PARADIGM SEG THEATER PRESENTATION ABSTRACTS AND TECHNICAL PAPERS

Improving Resolution with the Seismic Method

Monday, 9:15 AM, 3:15 PM; Tuesday, 10:45 AM; Wednesday, 10:15 AM, 1:30 PM

Spatial and temporal seismic resolutions have improved dramatically over the years, through a combination of seismic acquisition, processing, imaging and inversion methods. A high-resolution interpretation deliverable for prospecting is more achievable when a careful combination of technologies in all of these domains is used, with particular attention paid to the known properties of the earth model. These broadband technologies become the building blocks of a more comprehensive workflow that should be considered for any high-resolution objective.

In the past few years several technologies have achieved notable attention, including broadband deghosting, azimuthal imaging and inversion, and Q-estimation and compensation. These are often pre-requisite inputs for seismic inversion when prospecting and developing fields with thin beds or other high-resolution subsurface targets. The resulting images allow geoscientists to resolve geologic features not resolvable by conventional technologies and acquisition methods. When applied correctly, these technologies improve seismic-to-well bore correlations.

This presentation will incorporate four technologies:

1. Broadband deghosting at source and receiver locations to condition the seismic spectrum for other operations (e.g. inversion)
2. Full-azimuth decomposition in the local angle domain to improve velocity resolution
3. Q-estimating from seismic data for application in Q-imaging methods formulated in the local angle domain
4. Seismic inversion with stochastic refinement, for improved vertical resolution of elastic properties

These technologies provide the basis for a stronger Quantitative Seismic Interpretation program, while making seismic data more relevant for both legacy and modern seismic acquisitions.
Supporting Technologies: Echos®, EarthStudy 360®, Epos®

Interpretation in a Complex Structural and Stratigraphic Environment: A Case Study

Monday, 9:45 AM, 3:45 PM; Tuesday, 10:15 AM; Wednesday, 9:15 AM

E&P projects require the interpretation of different seismic datasets. In complex structural and stratigraphic environments, interpreters spend a lot of time interpreting and correlating seismic reflectors across tectonic deformations. They look for the most appropriate technology to improve the speed and quality of their seismic interpretation, in order to extract more detailed information from seismic volumes. One solution is a workflow that introduces the concept of volume interpretation and geologic modeling while interpreting. This innovative workflow is based on the unbiased automatic extraction of unlimited seismic horizons from a 3D seismic volume or vertical focused window, and on validating the interpretations in paleo-chronostratigraphic space.

The presentation will address the challenges and show how this workflow increases productivity by ensuring that the interpretations are geologically valid, plausible and consistent. In this way, they accelerate the prospectivity and well planning decision-making processes.
Supporting Technologies: SeisEarth®, SKUA-GOCAD™

Precision Depthing – An Eagle Ford Example

Monday, 10:15 AM, 1:30 PM; Tuesday, 3:15 PM; Wednesday, 11:15 AM

While seismic data plays an important role in characterizing unconventional plays, a major challenge is to precisely map the formations in depth using such data. Activities such as well planning and geosteering require accurate depthing. Although the earth model is much better represented through a set of optimized anisotropic parameters, mis-ties remain when seismic interpretation is correlated to the well tops.

Paradigm's well data-constrained, time-preserving tomography provides a stable and systematic solution that can be invoked at any stage of the velocity modeling workflow. This presentation illustrates the technologies and workflows using an Eagle Ford shale play as an example. With this solution, accurate seismic time-to-depth conversion or re-depthing can be efficiently achieved.
Supporting Technologies: GeoDepth® Tomography

Building Geologically-Consistent Velocity Models Using SKUA-GOCAD

Monday, 10:45 AM; Tuesday, 1:00 PM, 4:15 PM; Wednesday, 10:45 AM. 3:45 PM

For years, SKUA-GOCAD has been used to create velocity models in many types of plays, including sub-salt, using unique salt modeling capabilities. Where there is a need for a sealed model that includes salt bags, faults and horizons, or where the velocity volume needs to follow stratigraphic layers, the advanced technologies in SKUA-GOCAD can have a significant impact on the resulting seismic images.

Through tight integration with the GeoDepth velocity determination solution, velocity volumes, geological formation volumes, and dip/azimuth volumes created in SKUA-GOCAD can be used in illumination, grid tomography, seismic imaging and modeling workflows. Subsets of the complex SKUA-GOCAD model can be sent to GeoDepth for model-based tomography.

