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Evolution of Cenozoic upper mantle beneath back arc region in NE Asia

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Back-arc region, an area away from a place where surface of a slab subducting below is at a depth of ˜300km, is characterized by high surface heat flow, slow upper mantle velocity, and continual sporadic volcanism. These lines of evidence suggest that the upper mantle beneath not only subduction zone but also back-arc region is influenced by the subducting and stagnant slab. In order to understand material recycling process by subduction of the oceanic lithosphere, it is, therefore, necessary for us to understand upper mantle dynamics beneath not only subduction zone but also back-arc region.

Eastern margin of the Eurasian Plate is a region where Cenozoic back-arc volcanism extensively and sporadically occur over back-arc width of $>$1000km. Despite numbers of geophysical and geochemical investigations on the upper mantle and rocks in this region, a number of analysis combining phase petrology and geochemistry on volcanic rocks is quite limited. Evolution of thermal structure of the back-arc upper mantle during the Cenozoic and their relationship with volcanism are, therefore, still poorly understood.

Alkaline basaltic volcanism sporadically occurred in Shandong area, center of eastern China, from late Palaeogene to Quaternary. High resolution seismic tomography studies have revealed that there is a slab stagnating beneath eastern China and the western edge of the slab locates beneath around Shandong area. We made systematic petrological and geochemical investigations on Cenozoic volcanism in Shandong area in order to address the issue above.

Most basaltic samples are aphyric ($<$5 vol%) and have olivine phenocryst and minor amount of clinopyroxene and plagioclase microphenocrysts. Several samples contain peridotite xenoliths and olivine crystals with kink band, but there is no lines of petrographic evidence which suggests magma mixing and contamination of crustal material. Basalts in Shandong area are concentrated in K_2O (0.7-2.5 wt%), Na_2O (3-5 wt%), FeO$*$ (11-13 wt%), and incompatible trace elements (30-120 ppm in Nb; 150-400 ppm in Zr, 15-28 ppm in Y; 30-90 ppm in La), poor in SiO_2 content (40-46 wt%), and show relatively undifferentiated chemical composition (7.5-14 wt% in MgO; 100-450 ppm in NiO; 0.9-1.5 in FeO$*$/MgO ratio). Primitive mantle normalized trace element pattern is strongly enriched in LREE and Nb without depletion of high field strength elements relative to large ion lithophile elements or Eu anomaly. Strontium and Nd isotope compositions of the basalts are within the range in epsiron, and $^{87}Sr/^{86}Sr$, from 0 to +6 and from 0.7031 to 0.7045, respectively.

Whole variation of major element composition cannot be reproduced solely by crystal fractionation process. Provided mantle source lithology as peridotite and a certain amount of water in primary melt, mantle potential temperature is estimated to be 1400˜1500^{o}C. Variation of trace element compositions of primary melts cannot be reproduced by melting of primitive mantle or depleted MORB source mantle, but is reproducible by different degree of melting of a single source material of which composition is similar to that of a metasomatized spinel harzburgite xenolith reported from eastern Asia. As estimated melting pressure decreases, degree of melting increases.

By comparing estimated mantle temperature with those beneath surrounding area which includes whole eastern China, Korea, and southwestern Japan, uppermost mantle is the highest beneath Shandong area and mostly depleted in isotopic composition, while the lowest temperature regions are located in northeastern and southeastern China and in Chugoku district, southwestern Japan. This concentric zonation of mantle temperature and geochemical composition with an order of ˜1000km suggests existence of a thermal and chemical asthenospheric mantle anomaly associated with a stagnant slab.

Keywords: alkaline basalt, northeastern China, back arc, Cenozoic