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

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

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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.

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

Volcanic Process of the 2011 Shinmoedake Eruption inferred from Strain Data

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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 5.25x$10^{+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

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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

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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

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

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

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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)

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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.

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

Sulfur dioxide flux of Shinmoedake 2011 eruption II

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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

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

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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

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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-

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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

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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

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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

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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

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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

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

Unique characteristics of cone in Central Elysium Planitia, Mars

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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

Japan Geoscience Union Meeting 2012
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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

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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

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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

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

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]

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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
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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*]

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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 $1.4x10^9 m^3$. 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 $2x10^8 m^3$ 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 $2x10^8 m^3$ in short term, 2) intermittent effusion of magma of $2x10^8 m^3$ in long term, similarly to vulcanian activity at Minamidake summit crater, and 3) large eruptions at two flanks with extrusion of magma of $2x10^9 m^3$.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

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

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

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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

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

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

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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 ($SiO2$ = 58.5-59.7 wt.%). The matrix glass compositions of Juvenile-A type materials are dacitic ($SiO2$ = 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
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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

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

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

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<**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

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

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

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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.

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

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

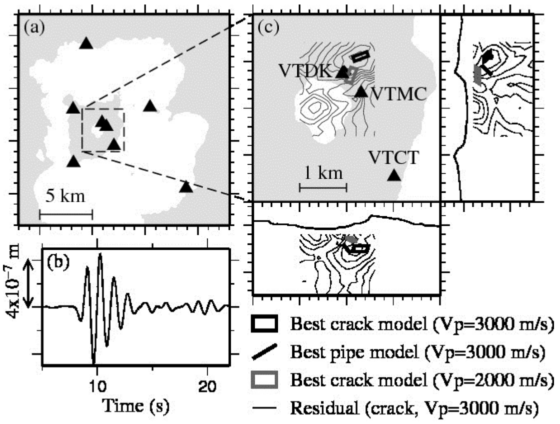

Fig. 1

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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

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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
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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

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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

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

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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.