Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SVC050-01 Room:302 Time:May 23 08:30-08:45

Outline and Eruption Scenario of the 2011 Eruption of Kirishima Volcano

Setsuya Nakada[1*], Joint Observation Team of Kirishima Volcano[1]

[1]Earth. Res. Inst., University of Tokyo

Subplinina and vulcanian explosions were repeated with a lava dome growth in the eruption of Kirishima Volcano which began since January 2011. Observation researches on this eruption was carried out by Joint Observation Team (leaded by Yoichi Morita). Phreatic explosions had been repeated at Shinmoedake since August 2008 and inflation had been observed by the GPS network for one year before the eruption. Products of the phreatomagmatic explosion on 19 January 2011 contained ~10 % of juvenile pumice. An explosive phase began on 26 January; subplinian explosions were repeated during the first three days, depositing ~10 million m3 (DRE) of tephra. On 28 January, a small lava dome appeared on the crater floor nearby the vent of 200 m across for the subplinian explosions. It continued its growth up to ~600 m across (~10 million m3) only for 3 days. The growing lava covered the explosion vent completely. The growth was confirmed the next day. Multiple vulcanian explosions occurred on 1 and 2 February, destroying a part of the dome.

The volume of inflation of volcano before the eruption was estimated ~20 million m3. It is roughly equal to that of magma erupted during 26-31 January. Deflation was recorded by sub-plinian explosions and growth of lava dome during 26-31 January.

At the night of 31 January, >1,000 people who live along the possible course of pyrolcastic flows were ordered evacuation due to a possibility of a plinian explosion. Pumice of this eruption ranges from 57 to 62 % in SiO_2 showing mingling of two magmas with different colors. The progress and the magma chemistry of this eruption is similar to those in the early stage of the 1716-17 eruption at this volcano, which lasted for one year and half including 3-months explosive stage characterized by three pyroclastic flow-generating plinian explosions.

One of the outputs of the national research project for Earthquake and Volcanic Eruption Prediction is preparing the eruption scenario and its testing for on-going eruption. This time eruption is giving us a good chance to test the scenario.

Keywords: Kishirima Volcano, Shinmoedake, magmatic eruption, lava dome, subplinina eruption, vulcano eruption

Japan Geoscience Union Meeting 2011
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SVC050-02 Room:302 Time:May 23 08:45-09:00

Eruption of Sinmoedake volcano, Kirishimayama, 2011 (Outline)

JMA[1], Hitoshi Yamasato[1*]

[1]JMA

Sinmoedake volcano, Kirishimayama, at which small phreatic eruptions had occurred since 2008, started eruptive activity on 19 January 2011 and is active still now.

The eruption on 19 January was small magmatophreatic eruption and the continuous eruption since 26 January is magmatic eruption, in which magma reached the summit crater. Lave lake gradually grew up and Vulcanian explosive activity started since 27 January. Window glasses were broken by the strong explosion on 1 February, ballistic bombs reached 3.2 km distant from the crater. SO2 flux is more than 10,000 ton/day.

From the tilt observation, deflation of a magma chamber has been observed. The deflation rate corresponds with the eruptive activity and lava lake growth.

In this presentation, I will introduce the general view of the eruptive activity with the observational data mainly by the Japan Meteorological Agency.

Japan Geoscience Union Meeting 2011
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SVC050-03 Room:302 Time:May 23 09:00-09:15

Outline of the observation and data analyses of 2011 Kirishima-Shinmoe-dake eruption

Motoo Ukawa[1*]

[1]NIED

Crustal Deformation; NIED has started the Kiban volcano monitoring network at 8 volcanoes in 2009 and, for the monitoring of Kirishima volcano, KRMV and KRHV stations were installed at about 7 kms to the northwest and northeast of Shinmoe-dake crater, respectively. This network successfully detected the abnormal signal associated with the initiation of eruptive activity at 07:31, January 26th. Then, from the first remarkable eruption on 14:49, tilting change indicated the contraction of volcanic body, which continued till around January 31st at almost constant rate. This deformation source can be modeled by a Mogi source, located at about 7 km to the northwest of the Shinmode-dake, 9.8km depth, whose of shrinkage is 13.2x10ˆ6m3. In addition, SAR analysis clearly revealed the growth of the lava dome in the summit crater from January 27 to February 1st, with the rate about 3 ˜ 5x10 ˆ 6 m3/day.

- Seismic activity; Kiban volcano monitoring network and Hi-net recoreded seismic activities during this eruption. In particular, we observed volcanic tremor (accompanied by the eruption, Harmonic, etc.) and low-frequency earthquakes, but few volcanic earthquakes (VT) were recorded by February 3rd. F-net also recorded seismic activity at explosive eruptions.

Keywords: Kirishima, Shinmoedake, Eruption

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SVC050-04 Room:302 Time:May 23 09:15-09:30

Magma of the January 2011 eruption of Shinmoedake, Kirishima Volcano

Nobuo Geshi[1*], Genji Saito[1], Akihiko Tomiya[1], Isoji Miyagi[1], Ryuta Furukawa[1], Shun Nakano[1], Hideo Hoshizumi[1], Shinji Takarada[1]

[1]Geological Survey of Japan, AIST

A sub-plinian eruption occurred on 26-27 January, 2011, from Shinmoedake, Kirishima Volcano and produced ca $7*10^7$ ton of andesitic pumice tephra. Prior to the onset of pumice eruption on 26 - 27 January, the volcano repeated small phreatic - phreatomagmatic eruption since 2008. Continuous ash emission and intermittent violent explosions follow the pumice eruption and lava is filling the previous summit crater of Shimoedake since 30 January. Total volume of the products is approaching to 108 tons on 4, February. The tephra ejected on 19 January contain pumiceous particles about 10% of total volume. The tephra ejected 26-27 January consists mainly of poorly-vesiculated pumices. The intense explosion on 1 February ejected bombs with cooling joints and chilled margin. These grains are the magmatic materials which is driving this eruption.

Our primary petrological examinations are revealing the nature of the magma. The juvenile materials erupted during 26-27 January eruption consists mainly of light-gray pumice associating with small amount of white pumice. Banded pumice consists of gray part and white part are often observed.

Whole-rock compositional analysis by XRF indicates that the composition of gray pumice concentrates around SiO2=57 wt% and the white pumice SiO2=62-63 wt%. These whole rock compositions of the juvenile materials are almost same as the previous magmatic eruption in 1716-17. The gray pumices have andesitic composition and contain olivine, orthopyroxene, clinopyroxene plagioclase and magnetite. Core compositions of plagioclase have wide compositional range from 46 to 90 in An contents. Mg# values of orthopyroxene concentrate around Mg# = 72 and clinopyroxene around Mg#=66. These mineral compositions are also similar to that of the 1716-17 tephra.

