Detailed 3-D S-velocity structure within D" at the western Pacific LLSVP margin: smaller scale plumes and paleoslabs

*鈴木 裕輝[1]、河合 研志[1]、ゲラー ロバート[1]、田中 聡[2]、Weerachai Siripuvaraporn[3]、Songkhun Boonchaisuku[3]、Noisagool Sutthipong[3]、石原 靖[2]、Taweoon Kim、宮川 幸治[4]、竹内 希[4]
*Yuki Suzuki[1], Kenji Kawai[1], Robert J. Geller[1], Satoru Tanaka[2], Weerachai Siripuvaraporn[3], Songkhun Boonchaisuku[3], Noisagool Sutthipong[3], Yasushi Ishihara[2], Taweoon Kim, Koji MIYAKAWA[4], Nozomu Takeuchi[4]

1. 東京大学、2. 海洋研究開発機構、3. Mahidol University、4. 東京大学地震研究所
1. The University of Tokyo, 2. Japan Agency for Marine-Earth Science and Technology, 3. Mahidol University, 4. Earthquake Research Institute, The University of Tokyo

Global tomographic models of shear velocity have shown two large-scale low shear velocity provinces (LLSVPs) in D″ beneath the Pacific and Africa. It has been controversial whether these LLSVPs are due to thermal effects, chemical effects, or their combination. The nature and origin of the LLSVPs are of fundamental importance since each of the proposed geodynamical scenarios carries different implications for the thermal, chemical and dynamical evolution of the Earth. Previous seismological studies based on travel-time analysis or forward modeling inferred a sharp-sided velocity contrast of the Pacific LLSVP beneath the western Pacific and suggested that the LLSVP is chemically distinct, although the suggested structures of the western edge of the Pacific LLSVP different from each other. To better understand the origin of LLSVPs, it is essential to infer the detailed three-dimensional (3-D) velocity structure within LLSVP beneath the western Pacific. We recently deployed a seismic array stations in Thailand (Thai Seismic Array—TSAR). We assemble waveforms recorded by TSAR as well as other networks such as TM, AU, MM, and MY, allowing us to sample a wider region than previous studies. We conducted waveform inversion using ~5,300 transverse component records of this dataset for the detailed 3-D shear velocity structure in the lowermost 400 km of the mantle beneath the western Pacific. The inferred model shows a low-velocity anomaly immediately above the core-mantle boundary (CMB) and high-velocity anomalies extending vertically from 400 km to the CMB. Taken into account the previous geodynamical simulation studies, the size of the inferred low velocity anomaly suggests a thermal plume rather than a chemical anomaly. The location of the high velocity anomaly in D″ is consistent with the paleo-Izanagi plate subduction boundary about 200 Ma. This implies that a cold paleo-slab produces the strong lateral velocity contrast at the western edge of the western Pacific LLSVP. Hence, we conclude that the western margin of the Pacific LLSVP and its sharp velocity boundary can be explained mainly by thermal effects, and this implies that the lowermost mantle would be well-mixed and the Pacific LLSVP would not be geochemical reservoir.

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