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S-wave attenuation on the western side of Nankai subduction zone: implications for geofluid distribution and dynamics

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One major cause of seismic wave attenuation is the presence of fluid in rocks. In this study, we estimated the attenuation structure in southwestern Japan and western Nankai trough by applying the attenuation tomography that takes account of apparent amplitude attenuation due to multiple forward scattering [Takahashi, 2012]. Because the estimated attenuation 1/Q in our tomographic study was much larger than 1/Q due to wide-angle scattering, our estimated 1/Q is composed mainly the intrinsic 1/Q.

High 1/Q (>1/500 at 4-8 Hz) was imaged beneath the Quaternary volcanoes. The highest attenuation (1/Q ~1/250 at 4-8 Hz) distributes beneath the Beppu-Shimabara rift zone at 40-60km depth. Beneath this rift zone, 1/Q becomes larger as depth increases. Random inhomogeneities in this zone are relatively strong at 0-40 km depth; whereas at 40-60 km depth random inhomogeneities are almost comparable to those in non-volcanic area. Meanwhile, in northeastern Japan, uppermost mantle beneath the volcanoes shows strong inhomogeneities and high attenuation. Apparent attenuation at the uppermost mantle beneath the Quaternary volcanoes is high in both study areas, but relative contributions of scattering and intrinsic attenuation differ between northeastern Japan and the Beppu-Shimabara rift zone. If we consider random inhomogeneities and 1/Q in other areas, the weak random inhomogeneities and high 1/Q beneath this rift zone suggest that random inhomogeneities due to the presence of igneous rocks are not significant, and that any magma inclusions are too small to excite S-wave scattering at 4-32 Hz.

At off Shikoku region, moderate 1/Q (1/800 ~1/1000 at 4-8 Hz) is imaged at 0-20 km depth. This moderate 1/Q is estimated as 1/Q (f) ~$10^{-2.5} f^{-0.5}$. Similar moderate attenuation can be found beneath the south of Shikoku at 20-40km, beneath the northern edge of Shikoku at 40-60km depth, and beneath Chugoku area at 40-60km depth. From geometry models of subducting Philippine Sea plate, most of the moderate 1/Q zone is located in and around the oceanic crust of subducting Philippine Sea plate except beneath Chugoku region. In this area, Shelly et al. [2006] pointed out fluid existence in the oceanic crust by estimating Vp/Vs structure. This correspondence implies this moderate 1/Q reflects fluid in the subducting slab. If we suppose that 1/Q of P- and S-wave have the same frequency dependences and that random inhomogeneities of P- and S-wave has the same scale dependences, we can show possible cases of fluid flow induced by the passage of low frequency seismic waves (<1 Hz) by applying a theoretical model of wave attenuation in saturated porous random media [Muller and Gurevich, 2005]. As a phenomenon suggesting such fluid flow by lower frequency seismic wave, triggering of non-volcanic tremors by surface waves passing has been observed [e.g., Miyazawa and Brodsky, 2008]. Even though we further need P-wave studies for detailed examination of this topic, it is likely that random inhomogeneity, intrinsic at 4-32 Hz and triggered tremors can be used to investigate medium properties and fluid dynamics.