In this presentation, we will demonstrate a wide range of powerful and easy-to-use tools and workflows contained in SKUA-GOCAD technology. These include tools for building and editing salt bodies, workflows for building simple-to-complex structural frameworks and geological grids, advanced geostatistical interpolation methods, structural smoothing, and structural dip and azimuth calculations.
Supporting Technologies: SKUA-GOCAD™

Advanced Diffraction Imaging for High-Resolution Interpretation and Fracture Characterization: Getting the Most Out of Seismic Data in Conventional and Unconventional Plays

Monday, 11:15 AM; Tuesday, 1:30 PM; Wednesday, 9:45 AM, 3:15 PM

In this presentation, we will demonstrate the importance and relevance of seismic information to obtaining a better understanding of the subsurface; a high-resolution interpretation; a more accurate well trajectory and geosteering plan; and as an instrument for production flow analysis.

This presentation will show the advantages of working in the Local Angle Domain through use of the EarthStudy 360 technology. Fracture characterization analysis generated by EarthStudy 360 delivers reliable results, constructed from full-azimuth angle gathers generated in situ and in depth, with minimal assumptions and honoring the laws of physics.

This system is also able to extract diffraction energy. Diffraction energy is acquired in standard acquisitions, but is largely lost during processing, as most imaging algorithms fail to separate the different wavefields during the summation process.

EarthStudy 360 generates two different types of image volumes, one dominated by continuous or specular energy and the other by discontinuous or diffraction energy, with the aim of providing interpreters with valuable information that will increase confidence in their interpretation. Specular reflection stacks are high-quality stacks used to emphasize and interpret major continuous events and major discontinuities. Diffraction stacks, on the other hand, can be used to interpret and delineate small-scale features and fault systems at the reservoir level.

The different attributes that are extracted from this system can be crucial to a better understanding of the subsurface, and are of great importance to engineers when determining well trajectory in order to minimize risk and optimize production.

In this presentation, examples and case studies from data sets around the world, including the Eagle Ford and Barnett Shales, will be presented.
Supporting Technologies: EarthStudy 360®, GeoDepth®

A Machine Learning Technique for Lithology and Fluid Content Prediction from Prestack Seismic Data: A Permian example

Monday, 12:00 Noon (Lunch and Learn); Tuesday, 2:45 PM

One of the leading challenges in hydrocarbon recovery is predicting rock types/fluid content distribution throughout the reservoir away from the boreholes. This is because rock property determination is a major source of uncertainty in reservoir modeling studies. Spatial determination of the lateral and vertical heterogeneities has a direct impact on a reservoir model because it affects the property distributions.

Paradigm has developed a new neural network-based methodology called Democratic Neural Network Association (DNNA). For over twenty years, the industry has relied on unsupervised waveform classification for seismic facies analysis. While this approach has proven to be highly efficient for stratigraphic interpretation, it ignores a wealth of information at well locations. DNNA provides a bridge between the petrophysics and reservoir modeling domains, using geophysical data.

The DNNA method is trained using facies logs from wells simultaneously with seismic data. The principle of DNNA is to combine several networks that learn differently, to segment the seismic data space according to facies interpretation, and to have it validated by petrophysicists.

Several case studies have been performed in different geological environments using this method. In clastics, the use of DNNA provided a more precise differentiation between facies types, which played an important role in reservoir connectivity analysis. In carbonates, this machine learning approach overcame the lack of consistency in the seismic response and provided a geologically meaningful facies model calibrated to wells, in record time.

Using a probabilistic approach, this technique provides a way to predict lithology distribution and quantify uncertainty. From unsupervised to supervised, machine learning provides a new way to handle massive amounts of data.
Supporting Technologies: SeisEarth®, Classification for Interpreters

Predictive Modeling in the Cloud

Monday, 1:00 PM; Tuesday, 11:15 AM, 3:45 PM; Wednesday, 12:00 Noon (Lunch and Learn)

Every downturn forces the industry to make technological step changes in order to become more productive; for example, workstation computing in the 80s and personal computing in the 90s. Today, it's cloud computing. In turn, these new computing platforms unlock new scientific advancements. 2D visualization becomes 3D. Data volumes became exponentially larger. In our era, the cloud unlocks machine learning and online collaboration, as we enter the Age of Big Data.

Paradigm provides customers with cloud solutions that match what they are ready to adopt today. Our Hybrid Clouds run some software locally while other components are remote. Paradigm Managed Clouds are available for customers who would like Paradigm to manage it all. Cloud Native Applications that were custom written on the cloud are also available. This presentation outlines and demonstrates some of the capabilities, and lays out the options that best fit your organizational needs.

