Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SVC48-01 Room:104 Time:May 19 11:00-11:15

Relationship between volcanic activity and chemical and isotopic compositions of thermal waters in Tokachidake, Japan

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Tokachidake volcano, one of the most active volcanoes in Japan, caused three magmatic eruptions (AD 1926, 1962 and 1988-89) in the 20th century, and the volcanic activities tend to increase recently. In this study, we investigate chemical and isotopic compositions of thermal waters in Tokachidake volcano and discuss the relationship to the volcanic activity.

Bengara hot spring (BHS), Hakuginso hot spring (HHS), Fukiage hot spring (FHS) and Okina hot spring (OHS) are located at the western flank of the volcano, about 3 km from the summit craters. Chemical compositions of BHS, FHS and OHS and those of HHS have been continually investigated since AD 1986 and 1992, respectively. The temperature of thermal waters of BHS, HHS and FHS ranges from 48 to 56 ^{o}C, whereas that of OHS is about 25 ^{o}C. These thermal waters are acidic with the pH ranging from 2.5 to 3.0.

The chemical compositions of these thermal waters show temporal changes. The Cl/SO_4 ratio of these thermal waters was about 0.2 in AD 1986. Since then the Cl/SO_4 ratio had abruptly increased, and the ratio of BHS and FHS was about 2.9 and 3.9, respectively, at the time of the AD 1988-89 eruption. The increase of the ratio had continued until AD 1992, whereas then the ratio had decreased to 0.6 until AD 2010. Temporal change of the chemical compositions of HHS shows nearly the same as that of BHS and FHS, and the ratio had decreased until AD 2010. Since AD 2010, however, temporal change of the ratio of these three thermal waters has changed to constant or weak increase. In addition, these thermal waters have shown obvious increase of the ratio since June 2012, and the ratio reached about 1.0. In contrast, temporal change of the chemical compositions of OHS is clearly distinct with that of other thermal waters, and the ratio have roughly decreased until the present. In all thermal waters, there is no remarkable temporal variation of SO_4^{2-} concentration, and hence we can consider that temporal change of the Cl/SO_4 ratio has been caused by change of Cl^{-} concentration.

In addition to the chemical compositions, the oxygen and hydrogen isotopic compositions of these thermal waters have been investigated since AD 2011. All samples collected before July 2012 show nearly the same isotopic compositions as meteoric waters, ranging from $d^{18}O$=-13.6 to -12.1 per mil. In contrast, thermal waters of BHS and HHS, which were collected after October 2012, show heavy oxygen isotopic composition compared with meteoric waters, ranging from $d^{18}O$=-10.9 to -9.8 per mil.

The increase of the Cl/SO_4 ratio of thermal waters and shift of the oxygen isotopic composition toward heavier value indicate that supply of volcanic gas into thermal waters has increased. Observations of chemical and isotopic compositions of thermal waters are important for evaluating the future volcanic activity of Tokachidake volcano.

Keywords: Tokachidake volcano, thermal water, stable isotope, chemical composition

Japan Geoscience Union Meeting 2013
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Resistivity structure around the Aira caldera

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The Aira caldera is located in southern Kyushu and was formed by the catastrophic eruptions of the Aira volcano approximately 29,000 years ago. Sakurajima is a post-caldera volcano and started to grow in the southwestern part of the caldera after 3,000 years of the Aira eruptions. It repeats explosive eruptions more than eight hundred times per year in recent three years. Since co-eruptive depression of the ground around the Kagoshima Bay was observed after the 1914 eruption of Sakurajima volcano (Omori, 1916), the source of magma supply to Sakurajima is presumed to be located at a depth of 10km beneath the Aira caldera (Mogi, 1958).The objective of this study is to clarify the corresponding electrical resistivity structure to the assumed magma reservoir and to the supply paths to Sakurajima volcano.

We have conducted the magnetotelluric (MT) measurement mainly along two traverse lines in the direction of WNW-ESE crossing the Aira caldera since 2009. The MT data at 39 sites in total, including 16 seafloor sites, were obtained for the last four years. For the seafloor observation, the electromagnetic field was recorded for about two to three weeks with a sampling interval of 8 Hz using several OBEMs (Ocean Bottom Electro-Magnetometers). For the land observation, the MTU-5 systems of Phoenix Geophysics Ltd. were used to measure the EM field with the frequency range of 0.001-320 Hz. We performed a 2-D analysis along two lines across the Aira caldera. The strike direction for 2-D analysis was estimated from the individual impedance data obtained on land by using a decomposition technique (Groom and Bailey, 1989).

As results of the 2-D inversion (Ogawa and Uchida, 1996) applied to the TM-mode data set, a high conductive region of less than 10 ohm-m was found in the southern profile beneath eastern Aira caldera at depths greater than 7-8 km. This conductor appears to extend upward, but it is not clear because of shortage of the higher frequency data obtained by OBEMs. Location of the conductor seen in the resistivity model is roughly in agreement with the location of depression source inferred from the geodetic data (Eto and Nakamura, 1986). This indicates that the conductive zone is possibly the structure relevant to the magma reservoir.

Keywords: magma reservoir, Sakurajima volcano, resistivity structure, Aira caldera, OBEM

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SVC48-03 Room:104 Time:May 19 11:30-11:45

The fourth round of repetitive seismic experiment in Sakurajima Volcano

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Evolution of seismic reflectors beneath Sakurajima Volcano is presented, which is revealed with rounds of seismic experiments after 2008. Sakurajima Volcano is one of the most active volcanoes in Japan. The rounds of seismic experiments have been carried out while the activity on the 1946's crater in the eastern frank rose up after its revival on 2006, after the pilot survey in 2008. A round of seismic experiments includes 14 shot points with charges and 252 temporary stations with a vertical seismometer for seismic reflection survey. The temporary stations were deployed along two lines in the east foot and in the northern frank of the volcano. The evolutions of seismic response are detected in seismic records corresponding to the ray paths passing through the northern to north eastern part of Sakurajima. The migrated sections from the differential seismograms show detailed evolution in the seismic reflector distribution beneath the depth of 4km which can represent magma intrusion. A seismic reflector with negative polarity rose up to the depth of 4km in the north-eastern portion of Sakurajima Volcano where a chimney like structure locates, during 2008 to 2009 while constant inflation of the volcano. Other negative reflectors enhanced and decayed in the deeper part. These movement of seismic reflectors is consistent with geodetic evidence of the magma movement in the period. Therefore such evolution of seismic reflectors can represent intrusion of magma towards the craters. On the other hand, sporadic reflectors with positive polarity appear around the depth of 2km in two sections on the 2009's and the 2011's round which obtained while frequent explosions at the 1946's crater. The depth of the sporadic reflectors are coincident with the bottom depth of the effective part in the explosion models which have been presented by Iguchi(1994) and Tameguri(2004). Therefore the sporadic reflectors in the shallow part can represent a sort of mass deficiency raised by the explosions. We found controlled source seismic monitoring of volcano is feasible. The controlled source seismic monitoring will provide certain advantages in understanding scale and in evaluation of its potential risk in the next phase of current activity. Detail of the experiment 2012 and our method will be presented.

Keywords: Sakurajima Volcano, Subsurface structure, Seismic exploration, Dynamic structure, Magma

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SVC48-04 Room:104 Time:May 19 11:45-12:00

Three dimensional resistivity structure of Kirishima volcanoes inferred from anomalous magnetotelluric data

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Broad-band magnetotelluric (MT) measurements were conducted on 2010?2011 around Shinmoe-dake volcano in the Kirishima volcanic group, Japan, where sub-Plinian eruptions took place three times on 26?27 January 2011. Combining with the previous MT data, it is found that the anomalous phase in excess of 90 degree is commonly observed at the northern part of the Kirishima volcanic group. Because the anomalous phase is not explained by 1-D or 2-D structure with isotropic resistivity blocks, 3-D inversions were conducted. By applying the small error bars on anomalous phase, we successfully estimated a 3-D resistivity structure that explains not only the usual data but also the anomalous phase data. The final model shows a eastward inclined and clockwise twisted pillar-like conductor that connects a deep-seated conductive body (at a depth greater than 10 km) to a shallow conductive layer at the central part of Kirishima volcanoes. By using the geophysical and petrological studies of the 2011 sub-Plinian eruptions, we infer that the pillar-like conductor represent the zone of hydrothermal aqueous fluids over 400 C, in which a magma pathway (interconnected melt) is partly and occasionally formed before magmatic eruptions. To the north of the deep conductor, earthquake swarms occurred on 1968?69, suggesting that these earthquakes were caused by volcanic fluids.

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SVC48-05 Room:104 Time:May 19 12:00-12:15

Imaging of the inner structure of a lava dome in Unzen, Japan and a shallow conduit in Stromboli, Italy

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The latest lava dome in Mt. Unzen was formed in the eruption from January 1991 to early 1995 and the activity was calmed down in 1995. The researchers kept to observe the eruption in this period precisely. Some of them proposed the growth model, another person proposed different model from their data. It is significant for the growth model and the landslide prediction to investigate the density structure in the lava dome. The observation of the lava dome density 2D map was performed by using cosmic-ray muon and muon detector in Unzen. The muon detector, nuclear emulsion films which has high position resolution and 0.85m2 effective area, was installed in a natural cave from early December 2010 to the end of March. The developed nuclear emulsion films has been scanned by automated muon readout system.

Stromboli is one of the Aeolian Islands, which is located at a volcanic arc north of Sicily Island Italy. 1.0m2 nuclear emulsion films was installed at the site which is 500m far from active volcanic conduit. After there month exposure, the films were developed and we started to analyze them in the beginning of April 2012. The systematic analysis of efficiency and random noise ratio estimation are performed by taking a pattern match and making a connection of muon tracks between several films. We will report the first results of Unzen and Stromboli results.

Keywords: volcano, imaging, muon radiography, Stromboli, Unzen, lava dome

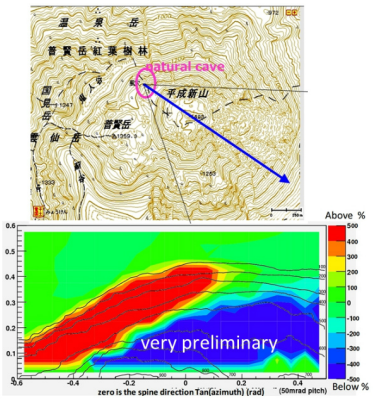

図1上：検出器設置点，方向と，溶岩ドームの位置関係．
図1下：溶岩ドームを通過するミューオン数(暫定)．

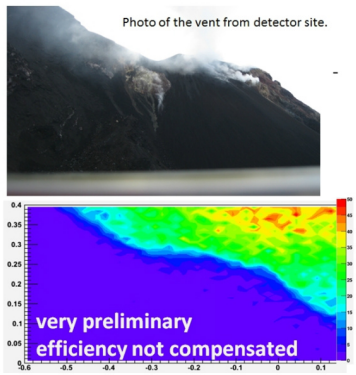

図2上：検出器設置点から見たストロンボリ火口．
図2下：ストロンボリ火道イメージング暫定結果．

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SVC48-06 Room:104 Time:May 19 12:15-12:30

Development of a multifold segmented muon detection system to improve the maximum resolvable distance of muography

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In order to perform cosmic-ray muon radiography to image a volcano with a thickness of more than 1 km, a detector with a large active area is necessary to collect the sufficient number of muon events since the penetration flux of cosmic-ray muons is reduced steeply as a function of the thickness of the target of which the muon traverses. However, the size of the active area is not a unique factor to improve the measurement. The signal-to-noise (S/N) ratio also decreases seriously as the size of the target becomes larger, and thus the density distribution cannot be accurately measured. The background (BG) noise that reduces the S/N ratio mainly consists of the fake tracks that are generated by the accidental coincidence of the vertical electromagnetic (EM) shower particles. In order to solve this problem, we developed a novel muon detection system that consists of many layers of position sensitive detectors (PSDs) in conjunction with a new analysis method to effectively reduce the BG noise. In this method, the EM shower-originated fake tracks are rejected by requesting a linear trajectory for a muon event (linear cut method) since vertical EM showers randomly hit each PSD layer and make a non-linear trajectory in the detection system. The developed detection system was tested by imaging the internal density structure (the spatial distribution of the density) of Usu volcano, Hokkaido, Japan. In this measurement, we used a muon detection system that consists of 7 layers of PSDs. One PSD layer consists of *x*- and *y*- arrays of scintillator strips to make an active area of 1.21 m^2 with a segmented area of 10x10 cm^2. The angular resolution is +/- 3 degrees. The measurement duration was 1977 hours (82 days and 9 hours). This measurement yielded the following results: (A) by analyzing the region that has a thickness of more than 1000 m, we confirmed that our detection system is sensitive to a density variation of 10% in 1300-m rock; and (B) we found that there are high- and low-density anomalies beneath between Oo-Usu and Usu-Shinzan, which is consistent with the magma intrusion and the resultant fault generation suggested by Yokoyama and Seino (2000) and Ogawa et al. (1998).

Keywords: cosmic ray, muon, radiography, spatial density distribution, muography

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SVC48-07 Room:104 Time:May 19 12:30-12:45

3D imaging of the internal density structures of volcanoes by a combination of gravity and muon radiograpy

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We have developed an integrated processing of gravity anomaly and muon radiography (muography) data for determining the 3D density structures of volcanoes with high spatial resolutions (100 - 200 m). In this report, we describe the method and the case study at Showa-Shinzan Lava Dome at eastern foot of Usu volcano, Hokkaido, Japan. We focus on the resolution test using a checkerboard model to show that muography data is helpful in gravity data interpretation.

Muography is a recently developed inspection method and is based on measuring the absorption of cosmic-ray muons inside matter. From attenuation of muon flux, one can determine the amount of matter, which is given by density-length (density times length), present along muon trajectories. Forward modeling is made by supposing the region of our interest which is subdivided into several voxels with unknown density parameters. Then, both gravity anomaly and density-length data can be written as linear combinations of the unknown parameters. The observation equation is solved by using Tarantola's [1987] probabilistic approach, in which an initial guess density and a correlation length are given as a priori information.

To verify the performance of our method, we performed a resolution test using a checker-board density model superimposed on the shape of Showa-Shinzan. We compared the models reproduced from the following data sets: (a) gravity anomaly data only; (b) gravity anomaly data and muography data. The result of the case (b) is better than that of the case (a), which ensures that muography data constrains the solution well and is helpful in gravity interpretation. In the case (b), the horizontal and vertical resolutions are better than 200 m and 100 m, respectively.

