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Strategic seismic data acquisition and processing for the delineation of subducting slab

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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 full-azimuth 3D or 100-200km 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 the extraction of reflection patterns related to subducting Philippine sea plate. The high-resolution velocity structure can be estimated by the hybrid profiling of wide-angle reflection and refraction data. 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 CRS-driven velocity attribute with the short-wavelength structural heterogeneity has the potential imaging capabilities including velocity model for improved prestack depth migration.

In order to build the detailed geophysical model of subducting Philippine Sea plate, we developed a processing workflow based on the combined tomographic analysis of refraction, wide-angle reflection, and CRS-driven reflection data. Through the strategic seismic data acquisition and processing for several reflection suvey around Tokyo metropolitan region, the geometry constraints for subduction megathrust and the connectivity of the spray faults were identified. Further, steady-creep and seismogenic asperities zone related the slip deficit on the plate interface were characterized by the distribution of reflection intensities for relative-amplitude preserved CMP/CRS ensembles.

Keywords: Subducting Slab, Seismic Reflection Profiling, Multi-dip CRS Analysis