Using Prestack Seismic to Understand Stress and Fracture before You Frac

Monday, 2:45 PM; Tuesday, 4:45 PM; Wednesday, 1:00 PM

Knowledge about the presence and orientation of fractures and stress is fundamental to shale operators. From a seismic point of view, P-wave seismic energy propagating across fractures can be influenced and decelerated because of microscopic opening and closing of fractures as the P-wave propagates. Stress also affects seismic velocities. A phenomenon known as "strain hardening" occurs when applying stress to materials; they strengthen in

different directions, and their seismic velocity changes. Therefore, the seismic velocity will be different, depending on the azimuthal orientation of the seismic wave.

We can measure these azimuthal velocity changes using azimuthally diverse prestack seismic data. In this presentation, we show how we develop 3D spatial estimates of horizontal anisotropy caused by fractures and stress on an Eagle Ford example (from Seitel) using AVAZ and VVAZ technology. These estimates enable the engineer to allocate the finite completion budget to the rock mostly likely to develop complex, richly-connected fracture networks. This reduces the costly occurrence of large numbers of stimulated but ultimately non-productive intervals, for significant economic savings. While AVAZ and VVAZ will function on conventional source-receiver sectored azimuthal gathers, optimal results can be expected on full-azimuth reflection angle gathers generated by EarthStudy 360.
Supporting Technologies: QSI for Reservoir Geophysics, AVAZ, VVAZ

Integration of the Geophysical and Geologic Earth Models for Improved Seismic Imaging and Inversion

Monday, 4:15 PM; Tuesday, 9:15 AM

An optimal earth model is one that follows both geophysical and geological laws and assumptions. When properly applied using the seismic method, we obtain flattened image gathers, a better seismic image that matches well tops, and an earth model that accurately reflects structure and stratigraphy. This proposition is generally true, but it becomes particularly challenging to implement and requires intense human resources when working in areas with complex structures, such as overthrusts, rotated blocks or highly faulted regimes.

Paradigm's solution to this challenge includes the integration of geomodeling and velocity modeling, where subsurface displacement updates between the disciplines and supporting products are synchronized. The solution accounts for both fault displacements and multi-value surfaces with tomography update support. A sealed velocity model is generated at the onset of the workflow and maintained throughout, making the process of complex model building more efficient and less human intensive, without compromising model accuracy. The final earth model honors both geophysical and geological invariants.

Two industry-leading products, GeoDepth (Velocity Determination) and SKUA (Subsurface Modeling) provide the foundation for this workflow, where SKUA incorporates all of the structural and stratigraphic model detail and GeoDepth provides the parameterization and updating of high-resolution anisotropic velocities. This presentation will cover the velocity modeling workflow and its effect on imaging and inversion outcomes.
Supporting Technologies: GeoDepth®, SKUA®

Rapid Prospect Generation – Methodologies and Examples

Monday, 4:45 PM; Tuesday, 9:45 AM; Wednesday, 2:45 PM

This fast-paced demonstration will show the application of several distinctive and mutually supporting methodologies applied to seismic data from the Taranaki basin, currently the only sedimentary basin in New Zealand with commercial hydrocarbon production. The goal is to gain maximum understanding of the structure, stratigraphy and fluid content, with the smallest amount of user time and effort.

Pursuant to this goal, all the work will be done using only two apps, Paradigm Integrated Canvas and the Well Log Window, in a true multi-user environment. There will be no movement of data.

The workflow will begin by applying Paradigm's horizon and fault tracking tools, Seismic Propagator and FaultTrak, to build the basic structural framework in the area. Fault contacts will be automatically generated, and the resulting fault polygon will be immediately applied to the gridding process.

The demo will transition to show how insights can be gained into the seismic stratigraphy of the area. Proportional (stratal) slicing, multi-horizon, multi-survey seismic cube flattening, RGB/HSV visualization, and neural network waveform classification will be applied to the intricate channel features found in the basin.

Once the structure and stratigraphy are better understood, the interpretation process will proceed to detecting seismic anomalies related to hydrocarbon content. An AVO anomaly related to pay in the synthetic seismogram gather will be presented, and used with AVO crossplotting to find the extension of that anomaly away from well control.

Finally, the AVO anomaly volume will be converted to depth, and visualized with opacity-controlled voxels. A well trajectory plan will be constructed to hit desired drilling targets.
Supporting Technologies: VoxelGeo®, SeisEarth®

LUNCH & LEARN PRESENTATIONS

A Machine Learning Technique for Lithology and Fluid Content Prediction from Prestack Seismic Data: A Permian Example

Monday, 12:00 noon
See relevant Abstract.

