Origin of a transition zone-derived mantle plume at Changbai volcano

TAKESHI KURITANI[1]*, QUNKE XIA[2], JIA LIU[3], DAPENG ZHAO[4], MITSUHIRO NAKAGAWA[1]

[1] Hokkaido University, Sapporo, 060-0810, Japan
[2] Zhejiang University, Hangzhou, 310027, China
[3] Second Institute of Oceanography, Hangzhou, 310027, China
[4] Tohoku University, Sendai, 980-8578, Japan

Changbai volcano, located on the border between China and North Korea, forms one of the largest active volcanic fields in East Asia. The subducted Pacific slab has been accumulating in the mantle transition zone under eastern China[1], and the transition zone is remarkably hydrous as evidenced from the electric conductivity observations[2]. A prominent low-Vp anomaly with a plume-like shape is observed in the upper mantle beneath the volcano, which is suggestive of an upwelling of materials from the mantle transition zone[3]. Geochemical studies have also confirmed that materials derived from the mantle transition zone were involved in the magma genesis[4]. In this study, we estimated water content of basaltic magma from the volcano to examine the buoyancy of the transition zone-derived mantle plume.

The water content of a basaltic sample, which is one of the most magnesian plagioclase-bearing samples, was estimated as ~1.5 wt.% using plagioclase–melt hygrometery. Given that the primary magma was in equilibribrium with the mantle olivine of Fo90, the water contents of the primary magma was ~1.2 wt.%. The mantle melting parameters for the magma were estimated by applying the Ocean Basalt Simulator model–1[5] to the trace elements and water content of the primary magma. The result showed that the fraction of pyroxenite in the source mantle was ~12%, the degree of melting was ~7%, the water content of the source mantle was ~500 ppm, and the pressure and temperature of the melt segregation were ~2.6 GPa and ~1350ºC, respectively. In this case, the mantle potential temperature was obtained as ~1330ºC. Considering that the mantle potential temperature for the Changbai magma is well within the range of 1300–1400ºC for MORB, the mantle plume did not have an excess heat relative to the ambient mantle. This observation suggests that the Changbai mantle plume was not a thermal plume but a compositional plume from the mantle transition zone.

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