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

SVC52-01 Room:101A Time:May 21 16:15-16:30

Tracer test at Minami-Izu hot spring area, Shizuoka

Norio Yanagisawa[1*], Kazuo Matsuyama[2], Kazuo Tomita[2], Yasuto Takeda[2], Keiichi Sakaguchi[1], Kasumi Yasukawa[1]

[1]Green-AIST, [2]TEPSCO

Tracer test is carried out in high temperature hot spring fluid layer at Minami-Izu geothermal field, Shizuoka, Japan. In Minami-Izu field, the temperature of several hot spring wells is about 100 degree C at a depth around 150 m. About 500g uranine tracer was injected at 16 September. We monitored tracer appearance at 5 wells using optical fiber system and lab spectrometer.

1)At Daigaku-yu (K-13) well, the first tracer appeared 9 hours after tracer injection and tracer concentration rapidly increased and showed peak at three days after injection. The return ration at K-13 is estimated about 30%.

2)In other wells, at Tamagawa-yu (K-11) about 150 meter from injection well, the first tracer appear at 10 days after injection and earlier than Kyodou-yu (K-3).

3)The main flow injected tracer is along with the large fault between injection well and K-13 and the main flow in hot spring reservoir seem to the right angle of fault and ENE direction.

Keywords: Tracer test, Uranine, Hot spring, Optical fiber system, Fault, Horizontal flow

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

SVC52-02 Room:101A Time:May 21 16:30-16:45

Geochemical characteristics of hot springs in Bulusan Volcanic Complex, Southern Luzon, Philippines.

Sachihiro Taguchi[1*], Ramil Lelay Vaquilar[2], Laguerta, Eduardo P.[2], Bornas, Mariton, A.V.[2], Solidum, Renato, U. Jr.[2], Reyes, Perla, J.D.[2], Mirabueno, M. Hannah. T.[3], Daag, Arturo S.[2], Bariso, Ericson B.[2], Okuno, Mitsuru[1]

[1]Department of Earth System Science, Fukuoka Univ., [2]Philippine Institute of Volcanology and Seismology (PHIVOLCS), [3]Christchurch City Council

Bulusan Volcano located in the southernmost part of the Bicol Peninsula is one of the active volcanoes in the Philippines. This paper reveals geochemical characteristics of hot springs in the Bulusan Volcanic Complex (BVC).

All of the hot springs except Buhang shows the HCO3-SO4 and/or HCO3 types, and also is plotted within the immature water area in the Na-K-Mg diagram, suggesting no strong outflow of neutral Cl-rich deep waters in the BVC. Isotopic compositions (delta D and delta 18O) of the hot springs indicate the local meteoric water origin. On the other hand,Buhang hot spring shows the Cl-HCO3 type formed by mixing of meteoric origin CO2-rich hot fluid and sea water.

Acidic pH of river water was observed during a small lahar caused by heavy rain, probably this is due to erosion of newly sedimented pyroclastics by the rain and dissolving the volcanic gases absorbed on the surface grains of the pyroclastics.

San Benon hot spring was monitored for chloride and sulfate ions to detect any precursor of volcanic eruption. The variation of chloride and sulfate ions were directly proportional with each other, ranging from 81 to 168mg/l and 270 to 601mg/l, respectively. This suggests that these ions are strongly affected by the mixing of groundwater in the area. Therefore, chemical monitoring using chloride and sulfate ions at San Benon will not be recommended.

Keywords: Hot spring, Geothermal, Bulusan Volcanic Complex, Philippine

SVC52-03 Room:101A Time:May 21 16:45-17:00

Implications of a large hydrothermal reservoir beneath Taal Volcano (Philippines) as revealed by magnetotelluric surveys

Paul Karson Alanis[1*], Yusuke Yamaya[2], Akihiro Takeuchi[3], Juan Cordon[1], Jesus Puertollano[1], Christian Clarito[1], Takeshi Hashimoto[4], Toru Mogi[4], Yoichi Sasai[3], Toshiyasu Nagao[3]

[1]Philippine Institute of Volcanology and Seismology, [2]Earthquake Research Institute, The University of Tokyo, [3]Earthquake Prediction Research Center, Tokai University, [4]Institute of Volcanology and Seismology, Hokkaido Universituy

