SVC50-01 Room:104 Time:May 23 13:45-14:00

Crustal deformation after the eruption on January, 2011 by continuous GPS observation in Kirishima Volcano

NAKAO, Shigeru[1*], MORITA, Yuichi[2], GOTO, Kazuhiko[1], YAKIWARA, Hiroshi[1], Shuichiro Hirano[1], OIKAWA, Jun[2], UEDA, Hideki[3], KOZONO, Tomofumi[3], Yasuhiro Hirata[2], TAKAHASHI, Hiroaki[4], ICHIYANAGI, Masayoshi[4], OHTA, Yusaku[5], MATSUSHIMA, Takeshi[6], IGUCHI, Masato[7]

[1]GSSE, Kagoshima Univ., [2]ERI, Univ. of Tokyo, [3]NIED, [4]ISV, Hokkaido Univ., [5]RCPEV, Tohoku Univ., [6]SEVO, Kyushu Univ, [7]SVO, Kyoto Univ.

In January, 2011, sub-Pulinian eruption occurred in Shinmoedake. Before the eruption four continuous GPS sites are operated with one site of DPRI, Kyoto University, three GEONET and two NIED sites. Four continuous GPS sites were added to the existing GPS network after the eruption. Two other GPS sites were settled in April, 2011. The dense GPS network is consisted of 17 GPS sites.

The deflation source of the eruption is estimated about 7km westward from Shinmoedake with 9.3km depth. The amount of deflation is about 24 M cubic meters. This deep deflation source seems to be magma chamber in this activity.

Length changes are calculated on several baselines. Extension rate of baseline lengths after the eruption are almost same as that before the eruption. However, there are three period of rate change, May, August and November to December, 2011. In May, rate of baseline occurred, whose end point is located near the deep source. In August, rate of baselines decreases to almost zero, where baselines are across on the Shinmoedake. Rate of baselines also decreases to almost zero, where baselines are over the deep source. Length of these baselines became extended in August. It seems that magma supply into the deep chamber becomes lower.

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-02 Room:104 Time:May 23 14:00-14:15

Volcanic Process of the 2011 Shinmoedake Eruption inferred from Strain Data

TERAISHI, Masahiro[1*], ISHIHARA, Kazuhiro[1], YAMAZAKI, Ken'ichi[1], KOMATSU, Shintaro[1], KATO, Koji[2]

[1]Disaster Prevention Research Institute, Kyoto University, [2]Fukuoka District Meteorological Observatory

Measurements of crustal deformation with high precisions are essential in understanding and forecasting volcanic processes. The most precise observation of crustal deformation is achieved by means of extensometers in vaults. When observation in a vault is conducted at a suitable location to monitor volcanoes, they will provide extremely small changes in strain of the order of 10^{-9}-10^{-10}, which are undetectable by GPS.

Disaster Prevention Research Institute, Kyoto University, has been conducting highly accurate observations of crustal strain at Isa (Yoshimatsu) Observatory (ISA). The ISA site is approximately 18 km away from the summit crater of Shinmoe-dake, which produced major eruptions in January 2011. Extensometers at ISA are composed of 30 m lengths of super-invar rods installed in tunnels in three independent horizontal directions in order to determine a horizontal strain tensor. Considering sensor resolutions and electric noise-level, accuracies of data during the activity of Shinmoe-dake were evaluated to $2x10^{-10}$ in two directions, and $2x10^{-9}$ in one direction.

The strain data at ISA are examined in order to understand magmatic processes involved in the activity of Shinmoe-dake. We picked up remarkable changes in strain data by visual inspections, and estimate locations and sizes of sources of deformation by assuming a point source in a half-space (i.e. Mogi model). When the Mogi model is assumed, direction to a source from the observation point can be estimated even if data are available only at one site. Moreover, the size and depth of the source can be estimated if we assume certain values of horizontal distance between the site and the source. Given the horizontal distance between ISA and Shinmoe-dake is sufficiently larger than the size of magma chambers, we can expect point source approximation is sufficient enough to trace movements of pressure sources.

Most prominent changes in strain are recorded at the time of three subplinian eruptions on 26 and 27 January, and during a magma accumulation process from 28 through 31 January. We estimated locations and sizes of sources by using only strain data at ISA and compared them with results of GPS data inversions in order to evaluate the accuracy of estimations given by strain data at ISA. In the estimation, we assume horizontal distance between ISA and the source is fixed to 15 km. Estimated depths of volume changes corresponding to three subplinian eruptions and following magma accumulation are 7.2, 7.0, 7.6 and 8.3 km, respectively, which are consistent to those inverted from GPS data. Estimated changes in volume corresponding to these events are 1.25, 1.59, 0.94 and $5.25x10^{+6}m^3$, respectively, which are smaller than those estimated by other means. These results suggest that we can estimate directions to the source from ISA only by using strain data at ISA, although the quantitative estimation may be somewhat erroneous.

In addition to large changes simultaneous to eruptions, small changes several hours prior to each suplinian eruption are also found in strain data at ISA. The magnitudes of the pre-eruption strain changes are of the order of $1x10^{-9}$, which are about 1% of the magnitudes of co-eruption changes in strain. Temporal changes in these pre-eruption changes suggest that a gradual expansion and following quick contraction occurred beneath Shinmoe-dake. Accurate estimation of locations and sizes of these deformations is difficult because changes in strain are close to detectable limits. Nevertheless, calculations considering reading errors indicate that the deformation source is on the same direction to the magma chamber from the ISA, and its depth is shallower than the magma chamber. This result proposes a hypothesis that some portion of magma in a chamber moves upward in a final stage of the eruption processes, and it is ejected from the surface of the ground.

Keywords: extensometer, geodetic observation in vaults, Shinmoe-dake, volcanic process, crustal deformation prior to eruptions

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-03 Room:104 Time:May 23 14:15-14:30

Surface topography change of 2011 eruption lava stored in the Sinmoedake crater depicted by remote sensing techniques

MURAKAMI, Makoto[1*], Atsushi MATOBA[1]

[1]Inst. of Seismology and Volcanology, Hokkaido Univ.

Shinmoe-dake of Kirishima volcanic group is an active volcano sitting on the border of Miyazaki and Kagoshima prefectures in Southern Kyushu, japan. It erupted in the beginning of 2011; this was the first magmatic eruption for the last three centuries. The volcano was firstly formed between 25Ka and 15Ka. After thousands of years of quiescence, it became active with a sub -Plinian eruption during 1716 and 1717. Then it entered again a period of quiescence, but the signs of increased activity was suggested by a series of small phreatic eruptions in 1991, 2008,2009, and2010. Finally, a magmatic eruption began in January 2011. Before this eruption, the crater was of bowl-shape having a small lake at its bottom. After the eruption, the crater is almost completely filled by newly extruded lava whose surface is almost reached to the level of the lowest part of the crater rim. In this eruption, the extrusion of lava was completed in a short period of the first stage, then, it was followed by repeating small explosive eruptions on the surface of the lava. Those explosive activities became less-frequent in recent days.

Continuous GPS observations around Kirishima volcanic area has been conducted by the GSI and others since mid-1990s. The GPS data clearly indicated regional expansion of the western part of Kirishima during one year before eruption. A sharp contraction was observed during eruption. Immediately after the eruption a resumed expansion continued until recently. Those crustal deformations are considered to be a direct reflection of the underground magma migration activity. The horizontal and vertical displacements derived by GPS are well explained by a pre-and post- eruptive inflation and sin-eruptive deflation of the same magmatic pressure source at the depth several killometers northwest of Shinmoe-dake crater..

The GPS data also suggest that almost the same amount of magma has been already accumulated in the magma chamber. Consequently a possibility of future eruptitions are of deep concern among scientific and civil protection community..

One of the most basic information that will be useful both for the scientific and civil protection engagements is accurate data of surface topography. Since the type of eruptions is significantly controlled by the surface topography, it is highly desirable to acquire the 3-D digital topographic data before an eruption begins. Similarly it is also important to keep the data updated when the shape of the surface is changed by any volcanic activity.

Since the beginning of 2011 eruption JMA and other groups have repeated taking of photographs of the Shinmoedake crater from airplanes and helicopters. Interpretation of those pictures indicated that the shape of the lava surface is now flat and its level is close to the lowest part of the crater rim.

If a new eruption takes place in the near future, similar quasi-real-time topography measurement is necessary for both scientific and civil protection engagements. However such observation in unrest situation is not an easy task. In contrast, during quiet period, a number of techniques are available for the purpose, i.e., i) Lidar , ii) aerial photogrammetry (Visible), iii) airborne SAR , and iv) satellite remote sensing . Nevertheless , i) and ii) are difficult when the crater is erupting. Furthermore, high cost of iii) and a long recurrence time of iv) prevent frequent observations. To remedy those, we are in the process of developing of new methods applying a digital photogrammetry technique for both visible and thermal infrared imagery.

In this presentation, we compare different 3-D measurement results on surface topography made by the various institutions including one of our own, and then discuss the temporal change of the surface topography of the Shinmoe crater lava. The preliminary results suggest that no significant changes took place since the beginning of February

Keywords: Shinmoedake, remote sensing, topography, lava, disaster mitigation, forecast

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-04 Room:104 Time:May 23 14:30-14:45

Gravity change around the Kirishima volcanoes after the 2011 eruption of Shinmodake

OKUBO, Shuhei[1*], UEKI, Sadato[2], TANAKA, Yoshiyuki[1], OSHIMA, hiromitsu[3], Maekawa Tokumitsu[3], IMANISHI, Yuichi[1]

[1]Earthquake Research Institute, The University of Tokyo, [2]Graduate School of Science, Tohoku University, [3]Graduate School of Sciences, Hokkaido University

1. Introduction

Mt. Shinmoedake of the Kirishima volcanoes woke from a 300 year long period of dormancy in 2011. Semi-Plinian eruptions on Jan. 26 and 27 were followed by formation of a lava dome and Vulcanian eruptions in February 2011. Although crustal deformation revealed deflation of a magma source in the early stage of the eruption, recent observation suggests magma accumulation is still ongoing. Since gravity is sensitive to movement of mass such as magma, we carried out two types of gravity observations from the early February 2011. One is continuous absolute gravity measurement and the other is hybrid gravity observations around the Kirishima volcanoes. These are complementary in a sense that the former has higher temporal resolution but with poor spatial resolution and the latter vice versa. We shall integrate the two kinds of observation to describe the overall picture of the mass movement around the Kirishima volcanoes.

2. Absolute gravity measurement

We installed an absolute gravimeter FG5 at the Kirisima Volcano Observatory, which is located just above the supposed inflation/deflation source before and after the 2011 eruption. Gravity shows a peculiar temporal change before the Vulcanian eruptions in February 2011; Gravity started to decrease from 8-10 hours before Vulcanian eruptions followed by quick recovery 2 hours before the eruption. Besides the short term change, we observed 30 microgal gravity variation during the recent 1 year, which is mostly attributable to gravity disturbance arising from groundwater. In particular, we detected 16 and 12 microgal gravity step during the two heavy rainfall periods; 1200 mm rainfall during 10 days in June 2011 and 700 mm rainfall during 6 days in September. The gravity disturbance should be properly eliminated so that we may discuss the magma transport process from gravity observations.

3. Repeated hybrid gravity measurement

Precise relative gravity measurement using 4 LCR gravimeters were carried out in March and in August 2011 and is planned in March 2012 at 23 stations around the Kirishima volcanoes. The measurements are tied to the absolute gravity station so that we may derive absolute gravity values at each station. The result in Aug. 2011 also indicated significant contribution of groudwarter disturbance to the observed gravity (Ueki et al. 2011). We shall also describe the result in March 2012.

Keywords: Eruption of Shinmoedake 2011, Gravity change, Magma accumulation process, groundwater

SVC50-05 Room:104 Time:May 23 14:45-15:00

Characteristics of volcanic tremor in Kirishima volcano based on seismic array (2)

NAKAMOTO, Manami[1*], MATSUMOTO Satoshi[2], YAMANAKA Yoshiko[3], SHIMIZU Hiroshi[2], NAKAMICHI Haruhisa[3]

[1]Grad. Sch. Sci., Kyushu University, [2]SEVO, Kyushu University, [3]EVRC, Nagoya University

Volcanic tremors are indicators providing clues for magma behaviour, which is strongly related to volcanic eruptions and activity. Detection of spatial and temporal variations of volcanic tremors is important for understanding the mechanism of volcanic eruptions. However, short-term temporal variations within a tremor event have not always been previously detected by seismic array observations around volcanoes. Here, we show that volcanic tremor sources were activated at the top of the conduit (i.e. the crater) and at its lower end by analyzing seismograms from two dense seismic array about 3.5 km from the Shinmoedake volcano, mount Kirishima, Japan. We observed changes in the seismic ray direction during a volcanic tremor sequence through MUSIC spectrum processing and inferred two major sources of the tremor from the slowness vectors of the approaching waves. One was located in a shallow region beneath the Shinmoedake crater. The other was found in a direction N30W from one of the arrays, pointing to a location above a pressure source. The time evolution of the tremor suggests that instability occurs at the edge of the conduit due to magma intrusion.

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-06 Room:104 Time:May 23 15:00-15:15

Sulfur dioxide flux of Shinmoedake 2011 eruption II

MORI, Toshiya[1*], Kagoshima Local Meteorological Observatory[2]

[1]Grad. School of Sci., the Univ. of Tokyo, [2]Meteorological Agency

Shinmoedake at Kirishima volcanoes had a small eruption on Jan. 19, 2011 and one week later on Jan. 26m the volcano started magmatic eruption. In the Shinmoedake 2011 eruptive activity, there were altogether 13 explosive eruptions until March 2011 including sub-plinian eruptions occurred on Jan. 26 and 27. The number of smaller eruptions also decreased by the end of March and the eruptions sporadically occurred until first week of Sept. 2011.

From Jan. 27, 2011, we started sulfur dioxide flux measurements from the volcano using SO_2 monitoring system based on a compact UV spectrometer (COMPUSS). The flux measurements were carried out by traverse method. The sulfur dioxide flux was retrieved by multiplying the sulfur dioxide amount in the cross-section of the plume and the plume speed. For the plume speed, we used GPV wind speed data corresponding to the plume height.

The sulfur dioxide flux of the first 10 days were huge and exceeded 10000 ton/day. Especially, on Jan. 28, when the lava dome was growing inside the summit crater, the observed flux recorded more than 40000 ton/day. This huge flux decreased exponentially to several hundred ton/day by the second half of March 2011. Since April 2011, the flux basically kept several hundred ton/day until present (Feb. 2012) except soon after the eruptions occurred on June 23 and August 31. The flux exceeded 1000 ton/day in these occasions.

In the presentation, we will discuss the sulfur dioxide flux variation of the Shinmoedake 2011 eruption and estimate the total SO_2 amount emitted by the eruptive activity. Precursory SO_2 flux decrease was observed for a Vulcanian eruption at 12:18 on Feb. 3, 2011. Precursory variations were also observed for tilt meter at Shinmoedake NE observation site and summit video footage of Japan Meteorological Agency. We also discuss the precursory decrease of the sulfur dioxide flux by comparing with other observed precursory changes in the presentation.

Keywords: Kirishima Volcano, Shinmoedake, sulfur dioxide, volcanic gas, flux

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-07 Room:104 Time:May 23 15:30-15:45

Constraining tephra dispersion and deposition from cyclic subplinian explosions at Shinmoedake volcano, Japan, 2011

MAENO, Fukashi[1*], NAGAI, Masashi[2], NAKADA, Setsuya[1], Rose BURDEN[3], Samantha ENGWELL[3], SUZUKI, Yuki[1], KANEKO, Takayuki[1]

[1]Earthquake Research Institute, University of Tokyo, [2]National Research Institute for Earth Science and Disaster Prevention, [3]Department of Earth Sciences, University of Bristol

Andesitic subplinian explosions were repeated at Shinmoedake, Kyushu, Japan, on 26-27 January 2011. Tephra produced from the explosions were transported by strong seasonal wind, and crossed over the Kyushu Island then reached Pacific Ocean. The fallout deposits were widely observed in the area of down-wind direction. We estimate tephra volume, plume height, and magma discharge rate of the explosions based on field data and theoretical and empirical approaches.

In general theoretical and empirical models or methods are used to study tephra dispersal and physical parameters, in which a plenty of tephra data (mass per unit area, thickness, and clast size with distance) is required to give improved constraints on modeling results and to reduce uncertainties in estimates of eruption parameters and hazard. Although large-scale volcanic eruptions have provided such opportunities to examine theoretical and empirical approaches, small-scale eruptions are often more difficult to constrain because smaller volumes of erupted tephra tends to give only a small number of outcrops due to poor preservation of deposits. Data typically need to be collected soon after an eruption. Thus model applications to relatively small-scale eruptions have not been well studied.

The subplinian eruption that occurred at Shinmoedake volcano provides an interesting tephra dataset and an excellent opportunity to examine theoretical and empirical approaches on tephra volume estimation, clast dispersion under wind effect, which are crucial to evaluate quantitatively tephra dispersal and resultant hazards. Tephra volume is estimated using a relationship between dispersal area and thickness of tephra, or a relationship between dispersal area and mass per unit area. Bi-cubic spline interpolation method is also examined. Results from different methods produced similar tephra volume (11-21 million m^3 for the 26 pm to 27 am explosions and 2-4 million m^3 for the 27 pm explosion). For plume height estimation, a classical clast dispersal model and a predictive numerical model both using maximum clast size are applied. For all subplinian explosions, estimated plume height and magma discharge rate lie on 8.5-9.5 km above sea level and $7 \pm 3 * 10^5$ kg/s, respectively. The results are consistent with direct and geophysical observations, and also suggest that the explosions occurred every 12 hours with similar mass discharge rate but a decrease of erupted magma volume.

Keywords: Tephra, plume height, subplinian, Shinmoedake, Kirishima

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-08 Room:104 Time:May 23 15:45-16:00

Petrology of 2011 ejecta from Shinmoe-dake in Kirishima volcano 3-Phase equilibria experiment for low-T endmember magma-

SUZUKI, Yuki[1*], YASUDA, ATSUSHI[1], HOKANISHI, Natsumi[1], KANEKO, Takayuki[1], NAKADA, Setsuya[1], FUJII, Toshitsugu[1], HIRABAYASHI, Jun-ichi[2]

[1]Earthq. Res. Inst., Univ. Tokyo, [2]Tokyo Tech

The determination of magma storage depths beneath active volcanoes helps to understand origin of pressure sources detected by geophysical observations. The previous petrological results on 2011 eruption of Shinmoe-dake (Suzuki et al., 2011) include, 1) most erupted magmas are mixing products between basaltic andesite and dacite (1:1) and dacite partly erupted without mixing (white pumice, very scarce), 2) variable Mg/Mn contents of magnetite phenocrysts from dacite indicate temperature variety in dacite magma body, and the white pumice corresponds to low-temperature part, 3) crystallization of basaltic andesite took place over a depth of 10-6 km (melt inclusion analyses of olivine). The skeletal form of olivine and the variable crystallization depth indicate the crystallization is associated with syneruptive magma ascent.

To further constrain magma storage conditions, we have performed phase equilibria experiments that requires magma erupted without syneruptive mixing. Therefore, our target is white pumice and a pumice block erupted on January 26, 2011(SiO_2=63.3wt%) was selected. The pumice includes orthopyroxene (Opx), clinopyroxene (Cpx), plagioclase (Pl) and Fe-Ti oxides as phenocrysts (48.2 wt% in total), with groundmass of SiO_2 76.6 wt%. Plagioclase phenocrysts have rims with An 53.2-58.9 mol%. The magma was at conditions of 861-874C and NNO+1.5.

The experiments were performed with internally heated pressure vessels at ERI. Hydrous glass that ensures water saturation in 875C runs (110-250MPa) was formed at 1200C and 310MPa, from crushed white pumice. The capsules for 875C runs had triple structure (Innermost $Ag_{75}Pd_{25}$, Pt, and Au). The hydrous glass was placed in the AgPd capsule, and buffering material (mixture of Ni, NiO and water) was placed between Pt and Au. The innermost capsule minimizes Fe loss from hydrous glass to capsule. Pt prevents reaction between Ag-Pd alloy and Ni and contamination of glass by Ni. Lower H_2 permeability of Au keeps H_2 from buffering material inside capsules. Buffering material was once replaced with new one in the middle of whole run term. Even if buffering was not successful, Fe-Ti oxide pairs in products indicate oxygen fugacity was NNO+2.3 or lower.

Coexistence of all phenocryst phases are found at 210MPa or lower; Opx lacks in 250MPa run. Phenocryst contents and compositions of plagioclase rims and groundmass in natural pumice are best replicated at 110MPa. SiO_2 contents of experimental glass are mostly constant (ca. 70wt%) between 250MPa-160MPa, but that of 110MPa reaches 74.1wt%. Crystallinity of run products (wt%, calculated using K_2O contents in glass) show systematic increase with decreasing pressure; ca. 20% at 250-210MPa, 29.3% at 160MPa, 42.1% at 110MPa. Mass balance calculation with use of all major elements in all phases yields similar change, but higher estimates (26.9% at 250MPa and 52.8% at 110MPa). An mol% of experimental plagioclase decreases with decrease of pressure (79-74 at 210MPa, 69-62 at 160MPa, 62-58 at 110MPa).

