Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC54-01 Room:411 Time:May 1 09:00-09:15

Eruption History and Future Scenario of Sinabung volcano, North Sumatra, Indonesia

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Sinabung Volcano is an andesitic stratovolcano located 40 km northwest of Lake Toba, North Sumatra. The activity began after the latest caldera-forming eruption of Toba Lake (ca. 74ka). The eruption history can be divided into two stages (old and young stages) based on topographical and geochemical features. The edifice is characterized by multiple thick lava flows/domes, and their collapsed materials of block-and-ash flow and associated surge deposits. The lava spine is located at the southern end of one of the summit craters which trend in N-S. Pumice-fall deposits by relatively large explosive eruptions, such as plinian- to subplinian types, were not recognized. The last magmatic eruption before 2010 occurred during 9 to 10th century, whose products are mainly pyroclastic-flow deposits, distributed in the SE slope.

The present activities began with phreatic events in August and September 2010. It resumed its activity in September 2013 with phreatic events. After the repeated phreatic to phreatomagmatic events, lava appeared in the summit crater in late December and started its partial collapse on 30 December. Several tens collapses occurred everyday in January 2014. Those pyroclastic flows descended on the SE slope of the volcano and traveled 4.5 km in maximum.

Lavas of the volcano are basaltic andesite to andesite in composition, and andesitic lavas contain hornblende phenocrysts. Although old lava have a SiO2 range similar to young lavas, the old lava are more enriched in K2O than the young lava. The lava spine is highly enriched in SiO2 and extremely depleted in Na2O, a result of high alteration by volcanic gases, suggested by the mineralogical features. Bulk composition of 2010 ash seems to be intermediate between the young lava and the altered lava spine. In contrast, pumice of 2013 eruption has a similar composition of juvenile materials of 9-10th eruption.

Before the 2013-2014 events, highly possible scenario for future eruption have been proposed the similar case of lava-dome eruptions at Unzen, Japan, in 1991-95 and at Soufriere Hills, Montserrat, West Indies, in 1995-present, based on the eruption history. The present eruption at Sinabung follows the proposed scenario of the highest probability.

This work was supported by SATREPS research project (Multi-disciplinary Hazard Reduction from Earthquakes and Volcanoes in Indonesia) and the Indonesian Center for Volcanology and Geological Hazard Mitigation (CVGHM).

Keywords: Indonesia, Sinabung, volcanic eruption, eruption history, Scenario, pyroclastic flow

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC54-02 Room:411 Time:May 1 09:15-09:30

Petrological study of monogenetic volcanoes in the fore-arc region of the northern Kamchatka Peninsula

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The western part of the Pacific Plate is subducting under the Okhotsk Plate along Kuril-Kamchatka Trench, and the northern part of it is subducting under the Bering Sea Plate with high obliquity along the western Aleutians arc. The three plates form the Aleutian-Kamchatka triple junction (Eichelberger *et al*., 2013). The northern edge of the Pacific Plate is separated from Bering Sea Plate by transform fault, and the mantle edge beneath the Kamchatka Peninsula is thought to be open towards the Bering Sea.

There are at least 29 active volcanoes in the Kamchatka Peninsula. From the east to the west, arc volcanism on the Kamchatka Peninsula forms three zones parallel to the Kamchatka trench: the Eastern Volcanic Front (EVF), the Central Kamchatka Depression (CKD) including Klychevskaya Volcano Group (KVG) where the large volcanoes concentrate, and the Sredinny Ridge (SR) in the back arc side.

Along EVF, the straight volcanic chain is terminated around 55^{o}N (near the Kizimen volcano), and in further north the volcanic chain seems to deflect toward KVG corresponding to deeper depth of subducting slab. However, monogenetic volcanoes on the northward extension of the EVF exist and were studied in 1960s, called ‘ Kumuroch range ’ (Fedororenko., 1969). The present-day slab depth beneath the monogenetic volcanoes is about 60km (Gorbatov *et al*., 1997), and the crustal thickness is about 20-30km (Levin *et al*., 2002). These volcanic rocks were reported as basalt to andesite, having relatively high MgO content ($\sim$11.8 wt. %) and low FeO/MgO ratio ($<$1.0) (Uspensky and Shapiro., 1984). In summer 2013, we have identified 15 monogenetic volcanoes in this area (hereafter ‘ East Cone volcanic group ’ , EC) by using stereogram, and had investigated 8 volcanoes by using a helicopter.

