Waveform inversion for localized 3-D shear velocity structure in the lowermost mantle beneath Caroline hotspot

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The origin of hotspots is a key to understanding the dynamics of the Earth’s mantle. The origin of the Caroline hotspot is still seismologically unknown although Jackson et al. (2017) suggested that the source of the Caroline hotspot would be in the deep mantle by investigating He isotope ratio in lavas of the Caroline hotspot. Previous global tomographic studies showed about relatively weak (~2%) low-velocity anomaly in the lowermost mantle beneath the Caroline hotspot (e.g., Ritsema et al. 2011, French & Romanowicz 2015). Although the regional waveform inversion showed a strong (~5%) ‘tower shaped’ low-velocity anomaly immediately above the CMB beneath the Caroline hotspot of Wessel & Kroenke (1998), it is not clear whether it reaches 300 km or more above the CMB due to the lack of the resolution (Konishi et al. 2014). Here, in this study, we conduct waveform inversion to infer the 3-D S-velocity structure in the lowermost mantle beneath Caroline hotspot using not only F-net but also NECESS-Array waveform data of deep earthquakes at around Tonga and Fiji. The dataset with better epicentral distance coverage than used in our previous study (Konishi et al. 2014) enables us to study more detailed structure beneath the Caroline hotspot.

The result of checkerboard test shows that the resolution of 300-400 km above the CMB is improved as compared with that of Konishi et al. (2014). The inferred structure has two features: (1) two low-velocity anomalies immediately above the CMB, which merge into one low-velocity anomaly (about 6%) at 100 km above the CMB and is continuous up to at least 400 km above the CMB. The location of low-velocity anomaly is consistent with that of Konishi et al. (2014). (2) about 3% high velocity anomaly from 150 to 400 km above the CMB to about 1000 km northwest of the low velocity anomaly. We interpret these features as: (1) the ‘tower shaped’ low-velocity anomaly indicates upwelling flows from the two separated low-velocity roots immediately above the CMB. The location of the prominent low-velocity anomaly is consistent with the location of the Caroline hotspot. (2) Suppose the velocity anomalies are due to the thermal effects, this high-velocity anomaly indicates colder materials than its surroundings. Since the location of the high-velocity anomaly is consistent with the paleo-subduction of the Izanagi plate in 200 Ma (Matthews et al. 2016), this high-velocity anomaly could be a remnant of the subducted Izanagi plate.

Keywords: Caroline hotspot, waveform inversion, S-velocity structure, lowermost mantle

