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

SVC050-P01 Room:Convention Hall Time:May 23 16:15-18:45

The development of infra-free and portable muon counting system for muon radiography

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We will report the development of portable and infra-free muon counting system with silicon photon-counting device, which will achieve more frequent observations for muon radiography. We are hoping for discussing what kind of geological information can be retrieved with the new muon detector.

Muon radiography is a non-destructive inspection based on high penetration power of cosmic ray muon. It has been applied to several volcanoes. For example, the observation at Mt.Showa-Shinzan (Tanaka.et.al,2007) found the density excess which implies the intrusive magma. In Satsuma-Iojima Island, the density deficit below the crater was detected which indicates the existence of high porosity region. In addition, three-dimensional tomography with dual observations was conducted in Mt.Asama(Tanaka.et.al,2010).

However, all of these observations were conducted where the infrastructure (e.g. electricity and road) was well-organized. If we can improve the flexibility in measurement location, more comprehensive search for various volcanoes becomes possible. For instance, we could place a detector near an active volcano and could detect the movement of magma in a vent. Three-dimensional tomography will be more easily achieved.

The present muon detector comprised of plastic scintillators and photomultiplier tubes (PMTs) requires commercial electricity or huge solar panels (at least 1 meter square). Therefore, the measurement locations have been limited. A more power-effective and light detector has to be developed. For these purposes, silicon photon-counter MPPC(Multi-Pixel Photon Counter) is a feasible device because it is small ($<$ 1cm cube) and does not need high voltage compared with PMT (70V for MPPC and $>$ 1kV for PMT). If we can build a detector with MPPC, the power consumption of front-end electronics becomes almost negligible. MPPC is also good at cost compared with PMT (50 USD for MPPC and 1000 USD for PMT per channel).

In this report, the inspection of MPPC's performance and the whole design of MPPC muon counting system will be explained. The authors are hoping for discussing the possible applications to volcanology.

Keywords: muon, radiography, density structure, MPPC

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Development of a small unmanned aerial vehicle with GPS-guided automatic navigation for volcano observation

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An unmanned aerial vehicle (UAV) named ”Sky-1 Stonefish” with GPS-guided automatic navigation system was developed as a tool that the researchers and the staff of the municipality who investigate volcanic field were able to operate easily and at low cost. Sky-1 Stonefish was developed from a radio-control (RC) UAV ”Sky-1” . RC Sky-1 had shown good performance at volcanic fields, but the actual control range is limited to ˜400 m by human ability. To overcome this defect, GPS-guided autopilot system Ardupilot was added to Sky-1. Ardupilot is a low-cost autopilot system based on the Arduino open-source hardware platform. It uses 3 axis accelerometer and three gyro sensors for stabilization and GPS and Pitot tube for navigation. The strong points of Sky-1 Stonefish are as follows: ”An electric ducted fan is employed to secure the safety”, ”Portable on one’s back because of the new design of the airframe division”, ”The payload that reaches 300 g is reserved”, and ”Achievement of the high flight performance against the strong wind around 10 m/s”, etc. RC Sky-1 was tested at Kusatsushirane volcano, Aso volcano, and Izu-Oshima, and Autopilot Sky-1 Stonefish was tested at Izu-Oshima and Kansai Mokei Airport (Uji, Kyoto). The design and performance of SKY-1 Stonefish will be presented.

The specification of Sky-1 Stone Fish is listed as follows;
Name: Osaka University Sky-1 Stonefish,
Maximum length: 90 cm,
Maximum width: 90 cm,
Airframe Material: Expanded polypropylene (EPP),
Weight: 500 g (with a battery),
Payload: 300 g maximum,
Battery: 11.1V Lithium-polymer battery,
Propulsion: Ducted fan with brushless motor,
Thrust: 500 gf, Control: 3 ch (motor, aileron, elevator) by GPS waypoint navigation,
Flying range: 3˜4 km (with a standard battery)

Keywords: UAV, robot, GPS, volcano, airplane, arduino

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Trial of measuring hydrogen isotopic ratios of water vapor in fumarolic gas collected in a gas bag

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1. Introduction

Isotopic ratio of water vapor in fumarolic gas reflects geothermal structures where magmatic water is mixed with meteoric water, and it is one of the indicators which represent the state of volcanic activity. We are evaluating the method to collect volcanic gas with gas bag in order to develop the gas-collecting method using mobile vehicles such as an Unmanned Aerial Vehicle. Because the amount of water collected in a gas bag is little, we applied "Zn shot method"(Coleman et al., 1982) to reduce the water into H_2. However, the percentage of success of the reduction was low, so we reviewed the factor of our failure.