100MPa would be created at a depth of 4km, which is similar to storage depth of mixed magma (estimated with plagioclase hygrometer), but is shallower than crystallization depth of the high temperature magma (10-6km). It is believed that most erupted magma in the 2011 activity came from a region of 6-10km depth beneath 7km NE of Shinmoe-dake, based on 1) large-scale deflation just after the sub-Plinian event in January, 2011(Nakao et al., 2011, GSI, 2011) and 2) the volume change in the deflation matches volume of ejecta (Nakada et al., 2011). The shallower estimated depth (4km) in this study may be explained by as follows. As described, the dacite magma of the white pumice had lower temperature than the dacite magma that mixed with high temperature magma. Thus, it is possible that magma of white pumice occupied shallow end of the dacite magma body.

Keywords: 2011 eruption of Shinmoe-dake, magma plumbing system, magma mixing, basaltic andesite, dacite, phase equilibria experiment

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-09 Room:104 Time:May 23 16:00-16:15

Stratigraphy and grain-size characteristics of the 2011 Shinmoedake eruption deposits, Kirishima Volcano, Japan

MIYABUCHI, Yasuo[1*], Daisuke Hanada[1], Hiroshi Niimi[2], KOBAYASHI, Tetsuo[3]

[1]Faculty of Education, Kumamoto University, [2]National Agricultural Research Center for Kyushu Okinawa Region, [3]Faculty of Science, Kagoshima University

Shinmoedake Volcano, Kirishima Volcanic Complex in southern Kyushu, southwestern Japan, began a series of eruptions on January 19, 2011. Activity started with a small phreatomagmatic eruption, but shifted to magmatic eruptions characterized by subplinian eruptions on January 26. Lava appeared in the summit crater on January 28 and filled the crater completely until February 2. Multiple vulcanian explosions occurred in the crater filled by the lava, and the number of eruptions declined after February 9. The largest vulcanian explosion happened on March 13, thereafter relatively small eruptions occurred intermittently until September 7, 2011. We performed fieldwork around Kirishima Volcano in order to examine the distribution and characteristic features of tephra deposits associated with these eruptions. In this paper, we describe the stratigraphy and grain-size characteristics of the 2011 Shinmoedake eruption deposits.

In the proximal area (2.5-3 km SE of the vent), the 2011 Shinmoedake eruption deposits are divided into six units: unit 1 to 6 in ascending order. Unit 1, which is probably the 19 January 2011 deposit, is less than 0.5 cm thick and composed mainly of lithic fragments. Unit 2 is the subplinian pumice-fall deposits from the evening of January 26 to early morning of January 27, and 10-25 cm thick in the proximal area. The unit 2 tephra is subdivided into three units and is characterized by the upward coarser and poorer sorted nature. Moreover, the lower part is lithic rich and proportion of lithic fragments decreased upward, whereas major component of the upper part is yellowish gray pumice. Differently from other units, the unit 2 deposit is clearly observed at distal areas more than 20 km SE of the Shinmoedake crater. Unit 3 ($<$2 cm thick) is a lithic-rich well-sorted (coarse sand sized) pumice-fall deposit, and is thought to be emplaced in the morning of January 27. Unit 4 is related to explosive eruptions after 15h41m on January 27, and is composed mainly of coarse yellowish gray pumiceous lapilli. Unit 5 is a fine-grained ($>$50 % silt sized) ash-fall deposit and consists mostly of fresh lithic fragments and crystal grains. This fine ash is believed to be deposited between 28 and 29 January according to the stratigraphy and observation record of the eruptions. Unit 6 is originated from multiple vulcanian explosions after early February, but most of unit 6 is considered to be the largest vulcanian eruption deposit on March 13. The vulcanian ash is medium to coarse sand sized and composed mainly of fresh lithic fragments. The unit 6 also contains scoriaceous grains.

Based on the isopach maps, bulk volumes of unit 2, unit 3, unit 4 and unit 5 were calculated at 0.004 km^3, 0003 km^3, 0.0005 km^3, 0.0003 km^3, respectively. The volume of unit 2 is one order of magnitude greater than those of other units. However, the estimated volume of unit 2 is one order of magnitude smaller than those of previous reports because we cannot use thickness data in the proximal area within 2.5 km of the source crater.

Keywords: Kirishima Volcano, Shinmoedake, 2011 eruption deposits, eruption sequence

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-10 Room:104 Time:May 23 16:15-16:30

On the recent volcanic crisis of Baitoushan volcano and the probable volcanic risk to the Chisong nuclear power plant

TANIGUCHI, Hiromitsu[1*], HIMENO Yoshiaki[2]

[1]Tohoku Univ., [2]Tokyo Tech

Baitoushan volcano located in the border with China and North Korea caused large-scale eruption in the 10th century and is known by having brought a disaster for not only the two countries but also Japan. China and North Korea began volcano observation together recently. According to their report, it changed calmly until 2002. However, the seismic activity added to the frequency from about 2002, and the uplift of top of the volcano came to be confirmed. According to the Seismological Bureaus of China and North Korea, the active situation continued until 2005 and stopped. Among China and North Korean scientists, they are negative about the possibility of immediate eruption now. However, the activation of seismicity and the uplift of the volcanic edifice occur, and the supply of magma to the edifice is estimated. These evidences suggest the preparation for eruption advance. The 10th century eruption produced a large scale of pyroclastic fall, pyroclastic flow and lahar. If it assumes that it breaks out that it will be the same as that of the 10th century eruption now, it is clear that a destructive disaster attains to the northeast part of China and North Korea.

Furthermore, a new risk different from 1,100 years ago is going to be born. China builds the nuclear power plant now in Baishan City approximately 100 km away from the Baitoushan top. This nuclear power plant uses the lake which dammed up the source of Songhua River running down from the Baitoushan as the source of a river for cooling. Judging from a geographic characteristic, the western half of pyroclastic materials piled up on the mountaintop will change to lahar by mixing with rain or snow water, and will attack the nuclear power plant setting spot before long if eruption occurs. In addition, according to the satellite image analysis, the risk of the large-scale collapse of the western flank of mountain edifice is pointed out, too. This can also cause the lahar in the 100 km distant place. According to the geological map by Wei (personal com.), the lahar by 10th century eruption arrived event at the installation predetermined area of the nuclear power plant. Even if the nuclear power plant (AP1000) of the schedule installed cannot obtain cooling water from the river, for three days, it can bear and is a nuclear reactor new type which stops safely by air cooling after that. At this point it may be reliable to the lahar risk. However, there are more than 15 million inhabitants in China and Russia along the river more downstream than nuclear power plant.

Therefore the examination of the thorough enforcement of the field survey and certain safety measures is necessary. Furthermore, organization establishment for the joint research among related countries of East Asia including North Korea is also desired.

Keywords: Baitoushan, volcanic crisis, volcanic risk, nuclear power plant

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-11 Room:104 Time:May 23 16:30-16:45

Unique characteristics of cone in Central Elysium Planitia, Mars

NOGUCHI, Rina[1*], KURITA, Kei[1]

[1]Earthquake Research Institute, The University of Tokyo

Martian magmatism within recent several hundreds of millions years is still inside the certain of enigma. Thanks to high-resolution images taken by recent Martian orbiters, analysis technology for Martian morphology have developed. We investigate Martian recent magmatism based on volcanic morphologies.

Central Elysium Planitia (CEP) is suspected as a site of the latest magmatism on Mars. In CEP, there are several distinct morphological features: Cerberus Fossae, Athabasca Valles, young flow, and cone morphology. The origin of the young flow is unknown; whether lava flow or mud flow because these morphologies are difficult to distinguish only by its appearance. Cones in CEP have unique characteristics. It will be a key to reveal detail activity style of recent magmatism in CEP. In previous works, there are 2 models proposed for the origin of CEP cones; volcanic rootless cone [e.g. Jaeger et al., 2007] and periglacial pingo [e.g. Burr et al., 2002].

In this study, we described distribution and size of CEP cones by using high-resolution images (>0.25m / pixel).

Result from this study, we found 25578 of cones in CEP. CEP cones are classified into 3 morphological types; Single Cone Structure (SCS), Double Cone Structure (DCS), and Lotus fruit Cone Structure (LCS). DCS have an inner cone in summit crater of outer cone, and LCS has several inner cones in summit crater of outer cone. Several cones have moat structure around cone edifice with peripheral rise. CEP cones distribute on the young flow. DCS and LCS distribute in specific area in the vicinity of Cerberus Fossae. Several SCS are found in border area of the young flow and original plain. Several CEP cones are aligned parallel to the young flow direction. The diameter of CEP cone is 2, 3 m - 150 m. The larger the cone diameter, the more complex the cone structure. DCS and LCS are larger than SCS.

We compared CEP cones with terrestrial rootless cones and pingos by using aerial photos. In Lake Myvatn, Iceland, there are several double rootless cones and lotus fruit rootless cone. We could not find double cone type pingos in North America, which is famous for pingo area.

From result of this study and these comparisons, it is indicated that CEP cones are rootless cone, a volcanic origin.

Keywords: Mars, volcano, cone, rootless cone, lava-water interaction, Central Elysium Planitia

SVC50-12 Room:104 Time:May 23 16:45-17:00

Crustal Deformation During the 2011 Volanic Crisis of El Hierro, Canary Islands, Revealed by Continuous GPS Observation

SAGIYA, Takeshi[1*], MARTINEZ, Jose Barrancos[2], CALVO, David[2], PADRON, Eleazar[2], HERNANDEZ, German, P.[2], HERNANDEZ, Pedro, A.[2], PEREZ, Nemesio Rodriguez[2], SUAREZ, Juan Manuel Poveda[3]

[1]Disaster Mitigation Research Center, Nagoya University, [2]Institute Volcanologico de Canarias (INVOLCAN), [3]Cartografica de Canarias (GRAFCAN)

Seismo-volcnic activity of El Hierro started in the middle of July of 2011 and resulted in the active submarine eruption after October 12 south off La Restinga, the southern tip of the island. We have been operating one continuous GPS site on the island since 2004. Responding to the activity, we quickly installed 5 more GPS sites. Including another site operated by the Canary Islands Cartograhical Service (GRAFCAN) for a cartographic purpose, we have been monitoring 7 GPS sites equipped with dual-frequency receivers. We present the result of our crustal deformation monitoring and the magmatic activity inferred from the deformation data. In accordance with the deformation pattern, we divide the volcanic activity in 2011 into 4 stages. The first stage is from the middle of July to middle of September, during which steady magmatic inflation is estimated at the center of the island. The inflated volume of the first stage is estimated to be about 1.3 X 10ˆ7 mˆ3 at the depth of about 5km. The second stage, which continued until the first submarine eruption on October 12, is characterized by the accelerated deformation due to the upward as well as southward migration of magma. Additional inflation of about 2.1 x 10ˆ7 mˆ3 occurred in the depth range of 1-2km. The third stage continued for about 3 weeks after the first submarine eruption. During this stage, submarine eruption continues while no significant surface deformation is observed. It is considered magma supply from a deeper magma chamber continued during this 3 weeks period. Therefore, the total inflation volume during the first two stages gives the minimum estimate for the total magma volume. Since the beginning of November 2011, many GPS sites started subsiding. However, this deflation pattern is quite different from those in the shallow inflation stages. Horizontal deformation during this 4th stage is not significant, implying that deflation is occurring below the moho.

Keywords: Canary island, El Hierro, eruption, crustal deformation, GPS

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-13 Room:104 Time:May 24 09:00-09:15

Space-time Analysis of the Eruptions in Japan for the Past 2,000 Years

Youtaro Ito[2], NAKAMURA, Yoichi[2]*

[1]Yutaro Ito, [2]Yoichi Nakamura

Base on the historic records of all eruption in Japan for the past 2,000 years, we have investigated the volcanic activity by using space-time analysis. The 1135 eruptions were accumulated and the breakdown numbers are the 615 eruptions of rank-A volcanoes, 397 of rank-B, and 63 of rank-C volcanoes. The eruption frequency rates are approximately 3.3 years duration for the rank-A volcanoes, and 5 years for the rank-B, and 32 years for the rank-C, respectively. The VEI values of the 998 eruptions were estimated and the frequency rates of the eruption are VEI5 for 142 years duration and VEI4 eruption frequency for 70 years duration of rank-A volcanoes. The VEI3 eruption frequency for 15 years duration of rank-A volcanoes and rank-B, and 50 years of rank-C. The eruption frequency rates of less than VEI2 are one year duration of rank-A volcanoes, 2 years of rank-B, and 20 years of rank-C. The top 3 very active volcanoes with higher VEI eruptions are Sakurajima in the southern Japan, Asama in the central Japan, and Oshima in the Izu island chain.

Keywords: Active volcanoes, Eruption, VEI

SVC50-14 Room:104 Time:May 24 09:15-09:30

Volcanic activity history of Io To Island in Ogasawara Archipelago estimated by terrace chronology and crustal deformati

NAKANO, Takayuki[1*], IMAKIIRE, Tetsuro[1], KOARAI, Mamoru[1], Kosei Otoi[1], Shinzo Ooi[1], SASAKI, Keiichi[2]

[1]GSI of Japan, [2]Kanazawa Gakuin University

No detailed studies about geoscience phenomena in Io To Island in Ogasawara Archipelago were kept since it was summarized on "Journal of Geography" in 1985. We have conducted survey of topography and geology and observation of crustal deformation using GPS in order to interpretate a detailed uplift activity history, volcanic chronology and recent crustal deformation. This works was supported by MEXT KAKENHI (21510193). Primary results of this study were reported on Ooi and Yarai (2007) and Imakiire et al. (2010). In this presentation, we report the result of radioactive dating and component analysis about the samples extracted in Io To Island, and volcanic evolution history in Io To Island reached by making use of those results is suggested.

The volcanic activity history for 3,000 years past in Io To Island estimated by these results and existing results is as follows: (1) a great volume of lava and pyroclastic material (Motoyama tuff) spewed out about 2,700 years ago, and old Io To island covered thickly with it, (2) a submarine volcano erupted around Kangoku Iwa about 1,600 years ago, and the peperite was generated, (3) a large scale eruption of the volcano occured around Suribachi Yama volcano about 1,400 years ago, and pumice drifted in Okinawa, (4) Suribachi Yama volcano erupted with a uprifting rapidly Motoyama volcano about 500-600 years ago, and Suribachi Yama volcano was connected with Motoyama volcano by a large amount of pumice, (5) a small scale eruption occured in Suribachi Yama volcano about 400 years ago, the scoria hill was formed on southern edge of the crater of Suribachi Yama volcano, (6) an eruption with magma occured at the sea bed off south coast of Motoyama volcano after the second World War.

It was confirmed that the uplift velocity past of Io To Island (Motoyama volcano) was intermittent and fastest in about 500-600 years ago by terrace chronology. On the other hand, the average uplift velocity during the past 100 years by a reference point and GPS observation is 15cm/yr (Hiraoka et al., 2009), and maximum uplift velocity was recorded in the 1950s-1960s and from late 2006 to 2010, about 56cm/yr (Tsuji et al., 1969) and about 40cm/yr (GSI, 2011) respectively. These recent uplift velocity is comparable to it in about 500-600 years ago, when Suribachi Yama volcano erupted with a uprifting rapidly Motoyama volcano.

Keywords: Io To Island in Ogasawara Archipelago, terrace chronology, crustal deformation, volcanic activity history

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-15 Room:104 Time:May 24 09:30-09:45

Phenomena prior to the 1914 eruption of Sakurajima volcano based on recent observation at the volcano for branching of e

IGUCHI, Masato[1*]

[1]DPRI, Kyoto Univ.

In the 20th century, 3 eruptions occurred at Sakurajima volcano. The 1914 eruption started by plinean type at parasitic craters at west and east flank and extruded lava of $1.4 \times 10^9 m^3$. The 1946 eruption effused lava flow from the crater at eastern flank, however the volume of lava is 1/10 of the 1914. Vulcanian eruptions frequently repeated at the summit crater of Minamidake since 1955. Volcanic ash amounted $2 \times 10^8 m^3$ during the period from 1978 to 1992. It is expected that such eruptions will repeat in the 21 century. Eruption scenarios are 1) effusion of magma of $2 \times 10^8 m^3$ in short term, 2) intermittent effusion of magma of $2 \times 10^8 m^3$ in long term, similarly to vulcanian activity at Minamidake summit crater, and 3) large eruptions at two flanks with extrusion of magma of $2 \times 10^9 m^3$.It is possible that branching to the 3 scenario is controlled by intrusion rate of magma. Phenomena prior to the 1914 eruption are examined based on recent volcanic observation at the Sakurajima. The phenomena is referred to **The day of explosion of Sakurajima Fear, panic and lessons still alive** summarized by Takeshi Nozoe.

Keywords: Sakurajima, 1914 eruption, eruption scenario, precursor

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-16 Room:104 Time:May 24 09:45-10:00

Evolution of magma plumbing system of Sakurajima volcano in the last 50 years

EBIHARA, Kaho[1*], NAKAGAWA, Mitsuhiro[1], MATSUMOTO, Akiko[1], AMMA-MIYASAKA, Mizuho[1], IGUCHI, Masato[2]

[1]Hokkaido University, [2]Kyoto University

Sakurajimna volcano, a post-caldera volcano of Aira Caldera in South Kyushu, has repeated three plinian eruptions since 1471 and effused lava in 1946. Vulcanian eruptions have continued since 1955. Volcanic activity reduced in 2000, but increased its number since 2006. So researchers try to predict what will happen in the future. Yanagi et al.(1991) suggested that magma mixing of two end-member magmas(dacitic and basaltic) occurred during 1471-1946, judging from a linear trend of whole-rock compositions, compositionally bimodal distributions of plagioclase and coexistence of normally and reversely zoned pyroxenes. However, Nakagawa et al. (2011) concluded that three end-member magma mixing should hane occurred since the 20th centuty; basaltic magma (B) inject into mixed magma of silisic (S) and andesitic (A) just before eruption. We carried out the petrological study of the vulcanian eruptions in the last 50 years and discussed temporal change of magma plumbing system.

Whole-rock SiO_2 content of erupted materials in the last 50 years are 58-64% (andesitic). Compositional trend of these ejecta is consistent with that of 1914 and 1946, and change to more mafic with time since 1914. All the ejecta contain plagioclase, orthopyroxene, clinopyroxene and magnetite as phenocrysts, and sometimes accompanying olivine. Phenocryst contents tend to increase with time. Most of the plagioclase phenocrysts show melted structure, compositionally bimodal distributions (An60 and An80), and sometimes there exist compositional peaks of An90. Orthopyroxene phenocrysts show unimodal or bimodal distribution in the range of Mg#65-75, and clinopyroxene phenocrysts similarly in Mg#70-80. Furthermore, normally and reversely zoned phenocrysts of plagioclase and pyroxene usually coexist in a single sample. Olivine phenocrysts are mainly divided into two types, one is Fo70 (surrounded by thick pyroxenes), and another is Fo80 (surrounded by microlites, have no reaction rims). Core compositions of magnetite phenocrysts are in the range of Mg/Mn=8-12, but sometimes show Mg-rich composition.

Bimodal distribution of plagioclase phenocrysts, coexistence of normally and reversely zoned phenocrysts and presence of Mg-rich olivines that compositionally disequilibrium with pyroxenes suggested that magma mixing also occurred in the last 50 years. S-magma: plagioclase (An=46-64), orthopyroxene (Mg#=60-68), clinopyroxene (Mg#=66-72) and magnetite, and A-magma: plagioclase (An=64-86), orthopyroxene (Mg#=68-76), clinopyroxene (Mg#=72-79) and magnetite, and B-magma: plagioclase (An=86-94) and olivine (Fo=75-82). The end-member magmas of these vulcanian eruptions are similar to those of Nakagawa et al.(2011); focusing on plagioclase phenocrysts, low-An ($An<64$) phenocrysts is considered as being derived from S-magma and high-An ($An>64$) ones from A and B-magma. Examining relationships between ratios of these phenocrysts and whole-rock SiO_2, high-An phenocrysts increase with decreasing whole-rock SiO_2. This suggests that increasing of B-magma resulted in increasing ratios of high-An plagioclase and decreasing of whole-rock SiO_2, considering that compositional trend since 20th century should be formed by instrusion of B-magma to the mixed magma of S and A (Nakagawa et al., 2011). Furthermore, SiO_2-poor ejecta observed when eruptions are frequent in the late 1970s and 1980s. This fact suggests that intrusion of B-magma promotes vulcanian eruptions. However, phenocryst contents of olivine in these eruptions are different and no relationship with whole-rock SiO_2. We consider that volume of olivine phenocrysts is variable in B-magma; olivine-rich in the late 1970s, whereas olivine-poor in the late 1980s.

Keywords: Sakurajima volcano, magma plumbing system, magma mixing, vulcanian eruption

SVC50-17 Room:104 Time:May 24 10:00-10:15

Eruptive activity during AD 2006-2011 at Sakurajima volcano, inferred from Petrological features of eruptive materials

MATSUMOTO, Akiko[1*], NAKAGAWA, Mitsuhiro[1], AMMA-MIYASAKA, Mizuho[1], IGUCHI, Masato[2]

[1]Department of Natural History Sciences, Graduate school of Science, Hokkaido University, [2]Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University

On June 2006, Sakurajima volcano, located in southern Kyushu, Japan, resumed its eruptive activity at Showa crater, and the explosions have been continued until now (February 2012). Recently, on the basis of the petrological features of the eruptive materials, we divided the eruptive activity at Showa crater into the four periods: from June 2006 to August 2009; from September 2009 to March 2010; from April to May 2010; and from June to September 2010 (Matsumoto et al., 2011 in JpGU). In this study, we discuss the relationship between the petrological features of eruptive materials and the change of eruptive activity using new data during AD 2006-2011. On the basis of their relationship, we also mention the present condition of Sakurajima volcano.

