Global seismic tomography: Model Ehime-2004

Dapeng Zhao[1]; Yuhei Ohta[2]; Jianshe Lei[1]; Akira Yamada[3]; Tetsuo Irifune[3]

[1] GRC, Ehime Univ; [2] Biology and Earth Sci., Ehime Univ; [3] GRC, Ehime Univ.

http://www.epsu.jp/jmoo2004/

During the last two decades, many global tomographic models have been created to map the three-dimensional (3-D) structure of the Earth, which greatly improved our understanding of the structure and dynamics of the Earth's deep interior. In our first global tomographic model (Zhao, 2001), a novel approach was applied to a large data set of ISC travel times. In this approach, a grid parameterization is adopted to express the Earth structure; depth variations of the Moho, 410 and 660 km discontinuities are taken into account in the inversion; ray paths and travel times are computed with a 3-D ray tracing scheme. In the present study, the model of Zhao (2001) is improved significantly by adding a large number of teleseismic data recorded by four portable seismic networks and one permanent network which are newly installed in regions where few ISC stations exist. We picked 12,664 high-quality arrival times from the seismograms of 442 teleseismic events recorded by 236 seismic stations of the five seismic networks in NE China, Iceland, Tibet, South Africa, and Western Pacific. These new data are added to the ISC data set (about 1 million P, PP, PcP, pP and Pdiff arrivals) to make a new global tomography model (Ehime-2004).

The overall features of our new tomographic model are quite consistent with that of Zhao (2001). A low-velocity ring appears around the Pacific Ocean basins and high-velocity anomalies exist under the old and stable continents in the depth range of 0-300 km. Stronger and wider fast anomalies are visible in the transition zone depths under the subduction regions, suggesting that most of the slab materials are stagnant in the transition zone before finally collapsing down to the lower mantle as a result of large gravitational instability from phase transitions. Very slow anomalies exist in the upper mantle right beneath the active intraplate volcanoes in NE China, right above the stagnant Pacific slab in the transition zone, suggesting that the origin of the intraplate volcanism in East Asia is closely related to the Pacific plate subduction process. Plume-like slow anomalies are clearly visible under the major hotspot regions in most parts of the mantle, in particular, under Hawaii, Iceland, South Pacific and Africa. The slow anomalies under South Pacific and Africa have lateral extensions of over 1000 km and exist in the entire mantle, representing two superplumes. The Pacific superplume has a larger spatial extent and stronger slow anomalies than that of the Africa superplume. The slow anomalies under hotspots usually do not show a straight pillar shape, but exhibit winding images, suggesting that plumes are not fixed in the mantle but can be deflected by the mantle flow.

A new feature we found from the new model is that the oceanic ridges are also well imaged as belt-like low-velocity anomalies, thanks to the addition of P and PP rays from the new networks that pass through the shallow mantle under the oceanic regions. Previous studies using surface wave tomography suggested that slow anomalies extend down to about 300 km under oceanic ridges. However, our present tomography model shows that slow anomalies extend down to 550 km under the East Pacific Ridge and the Indian Ocean Ridge. In the lower mantle all the ridge-related features disappear. These results suggest that the up-welling flows under the oceanic ridges may exist in the entire upper mantle, even down to the mantle transition zone. The new findings may have important implications for the understanding of the flow patterns of mantle convection and deep Earth dynamics.

Zhao, D. (2001) Seismic structure and origin of hotspots and mantle plumes. Earth Planet. Sci. Lett. 192, 251-265.