In this study, we aim to reveal the origin of the EC lavas. For this purpose, we have first examined mineral assemblages under optical microscope and analyzed the whole rock major element compositions by XRF. All 16 samples are classified as basalt or basaltic andesite, of which the two lavas contain xenoliths, and one sample oxidized to red. The rocks exhibit porphyritic to seriate texture, containing plagioclase, clinopyroxene, olivine, opaque minerals, although, the proportion of minerals varies from sample to sample. The silica contents of all samples are over 50 wt. %, with the FeO/MgO ratio less than 2, indicating relatively undifferentiated characteristics.

In comparison to the typical island arc basalts having a similar silica content, the MgO contents of the EC lavas are higher by $\sim$4 wt. %. Accordingly, the EC lavas are similar to or classified into high-Mg andesite, which is considered to be generated by melting of relatively hydrous mantle (as an example, unsaturated with H_2O, 1.0GPa, 1100-1250 ℃, saturated with H_2O, 1.5GPa, 1030-1150 ℃) (Tatsumi., 1995; 2003).

The EC lavas scarcely include orthopyroxene, on the other hand, volcanic rocks of KG include orthopyroxene (Churikova *et al*., 2013). Mantle xenoliths from the Bezymianny volcano of KG is reported to be spinel harzburgites (Ionov *et al*., 2013). Combining these constraints, we discuss a regional variation in mineral assemblage and H_2O content in source mantle, H_2O content in the primary magma, and the crystallization temperature and pressure of the magmas.

By comparing the petrological characteristics of the EC lavas with those from other regions (e.g., KG), cleare constraints on the relationship between magma genesis and the tectonic setting are expected to be imposed.

Keywords: arc, high-Mg andesite, Kamchatka Peninsula, triple junction

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC54-03 Room:411 Time:May 1 09:30-09:45

Geology and petrology of Taisetsu volcano group, Japan; Evolution of magma and long-term time variation of eruption rate

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Taisetsu volcano group locates at the northern part of the Taisetsu-Tokachi volcanic chain, which is situated at the southern end of Kuril arc. The volcano group started its activity ca. 1 Ma and is composed of andesitic lava domes and stratovolcanoes. Although previous studies (eg., NEDO, 1990; Katsui, 1979) revealed the outline of structure and eruptive history of the group, detail chronological and petrological studies have not been carried out. We have revealed the volcano stratigraphy and petrological features of the whole area of the volcano group. In addition, K-Ar ages of representative samples are also determined. Based on these data, we focus on the temporal change of eruption rate and magma types during 1 My in the volcano group.

According to the stratigraphy, location of eruption centers, mode of eruptive activity and petrological features, the activity of the volcano group can be divided into four major stages, as follows. Stgae 1(1.0 ˜0.75Ma): Fluidal andesite lava were effused from several eruption centers to form flat-shaped volcanic edifices which are distributed in N-S direction. Their total estimated eruptive volume is 26km^3(DRE). Stage 2: It can be subdivided into sub-stage 2-1 (0.6Ma) and 2-2 (0.35 ˜0.05Ma). Eruptive lavas of the former sub-stage are mostly coverd by younger deposits. Detail structure of the edifice and the distribution of deposits have not been clear. The sub-stage 2-2, is further subdivided into central and western group according to the differences in mode of activity and location of eruption centers. The total estimated eruptive volume of stage 2 is 23km^3. Stage 3(ca. 30 ka): The stage is characterized by most explosive eruptions in the volcano group, resulting to the formation of a plinian column and related pyroclastic flows. These activities formed the Ohachidaira caldera with 2 km in a diameter. The total eruptive volume is estimated to be 13km^3. Stage 4 (ca. 30 ka - present): Main eruption centers moves to the southwestern part of the caldera to form several stratovolcanoes and lava domes. The total eruptive volume of stage 4 is 10km^3.Based on the ages and estimated eruptive volume, the magma discharge stepdiagram of the volcano group is created to discuss a temporal change of magma discharge rate. The eruption rate of each stage is as follows; $>$0.07km^3/ky for stage 1, $>$0.01km^3/ky for stage 2-1, $>$0.06km^3/ky for stage 2-2, $>$0.33km^3/ky for stage 3, $>$0.33km^3/ky for stage 4. According the stepdiagram, the period from 0.7 to 0.4 Ma could be characterized by extremely low eruption rate and/or the presence of dormant stage.