The eruptive materials are represented by ash-size samples (scoria, lithic and pumice), and sometimes lapilli-size ones appear in November 2009, April 2010, June 2010, and December 2010. Regardless of the grain size, the main components of eruptive materials are Juvenile-A type (magmatic materials ejected in this eruption), Juvenile-B type (magmatic materials related to the eruptive activity since AD 2006, but not ejected in this eruption), strongly-altered rock. The ash-size samples are also included isolated crystals. There are many strongly-altered rocks in the eruptive materials during June 2006 to August 2009, in which Juvenile-A type materials are absent. In contrast, Juvenile-A type materials are found in the eruptive materials since September 2009. The whole-rock compositions of Juvenile-A and -B type lapilli are consistent with the compositional trends of the 20th juvenile materials, showing the most mafic compositions (SiO_2 = 58.5-59.7 wt.%). The matrix glass compositions of Juvenile-A type materials are dacitic (SiO_2 = 65.8-72.7 wt.%). Focusing on the temporal variations of their matrix glass compositions, we can recognize the periodic change that the compositions become mafic at some period, and again become silicic at the following period.

On whole-rock chemistry, the juvenile lapilli agree with the compositional trends of the 20th juvenile materials. Thus, the magma system of Sakurajima volcano since AD 2006 would be the similar to that of the 20th century: magma mixing is the main magmatic process. Focusing on the matrix glass compositions of Juvenile-A type materials, they show more mafic compositions in the following three periods: from January to early April 2010, from November 2010 to February 2011, and from late August to September 2011. This suggests that the effect of mafic component became larger in these periods. Comparing the variations of the matrix glass compositions with the other monitored data, the number of explosions and its eruptive volume increased clearly in these three periods. Therefore, it is interpreted that the eruptive activity since AD 2006 becomes more explosive when the mafic component affects largely in the magma system.

Based on the continuous change of ground deformation, the increase of eruptive volume, and the decrease of silica content of the matrix glass compositions, the eruptive activity from January to early April 2010 is considered as a series of the activity since September 2009. That is, from September 2009 to early April 2010, the mafic component largely affected the magma system, resulting in the construction of the conduit system. In contrast, in the other two periods, the number of explosions and eruptive volume were not so large. Especially in the period from late August to September 2011, the glass compositions are slightly more silicic than those of the other periods, suggesting the weakly-effect of mafic component. In summary, Sakurajima volcano reached the climax of the eruptive activity from September 2009 to early April 2010. After then, the volcano has continued the eruptive activity at relatively-lower level, without obvious change of condition.

Keywords: Sakurajima volcano, Showa crater, volcanic ash, glass chemistry, temporal variation

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-18 Room:104 Time:May 24 10:45-11:00

Stress triggering of volcano-tectonic earthquakes:stress changes in the case of magma intrusions and great earthquake

MORITA, Yuichi[1*]

[1]Earthquake Research Institute, University of Tokyo

It is well known that seismicity around a volcano is one of the well-prevailing indicators of volcanic activities. The earthquakes are generated by the temporal change of stress field that is sometimes caused by magma intrusion and/or emplacement. Many evidences show that increasing seismicity leads to the volcanic eruption. For example, the seismicity around Kirishima volcano increased since 2006, and it is followed by sub-pulinian eruption on January 2011. This increase of seismicity is about 3 years prior to the remarkable inflation of volcanic edifice measured by GPS network. However, seismicity around volcano is generally treated as only an appearance of the possibility of volcanic activity and is not regarded as reliable evidence because it does not always leads to the eruption. It is partly because the stress change that generates earthquake swarms has not been considered deeply and the cause of the change has not been studied systematically. In this paper, we evaluate stress changes on known fault planes located near Izu-Oshima volcano quantitatively, and reveal the relation between the activity of the earthquake swarms and the stress change not only caused by a magma intrusion in the volcano but also induced by the great earthquake in 2011.

Several clusters of earthquake swarms occur frequently around Izu-Oshima volcano that stays in a quiescent stage since the latest eruption in 1986 but with small ground inflations in the interval of about three years in the present. The pattern of the ground deformation measured by GPS demonstrates that the magma rises and settles at the depth of about 5 km. The seismicity around the volcano increases at the several specific several regions during the ground inflation. Among them, earthquakes occurring at northward, northwestward and southwestward off the Izu-Oshima Island are located on several sub-vertical planes and their focal mechanisms support that they occur on the sub-vertical strike-slip faults. Each swarm activity begins abruptly and lasts one day to one week. It shows that the stress is accumulated on the pre-existing faults and the earthquakes occur when the stress exceeds its threshold. The cause of the stress accumulation might be the inflation source beneath the volcano.

We evaluate the Coulomb stress changes on the fault planes caused by magma intrusion. From this analysis, it becomes clear that the new earthquake swarm begins when the Coulomb stress rise 10-50 KPa from the level of the previous swarm activity. It is much affected by the geometry and location of the pre-existing faults, and the location and amount of inflation source. These parameters are well determined by intense seismic and GPS networks conducted by ourselves. We also evaluate the stress caused by the great earthquake in 2011. On a few hours after the origin time of the 2011 Taiheiyo Tohoku-Oki earthquake (M9.0), a few earthquake swarms are activated on the pre-existing faults. The Coulomb stress caused by the great earthquake is 20 and 50kPa. The value is similar with the case of magma intrusion, even the stress field acting caused by the great earthquake differs from that by magma intrusion.

From the above, we can illustrate that the accumulation of the stress can be measured quantitatively if the geometry of the pre-existing fault is known like the case of the Izu-Oshima. The seismicity around volcano reflects the stress field change, and can detect the magma intrusion and/or emplacement at the depth like Kirishima volcano. Quantitative analysis of the stress field using seismicity may become stress sensor that detects the deeper magma source if we know the features of the pre-existing faults around the volcano.

Keywords: volcano-tectonic earthquake, Coulomb stress change, magma intrusion, induced seismicity, evalueation of volcanic activity

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-19 Room:104 Time:May 24 11:00-11:15

Focal Mechanisms of Semi-Volcanic Deep Low-Frequency Earthquakes in Eastern Shimane

ASO, Naofumi[1*], OHTA, Kazuaki[1], IDE, Satoshi[1]

[1]The University of Tokyo

<**Backgrounds**>

Many deep low-frequency earthquakes (LFEs) occur near the island arc Mohorovicic discontinuities and far from both active volcanoes and plate boundaries. They are quite similar to volcanic LFEs beneath active volcanoes, which infers some fluid movement in the source region, and regarded as "semi-volcanic" LFEs [*Aso et al.*, 2011; 2012 (this meeting)]. Several previous studies determined the focal mechanisms of volcanic and semi-volcanic LFEs using only a small portion of information of the waveforms. Although the estimated focal mechanisms are various, they may not necessary support the variety of the actual physical process, owing to the large determination error [e.g., *Nishidomi and Takeo*, 1996; *Ohmi and Obara*, 2002; *Nakamichi et al.*, 2003]. Here we determine the reliable focal mechanisms by waveform inversion for LFEs in eastern Shimane, where many large LFEs occurred in a quiet region. The locations are also close to the fault plane of the 2000 western Tottori earthquake of M_w 6.6, and right beneath Yokota volcano, which is a Quaternary volcanic cluster.

<**Data and methods**>

We estimated the focal mechanisms of semi-volcanic LFEs in eastern Shimane by moment tensor inversion. The data are velocity seismograms at five stations of Hi-net near the epicenters. For each seismogram, we extracted a 2.5-second time window beginning from 0.2 seconds before the arrivals of either P-wave in a vertical component or S-wave in a horizontal component. The synthetic waveforms were calculated using the discrete wavenumber integration method developed by *Takeo* [1985] for a horizontally layered structure. For 60 LFEs larger than $M1$ and recorded at all five stations, the focal mechanisms and moment rate functions were estimated by grid search and linear inversion, respectively. We also tested the stability of solutions.

<**Result and discussions**>

The moment rate functions of the semi-volcanic LFEs oscillate between positive and negative values unlike those of regular earthquakes. The focal mechanisms are dominated by isotropic and CLVD components for most of the LFEs, and the breaking of symmetry might yield a minor double-couple component. Although the sign combination of the isotropic and deviatoric components is consistent with that of a tensile crack, the ratio of them is better explained by a linear dipole. This result is equivalent to the combination of the single force solution estimated by *Ohmi and Obara* [2002] from S/P amplitude ratios and its reaction force. The principal symmetry axis of the focal mechanism is parallel not only to the lineation of hypocenters obtained by *Aso et al.* [2012 (this meeting)], but also to the T-axis of the focal mechanism of the western Tottori earthquake and the minimum principal axis of a regional stress field in southwestern Japan, which suggests the existence of a scale-independent orientation. These focal mechanisms may represent some fluid movement in a crack-like structure aligned in the lineation direction.

Keywords: Low-Frequency Earthquake, Semi-Volcanic LFE, Eastern Shimane

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-20 Room:104 Time:May 24 11:15-11:30

Shallow hydrothermal activity at Taal volcano, Philippines, inferred from long-period seismic events

MAEDA, Yuta[1*], KUMAGAI, Hiroyuki[1], Rudy Lacson[2], Melquiades S. Figueroa II.[2], YAMASHINA, Tadashi[3]

[1]NIED, [2]PHIVOLCS, [3]Kochi University

Taal volcano is located 60 km south of metropolitan Manila. Most of the Taal eruptions have taken place after quiescent periods of less than 30 years, but more than 30 years have passed since the last eruption in 1977. This implies a high risk of near-future eruption at Taal. We have monitored the volcano after installation of a multi parameter observation network including five broad-band seismometers (Fig. 1a) in fall 2010 through a JST-JICA project.

Long-period (LP) seismic events with a dominant period of 0.8 Hz (Fig. 1b) have been observed by the network. They are most distinct in vertical component at station VTDK. Using this component, we have detected 46,687 events having amplitudes and waveform correlations larger than $2x10^{-6}$ m/s and 0.8, respectively. Most of them occurred between December 2010 and January 2011. Waveform correlations among the events are quite high, often exceed 0.95. Amplitudes of the events are smaller than $5x10^{-6}$ m/s and obey two exponential distributions partitioned at $3x10^{-6}$ m/s. The event intervals obey a superposition of Weibull and log Weibull distributions. Dominant frequency represents a bi-modal distribution with peaks of 0.8 and 0.72 Hz, and proportion of the events having the lower dominant frequency was relatively high during periods when the LP activity was high. We can see no distinct relationship among the event amplitude, interval, and dominant frequency.

We applied the waveform inversion method of Nakano and Kumagai (2005) for the LP events that occurred after 6 March 2011 when vertical component data at VTMC were available. We used stacked waveforms at stations VTDK and VTMC. Only events having large waveform correlations at the both stations were used. To calculate the Green functions, we used a homogeneous medium with a P-wave velocity V_p = 3000 m/s. Following Maeda and Kumagai (2011), we took into account crater and caldera lakes as well as topography. Fig. 1c indicates the inversion result. The minimum residuals for tensile crack and pipe sources are 61.2 and 61.9 %, respectively. The residual difference is too small to infer which mechanism is better. We also conducted inversion using V_p = 2000 m/s. The source locations obtained using the two structures were similar but the crack orientations were quite different to each other (Fig. 1c). These results indicate that the source location was relatively well determined whereas the mechanism was poorly determined.

The estimated source location is close to surface dikes intruded in 1990s and current steaming vents. The obtained source depth of 300-500 m is similar to the depths for LP events at other volcanoes, which were interpreted in terms of hydrothermal activity (e.g. Nakano et al., 2003; Ohminato, 2006). The vertical waveforms at VTDK indicate Q=6, which can be explained by a fundamental mode oscillation of a crack filled with vapor using the crack model of Kumagai and Chouet (2000). Assuming that this mode corresponds to the observed oscillation frequency of 0.8 Hz, we obtain the crack length L = 150 m, which is a reasonable crack size for the LP source. Anomalies including intense seismicity, inflation, water temperature increase, and increase in steaming activity were observed from June to August 2010 and from April to July 2011 at Taal. The LP activity was intensified between these two active periods. A possible interpretation is that a magma intrusion related to either of these active periods may have supplied heat to a shallow hydrothermal system at Taal, generating the LP events. No LP event has been observed after September 2011, which is consistent with a low level of volcanic activity during this period.

References

Kumagai H., and Chouet B.A., 2000, J. Geophys. Res., 105, 25493.
Maeda Y., and Kumagai H., 2011, AGU Fall Meeting, S31B-2231.
Nakano M., and Kumagai H., 2005, Geophys. Res. Lett., 32, L12302.
Nakano M. et al., 2003, J. Volcanol. Geotherm. Res., 122, 149.
Ohminato T., 2006, J. Volcanol. Geotherm. Res., 158, 467.

Keywords: Taal volcano, Long-period events, Waveform inversion

SVC50-20 Room:104 Time:May 24 11:15-11:30

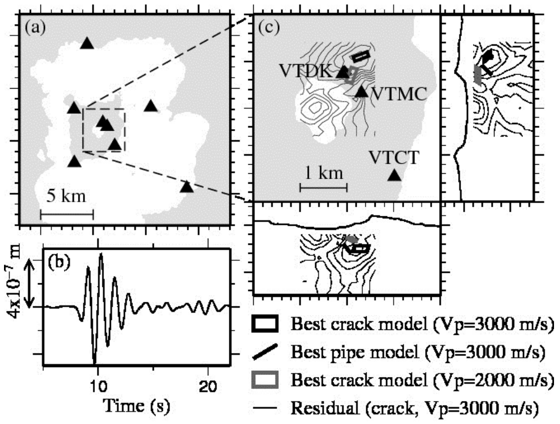


Fig. 1

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-21 Room:104 Time:May 24 13:45-14:00

Comprehensive study on the 2011 eruption at Shinmoedake (Kirishima Volcano) and the eruption scenario

NAKADA, Setsuya[1]*, MORITA, Yuichi[1]

[1]Earthquake Research Institute, University of Tokyo

Magmatic eruption began in January 2011 after about 300 years of hiatus. We started comprehensive study using a Grant-in-Aid in 2010-2011 jointly with researchers from national universities. This study was carried out by four investigation teams on (1) condition and structure under crater and near conduit, (2) magma accumulation system in geodetic and seismological methods, (3) products in the geochemical and geological methods, and (4) volcanic mud flows.

Inflation had occurred at the point about 10 km below the surface and 7-8 km northwest of the Shinmoedake crater since 2006. Phreatic eruptions were repeated in 2008 and 2010. Subplinian explosions were repeated in three times in January 26 and 27, 2011, which preceded lava accumulation at the Shinmodeke crater and repeated vulcanian explosions since February 1. The inflation was canceled during the eruption of the plinian explosions and lava accumulation in crater. The volume of deflation is balanced with the volume of erupted magma.

The eruption scenario was formed soon after the start of eruption and revised, based on the geological history of the eruption in this volcano 300 years-ago (Imura and Kobayashi, 1991). We should revise the eruption scenario by reflecting the research results of this study.

Keywords: Shinmoedake, volcanic eruption, comprehensive study, eruption scenario, Kirishima volcano

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-22 Room:104 Time:May 24 14:00-14:15

Tilt motions associated with sub-Plinian, Vulcanian eruptions, and an effusive stage in the 2011 Shinmoe-dake eruption

MAEHARA, Yuki[1], TAKEO, Minoru[1*], OHMINATO, Takao[1], ICHIHARA, Mie[1], OIKAWA, Jun[1]

[1]Earthquake Research Institute, University of Tokyo

Numerical simulations and experimental studies suggest that bubble formation and fragmentation in magma ascending through a conduit play an important role in an explosive eruption. These phenomena should cause some kind of ground deformations, and such observations have been reported in several volcanoes [*e.g.*, Iguchi *et al.*, 2008]. In this paper, to reveal a behavior of magma associated with an eruption, we investigate tilt motions near a summit crater during the 2011 eruption of Shinmoe-dake, Kirishima volcano. As a broadband seismometer is capable of measuring a ground tilt motion [*e.g.*, Graizer, 2006; Aoyama & Oshima, 2008], we obtained tilt motions from a broadband seismometer (SMN) installed at 1 km northward and a tilt-meter (KISH) at 1.5 km NEN-ward from the crater by elimination of tidal trends and daily noises. A comparison of tilt motions obtained from the broadband seismometer with those from tilt-meter reveals us that the broadband seismometer is available to measure tilt motions with a period up to a few thousand seconds.

Tilt motions indicating summit-up inclines about a few thousand seconds before eruptions preceded most of explosive eruptions, including sub-Plinian eruptions in 26^{th} and 27^{th} January and Vulcanian eruptions between 1^{st} and 7^{th} February. Any clear distinctions, such as in precursor times and in sizes of tilt motions, have been recognized between the tilt motions preceding the sub-Plinian eruptions and the Vulcanian eruptions up to this time. However, we found systematic changes of the tilt ratio between these two stations: the tilt ratio of the far station (KISH) to the near station (SMN) gradually increased from around 0.3 to 0.4 as the eruptions closed in, not only the sub-Plinian but also the Vulcanian eruptions. In the effusive stage, we observed periodic summit-up and summit-down tilt motions with a period of about 1 hour; some parts of these periodic motions correlated with volcanic tremors.

There are several speculative interpretations about the temporal change of the tilt ratio. If we assume the location of source in the conduit and fixed source mechanism, the ratio change could be explained by the change of source depth. On the other hand, assuming the fixed source depth in the conduit, it could be explained by the change of source mechanism. We don′t have enough data to bring to an end, so hereafter we tentatively interpret these observations based on the assumption of fixed source mechanism. Employing an isotropic pressure source (Mogi model) as the source, the ratio change corresponds to the deepening of source from 420 m to 140 m above sea level. The absolute values of tilt change preceding the first sub-Plinian eruption on 26^{th} January can be explained by pressure increase of around 10 MPa assuming the source volume of $10^6 m^3$. This pressure decreased rapidly just after a small eruption which occurred about 30 min before the start of the sub-Plinian eruption. This depressurization in the conduit might have triggered the fragmentation of magma in the shallow part of the conduit.

Keywords: volcanic eruption, tilt motion, Shinmoe-dake, Kirishima volcano

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-23 Room:104 Time:May 24 14:15-14:30

Temporal changes in electrical resistivity of Kirishima volcano from continuous magnetotelluric observations

AIZAWA, Koki[1*], KOYAMA, Takao[1], HASE, Hideaki[1], UYESHIMA, Makoto[1], HASHIMOTO, Takeshi[2], UTSUGI, Mitsuru[3], YOSHIMURA, Ryokei[3], KANDA, Wataru[4], OGAWA, Yasuo[4]

[1]Earthquake Research Institute, Univ. of Tokyo, [2]Hokkaido Univ., [3]Kyoto Univ., [4]Tokyo Institute of Technology

Continuous magnetotelluric (MT) measurement was conducted since March, 2011 at Iwo-Yama, which is located 5km NWN of Shinmoe volcano. Five components of EM fields were measured in the sampling frequency of 32Hz (00:00~23:50 UT) and 1024Hz (17:00~19:00UT). By applying the comb filter to reduce the harmonics of 60Hz and the robust MT response function estimation code, slight resistivity change were obtained. The diagonal component of impedance tensor (Zxy, Zyx) showed temporal variations in apparent resistivity of approximately 5% and phase of 1 %, which is smaller by a factor of five than those observed at Sakurajima volcano (Aizawa et al., 2011, JVGR). In this presentation, we will show the temporal change of the resistivity structure by 1D inversion, and will discuss the mechanism of the electric resistivity change.

SVC50-P01 Room:Convention Hall Time:May 24 15:30-17:00

Active Monitoring at Active Volcanoes - Deployment of ACROSS at Sakurajima Volcano -

YAMAOKA Koshun[2], WATANABE Toshiki[2], IGUCHI Masato[3], TAMEGURI Takeshi[3], YAKIWARA Hiroshi[1], MIKADA Hitoshi[4], TAKENAKA Hiroshi[5], SHIMIZU Hiroshi[5], MIYAMACHI, Hiroki[1*]

[1]Graduate school of Science and Engineering, Kagoshima University, [2]Graduate School of Environment, Nagoya University, [3]Disaster Prevention Research Institute, Kyoto University, [4]Graduate School of Environment, Kyoto University, [5]Graduate school of Science, Kyushu University

Quantitative monitoring of magma transport process is essentially important for understanding the volcanic process and prediction of volcanic eruptions. To realize this monitoring, a project, an establishment of active monitoring using a vibration source called ACROSS in Sakurajima volcano, is being underway and will be finished by the end of March 2012. In this report we show how the ACROSS source was deployed in Sakurajima volcano, and also show the feasibility of monitoring using ACROSS vibrator system for Sakurajima volcano in terms of detectability of signal and its temporal variation due to reasonable change in volcanic structure. Sakurajima volcano is one of the most active volcanoes in the world, which made about 1000 explosive eruptions in 2011, and has been intensively monitored by high-performance observation networks operated by institutions such as Sakurajima Volcano Research Center of DPRI, Kyoto University. Therefore, Sakurajima volcano is one of the best volcanos as a first test site for volcano monitoring with ACROSS.

