Trace elements and Sr-Nd-Hf-Pb isotopic composition of Miocene Tomari volcanic rocks, Shimokita Peninsula, Aomori, NE Japan

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Introduction

Tomari volcanic rocks, located in Shimokita Peninsula, Aomori Prefecture, NE Japan, formed volcanic front at Miocene period. They include primitive tholeiitic basalts (Takimoto, 1986), therefore volcanic activity in this area strongly suggest relation to opening Japan Sea back-arc basin caused by upwelling asthenosphere. Volcanic activities divided into 4 stages and their K-Ar dating have been reported 13-15 Ma (Watanabe *et al.*, 1993). This study use boring core sample dug from Shimokita Peninsula (SN-010 core; drilling stop depth is 1484 m). Tomari Formation appear deeper than 308.82 m in this core and it has been reported 13.1-14.5 Ma at 385 m (micro fossils), 16.0 Ma, 24.2 Ma (zircon U-Pb dating) at 467 m and 818 m, respectively (Nuclear Regulatory Agency, 2016).

Lithofacies and occurrence of Tomari volcanic rocks

We collected samples from the 1st and 2nd stage of surface Tomari Formation and 8 depth from SN-010 core. Core samples are volcanic breccia, lava and lapilli tuff. And the 1st stage surface volcanic rocks include reddish rounded gravel and pillow lava fragments into deposition layer with lamination. The 2nd stage surface volcanic rocks mainly erupted as pillow lava and hyaloclastite.

Geochemical characteristics

Shallow core samples (SCS; shallower than 862.26 m) and middle core samples (MCS; 999.00-1003.20 m) show middle-K series and deep core samples (DCS; deeper than 1197.86 m) show low-K series. Incompatible elements (especially LILE) concentrations of SCS and MCS are higher than DCS. Surface 1st and 2nd stage samples are plotted middle-K series. Incompatible elements features are similar as SCS and MCS. Multi-elements diagrams normalized by N-MORB show high LILE, negative Nb-Ta and positive Pb anomalies, they mean these rocks were produced at subduction zone. Sr-Nd isotopic composition of MCS-DCS show more depleted and SCS have more enriched composition. Pb isotopes are plotted into volcanic rocks field of Quaternary volcanic front of NE Japan without difference each strata. Primitive tholeiitic basalts are produced in 2nd stage and they show most enriched isotopic composition (Hanyu *et al.*, 2006). Primitive basalts and SCS-MCS have higher Ba/Nb than DCS.

The relationship to opening Japan Sea event

SN-010 core dating suggest that volcanic activity formed Tomari Formation already started late Oligocene-early Miocene. Whole-rock chemical composition of 563.48 m samples is similar to surface 1st stage volcanic rocks, therefore upper level of core sample may be comparable with surface 1st stage volcanic rocks (Aizawa *et al.*, 2018).

Enriched isotopic composition of primitive basalts cannot be explained by assimilation of lower crust due to their high MgO, Cr, Ni composition. In addition, SCS-MCS and primitive basalts have higher Ba/Nb and MCS-DCS show depleted isotopic composition. Thus, it is considered that partial melting of DMM produced volcanic rocks of MCS-DCS, and MCS (high Ba/Nb) were strongly affected slab derived components. Then, volcanic rocks of SCS and surface samples were originated magma from sub-arc

enriched lithospheric mantle (EM II-like isotopic composition).

Petrography of DCS and MCS suggest volcanic activity on land environment because there are reddish volcanic gravels at 1482.00 m and 1335.87 m, and 999.00 m lapilli tuff matrix color is red. Although SCS have no evidence for judging stationary environment of volcaniclastic rocks, the 1st stage outcrop include rounded reddish volcanic gravels into lamination, and the 2nd stage volcanic rocks are mainly erupted as pillow lava and hyaloclastite. These occurrences suggest the development of lifting at late Oligocene-early Miocene period and stationary environment change from on land to underwater. The change of geochemical features, from depleted to enriched composition, may mean to change partial melting position in sub-arc mantle due to the hot asthenosphere upwelling under this area.

Keywords: Miocene, Volcanic front, Japan Sea, Back-arc basin, Tomari volcanic rocks