Petrological features of the ejecta of Taisetsu volcano group can be distinguished among stages. All of the rocks are andesite and dacite, often containing mafic inclusions. These rocks contain plagioclase, clinopyroxene, orthopyroxene and Ti-magnetite as phenocrysts, associated with minor amounts of olivine, and quartz phenocrysts in some rocks. Although the rocks of stage 1 do not contain hornblende phenocrysts, those of stage 2 and 3 usually include hornblende phenocrysts. However, there rarely exist hornblende phenocrysts in the rocks of stage 4. The whole-rock SiO_2 contents range from 56.4 to 69.1 wt.% for host rocks and from 52.7 to 57.4 for the inclusions. Almost all the rocks are defined as medium-K in SiO_2 - K_2O and CA types in SiO_2-FeO/MgO diagrams, respectively. The host of the rocks from stage 1 is characterized by high Zr contents, compared with the rocks from other stages, whereas Zr contents in the mafic inclusions in the rocks from stage 1 are the same as those from other stages. Considering Zr contents and occurrence of hornblende phenocryst in andesite, magma type had changed largely during the possible long dormancy from 0.7 to 0.4 Ma. This would be related to the tectonic change at the junction between NE Japan and Kuril arcs.

Keywords: Volcano, Eruption rate, Formation history, Taisetsu, Geology and petrology, Transition of magma

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC54-04 Room:411 Time:May 1 09:45-10:00

Reconstruction accuracy of eruptive sequence inferred from the pyroclastic fall deposits of the Asama-Maekake volcano

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The pyroclastic fall deposits of the Asama-Maekake volcano, such as A (1783AD), B′ and B (12^{th} century), and C (4^{th} century), are mainly composed of pumice layers. On the other hand, ash fall derived from the recent vulcanian eruptions (e.g., 2004 and 2009 eruptions) is too small in scale to be preserved as a geologic unit. Ash particles from such small-scale eruptions are mainly lithic fragments originating from solidified lava in a shallow level of the conduit. After the 1783 eruption, repeated vulcanian eruptions have formed ash and soil mixtures on the flank of the volcano. Similar ash and soil mixtures are also recognized beneath A, B, C, and D pyroclastic fall deposits, respectively. These ash and soil mixtures contain lithic fragments as the ash component, indicating that vulcanian eruptions occurred repeatedly in the period between large-scale eruptions, similarly to the period after the 1783 eruption. Lithic ash layers are also interbedded with pumice fall layers of B′, B, and E pyroclasic fall deposits. There seem to be some cases of intermittent vulcanian and sub-plinian eruptions in the course of the large-scale eruption.

In the case of the 1783 eruption, detailed reconstruction of the eruptive sequence is possible on the basis of correlation between the stratigraphy of the eruptive products and old documents. The large-scale sub-plinian eruption is considered to be associated with the formation of a pyroclastic cone in a proximal area owing to vigorous fountaining. Subsequently, large-scale clastogenic lava flows are generated throughout its climactic eruption. On the other hand, little information is available for eruptions before 1783 because of limited exposure and few old documents. Although the reconstruction accuracy for the eruptions in the 12th century is not as good as that for the 1783 eruption, these eruptions might have occurred with a different sequence from the 1783 eruption. Intermittent events of ash and pumice fall occurred in the initial stage of these eruptions. Phreatomagmatic eruption also occurred in the early stage of the 1128 eruption, resulting in a B′ pyroclastic fall deposit. The existence of many units of pyroclastic flows in the 1108 eruption indicates that pyroclastic flow occurred on multiple occasions. Since the stratigraphic relationship between the B pyroclastic fall and these pyroclastic flows is unclear, the sequence of the eruption is still in question. Furthermore, little information is available for eruptions predating the 12^{th} century.

