H2O distribution in the mantle wedge and origin of arc magmas in the Sengan region, Northeastern Japan

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Subduction zone processes are considered to play important roles in the geochemical evolution of the mantle-crust system (e.g; Paul et al., 2002). Understanding chemical and physical processes in subduction zone is key to investigate dynamics and material/thermal evolution of the earth. Recent geophysical and geological studies suggest that there are along-arc periodical structures with about 50km intervals in the mantle wedge and crust beneath Northeastern Japan: east-west trending volcanic zones (Kondo et al., 1998), bouguer anomaly and thick seismic low velocity zones beneath the volcanic zones appear periodically along the arc (Nakajima et al., 2001; Tamura et al., 2002). These observations could be related to along-arc variations of melting conditions and processes in the mantle wedge and crust of northeastern Japan. We investigate thermal and compositional states of the mantle wedge and crust beneath the volcanic zone of Northeastern Japan and discuss the origin of the periodical structures, based on the compositional variations of volcanic rocks collected from Quaternary volcanoes in a volcanic region, the Sengan region.

The Sengan region is a volcanic region of 30km X 30km, and involves 45 Quaternary volcanoes, including those aligned on the volcanic front (Committee for Catalogue of Quaternary Volcanoes in Japan, 1999). Basaltic and andesitic volcanic activities have occurred continuously to the present after the eruption of voluminous Tamagawa welded tuff (dacite to rhyolite) around 2Ma. Volcanoes in the Sengan region are divided into following two groups, based on the compositional trends. Compositional trends of volcanoes of the first group show a negative correlation between Al2O3 and FeO∗(as a total iron oxide). Compositional trends of volcanoes of the second group show linear Al2O3- and FeO∗-depletion trends with decreasing the MgO content. Thermodynamic calculations using MELTS (Ghiorso and Sack, 1995) and reported crystallization experiments (e.g; Kawamoto, 1996; Hamada and Fujii, 2008) suggest that the compositional trend of the second group is reproduced by crystal fractionation at a relatively high H2O content (over 2 wt. %), whereas the compositional trends of the first group are reproduced at a low content (less than 2 wt. % H2O). In addition to the crystal fractionation, evidences for magma mixing of basalt and dacite are observed in the second group, based on mass balance calculation of the major element and AFC calculation of the incompatible trace elements. The major element composition of the silicic end member magma is similar to that reproduced by melting experiments of amphibolite (e.g; Beard and Lofgren, 1991).

The lavas without magma mixing are mainly distributed along the outer rim of the region, while those with magma mixing are distributed in the central part of the Sengan region associated with the crater of the Tamagawa welded tuff.

Melting conditions in the mantle wedge have been estimated to minimize the difference between the compositions of partial melt calculated at a given P, T, H2O-content (Ghiorso et al., 2002) and the primary magma estimated from the observed volcanic rocks. The calculation shows that mantle melting has occurred with 1 wt. % H2O at 1.0 GPa beneath the central part, while it has occurred with 0.3˜0.4 wt. % H2O at 1.4 to 1.5 GPa beneath the outer rim. Our result suggests that the fluid has been supplied to the central part more than the rim part, and that the crustal melting has occurred in the central part where the fluid flux is greater. Therefore it is suggested that mantle derived wet magma had supplied both heat and H2O to the crust, and induced crustal melting and magma mixing at the central part of the volcanic cluster, linking the mantle and the crustal melting processes. On the other hand, beneath the outer rim, basaltic magmas ascended to the surface without causing crustal melting.