GX TECHNOLOGY | Full-Wave Imaging
With world demand for energy growing at ever increasing rates, the oil & gas industry is facing numerous challenges in the quest to meet consumer demand. As the easy reserves have already been found, exploration for new reserves has become more difficult, time consuming, and expensive. Much of the focus is shifting from conventional to unconventional plays that require new acquisition and processing techniques to maximize production in an efficient and environmentally friendly manner. Full-wave (multicomponent) data can help meet these new demands by delivering a more complete measurement of the seismic wavefield.

WHAT IS FULL-WAVE IMAGING?

Full-wave seismic is a way of acquiring and processing seismic data that maximizes the geologic and geophysical information by utilizing full azimuth and multicomponent data. Full-wave can provide high resolution P-wave and C-wave data, fault and fracture information, lithology information, fluid detection, density, and more. Full-wave data helps solve exploration challenges and reduces drilling risks, as it provides information on where and how to drill and improves the overall understanding of the reservoir.

Multicomponent (Full-wave) Imaging

Challenging environments present unique obstacles, and reservoir potential in these cases can best be unlocked through cutting-edge, integrated solutions that incorporate full-wave technologies. ION’s GX Technology (GXT) group is a recognized leader in developing technologies across the entire seismic workflow that are helping the oil & gas industry move into the full-wave era. To realize the benefits of full-wave data, several guidelines for acquiring the data include:

- Acquiring data using high fidelity multicomponent, single point sensors such as VectorSeis®
- Designing wide azimuth surveys
- Acquiring a full range of offsets
- Recording and preserving the maximum seismic bandwidth

GXT has advanced full-wave imaging tools and technologies to properly sample images of the reservoir acquired using the guidelines above.
IMAGING THROUGH A GAS CLOUD
GXT’s full-wave imaging helps image through gas clouds, improve resolution, and reduce noise to provide a clearer and more accurate image.

WHY USE FULL-WAVE?
Full-wave imaging helps E&P companies acquire superior seismic data in even the most complex seismic acquisition environments, including:
→ Land, marine, and transition zones, where the data is usually acquired in a producing field to high-grade the reservoir
→ Complex reservoir targets, including those that are fractured, thin, highly faulted, or steeply dipping
→ Time-lapse (4D) reservoir monitoring, where high resolution images (of both lithology and fluid location) are required, and ambient noise from production operations can interfere with data quality

Full-wave imaging can help resolve several issues:

Imaging
Full-wave imaging helps image through gas clouds, resolution, and noise to provide a clearer and more accurate image.

Fractures
To optimize drilling success in unconventional fracture-dependent reservoirs, we use azimuthally varying P-wave attributes, plus C-wave shear splitting attributes, in combination with well cores and log analysis, to identify “sweet spot” areas of favorable fracture density and orientation.

Rock Properties
GXT has the tools needed to detect thickness, lithology, porosity, density, and permeability, including wavelet-based approaches that overcome the limitations of traditional AVO. We can apply these techniques to harder rocks, deeper horizons, thinly bedded or fractured reservoirs, and areas with low signal-to-noise ratios. This gives us the potential to discriminate fluid content type.

DETERMINING FRACTURE ORIENTATION
Using azimuthally varying P-wave attributes and/or shear splitting attributes in combination with well core and log analysis information, GXT can identify areas with favorable fracture densities and orientations to improve drilling success ratios in unconventional reservoirs.
Using full-wave data, GXT provides better lithological discrimination than from P-wave only datasets.

GXT has processed over 40 full-wave projects around the world through our global processing centers.

**GLOBAL EXPERIENCE**

Challenging environments present unique obstacles, the potential of which can best be unlocked through cutting-edge, integrated solutions that incorporate full-wave technologies. GXT is a recognized leader in developing technologies across the entire seismic workflow that are helping the oil & gas industry move into the digital, full-wave era. From Asia to Africa, our team has delivered improved high resolution images of the subsurface that are allowing E&P operators to better target their wells into the sweet spots of reservoirs and improve the ROI of development drilling programs. GXT has processed over 40 full-wave projects worldwide, including the largest ocean bottom cable (OBC) multicomponent project ever recorded.

**DEDICATED TEAM OF SPECIALISTS**

Getting the most from your full-wave data calls for specialized skill and expertise. Our global, dedicated team of full-wave specialists includes over 20 production geophysicists and dedicated full-wave R&D specialists. For more than a decade, our processors have been working closely with geoscientists in E&P companies and a network of third-party practitioners to get the most out of acquired multicomponent data. We work backward from the imaging objectives that uniquely define each project and, to the extent possible, ensure the processing workflows, acquisition technologies, and survey design parameters are optimized to meet our customers’ goals.

**A FULL SUITE OF OFFERINGS**

Full-wave processing requires a specialized set of tools and technologies. GXT has the broadest and deepest set of full-wave processing technologies in the industry and the expertise to exploit them on your behalf to help ensure you get the most information out of your full-wave data.

