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Seismic imaging of the mantle transition zone and lithosphere deformation beneath NE China

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To better understand the intraplate volcanism, the subduction geometry of the Pacific plate, and lithospheric thinning, we installed 127 broadband seismic stations across northeast China between 2009 and 2011. The NECESSArray covers an area 1800 and 600 km in the EW and NS directions, respectively, with a station spacing of 70-80 km. While seismic tomography offers a direct way to map a descending cold slab and a hot mantle upwelling with a high and low seismic velocity, respectively, receiver function data provides an indirect approach to image them when they interact with the 410-km and 660-km seismic discontinuities. The two discontinuities, which define the upper and lower bounds of the mantle transition zone, are believed to be associated with the two phase transitions of olivine that have a positive and negative Clapeyron slope, respectively. Lateral variations in the transition-zone thickness, as well as variations in the depths of the two discontinuities thus can be used to indirectly map out a descending cold slab and an uprising hot plume. We also measured seismic anisotropy in the upper mantle using core shear phases recorded by the array to investigate mantle flow beneath NE China.

We collected a total of 50,000 receiver-function data from 800 teleseismic events, and employed a common-conversion-point stacking (CCP) method to generate a 3D reflectivity volume beneath the study area. To position the P-to-S conversions to the correct depths, we utilized 3D crustal and mantle models as the reference velocity model to make the time-depth conversion. The 3D reflectivity volume was generated in an area between 115-135E and 40-49N, in the depth range of 200 to 1000 km. We found significant topographic relief on both the 410-km and 660-km discontinuities across the study area. In particular, the 660-km discontinuity is depressed by as much as ~30-40 km in the western end of the deep seismicity. The depression is elongated along the strike of the deep seismicity and is limited within less than 200 km in the E-W subduction direction. To the west of this depression, the 660-km discontinuity rises suddenly by as much as 20 km in a circular area with a radius of 100 km centered at 123.5E and 42.5N. The depression and uplift correspond well with a high and low velocity anomaly, respectively, in the P- and S-wave tomographic velocity maps at the same depth. Our results thus suggest that stagnant subducted slab may not be the extensive feature of deep subduction in this region, and the origin of the Changbaishan volcano located in the border between China and North Korea may not be derived from dehydration of the flat-lying Pacific plate. The low velocity mantle upwelling arising at the tip of the subducting slab may be the eventual source that feeds the enigmatic volcano.

We employed a multi-event signal-to-noise ratio (SNR) weighted method and obtained measurements of splitting parameters at 126 stations. Overall, the observed SKS splitting times are of low amplitude (0.8 s), indicating that the underlying mantle experienced relatively weak deformation in this region. Overall the study region shows a NW-SE fast direction, which is close to the absolute plate motion (N64W, NUVEL-1A model), but is difficult to conciliate with the EW flow expected by the so-called big-mantle-wedge (BMW) model, which hypothesizes a large-scale mantle upwelling in this region as the deep origin of the Cenozoic volcanism. The observed anisotropy also varies consistently from place to place and exhibits an asymmetric pattern across the Songliao basin. At the southeast and east edge of the Songliao basin, the fast axis aligns along the NW-SE direction, whereas the axis rotates slightly to NNW toward northeast beneath the Jiamusi massif and the Sanjiang basin. At the west edge of the basin where the North South Gravity Lineament (NSGL) is located, we found significant scatter in the fast-axis direction.

キーワード: mantle transition zone, deep subduction, intraplate volcanism, lithospheric dripping, receiver function, SKS splitting
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