that connect microseismically derived stimulated reservoir volumes to actual produced volumes in the context of reflection seismic, geologic and well log data. This 3-D model helps identify subsurface properties that predict microseismicity, frack success and ultimately production.

Users have validated the results of the Shale Capacity models against known production in other nearby wells and see consistently 80% to 90% confidence factors of the distribution and variability of the primary geologic drivers controlling production. Seismic- and well log-driven fractured reservoir characterization is able to significantly increase the probability of drilling the best producing wells while reducing the risk of drilling poor producers in both exploration and field development scenarios.

Meaningful interpretation, optimized engineering

The relevance of microseismic events—how they can be used as a proxy to qualify the stimulated rock volume and ultimately production—along with optimal well and frack design is what transforms average wells into exceptional producers.

See EUR continued on page 28 >>

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Improving the Quality of Prestack Seismic Data

Sequentially assembled algorithms aim to preserve the relative AVO relationship.

By Francisco Bolívar, Rock Solid Images

Most seismic data are processed to optimize the image quality for post-stack qualitative structural interpretation, with little regard to preserving characteristics needed for successful quantitative interpretation. Frequently, these kinds of seismic data might be improved through the application of specialized tools in the prestack time-migrated common depth point gather domain. Beyond the in-depth science of the algorithms, the quality-control (QC) processes involved after each step ensure that the results from the final workflow form a robust and reliable input for analyses such as amplitude vs. offset (AVO)/amplitude vs. angle, amplitude variation with angle and azimuth, and seismic amplitude inversion.

In the past, seismic processors would have minimal information about the geology of the survey area. Today, integration of geophysical, geological, petrophysical and rock physics components with signal analysis plays a fundamental role in successful geoscience studies with E&P goals.

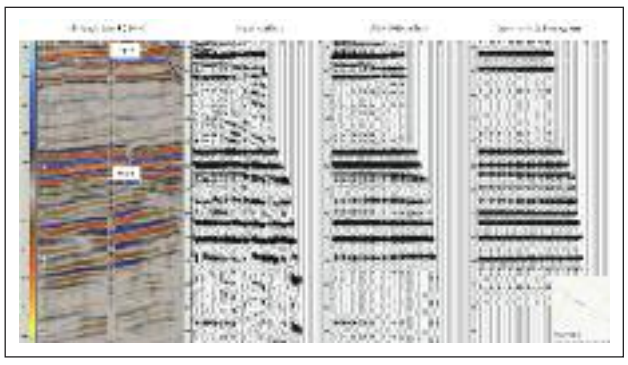

FIGURE 1a. Full-stack well tie and comparison data between input, conditioned and synthetic gathers are shown. (Images courtesy of Rock Solid Images)

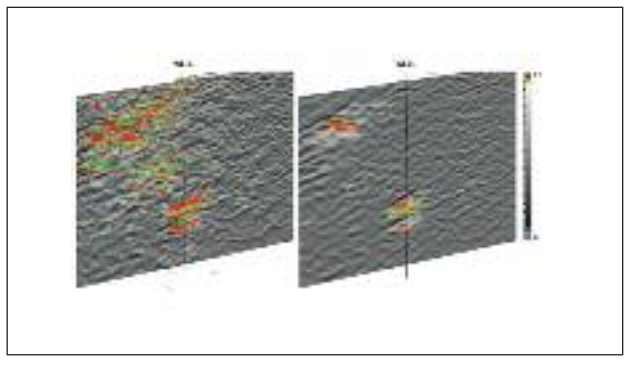

FIGURE 1b. Before application of the AVATAR workflow, interpretation of AVO gradient would be challenging (left panel). Once the seismic data have been conditioned, the AVO gradient response at the well location is clearer, and interpretation of surrounding AVO gradient anomalies is possible.

A standard conditioning sequence begins with a noise analysis step to identify random and coherent noise that should be removed and other defects in the gathers such as residual moveout or undesirable amplitude or frequency behavior. The multiples are modeled by a high-resolution, laterally/vertically variable parabolic radon transform and are subtracted from the input data. AVO extractions, amplitude spectrum comparison and differencing seismic data before and after this process ensure the preservation of the primaries.

A residual normal moveout (RNMO) analysis is then carried out. The goal is to minimize the AVO gradient assuming that the gradient due to improperly aligned events is much greater than the gradient due to fluid effects. After this correction, RNMO volumes are visualized to examine trends in the moveout corrections and verify patterns. It is extremely important to compare synthetic gathers side by side with actual gathers for any residual velocity analysis or flattening algorithm. Rock physics analysis provides the analyst information about the expected AVO class(es) in the area so that any special considerations can be taken into account to preserve them.

In the example shown in Figure 1a, spectral balancing followed by random noise removal was applied at the end of the workflow. Gabor-Morlet joint time-frequency analysis is used to separate the frequency spectra of each gather trace into a user-specified number of sub-bands, calculated using a running Gaussian-shaped window that yields a slowly varying amplitude profile of each sub-band. Then each sub-band spectrum is balanced against that of the pilot trace.

Comparison between far angle stacks before and after the process demonstrates the improvement and impact of this step, but a simple amplitude spectrum analysis provides a clear metric of the results. The last step consists of applying an offset domain signal-to-noise (S/N) enhancement routine that preserves any AVO effects in the gathers. It takes into account the spatial dip of coherent reflections so that frequency and continuity are preserved.

The conditioning sequence is completed with a final QC analysis at the top of the reservoir. Horizon amplitude extractions from seismic gathers and stacks and their correlation with geological features before and after the entire workflow, crossplot analysis of synthetic and actual partial angle stacks before and after the conditioning, and S/N ratio comparison will help to gauge the improvement made to the seismic data (Figure 1b).

This example demonstrates the impact AVATAR can have on seismic, applied prestack or post-stack. Figure 1b illustrates the improvement in AVO gradient after application of the AVATAR gather conditioning workflow. Cleaner, clearer data permit improved and more rapid manual or semiautomated interpretation of reservoir architecture, superior well ties, more robust inversion for reservoir properties and improved property prediction. AVATAR conditioning also seeks to be a cost-effective alternative to new acquisition or full reprocessing.

Visit Rock Solid Images at booth 2538 for more information. ■

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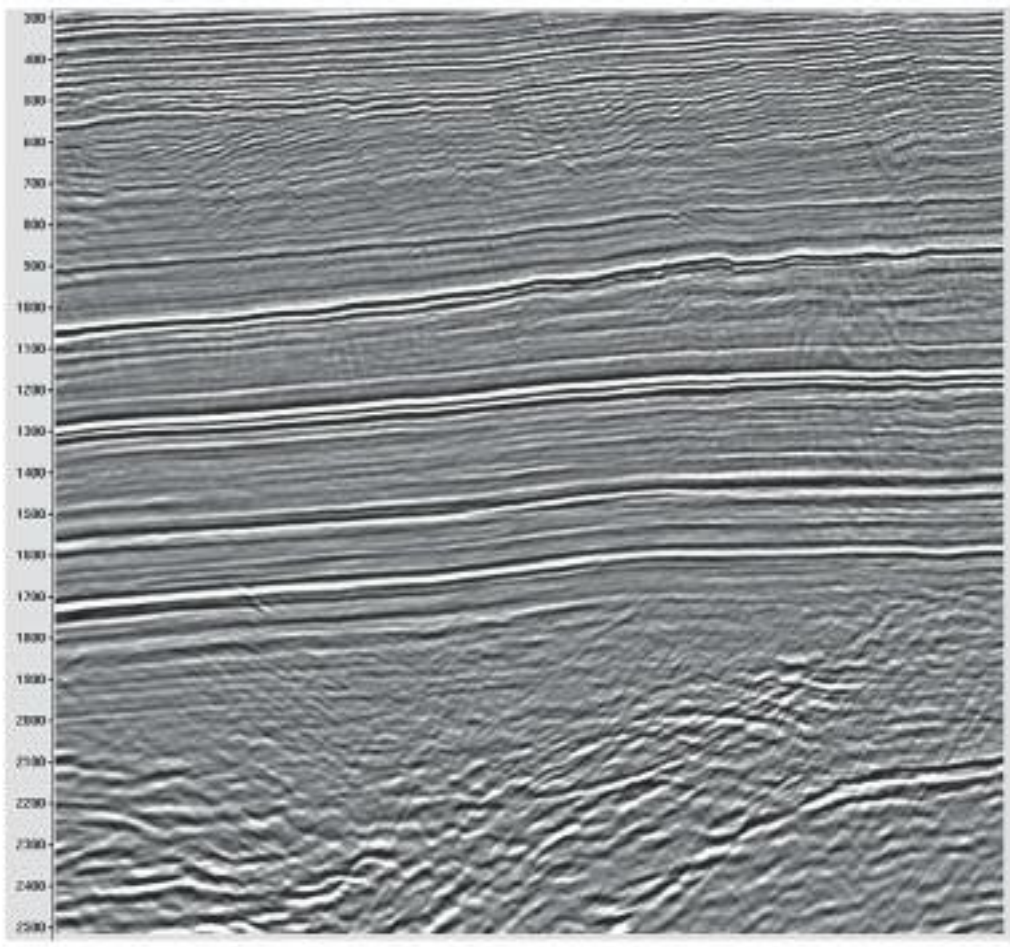
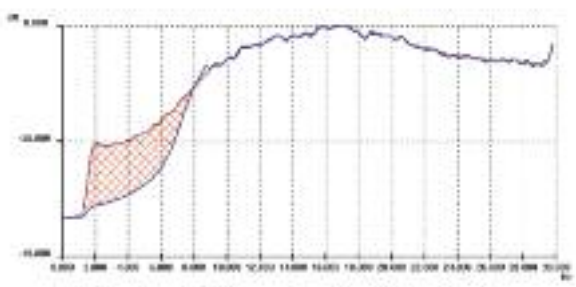
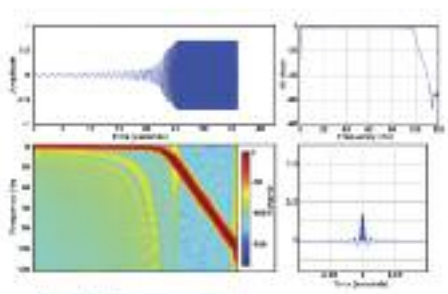




Additional bandwidth resulting from the low dwell sweep.



Low dwell sweep example.

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Seismic Facies Analysis Using Generative Topographic Mapping

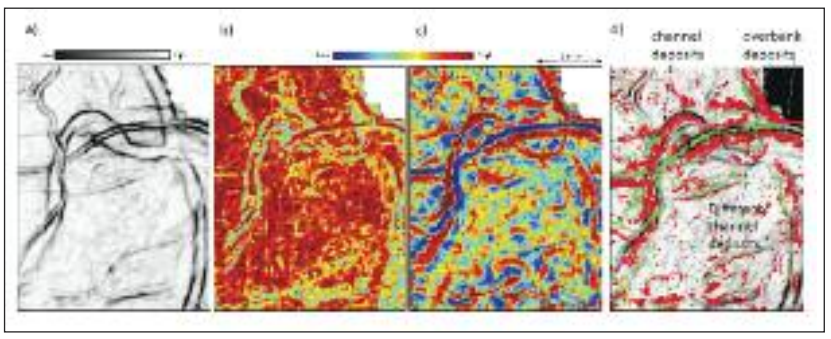
Using pattern recognition to study the shape and character of seismic waveforms can reveal seismic facies variation at the target level.

By Satinder Chopra, Arcis Seismic Solutions, and Kurt J. Marfurt, University of Oklahoma

The shape and character of the seismic waveform often is used to characterize reservoir quality. Such a seismic waveform carries information about the phase, frequency and amplitude; any variation in these parameters is a function of the lateral variations in lithology, porosity and fluid content. If the shape and character of seismic waveforms in a given target zone can be studied using some type of pattern recognition process and then displayed in a map view, the display would indicate seismic facies variation at the target level.

One approach to pattern recognition is with the use of neural networks to compare seismic waveforms within the interval of interest with a series of synthetic traces. These synthetic traces are generated according to the user-defined number of groups that best represent the different shapes in the interval. They are arranged in a progression (assigning numbers to these traces), which is examined to get a feel for the shapes of the waveforms. Next, each trace in the interval is compared with the different synthetic traces. Those traces that have maximum correlation with a given synthetic trace are classified into a group. The resulting map is essentially a facies map or a similarity map of the actual traces to the different synthetic traces. This technique is commonly referred to as a self-organizing map (SOM) waveform classification, originally introduced by Kohonen and subsequently extended into 2-D and 3-D subspace. Using seismic attributes such as amplitude envelope, bandwidth, impedance, amplitude vs. offset slope and intercept, dip magnitude and coherence, attempts have been made to project them into 2-D latent space and plot the results with a 2-D color bar.

More recently, a 3-D SOM multiattribute application has been developed to generate a 3-D seismic facies volume. The different mathematically independent input attributes determine the dimensionality of the latent space. The input data vectors are first normalized and then projected into the 2-D latent space using principal component analysis (PCA) in the form of eigenvalues and eigenvectors. As part of the training process, each vector is chosen at random and compared to all the other vectors on the 2-D latent space grid in a neighborhood radius, and the vectors with good correlation are updated. Next, smaller neighborhoods around the correlated vectors are also updated, and gradually the neighborhood radius is shrunk iteratively. If there are five attributes and a 2-D latent space is being used, the initial PCA plane is deformed into a 2-D nonplanar manifold (or surface) in 5-D space that best fits the data. Colors are assigned to the vectors according to their distance from the center of a given cluster of points. In this way a 3-D volume of facies is generated. The generative topographic mapping (GTM) algorithm is a nonlinear dimension-reduction technique that provides a probabilistic representation of the data vectors in latent space.