Located in the island of Luzon and 60 km south of the capital city of Manila, Taal Volcano is one of the most active volcanoes in the Philippines. The first recorded eruption was in 1573 and since then it has erupted a total of 33 times, with the last eruption in 1977. These eruptions resulted in thousands of casualties and considerable damage to property. In 1995 it was declared one of the ’1990s decade volcano’ by IAVCEI. Although the volcano remained fairly quiescent after the 1977 eruption, at the beginning of the 1990s it began to exhibit several phases of abnormal activities, such as episodes of seismic swarms, ground deformation and fissuring, and hydrothermal activities, all of which continues to the present. Examining past eruptions of Taal Volcano however, it has been observed that these can be divided into 2 distinct cycles, depending on the location of the eruption: eruptions centered at the Main Crater (1572-1645 and 1749-1911); and eruptions occurring at the flanks (1707-1731; 1965-1977).

We conducted (as part of the PHIVOLCS-JICA-SATREPS Project), magnetotelluric and audio-magnetotelluric surveys on Volcano Island, in March 2011 and March 2012. The objective of this survey was to create a resistivity model of the hydrothermal system beneath the volcano. Initial (2-D) inversion modeling revealed a prominent and large zone of relatively high resistivity between 1 to 4 kilometers beneath the volcano and almost directly beneath the Main Crater and surrounded by zones of relatively low resistivity. The anomalous zone of high resistivity is hypothesized to be a large hydrothermal reservoir filled with volcanic fluids in a gaseous phase. Three-dimensional forward modeling reveals the size of the reservoir to be as large as 3 km in diameter and between 1 km to 4 km in depth. This reservoir appears to be overlain by an impermeable cap, which exhibits a lower resistivity signature compared to the hydrothermal reservoir. Past eruptive activities of Taal Volcano (which are characterized by repeated changes in eruption sites, i.e. alternating between the Main Crater and the flanks and separated by long repose times), could be related to the presence of such a large hydrothermal. During the cycle of Main Crater eruptions, this hydrothermal reservoir is depleted, whereas during a cycle of flank eruptions this reservoir is replenished with hydrothermal fluids. In particular, the 1911 January 30 eruption showed an anomalous feature similar to a gas explosion, which can be attributed to the large hydrothermal reservoir collapsing catastrophically.

Keywords: hydrothermal reservoir, phreatic eruption, magnetotellurics, Taal Volcano

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

SVC52-04 Room:101A Time:May 21 17:00-17:15

Gravity variation in Akita-Komagatake volcano and thermal expansion model

Choro Kitsunezaki[1*], MURAOKA, Atsushi[2]

[1]none, [2]Sogo Geophysical Exploration Co.

(1) In Akita-Komagatake volcano, we have monitored volcanic condition after the 1970-eruption by repeated observations at fixed points, on ground-temperature, geomagnetic total intensity, and gravity. After the end of the eruption in 1971, ground temperature rose in the surrounding area, though the crater itself cooled rapidly. The peak of this geothermal activity was about 1977-78. After then the activity decayed, and the temperature lowered to almost normal level in 1995-98. This high geothermal (HG) period is called the post-eruption HG period. Geothermal activity again revived since about 2006, and the active area is now expanding to almost east-half of Medake (the present HG period). Variation of gravity is focused in this paper, though that of geomagnetic intensity was also conformable to the above geothermal activity. Gravity remarkably increased with drop of ground temperature, and lowered with rise of it.

(2) In both HG periods (the post-eruption and the present), the ground temperature has not yet exceeded the boiling point of water and volcanic gas has not yet been detected. Hence, increase of the geothermal activity until now does not mean new magma intrusion to shallow zone. The post-eruption HG activity was probably caused by transfer of heat from the magma, which had been intruded and remained near and in the vent originally at the eruption, to the surrounding zone through convection of thermal water. The present HG activity may be caused by new upward intrusion of thermal water from deeper zone. Accumulation of aqueous vapor in the ground often behaves as effective pressure source to cause crustal deformation. This mechanism, however, seems unlikely in Medake, whose formation composed of much pyroclastic material seems to be permeable. In this condition, thermal expansion of the formation is considered to be rather appropriate mechanism to cause gravity variation, which results primarily from variation of the surface altitude (free-air effect) and secondarily from that of the formation density.

