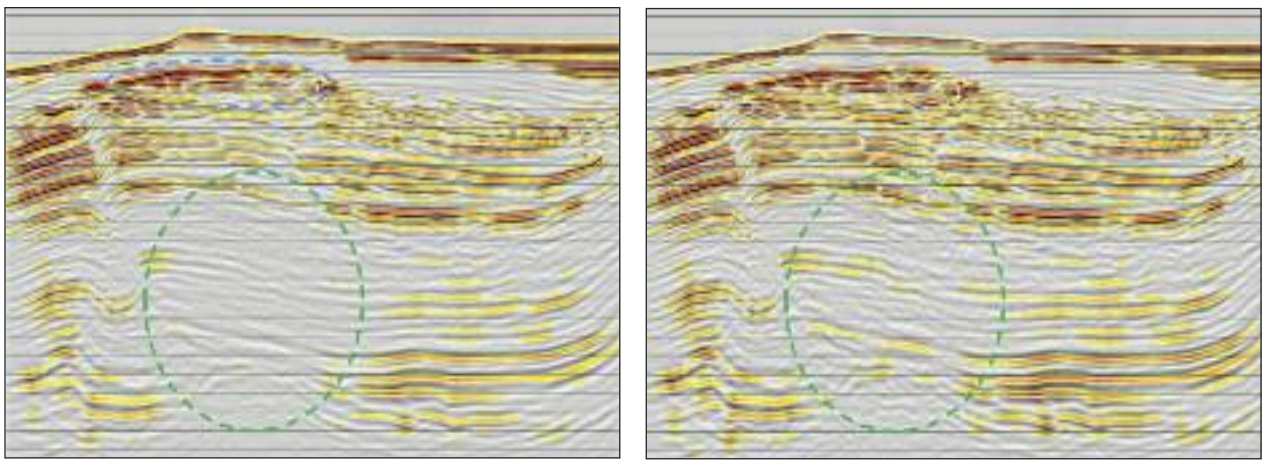
Innovations in Reverse Time Migration

CGGVeritas has added further innovations to the RTM toolbox to take advantage of wave information and produce clearer images.

Contributed by CGGVeritas



Conventional RTM (left) and Q RTM (right) on data from the Alaminos Canyon area of the Gulf of Mexico are compared. Shallow gas hydrates (blue circle) cause a shadow zone in the deeper section (green circles), for which the Q RTM is able to compensate. ***(Images courtesy of CGGVeritas)***

Reverse time migration (RTM) is considered the benchmark in imaging due to its ability to handle complex velocity models with abrupt discontinuities typical of structures such as salt bodies, with which ray-based methods typically struggle.

The clarity of transverse tilted isotropy (TTI) RTM now is available prestack on 3-D common-image gathers (CIGs) that retain the rich azimuth and reflection angle information inherent in wide-azimuth data while honoring anisotropy.

This is a significant industry-first for CGGVeritas, allowing the company to provide the accuracy of RTM for tomography, velocity modeling, anisotropy inversion, and true-amplitude reservoir attribute analysis. It also helps evaluate subsurface illumination and stack optimization for wide-azimuth data.

RTM CIGs are equally applicable to land and marine. They can improve amplitude versus azimuth analysis, often applied for onshore fractured reservoirs. Complex thrust belt and foothills data share in these benefits. RTM CIGs also can be generated for ocean-bottom and vertical seismic profile (VSP) scenarios.

RTM CIGs are free of migration artifacts typical of ray-based algorithms due to multipathing issues in the vicinity of complex structures. Using RTM for the entire model-building process results in a more accurate velocity model and better final images. It signals the end of using inconsistent ray (or beam) methods for model-building and RTM only for the migration stage.

Deriving an accurate salt geometry is critical to subsalt imaging. In recent years, the ability to define the external salt boundary has improved significantly. However, the internal salt geometry (i.e., intrasalt inclusions, or "dirty salt") generally is ignored during modeling; assuming constant velocity is a common shortcut. CGGVeritas has designed an iterative reflectivity inversion to derive dirty salt velocities. This can be used where picks from intrasalt reflections are too sparse or erratic to constrain tomographic updates.

With speed gains from extensive code optimization, the company can generate multiple RTM volumes overnight that is critical for subsalt and complex imaging. It allows interpreters to compare different geological scenarios during office hours and determine the best scenarios to run the following evening. The dream of routinely using RTM for rapid velocity model-building now is a reality.

Spatial variations in absorption properties cause frequency-dependent dissipation effects. These result in amplitude attenuation, wavelet phase distortion, and loss of resolution. Tomography using prestack gather attributes can estimate a detailed 3-D interval model of attenuation (Q) relative to the background.

The RTM algorithm has been extended so that, in addition to the usual models of velocity and anisotropy parameters, a model of Q can be input.

The CGGVeritas Q RTM technique can compensate for frequency-dependent loss during wave propagation. This mitigates absorption effects, broadens bandwidth, recovers resolution, and gives the correct phase and amplitude of events. Benefits include improved amplitude variation with offset attributes, better prediction of reservoir properties, and easier interpretation of deeper reflectors.

