Japan Geoscience Union Meeting 2012
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SVC53-01 Room:301A Time:May 21 09:00-09:15

Petrological significance of Takayubaru lava flow, a precursory event of Aso-4 caldera-forming pyroclastic eruption

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Contrasting type of eruption occurred close in space and time, in central Kyushu, 90,000 years ago. Omine pyroclastic cone and associated voluminous Takayubaru lava flow was formed just before Aso-4 caldera-forming eruption, 5 km west of caldera rim. The lava flow is 80-120 m thick, extends 9 km E-W, 4 km N-S, and has a volume of 2.0 km^3. It forms a flat plateau on which Aso-Kumamoto airport has been built. Aso-4 tephra overlies Takayubaru lava flow without recognizable soil formation. Reported K-Ar ages for Takayubaru and Aso-4 are nearly identical, also supporting a short interval time between the two.

We analyzed lava samples collected from the edge of Takayubaru lava flow and drilling core samples provided by Kumamoto River National Highway Office. We added scoriae collected from Omine cone and compared them with Aso-4 pyroclastic products in order to find changes in physical or chemical conditions leading to the contrasting eruption types.

All the analyzed samples were two-pyroxene andesite and dacite. They all include microphynocrsyt-size hornblende, varying from fresh to completely opacitized, suggesting a later crystallization event than phenocryst stage of pyroxene, plagioclase and opeque mineral crystallization. Most plagioclase phenocrysts show characteristic fractured texture, indicating melting along cleavage. Some of the groundmass shows inhomogeneous appearance. Silica content varies from 63 to 66 wt. % for lavas, and 61 to 66 wt. % for scoria samples, all of which are high-K. In contrast, Aso-4 pyroclastic products are bimodal. Mafic member contains basalt to basaltic andesite scoriae (49-56 wt. % SiO_2), whereas silisic member contains dacite pumice (65-72 wt.% SiO_2). Thus, our result shows that mafic magma did not erupt during the formation of Omine cone and associated Takayubaru lava flow, as opposed to a sequence of magmas erupted during Aso-4 event. Formation of hornblende, and decomposition of plagioclase suggest an important clue to physical changes that caused evacuation of felsic magma before Aso-4 eruption. Location of Omine cone on the active Futagawa fault suggests a possible precursory event including earthquakes caused by the fault movement.

Keywords: Takayubaru Lava, Omine volcano, Aso volcano, Aso-4 pyroclastic eruption, precursory event, Futagawa fault

SVC53-02 Room:301A Time:May 21 09:15-09:30

Stratigraphical and petrological studies of Benri scoria flow in Aso-4 pyroclastic flow deposits, Aso volcano, Japan

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Aso volcano is the largest caldera bearing volcano in central Kyushu, Japan. The large caldera was formed by four pyroclastic eruptions (Aso-1 -4) during 270-90 ka. The latest (90ka) and largest (600 km^3) eruption generate Aso-4 pyroclastic flow deposits. They are divided into seven flow deposits in the west side of caldera, and were formed by two sub-cycles eruptions of mafic to felsic magmas (Watanabe, 1979, Kaneko, 2007).

This study focused on the Benri scoria flow deposits (0.5 km^3, hereinafter called Benri-deposits), in which the transition of deposits from pumice to scoria are seen. We carried out the detailed field and microscopic observations, EMPA analyses of phenocrysts and whole rock chemical analyses by XRF, and then tried to presume detailed eruption processes in Benri-deposits.

Benri-deposits, about 20m in total thickness, are composed of scoria, pumice, banded pumice, andesitic lithic fragments and pyroclastic matrix (Oshika, 2007). We divided them into seven layers based on essential components. They are as follows from lower to upper part; (1) pumice and banded pumice layer, (2) pumice and scoria layer, (3) scoria and lithic fragment layer, (4) scoria -rich layer, (5) lithic fragments concentrated layer, (6) scoria-rich layer, (7) scoria and pumice layer. Although scoria and lithic fragments are found in most of layers, pumice and banded pumice are in limited layers. Lithic fragments concentrated layer is composed of andesitic lithic fragments (grain size; 3-6cm). The existence of banded pumice suggests the possibility of mingling in the layered magma chamber.

Phenocryst assemblage is plagioclase, amphibole, clinopyroxene, orthopyroxene, (olivine), (magnetite), (ilmenite). The corrosion form and dusty zoning in plagioclase and amphibole are found in most of layers. An mol. % of plagioclase in scoria and banded pumice have wide ranges (An32-97). However, they show relatively narrow ranges in pumice, and the value roughly rise from layer 1 (An30-57) to layer 3 (An50-84). These results suggest that the amount of mafic magma gradually increase toward layer 3. Together with whole rock chemical composition data for scoria and pumice, we try to clarify the eruption process of Benri-deposits.

Keywords: Aso Volcano, pyroclastic flow, scoria, pumice, banded pumice

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SVC53-03 Room:301A Time:May 21 09:30-09:45

Holocene Eruptions in Daisen Volcano, Western Japan

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Daisen is a large Quaternary composite volcano in western Japan (Tsukui, 1984). After the deposition of widespread tephra, AT ash (30 cal kBP), its last magmatic activities produced three lava domes (Karasugasen, Misen and Sankoho) and corresponding pyroclastic flows (Sasaganaru, Misen and Shimizuhara) that were intermittently erupted (Miyake et al., 2001). Among the fall deposits, Kusatanihara pumice fall deposit (KsP: 21 cal kBP) is found in sediments from Lake Ichi-no-Megata (Okuno et al., 2011). Previous studies thought that Shimizuhara pyroclastic flow deposits which was generated following the KsP is the latest product of the volcano. In this study, we found Holocene tephra layers from Daisen volcano. The products of Holocene eruption from Daisen are lava dome located between Karasugasen and Misen domes, block-and-ash flows and associated ash-falls.

We obtained radiocarbon dates for the Holocene tephra using AMS through the Common-Use Facility Program of JAEA. The radiocarbon date of charcoal fragments in a sandy layer of pyroclastic flows/surges (alternation of volcanic silt and sand layers) is 3110+/-60 BP corresponding to ca. 3.35 cal kBP. The radiocarbon date of the humic soil immediately below the associated ash-falls that are distributed toward the east is 3290+/-40 BP. Although both dates are almost consistent with each other, the obtained age for soil layer is slightly old. This difference is sttributed to soil reservoir effect.

Keywords: Daisen Volcano, Holocene, Lava dome, pyroclastic flow

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SVC53-04 Room:301A Time:May 21 09:45-10:00

Magma series and their source materials at Akita-Komagatake volcano, Northeast Japan arc

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Geologic background: Akita-Komagatake volcano has been erupted mainly tholeiitic magmas with subordinate amount of calc-alkaline magmas to develop a composite volcanic edifice in the recent 100,000 years. It consists of the main strato cone with a caldera in the southern area and several parasitic cones involving central cones were formed in the caldera floor. About 13 ka, an explosion event involving major pyroclastic flow with huge amount of air-fall ash resulted in the caldera collapse, which accompanied drastic change of the magma plumbing system beneath the volcano. Magmatic eruption history in the post-caldera stage can be further divided into two sub-stages by the presence of about 3,000 years of dormancy from 7 ka to 4ka. Parasitic cones in northern area had been built predominantly in the early sub-stage, whereas central cones in the southern area have been developed during the later sub-stage. Episodic explosive eruption occurred immediately after the dormancy (ca. 4 ka), resulting in the last cinder cone in the northern area.

Aim of this study: In the present study, the erupted magma series and their temporal compositional variations were revealed by correlating the frequency of magmas with their localities of the eruption centers to their bulk chemical compositions. The temporal and spatial compositional variations of the magmas further examined to the chemical characteristics including isotopic compositions, so as to investigate the genetic relationship among a variety of the magmas erupted in the post-caldera stage of the volcano.

Results: Low-K tholeiitic magmas showing high FeO/MgO have been the dominant type throughout the post-caldera stage. Calc-alkaline andesitic magma erupted episodically at the beginning of the late sub-stage. The early sub-stage began with eruptions of the tholeiitic andesite magmas, followed by effusions of the basaltic to basaltic andesite magmas of the same magma series. After the dormancy, calc-alkaline andesitic magma erupted in the northern vent, which was succeeded to the magmatic eruptions in the caldera floor in the southern area. Tholeiitic andesite magmas erupted first in the caldera floor, but superseded soon by the tholeiitic basalt to basaltic andesite magmas. The latest magmatic eruption occurred in 1970, and produced a lava flow of andesitic in composition.

