Deep Structure Beneath the Cenozoic Volcanoes of Northeastern China and Geodynamic Implications

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Cenozoic volcanoes are widespread in northeastern China and are situated far from the plate margin. The mechanism of these intraplate volcanoes remains controversial, and various interpretations have been proposed. Among these, the big mantel wedge and the subduction-induced mantle upwelling are two end-members. We determined the travel times of teleseismic P body wave phases, respectively recorded by a passive broadband seismic array around the Nuomin Volcano, the NECESSARY seismic experiment, the Suifenhe-Manzhouli passive seismic profile, the Hulin-Erguna passive seismic profile, deployed at different time spans, with permanent seismic stations in northeastern China as the backbone to constrain the travel time variation. We also conducted travel time tomography to map the 3D velocity variation of upper mantle in northeastern China. Our tomography results show that a low velocity anomaly is located at a depth of less than 200 km between the Nuomin Volcano and the Wudalianchi Volcano. A normal to high velocity anomaly is situated just underneath the low velocity anomaly and extends to a depth of 410 km. A low velocity anomaly with a thickness of 50 km is located at a depth of 500 km with a high velocity anomaly extending to 660 km depth between the Nuomin Volcano and the Wudalianchi Volcano. We speculate that both the Nuomin Volcano and the Wudalianchi Volcano possibly originated from the low velocity anomaly of the upper mantle between the two volcanoes, which are separated ~200 km from each other. The normal to high velocity anomaly just beneath the inferred volcano source region may represent the detached lithospheric mantle, and the low velocity anomaly above the high velocity anomaly is possibly the result of upwelling of asthenospheric material and induced both the Nuomin Volcano and the Wudalianchi Volcano. The high velocity anomaly lying on the 660 km discontinuity may represent the stagnant Pacific slab, and the thin low velocity zone at the depth of 500 km just above the inferred stagnant Pacific slab may be caused by dehydration-induced partial melting. A continuous low velocity zone extending to 400 km depth is observed beneath the Aershan Volcano and is isolated from the low velocity anomaly within the mantle transition zone by a thin high velocity zone just below the low velocity zone. Nevertheless, the low velocity zone in the upper mantle beneath the Aershan volcano seems to connect with the low velocity zone within the mantle transition zone, which needed to be further confirmed. The Aershan Volcano is inferred to be related to the deep continuous low velocity anomaly of the upper mantle. We further confirm that the low velocity anomaly related to the Changbai volcano may extend deeper to the low mantle just below the 660 km discontinuity, caused by the tearing of the stagnant Pacific slab within the transition zone. Our new teleseismic tomography results reveal that both the Nuomin Volcano and the Wudalianchi-Kelo volcano may share the same magmatic origin at depth, which may explain their ultrapotassic features.

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