Mirror-imaging migrates the first-order surface multiple (receiver-side ghost) for ocean-bottom seismic or VSP data. Due to effective offsets in mirror-imaging being much wider than in normal imaging, it has a wider effective aperture and provides better illumination, allowing receivers on the ocean bottom, or in boreholes, to clearly image the water-bottom and shallow sediments.

Mirror-imaging has been commonly used in Kirchhoff migration. CGGVeritas now has incorporated mirror-imaging into TTI RTM to enable its use in complex environments where ray-based methods have difficulties handling the velocity models.

RTM is a key part of a range of advanced imaging and 3-D wide-azimuth processing algorithms found in CGGVeritas' geovation suite of software. The further advance of imaging technology remains a research priority for CGGVeritas, with active work ongoing.

Find out more about new developments in imaging at CGGVeritas booth 1638, at our presentations in the technical sessions, or at *www.cggveritas.com/RTM*. ■

Solution Provides High-performance, High-quality, and Reliable Seismic Imaging

Paradigm reverse time migration makes its market entry.

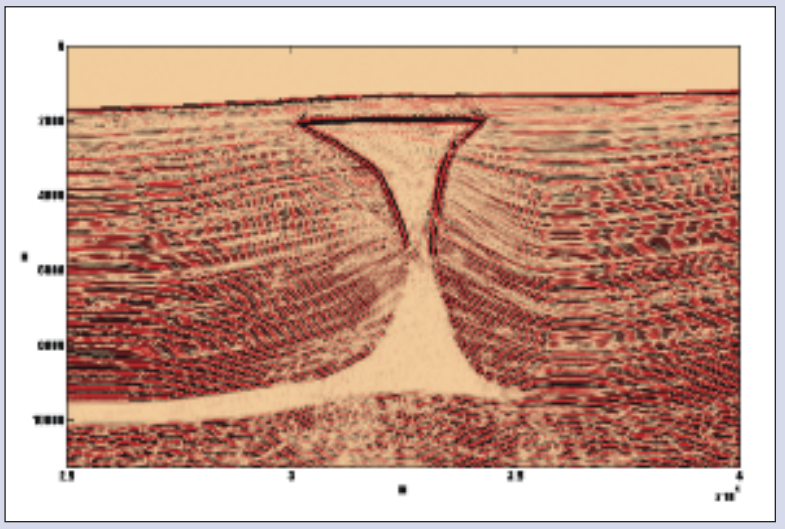
By Ryan Schneider, Acceleware Corp., and Duane Dopkin, Paradigm

Earlier this year, Paradigm and Acceleware teamed up to provide an enterprise-class, high-performance anisotropic, full-wave reverse time migration (RTM) imaging solution designed to improve the quality and reliability of subsurface images generated for the global oil and natural gas E&P industry. This solution is now available for evaluation and licensing at this year's SEG.

Early recognized work on RTM was carried out and published by Paradigm scientists (Dan Kosloff and Edip Baysal) in the beginning of the 1980s. Although the potential of the advanced imaging capacity of this migration was recognized at the time, immense computational barriers prevented its deployment for application in processing centers. Much has changed since this time as the relentless progress in both hardware technology and algorithms has now made the RTM solution a viable option for the entire seismic imaging market.

Today RTM is adaptable to modern clusters. This evolutionary story has been played before as the widespread introduction of RTM software capability can be likened to the early years of Kirchhoff depth migration. At one time, depth migration and even prestack migration were viewed as "too expensive." When those technologies first arrived, only those with the largest datacenters and budgets could apply these technologies, with incrementally better results (in some cases large increments) dependent on the objectives. Today, these technologies – depth and prestack – are in everyone's toolbox, and the projects are second nature. RTM is at the same point in its career. The application of multi-core processing and the introduction of accelerators (like GPUs) are bringing the costs of RTM within range of common depth migrations much faster than anticipated.

By implementing the latest technologies and techniques in high-performance computing, the industry has brought RTM to some of the richest and largest seismic acquisitions with seismic imaging objectives designed to unravel complex wave phenomena that challenge other imaging approaches. Operating on shot records, the migration has been a perfect match for multi-boat wide-azimuth acquisitions, supershots, and shots with tens of thousands of channels.



This image shows the BP 2007 synthetic model migrated with tilted transverse isotropy anisotropy.
(Image courtesy of Acceleware)

So what can the seismic community expect from Paradigm and Acceleware? The two companies have brought together their collective expertise, experiences, and leadership in seismic imaging, high-performance computing, and algorithm acceleration to deliver a high-performance solution and quality results in a setting familiar to Paradigm customers. Implemented as a component of Paradigm's exploration and development platform and infrastructure (Epos), the RTM solution is designed to operate seamlessly with other solutions that streamline the time to final image. The implementation ensures that the most appropriate data conditioning, velocity models, and interpretations are worked into the imaging process. Rich- and wide-azimuth acquisitions are easily supplemented with the latest surface-related multiple suppression techniques, anisotropic velocity models, velocity model topologies, and velocity model validation tools to ensure that customers' return on investments are met.

Paradigm and Acceleware jointly believe that customers will appreciate the adaptability of the solution to their CPU and GPU core configurations to drive continuous advances to a geophysically rich first release. ■