The calc-alkaline magma is distinctive to the tholeiitic basaltic magma in terms of the chemical characteristics including isotopic compositions; the former strongly suggests incorporation of (smaller degree of) partial melt of crustal materials into the magma, whereas the latter more likely derived from depleted MORB source mantle (DMM) with slab-derived components. These are indeed compatible with the traditional hypothesis on the genesis of tholeiitic vs. calc-alkaline magmas.

At least two kinds of tholeiitic andesitic magmas can be recognizable with respect to the chemical characteristics. One is that erupted about 3 ka, showing characteristics reflecting dominant involvement of crustal materials, even when compared with the calc-alkaline andesite magma. The other is that erupted in 1970, showing similar characteristics to those for the MORB, relative to the co-existing tholeiitic basalts.

Discussion and conclusion: From the above mentioned data, we can infer the genetic relations among the co-existing magma series in the post-caldera stage as follows: (1) Tholeiitic basaltic magma was generated by partial melting of the DMM, and derived andesitic members of the same series through fractional crystallization with or without assimilation. (2) Calc-alkaline andesitic magma was to be the product of mixing between the tholeiitic basalt magma and felsic magma enriched in crust-derived materials. (3) Some of the tholeiitic andesite magma might be generated from (lower) crust by considerable degrees of partial melting, which is similar to those preferable for the tholeiites in the middle area of the Northeast Japan arc.

Keywords: Island-arc volcanism, Tholeiite magma, Calc-alkaline magma, magma source materials, Isotopic compositions of magmas

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SVC53-05 Room:301A Time:May 21 10:45-11:00

Modeling a stepwise diagram of discharge rate by an upward migration of magma chambers: An example from the Esan volcano

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A long-term sequence of volcano growth is an important clue in forecasting how magma inputs and when it erupts, through magma-plumbing system. The Esan volcano, 6km wide, northern Japan, is the best candidate to unravel changes of a long-term discharge rate. A simple 2D elastic model in a hydraulic connection state was performed to study variations of discharge rate that have been attributed to changes of storage conditions rather than supply rate from a deep magma source. The elastic model can forecast either change of time or of volume at the next eruption. A stepwise change in steady-state curve, where the smaller volume is the shorter interval, has been found, and it can be fit to the change of the ratio between radius (*Rc*) and depth (*Hc*) by an upward migration of magma chamber. In the processes, as the ratio *Rc/Hc* becomes to 1.0, the overpressure (*delta Pe*) goes to zero in the shallower crustal levels, where the magma cannot erupt. This constraint could result in the long dormancy for 22,400 years prior to the latest magmatic eruption. Yet in the case that the magma supply is constant, magma continues to input from the deep source to certain crustal depths, which is able to renew an original magma storage system for the next future eruption.

Keywords: volcano, eruption history, magma chamber, migration

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SVC53-06 Room:301A Time:May 21 11:00-11:15

Transition magma and formation history of Asahidake volcano of Taisetsu volcanic field,central Hokkaido,Japan

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Taisetsu volcanic field consists of quaternary volcanoes located in the northern part of Taisetsu-Tokachi volcanic chain , central Hokkaido. In the youngest activity, the large eruption forming Ohachidaira caldera occurred in the center of Taisetsu volcanic field in c.a. 30 ka, and after that stratovolcanoes namely Pon-Asahidake, Ushiro-Asahidake, Kumagatake and Asahidake have been formed at the southwestern rim of the caldera. Although the studies of eruptive history and magma plumbing system of Asahidake which is only an active volcano within these volcanoes have been carried out (e.g. Sato and Wada, 2007), stratigraphic relationships and petrological studies of Asahidake volcanoes including Kumagatake and Usiroasahidake has not been done sufficiently. Thus, we performed geological and petrological study of Asahidake, Kumagatake, Ushiroasahidake in order to reconstruct spatiotemporal evolution of magma and history of these volcanoes.

Asahidake (2,291m) consists of a pyroclastic cone formed above the 1600m altitude and many lava flows on the west side. The horseshoe-shaped explosion crater called Jigokudani crater exists on the west side of the cone and the fumaroles still active. Older pyroclastic cones, Ushiro-Asahidake (2216m) and Kumagatake (2210m) are located in the eastern side of Asahidake.

Based on the stratigraphic relations, degree of preserved land forms, field occurrences and petrological characteristics, Asahidake volcanic activities are distinguished into 3 stages: Ushiro-Asahidake, Kumagatake and Asahidake stage, in ascending order. Ushiro-Asahidake stage edifices are composed of a pyroclastic cone and lava flows which was considered as Asahidake volcanic edifice. Kumagatake stage edifices consist of a pyroclastic cone and lava flows which flowed down to the northwest from the cone. Asahidake stage can be divided into three stages: Stage 1~3, in ascending order. Stage1 volcanic edifices are composed of large amount of lava flows at the southwest-western foot of Asahidake, and are subdivided into Stage1-2 (Late) and Stage1-1 (Early). Stage1-1 lava flows are distributed in the south western foot of Asahidake. Stage1-2 lava flows are distributed in the western foot of Asahidake and its runout distance from Asahidake is more than 8 km. Stage2 edifices consist of Asahidake pyroclastic cone and the lava flows effused from the cone. These Asahidake stage deposits are often recognized heterogeneous structure such as mafic inclusions over the period of time. In addition, the formation age of the cone is estimated to be c.a. 6,700 years ago on the basis of radiocarbon dating. Stage3 is characterized by phreatic explosion which formed Jigokudani crater. The last small phreatic explosion might occur in 250 years ago.

Eruptive deposits of Asahidake, Kumagatake and Usiroasahidake comprise andesite and dacite. Phenocrysts contents range from 10 to 35%. Phenocryst minerals are Pl + Cpx + Opx + Mt (+-Ol) in andesite, and Pl + Cpx + Opx + Mt (+- Ho) in dacite, respectively. Whole-rock composition shows different features for each stage in the Harker diagrams, especially in SiO2-MgO.

It is newly revealed that Ushiro-Asahidake and Kumagatake activity may be able to be recognized as adjacent activity of Asahidake volcano in this study. The eruptive history and spatiotemporal magma changing of these volcanoes is as follows: After the Ohachidaira eruption (30 ka), Ushiro-Asahidake and Kumagatake activity had occurred. Between these activities, magmas were similar in each other. Thereafter these activities, Asahidake had effused a large amount of magmas which is different from Ushiroasahidake and Kumagatake (Stage1), and erupted magmas forming a large stratocone which might be occurred by different several magmas during the following stage (Stage 2).

Keywords: Asahidake, petrology, formation history, Transition magma, geology, Taisetsu volcanic field

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SVC53-07 Room:301A Time:May 21 11:15-11:30

Temporal and spatial change of volcanism in Hokkaido during late Pleistocene and related tectonics

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Arc volcanism at Hokkaido, which locates at the junction of NE Japan and Kuril arcs, has continued since late Miocene. It seems that the temporal and spatial change of the volcanism has been related to tectonic movement at the junction. Since middle Pleistocene, three volcanic fields, southwestern (SW), central and eastern Hokkaido, have been constructed since 1.7 Ma. Although Rishiri volcano exists far from these volcanic fields, it could be included into the SW Hokkaido on the basis of geochemical features of the rocks of the volcano. In this paper, we revearl temporal and spatial change of volcanism including style of activity and geochemistry of the volcanic rocks during late Pleistocene.

Magma discharge rate has increased at the SW Hokkaido and eastern Hokkaido fileds since 0.3 ? 0.2 Ma. The volcanism in the eastern Hokkaido is characterized by caldera volcanoes. Frequncey and scale of caldera-forming eruption of Kutcharo volcano have increased since 0.21 Ma, followed by the activity of Mashu volcano since 0.03 Ma. In Shiretoko peninsula, andesitic stratovolcanoes and lava domes have been constructed since 0.3 ? 0.2 Ma. The discharge rate has changed from 0.23 to 1.1 DRE km3/1ky in the eastern Hokkaido. On the other hand, activity of caldera volcanoes has increased in SW Hokkaido since 0.11 Ma. Caldera-forming eruptions have moved from Toya in 0.11Ma, Kuttara in 0.08 Ma and Shikotsu in 0.06 Ma. In addition, new volcanoes have appeared along the eastern margin of Japan Sea since 0.3 ? 0.2 Ma, such as Oshima-Kojima, Oshima-Oshima, Katsuma (Okushiri) and Rishiri volcanoes. The discharge rate in the SW Hokkaido has increased from 0.33 to 2.2 DRE km3/1ky. On the other hand, activity of caldera volcanoes had terminated since 0.9 Ma in the central Hokkaido. Andesitic ? dacitic stratovolcanoes and lava domes have been active since then. The discharge rate has decreased from 0.38 to 0.11 DRE km3/1ky.

