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Waveform inversion for the 3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific

Kensuke Konishi (1), Frederic Deschamps (2), and Nobuaki Fuji (3)

(1) Academia Sinica, Institute of Earth Sciences, Taiwan, Province Of China (kensuke@earth.sinica.edu.tw), (2) Academia Sinica, Institute of Earth Sciences, Taiwan, Province Of China, (3) Institut de Physique du Globe de Paris, France

The existence of large low shear velocity provinces (LLSVPs) in the lowermost mantle has been widely attested by seismological global-scale studies. However, their detailed nature, purely thermal or thermo-chemical, is still a matter of debate. Because seismic velocities and seismic attenuation carry complementary information, joint determination of these two properties is expected to resolve, at least partially, the trade-off between temperature and composition. To better constrain the nature of the Pacific LLSVP, we have inverted 1341 seismic waveforms data from the Japanese F-net of seismic station for 31 deep earthquakes beneath Tonga and Fiji (transverse component data, filtered between 12.5 and 200 s) for the shear velocity (Vs) and attenuation (measured by the quality factor, Q) structure of the lowermost mantle. Recently, radial 1-D models of Vs and Q for three subregions (separated from west to east) in the Pacific LLSVP concluded that at depths greater than ∼2500 km, the differences in the three models may indicate lateral variations in temperature of ∼100 K within the Pacific LLSVP, while at shallower depths, the differences may be due to temperature difference between the Caroline plume and its surroundings, and possibly to a small fraction of iron-rich material entrained by the plume (Konishi et al., 2017). Using the same dataset as above and a newly developed seismic waveform inversion method, we obtained 3-D structure of Vs and Q at the same region (western tip of Pacific LLSVP) for the lowermost 900 km of the mantle. The 3-D model is parametrized on a grid of dimensions $5^\circ \times 5^\circ \times 100$ km. Our model shows low values of the shear velocity and attenuation at the deepest depth ranges. The locations of the lowest values are around 10° N 160° E at the bottom. In addition to our preferred model, show distribution of resolution for 3-D structures and improvement of waveforms in several ways (not only peak-to-peak times and amplitudes but waveform variance, peak sharpness). We then interpret our preferred model in terms of temperature and compositional anomalies. In particular, we show that Vs anomalies cannot be purely thermal in origin. Finally, assuming that Q is mostly sensitive to temperature, we calculate temperature anomalies.