Scattering waveguide in the heterogeneous subducting plate

Takashi Furumura[1]; Brian L. N. Kennett[2]

[1] ERI, Univ. Tokyo; [2] RSES, ANU

The subducting plate is an efficient waveguide for high-frequency seismic signals. Such effects are often noticed in northern Japan leading to an anomalously large and distorted pattern of intensity extending along the eastern seaboard of the Pacific from deep earthquakes in the Pacific plate. Seismograms in the high intensity zone show very large S-wave signals and a following high-frequency coda with very long tails. Such observations are not explained by the traditional plate model comprising just high wave speed and low attenuation material in the slab.

The new plate model to produce guided high-frequency signals is characterized by multiple post-critical scattering of seismic waves due to small-scale heterogeneities within the plate. The preferred model of heterogeneity has elongated scatterers parallel to the plate margin with longer correlation distances in the plate downdip direction and much shorter correlation distances across the plate thickness. Such quasi-laminated structure in the plate can guide high-frequency signals with wavelengths shorter than the correlation distances along the plate, while very low-frequency signals with longer wavelength are not affected by such small scale heterogeneities. The high wave speed property of the plate at the same time allows seismic waves to escape into the surrounding, low wave speed mantle by refractions of seismic waves. The net result is a frequency-dependent guiding property of the subducting plate with efficient guiding of high-frequency signals by multiple scattering and loss of intermediate frequency signals due to internal velocity gradients. Low frequency signals with wavelength larger than the plate thickness are not significantly affected by the presence of the plate.

We demonstrate the presence of frequency selective wave propagation effect from observations an intermediate depth earthquake in the Philippine sea plate and are able to provide a good representation of the behaviour from 2-D finite-difference calculations for elastic waves with a heterogeneous slab model. The frequency dependence of the models is quite sensitive to the thickness of the thin plate and also depends on the scale lengths of the heterogeneity distribution.