ACROSS source is deployed in the northwestern flank of the volcano at the site of former Sakurajima Clean Center. Two vibrators are deployed, which were originally operated as a four-vibrator system. The control-gear, that is originally designed to operate the four-vibrator system, has been already modified for two-vibrator system and in operation at Toyohashi site. We brought the system to Sakurajima volcano in order to prevent unexpected troubles. The two vibrators are firmly fixed in a basement, that is called a "core-coupler", which is build with steel-beamed frame. The core-couple is cemented in the square-shaped hole with a dimension of 4.3 x 3.8m and 3m depth. As the ground of the site is not solidified well for the vibrator, twelve stakes are driven to the depth of 5m and the centroid of the vibrator is situated at a depth of about 1.5m below the surface, that is 0.5m deeper than that of Toyoyashi site. The vibrators can produce a sinusoidal force of about 10^6 N at 15Hz, and can be reduced by changing eccentric moment of the mass. The operation will be made with an accurately repeating sweep signals with a frequency range of about 10-20Hz that are synchronized to GPS clock. We look for best parameters for operation when the deployment finished.

Before operation we simulated the wave propagation with a 3D structure model of Sakurajima volcano and assess the detectability of signal in the seismic stations in the volcano. 3D model is made based on a structure model (Miyamachi et al. 2010), and implemented for the simulation system GEOWAVE. The attenuation is given by the analysis using the data of the explosion experiment in 2008. The simulation shows that the maximum change in the signal can be observed at the seismic stations in the southeastern flank of the volcano if the magma ascent beneath the Showa or Minamidake craters. Based on the estimation of the distance-dependent attenuation relationship by Yamaoka et al. (2011), the signal of an ACROSS vibrator can be recorded with a signal-to-noise ration of 10 for the whole area of Sakurajima island for the staking length of 3 months. We will, therefore, be able to monitor the change of signal that may be correlated with long-term activation or deactivation of the Sakurajima Volcano with ACROSS system.

Keywords: Sakurajima, Volcano, ACROSS

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P02 Room:Convention Hall Time:May 24 15:30-17:00

The third round of the repetitive seismic experiment in Sakurajima Volcano.

TSUTSUI, Tomoki[1*], Masato IGUCHI[2], Akira SUGAI[3], Hiromitsu OSHIMA[4], Tokumitsu MAEKAWA[4], Sadato UEKI[5], Mare YAMAMOTO[5], Kenji NOGAMI[6], Minoru TAKEO[7], Takao OHMINATO[7], Jun OIKAWA[7], Atsushi WATANABE[7], Haruhisa NAKAMICHI[8], Shinichiro HORIKAWA[8], Takahiro OHKURA[9], Shin YOSHIKAWA[9], Tetsuro TAKAYAMA[2], Tadaomi SONODA[2], Hiroshi SHIMIZU[10], Takeshi MATSUSHIMA[10], Hiroki MIYAMACHI[11], Hiroshi YAKIWARA[11], Shuichiro HIRANO[11], Kazuki OKAMOTO[3], Yoshihisa KATAOKA[3], Shinichi MATSUSUE[3], Norio KOKUBO[3], Taisuke KOHNO[3], Junichiro MASAKI[3], Masaki NAKAHASHI[3], Shingo UTSUNOMIYA[3], Yoshitomo IKOMA[3], Mayumi AKUTAGAWA[3]

[1]Graduate school, Akita University, [2]DPRI, Kyoto University, [3]Japan Meteorological Agency, [4]Graduate School of Science, Hokkaido University, [5]Graduate School of Science, Tohoku University, [6]Volcanic Fluid Research Center, Tokyo Institute of Technology, [7]Earthquake Research Institute, University of Tokyo, [8]Graduate School of Environmental Studies, Nagoya University, [9]Graduate School of Science, Kyoto University, [10]Faculty of Sciences, Kyushu Universit, [11]Graduate School of Science, Kagoshima University

The third round of repetitive seismic experiment in Sakurajima Volcano will be presented.

Explosive activity at the 1946 crater has been increasing in the east flank of Sakurajima in southern Kyushu since June 2006. The crater had enhanced its explosive activity before emergence of lava flow on 1946. Since uplift in Aira caldera is approaching up to the same level with that of preceding stage of 1914's eruption (Yamamoto et al, 2010) and the historical description, forthcoming sequence at the 1946 crater is of interest and of importance.

Amount of magma supply to the crater is essential on discussing volcanic eruptions. In order to make direct monitoring of the magma flux, surface geophysical observations are necessary just above the migration route. In Sakurajima, the survey lines have designed after the model which presented by Hidayati et al.(2007). in order to detect structural changes for magma migration.

The repetitive surveys have been carried out since 2009 after the pilot survey on 2008. Two lines, NS and EW were deployed in the eastern foot and the northern flank of the volcano, respectively. The survey lines include 14 shot points and 252 temporary stations, those are the same specification as those of the previous observations. Charge size was 20kg at the shot. Vertical seismometer and the logger LS-8200SD is installed at each station. More than 90% stations are placed at the same place with the previous observations.

Data retrieval was successful and 99.6% of stations were retrieved. Significant change in the later phases were observed for three shots. Coherence and phase rate in the coherent band of 5 - 8Hz also changed against those of the same shot in the previous observation. Contributions of shot effect variation will be discriminated and evolution in structural responses will be discussed.

Keywords: Sakurajima, Geophysical survey, Seismic survey, Seismic survey

SVC50-P03 Room:Convention Hall Time:May 24 15:30-17:00

Characterization of volcanic ash samples from Sakurajima volcano by CCD camera image

MIWA, Takahiro[1*], SHIMANO, Taketo[2], NISHIMURA, Takeshi[1]

[1]Department of Geophysics, Graduate School of Science, Tohoku University, [2]Graduate school of Enviroment and Disaster Research, Fuji Tokoha University

In order to conduct a petrologic monitoring of ongoing eruption, a speedy and simple characterization method of volcanic ash particle is needed. We develop a new simple system for quantitatively characterizing of volcanic ash properties that analyzes CCD camera images, and apply the method to volcanic ash samples from Showa crater of Sakurajima. Our method characterizes volcanic ash particles by 1) apparent luminance through RGB filters and 2) irregularity of the shape of ash particles. Using a monochromatic CCD camera (Starshoot by Orion Co. LTD.) attached to a stereoscopic microscope, we captured images of ash particles set on white colored paper. These images are taken through three kinds of filters (Red, Green and Blue) under incandescent light with constant brightness. The images are analyzed by Adobe photoshop and Scion Image software. Apparent luminance of the ash particle images are represented by 256 tones for each pixel, and the average, median and standard deviation are measured for each ash particle for each filtered image in Adobe photoshop. Luminance is calibrated by taking images of white and black colored paper. Binary image converted from the 256 tones through Red filter is used for the analysis of the FF (Form Factor: 4*pi*A / perimeter^2; A is cross sectional area) of ash particles by Scion Image program.

To compare a result of the image analysis and a classification under stereoscopic microscope, we characterized a day (January 13, 2010) sample of volcanic ash from Showa crater of Sakurajima volcano. Firstly, we divide volcanic ash into 11 types of particle under the stereoscopic microscope. Subsequently, we quantify the luminance and FF for the each type of the ash particles. The results show that the distributions of luminance and FF differ for different type of the ash particles. This suggests that classification using luminance and FF is quite useful to quantitatively distinguish and group the volcanic ash samples, and suitable for the petrologic monitoring of ongoing eruption.

Keywords: Volcanic ash, Classification method, CCD camera, Image analysis, Monitoring of ongoing eruption

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P04 Room:Convention Hall Time:May 24 15:30-17:00

Vertical ground deformation in Sakurajima volcano measured by precise leveling surveys (during Nov. 2010 - Nov. 2011)

YAMAMOTO, Keigo[1*], Tadaomi Sonoda[1], Tetsuro Takayama[1], Nobuo Ichikawa[1], OHKURA, Takahiro[2], YOKOO, Akihiko[2], Shin Yoshikawa[2], Hiroyuki Inoue[2], Kohei Hotta[2], MATSUSHIMA, Takeshi[3], UCHIDA, Kazunari[3], NAKAMOTO, Manami[3]

[1]DPRI, Kyoto Univ., [2]Graduate School of Science, Kyoto Univ., [3]Faculty of Sciences, Kyushu Univ.

We conducted the precise leveling survey in Sakurajima volcano in November 2011, in order to evaluate the vertical ground deformation associated with the recent eruptive activity of this volcano. In this paper, we report the results of this survey and discuss the recent ground deformation of this volcano. From the measured survey data, we calculated the relative height of each bench mark referred to the reference bench mark S.17 which is located at the western coast of Sakurajima. The calculated relative heights of the bench marks were then compared with those of the previous survey conducted in November 2010, resulting in the relative vertical displacements of the bench marks during November 2010 - November 2011. No remarkable vertical displacements are obtained during this period at bench marks around the northern part of Sakurajima, where the ground uplifts which reflect the inflation of the magma reservoir beneath Aira caldera have been observed since 1991. On the other hand, the resultant displacements indicate the ground subsidence near the central part of this volcano. This subsidence is thought to reflect the deflation of the magma reservoir located beneath the summit crater, caused by the recent increase of the volume of ejected magma associated with the eruptive activity at Showa crater. These results suggest that it is needed to monitor the future change of the ground deformation associated with the volcanic activity of this volcano.

Keywords: Sakurajima volcano, Aira caldera, precise leveling survey, vertical ground deformation

SVC50-P05 Room:Convention Hall Time:May 24 15:30-17:00

Repeated aeromagnetic survey on Sakurajima Volcano(2007-2011)

UTSUGI, Mitsuru[1*], KANDA, Wataru[2], HASHIMOTO, Takeshi[3], INOUE, Naoto[5], KOMORI, Shogo[4], Hiroyuki Inoue[4], IGUCHI, Masato[4]

[1]Kyouto Univ., [2]Tokyo Inst. Tech., [3]Hokkaido Univ., [4]D.P.R.I., Kyoto University, [5]Geo-Research Inst.

To detect the temporally change of the magnetic field associated with the volcanic activities on Sakurajima volcano, we made helicopter-borne aeromagnetic survey around Sakurajima volcano on Oct. 24-26, 2011. The survey was conduced on 22 N-E lines(2-8km) and 15 E-W(5-12km) lines inside the Sakurajima island. The spacing of each lines is about 500m, the ltitude of flight is about 150-200m from the ground.

The total flight time was about 6 hours. On this volcano, dense aeromagnetic survey was made on Nov. 2007. Using this data as a reference field, we tried to detect the temporally change during 2007-2011. On this analysis, we applied the equivalent anomaly method to calculate the upward continuation of the observed geomagnetic field (Nakatsuka and Okuma, 2002). As the result, a remarkable dipoler temporally change was detected around eastern part of Sakurajima volcano. On this area, active volcanic eruptions occurred in a new crater, Showa-crater, repeatedly. It is possible that the temporally magnetic field change detected in this area is related with the activities of the Showa crater.

Keywords: aeromagnetic survey, magnetic anomaly, temporally change of geomagnetic field

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P06 Room:Convention Hall Time:May 24 15:30-17:00

Audio-frequency magnetotelluric survey of Sakurajima volcano in 2011

KANDA, Wataru[1*], OGAWA, Yasuo[1], TAKAKURA, Shinichi[2], KOYAMA, Takao[3], HASHIMOTO, Takeshi[4], KOMORI, Shogo[5], Tadaomi Sonoda[6], SATO, Izumi[1], INOUE, Naoto[7], UTSUGI, Mitsuru[5]

[1]Volcanic Fluid Research Center, Tokyo Institute of Technology, [2]National Institute of Advanced Industrial Science and Technology, [3]Earthquake Research Institute, University of Tokyo, [4]Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, [5]AVL, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, [6]SVO, Disaster Prevention Research Institute, Kyoto University, [7]Geo-Research Institute

We investigated a shallow resistivity structure of Sakurajima volcano by using the AMT (audio-frequency magnetotelluric) method as a part of "Process of migration of magma toward Sakurajima volcano, Japan (Project No.1809)" under the framework of the "Observation and Research Program for Prediction of Earthquakes and Volcanic Eruptions" in 2011 fiscal year.

Keywords: resistivity structure, Sakurajima volcano, hydrothermal system, flank eruption

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P07 Room:Convention Hall Time:May 24 15:30-17:00

Shallow magma feeding system of the 1914 eruption of Sakurajima inferred from mineral chemistry and volatile contents

SATO, Tomoki[1*], NAKAMURA, Michihiko[1], OKUMURA, Satoshi[1], MIKI, Daisuke[2], IGUCHI, Masato[2]

[1]Earth Material Sci., Tohoku Univ., [2]S.V.R.C., D.P.R.I., Kyoto Univ.

Volatile contents and major element compositions of eruptive materials provide key information on eruption phenomena. To explore the pre-eruptive magmatic processes of the 1914 Plinian eruption of Sakurajima volcano, we analyzed volatile contents and major compositions of melt inclusions, and their host phenocrysts in the pumices.

Major compositions of pyroxenes and melt inclusions were analyzed by using EPMA (JEOL JXA-8800M). The core compositions of ortho- and clinopyroxene phenocrysts showed a wide range, but divided into two groups showing reverse and normal zonings toward the rim, with the boundaries of Mg# of 69 and 73, respectively. The higher-Mg# pyroxenes are normally zoned, while the lower-Mg# groups, reversely. The pyroxene phenocrysts contained plagioclase as a mineral inclusion. The range of An content of the plagioclase inclusions was 52-83. When the host pyroxene shows high-Mg#, the An content was more than 80.

The FT-IR analyses on melt inclusions were carried out using a Nicolet iN10. The analytical results showed a wide ranges of H_2O and CO_2 contents (H_2O=0.8-2.5 wt.%, CO_2<40 ppm).

The volatile saturation pressures of the silicic magma, which was represented by the melt inclusions in the lower-Mg# pyroxenes, was calculated approximately to be 60 MPa (corresponding to the depth of ca. 2.4 km). This depth may be consistent with the shallow magma chamber suggested in the previous geophysical studies. In addition, we found melt inclusions which contain relatively high CO_2 and low H_2O. Such volatile compositions cannot be produced only by a degassing process but suggest fluxing of relatively CO_2-rich fluid or mixing with mafic magmas.

SVC50-P08 Room:Convention Hall Time:May 24 15:30-17:00

Oxidation texture of pyrrhotite in the eruptive products of the Sakurajima Taisho eruption

MATSUMOTO, Keiko[1*], NAKAMURA, Michihiko[1]

[1]Dept. Earth Science, Tohoku Univ.

Since sulfur(S) in magmas changes its redox state and chemical species, and thus solubility in silicate melts, sulfide minerals in volcanic rocks may record unique information on eruption processes. In the pumice clasts of the Plinian fall deposits in the Sakurajima Taisho eruption (1914), globular pyrrhotite ($Fe_{1-x}S$) with 20-50 micrometers in diameter occurs as aggregates with or inclusions in magnetite and less commonly in silicate phenocrysts, and rarely as isolated microphneocrysts. They are often replaced with spongy Fe-oxide that has scarce or low Ti content. Small amount of S was sometimes detected in the EPMA analyses with a broaden beam. The porosity of the spongy part is ca. 60-80%, which is consistent with the decrease in volume fraction of solids (67.3-81.0%) in the desulfidization and oxidation reaction: $FeS + 3/2O_2 = FeO + SO_2$, or $2FeS + 7/2O_2 = Fe_2O_3 + 2SO_2$. These observations show that the sponge Fe-oxide was formed by the oxidation reaction of sulfide.

Hattori (1993) reported similar reaction textures in the dacite of Mt. Pinatubo eruption, and interpreted that they were formed as a result of upward volatile fluxing of an SO_2-rich fluid. In the Sakurajima Taisho eruption, it has been shown that magma mixing has occurred since A.D. activity (e.g. Yanagi et al.,1991). Sato et al. (this meeting) suggest that an underlying mafic magma supplied CO_2-rich fluid to the silicic magma, which possibly accompanied influx of SO_2-rich fluid. The oxidation reaction of pyrrhotite could have been occurred in the magma mixing or the fluid fluxing during or prior to the Taisho eruption.

Keywords: sulfur, pyrrhotite, spongy Fe-oxide, Sakurajima Taisho eruption

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P09 Room:Convention Hall Time:May 24 15:30-17:00

Ground deformation measurements in Izu-Oshima volcano (3)

ONIZAWA, Shin'ya[1*], TAKAGI, Akimichi[1], KOKUBO, Kazuya[1], YAMAMOTO, Tetsuya[1], SHIMBORI, Toshiki[1]

[1]Seismology and Volcanology Department, MRI

In Izu-Oshima volcano, inflation continues over 20 years since the end of the last eruption in 1986-87, suggesting magma accumulation for future eruptions. Recent continuous ground deformation observations revealed repetition of shorter term of deflation - inflation events of the volcano. High dense GPS network installed by Meteorological Research Institute made obvious that both the deflation and inflation occurred at the northern part of the caldera. Volumetric strain-meter installed at the northwestern flank by Japan Meteorological Agency also detects contraction and extension as associated with the deflation and inflation events. Further, three tilt-meters has been installed on the volcano since 2010 to reinforce surveillance of the volcanic activity. Cooperative use of dense GPS network and high sensitive and temporal resolution in-situ instrument data will contribute to development of the volcanic activity surveillance and estimation system.

Horizontal strain obtained from GPS baseline analysis results indicated both deflation and inflation sources locate beneath the northern part of the caldera. Since the areal and principal strains approximately show isotropic patterns, we estimated source parameters of Mogi model for the 2009-2010 deflation and 2010 inflation events. Both the deflation and inflation sources are estimated at the depth of 3600 m b.s.l., when horizontal components of the relative displacement data are used. -1.3 million cubic-meters and 2.9 million cubic-meters of the volumetric changes are obtained. Areal strain at the location of the volumetric strain-meter is calculated for the source parameters inferred from the GPS data. The estimated contraction and extension are -1.0 and 3.2 micro-strains for the 2009-2010 deflation and 2010 inflation periods. These values coincide well with about -1 and 3 micro-strains of the observed ones.

Keywords: Izu-Oshima volcano, ground deformation, geodetic data

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P10 Room:Convention Hall Time:May 24 15:30-17:00

Application of PS-InSAR analysis to Izu-Oshima volcano, using ALOS/PALSAR

KASAI, Ayaka[1], FURUYA, Masato[1*]

[1]Hokkaido University, Graduate School of Science

We performed PS-InSAR analysis at Izu-Oshima volcano, based on L-band ALOS/PALSAR data. We used the StaMPS software, and applied it to both ascending and descending track. Using 5 years' long PALSAR data, we were able to derive the secularly inflating deformation signals that are consistent with the GEONET GPS data. While it has been pointed out before, we could also confirm the subsiding signals around the caldera region. In view of the PALSAR-based time series data, the subsidence near the caldera does not appear to evolve uniformly over time, but we will need to evaluate the measurement precisions more rigorously.

Keywords: Izu-Oshima volcano, crustal deformation, PSInSAR, ALOS/PALSAR

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P11 Room:Convention Hall Time:May 24 15:30-17:00

Ground deformation at Suwanose-jima volcano as viewed from ALOS/PALSAR InSAR: 2007-2011

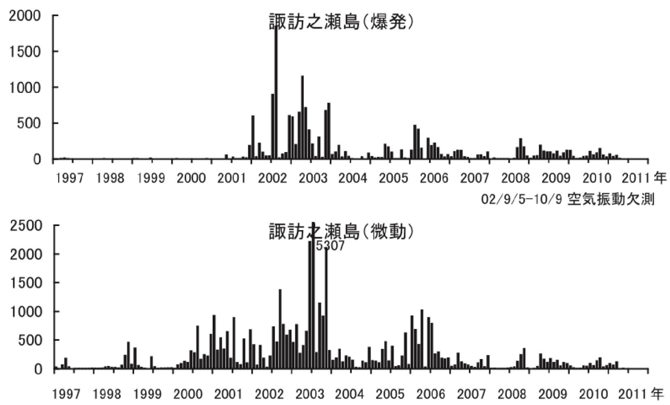
OIKAWA, Jun[1*], AOKI, Yosuke[1], FURUYA, Masato[2], IGUCHI, Masato[3], WATADA, Shingo[1]

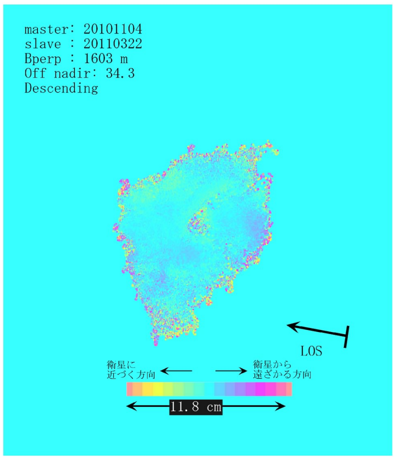
[1]ERI, Univ. of Tokyo, [2]Hokkaido Univ., [3]DPRI, Kyoto Univ.