The increasing of activity of caldera volcanoes and appearance of new volcanoes must be related to temporal change of tectonic setting of Hokkaido. The possible tectonic change during late Pleisotocene is the movement and/or fluctuation of the plate boundary between Eurasia and North America (or Okhotsk) plates from the central Hokkaido to the eastern margin of Japan Sea. The timing of the movement has been controversial. However, temporal and spatial change of volcanism suggests that the change of the tectonic setting of the plate boundary should occur around 0.3 ? 0.2 Ma.

Keywords: volcanic activity, caldera volcano, temporal and spatial change, magma chemistry, tectonic setting

SVC53-08 Room:301A Time:May 21 11:30-11:45

What controls the time interval between gigantic earthquake and its induced volcanic eruption?

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It is well known that some volcanic eruptions were triggered by large earthquakes. Although volcanic eruptions that take place soon after (day to a year) the triggering earthquake are counted in this category, here I propose that some volcanic eruptions may take place 30 to 50 years after the triggering big earthquakes. First example that I propose is the synchronous start of modern volcanic activity of three volcanoes in Hokkido, Komagatake (started 1640AD after dormant period of ˜3000 years), Usu (started 1663AD after dormant period of ˜5000 years) and Tarumae (started 1667AD after dormant period of ˜3000 years). Change in crustal stress field caused by large earthquake may be most plausible reason to explain the synchronous volcanic activity. Analysis of tsunami deposit in Hokkaido revealed that large earthquake >M8.4 took place in the early 17th century at Kuril trench east of Hokkaido (Nanayama et al 2003, Nature). This may be the source of the Keicho-tsunami earthquake in 1611. Because earthquake was not recorded, magnitude of this earthquake is uncertain. It may be one of the M9 class earthquakes. If modern activity of Komagatake, Usu, and Tarumae were triggered by the 1611 M9? Keicho earthquake in Kuril, then interaction time between the earthquake and the volcanic eruption is 30 to 50 years.

According to A.Hasegawa (personal communication), 2011 March 11 Off-Tohoku M9 earthquake caused dramatic change in crustal stress field in North Honshu Arc. Source mechanism of crustal earthquakes changed from reverse fault type to strike slip type in most part. Even normal fault type earthquake has started after the great earthquake. These lines of evidences indicate that regional stress field changed from horizontal compression to horizontal extension as a result of the M9 earthquake. Similar change in crustal stress field may have happened in Hokkaido after the M9? Keicho earthquake. Injection of large amount of basalt magma from mantle source to crustal magma chamber may have started after the Keicho earthquake and may still continues. This increased magma flux from the mantle may have triggered the eruption in the three volcanoes 30 to 50 years after the Keicho earthquake.

Following Jogan great earthquake (869 AD, >M8.4), only 871AD eruption of Chokai volcano is recorded. However, if we allow volcanic eruption 30 to 50 years after the earthquake, the last eruption of Towada volcano (Towada-A) that took place in 915 AD may be counted as a possible eruption triggered by Jogan earthquake. Towada volcano erupted episodically in the last 150000 years. Interval time between Towada-A and Towada-B is about 1700 years. It is plausible that silica-rich magma chamber beneath Towada caldera volcano was activated by injection of large amount of basalt magma from mantle source due to stress drop caused by the Jogan great earthquake.

If activity of a volcano is controlled by enhanced flux of basalt magma from mantle source to crustal magma chamber, why volcanic eruption take place 1 to 50 years after the triggering earthquake? In the conference, I will discuss the mechanism that will determine the characteristic reaction time. In the volcano at which basalt magma plumbing system is established from the bottom of crust to the top, characteristic reaction time would be as short as ˜1 year. Fuji volcano and Iwate-Akitakomagatake may be in this category. On the other hand, lessons in 17th century in Hokkaido indicate that characteristic reaction time would be 30 to 50 years in the case of volcanoes which has complex magma plumbing system consisting of basalt and silica-rich magma. Most Quaternary volcanoes in North Honshu Arc may be in this category. It is essentially important to estimate their future activity after the 2011 March 11 M9 Off-Tohoku earthquake.

Keywords: volcanic eruption, long term volcanic activity, earthquake, crutal stress field

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SVC53-P01 Room:Convention Hall Time:May 21 17:15-18:30

Stratigraphic variation in characteristic of pyroclastic deposits during the 2011 subplinian eruption of Mount Shinmoe

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In general, we observe stratigraphic variation in characteristic of pyroclastic deposits (i.e. grain size and color), which may reflect temporal behavior of eruption intensity. However, the connection between stratigraphic variation of pyroclastic deposits and temporal behavior of eruption intensity cannot be straight found according to settling sequence because pyroclastic deposits may experience sorting process during the transportation and erosion process after the deposition. These processes make it difficult to precisely interpret time development of plinian eruption from analysis of pyroclastic deposits. Fortunately, we have a chance namely three subplinian phases of the 2011 Sinmoedake eruption January (26, 27 morning, and 27 evening), which represent the minimum influence of loss of materials. Furthermore there are additional constraints which are from different sources of observations concerning the eruption sequence such as satellite images. This opportunity allows us to consider the effect of sorting process during transportation on the stratigraphic variation of pyroclastic deposits.

We collected samples at two localities, Miike elementary school (about 7.5 km far from vent; nearer) and Natsuo elementary school (about 11 km far from vent; farther) on 29th and 30th, January. In order to observe the temporal change of deposits, we divided into 8 or 5 layers in sampling. We conducted grain size analysis for each layers by using sieve (phi=-2, -1, 0, 1) and calculated statistical properties based on Inman (1952). As a consequence, characteristic of stratigraphic variation of grain size in terms of median or mean showed two peaks at nearer locality and one peak at farther locality. Furthermore, values of dispersion increase around peaks of median or mean. In addition, we classify the sample (ash particle) into four categories depending on color (i.e. they are White, Gray-Brown, Black, and Reddish-Black), and determined number fraction of grains in each categories from counted numbers of grains. As a result, it is found that: (1) a fraction of Gray-Brown particles occupies the major part (about nine tenths) of deposits, (2) a fraction of Reddish-Black particles decreases with stratigraphic height, (3) a fraction of Black particles correlates with change of median or mean, (4) a fraction of White particles increases with stratigraphic height.

Assuming that a single plinian eruption makes a single peak of median or mean of grain size distribution, analyzed deposits correspond to two subplinian eruptions. Together with isopach data (AIST) and satellite image (Meteorological Agency) on January 26th and 27th, we can conclude that pyroclastic deposits corresponded to eruptions of 26th (16:10-18:35) and 27th (02:10-04:40). As a result, it reveals order of sedimentation, reflecting characteristic of size and color of pyroclastic deposits. From changes of number fractions of grains in each category depending on color, we speculate where particles of each category are originated from; grains of Black and Reddish-Black come from vent, grains of White come from the rim of magma chamber, and grains of Gray-Brown correspond to magma. It is also confirmed that the deposit at farther distance, contains smaller sedimentary particle size.

This study provides some extensive information of stratigraphic variation. Hereafter we need another approach to estimate how eruption intensity changes in a single eruption by considering the effect of sorting process.

Keywords: Pyroclastic Deposit, Stratigraphic Variation, Eruption Intensity

SVC53-P02 Room:Convention Hall Time:May 21 17:15-18:30

Vesiculation and degassing processes inferred from the ejecta in the Shinmoedake 2011 eruption

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The Shinmoedake 2011 eruption which started on 26th January 2011 showed a characteristic transition of eruption styles. Two sub-plinian eruptions from 3 p.m. on 26th Jan and from midnight of 27th Jan produced a pumice deposit of 6 cm in thickness at 8 km from the vent. After the sub-plinian phase, the eruption style shifts to the phase of vulcanian eruptions which majorly produced volcanic ash since an eruption at 3 p.m. on 27th Jan. We obtained samples from the pumice deposits of the sub-plinian eruptions (26-27th Jan) and the bombs of the vulcanian eruptions (1st Feb and 14th Feb). The observation of these ejectas is expected to provide a clue to understanding the transient behavior of eruption styles.

Pumice deposits mainly consist of white, gray, brown and black-colored pumices. It is highly likely that both gray pumices and bombs originate from the mixed magma formed by mixing between dacitic and basaltic magmas (Suzuki et al., 2011, Hoshide et al., 2011, JpGU Meeting). The vesicularity of gray pumices (SiO_2= 58.6 wt%) varies about from 40% to 80% and the vesicle distributions in gray pumices are relatively homogeneous. The connectivity of pores and the average size of vesicle in pumices drastically increases at about 60-65% vesicularity.

