Waveform-based estimation of velocity heterogeneity for prestack imaging from broadband seismic reflection data

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Deep seismic reflection profiling with rugged acquisition topography, crookedness of seismic lines has been imposed serious restrictions and compromises on both data processing and acquisition. In addition to complex subsurface structure, irregular distribution of shots, and large noise level of surface wave and back-scattered wave often result in deterioration of the data quality and poor reflection image in seismic profile. In recent years, the quest for increased precision and channel capacity of receiver system led to the combination of telemetry and autonomous recorders with the deployment of dense seismic array for deep seismic profiling. For deep seismic profiling with wide aperture, dense spatial sampling and low-frequency, velocity structures estimated through turning-ray tomography (TRT) are restricted in resolution, since TRT depends on direct arrivals of seismic wave with the assumption of asymptotic ray theory. On the other hand, full waveform inversion (FWI) based on full wavefield modeling and inversion has an advantage to estimate high-resolution velocity heterogeneity compared to TRT. However, pre-conditioning including coherent noise suppression and relative-amplitude preservation is indispensable for the application of FWI. In our study, multilateral approach beyond the conventional CMP stack is applied to the multi-scale, multi-mode seismic data for extraction of deep crustal reflectors through the reconstruction of velocity heterogeneity. The high-resolution velocity structure can be estimated by the hybrid profiling of reflection velocity analysis, TRT and FWI. The uncertainty of the tomography solutions is evaluated using a nonlinear Monte Carlo approach with randomized initial models, and the velocity structure of upper crust is constrained by subsequent forward reflection and refraction modeling. The combination of CRS-driven velocity attribute and FWI with the short-wavelength structural heterogeneity was confirmed to have the potential imaging capabilities including velocity model for improved prestack depth imaging.

Keywords: Fullwave inversion, Velocity estimation, Reflection seismic exploration

