Redox state of magma in the deep crust beneath NE Japan arc: constraints from cumulate xenoliths from Ichinomegata Maar

*Naoya Tsushima[1], Michihiko Nakamura[1], Yasuhiro Yanagida, Takeyoshi Yoshida[1]

1. Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University

Significant number of previous studies suggest that arc magmas have relatively higher fO_2 than that of mid ocean ridge basalt (MORB) or oceanic island basalt. It has been a matter of debate whether the oxidized nature of subduction zone magmas is derived from the mantle source or acquired through their differentiation in the crust. Behavior of sulfide and sulfate is sensitive to and thus can be a tracer of the redox state (or oxygen fugacity, fO_2) of magmas, because the valence state of sulfur in the magma changes from -2 to +6 through oxidation. The arc's lower crust in the subduction zones has been recently attracting many attentions as a region where magmas may change their chemical compositions significantly. The Ichinomegata maar, located in the back arc of NE Japan, is known for the rare occurrence of deep-crustal xenoliths in subduction zones. A recent petrographic study revealed that mafic xenoliths are fractionated cumulates of the calc-alkaline host magmas (Yanagida et al., 2018). Those cumulates are, therefore, the best samples to investigate the differentiation conditions of arc magmas.

In this study, we found both pyrrhotite and anhydrite from the deep crustal mafic xenoliths from the Ichinomegata maar. Almost all the pyrrhotite grains occur as small rounded inclusions whereas some as relatively large irregular shaped interstitial phases. Pyrrhotite inclusions are mainly in hornblende and some inclusions are in clinopyroxene and plagioclase. Magmatic pyrrhotite shows approximately constant non-stoichiometoric compositions (Fe+Ni+Cu/S) and a trend from Ni-rich to Cu-rich metal composition. Anhydrite occurs as inclusions in plagioclase. The occurrence of anhydrite and the fO_2 calculated from the pyrrhotite non-stoichiometry show fO_2 of +1 log unit above Ni-NiO buffer, which is almost the same as the average value of arc magmas and clearly higher than that of MORB. This study shows that the oxidized nature of the magmas of the Ichinomegata-maar was already achieved in the deep crust and the shallow oxidation model should be discarded.

Keywords: Sulfide , Sulfate , Ichinomegata maar, Mafic xenoliths

