Waveform Tomography Applied To Long Streamer MCS Data from the Scotian Slope

Seismic reflectivity imaging is a standard exploration tool for structural interpretation of the subsurface. However, unraveling the physical properties of the sedimentary rock with the same technique is a challenge that often yields uncertain results. This can be explained by the numerous approximations made in conventional approaches (e.g. NMO and AVO analyses), the primary one being the near offset approximation.

Today, modern MCS acquisition offers new opportunities to test other imaging methods beyond reflectivity. Long streamer offsets can record refracted waves that add significant additional control on the velocity field. Since these refracted waves are not used in conventional processing, such as prestack depth migration, it is worthwhile to study what additional constraints they can offer for the data interpretation.

In this study, we use 2D MCS data acquired with a 9-km-long streamer by Ion-GX-Technology over the Nova-Scotia Slope in water depths of ~1600 m. We show that the refracted arrivals, although restricted to receivers between offsets of 7.5 and 9 km, provide sufficient information to successfully invert for a high-resolution velocity field using waveform tomography. Waveform tomography is a method allowing the inversion of seismic data for a highly detailed velocity field through the modeling of the entire MCS dataset for all offsets, including both phase and amplitude of the wavefield.

Several important features, not present in the initial prestack migration velocity model, are resolved by the waveform velocity model. In particular, a high velocity layer due to gas hydrates is imaged along the entire profile even where a characteristic BSR is not visible in the depth image. The velocity increase in the gas hydrate layer is resolvable even though it is small (< 100 m/s). In addition, a strong velocity increase of ~ 300 m/s exists below a deeper, gently dipping reflector along which low-velocity zones, probably related to gas, are present. Detailed features of the velocity models are found to be remarkably consistent at the crossing point of two separate profiles, to a depth of ~ xx km below sea floor. Results will be compared to downhole measurements at the Torbrook C-15 borehole, which was drilled at this location. The depth limitation of the waveform imaging is due primarily to the coverage of the refracted wave paths. Extending the imaging to greater depth would require longer streamer offsets (e.g. 15 km) or joint inversion with data from fixed bottom receivers (OBS).