Keywords: Voclano, Eruption, Magma, Kirishima, Shinmoedake

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SVC050-05 Room:302 Time:May 23 09:30-09:45

Urgent survey of eruptive deposit in January, 2011, from Shinmoedake volcano, Mt. Kirishima, South Kyushu, Japan

Ryuta FURUKAWA[1*], GESHI Nobuo[1], NAKANO Shun[1], HOSHIZUMI Hideo[1], TAKARADA Shinji[1], TAKEUCHI Shingo[2], TOSHIDA Kiyoshi[2], TAJIMA Yasuhisa[3], TSUTSUI Masaaki[4]

[1]Geological Survey of Japan, AIST, [2]CRIEPI, [3]Nippon Koei Co., Ltd., [4]DIA CONSULTANTS CO., Ltd.

A sub-plinian eruption occurred on 26-27 January, 2011, from Shinmoedake, Kirishima Volcano and produced about 7x10ˆ7 tons of pumice fall deposit. Prior to the onset of pumice eruption on 26 - 27 January, the volcano repeated small phreatic - phreatomagmatic eruption since 2008 and the pumiceous particles have been found in these tephra. Continuous ash emission and intermittent violent explosions follow the pumice eruption and a lava is filling the previous summit crater of Shimoedake since 30 January.

The field survey was done within 4 days after the first subplinian eruption and revealed the facts that the tephra covered an area more than 1000 km2 and the distribution axis toward N120oE direction. The volume of the tephra is more than 100 kg/mˆ2 at the point 3 km away from the vent and 1 kg/mˆ2 at the point about 60 km from the volcano. Pumiceous lapilli and blocks are found in the area within about 10 km from the volcano. In the area more than 10 km away from the volcano, the tephra consists mainly sand - silt size grains. The distribution of tephra indicates that the total mass of the products is 7x10ˆ7 ton, including the estimation of proximal and distal phases.

Petrological analysis indicates that the magma has pyroxene andesitic composition with 57-58 wt% of SiO2. Detailed observation reveals that the andesite is the products of mixing between dacitic and basaltic magmas The petrological character and the sequence of the eruption are quite similar to that of the previous magmatic eruption of 1716-17 AD, during which some layers of pumice-fall deposits and pyroclastic flows were produced.

Keywords: volcano, eruption, Kirishima, Shinmoedake, eruptive mass, pumice

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Petrological characteristics and time evolution of the 2011 eruptive products from Shinmoe-dake of Kirishima volcano

Yuki Suzuki[1*], Atsushi Yasuda[1], Natsumi Hokanishi[1], Takayuki Kaneko[1], Setsuya Nakada[1], Jun-ichi Hirabayashi[2]

[1]Earthq. Res. Inst., Univ. Tokyo, [2]none

Continuous sampling and analyses of eruptive products from an ongoing eruption can give detailed insights into the magmatic processes operating beneath the volcanoes. Furthermore, whole rock compositions and phenocryst contents obtained in the petrological analyses are necessary to model variable eruptive styles in Andesitic volcanoes (such as Plinian, Strombolian), because the compositions and contents partly control viscosity of magma at and near surface. From above points of view, we are analyzing eruptive products from the 2011 eruption of Shinmoe-dake, Kirishima volcano.

In our preliminary study, we used pumice blocks of up to 10 cm size and pumice particles in the ash, both of which were erupted on 26 January 2011. Pumice blocks were used for bulk rock analyses. On the other hand, pumice particles (ca.1-5mm) were used for chemical analyses of groundmass glass and phenocryst, as small particles are convenient for mounting many particles in a limited area in short time.

Both of pumice blocks and particles show a variable color; white, brown and gray. White and gray or brown parts coexist in some blocks and particles (banded pumice). White pumice blocks have higher bulk rock SiO_2 contents (61-62wt. %) than gray and brown ones (57-59 wt. %). On the other hand, MgO contents of white pumice blocks (ca. 3wt. %) are lower than in gray and brown blocks (ca. 4wt. %).

Groundmass compositions of pumice particles are correlated to their bulk rock compositions. Groundmass glass in gray and brown parts of pumice particles has lower SiO_2 and higher MgO contents than in white parts; SiO_2 =66-68wt. % and MgO=1.1-1.4wt. % for the former and SiO_2 =ca. 76wt. % and MgO=ca.0.3wt. % for the latter. Microlites (plagioclase, pyroxene and Fe-Ti oxides) are exceptionally found in gray and brown parts of the pumice particles. Therefore, whole groundmass of gray and brown parts should have lower SiO_2 and higher MgO contents than its glass part.

Above described chemical variety in pumice samples resulted from mixing of high and low temperature magmas. Although our observations are limited to small total area of pumice particles, phenocrysts of clinopyroxene, orthopyroxene, plagioclase and Fe-Ti oxides are commonly found in all colors of pumice particles. Core compositions of these phenocrysts are the same regardless of the colors of pumice particles. On the other hand, olivine phenocrysts are limited to gray and brown parts of the pumice particles. In addition, cores of olivine phenocrysts are not in equilibrium with those of two pyroxene phenocrysts. Furthermore, extensive reverse zonings of orthopyroxene phenocrysts are exceptionally found in gray and brown parts, as in Suzuki and Nakada (2007). These lines of evidence indicate low-temperature magma in the mixing corresponds to the white pumice sample. The high-temperature magma includes at least olivine as phenocryst. The high temperature magma was not erupted independently (i.e. without mixing with low-temperature magma) on 26 January.

The determination of the storage depths of the above two magmas may help to understand origin of the pressure sources detected by geophysical observations. By the way, our continuous examination of ash samples from small-scale eruptions of Shinmoe-dake since 2008 has revealed that fresh pumice particles (juvenile material) first appeared in ash at eruption on 19 January 2011. Hence, this presentation also seeks petrological relationship between the pumice particles issued on 19 January and the pumice samples issued on 26 January. Adding future samples from the ongoing activity and acquiring another data, such as volume ratios among pumice types of different colors and detailed analyses of phenocryst chemical zonings, we aim at revealing evolutions in the interactions between the high and low temperature magmas.

Keywords: magma mixing, banded pumice, bulk composition, groundmass glass composition, volcanic ash, juvenile material

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SVC050-07 Room:302 Time:May 23 10:00-10:15

Transition of Shinmoe-Crater activity inferred from correlation patterns between infrasound and ground motion

Mie Ichihara[1*], Jun Oikawa[1], Takao Ohminato[1], Minoru Takeo[1]

[1]ERI, University of Tokyo

Shinmoe-dake of Kirishima volcano complex started major eruptions on January 26, 2011. Three eruptions occurred in two days from 26th to 27th, each of which emitted a large ash cloud for a couple of hours. Isolated explosions generating large N-shaped airwaves started on 28th. The volcanic activity is still changing. In December, 2010, we installed a microphone at 1-km north of Shinmoe-Crater, and the data is being sent to the institute with the pre-installed broad-band seismometer signals. This is the closest station to the crater available during these eruptions. Correlation function between infrasound and seismic signals measured at this station is continuously calculated and change of its pattern is investigated. This method has been found to be useful in detecting the crater activity at Asama Volcano. Clear correlation patterns are observed associated with the activities of Shinmoe-Crater, and the patterns change with time visualizing the change of the crater activities. The strength of the correlation is not related to the amplitudes of the seismic or infrasonic waves. Distinct changes of the correlation pattern are sometimes observed in the middle of a sequence of ash cloud emission. In some periods, a couple of patterns are overlapped and an alternate one of them sometimes dominates the others. Such a feature may indicate existence of plural active craters changing their strength alternately. It is confirmed that this method is useful in detecting the crater activities. The mechanisms generating the correlation between infrasound and seismic signals and controlling its patterns are to be understood.