Stratal slice at a level close to a horizon picked at 1,020 ms from (a) coherence volume computed using the energy ratio algorithm, (b) GTM1, (c) GTM2 and (d) cluster points from the cross-plot of GTM1 and GTM2 attributes within two polygons–one in red and the other in green–that are projected onto the coherence stratal slice, highlighting different channels. (Image courtesy of Arcis Seismic Solutions and the University of Oklahoma)

A team from Arcis Seismc Solutions and the University of Oklahoma applied GTM to a 3-D seismic volume from central Alberta, Canada, where the focus was on the Mannville channels that are filled with interbedded units of shale and sandstone at a depth of 1,150 m to 1,230 m (3,773 ft to 4,035 ft). On the 3-D seismic volume, these channels show up at a mean time of 1,000-plus ms or minus 50 ms. The team used the sweetness, gray-level co-occurrence matrices (GLCM) energy, GLCM entropy, GLCM homogeneity, peak frequency, peak magnitude, coherence and impedance attributes and derived GTM1 and GTM2 outputs. These attributes provide the cluster locations (projection of the mean posterior probability of the data vectors) along the two axes in the latent space to be used in the cross-plotting that follows.

Figure 1a shows a coherence stratal slice distinctively exhibiting the different channels. Figures 1b and 1c show the equivalent displays for GTM1 and GTM2 attributes. Breaking the 2-D latent space into two components allowed the team to use modern interactive cross-plotting tools. While GTM1 shows the definition of the edges very well for the channels, GTM2 exhibits the complete definition of the channels along with their fill in red and blue. In a narrow zone passing through the center of the channels, the GTM1 and GTM2 attributes were cross-plotted. Then, by assigning red and green polygons on two clusters (not shown), the team noticed how the enclosed points were projected back on the coherence displays shown in Figure 1d. The two clusters highlight the fill of the channels differently. Similar applications of GTM analysis to other datasets from Alberta, Canada, have shown encouraging results. ■

Wikithon 2014: Advancing the Future of the Science of Geophysics

SEG gathering seeks to connect those who are passionate about applied geophysics on a wiki forum.

By Isaac Farley, SEG

As the manager of the SEG Wiki, I have challenging and fulfilling work that fills my day. Luckily, I am surrounded by a great team within SEG Publications (most notably Andrew Geary, SEG Wiki editor) to help meet the goals of connecting those passionate about the science of applied geophysics, providing the necessary tools to make lasting contributions and advancing the mission of SEG. Beyond the core wiki team, our volunteers transform our work into an exceptional community asset. We're all lucky to have the support of John Stockwells, Karl Schleichers and Matt Halls, who invest so much into the resource.

If you have visited the wiki to read a biography (*wiki.seg.org/wiki/biographies*) of a former SEG award winner, you should thank John Stockwell. He's poured hundreds of hours of time and energy into these pages. If you have found a useful open dataset (*wiki.seg.org/wiki/open_data*) for your research, stop Karl Schleicher at the annual meeting in Denver and shake his hand. If you're enjoying the *The Leading Edge* geophysical tutorial series (*wiki.seg.org/wiki/geophysical_tutorials*) or need access to the newly launched, freely available book "Seismic Data Analysis" in the wiki (*wiki.seg.org/wiki/seismic_data_analysis*), let Matt Hall know—he's been instrumental in both and, like Stockwell and Schleicher, so much more at *wiki.seg.org*.

"Our community needs this resource," Hall said. "Now it's up to us to increase the momentum and build an open, collaborative resource that will benefit all geophysicists for decades to come."

I invite you to join us at the 2014 SEG Wikithon this week. The second annual wikithon will be held daily from 12 p.m. to 2 p.m. and from 5 p.m. to 6 p.m. Sunday, Oct. 26 to Wednesday, Oct. 29 in room 708 of the Colorado Convention Center. Visit *wiki.seg.org/wiki/wikithon_2014* for more information about the event.

What's a wikithon?

Perhaps I should take a step back. If my previous wiki-related conversations are any indication of what you are currently thinking, the two most popular questions among readers might very well be: Wait, what's a wiki? And: Did you say wikithon? Those are perfectly valid questions and the type that we welcome at *wiki@seg.org* or during the 2014 SEG Wikithon.

Ward Cunningham, the developer of the first wiki software, used the Hawaiian word "wiki," meaning "quick," to convey his vision for building the simplest form of a working database. Today, in the digital sense, a wiki refers to an online application that is maintained collaboratively by people through content modifications (oftentimes quick contributions) as an asset for a larger community. If you've yet to benefit from the wiki collaboration of Stockwell, Schleicher, Hall and others, I invite you to take a look. If we are missing entries or entire topics that you believe would be an asset to your community, there is the wikithon. There is the wiki. Join us!

The wikithon, purposefully designed as a participant-driven meeting, is a physical gathering of like-minded SEG members joining to advance individual

See WIKI continued on page 28 >>

#WIKITHON14

Goal
To connect those passionate about the science of applied geophysics and provide the necessary tools to make a difference

Who
All SEG members and participants at the annual meeting, regardless of wiki experience

Location
Room 708, Colorado Convention Center

Time
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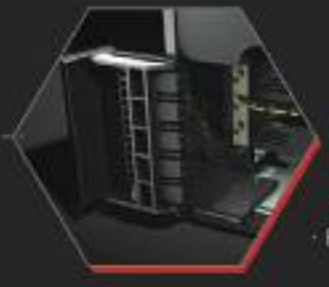

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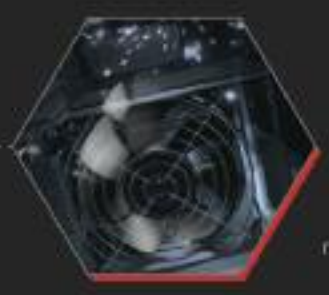

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Second-generation System Provides 'Maximum Value and Minimum Effort'

Rock physics information management system has been installed at two of the world's supermajors and is being deployed by other companies on a global basis.

By Paul O'Brien, Ikon Science, and Rachel Blackman, Fuse IM

In many settings, rock physics information tends to be stored either in an ad hoc fashion or in proprietary formats, making it complicated and inefficient to archive, query, retrieve or share with others. The Ikon MetaStore is a complete rock physics information management system designed to mitigate these inefficiencies.

Jointly developed by Ikon Science and FUSE IM, the system has a web-based front end and can run either on a company's intranet or as a fully enabled cloud system that can be accessed by any web-enabled device.

In its first year, the MetaStore already has been installed at two of the world's supermajors and is being deployed by other companies on a global basis.

The system is designed to store a wide variety of rock property data as well as many other data types, allowing users to investigate information from a rich variety of sources. The system also has the capability to handle complete projects and data from other applications, allowing companies and users to search and access all geospatially located data assets from a single online repository using a detailed map interface.

Martyn Millwood Hargrave, CEO of Ikon Science, said, "The current version provides safe storage for all RokDoc project data as well as data from lots of other sources and allows users to search both geographically and geologically for data in a flexible and customizable way, giving our customers a really new and innovative way of engaging with their data for maximum value and minimum effort."

The system allows administrators to enable configurable levels of access for selected groups or individual users for security and governance purposes. This provides users with an overview of available data within a specified geographical location, domain, asset or other variable parameters.

The Ikon MetaStore cross-plotter delivers understanding of regional trends. (Image courtesy of Ikon Science)

Data can be uploaded from documents (.pdf, .doc, .ppt, .xls) as well as vector and geomechanical data and can be associated with the correct assets, wells, fields and basins.

In the same way that many mass consumer sites operate, users have the ability to quickly identify and locate data based upon specific search criteria and then export those data as LAS or other format files for input into other systems like RokDoc or Schlumberger's Petrel using a "shopping basket" checkout approach.

The system provides automated workflows to generate reports and guided workflows to make it easy to both upload and retrieve data, with audit trails captured on previous versions of projects and the ability to retrieve old projects if necessary.

Standardized rock physics format

Rock properties are stored by lots of companies in various formats (Excel, PDF, CSV, XML and proprietary databases). There is a widespread desire to move toward a more standardized format, which would at least be partially accomplished by moving properties to a single database, and the Ikon MetaStore is well positioned to facilitate this process.

MetaStore 2.0 will introduce the ability to manage and load rock properties data from a wide variety of data sources, including company internal spreadsheets, documents, text files and databases. It also will include enhanced searching, visualization and analytical tools (e.g. matrix cross-plots, rose diagrams and well trajectory plots with markers) for working with data across projects in a global operating environment. It also will store the managed data in an industry standard corporate database based on the public petroleum data model (PPDM).

"PPDM is an important foundation component in XStreamline, our open, integrated E&P data management environment," said Jamie Cruise, FUSE IM director of products and technology and solution architect. "It has a strong community and is constructed largely from generic commodity infrastructure. We supplement PPDM with our tools to deliver the specialist upstream functionality that the industry needs to fulfill demands for vendor-neutral standardization."

See SYSTEM continued on page 30 >>

Multiattribute Seismic Analysis Platform Can Reduce Exploration Risk

Updates to a multiattribute seismic analysis platform include a new and larger geoscience workspace and enhanced well-loading performance.

Contributed by Geophysical Insights

Geophysical Insights has released the commercial availability of Paradise 2.0, the multiattribute seismic analysis platform, which will be announced at SEG 2014.

Some of the more significant changes in Paradise 2.0 include:

- New and larger geoscience workspace, providing space for future workflows;
- Easily customizable themes and backgrounds;
- Horizon ghosting—move a shape of the horizon in time or depth;
- Horizon stratal slices—create a slice between two horizons and move it in time or depth;
- 2-D color bar support for self-organizing maps (SOM) on horizons and grids;
- Principal component analysis (PCA) on attributes delimited by horizons;
- Running an SOM over a larger area than the PCA sample area;
- Saving arbitrary lines as 2-D lines; and
- Enhanced well-loading performance.

"The concept of analyzing multiple attributes simultaneously and thereby gaining greater insights from the seismic response is being widely received by the industry," said Tom Smith, president and CEO of Geophysical Insights. "Paradise 2.0 is a major advancement for the platform, positioning the technology to host many new geoscience workflows and capabilities we have planned for 2015. I invite interpreters to drop by our booth and find out why Paradise is unique in the application of advanced pattern recognition methods and how these methods can be used to reduce exploration risk and field development cost."

Geophysical Insights will have a series of presentations daily at booth 2163 by geoscientists and interpretation software specialists. Printed schedules of presentations are available at the booth. ■

Building Better, More Accurate Earth Reconstructions

Seismic inversion algorithm can be applied to post-stack and prestack data to recover rock properties.

By Dave McCann, ION Geophysical

When ION Geophysical embarked on the task of building a new inversion algorithm that would more accurately reconstruct the Earth, the company went back to first principles. This meant looking at the various depositional environments and the distributions of impedance contrasts. What was determined was that commercially available inversion algorithms assume a Gaussian distribution that does not adequately represent the broad range of impedance contrasts observed in geology. A different approach was needed. Based on that realization, the company developed its new inversion algorithm, PrecisION.

In every geologic province, obtaining an understanding of the rock properties is essential for successful operations. Unfortunately, there is a significant difference between what can be predicted from seismic data and what can be seen in a well. Built with insights derived from actual earth and physics data, PrecisION is a novel seismic inversion technique that can be applied to post-stack and prestack seismic data to recover rock properties.

When compared to commercial software, the new algorithm can provide superior earth reconstructions with greater accuracy and resolution. This is very helpful in clearly identifying layer boundaries necessary for prospect evaluation, drill planning and reservoir modeling. The inversion algorithm performs its analysis in the Eigen domain, a province in which usable information is easily separated from noise to produce very stable inversion results.

Within the Eigen domain, independent signals are naturally segmented into various Eigen vectors. Due to algorithmic parameterization, the Eigen vectors are inverted are for Vp, Vs and density. This approach is advantageous because the algorithm determines whether or not the offsets and signal-to-noise ratio will allow for the successful inversion of Vs and density. It also yields an uncertainty volume associated with each of the parameters that can be inverted. This uncertainty volume also can be used to quality-check the processing and ensure the highest possible quality. These advantages can be used to aid in the evaluation of prospect risk and decision-making.

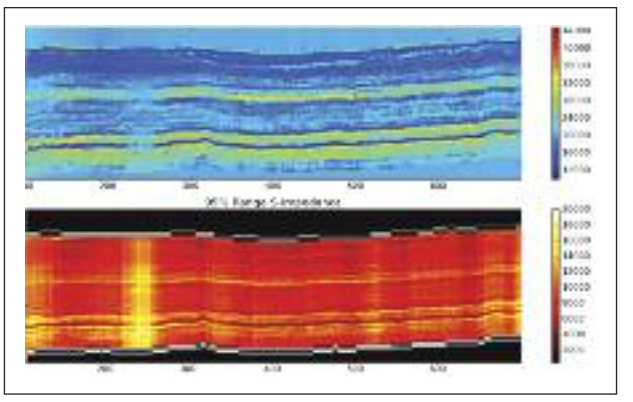


Figure 1. Inverted shear impedance (top) and its 95% confidence range (bottom) are shown. (Image courtesy of ION Geophysical)

Figure 1 shows the inverted shear impedance from one of ION's studies. The impedance values range from a low of 12,000 to a high of 44,000. Below the shear impedance image, a related image can be seen that identifies the uncertainty of the inversion. For

See EARTH continued on page 30 >>

Gathering Seismic Data Using Hybrid Radio Telemetry

A seismic recording system can deliver uninterrupted seismic crew productivity and effective data storage.