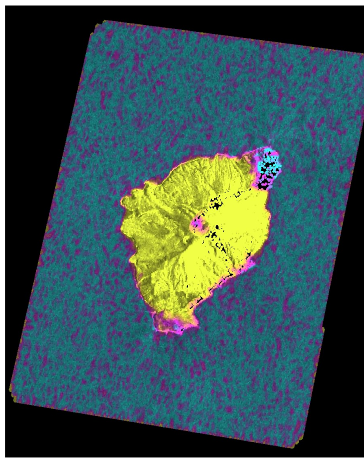
Suwanose-jima is one of the most active volcano of Japan with quasi-continuous unrest since 1957. It is monitored with broadband seismometers and tiltmeters but the difficulty in ground access to the island prohibits us to construct large-enough network to understand the magma plumbing system solely from the ground-based monitoring network. Ground deformation observed by the InSAR analysis thus has a potential to gain more insights into our understanding of the magma plumbing system of this volcano.

We analyzed 13 images (6 ascending and 7 descending images, respectively) taken between March, 2007, and February, 2008. Despite 70 explosive eruptions in 2007, our least-squares inversion did not detect any significant deformation. Explosive eruptions without significant deformation can be interpreted as eruptions without feeding magma from depth or magma propagation through the conduit without deformation.

Keywords: Suwanose-jima, active volcano, ground deformation, InSAR







Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P12 Room:Convention Hall Time:May 24 15:30-17:00

Crustal deformation since eruption in 2000 at Miyakejima by GPS observation

YUMITORI, Natsumi[1], MATSUSHIMA, Takeshi[1*], OIKAWA, Jun[2], WATANABE, Atsushi[2], OKUDA, Takashi[3], KOHNO, Yuhki[4], OZAWA, Taku[4]

[1]Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, [2]Earthquake Research Institute, University of Tokyo, [3]Research Center for Seismology, Volcanology and Disaster Mitigation,Gldiate School of Enviromental S, [4]National Research Institute for Earth Science and Disaster Prevention

Densely GPS observation network was constructed cooperate with University of Tokyo, Kyushu University and Nagoya University since 1995 at Miyakejima volcano, Izu Islands. GPS Campaign observation was carried out for next Miyakejima eruption every year. Rapid static survey was carried out at about 40 fiducial points of Tokyo Metropolis. Maximum of 70cm displacement was observed at the eruption in June 2000. Sign of magma intrusion from southwest to western part of Miyakejima was grasped in detail by amounts of displacement at these points of observation. However, we lost many fiducial points because of eruption disaster and reconstruction work after the eruption. In addition to that, the Universities stopped continuous stance for observation and research at Miyakejima. As the result, the GPS observation was kept stopping since 2002. Presently, detailed crustal deformation at Miyakejima cannot obtain because there were only four GEONET sites of GSI. It was difficult to grasp in detail circumstances of Miyakejima volcano. Therefore, we carried out GPS campaign observation at Miyakejima in September 2011. We aimed to grasp detailed crustal deformation since 2000 eruption at Miyakejima, to get data of basis of the next eruption activity.

We carried out static and rapid static measurement at this time GPS campaign observation. Static measurement was carried out fifteen observation points at Miyakejima on September 6-9, 2011. Among these, the existing observation point is eight points and a newly establishing point is seven points including five observation stations of NIED. Rapid static measurement was carried out along ring road at Miyakejima on September 8. By this rapid static observation, the level point 1004 located in the south of an island was made into a base station. Observation for about 10 minutes was carried out for 22 points of a public fiducial point in sampling interval 5 seconds.

The data derived from observation on September 2011 and January 2001 was analyzed by RTK-LIB (Takasu et al. 2007). The data of two GEONET sites of GSI and GPS precise ephemeris from IGS were also used. As the result, horizontal deformation from January 2001 to September 2011 was shown shrunk tendency toward the center of Miyakejima. Pressure source was estimated based on data of crustal deformation. Deflation source of $1.6x10^7 m^3$ was estimated at the depth of 4km directly under Mt. Oyama. However, there were major differences from observed value to calculated value at the west side observation points of the island. Therefore, it is necessary to calculate more complicated model. The accumulation of data is important in order to prepare for next eruption.

Keywords: Miyakejima, GPS, Crustal Deformation

SVC50-P13 Room:Convention Hall Time:May 24 15:30-17:00

Magma-plumbing System of Asama Volcano after 2004 Eruption, Estimated from Vertical Deformation above the Presumed Press

KIMATA, Fumiaki[1*], Research Group of Precise Leveling on Asama Volcano[1]

[1]Graduate School of Environmental Studies, Nagoya University

[Introduction]

Asama volcano is one of the active volcanoes in Japan, and it erupted on September 1, 2004. A shallow dike intrusion is estimated in the Takamine, 4 ? 5 km west of the Asama crater from the ground deformation detected by GPS measurements (Murakami, 2005; Aoki et al., 2005). However they discussed pressure sources based on GPS data observed far field as 4 km away from the presumed pressure source.

Ground deformation observation close to the pressure source should clarify the depth and volume change of pressure sources. We establish the precise leveling routes ranging to Mt. Takamine above the presumed pressure source from Oiwake, at the southern foot of Asama volcano in May 2005. The route is consisting of 60 benchmarks in 28 km distance.

[Vertical deformation detected precise leveling]

The precise levelings have practiced seven times for five years since May 2005 to June 2011. We calculated the vertical deformation for six-months to two-years between leveling epochs. Generally, deformations detected by the precise leveling are small of 10 mm. For example, it is measured the subsidence of 9 mm in the mountainside and relative uplift of 7 mm to the mountain path in the period of May 2005 to June 2011.

Vertical deformations detected in the periods of May 2005 ? Nov.2005 ? May 2006 ? May 2009 ? June 2010 ? June 2011, are grouping two patterns. One is definite subsidence, and another is slight uplift. Murakami (2005) discusses the line length changes between two GPS sites of Tsumagoi and Tobu, and he shows that the extension of line length just before the eruption in 2004 and 2009 and contraction between the eruption. Slight uplifts in the periods of May 2005 ? May 2006 are corresponding to the period observed the extension, and subsidence in the periods of May 2006 ? May 2007, May 2009 ? June 2010, and June 2010 ? June 2011.

[Magma-pluming system after the 2004 explosions]

Two pressures sources are estimated from the ground deformation detected by precise levelings. One is a deeper spherical deflation source in the 6 km BSL depth beneath the mountainside, and another is the shallow dike intrusion beneath Mt. Takamine.

A spherical source is previously estimated from the leveling data for last 100 years (Murase et al., 2007), and it is suggestive a dominant source of the Asama volcano. They suggest a slight inflation after 1960, however our results show the deflation of -6.6 km3/6yr in the deeper sources for five years after the 2004 eruption.

A shallow pressure source at 1.3 km BSL depth is corresponded to the presumed dike intrusion in 2004 eruption. It is very difficult to discuss the volume change of the dike, because of insignificant identification of dike length and width. Since May 2009, large deformation of 10 mm uplift and subsidence are detected around Mt. Takamine. It is suggested a drain back in May 2009 ? June 2010 and an intrusion in June 2010 ? June 2011. There is one possibility that the deformation of the dike caused by 2011 Tohoku earthquake (Takada and Fukushima, 2011).

Members of research group; Fumiaki Kimata, Keita Ishikawa, Masao Matsumura, Enrique Fernandez (Nagoya Univ), Masayuki Murase (Nihon Univ), Hitoshi Mori, Atsuo Suzuki, Tokumitsu Maekawa (Hokkaido Univ), Tomoyuki Matsumura, Yoshio Yamagiwa, Makoto Miyashita, Mitsuharu Arisono, Jyun-ichi Miyamura (JMA)

Keywords: Asama volcano, magma-plumbing system, vertical deformation, precise leveling

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P14 Room:Convention Hall Time:May 24 15:30-17:00

Repeat of accumulative expansion of summit area of Kuchinoerabujima volcano

SAITO, Eiji[1*], IGUCHI, Masato[2]

[1]Geological Survey of Japan, AIST, [2]Sakurajima Volcano Research Center, DPRI, Kyoto Univ.

Continuous GPS observation is performed at the Kuchinoerabujima volcano in Kagoshima Prefecture. Four episodes of expansive displacement were detected by the observation at 250 m northwest of Shindake summit crater. Characteristics of the deformation are as follows:

a. Amount of displacement in each episode is several centimeters.
b. Expansive process has been accumulated showing a growth curve in general.
d. Correspondence of the deformation to increase in seismicity in early stages became ambiguous gradually.

The source of expansion is presumed at a depth of 300 m beneath the summit crater (Saito & Iguchi, 2006, Iguchi, 2008). It is thought that the inflations are caused by intermittent rise of hot water, referring to observation results of earthquakes (Hetty et. al, 2007), total magnetic force (Kanda et. al. 2007) and volcanic gases (Mori et. al, 2007). Process of expansion is composed of pressurization of fluid, absorption of heat and a relief. Temporal change of the deformation will be presented to discuss on possibility of eruption.

Keywords: GPS, Volcano, Ground deformation, Expansion, Kuchinoerabujima

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P15 Room:Convention Hall Time:May 24 15:30-17:00

Estimated pressure source and vertical deformation in Tatun volcano ,Taiwan, detected by precise leveling in 2006-2011

MURASE, Masayuki[1*], LIN Cheng-Horng[2], KIMATA Fumiaki[3], MORI Hitoshi[4], SUZUKI Atsuo[4], Research Group of Precise Leveling on Tatun Volcano[1]

[1]Department of Geosystem sciences, Nihon University, Japan, [2]Institute of Earth Sciences, Academia Sinica, Taiwan, [3]Graduate School of Environmental Studies, Nagoya University, Japan, [4]Institute of Seismology and Volcanology, Hokkaido University, Japan

Tatun volcano group (TVG) including more than 20 volcanoes such as Chihsing, Siaoguanyin, and Huangzuei volcanos is located in the 15 km northeastward from Taipei, Taiwan. Although TVG has a hydrothermal activity characterized by some strenuous fumarolic activities and hot springs, it was evaluated that there is no resent eruptive activity and the nuclear power stations were constructed on the mountainside. Seismological network installed in 2003 detects a micro-seismic activity such as the volcano-tectonic earthquakes, tremors, monochromatic events and long-period earthquakes in and around Chihsing volcano (Lin et al., 2005; Konstantinou et al., 2007).

Based on the recent stratigraphy research, it makes clear that the magmatic eruption of 13,000-23,000 years ago and the phreatic eruption of about 6,000 years ago occurred at TVG and Chihsing volcano respectively. As results, the government established the volcano observatory in TVG to monitor the volcano activity in 2011.

Since those volcano-seismic swarm occur just around some fumaroles, it strongly suggests that the micro-seismic activity and the hydrothermal activity are closely related. Basically, the swarm activity around volcano is often accompanied by the deformation (e.g.: Kimata et al., 2004; Daita et al., 2009). Since these deformations are sometimes localized to a small region and few mm scale, a precise leveling survey is the most efficient survey to detect the deformation successfully.

Therefore, we established a 10km leveling route crossing the Chihsing volcano from south to north to detect the vertical deformation in June 2006. The leveling route is consisting with 30 benchmarks, and the defference of height is 300m. Our leveling surveys were re-conducted five times of June 2006, March 2007, August 2007, March 2009, and March 2011. Additionally, the leveling route was extended to the fumarolic area in the east part of the Chihsing volcano in August 2007.

We detected the subsidence of 5 mm in the east part of the Chihsing volcano for 9 months from June 2006 to March 2007. The subsidence was observed in the period of March-August 2007, and it became 10 mm in total for 14 months from June 2006 to August 2007.

After the leveling route extension, we detected the significant deformations in two areas. One is the subsidence of 5 mm in the mountainside, and another is the uplift in the fumarolic area for 19 months from August 2007 to March 2009. The similar deformation pattern to the preceding observation was observed in March 2011. However, the subsidence in the mountainside was relatively larger than the uplift close to the fumarolic area.

Based on the observed deformation in the period between August 2007 and March 2011, we estimate the volume changes and the locations of two spherical sources on that condition by employing a genetic algorithm (GA).

As a result, shallow pressure sources are estimated. One pressure source is estimated with -1.7*10ˆ5 mˆ3 at 3 km depth beneath the northeast foot of the Chihsing volcano, and another source is estimated with 0.3*10ˆ5 mˆ3 at 0.7 km depth in the fumarolic area.

It suggested that the estimated pressure sources are related to the hydrothermal activity. In the study period, the subsidence in the mountainside was detected to be caused by a major deeper deformation in TVG. The hydrothermal fluid supplied to the shallow sources in TVG may not be significant in this period.

Keywords: Tatun volcano, Taiwan, leveling, pressure source, vertical deformation

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P16 Room:Convention Hall Time:May 24 15:30-17:00

Analysis of tilt data at Stromboli volcano using boundary elemental method

KAWAGUCHI, Ryohei[1*], NISHIMURA, Takeshi[1], SATO, Haruo[1]

[1]Geophysics, Science, Tohoku Univ.

Recent geodetic observations at active volcanoes succeeded in detecting volcano inflation prior to volcanic eruptions. These data can be used for quantitatively understanding the magma ascent dynamics before eruptions. In this study, we calculate the volcano deformation on the basis of 3D boundary element method to explain the observed tilt data at Stromboli which are associated with volcanic eruptions. Assuming a pressure sources extending from the vent to a depth inside a cylindrical conduit and using topography of Stromboli volcano, we calculate tilt motions at tilt stations. Our forward modeling shows that pressure sources extending down to about 450 m depth with about 1.3 MPa can explain the tilt amplitudes reported in Genco and Ripepe (2010). Using temporal changes of tilt amplitude will enable us to constrain the pressure sources, which may give a new constraint on magma ascent process before eruptions.

Keywords: Stromboli Volcano, volcano deformation, boundary element method, tilt motion

SVC50-P17 Room:Convention Hall Time:May 24 15:30-17:00

MaGCAP-V (5) - Upgrade for strainmeter data

KOKUBO, Kazuya[1*], FUKUI, Keiichi[2], ANDO, Shinobu[3], TAKAGI, Akimichi[1], ONIZAWA, Shin'ya[1], SHIMBORI, Toshiki[1], YAMAMOTO, Tetsuya[1], Hiroshi, OHSUGA[4]

[1]Meteorological Research Institute, JMA, [2]Kakioka Magnetic Observatory, [3]MEXT, [4]VisCore Corp.

We developed the software MaGCAP-V (Magnetic and Geodetic data Computer Analysis Program for Volcano) to evaluate the magmatic activity from ground deformation data and geomagnetic changes observed at volcano. MaGCAP-V can handles both geodetic and geomagnetic data, and can do modeling the source of change through trial and error or inversion method by using GUI on Windows PC (Churei et al., 2002; Fukui et al., 2005).

MaGCAP-V Version 1.3 (released in 2011) handles the following data, 1) GPS (X,Y, Z, latitude, longitude, and ellipsoid high), 2) displacement (also leveling data), 3) EDM, 4) tilt, 5) In-SAR, 6) gravity, 7) magnetic total intensity, 8) atmospheric pressure, temperature, humidity, precipitation, and 9) hypocenter. DEM data (GSI DEM or user's DEM) are used for the modeling and drawing the topography. And also users can use the vector data to display the lakeshore and fault, etc.

It is possible to plot data in any combination of observation items as time series graph and as distribution map. Distribution map shows marks and vectors on observation points, or draws as color map created from interpolated grid data. GPS and displacement data can be processed as a difference between two-period or displacement speed calculated from data. The effect of the regional stress field can be removed from GPS and displacement data.

The following models are used, 1) Mogi model, dislocation model, spheroidal model (Sakai et al., 2008), and composite source for ground deformation, 2) thermal demagnetization model for sphere, column, conical, box, and composite source, 3) piezo magnetism which makes the multiple Mogi models. In order to reduce the effect of topography, we use a simple mode such as the modified Mogi model (Fukui et al., 2003). And modeling of volcano deformation by using a FEM simulation database (Fukui et al., 2006) are used to remove the effect of topography, heterogeneity structure and the shape of source. A kind of dynamic analysis is available (Fukui et al., 2010).

MaGCAP-V runs on personal computers and has improved for multi-threading CPU and double buffer to get higher performance (Fukui et al., 2010).

It was upgraded for the application to borehole type strainmeter data to estimate changing process of pressure source toward eruption. In Izu-oshima Island, JMA has one volumetric strainmeter and we are installing a new strainmeter which has sensors in different directions to observe horizontal strain tensor. MaGCAP-V can process and analyze these data and apply them to those crustal deformation models of volcanoes.

Acknowledgements

The preliminary version of this software was developed under the special coordination funds for the promoting science and technology 'Unzen volcano: International cooperative research with scientific drilling for understanding eruption mechanisms and magmatic activity (1999-2001)'. We are grateful to Mr. Koji Nakamura for information on SEIS-GPS and PAT-ME, and to Mr. Hiroto Naito on PAT-ME, and to Dr. Masato Furuya for gravity model.

Keywords: software, volcano monitoring, ground deformation, geomagnetic change, model analysis, strain

SVC50-P18 Room:Convention Hall Time:May 24 15:30-17:00

Chemical and isotopic composition of fumarolic gas at Mihara volcano, Izu-Oshima Island, Japan

OGINUMA, Yu[1*], OHBA, Takeshi[1]

[1]Dep. Chem. School Sci. Tokai Univ.

1. Introduction

Since the late of 19 century, Izu-Oshima volcano has erupted periodically every thirty to forty years. During the last eruption in 1986, a lave flow issued on the flank of volcano resulting in the evacuation of all residents in island. For the mitigation of volcanic hazard, early warning is needed. As volcanic gases move quickly in crust, the composition of fumarolic gases may change responding the activation of magmatic activity. According to Suwa and Tanaka (1959), increases of outlet temperature were observed at some of fumaroles. Sano et al. (1995) detected a quick increase of 3He/4He ratio in vapor discharged at a bore hole on the volcanic flank following the eruption in 1986. Shimoike and Notsu (2000) observed the change in CO2/H2O ratio of vapor at the bore hole. The ratio decreased gradually after the eruption in 1986. The above results indicate the close relationship between the composition of gas and volcanic activity.

2. Observation

Since 2004 two fumaroles (X-15 and K) have been the subject of observation until. X-15 and K are located near the central pit crater of Mt. Mihara. X-15 and K are located at the west and east of the crater, respectively. The outlet temperature of fumarolic gas, CO2/H2O ratio and isotope ratios (dD and d18O) have been measured periodically along the method by Ohba (2008).

3. Result

(X-15) The outlet temperature of X-15 had been about 65C until 2008 then decreased to 62C in 2011. The CO2/H2O ratio has been variable, which may be due to the low density of H2O vapor and the sampling of H2O was not complete. The isotope ratio of H2O decreased in 2011. No smell of H2S and SO2 were felt.

(K) The fumarolic gas at K has been discharged on the inner wall of crater. The flux of fumarole is significant within the fumaroles on summit area of Mt. Mihara. The fumarolic gas can be noticed at a place 2 km far from the fumarole. The outlet temperature of K was stable, within the range of 77 to 79 C. The CO2/H2O ratio was also stable within the range of 0.02 to 0.03. The isotope ratio of H2O was slightly higher than that of H2O at X-15. The isotope ratio of H2O at X-15 and K was lower than the ratios of local meteoric water at Izu-Oshima Island (Takahashi et al., 2000). No smell of H2S and SO2 were felt.

4. Factors controlling the composition of fumarolic gas

Ohba (2008) proposed a model for the formation of fumarolic gas at Mt. Mihara, in which, a magmatic gas enriched in CO2 is mixed with cold ground water, resulting in the generation of vapor phase. The vapor phase is diluted by a vapor derived from meteoric ground water. The diluted vapor phase is discharged at surface as fumarolic gas. A part of vapor was removed as a condensed liquid phase before the discharge at surface. If the flux of magmatic vapor increases, a high isotope ratio of H2O is expected. The CO2/H2O ratio is expected to decrease because the condensation of vapor phase would be suppressed prior to the discharge. The observed changes in the composition of fumarolic gas at X-15 and K are not compatible to the expected changes the case that the flux of magmatic vapor increases.

Keywords: Izu-Oshima, Volcanic gas, CO2/H2O, Isotope ratio, Fumarolic gas

SVC50-P19 Room:Convention Hall Time:May 24 15:30-17:00

Atmospheric CO2 observation at the fumarolic area of Hakone volcano by use of TDLAS

OHBA, Takeshi[1*], Shingo Nakatsuka[1], OGINUMA, Yu[1]

[1]Dep. Chem. School Sci. Tokai Univ.

1. Introduction

Volcanic gas is the mixture of H2O vapor, CO2, SO2, H2S, HCl, etc. In general, CO2 is a dominated component in volcanic gases next to H2O vapor. H2O vapor can be condensed by cooling. H2O vapor is contained in normal ambient air with high concentration. On the other hand, CO2 cannot be condensed and the concentration in normal air is only 390 ppm. In terms of the flux determination, CO2 would be observed correctly relative to H2O vapor. Volcanic gases are discharged as fumarolic gas and diffusive gas through soil. Therefore, the flux observation is not straightforward even for CO2 gas. The practical observation of components in volcanic gas is possible for SO2 gas by use of COSPEC and DOAS. Those methods are not useful for the fumarolic gases at volcanoes the activity of which is dormant or quiescent, because the SO2 concentration in such a gas is limited. Recently the optical absorption measurement by use of tunable diode laser (TDLAS) became possible for atmospheric CO2 observation. TDLAS has advantages in terms of CO2 observation at fumarolic area, because, 1) it enable to measure CO2 concentration in open path the length of which extends up to 1 km, 2) the time resolution of measurement is the order of second, 3) it can be operated with battery therefore it is portable. In this study an example of TDLAS application at fumarolic area is reported.

