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SCG10-P01 Room:Convention Hall Time:May 22 18:15-19:30

Temperature of primary magma from Sannome-gata volcano, NE Japan Arc

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Materials and energy transport in subduction zones has played important roles in the Earth's evolution, and has been investigated extensively from petrological, geochemical, experimental, numerical, and geophysical studies. In these approaches, petrological studies on volcanic products can provide direct information on the thermal and geochemical states of the sub-arc upper mantle. However, arc volcanic rocks are commonly differentiated from their primary compositions, and it is not easy to extract reliable information of the source mantle from the rocks.

In this study, the temperature condition is estimated for a primitive basaltic scoria from Sannome-gata volcano, which is located in the rear arc of the NE Japan arc. A petrological study was carried out on the scoria by Yoshinaga and Nakagawa (1999), and they showed that some scoria represent nearly primary magmas. We have collected many scoria samples from the same outcrop, and detailed petrological and geochemical analyses have been performed for selected samples. The samples show significant variations in whole-rock compositions (SiO_2: 46.7-56.2 wt.%; MgO: 2.4-11.1 wt.%). The samples with MgO $>$~9.5 wt.% ("magnesian samples") are mostly homogeneous in $^{87}Sr/^{86}Sr$ ratios (~0.70318), whereas those with MgO $<$~9.0 wt.% ("less magnesian samples") have higher $^{87}Sr/^{86}Sr$ ratios ($>$0.70327) and the ratios tend to increase with decreasing the whole-rock MgO contents. The phenocrysts contents correlate with the whole-rock compositions; the magnesian samples are aphyric, containing ~5 vol.% olivine microphenocrysts, and the less magnesian samples contain plagioclase, alkali feldspar, and quartz phenocrysts, as well as olivine microphenocrysts. The Mg# of olivine microphenocrysts is up to Mg#90.

The phenocrysts assemblage and the correlation between the $^{87}Sr/^{86}Sr$ ratios and the whole-rock major element compositions clearly suggest that the less magnesian samples experienced extensive interaction with the crust. In contrast, the magnesian samples may have been essentially free from crustal assimilation, because they are aphyric and the $^{87}Sr/^{86}Sr$ ratios are homogeneous irrespective of the variations in the whole-rock major element compositions (9.5-11.1 wt.% in MgO). Considering that the magmas can equilibrate with ~Mg#90 olivine, the magnesian samples may represent primary magmas. Using thermodynamic calculations and the observed petrological features of the magnesian basalts, the temperature of the magmas shortly before eruption is estimated to have been ~1220^{o}C, and the water content of the magma at depth is estimated to have been $>$~3.1 wt.%. Given that the water content of the magma was 3.1 wt.% and the magma was generated at 2 GPa (Kimura and Yoshida, 2006), the temperature of the source mantle is estimated to have been ~1300^{o}C.

Keywords: Island arc magma, mantle, temperature, water content

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Thermal history of lower crustal xenoliths from Ichinomegata Maar, NE Japan

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Xenoliths derived by maar eruptions are important source of information on the deep earth. In this study, we carried out petrographical study of crustal xenoliths from Ichinomegata Maar, NE Japan to constrain their origin and ascent processes. Among the xenoliths correction of Tohoku University, we selected seven hornblende (Hb) gabbro samples having cumulate texture. These samples include small amount (<˜10 vol. %) of fine-grained crystals of plagioclase, olivine, clinopyroxene and magnetite with or without trace amount of intergranular glass. The Hb-gabbro xenoliths were divided into two types on the basis of modal composition and Hb mineral chemistry, one with abundant (ca. 50?65 vol.%) aluminous pargasite-tschermakite (Type-2) and the other less abundant (15?35 vol.%) and less aluminous (Type-1). The amphibole geothermo-barometer yielded equilibrium P-T conditions for the core compositions as follows: 400?650 MPa and 930?980oC for Type-1, and 500?1000 MPa and 900?1020oC for Type-2. These temperatures are higher than hydrous basaltic solidus, showing that the Hb-gabbro xenoliths were derived from cumulate zones of magma reservoirs in the lower and middle crust. The anorthite content (An#) of plagioclase cores are 85?95 mol%, which is consistent with the estimated temperatures. In order to constrain xenoliths capturing and ascent processes of host magma, we examined rim compositions and fine-grained crystals in the melt. In Type-1 xenoliths, Hb grains have relatively wide rim with relatively AlIV and alkali-rich, high Mg# (Mg/(Mg+Fetotal) in mol.%) compositions compared to the core. The plagioclase grains have a rim with Na-rich compositions (An# ˜50?70) that overlap with the range of fine-grained plagioclase composition. These mineralogical characteristics show that rim compositions of Hb and Pl record heating event and magma ascent process, respectively. In Type-2 xenoliths, by contrast, Hb crystals have very thin, if any, rim and fine grained crystals are much less than Type-1. This indicates that Type-2 xenoliths have a shorter heating duration than Type-1, i.e., Type-2 were derived from the lower crust immediately after they were captured by the basaltic magma. The preheating event of Type-1 may correspond to the injection of hot basaltic magma into the lower crust.

