Wall-to-wall seismic data is still the geoscientist’s primary deep-water asset for locating slope sands; ranking prospects; and avoiding risks associated with shallow geohazards, overpressure, and salt structures. A new generation of rich and wide seismic azimuth acquisitions has advanced the ability to image the deepwater subsurface with more confidence, especially in areas where complex salt structures can obscure subsalt sand facies. While geoscience has come a long way to improve the seismic method for subsalt plays, the challenges and risks associated with subsalt interpretation remain high.

The deepwater exploration frontier contains deepwater slope sands deposited in rich shale environments. Locating these sands is challenging because they have been subject to large-scale compressional and extensional events and obscured by diapiric events. Once located, the challenges shift to high well costs, with a direct correlation to depth of water; depth of wells; and the high risks associated with geohazards, overpressure, and salt.

These challenges and costs can be significantly mitigated with the application of a new generation of exploration technology designed to correct problems routinely encountered with legacy technologies applied in deepwater and subsalt regimes.

Wide-azimuth acquisitions and seismic imaging

The modern rich and wide seismic azimuthal acquisitions provide exploration geophysicists with measurements that have been demonstrated to reduce the non-uniqueness of the seismic method. This reduction in non-uniqueness is achieved in both the velocity model building and updating process and the seismic data imaging process with the use of multi-azimuth data. Unfortunately, surface-recorded azimuthal data do not always bear resemblance to subsurface azimuthal data sampled in the subsurface. Salt structures, for example, can have a tremendous influence on “distorting” the azimuthal orientation of wavefronts as they propagate through the subsurface. New imaging technology such as EarthStudy 360, which decomposes the full seismic wavefield into a full 360 degrees of in situ azimuthal data, allows the geoscientist to bring “true azimuth” data to the velocity model-building process. This innovation not only facilitates the incorporation of challenging anisotropic velocity models but also dramatically improves the quality of velocity model updates with the tomography process.

Full automatic interpretation of both intra-formational layers and the full-azimuth prestack gathers are prerequisites for ensuring that this “additional” data becomes an asset rather than an impediment to the velocity modeling process.

Full-azimuth velocity models are readily available for use with imaging applications like reverse time migration (RTM) that are structured to handle all aspects of complex wave phenomena associated with salt structures including multi-
waves, multi-arrivals, caustics, and prismatic waves. These two imaging approaches (full-azimuth decomposition and RTM) provide a workflow highly suited for salt structures.

**Velocity models that honor geology**

Subsalt prospects are ranked based on seismic and geologic models. However, traditional technologies for modeling subsurface data in the presence of salt structures are limited in their capacity to handle fault-salt and fault-sediment interfaces and to generate the required “sealed” model for proper seismic imaging. For the seismic imaging community, these limitations need to be addressed early in the exploration process. For the geologic modeling community, stratigraphically constrained models become a challenge under tight project deadlines.

SKUA implements a paleostratigraphic transform, providing a true 3-D solution for velocity modelers where horizons are represented as continuous 3-D geochronologic surfaces. By performing this transformation (forward and inverse), velocity modelers are able to generate a sealed model at virtually no cost, with no structural complexity limitations and no fault geometries biases. Stratigraphic constraints are easily incorporated into the velocity model, providing a unified structure for both velocity modelers and geologists. Uncertainties are inherently reduced in the model-building process by the “embedding” of geologic rules.

**Improving the geoscientist’s performance**

Wall-to-wall seismic data in the deepwater subsalt frontiers has proven to be a computational challenge for desktop and cluster users. Imaging technologies like RTM are easily adapted to the latest generation of graphical processing units (GPUs), allowing for more imaging iterations and improvements in the final images. New voxel-rendering technologies also can be adapted to these GPUs, allowing the seismic interpreter to change the interpretation scene “at will,” even for large volumes of data. New modeling solvers also benefit tremendously from these GPUs with improvements in fault construction and horizon construction.

Reducing uncertainty in subsalt exploration requires a proper understanding of the sources of the uncertainty and the mapping of these uncertainties to the appropriate technologies. New software innovation can play a huge role in oil companies’ exploration and development programs in these challenging regimes.