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# Multiscale seismic tomography and mantle dynamics

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Multiscale (local, regional and global) tomographic studies are made to determine the 3-D structure of the Earth, particularly for imaging mantle plumes and subducting slabs. Plume-like slow anomalies are clearly visible under the major hotspot regions in most parts of the mantle, in particular, under Hawaii, Iceland, Kerguelen, South Pacific and Africa (Zhao, 2001, 2004, 2009). 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 Hawaiian plume is not part of the Pacific superplume but an independent whole-mantle plume (Zhao, 2004, 2009). 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. As a consequence, hotspots are not really fixed but can wander on the Earth's surface, as evidenced by the recent paleomagnetic and numeric modeling studies. Wider and more prominent slow anomalies are visible at the core-mantle boundary (CMB) than most of the lower mantle, and there is a good correlation between the distribution of slow anomalies at the CMB and that of hotspots on the surface, suggesting that most of the strong mantle plumes under the hotspots originate from the CMB. However, there are some small-scaled, weak plumes originating from the transition zone or mid mantle depths (Zhao et al., 2006; Zhao, 2009; Lei et al., 2009; Gupta et al., 2009).

Clear images of subducting slabs and magma chambers in the upper-mantle wedge beneath active arc volcanoes are obtained, indicating that geodynamic systems associated with arc magmatism and back-arc spreading are related to deep processes, such as convective circulation in the mantle wedge and dehydration reactions of the subducting slab (Zhao et al., 2002, 2007; Zhao, 2004). Evidence also shows that arc magma and slab dehydration may also contribute to the generation of various types of earthquakes in subduction zones (Zhao et al., 2002). Most of the slab materials in NW Pacific regions are stagnant in the mantle transition zone before finally collapsing down to the CMB as a result of large gravitational instability from phase transitions. The active intraplate volcanoes in NE Asia continent (such as Changbai and Wudalianchi volcanoes) are not plume-related hotspots, but are a kind of back-arc volcanoes whose formation was closely related to the deep subduction of the Pacific slab and its stagnancy in the mantle transition zone (Zhao, 2004; Zhao et al., 2009). The origin of the active Tengchong volcano in SW China is related to the subduction of the Burma microplate (Huang and Zhao, 2006; Zhao, 2009). The Philippine Sea slab is subducting aseismically down to about 500 km depth (Abdelwahed and Zhao, 2007; Zhao, 2009). The Apollo seismic data (1969-1977) are used to estimate P and S wave tomography down to 1000 km depth under the near-side of the Moon, which shows a correlation between the lateral heterogeneity in the lunar mantle and distribution of deep moonquakes (Zhao et al., 2008).

The non-uniform nature of the current distribution of seismic stations and earthquakes on Earth requires a multiscale approach to seismic imaging. Regions that are covered densely by stations and/or seismicity can be imaged with a high resolution by using local tomography, while poorly instrumented regions can only be imaged roughly by global or large-scale regional tomography. This situation will last for quite a long time. A thorough understanding of the seismic structure and deep Earth dynamics will only be achieved by a combination of more effective seismic imaging techniques and dense coverage of global seismic networks, particularly in the oceans.

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