Contributed by Wireless Seismic Inc.

Modern seismic recording instruments fall into two camps: cabled and cablefree. Cabled systems have long been the default system of choice, recording data in real time and allowing operators to continuously gauge and control the condition of the spread.

A screenshot of the RT System 2 Central shows WRUs in green collecting data in real time. The blue WRUs designate lost radio connectivity while continuing to record and store data to flash memory. Production continues with no data loss. (Image courtesy of Wireless Seismic Inc.)

This choice comes at a price. The cables that enable instant data transmission are cumbersome to move around and need to be in perfect condition to function. The difficulties in transmitting high-bandwidth data through miles of cables and thousands of connectors can result in significant downtime while troubleshooters check the spread for problems and make repairs. This downtime reduces the working day and crew productivity.

See HYBRID continued on page 30 >>

Seismic Interpretation and Cognitive Cybernetics

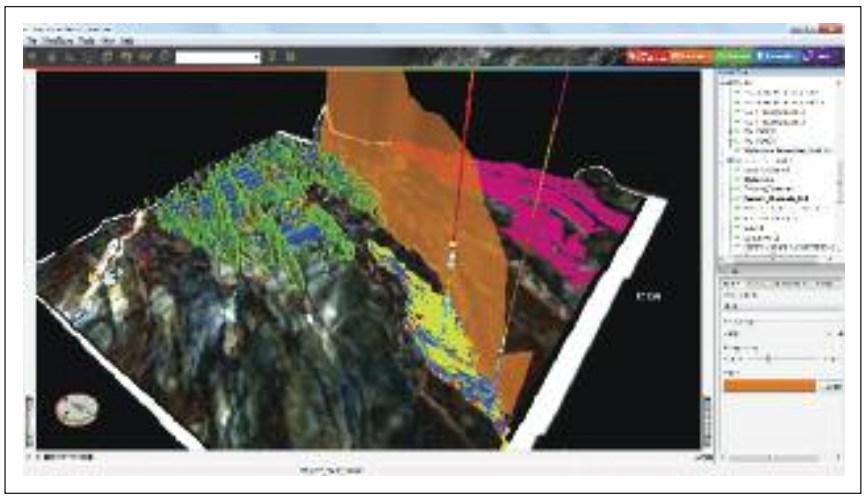
Software provides a geological expression approach to seismic interpretation.

Contributed by ffA

In 2014, the E&P industry is expected to spend about $10 billion on acquiring and processing seismic data, producing about 10 petabytes of new data. Interpreting such volumes of data is a huge challenge, particularly when correctly identifying and understanding subtle geological variations can have such a large impact on prospect risking, production optimization and strategies for maximizing recovery.

The usual approach to solving such challenges is automation. However, the essence of interpretation is to convert incomplete and often ambiguous data into an accurate understanding of a geological system and then be able to communicate that understanding so that it can be used effectively to guide a complex decision-making process. Automating this process fully is extremely difficult since understanding is a human quality that comes from assessing information in the wider context of *a priori* knowledge and past experience.

However, the process of gaining geological understanding from seismic data can be made much more efficient if the way that interpretation technology is designed is informed by the knowledge of human cognition.



GeoTeric from ffA uses an understanding of human cognition to deliver greater subsurface understanding and productivity gains in seismic interpretation. (Images courtesy of ffA)

In many respects, the human brain is still the most powerful information analysis tool, and up to 40% of prime cortical real estate is devoted to vision. Things that are taken for granted, such as the ability to instantly identify and classify objects—despite enormous differences in their morphology, size, color and orientation—are still almost impossible to mimic using computers. This is a critical factor in seismic interpretation, where there is a need to identify geological features whose real-world and seismic expressions can vary enormously.

Another important cognitive property is the ability to recognize an object through connecting disparate elements in a scene. However, the human visual system can be fooled, as the number of optical illusions testifies. In particular, people's perception of size, boundary positions and the spatial relationship between objects in different scenes is highly subjective. What this means is that seismic data need to be presented to interpreters in such a way that they can use their cognitive abilities to the full capacity.

For this reason, cognitive cybernetics is at the heart of the geological expression approach to seismic interpretation on which ffA's GeoTeric software is based.

Using a knowledge of cognitive cybernetics in designing interpretation software requires specific attention to be paid to interactivity. Cognitive cybernetics refers to the feedback loops that control how people update their understanding of a situation as they get more data. This works most efficiently if information is updated at the correct rate. For example, ideally, software needs to work at the same pace as the cognitive process. Two areas in which cognitive cybernetics has a major role to play are in optimizing attribute generation and object delineation.

There are three data-comparison techniques that can be used to make the most of visual cognitive abilities: juxtaposition, superposition and explicit encoding. These three techniques are at the heart of GeoTeric's example-driven approach to seismic noise filtering (noise expression) and fault imaging (fault expression).

In fault expression, juxtaposition is used to allow side-by-side comparison of multiple parameter choices, while superposition is used to allow the preferred fault image to be compared to the underlying seismic reflectivity data. Explicit encoding enables multiple pieces of fault-related information to be viewed simultaneously, providing a more complete picture of the imaged fault network. This example-driven or cognitive cybernetic approach makes it possible to get an optimal fault image in seconds rather than days or weeks.

Explicit encoding is perhaps the most powerful data-comparison technique available. As a result, RGB color blending is rapidly becoming a mainstream element of seismic interpretation workflows. However, color blending only partially leverages the advantages that can come from approaching seismic interpretation from a cognitive cybernetics perspective. For example, using techniques such as the adaptive geobodies and facies classification functionality (IFC+) in GeoTeric makes it possible to construct a 3-D geological model extremely fast, fully honoring the information in the seismic data.

Overall, building an understanding of cognitive cybernetics into the software development process can transform seismic interpretation and can provide the technology necessary to turn a mountain of data into a wealth of subsurface understanding. ■

New Crews, New Technology

A deal with CGG will enable Geokinetics to be the largest land seismic contractor in North America.

By Rhonda Duey, Executive Editor

There are deals, and then there are big deals. The recent announcement that Geokinetics has signed a binding agreement with CGG for the purchase of the latter's North American land seismic contract acquisition business is a very big deal indeed.

Geokinetics filed for Chapter 11 bankruptcy in March 2013, emerging from the process one month later. The move will increase its presence in Canada and the Lower 48 and give it a presence in Alaska again, which it moved out of in 2011. CGG will retain its multiclient land library, but its multiclient team will use Geokinetics crews exclusively for acquisition of these datasets for six years.

In return for the "contribution" of its North American land business, according to CGG, the French company will retain a 16% equity in Geokinetics.

The deal is considered to be a sweet one by both companies. It enables Geokinetics to double the number of marketed land crews in the region while retaining experienced CGG staff, and it is part of CGG's strategy to "refocus and reconfigure the worldwide perimeter directly operated by our land business line," according to CGG CEO Jean-Georges Malcor. "This combination will offer our North American customers an unprecedented opportunity to meet their expectations for performance, technology and flexibility. As for CGG, I am convinced [the land group], in its new configuration, will be able to better seize future opportunities and to contribute strongly to the group's continuing success."

According to David Crowley, Geokinetics president and CEO, this agreement might seem to be somewhat contrarian. "The Lower 48 states over the past three years have certainly shown a decline in land seismic crew activity," he said. "Canada has gone through a rough spell over the last two seasons, and although Alaska has shown a recent uptick, it's been reasonably flat over the past two or three years.

"We emerged from our Chapter 11 filing a year ago, we've looked at what markets we wanted to invest in and why, and the argument against North America is that it's not very consolidated; there's a lot of competition. But there's also ready access to capital, talent and technology in this key market."

Crowley added that Geokinetics was trailing some of its competitors in its investment in cableless equipment, which was affecting its ability to compete. "We thought that our knowledge base, the way we design the shoots, the way we manage contracts and our reputation in the industry are such that if we could get access to this newer technology and increase our scale and footprint, we would then compete at a much higher level."

The company set forth to acquire the new nodal systems and managed to access 60,000 from a local manufacturer. Then came the CGG opportunity, with an additional 35,000 nodes. It also brought CGG's brand and reputation.

"They differentiate through technology and operational excellence," Crowley said. "For me the driver was to get critical mass in something that's scalable in Canada, get further scale in the Lower 48 and then reenter the Alaskan market."

Due to CGG's joint venture with Fugro owning Seabed Geosolutions, a direct competitor with Geokinetics in shallow water, the company can't take any controlling interest in Geokinetics, although it does have the option to increase its stake to 19.5% at a later date. He likes the relatively low-risk aspect of the transaction as none of the markets are new to Geokinetics. "We won't be able to say in the future how surprised we were and that we didn't know the market was like this," he said. "We live in these markets."

David Crowley is president and CEO of Geokinetics.

And though the market is currently depressed, Crowley doesn't expect it to stay that way. "When equipment is flying off the shelves and you can't hire enough people to stay in business, that may not be the right time to be making a significant purchase," he said. "We have the viewpoint that there is a lot more upside for land seismic in North America than downside based on current activity levels."

Synergies abound. The two companies have very complementary client bases in North America, with CGG bringing the supermajors to the table and Geokinetics working with medium and large independents. They're also working with an independent consulting firm to integrate the teams. "We know they operate their crews differently than we do, so we're investing time and effort at the front end to bring in both sides and decide whether to adopt one method or the other or perhaps meld them into a hybrid scheme.

"We're also looking at all of the disciplines: how we manage assets and people, how we design our surveys, logistics and project management. It's not a white sheet of paper. We've all been in the business long enough."

So far the integration is going quite well, he added—in fact, the consultants have commented on the professionalism expressed by the employees. "I don't see the social issues that can really kill a deal," he said.

While Crowley doesn't believe in growing for the sake of growth, the added scale does have its advantages. Having more crews enables more flexibility. Being larger gives the company a better seat at the table when working with suppliers. And client feedback has been extremely positive.

"It is an opportunity for both teams to high-grade their operations," Crowley said. "And having recently met the CGG teams and knowing the Geokinetics teams I have every reason to believe that our combined future will be brighter." ■

Advanced Seismic Solutions for Reducing Exploration Costs

Seismic workflow technology can accelerate project turnaround while optimizing decision-making around geological and project constraints.

Contributed by Polarcus

Time is money, and in a fast-moving world the pressure to make quick and accurate decisions on key exploration milestones is greater than ever. Polarcus' RightFLOW can seamlessly integrate and accelerate every step of the seismic data acquisition and processing workflow. This includes everything from the initial survey design to the delivery of final data products, with the technology able to tailor the workflow for any given geologic and geophysical environment. The result will enable users to make more informed decisions about potential well commitments earlier in the exploration cycle.

This latest Polarcus offering is the result of a data processing collaboration between Polarcus and DownUnder GeoSolutions (DUG) that has taken a fresh look at the entire seismic workflow. The partnership combines the survey design and acquisition expertise at Polarcus with the processing and imaging expertise at DUG. As a result of that collaboration, Polarcus is deploying DUG's Insight software system onboard its fleet of high-end 3-D seismic vessels. The software system is powered by SGI-engineered hardware, which will enable the company to offer companies a processing flow designed in conjunction with each companies' own experts to address both the specific geological objectives and the critical time lines for the project.

At the core of any offering will be onboard quality-control (QC) flows to ensure that seismic data are recorded well within the tolerance specifications set by the user. Key modules have been specified by Polarcus' own field geophysicists and designed by DUG software engineers to ensure that a full suite of QC products are produced in real time on a line-by-line basis and offline during the course of acquisition to monitor surveywide seismic data quality and temporal and spatial continuity.

As the result of a data processing collaboration, DUG's Insight software system will be deployed onboard Polarcus' fleet of high-end 3-D seismic vessels. (Image courtesy of Polarcus)

A significant component of the onboard processing flow is the inclusion of DUG Broad, a deghosting technology that removes the variable amplitude and phase distortion caused by the interference of source and receiver side ghosts. Variations in receiver depth, source depth, obliquity, sea state and signal-to-noise ratio are all taken into account. This results in a broadening of the spectrum as frequencies suppressed by destructive interference have their amplitude (and phase) restored. This means that Polarcus can deliver high-quality broadband data as either prestack gathers and/or as part of the processing flow producing prestack-migrated volumes.

The hardware systems deployed on the Polarcus vessels will include up to 172 trillion floating-point operations per second of processing capacity designed to interface in real time with the seismic data recording system. The real-time software environment is interactive and intuitive, meaning no scripts are required for onboard QC or processing. The offline processing toolkit has been specifically designed to allow production of full-fold migrated 3-D volumes, incorporating a suite of multichannel noise attenuation techniques including shallow-water demultiple, 3-D surface related multiple elimination, highly interactive velocity picking and QC, Voronoi area regularization and prestack time migration.

The offering can itself be structured in different ways to suit individual user requirements including comprehensive onboard acquisition QC followed by full onshore processing; ultrafast advanced onboard 3-D processing followed by a more complex onshore processing sequence; or a combined offshore and onshore flow that passes an onboard processed intermediate dataset to a DUG onshore processing center for more sophisticated multichannel noise attenuation, velocity analysis, regularization, and time and/or depth imaging.

Polarcus believes that the "right" processing flow has to be considered as part of the overall 3-D survey design, acquisition and data delivery effort. The essence of the concept is that the right processing flow can be designed for any given geologic and geophysical environment to provide very high-level processed products in as short a turnaround time as possible.