Keywords: Ichinomegata, xenolith, hornblende Gabbro

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New geochemical classification of global boninites

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Boninite is an important volcanic rock type associated with the initiation of a subduction zone. It is generally defined as a variety of high-magnesian andesites with $SiO_2 > 52$ wt%, $MgO > 8$ wt% and $TiO_2 < 0.5$ wt%. Compilation of the global data on bulk geochemistry of boninites defined as such shows a broad compositional range consisting of a number of regional trends which are characteristic to the individual volcanic suites, suggesting that the genetic conditions of boninite magmas are highly variable dependent on the tectonomagmatic situations. Therefore, re-evaluation of the classification scheme of global boninites is crucial to understand the genetic conditions of boninite magmas and their relationships with the tectonomagmatic settings.

Boninite is usually a part of volcanic rock suites which forms a continuous fractionation trend from magnesian ($MgO > 20$ wt%) boninite through less magnesian andesite to dacite and rhyolite. These regional fractionation trends form subparallel curves on a SiO_2-MgO plot, namely boninite series, that differ from volcanic suites to suites. We advocate to classify these boninite-series rocks into high- and low-Si boninites by a discrimination line running through points of SiO_2 = 55 wt% at MgO = 20 wt% and SiO_2 = 59 wt% at MgO = 8 wt% on a SiO_2 vs. MgO plot. Boninites from Ogasawara (Bonin) Islands on the IBM forearc and western Pacific ophiolites in Papua New Guinea and New Caledonia show compositional trends of high-Si boninite series which are controlled by crystal fractionation of olivine and orthopyroxene. Whereas, boninites from Tonga arc, DSDP Site 458 and Guam, and Neo-Tethys ophiolites such as Oman and Troodos show Low-Si boninite series trends controlled by olivine, orthopyroxene and clinopyroxene fractionation. Low-Si boninite-series rocks do not evolve across the discriminate line by crystallization differentiation. Primary magmas of Low-Si boninites are characterized by enhanced LILEs and LREEs by slab-derived H_2O-rich fluids. Melting experiments of peridotites have demonstrated that low-Si boninite-like melts with $SiO_2 < 54$ wt%, $MgO < 23$ wt% could be produced under 1-2.5 GPa and dry and water-undersaturated conditions. On the contrary, SiO_2-rich ($SiO_2 > 54$ wt%) melts like high-Si boninites have never been produced by peridotite melting experiments. Instead, highly depleted REEs and high Zr/Ti ratios of high-Si boninite magmas require slab-derived felsic melts that reacted with the depleted harzburgite in the mantle wedge.

Keywords: boninite, Ogasawara (Bonin) Islands, Oman ophiolite, Troodos Ophiolite

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Primary boninite magmas explored from melt inclusions

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Boninite melt inclusions were analyzed in Cr-spinel collected from beach sand from Mukojima, Chichijima, Anijima and Ototojima, Bonin Islands. The common constituents of the inclusions are quenched glass, daughter minerals which grew after trapping, and euhedral crystals of olivine, orthopyroxene and clinopyroxene that were trapped with the surrounding melt, and shrinkage bubbles. We classified the inclusions into 6 types (Type-A - F) based on the combination of the constituents and their textures. The difference in these inclusion types inherited from the melt compositions and the cooling history dependent on the mode of occurrence of the host rocks. Because of the homogeneity of the glass in inclusions and the host spinel adjacent to the inclusion walls, the bulk compositions of quench glass with or without quench crystals (Type-A, B, E and F) are considered to represent the liquid compositions when captured by the host spinel. Major and trace element compositions of melt inclusions show a wide range of boninitic compositions with SiO_2 53-63 wt.%, TiO_2 0.02-0.25 wt.%, Al_2O_3 6-13 wt.%, MgO 8-23 wt.%, CaO 4-11 wt.%, Zr/Ti 0.01-0.04, Gd/Lu 2.4-7.2 and Gd/La 0.24-0.87. We classified the compositions of melt inclusions into five types. BIC (Boninite Inclusion Compositions)-1 is characterized by a low-SiO_2 trend and belongs to high-CaO boninite series. It has a subhorizontal chondrite-normalized pattern with high REE abundances. These features are similar to low-Si boninite by Kanayama et al. (2012). BIC-2 is characterized by relatively high CaO content and low Zr/Ti, which resembles to high-Si type 2 boninite by Kanayama et al. (2012). BIC-3 shows a low-Ca and low-SiO_2 trend. BIC-4 and BIC-5 are typical low-Ca boninite with high Zr/Ti ratios and high SiO_2 contents. However, BIC-4 has a lower Al_2O_3 content than BIC-5 and a U-shaped chondrite-normalized REE pattern and is mostly sampled from Mukojima. On the other hand, BIC-5 shows a characteristic V-shaped chondrite-normalized REE pattern. In general, BIC-types show a systematic relationship with the host Cr-spinel compositions. BIC-1, 2 and 3 are hosted by low-Cr# spinel, whereas BIC-4 and 5 are hosted by high-Cr# spinel. I have estimated the pressures and temperatures for the most primitive melt inclusions in each BIC type to have been in equilibrium with the mantle peridotite under anhydrous or hydrous conditions by using the olivine-liquid geothermometer by Putirka et al. (2007) and the olivine-orthopyroxene-liquid geobarometer by Putirka (2008). As a result, it is shown that BIC-1 type was generated in higher pressure condition than other BIC types.

