Generation of TH and CA suite magmas in the Quaternary NE Japan arc

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Tholeiitic (TH) and Calc-alkaline (CA) suite lavas frequently coexist at the Quaternary volcanos in the NE Japan arc. Recent works suggested that the origin of some low-K TH basalt was melts produced by high-degree melting of a lower crustal amphibolite (Nekoma volcano: Kimura et al., 2002; Zao volcano: Tatsumi et al., 2008; Azuma volcano: Takahashi et al., 2012). We examined the generation process of the TH/CA suite lavas over the NE Japan arc including volcanic front lavas from Osore, Hakkoda, Iwate, Akita-koma (North group), Zao, Azuma (Central group), Nasu, Takahara (South group) and rear-arc lavas from Chokai using bulk rock Sr-Nd-Pb-Hf isotope compositions and Sr-Pb isotope compositions of plagioclase phenocrysts analyzed by in-situ micro-analytical techniques.

The TH/CA suite lavas at the volcanic front were classified into three groups by the isotopic compositions. The North group lavas are derived from depleted source with narrow variations (e.g. 87Sr/86Sr: 0.7038-0.7042), and the variations between TH and CA sites are narrow. The Central group lavas have wide isotopic compositions (e.g. 87Sr/86Sr: 0.7036-0.7062) with relatively enriched source for the TH lavas than that for CA. The South group lavas have enriched source composition (e.g. 87Sr/86Sr: 0.7043-0.7062) with the TH lavas usually from depleted source than for CA, although both the TH and CA lavas show a continuous isotopic trend when their isotopic compositions plot against element abundances. The Rear-arc TH/CA suite lavas have the most depleted source among others (e.g. 87Sr/86Sr: 0.7029-0.7034), and TH lavas are from slightly enriched source than for CA.

Tatsumi et al. (2008) and Takahashi et al. (2012) argued that the Central group TH basalt formed by melting of the lower crustal amphibolite, whereas CA lavas of the same group formed by magma mixing between a mantle-derived basalt and a felsic magma from the crust or fractionated felsic magmas from TH basalt. The rear-arc Chokai lavas have affinities with the TH/CA at Zao and Azuma. Therefore, the Chokai lavas can be explained by the same model for the Central group lavas. However, the melting conditions and geochemical composition of the source mantle and the lower crust amphibolite should differ from those for the Central group lavas. In contrast, North and South group lavas indicate that the parental basalt for both the TH and CA suites is common. The TH suite lavas were derived from the basalt by fractional crystallization, whereas the CA suite lavas formed by magma mixing between the basalt and felsic magmas from enriched crustal source. Moreover, the isotopic contrasts between the mantle and the crustal source rocks are smaller in the North group than that for the South group lavas. These results indicate that the genetic processes and the source materials of the TH/CA suite vary considerably for the Quaternary NE Japan arc and, therefore, any unique model cannot account for the origin of TH/CA series.