Visit Polarcus at booth 2524 for more information. ■

Hydrocarbon Prospect Delineation and Seismic Imaging

Broadband processing and TTI migration can lead to improved subsalt imaging.

Contributed by TGS

One of the major challenges for subsalt imaging in the Gulf of Mexico is the poor signal-to-noise ratio and the lack of signal content in the lower frequencies. For deeper prospecting, the application of modern de-multiple and de-noise techniques is very important along with protecting and enhancing the seismic signal toward the lower frequency. This might contain subtle geologic information under the salt, which can better image the pay zone. Correct lateral and vertical positioning of steeply dipping salt flanks is important to define the closure near the complex salt overhang for which an accurate velocity model is needed. Below, a case study discusses where both of these challenges were addressed to improve the subsalt imaging with respect to the legacy processing.

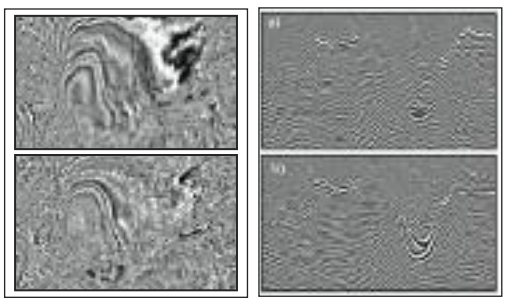


Figure 1. A depth slice compares the resolution of legacy vs. reprocessed data.
Figure 2. An inline comparison shows legacy VTI vs. reprocessed TTI data. (Images courtesy of TGS)

Seismic bandwidth enhancement

In addition to applying appropriate de-noise and de-multiple techniques, a TGS proprietary workflow known as Clari-Fi was applied to the seismic data to enhance its overall bandwidth. Clari-Fi is a multistep workflow that removes both the source and receiver ghosts, broadens the bandwidth of the data on both the low and high ends of the usable frequency spectrum and accounts for the Earth's Q compensation effects. For this reprocessing effort, Clari-Fi proved beneficial in improving the stability of offset picking during depth-imaging tomography, which eventually provides a better subsalt velocity mode and final migration image.

TTI modeling and migration

In this particular dataset, the sediment and salt structure are in the moderate to steep dip range. Correct vertical and spatial imaging of steep salt flanks and the sediment

See IMAGING continued on page 30 >>

Driving HD Evaluation from Imaging to Interpretation and Modeling

New technologies extend standard workflows and improve accuracy of production forecasts.

By Indy Chakrabarti, Paradigm

While seismic data acquisition today is done in high definition (HD), analysis of HD data has not traditionally kept pace. This is about to change. With its latest release, Paradigm seeks to provide users with a return on their HD seismic acquisition through the analysis of data in HD. Paradigm 14 HD capabilities span workflows across seismic data processing and imaging, velocity modeling, and seismic interpretation and include quantitative analysis and earth modeling.

Paradigm 14 includes advancements in HD processing and imaging that allow users to visualize the small features, such as fractures, thin beds and small faults, that are important in the exploitation of modern reservoirs. The release also includes quantitative seismic interpretation (QSI) technologies that enable qualification of amplitude prospects to more accurately identify sweets spots in the reservoir. Now, with the most recent iteration of the release, the company is moving toward HD earth modeling using the volume-based SKUA-GOCAD modeling suite. HD earth modeling facilitates high-fidelity delineation of the most relevant geological features of the subsurface and improves the accuracy of production forecasts with geologic models that are closer to reality. By honoring geology and seismic, users are able to better quantify uncertainty in their reservoir, resulting in lower-risk reservoir management decisions and more accurate production planning and forecasting.

For greater efficiency when working with large data volumes, the Paradigm SeisEarth interpretation and visualization solution suite enables roaming in rendering mode with volumes larger than GPU memory. Well planning is tightly coupled with SeisEarth, and platform positioning optimizations have been introduced. Within VoxelGeo, users can achieve more precise geobody detection results with extended support for greater than 8-bit seismic volumes. The interpretation solution also strengthens support for production and engineering data through new displays for casing, perforations and core property data, and gridding of time-based production data.

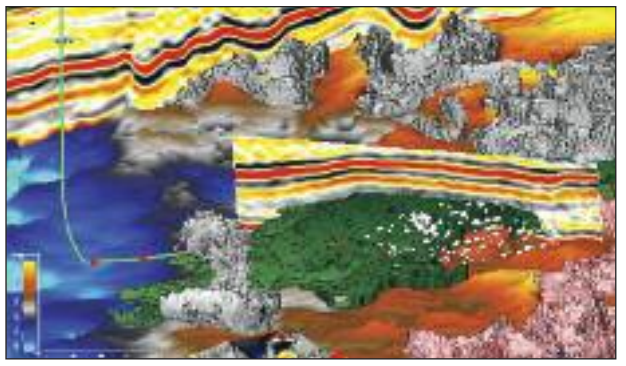
Major additions to QSI include synthetic workflows for all interpretation and seismic characterization applications. These are enhanced with improved layouts, new checkshot calibrations and new workflows when working with depth-migrated data. The release also provides support for full seismic inversion workflows on the Windows platform. Prestack gather preconditioning, stacking and inversion are available in both the SeisEarth 3D Canvas and the new 2D Canvas to support QSI workflows.

New technologies for modeling unconventional plays have been added to the volume-based Paradigm SKUA-GOCAD modeling suite. These include microseismic data analysis, stimulation path generation for better characterization of complex hydraulic fracture growth and improved assessment of stimulated rock volumes in low-permeability reservoirs.

The new SKUA structural uncertainty modeling module enables geoscientists to assess the impact of fault position and structural uncertainty on in-place hydrocarbon estimates and production forecasts to overcome uncertainties and improve forecasting. A restructured volumetric interpretation capability provides a full 3-D interpretation of all faults and stratigraphic horizons in the seismic volume to fast-track interpretation and interpretation validation in depositional space. Through the use of 3-D paleo-flattening, geoscientists can extract stratigraphic features from seismic data that were undetectable until now, resulting in enhanced geologic accuracy.

Geologic interpretation in the Paradigm StratEarth well log correlation solution has been enhanced with improved data communication with the Paradigm Epos infrastructure and data management system. Geologic interpretation also includes support for raster logs and zone track improvements, which can enhance ease of use and streamline workflows.

Automatic and with no configuration required, Paradigm 14 product installation is simpler, especially for single users. Numerous connectivity improvements support convenient coexistence with other geology and geophysics platforms. It is now easy to transfer interpretations between the Paradigm Epos infrastructure and Schlumberger's Petrel software via RESQML using a dedicated Petrel plug-in. Similarly, users can transfer data directly from Geolog to the Petrel software for improved multi-team collaboration on shared projects. These connectors augment pre-existing support to Halliburton OpenWorks.



An integrated display of data in the Barnett incorporates seismic data, horizons, geobodies, karsts, wells and microseimic data. (Image courtesy of Paradigm)

In other developments in this release, the Stratimagic seismic facies classification system is the first Paradigm application to plug in to the Paradigm Epic open and integrated platform. Additional workflow efficiencies have been achieved by enabling seismic classification results from Stratimagic to be visualized and used in the Paradigm SeisEarth and VoxelGeo interpretation systems.

Visit Paradigm at booth 623 for more information. ■

Achieving Performance Gains in Seismic Interpretation

New platforms could potentially enable demonstrable gains to accelerate and enhance interpretation processes.

By Christopher McCoy, Lenovo

When it comes to seismic interpretation, geophysicists understand that time and accuracy are everything. Any improvements in the ability to interpret seismic data can lead to faster project completion, which can make the difference in winning a contract bid or having additional interpretation time before project inception.

Stephen Dominguez, software developer and applications engineer at CGG, understands this. CGG's Insight Earth application, which the company added to its software portfolio in January 2014, is advanced 3-D visualization and interpretation software that greatly enhances seismic interpretation systems and provides geophysicists with a guided tool that can automate the fault extraction process, precisely define salt bodies, deliver fast depictions of paleo-depositional environments and enable the visualization of discrete fracture networks in unconventional plays. Running the application on the Lenovo ThinkStation D30 workstation using NVIDIA Quadro K5000 GPU technology, Dominguez and CGG were able to bring the most complicated structures into clear definition and deliver superior results for CGG's global users.

Dominguez is constantly in search of new technologies that can improve performance of the algorithms, processes and workflows in the Insight Earth application suite. With Lenovo's launch of its ThinkStation P Series workstations and NVIDIA's launch of its new Quadro K5200 GPU cards in August 2014, Dominguez realized that these new platforms could potentially enable demonstrable gains to accelerate and enhance interpretation processes. Lenovo's ThinkStation P900 is a dual-processor workstation built on the latest Intel Xeon processors and includes a highly expansive motherboard, a Gen 3 PCI bus and a specially enabled BIOS that can initialize multiple NVIDIA GPU accelerators. With this new hardware that includes the introduction of the NVIDIA Quadro K5200, Dominguez was determined to put these advanced offerings to the test and find out just how they would help geophysicists gain the performance edge they needed.

Working with Lenovo and NVIDIA engineers, Dominguez mapped out a comprehensive plan to determine performance improvements in the new hardware architecture across three key categories: CPU, GPU and file I/O (disk processing). This would illustrate the system's ability to render accurate visualizations using CGG's advanced Insight Earth seismic interpretation workflow. His plan included multiple configurations of Lenovo ThinkStation hardware and NVIDIA GPU technology because Dominguez felt it was critical to demonstrate both aspects in isolated performance benchmarks (Lenovo ThinkStation D30 workstation running Quadro K5000 cards vs. ThinkStation P Series running those same cards, and so on) as well as in comprehensive system performance gains to get a full picture of the capabilities of the new hardware to provide tangible advancements for seismic interpretation workflows.

"I wanted to see what this new hardware could really do," Dominguez said. "This required testing for virtually every scenario our customers might face to get an accurate picture of the realizable improvements in performance and efficiency."

With the plan in place, Dominguez set to work on running the benchmarks. Running the application on the Lenovo ThinkStation P900 with the NVIDIA Quadro K5200 GPU technology installed, Dominguez was able to benchmark an overall 15% performance improvement (geometric mean of GPU score, CPU score and the I/O score) in Insight Earth's ability to process and render seismic data, meaning that geophysicists using the solution would be able to complete projects more than 15% faster than was previously achievable. For example, projects estimated to take 100 days could now be completed in 85 days, leaving that extra time for additional interpretation, risk mitigation and any number of tasks that were unachievable under previous circumstances. Companies using the Insight Earth software could now gain a competitive edge in project bidding by offering 15% faster completion rates done with greater attention to characterizing the subsurface structure.

"Previous generation hardware was enough to get the job done, but it is now mainly utilitarian as geophysicists have pushed the capabilities to the limit," Dominguez said. ■

SEG Challenge Bowl Finals

The Challenge Bowl Finals are an international test of students' knowledge in the field of geosciences. Students who participated in regional competitions all over the world now come down to this final moment where only one team will take the ultimate grand prize!

Monday, Oct. 27, 3 p.m. to 6 p.m.
Hyatt Regency Denver, 3rd floor,
Centennial Ballroom E

Are You Managing Your 2-D seismic?

New tool set aims to simplify, facilitate data interpretation.

By Gary L. Jones, IHS

In the seismic interpretation world today, 3-D seismic data is the dominant tool for reservoir characterization and geologic modeling. However, there are vast areas where 3-D is too expensive to completely cover all of the study areas, so 2-D data fills that role. These seismic data are used to connect existing 3-D surveys, analyze basins, map out regional plays and help define geology on a much larger scale.

To achieve this coverage, the industry is actively acquiring new 2-D surveys and repurposing many older 2-D surveys to fill the void. This large accumulation of seismic data brings with it the challenges of managing and incorporating this data into existing and new projects. IHS Kingdom has long been a user of 2-D seismic data and recently introduced a new philosophy and tool set to help bring this data easily and accurately into the interpreter's world.

Past experience has shown that 2-D data can pose challenges for the user when reading and loading the data into the Kingdom project. It was clear that the process needed to be simplified but understood that the process also needed to handle the inherent complexity of 2-D data. The result is SeismicDirect, introduced in the Kingdom 2015 release.

SeismicDirect allows for batch loading of clean, well-documented data with common attributes while incorporating older data with complex formats and minimal information to guide the usage of the files. Often there is little or no information in the file's metadata to assist the interpreter or data loading technician in loading the data into a project. SeismicDirect, along with its new SEG-Y viewer and editor, SeismicExplore, assists in understanding, preparing and cleaning up the data so it can be served up to multiple projects for interpretation. Once the simple, straightforward preparation process is completed, the data can be attached to any number of projects. Required coordinate conversion and datum shifts are handled automatically with each project, saving countless hours and even days of effort.

During SEG IHS will be presenting the concepts behind SeismicDirect in several presentations. Come and see how you can manage your old and new 2-D data efficiently and effectively. ■

What's Lurking in the Basement?

Illuminating the basement can reveal key drivers of reservoir performance beyond the shale.

By Craig Beasley, NEOS GeoSolutions

As all geoscientists know, the basement is the foundation upon which all other sedimentary layers rest, hence its name. Given its role as the foundation of the geologic column, understanding the basement often can provide explorationists with critical insights into the relative productivity, prospectivity and economic potential of shallower horizons deposited above it, including in the reservoir zone(s) of interest.