**Noise attenuation** – Due to the later arrival time of converted wave reflectors, the impact of both source-generated noise, such as ground roll, and background and environmental noise is much higher. We have developed a foundation of proprietary algorithms capable of attenuating all noise commonly found in converted wave data. These include global and local adaptive filtering, 2D and 3D adaptive FK, FX, and FKK filters, radial domain, and TauP filters.
**Horizontal rotation** – Rotation of the horizontal sensors may be required multiple times during the processing of a C-wave volume. These include the simple rotation from the recorded orientation H1-H2 to the radial-transverse direction and the more complex rotation to fast-slow directions in the presence of birefringence. Our rotation tools are highly flexible and include rigorous data-driven quality controls to ensure the correct rotations are applied.

**Vector fidelity** – Modern multicomponent sensors, such as VectorSeis and VectorSeis Ocean (VSO), offer excellent vector fidelity including an automatic correction to vertical. Data processed using older equipment usually needs correction. We’ve developed a number of tools to analyze, correct, and quality control deviations from vertical.

**Shear statics** – Shear statics can be a huge problem in converted wave data. Due to the extremely slow shear velocities often encountered in the unconsolidated near-surface layers, shear statics may be five to ten times greater than P-wave statics. To address shear statics, we have developed a number of techniques and algorithms, including surface wave inversion and PP-PS registration with cross-correlation.

**Signal processing** – To get the full value from full-wave data, both P-wave and C-wave data must be processed with phase and amplitude preservation. We have adapted our signal processing tools to be compatible with both P-wave and C-wave data. In addition, where possible, we integrate well and VSP information.

**Interpolation** – To help address gaps and irregularities in acquisition, we have developed a suite of interpolation tools. These can handle both regular and irregular spatial sampling, and aliased and non-aliased data in two, three, and five dimensions. We also offer interpolation in common offset, cross-spread, and offset vector tile (OVT) domains.

**Migration & velocity model building** – GXT’s principal migration algorithms (Kirchhoff and reverse time migration) have been fully adapted to image PP, PS, and SS data. In addition, we’re able to handle both vertical and horizontal anisotropy. Our Kirchhoff pre-stack time migration workhorse is based on a modified version of the EAP (Edinburgh Anisotropy Project) scheme. Because shear (SS) is not measured directly, we have developed a suite of interactive tools to extract P-wave and S-wave velocities directly from converted wave data.

**Shear-wave splitting** – GXT has developed a full suite of proprietary tools for analyzing and addressing shear-wave splitting called Splitting Estimation and Compensation (SEAC). These tools can address multiple anisotropic layers. Careful correction for splitting will yield not only higher resolution C-wave images but also fracture orientation and fracture density.

**Registration** – In its simplest form, registration is how we stretch and squeeze C-wave profiles to match P-wave profiles. In reality, this is a complex process that is best achieved using P and S well logs combined with forward modeling. This allows registration that honors the subtle phase and amplitude variability between PP and PS data.
PUTTING IT ALL TOGETHER

Getting the most out of your full-wave data starts with survey design and planning to ensure data is acquired properly and ends with collaborative interpretation.

Efficient Acquisition

ION partner INOVA’s FireFly® cableless and Scorpion® cable-based acquisition systems are efficient, reliable choices for any land acquisition environment. INOVA offers a comprehensive portfolio of rugged and reliable seismic instruments that enable geophysical service providers to efficiently design and execute complex seismic acquisition programs for their E&P customers around the world.

For seabed acquisition, ION’s VectorSeis digital 3C sensor is ideal for recording enhanced P-wave and C-wave data, and ION’s VectorSeis Ocean (VSO) redeployable, ocean bottom cable-based system is ideal for data acquisition from the seabed.

Leading Processing Technologies

GXT is a leader in processing full-wave data in both conventional and unconventional reservoirs using class-leading technologies such as AZIM™ and RTM. A premier processing company, GXT is committed to developing tailored solutions that address our clients’ unique business challenges across all acquisition environments, including subsalt, sub-basalt, naturally fractured reservoirs, and the Arctic. Through our expertise and ongoing R&D efforts, we continue to push the limits in full-wave imaging, developing new and innovative technologies in collaboration with our clients to help ensure their exploration and production success.

Expert Interpretation

GXT’s Reservoir Solutions team of experienced geoscientists and engineers offers a wide range of interpretation solutions to help extract maximum value from full-wave data and decrease cycle time to facilitate faster recovery of your investment. The team’s offerings range from individual services, such as simultaneous inversions or pore pressure prediction, to fully integrated interpretations, including selection of optimized well locations.

Regardless of your imaging challenge, we have the expertise, solutions, technology, and global experience to help overcome them. When you think of advanced seismic imaging, think of GXT’s full-wave imaging.
Charged to innovate. Driven to solve.

ION Geophysical Corporation is a leading provider of geophysical technology, services, and solutions for the global oil & gas industry. ION’s offerings are designed to allow E&P operators to obtain higher resolution images of the subsurface to reduce the risk of exploration and reservoir development, and to enable seismic contractors to acquire geophysical data safely and efficiently.
To learn more about how ION helps oil & gas companies and seismic contractors solve their toughest imaging and operational challenges, visit us at iongeo.com

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