Showa-Shinzan, a target volcano in our case study, was formed at eastern foot of Usu volcano in the 1943-45 Usu eruption. We applied our method to the gravity data at 30 stations on/around the dome and the muography data reported by Tanaka et al. [2007]. The results show that the western part, where the dome exists, has higher density ($>$ 2.0 g/cc) than the eastern part of the uplifted plateau ($<$ 2.0 g/cc). Inside the dome, we find significant density variation, characterized by two high density anomalies. One high density anomaly (2.4 - 2.8 g/cc) is located below the dome and is considered to be the lava stuck in the conduit. We conclude from this that the diameter of the conduit is about 200 m. The other dense anomaly (2.4 - 3.0 g/cc) is near the surface and is considered to be the solidified lava which was uplifted significantly at the last stage of the eruption.

Keywords: Showa-Shinzan, lava dome, gravity, muon radiography

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SVC48-08 Room:104 Time:May 19 14:15-14:30

Correration between crystal size and chemical compositions; the effect of fluctuation of degree of supersaturation

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The plagioclase microlite sometimes show positive correlation between their size and chemical composition of core as shown by some studies (e.g. Noguchi et al., 2006, 2008). We analyze crystal size and An# (Ca / Ca + Na) of plagioclase microlites witch were ejected by Shinmoe-dake 2011 eruption. Crystal size is positively correlated with An#. An# of microlites range in 0.65 - 0.57, for the smallest size (10 um) and increase with size converging to 0.65 for the largest size. They are distributed within upper and lower bounds. This correlation can be explain the continuous nucleation and growth process including the evolution of melt composition, namely high and low An# evolution series.

In order to quantitatively interpret this correlation, we develop a simple model. We assume that growing surfaces of nucleated crystals are in local equilibrium with adjacent melt in their compositions, namely the effective partial coefficient is defined. We calculate An# with software package Rhyolite-MELTS (Gualda et al., 2012). We denote the rate of nucleation and crystal growth, as J [$m^{-3}s^{-1}$] and G [ms^{-1}] respectively. In the case that rate of crystallizing change P is constant, if we set J as constant, G is automatically calculated, because G depends on the total crystal surface area S and P = SG. In our calculation, G is decrease with time, because surface area is increasing. Crystals that nucleate at earlier stage grow by large G. We calculate final crystal size distribution and An# with as a varying parameter J.

The correlation between crystal size and An# become tight with increasing J, and round with decreasing J. When J is high, crystals mostly crystallize at early stage and later growth is few. When J is low, crystals grow later stage. High An# evolution series can be explain cooled at high J, and low An# evolution series can be explain cooled at low J condition. As a result of simulation, it is found that a relatively higher value of J and vice versa, corresponds to low An# evolution series in size vs. An# trends.

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Precursory activity and evolution of the 2011 eruption of Shinmoe-dake in Kirishima volcano-insights from ash samples

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After a precursory phreatic stage (2008 to 2010), the 2011 Shinmoe-dake eruption entered a phreatomagmatic stage on January 19, a sub-Plinian and lava accumulation stage at the end of January, a vulcanian stage in February-April, and a second phreatomagmatic stage in June-August. We examined ash samples from all the stages (Suzuki et al., in review for EPS, as of February, 2013). Component ratio, bulk composition, and particle size of the samples helped us define the eruptive stages. The juvenile particles were first found in the January 19 sample as pumice (8 vol%) and were consistently present as scoria and pumice particles thereafter (generally ~50 vol%, decreasing in weaker events). The January 19 pumice has water-quench texture. After the lava accumulation, particles of that lava origin came to account for 30-70 vol% of the ash. The second phreatomagmatic stage is proposed because of fine ash and long eruption period. The SiO2 contents of bulk ash are lower in post-January 19, 2011 eruptions, reflecting lower average SiO2 contents in 2011 ejecta than in past ejecta. The free-crystal assemblages were two pyroxenes + plagioclase + Fe-Ti oxides until 2010; olivine joined the assemblage in 2011, when juvenile ash was erupted. This change is consistent with the absence or smaller sizes of olivine phenocrysts in past ejecta forming the volcanic edifice.

Aside from these scientific results, we also emphasize the importance of continuous observation of ash samples, for monitoring ongoing eruptive activity and forecasting activity change. As far as we know, ash characterization was the only method which detected the change of eruptive activity before the sub-Plinian event in the 2011 eruption; first detection of juvenile material in the January 19 sample showed that magma was rising to shallow depth. The continuous ash sample observation starting from a period of low activity (August 2008-June 2010 in the Shimoe-dake 2011 case) helps us detect appearance of juvenile material.

Keywords: Volcanic ash, Shinmoe-dake, bulk ash composition, component ratio, particle size distribution

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SVC48-10 Room:104 Time:May 19 14:45-15:00

Historic records of Vulcanian eruption during 1800-1804 activity of Chokai volcano

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We briefly discuss record of historical documents about the A.D. 1800-1804 eruption of Chokai volcano, northeastern Japan. We found documents suggesting intermittent explosion, ballistic ejection of hot blocks or bombs, acoustic waves and emission of hot ash cloud, and concluded that Vulcanian eruption took place during August of 1801(July of Kyowa Gannen). Magmatic activity of 1800-1804 eruption of Chokai volcano began with Vulcanian eruption between July 2nd and July 10th and ended by emission of Shinzan lava dome around July 23rd.

Keywords: Vulcanian eruption, Chokai volcano, Historic record

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SVC48-11 Room:104 Time:May 19 15:00-15:15

Eruption scenario of Usu volcano, Japan

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The national research group on volcanic eruption forecasting is preparing the eruption scenarios (event trees with probabilities) for representative active volcanoes in Japan. At Usu volcano, the eruptive activity resumed in 1663 with the plinian and pyroclastic surge events after a sector collapse about 7 to 8 ka. Since then, five summit eruptions with the plinian columns had occurred, and three flank eruptions with phreatic to phreatomagmatic events had occurred. These eruptions were recorded in old documents or observed geophysically from the beginning of 20th Century; they occurred every 30 +/- 4 years. They ended with the formation of lava domes or cryptdomes, except for the 1663 eruption. Except for flank eruptions which are small in the scale, there is a good negative correlation between the erupted volume and frequency in log unit. The larger the erupted volume, the shorter the eruption duration. As a whole, the volume of eruption decreased with time. Seismic precursory continued generally for a few days in respective of eruption locations. The summit eruptions started, accelerating seismic activity, while the flank eruptions did after passing the peak of seismic activity. The probability of flank failure in future can be calculated about 1%, and those of the summit and flank eruptions are about 30 and 50 %, respectively. The summit eruption starts with the plinian event column in about 75% probability, while the flank eruption starts in about 70 % probability without magmatic eruption. Movement of the fault system suggesting a possibility of future failure of the volcano northern slope was observed during the last two eruptions. New eruption scenario not based only on the past eruption records may be required.

Keywords: Eruption Scenario, Event tree, Usu Volcano

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SVC48-12 Room:104 Time:May 19 15:15-15:30

On the volcanic risk to the Chisong nuclear power plant in China by probable eruption of the Baitoushan volcano

Hiromitsu Taniguchi[1*], Yoshiaki Himeno[2]

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In the last presentation, I omitted the talk about the volcano risk to Chisong nuclear power plant by time restrictions. I will focus on this point and performs the talk this time.

The activity of an earthquake and the upheaval of the summit of Baitoushan volcano which started in 2002 ceased in 2005. Six years afterward, the 2011 off the Pacific coast of Tohoku Earthquake occurred and it had worries about an eruption also in Baitoushan volcano like the active volcano in Japan. For example, in North Korea, the law about an earthquake and an eruption was newly built in August, 2011. On the other hand, in China, a construction plan of the nuclear power plant (NPP) was pushed forward in Jingyu County approximately 100km away from the Baitoushan volcano. The plan was stopped by the 3.11 megathrust earthquake, but it restarted and construction is now pushed forward. Doesn't an eruption do a risk to the nuclear power plant? Supposing it does, what kind of risk is there? And what is the defense method?

This NPP uses the lake water which dammed up the source of Songhua River running down from the Baitoushan volcano as the source 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 NPP setting spot. In addition, according to the satellite image, the risk of the large-scale collapse of the western flank of mountain edifice is pointed out. This can also cause the lahar in the 100 km distant place. According to the geological map by Wei H. (personal com.), the lahar by 10th century eruption arrived at the installation predetermined area of the NPP. Even if the NPP (AP1000) of the schedule installed cannot obtain cooling water from the river, for three days, it can bear and is a nuclear reactor of new type which stops safely by air cooling after that. At this point it may be reliable to the lahar risk. Although the pyroclastic flow of 10th century could not reach to the NPP site, another probable risk may be the ash fall accompanied to the ash cloud due to the pyroclastic flow.

There are more than 15 million inhabitants in China and Russia along the river more downstream than the NPP. 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 volcano, volcanic risk, nuclear power plant, eruption

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SVC48-13 Room:104 Time:May 19 16:15-16:30

Basic Characteristics of Crustal Deformation Measurement in a Vault of the Tokachi - dakeVolcano, Hokkaido, Japan

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Tokachi-dake volcano sitting in the central Hokkaido is one of the most active volcanos in the region. In the recent 100 years, it frequently erupted including 3 major ones in 1926, 1962, and 1988. Among them the 1926 eruption triggered a lahar driven by melting snow and ice and claimed 144 lives. A lesson we can learn from the erupting history of this volcano is that each eruption was preceded by a series of small events suggesting gradually magnifying volcanic activity. In each eruption manifestations of precursory signs started to appear and then grow about several years before the eruption. Because almost 25 years, that are comparable to recent recurrence period, have passed since the last major eruption, we should be prepared for the future eruption that might come soon. It is noteworthy that there are already some signs of increased activity that probably suggest growing volcanic potential for the next eruption. Such signs are self-illumination of a spot on a wall of the 1926 crater and sporadic increase of micro seismicity around the active crater including magnitude 2.8 (JMA preliminary estimation) earthquake on February 2, 2013. The ongoing inflation localized around1962-II crater since 2006 might have to be reconsidered as one of the manifestations indicating ongoing development of volcanic potential.

The high likelihood of having precursory signals before Tokachi-dake climactic eruption encourages us to set up a network of monitoring instruments of sufficient spatial density. For the mitigating purposes it is also crucial to achieve temporally continuous monitoring with real time data transfer capability. Because of the high altitude and location in the northernmost island of Japan, the deployment of such monitoring network is difficult in reality. The biggest hindrance is originated from the heavy accumulation of snow and ice during the winter season. Instruments installed on the surface are likely to be covered by thick snow accumulation and sometimes are destroyed by avalanche or moving ice. To avoid such a risk a vault observation is preferable. For that purpose Tokachi-dake vault observatory (TKC) was constructed on the southwest flank of the volcano in 1985. Tiltmeters and extensiometer for continuous crustal deformation measurement were installed. The acquired data are being transferred to the laboratory using telemeter system working on microwave frequency.

To make the volcano monitoring reliable we should be able to distinguish signals coming from the volcanism from noises of different nature. For example precipitation is a common error source for vault measurement. For the purpose of evaluating the stability and identifying of possible error sources, we analyzed the recorded crustal deformation data (tilts and linear strain) of recent years. The data indicated that basically the measurements are quite stable. Yearly repeating variation and linear trend are found in each deformation component but those evolutions are relatively smooth and easy to identify. No variations that might be related to precipitation were recognized. On the other hand, steps were found only during winter season. A possible explanation is that crustal deformations are excited by massive motion of snow and ice, but further studies are necessary for the confidence. In the presentation, we will discuss the stability of the observation further in detail.

Keywords: Volcano, Crustal Deformation, Monitoring, Tiltmeter, Strain Gauge, Tokachi-dake Volcano

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SVC48-14 Room:104 Time:May 19 16:30-16:45

Earthquake swarm activities and dilatational crustal deformation in Hakone volcano

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Hakone volcano is located in the northernmost part of the Philippine Sea plate. The Hot Springs Research Institute (HSRI) has been carrying out seismic observation in and around Hakone volcano since 1968. In June, 2001, the largest swarm activity after introduction of telemeter system occurred and it lasted about a half year. Since then, notable swarm activities were observed in 2006 and in 2008-2009. These activities were accompanied with dilatational crustal deformation.

We have been observing a new swarm activity. It started in the first days of 2013. Tilt meters operated by the HSRI have been showing crustal movements similar to that observed at the 2001 event. The GSNN data of the Geospatial Information Authority of Japan also show appearance of crustal deformation. This is the 4th time which dilatational deformation is observed by the GNSS.

We investigated progress of the dilatational crustal deformation and the swarm activity for the four cases and found a feature that crustal deformation tends to precede notable swarm activities. A notable feature is a tendency which rise occurrence of the clustered activity are delayed to the start of the dilatational crustal deformation. This suggests a possibility that occurrence of swarm activity might be forecasted by monitoring progress of crustal deformation. We discuss plausible causal relationship between a deep source of dilatation and shallower swarm activities.

Keywords: Hakone volcano, earthquake swarm, de-cluster, crustal deformation, forecasting

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SVC48-15 Room:104 Time:May 19 16:45-17:00

Hybrid method to estimate discharge rate of volcanic ash by using seismic and ground deformation data

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Eruptive activity at the Showa crater resumed in June 2006 and the explosivity has increased since autumn in 2009. A method to estimate weight of volcanic ash ejected from the crater is proposed by using deflation of volcano associated with explosive eruptions and seismic amplitude (2-3 Hz) of volcanic tremor generated by non-explosive but continuous eruptions.

Keywords: Sakurajima, Volcanic ash, volcanic tremor, ground deformation

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SVC48-16 Room:104 Time:May 19 17:00-17:15

Vertical ground deformation in and around Sakurajima volcano measured by precise leveling survey (until Dec. 2012)

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We conducted the precise leveling survey in and around Sakurajima volcano in November and December 2012, in order to evaluate the vertical ground deformation associated with the recent eruptive activity of this volcano. The survey data measured in Sakurajima are compared with those of the previous survey conducted in November 2011, resulting in the relative vertical displacements of the bench marks during the period from November 2011 to November-December 2012. The resultant displacements indicate the ground uplift at the northern part of Sakurajima. The relative ground height level at the northern part of Sakurajima at the time of November-December 2012 recovers and further exceeds the height level in around 1973, when the intense summit eruptions during the 1970s and the 1980s started. From the analysis based on a spherical source model, the inflation source is located at 9.6 km depth beneath the center of Aira caldera. The relative vertical displacements around the western coast of Kagoshima Bay calculated during the period from November 2009 (the previous survey) to November-December 2012 also show the ground uplift near the center of Aira caldera. These results suggest that the magma storage at the magma reservoir beneath Aira caldera is progressed in spite of the recent increase of the volume of ejected magma associated with the eruptive activity at Showa crater.

