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Slab-mantle thermal structure beneath northeast Kamchatka Peninsula constrained from high-Mg basalts and andesites

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The Kamchatka Peninsula is one of the most active volcanic arcs and corresponds to subduction of slab near the northwestern edge of the Pacific Plate. The northeastern part of Kamchatka Peninsula involves (i) triple junction including the edge of the Pacific Plate, and (ii) subduction of the seamount chain. As a result, the world-most active volcanic group (Kliuchevskoy Volcanic Group; KVG) with a wide across-arc volcanic zone (~ 400 km) is seen in this area, associated with systematic spatial variations in rock type and chemistry, including adakite near the slab edge (Portnyagin and Manea, 2008; Bryant et al., 2011). This study aims at understanding the physical-chemical conditions beneath the northeastern Kamchatka Peninsula, by studying monogenetic volcanoes and the primitive lavas near the northeastern end of the volcanic chain.

We have performed field survey and sampling of the monogenetic volcanic group (East Cones; EC) in the Kumroch Range where the Eastern Volcanic Front (EVF) terminates. EC are located above the slab of 50-80 km depth (i.e., in a fore-arc region) (Gorbatov et al., 1997) and 60-100 km south from the slab edge. About 15 monogenetic cones are distributed along the eastern cast over ~ 60 km distance. The samples from eight cones have been newly analyzed to yield the first data set on major-trace-isotopic compositions and, the K-Ar age.

The mineral assemblage of EC lavas is uniform: olivine, clinopyroxene, plagioclase, and magnetite. Based on the SiO_2, MgO, and Al_2O_3 contents, the EC lavas are classified into 5 rock-types: high-Mg basalt (HMB), high-Al basalt (HAB), high-Mg andesite (HMA), and other basalts (B) and basaltic andesites (BA). Most of the EC lavas have primitive compositions (FeO/MgO$<$1, Mg#$>$0.63) except for HAB.

All EC lavas have the common geochemical feature of the subduction-related magmas (e.g., HFSE depletion relative to LILE), suggesting important roles of water. Based on hydrous melting experiments of HMB and HMA (Tatsumi, 1982), the water contents for individual primitive magmas are estimated as follows: HMB: 2 wt.%, HAB:4 wt.%, HMA: 4-7 wt.%, B: 2.6 wt.%, BA: 3.3 wt.% respectively. Melting temperature of these primitive melts in the mantle (1.5 GPa) is estimated to be 1100-1200 ℃, based on modeling for HREE abundances and the water contents estimated above, using the hydrous melting relations (Iwamori, 1998). The melting temperature is comparable to numerical model with an average thermal condition in arc setting (Iwamori and Zhao, 2000; Manea and Manea, 2007). Combining these information with the previously published genetic PT and water conditions in the neighboring areas, horizontal heat transport from the slab edge region (i.e., roughly from north to south) as was suggested in the previous studies (Yogodzinski et al., 2007) is not supported. We also estimate the slab surface temperature by using H_2O/Ce thermometer (Cooper et al., 2012). The estimated slab surface temperature is 620 ~ 730 ℃. Unifying the estimated slab surface temperature and the mantle melting temperature, together with trace element and isotopic characteristics, we propose that a subducted seamount which inherited a local thermal anomaly could have enhanced the flux of slab-derived fluid (not slab melt), and caused flux-melting to produce the high-Mg andesite and basalts, in the for-arc region.

Keywords: mantle thermal structure, arc volcano, high-Mg andesite, slab, subducting seamount