2. Fumarolic gas samples

We collected condensed water and gas samples from Kengamine fumarole in Mt.Mihara, Izu-Oshima. The samples are 100 mL water condensed from the fumarolic gas by iced-water, and gas collected in 10 L gas bag just above the fumarole (Bag 1, 2, 3), gas collected in 10 L gas bag about 10 m above the fumarole along slope (Bag 4, 5, 6) .The 2 micro L of the condensed water measured with microcyringe was packed into a reduction glass tube with Zn shots using a glass-line. Water samples in gas bags were also extracted and packed into the reduction tube in the same way. The maximum amount of water in the gas bag was estimated to be 10 micro L.

3. Experimental method

The reduction tube containing Zn shots and water was set into a mantle heater whose temperature was set to 490 to 495 deg C to reduce the water. The reduction time was set to 30 minutes. After reduction, Zn metal re-condensed on inside the tube like mirror. We judged the end of the reduction by appearance of the mirror. Hydrogen isotopic ratio of samples was measured on a mass spectrometer of Sercon, Geo20-20.

4. Results

Three samples of the condensed water were succeeded in reduction, and their hydrogen isotopic ratio were delta D_{SMOW}=-69 permil. This value is consistent with the result of Ohba(2007). The reduction of the sample of Bag 2 had not finished for 30 minutes heating. The reduction of the samples of Bag 5 and 6 also had not finished for 30 minutes heating, therefore the duration of reduction was extended for another 30 minutes. The isotopic ratio of Bag 5 sample is delta D_{SMOW}=-78 permil and that of the Bag 6 is -141 permil. There is wide difference between the isotopic values of 2 samples, though they had been collected in the same site.

5. Discussion

The results show that there were some problems in the processes of Zn shot method. The reduction processes have 3 steps, evaporation of Zn, diffusion of Zn vapor, and reduction of water. Every step can be hindered by excess water vapor pressure. We have estimated the influence of initial water content on the diffusion and reduction steps.The diffusion profile of Zn vapor was calculated for the two initial water contents; 2 micro L (proper amount), and 20 micro L (excess amount). We derived diffusion coefficients D of Zn from its mean free path for two cases. Using these D values, we calculated the profile of Zn vapor contents in the reduction tube by the finite difference method. The result shows there is little difference in the Zn content profiles between these two cases.Next, we estimated the equilibrium constant of the reduction at 500 degC, and calculated hydrogen partial pressure in equilibrium state for 2 and 20 micro L of water content. The result indicated that in both cases, hydrogen partial pressure nearly equals to total pressure.The results of our calculations suggest that, as far as Zn vapor is supplied from solid Zn, Zn vapor spread sufficiently within the tube, and all the water is reduced to be hydrogen. The remaining cause of failure in case of excess amount of initial water would be inhibition of Zn evaporation. When oxidation speed of Zn is faster than its evaporation speed, the surface of Zn liquid might be immediately covered with the film of ZnO.

Keywords: Zn shot method, water vapor, hydrogen isotope, fumarolic gas

Japan Geoscience Union Meeting 2011
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Tilt response of broadband seismometer

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Recently,we often use boradband seismometers to mesure long period motion near the volcano. We know clearly broadband seismometers have enough sensitivity to tilt change. We can calculate the trace under the equation of motion of the seismometer. The trace is gave to convolve a tilt motion with a responce function of tilt change. On the other hand, tilt motion is gave to deconvolve a trace with that. In this study, to ascertain whether the trace of broadband seismometer on tilt change consists previous calculated result.

