

Localized scatterer distributions on the subducting Pacific plate and in the lower crust beneath northeast Japan

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Seismologists' attention to the structure in the lower crust is increasing due to new findings of anomalous seismic activities such as the deep low-frequency earthquakes not only beneath active volcanoes but even under non-volcanic areas mainly in the northeast Japan, as well as the non-volcanic low-frequency tremor in the southwest Japan. We found an unusual increase in amplitude of seismogram envelope from a shallow earthquake near Lake Towada in the northern Tohoku. Judging from the lapse time from the earthquake origin time, the increase is probably due to scattered waves from the lower crust. We further investigated envelopes from shallow earthquakes in the northeast Japan to find the similar scattered waves from some event-station pairs. We estimated the location and spatial extent of strong scattering zones by a simple analysis in which the amplitude ratio between the observed and theoretical envelopes at a time window is projected onto a scattering shell with a dimension determined by the lapse time of window.

The most significant feature of scatterer distributions we found is their localization to isolated small patches. In the central part of coastal area of Iwate Prefecture, the strong scattering zone exist at depths around 50 km. The depth corresponds to that to the upper boundary of subducting Pacific plate. The area has some unusual seismotectonic characteristics such as the western bend of deeper limit of thrust earthquakes and the occurrence of an anomalous intermediate-depth earthquake ($M = 6.5$) with a horizontal fault plane. Thus the localized strong scattering zone is probably related to this anomalous plate structure in the area. In the inland area of Tohoku, the most prominent scattering is found at stations along the volcanic front of the area, but the depths to scatterers show considerable spatial variation. In the northern part and to the east of volcanic front, the depth to the zone is around 30 km, which is slightly shallower than the Moho depth estimated by previous studies using travel times of converted phases. On the other hand, the depth is about 25 km beneath Lake Tazawa. This zone corresponds to low-velocity zone located to the west of volcanic front in the central Tohoku. The other characteristics of scattered waves are the frequency dependence of scattering. The scattering is evident in the high frequency bands centered at 8 and 16 Hz, suggesting the contribution of small-scale heterogeneities to scattering. Beneath the volcanic front magma is believed to lie at gravitationally neutral depths around Moho. The depth variation of strong scattering zones imply that some fluids dehydrated from magma has risen to the mid crust in the area to the west of volcanic front while they stay just above Moho in the area to the east of volcanic front.