Geologic activity in the basement, including fault reactivation, intrusion emplacement and control on hydrothermal fluid migration, impacts heat flow in the overlying sedimentary section and ultimately affects thermal maturity in the hydrocarbon "kitchens." Oil is the first hydrocarbon type to be liberated from kerogen as increasing levels of heat and pressure are applied in the kitchen; oil generation is followed by the subsequent liberation of wet-gas/condensate, dry gas and, when "overcooked," CO_2 and graphite. Knowing which hydrocarbon type one will be dealing with is an important factor in exploration decisions and in project economics, especially in shale plays.

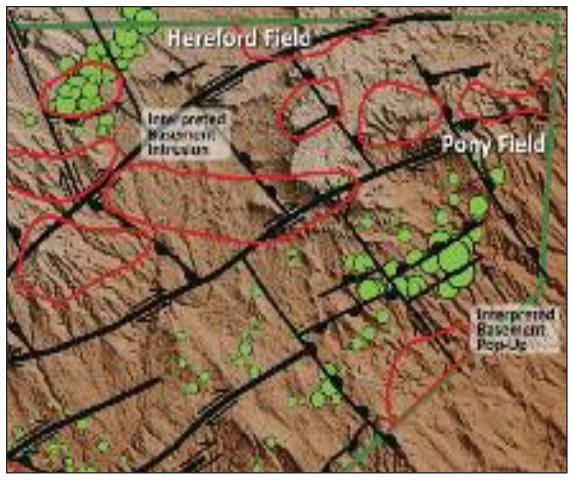


Figure 1. In the D-J Basin, Niobrara oil and gas production is related to basement features. (Images courtesy of NEOS GeoSolutions)

The conventional wisdom that has prevailed in the petroleum industry for the last 50 years is that thermal maturity varies in a straightforward linear manner with burial depth. The shale boom of the last decade has dramatically changed that conventional wisdom, as the most astute explorers now realize that variations in basement topography, fault networks and composition can all cause localized distortions in the burial depth vs. thermal maturity relationship.

For example, a senior technical adviser for one of the largest pressure pumping companies in the world said at a Denver Rocky Mountain Association of Geologists luncheon that one of the key elements in identifying sweet spots in the Niobrara Shale play of the Denver-Julesburg (D-J) Basin was, "identifying the location of basement faults that have been reactivated and that, over the course of geologic time, have acted as conduits for hydrothermal fluids that affected the thermal maturity of the Niobrara."

NEOS GeoSolutions recently delivered the results from a 7,770-sq-km (3,000-sq-mile) multiphysics survey in the D-J Basin and, among other things, confirmed that this technical adviser was right. As Figure 1 shows, basement-related features—including intrusive complexes and fault-driven horst structures—appear to correspond to two of the D-J Basin's more prolific fields, Hereford and Pony. This same multi-client survey, which is available for license to other E&P operators, identified at least seven similar basement-related features that, at present, do not have significant exploitation or production operations underway.

On another project in the Appalachian Basin covering the Marcellus and Utica shales in Pennsylvania, a chief geophysicist at one of NEOS's clients speculated that changes in basement composition were altering the thermal profile in an area undergoing development drilling. These changes were responsible for differences in production rates and especially the Btu content (i.e., liquids vs. gas) of the flowstreams obtained from newly drilled wells.

NEOS undertook an analysis of several multiphysics datasets—in particular gravity, magnetics and electromagnetics—and applied workflows that included simultaneous joint inversions and Euler deconvolutions. The results, depicted in Figure 2, proved the hypothesis of this chief geophysicist: Compositional changes in the basement are better at predicting the flow rates and Btu content of newly drilled wells compared to more widely acknowledged geological and geophysical factors such as structural setting (e.g., burial depth or shale thickness) or acoustic attributes (e.g., brittleness or fracture density).

This isn't to say that structural or acoustic insights aren't valuable; they absolutely are. But it does imply that a multiphysics approach—in which a variety of geophysical measurements are analyzed at depths of investigation ranging from the basement to the near-surface—might provide a more constrained subsurface model and valuable set of related interpretive products than an approach that relies on only one or two geophysical measurements or properties.

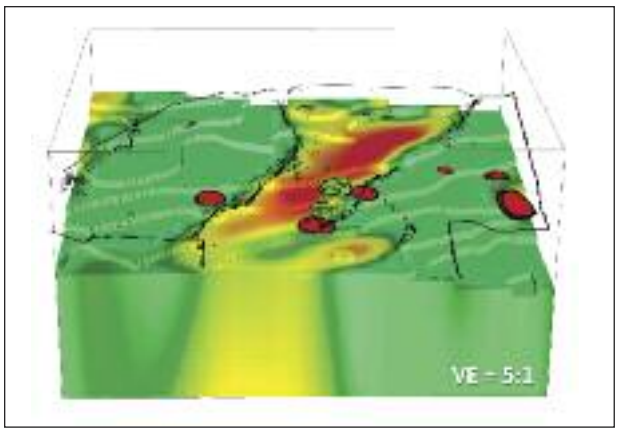


Figure 2. Marcellus oil (green spots) and gas (red spots) production draped on a basement model is shown. Correlations are noted from the basement to the reservoir.

These multiphysics projects and others that are being undertaken in regions extending from Argentina's Neuquén Basin to onshore Lebanon are helping explorationists better understand the role that basement faulting might play in influencing sweet spot locations in unconventional shale reservoirs as well as the impact basement composition variations have on the relative liquids vs. gas content of the flowstreams from newly drilled wells. ■

Creating Exploration Success in the GoM

Integrating 3-D CSEM data with seismic data can increase discovery rates and lower exploration costs.

Contributed by EMGS

With well data often scarce, many Gulf of Mexico (GoM) operators today rely on the structural images and elastic properties derived from seismic when evaluating the probability of success and estimating reserves in their prospective fields.

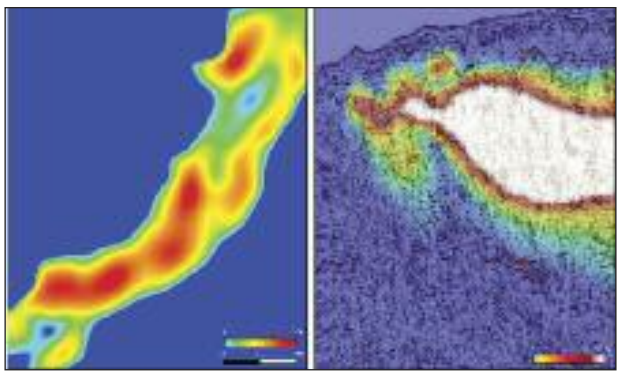
Yet, while this information is crucial, gaps still remain in the geological model, particularly in regard to fluid content information and hydrocarbon volumes. A complete picture of the subsurface only can be achieved through combining different complementary data sources.

At SEG this year, EMGS will illustrate how 3-D controlled-source electromagnetic (CSEM) data, when integrated with seismic data, can lower exploration costs and increase discovery rates in the U.S. and Mexican GoM.

3-D CSEM surveys map resistive bodies in the subsurface where, the larger the resistive body, the greater the response. Integrating electromagnetic (EM) data into the exploration workflow allows for a better classification of prospects in an area by downgrading or upgrading the probability of finding hydrocarbons and improving the evaluation of the size of the accumulation.

Mexican operator Pemex, for example, has found that the integration of 3-D CSEM data into its exploration workflow has significantly reduced uncertainties in the evaluation of prospects in the Perdido Fold Belt and other areas in the GoM.

Since 2010, EMGS has acquired more than 16,000 sq km (6,178 sq miles) of 3-D CSEM data for Pemex over more than 40 identified prospects. The results—proven by the drillbit—were revealing and highlighted how the integration of 3-D CSEM data with 3-D seismic data can enhance subsurface understanding, resolve interpretation ambiguity and reinforce independent observations.



A Wilcox resistivity map (left) and an improved salt body interpretation (right) show data from the Daybreak survey in Alaminos Canyon in the GoM. (Data courtesy of TGS)

In one case, Pemex identified a prospect located about 700 m (2,297 ft) below the mud line where the top of the reservoir interval presented a seismic bright spot with two associated flat spots interpreted as gas-oil and oil-water contacts. Seismic amplitude analysis indicated the presence of a likely hydrocarbon-bearing reservoir with the main uncertainty being the hydrocarbon saturation as it was possible that low gas saturation was producing the bright amplitudes.

In the 3-D CSEM inversion, an anomaly was seen at the top of the structure that was consistent with the uppermost part of the seismic anomaly and the first flat spot in the structure. Together, the integrated interpretation of seismic and CSEM data was an accumulation in a quality reservoir with high gas saturation down to the first flat spot and low saturation (fizz gas) farther downdip. This interpretation was later confirmed by a productive gas and dry appraisal well.

In another example from the same survey area, wide-azimuth 3-D CSEM data were acquired over the prospect, and no vertical resistivity anomalies corresponded to the proposed target. Instead, a low-resistivity zone over the crest of the structure was present with the zone suggesting the presence of high-salinity brine around the faulting. This resulted in an increase in seal risk and a decreased probability of success.

Adding 3-D CSEM data to seismic data is a highly effective exploration strategy that is proven by these and several other cases in the GoM and will be an important tool preparing for Round 1 in Mexico.

Looking northward, EMGS completed a 1,850-sq-km (714-sq-mile) CSEM survey in the Alaminos Canyon area of the U.S. GoM earlier this year. The integrated interpretation of CSEM and seismic data was a valuable tool for companies participating in lease sale 238 and will continue to play a key role in future leasing decisions and well placements.

In addition, the ability of 3-D EM data to map salt bodies and provide improved velocity models for more robust seismic imaging without scatter and refraction issues is of particular benefit in this basin.

The exploration landscape is changing. To find out how EMGS and CSEM data can help reduce interpretation uncertainty, lower exploration costs and increase discovery rates, visit EMGS at booth 448. ■

Understanding Seismic Energy Release and Implications for Stimulated Surface Area

Multi-array microseismic data reveal that up to 83% of seismic energy released during hydraulic fracturing might be caused by a handful of larger magnitude events.

Contributed by ESG Solutions

In hydraulic fracturing operations, well production success depends not only on effective well placement and treatment design but also on the inherent characteristics of the reservoir, including geology, local and regional stress conditions, and the presence of natural fractures. Maximizing production volume requires the successful generation of complex fracture networks with optimal stimulated surface area, all with good connection pathways back to the well. It is therefore useful to accurately characterize natural fracture systems and understand generated fracture behavior within the formation to optimize operations.

Microseismic, or passive seismic, monitoring has emerged as a powerful fracture characterization and production optimization tool for hydraulic fracturing operations. Hydraulic fracturing in naturally fractured reservoirs is known to generate seismicity due to the interaction of injected fluids with the pre-existing fracture network. Typically, the observed moment magnitudes for such operations are small, usually with magnitudes less than zero. Microseismic methods commonly provide information on relative stimulation volumes and overall fracture dimensions; however, many advances in acquisition and data processing have provided new ways to visualize and understand fracture development.

The reliability of typical microseismic geophones (15 Hz) in accurately detecting larger magnitude seismicity recently has been questioned, prompting the addition of lower-frequency geophones to sensor networks (known as a hybrid configuration) to accurately characterize events over a wider-magnitude band. The result is a new understanding of the effect of larger magnitude seismicity on reservoir deformation and fracture network development.

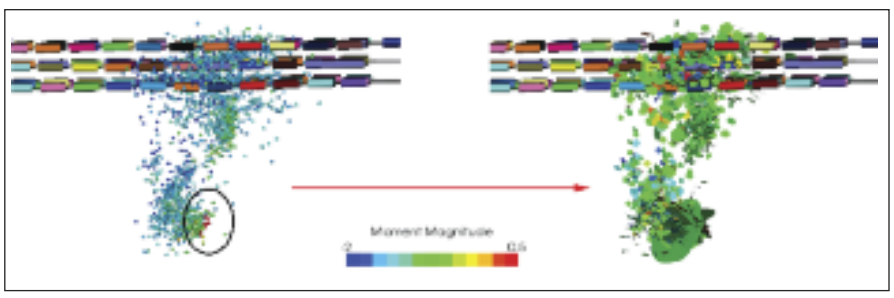


Figure 1. Microseismic events colored by moment magnitude are shown on the left. At right, a microseismic-derived discrete fracture network was obtained using data from a hybrid sensor network. Larger magnitude seismic events represent considerably larger fracture surface areas and result in more energy release and reservoir deformation compared to typical microseismic events. (Image courtesy of ESG Solutions)

Figure 1 illustrates the occurrence of seismic events between magnitude 0.0 and 0.5 (left image, red dots) and depicts the resulting discrete fracture network generated from the seismic data. Fracture planes associated with the large-scale seismicity are significantly larger in diameter (right image, large green discs) compared to those associated with typical small-scale microseismicity. It is clear that larger seismicity considerably affects the reservoir in terms of energy release and deformation, often producing failure planes hundreds of feet in diameter. Accurate characterization of large events therefore has implications for understanding stimulated surface areas and potential fluid connection pathways.

Recently, ESG has had multiple opportunities to supplement traditional downhole microseismic recording with sparse six- or eight-station near-surface networks consisting of low-frequency sensors during hydraulic fracture stimulations. In one example in a North American unconventional shale play, a total of 4,500 events were recorded on the downhole array situated close to the reservoir, ranging in magnitude from M-1 to M-2.6. The near-surface network recorded a total of 28 events ranging from M-0.4 to M1.4. These events also were recorded on the downhole array; however, the downhole signals were saturated and underestimated event magnitude by at least one order of magnitude.