To estimate tilt motion at the Kirishima volcano in the future, I used Trillium40, Trillium120 and CMG3T. I will express how to check below. First, I put seismometer on one side of 1m plate. Second, I move the other hand fluctuation. If the displacement is smallness than the length of the plate, I can approximate the tilt by displacement. I mesure the displacement with a dial gauge and a laser. I gave a few micro radian.

I resulted that the trace of horizontal component consists the result calculated from the equation of motion. And vertical component is smallness than that. The application of this result to real observed data is the future work.

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SVC050-P05 Room:Convention Hall Time:May 23 16:15-18:45

MaGCAP-V (4) -Upgrade for gravity data and shperoidal model

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

MaGCAP-V Version 1.1 (released in 2005) handles the following data, 1) GPS (X,Y, Z, latitude, longitude, and ellipsoid high), 2) displacement (also leveling data), 3) tilt, 4) magnetic total intensity, 5) atmospheric pressure, temperature, humidity, precipitation, and 6) hypocenter. DEM data (GSI DEM or user's DEM) are used for the modeling and drawing the topography. And also users can use the vector data to display the lakeshore and fault, etc.

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

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

MaGCAP-V was upgraded for the application to electro-optical distance measurement (EDM) data, interferometric SAR (InSAR) data and analysis of dynamic process in 2009, and was upgraded for gravitmetric data.and spheroidal model (Sakai *et al.*, 2008), and improvedt of performance through programming for maluti-threading CPU and double buffer in 2010..

Acknowledgements

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

Keywords: software, volcano monitoring, gravity, GPS, InSAR, EDM

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Stratigraphy of the 1883 Krakatau Mega Eruption and Tsunami in the Coastal Area of Java and Sumatra, Indonesia

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The 1883 mega eruption destroyed large part of Krakatau and formed a 7 km diameter caldera. During the paroxysmal stage, a series of eruption and tsunami occurred and destroyed more than 250 coastal villages along the Sunda Strait. This tsunamigenic volcanic activity left a unique stratigraphy along the coastal zone of Sunda Strait. This stratigraphy was formed by successive deposition of tephra and tsunami deposit, and also erosion by tsunamis. These near-field volcano-related tsunami deposits are different from usual sandy tsunami deposit caused by subduction-type earthquakes. The tsunami layers sometimes contain pumice and/or ash that have been carried up inland together with beach sand from their original position by the tsunami run up. In this study, we conducted field work at two sites in the coastal area of Java (Anyer, located 45 km east of Krakatau volcano and Carita, located 40 southeast of Krakatau volcano) and two other sites in the coastal area of Sumatra (Tarahan, located around 50 km north of Krakatau volcano and Limus, located around 70 km northwest of Krakatau). This geological work is important to reveal transport and depositional processes of the tsunami deposits. Beside careful examination of sedimentology characteristics, we used historical record account in conjunction with the stratigraphy characteristics. At each site, the stratigraphic profile is different, but all composed of sand layers intercalated by ash and pumice layers. The ash layers contain shell fragments with no lithic in Tarahan, and they contain shell fragments and foraminifera with minor lithic and heavy mineral in Anyer. We interpreted this layers had been deposited by the tsunami. The shape of the pumice is also a key feature for this recognition. The shape of pumice fragments in Limus is more angular than that of other locations. This pumice layer does not contain any shell fragments nor foraminifera. We interpreted this layer as the primary tephra fallout deposit. This conclusion is also supported by historical record in which the pumice fall was apparently directed to the west. As the depositional processes of the deposits obtained, thus the chronology of eruption and tsunami during the paroxysmal stage of the 1883 Krakatau eruption can be described.

Keywords: Krakatau, eruption, tsunami deposit, stratigraphy, historical record, 1883

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The volcano monitoring system installed in 47 active volcanoes

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JMA installed the observation system, including seismometers, GPSs, infrasonic sensor in 47 active volcanoes. We will report the overall information about the installation and the observed data.

