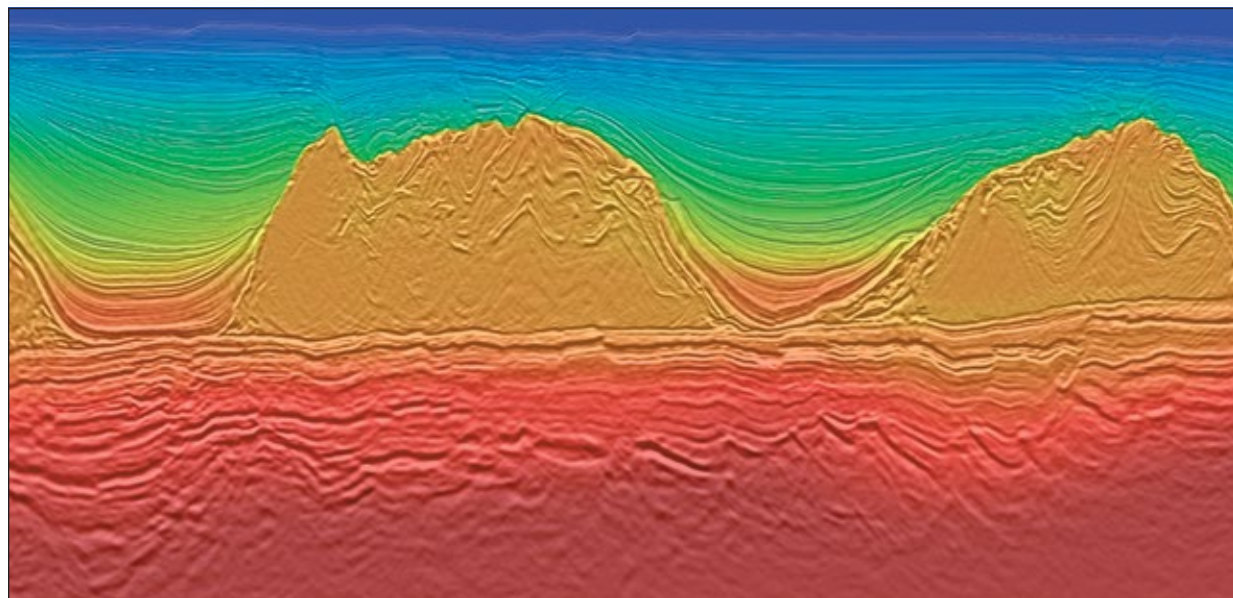# Basin-scale RTM Migration Delivers Seamless Data in Santos Basin

Seismic data from 11 separate surveys have been merged into a single broadband product.

CONTRIBUTED BY PGS

PGS' largest ever migration has been completed to deliver the final data products for Santos Vision. More than 34,000 sq km (13,127 sq miles) of seismic data from 11 separate surveys have been merged into a single seamless high-quality broadband product covering a large swath of the prolific Santos Basin.

The Santos Vision program satisfies the industry's demand for accurate seismic imaging of the presalt

Left, presalt imaging is key for mitigating risk in the area. With a data-driven approach utilizing both FWI and tomography generated continuous velocity model updates through the salt and into the presalt, this avoids an imprecise horizon-based velocity boundary at the base of salt. (Image courtesy of PGS)

Software Extends Field Life, Maximizes Value of Large Datasets

A new software provides improved onshore data handling and delivers powerful new workflows through improved knowledge management and machine learning.

CONTRIBUTED BY IKON SCIENCE

Ikon Science has released RokDoc 6.6.0 and launched the RokDoc Reservoir Monitoring product, with a continuing focus on enabling E&P companies to improve efficiencies, reduce costs and maximize return on investment.

RokDoc supports corner point grid data, allowing the integration of static (geomodel) and dynamic (flow simulation) property models into 3-D/4-D shared earth models that can be utilized for 4-D time-lapse feasibility and "close the loop" workflows. Using this comprehensive new toolset, asset teams can work collaboratively to update geomodel and simulation data with information from 4-D seismic and other sources.