Breadcrust bombs (several meters in size) on 1st Feb are composed of a surface quenched rind and an internal slowly-cooled part. The internal part (vesicularity: 50%~) has small (10-20 microns in size) and large (>100 micron) vesicles but the quenched rind (vesicularity: 30%~) rarely contains small vesicles. Large vesicles tend to attach to phenocrysts. Small bombs (3-4 cm in size) on 14th Feb have the vesicularities of about 0-20%. The vesicle distributions in them are heterogeneous and small vesicles (tens of microns in size) have a network arrangement.

In this presentation, we consider degassing processes of magma on the basis of quantitative texture analyses of these ejectas using SEM and X-ray computed tomography.

Keywords: bomb, pumice, degassing, vesicle texture, microlite

SVC53-P03 Room:Convention Hall Time:May 21 17:15-18:30

Petrological groups of Nekodake volcanic rocks and origin of their compositional variations

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Volcanic activities prior to caldera-forming eruptions give important constraints on the magma supply system leading to catastrophic eruptions. Nekodake volcano, located in the eastern end of Aso Caldera, Central Kyushu, SW Japan, was considered to have been active during the post-caldera period. However, the stratigraphic relations and radiometric ages suggest that the Nekodake volcano was active during the caldera forming periods. This study elaborated the magma genesis of the Nekodake volcano from those geological, petrographic, mineralogical and geochemical features.

We classified the Nekodake volcanic products into six groups from phenocryst assemblage, rock type and chemical composition. We also found a correlation between petrographic groups, compositional groups and stratigraphy. For instance, incompatible elements are mainly abundant in olivine group (olivine + 2 pyroxene + plagioclase), and the volcanic ejecta of these groups are predominantly located in lower eastern part of Nekodake. Petrographical and petrological disequilibrium features, such as co-existence of olivine and hornblende, dusty plagioclase, An-rich (An72 - An92) and An-poor (An48 - An58) plagioclase, were observed in lower part and some upper part of Nekodake volcano. In contrast to them, some ejecta shows clear plagioclase and mono-modal distribution of An contents of plagioclase (An58 - An72). Moreover, we found many crustal materials in these upper parts of volcanic ejecta.

These observations indicate that several types of magma chambers are developed during volcanic activities of Nekodake, and that compositional diversity of the magmas can be explained by magma mixing among the end-member magmas in addition to fractional crystallization and crustal assimilation.

Keywords: Aso, Nekodake volcano, Whole rock chemical compositions, Mineral compotisions, Magma mixing, Assimilation

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SVC53-P04 Room:Convention Hall Time:May 21 17:15-18:30

Thickness of AT tephra in the Uwa-basin in western Shikoku, southwest Japan

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To estimate accurate thicknesses of widespread tephra is important to anticipate potential size and influence of the eruption. However, to estimate it is sometimes difficult due to post-depositional remobilization and resedimentation. Then we drilled nine boreholes and four geo-slicers at the Uwa basin in western Shikoku, with observation and grain-size analysis to estimate accurate thickness of AT tephra.

The Uwa basin is 2.5 km in north-south by 3 km in east-west located in the uppermost part of the Hijikawa River catchment and includes many layers of widespread tephras from Kyushu Island. AT exists at the depth of 1-3 m from the surface and well-preserved condition, depositing on humic soil and being covered by clay or humic clay. The thickness of AT is thinner near the margin of the basin and thicker in the center of the basin. The maximum thickness including resedimented layer is 170 cm. The representative sequence of AT is as following from the bottom.

A: White colored glassy tephra consists of very fine sized glass shards with minor medium sized pumice. The thickness is 5 cm.

B: Brown gray colored laminae-rich tephra consists of medium to fine sized glass shards. The thickness is less than 50 cm.

C: Massive tephra consists of fine sized glass shards. The thickness is less than 50 cm.

D: Gray brown colored laminae-rich tephra consists of fine sized glass shards with heterogeneous clasts. The thickness is less than 90 cm.

Remobiled layer is recognized based on sedimentary structure and heterogeneous clasts. D layer is interpreted as remobiled layer consists of highly concentrated glass shards. There are many examples of thick AT in southwest Japan. Further observation from these may contribute to distinguish original and remobiled tephra layer.

Keywords: AT tephra, thicknesses, Uwa basin, western Shikoku

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Magma plumbing system in Ofunato stage of Miyakejima volcano based on high-pressure experiments and melt inclusion study

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Miyakejima is an active volcanic island located about 200 km south of Tokyo in Izu-Mariana arc. Forecasting future eruptions of Miyakejima is important, and precise knowledge on its magma pluming system is essential. Tsukui et al. (2001) divided the volcanic activity of the last 10000 years into four stages: 10000-7000 (Ofunato Stage), 4000-2500 (Tsubota Stage), 2500 y.B.P to AD1154 (Oyama Stage) since AD1469 (Shinmio Stage). Products of the Ofunato stage are basalts and they are relatively primitive. On the other hand, products in Tsubota Stage are andesites and those in the later three stages are mixed products of basalt and andesite. To understand the evolution of the magma plumbing system, first I reconstruct the simple magma chamber in Ofunato Stage by high-pressure experiments and also analyzed major elements and volatile contents in melt inclusions of phenocrysts of products in Ofunato stage in order to confirm experimental results.

OFS scoriae, which are one of the least fractionated Miyakejima basalt in Ofunato stage, were used. Phenocrysts of OFS are only plagioclase (10.9 vol.%) and olivine (0.7 vol.%). Core composition of plagioclase phenocrysts is 90 to 96 % An. Core composition of olivine phenocrysts is 78 to 82% Fo. Fig,1 shows melt composition of OFS, composition of melt inclusions (MIs) in olivine and plagioclase phenocrysts and bulk composition of eruptive products in the last 10,000 years. The chemical composition of the melt inclusions in olivine were corrected for post entrapment crystallization by adding a host olivine component up to the composition which satisfies olivine˜melt equilibrium, KD = 0.30.

Most compositions of MIs in olivine were plotted near the melt composition of OFS (gray circles in Fig.1) indicating that melt of OFS is in equilibrium with phenocrysts of olivine. Small numbers of MIs in olivine was more primitive than the other, therefore low-evolved magma may have mixed. MIs in plagioclase were not corrected for post entrapment crystallization so that their compositions are scattered (gray squares in Fig. 1)

Experiments were performed in the temperature ranges of 1050-1200C at 1.0, 1.5, 2.0, 2.5kbar using IHPV at the Magma Factory, Tokyo Tech. Based on the experimental results (phase relation, mineral composition) and petrology of OFS (modal composition and core compositions of phenocrysts), magma chamber in Ofunato Stage was reconstructed. The magma chamber was located at 5˜6km depth (˜1.5kbar) and water-rich (˜3 wt.%) basalt magma crystallized olivine and calcic plagioclase (which is the typical phenocryst assemblage throughout Ofunato Stage) at ˜1100C under NNO-buffer. Estimated depth of OFS magma chamber (ca. ˜7000 YBP) is equal to that of the shallow magma chamber in 2000 eruption (Saito et al. 2005, 2010). Accordingly, it is suggested that magma chamber survived through time in spite of two caldera forming stages.

Keywords: Miyakejima, magma chamber, high-pressure experiments, melt inclusion, volatile content

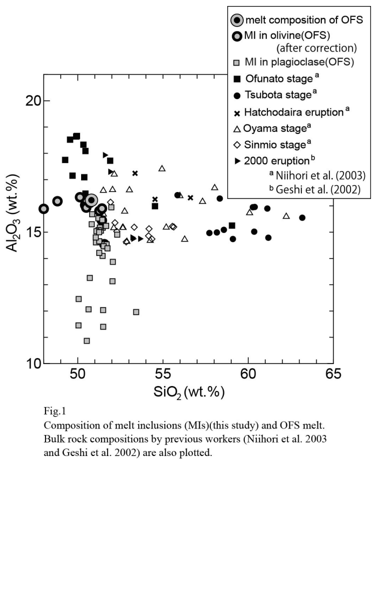

Fig.1
Composition of melt inclusions (MIs)(this study) and OFS melt. Bulk rock compositions by previous workers (Niihori et al. 2003 and Geshi et al. 2002) are also plotted.

SVC53-P06 Room:Convention Hall Time:May 21 17:15-18:30

Petrology of gabbroic rocks from the Niijima Island, northern Izu-Ogasawara arc

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Niijima Island is the subaerial portion of the northern extremity of arcuate structural high, the Izu-Ogasawara island arc. It is composed of thirteen rhyolitic monogenetic volcanoes, one or two andesite and a basalt volcano (Isshiki, 1987). Each volcanic activity consist of pyroclastic flow or surge deposits, pyroclastic cones and a lava dome, and the latest eruption occurred in 886 A.D. Isshiki (1987) reported that Lithology of the volcano changed from hypersthene-cummingtonite-hornblende rhyolite through cummingtonite rhyolite to biotite rhyolite with some exceptions, as time elapsed. Olivine basalt of high-alumina basalt clan magma was erupted at 3ka during the activity of biotite rhyolite in the Northern part of the island. Rhyolite lavas often carry mafic inclusions which are thought to be products of mixing and/or mingling with basaltic magmas (Koyaguchi, 1986).