Keywords: Shinmoe-dake, eruption, infrasound, explosion, Kirishima

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SVC050-08 Room:302 Time:May 23 10:15-10:30

Numerical simulation of the volcanic ash transpotation during the eruption of Mt. Shinmoe-dake of Kirishima Mountains

Akihiro Hashimoto[1*], Toshiki Shimbori[1], Keiichi Fukui[1]

[1]Meteorological Research Institute

The volcanic ash transpotation during the eruption of Shinmoedake for 26 to 27 January, 2011 is simulated with the volcanic eruption cloud/ash fall model (See V159-P026, JPGU2009) which is developed on the basis of Japan Meteorological Agency Non-Hydrostatic Model (JMA-NHM). The simulation is conducted with the domain covering the region of 2500km x 2500km centering south coast of Japan so as to reproduce the atmospheric condition on the eruption date. In the simulation, volcanic ash is emitted from the prescribed eruption column. The top height of the eruption column varies according to the temporal variation of echo top height observed with the meteorological radars at Fukuoka and Tanegashima. The distribution of volcanic ash simulated with the model well reproduced the observation from the meteorological satellite (MTSAT). Another simulation is performed in the 60km x 60km wide domain with the horizontal rezolution of 200 m to irustrate the behavior of ash cloud in detail. At first, the ash cloud distributed with its axis directing vertically over the crater. The top of ash cloud flows to the east while the bottom flows to the southeast, tilting its axis. This feature indicates that the vertically sheared wind, as well as the top height of eruption column, considerably influence the volcanic ash transpotation.

Keywords: Mt. Shinmoe-dake, volcanic ash, advection and diffusion, numerical simulation

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SVC050-09 Room:302 Time:May 23 10:45-11:00

Volcanic earthquakes and tremor associated with the 2008-2011 Shinmoe-dake eruption

Jun Oikawa[1*], Atsushi Watanabe[1], Hiroshi Tsuji[1], Yuuichi Morota[1], Takao Koyama[1], Takao Ohminato[1], Minoru Takeo[1], Setsuya Nakada[1], Yosuke Aoki[1], Mie Ichihara[1]

[1]ERI, University of Tokyo

Shinmoedake, one of a volcano in Kirishima volcanic chain, southwest, Japan, erupted on 30 March 2010, for the first time since 22 August 2008. Subsequently, it erupted on 17 April, 27 May, 27 June, 28 June, and 5 July. Here we overview seismic observation associated with these eruptions.

Figure shows a displacement seismogram of the volcanic tremor associated with an eruption on 27 May recorded with a broadband seismometer with a natural frequency of 40 seconds. This seismogram was recorded at a site approximately 1 km north of the eruption site. The record shows that an outward-upward impulse preceded the eruption by about 4 minutes, followed by a large inward movement. This can be interpreted to be due to a combination of a translation and tilting by a pressurization at the conduit. Similar observations are made during eruptions on 27 June, 28 June, and 5 July, too.

Seismic activity around the area is relatively high with depths at 2 km below sea level or shallower. The activity consists of temporal clustered earthquakes; for example, significant quiescence was observed right before an eruption on 27 May. This quiescence preceding the eruptions is a common feature for the 2010 eruptions, in contrast with the 22 August eruption, where a seismic swarm continued since 3 days before the eruption.

Keywords: Kirishima Volcano Group, Volcanic Earthquake, eruption

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SVC050-10 Room:302 Time:May 23 11:00-11:15

Crustal deformation of Kirishima Volcano before eruptions in January 2011

Shigeru Nakao[1*], Yuichi Morita[2], Kazuhiko Goto[1], Hiroshi Yakiwara[1], Shuichiro Hirano[1], Hideki Ueda[3], Tomofumi Kozono[3], Jun Oikawa[2]

[1]GSSE, Kagoshima Univ, [2]ERI, Univ. of Tokyo, [3]NIED

Shimoedake in Kirishima Volcano began eruption activity on 26 January 2011. On 27 January blast eruption occurred after 52 years. Activity of Shinmoedake is kept high.

In 2007 three continuous GPS (CGPS) observation started around Kirishima Volcano and an additional CGPS started in October 2010. Joint GPS analysis with GEONET site is carried out and crustal deformation with volcanic activity was able to observe. We discuss source of volcanic activity.

Three CGPS, which is KVO, KRSP and YMNK started in March in 2007 and KKCD occupied in October 2010. KRMV and KRHV of NIED started CGPS observation in April, 2010. Bernese GPS Software Ver. 5.0 is used for GPS data analysis for our CGPS and GEONET sites. IGS precise and rapid ephemeris and earth rotation parameters are used, and troposphere delay parameters and gradient estimate every one hour and 24 hours, respectively. IGS2005 coordinate system is used.

Crustal deformation, 1 to 15 mm, in the period from October 7, 2010 to January 25, 2011 is detected. Source of this deformation is estimated about 4 km WNW from Karakunidake, whose depth and volume change are 9.7 km and 6.8 million cubic meter. Crustal deformation, 1 to 14 mm, in the period from January 25, to January 31, 2011 is detected, whose source is estimated also about 3- km WNW from karakunidake. Its depth and volume change are 6.9 km and 10 milion cubic meter.

Keywords: Kirishima Volcano, GPS, Crustal deformation

Japan Geoscience Union Meeting 2011
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SVC050-11 Room:302 Time:May 23 11:15-11:30

Crustal velocity structure beneath Mt. Asama using ambient noise tomography

Yutaka Nagaoka[1*], Kiwamu Nishida[1], Yosuke Aoki[1], Minoru Takeo[1]

[1]ERI, Univ. of Tokyo

Mt. Asama is an active volcano, experiencing minor and moderate eruptions in 2004, 2008 and 2009. Probing crustal structure is expected to provide additional insights into the dynamics of magma transport and resulting eruptions of Mt. Asama. In this study we estimated the crustal seismic velocity structure beneath Mt. Asama from surface wave tomography using Rayleigh wave extracted from ambient seismic noises.

We employed the seismic wave interferometry to extract the seismic wave propagation between two seismic stations by taking a cross correlation of random wavefields, such as the ambient seismic noise or the seismic coda wave, recorded at two stations. The cross correlations of random wavefield recorded at two receivers can be represented as if the source is at one receiver and the recorder is at the other. This technique is suitable for exploring local structure since the extracted wave is sensitive to the internal structure between two stations.