During the SEG conference, the Ikon Science team, along with industry thought leader in 4-D technology, Dave Johnston, will deliver a number of talks and demonstrations of these new capabilities.

"With numerous oil and gas basins across the globe entering into a new era of late-stage production and decommissioning, it is more important than ever that technology keeps pace and enables economic tail-end production to be realized and vital infrastructure to be preserved," said Kester Waters, global portfolio manager, reservoir. "In order to achieve this goal, we need to handle larger, more complex, multivintage datasets and apply algorithms that are capable of delivering more information both spatially and temporally and at a higher resolution. This new software release is delivering solutions that help our clients to do that."

Case studies

At the company's booth, Ikon Science also will be unveiling new case studies demonstrating recent improvements in the field of corporate knowledge management, allowing the capture, aggregation and management of rock property information and providing a framework for large-scale machine learning and artificial intelligence applications. The case studies, which will be presented in a lunch and learn on Monday, Oct. 15, will demonstrate Ikon's machine learning approach to quantitative interpretation, leveraging the knowledge management system to identify, extract and deliver high-quality data for
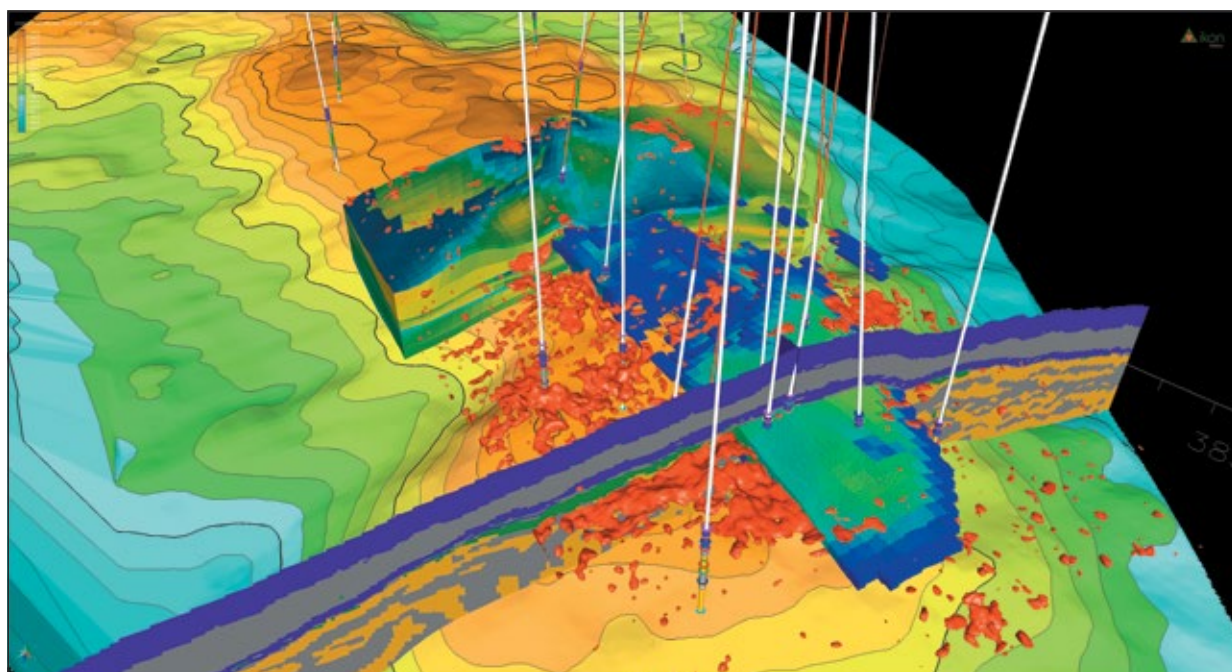
A 3-D perspective of a 3-D/4-D shared earth model shows geomodel and simulator properties combined with 3-D and 4-D seismic properties (inverted ΔSw and facies) to deliver an integrated interpretation of the subsurface. (Image courtesy of Ikon Science)

training of machine learning algorithms using RokDoc's External Interface. Machine learning algorithms can then be rapidly deployed across assets delivering novel solutions to subsurface E&P and drilling challenges.