In the same example, an assessment of seismic energy release showed that larger magnitude events detected with the near-surface network accounted for a full 83% of the total seismic energy released during the hydraulic fracture stimulations. Additionally, these events accounted for another 11,870 sq m (127,768 sq ft) of activated fracture surface area, about 10,295 sq m (110,814 sq ft) more than would have been estimated from the downhole array alone. Overall, the 28 events as derived from the near-surface network accounted for less than 1% of all the recorded events but added an additional 4% to the total liberated surface area when combined with the surface area generated by the 4,500 events recorded downhole.

Evaluation of reservoir stimulation over a wider-magnitude range using the hybrid configuration allows for a more accurate assessment of reservoir deformation and fracturing processes associated with stimulations than would have been achieved using traditional microseismic techniques alone.

Visit ESG Solutions at booth 2348 for more information. ■

Unlocking the Value of Assets Through Model-Driven Interpretation

New workflow relies on uncertainty management for reservoir decision-making and can reduce lead times.

Contributed by Emerson Process Management

For all the benefits reservoir modeling has brought over the last few years, limitations still remain as to how data are captured and analyzed, the link between the seismic data and the model, and the difficulties in quantifying uncertainties and improving reservoir management decision-making.

Too often, there is a focus on just a single reservoir model despite data supporting different interpretations. There also can be an ambiguity in the seismic data—especially if only a portion of the earth's response is captured within a seismic image or where there are bandwidth limitations.

Furthermore, the time-consuming nature of the seismic interpretation and model-building process (especially with large 2-D and 3-D seismic datasets) and long lead times in taking the model to simulation can result in delays to reservoir volume estimates and ultimately to decisions relating to bid valuations, production estimates and operational plans.

At SEG's Annual Meeting, Emerson Process Management will be demonstrating the potential of reservoir modeling through its Roxar reservoir management software solution and new Model-Driven Interpretation (MDI) workflow.

The company's vision is simple: an integrated, flexible seismic-to-simulation workflow where the modeler can move back and forth between domains (seismic interpretation and structural modeling, for example), receive instant feedback on measurements, and capture uncertainty and increase confidence in reservoir management decisions from the outset.

In this way, operators can make informed decisions across the prospect life cycle on crucial areas such as where to drill, what production strategies to adopt and how to maximize oil and gas recovery.

MDI, developed within Emerson's reservoir modeling software Roxar RMS, enables modelers to not only create the geological model while conducting seismic interpretation but, for the first time, to also capture uncertainty during the interpretation process.

MDI quantifies geologic risk early and allows geoscientists to guide and update the model directly from the seismic and other data. Rather than creating one model with thousands of individual measurements, the new workflow enables interpreters to create thousands of models by estimating uncertainty in their measurements.

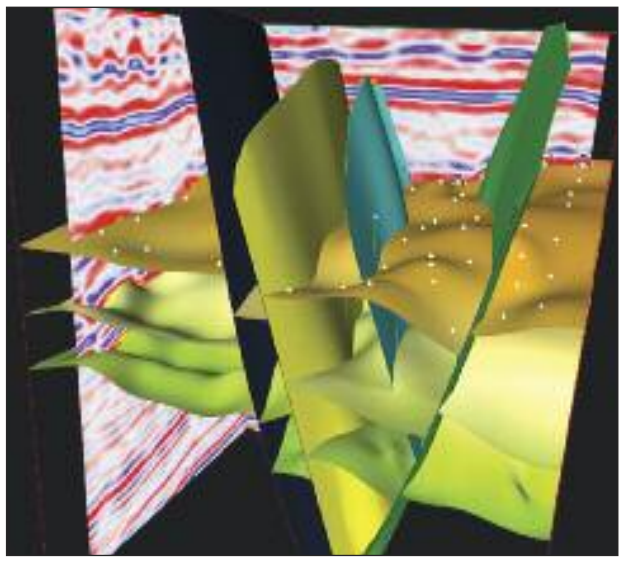
Interpreters can use MDI to calculate probabilities for different outcomes with uncertainty information collected and paired with geologic features to accurately represent the geologic structure. Interpreters also can see what parts of the model are most uncertain and where more detailed analysis is needed.

So what does the new workflow mean to reservoir modeling? The benefits can be seen in the quality of the models and the speeds in which they are generated.

First, MDI can generate a highly accurate depiction of the geometry and properties within the reservoir. Geoscientists can guide and update a 3-D geologically consistent structural model directly from the seismic and other data, resulting in a more complete representation of the reservoir.

A Middle Eastern operator is using MDI to calculate gross rock volume (GRV) uncertainty on a high-profile offshore field. MDI is creating P10, P50 and P90 GRV values that provide valuable input and reduce risk in future field appraisal and development plans.

It's through MDI that early estimates of reservoir volumes can be generated to support future commercial decisions. Operators also can make predictions of horizon or fault positions and integrate these with LWD data and precision steering to reduce drilling risk.



MDI enables users to not only create the geological model while conducting seismic interpretation but also to capture uncertainty while interpreting. (Image courtesy of Emerson Process Management)

Secondly, the new workflow can dramatically accelerate the decision-making life cycle. MDI can generate a more complete representation of the data in less time with models updated in real time and often built on relatively sparse data, with the flexible but integrated nature of the process ensuring increased productivity throughout asset teams.

Leaner asset teams, shorter decision-making time scales and domain experts are able to quickly integrate and share knowledge across the prospect life cycle.

Emerson's new workflow places uncertainty management at the heart of reservoir decision-making and can reduce lead times.

Visit Emerson Process Management at booth 759 for more information. ■

Mile High City Offers Feasting and Fun

Discover all that Denver has to offer from its finest restaurants to its best attractions.

By Ariana Benavidez, Associate Editor, *E&P*

Denver is famous for more than its Mile High nickname. It's also known for its breathtaking scenic beauty, spectacular dining, abundant number of attractions and the 225-km-long (140-mile-long) Rocky Mountains panorama.

Amid the variety of attractions the city offers is the Denver Museum of Nature and Science, open daily from 9 a.m. to 5 p.m. at 2001 Colorado Blvd. Currently, the museum is showcasing its "Whales: Giants of the Deep" exhibit, which features more than 20 skulls and skeletons, including that of a 18-m-long (58-ft-long) sperm whale. Also on display is a life-size replica of a blue whale heart that is equivalent to the size of a car. Admission is $13. For more information, visit *dmns.org*.

However, if art better suits your fancy, be sure to check out the "Matisse and Friends" exhibit at the Denver Art Museum. The paintings on display are from the National Gallery of Art in Washington, D.C., and featured artists include André Derain, Albert Marquet, Maurice de Vlaminck, Raoul Dufy, Georges Braque and Kees Van Dongen, in addition to Henri Matisse. The museum hours are 10 a.m. to 5 p.m. Tuesday through Thursday and 10 a.m. to 8 p.m. on Friday, and it is located at 100 W. 14th Ave. Pkwy. Admission is $13. For more information, visit *denverartmuseum.org*.

Perhaps after a full day of SEG events, sitting down to a satisfying gourmet meal sounds like the more relaxing option. In that case, check out one of Denver's top spots for dining: Guard and Grace. This fine-dining steakhouse located at 1801 California St. offers more than just succulent beef. Entrees include Skuna Bay salmon, Hawaiian tuna, Rocky Mountain trout, prime rib, New York strip, filet mignon and rack of lamb, among many other options. The restaurant is open from 11 a.m. to 10 p.m. Monday through Thursday, 11 a.m. to 11 p.m. on Friday and 5 p.m. to 11 p.m. on Saturday. See the full lunch and dinner menus at *guardandgrace.com*.

The 13th step on the west side of the Colorado State Capitol building is exactly 1,609 m (5,280 ft) above sea level–one mile high. (Image courtesy of Dave Falconer and Visit Denver)

The Denver Art Museum is housing a 'Matisse and Friends' display on loan from the National Gallery of Art. (Image courtesy of Steve Crecelius and Visit Denver)

If you'd like something with a more casual setting, try Old Major on 3316 Tejon St. and see why USA Today named this place one of the 10 best dining hot spots in Denver. The entrees include a 21-day dry-aged Colorado rib eye, Block Island swordfish, lobster, fish and chips, roasted chicken, smoked country sausage and homemade pasta with clams. To make a reservation or to view the full menu, go to *oldmajordenver.com*.

Want to squeeze in some shopping before leaving the Mile High City? One unique shopping experience can be had at the Rockmount Ranch Wear flagship store and museum. Denver's very own fashion pioneer Papa Jack Weil invented the western snap-button shirt and opened his shop in 1946. He sold his shirts to everyone from presidents to rock stars, including Eric Clapton and Bruce Springsteen. Weil worked daily until he was 107 years old, passing away in 2008. Visit Rockmount for your very own western-style shirt souvenir at 1626 Wazee St. in downtown Denver.

Afterward, stroll on over to metro Denver's No. 1 tourist attraction: 16th Street Mall. The 16-block mall is packed with restaurants, cafés, public art and vast shopping options. From bookstores and charming gift shops to brand name stores, there is something for everyone. After a long day on the SEG show floor, shoppers might welcome hopping on one of the free shuttles that run the length of the mall. Parking can be expensive and hard to find due to the popularity of this attraction, so visit *16thstreetmalldenver.com* to make online parking reservations or to retrieve a 16th Street map or shopping map. ■

>> PATHWAY continued from page 3

intrasalt velocity variations. Inaccuracies in topsalt interpretation result in errors in positioning base salt, which in turn degrade the subsalt image. A rugose topsalt interface demands finer spatial sampling than is achievable using conventional acquisition techniques—deficiencies that are naturally addressed by the IsoMetrix system.

Finally, at the subsalt level, reflected waves returning to the surface from deep formations might be expected to be near vertical. This might question the need to measure horizontal pressure gradients. However, modeling studies demonstrate that even areas of relatively simple subsurface structure and moderate salt complexity can create strong distortions of the wavefield. Fine-scale isometric sampling means that such distortions are measured without spatial aliasing, ensure correct handling through the data-conditioning stages and can even benefit the subsalt image directly.

In addition to adequate spatial sampling, it is well known that azimuth diversity and long offsets are important elements in ensuring good illumination of subsalt plays. Various acquisition designs have been used to address this, such as wide-azimuth multivessel configurations. Designs based on the Coil Shooting single-vessel full-azimuth acquisition technique also are prevalent. These provide an efficient method of recording full-azimuth data and, when combined with multiple vessels, also can deliver long offsets. Field trials performed this summer demonstrate the compatibility of IsoMetrix technology with a wide range of acquisition techniques to address offset and azimuth diversity.

WesternGeco is featuring a daily booth theater presentation highlighting the benefits of IsoMetrix technology for successfully navigating the pathway to subsalt plays. Visit Schlumberger at booth 1319 for more information. ■

>> EUR continued from page 12

"Investing in the best downhole acquisition geometry and leveraging SIGMA^3 innovations in 3-D anisotropic velocity modeling and enhanced signal processing demonstrates high-confidence event locations delivered in the context of the earth model," Machnizh said. "Doing things right costs money, but it is far more expensive to waste money on costly nonproductive frack stages by not implementing a comprehensive integrated science that can be validated in real time." In partnership with FracGeo, the company is doing geomechanical modeling that can predict microseismicity before the microseismic data are acquired and thus can help to better design the microseismic acquisition and completions engineering to improve success.

When it comes to engineering services integration, determining the best way to complete and frack is about production response. Operators maximize return on investment by drilling the optimal number of wells and leveraging their trajectories to make the most of reservoir properties. SIGMA^3 engineers have performed more than 35,000 stages, including onsite stimulation programs on major producing basins worldwide. Optimized fracturing campaigns lead to fewer costly stages and better recovery.

Manage reservoir variability through integration

Discrete solutions do not address the value of integrated reservoir characterization workflows that enable real-time frack data and microseismic events to be processed, interpreted and visualized in tandem with the earth models, well geometries and geomechanical properties. This is the only way to manage variability and extract more from shale reservoirs.

SIGMA^3 is showcasing Integrated GeoEngineering workflows, including seismically driven reservoir characterization, subsurface microseismic, completions and onsite frack engineering, at booth 308. ■

>> WIKI continued from page 16

articles and, in so doing, the shared community asset. As always, the wikithon is open to all annual meeting attendees, regardless of wiki experience. Do you excel at correcting grammar? Are you interested in connecting SEG entries with one another? Is the wiki missing photographs (hint: yes)? If you are an experienced wiki champion, we need you, too.

For several of the wikithon sessions, we will be joined by staff and researchers representing Geoscientists Without Borders (GWB). If you are interested in learning more about their projects or assisting with launching GWB-specific program and project wiki pages, we'll see you in Denver. We have a good start (*wiki.seg.org/wiki/geoscientists_without_borders*) but always welcome more help.

If you are reading this and thinking, "Hey, I know what the wiki really needs," stop by the wikithon during the annual meeting and introduce yourself (or send me an email). I look forward to assisting you in crafting contributions that advance the science of applied geophysics. If you would like to take the discussion to the wiki itself, click on the discussion tab on *wiki.seg.org/wiki/wikithon_2014*. Within the tab, we appreciate any questions or thoughts you might have about all things wiki.

Seismic data analysis in the SEG Wiki

Oz Yilmaz's renowned book "Seismic Data Analysis" is now fully available as an open-access book in the SEG Wiki. With its launch, SEG's two best-selling books, "Seismic Data Analysis" and "Sheriff's Encyclopedia Dictionary of Applied Geophysics," are freely available at *wiki.seg.org*. I invite you to evolve, expand and transform "Seismic Data Analysis" to reflect the latest in science and technology via wiki contributions. Join us at the 2014 wikithon in Denver to discuss the new addition of "Seismic Data Analysis" and the exciting plans we have for the year ahead. ■

Direct Hydrocarbon Indicators from Calibrated AVO Stacks

AVO techniques will be integral to the Sergipe Basin exploration cycle.