Keywords: boninite, melt inclusion, primary magma composition, Cr-spinel

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Magmatic accretion and backarc opening controlling crustal structure of the Izu-Ogasawara-Mariana island arc

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has carried out seismic surveys using a multi-channel reflection streamer system and ocean bottom seismographs (OBSs) since 2002. Through these surveys, we obtained a lot of velocity structures and reflective images across and along the arc. The arc crust has strong variation in the crustal thickness and is composed of an upper crust with a P-wave velocity (Vp) of 4.5-6.0 km/s, a continental middle crust with Vp of 6.0-6.5 km/s, a lower crust with Vp of 6.5-7.5 km/s and with much proportion, and mantle with lower Vp of less than 8 km/s beneath the arc. In the lower crust, two layers are distributed, one is a thin upper layer with Vp of 6.5-6.8 km/s and the other is thick lower layer with Vp of 7.0-7.5 km/s. The characteristics of the velocity structure of this region are thick crust with much volume of a layer with Vp of 6.0-6.8 km/s and broad distribution of high Vp lower crusts. The former has developed lower crust adding the thick middle crust. Although the crustal thickness along the volcanic front is not homogeneous but various, the rough thicknesses are 20-25 km, 10-15 km and 15-20 km at the northern, central and southern arcs. The change of the crustal thickness is mainly brought by the middle crust. Such variation of the crustal structure can be seen around the rear arc and forearc regions, and we confirmed three rows of the thick crustal chain like the volcanic front. The thickest crusts, however, distribute beneath not the volcanic front but initial rifting region. The Sumisu rift in the northern arc and the northern tip of the Mariana Trough has thickest crust and the origin is thick lower crust with high Vp of over 7 km/s. Inside of the crust is also heterogeneity. In particular, pairs of thick middle crust and thin upper part of the lower crust or thin middle crust and thick upper part of the lower crust are identified. The thick upper part of the lower crust was detected beneath the rhyolite volcanoes. On the other hand, the middle crust beneath the forearc region is thinner than that of the volcanic front. This suggests that the variation of the crustal composition depends on the situation of crustal differentiation and degree of the crustal evolution. The latter distributes broadly at eastern half of the Shikoku Basin, between the rear arc and the volcanic front and between the volcanic front and a row in the thick arc crusts in the forearc region. Over the high velocity lower crust, many normal faults are identified on the reflection records. Areas with normal faults are in backarc side like the Sumisu rift, and front side of the volcanic front also has half graben with normal faults. The central arc has much volume of the high velocity lower crust between the rear arc and forearc regions except a part of the volcanic front. And the twice timing that these normal faults were activated was recorded on the basement. The degree of the backarc opening and the crustal thickening by magmatic accretion at a bottom of the crust control the arc structures, which are the crustal thickness, the crustal compositions of the middle crust plus the upper part of the lower crust and the proportion of the high velocity lower crust. At the eastern end of the arc, it is possible that a part of the old oceanic crust is distributed. The Ogasawara ridge has complicated and asymmetry structure and has thin crust locally. Inside the crust, there are no clear layers with high acoustic impedance and its velocity distribution shows strong heterogeneity. This suggests that initial subduction and the accompanied subsidence occurred in relative short period.

Keywords: Izu-Ogasawara-Mariana arc, velocity structure, crustal evolution, backarc opening, ocean bottom seismographs, MCS