We inferred the crustal phase velocity structure from surface wave tomography using the vertical component of the ambient seismic noise recorded by a dense seismic array between July 2005 and June 2006. We first extracted a Rayleigh wave by taking cross correlations. We divided the analysis area into three regions, for each of which measured the reference dispersion curve. Next, we measured the Rayleigh-wave phase-velocity anomaly against the reference for each path in various frequency bands and convert it into travel time anomaly. We finally obtained tomographic images of phase velocity structure by inverting the travel time anomalies. The velocity structure we thus obtained for 0.1-0.2 Hz shows that the low velocity zone is located beneath the west part of Mt. Asama at the depth of 5-10 km. Combining our results with the tilt motions observed after the eruption of Mt. Asama in February 2nd, 2009, suggests that the low velocity zone to the west part of Mt. Asama marks the magma chamber of the volcano.

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SVC050-12 Room:302 Time:May 23 11:30-11:45

Development of the near real-time analyzing system for GPS observation data of the volcano monitoring network in NIED

Seiichi Shimada[1*], Hideki Ueda[1]

[1]NIED

We develop the near real-time automated analyzing system of GPS observation data to obtain every three-hourly updated site coordinates of volcano observation network introducing in NIED. In the present GPS analyzing system of volcano observation network in NIED, GPS site coordinates are estimated once per day using 24-hourly data. In the system developed in this study, GPS observation data in the network sites are analyzed near real-time with the nearby GEONET fiducial sites every three-hour using 24 hourly, 12 hourly, 8 hourly data and so on.

In the present analyzing system, GPS observation raw data of the volcano observation network are telemetered to NIED in Tsukuba one per hour, transformed to RINEX format file once per day, and the site coordinates are estimated automatically every day. In the system in this study, at first we develop the automated RINEX transformation program from GPS observation raw data every three-hour. Next we develop the program to estimate the best-fitting site coordinates of GEONET fiducial sites near volcano observation network, analyzing GEONET sites with around 20 IGS fiducial sites in and around Eastern Asia once per day to estimate daily GEONET site coordinates, then estimating updated best-fitting GEONET site coordinates applying recent 30 days daily coordinates solutions. In the last, GPS data of the volcano observation network sites are analyzed with the GEONET fiducial sites data automatically and estimated the latest site coordinates applying 24 hourly data or the data less than 24 hour (for instance, 12 hourly, 8 hourly, and 6 hourly data). For the RINEX converting program we adopt teqc program, for the GPS analyzing software we adopt GAMIT program, and we develop the programs to control those software adopting perl language. For from GSI data server GEONET data are available every three-hour with about 70 minutes delay, in this system we download RINEX files of the GEONET sites automatically just after the release of GEONET data, then begin to analyze GPS data, and obtain the latest site coordinates solutions around 90 minutes delay.

In this paper we also present the stability of site coordinates solutions obtained in the system automatically applying short (less than 24 hour) observation data.

Keywords: near real-time analysis, GPS observation, volcano monitoring network

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Towards mid-term eruption prediction of Izu-Oshima volcano (4): deep LF earthquakes, magma accumulation, CO2 degassing

Hidefumi Watanabe[1*]

[1]Disas. Prev. Div., Tokyo Met. Gov.

In order to make successful mid-term or long-term eruption predictions, we need to detect particular precursor processes operating in magma-plumbing system. Since 1989, we have detected the secular re-inflation of the volcano and further revealed the repeated deflation-inflation cycles, resulting a net inflation of the volcano. The rate of secular inflation has decreased exponentially until 2006, and since then kept a constant speed. The amplitude of deflation-inflation cycles has also increased. The JMA catalog of hypocenters indicates that the activity of deep low-frequency (LF) earthquakes occurring at depth rages of 30-40 km beneath Izu-Oshima volcano has increased since 2007, and that the elevation of LF earthquakes activity has preceded the volcano inflation. We naturally suppose that the volcano inflation is caused by the supply of magma from depths. What is the origin of the deflation? There are two possible processes causing the deflation, magma drain back and the contraction of magma due to degassing. In order to discriminate the deflation mechanisms, we need to combine the magma accumulation and degassing processes. To monitor the degassing of basaltic magma accumulating beneath the volcano, CO_2 is most helpful because CO_2 separates from melt at the earliest stage of accumulation. In September 2005, we started continuous monitoring of soil CO_2 concentration at the eastern part of the summit of Izu-Oshima volcano. We observed the correlated increase of soil CO_2 concentration during the periods of not only accelerated inflation but also deflation of the volcano, suggesting that the degassing of accumulated magma might cause the deflation. By integrating the observation data, we suppose that the rate of magma supply from the upper mantle has increased since 2007 causing an increase of CO_2 over-saturated region at the upper part of magma reservoir beneath the volcano.

Keywords: eruption prediction, precursors to eruption, Izu-Oshima volcano, magma accumulation, CO2

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SVC050-14 Room:302 Time:May 23 12:00-12:15

Ground deformation measurements in Izu-Oshima volcano (2)

Shin'ya Onizawa[1*], Akimichi Takagi[2], Keiichi Fukui[1], Hitoshi Yamasato[3], Shinobu Ando[1], Toshiki Shimbori[1], Akimi Kajiya[3], Kazumasa Kurokawa[3]

[1]Seismol. and Volcanol. Res. Dep., MRI, [2]Research and Development Bureau, MEXT, [3]Seismol. and Volcanol. Dep., JMA

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 GPS observations revealed repetition of shorter term of deflation ? inflation events of the volcano. Meteorological Research Institute has been reinforcing the ground deformation observation such as GPS and APS. On February of 2009, dense GPS network was installed in the caldera area to enhance spatial resolution of ground deformation and source parameter estimations.

Deflation and inflation events occurred in 2009-2010. GPS and APS baseline lengths whole the island started to shorten around October of 2009 and continued until April of 2010. Then, baseline lengths reversed to extend and the number of earthquakes increased. Horizontal strain distributions derived from GPS baseline length results suggest deformation sources of both deflation and inflation events locate beneath the northern part of the caldera. If the Yamakawa-Mogi source located at 5 km-depth is applied, 2.4 million cubic-meters of volume decrease and 4.2 million cubic-meters of volume increase are estimated for the deflation and inflation events, respectively. However, calculated horizontal displacements at the northern and southern coastal areas do not fit well to the observed ones. This may indicates existence of another deeper deformation source.

