Regional distribution of low-Ni basalt-andesite in the Miocene volcanics around Fukui City, central Japan

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Ishiwatari and Katsuragi (2003; This meeting) reported a basalt boulder with fresh olivine phenocrysts of magnesian (Fo_{86}) composition with very low Ni (less than 0.02 wt.% NiO) from the Ichijo Valley to the east of Fukui City. The bulk rock composition of this basalt boulder and the other Lower Miocene basalts cropping out in the neaby areas are also very poor in Ni (less than 40 ppm at $FeO*/MgO=1.0$). In general, basaltic olivine phenocryst of Fo_{86} may contain 0.2 or 0.3 wt.% NiO, and the above reported olivine is one order of magnitude poorer in nickel. In recent two years, Yamazaki and Ishiwatari studied volcanic rocks of the Lower Miocene Ito Formation in the Nyu Mountains to the west of Fukui City, and found two outcrops of the low-Ni basalt with fresh olivines as well as some fresh river boulders and altered outcrops. The olivine phenocrysts in these rocks are slightly richer in iron (Fo_{83}) than that in the Ichijo Valley boulder, but are similarly poor in Ni (less than 0.02 wt.% NiO). We also find that most volcanic rocks (basalts, andesites and dacites) of the Ito Formation are also poor in Ni in their bulk rock chemistry, though some moderately Ni-rich arc basalt, calc-alkaline andesite and adakite are present.

In view of the progress of our study, it is now clear that the Miocene volcanic rocks (so-called Green Tuff) distributed around the Fukui City are regionally depleted in Ni, in comparison with the Cenozoic volcanic rocks of the other parts of Japan and oversea world. Low-Ni basalt was reported from Tonga-Kermadec arc, and pyroxenite melting is proposed to explain its low-Ni nature. Other origins such as crystal fractionation of magma at extremely low oxygen fugacity (allowing crystallization of Ni metal) or extensive olivine fractionation from a magma generated by partial melting of extremely depleted mantle (with high Fo olivine) are possible, but the presence of magnetite inclusions in olivine (which indicates moderate oxygen fugacity) and relatively enriched REE and incompatible trace-element patterns do not support these origins. Thus, pyroxenite melting is the most probable origin for the low-Ni basalt.

Pyroxenites commonly occur as a few 100 m-thick layer between the gabbroic rocks of the lower crust and the peridotites of the upper mantle in the oceanic lithosphere (or ophiolite). It is possible that a part of an old subducted lithosphere remains in the present wedge mantle by jump of subduction zone or change of the direction of subduction, and such oceanic lithosphere may have been melted by increasing temperature of the wedge mantle most probably enhanced by the upwelling of the asthenosphere associated with the Early Miocene opening of the Japan Sea. Close association of the low-Ni basalt with ordinary island-arc basalt, andesite and adakite of moderate Ni contents suggests that the source region of the magmas were occupied not only by pyroxenite but also by some gabbroic rocks (for adakite) and peridotites (for Ni-rich basalts). Large ophiolite belts on the earth extends for more than a few 100 km, and the sub-surface, relict oceanic lithosphere in the wedge mantle may have similar size. At present, the low-Ni basalts are very minor among the arc magmas, but their wide distribution in the Fukui area suggest their major role in the supra-subduction zone magmatism.