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Waveform inversion technique for imaging gas hydrate and free gas zones on the Scotian margin: Case study using ocean-bottom seismometer data

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This study presents the application of 2-D acoustic waveform tomography inversion (Pratt and Worthington, 1990; Pratt, 1999) on marine wide-angle reflection data. The velocity structure that was applied in the modeling represents the low-concentration gas hydrate environment of the passive Canadian margin. The synthetic modeling runs were performed to obtain information on the optimal acquisition geometries using ocean-bottom seismometer (OBS) to detect the low-concentration gas hydrate occurrences. Large instrument spacings (>500 m) are beneficial for covering a wide target region with only a few instruments, but large spacing decreases the lateral resolution for imaging the subsurface targets. Velocity perturbation tests show that half of the instrument spacing defines the lateral target resolution limit. The modeling tests on noisy data reveal that a signal-to-noise (S/N) ratio of 0.1 is acceptable for successful recovery of the original velocities. Waveform modeling with real OBS data acquired in 2006 shows that low frequencies in the source spectrum are necessary for the background velocity of the model. The starting model for the inversion was derived from travel-time tomography with the 2006 OBS data (Schlesinger et al., 2012). The modeled 2-D velocity structure is lacking information from the low-velocity zone below the base of the gas hydrate stability field. Thus the first-arrival refractions of the observed 2006 data and the modeled waveforms with the travel-time inversion result are barely within half a cycle. Further, the S/N ratio of 1.25 for the first-arrival refractions and the starting frequency of 8 Hz prove to be challenging for the successful recovery of the true velocities.

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