Contributed by Spectrum

In clastic depositional settings such as the Sergipe Basin, amplitude vs. offset (AVO) techniques are important direct hydrocarbon identification tools for E&P and development teams. Brazil's National Petroleum Agency, ANP, recently announced that the Sergipe Basin will likely be included in Round 13, which suggests there will be considerable opportunity for additional prospecting in this basin. AVO analysis will prove to be important as the exploration cycle expands and progresses to development in this basin.

The Sergipe Basin is a relatively mature hydrocarbon province on the northeast coast of Brazil comprising 44,370 sq km (17,131 sq miles) both onshore and offshore. Petrobras has made several offshore discoveries since 2010, including the 2010 Barra well (1-SES-158) and the subsequent Barra 1 appraisal well (3-SES-165). The wells targeted oil- and gas-charged Maastrichtian sandstones that display readily identifiable AVO anomalies on 2-D seismic profiles.

Seismic data

In 2013, Spectrum reprocessed 8,200 km (5,095 miles) of seismic data using modern prestack time and depth imaging algorithms. The seismic data were acquired with an 8-km (5-mile) streamer in 1999, providing a wide range of reflection angles for quantitative interpretation. The reprocessing illustrates clear images of stratigraphic features within the prospective section, and numerous potential AVO anomalies are evident. Two profiles near the 1-SES-158 Barra discovery well were selected, and the digital logs from this well were incorporated into the analysis.

Discovery well

The Barra discovery well was drilled in 2010 in 2,341 m (7,680 ft) of water, reaching a depth of 6,510 m (21,358 ft). Porosity and permeability conditions in the reservoir are excellent at depths of 4,650 m to 4,750 m (15,256 ft to 15,584 ft), where drillstem tests indicate the presence of commercial quantities of gas and condensate. The sandstones encountered in the Barra well are about 80 m (262 ft) thick, and well tests indicate a high-porosity gas-charged reservoir. The accompanying figure shows a strike line near the Barra 1 well with the AVO anomaly highlighted by brackets.

AVO attributes

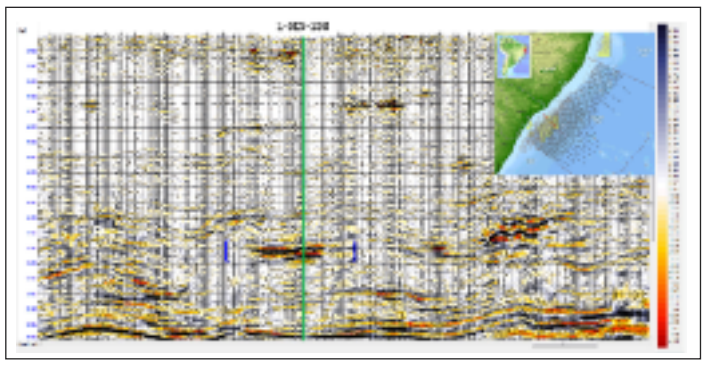
For mid- to high-porosity sandstones encased in shales or mudstones, gas- and light oil-saturated sandstones can be identified using AVO techniques with high-quality long-offset seismic data.

Available well data show that the sandstone in the Barra well has 25% to 33% porosity, with velocities that are equivalent to or slightly faster than shale velocities and sand densities that are less than the shale densities. AVO modeling indicates a Class 2 to Class 3 AVO response, depending on the thickness of the sand modeled. Computed AVO attributes indicate that enhanced gradient (FNxF) and scaled Poisson's ratio change (SPR) attributes should be diagnostic for sands of sufficient thickness.

SPR change is the weighted sum of the AVO intercept and gradient, where the weighting is determined by the background velocity ratio of the geology. The SPR attribute is a fluid factor AVO attribute that should illuminate hydrocarbon-saturated reservoirs and marginalize wet- or brine-saturated reservoirs. The FNxF attribute is computed by calculating the difference between the far-angle stack and the near-angle stack and multiplying the difference by the far-angle stack. Angle ranges are used in place of offset ranges so they are optimized for the geology and objective depth.

To determine whether AVO attribute stacks can identify potential hydrocarbon reservoirs, 2-D seismic profiles that tie the Barra discovery well were analyzed. For each of these profiles an SPR and FNxF stack were computed, both of which show visible anomalies for the high porosity gas-saturated sands found in the Barra discovery well.

Based on the available well data and the 2-D profiles covering this basin, AVO anomalies from SPR and FNxF attributes can identify hydrocarbon charge in sandstone reservoirs for thick sands with 18% or higher porosity. This screening process will not necessarily eliminate other geologies with lower velocity ratios; however, it will highlight prospective anomalies and cull out leads and prospects that do not exhibit AVO signatures associated with hydrocarbons. ■



An AVO-conditioned stack using 4 degrees to 32 degrees after noise attenuation and residual moveout corrections is shown. The multilegged seismic amplitude anomaly is bracketed in blue. The projected well path is shown by the green line. (Image courtesy of Spectrum)

2014 SEG SHPCPHPC Focus Theater Schedule

Day	Time Slot	Presenting Company	Presentation Title	Presenter	Presenter Job Title
Monday	9:00AM	Christie Digital/Landmark	Taking Exploration Geophysics to a Next Level with Big Data	Dr. Satyam	Landmark Chief Data Scientist
10/27/2014	9:30AM	Intel	Methodology for Application Characterization and Modernization Applied to Seismic Imaging	Gregg Skinner	Senior Application Engineer
	10:00AM	Altair & Cray	Leveraging HPC for Deep-Sea Component Engineering	Altair: Rick Watkins & Cray: Geert Wenes	Altair: Business Development Manager-Oil and Gas & Cray: Senior Practice Leaderin Custom Engineering
	10:30AM	Nimbix	Why the Time is Right for High Performance Computing in the Public Cloud?	Leo Reiter	Chief Technology Officer
	11:00AM	Kitware	Enterprise HPC Analysis and Visualization with ParaViewWeb	Patrick O'Leary	Assistant Director of Scientific Computing
	11:30AM	Cray	Full Range RTM in Support of FWI using Dense GPU and HPC System	Bert Beals	Global Lead, Energy Industry
	Noon		Lunch		
	1:00PM	HGST	Accelerate Exploration Data Access with HGST Flash Storage	Brian Morris	Oil and Gas Enterprise Account Manager
	1:30PM	Avere System	How to Leverage a Hybrid Cloud Solution to Optimize Upstream Workflow: Increase Agility while Accelating Performance	Tom Ledoux	Senior Systems Engineer
	2:00PM	SimpliVity Corporation	The Best of Both Worlds for Oil & Gas IT Environments: x86 Cloud Economics with Enterprise Capabilities	Marty Sanders	VP of Sales
	2:30PM	Adaptive Computing	Accelerate Insights – Speed Hydrocarbon Exploration	Paul Anderson	Director of Professional Services
	3:00PM	Altair	Simplifying the Management of HPC Application Environments	Victor Wright	Enterprise Computing Solutions Specialist
	3:30PM	Acceleware	Computational Trade-Offs of Higher Order in Time RTM	Scott Quiring	Team Lead Software Developer
	4:00PM	PCPC Direct	High Performance Computing technology trends and directions	Eric Collins	Chief Architect
	4:30PM	NetApp	High Performance Storage Solution for Landmark SeisSpace	Ajay Kale	
	5:00PM	Rescale	Introduction to Rescale: Cloud Simulation Platform	Joris Poort	CEO
	5:30PM	Hitachi Data Systems	Check Electronic Monitor for updates	Larry Rice	Director of Energy Vertical

>> SYSTEM continued from page 18

Standardization will allow companies to manage data for the long term, providing an audit trail of data loading, identification of data sources, management of access/entitlements and tagging data quality.

The MetaStore 2.0 beta version includes basic data management, analytical and visualization capabilities on the PPDM database (supporting both Oracle and MS SQL Server).

The future is open

The Metastore has been designed as a fully flexible, open system with an open door policy to allow vendors to either write data access routines or provide an API such that any vendor's data or proprietary rock property data may be stored, queried and accessed in the system.

Giving companies the ability to create comprehensive and accessible repositories of their data assets using open technology shifts the emphasis away from data management as a passive task and encourages active engagement with end users.

Demos of the Ikon MetaStore will run daily at booth 1208. ■

Exhibition Hours

Sunday, Oct. 26 (Icebreaker).....6 p.m. to 8 p.m.
Monday, Oct. 27 .....9 a.m. to 6 p.m.
Tuesday, Oct. 28.....9 a.m. to 6 p.m.
Wednesday, Oct. 29.....9 a.m. to 4 p.m.

>> EARTH continued from page 19

this study, the company displayed uncertainty to three standard deviations or a 95% uncertainty range. In this display, the lower values, or red color, indicate a more reliable value of the inversion. The yellow color indicates a larger uncertainty, i.e. less reliable inversion.

A vertical yellow bar to the left of the display also can be observed—this is an area of limited seismic coverage, with an associated lower confidence in the inversion. In addition, for this pass of the processing, a small degree of residual moveout was left on the gathers. This can be seen per the uncertainty volume as yellow spectrum colors that correspond to major events along the seismic line. This clearly indicates a need to review the preprocessing of the data.

The key risk in any inversion lies with the quality of the preprocessing. It's a simple formula: The greater the quality, the lower the risk. ION optimizes data quality by embedding a reservoir characterization specialist within the processing team. At each stage of processing, the parameters selected are checked to confirm that the resultant data still meet the stringent criteria necessary for elastic inversion. By following this rigorous workflow, the company can reduce the possibility that preprocessing will yield data inadequate for reservoir prediction. This would prove a significant risk were the preprocessing done elsewhere.

Through careful preprocessing and the analysis of uncertainty offered through the PrecisION workflow, ION seeks to improve the reliability of the data used to predict reservoir properties and related prospect and/or field economics. ■

>> IMAGING continued from page 22

truncation against the complex salt overhang are very important to increase confidence while prospect mapping. Analysis of the legacy vertical transverse isotropic (VTI) dataset showed mis-ties at key well locations along dipping salt flanks, which established the need for a tilted transverse isotropic (TTI) approach during model building. Major steps in the depth-modeling workflow included calibration of the existing model with checkshot information, estimation of epsilon and delta parameters using an automated focusing analysis and multiple iterations of grid-based tomography for sediment definition to solve for both the short and long wavelength features of velocity anomalies in the model. Both Kirchhoff migration and reverse time migration (RTM) were used for salt body interpretation and modeling. Broadband processing helped improve the low-frequency signal in the subsalt, which generated good-quality picks on the migrated gathers. For subsalt velocity and model updating, both conventional tomography and RTM-based delayed image time (DIT) scans also were used.

Image comparisons

The reprocessed data showed better overall resolution due to the Clari-Fi processing that had been applied. In particular, the major and subtle fault features are more interpretable as visible on the depth slice. In addition to better ties at the well locations along the steep flanks due to well calibration and TTI modeling, the signal below salt and subsalt truncations are now better focused due to usage of RTM and DIT.

Visit TGS at booth 825 for more information. ■

>> HYBRID continued from page 19

The advent and adoption of autonomous cable-free systems in recent years has circumvented many of the cable systems' problems. These autonomous nodal systems tend to be lower in weight and volume than cable systems. Operators simply deploy them in the field and leave them to acquire data, trusting that data are being recorded and that the spread remains within specification (e.g., noise levels, quality of geophone coupling, etc.). As the electronics of these systems are reliable, this choice is often a safe bet. Contractors don't have to wait on the recording system status to start shooting, so productivity is limited by the energy source, not by the recording system.

Since autonomous nodes are blind, the user has no idea if they are recording or are still in place. They have no real-time quality control, making it impossible to monitor the state of the spread. Data have to be harvested from the nodes by bringing them back to the camp or by harvesting the data *in situ* using complex field terminals. The contractor has to invest in and mobilize large transcription trailers to house the expensive computers needed to carry out this work. The user has to wait for days or weeks to see the data produced by skilled technicians in the field, which often leads to delays in making informed decisions on the ongoing survey parameters.

Up to 20% extra units are needed in the field with some nodal systems since they need to be taken off the line for harvesting and battery recharging. At the end of the survey, all of the nodes are brought back to camp, resulting in a huge backlog as they wait to be harvested.

Wireless Seismic's RT System 2 is an alternative system that seeks to offer the best of both worlds. The system architecture is best imagined as a cable system, where the cables are replaced by high-bandwidth radios that transmit data wirelessly in real time between wireless remote units (WRUs). The system works by digitizing the analog input data from the geophones and storing them in the WRU's memory. The data are then streamed through the telemetry system to the central recording system. As the transmission distance between WRUs is small, the system is not subject to the limitations of other radio architectures. RT System 2 is free from the drawbacks of cabled systems and offers the benefits of autonomous nodes.

The system features a hybrid radio telemetry system so that if a WRU loses radio connectivity, its internal GPS turns on and continues to record seamlessly, storing data into its large flash memory. When radio connectivity is restored, the buffered data are transmitted wirelessly to the central recorder, as telemetry bandwidth permits, and the internal GPS switches off to extend battery life.

Visit Wireless Seismic at booth 908 for more information. ■

>> SOCIETY continued from page 1

"We find that there are areas that are not served by our national meetings," Liner said. "We feel like we need to get out there."

SEG and AAPG also are collaborating on the journal *Interpretation*, which launched in 2013. *Interpretation* is a peer-reviewed journal for advancing the practice of subsurface interpretation. "That's a cooperative effort with AAPG," he said. "We alternate between editors that are SEG members and AAPG members."