Keywords: Izu-Oshima volcano, ground deformation, GPS

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Magma intrusion model on the 2006 Mayon Volcano eruption based on GPS measurements

M. Matsumura[1], Fumiaki Kimata[1*], Teresito C. Bacolcol[2], Alfie Pelicano[2], Eduardo Laguerta[2], Renato U. Solidum[2]

[1]Nagoya University, [2]PHIVOLCS

Mayon Volcano

Mayon volcano is located in the southern Luzon Island in Philippine. The volcano is an eruption history since 1616, and ranging from strombolian to basaltic plinian including lava flows. After the 2001 eruptions of central vent eruption, pyroclastic eruptions and lava flows, the volcanic activities was quiet until July 13, 2006. The 2006 eruption is characterized by lava flow of 3.8x107 m3 and no explosion. We discuss the magma intrusion process of the 2006 eruption based on ground deformation by GPS measurements and seismic records.

Ground deformation detected by continuous GPS measurements

PHIVOLCS (Philippine Institute of Volcanology and Seismology) established eight continuous GPS network consisting 8 stations in 20 x 40 km radius around the Mayon volcano in 2004. The measurements are maintained by hand pick until now. The baseline lengths between the 8 GPS stations show the contraction of 1 cm in 2004 and the extension of 1 cm in middle of 2005. In 2006, the rapid contractions of 1-3 cm of the line lengths are detected until end of the year.

Estimated pressure sources beneath the summit

We discuss the spherical pressure source model by Mogi solution and divide three periods of Jan.2004 - Dec.2004 (period 1), June 2005 ? Dec.2005 (period 2) and Jan.2006 ? Dec.2006 (period 3).

In the period 1, because of shortening line lengths, one deflation sources is estimated at the depth of 6.5 km beneath a little bit to the north from the summit, and another inflation source is calculated at the depth of 5.0 km. It means the migration of magma from the 6.5 km depth to 5.0 km depth. In the period 2, line length shortenings are turn to extension, an inflation pressure source is estimated at the depth of 7.5 km. In the period of 3, line length changing are come back to contractions and they are very rapid in few months since July 13. One deep deflation source of -1.8x107m3 is estimated at the 11.5 km depth.

2006 eruption

Since the 1999-2001 eruption, Mayon volcano was very silent and there are few small phreatomagmatic eruptions only. On July13, the 2006 Mayon volcano eruption was started as the lava dome forming and lava flow at the summit.

It is estimated the magma migration at the depth from 6.5 km to 5.0 km. Moreover long-term volcanic tremors over few ten minutes are observed since June 2004 to February 2005. Long-term volcanic tremors are coursed by magma migration to the shallow depth.

In the period 2, magma are intruded to the magma chamber at the 7.5 km depth, and there is no volcanic activity on the ground surface.

In the period 3, line lengths changing on the most baselines are to the contraction in 2006, and long-term volcanic tremors are observed again in March. On July 13, lava doom is observed at the summit creator and lava flows are recognized as the shaking by lava falling. Lava flows arrives 5 km from the summit in the southeast flank and continued until September 2006. The volume of lava flows is estimated 3.8x107m3 (PHIVOLCS) and it just half volume of the estimated deflation source in the 11.5 km depth.

The research is depend on the collaboration between Philippines and Japan under the JIST=JICA projects. We have a plan to extend the monitoring system at the Mayon volcano in 2011.

Keywords: Mayon Volcano, Maguma intrusion model, GPS measurements, volcanic activity, 2006 Mayon volcano eruption

SVC050-16 Room:302 Time:May 23 12:30-12:45

Steady deformation pattern and the magma storage system of Kilauea volcano

Yo Fukushima[1]*

[1]DPRI, Kyoto Univ.

1. Introduction

At Kilauea volcano, Hawaii, it has been known from GPS and other data sets that, at least after 1983, the summit and rift zones are subsiding and that the southern flank is displacing at up to ~8cm/year. This deformation pattern is usually explained by a superposition of the effects of opening of a vertical rift reservoir and slip of a subhorizontal decollement located at ~9km depth connected to the base of the rift reservoir (Owen et al., 2000). In the summit area, signals of subsidence and tilt change toward the summit have been observed, which has been interpreted by the activities of magma reservoirs located at depths of 3.5km and 0.5km (Cervelli and Miklius, 2003, USGS prof. paper).

The rift zones are bent especially at the summit where the east and southwest rift zones meet. Therefore, if the rift reservoir opens, strain is expected to accumulate around the bending points. Such effects of realistic rift reservoir geometry has not been fully studied by previous works. This study investigates such effects by assuming realistic structures of the rift reservoir and subhorizontal decollement and modeling the surface deformation pattern using the 3D mixed boundary element method (Cayol and Cornet, 1997).

2. Model setting

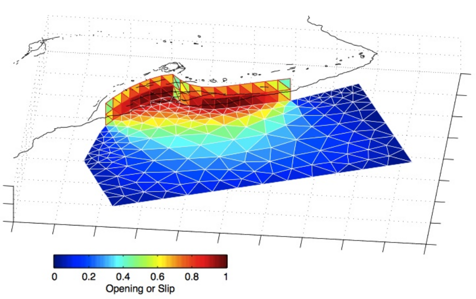
The rift reservoir and decollement are modeled by dislocations. The rift reservoir is vertical and has its upper and lower limits at 3km beneath the surface and 8km below sea level (9km beneath the summit), respectively. The horizontal location of the rift reservoir is assumed to coincide with the micro-seismicity which is considered to well characterize the tip of the reservoir. Furthermore, the subhorizontal decollement is assumed to be connected to the rift reservoir. Displacements on the ground surface are solved under boundary conditions of 1) uniform overpressure on the rift reservoir surface, 2) null shear stress change and normal displacements on the surface of the decollement. Under such conditions, the rift reservoir opens and the decollement slips in response to the overpressure of the rift reservoir.

3. Results

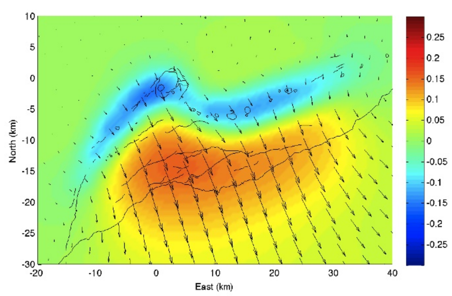
As shown in the figure, the considered model well explains 1) the sudsidence of the rift zones, 2) the localized subsidence at the summit, and 3) the seaward displacements and uplift of the southern flank. Especially, the localized subsidence at the summit questions the presence of a summit reservoir at ~3.5km depth. The deformation pattern after 2007 has changed; the same patten on the southern flank but a higher subsidence rate along the rift zone. The obtained results indicate that this kind of pattern can not be explained unless developed shallow reservoirs are considered beneath the rift zones.

Acknowledgements

I thank the Hawaiian Volcano Observatory for providing GPS data and Dan Sinnett of Stanford University for data preparation.



(a) Opening distribution on the rift reservoir surface and slip distribution of the decollement. These displacements are created by over-pressurizing the rift reservoir.



(b) Surface displacements. Color shows the vertical and arrows show horizontal displacements, respectively.