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

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SVC48-17 Room:104 Time:May 19 17:15-17:30

Temporal variation of HCl/SO_2 ratios in the volcanic plumes of Showa and Minamidake craters, Sakurajima volcano

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After the reactivation of Showa crater at Sakurajima volcano in June 2006, the volcano has been emitting volcanic gas from two craters, Minamidake and Showa craters. Due to the difficulty of volcanic gas sampling at this volcano, remote measurement is effective for monitoring volcanic gas composition. Notsu and Mori (2010) reported that HCl/SO_2ratio of the volcanic plume of Minamidake crater was 0.24-0.48 between 1999 and 2001, This presentation will report the temporal variation of HCl/SO_2 ratios of volcanic plumes of the two craters observed using remote FT-IR measurements.

The observations were carried out using a FT-IR spectrometer of Air Monitoring System (MIDAC Inc.). This FT-IR spectrometer equipped with a liquid Nitrogen cooled InSb detector has spectral resolution of 0.5 cm^{-1}. A movable mirror installed in front of the entrance window was adjusted to introduce the sunlight into the spectrometer. For the measurements, solar occultation method (Francis *et al.*, 1998) using the sun as an infrared light source was used due to the lack of infrared source on the flank of the volcano.

Since the plumes from the two craters mix as they flow, it is impossible to separately measure the HCl/SO_2 ratios for the respective craters by measuring the plume a few km away from the volcano. In order to separately measure the ratios, plume just above one of the craters was aimed using the sun going down behind the crater.

The FT-IR observations revealed that two craters have different HCl/SO_2 ratios. The HCl/SO_2 ratio of Showa crater is relatively stable raging 0.1-0.18 for the last three years. In contrast, the ratio of Minamidake crater varied between 0.13 and $>$0.3 and is usually higher than that of Showa crater except for the end of 2010. There is no noticeable correlation between the ratios and the SO_2 flux of the volcano. In two of the observations, we were able to separately measure the ratios of two vents in Minamidake crater (A and B craters) and found that they also have different ratios (the ratio of A crater is higher than the ratio of B crater). Some part of the large variation of Minamidake's ratio may be explained by changes in relative degassing strength of the two vents.

Keywords: volcanic gas, Sakurajima, remote measurement

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SVC48-18 Room:104 Time:May 19 17:30-17:45

Shear wave splitting measurements and shallow crustal structure of Mt. Fuji region

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Seismic activity in volcanic region have been reportedly changing after the Great 2011 Tohoku Earthquake. An aftershock(Mw 5.9) occurred on 15 March 2011 in Mt. Fuji region after 11 March 2011. The stress fields of the area can be affected by these events. A clear NW-SE trend of dike formations is observed in the vicinity of the volcanic edifice of Mt. Fuji and the maximum horizontal stress of the regional stress field in the area is presumed to be parallel to the strike of dike formations. The interactions of these major events and the regional stress field may affect the geologic processes in Mt. Fuji region. Seismic anisotropy can provide us with timely and spatial information about the seismic structure and stress fields. We measure shear wave splitting (SWS) by using MFAST (Savage et al., 2010) to interpret the upper crustal structure and stress fields of the region. We use data retrieved from seismic stations installed by ERI or NIED from 2009 to 2011. The measure trend of fast polarization directions (depth$<$20 km) in 2009 are almost N-S and the trend is not consistent with the regional maximum horizontal stresses (NW-SE). The trends of fast polarization directions did not change significantly after 11 March 2011. The number of events increased after March 2011 while the number of events whose SWS can be measured did not increase significantly. Previous studies indicate increase of the dilatational strain from 2006 and stress perturbations by the Great Tohoku earthquake and an aftershock (Mw 5.9). Lack of significant temporal change of fast polarization directions may indicate that the seismic anisotropy of the area is not sensitive to changes of the stress field by the events. At least, the stress perturbations by the Great Tohoku earthquake did not significantly affect the seismic anisotropy in the shallow ($<$20km) crust around Mt. Fuji region at the end of 2011. By contrast, Results of SWS from deep events ($>$20km) were unstable due to number of events and noise level. We expect that we can infer the relationships between regional or local stress field and seismic anisotropy from further analysis of SWS and comparison with focal mechanism and seismic structures.

Keywords: Mt. Fuji, Shear wave splitting, Volcano monitoring

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SVC48-19 Room:104 Time:May 20 09:00-09:15

A sketch in a shallow part of the conduit preceding a Vulcanian eruption

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The sub-Plinian and the Vulcanian eruptions at the Shinmoe-dake volcano were preceded by inflations at shallow depths near the summit. The inflation-deflation cycles were also recorded during the magma-effusive stage, with a typical period of one hour, synchronized with volcanic tremors or long-period events. Almost all Vulcanian eruptions were preceded by trapezoidal inflations, whose durations systematically lengthened as time progressed, and were followed by various time sequences of tilt motions, which became increasingly more complicated throughout the frequent Vulcanian eruptions. In spite of the complicated time sequences of the preceding inflations, we have found clear linearity with a constant gradient of 0.45 between the logarithm of the preceding durations versus elapsed time for each sub-stage.

During the magma-effusive stage, the conduit must have been filled up by magma, which was more degassed than in the sub-Plinian stage, including pores or porous structures. Therefore, it seems to be probable that certain parts of the conduit interior were occupied by poroelastic material, and that the strength of the conduit interior was heterogeneous. The preceding inflation should begin at this instant, gradually increasing in proportion with pressure buildup. When the pressure exceeded a yield value, the gas pocket area should be deformed plastically, causing a slight leakage of volcanic gas to the upper side in the conduit, and creating a volcanic glow and a slight deflation and/or a phreatomagmatic eruption. On the contrary, the lower side of the gas pocket area acted as a porous media, defusing the high-pressured gas to the deeper part in the conduit. This caused the deepening of the centroidal source depth approaching the eruption. During this time, the pressure confined in a closed strong magma frame must increase without any dynamic affect on the outside. Assuming that a Vulcanian eruption is induced by a catastrophic rupture of the closed magma frame in a conduit due to magma degassing overpressure, the clear linear relation could be interpreted that the degassing from the magma in the conduit declines exponentially with time. In conclusion, the observations can be consistently explained based on the assumption that a Vulcanian eruption is induced by a catastrophic rupture of the closed magma frame due to overpressure caused by magma degassing, and the degassing from magma declines exponentially with time. To sum up the above discussion, we propose a sketch in a shallow part of a conduit preceding a Vulcanian eruption.

Keywords: Vulcanian eruption, Tilt motion, Physical process in a conduit

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SVC48-20 Room:104 Time:May 20 09:15-09:30

Tilt motion and volcanic tremor during lava-effusive stage in the 2011 Shinome-dake eruption

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Introduction

Observations such as tilt motions and tremors are important in considering magma behavior. Tilt motions observed near a crater may represent pressure change in conduit and tremors observed near a crater may be generated by volcanic fluid (gas, magma, water) in conduit. In order to reveal dynamics of eruptions, various observations such as tilt motions and volcanic earthquakes have been observed around volcanoes. In this research, we focused on tilt motions and tremors during lava-effusive stage in the 2011 Sinmoe-dake eruptions and revealed the character of them.

A series of eruptions at Shinmoe-dake

The Shinmoe-dake volcano started a magmatic eruption at 15:29 (JST) on 26 January 2011. Three sub-Plinian eruptions occurred between 26 and 27 January 2011, followed by two Vulcanian eruptions at 02:05 and at 12:48 on 28 January 2011. Midmorning on 28 January 2011, a small magma dome emerged from the center of the summit crater, progressively increasing in volume. After 1 February 2011, Vulcanian eruptions occurred frequently. Later, volcanic activity has continued during the year 2011 at least.

In this research, we focused on a lava-effusive stage (28-31 January). In this stage, deflation-inflation cycles of tilt motions with a typical period of one hour were observed at stations near by the summit of Shinmoe-dake (Maehara 2012). We also observed volcanic tremors related to deflation-inflation tilt motions. Only when the tilt motions were lower than the threshold, tremors occurred.

The frequency structure of tremors

The frequency structure of tremors differed in deflation stage from in inflation stage. In frequency domain under 2Hz, tremors are dominated by two frequencies (about 1Hz and about 1.5Hz) during deflation stage, but are dominated by a frequency (about 1.2Hz) during inflation stage. In frequency domain over 2Hz, the intensity of frequency structure in inflation stage is much smaller than in deflation stage only on 31 January.

Pressure source exciting tilt motions

We estimated the depth of pressure source exciting tilt motions by using the ratio of tilt amplitude recorded at two stations, under the assumption that pressure source generating deflation-inflation cycles was located under the center of crater and cylindrical pressure source. Then, we estimated pressure change dP which could generate tilt motions comparable to observation.

When the centroidal depth of pressure source was located at 600m above sea-level, the point sources extending 250m from 475m to 725m above sea-level could explain the observed ratio. In this case, at most a few MPa pressure change dP could generate tilt motions comparable to observation.

Keywords: lava effusion, tilt, tremor

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SVC48-21 Room:104 Time:May 20 09:30-09:45

Spatio-temporal variations of the volcanic tremors on Kirishima volcano estimated by dense seismic array

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Shinmoedake Volcano, mount Kirishima, Japan, began a series of eruptions on January 19, 2011. We installed 25 seismometers near Shinyu springs located at about 3 km away from the crater. On the other hand 16 seismometers were installed at Hinamori-dai located at about 5 km away from the crater by Nagoya University.

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 been revealed. Here, we observed change in the seismic ray direction during the volcanic tremor sequence through MUSIC spectrum processing and estimated spatial distribution of the source of volcanic tremors by combination of the two dense seismic arrays. MUSIC spectrum processing was applied to seismograms of a volcanic tremor occurred on February 2, 2011, and its duration was about 40 minutes. Most part of the tremor arrived from Shinmoedake crater. However, at some parts of the tremor sequence the slowness vectors show change in the tremor's source location. One part of the tremor with large slowness and with relatively long duration was generated at a shallow region beneath the crater. Another part of the tremor with short duration was found near Ohnami pond, 3.3 km northeast of the crater. Because of using a constant velocity structure model, accuracy of locations for tremor with small slowness was not enough to discussion relationship between their and volcanic activities. We will estimate distribution of the volcanic tremor source by using more realistic velocity model, and compare other geophysical data in order to understand the eruption activity.

Keywords: Shinmoedake, volcanic tremor

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SVC48-22 Room:104 Time:May 20 09:45-10:00

Hypocenter determination of B-type earthquakes at Miyakejima volcano using the envelope correlation method

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After the 2000 eruptions, Miyakejima volcano still continues to emit large amount of volcanic gases. Meanwhile, B-type earthquakes have also been continuously and frequently observed after the eruptions, and often show emergent onsets of P- and S-phases, which makes the application of conventional phase-picking hypocenter determination rather difficult. Recently, Uchida et al. (2012) analyzed B-type events at Miyakejima volcano, which are observed by Japan Meteorological Agency from August 2010 to April 2011, and succeeded in determining 18 % of the observed 1,049 B-type events by stacking the waveforms of earthquake families to read the P- and S-wave onset times. However, the hypocenters of the rest of B-type events still remain unknown.

In this study, aiming to locate all of the B-type earthquakes at Miyakejima, we apply the method of Obara (2002), which was used for non-volcanic deep tremors on the subducting Philippine Sea Plate in south west Japan, to the seismograms observed at nine stations located within 4 km of the summit. At each station, we compute a RMS envelope from 4 - 8 Hz band-pass-filtered three-component seismograms, and measure the differential travel times between stations by taking cross-correlations of the envelopes. We assume that the envelope is composed of S-wave traveling with the velocity of 1250 m/s, as in Uchida et al. (2012).

To assess the applicability of the method to B-type earthquakes, we determine the hypocenters of individual events in each of the four earthquake families by applying the envelope correlation method, and compare the resultant hypocenters with those obtained from phase picking of the stacked waveforms. As a result, we found that the epicenters located by the envelope correlation almost coincide with those determined by the phase picking. On the other hand, the method sometimes yields large error in depth. That is probably due to the difficulties in measuring the S-wave travel times from the envelopes. To improve the accuracy, we need to consider the envelope broadening by scattered waves, surface waves and/or reflection phases.

We then apply the envelope correlation method to all of the observed 1,049 B-type earthquakes, of which about 80 % had never been located, and successfully locate them in an automated way. As a result, we found that 97 % of them are located within a 1.5 km diameter centered on the southern part of the summit caldera, where continuous fumarolic gas emission occurs. It strongly suggests that the occurrence of B-type earthquakes is related to the gas emission activity at Miyakejima. Those hypocenters are distributed at the depths shallower than 3 km. Our study shows the usefulness of the method as a tool to monitor volcanic earthquakes which are difficult to locate by conventional phase picking.

Keywords: Miyakejima volcano, B-type earthquake, hypocenter determination, envelope correlation method

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SVC48-23 Room:104 Time:May 20 10:00-10:15

Wave properties of explosion earthquake and precursory tilt change associated with vulcanian eruptions at Lokon volcano

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Lokon-Empung is one of the most active volcanoes in Indonesia. It is a twin volcano located in the north arm of Sulawesi Island. The volcano began eruptive activity at Tompaluan crater, which is on the ridge connecting Lokon and Empung peaks, in the year of 1829 after several hundred years of quiescence. Vulcanian eruption activity is considerably high, so we began temporal seismic and tilt observation at Lokon-Empung volcano since September 2012 to understand the mechanism of the vulcanian explosion and its preparatory process. Here we report wave properties of explosion earthquakes and precursory tilt changes as a preliminary step toward the source mechanism analysis.

