Reverse Time Migration: Without Compromise

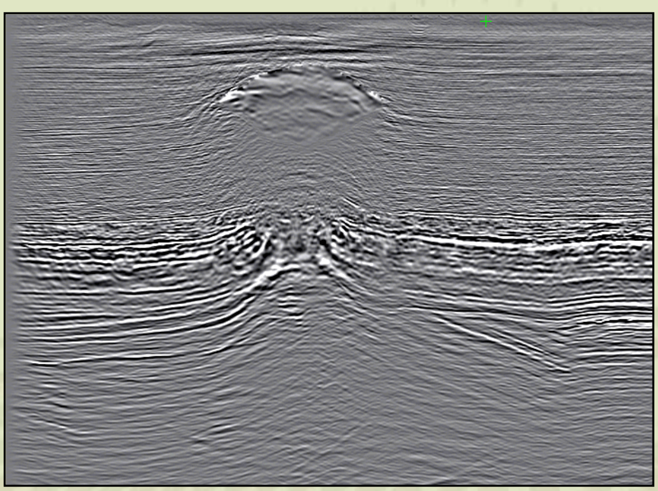
Current migration methods face limitations in the presence of complex, steeply dipping reflectors such as those found on salt flanks. Reverse time migration (RTM), winner of the World Oil Award for Best Exploration Technology, overcomes these compromises, enabling structures with dips greater than 80 degrees to be properly imaged.

World Oil AWARDS 2006 WINNER

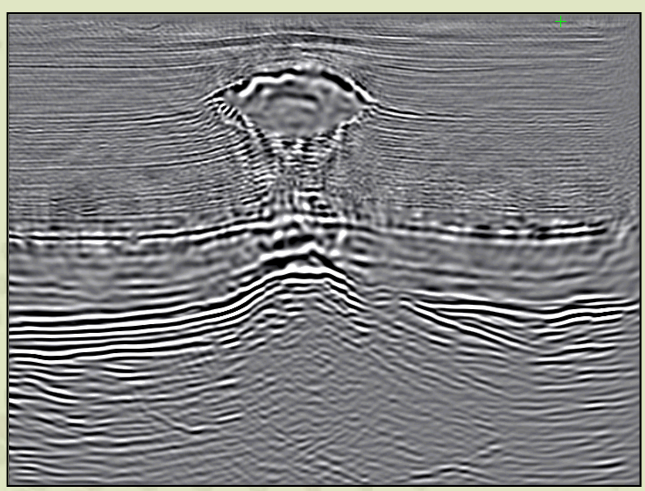
Standard wave equation extrapolation techniques make mathematical compromises that assume wavefields propagate in only one direction – down for the source wavefield and up for the receiver wavefield. As dip increases, the integrity of these wave equation approximations breaks down; for dips greater than 80 degrees, conventional wave equation techniques cease to be applicable. In these circumstances, geophysicists are forced to revert to the Kirchhoff technique, introducing another series of compromises.

RTM provides an alternate approach to migration. RTM works by running the wave equation forward in time for the source and backwards in time for the receiver. RTM properly propagates the wavefields through the most complex velocity regimes, including subsalt, for structures having dips in excess of 80 degrees. RTM can successfully image prism wave reflections (double bounces), turning wave arrivals, and events in the presence of reflection boundaries that may generate internal multiples.

Although RTM is not a new concept, its application has been limited due to lack of computational power needed to run the RTM algorithms cost effectively and in a timely manner. GX Technology's (GXT's) RTM was developed by matching highly sophisticated algorithms with newly available computational power, resulting in an improved and economical solution for imaging complex subsalt prospects. GXT has successfully applied advanced RTM methods in the Gulf of Mexico, West Africa and the North Sea and anticipates its usefulness in areas with similar imaging problems. As noted in the example below, the improvements to image quality can be significant. The application of GXT's RTM demonstrates the uplift in image quality of the subsalt sediments, as well as the salt boundary.



A subsalt image generated with conventional shot-profile WEM technology, showing poor imaging of salt flanks and subsalt structures.



A subsalt image generated with RTM technology, showing significant improvement in imaging salt flanks, even beneath the salt.

THE SUBSALT IMAGING CHALLENGE

Steeply dipping traps can be extremely prolific and capable of being drained with relatively few high-rate wells. These prospects are often found in high-cost deepwater environments. However, they also typically have a small surface footprint, perhaps just a few hundred acres, and are thus hard to delineate. With all these factors combined, they become ideal prospects for the RTM approach.

Imaging reservoirs beneath salt bodies or along their steep flanks pose two serious problems for conventional seismic imaging technologies. First, the seismic waves reflected by the steep flanks of subsurface features are nearly horizontal; specialized techniques are required to recognize and image these waves. Second, the top of salt structures is often highly irregular (rugose), which scatters seismic waves into multiple paths. Unless the imaging process is able to reconstruct this scattered energy, information from any wave that passes through the top of the salt mass is effectively lost.

The RTM method is often described as the ultimate imaging solution because it allows waves to propagate in all directions, thus handling the full array of imaging information. RTM's great advantage in subsalt applications is the ability to image both the steep sides of salt bodies and underneath them, regardless of the dip and rugosity at the top.

THE RTM PROCESS

RTM is not a standalone process. The key to its effective, economic use is a process with three robust key phases: Data Conditioning, Velocity Model Estimation, and Final Migration.

First, the data must be conditioned properly. Key conditioning steps include noise removal and the attenuation of unwanted multiple reflections, phase corrections and deconvolution. It is important to avoid those conventional pre-processing algorithms that can remove energy associated with two-way wave propagation paths. Good conditioning improves both the quality and speed of the next phase: Velocity model estimation.

Velocity model building is an iterative process that typically uses redundant structural information from within the conditioned dataset to derive the model. Imaging the shape of the high-velocity salt body is a key to velocity modeling, and RTM can be "tuned" to make this process more efficient. Using tools currently available that effectively combine visualization with computational rigor, velocity models are derived and are sufficiently accurate to commence the final migration phase. These tools ensure the quality of the velocity model.

During the final migration phase, RTM is computationally intensive. However, the tuned algorithms and GXT's built-for-purpose computing power have eliminated this barrier. Significant reductions in processing time can be achieved by ensuring that the computing resources work together like a well-tuned machine. Active management of the computing infrastructure, such as checking interim results while the image builds, is key to success as well.

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