Keywords: Kilauea volcano, Magma storage system, Crustal deformation, GPS, Boundary Element Method

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SVC050-17 Room:302 Time:May 23 14:15-14:30

Electromagnetic volcano-monitoring of Taal volcano, Philippines, under the SATREPS project

Toshiyasu Nagao[1*], Yoichi Sasai[1], Akihiro Takeuchi[1], Yusuke Yamaya[2], Takeshi Hashimoto[2], Toru Mogi[2], Paul Alanis[3]

[1]EPRC, Tokai University, [2]Institute of Seismology and Volcanology, [3]PHIVOLCS

We launched a five year (2010-2014) project to develop earthquake and volcano monitoring capability for effective disaster mitigation in the Philippines under the SATREPS (Science and Technology Research Partnership for Sustainable Development) program. Although the major objective of the prgrogram is to enhance the seismological and deformation monitoring of earthquakes and volcanoes in the Philippines with the aid of broadband seismometers and GPS network, our group are in charge of electromagnetic monitoring of volcanoes. We selected Taal volcano as our target area, which had frequently erupted and killed local people on Volcano Island (the central cone) for the past centuries. In November, 2010, we installed an integrated real time EM observation system with one magneto-telluric station and three highly-sensitive Overhauser proton magnetometers to watch the hydrothermal and magmatic system in the shallower part of the volcano. The data quality is extremely high thanks to no commercial electricity on the island. Furthermore, to clarify the 3-D resistivity structure of the volcano, we have a plan to make a magneto-telluric survey in FY2010-2012. The results will be included in our presentation. Other experimental studies are also planned such as magnetic susceptibility and Curie temperature measurements of the rock samples.

Keywords: Taal volcano, Electromagnetics

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SVC050-18 Room:302 Time:May 23 14:30-14:45

Preliminarily report on geological survey in and around Lake Nyos, northwestern Cameroon

Yasuo Miyabuchi[1*], Katsuya Kaneko[2], Festus T. Aka[3], Minoru Kusakabe[4], Yutaka Yoshida[5], Akira Ueda[4], Katsuro Anazawa[6], Takeshi Ohba[7]

[1]Fac. Edu., Kumamoto Univ., [2]Human & Environ., Kyoto Univ., [3]IRGM, Cameroon, [4]Dept. Environ. Biol. Chem., Toyama Univ., [5]Yoshida Consulting Engineer Office, [6]Dept. Nat. Environ., Univ. Tokyo, [7]Dept. Chem., Tokai Univ.

Lake Nyos, which is a maar volcano in northwestern Cameroon, exploded in August 1986, releasing a large amount of CO_2 that killed ca. 1800 people and over 3000 cattle. Since steady input of gas to the lake after the disaster implied recurrence of a similar event in the future, artificial degassing of the lake started in 2001 as an international project. However, a large amount of CO_2 still remains in the lake.

Recently a new project launched with a title "Magmatic Fluid Supply into Lakes Nyos and Monoun, and Mitigation of Natural Disasters through Capacity Building in Cameroon" under the Science and Technology Research Partnership for Sustainable Development (SATREPS, co-sponsored by JICA and JST). We performed preliminarily fieldwork at Lake Nyos in January 2011 to clarify an eruptive history of the Nyos maar volcano. We found that pyroclastic deposits derived from the eruption of the volcano directly overlie the Pan-African quartz monzonite basement. The deposits can be divided into three units: pyroclastic-flow deposits, scoria-fall deposits and pyroclastic-surge deposits in an ascending order. Basal pyroclastic flow deposits are observed at the base of the eastern lakeshore wall and the downstream side of the dam. The deposits are poorly sorted and divided into the lower, fine grained unit and the upper clast-rich unit. Scoria-fall deposits overlying the basal pyroclastic flow deposits are recognized at the eastern to northeastern lakeshores. They are partially densely welded. Pyroclastic-surge deposits occur at the northern to eastern lakeshores. The surge deposits are well-stratified and thickest of all the pyroclastic deposits. The depositional sequence suggests that a series of eruptive events that formed Lake Nyos started with a pyroclastic flow eruption followed by a strombolian activity that produced scoria-fall deposits, and finally by explosive eruptions discharging multiple pyroclastic surges.

Keywords: volcanic lake, volcanic gas disaster, pyroclastic deposit, eruptive history

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SVC050-19 Room:302 Time:May 23 14:45-15:00

Instantaneous and localized temperature changes in atmosphere associated with the Icelandic eruption in April 2010 obser

Ikuya Okazaki[1*], Kosuke Heki[2]

[1]Natural History Sciences, Hokkaido Univ., [2]Natural History Sciences, Hokkaido Univ.

GPS radio occultation is a technique to observe phases of microwaves from GPS satellites near the horizon of the Earth with a receiver on board a low earth orbiter. Changes of the received phase are converted to the vertical profile of the atmospheric refractive index, which are further converted into quantities such as temperature and water vapor pressure of neutral atmosphere and electron density of ionosphere. With this technique, one can observe global atmosphere with high vertical resolution and accuracy comparable to radiosonde observations. FORMAT-3/COSMIC, launched in April 2006, is composed of six low earth orbiters, and is capable of obtaining up to 2500 profiles per day. As a brand-new application of the GPS radio occultation, Wang et al. (2009) analyzed temperature profiles obtained by COSMIC, and reported that temporary cooling occurred locally in the lower stratosphere above the volcanic fumes of the Chaiten volcano, South America, shortly after its eruption in May 2008. Temperature was found to have increased/decreased beneath/above the height of 12 km. SO_2, a major constituent of volcanic gas, often reacts with atmosphere and forms sulfuric acid aerosols. By staying for a long time in the lower stratosphere, they bring about climatic impacts by blocking sunlight and performing as a greenhouse gas (McCormick et al., 1995). Water vapor is also included in volcanic gas and is another greenhouse gas that warms/cools troposphere/stratosphere. However, we still do not understand the mechanism responsible for the instantaneous atmospheric changes after the eruption as reported in Wang et al. (2009). Eruption of the Eyjafjallajokull, Iceland, started 14 April, 2010, and its volcanic ash and fumes reached maximum height of 11 km. They were carried to the European mainland causing disruptions in civil aviation. In this study, we use the temperature profile obtained with COSMIC, and try to detect localized changes in atmosphere after this eruption. We will then compare the results with the Chaiten volcano case. We first compiled the daily temperature profiles by COSMIC and calculated day-to-day average temperatures at a certain altitude. We then subtracted the reference temperature distribution forecasted from the atmosphere at 0 UT on the previous day by the NCEP GFS (Global Forecast System). We found that significant cooling above the volcano around the tropopause (height ˜10 km) started on the next day of the eruption. This is similar to the Chaiten volcano case, but we could not find warming in troposphere as reported by Wang et al. (2009). Altitude of maximum cooling was ˜14 km in the Chaiten volcano, but it was ˜10.5 km in the present case. This possibly reflects the difference in the heights that the volcanic fumes of the two eruptions reached (Chaiten: ˜20 km, Iceland: ˜11 km). In addition to that, we found significant warming at the height of ˜13 km to the east of the volcano where cooling was observed on the next day of the eruption. Such warming in the stratosphere was not observed in the Chaiten volcano case, and we do not know if it has a causal relationship with the eruption. Atmospheric cooling above the volcanic fumes might be due to the blocking of the long wave radiation from the lower atmosphere by the fumes, but definitive answer cannot be given until we get more examples. In the future, we would like to re-evaluate the reliability of the reference temperature and analyze other volcanic eruptions to get more examples.