Four broadband seismometers (Trillium 40) are deployed around the Lokon-Empung volcano in the distance range of 1.6 - 6.8 km from the Tompaluan crater. A high-sensitive tilt meter (Pinnacle Denali) is also installed at the closest station WAILAN which is connected by a wireless network to Kakaskasen Volcano Observatory (KKVO) in Tomohon City. Each seismometer is connected to a data logger (HKS-9550) to record seismic data in a CF card with an A/D resolution of 24 bit and a sampling rate of 100 Hz with time stamps of GPS clock. Tilt data digitized every one second within the tilt meter are transmitted to a laptop PC at KKVO once per day. Seismic data of WAILAN is sent to Japan as win format packet through the wireless network and global internet on a trial basis.

An explosion earthquake on September 28 was relatively small, but recorded at all four seismic stations. Polarity of P waves show compression at all stations. Seismogram of the station TINOOR, about 2.6 km northeast of the crater, has the largest amplitude among four stations and shows monochromatic waveform different from those of the other stations. Since a tectonic earthquake shows similar waveform and a noise spectrum has a dominant peak around 2 - 4 Hz corresponding to the monochromatic waveform, it is recognized as the special site effect at TINOOR. Explosions on October 5 and November 11 had obvious onset and short duration within about 1 minute. Among the analyzed events, the explosion earthquake on October 5 has the largest amplitude in the order of 0.001 m/s at the station WAILAN. The visual report on the height of ash column is about 1500 m above the crater. Before the October 5 eruption, small inflation phase around crater area can be seen in tilt record. The amount of tilt change is about 80 nanoradian. Duration of the inflation phase is about 40 minutes, which is almost same order to those found in Semeru volcano (3˜30 minutes). Polarities of P wave of October 5 and November 11 explosions are both compression as with the explosion on September 28. Although the seismograms of these three explosions seem different each other in original non-filtered traces, we can find very similar waveforms in the lower frequency band below around 1 Hz. This similarity indicates that the explosion mechanisms of these events have common physical process. In the low-pass filtered seismogram, large dilatational phase is identified after the compressional P wave and then clear retrograde motion representing Rayleigh wave appears. These waveform characteristics are similar to the explosion earthquakes at Sakurajima, Suwanosejima that often explode with Vulcanian eruptions. While, small deflation phases appearing about a few seconds before the initial compression phase that are reported for the explosion of Suwanosejima and Semeru volcanoes are not well recognized.

Keywords: Vulcanian eruption, explosion earthquake, tilt change

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SVC48-24 Room:104 Time:May 20 10:15-10:30

Source amplitudes of volcano-seismic signals determined by the amplitude source location method

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The amplitude source location (ASL) method, which uses high-frequency amplitudes under the assumption of isotropic S-wave radiation, has been shown to be useful for locating the sources of various types of volcano-seismic signals. We tested the ASL method by using synthetic seismograms and examined the source amplitudes determined by this method for various types of volcano-seismic signals observed at different volcanoes. Our synthetic tests indicated that, although ASL results are not strongly influenced by velocity structure and noise, they do depend on site amplification factors at individual stations. We first applied the ASL method to volcano-tectonic (VT) earthquakes at Taal volcano, Philippines, where the seismic network consists of eight seismometers (five broadband and three short-period seismometers). Our ASL results for the largest VT earthquake showed that a frequency range of 7-12 Hz and a Q value of 50 were appropriate for the source location determination. We proposed a two-step approach to minimize site effects on the source amplitude estimation as follows: The source location is first determined by using a frequency band of 7-12 Hz and Q = 50 with site amplification corrections, and then the source amplitude is estimated by using waveform data at broadband seismic stations only without site amplification corrections and a reference frequency band of 5-10 Hz and Q = 50. Using this two-step approach, we systematically applied the ASL method to VT earthquakes at Taal, and estimated their source locations and amplitudes as well as seismic magnitudes. We similarly analyzed LP events at Cotopaxi and explosion events at Tungurahua. At all three volcanoes, we found a proportional relation between the magnitude and the logarithm of the source amplitude without any strong dependence on event type. At these three volcanoes, all of broadband seismometers had been installed in a similar way, which may have minimized site effects. The ASL method can be used to determine source locations of small events for which onset measurements are difficult, and thus can estimate the sizes of events over a wider range of sizes compared with conventional hypocenter determination approaches. Previously, there has been no parameter widely used to quantify the sources of volcano-seismic signals. This study showed that the source amplitude determined by the ASL method may be such a useful quantitative measure of volcano-seismic event size.

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SVC48-P01 Room:Convention Hall Time:May 19 18:15-19:30

Petrological study of main stratocone eruption products in the western field of Akita-Komagatake volcano

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Akita-Komagatake volacano is located in the Sengan geothermal field of the frontal area in the northeren part of Northeast Japan arc, and consists of amain stratocone, with a caldera in the south, and several parasitic cones at its summit. Development history of this volcano is divided into two stages by caldera collapse event occurred at about 13 ka. This volcano is characterized by predominant low-K thokeiitic magma with minor medium-K calc-alkaline magma. The low-K tholeiitic magma that formed the main stratocone show complex compositional variation trends(ex.Kobatake et al.,2012).

The aim of this study is to reveal the mechanisms which gave rise to the various temporal compositional change of the tholeiitic magmas erupted in this stage, by examining the detailed stratigraphy and petrology for the eruption products of the main stratocone.

Many tongue-shaped flow lobes of fluidal lavas are observed near the foot of the stratocone and stratified lava piles were well observed on the caldera wall at the summit area. On the bases of lithology, petrology and petrography, 24 eruption units were identified, and their stratigraphic relations were also investigated. A dormancy was inferred from a thick secondary deposit intercalated between the lava flows in the middle stratigraphic horizon.

21 of the 24 eruption products were the low-K tholeiitic series, 2 were medium-K calc-alkaline series, and the rest 1 comes just boundary between the two magma series. The tholeiitic series varies from 51 to 61 wt.%silica, and the olivine-bearing basaltic lavas with the primitive compositions of 52 and 50 to 52wt.%silica have been erupted respectively, during middle and upper horizons of the stratigraphy.

Three series of magmatic evolution sequence are definable by cyclic eruption episodes of primitive basalt magmas with subsequent eruptions of evolved magmas.

The earlier 2 sequence show typical tholeiitic trends of iron-enrichment with increasing silica, whereas the variation trend for the last sequence shows a rapid increase K2O relative to the early 2 sequence. The former is probably reconciled with the fractional crystallization from basaltic parents, whereas the latter should be strongly affected either by magma mixing K2O-rich felsic endmenber or assimilation of wall rocks.

Keywords: Akita-Komagatake volcano, tholeiitic magma, bulk-rock geochemistry, pre-caldera volcanism

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The mechanisms of cyclic sub-Plinian activity and shifting eruption style in the 2011 eruption of Shinmoe-dake

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The climactic phase of the 2011 eruption of Shinmoe-dake is characterized by sub-Plinian eruptions (Jan 26-27) and lava accumulation in the crater (Jan 28-31), both of which accompanied vulcanian eruptions (Nakada et al., in review). Referring real-time observatory data on crater image, tremor and infrasound (Ichihara et al., in review) and tilt variation (e.g. Kozono et al., in review), a geological study (Maeno et al., in review) showed three sub-Plinian events (26PM, 27AM and 27PM, the most intense phase of each lasted 2.5-1.7 hours) occurred every 12 hours with a decrease of erupted magma volume and with a constant mass discharge rate.

This study reveals evolution of conduit flow through the climactic phase, by combining, a) records in groundmass microlite and vesicle textures and b) the above-mentioned, time-resolved observatory results. Based on a petrological result (Suzuki et al., in review JVGR), we judge that variable groundmass textures among the samples reflect different conditions in syneruptive magma ascent, not different characteristics of the magma at the reservoir. Although most ejecta (gray and brown ones as to pumice clasts) are products of magma mixing that resulted from syneruptive injection of basaltic andesite magma into a silicic andesite magma reservoir, the mixed magmas were homogeneous in the reservoir owing to constant mixing ratios (SiO2 57-58 wt.%, 30vol. % phenocrysts, 960-980C, 4wt. % H2O).

The volcanological questions we would like to address after we reveal evolution of conduit flow through the climax phase are, 1) mechanisms that led to the cyclic sub-Plinian eruptions, including the triggering processes of each event, 2) timing and conditions of syneruptive magma ascent that are responsible for shifting eruption intensity and eruption style (explosive and effusive). We expect this groundmass textural study also helps us newly define a boundary between the 26PM and 27AM pumice deposits. The corresponding deposit exhibits reverse and normal gradings, as if it was generated in a single event (Maeno et al., in review; Nakada et al., in review). Regardless of that, the groundmass textures of the samples may record waxing and waning phases of conduit magma flow in each sub-Plinian event.

Keywords: Shinmoe-dake, conduit flow, sub-Plinian eruption, lava emplacement, bulk density, groundmass texture

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Chlorine content and ferric-ferrous ratio of volcanic ash emitted at Minamidake, Sakurajima in the sequence of eruption

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Decompression of magma by moving toward the surface causes exsolution of volatiles, which provides the driving force for explosive eruptions. Moreover, degassing of volatiles from magma changes its viscosity and density drastically, and these can influence violence of a volcanic eruption.

At Sakurajima volcano, recent eruptive phase at Minamidake has been sustained since October 1955. Strombolian eruptions forerun vulcanian explosions, and vulcanian explosions are often followed by continuous ash emissions, which is the typical sequence of eruptive activity. Change in the mode of its eruptive activity is drastic, which is attributed to difference in source processes affected by the state of the magma conduit including gas phase. Nogami *et al.* (2006) revealed that Cl contents in the volcanic ash emitted by strombolian eruptions are higher than those values of the other modes of eruption, and the difference in the value between vulcanian explosion and continuous ash emission is not recognizable. This previous research examined the behavior of volatile component at different phase of activity. In this study, behavior of volatile components in magma is examined through the analysis of Cl in the volcanic ash collected is the sequence of eruptive activity in 1978 and 1979.

SiO_2 contents of most ash samples fall within the narrow range between 59 and 61 in wt.%, and chemical composition of the ash samples indicates that segregation of constituent minerals rarely occurred during drifting of ash cloud. Chlorine contents in volcanic ash emitted by strombolian eruption are significantly higher than those of the ash ejeceted by vulcanian explosions and continuous ash emissions, and decrease corresponding to the change in the mode of eruption.

These results indicate that volatile-rich magma ascend to the bottom of crater and caused strombolian eruption and that the mode of eruption changes due to degassing of volatile components. Degassing process control change in the mode of eruption because chemical composition of volcanic material discharged in the sequence of the volcanic activity is almost uniform. The variation of FeO/Fe_2O_3 ratio indicates that the redox state of magma is relatively reductive at strombolian eruption and become oxidative with the change in the mode of eruption. Temporal change in FeO/Fe_2O_3 ratio of the volcanic ash synchronized with that of Cl content in magma, which may indicate that degassing of HCl affect oxidation state of magma.

Keywords: Sakurajima, volcanic ash, chlorine, ferric-ferrous ratio

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SVC48-P04 Room:Convention Hall Time:May 19 18:15-19:30

Immediate Estimations of Volcanic Plume Heights without Visual Observations at Sakurajima Volcano

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Volcanic plume heights are estimated immediately in our study even when it is invisible, for example in bad weather or at night. The eruptions at Sakurajima Volcano are classified into three types according to the amplitude of infrasonic waves. The first is irrelevant to the amplitude of infrasonic waves, which is 0-20Pa. The second is featureless and the amplitude is 20-100Pa. The last has positive correlation between volcanic plume height and the amplitude of infrasonic waves which is 100Pa-. Volcanic plume heights are calculated by (1)the highest temperature of volcanic plume,(2)wind velocity at 850hPa surface and (3)the integration value of the amplitude of seismic waves in the first case, (1)the highest temperature of volcanic plume, (2)the amount of strain changes of quadrature component to source and (3)the biggest amplitude of infrasonic waves by in the second case, (1)the biggest amplitude of infrasonic waves and (2)the amount of strain changes of parallel component to source by in the last case.

Keywords: Volcanic Plume Height, Sakurajima Volcano

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Occurrence of the Take tephra distributed in the northern flank of Kitadake, Sakurajima Volcano, Japan

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Sakurajima Volcano, which is located in the southern part of Aira caldra, is one of the most active volcanoes in Japan. This volcano consists of two main edifices: Kitadake and Minamidake, which are composed of pyroclastic rocks and lava flows of pyroxene andesite and dacite. Four historic explosive eruptions in AD 764, 1471, 1779 and 1914 produced pumice fall deposits and lave flows, and damaged extensively its surrounding area.

The Take tephra distributed on the northern flank of Kitadake. The deposit is producted by the last summit eruption of Kitadake at 4900 ^{14}C years BP. Two lithofacies were identified in the Take tephra: massive facies and stratified facies. The massive facies are composed of relatively large pyroclastic flow deposits, while the stratified facies are alternating beds of small pyroclastic flow deposits and pumice fall deposits. Some small pyroclastic flow deposits contain accretionary lapilli. The large pyroclastic flow deposits are divided into pumice flow deposits and block-and-ash deposits. Most pumice flow deposits are welded within 2.2 km from the summit crater of Kitadake.

Based on the components, the Take tephra is divided into three types. Type 1 contains abundant pumice grains. Type 2 consists mostly of lithic fragments. Type 3 includes a large amount of crystal particles. Large pumice flow deposits are characterized by Type 1. Small pyroclastic flow deposits and pumice fall deposits are classified into Type 2 and 3.

These facts suggest that the pyroclastic flow is intra-plinian flows generated by successive partial collapses of the sustained plinian eruption column. Since some pumice flow deposits are fine grained and poorly sorted, and contain accretionary lapilli, they are interpreted to be formed as a consequence of an interaction of magma and water. It is suggested that a part of pumice flow deposits in the late stage are welded, and that a partial collapse of the welded pyroclastic rocks occurred.

Keywords: eruption sequence, pyroclastic flow, Sakurajima, tephra

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Re-examination of the correlation of pyroclastic deposits similar to Shimokado pyroclastic flow deposit and Ks18 tephra

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Tephra is one of the best indicators of the history of explosive eruptions. Thus, Middle to Late Pleistocene tephrochronology provides information on regional changes of the frequency, magnitude of eruptions and magma discharge rate as a function of time in a long term. So tephra study of explosive eruptions is one of the most positive approaches to volcanic hazard mitigation.