2. Observation

Atmospheric CO2 observation was carried out at 13 to 14 PM on 6th Jan 2012 at Owakudani fumarolic area of Mt. Hakone, Japan. Within the fumarolic area a observation line (263m) was set in the direction of south to north. At the northern end, laser emitter (GasFinder, Boreal Laser Inc) was placed. In the box of emitter, a receiver of laser light was included. The laser light (1575 nm) was transmitted to a retroreflector which was placed at the southern end of observation line. GasFinder outputs CO2 concentration as ppm*m which is the integrated CO2 concentration along the observation line. Dividing the value by the length of observation line, the averaged CO2 concentration was obtained. In parallel to the CO2 observation, climatic parameters (air temperature, wind speed, wind direction) were obtained on the northern end of observation line at the height 4m higher than surface.

3. Results

Thirty eight of values for the accumulated CO2 concentration were produced every minute. The averaged CO2 concentration was in the range of 500 to 515 ppm. The variation of the concentration looks as, short time variation was overlapped on a gradual base line change. The overall relationship between the concentration and climatic parameter was not clear. The wind direction was almost west over the whole duration of observation. In the middle of duration, the wind direction changed to west-south-west over only 3 minutes. In the short period, the CO2 concentration decreased quickly by 4 ppm and went back to the previous value after the period, which is a significant and short term correlation between CO2 concentration and wind direction.

Keywords: Laser, CO2, Volcanic gas, Mt. Hakone

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P20 Room:Convention Hall Time:May 24 15:30-17:00

Trial of real-time measurement of dissolved CO_2 concentration in CO_2-rich volcanic crater lakes

SANEMASA, Mitsuhisa[1]*, SAIKI, Kazuto[1], KANEKO, Katsuya[2], OHBA, Takeshi[3]

[1]Earth & Space, School Sci., Osaka Univ., [2]Earth Sci., School HES., Kyoto Univ., [3]Dept. Chem., School Sci., Tokai Univ.

Volcanic CO_2 is supplied continuously into Lake Monoun and Lake Nyos (Cameroon Volcanic Lakes) in Cameroon, Africa. There, the erupted CO_2 killed approximately 1800 people in 1984 and 1986. After those events, many scientists and engineers took steps such as monitoring the lakes and controlled degassing to prevent the disasters. Those steps have been decreasing the CO_2 amount and it is less than 10% of maximum dissolved CO_2 in Lake Monoun, but still the 73% of the maximum is remained in Lake Nyos [1]. Moreover, supply paths are not revealed, there is the possibility that the supply amount might increase rapidly by the activation of volcanoes.

At present, the vertical profiles of CO_2 concentration are estimated from the correlation of measurements of electronic conductivity and pH and chemical analyses of collected lake water samples at each depths. This method, however, requires time and effort in collecting samples and chemical analyses, so the measurement has been done only once in a year. It is difficult to catch up with in the case of sudden and rapid intrusion of CO_2-rich water into lake using this method, therefore a new method which enables to measure dissolved CO_2 concentration in real time or frequently is required.

There is the method to measure dissolved CO_2 using membrane. After the liquid phase and gas phase are equilibrated, CO_2 concentration in gas phase is measured using IR absorbance. Because it is difficult to maintain such delicate equipments continuously in the field, an easy and fast measuring method is required. We concluded that sound velocity method using the change of the velocity by dissolved materials and/or the refined electronic conductivity method are more applicable. In former method, the sound velocity change is expected to be owing mainly to CO_2, major dissolved species in the lakes. On the other hand, in the latter method, the effect of other dissolved species, those concentrations are relatively low, is suggested as a cause of error [1]. Therefore the sound velocity method was tested in the beginning. Although there is the previous investigation on sound velocity method for ionic solutions [2], there are no data for CO_2 solution. We conducted the sound velocity change experiments for CO_2 solution.

Two piezo-electronic devices set in face-to-face with 16 cm distance were packed in PET-bottle with tap-water, and high pressure CO_2 gas was charged to produce carbonated water. The CO_2 concentration was 172 mmol/kg (0.5 times of that in Lake Nyos). Sound velocity of the water was measured by Time of Flight method. 2 MHz signal drove the one piezo device to generate sound waves and the arrival time of the waves received was monitored by another device connected to the oscilloscope. The sound velocities before and after CO_2-pressurize were measured. The result shows the sound velocity did not change within the precision of 10 m/s. To measure the sound velocity change of carbonated water more precisely, we developed a pressure tank which can contain a sound velocity profiler (Minos X, made by AML oceanographic) and high pressure CO_2 gas. The results using those devices will be shown.

The vertical profiles of temperature and sound velocity were measured using the profiler in Cameroon Volcanic Lakes in 2012 February to March. The results will be also shown.

[1]Kusakabe et al.(2008) Evolution of CO_2 in Lakes Monoun and Nyos, Cameroon, before and during controlled degassing, Geochemical Journal, 42, 93-118

[2]S. J. Kleis and L. A. Sanchez (1990) Dependance of Speed of Sound on Salinity and Temperature in Concentrated NaCl Solutions, Solar Energy, 4, 201-206

Keywords: Cameroon volcanic lakes, dissolved CO_2, sound velocity

SVC50-P21 Room:Convention Hall Time:May 24 15:30-17:00

Hot water reservoir beneath Yudamari crater lake at Aso volcano

TERADA, Akihiko[1*]

[1]Volcanic Fluid Research Center, Tokyo Institute of Technology

The Nakadake first crater at Aso volcano, Japan, emits significant amounts of volcanic gas, including 200?400 tonne/day of SO_2 during calm periods. The first crater contains a hot crater lake, locally referred to as Yudamari with a diameter greater than 200 m. Throughout most of the calm period, the lake temperature remains at 60 degree C which is much higher than the ambient temperature.

Precipitation cannot explain the maintenance of the lake water volume because the volume of water lost from the lake surface caused by an evaporation rate of 60?80 kg/s is an order of magnitude greater than the volume of water gained through precipitation. This suggests that the lake water is obtained mainly via inflows at the lake bottom.

The numerical model revealed seasonal changes in mass flux (75?132 kg/s) and enthalpy (1,840?3,030 kJ/kg) for the fluid supplied to the lake. The relation between the enthalpy and mass flux indicates that the bottom input fluid is a mixture of high- and low temperature fluids. Assuming a mixture of high temperature steam at 800 degree C and liquid water at 100 degree C, Terada et al.(2012) revealed that half of bottom input fluid is hot liquid water.

In February 2009, an unusual thermal event occurred at Yudamari crater lake involving a large volcanic tremor, discolored lake surface, acoustic noise and interesting changes in water level and temperature.

Precise water level and water temperature measurements enable us to quantitatively evaluate heat and mass flux from lake bottom during the event. A numerical model employed by Terada et al. (2012) reveals that 30,000 m3 of hot water emit from the lake bottom. The analysis also shows the enthalpy of bottom input fluid is approximately 400 kJ/kg, corresponding to liquid water in 90 degree C. We suspect that a hot water reservoir exists beneath Yudamari crater lake.

Keywords: crater lake, Aso volcano, hydrothermal system

SVC50-P22 Room:Convention Hall Time:May 24 15:30-17:00

On the recent thermal demagnetization beneath the Oana Crater, Azuma Volcano

YAMAZAKI, Akira[1], FUKUI, Keiichi[1*], YAMAZAKI, Nobuyuki[1], KOBAYASHI, Tooru[2], ISHII, Kunio[2], YANADA, Takahiro[2]

[1]Kakioka Magnetic Observatory, JMA, [2]Volcanological Center of Sendai District Meteorological Observatory, JMA

The Oana crater of which the diameter is about 200m is located in geothermal fumaroles zone at southeast slope of Mt. Issaikyo, Azuma Volcano. In the recent years, a new 300m height fumarole named W-6 appeared inside the crater on November, 2008, and volcanic micro-tremors were observed after an interval of five years in 2010. It seems the recent hydrothermal activity beneath the Oana crater has been high level.

In order to monitoring hydrothermal activity beneath the Oana crater, a repeat measurement of the geomagnetic total force with 12 observation points has been carried out near the crater since 2003 by the volcanological center of Sendai district meteorological observatory cooperated with Kakioka magnetic observatory. Continuous secular variations in the geomagnetic total force have been observed within a 500m radius area from the center of the crater. Since the variation pattern is increasing at northern and decreasing at southern area of the crater, it suggests that demagnetization has been progressing beneath the crater. As the demagnetization occurred at geothermal active zone, we think it is a thermal demagnetization caused by hydrothermal activity.

A progressing rate of the thermal demagnetization beneath the Oana crater has been considered almost constant by analysis of secular variations in the geomagnetic total force up to 2010. However, on the observation on September, 2011, it is found that the trend of the secular variations at each observation point clearly changed toward acceleration of the thermal demagnetization. Depths of demagnetized sphere models estimated by annual secular variations up to 2010 are around 300m to 400m beneath the Oana crater, and radiuses are around 60m to 70m. On the other hand, the estimated depth is 500m and the radius is 108m on the model calculated from secular variations in the period from October, 2010 to September, 2011. This means the estimated annual volume of demagnetized source rapidly expands by five times during 2010 to 2011. We infer a something volcanic event happened beneath the Oana crater after October, 2010, and it caused raise up the hydrothermal fluid temperature.

Keywords: Azuma Volcano, geomagnetic total force, hydrothermal reservoir, thermal demagnetization, magnetic survey

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P23 Room:Convention Hall Time:May 24 15:30-17:00

The electrical resistivity structure of Aso volcano inferred from broadband MT surveys

ASANO, Tsuyoshi[1*], UTSUGI, Mitsuru[1], KAGIYAMA, Tsuneomi[1], KOMORI, Shogo[1], Hiroyuki Inoue[1]

[1]Kyoto Univ.

Aso volcano is a Quaternary active volcano located in the northeast of Kumamoto prefecture, central Kyushu, Japan. It had formed the huge caldera through the four large pyroclastic eruptions until 90ka, since then it has been in active mainly at the central cones.

Electrical resistivity structures of active volcanoes provide us the useful information for understanding mechanisms of current and past activity, and for foreseeing future activity. Therefore there are many previous works to estimate resistivity structure also at Aso volcano, for example, Takakura et al. (2000) and Utsugi et al. (2009) show the NE-SW cross-section diagram by broadband magnetotelluric(MT) survey. However, It's insufficient to conclude what kind of substances and the state are reflected because of the shallow exploration depth, down to only 5km below sea level. Because a seismic low velocity zone and a sill-like pressure variation source are expected at approximately 6km(Sudo and Kong, 2001) and 15km(GSI, 2004) respectively, we should fill the gaps in exploration depth so that we can compare resistivity data with other data and estimate the subsurface structure accurately. Additionally, there are many poorly-understood themes for Aso volcano, for example the shape of caldera floor and its formation process, subsurface structure related to large pyroclastic eruptions, complicated tectonics in caldera and so on. It's important to reveal the deeper resistivity structure for understanding them, thus we carried out broadband MT observations.

There are nine observation points, of these, seven arranged along a line of Utsugi et al. (2009) cover craters of Mt.Naka-dake, the low velocity zone and the sill-like pressure variation source. Other two arranged along a line of Takakura et al. (2000) lie directly on the low velocity zone. We invested one or two months for each point, and succeeded in obtaining data up to 1000[s] with low noise at the former seven. Then two-dimensional inversions(TM-mode) were applied to NE-SW profiles also with data of previous works. As a result, we revealed the resistivity structure down to 15km below sea level for the first time, and found three features as follows.

(1) A high resistivity body continuing to deep part

There is a region of Hundreds of ohm meter(ohm-m) continuing to about 15km below sea level with 5km width at the central part of caldera. Its strike seems to correspond to Oita-Kumamoto Tectonic Line(OKTL), hence it could be a large intrusion along OKTL.

(2) A low resistivity body at southern caldera

There is a region up to 100[ohm-m] centered at about 9km below sea level from southern slope of central cones to Nango-dani. In light of information of seismic velocity, magnetization and so on, it might be a low density region such as tuff body or some kind of hot region.

(3) A non-conductive magma chamber

There is no low resistivity region centered at Kusasenri, the seismic low velocity zone expected a magma chamber corresponds to relatively high resistivity region instead. Although molten rock is generally considered highly conductive, actual magma chambers so structurally and materially complicated that it might not show low resistivity.

Keywords: Aso volcano, broadband MT survey

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P24 Room:Convention Hall Time:May 24 15:30-17:00

Crustal structure beneath Aso caldera, Japan, as derived from receiver function analyses

ABE, Yuki[1*], OHKURA, Takahiro[1], SHIBUTANI, Takuo[2], HIRAHARA, Kazuro[3], Shin Yoshikawa[1], Hiroyuki Inoue[1]

[1]AVL, Kyoto Univ., [2]DPRI, Kyoto Univ., [3]Graduate School of Science, Kyoto Univ.

Aso volcano which rises in the Kyushu district, Japan, is one of the most active volcanoes in Japan. Aso volcano experienced a huge pyroclastic eruption 90 thousand years ago, and formed a caldera with dimensions of 18 km by 25 km, one of the largest in the world. After the huge eruption, small eruptions formed the central cones. For understanding the activity of a volcano, it is important to examine the crustal structure and reveal the region where fluid is contained and the amount of the fluid beneath the volcano. Beneath Aso caldera, Sudo and Kong (2001, Bull. Volcanol.) estimated the crustal structure down to 10 km in depth with seismic tomography. They detected a low velocity region which is interpreted to be a magma chamber at a depth of 6 km beneath the western part of the central cones. The crustal structure deeper than 10 km was estimated by Abe et al. (2010, J. Volcanol. Geotherm. Res.) with receiver function (RF) analyses. They obtained a low velocity layer whose S-wave velocity is 2.4 km/s at depths between 15 km and 21 km beneath the western part of the caldera, and interpreted that the low velocity layer contains 15% of molten rocks or 30% of aqueous fluid at maximum. They did not estimate the crustal structure beneath the eastern part of the caldera because of the lack of seismic stations. Therefore, Ohkura et al. (2010, JpGU meeting) set 5 seismic stations in the eastern part of Aso caldera in June 2009, and started the seismic observation for revealing the crustal structure. We use waveform data obtained at these temporal stations and permanent stations which are distributed in and around the caldera, and examine the crustal structure beneath the whole of Aso caldera with RF analyses.

We calculate RFs from waveforms of teleseismic events (epicentral distances: 30-90^o, Magnitude: greater than 5.5) which were observed at the 5 temporal stations and permanent stations of Hi-net and Aso Volcanological Laboratory, Kyoto University. RF is calculated by deconvolving vertical component of a teleseismic P-wave from the corresponding horizontal component. In this study, we calculate RFs with the extended-time multitaper method (Shibutani et al., 2008, Bull. Seismol. Soc. Am.) and estimate the S-wave velocity structure with genetic algorithm inversion (Shibutani et al., 1996, Geophys. Res. Lett.) of the RFs.

We reveal that the low velocity layer beneath the western part of the caldera detected by Abe et al. (2010) extends beneath the northeastern part of the caldera. It is also revealed that the low velocity layer does not exist beneath the southeastern part. This low velocity layer would have some relationship with the past huge pyroclastic eruptions and/or the future one. Petford et al. (2000, Nature) and Kaneko et al. (2007, Chikyu Monthly) indicated that magmas of huge pyroclastic eruptions are derived from the molten crust melted by high-temperature molten rocks intruded from the mantle. The low velocity layer beneath Aso caldera is possible to be such a molten region.

We use waveform data of National Research Institute for Earth Science and Disaster Prevention.

Keywords: Aso caldera, receiver function, genetic algorithm inversion, crustal structure

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P25 Room:Convention Hall Time:May 24 15:30-17:00

Hypocenter determination of B-type earthquakes at Miyakejima volcano using waveform cross correlation technique

UCHIDA, Higashi[1*], NISHIMURA, Takeshi[1], SATO, Haruo[1], YAMASATO, Hitoshi[2], FUJITA, Eisuke[3]

[1]Geophysics, Science, Tohoku Univ., [2]Seismol. and Volcanol. Dep., JMA, [3]NIED

The 2000 eruptive activity of Miyakejima volcano is characterized by dike intrusions, episodic large summit eruption, summit caldera formation and successive emission of volcanic gases. No noticeable eruption has occurred since September 2000, but Miyakejima still continues to emit a large amount of volcanic gases. During this long gas emission stage, many volcanic earthquakes also occurred, but most of them are so called B type earthquakes whose hypocenters are not determined because of unclear P and S phases. To better understand the activity of B type earthquakes, we classify the B-type earthquakes into several earthquake families based on waveform similarity, and determine their hypocenters.

We analyze seismograms of about 1,020 B-type earthquakes at Miyakejima volcano, which are observed by JMA and NIED for the period from August 2010 to April 2011. The seismic network consists of about 10 stations, each of which is equipped with a short period, three-component seismometer. All stations are located within 4 km from the summit crater. In order to find earthquake families, we first band-pass filter the seismograms at 2-4 Hz that is the dominant frequency of B-types. Then, we calculate cross-correlation coefficients for all of the pair of two earthquakes that are selected from 1,020 events. We select the pairs with a cross correlation coefficient larger than 0.7, and find 4 groups of the B type earthquake families, each of which consists of more than 20 earthquakes.

Assuming that all the B-type earthquakes belonging to a same group of earthquake family are closely distributed in space and their source mechanisms are same, we stack the observed seismograms at each station for the same group. As a result, P and S phases on the stacked seismograms become clearer, which enables us to precisely measure their arrival times. Under a homogeneous half space with a P-wave velocity of 2 km/s, we determine the hypocenters of 4 groups of the earthquake family from the arrival times. Their hypocenters are located at the southern part inside the summit caldera, at depth of about 1 km.

We further investigate low frequency component of these earthquake families. The individual seismograms at each station are band-pass filtered at 0.25-0.5 Hz, and are stacked for the same group. As a result, significant low frequency signals appear for one group of the earthquake families. Particle orbits of the low-frequency waves are characterized by linear trajectories in the horizontal plane. The major axes of the trajectories at all of the stations intersect at the southern part of the summit, which is almost the same location with the epicenters determined from P-wave arrival times.

We have succeeded in determining the hypocenters of about 18 % of the total B-type events by using waveform cross correlation techniques. Also, we found an interesting low-frequency phases that may represent an existence of volumetric seismic source beneath the active crater of Miyakejima.

Keywords: Miyakejima volcano, earthquake family, hypocenter determination, B-type earthquake

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P26 Room:Convention Hall Time:May 24 15:30-17:00

Stratigraphy records of 1883 Krakatau eruption and tsunami in Java coastline Indonesia

SULASTYA PUTRA, Purna[1*], Yuichi Nishimura[1], Eko Yulianto[2]

[1]Institute of Seismology and Volcanology, Hokkaido University, [2]Research Center for Geotechnology, Indonesian Institute of Sciences (LIPI)

During the paroxysmal stage of 1883 Krakatau event, a series of eruption and tsunami occurred and destroyed more than 250 coastal villages along the Sunda Strait. We reported the result of our field works in Java coastline located to the east of Krakatau volcano. Around 30 cores and pits were observed and samples were collected. We described and examined the cores and pits of tsunami-related deposits and primary tephra deposits. In general the stratigraphy of the 1883 eruption and tsunami in coastal Java composed of intercalation of sand, pumiceous sand and tephra. The stratigraphic record is unique and very complex and was formed by successive deposition of tephra and tsunami deposit and also erosion by tsunamis. The tsunami layers sometimes contain pumice and/or ash. These pumice and/or ash had been carried up inland together with the beach sand from their original position by the tsunami run-up. To understand the sedimentation processes and chronology of eruption and tsunami during the 1883 paroxysmal stage, we used the stratigraphy characteristics in conjunction with historical record account. At some locations, the stratigraphic records observed in the field and historical account are correlated.

Keywords: 1883 Krakatau, tsunami, eruption, stratigraphy, sedimentology, historical account

SVC50-P27 Room:Convention Hall Time:May 24 15:30-17:00

Temporal variation of geomagnetic total intensity before and after the 2011 summit eruption at Shinmoe-dake crater

UYESHIMA, Makoto[1*], KOYAMA, Takao[1], KAGIYAMA, Tsuneomi[2]

[1]Earthquake Research Institute, The University of Tokyo, [2]Graduate School of Science, Kyoto University

At Shinmoe-dake crater in Kirishima volcano, a weak summit eruption occurred in 22th, Aug., 2008. Since then, 3 weak eruptions took place in 2010, and intense magmatic activities including generation of lava dome and explosive summit eruptions have started since 26th Jan., 2011. Since moderate volcanic activities in 1991-1992, we have performed continuous monitoring of geomagnetic total intensities at several sites in the vicinity of the Shinmoe-dake crater, aiming at detecting temporal variation due to thermal magnetic effect or piezo-magnetic effect before and during the main eruptions. Although all the four observation sites (SMN, SMNW, SMW, SMS) just near the summit were damaged by the intense volcanic activities from 26th Jan., 2011, we could re-start the observation from July, 15, 2011 at SMW station. We present temporal variation before and after the recent eruption and discuss on source of the changes due to thermal geomagnetic effects.