(3) As the relevant model, it is assumed that temperature of a particular zone in the semi-infinitive homogeneous isotropic elastic medium is raised uniformly by t, compared with the surrounding zone. A semi-infinitive vertical cylindrical column is assumed as the heated zone. Its upper surface is coincident with the media surface. The thermal expansion causes the surface upheaval and the density decrease. The solution is as follows: A vertical infinitive cylindrical column zone with radius r is set up in the infinitive homogeneous elastic medium, and is heated by t. Stresses and deformations in and outside the zone are estimated by application of known formulas. The horizontal surface (the O-surface) is set up across the center (O) of the column. We focus on the lower half side of the O-surface. Normal stress (p) exists on the O-surface. New stress (q) is added, to make total stress zero on the O-surface. Hence p+q=0, then q=-p. By this process the O-surface is converted to the free surface (=the ground surface). The O-surface is upheaved with q, which is tension. At the O-point the upheaval (h) and the corresponding gravity variation are estimated by application of known formulas.

(4) The above model was applied to the variation of gravity at the post-eruption HG period (1977) from the succeeding quiescent period (1998). The observed gravity variation was -0.25mGal at the top of Medake. The same value was obtained by assuming parameters conformable to the volcanic feature as the following; r=200m, t =130K, linear thermal expansion coefficient $=10^{-5}$ /K, density=2.5g/cm^3, Poisson's ratio=0.25. In this case, h was estimated as 0.65m. Direct application of the same method to the present geothermal activity is not appropriate because the geothermal area is shifted from the gravity observation points.

Keywords: Akita-Komagatake, volcanic monitoring, ground temperature, thermal expansion, elevation variation, gravity variation

SVC52-05 Room:101A Time:May 21 17:15-17:30

Repeated gravity measurement for hydrothermal monitoring beneath Aso volcano

yayan sofyan[1*], Yasuhiro Fujimitsu[1], Jun Nishijima[1], Shin Yoshikawa[2], Tsuneomi Kagiyama[2]

[1]Department of Earth Resources Engineering, Graduate School of Engineering, Kyushu University, [2]Aso Volcanology Laboratory, Graduate school of Science, Kyoto University

At the end of 2010, the water level in the Nakadake crater in Aso volcano reduced and then was followed by a small eruption in May 2011. The eruption and water level variation in the crater has strong relation to hydrothermal dynamics beneath volcano. To monitor hydrothermal dynamics, the relative gravity measurements were performed with Scintrex CG-5 (549) and LaCoste Romberg type G-1016 gravimeter at 28 benchmarks before the eruption in April 2011 and some measurements after the eruption in 2011 and 2012. It covered the area more than 60 km2 in the west side of Aso caldera. In another measurement, we installed a new microgravity network on May 2010 at seven benchmarks using A10-017 Absolute gravimeter, which we re-occupied in October 2010, and June 2011.

Gravity changes in the monitoring study clarify mass variation in the subsurface. Large residual gravity changes between the surveys are found at benchmarks around Nakadake crater and Ikeno kubo, a southwestern area from Nakadake crater. The changes between April and August 2011 significantly raise about 60 microGal near to Nakadake crater. The next period gravity monitoring from August to November 2011 shows the broad positive anomaly shifted to Ikeno kubo area. The large positive gravity variation in second period is up to 80 microGal. The opposite variation trend of previous period appears in gravity variation between November 2011 and April 2012.

The gravity changes around crater have good validation from water level variation in Nakadake crater. The water level variation of Nakadake crater is supplied from groundwater, high temperature fluid supply from depth, and precipitation. The 3D inversion models of 4-D gravity data deduce density contrast distribution beneath Aso volcano. The model of the microgravity data in short period indicates mass variation or density contrast dynamically occurred at shallow depth beneath Aso volcano. The gravity monitoring can contribute to understanding the process of eruption.

Keywords: Repeated gravity measurement, Hydrothermal dynamics, Aso volcano

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

SVC52-06 Room:101A Time:May 21 17:30-17:45

Modeling of Geothermal System from Gravity Monitoring at the Takigami Geothermal Field, Oita Prefecture, Japan

Daisuke Oka[1*], Yasuhiro Fujimitsu[1], Jun Nishijima[1], Yoichi Fukuda[2]

[1]Kyushu University, [2]Kyoto University

In order to utilize the geothermal resources sustainably, it is necessary to monitor and recognize the behavior of geothermal reservoirs. Micro-gravity measurement is one of the serviceable methods for geothermal reservoir monitoring. Because of the underground mass change caused by the groundwater flow, the gravity change on ground surface is detected. Therefore, the gravity measurements have been introduced in the various geothermal fields. In the Takigami geothermal area, we have continued the geothermal reservoir monitoring by using Scintrex CG-3, CG-3M and CG-5 relative gravimeters since before the commencement of the Takigami geothermal power plant.