Shimokado pyroclastic flow deposit (SMPF) erupted from a certain caldera in the southern Kyushu during the middle Pleistocene is one of the stratigraphically important key beds in the whole area of the Japanese Islands. Previous study correlated SMPF to Ks18 tephra (vitric ash fall deposit) in the Kasamori Formation of the Kazusa Group at the Boso Peninsula in central Japan. This pyroclastic flow deposit has been called by various names at each local area in southern Kyushu. In addition, correlation and identification of SMPF in southern Kyushu are controversial among previous studies. Furthermoer, Ks10 tephra above Ks18, both in the Kasamori Formation, is petrographically similar to SPMF, resulting in complication in widespread correlation of SMPF.

In this study, in order to re-examine the correlation of the Shimokado pyroclastic flow deposit between southern Kyushu and central Japan, we revealed the petrographic and chemical properties of eleven pyroclastic deposits (nine pyroclastic flow deposits and two co-ignimbrite ash fall layers), using the following four different criteria; (1) types of glass shards, (2) mineral assemblages, (3) range and modal values of the refractive indices of glass shards and phenocrysts, (4) chemical compositions of the glass shards, hornblende and orthopyroxene. However, in some cases, by the similar pyroclastic deposits of which differences are not clear in these criteria, we examined the possibility of the correlation of the Shimokado pyroclastic flow deposit, taking into account the stratigraphy and ages of these pyroclastic deposits.

The results are as follows:

1. Four pyroclastic deposits (Kuwanomaru pfl, Mikaeri tuff, Matsuyama tuff, Ks18 afa) are correlated with Shimokado pyroclastic flow deposit. These pyroclastic deposits are mostly rich in fiber and sponge types of glass shards and in agreement with their stratigraphically horizons.
2. Three pyroclastic flow deposits (Fumoto pfl, Futami B pfl, Koseda pfl) are distinguished from Shimokado pyroclastic flow deposit by the refractive indices of glass shards and phenocrysts.
3. Compared with each K2O wt% in their volcanic glass shards, Hiwaki pyroclastic flow deposit which was correlated with Shimokado pyroclastic flow deposit by previous study is clearly distinguished from Shimokado pyroclastic deposit. Volcanic glass shards in Hiwaki pyroclastic flow deposit indicate higher K2O ratio.
4. Ks18 and Ks10 which have been indiscernible are easily distinguished by variation in the chemical compositions of glass shards and hornblende.

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Characteristics of grain composition of volcanic ash from each eruptive style

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Surface phenomena of eruptive activity, such as eruptive style, eruptive rate, column height, is usually variable in an activity. For understanding the mechanism of change of surface phenomena, correlation between the time series of eruptive style and characteristics of volcanic ash as direct evidence of magma is important.

We analyzed the grain compositions, morphologies and textures, groundmass chemical compositions of ash produced by the 2011 eruptive event of Shinmoedake, Kirishima Volcano, Japan. As the result, it was estimated that the highly-vesiculated magma was ascended and erupted at both sub-plinian and vulcanian eruptions, without resident in shallow conduit. This infers that the analysis of grain composition may be useful indicator for estimating the mechanism controlling eruptive styles. For these purpose, it is important to accumulate more data. Therefore, we analyzed the grain compositions of ash deposits derived from the eruptions of Showa crater of Sakurajima Volcano (recent eruptions), Suwanosejima Volcano (sampled in 2012), and Asama Volcano (2004 eruptions).

Fresh blocky, black-colored glassy particles are contained abundantly in the products from recent eruption of Sakurajima Volcano. Highly-vesiculated fresh glassy particles are contained less than 10 %. There are no significant changes for a few years, and eruptive style does not change, too.

In addition, we correlated the grain composition of ash products from Sakurajima Volcano, sampled at five localities from proximal to distal area, for the purpose of clarifying the differences of grain composition of ashes from one eruption. There are no differences about the grain compositions of these five samples.

The ash derived from the eruption of Suwanosejima Volcano consists mainly of lithic fragments characteristically. On the other hand, about 15 % of dark brown-colored fresh glassy particles are also contained.

In the 2004 eruptive event of Asama Volcano, fresh glassy particles in the ashes decrease from the eruptions of September 1 to that of 14, while, highly-vesiculated fresh glassy particles are contained abundantly in the ash of September 16. It may correspond to the continuous activity for three days. It may infer that proportions of highly-vesiculated glassy particles concerned with eruption styles, such as duration time.

We can not recognize the positive correlation between proportion of highly-vesiculated glassy particles and height of eruption column. We will discuss about the correlation between highly-vesiculated glassy particles and dulation time and eruption mass, for example.

Keywords: volcanic ash, grain composition, Sakurajima, Suwanosejima, Asama

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Measurements of Diffuse Carbon Dioxide Flux around the Summit of Asama Volcano

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Carbon dioxide is one of the volatile species which exsolves in the early stage of magma degassing. Soil CO_2 flux measurements have been conducted at many volcanoes to understand magma degassing conditions and to catch primitive signals of volcanic activities. For example, an increase of CO_2 flux was observed as a precursor of the 2000 eruption at Usu volcano, Japan, followed by a sudden decrease in the flux (Hernandez et al., 2001). Asama volcano is one of the most active volcanoes in Japan with recent eruptions in 2004, 2008 and 2009. We here report results of the first diffuse CO_2 flux measurements at Asama volcano.

The measurements were carried out at 40 sites in the Maekake-yama crater on 26th October, 2012. The data were obtained by the accumulation chamber method using portable flux meter (West Systems, Inc.). The results showed that the soil CO_2 flux values were in the background level (<10 g m^{-2} d^{-1}) in the western half of Maekake-yama crater including western flank of Kama-yama cone. In contrast, the east side of the Kama-yama cone had the fluxes more than several tens g m^{-2} d^{-1} with the highest value of 296 g m^{-2} d^{-1}. This high soil CO_2 flux area corresponds to the shallower highest conductive subsurface zone spreading beneath the eastern flank of Kama-yama cone (Aizawa et al., 2008). They interpreted this conductive zone as a hydrothermal system. Since the high flux area does not show any fumarolic activities or thermal anomalies, vapor in the hydrothermal fluid is probably condensing at subsurface and only dry residual gases including CO_2 are emanating from the area.

References

Aizawa, K., Ogawa, Y., Hashimoto, T., Koyama, T., Kanda, W., Yamaya, Y., Mishina, M., Kagiyama, T. (2008) J. Volcanol. Geotherm. Res. 173, 165–177.

Hernandez, P.A., Notsu, K., Salazar, J.M.L., Mori, T., Natale, G., Okada, H., Virgili, G., Shimoike, Y., Sato, M., Perez, N.M. (2001) Science 292, 83–86.

Keywords: Asama Volcano, Diffuse CO_2 Flux

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Preliminary report of wide band MT survey in the summit area of Mt. Asama, Japan

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We conducted MT and AMT surveys in the summit area of Mt. Asama in September 2012 in order to elucidate the shallow structure beneath the crater summit including its conduit. The electromagnetic measurements were performed at 27 sites, the spacing of which is as short as about several hundred meters to detect the highly resolved structure.

The AMT measurements were conducted at all the 27 sites for several hours, and MT measurements were conducted at 9 sites for several days. The five-component MT and AMT data were collected using the Phoenix MTU system and the Metronix ADU system. However only telluric measurments were carried out at some sites because the summit area is very rocky and the surface is too hard to dig halls and install large magnetic sensors.

By estimating MT impedance tensors at some sites, the following facts were found:

1) At higher frequency as several hundred Hz, the sites at eastern side of the crater show low apparent resistivity as several ohm-m, while other sites show higher apparent resistivity beyond 100 ohm-m.

2) Low resistivity parts move to the center of the summit at middle range of frequency as 1 Hz, although the data error is relatively large due to the dead band of the EM source.

3) The center and western parts of the summit show the low apparent resistivity at lower frequency as 0.01 Hz.

The preliminary results will be shown in this presentation.

Keywords: Mt. Asama, MT survey, apparent resistivity

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The temporal changes of the shallower resistivity structure associated with a small eruptions at Aso Volcano, 2011.

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On Aso volcano, central Kyushu, Japan, a small eruption was occurred on May 2011. Before and after this eruption, we carried out the electromagnetic survey around Nakadake crater of Aso volcano. From these observations, we obtained the data which suggest a decrease of the subsurface resistivity in the deeper part beneath Nakadake crater just after the eruption. In our presentation, we will show the observation data and the resistivity structure obtained by the 1-D analysis of our data.

On Aso volcano, many observations and research have been made to detect the subsurface structure and detailed information about the distribution of the subsurface hydrothermal system have been obtained from previous studies. From the high-density AMT survey, Kanda et al. (2008) found a low resistivity area is localized just beneath the Nakadake first crater. This area is considered as a chamber of the hydrothermal fluid which is formed by a part of the hydrothermal fluid which is supplied from the deeper magma. In recently, the activities of the Nakadake crater were often temporarily increased. Associated with these activities, it is expected that the distribution of the subsurface hydrothermal fluid is changed and subsurface resistivity structure is temporally changed. In order to detect such a temporal change of shallow resistivity structure according to these activities, we carried out the repeated control sourced electromagnetic survey around the Nakadake crater using ACTIVE observation system (Utada et al., 2007). In these observations, we installed electric current transmitter on 1 km NNE from the crater, and magnetic receiver was also installed on the 4 points around crater. We have performed a totally five repeated electromagnetic observation from April 2011 to April 2012 across the small eruption of May 2011.

Keywords: resistivity structure, hydrothermal system, temporal changes

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Remote temperature sensing on the fumarolic area in Aso Volcano using hydrogen isotopic compositions of plume H_2

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Molecular hydrogen (H_2) in a high-temperature volcanic fumarole ($>$ 400 degreeC) reach to the hydrogen isotope exchange equilibrium with coexisting fumarolic H_2O under the outlet temperature of the fumarole. In this study, we applied this hydrogen isotope exchange equilibrium of fumarolic H_2 as a tracer for the remote temperature sensing on the fumarolic area in the 1^{st} crater of Mt. Naka-dake (Aso volcano) where direct measurement on fumaroles was not practical, by deducing the hydrogen isotopic composition (dD value) of fumarolic H_2 remotely from those in volcanic plume. The reciprocal of H_2 concentration in the plume samples showed a good linear relationship with the dD values. The linear relationships suggested that both the concentrations and the dD values of H_2 in the plume samples can be explained by simple mixing between two end-members, both of which can be classified to a single category at least for the dD values of H_2. By extrapolating the linear relationship between $1/H_2$ and dD to $1/H_2$=0 to exclude the contribution of the tropospheric H_2 from the dD value of each sample, we estimated that the dD value of fumarolic H_2 to be -172+-16 per mil vs. VSMOW and the apparent equilibrium temperature (AET_D) to be 868+-97 degreeC. Although the estimated temperatures using the IR thermometers were much lower than the AET_D, we concluded that the AET_D represented the highest outlet temperature of the fumaroles in Aso volcano and that the dimensions of the fumaroles at surface smaller than the pixel of the IR thermometers was responsible for the temperatures lower than the AET_D. That is to say, temporal variation in the dimensions of fumaroles at surface, probably due to variation in the emission flux of fumarolic gases, was responsible for the temporal variation in the temperature determined by the IR thermometers, while the actual outlet temperature of the Aso fumaroles keeps the temperature almost equal to the equilibrium temperature of fumarolic gases.

Keywords: fumarolic gases, volcanic plume, molecular hydrogen, stable isotopes, isotope exchange equilibrium, remote temperature sensing

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Precise Leveling Survey in Aso Caldera(September, 2012)

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In Aso volcano, leveling survey has been conducted since 1937 by Kyoto University. As a result of these surveys, subsidence in Kusasenri about 2km west-southwest of Naka-dake crater has been observed. And this subsidence was considered to be caused by a contraction source located at about 3km west of Naka-dake crater with a depth of 4 to 6 km (Sudo et al. 2006). A seismic tomography showed a low velocity zone of a 2 to 3 km diameter located at a depth of 6km in Kusasenri (Sudo and Kong, 2001), almost in accordance with the position of contraction source. Therefore, this low velocity zone is considered to correspond to a magma chamber.

We conducted a first-order leveling survey in Aso caldera in September 2012. From the obtained survey data, we calculated the relative height change of each bench mark referred to a bench mark (AVL-1) which is located at the northern foot of central cones of Aso volcano. The calculated relative heights were compared with those of the 1998, 2003, 2004 and 2008 surveys, resulting in the relative vertical displacement at each benchmark. The resultant displacements show ground subsidence with amount of 1.5cm in the Kusasenri area in the period of 2008-2012, which is almost 60% of 2004-2008 subsidence. Deflation of the magma chamber decelerated recently suggesting increase of magma supply rate to the chamber from a deeper portion.

Keywords: Aso volcano, Caldera, Precise leveling survey, Magma chamber

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An explanation of volcano deformation during an eruption at Sakurajima Showa crater: decompression of open conduit

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It is necessary to investigate spatio-temporal changes of pressure source during the eruptions to understand the dynamics of magma flow in volcanic conduit. In this study, we numerically calculate volcano deformation due to a moving pressure source to investigate the characteristic of volcano deformation during vulcanian eruptions. We compare the results with the observed data at Showa crater of Sakurajima to understand the spatio-temporal change of magma recession.

The vulcanian eruptions are considered as follows. The explosion is triggered by a removal of a ”cap” that pressurizes magma in the conduit. The magma head propagates downward as volcanic ash ejects. As magma head falls down, normal stress applied on the conduit weakens. At the same time, the drag force generated by magma flow is applied on the conduit wall, and its reaction force works on the conduit bottom.

We calculate volcano deformation by using the 3-D boundary element method. We duplicate topography of Sakurajima by 10 m meshed DEM (GSI) and make cylindrical conduit with a radius of 15 m under Showa crater. We calculate tilt and strain on ground surface by the stress as mentioned above.

We calculate radial tilt and strain changes caused by the magma depression and drag force at the ground surfaces just above Arimura and Harutayama stations which are 2.1 km and 3.2 km respectively from the Showa crater. The initial position of the top of magma is set at 650 m altitude. We firstly explain deformation at Arimura caused by normal stress. Tilt does not change remarkably during the magma head is dropped from 650 m to 0 m. Tilt starts to subside toward the crater at about 0 m and turns to uplift at about -1300 m. Strain shows extension at the beginning and turns to contract when the magma head reaches at about -950 m. The tilt caused by the drag force and its reaction force shows uplift toward the crater, and then turns to subside when the magma head reaches at about -1300 m. The strain shows contraction at the beginning, and then turns to show extension at about -950 m. Similar changes are shown at Harutayama. These calculations indicate that recession process of magma in the conduit can be quantified by the tilt and the strain data.

