Seismic velocities are earth-model parameters that govern the propagation of seismic waves through subsurface formations. The ability to accurately position velocity parameters in the earth model can greatly influence the outcome of a project. When properly parameterized, velocity models can secure the successful outcome of seismic imaging, time-to-depth conversion, pore pressure prediction, reservoir geophysics, and microseismic positioning projects. When improperly parameterized, the velocity model can deteriorate seismic images and diminish its predictive and positioning capacity for exploration and development.

Building a velocity model consistent with the structural and lithologic style of the earth model is not simple. Despite the dependency of velocity parameters on the earth model, velocity-model building frequently is carried out independently of the earth model. Because seismic velocities are dependent on formation lithology, structural framework, and other basin influences, the earth model and velocity model should be built simultaneously.

A better understanding of the dependencies of seismic velocities on the full earth-model description has both improved and complicated the velocity model. Anisotropic velocity models needed to describe the dependency of seismic velocity on wave propagation and angle depend on the structure, composition, layering, and fabric of geologic formations. As a consequence, many parameters are necessary to fully model velocity behavior.

To help geoscientists synthesize earth-model- and velocity-model-building processes, Paradigm is integrating two of its solutions for velocity-model determination (GeoDepth) and velocity modeling (SKUA). These solutions have helped define accurate velocity models for a broad range of subsurface geologic regimes (subsalt, overthrust, naturally fractured reservoirs). This integration not only enforces best practices in connecting geologic and velocity data, it also empowers geoscientists to build velocity models that use all available data and reduce their nonuniqueness.

**Optimizing Velocity-modeling Outcomes**

Imagine a velocity-modeling system that uses fully recovered in situ azimuth data in depth and all well data and that is synchronized with a “chrono-stratigraphic” modeling system capable of modeling any level of structural and stratigraphic complexity without approximation or deformation. The integration of GeoDepth and SKUA seeks to build a properly sealed velocity-earth model honoring all available geophysical and geologic data.

By doing so, Paradigm hopes to institutionalize velocity modeling workflows that:

- reduce time and iterations to a final velocity-earth model in complex regimes
- minimize seismic imaging artifacts by creating a sealed, stratigraphically constrained, and structurally constrained velocity model
- ensure that all faults and discontinuities are properly honored in the velocity model, and complex structures (e.g. salts) are properly modeled
- create and extract structural seismic attributes consistent with the geologic model and use them in velocity-model updating (tomography)
- use in situ full-azimuth seismic data in depth to measure velocity parameters with precision, improve velocity model resolution, and mitigate uncertainty
- incorporate well marker data, VSP data, sonic data, checkshot data, and other geologic constraints
- distribute properties in chrono-stratigraphic space with geostatistical operations without spatial distortions
- seamlessly link near-surface and subsurface models

**Velocity-model Building in Complex Geological Environments**

Integration between these two velocity-model-building solutions has been strengthened in the Paradigm 15 release. The close connectivity enables complex earth models created in SKUA to be used as input for generating velocity volumes.

**Salt model accuracy is enhanced using an integrated GeoDepth-SKUA workflow.**

These volumes can be used for full-azimuth illumination, tomographic updates, imaging, time-to-depth and redepthing conversions, and full-wave (RTM) forward modeling. The reciprocal relationship also allows GeoDepth users to create accurate background velocity volumes for time-to-depth conversion of SKUA subsurface models.

The integration of GeoDepth and SKUA creates the pathway for the next generation of velocity-earth model workflows that will have a significant impact on oil companies’ exploration and development programs. The upcoming Paradigm 15.5 release, featured at this year’s SEG Annual Meeting, supports the use of SKUA-generated structural models in GeoDepth model-based tomography, yielding more accurate structural and stratigraphic constrained velocity model updates. This integration will evolve in future releases to automatic updates of the full SKUA model from tomography runs, a great time saver for velocity-model builders. For more information, visit Paradigm at booth 2808.