Imaging of the upper mantle beneath the northeast Asia:
Insights on lithosphere-asthenosphere interactions and the occurrence of intraplate volcanism

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Tectonic activities in continental margin and surrounding regions are complex and enigmatic. We present various seismic images of the crust and upper mantle, along the southern and eastern side of the Korean Peninsula, and adjacent to back-arc rifts (East Sea) in the northeast Asia. The observations provide robust constraints on seismic velocities of interfaces across the Moho, lithosphere-asthenosphere boundary, and astheospheric upper mantle. Relatively thinner crust (<30 km) and lithosphere (<60 km) are found beneath the central part (Gyunggi massif) and beneath the margins in the eastern part of the Korean Peninsula. In contrast, a preserved thicker root of the old continental lithosphere is observed beneath the south-western part of the Korean Peninsula. We relate the trend to sub-lithospheric low velocity structures, which might extend from the upper mantle transition zone vertically and from back-arc regions of subducting oceanic plates horizontally. By triggering upper mantle upwellings, former and current subducting oceanic plates likely affect adding and removing the bottom of the Archean-Proterozoic continental lithosphere heterogeneously. With interactions between the thick lithosphere and surrounding low velocity structures, the process could lead intraplate volcanism by melt generation and uplifting due to localized convections and following buoyancy effects along the margins.

More specifically, the mechanism of the formation and focusing of intraplate magma without particular mantle signatures, i.e., thermal anomaly and mantle shear, still remains elusive. Upper mantle rheology and thermodynamic properties conservatively constrained by high-frequency seismic attenuation and velocities show low viscosity zones are readily formed in the upper asthenospheric depths containing a fraction of melt (~0.05-0.8%) in the average upper mantle. Together with considering upper mantle dynamics, this evidence stresses the small-scale upflux driven by undulations in the lithosphere and asthenosphere boundary is a primary mechanism for intraplate volcanoes. Our estimation supports the ubiquitous occurrence of intraplate volcanoes regardless of localization mechanisms of mantle upwellings (e.g., thermal, or chemical plume), and potentially to be considered as an universal origin of intraplate volcanoes under normal thermodynamic conditions.