In order to estimate the gravity change caused by the mass redistribution in geothermal reservoir, it is necessary to remove the gravity change caused by the effect of the ground water flow in shallow parts. In this study, we tried to calculate a gravity response to precipitation by using G-WATER [E](Kazama et al., 2011).

We introduced an A10 absolute gravimeter (Micro-g LaCoste, Inc.) in 2008. Although it was impossible that the A10 absolute gravimeter was applied at all of the stations because the condition of the measurement was strict, we utilized the A10 gravimeter for not only the assessment of the gravity changes at the reference station, but also the detection of the absolute gravity change caused by the subsurface fluid mass changes at some other measurement stations. We chose 4 stations (T13B, T22A, T26A and T27A) to conduct the repeat absolute gravity measurement. T26A lies in the reinjection area, and there are the other 3 stations in the production area. As a result of absolute gravity measurements, the gravity change at the reference station T1 of the relative gravity measurements is small enough for this evaluation, within about 10 microgal. Therefore, we estimated that this reference station is appropriate for the relative gravity measurements.

As a result, shortly after the Takigami geothermal power plant had started power generation, a sharp gravity decrease occurred in the production area, after that, the gravity changed stably for 2 years in entire area, and then gradually decreased until 2002, and the gravity has increased since 2002. We divided the Takigami geothermal area into 3 areas from the pattern of the gravity change after the commencement of the Takigami geothermal power plant, and we estimated the 5 stages of geothermal fluid flow pattern from temporal gravity change. Based on these classifications, we led a conceptual reservoir model of the Takigami geothermal area.

Keywords: Repeat Gravity Measurement, Absolute Gravimeter, Relative Gravimeter, Takigami Geothermal Area

SVC52-P01 Room:Convention Hall Time:May 21 18:15-19:30

Conductivity distribution of the surface layer around active volcanoes

Tsuneomi Kagiyama[1*], Mitsuru Utsugi[1], Shin Yoshikawa[1], Shogo Komori[2]

[1]Graduate School of Science, Kyoto University, [2]Academia Sinica, Taiwan

Kagiyama and Morita(2008) proposed that volcanism has a wide range of diversity represented by two typical end members controlled by the easiness of magma storage beneath volcano; Eruption dominant (ED) volcanism in difficult condition and Geothermal activity dominant (GD) volcanism in easier condition. In GD volcanoes, magma stagnates beneath volcanoes and maintains geothermal activity. This seems GD volcanoes continue to give much benefit to human society. However, GD volcanoes sometimes have large eruptions after repeated stagnations of magma. This fact suggests it is very important to understand where and why magma stops ascending. Kagiyama and Morita (2008) indicated magma degassing is one of the important factors to control magma ascending. On this aspect, the authors have carried out VLF-MT survey around some active volcanoes in Japan, because electrical conductivity of ground strongly depends on the conductivity of pore water.

Aso Caldera has an acid crater lake in Nakadake, which is one of the post caldera cones, and has many hot springs such as Uchinomaki, Akamizu. Conductivity distribution shows two typical features; caldera floor has almost homogeneous and high conductivity (> 10mS/m), while the post caldera cones show wide range. Most cones such as Kishima-dake and Ohjo-dake have lower conductivity (<3mS/m), except around Naka-dake Craters and western flank of post caldera cones such as Yoshioka and Yunotani (>30mS/m). Kusasenri Volcano, located between Naka-dake and Yoshioka has also rather high conductivity (3-10mS/m). These areas locate along the E-W trend of the major post caldera cones. Most part of the northern flank of the post caldera cones shows low conductivity (<3mS/m). However, higher conductivity was found around Sensuikyo, just north of Naka-dake Craters. This suggests down flow of hydrothermal water from Naka-dake Craters to the caldera floor.