We compare the calculation results with observation records of Showa crater eruption on February 6, 2008, which is reported in Iguchi (2008). The observed radial strain shows a change from extension to contraction about 10 min after the start of eruption. The calculation indicates that the magma head downed to -950 to -1150 m at that time.

When the magma head becomes deeper than -2000 m, the tilt caused by normal stress shows uplift toward the crater, while such a change is not observed. This fact suggests that the eruption stopped at the depth shallower than -2000 m or that another deflation source exists at a deeper portion.

The observed uplift toward the recorded just after the start of the eruption may be explained by upward drag force due to magma ascent at shallower part of the conduit.

Keywords: volcano deformation, Sakurajima, open conduit

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Study of magma accumulation and supply processes based on ground deformation at Sakurajima volcano from 1998 to 2005

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Sakurajima is an active volcano located at the southern edge of Aira caldera. Vertical ground deformation of Sakurajima and Aira caldera during summit eruption activity from 1955 has been mainly detected by precious leveling. The vertical ground deformation has been related to the eruptive activity. The ground has been uplifting since 1946. The uplifting of ground stopped and had showed subsidence since 1974 when number of volcanic eruption began to increase. The subsidence pattern has been modeled with the 2 spherical pressure sources at the center of the Aira caldera (about 10km depth) and at beneath the summit crater (about 5km depth) (e.g. Eto and Nakamura, 1986; Eto, 1989). In contrast, the ground around the Aira caldera turned to uplift since 1993 and eruptive activity decreased except temporal increase in eruptions in 1999. Eruptive activity was shifted to Showa crater in June 2006. In this study, we analyzed GPS data to make clear process of magma accumulation and movement prior to eruptive activity at the summit crater in December 1999 and eruptive activity at Showa crater in June 2006.

GPS data observed by SVO (Sakurajima Volcano Observatory) and GEONET data during 1998-2005 were analyzed. The stations are distributed within about 30 km from Sakurajima. Variable deformation rates are found by the continuous GPS observation. In the periods of small deformation rate from January to December 1998 (phase A) and from September 1999 to November 2004 (phase C), we obtained pressure source at depths 9.6-9.7 km near the center of Aira caldera by assuming a spherical source. By contrast, in the periods of large deformation rate from December 1998 to September 1999 (phase B) and from November 2004 to March 2005 (phase D), we obtained the depths of pressure sources at depths 6-7 km, which were shallower than sources in the periods of small deformation rate. In the periods of small deformation rate (phases A and C), magma was thought to be accumulated to the magma reservoir at the center of Aira caldera. On the other hand, the periods of large deformation rate (phases B and D), pressure source migrated to shallower place. Those periods preceded the eruptive activities at the summit crater in 1999 and beginning of the eruption of the Showa crater from 2006. It is suggested that magma moved to relatively shallow place in those periods.

Volume change rates of the sources in phases A, B, and D were estimated to be $0.95*10^7$ m^3/year, which was close to average magma supply rate at Sakurajima ($1*10^7$ m^3/year). On the other hand, in phase C when the eruptive activity declined after eruptive activity in 1999, volume change rates of the source was estimated to be $0.5*10^7$ m^3/year which was about half of other phases. Increase in eruptive activity may be related to accumulate rate of magma.

Keywords: Sakurajima volcano, Aira caldera, ground deformation, GPS, precious leveling, Mogi's model

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Velocity structure beneath the Aira caldera in southern Kyushu

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Associated with the Philippine Sea plate subduction, a nearly straight chain of active Quaternary volcanism runs almost parallel to Nankai Trough in the central part of southern Kyushu. In this region, there are four large calderas: the Kakuto, the Aira, the Ata and the Kikai calderas.

We applied the tomography method with a fine grid configuration to the P- and S-wave arrival times of 829 local earthquakes well observed at 101 stations in central and southern Kyushu, and revealed the detailed three-dimensional seismic velocity structure of the crust, especially the region beneath the Aira caldera.

In a shallow range from 0 to 10 km depth, low velocity zones (LVZs) are found in the eastern part of Kyushu, where basement rocks are made up of uplifted sedimentary marine terraces (Nakada et al., 2002). The LVZs are also distributed along the volcanic front between Kirishima volcano to Kaimon volcano. Meanwhile, the hypocenters occurred in the inland area are obviously concentrated in regions with a relatively higher velocity and a low Poisson's ratio at a depth of 10 km.

At 20 km depth, the most interesting feature is that a distinctly high Poisson's ratio zone is located exactly beneath the Aira caldera. This compacted zone also extends southward and connects the Aira caldera with the Ata caldera.

At 30 km depth, a small zone with high Poisson's ratio appears to remain beneath the Aira caldera. This small zone is assumed to be a portion of the distinctly high zone at 20 km depth. We also found that the velocity distribution in the western region (Satsuma Peninsula) is quite different from that in the eastern region (Ohsumi Peninsula): the western region is characterized by high P- and S-wave velocities, while the eastern region is characterized by the low velocities.

The anomaly with a very high Poisson's ratio at 20 km depth beneath the Aira caldera possibly suggests the presence of partial melts and the source of volcanism in the area. It is also found that LF earthquakes occur in the lower crust in and around the Aira caldera. A deeper part of the focal zone of these LF earthquakes appears to overlap the high Poisson's ratio zone observed at 30 km depth. These facts lead us to postulate that magma penetrating into the crust from the upper-most mantle may construct the high Poisson's ratio zone at about 30 km depth, and move upwards through the LF focal zone, and finally be stored at about 20 km depth.

Ishihara (1990) described the magma supply system of Sakurajima volcano wherein one magma reservoir is located at about 4 km depth just beneath Sakurajima volcano and another at 8 to 10 km depth beneath the Aira caldera. Although space resolution in our tomography is insufficient to distinguish these magma reservoirs in the upper-most crust, our result puts forward a possibility of the deeper magma reservoir supplying two shallow magma reservoirs previously found.

Keywords: Aira caldera, Sakurajima, Velocity structure

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Active monitoring by using ACROSS in Sakurajima volcano - observation report 2 -

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In March, 2012, we installed the ACROSS (Accurately Controlled Routinely Operated Signal System) composed of two vibrators at the western foot of active Sakurajima volcano (Yamaoka et al., 2012).

The first test operation was carried out during a period from June 12th from September 17th, 2012. The objectives of this operation were to construct the remote monitoring and control manipulation system, and to ascertain whether the seismic stations, belonging to JMA, Hinet, Kyoto Univ. and Kagoshima Univ., located in and around Sakurajima volcano could detect the ACROSS signals. We configured one vibrator with a constant signal frequency of 10.01Hz and the other with a signal frequency range of 12.50Hz +/- 2.50Hz in a linear sweep interval of 50 sec. We found that the signals successfully propagated through the volcanic area: the transfer functions at the seismic stations located in Sakurajima island can be clearly estimated by stacking seismic data during three to five days. On the other hand, the stations around the Aira caldera need to the seven days stacked data to obtain the transfer functions.

On September 19th, we have started the second test operation under synchronized control of two vibrators: one vibrator with a signal frequency range of 7.510Hz +/- 2.50Hz and the other with the range of 12.505Hz +/- 2.50Hz. We also deployed four temporary seismic stations so as to surround the summits of Sakurajima volcano. Our purposes in this operation were to estimate a transfer function in a wide signal range from 5Hz to 15Hz at each station, and to detect temporal change of the function.

At first, we estimated the daily transfer functions for each station by every 5 days stacked data during a whole period of the operation. We simply calculate the mean transfer function for each station from the estimated daily transfer functions, and evaluated the difference (DTF) between the mean transfer function and the daily transfer functions. The DTF in the early part of the daily transfer function, which is corresponding to P wave arrivals, is found to be generally small. On the other hand, the DTF in the later phases is large. We also found that the DFT at some stations clearly and temporally changes. We supposed that the phases with a large DTF possibly indicate the temporal change of the transfer function. To verify the temporal change, we evaluated the travel time change of the phases with a large DTF by applying the cross-correlation procedure. In the presentation, we will report the observation results in detail.

Keywords: Sakurajima, ACROSS, volcano, transfer function

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Precursory eruptions of the 2011 Shinmoedake eruptions, Kirishima volcanoes

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It is important for us to have knowledge of what takes place in the pre-eruption stage of plinian or sub-plinian eruptions on the surface. We also need such information for hazard maps and the forecasting of eruptions in which new vents are opened. We therefore consider the vent position and small precursory eruptions of the 2011 Shinmoedake eruption. Sub-plinian eruptions occurred without a prior distinct increase in earthquakes or land deformations from January 26 to 27, 2011 at Shinmoedake volcano. Therefore, we need to know how to quickly evaluate unusual preliminary phenomena and eruptions for the forecasting for sub-plinian eruptions.

We were able to take fresh ashfall samples generated by the January 19, 2011 eruption, which occurred just 7 days before the January 26 to 27 sub-plinian eruptions. The ashfall deposit was characterized by a low bulk depositional density, with an increase in absorbed water and very fine grains. It is important information of bulk density of deposit meaning fragmentation degree and absorbed water content meaning alterd fragments content for earlier signal of plinian and sub-plinian hazard information in addition. We must search carefully for likely signs of the January 19 ashfall, because we did not find an increase in earthquakes or preliminary signals of the sub-plinian eruption on January 26. For this reason, we need both summaries and detailed discussion of information regarding such precursory or unplugged ashfalls that follow plinian or sub-plinian eruptions, as provided by geological and paleographical surveys in the world. In addition, we need to develop tools or methods to help in the identification of deposit characteristics, e.g., thickness, bulk density, grain size, etc.

Keywords: Kirishima volcanoes, Shinmoedake, 2011, Precursory eruption, ashfall, bulk density

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Three-dimensional seismic velocity structure of the upper crust beneath Kirishima Volcanoes

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Sub-Plinian and successive Vulcanian eruptions of Shinmoe-dake, Kirishima Volcanoes, started at January 2011. Before the eruptions, inflation of the volcano edifice had been observed by GPS monitoring network (GEONET of GJI). Combining the data of GEONET and temporal GPS observations, Nakao et al. (2012, submitted) located a pressure source (Mogi model) at 10km depth beneath northwestern part of the volcanoes (5km northwest of the Shinmoe-dake crater) for the period of magma accumulating process before the eruptions. Several previous studies used artificial explosive sources and natural earthquakes to obtain seismic velocity structures of the volcanoes. Except Yamamoto and Ida (1994), these studies solved velocity distributions limited in the shallow depth ranges from surface to about 3-5km depth (e.g., Tomatsu et al., 2001). Assuming incidence of plane P waves from regional hypocenters and dividing a target volume into blocks of constant velocity, Yamamoto and Ida (1994) calculated P-wave velocity perturbations on each block. The remaining studies did not map the velocity distributions deeper than about 5km depth by limitations of ray paths. The aims of the present research are to show three dimensional P- and S-wave velocity models below 5km to 15km depth derived from data of local earthquakes and to discuss the obtained seismic velocity structure and relation to the pressure source.

Nansei-Toko Observatory for Earthquakes and Volcanoes, Kagoshima University (NOEV) has recorded seismic data observed at seismic stations of Kagoshima Univ., Kyushu Univ., JMA, and NEID in and around southern part of Kyushu, southwest of Japan. 305 earthquakes with 15,221 P phases and 13,649 S phases recorded by 67 seismic stations during the period from 2001 to 2012 were selected to perform this analysis. In the 3-D inversion, we applied methods of grid model (Thurber, 1983), ray tracing with Pseudo-bending (Um and Thurber, 1987), Parameter separation (Pavlis and Booker, 1980), and Damped Least Squares (Aki and Lee, 1976). Damping factor (0.01) was set through the inversions after the performing several quantitative experiments using grid models and observed data. Examining different grid models, the spatial resolution for the velocity model was estimated about 5km horizontally. We also referenced results of checkerboard tests and diagonal elements of resolution matrix (DERMs) to delineate velocity models of only areas where the relative reliable velocity distributions seemed to be obtained. Consequently, we only show the velocities where the interpolated DERMs were larger than or equal to 0.8.

As a result of the 3-D inversions, we obtained reliable P- and S-wave velocities at the depth range of 5-15km beneath the area in and around the volcanoes. Because few seismic stations locate on the volcanoes, seismic ray paths passing through in the shallow part of the volcanoes were limited. Characteristics of the velocity structure at 10km depth are summarized as follows: (1) relative high P-wave velocities (high-Vp, 6.8-7.0km/s) distributed widely beneath the northwest, southwest, and southeast flanks of the volcanoes. The increases of Vp were 10-13%, (2) relative low P-wave velocities (low-Vp, 5.3-5.5km/s) areas, 11-15% decreases, were delineated beneath the whole areas of the volcano edifices, (3) an obvious low S-wave velocity (low-Vs, 2.7-3.2km/s) area, 10-26% decrease, located beneath the northwestern part of the volcanoes. The values of Vp/Vs for the characteristic low P- and S-velocity area were 1.9-2.1 (high-Vp/Vs). The obvious low velocity area contains the pressure source (Nakao et al., 2012, submitted). These features, low-Vp, low-Vs, high-Vp/Vs, and containing the location of the pressure source before the eruptions suggest that a significant volume of magma accumulation existed at the low velocity area and its environs.

Keywords: Kirishima Volcanoes, Seismic velocity structure

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Estimation of magma chamber related to the 2011 eruption of Shinmoedake volcano, Japan

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The estimation of location and geometry of a magma chamber is essential for understanding characteristics of volcanic activities including possible aspects for the future. Previous studies show that t here is a strong relationship between the movement of magma and the surface displacement (Dzurisin, 2006). Basically, when magma injection into the magma chamber causes the pressure increase at the depth, corresponding surface bulge can be observed. The surface area sinks as magma removes from the chamber. In this study, we analyzed GPS data and estimated the magma chamber related to the 2011 eruption at Shinmoedake volcano of the Kirishima volcano group in southwest Japan.

