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Seismic attenuation structure in the mantle wedge of NE Japan: Implications for arc magmatism and fluids

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In our previous study, we estimated 3-D attenuation structure beneath northeastern (NE) Japan, using the method of Eberhart-Phillips and Chadwick (2002). In that method, spectra of waveforms from local earthquakes were used to determine simultaneously whole ray path attenuation terms, t*, spectral level, Ω0 and corner frequency, fc. However, it is difficult to estimate accurate t* because of a strong trade-off between t* and fc. Here, we estimate an exact value of fc of each earthquakes, using the spectral ratio method, and then determine t* precisely for each event-station pair. The t* thus estimated is inverted to estimate 3D attenuation structure beneath NE Japan.
We apply Multi-window Spectral Ratio method (Imanishi and Ellsworth, 2006) to S-wave coda, instead of direct waves, to obtain more stable results. This method can remove the effects of a radiation pattern of source mechanism, site amplification, and attenuation along a ray path. We analyzed shallow and intermediate-depth earthquakes (M>2.5) beneath NE Japan for the period from 2003 to 2010. Waveforms were recorded at a nationwide seismograph network with a sampling frequency of 100 Hz. First, spectral ratios of a pair of earthquakes were calculated for common stations. Then, all the calculated spectral ratios were stacked, and fc of each earthquake was estimated by fitting the average spectral ratio to an omega-squared source model at frequency ranges of S/N > 2. Finally, t* of each event-station pair was estimated from the decay of spectrum at higher frequencies than fc.
The obtained results show that fc and t* are estimated more precisely than our previous method. Estimated corner frequencies follow a cube-root scaling with seismic moment and 0.1-10 MPa stress drop. In addition, t* calculated for adjacent earthquakes are very similar to each other, indicating the stability of our strategy used in this study.
We performed tomographic inversion using the calculated t* and estimated 3D P-wave attenuation structure. The obtained results show an striking across-arc variation in attenuation structures. Low seismic attenuation is observed in the fore-arc mantle, whereas an inclined high-attenuation zone is apparent in the back-arc mantle. In addition, we observe an along-arc variation in attenuation structure; a very high-attenuation zone is distributed in the mantle where Quaternary volcanoes are distributed on the surface, and attenuation is moderate in between. These features are very similar to those observed in seismic velocity structure (Nakajima et al., 2001; Hasegawa and Nakajima, 2004), suggesting that low-velocity and high-attenuation zones in the mantle wedge are closely related to arc magmatism.