Caldera floor has almost homogeneous conductivity. This feature is explained by the fact that the caldera floor was under the lake until 9 ka and is covered by lake deposit. However, extremely high conductivity was found at three areas (>50mS/m). Two of them correspond hot spring areas; Uchinomaki in the north and Akamizu in the west. The third area is distributed around old post caldera cones, Mietsuka. The age of these cones was estimated around 46 ka, and no hot spring is distributed. High conductive zones, Uchinomaki, Mietsuka and Naka-dake are located along the NNW-SSE line. Hydrothermal water may be supplied along this line.

These results suggest that hydrothermal water is supplied along the E-W trend crack from Naka-dake to Yoshioka, mainly supplied beneath Naka-dake, and expanded to the northern caldera floor. The NNW-SSE trend from Naka-dake to Uchinomaki may suggest a tectonic fault. Aso has wide high conductivity area and degassing in Aso might be large to be GD volcano.

Reference: Kagiyama and Morita, First steps in understanding caldera forming eruptions, J. Disaster Res., 3, 270-275, 2008.

Keywords: Active volcano, Electrical conductivity, Geothermal activity, Failed eruption

SVC52-P02 Room:Convention Hall Time:May 21 18:15-19:30

Temporal variations of self-potential at summit area of Izu-Oshima volcano

Nobuo Matsushima[1*], Yuji Nishi[1], Shin'ya Onizawa[2], Shinichi Takakura[1], Hideaki Hase[3], Tsuneo Ishido[1]

[1]Geological Survey of Japan, [2]Meteorological Research Institute, JMA, [3]Earthquake Research Institute, University of Tokyo

In order to detect a signal associated with the change of volcanic activity, we has measured continuous Self-Potential(SP) variation at 11 stations in the summit crater of Izu-Oshima volcano from 2006. Electrical differences between sites are recorded every one minute. Rain fall and soil water content are recorded every ten minutes at one station. SP data commonly show the annual change; the values are high in summer and low in winter. The amplitude of the annual change is observed to be 100mV in maximum. The short period variations in several days are also observed after rain fall. These variations are produced by the change of soil water content near surface. On the analogy of the short period variation, the annual variation is thought to be caused by the seasonal change of soil water content at depth. The temporary trends excluding the annual variation do not show any signals suggesting the increase of volcanic activity.

We estimate SP variations associated with the change of magmatic activity using the simulation code named STAR. The simulation considers mass and heat transfer of vapor and liquid fluid within porous media, and calculates the drag electrical current with fluid flow and electrical potentials induced by the drag current. For the initial condition which is satisfied with the present state of SP distribution in Izu-oshima volcano (Onizawa et al., 2009), we simulate SP variation if magma intrudes at seawater level and degassing occurs at the top of magma. The resistivity of formations is approximated with the parallel circuit of solid and pore resistivity. The pore resistivity changes remarkably with dissolved component. We assume that the acid fluid produced by the condensed volcanic gas has the resistivity similar to that of sea water (0.25 ohm?m). When permeability of the degassing vent is higher than the surrounding formations with two order of magnitude, and degassing occurs at the rate of 80 kg/s which corresponds to half the maximum vapor discharge rate during 1986 eruption, the positive SP anomaly up to 100 mV appears near the summit crater at 1 year after the onset of degassing, although volcanic gas does not reach to ground surface at that time. Due to the cooling of volcanic gas, the counter flow of upward vapor and downward liquid develops around the degassing vent. The drag electric current is produced only by downward liquid flow, but low resistivity of the acid liquid causes a strong positive anomaly at ground surface.

Keywords: Izu-Oshima volcano, Self-potential, Hydrothermal system, Numerical simulation

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

SVC52-P03 Room:Convention Hall Time:May 21 18:15-19:30

Resistivity structure around Chishinshan, Matsao, and Tayukeng areas, Taiwan, revealed by audio-magnetotellurics

Shogo Komori[1*], Mitsuru Utsugi[2], Tsuneomi Kagiyama[2], Hiroyuki Inoue[2], Chang Hwa Chen[1], Hsieh Tang Chiang[3]

[1]Institute of Earth Sciences, Academia Sinica, [2]Aso Volcanological Laboratory, Kyoto Univ., [3]Institute of Oceanography, National Taiwan University

Electromagnetic surveys have found the low resistivity region beneath the active volcanoes. This is because high- salinity and temperature hydrothermal fluids decrease the resistivity of the pore water and rock matrix, when the volcanic fluids are released from magma and injected into the aquifer. The spatial extent of the low resistivity region could be used for evaluating the eruptive potentiality of volcanoes from the viewpoint of magma degassing.