SEG is expanding in other ways as well. Recently the society brought a near-surface geophysics group from Germany into the fold. Liner said that a large segment of the membership is involved with near-surface issues, and it already had a section, so it brought a pre-existing society on board that wanted to join the larger organization. The topic of near-surface geophysics is becoming increasingly important as geophysicists become involved with environmental issues and production seismic, he said.

"One of the things we're trying to do is bring together all of these different constituencies and emphasize that they're working on the same thing," he said. "It's also an area where we have nonseismic. There's a lot of work done on conductivity, gravity, magnetics and other methods. Those things are front and center in the near surface."

Taking the reins of a thriving society might seem like an easy task, but Liner said there are always challenges ahead. For one thing, the industry as a whole is enjoying a sustained period of high commodity prices. "That really sets the tone in everything we do," he said. "If that were to change, we could have pressure on our membership like everyone else." Now is the time, he added, to build up reserves and put things in place to handle that kind of shock.

"We realize right now that things are pretty good, and we just want to fine-tune everything to where it's sustainable. Growth for its own sake is sort of a zero-sum game."

And while students are always a strong focus for the society, SEG isn't ignoring its baby-boomer members. Liner doesn't expect many of these older members to retire and spend their days golfing or fly fishing; they're more likely to become consultants and stay active members. "We do want to be aware of them as a group, though," he said. Outgoing President Don Steeples has created a volunteer registry for people who want to become more active within the society. It has already proven its value.

"We had someone ask about one of our foundation projects, and we had to dig very deep to find out who to talk to about it," he said. "We will soon have a button on the SEG web page that simply says, 'volunteer.' You click that, give your information, which committees you're interested in and what kinds of projects, and that gets pushed out to the appropriate person on staff and the volunteer base.

"Once you get to be this size—30,000 members, 100 employees—it's about lines of communication within your organization staying open," he added.

So what's on Liner's agenda for his upcoming presidency? "Well, now, isn't that an interesting question?" he quipped. "I'm not coming in with a big, audacious project in mind." Easy for him to say. One of his hopes is to mend fences with the European Association of Geoscientists and Engineers, which used to co-sponsor some of SEG's initiatives but has not been as involved recently. Liner is good friends with the incoming president of the association, Mohammed Al-Faraj, and hopes to leverage that into a stronger intersociety relationship.

"We have what I consider to be an historic opportunity to make it a good working relationship that helps our joint membership," he said. "We have a significant overlap in membership. There's no sense in us not cooperating."

He's also continuing the work of previous presidents in terms of enabling more members to have access to the annual meeting, even if they can't attend in person. Concepts like digital posters and a pay-as-you-go ability to listen to a session on a computer would reach many members who aren't able to travel. Liner said that even though these conventions attract up to 10,000 people, not all are members, and the annual meeting only represents 8% to 10% of SEG worldwide membership.

"With 65% of our membership outside the United States, there are many remote members out there who would like to sit in on a session of their interest and hear the talks as they're presented," he said. "We don't have that capability now. But we're definitely working on it."

Denver attendees will also enjoy the benefits of a streamlined registration process, he said. "The question is how you scale things up," he said. "Our meetings have been getting progressively larger each year. You never have a quantum jump where you just say, 'We've got to do something different,' but after a while it builds up to say, 'Surely there's something we can do better.'"

Liner also is tasked with leading the search for a new executive director to replace Steven Davis, who will be leaving the society when his contract expires. "We look forward to finding the right person to lead SEG going forward." The hope is to have a new director in place in mid-2015.

Overall, the goal going forward is to continue to give the members what they want and expect from a professional society. "We want SEG to be an association of choice for people doing applied geophysics, to reinforce that brand," Liner said. "And we want to do it well." ■

>> FEATURES continued from page 1

and signage to special new events including a members-only reception, students' open mike night and a sneak peek of New Orleans 2015. This is also the first year we have provided child care for our attendees, an initiative brought by the SEG Women's Networking Committee."

SEG seeks to bring the most up-to-date trends and technologies to delegates and exhibitors during this year's show. Major changes include faster registration, with delegates able to scan the QR code found on their confirmation email at self-serve kiosks at the convention center and select conference hotels. In addition, exhibitors can visit the exhibitor rebooking booth to view an online live digital floor plan of SEG's 2015 New Orleans event and book their booth.

The Denver event will kick off with an opening state-of-the-society address by SEG President Don Steeples, followed by the forum "Threats and Opportunities: Disruptive Innovation in Oil and Gas" by Rutt Bridges. The show also will include a special session on the Asia-Pacific region, student programs that offer the chance to interact with seasoned professionals and a Wednesday night wrap-up party at Denver's Museum of Nature and Science.

"We hope that this year's annual meeting offers attendees the chance to connect with more than 350 companies from around the world, people from more than 85 countries and the industry's most qualified professionals," McGuire said. The show also offers the chance for attendees to be inspired by the latest technological advances, to network and, with more than 120 educational sessions, propel their careers and industry knowledge.

The technical program reflects the annual meeting's theme of "connect, inspire, propel, climb" and is at the heart of the event, according to Bradley Birkelo, SEG AM technical program chair. This year's technical program, which is roughly the same size as last year's, encountered a record number of abstract submissions that required the addition of sessions to accommodate the increased demand for presentation slots.

"SEG's Annual Meeting Technical Program reflects the relevant geophysical problems of our day," Birkelo said. "These problems range from full waveform inversion to rock properties estimation from reflection seismic data. The common thread for these applications is the desire to use our geophysical data to provide more quantitative information about the subsurface."

Melanie McGuire is senior manager of conventions and meetings operations.

The program addresses the recent trend of geophysical applications targeting unconventional oil and gas reservoirs. The near-surface mining and geothermal geophysical communities also will present work applying similar techniques toward engineering and groundwater-related problems.

Many members attend the meeting for the knowledge-sharing that takes place, and the benefits of attending the technical program are just as great. "For researchers, the technical program represents an opportunity to share their work with their colleagues and receive feedback directly from their fellow researchers," Birkelo said.

The material presented in the technical program often serves to inspire and guide others' research efforts. As such, many SEG members look to the technical program for the latest ideas and innovations that they can apply to their daily jobs. "Nowhere else will you find such a concentrated collection of applied geophysics ideas," Birkelo added. "Our student members often use the SEG Annual Meeting as their first opportunity to present their work to a group of their professional peers outside of their institution. No matter who you are, staying abreast of the latest geophysical developments pays you dividends for your career."

The technical program will include several special sessions built around topics of heightened interest to members, including a session dedicated to invited papers from the 2013 Unconventional Resources Technology Conference (URTeC). "The URTeC papers highlight interdisciplinary collaboration with geophysics, geology and engineering all contributing to an integrated understanding for unconventional reservoirs," Birkelo explained.

Other special sessions will focus on hydrogeophysics, marine seismic acquisition environmental issues and what microseismic data can say about fluid flow.

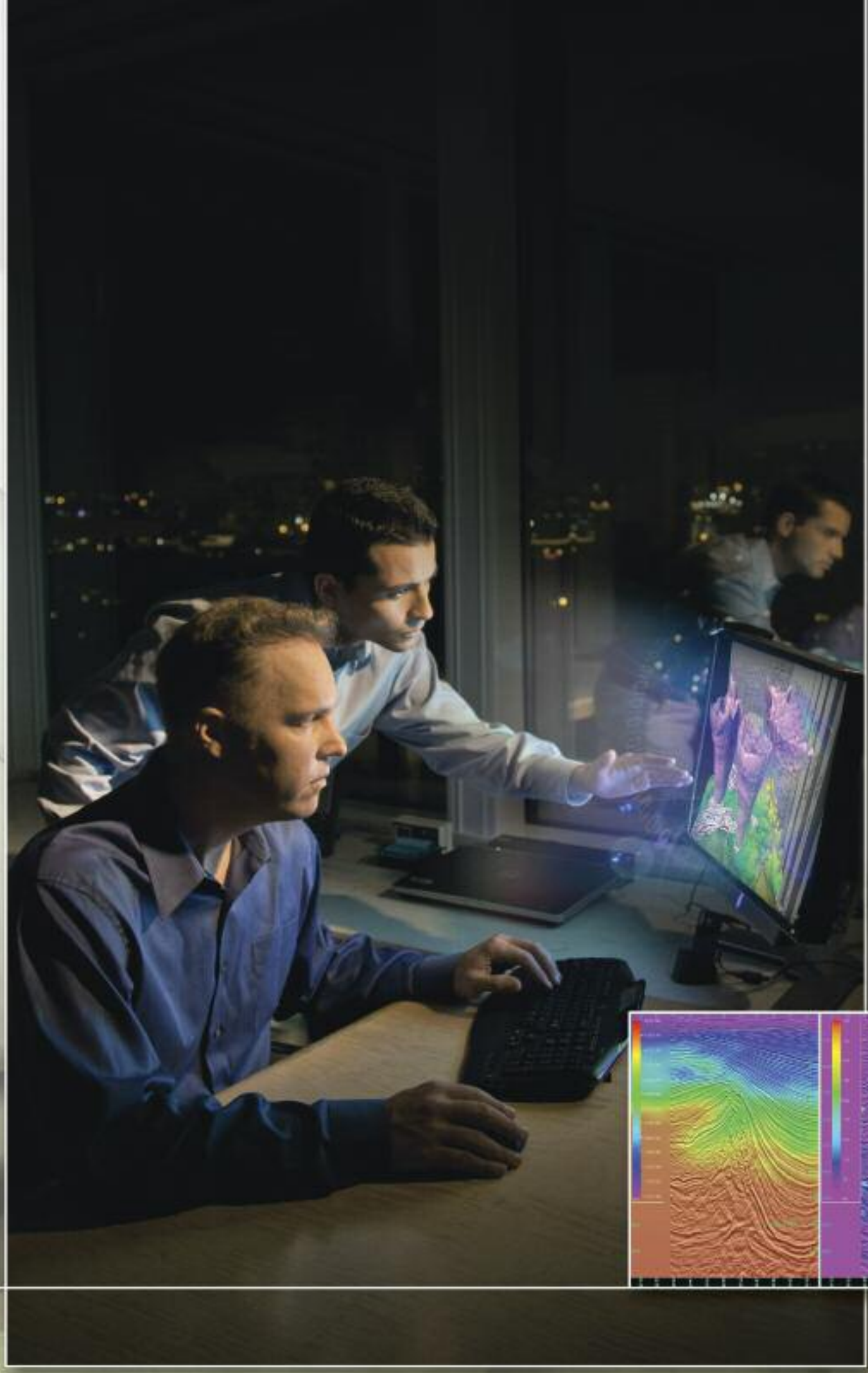
"Embedded in the near-surface technical program are a number of papers relating to projects funded by the SEG Foundation program, Geoscientists Without Borders," Birkelo said. "These papers document and highlight the applied geophysical work being done to improve the lives of people throughout the world."

The special session "Recent Advances and the Road Ahead" will provide a look into the future of applied geophysics. The technical program also features a special session with papers from this year's highlighted global region, Asia-Pacific.

The number of submitted abstracts was a record at 1,634. From these abstracts, the technical program committee created a program of 984 presented papers. In addition, the technical program also will include 72 oral presentations, 15 poster sessions and 36 oral discussion (e-poster) sessions. New this year, each oral discussion session will take place in its own room to eliminate any cross-talk. "We are giving authors the same 15 minutes for their presentations, but we have extended the discussion time afterward to 10 minutes to allow additional discussion between the author and the audience," Birkelo said.

The technical program is scheduled to contain 21 post-convention workshops focused on topics including induced seismicity, the use of geophysics in reserves estimation, reservoir and caprock integrity modeling, rock physics of unconventional reservoirs, and full waveform inversion. "The post-convention workshops represent an opportunity to look at the various topics in more focused detail with an opportunity for greater interaction with the presenters," Birkelo said.

Because it can be challenging for members to attend all of the presentations that might be of interest to them, SEG will be electronically recording presentations for playback the following day at one of the on-demand viewing stations. SEG also will be live-streaming the presidential address, the forum on disruptive technologies and the "Recent Advances and the Road Ahead" special session. ■



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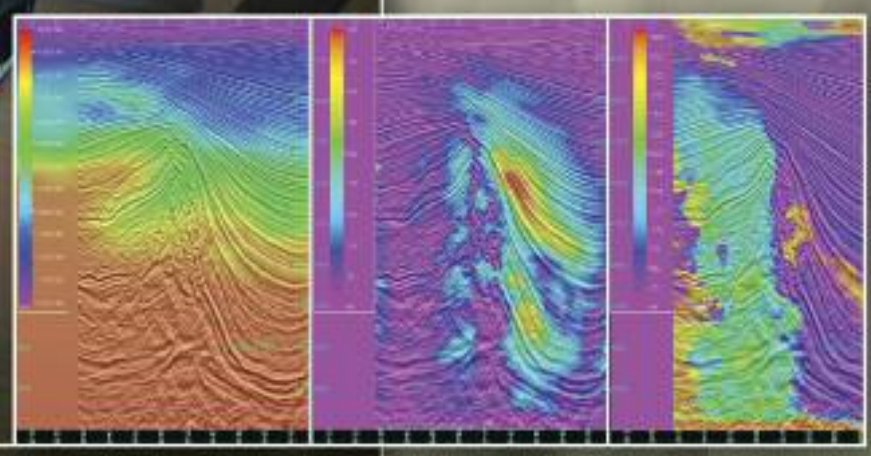

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