Shinmoedake volcano is one of the most active volcanoes in Japan and started to erupt in January 2011 after long-lasting earthquake swarms which occurred directly beneath the volcano. Prior to the eruption, an extending trend in displacement was observed between Ebino and Makizono from September 2010. After several explosions in February 2011, small-scale eruptions occurred intermittently till September 2011. (JMA report, 2011) There was no eruption in 2012, although the seismic activities continued. (JMA report, 2012)

The data used in this study were GEONET GPS displacement data provided by Geospatial Information Authority of Japan (GSI) from 2003 to 2012 around Shimoedake volcano. The GEONET is a permanent observation station network established for crustal deformation observations. These stations were installed with spacing of approximately 25-30km. In this study, we mainly used nine observation points around Shinmoedake volcano for our analyses. In addition to that, we included southern points from the volcano in order to evaluate ground deformation signals from Sakurajima volcano, which is another active volcano located about 40 km southwest of Shinmoedake volcano. We divided 2003-2012 into five separate terms so as to examine the variations of displacements and calculated possible magma chamber models for each term. The results showed that displacement changes may be explained by a combination of a spherical pressure source and a tensile fault with northwest trend.

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Continuous GPS observation in snow season with a hand-made radome at Mt. Meakan-dake

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Semi-continuous GPS observations were started at the northern flank (FPS), at the northeastern flank (HKT) and at the eastern flank (SMZ) of Mt. Meakna-dake in July 2011 and ended in November 2011. At the eastern part of Mt. Tokachi-dake, same GPS observations were made at two points between August and October, 2011. Those results were shown in the 2012 JpGU meeting. We use Trimble 5700 receivers and Zephyr Geodetic antennas at every station.

In May 2012, we started the observations at Mt. Meakan-dake and ended in November. There is the same seasonal change of coordinates in the both year. We cannot find the difference due to volcanic deformations. Because our observations are carried out only in no snow season, it is difficult to study the seasonal change strictly.

We try to make the observation at SMZ in snow season for the investigations of the seasonal change. There was the relatively less snow at SMZ than at the other two stations of Mt. Meakan-dake. It is thought that the antenna at SMZ will not be buried with snow. The antenna at SMZ installed in a radome. Data in every second are recorded in a 2GB CF card. An amount of data in a day is less than 14MB. It is able to store GPS data until the middle of April

For this observation, a 45cm diameter radome was made. It has a hemispherical dome and a circular sole, which are made of three millimeter thick acrylic acid resin. An Antenna with a tribrack installed in a radome. It is very hard to approach to SMZ in winter. Therefore, we made the other same dome and make observations at Hokkaido University campus in Sapporo city at the same time, for clarifying the observation condition in the snow season.

In the presentation, the results of observations through one year at SMZ will be shown and the effect of snow will be discussed.

Keywords: GPS, Mt. Meakan-dake, continuous observation, snow

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Crustal deformation of Miyakejima volcano, Japan since the eruption of 2000 using dense GPS campaign observation

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Miyakejima Island is an active volcanic Island located about 175 km south from Tokyo, Japan. Miyakejima volcano has had at least 15 historical eruptions and erupted about every 20 years in the past 100 years. The latest eruptive activities began in 2000. These activities included forming a caldera for the first time in 2500 years and gigantic volcanic gas emission that forced islander to evacuate over four and half years. This style was different from the style of the last 100 years.

A dense GPS observation campaign had begun at Miyakejima volcano in cooperation with the University of Tokyo, Kyushu University, and Nagoya University in 1995. At the eruption in 2000, the state of the magma intrusion was captured in detail from the observed displacement. However, this campaign observation had stopped from 2002 to 2010 because of the landing restrictions to the island due to the large amount of volcanic gas emission. We rebuilt the dense GPS network and restarted the campaign observation from 2011. In this study, we examined the magma-supplying system under Miyakejima volcano by means of GPS observations to get insights about the future activity of Miyakejima volcano.

We used the data of our campaign observation of 2011 and 2012 recorded by 45 stations, and the data of four GEONET sites of Geospatial Information Authority of Japan (GSI) in this analysis. The observation data were analyzed by RTKLIB (Takasu et al., 2007) using GPS precise ephemeris from IGS. We estimated the crustal deformation of Miyakejima from 2011 to 2012 from the obtained coordinate values, and calculated the position and volume of spherical source using the software named Magnetic and Geodetic data Computer Analysis Program for Volcano (MaGCAP-V). The result showed there was the small inflation source at a depth of about 3 km beneath Mt. Oyama, which is the central cone of Miyakejima volcano. From this result, we can say Miyakejima have the possibility that the magma supply to the magma chamber leading to the next eruption has begun. We will carry out the observation this year and examine whether the expansion trend continues or not.

Keywords: Miyakejima, GPS, Crustal Deformation

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A study on the oscillation of finite-length fluid-filled cracks

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To explain the observed properties of volcanic seismic signals, various models including resonator models with various geometries and flow induced oscillations have been proposed. Among these, one of the most standard source models of long-period events may be the fluid-filled crack model (e.g., Chouet, 1986). Chouet and his co-workers' studies demonstrated that many of the observed characteristics of long-period events can be well explained by the model. Furthermore, the possibilities to estimate the properties of fluid inside the crack and their temporal change from the observed seismic signals have also been discussed (e.g., Kumagai and Chouet, 2000). However, so far, the oscillation of finite-length fluid-filled cracks has been studied only by numerical methods like the finite-difference method (e.g., Chouet, 1986), the boundary integral method (Yamamoto and Kawakatsu, 2008), and the finite element method (Frechner et al., 2008), while analytical solutions for an infinite-length crack (e.g., Krauklis, 1962, Ferrazzini and Aki, 1987) and a 2-D ellipsoid (Yamamoto, 2007) have been derived. In this study, by feeding back the implications from numerical modeling into analytical consideration, we propose a simple method to obtain an approximate solution for the dynamics of finite-length fluid-filled cracks.

In this study, we consider a thin finite-length crack embedded in a 2-D infinite elastic medium. The crack is filled with an inviscid fluid, and the thickness of the fluid-filled crack is assumed to be much smaller than its length. Under the assumption, the motion of fluid inside the crack can be treated as one-dimensional one, and the distribution of normal dislocation of the crack surface can be well expressed by a series of Chebychev polynomials of the second kind with a weight depending on the position along the crack. Here, it is noted that among the series of polynomials, only the polynomials of low-degree are sufficient to expand the low-order modes of crack oscillation as demonstrated by Yamamoto and Kawakatsu (2008). The fact corresponds to the result of Spence and Turcotte (1985), who showed that the static normal dislocations due to uniform and linearly-varying changes in fluid pressure are expressed by the zeroth- and first-degree Chebychev polynomials, respectively. On the other hand, once we have an expression for distribution of the normal dislocation, we can analytically compute the motion of the fluid. In addition, using the obtained fluid motion in normal and along-crack directions, we can compute the effective bulk modulus of the fluid using the method of Yamamura (1997) and corresponding eigen oscillation of the fluid-filled crack.

For the fundamental mode of the oscillation of a fluid-filled crack, we can evaluate the effective bulk modulus using only the first-degree Chebychev polynomial, because the contribution of the first-degree polynomial to the dislocation distribution is about one order larger than those of higher-degree ones. The resultant effective bulk modulus is about half of that of the fluid, and the result is consistent with an empirical fact that the crack wave velocity corresponding to the fundamental mode is about half of the acoustic velocity of the fluid as pointed by the previous studies. For the higher modes, it is rather difficult to directly apply this method. However, considering that the crack wave velocity approaches to the fluid velocity in the limit of short wavelength, we can make a rough estimate from the result for the fundamental mode.

These results help us in understanding the physical basis of known empirical facts about the characteristics of dynamics of fluid-filled cracks, and at the same time, provide us an alternative efficient method to analyze observed volcanic seismic signals.

Keywords: fluid-filled crack, fluid-solid interaction, long-period event

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Detailed hypocenter distribution of the 2013 swarm activity in Hakone volcano

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Hakone volcano is located at the northern part of the Izu-Mariana volcanic arc in central Japan. Within the caldera of Hakone volcano, fumarolic activity has been observed around the Owakidani area. Many intense earthquake swarms have been reported. Recently, remarkable earthquake swarms were observed in 2001, 2006 and 2008-2009. Accompanying the 2001 activity, crustal deformation was detected by the tiltmeters and GNSS stations net-work (Daita et al., 2009). After the swarm activity in 2001, new fumarolic area emerged at the northern slope of the Owakidani area (Tanada, 2005). Since January 2013, the seismicity in Hakone volcano has been again activated. Synchronizing with the seismic activity, crustal deformation has been detected by the tiltmeters and GNSS stations net-work. To determine highly resolved hypocenter distribution is important to discuss mechanism of swarm earthquakes, and to clarify relationship between the swarm activity and the crustal deformation. We applied the Double-Difference method (Waldhauser and Ellsworth, 2000) to relocate the hypocenters of the swarm earthquakes using the data of the differential arrival time obtained by both manual picking and waveform cross-correlation analysis. We will present detailed characteristics of hypocenter distribution in this currently developing swarm activity.

Keywords: Swarm earthquake, Hakone volcano, Hypocenter distribution

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Geothermal activity around Owakudani at Hakone volcano: Recent growth and migrations of new vigorous steaming grounds

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Owakudani is located in the north side of the central cone at Hakone volcano, and its fumarolic activity is active. In this area, a fumarolic activity is active and the steam is rising from surface. The great earthquake swarm activity at Hakone volcano has been occurred from June, 2001. After this event, a fumarolic area crosses the ridge of Owakudani and the steam is found also along the northern side of Owakudani.

In some places, the tree has withered and broken down at the newly generated fumarolic area. Although the new fumarolic area was spread from Owakudani to Kamiyuba until 2010, it activated after 2011 on the western side. Even now, it is growth or migrations in the new fumarolic region.

We observed ground surface temperature using infrared thermal camera. We discuss about the relationship between the change of surface condition and geothermal field, and the earthquake swarm activities in Hakone volcano.

Keywords: Hakone volcano, streaming ground, infrared thermal camera observation, ground surface temperature, geothermal field, surface condition

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Crustal Deformation According to Earthquake Swarm Activities and Estimation of the Volcanic Deformation Source at Hakone

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The seismicity in Hakone volcano, central Japan, has been gradually activated since the beginning of January, 2013. The hypocenters of the earthquakes are mainly distributed in the shallow region beneath the central cone of caldera. In synchronization with this seismic activity, tilt changes were detected by the tiltmeter in and around the caldera of Hakone volcano. It is hypothesized that the crustal deformation was caused by pressure from a Mogi point source at a deep part, and a shallow open crack in the caldera. We will present the characteristic of the seismic activity and the source models for crustal deformation associated with this activity.

Keywords: Hakone Volcano, tiltmeter

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Three-dimensional electrical resistivity structure around Hakone volcano, Japan

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Seismicity around the Hakone volcano was activated just after the arrival of surface waves caused by the 2011 off the Pacific coast of Tohoku Earthquake. Most of these triggered earthquakes had similar distribution to prior occasional swarm activities. In order to image electrical properties around such seismic events, we carried out audio-frequency magnetotelluric (AMT) measurements at 39 sites in December 2011 (Yoshimura et al., 2012). The spatial distribution of the induction vectors and the phase tensor ellipses suggests that conductive bodies may lie beneath the remarkable regions around which the seismicity increased abruptly just after the occurrence of the Tohoku Earthquake.

In this study, we conducted 3D modeling of dense AMT/MT data (Yoshimura et al., 2012; Ogawa et al., 2012), to figure out electrical characteristics around the triggered seismicity. The full components the impedance tensors at 51 sites in total were inverted using the code developed by Siripunvaraporn et al. [2005]. Significant characteristics of the obtained three-dimensional resistivity model are: (1) the most of the triggered earthquakes, which occurred shallower than a depth of 4km, seem to align along resistivity structural boundaries; (2) surface conductive blocks, in which there were very few earthquakes, were observed beneath not only fumarolic areas but geothermal non-active regions.

Keywords: magnetotellurics, three-dimensional inversion, resistivity structure, Hakone volcano, triggered earthquake, earthquake swarm

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Estimation of magma migration in the initial phase of the 2000 Miyakejima eruption (1)

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1. Introduction

In the case of the Miyakejima eruption in 2000, it is confirmed that the large scale dyke intruded from the observations that hypocenter migrate from in the area of Miyakejima to Kozushima and Niijima between June 27. 2000 and July 1. 2000 as well as large ground inflation is measured by nation-wide GPS network. Several dyke intrusion models have been supposed in previous studies, but the detail process in this event has not been unsolved because hypocenter locations cannot be estimated precisely. Hypocenter migration is one of the most important information on magma migration, but is not well determined in this case, because the seismic stations are located in islands where are apart from hypocenter area. It is needed to relocate the hypocenters for improving the insight on the dyke intrusion process.

In this study, we try to relocate hypocenters occurring during June 28 ? July 1 (hereafter, target earthquakes) using the cross correlation (hereafter, CC). After the large scale dyke intrusion concluded, ocean bottom seismometers(OBSs) were installed just above the hypocenters area on July 2. Using OBSs data, the precision in hypocenter was improved very well. We try to relocate the hypocenters of the target earthquakes using waveform similarity with earthquakes (hereafter, reference earthquakes) whose hypocenters are well estimated by OBSs. From above analysis, we try to get more information of large scale dyke intrusion.

2. Data and analysis

We chose 6695 earthquakes for target earthquakes. Hypocentral migration in this period covers the main part of the area of the dyke intrusion from conventional analysis. We checked waveform similarity of the target earthquakes with the reference earthquakes. We used 1-8Hz band pass filtered waveforms of P wave onsets. We calculated CC of June 28-29 with 144 reference earthquakes firstly.

3. Results

Now, we have calculated CC and found out the pairs earthquakes with similar waveform among the target earthquakes and the reference earthquakes. Following results are revealed.

(1)The waveforms of 2110 earthquakes from whole located earthquakes occurring on June 28-29 (2886) have high CC with reference earthquakes. It demonstrates that we can relocate the many hypocenters during the large scale dyke intrusion using waveform correlation.

(2) Many earthquakes during the large scale magma intrusion have similar waveforms with those of a part of reference earthquakes (hereafter, core events) whose hypocenters are closely located at the midpoint between Miyakejima and Kozushima at depth of 8-13km. Seismic activity of the reference earthquakes is characterized by burst-type activity with upward migration. Among the reference earthquakes, the core events are located at the initial point of burst type activity. It may suggest that earthquake generating process such as localized pressurization continues during whole process of the large scale dyke intrusion. Further analysis is required to reveal the detailed process.

