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Tomographic Inversion of Ground Motion Amplitudes for the 3-D Attenuation Structure beneath the Japanese Islands

Shutaro Sekine[1], Kazuki Koketsu[2], Dapeng Zhao[3]

[1] NIED, [2] Earthq. Res. Inst., Univ. Tokyo, [3] Earth Sci.,Ehime Univ

The attenuation structure beneath the Japanese Islands should hold similar 3-D complexities to those in the velocity structure. For example, we often observe abnormal distributions of ground motion amplitudes, which are very different from a circular distribution about an epicenter. Seismic attenuation implies inelasticity or scattering in the Earth's materials, while seismic velocities imply their elastic properties. We can assume high attenuation under the volcanic fronts, and low attenuation along the subducting Philippine Sea plate similarly to the velocity structure. However, this similarity is not always expected in other parts of the Japanese Islands. Information on the seismic attenuation is also important for the simulation of strong ground motions.

The Japan Meteorological Agency (JMA) has compiled maximum velocity amplitudes observed at stations distributed in the whole Japanese Islands. In this study, the vertical components of ground velocity amplitudes reported from January 1994 to December 2000 will be used, because reports of horizontal components are very few before October 1997. The seismic attenuation will be represented with the indexes called Qp and Qs, and their 3-D structure will be obtained for two frequency bands about 5Hz (0.1-0.3s) and 2Hz (0.4-0.6s) by selecting amplitudes with periods within the bands. For the 5Hz band, amplitudes from 2328 or 3236 earthquakes are used for P-wave or S-wave tomography, respectively. The number of stations where amplitudes were observed is 947. For calculating ray paths and geometrical spreading factors, the velocity models by Yoshii et al. (2001) and the ray tracer by Koketsu and Sekine (1998) are adopted.

First of all, clear low-Q zones can be found beneath the volcanic front in the northeastern Japan, and the distinct high-Q is recovered in the east of the front. This high-Q area coincides with the strata of 100Ma or older. Low-Q zones appear only just below volcanoes in the upper and lower crust, while the low-Q area extends continuously along the volcanic front at a depth of 40km. The Qp distribution show similar tendencies zone, but the averaged Qp in the crust is significantly lower than the averaged Qs, so that corresponding low-Qp zones are not obvious. The tendencies can also be found along the volcanic front related to the subduction of the Philippine Sea plate.

Secondly, a low-Qs area is found at a depth of 40 km in the Kanto region, central Japan. Kamiya and Kobayashi (2000) also found low-velocity materials with larger Poisson ratios in this area. They considered the materials to be serpentine on the Philippine Sea slab. The resultant Qp in the area is not so low, since hydrated serpentine does not attenuate P-waves but S-waves.

Thirdly, a distinct low-Qp area is found at a depth of 65km in the Chubu region, central Japan. This should correspond to the low-Q area found by Sekiguchi (1991) and Obara and Sato (1995) in the same region. However, no low-Qs zone can be found in the area. This may imply a different attenuation process from that under the volcanic front in the northeastern Japan.

Fourthly, the high-Q area is found along the upper boundary of the Philippine Sea slab, which is determined from seismicity in the southwestern Japan. This area is more distinct in the Qp distribution with an average of 1000 than in the Qs distribution. The low-Qp area does not extend beyond latitude of 34.2N, and the area looks falling down into a deeper part there. On the other hand, in the Kyushu region, the low-Qp area reaches a depth of 100km or larger coinciding with the slab boundary determined by the seismicity.

Ground motion simulations are then carried out introducing the derived Q distribution. The amplitude distribution is recovered in the result of a ground motion simulation with the resultant Q distribution. If we neglect the Q distribution in the simulation, good agreement with the observed distribution cannot be found.