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# Proving the Role of Seismic in Unconventional Plays

## Reservoir imaging programs use multicomponent seismic data to determine rock properties.

CONTRIBUTED BY ION GEOPHYSICAL

Unconventional reservoirs such as those found in shale, tight gas and oil, and oil sand formations require unique strategies to develop and exploit. Recent advances in the development of new exploration, drilling, and completion technologies targeting unconventional resources have unlocked new plays in North America. As the industry continues to focus on unconventional resources, the related challenges of developing these resources are accelerating demand for more information to find the sweet spots to drill and fracture. High-quality 3-D multicomponent seismic can play a key role.

Cost-effective extraction is key to reaping the benefits of these abundant natural resources. To enable E&P companies to better understand and assess unconventional reservoirs, ION developed 3-D multicomponent onshore reservoir imaging and characterization programs, called ResSCANs, which are managed by its GeoVentures group and imaged by its GX Technology group.

Unlike traditional seismic programs, ResSCANs are designed to deliver rock property and engineering parameters. An essential component of the programs' success is the use of multi-component seismic data acquired with full-azimuth geometries. The use of multicomponent seismic data provides a more detailed and accurate view of *in situ* stress and rock and natural fracture properties in unconventional reservoirs.

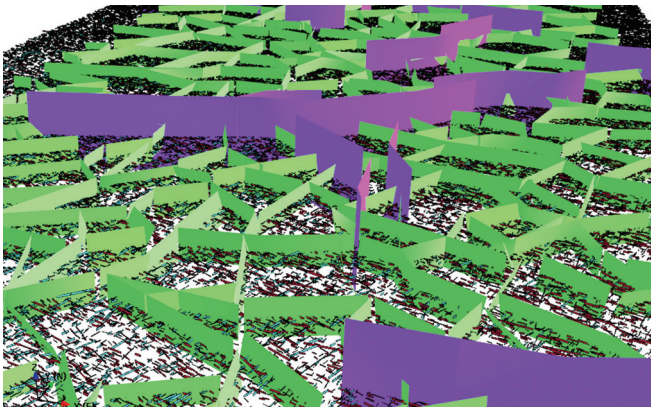
The reservoir imaging workflow recognizes that a comprehensive solution that integrates a wide variety of disciplines is required to answer reservoir development questions. Upfront geological, petrophysical, and rock physics analyses are used to establish which seismic attributes best predict key reservoir properties and, most importantly, impact drilling and completions decisions.

A major component of the workflow is the acquisition and processing of the multicomponent, full-azimuth seismic data. This step leverages the experience ION has gained processing more than 250 shale projects and acquiring seven 3-D reservoir imaging programs. To date, ION has delivered more than 56,980 sq km (22,000 sq miles) of seismic data across virtually all of North America's major shale plays and emerging international plays.

The programs are processed using advanced imaging techniques, which are fully anisotropic. Accounting for anisotropy in processing is now recognized as an important step in improving the quality of seismic data. Typically, two forms of anisotropy are considered: vertical transverse isotropy, which occurs when seismic waves pass vertically through sediment layers of different velocities, and horizontal transverse isotropy (HTI), which results from vertical fractures. The latter is the reason a full-azimuth geometry is used during acquisition.

ION uses its AZIM technology to measure and remove HTI in legacy full-azimuth P-wave data and the splitting estimation and compensation (SEAC) process to do the same with newly acquired full-azimuth converted (C)-wave data. AZIM quantifies the magnitude and orientation of HTI velocity anisotropy from P-wave data, whereas SEAC does the same with birefringence, which is the splitting of C-waves in the presence of vertical fractures. These two processes provide unique and independent confirmations of the orientation and intensity of natural fractures that might exist within the reservoir, which is critical to economically producing unconventional plays.

The ResSCAN workflow then uses this multicomponent data in a joint PP/PS inversion to ascertain rock properties – specifically bulk density and Young's modulus. These rock properties are of great value to asset teams because they can be used to quantify both the type and amount of hydrocarbon in place and rock brittleness.



**Discrete fracture network models like this Niobrara example from ION's BearCreekSCAN program are used to history-match unconventional reservoir models and simulate production at proposed well locations. Regional faults are in purple smaller polygonal faults are in green; and individual fractures are in black, red, and aqua. (Image courtesy of ION)**

The final step in the workflow is the creation of reservoir models that can be used by drilling, reservoir, and completion engineers to define their development programs. This is accomplished through discrete fracture network modeling that incorporates rock properties, natural fracture intensity, and orientation as well as geomechanical data from wellbores, logs, and other geological data. These models are history-matched to previous production and can be used to plan and refine future drilling programs.

A new and integral component of the reservoir imaging workflow is the use of microseismic technology for fracture monitoring. Fracture monitoring is faced with the challenge of recording very small signals in a high-noise environment. To more accurately locate and characterize microseismic events, the company developed a new solution employing proprietary, ultra high-sensitivity, low-noise SM-64 multicomponent sensors deployed in shallow buried arrays. ION's first two commercial monitoring projects are under way in the Marcellus and Mississippi Lime plays. By integrating the microseismic data with reservoir imaging 3-D multicomponent seismic data, rock and fracture property data, history-matched fracture models, and time series completion data, the company can provide operators with a detailed picture of their drilling and completion effectiveness.

The company's seven reservoir imaging programs encompass about 2,590 sq km (1,000 sq miles) across the Marcellus, Niobrara, and Mississippi Lime shale plays – a combination of oil, gas, and mixed plays. Through these programs and its microseismic offering, ION is working to prove the value of multicomponent data in addressing the two key uncertainties in unconventional reservoirs: reservoir quality and completions effectiveness. With this insight operators can focus their drilling plans on the most productive acreage and define more cost effective completions designs, essential in today's oil and gas price environment. To learn more, visit ION at booth 630. ■