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Mapping middle mantle heterogeneity beneath the Okhotsk Sea with S-P conversion phase

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In recent years, there have been many studies on the fine-scale (several kilometers) heterogeneities in the middle mantle at the depth range of 800-1700km. The distribution and physical properties of these middle mantle heterogeneities are important for examining their origin. Various seismic phases can be used to image these heterogeneities, including S-P/P-S converted phases, P-P scattered waves, and PP/SS precursor. Among them, the S-P conversion (usually written as SdP, d represents the conversion depth) as coda of P wave is commonly used.

Here we used the array analysis method to analyze global recordings of SdP for some deep earthquakes occurred beneath the Okhotsk Sea. The SdP is identified on the 4th-root vespagrams. Possible three-dimensional effects for the SdP phase are estimated by the f-k analysis. We further determine the location of the scatterers with both Joint Likelihood method and Semblance Coefficient method, which give identical results. Three strong scatterers are detected beneath the Okhotsk Sea: two around 880 km and one around 1200 km. By comparing our results to the tomography models and plate reconstruction result, we found that the two heterogeneities around 880 km in the north are related to the subducted Pacific plate, while the heterogeneity around 1200 km in the south is unlikely to associate with the subduction of the Pacific or Paleo-Pacific plate.

Along one profile with scatterer locating along the great circle path, we applied 2D Finite Difference simulation to determine the geometry and velocity of the scatterer. In order to improve the model accuracy, we applied a two-step inversion of focal mechanism. First, an initial focal mechanism is obtained with gCAP for global teleseismic data. Then we invert an improved focal mechanism by fitting the three-component records having the target SdP phases, The modelling results suggest the existence of a gentle dipping structure with S-wave velocity drop of 2% at 880 km. This velocity drop is smaller than the expected at least 4% for the phase change of the stishovite contained in the MORB to the CaCl2 type SiO_2, which is typically treated as the main cause of the middle mantle heterogeneities.