Improvements, new capabilities

RokDoc 6.6.0 also has numerous usability and workflow improvements for handling of large well datasets, with the addition of new multiwell selection capabilities across the software. The software now supports the loading, manipulation and conversion of gather datasets with irregular offsets, common in land-based projects. End users can move seamlessly from well-based rock physics, pressure and geomechanical analysis of conventional and unconventional reservoirs through to data-driven, 3-D seismic reservoir characterization, delivering 3-D analytical geomechanical, petrophysical and elastic property models in a single, unified platform.

"While many mature basins are seeing the onset of decommissioning projects and while U.S. onshore unconventional production creeps ever higher, several new regions (e.g., Mexico, Guyana and the Eastern Mediterranean) are emerging as significant new players, coinciding with a renaissance in deepwater drilling," said Alexander Edwards, global portfolio manager, wells. "As well as these significant new areas and discoveries, there is considerable and growing activity in underexplored regions of West Africa, GoM [Gulf of Mexico] and East Coast Canada among others, with some key new wells currently being drilled or planned in the next 12 months. In these data-poor areas, it is vital to leverage all available information and to integrate that information optimally to reduce uncertainty and risk."

The RokDoc 6.6.0 software delivers new capabilities that facilitate this integration and analysis allowing, for example, the use of basin model derivatives to drive Ikon's Joint Impedance and Facies Inversion as well as a significant number of new pore pressure and rock physics models that can be applied across the full spectrum of 1-D through 3-D/4-D workflows. ■

hydrocarbon plays offshore Brazil and delivers the most comprehensive and geologically sound dataset to date. It mitigates exploration risk and provides a reliable seismic foundation to pursue new opportunities.

Subsurface geology, seismic solutions

Challenges in the Santos Basin primarily relate to the reservoir targets, which are localized in presalt carbonate buildups underneath heterogeneously layered evaporate sequences (LES), i.e., salt, and interbedded with volcanic rocks. On legacy data the presalt image is not well expressed, so the complexity of the salt and the differing character of the post-salt carbonates throughout the area need to be understood and incorporated into the velocity model-building process. The high degree of complexity within the LES and the presence of areas with good reflectivity and others with little or no reflectivity must be accounted for in the modeling to obtain clear images in the presalt.

One major objective of the reprocessing was to image the presalt stratigraphic signature and rift architecture as these are directly related to the play type characterized by presalt carbonate buildups along tilted or uplifted fault block highs. Santos Vision delivers high-granularity imaging of the base salt and reveals reservoir presence, and accurate imaging of the rift fault patterns beneath the salt mitigates the risk of CO_2 invasion.

Utilizing a velocity modeling process that avoids a hard velocity boundary at the base of the salt has enabled the production of a high-quality image. A data-driven approach was favored with continuous velocity updates throughout the salt and the presalt section using both full waveform inversion (FWI) and tomography for velocity model building. The velocity updates were rigorously validated against geological conformity and structural constraints.

A good velocity model

One large, consistent velocity model is available for Santos Vision. It was built using a combination of geological interpretation, hyperTomo and FWI through the post-salt sediments to achieve an optimum and accurate velocity model of the area. Capturing the variability in the post-salt Albian carbonates and the avoidance of a hard velocity boundary at the base of the salt were key to this solution.

On a regional level, a domain approach addressed the variability in post-rift architecture, including the character of the dominant salt geometries and associated post-salt sediment cover. PGS' implementation of FWI utilizing the full wavefield was deployed. Following the success of FWI in the post-salt sediments, it was pushed deeper than ever before. Reflection-based FWI enabled robust velocity updates in the presalt section and down to the acoustic basement throughout the entire 34,000-sq-km area.

Imaging solutions for complex challenges

Merging 11 surveys of varying acquisition vintages and layouts to provide a seamless broadband dataset is not straightforward. The solution was a robust broadband processing sequence and a monster reverse time migration (RTM), using a much greater number of angle gathers than the industry standard, to deliver consistent quality over the whole area. The result is an excellent presalt image, better than previously achieved, and the advantage is being able to pick and choose data without worrying about consistency.