Comparative study of the distributions of pyroclastic fall deposits using isopach maps reveals that some fall units from B′ and B are larger in scale than that of the climactic pyroclastic fall deposit of the 1783 eruption. In addition, the A′ pyroclastic fall deposit is estimated to be comparable to or smaller than the preclimactic fall unit of the 1783 eruption. Although the isopach maps of A, B′, B, C, and E could be prepared, the accuracy of the isopach maps for the C and E pyroclastic fall deposits is insufficient. The preparation of an accurate map is difficult for deposits of older age. Consequently, at this point, the 1783 eruption is the only example in which the temporal variation in eruptive style and in eruptive volume can be discussed with high accuracy in the history of the Asama-Maekake volcano.

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC54-05 Room:411 Time:May 1 10:00-10:15

Polybaric crystallization of H_2O-saturated island arc low-K tholeiite magmas: A case study of the Izu-Oshima volcano

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Introduction: The H_2O concentration of pre-eruptive melts, particularly that of primitive melts, provides information on the *P-T* conditions of their generation, their differentiation pathways, and their potential explosivity of eruptions. Consensus with regard to the H_2O concentration of island arc low-K tholeiitic magmas (melts) remains elusive. We investigated conditions of their crystallization differentiation, particularly the H_2O concentration in melts, using geochemical data of volcanic rocks from Izu-Oshima volcano in the Izu arc, along with the results of hydrous melting experiments.

Geochemistry and petrology of volcanic rocks: We selected 68 aphyric volcanic rocks which exhibit multiply saturated liquid compositions of the Izu-Oshima volcano. Among them, two magma groups are distinguished by the K/Zr ratio, a lower-K subgroup (K/Zr$<$60) and a higher-K subgroup (K/Zr$\geq$60). In this study, we focus on the higher-K subgroup liquids. Two endmember trends, referred to here as a higher-Al/Si trend and a lower-Al/Si trend, have been distinguished in the higher-K subgroup liquids. All the liquids are bracketed by these two endmembers, and thus may be mixtures of the two endmembers or may have been derived under intermediate conditions between those responsible for the two endmembers. An experimental study by Hamada and Fujii (2008, *Contrib. Mineral. Petrol.*) suggests that the higher-Al/Si and lower-Al/Si trends can be reproduced by upper crustal crystallization differentiation of primitive basalt under moderately hydrous ($\sim$3 wt % H_2O) and almost dry conditions, respectively.

Hydrous melting experiments on island arc low-K tholeiite magmas: Island arc low-K tholeiite magma is characterized by presence of Ca-rich plagioclase (An$\geq$90), with Ca-poor rim ($\sim$An75). Hydrous melting experiments on two volcanic rocks from the Izu-Oshima volcano, MA43 and MA44 (MgO$\sim$5 wt %), were conducted at 250 MPa to constrain the origin of Ca-rich plagioclase (Hamada and Fujii 2007, *Geochem. J.*). MA43 and M44 represent less differentiated liquid compositions on the higher-Al/Si and lower-Al/Si trends, respectively. In the melting experiments on MA43, plagioclase crystallized as the liquidus phase at all H_2O content (1$\sim$6 wt % H_2O), and anorthite content of the plagioclase increased from $\sim$An80 under nearly dry conditions to An$\geq$90 with $\geq$3 wt % H_2O in melt. In the melting experiments on MA44, plagioclase crystallized as the liquidus phase under low-H_2O ($\leq$2 wt %) conditions, but augite replaced plagioclase as the liquidus phase with more H_2O in melt. Anorthite content of plagioclase increased from about An70 under nearly dry conditions to An80 with $\sim$4 wt% H_2O in melt. Increases in anorthite content of plagioclase crystallized from the MA44 melt were suppressed compared with plagioclase crystallized from the MA43 melt. In short, Ca-rich plagioclase (An$\geq$90) can be crystallized from melts on the higher-Al/Si trend with $\geq$3 wt % H_2O, but cannot be crystallized from melts on the lower-Al/Si trend with any H_2O. Ca-poor rim ($\sim$An75) cannot be crystallized from melts on the higher-Al/Si trend, but can be crystallized from melts on the lower-Al/Si trend.