Xenoliths of gabbroic rocks are widely recognized in Quaternary mafic (basalt to basaltic andesite) volcanoes, in the northern part of Izu-Ogasawara arc (e.g. Oshima volcano, Miyakejima volcano). Such kind of rocks provides us important information for the structure and compositions of the underlying crust and mantle. Gabbroic rocks are also identified from silicic volcano.

In this study, we will report the newly observed gabbroic xenoliths from Niijima Volcano. Gabbroic xenoliths were collected from 2 localities, 8 samples from Wakago pyroclastic surge deposits (host rock is olivine basalt; bulk SiO_2 wt% = 49.5-51.0) and 2 samples collected from Attiyama lava dome (host lava is biotite rhyolite; bulk SiO_2 wt% = 76.8-78.0). Most of these were enclaved by thin basaltic envelopes. They are classified into amphibole absent type; leucocratic gabbro, gabbro (Streckeisen, 1976) and amphibole present type; leucocratic hornblende gabbro (Streckeisen, 1976). Petrological features of each type as shown below:

Amphibole absent (B) type: This type has relatively coarse grained (0.5-3 mm) equigranular texture and it has miarolitic cavities. This type consists of plagioclase (An mol % = 58-90) and clinopyroxene (Mg# = 76-80), orthopyroxene (Mg# = 73-78), Fe-Ti oxide and olivine (Fo = 75-80). Most of the Pl crystals show normal zoning.

Amphibole present (B) type: This type has relatively fine grained (0.3-2 mm) equigranular texture. It consists of plagioclase (bimodal compositions in An mol % = 45-55, 70-88), hornblende (Mg# = 68-73), cummingtonite (Mg# = 69-73), quartz and Fe-Ti oxide. Using amphibole-plagioclase thermometry (Holland & Blundy, 1994) and Al-in-hornblende barometry (Anderson & Smith, 1995), P-T conditions will be estimated.

A types are depleted in trace elements and REE contents (bulk compositions) compared with host basaltic rocks. N-MORB-normalized (Pearce, 1983) trace elements patterns of these rocks are similar to that of gabbroic rocks from Tanzawa plutonic complex (Kawate & Arima, 1998). B types have less evolved compositions in mineral chemistry compared with Niijima rhyolite. Hornblende compositions in that types overlap with that of gabbroic suites in Tanzawa rocks.

As proposed by Nakajima & Arima (1998), above evidences suggest a possibility that the rhyolitic magmas in Niijima volcano could be formed by partial melting of amphibolite crust.

Keywords: gabbro, xenolith, rhyolite, amphibole, Izu-Ogasawara arc

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Mode of A.D.838 eruption of Tenjyo-san volcano,Kozu-shima island based on hydration of glassy fragment

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Kozu-shima is one of the Izu Islands and located about 170 km southwest of Tokyo. The island mainly consists of rhyolitic lava domes, thick lava flows and pyroclastic deposits. The latest eruption occurred at Tenjyo-san in 838 A. D. Individual lava activities are able to be separated easily, but pyroclastic deposits are difficult to be distinguished in detail because their component and composition are very similar. Thus it is difficult to identify sources of pyroclastic deposits and the eruption history is still uncertain. I measured the thicknesses of the hydration layers along the cracks in the glassy groundmass of Tenjyo-san lava and glassy rock fragments in pyroclastic deposits to distinguish 838 Tenjyo-san pyroclastic deposits.

Hydration layers were measured on thin sections, and results were plotted in histograms. According to the histograms, some fragments have two or more peaks of hydration layers. When the cracks are formed by cooling of magma or fracturing of rock, hydration layers begin to be formed along the crack. The thickest peak is considered to correspond to the cooling of magma. The others are estimated to relate the fracturing of rock. In the measured data, the thinnest peak of hydration layer is almost corresponding to the Tenjyo-san lava's peak. Therefore, these glassy rock fragments were formed before Tenjyo-san eruption and caught in the pyroclastic deposit when the eruption occurred.

Contrast of deposit which is based on the results of hydration layers show that the pyroclastic flow which is distributed at the southwest of island is corresponding to the base part of pyroclastic flow at northwest.

This result and shape of Tenjyo-san lava and distribution of pyroclastic flows indicate Tenjyo-san eruption began in the south part of present Tenjyo-san lava dome, and the vent shifted to the north part of the dome.

Keywords: hydration, rhyolitic magmatism

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Stratigraphy and Lithologic features of the Borehole Core from the Takamine Observation Well, Asama Volcano

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Stratigraphy and lithologic characteristics of borehole cores from the Takamine observation well, located at the western flank of Asama Volcano, were described. The total depth of the borehole was 201 m from the surface. Based on the lithologic features, the borehole cores can be divided into of four stratigraphic groups. The uppermost part (0 to 2.8 m in depth) is of dacitic pyroclastic-flow deposits. The upper part (2.8-77.6 m in depth) consists mainly of mafic andesite debris-flow (lahar) and pyroclastic-flow deposits. The middle part (77.6-103.6 m in depth) consists mainly of andesite lava flow and debris-flow deposits. The lower part (103.6-201 m in depth) is of felsic andesitic pyroclastic-flow deposits.

The uppermost part can be correlated to pumice-flow deposits of the Hotokeiwa Stage. Pumiceous lumps found in soil at the depth of 72.0 m are similar pterographically to the On-Ot tephra (ca. 90,000 yBP). The upper part can be correlated to the deposits distributed on the mountain flank of Kurofu Volcano. The middle part can be correlated to Kurofu Volcano or Takamine Volcano that is a member of the Eboshi volcano group. The lower part may be correlated to an older felsic member of the Eboshi volcano group like Sampogamine or Mizumoto Volcano.

Keywords: Borehole core, Asama volcano, Eboshi Volcano Group, Eruptive History

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The Ashikuraji pyroclastic flow deposit: a newly found pumice flow deposit erupted during Stage 2 of Tateyama volcano

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Tateyama volcano in the Toyama Prefecture, central Japan, is a partly dissected stratovolcano, and its summit area is truncated by a ~5 km wide caldera. The volcanic history of Tateyama volcano has been divided into five stage (1a, 1b, 2, 3, and 4; Harayama et al., 2000). The stage 2 eruption (ca. 130-95 ka) formed voluminous pyroclastic flow deposits that have been collectively named the Shomyodaki pyroclastic flow deposits (SPFD: Nozawa et al., 1960; Yamasaki et al., 1966; Harayama et al., 2000). The juvenile pyroclasts of the SPFD are phenocryst-rich dacitic pumice and phenocryst-poor andesitic scoria with mingling and mixing textures. Our new major and trace element data on 29 juvenile pyroclast show that the juvenile pyroclasts from the distal part (500-1000 m a.s.l. of Ashikuraji area) and those from the proximal part (2200-2350 m a.s.l. of Murododaira area) of the SPFD form distinct dacite-andesite mixing lines. Dacitic pumices collected from the distal and proximal parts are similar in major and trace element composition but varying in phenocryst content and assemblage. The distal dacitic pumices have lower hydrous phenocryst (biotite + amphibole) contents and lack quartz phenocryst. In contrast, the proximal dacitic pumices have higher biotite, amophibole, and quartz phenocryst contents. Major and trace element compositions of the andesitic scoriae collected from the distal and proximal parts are different from each other. The proximal scoriae can be distinguished from the distal scoriae by their higher FeO*, K2O, V and lower Al2O3, Na2O, P2O5, Zr concentrations. These petrological features suggest that the formerly defined SPFD consists of two distinct pyroclastic flow deposits of different whole-rock and modal compositions and ages, i.e., the Ashikuraji pyroclastic flow deposit (APFD: the lower part of the formerly defined SPFD; mainly pumice flow deposits) and the SPFD (the upper part of the formerly defined SPFD; mainly scoria flow deposits). The former is a newly found pyroclastic flow deposits, and was previously regarded the distal margins of the formerly defined SPFD (Nozawa et al., 1960). Two widespread tephras derived from Tateyama volcano, i.e., the pumice-rich Tateyama D tephra and the overlying scoria-rich Tateyama E tephra (Machida and Arai, 2003), may be correlated to the APFD and SPFD, respectively.