Keywords: GPS, Radio occultation, Volcanic eruption, Iceland

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SVC050-20 Room:302 Time:May 23 15:00-15:15

Time-series analysis of volcanic ash from vulcanian eruptions at Showa-crater of Sakura-jima volcano, Japan

Takahiro Miwa[1*], Nobuo Geshi[2], Hiroshi Shinohara[2]

[1]Dept. of Geophys., Tohoku Univ., [2]GSJ, AIST

We study a temporal variation of texture of volcanic ash emitted by vulcanian eruptions at Showa-crater of Sakurajima volcano. We collected 34 ash samples during 14th-17th, January 2010. The collected ashes were examined from view point of variation of ash texture 1) through single eruption and 2) before and after big eruption emitting pumice clast. Ashes were classified on the basis of particle morphology and component. The classification of volcanic ash was performed on stereoscopic microscope. Volcanic ash is divided into 15 types of particle, K (black ash ash), B (brown color ash), W (white to colorless ash), Pumiceous particle (ash with extremely high vesicularity), N (ash with non-smooth surface), A (altered), Pl (plagioclase), Cpx (clinopyroxene) and Opx (orthopyroxene). Moreover, K is subdivided into three types of particle, K-B (shows blocky morphology), K-F (shows fluidal surface) and K-V (shows vesicular morphology). Also B is subdivided into B-B, B-F and B-V as well as K particle. W type ash is subdivided into W-B-T (shows blocky morphology with transparency), W-B-NT (shows blocky morphology with non-transparency) and W-V (shows vesicular morphology). The examination on polarized microscope indicates that groundmass crystallinities of B, W-B-T, W-V and pumiceous particles are lower than that of K and W-B-NT particles. The classification and time-series analysis of the ash reveals that 1) the number fraction of ash with low crystallinity (B, W-B-T, W-V and pumice) and 2) vesicular morphology (K-V, B-V, W-V and pumiceous particle) in later phase is larger than that in initial phase in single eruption, and 3) the number fraction of ash with low crystallinity increases approximately 1 day before big eruption (emitting pumice clast) and decreases after the eruption. These results imply temporal variation of volcanic ash texture is possible to be an indicator of progress of eruptive activity.

Keywords: Volcanic ash, Texture, Time-series, Progress of eruptive activity

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SVC050-21 Room:302 Time:May 23 15:15-15:30

Repetition of inflation of Sakurajima volcano

Masato Iguchi[1*], Jun-ichi Hirabayashi[2], Takeshi Tameguri[1]

[1]DPRI, Kyoto Univ., [2]TITEC

Explosive activity at Minamidake summit crater of Sakurajima Volcano, Japan began in 1955 and the eruptivity continued for 54 years counting 7900 Vulcanian eruptions. The activity of Minamidake gradually transited to eruptions at Showa crater at eastern flank of the volcano from 2006. The eruptive activity increased step-by-step and 1033 explosive eruptions were counted in 2010. The main magma reservoir of the Sakurajima volcano is located at a depth of 10 km near the centre of Aira caldera, northern part of the Sakurajima and it is estimated that magma of 140 million m3 have been stored in the reservoir since 1993 from extensional baseline observed by GPS. Explosive activity at Showa crater remarkably jumped up in October 2009. The eruptive activity from October 2009 is divided into 2 periods; inflation of volcano (October 2009 ? May 2010) and deflation (June ? November 2010). In inflation stage, a lot explosive eruptions occurred (907 events). The inflation was accelerated due to inflation of Aira caldera and migration of magma toward northern part of Sakurajima during January-March 2010. Explosive eruptions also occurred in deflation stage; however discharge rate of volcanic ash was less than inflation stage. Intrusion rate of magma was calculated from tilt change and weight of volcanic ash ejected. In inflation stage, magma intruded into Sakurajima from Aira caldera (0.4 million m3/month) and excess magma was ejected by explosive eruption. In deflation stage, intrusion rate decreased ($<$0.1 million m3/month) and magma stored in inflation stage was consumed by eruptions. At the end of November 2010, the deflation turned to inflation again. The deflation was revealed by extension of the ground at Harutayama (northwest of the central cones) and tilt change of crater-side-up at north and northwest flank. Tilt vectors indicate that center of inflation is located at north flank of Sakurajima. Associated with inflation of the ground, concentration of CO2 from hot spring increased in observation well at Kurokami (4 km east of Showa crater). The number of explosive eruption increased and 95 explosive eruptions were recorded in January 2011. This suggests that magma intruded into Sakurajima from northern part with minor inflation of northern part and magma smoothly moved to Showa crater, increasing explosiveity at the crater.

Keywords: Sakurajima, ground deformation, intrusion magma

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SVC050-22 Room:302 Time:May 23 15:30-15:45

Change of mode of eruptive activity and the magma plumbing system of Sakurajima Volcano since 20th century

Mitsuhiro Nakagawa[1*], Akiko Matsumoto[1], Mizuho Amma-Miyasaka[1], Masato Iguchi[2]

[1]Hokkaido University, [2]Kyoto University

Sakurajima volcano repeated large eruptions with dormant periods in 1471, 1779 and 1914, which were composed of plinian eruption and lava effusion. After 1914 eruption, medium scale of lava effusion occurred in 1946. Frequent vulcanian eruptions have repeated since 1955 until now. Thus, mode of eruptive activity of the volcano has changed since 20th century. We carried out petrological research of eruptive materials from major historic eruptions from 1471 to 1946. In addition, we newly investigate the recent eruptive materials from 1955 to 2009. These suggest that magma plumbing system of the volcano has also changed, and that new type of magma has frequently injected into the pre-existed system. We discuss the relationship between the mode of eruptive activity and magma system to evaluate the present state of the activity of Sakurajima Volcano.

