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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

HASENAKA, Toshiaki[1*], Kiyoshi Kurokawa[1], Yasushi Mori[2]

[1]Grad School Sci & Tech, Kumamoto Univ., [2]Kitakyusyu Mus. of Nat. & Hum. History

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

SEKI, Takuma[1*], ARAKAWA Yoji[1], SHINMURA Taro[2], OSHIKA Junya[3]

[1]Life & Environmen. Sci. Univ. of Tsukuba, [2]Economics, Kumamoto Gakuen Univ., [3]JOGMEC

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

OKUNO, Mitsuru[1]*, Takeshi Inoue[1]

[1]Fac. Sci. Fukuoka Univ.

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

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

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

FUJINAWA, Akihiko[1*], BAN, Masao[2], OHBA, Tsukasa[3], KIMURA, Jun-Ichi[4], HIRAHARA, Yuka[4], TAKAHASHI, Toshiro[4]

[1]Faculty of Science, Ibaraki University, [2]Department of Earth and Environmental Sciences, Faculty of Science, Yamagata University, [3]Department of Earth Science and Technology, Faculty of Engineering and Resource Science, Akita Unive, [4]Institute For Research on Earth Evolution, Japan Agency for Marine-Earth Scienc and Technology

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

MIURA, Daisuke[1*]

[1]CRIEPI

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

ISHIGE, Kosuke[1*], NAKAGAWA, Mitsuhiro[1]

[1]hokkaido University

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 SiO_2-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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Temporal and spatial change of volcanism in Hokkaido during late Pleistocene and related tectonics

NAKAGAWA, Mitsuhiro[1*], KOSUGI, Ayumi[1], HASEGAWA, Takeshi[2], ISHII, Eiichi[3], ISHIZUKA, Yoshihiro[4]

[1]Div. Earth & Planetary System Sci., Hokkaido Univ., [2]Department of Earth Sciences, College of Science, Ibaraki University, [3]Japan Atomic Energy Agency, [4]Geological Survey of Japan

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

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

TAKAHASHI, Eiichi[1*]

[1]Magma Factory, Earth & Planetary Sciences, Tokyo Institute of Technology

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