Keywords: Tateyama volcano, pyroclastic flow deposit

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The Bentengawara pyroclastic flow deposit, Nantai volcano: a pyroclastic flow generated by scoria cone collapse

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Nantai volcano (2486 m asl), a near-conical stratovolcano with a ca. 1-km-wide summit crater, is located on the volcanic front of NE Japan. The 11-12 cal. ka BP Bentengawara pyroclastic flow deposit (BPFD; Miyake et al., 2006) occurs at the northern slope and northeastern foot of the volcano, and it consists of a single block-and-ash flow deposit unit. We describe the petrological features of the juvenile pyroclasts, identify the source, and establish the origin of the BPFD. The BPFD consists of a mixture of finely pulverized rock ash, lapilli, and volcanic blocks. The volcanic blocks are texturally and morphologically diverse, including vesicular scoria blocks, poorly to moderately vesicular cauliflower bombs, and none to poorly vesicular bread-crusted, densely-welded, lava-like blocks. The lava-like blocks commonly have curviplanar none-vesicular surfaces and prismatic joints extending inward from the surfaces to the poorly vesicular interior, which imply quenching, post-depositional vesiculation, and the resultant fracturing of hot welded materials. The coexistence of vesicular pyroclasts and densely welded blocks suggests that the BPFD was generated by the collapse of a pre-existing, partly welded, high-temperature volcanic edifice. On the basis of rock types, and modal and whole-rock compositions of the juvenile pyroclasts, we identified the partly collapsed scoria cone within the summit crater as the source for the BPFD. The scoria cone comprises a thick scoria and bomb fall deposits and a densely welded part occur at the base. Lithological characteristics of the BPFD and the source scoria cone suggest that the first phase of the eruption occurred within the summit crater and produced a scoria cone on the steep inner slope of the summit crater. During this phase, hot pyroclasts rapidly accumulated in the proximal zone as fallout, creating the variably welded source scoria cone. This phase was followed by the gravitational collapse of the scoria cone, thereby generating the BPFD.

Keywords: Nantai volcano, pyroclastic flow deposit, scoria cone

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Contrasting tapping processes from the magma chambers of the 17 cal. ka BP eruption of Nantai volcano, NE Japan

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Nantai volcano, located on the volcanic front of NE Japan, has been characterized by intermittent plinian and subplinian eruptions since its birth (Yamasaki, 1957; Akutsu, 1979; Muramoto, 1992; Suzuki et al., 1994), and the latest and largest one occurred at 17 cal. ka BP (Nakamura et al., 2011). The eruption sequence of the 17 cal. ka BP eruption is complex, being initiated with scoria fallout (Nantai-Imaichi tephra) and subsequent scoria flow (Sizu and Takanosu pyroclastic flow deposits) followed by pumice fallout (Nantai-Shichihonsakura tephra) and terminated by the generation of pumice flows (Arasawa-Ryuzutaki pyroclastic flow deposits) (Ishizaki and Morita, 2011). Our previous studies on the geochemistry and mixing/mingling relationships of the juvenile materials have revealed that two dacitic magma chambers (tholeiitic one and calc-alkaline one) fed the 17 cal. ka BP eruption products (Ishizaki and Kureyama, 2004). In addition, petrologic evidence have shown that the initial scoria eruption was triggered when mafic magma intruded the tholeiitic dacite chamber; then, emptying of the tholeiitic chamber and the new mafic replenishment led to successive eruption of the adjacent calc-alkaline chamber. Our new componentry data show that the tapping processes differ between the early scoria eruption and the later pumice eruption. During the scoria eruption, homogeneous phenocryst-poor chamber dacite (64.6-67.4 wt.% SiO2) was first tapped by the plinian phase from the main portion of the preexisting magma chamber. As eruption proceeded, less-evolved, replenished andesitic magma (53.6-54.5 wt.% SiO2) was tapped from the deeper part of the chamber, forming the uppermost part of the scoria-fall deposit and the overlying scoria-flow deposits. A similar eruption sequence from the chamber dacite to the replenished andesite has been reported for many other plinian-related eruptions (e.g., the 1912 eruption of Katmai; Hildreth, 1983). In contrast, during the later pumice eruption, relatively less-evolved hybrid magma (59.1-60.8 wt.% SiO2) was first tapped by the plinian phase. As the eruption proceeded, more-evolved, phenocryst-rich chamber dacite magma (64.4-65.7 wt.% SiO2) was tapped, forming the main part of the pumice-fall deposit and the overlying pumice-flow deposits. A similar eruption sequence has been reported for some other plinian-related eruptions (e.g., the 1929 eruption of Hokkaido-Komagatake; Takeuchi and Nakamura, 2001), suggesting that eruption of a mixed magma is a precursor of phenocryst-rich chamber dacitic magmas. The complex magma tapping processes and the resultant eruption sequence (i.e., dacitic precursor to andesitic successor vs. andesitic precursor to dacitic successor) may be controlled by the density contrast between the chamber dacite magma and the replenished mafic magma.

Keywords: Nantai volcano, Plinian eruption, pyroclastic flow, magma chamber

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The dacite to basalt zoned Nantai-Ogawa Tephra of Nantai volcano (Part I): componentry and whole-rock compositions

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Nantai volcano, located on the volcanic front of NE Japan, has been characterized by intermittent explosive behavior since its birth, and the numerous tephras were dispersed toward the east (Yamasaki, 1957; Akutsu, 1979; Muramoto, 1992; Suzuki et al., 1994). The Nantai-Ogawa tephra (Nt-Og) is the oldest plinian-fall deposit of the volcano (Muramoto, 1992), and is chemically zoned from dacite at its base through andesite towards basalt at the top of the deposit. Componentry and major and trace element data on 37 juvenile pyroclasts and their petrography have been used to obtain detailed information about processes taking place in the conduit and the crustal magma chamber associated with explosive volcanism. Petrological examinations revealed that a variety of juvenile pyroclasts was ejected during the eruption. Amphibole-bearing, highly vesicular dacitic pumice (AmPm: 61.8-63.7 wt.% SiO2) is a minor component of this eruption and expelled during the initial eruption phase. This suggests that water-rich dacitic magma have accumulated beneath the pre-eruptive chamber roof just before the Nt-Os eruption. Phenocryst-poor, highly to moderately vesicular gray scoria (GrSc: 51.6-62.7 wt.% SiO2) is the dominant type of pyroclast expelled during the early eruption phase. In contrast, euhedral-phenocryst-rich, moderately to poorly vesicular black scoria (BlSc: 46.7-51.7 wt.% SiO2) with characteristic cauliflower-like surface was the dominant type of pyroclast expelled during the later eruption phase. Partially melted granitic xenolith and their crystal fragments are observed in the juvenile pyroclasts, suggesting that assimilation of the granitic rocks played major role in the compositional variation of the juvenile pyroclasts. Trends of major and trace elements are consistent with crystal-liquid-fractionation of the observed phenocryst assemblages and minor crustal assimilation processes, and rule out syn-eruptive mixing processes between the compositionally diverse magmas. The vesiculation of the H2O-rich AmPm magma beneath the chamber roof may have triggered the Nt-Os eruption. In addition, the existence of dense cauliflower-like BlSc suggests that the interaction of the magma with the external water also played important role in the Nt-Og eruption.

Keywords: Nantai volcano, Nantai-Ogawa tephra, Plinian eruption, magma chamber

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Magma plumbing system of the pre-caldera volcanism: From the lithic fragments in pyroclastic flows, Shiobara Caldera

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Three Middle pleistocene pyroclastic flow deposits (Otawara pyroclastic flows) erupted from Shiobara caldera, consist of KN-pfl, KT-pfl (0.6Ma) and TN-pfl (0.3Ma) located in the north foot of the Takahara volcano, and distributed mainly on the southeastern side. KN-pfl and TN-pfl contain a lithic fragment concentration zone (LCZ), so this study investigated whole rock major and trace element compositions analyzed by XRF are reported from lithic fragments in LCZ of KN-pfl and TN-pfl. This study used fresh samples and analyzed each 40-50 samples at random. The results of analysis data compared with 288 samples of Takahara volcanics.

As a result, all of lithic fragments are similar to tholeiitic rocks of Takahara volcanics, be considered accessory rocks. In addition, most lithic fragments in LCZ of KN-pfl resembles that basalt-andesite rocks distributed east and south side of Takahara volcano. In contrast, many lithic fragments in LCZ of TN-pfl are undiscovered dacite rocks in this area. In Harker diagrams, K_2O content become two trends suggested the different processes of magma genesis.