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Migration of tremor locations associated with the 2008 eruption activity at Meakandake volcano

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We estimated locations of three tremor sequences occurred during the 2008 activity at Meakandake volcano, using the observed RMS amplitude at each station. While the tremor on Sep. 29(tremor A) were located about 1.5km far from the erupted crater, the continuous tremor on Nov. 18(tremor C) were located close to the erupted crater. The tremor on Nov. 16(tremor B) were divided into three phases by the temporal variations of amplitude. The first and second phases were located at similar points to that of tremor A, while the location of the later third parts was similar to that of tremor C. Locations are migrated systematically from far to close the erupted crater. In addition, locations of tremor B were changed in time, which implies the migration of volcanic fluid, as suggested by other geophysical observations. These two migration phenomena may be important for monitoring of volcanic activities as well as studies on the mechanism of volcanic eruption.

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Resistivity structure around the Kutcharo caldera

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Kutcharo caldera hoards potentials of disaster eruptions. From disaster prevention point of view, it is surely important to comprehend the mechanisms of eruptions of this volcano. This volcano belongs to Akan-Shiretoko volcanic line, the western end of Kurile volcanic line, which shows offset collocation. The offset is also clear around Kutcharo caldera, from topography and the gravity anomaly map. From this standpoint, the Kutcharo caldera locates on the offset point of the volcanic line. Several geophysical approaches for this area exist, however the precise structural model had never been proposed around this region. For instance, Satoh et al. (2001) installed three observation lines of MT survey over the Eastern Hokkaido region, while Nakanishi et al. (2009) executed seismic exploration over this area. Still, there are no arguments for the magma provision.

We executed MT survey around the Kutcharo region, during 2009 to 2010, and examined 2-D inversion analyses (Ogawa and Uchida, 1996), for five profiles. The observed data shows acceptably good quality. The strike angle of this region is assumed to the direction of the volcanic line. So the observation point is allocated for direction across the volcanic line. The principal axes of impedance phase tensor, for the southern part of the region, align across the volcanic line as expected. But it mostly deviates in the northern part. Therefore, we chose the TM mode analyses. The strike direction is decided by the rose histogram of the principal axis of impedance phase tensor.

The consequent resistivity structure shows aspects as follows. For all profiles, surface layer shows high resistivity, due to tephra. Then, the Tertiary stratum shows low resistivity. Then again, middle crust shows high resistivity. And the extraordinary low resistivity body penetrates the high resistivity crust. The resistive body rises to the Atosanupuri volcano. The top of this body rises to 6 km under the Atosanupuri volcano. The depth coincides to the source depth of the diastrophism, which reported from InSAR analyses during 1994 to 1995, accompanied an earthquake swarm.

Nakanishi et al., 2009. Tectonophysics, 472, 105-123.
Ogawa, Y. and Uchida, T., 1996. Geophys. J. Int., 126, 69-76.
Satoh et al., 2001. EPS, 53, 829?842.

Keywords: MT survey, resistivity structure, caldera

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Geomagnetic changes over Usu Volcano detected from aeromagnetic repeat surveys

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1. Introduction

We conducted an aeromagnetic survey over Usu Volcano in September 2010. The survey was planned to compare the previous one in June 2000 by GSJ, AIST (Okuma et al., 2001), with detection of temporal changes during this decade as its main objective. In this paper we summarize the 2010 survey and discuss the magnetic changes for the ten years by comparing with the recent measurements on the ground.

2. Summary of the 2010 aeromagnetic survey

The survey flight was designed to optimize the conditions required for the generalized mis-tie control method (Nakatsuka and Okuma, 2006). Magnetic field and sensor position were measured at 10 Hz and stored in the instruments in a bird which was suspended from a helicopter. Flight was done with a constant (about 150 m) spacing to topography. The 2010 survey successfully retrieved the magnetic total field over the recent eruptive areas in 2000 (NW foot), 1977-82 (summit crater), and 1943-45 (Showa-Shinzan).