Imaging deliverables include a full bandwidth Kirchhoff high-fidelity image and 35-Hz RTM and least square migration images, which feature illumination based amplitude compensation for better presalt resolution and rift fault imaging.

The Red Tank seismic characterization project focuses on an interval from the top of the Bone Spring through the Wolfcamp Formation. The Bone Spring interval is a tight, low-permeability, thick carbonate with interbeds of siliciclastic mudstone. The Wolfcamp interval has discontinuous thin bedded carbonates within an organic rich shale with some sandstone. It is clearly evident that the geology in this stacked play is very heterogeneous. Ji-Fi is capable of identifying some of this heterogeneity even at very low frequencies. Beyond characterizing the complex geology, this project is geared toward identifying optimum landing zones and reducing geosteering errors. Using the high-fidelity rock property volumes from Ji-Fi, Fairfield can start to understand the relationship between geology and fracture stimulation design. Furthermore, this information can be used to assess the relationship between geology and production in an effort to maximize the productivity of new wells.

For more information, visit the Fairfield Geotechnologies and Ikon Science booths at SEG. ∎

Determining leads, mitigating risk

Now with a large-scale view in a single dataset, Santos Vision offers exploration companies access to accurate data and images to improve exploration, reduce risk and create their own vision of this prolific basin.

The successful workflow developed here is applicable to the greater Santos and Campos basins, and PGS has future reprocessing plans for the area. For more information, visit PGS at booth 1841. ∎

Dan Hollis

Alumbaugh said the BAG sessions, which are scheduled for each day of the conference, are new to the annual SEG show and will run parallel to the technical program.

General Chairman Dan Hollis said BAG program topics include the Southern Gulf of Mexico (Oct. 15, 1:30 p.m.), Digital Transformation (Oct. 16, 9:30 a.m.), Operating in a Regulated Industry (Oct. 16, 1:50 p.m.), Impacting Society: Frontiers for Geophysicists (Oct. 17, 8:30 a.m.) and Return on Investment for Unconventionals (Oct. 17, 1:50 p.m.).

Hollis said the creation of the BAG sessions was a result of the meeting's technical program committee identifying trends of how economics, technology and social issues impact geophysics. The sessions are open to any attendee with full-delegate registration.

Alumbaugh noted that the conference's technical program committee also put an emphasis on topics associated with characterizing the shallow subsurface.

"Thus we have six oral and six poster sessions under the auspices of 'near-surface' as well as three special sessions that are oriented to engineering and hydrology applications," he said.

Among the program sessions that Alumbaugh said generated the most interest, based on the number of submitted abstracts for particular topics, are Seismic Full Waveform Inversion, Interpretation, Machine Learning and Data Analytics, and Reservoir Characterization.

Alumbaugh noted two special sessions and one vertical seismic profiling session will focus on the use of fiber-optic distribution systems.

"The use of distributed acoustic sensing technology has seen rapid growth in the last few years, especially with companies now deploying fiber optic in wells to provide long-term monitoring capabilities of pressure, temperature and acoustic emissions downhole," he said.

A session that Alumbaugh said could be of interest for attendees working across multiple disciplines is Geophysics and Medical Imaging Applications.

"Geophysical and medical imaging methodologies share a plethora of similarities and obey the same physics, with a primary difference that optimal data acquisition is much, much easier in the medical imaging realm than it is for geophysics," Alumbaugh said. "That is, it is much easier and less costly to surround a part of the human body with sensors than it is to completely surround a given volume of earth. This session will explore the similarities and differences between these two fields of imaging."

Hollis suggested attendees view the conference's official program to get a sense of what is new this year, such as the Digital Arena and the upgraded and rebranded HPC pavilion on the exhibition floor.

"Finally, I would suggest to an attendee that they yield to a little bit of serendipity and explore what is new," he said. ∎

Of Note: The Challenge Bowl World Finals take place today, Monday, Oct. 15, from 2 p.m. to 4 p.m. at the Hilton Anaheim. Regional champions and other teams will compete.