Tatun Volcano Group is composed of over twenty volcanoes, which were formed within the graben at the northern part of Taiwan. So far, these volcanoes were regarded as extinct because of no historical record of eruption. However, recent studies have found the relatively young ejecta (Chen and Lin, 2002; Belousov et al., 2010), high $^{3}He/^{4}He$ ratio (Yang et al., 1999; Ohba et al., 2010), and hypocenter distribution suggesting the fluid flow and the high temperature condition (Konstantinou et al., 2007); that suggest the presence of potentially eruptive magma beneath TVG. Further, active heat discharge from fumaroles and springs also suggests a large amount of the volcanic fluids released from magma beneath Chishinshan volcano. Focusing on this phenomenon, Utsugi et al. (2012, workshop at TVO, Taiwan) conducted AMT surveys at the volcano for a better understanding of this magma degassing, and showed the preliminary resistivity structure suggesting the low resistivity region at the depths of 1-2km.

On the basis of their work, the authors conducted further AMT surveys around Matsao hot spring and Tayukeng fumarole areas, about 2 km northeast of the volcano from Dec. 9th to Dec. 16th in 2012. Two Phoenix MTU5A systems were used at the same time for the remote reference processing (Gamble et al., 1979). Time series of the electric and magnetic fields were acquired for about 4 hours at each site. Totally 10 observation sites were configured to cover the areas. After data acquisition, the frequency domains were obtained from the time series, using FFT processing. The impedances were estimated for each frequency. The obtained frequency range was between 1 and 10400 Hz.

First of all, the spatial extent of the rotational-invariant apparent resistivity was estimated, using the both data obtained by the authors in 2012 and Utsugi et al. (2012) in 2011. At a several thousands Hz, the low resistivity areas of 10-30 Ohm-m are found separately at Lengshueiken, Matsao, and Tayukeng. With decrease in the frequency, the area is extending more spatially. At a several tens Hz, the above three low resistivity areas are connected to each other, and the extremely low resistivity area less than 3 Ohm-m emerges near the central part of Chishinshan volcano. These features suggest the hydrothermal fluids are flowing from the central area of the volcano toward Matsao and Tayukeng areas.

Impedance phase tensor analysis (Caldwell et al., 2004) found that Chishinshan volcano, Matsao, and Tayuheng areas have each features with respect to its main axes. The axes almost perpendicular to the Jinshan fault are dominant at Chishinshan volcano. Matsao area has two modes of the axes; one is almost perpendicular to the fault, and the rest is toward the valley between Chishinshan and Chigushan, where hot spring is discharged. Tayuken area has the axes toward its fumarole area. Following the above features, the following regional strikes were estimated: N52.5E for Chishinshan volcano, N70E for Matsao, and N90E for Tayuken. In the presentation, the estimated two-dimensional resistivity structures beneath three areas will be shown.

Keywords: low resistivity region, hydrothermal fluids, hydrothermal alteration, magma degassing, Tatun Volcano Group, Taiwan

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

SVC52-P04 Room:Convention Hall Time:May 21 18:15-19:30

Fluid injection at the 1st crater of Aso volcano

Akihiko Yokoo[1*]