3. Detection of temporal changes validated with the aid of ground surveys

After the data processing with the mis-tie control method, we successfully retrieved some distinct magnetic changes over the three areas mentioned above, in which amplitude of the anomalous changes overwhelms the detection error level. Another related paper (Nakatsuka et al., 2011; this JpGU meeting) discusses in detail on the data processing and a factorial analysis of possible contributing elements on the estimation errors.

Preceding the flight, Hokkaido University has repeated magnetic surveys on the ground since 2003 for NW foot and since 2008 for the summit crater and Showa-Shinzan. As was already reported by Hashimoto et al. (2010; JpGU meeting), these three areas show clear magnetizing trends which is plausibly due to cooling. We here extrapolated the linearly-fitted rates of change for ten years and projected the estimated magnetic changes onto a smoothed plane 200 m over the topography, which ensured a general agreement with the aeromagnetic result. Our result may be the second case succeeding the one at Kuju Volcano (Utsugi, 2010), in which magnetic time changes with grounded validation are detected from repeat aeromagnetic surveys. Availability and usefulness of this method now became more pronounced.

4. Discussion on the magma cooling beneath the summit crater

We here describe some features of the magnetic changes in the summit crater where the 1977-82 eruption tool place.

(1) A distinct magnetic increase was recognized around Gin'numa crater. It agreed well with the estimation from the ground measurements from 2008 through 2010. This subsequently suggests that the recent magnetizing trend is not a temporary one but a steadier process at least for these ten years.

(2) Cooling of the intruded magma in the 1977-82 eruption might be a candidate for the source. However, no remarkable magnetic change was detected over Usu-Shinzan itself, under which the intruded magna is thought to remain (e.g. Matsushima et al., 2001).

(3) A remarkable decrease was found over the NW somma (Kita-Byobu-Iwa). It might be the counterpart of the increase which is mentioned in (1). This implies the possibility that a substantial part of the intruded magma under Usu-Shinzan still keeps a high temperature and thus is not yet able to be magnetized.

(4) Some magnetic changes with relatively small amplitude are recognized around Oo-Usu lava dome, which also suggest cooling magnetization. The significance, however, should be carefully investigated as we have no ground data on that area.

Acknowledgments: This study was supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, under its Observation and Research Program for Prediction of Earthquakes and Volcanic Eruptions.

Keywords: Geomagnetic field, Usu Volcano, Aeromagnetic survey, temporal variations, helicopter, magma cooling

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Relationship between mode of eruption and plagioclase in the basaltic eruption products of Fuji volcano

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In this work, we analyzed some of the textural features of basaltic eruption products of Fuji volcano to identify the key processes determining the mode of eruptions. Fuji volcano mostly consists of mildly evolved basalt, although its mode of eruption varies from explosive sub-Plinian type to effusive lava flow emplacement. Previous studies suggested that degassing of magmas during ascent mainly determines the mode of eruptions. Jaupart and Allegre(1991) suggested that variation of initial ascent rate of magmas eventually bifurcates the ascent rate by vesiculation and degassing at shallow depth, whereas Woods and Koyaguchi(1994) presented a model that accounts for the two numerical solutions for explosive and effusive eruptions caused by the variation of mass eruption rate. Degassing of water from magmas raises the liquidus temperature of the magma, thus causing degassing-induced crystallization. Because Ca/(Ca+Na) ratio of plagioclase is strongly affected by water content of magmas, we examined the zoning profiles of plagioclase in the basaltic ejecta of Fuji volcano to find water content of magmas where plagioclase crystallized. We examined the effusive samples of the Aokigahara, Kennomarubi, Takamarubi, Hinokimarubi, Kansuyama lava flows and explosive Hoei, Yufune-2, Zunazawa, S-18, S-12, and explosive to effusive eruption products of Omuroyama parasitic cone. The core composition of plagioclase in explosive eruption products generally have high Ca/(Ca+Na) ratio (0.80-0.92), whereas those in effusive eruption products tends to have lower Ca/(Ca+Na) ratio of 0.6-0.75 in Aokigahara and Kenmarubi lava flows, and of 0.75-0.88 in Takamarubi and Hinokimarubi lava flows. Previous experimental studies suggest that equilibrium liquidus plagioclase have high Ca/(Ca+Na) ratio at high water contents, and the core composition of plagioclase suggests that effusive magmas tends to have lower water contents just before the eruption compared with the explosive magmas. It is suggested that magma chamber of Fuji volcano is located at ca. 15km depth, and magma is halted at some depth (1-5km) before eruption where some degassing may induce crystallization of phenocrysts, and successive intrusion/mixing of magmas may eventually cause the final outbreak of vent to form either explosive or effusive eruptions depending on the water contents of magma, mostly determined by the depth of the magma pocket.