Considering these characteristics of chemical compositions about lithic fragments in LCZ, two types of tholeiitic basalt-andesite magma activity were until 0.6Ma, and KN-pfl and KT-pfl erupted by two types of felsic magma activity, then the caldera was formed. The tholeiitic dacite-rhyolite magma fed at 0.6Ma to 0.3Ma, and the caldera forming or expanding eruption by TN-pfl. Since 0.3Ma, the magma plumbing system of Takahara volcano has extremely changed. Then calc-alkaline magma activity built post-caldera stratovolcano.

Keywords: Volcanic history, Magma plumbing system, Caldera, Pyroclastic flow, Lithic concentration zone, Whole rock composition

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Stratigraphy of pryoclastic flow deposits in the Onoda Formation distributes on Iwagasaki region in the north of Miyagi

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Introduction

The Onoda Formation, formed in the Late Pliocene to the Pleistocene, distributes on Iwagasaki region on the east of Onikobe and Naruko calderas (Tsuchiya et al. 1997). It is mainly recognized at Mozume area in Osaki City and Uguisuzawa area in Kurihara City. Pyroclastic flow deposits on Quarternary period over lie on the Onoda Formation, and some similar pyroclastic flow deposits are also in Onoda Formation. Soda (1993) and Kuzumaki and Oba (2009) counted five and four pyroclasic flow deposits in Onoda Formation at Mozume area, respectively, and three of them are considered to be identical. Kuzumaki and Oba (2011) also studied Uguisuzawa area and found that two pyroclastic flow deposits are identical with those at Mozume area, although they did not reveal their source.

It is important to reveal the source of the pyloclastic flow layers in Onoda formation and to investigate their relations with the eruption products of Onikobe and Naruko calderas. To re-examine the stratigraphy of pryoclastic flow deposits in Onoda formation we observed the outcrops at Uguisuzawa area.

Stratigraphy of pyroclastic flow deposits in the Onoda Formation

The stratigraphy was studied based on the distributions of each deposit, inferred topography at deposition, heavy mineral assemblages and bulk chemical compositions ofpumice clast.

These analyses revealed that the Onoda Formation at Uguisuzawa area contains at least seven discrete pyroclastic flow deposits, named Flow 1 to Flow 7 from bottom to top. Heavy minerals in pumice are: opx and cpx in Flow 1; opx in Flow 2; opx (minor) in Flow 3; opx in Flow 4; opx and cpx in Flow 5; opx in Flow 6; opx and hb in Flow 7 (opx=orthopyroxene, cpx=clinopyroxene, hb=hornblende).

Among the seven flows five of them are identical to those at Mozume area reported by Soda (1993).

Characteristics of chemical composition

SiO_2 content in bulk pumice ranges 70-74 wt% on Flow 1 and 2, 74-77 wt% on Flow 3 and 4, and 72-75 wt% on Flow 5, 6 and 7.

SiO_2-K_2O plot shows that K_2O content of Flow 5-7 pumices are higher than those of Flow 1-4. Compared with these, and with Onikobe pumice, Naruko pumice is poor in K_2O. Flow 1-4 pumices are on the same SiO_2-K_2O trend with the pumices from Onikobe caldera, but Flow 5-7 pumices, which are rich in K_2O, deviate from it.

Discussion

Since five pyroclastic flow deposits in Mozume area (Soda, 1993) are identical with those found in Uguisuzawa area, the distribution area of each flow in Onoda Formation is over 200 km^2, all of which are categorized as large pyroclastic flow.

SiO_2-K_2O plot indicates Flow 1-4 were from the same eruption source and the source magma had become felsic with age. They might be from Onikobe caldera because Flow 1-4 pumices are on the same chemical composition trend with the pumice from Onikobe caldera.

K_2O content of Flow 5-7 are so high that they should not be from Onikobe and Naruko caldera. There are calderas, formed in the Late Miocene to the Pleistocene, around the Iwagasaki region (Ito et al. 1989). Among them Innai, Sanzugawa, Genbi, and Ginzan calderas are not the origins of Flow 5-7 because they are too old and topographic barriers on their activity periods should hinder to distribute the Onoda formation pyroclastic flow deposits on Iwagasaki region. To the contrary Akakura caldera and Mukaimachi caldera, locate on the west of Mozume area and back arc side of Onikobe and Naruko calderas, formed between 3-1.4 Ma (Otake, 2000) and between 1.0-0.6 Ma (Koike et al. 2005), respectively, which agrees with the period when Onoda formation was deposited (3.3-0.6 Ma; Tsuchiya et al. 1997). In addition, there was no obstacle between these calderas and Iwagasaki region. For these reasons we propose Akakura and Mukaimachi calderas are the source of Flow 5-7. Our proposal is in harmony with the fact that K_2O content of Flow 5-7 are higher than that of Onikobe and Naruko, because K_2O content tends to be higher from fore to back arc.

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Temporal variation of geological and petrological features of the Kattadake pyroclastic rocks in the Zao newest activity

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Based on petrologic analyses of successively corrected samples, we have examined the magmatic evolution in the newest activity (ca. 30 ka to the present) of Zao volcano. In this study, we will present geological and petrologic characteristics of the Kattadake pyroclastic rocks which is one of the units of the newest activity, and reveal the magmatic evolution of this unit.

The Kattadake pyroclastic rocks distribute inner part of the Umanose caldera which formed in early part of the newest activity. This unit is composed of more than 20 pyroclastic layers, which are divided into lower, middle, and upper parts. The deposits show four facies, scoriaceous ash, agglutinate, volcanic breccia, and tuff breccia. The dominant facies is scoriaceous ash all the way. The tuff breccia facies is observed in lower and upper parts, and the agglutinate and volcanic breccia facies are in the upper part. The agglutinate facies also occur in top of the middle part. The scoriaceous ash facies layers are composed of black scoriaceous ash matrix with planer stratification, and include black scoriae fragments. The agglutinate facies layers are composed of black scoria spatters, bombs and fragments. The volcanic breccia facies is characterized by abundant andesitic blocks in blown ash matrix. The tuff breccia facies layers are constituted of white to pinkish clay matrix with altered lithics.

The rocks belong to medium-K, calc-alkaline rock series, and are mainly olv-bearing-cpx-opx basaltic-andesite to andesite. In the upper part, olv-cpx-opx basaltic-andesite also occur. The range of the SiO_2 and K_2O contents are ca. 55.0-58.4 % and ca. 0.69-1.18 %, respectively. The whole rock SiO_2 contents of rocks from lower to middle parts are almost constant, ca. 55.5 %. In contrast, the contents increase to ca. 57.0 % in upper layers. In addition, the rocks form top layer of the upper part show Cr-Ni richer trends than the other layers.

By textural and compositional features, phenocrysts can be divided into following three groups. Group A includes low-An plagioclase (An = ca. 58-80), orthopyroxene (Mg# = ca. 64-68), and clinopyroxene (Mg# = ca. 65-71). Most of these plagioclases have patchy textured core, oscillatory zoned mantle with or without dusty zone, and thin clear rim. Some of An-richer ones have honeycomb textured core and clear rim. The pyroxenes show homogeneous core and have narrow Mg-rich zone (Mg#, up to 78) just inner part of rim. Glass inclusions in core are common. Group B includes high-An plagioclase (An = ca. 88-92) and olivine (Fo = ca. 74-85). Both plagioclase and olivine usually show a homogeneous clear core with normal zoned rim, whereas some Fo-poorer olivines (Fo, lower than 80) have narrow Fo-rich zone (Fo = ca. 83) just inner part of rim. Group C includes small and subhedral orthopyroxene (Mg# = ca. 70), although this phenocryst is always rare.

We inferred that the Kattadake pyroclastic rocks were formed by magma mixing between two end-member magmas for group A and B. Proportion of felsic end-member would increase form lower to upper parts. The bulk SiO_2 content and temperature of the felsic end-member magma are estimated to be ca. 59-61 % and ca. 950 degrees C. The similarity of the chemical compositions of group A phenocrysts among layers suggests that the felsic end-member magma had similar composition during the activity. The bulk SiO_2 content of the mafic end-member magma are estimated to be 50-52 %. Further, the olivines with Fo-rich zone indicate that the mafic end-member magma would be tapped by more mafic basaltic magma form deeper area. The more mafic magma would be effective in forming the Cr-Ni richer magma in top of upper part. During the injection of the mafic end-member magma into the felsic magma chamber and subsequent mixing, dusty zone of plagioclase, Mg-rich zone of pyroxene, and group C phenocrysts would be formed. Consequently, well mixed magma erupted.

Keywords: Magma evolution, Magma mixing, Phenocryst types, Kattadake pyroclastic rocks, Zao volcano, NE Japan

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Recent volcanic activity at Akita-koma. and Iwate Volcanoes after large trench-type earthquakes

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The gigantic reverse-faulting of the 2011 earthquake off the Pacific coast of Tohoku brings about large crustal movements in the eastern part of Japan. The crustal movements occur the temporal extensional stress field which activates the volcanic activity and seismicity in the eastern and central parts of Japan.