Summary: Geochemical variations in the liquids from the Izu-Oshima volcano are bracketed by two endmember trends, namely, the higher-Al/Si and the lower-Al/Si trends. Origins of the higher-Al/Si and the lower-Al/Si trends can be explained by crystallization differentiation under moderately hydrous conditions ($\sim$3 wt% H_2O) and almost dry conditions, respectively. We propose that polybaric crystallization of H_2O-saturated melts, at a depth range between the $\sim$4-km-deep magma chamber ($\sim$3 wt% H_2O) and near surface level (nearly dry) beneath the Izu-Oshima volcano, is a ubiquitous feature of island arc low-K tholeiite magmas.

Keywords: Island arc low-K tholeiite, Volcanic front, Ca-rich plagioclase, Izu-Oshima volcano

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC54-06 Room:411 Time:May 1 11:00-11:15

The change time from magmatic to phreatomagmatic eruption, in the Hachodaira caldera eruption at Miyakejima Volcano

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The Miyakejima volcano formed the caldera in 2000. This volcano erupted Hachodaira Scoria and Hachodaira Ash at ca.3ka of Hachodaira caldera collapse. Many plant fossils (Miscanthus sp.) are recognized in Hachodaira Scoria and Ash. Based on plant fossils in these tephras occurrence, deposition late of soil in the Miyakejima volcano, and form of the boundary of Hachodaira Scoria and Ash, The change time from magmatic eruption (Hachodaira Scoria eruption) to phreatomagmatic eruption (Hachodaira Ash) is under 1 year, probably it is several days or less. Thus, there was no time gap almost between magma eruption and phreatomagmatic eruption. This eruption style change can be explained such as 2000 eruption (Geshi and Oikawa,2008:JVGR) as follows. The altitude of the summit part approached the sea level by caldera collapse; as a result, phreatomagmatic eruption occurred.

Keywords: volcano, caldera, Miyakejima, eruption, Miscanthus

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC54-07 Room:411 Time:May 1 11:15-11:30

Pumice deposits of the pre-Ofunato stage distributed in northwest of the Miyake-jima volcano, northern Izu-Bonin Arc

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Miyake-jima Island, a volcanic island of the northern Izu-Bonin Arc, is located in the northwestern Pacific Ocean, approximately 180 km south of Tokyo. A pale-orange-tuff layer had been reported by Issiki (1960) on coastal cliff in the northwestern part of the island. The aim of this study is to clarify (i) distribution, (ii) stratigraphic position, (iii) sedimentary structure, (iv) petrological features, and (v) mineralogical features, for this pyroclastic deposit in more detail. The layer was re-defined as ”Miyake-jima Ofunato Pumice deposit: OFP”. The OFP is distributed from western to northern parts of the island. The OFP exists below the Aira-Tn tephra, erupted at 30 ka. The sedimental facies of OFP deposits suggest it formed as a pyroclastic flow deposit.

The relation between K_2O and FeO concentrations in the OFP is characterized by higher FeO wt.% and lower K_2O wt.%. Tsukui et al. (2006) and Saito & Miyairi (2008) showed that the chemical trends in the volcanic products of forearc of Izu-Bonin Arc such as Izu-Oshima and Hachijo-jima are characterized by high FeO wt.% and low K_2O wt.%, and those of the backarc Izu-Bonin Arc such as Nii-jima and Kozu-shima shows low FeO wt.% and high K_2O wt.%. Consequently, chemistry of the OFP suggests that it was originated from forearc of Izu-Bonin Arc.

This paper concludes that the activities of the Miyake-jima volcano around 30 ka are characterized by a production of pumice by the eruption at the northwestern part of the present island. The current stage of this study, it is not possible to discuss the source vent of the OFP in detail and specify the type of the volcanic eruption produced the OFP. In future, we attempt to find a clue to account for these two problems by the detailed study on the OFP with referring to its faces like a pyroclastic flow deposits.

Keywords: Miyake-jima volcano, Pumice, Miyake-jima Ofunato Pumice deposit, Northern Izu-Bonin Arc

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC54-08 Room:411 Time:May 1 11:30-11:45

Formation process of a volcanic island during the 2013-2014 eruption at Nishinoshima, Ogasawara, Japan

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New volcanic islets created by submarine eruptions are often observed around Japanese Islands. However, in most cases, such new islets are disappeared by wave erosion in short periods. To make a new volcanic island remaining for a long time, an amount of lava flows must occur and reclaim land from the sea. However, such relatively large-scale lava eruptions rarely occur. Therefore, the very initial stage of the formation process of a volcanic island has been poorly understood.