Keywords: kirishima shinmoe-dake crater, volcanic eruption, geomagnetic total intensity, thermal demagnetization

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P28 Room:Convention Hall Time:May 24 15:30-17:00

MT survey around Mt. Shinmoedake, Kirishima Volcanoes in 2010-2011

KOYAMA, Takao[1*], UYESHIMA, Makoto[1], HASE, Hideaki[1], AIZAWA, Koki[1], YAMAYA, Yusuke[1], WATANABE, Atsushi[1], Koji Miyakawa[1], MAEHARA, Yuki[1], HASHIMOTO, Takeshi[2], KANDA, Wataru[3], OGAWA, Yasuo[3], UTSUGI, Mitsuru[4], KAGIYAMA, Tsuneomi[4], YOSHIMURA, Ryokei[5], YAMAZAKI, Ken'ichi[5], KOMATSU, Shintaro[5]

[1]Earthquake Research Institute, Univ. Tokyo, [2]Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido Univ., [3]Volcanic Fluid Research Center, Tokyo Institute of Technology, [4]Graduate School of Science, Kyoto Univ., [5]DPRI, Kyoto Univ.

We conducted broadband magnetotelluric (MT) survey at Kirishima volcanoes in 2010 and 2011 to elucidate the electrical resistivity structure. From We made MT measurements at 17 sites around Mt. Shinmoe in July to September 2010, and made another MT measurements at 12 sites in March to April 2011. ADU07s of Metronix were used for measurements and measurement term was almost three weeks at each site. By preliminary results, directions of induction vectors go to north of Mt. Shinmoe, around Mt. Karakuni in and below the periods of 1 seconds, and tend to go to north-west of Mt. Shimoe, westward of Mt. Karakuni around 100 seconds. This may indicate that a shallow low resistive body exists at a few km depth of the north position of Mt. Shinmoe and a deep low resistive body exists at tens km depth of the north-west position of Mt. Shinmoe.

From 26 January 2011, it occured the active eruptoins of Mt. Shinmoe. GPS measurements found that the position of 6km apart from Mt. Shimoe in north-west direciotion is the source of stress at 10 km depth, that is, a magma chamber. Thus the induction vectors may point at a deep main magma chamber and a shallow sub magma chamber.

Keywords: Mt. Shinmoedake, MT survey

SVC50-P29 Room:Convention Hall Time:May 24 15:30-17:00

The relation between amount of tilt change preceding the eruption and the volume of tephra at Shinmoedake Volcano

KATO, Koji[1*], FUJIWARA, Yoshiaki[1]

[1]Japan meteorological agency

The eruptive activity at Shinmoedake volcano began on January 19, 2011, and shifted magma eruption on January 26. Preceding these eruptions, characteristic tilt changes were detected by tilt-meters about 3km from crater. We report the relation between amount of tilt change preceding eruption and the volume of tephra, air wave amplitude.

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P30 Room:Convention Hall Time:May 24 15:30-17:00

Geodetic aspects in difficulties of eruption scenario inferred from Shinmoedake events in 2011

YAMAMOTO, Tetsuya[1*], TAKAGI, Akimichi[1], ONIZAWA, Shin'ya[1]

[1]Meteorological Research Institute, JMA

Japan Meteorological Agency monitors activity of volcanoes in Japan and issues information to mitigate damage from volcanic disasters, one of which is the Volcanic Alert Level based on an eruption scenario for each volcano. In these days, geodetic observation to detect deformation of volcanic body plays an important role in assessment of volcanic activity, however, an occurrence of anomalous deformation is rarely described in the eruption scenario, because no deformation event has observed in most of volcanoes. For rapid and adequate determination of the Volcanic Alert Level, it is desired to understand a condition of underground magma more quantitatively by the volcano geodetic observation.

A subplinian eruption occurred at Shinmoedake, Kirishima Volcanic Group in January 2011. Preceding the eruption, GPS observation revealed an inflation centered at about 10 km northwest from Shinmoedake. Though the inflation seemed to be caused by a magma supply from the depth to a chamber, this kind of event did not appear in the eruption scenario, and hardly expected a relation to the activity of Shinmoedake because the inflation took place in rather distant area from the volcano. After the subplinian eruption and following lava effusion, a simultaneous deflation was found out and it became clear that the erupted magma was supplied from this distant magma chamber. Here we make an attempt to summarize the condition of magma quantitatively in order to make use of the geodetic observation for the eruption scenario in future.

Keywords: eruption senario, Shinmoedake, volcanic deformation

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P31 Room:Convention Hall Time:May 24 15:30-17:00

Vertical deformation at the northwestern part of Mt. Kirishima(Feb.,2011-May,2011-Mar.,2012)

MORI, Hitoshi Y.[1*], OSHIMA, hiromitsu[1], Etsurou Koyama[2]

[1]ISV, Faculty of Science, Hokkaido University, [2]Earthquake Research Institute, University of Tokyo

Shinmoe-dake, one of the craters of Mt. Kirishima, started eruptive activity in Jan, 2011. In Feb, 2011, when the volcano was still active, remeasurements of 'Ebino highland - Iino elementary school' leveling route, which settled by ERI of University of Tokyo in 1969, were carried out. Deformations between 1969 and 2011 were reported at the last JGU meeting in May, 2011.

In June, 2011, we made remeasurements of that leveling route and extended the route to 'Shin-yu'. We also will make remeasurements of those routes in Mar, 2012.

But, at the time of this abstract, we have no data about remeasurements in Mar, 2012. In the followings, the deformation between February and June 2011 are discussed.

The Vertical movements of benchmarks in 'Ebino highland - Iino elementary school' leveling route show that Mt. Kirishima uplifted from February to June 2011. The maximum uplift is c.a.12mm referred to the bench mark in 'Iino elementary school'. In detail, local depression is detected at the distance of 2-8km from 'Iino elementary school' along the leveling route. But main trend of the vertical movements of the route seems to be able to explain with a spherical pressure source. In this time, we make estimations of the pressure source parameters in consideration of the heights of benchmarks.

The benchmark in 'Iino elementary school' is seemed to be uplifted from the trend pattern of the deformation of the leveling route. We checked the vertical movement of #960714 'Ebino' GEONET station referred to other five GEONET stations located at the northern part of the south-Kyushu district inland, which have no volcanic deformations. As the result, 'Ebino' GEONET station seems to be uplifted 2.9-6.7mm.

Considering that uplift of 'Ebino' GEONET station, we estimated the position of the pressure source by the method of grid searching with the spherical pressure source model in consideration of the heights of benchmarks. As the result, the pressure source locates at c.a. 3km west of 'Karakuni-dake' crater and its depth is 10.2-11.0km, in the case of about 3mm uplift of 'Ebino' GEONET station. In the case of 6-7mm uplift of 'Ebino' GEONET station, the pressure source locates at c.a. 3.8km WSW of 'Karakuni-dake' crater and its depth is 15.2-15.8km.

The estimated horizontal position of the pressure source is similar to the positions estimated by other methods. But the estimated depths by other methods are 4.5-8km and much shallower than the depth estimated bay our leveling survey.

The remaining uncertainty of the horizontal position is elongating in the direction NNE-SSW. As this uncertainty is caused by the locations of bench marks, it will be decrease after the next remeasurements at the leveling route extended in the last survey.

We thank the members of Hokkaido University in the February leveling survey, who are Mr. Suzuki, Mr. Maekawa, Mr. T. Mori and Mr. Matsumoto.

Keywords: Mt. Kirishima, Shinmoe-dake, volcanic deformation, leveling survey

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P32 Room:Convention Hall Time:May 24 15:30-17:00

Source Model of Kirishima Volcano Based on GPS Integrated Analysis in Volcanic Region(2nd report)

IMAKIIRE, Tetsuro[1*], NISHIMURA, Takuya[1]

[1]Geospatial Information Authority of Japan (GSI)

Geospatical Information Authority of Japan (GSI) has been monitoring the crustal deformation of Kirishima volcano using the GPS continuous observation network. Observtion data by GEONET revealed that the volcano had started to inflate from December 2009, at first. We combined the observation data from GPS sites of JMA and NIED to estimate the inflation sources under the volcano. We reported the source model, which interpreted the inflation before the eruption of Shinmoedake on January 26, 2011 and the deflation during a few days following the eruption until February 2011, at the 2011 JPGU meeting and CCPVE. The main source of the inflation and the deflation is estimated at the deeper part on the northwest side of the volcano, accompanied by a shallow source under the crater of Shinmoedake. As the shortening of the baseline after the eruption was smaller than the extension that was observed before the eruption, estimated deflation of the source was smaller then the inflation before the eruption.

GSI installed an auxiliary GPS continuous observation site on the northwestern side of the volcano to reinforce the monitoring of the volcano, on February 2, 2011. As we have been monitoring the crustal deformation carefully since then, the inflation by the same rate as before the eruption was observed until the November 2011. The inflation rate of the source was estimated about one million cubic meter per month, as same as the rate before the eruption. Even though the extension of the baseline length crossing the volcano was calming down after December 2011, we would not be able to conclude the supply of magma to the inflation source have finished, as this kind of the slowing down of the inflation had be seen during July to August of 2010, before the preceding stage to the eruption. We are going to watch more carefully how the deformation pattern would change, further.

Keywords: Kirishima Volcano, Crustal deformation, GPS, Inversion, Source model, 2011 Shinmoedake eruption

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P33 Room:Convention Hall Time:May 24 15:30-17:00

Activity of crustal earthquakes in and around the Kirishima volcano synchronizing and activating with ground inflations

YAKIWARA, Hiroshi[1*], GOTO, Kazuhiko[1], Shuichiro Hirano[1], MIYAMACHI, Hiroki[1], NAKAO, Shigeru[1]

[1]GSSE, Kagoshima Univ.

Crustal earthquakes in and around volcanoes may become active by static stress changes caused by magma stores at the major reservoirs beneath the volcanoes. We detected the numbers of the earthquakes in and around the Kirishima volcano increased in 2002, 2006, and 2009. The timings of the increase nearly agree with the timings of inflation of the magma chamber beneath the volcano shown by temporal changes of a baseline length between 2 stations of GEONET. In this study, we discuss the relation between increases of the earthquake and crustal deformation.

A seismic network of Nansei-Toko Observatory for Earthquakes and Volcanoes, Kagoshima Univ. (NOEV) has observed the earthquakes around southern Kyushu. The network can locate earthquakes in and around the volcano larger than or equal to M0.8 since October, 2000 incorporating data from Kyushu Univ., JMA, and Hi-net (Mori, 2001). Therefore, we can follow the seismicity in and around the volcano on equal condition for 11 years long from 2001 through 2011. The authors compared the cumulative number of these earthquakes with the length change of the GPS baseline between Ebino (960714) and Makizono (950486) of GEONET (GSJ, 2011) in time domain. Also we calculated the numbers per day (NPD) of the earthquakes every month through the period. The increases of the average NPD (ANPD) synchronized with the relaxations of shortening or distinct extension of the baseline. The ANPD increases from 0.1-0.2 at the first half year in 2002 to 0.8-1.0 in 2003, and changes from 0.3 at the first quarter in 2006 to 0.7 after the period. The ANPD also increase from 0.8 in December, 2009 to 1.3 through 2010. Previous studies reported the slight changes of Coulomb failure stress (only 0.01-0.1MPa) caused the increase or decrease of the earthquakes (e.g. Reasenberg and Simpson, 1992; Toda et al., 1998). Changes of static stress with the inflations of the main magma chamber beneath the volcano may cause the changes of the seismicity (ANPD).

Crustal earthquakes also may arise tectonically by the plate motions. We hope the earthquakes mainly caused by the magma pressure increase can be distinguished. We therefore calculated z values (e.g. Habermann, 1983; Wiemer and Wyss, 1992) to extract the earthquakes with inflating the volcano edifice. The positive and negative numbers of the z value show decreases and increases of the seismicity rate of interesting areas, respectively. We compared the z values between the first and second half year of 2010 when the most distinct extension of the GPS baseline has been observed. We got negative z values beneath the southwest, northeast, and northwest flank of the Kirishima volcano. The static stress changes by magmatic inflations cause the earthquake activities in these areas. The authors also analyzed the source mechanisms of the earthquakes to examine whether the temporal change of the main principal stress axis exists or not. As a result, we observed no obvious change of the axis. The crustal earthquakes around the area of negative z value may occur on existing faults with static stress changes produced by magma accumulations in the chamber (Morita and Ohminato, 2005).

Keywords: Kirishima Volcano, seismicity

SVC50-P34 Room:Convention Hall Time:May 24 15:30-17:00

Characteristics of volcanic tremor at Shin-moe dake inferred from two seismic array analysis

YAMANAKA, Yoshiko[1*], NAKAMICHI, Haruhisa[1], TERAKAWA, Toshiko[1], OKUDA, Takashi[1], HORIKAWA, Shinichiro[1], YAMAZAKI, Fumihito[1], MATSUMOTO, Satoshi[2], SHIMIZU, Hiroshi[2]

[1]Nagoya Univ, [2]SEVO, Kyushu Univ.

Two dense seismic arrays were deployed at 5 km east-northeast away from the Shinmoe volcano by Nagoya University (Hinamoridai), and 3km southwest by Kyushu University (Shinyu). We estimated the apparent back azimuth and slowness of volcanic tremor and earthquakes associated with volcanic eruptions continuously by using semblance method to seismic waves of up-down component. Estimated average back azimuth for the activity around Shinmoe-dake are N265E-N275E for Nagoya Univ. array, N55E-N70E for Kyushu Univ. array. Difference between the directions of ray path obtained by two arrays may be due to the velocity structure beneath Shinmoe-dake. Furthermore, we were able to obtain the continuous change of slowness and back azimuth for the volcanic tremor.

Keywords: Kirishima Volcano, Shinmoedake, seismic array, eruption, volcanic tremor

SVC50-P35 Room:Convention Hall Time:May 24 15:30-17:00

Eruptive activity of Shinmoedake Volcano

JMA[1], NAGATO, Shinya[1*]

[1]Fukuoka District Meteorological Observatory

Shinmoedake volcano is one of the members of Kirishimayama volcanoes group, located in Kyushu, southwestern Japan. Major eruptions occurred in 1716 ? 1717, fall out deposits, pyroclastic flows and mudflows were widely dispersed around the volcano. Recently, small phreatic eruption occurred in 1959 and 1991. After Shinmoedake volcano repeated phreatic eruption on August, 2008 and during March ? July 2010, started magmatic eruptions from 19 January, 2011, after 300 years dormancy.

Fukuoka Volcano Observation and Information Center, JMA and Kagoshima Local Meteorological Observatory, JMA monitor Shinmoedake volcano for 24 hours a day. Based on an analyzed result of monitoring, a volcanic warning is released. In this presentation, we report about 2010 - 2011eruptive activity of Shinmoedake volcano with the observational data manly by the JMA.

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P36 Room:Convention Hall Time:May 24 15:30-17:00

Pyroclastic fall deposit and eruptive mass of 2011 eruption from Shinmoedake Volcano, Kirishima Volcanic Group

FURUKAWA, Ryuta[1], GESHI, Nobuo[1*], OIKAWA, Teruki[1], CHIBA, Tatsuro[2], NAKADA, Setsuya[3], NAGAI, Masashi[4]

[1]Geological Survey of Japan, AIST, [2]Asia Air Survey Co., LTD., [3]Earthquake Research Institute, University of Tokyo, [4]National Research Institute for Earth Science and and Disaster Prevention

Original data for pyroclastic fall deposit from the Shinmoedake Volcano at the eruption of 2011, allows us to estimate its eruptive mass as ca. 29 MT. Our data are obtained from field survey measurement at the distant terrestrial region from the volcano performed within ten months after the eruption and remote sensing investigations by high altitude-LiDAR, unmanned helicopter and satellite observations. We integrated distribution function of area and mass as logarithmic function resulting ca. 29 MT for whole deposit. We are very much grateful for providing original data from TSUTSUI T. (DIA Consultants Co., Ltd.), TAJIMA Y. (Nippon Koei Co., Ltd.), TAKEUCHI S. and TOSHIDA K. (Central Research Institute of Electric Power Industry), HASENAKA T. (Kumamoto University), Japan Meteorological Agency and Public Works Research Institute.

Keywords: Kirishima, Shinmoedake, AD2011, eruption, eruptive mass, pyroclastic fall deposit

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P37 Room:Convention Hall Time:May 24 15:30-17:00

Remelting experiments of the erupted materials of the 2011 eruption of Sinmoedake, Kirishima Volcano

MUJIN, Mayumi[1*], NAKAMURA, Michihiko[1], OKUMURA, Satoshi[1]

[1]Dept. Earth Science, Tohoku Univ.

The 2011 eruption of the Sinmoedake crater was the first sub-Plinian eruption in the last 300 years in the Kirishima volcanic chain. The activity in January and February showed eruption styles changing from sub-Plinian to vulcanian. The apparent color variation of the erupted materials was mainly resulting from crystallinity of groundmass.

The white pumice has scarce microlites, with few dendritic ones. The crystallinity of microlite increases in the following order: white pumice, gray pumice, dark-gray lithic fragments, and volcanic bombs. The microlites of gray pumice, lithic fragments, and volcanic bombs are composed of plagioclase, pyroxene, and Fe-Ti oxide. The highly crystallized groundmasses include abundant small crystals with sub-micrometer size.

In order to investigate the magma ascent and emplacement processes in the 2011 eruption, we conducted non-crushed reheating experiments of the gray pumice with a silica-glass tube covered with a bolt/nut cell. The samples were heated at a temperature of 957?C under the pressure of 0-8 MPa with NNO buffered fO2 and water-saturated conditions for 0.5 h to 1 week.

The crystallinity of microlites in the groundmass increased from that the initial crystallinity of the gray pumice at all the experimunts performed at 0-8 MPa pressure. The crystallization of FeTi-oxide nanolites first proceeded at 0.5 hours run, and then the crystallization of plagioclase, pyroxene, and FeTi-oxides followed for 1 week. The crystallinity of the run products covers the range of natural samples except for that of white pumice and the highly-crystallized volcanic bomb. The emplacement pressure of the magmas of gray pumice was inferred to be larger than 8 MPa. The effects of the melt composition, water vapor pressure, and run duration should be further investigated.

Keywords: Sinmoedake, microlite, remelting experiment

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P38 Room:Convention Hall Time:May 24 15:30-17:00

The mechanism that causes shift of explosive intensity; petrological case-study for Mt. Shinmoe 2011 eruption

KICHISE, Tsuyoshi[1*], TORAMARU, Atsushi[2]

[1]Dept. of Earth and Planet. Sci., Grad. school of Kyushu Univ., [2]Det. of Earth and Planet. Sci., Faculty of Sci., Kyushu Univ.

In general, explosive eruptions have some variation in duration time, intensity, erupted volume and textural and compositional characteristics of erupted materials. These variations shift in few days at a same volcano. There might be any endogenous mechanisms for shifting eruptive styles, except geological or tectonic settings as exogenous mechanisms. However, endogenous mechanisms are still not understood well. Moreover, these parameters shift even in a simple explosive eruption with time. There has been only a few petrological studies which analyze erupted materials with high time resolution. Together with geophysical and geochemical observations, the petrological study may provide clues for these shifting mechanisms. We focus on the pumice deposits of the 2011 eruptions of the Mt. Shinmoe volcano, Kyushu, Japan, which were well observed several geophysical methods (e.g. tilt, GPS seisomograms and echo height by weather radar).

The Shinmoe 2011 eruption generated three sub-Plinian eruptions on January 26-27 and shifted to lava dome growth with vulcanian eruptions. Because the eruption cloud by the 3rd sub-Plinian eruption on 27 afternoon, Jan traveled different direction from those of the 1st and 2nd eruptions (Furukawa et al., 2011, JpGU), deposits by the 3rd eruption at specific localities are distinctive from deposits by the 1st and 2nd eruptions. In this study, we petrologically analyze pumice samples during the whole sequence of eruption. We collected pumice samples at approximately 3 km south from the vent along the major axis of this eruption, Takachiho gawara, where the thickness of deposit was 7 cm. We divided the whole deposits into three layers; below, middle and above layer with two sub-layers for each. Deposits commonly contain white pumice, gray pumice and black particles, which occupy $>$3.2 wt.%, 58.3 ? 82.9 wt.% and 15.6 ? 36.2 wt.% in this section, respectively. The black particles have the characteristics of juvenile pyroclastic lava as pointed out by Kichise et al. (2010, JpGU). White pumice is most abundant in the bottom layer, the gray pumice was most abundant in middle to upper layer and the black particles are most abundant in uppermost layer.

We measured the bulk density of particles as a proxy of eruption intensity, which changes with time. We calculated the bulk density from a volume of sample by using David Laser Scanner 2.6.3, and the weight by an electronic balance. The density of gray and black particles are (0.7-2.2 g/cm^3) and (1.4-2.7 g/cm^3), respectively. For the same particles, we analyze chemical compositions of microlites, groundmass and matrix glasses. The black particles have higher bulk densities than gray pumices while the black particles have similar local bulk compositions to those of the gray particles. Particles with higher bulk density have higher groundmass crystallinity and higher in SiO_2 content of matrix glasses. It is interesting that the similar correlation between vesicularity and microlite crystallinity is also observed in the sub-Plinian eruption of the 1986B Izu-Oshima eruption and the Plinian eruption of the Fuji Hoei eruption, suggesting a common conduit process which may work widely in most of basaltic andesitic to andesitic sub-Plinian eruptions.