Keywords: Fuji volcano, mode of eruption, plagioclase composition, water content of magmas, degassing of magmas

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Subsurface airflow detection at Miyakejima and Piton de la Fournaise volcanoes from micrometeorological and thermal data

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Subsurface airflow in the unsaturated zone of the soil has been extensively investigated in a variety of engineering disciplines such as mining, nuclear waste or agriculture science. In volcanology, the recent discovery of subsurface airflow close to the terminal cone of Piton de La Fournaise volcano (La Reunion Island, France) provides for the first time insights into the convective behavior of air within the unsaturated layer [1]. The characteristics of the aerothermal system, its occurrence in other volcanoes, its ability to transport heat during quiescent periods and the perturbation of this system before eruptions are the key questions we want to address following this discovery.

In this study, we present observations of subsurface convective airflow within surface-exposed fractures located at the summit of Miyakejima and Piton de la Fournaise volcanoes from micrometeorological and thermal data. At Miyakejima, air exhausts from several fractures with a vertical velocity of tens of cm/s. A difference of temperature of 10-15 degrees Celsius between the fractures and the atmosphere has been measured, while the fractures never cool during the diurnal cycle. In the case of Piton de la Fournaise volcano, several air exits as well entrances have been observed at the summit, suggesting that the aerothermal system may affect the whole volcano. The velocities and temperatures are close to the ones recorded at Miyakejima. Finally, thermal profiles realized across the fractures allow us to define the convective patterns. This study is the first concerning the occurrence of an aerothermal system within another volcano than Piton de la Fournaise. It constitutes a preliminary step to further investigations dedicated to the understanding of the perturbation of such systems before eruptions.

[1] Antoine R., Baratoux D., Rabinowicz M., Fontaine F.J., Bachelery P., Staudacher T., Saracco G., Finizola A., Thermal infrared images analysis of a quiescent cone on Piton de La Fournaise volcano: Evidence for convective air flow within an unconsolidated soil, Journal of Volcanology and Geothermal Research, Volume 183, Issues 3-4, 2009, Pages 228-244

Keywords: Volcano, Subsurface Airflow, Convection, Porous Medium, Micrometeorology, Thermal data

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Shallow ultra-micro earthquakes beneath a long dormant Moedake Lava Dome at Kuchinoshima Vocano

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Kuchinoshima Volcano, an active volcano which is composed of several lava domes, is located in northern part of Tokara Islands. Moedake Lava Dome, the newest lava dome among ones within the volcano, was formed at 12 or 13 century (Geshi and Nakano, 2007). They also have estimated the occurrence of some phreatic eruptions and no magmatic eruption after the dome formation. We have seen very weak fumarole activity at craters on the dome for long time. Iguchi et al (2003) estimated the rate of thermal discharge from the lava dome to be 0.1MW. On the other hand, the activities of micro earthquakes in other geothermal fields concerning hot water and/or fumaroles have been studied. We, therefore, have performed the seismic observation in and around Moedake Lava Dome to clarify whether micro earthquakes occur or not inside the lava dome. As the result, we detected that the ultra-micro earthquakes occurred beneath the long dormant lava dome throughout the observation period. Most of these earthquakes are high frequency type that P and S phases are identified on the seismographs. Additionally, the high frequency events followed by weak precursor, and nearly monochromatic events were also observed. In the present study, we mainly focus on the hypocenter distribution of the high-frequency earthquakes in the 90 days from September 17, 2010 through December 15, 2010.

