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Strategic seismic data processing for extraction of deep crustal reflectors through reconstructed velocity heterogeneity

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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 100-250km long 2D survey. Furthermore, multi-scale and multi-mode survey layout has been realized by the simultaneous data acquisition of regional refraction, low-fold wide-angle reflection and standard reflection survey for the several targets on the same seismic line.

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, turning-ray tomography and full-waveform inversion. The uncertainty of the tomography solutions is estimated 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. In the last decade, many case studies have demonstrated that the Common-Reflection-Surface (CRS) stack based on paraxial ray theory produces an efficient alternative profile to conventional CMP stack with a pronounced signal-to-noise ratio. The combination of CRS-driven velocity attribute and full-waveform inversion with the short-wavelength structural heterogeneity has the potential imaging capabilities including velocity model for improved prestack depth migration.

We evaluated the relation between reconstructed velocity heterogeneity and the resolution of deep reflection patterns using typical multi-scale deep reflection data acquired in the northeast Japan.

Keywords: deep reflection, velocity heterogeneity, fullwave inversion, seismic reflection survey