Arc volcanism, forearc seismogenesis and interplate coupling in the Kuril-NE Japan subduction zone

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Subduction of the Pacific plate into the entire Kuril–NE (northeastern) Japan arc plays important roles in tectonic evolution, repeated occurrences of megathrust earthquakes (M >7.5) and arc volcanism and genesis of inland earthquakes. To improve our knowledge of crustal and upper mantle structures through tomographic imaging, we determined the three-dimensional (3-D) velocity (Vp, Vs) and Vp/Vs structures under the Kuril–NE Japan subduction zone. In this study, three groups of data sets are included in the hypocenter location process simultaneously with tomographic inversion. The first data group includes 385 offshore earthquakes, from which 2843 sP depth phases were identified. The second data group includes 3546 offshore earthquakes that occurred close to the first data group. The third group includes 13,603 onshore earthquakes that are located within the land-based seismic stations. The offshore hypoceters were relocated using the Master event location method (Wang and Zhao, 2006b, c). As a result, 3546 offshore earthquakes were selected from a large number of offshore earthquakes. Finally, a total of 413,032 P- and S-wave source-receiver pairs were collected from the 17,534 onshore and offshore earthquakes for imaging the P- and S-wave velocity and Vp/Vs structures.
A new method to invert Vp and Vp/Vs images simultaneously using a large number of high-quality arrival times of P-wave and S-wave source-receiver pairs from both onshore and offshore earthquakes is presented, indicating that the inverted Vp and Vp/Vs models are mutually correlative compared with the previous models. The hypocenters of the offshore earthquakes relocated by using sP phases jointly with the master-event location (MEL) method, enabling us to reliably image seismic structures not only under the onshore areas but also under the offshore areas. The Vp, Vs and Vp/Vs models provide compelling evidence for a highly hydrated and serpentinized forearc mantle and the fluids related to low-velocity and high-Vp/Vs anomalies associated with the slab dehydration (Figure 1). Significant slow anomalous Vp and Vs with a high-Vp/Vs ratio are clearly imaged along the volcanic front with an extended depth of ?100 km under the Kuril–NE Japan arc, showing good consistency with the results of previous studies, which is caused mainly by the fluids associated with the extensive dehydration of the subducting Pacific slab. More than 85% of the historical megathrust earthquakes (M >7.5) occurred in or around the high-velocity areas along the upper interface of the subducting slab under the forearc regions, suggesting strong interplate coupling (asperities) with the subducting slab. Alternatively, prominent low-velocity areas with high-Vp/Vs anomalies are revealed along the slab’s upper boundary in the offshore regions, which may reflect weak coupled or decoupled patches (aseismicity) of the plates caused by serpentinization of the forearc mantle wedge. Our study suggests that the fluid-related anomalies under the Kuril–NE Japan arc system, attributed to various processes such as slab dehydration and serpentinization of the forearc mantle wedge, are contributed mainly by arc magmatism, interplate coupling and the repeated generation of megathrust earthquakes.

Keywords: Subduction zone, Forearc seismotectonics, Arc magmatism

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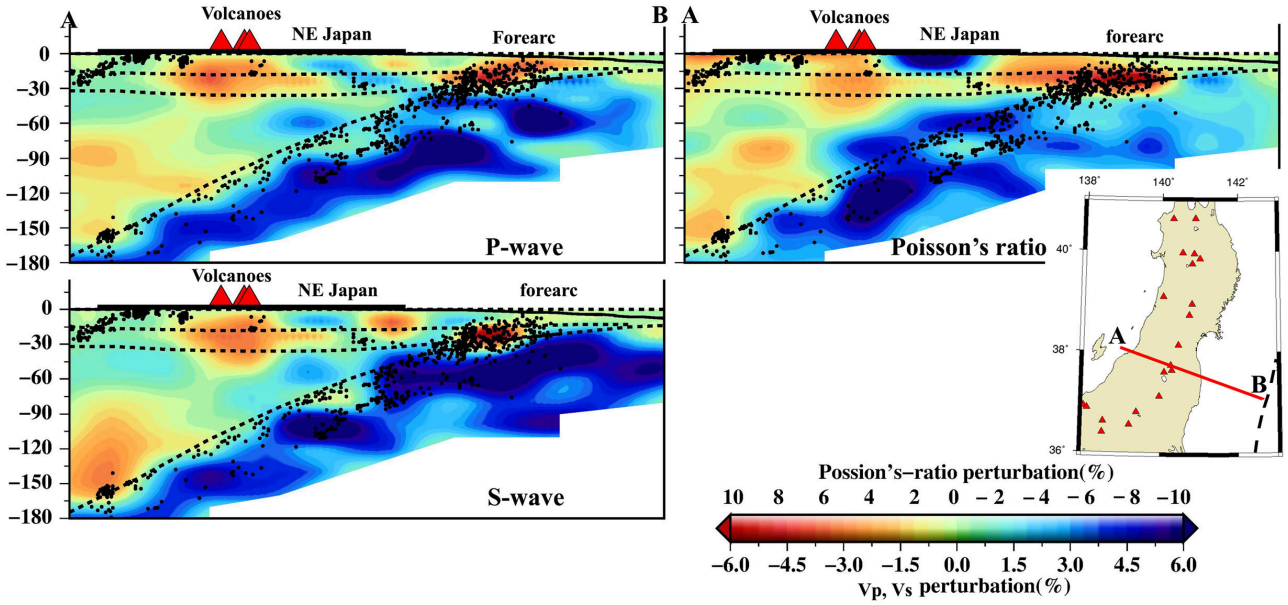

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