Evolutionary Movements in Geophysics
Tuesday, 12:00 noon
Historically, advances in geophysics have come equally from inside and outside the domain of geoscience. Many of these advances have been enabled by computer technology companies, where step changes in desktop computing, processors, graphics, operating systems, and high-performance computing have transformed the way geophysicists process, interpret, and interact with seismic data.

Step changes in geophysics have also resulted from changes in asset focus. While asset focus has largely been driven by advances in drilling technology, those advances in turn have resulted in geophysical technology targeted at specific reservoir types and objectives. Today, asset-dependent geophysical applications are readily available for deep water, shale plays, fractured carbonates, and conventional reservoirs.

While downturns in the oil and gas market negatively impact organizations and operations, they also present a good opportunity to reflect, refresh, and innovate based on trends both inside and outside of our industry. This Lunch and Learn presentation will highlight those trends and their impact on Geophysics. Topics to be covered include:

- The integration of geology and geophysics for velocity model building
- High-resolution azimuthal imaging for natural fracture determination, shallow velocity determination, and feature detection with diffraction energy
- Velocity model uncertainty
- Machine learning and geophysics
- Cloud delivery and geophysics

Predictive Modeling in the Cloud

Wednesday, 12:00 noon
See relevant Abstract.

PARADIGM PAPERS IN THE SEG TECHNICAL PROGRAM

A Simple Statistical Approach to Guide Fault Interpretation

Kamal Hami-Eddine and Bruno de Ribet
Session: INT P1: Fault and Salt (Poster Discussion)
Date and Time: Tuesday, September 26, 9:20 AM
Location: 9G, Exhibit Hall C/D

Normalized Global Effective Parameters for Symmetric Moveout in Layered Triclinic Media

Zvi Koren and Igor Ravve
Session: ANI 2: New Methods in Anisotropy (PC-Based Oral Discussion)
Date and Time: Tuesday, September 26, 11:00 AM
Location: Room 360D

Wavefield Separation via Principle Component Analysis and Deep Learning in the Local Angle Domain

Yuval Serfaty, Liron Itan, David Chase and Zvi Koren
Session: DIM 1: Diffraction Imaging and Modeling 1 (PC-Based Oral Discussion)
Date and Time: Wednesday, September 27, 10:10 AM
Location: Room 381A

Two-way Relationships between Slowness- and Offset Azimuths in Horizontally Layered Triclinic Media

Igor Ravve and Zvi Koren
Session: ANI E-P1: Modeling and Inversion with Seismic Anisotropy (PC-Based Oral Discussion/E-Presentation)
Date and Time: Wednesday, September 27, 10:35 AM
Location: Exhibit Hall D/E, E-P Station 2

Neural Networks Approach to Spectral Enhancement

Anat Canning, Dominique Moulière-Reiser, Yuval Weiss, Alex Malkin, Eitan Philip, Nimrod Grinberg, Anastasya Teitel, Margaret Reznikov and Vardit Yehezkel
Session: SPIR 2: Regularization, Spectrum, and Algorithms (PC-Based Oral Discussion)
Date and Time: Wednesday, September 27, 1:50 PM
Location: 360A

Mapping of Carbonate Mounds in the Brazilian Pre-Salt

Carlos Jesus and Maria Olho Azul (Petrogal Brasil), Wagner Lupinacci (UFF), and Leandro Machado (Paradigm)
Session: RC 8: Integrated Analysis and Interpretation (PC-Based Oral Discussion)
Date and Time: Wednesday, September 27, 2:40 PM
Location: 330A

A Growing Machine Learning Approach to Optimize Use of Prestack and Poststack Seismic Data

Kamal Hami-Eddine, Bruno de Ribet, Patrick Durand and Patxi Gascue
Session: INT 7: Machine Learning and Pattern Analysis (PC-Based Oral Discussion)
Date and Time: Wednesday, September 27, 3:55 PM
Location: 350D

Time-varying Q Estimation on Reflection Seismic Data in the Presence of Amplitude Variations

Amine Merouane and Orhan Yilmaz
Session: RC P5: Resolution and Attenuation/Dispersion 2 (Poster Presentation)
Date and Time: Wednesday, September 27, 3:55 PM
Location: 3F, Exhibit Hall C/D

Automatic Global Optimal Estimation of Large Residual Statics

Nicolas Rey III
Session: NS 3: Statics, Tomography and Inversion (PC-Based Oral Discussion)
Date and Time: Thursday, September 28, 11:25 AM
Location: 370C