The rocks of 1471 and 1779 eruptions are CPX-OPX dacite, in which normally and reversely zoned pyroxene and plagioclase phenocrysts coexist. In addition, compositional distribution of plagioclase phenocrysts is bi-modal. These suggest that these rocks are mixing products between dacitic and andesitic magmas. This is consistent with compositional variations of whole-rock chemistry for these rocks. On the other hand, the rocks of 1914 and 1946 eruption often contain olivine phenocrysts. Plagioclase and pyroxenes phenocrysts in these rocks show similar features to those of 1471 and 1779 eruptions, suggesting that these rocks are also mixing products of two end-member magmas, dacitic and andesitic ones. However, olivine phenocrysts are much magnesian compared with pyroxenes phenocrysts, indicating that these olivine phencorysts are derived another magma, basaltic one. Thus, the basaltic magma injected into the mixed magma between dacitic and andesitic ones. Mixing among three magmas has been recognized since 20th century. We estimate the timing of mixing on the basis of compositional variations of rim of phenocrysts and compositional zonation of pyroxene phenocrysts. It seems that mixing between dacitic andesitic magma had occurred more than 10 years before eruption, and that the basaltic magma had injected several tens days before eruption. According to geophysical observation, voluminous magma has accumulated beneath the Aira caldera, and part of the magma has moved beneath Sakurajima volcano to occur eruption. Our petrological analysis suggests that monitored voluminous magma would be dacitic magma, in which andesitic magma has repeatedly injected beneath Aira caldera. Before 20th century, the mixed magma had moved toward the volcano to accumulate for large plinian eruptions. In contrast, injection of basaltic magma has repeated occurred to mix with accumulating mixed magma since 20th century. This injection would occur beneath the Sakurajima volcano, because timing of the injection must not be long before eruption.

The rocks from frequent vulcanian eruption since 1955 also contain minor amount of olivine phenocrysts, suggesting the injection of basaltic magma has continued after 1946 eruption. In 1974-78 and 1987 periods, relatively larger scale of vulcanian eruptions had occurred. The rocks from these periods contain considerable amount of olivine phenocrysts, indicating mixing ratio of the basaltic magma was relatively larger than that of other periods. Thus, the effect of the injection correlates with scale of the vulcanian eruptions. During 20th century, frequent eruptions had been triggered by the injection of the basaltic magma. In addition, large scale of the injection would cause larger eruption. Temporal change of mode of eruptive activity of Sakurajima Volcano must be related with frequent injection of basaltic magma. In order to predict future eruptive activity, detecting of movement of the basaltic magma should be important.

Keywords: Sakurajima Volcano, magma plumbing system, magma mixing, eruption prediction, mode of eruptive activity

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SVC050-23 Room:302 Time:May 23 15:45-16:00

Temporal variations of the petrological features of the juveniles from Showa crater since 2006, Sakurajima volcano

Akiko Matsumoto[1*], Mitsuhiro Nakagawa[1], Mizuho Amma-Miyasaka[1], Masato Iguchi[2]

[1]Faculty of Science, Hokkaido University, [2]DPRI, Kyoto University

On June 2006, Sakurajima volcano, Japan, has resumed its eruptive activity at Minamidake after ca. 6 years' quiescence. Most of the explosions have occurred at Showa crater. The eruptive activity from Showa crater is divided into the following four episodes: Episode-1, from June 2006 to August 2009, low explosive activity with slow inflation; Episode-2, from September 2009 to March 2010, high explosive activity with inflation; Episode-3, from April 2010 to May 2010, lower-explosive activity without inflation; and Episode-4, from June 2010 to September 2010, high explosive activity with deflation. The eruptive products are mainly composed of volcanic ash, and sometimes lapilli. Focusing on the petrographical features, the volcanic ashes are distinguishable into four types, agreeing with the eruptive episodes as follows. Episode-1: the absence of fresh glass particles; Episode-2: the existence of many fresh glass particles increasing its ratio with time; Episode-3: the existence of a small amount of fresh glass particles in addition to strongly-altered lithics; and Episode-4: the existence of fresh glass particles almost without strongly-altered lithics. Petrographical features of the lapilli are similar to those of the fresh glass particles. On whole-rock chemistry, the lapilli are consistent with the compositional trends of the juveniles from Minamidake crater since 1955, showing the most mafic compositions (SiO_2=58.5 wt.%). The glass compositions of the lapilli and fresh glass particles are dacite (SiO_2=67.2-72.7 wt.%), and they have a systematic variation: the silica content decreases with time in Episode-2 and Episode-3, and again increases in Episode-4. Such temporal variation corresponds to the geophysical change: from inflation to deflation. This agreement suggests that the recharge of mafic magma into magma chamber affects the compositions of volcanic glass. The comparison between the temporal change of the petrological features of juveniles and the geophysical dataset can contribute to understand the detailed magma migration beneath the volcano.

Keywords: Sakurajima volcano, Showa crater, temporal variation, volcanic ash, juvenile materials

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SVC050-24 Room:302 Time:May 23 16:00-16:15

The second seismic survey round in Sakurajima Volcano

Tomoki Tsutsui[1*], Masato Iguchi[2], Takeshi Tameguri[2], Koichiro Saito[3], Research Group of the Seismic Survey Round 2010 in Sakurajima[2]

[1]Graduate School of Akita University, [2]DPRI, Kyoto University, [3]Japan Meteorological Agency

The second seismic survey round in Sakurajima Volcano and the variation of reproduced seismograms are presented. The seismic survey rounds have been done in the northeastern part of Sakurajima Volcano since November 2008 in order to detect movement of underground magma. The pilot survey had been done on November 2008 and the first survey was carried out on December 2009.

The survey includes 14 shot points, 248 temporary stations and 39 participants. The geometry of the network was the same as that of 2009's survey. The shot points and almost all stations were well reconstructed. Charge size are 20kg and the charge was detoneted in a single hole in all 14 shot points, which were the same condition as that of the previous year. Each station included a vertical motion sensor (4.5Hz) and the compact digital recorder LS8200SD. The observation was successfully finished at 245 stations except for failed three stations. Peak amplitude ratio ranges 0.83 to 1.52 with referrence to 2009's seismograms. Variation in the seismograms will be reported with comparison to those of preceding years along the same lines, and with referring to volcanic activity in Sakurajima.

Member of Research Group of the Seismic Survey Round 2010 in Sakurajima: Tomoki Tsutsui, Takeshi Tameguri, Masato Iguchi, Jun Oikawa, Hiromitsu Oshima, Tokumitsu Maekawa, Hiroshi Aoyama, Sadato Ueki, Satoshi Hirahara, Kenji Nogami, Takao Ohminato, Mie Ichihara, Hiroshi Tsuji, Shinichiro Horikawa, Takashi Okuda, Hiroshi Shimizu, Takeshi Matsushima, Takahiro Ohkura, Shin Yoshikawa, Tadaomi Sonoda, Hiroki Miyamachi, Hiroshi Yakiwara, Shuichiro Hirano, Koichiro Saito, Koichi Suemine, Susumu Goto, Takamitsu Ikegame, Koji Kato, Shinichi Matsusue, Taisuke Kohno, Shingo Utsunomiya, Hirohito Goto, Ryuichi Watanabe, Yuki Maehara, Izumi Satoh, Ryudo Oyabu, Hidehiko Shimizu, Yusuke Yamashita

Keywords: Sakurajima Volcano, Volcano structure, Active volcano, Seismic survey, Underground movement detection