The submarine eruption off Nishinoshima, Ogasawara, has created a new volcanic islet since Nov 2013. The lava flow eruption continues for more than a few months, and the islet keeps growing. This eruption will give an opportunity to understand the birth and growth of a new volcanic islet. We studied variation of eruptive styles and sequences of this 2013-2014 eruption at Nishinoshima based on airborne observations and publicized aerial and satellite images (taken by JCG, GSI, and JAXA).

Nishinoshima forms a part of summit crater rim of a huge submarine volcano. The 2013-2014 eruption occurred inside the summit crater about 400 m off Nishinoshima with a depth of dozens of meters. In the first stage, Surtseyan eruptions repeated due to seawater entering a main crater of an islet. With the growth of the islet, the main crater was dried up and the eruption style changed to Strombolian with a scoria cone formation and lava flows that continuously effuse from the main crater over a few months. Lava flow front is brecciated by rapid cooling, or auto-brecciated, and eventually reclaimed the foreshore from the sea. The lava flows are then branched many times and extended to almost all directions. The continuous activity of Strombolian with lava flows suggests that magma is stably supplied from the deeper part of conduit.

Based on the change of outline of the islet and bathymetry data before the eruption, volume and discharge rate of lava flows are estimated. For the first 2.5 months by early Feb 2014, the volume of lava flow is estimated at about 6 M m^3. The discharge rate is estimated at 0.5-1$*10^5$ m^3/day with some fluctuations. This discharge rate is almost the same as that estimated for lava effusion in the 1934-1935 eruption at Showa Iwojima, southern Kyushu (1$*10^5$ m^3/day; Maeno and Taniguchi, 2006), which is one of the youngest remained volcanic islands in Japan. The volume of the 2013-2014 eruption is so far 1/4 of the total volume (24 M m^3) of the last 1973-1974 eruption, in which the volume of the last eruption was estimated based on bathymetry change before and after the eruption. The eruptive sequence and growth rate of the islet in 2013-2014 is different from the last eruption. This is probably because the eruption began at shallower depth than the last eruption. At the time of early Feb 2014, erosion signatures on lava flows are little, so that the new island is expected to further grow.

Keywords: Nishinoshima, volcanic island, lava flow, Surtseyan eruption, Strombolian eruption

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC54-09 Room:411 Time:May 1 11:45-12:00

Petrological characteristics of volcanic materials ejected during 2012-2013 explosive events on Ioto Island

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Ioto is an active volcanic island (8.5km long in NE-SW and 4.5km wide) located about 1250km south of central Tokyo. Since early February 2012, small explosive eruptions have repeatedly occurred at the Old Crater (Million Dollar Hole) in the western part of the island (JMA, 2013). Four (February 2012, March 2012, February 2013 and April 2013) ejected mud materials collected in the vicinity of the crater consist of free crystals (plagioclase, clinopyroxene, olivine, and Fe-Ti oxides), relatively fresh volcanic glass, altered volcanic glass, lithic fragment, altered lithic fragment and pyrite aggregate (Ikehata and Tamura, 2013). Among the mud samples, there is little difference in component of grains except for high abundance of altered lithic fragment in the mud ejected in February 2012.

Detailed SEM/BSE image observation of the relatively fresh volcanic glasses show that even these fresh glasses have pitted alteration and hydration features. The extent of hydration could be different among volcanic glass shards in geothermal field like Ioto because hydration rate depends on chemical compositions of volcanic glasses and groundwater, and soil temperature. To eliminate such hydration effects, heating (400 ℃-12h) is conducted for the relatively fresh volcanic glasses before analyzing. As a result of the chemical analysis, all of these volcanic glasses are trachytic, and their chemical compositions are homogeneous within the analytical error. In conclusion, no juvenile materials existed in the mud samples, suggesting these explosive events were not phreatomagmatic but phreatic eruption.

We would like to thank members of JMSDF Ioto Air Base weather team for sampling around the Old Crater and providing information on the studied area. Ministry of Defense, JMA and NIED are also thanked for their cooperation.

