Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

SCG089-P03 Room: Convention Hall Time: May 26 17:15-18:45

Magma generation and evolution processes of Calc-alkalic and Tholeiitic magma series in Azuma Volcano, Northeast Japan

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In sub-alkalic volcanic rocks two differentiation trends, calc-alkalic (CA) and tholeiitic (TH), are recognized. CA magmas are dominant in continental arcs and mature arcs with thicker crust, whereas TH magmas characterize the magmatism in intra-oceanic arcs. However, both types of magma are erupted along the Quaternary volcanic front of the NE Japan Arc, e.g., at Zao volcano. The genetic relationship between these two magma series is therefore critical in providing a better understanding of andesite genesis and arc crust evolution. Tatsumi et al. (2008) argued that Zao TH rocks were formed by melting of lower-crustal amphibolite and CA rocks were formed by magma mixing between the mantle-derived basalt magma and the crust-derived basaltic andesite to dacite magmas. Azuma volcano is located south of Zao volcano and also erupts CA and TH magmas. We show that the geochemical characteristics of these magmas verify the magma genesis and evolution model developed for Zao.
Unlike Azuma TH rocks, Azuma CA rocks show a typical CA variation trend on a SiO2vs. total FeO/MgO diagram (Miyashiro, 1974). Azuma TH rocks have enriched radiogenic isotope signatures ($^{87}Sr/^{86}Sr$ = 0.7055-0.7059, $^{143}Nd/^{144}Nd$ =0.5126-0.5127, $^{206}Pb/^{204}Pb$ = 18.48-18.49, $^{207}Pb/^{204}Pb$ = 15.58-15.60; $^{208}Pb/^{204}Pb$=38.6), are depleted in incompatible elements and contain little petrographic evidence for magma mixing. The CA rocks on the other hand, have depleted radiogenic compositions ($^{87}Sr/^{86}Sr$ = 0.7039-0.7047, $^{143}Nd/^{144}Nd$ =0.5127-0.5128, $^{206}Pb/^{204}Pb$=18.43-18.46, $^{207}Pb/^{204}Pb$=15.56-15.58; $^{208}Pb/^{204}Pb$=38.5) and contain strong evidence for magma mixing. These observations are similar to the relationships between TH and CA rocks from Zao. The cores of plagioclase phenocrysts in the TH basalts have higher Sr isotope ratios ($^{87}Sr/^{86}Sr$=0.7058-0.7062) and anorthite contents (An% =80-90). Plagioclases in Azuma TH andesites and CA rocks (basalts and andesites) exhibit a wide range of anorthite contents (An%=48-94) and Sr isotope ratios ($^{87}Sr/^{86}Sr$=0.7039-0.7056). Together with the estimated melt compositions in equilibrium with each plagioclase phenocryst, these observations indicate that 1) Azuma TH basalts originated from a source enriched in radiogenic compositions and depleted in incompatible elements, and 2) Azuma CA basalts and andesites and TH andesites are formed by mixing between three end-member magmas; a mafic end-member with similar geochemical characteristics to the Zao CA primitive basalts, a felsic end-member, and a mafic end-member, which both have a source in common with the Azuma TH basalts.
We conclude that the magma generation and evolution model developed by Tatsumi et al. (2008) for Zao is also applicable to the Azuma TH and CA rocks. Applying the model, Azuma TH basalt magmas are derived from melting of mafic lower crust, whereas Azuma CA rocks and TH andesites evolved through mixing of mantle-derived basalt magmas (similar to the Zao CA primitive basalts) and crust-derived mafic or felsic magma. Zao TH andesites evolved as a result of magmatic fractionation. Azuma TH andesites show less evidence for mixing than Azuma CA rocks. This indicates that magmatic fractionation processes play a more important role in the evolution of Azuma TH andesites than they do in that of the CA rocks. We infer that Azuma TH andesites were formed by the magmatic fractionation of a mixture of basaltic magmas, which

were dominated by crust-derived magma compositions.
Tatsumi, et al. (2008) New Insights into Andesite Genesis: the Role of Mantle-derived Calc-alkalic and Crust-derived Tholeiitic Melts in Magma Differentiation beneath Zao Volcano, NE Japan. J. Petrol., 49, 1971-2008.

Keywords: Northeast Japan arc, Azuma Volcano, Calc-alkalic and Tholeiitic magma series,
Sr isotope micro-analyses of plagioclase, Sr-Nd-Pb isotopic composition