(3)The earthquakes which have good correlation with the reference earthquakes occurring in the area of around Kozushima started at 07:00 on June. 28 and there is no such earthquake before the time. This does not contradict the results of precious researches that showed hypocenters migrate northwestward.

4. Future study

We found the good correlation in waveforms of the events of June 28-29 with reference earthquakes, and hereafter we will relocate hypocenters of target earthquakes using CC. In addition, we will read onset of OBSs data which have not been analyzed yet and increase reference earthquakes to analyze waveform correlation. Thus, our last goal is to relocate precise hypocenters precisely and investigate the dyke intrusion in the initial phase of 2000 Miyakejima eruption.

Keywords: Miyakejima volcano, earthquake family, dike intrusion, the 2000 Miyakejima eruption, hypocentral migration

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The volcanic activity monitoring with the concentrated observation in Izu-Oshima Island

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Izu-Oshima Island is one of 110 active volcanoes which exist in Japan and is given status as the volcano where needs suitable monitoring system for volcanic disaster prevention. The cycle of middle-scale eruption is about 30-40 years on and after twentieth century. The last eruption in this volcano occurred in 1986 and about 30 years passed. So we have to prepare for next eruption.

Geospatial Information Authority of Japan is monitoring volcanic crustal movement by 6 GNSS monitoring points including GNSS-based Control Station. We have installed the automated distance and angle surveying system (Total Station) around the caldera in 2002 and have been monitoring the movement.

In 2012 we conducted the concentrated observation that is leveling and gravity survey addition to usual monitoring. The leveling that survey both bench marks and temporary points allows us to the following vertical movement. That movement has high space density and accuracy. By comparing with result in 2008, we could find the elevated area in caldera and the downward area at northeast and southwest part of the Island. In addition, it conducted gravity survey on bench marks in caldera, GNSS-based Control Stations and absolute gravity points in circumference of Island. In consequence of comparing with gravity value at 2008, it trend to increase the value of points around a crater of summit, MOTOMACHI port in west side of island and HABU port in south side, on the other hand, to decrease it at east and north side in the outer rim of a crater, and north side of island.We will report the review and a comprehensive consideration for their results.

Keywords: Izu-Oshima Island, GNSS Earth Observation, Leveling survey, Gravity survey, Automated distance and angle survey

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Geometry of pressure source beneath Izu-Oshima inferred from vertical component of volcanic deformation

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In Izu-Oshima Volcano GPS observation of volcanic deformation has been conducted since 1990s, and it is suggested that the volcano is continuously inflated in long-term. Onizawa el al.(2012) investigated intensively on the long-term change of the deformation by the GPS displacement data, picking up observation points which had no data gap caused by replacement of the GPS antenna. Analyzing the three component displacement of the long-term change using the Mogi model with altitude correction, a pressure source was estimated located beneath the northern part of the summit caldera at depth of 6.68km. We carried out further research on the deformation and on the source.

The displacement at each station, depending on the horizontal distance from the source, has following features: for horizontal component, the displacements by the observation and by the calculation using the Mogi model are similar to each other; for vertical component, the observed and calculated values are rather different, that is, the vertical displacement (uplift) is largest at 0km distance by the calculation, though the observed uplift has no clear dependence on the distance from 0km to 5km, exactly speaking, the uplift at 0km distance is a little smaller than at 2 or 3km. The observed long-term displacement in Izu-Oshima cannot be fully explained by the Mogi model especially for the vertical component in the summit area, namely the observed uplift is smaller than expected.

The difference can be caused by some factors such as topography of volcano, underground structure and a pressure source of not simple shape, all those are not accounted in Mogi model. In order to understand the long-term deformation in Izu-Oshima precisely, it is necessary to consider these factors to analyze the displacement. In our investigation finite element models with various shapes of the deformation source were utilized, assuming axisymmetric structure and topography. The source has a prolate spheroidal shape elongated vertically with aspect ratio from 1.0 to 4.0 as a parameter. The source depth, the other parameter, was in a range from 3.0km to 8.0km. The finite element analysis was carried out with all combinations of parameters to solve the horizontal and vertical displacements on the surface.

Searching in the parameter space, we found that calculated value was most similar to the observation when the source depth was about 4km and the aspect ratio was larger than 3. The uplift around the summit, that was a little less than in the surrounding area, was realized by the model. Compared with the case of the Mogi model, the source depth was quite shallow and the change of source volume was about a half. A calculation on a finite element model with the uniform structure implied that the shape of the source had larger contribution to the feature of deformation than the underground structure.

Keywords: volcano, Izu-Oshima, crustal deformation, finite element analysis

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Seismic activity beneath the Hakusan Volcano in Oct. 2012 and Jan.-Feb. 2013

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No volcanic activities have not observed since the 1659 eruption except the appearance of a blowhole in 1935. It is, however, pointed that the Hakusan volcano may reactivate its volcanic activity on the near future from studies of past activities based on tephra stratigraphy and historical records (Moriya, 2000). The seismogenic zone just beneath the Hakusan volcano is shallow, 0˜1 km (Takahashi et al., 2003), and a low velocity and high Vp/Vs region exists in the depth of 10˜14 km beneath the volcano (Takahashi et al., 2004). Four swarm activities and the largest event of Mj4.5 for recent 30 years were observed in 2005 beneath the volcano. We observed swarm activities in 2008 and 2009. We report here recent seismic activity, seismic activity in Oct. 2012 and Jan.-Feb 2013, beneath the Hakusan volcano.

We use the velocity structure of Takeuchi (1978) and the formula of magnitude of Watanabe (1971) in this study. For seismic events in Oct. 2012, most of the events are distributed 1 km off north from the summit and the hypocentral depths are 0-1.5 km. We estimate fault plane solutions using the polarity of P-waves for larger six events. Five events show strike-slip types with the compression axes of E-W and NW-SE while one event normal type with the extension axis of NW-SE. Seismic events in Jan.-Feb 2013 are characterized by two events as mainshock over M3, which has never observed since 2005. The hypocenters are distributed 0.5 km off east from the summit and 1-2 km in depth. The largest five events show strike-slip types with the compression axes of E-W and NW-SE, which are coincident with the regional stress field. We observe no volcanic tremors and low frequency events through the analysis period. These facts suggest that these seismic activities do not relate to the magmatic activity beneath the Hakusan volcano.

Keywords: Hakusan, swarm earthquakes

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Automatic hypocenter determination of deep low-frequency earthquake beneath Mt. Asama volcano

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1.Introduction

Deep low-frequency (DLF) earthquakes beneath active volcanoes are considered to occur related to magma activity in the deeper part and studied since 1980's. But since their relationship with surface phenomena such as eruptions seems not to be so clear unlike that of shallow volcanic earthquakes, accumulation of analysis of DLF earthquakes is not enough. For the further accumulation of analysis, it is very important to detect more DLF earthquakes. Japan Meteorological Agency (JMA) monitors seismic activity with Earthquake Phenomena Observation System (EPOS) using data from seismic observation points operated by JMA, universities, National Research Institute for Earth Science and Disaster Prevention (NIED) and other related organs and make the seismological catalogue of the JMA. In the catalogue, "low-frequency" flags are appended to earthquakes occurred at 10km depth or deeper. LFE earthquakes can be distinguished from other earthquakes by them. But, data of seismometers which are operated in volcanic areas is not used in this process. On the other hand, these seismometers are used mainly to monitor shallow volcanic earthquakes. Hence for monitoring of LFE earthquakes, data of seismometers in volcanic areas is not considered. Then we tried to improve detecting power of LFE earthquakes by using data of them.

2.Analysis

We examined LFE earthquakes occurred beneath Mt. Asama, one of the most active volcanoes in Japan. We use waveform data obtained at 12 observation points on the volcanic body operated by JMA (10 points) and NIED (2 points). We also used waveform data from 7 points of High Sensitivity Seismograph Network (Hi-net) operated by NIED near Mt. Asama.

We made a program for automatic detection and hypocenter determination. We used modified energy ratio (MER) method (Hang et al., 2010), which is regarded to be more useful than STA/LTA method for time-picking in noisy waveform data, for detection of earthquake signal and picking of arrival time of P-wave and S-wave. We regarded the time section where signal appeared about the same time as the time earthquake was occurring to remove the effect of non-seismic oscillation of seismometer. We calculate the hypocenter with hypomh, hypocenter calculation program by Hirata and Matsu'ura(1987) using P-wave arrival time and S-wave arrival time at the observation points obtained with MER method. After the hypocenter calculation, we.

Keywords: Mt. Asama, deep low-frequency earthquake, automatic detection, automatic hypocenter determination

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Cyclic activity of earthqaukes and ground deformation observed during the 1991-1995 dome growth at Unzen Volcano, Japan

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Unzen Volcano in SW Japan began to erupt on November 17, 1990, and growth of an associated dacite lava dome occurred from May 20, 1991 to early February 1995. The volume of extruded lava is estimated to be about 0.21km^3 (Nakada et al., 1999). Pyroclastic flows occurred frequently during the dome growth.

Just before the dome emergence and during the dome growth, cyclic tilt oscillation within a period of 1 to 3 h was observed in the EW component at the FG1 station located about 680m west from the crater. Yamashina et al. (1994) assumed that the oscillation presented the repetition of inflation and deflation at the uppermost part of the active vent, suggesting a cyclic upward flow of lava with high viscosity. They made a formula to successfully estimate the daily supply rate of lava using the magnitude of tilt oscillation. Umakoshi et al. (2011) revealed that the HF seismicity in the crater area around the dome emergence of May 20, 1991, increased and decreased repeatedly within a period of 1 to 2 h, which correlated with tilt cycles in such a way that the seismicity increased during uplifting on the side facing the crater. In contrast, when the craterward ground was subsiding, the seismicity rate was much lower. However, it has yet to be investigated whether such synchronization emerged in other periods of dome growth or not except for the period from October 1994, when a lava spine was growing (Yamashina et al., 1999). In this study, therefore, we investigated the relationship between tilt oscillation and temporal changes of seismicity level during the entire period of dome growth.

We used the tilt data at FG1, which were telemetered to the Shimabara Observatory of Kyushu University, and the earthquake list created by Umakoshi et al. (2008). Using earthquake counts in 10-min intervals and the tile data, we calculated cross-correlation coefficients in the time window of 12 h. As a result, we found three periods in which the temporal changes of the seismicity level correlated with the tilt oscillation. These were after November 1993, when the HF seismicity level was high. However, the manner of synchronization was different from that found in May 1991, that is, the seismicity rate increased gradually during the uplifting on the craterward side, and then decreased gradually during subsidence on the craterward side. This suggests that the source process of HF earthquakes is different between the cases in May 1991 and those after November 1993. No clear correlation with tilt oscillation was found in the period from June 1991 to October 1993, when the LF seismicity level was high. Also, there are some cases in which the temporal changes of HF seismicity did not correlate with the tilt oscillation. These indicate that the synchronization between tilt oscillation and seismicity level emerged only in parts of the periods when the HF seismicity level was high.

In other cases of cyclic activity of earthquakes, we found the temporal changes of the seismicity level related to the occurrences of pyroclastic flows. Also, we investigated the relation between tilt oscillation and seismicity level during the growth of a lava spine in detail.

Keywords: lava dome, tilt oscillation, cyclic activity, seismicity, high-frequency earthquake

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Geomorphological Growth of Lava Domes

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The lava dome is one of the remarkable shapes in volcanic landforms. The average height and diameter are about 540m and 170m, and the range of the aspect ratio is 0.125-0.35. Lava domes have been formed at 58 volcanoes in the world, including 3 volcanoes in Japan, since 1900, but little comparative study on the growth of a lava dome has been carried out.

In this work, we try to investigate features of the lava dome growth through the comparison with temporal changes in the height and the radius of lava domes.

It was only 9 lava domes that the height and the radius of a dome continuing to grow were observed. The normalized height-time and radius-time curves show that the height and the radius increase with the time according to logarithmic or power low, and they exceed 50% of the maximums for 5-20% of the whole growth time. The curves suggests that the termination of the dome forming activities and an ultimate size of the lava dome can be predicted from the temporal changes in the height and/or the radius of a lava dome. The height-radius relations of each lava dome reveal that growth paths branch in two directions at the transition zone from the higher growth rate to the lower one. The two directions are approximately parallel with the height-radius relation line of Peleean dome and of Low lava dome (Blake, 1990) respectively.

We also investigate a morphological feature of spines accompanying some Peleean domes. The aspect ratios of them fall between the lower limit of 0.35 and the upper limit of 3.0, and the maximum heights are less than the upper limit of 300-350m.

Although the height and the radius data from only 9 domes allow to lead two features of the lava dome growth, more detailed topographic data during the growth of a lava dome are required to better understand the feature of the dome growth. The result suggests the possibility that we can predict growth periods and size of lava dome. It will be necessary to measure even height and a diameter.

Keywords: Lava dome

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Possible application of stroboscopic muography to monitoring periodic eruptions

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Many of the muon radiography observations have been applied to static objects, but some dynamic studies have so far been performed (e.g. imaging before and after the 2009 Asama eruption; Tanaka et al., 2009). One of the reasons which makes it difficult for us to perform real time or rapid time sequence radiography is the relatively low intensity of the cosmic ray muon flux that leads to long integration times to reach an adequate contrast in radiographic images. However, such low cosmic ray muon flux can be compensated for by averaging a large number of short acquisition frames, as in the case of periodic processes. If we assume a vent, with a radius of 10 m to detect it through 400-mwe-thick rock, the horizontal penetrating muon flux will be $5x10^{?5}$ $sr^{?1}cm^{?2}s^{?1}$ and $7x10^{?5}$ $sr^{?1}cm^{?2}s^{?1}$ for the filled and vacant vent respectively. A detector with an active area of 4 m^2 and the required angular resolution of 100 mrad, located at a distance of 200 m from the vent, can therefore collect 0.02 and $0.03^{?1}$ for each condition, and 2500 eruption events can distinguish these conditions in 1 s at a 3 sigma confidence level. 2500 eruption events are not unrealistic if we consider that 110 eruptions were observed in Stromboli between 14 and 17 October 2007 (Goto et al., 2008). In this work, we evaluated this idea by utilizing a comprehensive model system that consists of a muon detector with an active area of 0.16 m^2 and an electric furnace with a diameter of 15 m as a periodic test target. The variations in the density contrast were clearly observed in the furnace with a period of 12 hours by averaging 17 frames. The result infers a possible application of stroboscopic muography to monitoring periodic eruptions.

Keywords: muon, radiography, stroboscope