Heterogeneous modification and reactivation of craton margin in northeast Asia: insight from teleseismic traveltime tomography of the Korean Peninsula

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Margins of craton lithosphere are prone to ongoing modification process. Marginal tectonism such as slab subduction, continental collision, and mantle dynamics significantly influence properties of lithosphere in various scales. Thus, constraints on the detailed properties of craton margin are essential to understand the evolution of continental lithosphere. The eastern margin of the Eurasian plate is a natural laboratory that allows us to study the strong effects from multiple episodes of continental collision and subduction of different oceanic plates since their formation. Extensive reworking and destruction of the cratonic lithosphere mainly occurred in eastern China during the Mesozoic to Cenozoic, which leaves distinct geochemical and geophysical signatures. Specifically, the Korean Peninsula (KP) is known to consist of Archean–Proterozoic massifs (e.g., Gyeonggi, Yeongnam Massif) located in the forefront in northeast Asia, where current dynamics in the upper mantle and effects due to nearby subducting slabs are the most significant.

Here we present, for the first time in detail, 3-D velocity structure of KP by teleseismic body wave traveltime tomography. Detailed P-wave and S-wave images of the crust and upper mantle were constructed by approximately 5 years of data from dense arrays of seismometers. We newly found a thick high-velocity body beneath the southwestern KP with a thickness of ~150 km, which is thought as a fragment of lithospheric root beneath the Proterozoic Yeongnam Massif. Also, we found low velocities beneath the Gyeonggi Massif, eastern KP margin, and Gyeongsang continental arc-back-arc system, showing significant velocity contrasts (dlnVp of ~4.0% and dlnVs of ~6.0%) to the high-velocity structure. These features indicate significantly modified regions. In addition, there was a clear correlation of the upper mantle low-velocity anomalies and areas characterized by Cenozoic basaltic eruptions, high heat flow, and high tomography, suggesting that there are close associations between mantle dynamics and recent tectonic reactivation.

The presence of a remnant cratonic root beneath the KP and contrasting lithospheric structures across the different Precambrian massifs suggests highly heterogeneous modification along the Sino-Korean craton margin, which includes the KP and North China Craton. A striking localization of lithosphere modification among the different Precambrian massifs within the KP suggests that the structural heterogeneity of the craton margin is likely sharp in scale and thickness within a confined area. We suggest that intense interaction of upper mantle dynamics and inherent
structural heterogeneities of a craton margin played an important role in shaping the current marginal lithosphere structure in northeast Asia.