Keywords: Ioto Island, the Old Crater, mud, volcanic glass, phreatic eruption

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC54-10 Room:411 Time:May 1 12:00-12:15

Compositions of minerals in volcanic products from pre- and the early stage of Aso-4 large-scale pyroclastic flow

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Formation of Omine scoria cone, Takayubaru lava flow, and Oyatsu pumice flow are a series of volcanic events just before and after the large-scale Aso-4 pyroclastic eruption. Compositions of volcanic products change from 62-66 SiO_2 wt.% for Omine scoria, 63-66 SiO_2 wt.% for Takayubaru lava, to 67-69 SiO_2 wt.% for Oyatsu pumice. The difference between Omine-Takayubaru compositional trend and Oyatsu trend is small but evident (Yamasaki et al., 2013). Common phenocrsyt assemblage is plagioclase, orthopyroxene, clinopyroxene, and opaque minerals. In addition, Omine scoria and Takayubaru lava contain hornblende microphenocrysts, whereas Oyatsu pumice contains phenocrysts of hornblende. Most plagioclase characteristically shows sieve texture among Omine-Takayubaru samples. Such texture is not so common among Oyatsu pumice samples. We analyzed these minerals using EPMA in order to characterize the change in magma supply system that lead to large-scale pyroclastic eruption.

In response to different compositional trends observed between Omine-Takayubaru and Oyatsu samples, different mineral compositions are also found. Plagioclase phenocrysts in Omine-Takayubaru samples are An50-An60 with uni-mordal peak, where as those in Oyatsu samples are An37-An56 with three peaks. Slight difference in Mg# are also found between orthopyroxene, clinopyroxene, and hornblende of Omine-Takayubaru and those of Oyatsu samples.

Estimated temperature for Omine scoria using Wells (1977) pyroxene thermometer is 950 ℃, and dry viscosity is 10^5.6 Pa • s. That for Tamaraigawa lava (SiO_2=61 wt.%) extruded before Aso-2 pyroclastic eruption was reported as 1120 ℃ and 10^3.9 Pa • s, respectively, by Kobayashi (2013). The difference in viscosity is reflected by different aspect ratio, i.e. 100 m thick and 7 km long for Takayubaru lava flow, and 10 m thick and 10 km long for Tamaraigawa lava flow.

Sieve texture and microphenocrysts in Omine scoria and Takayubaru lava make an important restriction for making models of magma supply system before and after the large-scale pyroclastic eruption. If sieve texture suggests melting process of plagioclase, it indicates temperature ascent and/or water vapor pressure increase. In contrast, growth of hornblende microphenocryst suggests temperature drop and/or water vapor pressure increase. Omine-Takayubaru samples do not contain mafic inclusions and mafic minerals with reverse zoning, thus possibility of magma mixing and temperature ascent is small. The change in physicochemical condition in Aso-4 magma supply system is yet to be solved.

Keywords: Aso-4 pyroclastic flow, Takayubaru lava, Omine volcano, lava flow

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SVC54-11 Room:411 Time:May 1 12:15-12:30

Forming process of Minamidake stratovolcano, Sakurajima, inferred from paleomagnetic age and volume of lava flows

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A paleomagnetic measurement was carried out on the Arimura lava, which consists uppermost part of the main body of Minamidake stratovolcano, Sakurajima volcano, Kyushu, Japan. A mean paleomagnetic direction, D=4.0 ^{o} E I=40.5 ^{o} down, was obtained from the Arimura lava. By comparison between measured paleomagnetic direction and the paleo-secularvariation of geomagnetic field, the age of the Arimura lava was estimated as about 3.1-2.7 ka, moreover the age of the Kannonzaki lava lying beneath the Arimura lava, was thought as about 3 ka. These two lavas are considerable to be formed by a sequence of intermittent eruption during several hundred years at around 3 ka. The volumes of individual lava that extruded in recent 4,000 years were estimated. The main body of Minamidake stratovolcano had grown rapidly at around 3 ka, since estimated lava volume. The volume of the Nagasakihana lava erupted in 764-766 AD was estimated as about 0.8km^{3}. The scale of 764-766 AD eruption may be greater than previously thought. The long?term magma effusion rate during historic time, particularly recent 240 years, was estimated as larger than earlier.