We have installed four seismic stations in and around the lava dome to obtain the continuous seismic data. The triggered data files were made from the continuous data to be used for the analysis. We picked up arrival times of P and S waves and maximum amplitudes at each station on a computer display. Because seismic velocity structures in and around the lava dome had been unknown, we examined 18963 seismic velocity models to search feasible velocity structure. We also performed hypocenter determination with the suitable seismic velocity structure. The estimated extents of the P and S wave velocities are 2.7-2.8 km/s and 1.5-1.6km/s, respectively. The calculations of 106 hypocenters throughout the observation period converged with the velocity model.

The most epicenters of the high-frequency earthquakes locate the limited area of about 150 meters radius, which is very close to the largest summit crater. The depths of the earthquakes were 0.0-0.6km below sea level. We estimated the depth of the largest crater on the lava dome to be about 250m by a simple measurement. The altitude of the upper limit of the hypocenters is about 150m deeper than the estimated crater bottom. The Magnitudes of these events were -0.7 and below. We concluded that ultra-micro earthquakes occur quasi-steadily in the quite limited area below the long dormant lava dome.

Keywords: Kuchinoshima Volcano, Moedake, Lava dome, micro earthquake

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Crustal structure of Sakurajima Volcano and Aira Caldera from receiver function analysis

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SSakurajima volcano, located at the southern rim of the Aira caldera approximately 20 km in diameter, is well known to be one of the most active volcanoes in Japan. As a result of precise leveling surveys and GPS observation from 1995 to 2010, in the caldera, it was found that an inflation source is located at depths of about 10 km beneath the Aira caldera and the volume of the source increased by 0.1 km^3 in the period. Although this source is considered to be a magma chamber, the total volume of the chamber is unknown. Therefore, in order to determine the crustal structure of the Aira caldera and to estimate a total amount of magma accumulated beneath the caldera, we investigated seismic velocity structure of Sakurajima volcano and Aira caldera by a receiver function (RF) analysis.

A RF is calculated by deconvolving vertical component of a waveform of a teleseismic P-wave from its horizontal component. We used more than 3000 waveforms from 500 teleseismic events (epicentral distance: 30-90 deg, magnitude greater than 5.5) to estimate RFs, observed at Hi-net , J-array and seismic stations established by Sakurajima Volcanological Observatory, DPRI, Kyoto University. We extracted vertical and radial components of a teleseismic P-wave between 35 seconds before and 90 seconds after the onset, and vertical components of noise for 125 seconds before the onset. We cut off frequency content higher than 0.56 Hz with a Gaussian high-cut filter and applied an extended-time multitaper (Shibutani et al., 2008) to compute RFs.

Then, we constructed images with RFs migrated to the depth domain with a velocity model JMA2001 and projected on a cross section along WNW-ESE direction. Beneath the caldera, two phases with positive polarity were observed, corresponding to discontinuity with upward decreasing seismic velocity, at depths of 20km and 40km. This suggest the existence of a low velocity layer beneath the caldera like in the Aso caldera (Abe et al. 2010 JVGR).

In order to get the detailed seismic velocity structure beneath the Aira caldera, we used a genetic algorithm (GA) inversion for the obtained RFs. For the GA inversion, we stacked RFs for each station according to back-azimuth. As a result of inversion, a low velocity layer (VS =2.8 km/s, 15-20 km in depth) was found in the north western part of the caldera. However, no low velocity layer could be found at the eastern rim of the caldera.

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Magnetotelluric surveys in and around the Aira caldera (3)

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1. Introduction

In the present study, we conducted the electromagnetic investigation including the sea bottom in the area centered on the Kagoshima Bay (Aira caldera) in the north of Sakurajima, southern Kyushu, Japan. A magma reservoir of Sakurajima volcano is considered to exist at about 10km depth beneath the Aira caldera, which was inferred from the geodetic and the seismological observations over many years (Ishihara, 1990; Hidayati et al., 2007). It is presumed that accumulation of the magma to the reservoir is lasting because an upheaval of the ground around the Sakurajima has been observed since the first half of the 1990's. The objective of this study is to clarify the corresponding electrical resistivity structure to the assumed magma reservoir and to the supply routes to the Sakurajima volcano and to a submarine volcano called Wakamiko. Based on the results, we also aimed to verify the conventional image of the magma supply system inferred from the geodetic and seismic observations.