The volcanic earthquakes began to occur at the north flank of Akita-komagatake Volcano after about 33 hours of the Miyagi-ken Oki earthquake on May 28, 2003 (Ueki at al., 2004). Earthquakes have occurred at the southern area in 2004, and below the summit in 2005. It is important to note that no volcanic earthquake below the summit has been found during the past observations. The geothermal manifestations were found out at the northeastern flank of the Medake cone on April, 2009, which has been the most active cone for about 80 years in Akita-komagatake Volcano. The manifestations are becoming gradually larger now.

The volcanic tremors and earthquakes began to occur at Iwate Volcano after the Sanriku-haruka Oki earthquake (M7.6) on December 28, 1994. The volcanic tremor which continued for 45 minutes occurred at a depth of about 8km at the eastern flank of the volcano on September 15, 1995. Many volcanic earthquakes continiued to occur from December, 1997 (Hamaguchi, 2005). The crustal movements also suggested the intrusion of magma in the direction of EW. On March, 1999, the geothermal manifestations were discovered at the Nishi (West)-Iwate Volcano and became large rapidly to the peak of activity in eary 2001.

The volcanic eruptions and/or geothermal activities of Akita-komagatake and Iwate Volcanoes have often occurred five years before or after the large trench-type earthquakes since 1896 (Doi, 2000).

It is clear that Akita-komagatake and Iwate Volcanoes have erupted and/or activated the geothermal activities in relation to the large trench-type earthquakes. So, it is necessary to predict their long-term activities by the eruption-model which is combined with the crustal movement and temporal extensional stress field caused by the large trench-type earthquakes.

Keywords: trench-type earthquake, Akita-komagatake Volcano, Iwate Volcano, extensional stress field

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Magma ascending and formation processes of Tokachi-Ishizawa obsidian lava, northern Hokkaido, Japan

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Volcanic products generally contain several crystals. These crystalline materials can be formed due to cooling, ascending and vesiculation processes of magma. Obsidian is also volcanic product, and obsidian-forming magma must experience these processes. However, obsidian contains rare crystals, and formation processes of obsidian are poorly understood. This includes the poor understanding of obsidian eruption process, like a magma ascending and emplacement. Thus we need the discussion about these processes.

Obsidian lava complex in Shirataki, Hokkaido, erupted at 2.2Ma and formed obsidian monogenetic volcanoes. A cross section of Tokachi-Ishizawa obsidian lava (TI lava) in the complex is about 50 m in height and is stratigraphically observed from its flow bottom; brecciated perlite layer, obsidian layer (Ob layer), banded obsidian layer (BO layer), and rhyolite layer (Rhy layer). The BO is alternate layer of obsidian and rhyolite. We collected lowermost (Rhy-1) and interior (Rhy-2) samples in rhyolite layer. Rhyolite in BO layer (BO_rhy) is the brittlest and the most vesiculated in all rhyolite samples. On the other hand, Rhy-1 has low vesicularity.

In this study, we conducted chemical analysis and precisely described the rock micro-textures of TI lava samples from obsidian layer to the rhyolite interior in order to understand the magma ascending and formation processes of silicic obsidian lava structure.

TI lava obsidian is almost aphyric, composed of glasses (>98% in volume), rare plagioclase phenocryst (0.4-1.0 mm), plagioclase microlite (<0.2 mm), magnetite microphenocryst (= 0.05-0.07 mm), magnetite microlite (<0.05 mm) and rare biotite (<0.01 mm). Rhyolite samples have crystalline texture.

We counted crystal number (N_v) of magnetite microlite by 3D counting method (Castro et al., 2003). The N_v value in all of the TI lava samples is high with $10^{13.4}$-$10^{14.2}$ [number/m^3]. N_v is considered to reflect the super-cooling of crystallizing magma (Toramaru, 1991; Toramaru et al., 2008). TI lava magnetite microlite indicates no systematic change of crystal number toward lava interior. If the magnetite microlite is cooling-induced crystal, N_v of TI lava samples should indicate the decreasing correlation toward lava interior due to the slow cooling of lava interior. Furthermore, Rhy-1 shows the lowest number density and the highest value of mean width of magnetite microlite. This tendency of crystal growth observed in Rhy-1 can not be explained by cooling, because Rhy-1 is the outer sample than Rhy-2, and cooling rate of Rhy-2 should have been lower than Rhy-1. And for so we infer the magnetite microlite in TI lava are decompression-induced (i.e. crystallized by vesiculation) crystals.

We performed X-ray diffraction analysis (XRD) for all TI lava samples. Rhyolite samples indicated the distinguished peak of albite. Based on the result of XRD, crystallinity of all rhyolite samples are following order: Bo_rhy > Rhy-2 > Rhy-1. Furthermore, this order is corresponding to the N_v value and degrees of vesiculation, that is, high N_v sample indicated the highest crystallinity and vesiculality in TI lava rhyolite. This relation may reflect the crystallization process by the vesiculation.

N_v and crystallinity inferred from XRD in TI lava indicate magma ascending and formation processes of obsidian-rhyolite layer during conduit and surface flow. Based on the rock texture and XRD, we can consider that crystallization process in rhyolite layer is affected by vapor phase. We intend to model the formation process that produced the obsidian-rhyolite internal structure of TI lava by viscous silicic magma.

Keywords: obsidian, rhyolite, lava, Shirataki

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Eruption history of Akanfuji in the Me-akan volcano, eastern Hokkaido, Japan

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Akanfuji, situated in the Me-akan volcano of Eastern Hokkaido, started its eruption ca. 2.5 ka, and its activity continued for 1,500 years. For about 1,500 years during the period, 17 eruption deposits (Ak1-Ak17) were recognized. The mode of eruption of this volcano was mainly scoriaceous sub-plinian type. Lava flows were often associated with the scoria eruption.

The eruption history of Akanfuji is divided into five stages. In the first stage (Ak1), scoria fall with many lithic fragments was deposited from northeast to east of the volcano. In the second stage (Ak2-Ak3), two larger eruptions occurred and the coarse scoria falls were deposited to northeast. In the third stage (Ak4-Ak13), some eruptions occurred and the scoria falls were dispersed in a northeast to southeast direction. This stage is characterized by finding orthopyroxene in the deposits. In the forth stage (Ak14-Ak16), three larger eruptions occurred and voluminous scoriae were deposited from southeast to south. In the final stage (Ak17), fine scoria fall was deposited from northeast to southeast.

Keywords: Me-akan volcano, Akanfuji, eruption history, scoria fall, lava

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Characteristic Eruption Sequence at the Main Stage of Nakamachineshiri in the Me-Akan Volcano, Eastern Hokkaido

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Throughout the eruption history of Me-Akan volcano on the Akan caldera, eastern Hokkaido, the largest eruptions occurred about 13000 years ago, referred to as Nakamachineshiri eruptive stage-I (Nak-I). Nak-I can be subdivided into two eruption stages. The initial eruptive stage is characterized by pumice-rich pyroclastic flows followed by lava eruptions (Nak-I-E), whereas the main eruptive stage by continuously eruptive sequence of lava fragments-rich pumice and scoria pyroclastic flows, Plinian pumice and scoria eruption, and pyroclastic flow eruption (Nak-I-M). From the observation of outcrop along the Me-akan river at eastern frank and analysis of eruption products, we report the characteristics of eruptive sequence and its magma plumbing system at Nak-I-M.

Nak-I-M is stratigraphically composed of scoriaceous pyroclastic flow layer containing plenty of lava rock fragments (M1 to M7), pumice and scoria pyroclastic flow layer (M8), Plinian pumice scoria fall layer (M9), pumice and scoria pyroclastic flow layer (M10), Plinian pumice scoria fall layer (M11), pyroclastic surge and volcanic ash fall layer (M12). These layers are piled up without gap of time, and are throughed by degassing pipe. The eruption sequence of M1 to M7 was formed by repeated basaltic andesite pyroclastic flows with scoria and agglutinate fragments accompanied by much of destructive lava fragments. The following eruptions (M8 to M12) are due to the magma mixing plumbing system of basaltic andesite and dacite magma. This eruption cycle of pyroclastic flows to Plinian falls, characterized by the increasing vesicularity and simultaneity of Plinian and pyroclastic flows eruptions, shows no typical eruption seqence but can be tentatively called ”eruptive sequence of Me-Akan type” .

Keywords: Me-akan volcano, Nakamachineshiri, eruption sequence, pyroclastic flow