Keywords: Shinmoe volcano 2011 eruption, explosive eruption, bulk density, duration time

SVC50-P39 Room:Convention Hall Time:May 24 15:30-17:00

Dynamics and timescales of magma ascent in the shallow conduit of Shinmoedake volcano, Japan, deduced from ash texture

VINET, Nicolas[1*], OISHI, Masayuki[1], GESHI, Nobuo[1], SHINOHARA, Hiroshi[1], TOMIYA, Akihiko[1]

[1]Geological Survey of Japan, AIST

Shinmoedake, Kirishima volcano, located in southern Kyushu, Japan, renewed its activity after almost 300 years of near-dormancy on January 19, 2011 through a phreatomagmatic eruption. It was followed by sub-Plinian eruptions on January 26-27 that emitted $7x10^7$ tons of andesitic tephra, extrusion of lava that filled the summit crater, repeated Vulcanian eruptions and minor ash emission. The variety of eruption styles during a year of near-continuous activity and the extensive on-site sampling of fresh tephra over time, make it possible to investigate the textural and petrochemical variations of the tephra through time, and gain insights into shallow conduit processes. The juvenile materials consist mostly of gray pumice, along with small amount of brown or white pumice plus banded pumice. They contain olivine, orthopyroxene, clinopyroxene, plagioclase and Fe-Ti oxides as phenocrysts and microlites. The mineral and groundmass content varies regarding the eruption and type of material. Gray pumices has a whole-rock composition of 57 wt% SiO_2, while white pumices have 62-63 wt% SiO_2. Both types of pumice represent two different magmas. The erupted ash contains different types of juvenile grains, which are pumiceous grains, scoriaceous grains, and dense glassy blocks (see Oishi et al., this JpGU meeting). The proportion of the different types to the total population of ash grains is variable with time and eruption, but the constituents are the same throughout the eruptive sequence. Thus, Vulcanian eruptions are not generated by dome (lava plug) destruction but are likely driven by input of fresh magma and/or change of the conduit processes (including cooling and ascent rates). The textural approach using the crystal size distribution (CSD) analysis can aid in determining and quantifying such conduit processes and timescales. We determined CSDs of plagioclase microlites for each type of ash grain from each major event from January 19 to September 2011, using backscattered-electron images. No typical CSD was found to be fully representative of each juvenile grain type. Many samples from different types of grains have a curved concave-up CSD, which indicates several crystal populations in the conduit, and maybe mixing of magmas with different texture. Such curved CSDs can be found together with straight CSDs in grains of the same type and from the same eruption, either of sub-Plinian or Vulcanian type. This shows that the crystallization, and thus undercooling, conditions in the conduit are changing in a short timescale during a single event. In addition, we observed at least one straight CSD with the same characteristics (slope, intercept, size range) for the ash from every eruption type (phreatomagmatic, sub-Plinian or Vulcanian), but not necessarily from every single event. This suggests similar conduit properties and processes (simple nucleation and growth) with respect to the eruption style. The CSD-derived timescales of magma ascent in the shallow conduit are within hours to days. The same order of magnitude was found based on diffusion profiles in magnetite.

Keywords: Kirishima volcano, Shinmoedake, 2011 eruption series, Crystal size distributions, Timescales of magma ascent

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P40 Room:Convention Hall Time:May 24 15:30-17:00

The eruption styles and grain compositions of deposits from the 2011 eruption of Shinmoedake, Kirishima volcano, Japan

OISHI, Masayuki[1*], GESHI, Nobuo[1], SHINOHARA, Hiroshi[1], Nicolas Vinet[1]

[1]Geological Survey of Japan, AIST

We determined the grain and chemical compositions of ash fall deposits emitted from the 2011 eruption series of Shinmoedake, Kirishima volcano. As the main result, we found that the products from both eruption types, sub-plinian and vulcanian, have similar grain and chemical compositions. This suggests that all eruptions were fed by a homogeneous magma and driven by similar magma ascent processes.

Shinmoedake, one of the eruptive centers of Kirishima volcanoes located in southern Kyushu, Japan, repeated eruptions from January to September 2011. The eruption series started by a phreato-magmatic explosion in January 19, followed by sub-plinian eruptions on January 26-27, extrusion of lava that filled the summit crater, vulcanian eruptions since the end of January, and minor ash emissions. We collected on-site ash samples for each event, thus derived from all types of eruptions. This provides a rare chance to investigate the mechanisms controlling the eruption style, from the viewpoint of characteristics of the eruptive products through time and possible correlations with the eruption type.

We observed color, shape, and vesicularity of the grains in the size range 0.25-0.50 mm, using the optical stereoscopic microscope and SEM. We regarded grains with fresh morphology as juvenile materials. We distinguished five types of juvenile grains based on their vesicularity and color: P (light-colored pumice), S (dark-colored scoria), WG (white glassy dense block), GG (gray glassy dense block), and BG (black glassy dense block). For each eruption, we counted the number of grains of each type among an original population of 200 grains.

The proportion of highly-vesicular grains (sum of P and S types) goes from 14%, corresponding to the phreato-magmatic explosion of January 19, to 26.5%, corresponding to the sub-plinian eruption of January 26. The proportion then fluctuated between 2-25.5% during the subsequent vulcanian eruptions and/or minor ash emissions that occurred from February to August. This means that despite the change in the eruption style, highly-vesicular grains were always present in every ash sample. The proportion of dense grains (sum of WG, GG and BG types) ranges between 35 and 70.5 %, and the three types are found in every ash sample.

The groundmass of the juvenile grains from all eruptions has chemical compositions that lie around 65 wt% SiO_2, despite the variation in color, shape, and vesicularity of the grains. There are some grains with a differentiated groundmass (70 to 75 wt% SiO_2), but they belong to the same differentiation trend as all other grains.

We conclude that the constituents and chemical compositions of all types of grains are similar, despite of the great variability in the eruption style (phreato-magmatic explosion, sub-plinian eruptions, vulcanian eruptions, and minor ash emissions), and thus eruption intensity. In particular, highly-vesicular grains are ubiquitous in all ash samples, although their proportion is varying. This suggests that fresh magma fed every eruption of the 2011 series. As a consequence, vulcanian eruptions are not the results of lava dome and/or cap-rock destruction, but likely the results of input of fresh magma in the shallow conduit system, which is comparable in a certain extent to what occurs for sub-plinian eruptions.

Keywords: Kirishima volcano, Shinmoedake, 2011 eruption series, ash deposit, grain composion, eruption style

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P41 Room:Convention Hall Time:May 24 15:30-17:00

Petrological characteristics and magma mixing of minor eruptions in 2011 at Shinmoedake, Kirishima volcano, Japan

SAITO, Genji[1]*

[1]Geological Survey of Japan, AIST

The 2011 eruption of Shinmoedake, Kirishima volcanic group, Japan, started with phreatomagmatic eruptions on 19 January. The eruptive activity was culminated with the sub-Plinian eruptions on 26-27 January, followed by lava effusion within the summit crater. Vulcanian explosions and minor ash emissions together with degassing activity from the summit crater occurred intermittently from February to September. Petrological studies on the eruptive products in January and February indicated that input of mafic magma to a magma chamber just before the sub-Plinian eruptions (e.g., Geshi et al., 2011; Saito et al., 2011; Tomiya et al., 2011). The products of the minor eruptions also contained essential material (Oishi et al., this JpGU meeting) but the origin of the material was not clear.

In this study, the essential products of the minor eruptions in March to June were analyzed to know their petrological characteristics and the eruption process. The samples are ash particles of the eruption on 13 March (March-ash), lapilli of the eruption on 18 April (April-lapilli) and pumiceous and scoriaceous ash particles (P- and S-types ; Oishi et al., 2012) of the eruption on 29 June (June-ash). Mode composition, chemical composition of phenocrysts and groundmass minerals, zoning profiles of olivines and bulk composition of groundmass were analyzed using EPMA.

Phenocryst contents of March-ash, and April-lapilli (34 vol%) are slightly higher than that of pumices of the sub-Plinian eruptions (26-28 vol%). Chemical composition of groundmass of March-ash and April-lapilli have slightly SiO_2 and K_2O-rich composition (65-67 wt.% SiO_2 and 3 wt.% K_2O) than that of the pumices of the sub-Plinian eruptions (61-62 wt.% SiO_2 and 2 wt.% K_2O). P- and S-type June-ash have similar groundmass composition to that of the pumice of the sub-Plinian eruptions. Plagioclase, clinopyroxene, orthopyroxene of phenocrysts and groundmass minerals of March-ash, April-lapilli and P and S types of June-ash have similar chemical composition to the sub-Plinian eruptions. Two-pyroxene thermometry applied to the March-ash and April-lapilli samples gave 960-970 degree C, that was similar to the estimates for the magmas erupted January and February. Core compositions of olivine phenocrysts of all samples are similar, but March-ash and April-lapillil have slightly Fo-poor rims.

Similar chemical compositions of phenocrysts, groundmass minerals and groundmass of the eruptive products to those of the sub-Plinian eruptions indicated that magma mixing process proposed for the sub-Plinian eruptions occurred in March to June. Slight variation in the groundmass composition and mode composition from March to June could be caused by change of mixing ratios between mafic and felsic magmas. Assuming that the normal zoning in the rim of the olivines was produced by the magma mixing event, the residence time of the olivines was 5-30 days for March-ash and 2-20 days for April-lapilli. The residence time is similar or a little longer than that estimated for the eruptions in January and February (1-10days). These results suggest that the mafic magma input to felsic magma intermittently occurred after the sub-Plinian eruptions to cause the mionor eruptions in March to June.

Keywords: Kirishima volcano, Shinmoedake, 2011 eruption, petrology, magma mixing, olivine

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P42 Room:Convention Hall Time:May 24 15:30-17:00

Prehistorical volcanic stratigraphy of Shinmoedake in the Kirishima volcanic complex

TAJIMA, Yasuhisa[1*]

[1]Nippon Koei Co., LTD.

Eruption of the Shinmoedake volcano accompanied by pumice fall occurred in January 2011. We have little information regarding the prehistorical eruptions of this volcano. Inoue (1988) reported three pumice falls (Setao pumice: StP, Maeyama pumice: MyP, and Shinmoedake pumice: SmP or SmKP) from the Shinmoedake volcano. Imura and Kobayashi (1991) discussed about the two pumice falls that occurred after the SmKP. Tajima et al. (2011) reported about a prehistorical pumice fall (i.e., Shinyu tephra: SyT) that occurred between SmKP and K-Ah tephra eruptions in the region around Shinyu, in the western part of Shinmoedake volcano. The distribution axis of the SyT is to the north of the vent; we had not known about the north distribution pumice from the Shinmoedake volcano. As described by Inoue (1988), MyP was observed to the northeast of the vent. In this study, first, we considered both the pumice falls to belong to the same horizon because of lack of any other evidence. We attempted to measure the C14 age of the soil under the SyT pumice fall deposit to the north of the vent for determining the horizon of the unit. The age of the soil under the SyT was determined to be 4030 +- 20 yr BP. The result shows the different horizons that occurred in the SyT (4.5 cal ka BP) and the MyP, whose age has been determined as 5.6 cal ka BP by Okuno (2002). In addition, we measured the ages of two ash falls that overlie SyT and were attributed to eruptions from the Shinmoedake volcano. The age of the lower ash layer was determined to be 2635 +- 20 yr BP and that of the upper ash layer was 2305 +- 20 yr BP. Tajima et al. (2011) reported about the RyL-A and RyL-B lava flows above the SyT tephra. The age of RyL-A and RyL-B lava flows is presumed to be close to the age of the two ash falls.

Magmatic eruptions of the Shinmoedake volcano before the 2011 eruption were known to have occurred at 10.4 cal ka BP (StP), 5.6 cal ka BP (MyP), and AD 1716-1717 (SmKP). The results of this study show that the three magmatic eruptions occurred between the MyP and the SmKP eruptions. These results show that high-frequency magmatic eruptions have occurred at the Shinmoedake volcano. However, the eruption intervals were not same. We know that the crater had filled with lava (ScL) after the SmKP eruptions. This lava erupted before AD 1822 (Imura and Kobayashi, 1991). The repose time between the 2011 eruptions and SmKP or ScL is about 300 to 200 years. The repose time between SmKP and previous ash falls is over 2000 years. The Shinmoedake volcano has repeated active periods and quiet periods. These eruption intervals indicate that the recent age may be the active period. Tajima et al. (2008) determined the age of Eb-D (Eb-D) erupted in the western part (Ebinokogen) of the Kirishima volcanic complex. The age of SyT, erupted in the center part of the Kirishima volcanic complex, is the close as that of Ebino D tephra. Around 4.5 cal ka BP, Miike pumice (MiP) erupted in the eastern part of KVC. The MiP, SyT, and Eb-D eruptions occurred close time from each vents in the Kirishima volcanic complex.

I thank Paleo Labo Co. LTD for providing aid in C14 age measurements as well as for the information regarding geological records of disasters. We thank Profs T. Kobayashi of Kagoshima University.

Keywords: Shinmoedake, pumice fall, prehistorical eruptions, C14 age, Kirishima, long term activity

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P43 Room:Convention Hall Time:May 24 15:30-17:00

Magma systems of the Kyoho eruption in Shinmoe-dake volcano, Kirishima volcanoes: 2

MIYAMOTO, Tsuyoshi[1*]

[1]Center for Northeast Asian Studies, Tohoku University

The eruption from Shinmoe-dake, Kirishima volcanoes, occurred in January 2011. Although no activity is being observed currently, there is concern that the volcano might erupt again in the near future. From the similarities in the magma composition and the eruption sequence between the 2011 eruption and the early stage of the Kyoho (1716-17) eruption, to predict the next eruption, it is important to understand the magma process of the Kyoho eruption. Considering the above points, I analyzed the Kyoho eruption products to understand the magma systems of the Kyoho eruption.

The Kyoho eruption products are classified into eight units (Sm-KP1 to Sm-KP7, and Sm-MP) (Imura and Kobayashi, 1991; Tsutsui and Kobayashi, 2011). Pumice clasts in all the units are dark gray and rare yellow. Dark-gray pumices have lower bulk-rock SiO_2 content (57-58.5 wt.%) than the yellow ones (62 wt.%). There is a clear compositional gap between the two pumices. The heterogeneous texture on a scale from millimeters to tens of micrometers in both the pumices indicates that the dark-gray parts mingle with the yellow ones.

Mineral assemblages of phenocrysts in both the pumices are composed of plagioclase, orthopyroxene (Opx), clinopyroxene (Cpx), and Fe-Ti oxides. Olivine phenocrysts are contained only in the dark-gray pumice of Sm-KP4.

In dark-gray pumices, the distribution of the core $Mg^{\#}$ in Opx phenocrysts is bimodal in the $Mg^{\#}$ range of 64-66 and 73-76. Low-Mg core Opx has a thick rim with reverse zoning because the rim $Mg^{\#}$ is in the range of 72-74. Although the distribution of the core $Mg^{\#}$ in Cpx phenocrysts is not bimodal in a wide $Mg^{\#}$ range of 68-75, two kinds of phenocrysts with normal and reverse zoning are found. Low-Ca plagioclase (An_{50-75}) with extensive reverse zoning coexists with high-Ca plagioclase (An_{80-90}). The above mineralogical features in the dark-gray pumice are a result of mixing of mafic and felsic magmas. The dark-gray pumice in Sm-KP4 with olivine phenocrysts (Fo_{77-80}) includes the Cpx phenocryst with a high $Mg^{\#}$ (78-81). Because the olivine can equilibrate with the Cpx, mafic magma includes olivine and the Cpx as a phenocryst. On the other hand, the pyroxene phenocrysts characterized by bimodal distributions at core compositions are not in equilibrium with the olivine. The high-Mg pyroxene was derived from mixed magma without mafic magma, whereas the low-Mg pyroxene was from felsic magma. The pyroxene phenocrysts in the yellow parts with heterogeneous textures are homogeneous without zoning, and plagioclase is Ca poor.

Mafic magma did not erupt independently in the Kyoho eruption. The heterogeneous texture constituting the gray and yellow parts indicates that both mafic and felsic magmas ascended in conduit at the same time. In addition, the absence of isolated olivine and a thick reverse-zoned rim of Opx in the dark-gray pumice indicate that mixed magma was already produced before the Kyoho eruption. Because the chemical contrast of the Usp component between the core and the rim in a magnetite phenocryst was 0.09, deduced from the degree of zoning in magnetite, mafic magma injection occurred just prior to eruption. However, the various zoning profiles in each phenocryst indicate that mafic injection occurred repeatedly before eruption. The magnetite phenocrysts have significant compositional variation, which is larger than the zoning within each phenocryst. This shows that the pre-eruptive magma chamber was heterogeneous against the stable state in magnetite. In spite of the fact that the heterogeneous magmas blend on the magma ascent, the bulk chemical compositions of the mixed magma lie in a narrow range; this implies that the heterogeneity is derived not from the chemical composition but from physical conditions such as temperature and oxygen fugacity. The mafic magma injected just prior to eruption might not react directly with the mixed magma that erupted during the Kyoho eruption for the existence of large mixed magma .

Keywords: Kirishima volcanoes, Shinmoe-dake, Kyoho eruption, magma mixing, 2011 eruption

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC50-P44 Room:Convention Hall Time:May 24 15:30-17:00

Magmatic-phreatomagmatic transition and vesicularity change in Heian eruption of Towada Volcano

HIROI, Yoshimi[1*], MIYAMOTO, Tsuyoshi[2]

[1]Grad.Sci.Tohoku Univ., [2]CNEAS.,Tohoku Univ.

1. Introduction

The occurrence of phreatomagmatic eruption is considered to be controled by external water and magma ratio (Wohletz and McQueen, 1984). However, this criterion holds true for only mafic magma (Kato et al., 1997). On felsic explosive eruptions, magma is vesiculated and fragmented before contacting with water, and degree of fragmentation seems to be one of the controlling factors through the difference of contact surface (Yamamoto, 1989). This study examines the factor for magmatic-phreatomagmatic transition other than magma-water ratio.

2. Magmatic-phreatomagmatic transition in the Heian eruption of Towada Volcano

Heian eruption, the latest silicic volcanism at Towada volcano, began with magmatic eruption, thereafter repeated magmatic and phreatomagmatic eruptions alternately (Hiroi and Miyamoto, 2010). Through the activity the vent was in Nakanoumi caldera lake (Kudo, 2010) and the magma contacted with lake water inferred from the existence of cauliflower pumice (Heiken, 2006).

From the steadiness of grain size distribution with time, the first magmatic eruption (plinian pumice fall deposit: unit OYU-1) kept constant magma discharge rate. And from the steadiness of grain size distribution in the deposit that depends on column height, which is controlled by magma-water ratio (Koyaguchi and Woods, 1996), magma-water ratio can be regarded as constant at OYU-1 stage. Following few hours OYU-1 activity, the eruption proceeded to phreatomagmatic one rapidly (base surge deposit: unit OYU-2).

3.Vesicularity change in pyroclastics during the transition

Phreatoplinian eruption, the typical felsic phreatomagmatic eruption, produces extremely fine-grained ash deposit (Self and Sparks, 1978) mostly consisting of plate-like shards originated from large expanded bubble wall (Heiken and Wohletz, 1985). Because external water hinderes bubble growth by cooling, bubbles should grow before contacting with external water. Hiroi and Miyamoto (2011) classified shards into large expanded bubble group and small bubble group, and proved successive bubble growth through OYU-1 and OYU-2 stages.

Past studies demonstrated that pumice from magmatic eruption has low density than that from phreatomagmatic one (e.g., Walker, 1980), that is in harmony with the density measurements for pumices of Heian eruption, but seems to be in conflict with vesicularity expected from glass shards analysis.

It is inferred that pumices by magmatic eruption still vesiculate even after their ejection. To the contrary pumices by phreatomagmatic eruption freeze their vesicularity at contact with water. This implies vesicularity difference occurrs after the magma-water contact. Since the surface of pumice should hold their texture at fragmentation, we focused on their bubbly and foamy portions ratio to investigate the difference of bubble growth estimations from shards and pumice density, and confirmed the similar increase of bubbly portion on pumice surface with time (25 - 58 % and 53 - 62 % from bottom to top in OYU-1 OYU-2 deposits, respectively). Contrary to the shards, however, their increase is not successive throughout but decreased temporarily at the transition from OYU-1 to OYU-2. It may be the result of superposition of additional vesiculation on inherent vesicularity increase with time on OYU-1 pumice to acquire higher bubbly portion in its late stage than that of the beginning of OYU-2.

4. Conclusions

Fine-grained shards on magmatic and phreatomagmatic eruptions hold the information at fragmentation, but pumice on phreatomagmatic eruption freezes its texture immediately before magma-water contact rather than at fragmentation, and pumice on magmatic eruption may loose both of them to some degree by further vesiculation after the ejection.

The increase of large expanded bubble, suggested by fine-grained shards analysis, is an important factor for the transition from magmatic to phreatomagmatic eruptions through the efficient heat transfer from magma to water.

Keywords: magma eruption, phreatomagmatic eruption, vesicularity, fine-grained shards, coarse-grained pumice, felsic eruption