2. MT surveys

The surveys are planned for three years from 2009 to 2011 within a framework of Grants-in-Aid for Scientific Research (KAKENHI). We set three traverse lines in the direction of WNW-ESE crossing the Aira caldera and electrical resistivity structures are inferred from the magnetotelluric (MT) measurements on land and on the seafloor along the traverse lines. In fiscal year 2009, we carried out the MT survey at the 10 land sites and the 5 seafloor sites mainly along the middle of three traverse line. A similar survey was conducted along the northern traverse line in fiscal year 2010. The MT data at 30 sites in total were obtained for the last two years. In this presentation, we will report some results of a 2-dimensional inversion, in which the strike direction of the underground resistivity structure is assumed as the north-south against each traverse line.

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

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Change in the water-soluble components of the ash from Sakurajima in the sequence of its eruptive activity

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Sakurajima, located on the south edge of Aira caldera, is a stratovolcano and one of the most active volcanoes in the world. Recent eruptive phase has been sustained at the summit crater, Minamidake, since October 1955. In 1970s and 1980s, its activity was extremely heightened with numerous powerful explosions, and huge amounts of tephra were discharged from the summit crater.

Strombolian eruptions with swarm of BL-type earthquakes forerun vulcanian explosions with explosion earthquakes, and vulcanian explosions are often followed by continuous ash eruptions with tremor, which is the ordinary sequence of the eruptive activity of Sakurajima volcano (Kamo, 1978). Geophysical observation revealed that hypocenters of BH-type, BL-type and explosion earthquakes are concentrated inside a cylindrical chamber with a radius of 200m, at depths from 1 to 3 km beneath the crater. The cylindrical chamber was a magma conduit, which connected the summit crater and a shallow magma reservoir (Ishihara, 1990; Iguchi, 1994). BH-type earthquake swarm is associated with slow inflation of the summit without significant eruptive activity, whereas BL-type earthquakes swarms during rapid deflation of the summit with strombolian eruptions (Ishihara and Iguchi, 1989). Dominant frequencies of BH-type, BL-type and explosion earthquakes are different from each other although hypocenters of these earthquakes distribute inside the cylindrical chamber beneath the crater, which attributed to difference in source processes affected by the state of the magma conduit (Iguchi, 1994).

Volatile components such as water (H2O), fluorine (F), chlorine (Cl), sulfur (S) and carbon (C) are chemical substances dissolved in magma under high pressure. Ascent of magma causes exsolution of volatiles, mostly H2O, which provides the driving force for explosions. Further, release of volatiles highly changes viscosity and density of magma, and thus influences the violence of explosions. Examination of the behavior of volatiles can provide a better understanding of eruptive activity and degassing processes from magma. Pristine ash particles react with HF, HCl and SO2 in eruption plumes, and certain proportions of HF, HCl and SO2 in gas phase are fixed onto the surface of the particles in water-soluble forms. The HCl/SO2 value of smoke is equal to the Cl/S04 values of the water leachate of ash (Ossaka and Ozawa, 1975; Nogami et al., 2008). Change in the mode of the eruptive activity at Sakurajima is drastic and release of volatiles from magma corresponding to its activity is examined by analysis of water-soluble Cl and SO4 in volcanic ash.

The Cl/S04 values of the ash issued by strombolian eruptions with BL-type earthquake swarm are significantly higher than those of the ash ejected by vulcanian explosions and continuous ash emission. In the sequence of strombolian eruption to continuous ash emission, the Cl/S04 values of the ash decline steeply. And re-ascent of magma with BL-type earthquake swarm after continuous ash emission synchronized with return increase of the Cl/S04 values of the ash. These results demonstrate that magma intrusion to the shallow zone of the volcanic edifice is detectable through geochemical observation if the swarm of BL-type earthquake is not significant.