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Waveform Tomography Applied to Long-Streamer MCS Data From the Nova-Scotia Slope: Challenges and Applications

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Standard methods of seismic imaging treat the derivation of lower wave-number velocity models using refraction tomography separately from higher resolution images produced by MCS reflection techniques. Recent advances using synthetic datasets, however, suggest that waveform tomography may now permit the joint inversion of both types of seismic arrivals to produce high-resolution velocity images. An accurate starting velocity model is crucial for such a highly non-linear inversion to succeed. Phase and amplitude information of mid-offset refracted arrivals are particularly sensitive to velocity variation. The method, therefore, requires wide- angle datasets with long shot-receiver offsets. Modern MCS data, collected with streamers from 6 to 12 km long, can fulfill the required offset criteria for application of 2D waveform tomography. Accurate high-resolution velocity images of the shallower subsurface can be determined because the MCS data are characterized by high density of shots and receivers. These data can then be combined with larger offset data from ocean bottom receivers to allow extension of the velocity images to greater depth at improved accuracy. We analyzed 2D MCS data acquired in 2003 on the Nova Scotia continental slope (water depth 1600 m) by GX Technology (now ION), using a 9-km-long streamer with a shot interval of 50 m and receiver spacing of 25 m. The data show a refracted phase arriving ahead of the seafloor reflection in the 7.5-9 km offset range and some additional later arrivals from deeper refraction events. We test both standard NMO and prestack depth migration velocity models as initial input to 2D waveform tomography but find that in our case neither is sufficiently accurate for the inversion to converge to global minima. The picked refracted arrivals are accurately forward-modeled only with a starting velocity derived from traveltime tomography. This starting velocity field is then updated and refined using 2D waveform tomography in frequency domain. We also plan to combine and compare the GX Technology MCS dataset to ocean bottom data recorded independently along the same profile. A validation of the velocity model will be possible by comparison to in-situ velocity measurements from the 3-km deep Torbrook well which is crossed by the seismic profiles.

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