[1]Aso Volcanological Laboratory, Kyoto University

An active crater at Aso volcano, Japan, is typically filled with green colored hot water, which is seen as a crater lake. The water is sometimes dried up and then an eruption occurs. Although these two stages seem to be quite different, both may be same in essential quality. The author applied the cross correlation method of infrasound and seismic signals (Ichihara et al., GRL, 2012) to data observed at the small events of gas emissions in 2011, and also the data after the eruption period. As a result, clear patterns of cross correlation functions (CCFs) during the eruptive period, May-June 2011, could be recognized; a stable node of the CCFs was positioned around dt=0, and the seismic data had a pi/4 phase delay relative to the infrasound. It suggests that infrasound signals were generated at the gas emissions and they thus induced ground motions at local area around the station, although we could not identify the signals from the original infrasound wave traces. Characteristic patterns of CCFs were also identified several times after the eruptive period, when the crater was perfectly refilled with hot water. The patterns in these post-eruption periods had different features from the ideal ones; the maximum value of the CCFs was seen at the lag time far from the expected pi/4 phase delay of the seismic data, and the position of the node was not same as those during the eruptive period. In some cases, the seismic data had a phase ahead of that of the infrasound. From numerical calculations, it was confirmed that these seemingly-peculiar features are owing to continuous tremors in the background (Takagi et al., JVGR, 2009). When the patterns of CCFs were observed, whether they were affected by the background continuous tremors or not, the source location of the infrasound signals were determined as the central part of the crater based on analysis of infrasound network data. Therefore, it is interpreted that some kind of events which emit infrasound signals also occurred in the crater after the eruption. One possible candidate of this infrasound source is an ejection of thermal fluids into the crater lake from the bottom, which made the water surface just above the vent swing. If much stronger ejections occur, we will be able to observe them as jets and/or ash plumes through the water surface such as the 2003 and 2004 eruptions (Miyabuchi et al., BVSJ, 2005). In order to clarify this hypothesis, we should carefully monitor the seismic signal relating to the fluid movement as well as the temporal change of the temperature and the water level of the crater lake, and compare them to the results of the cross-correlation analysis. In the presentation, the author also would like to discuss time relation between migration processes of volcanic tremors based on the amplitude ratio analysis of seismic signals (Taisne et al., GRL, 2011) and the fluid injections interpreted from patterns of CCFs.

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

SVC52-P05 Room:Convention Hall Time:May 21 18:15-19:30

Rising of the temperature of Kawayu hot springs in recent years, eastern Hokkaido, Japan

Takao Oka[1*]

[1]Earth Science Co. LTD, Japan

The author and co-warkers performed suryeying the present conditions of Kawayu hot springs concerned with the civil engineering plan of Teshikaga Town. He comprehend that most springs in Kawayu had 50 to 65 degrees centigrade water temperature, and come back to high temperature conditions in 1950's to the middle of 1960's in conseqence.

Keywords: Kawayu hot springs, Atosanupuri volcano, Kutcharo Caldera

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

SVC52-P06 Room:Convention Hall Time:May 21 18:15-19:30

Estimation of volcanic carbon dioxide emission rate from Kuju Volcano, Japan

Yasuhiro Fujimitsu[1*], MAEDA, Norihide[2], Sachio Ehara[3], NODA, Tetsuro[3]

[1]Faculty of Engineering, Kyushu University, [2]Graduate School of Engineering, Kyushu University, [3]Institute for Geothermal Information

Kuju Volcano is located in Kyushu and one of the active volcanoes in Japan. In order to provide data for construction of a numerical model of the hydrothermal system in the Kuju volcanic area, we tried to estimate volcanic carbon dioxide emission from Kuju Volcano.

We considered four forms of volcanic carbon dioxide emission; from the fumaroles, the bare area around the fumaroles, the flank by the soil gas, and some hot springs at the foot of the volcano. The present activity of Kuju Volcano is thought to return to the level of before 1995 phreatic eruption by the recent observation data (earthquake activity, heat discharge rate etc.). Therefore, we adopted the value of about 166 t/day from the plumes of Kuju Volcano estimated by Ehara et at. (1981). On the other hand, Itoi (1993) shows the distribution of soil gas carbon dioxide concentration in the bare area around the fumaroles. In our previous study (Araragi et al., 2008), the relationship between the soil gas carbon dioxide concentration measured by the Kitagawa Gas Detector Tube System and the carbon dioxide flux measured by a CO_2 flux meter in Kuju Volcano was found. Therefore, the soil gas carbon dioxide concentration values shown by Itoi (1993) were converted into the carbon dioxide flux values by using the relational expression, and the volcanic carbon dioxide emission from the bare area was estimated at about 0.8 t/day. We measured soil gas carbon dioxide concentration at 60 points on the flank of the volcano by the Kitagawa Gas Detector Tube System and collected 15 soil gas samples to conduct the carbon isotope analysis to identify the origin of the soil gas carbon dioxide. As a result, we concluded that the volcanic carbon dioxide emission from the flank was 0 t/day. And for the carbon dioxide emission from the hot springs at the foot of the volcano, the data of the Nagayu Hot Springs area was adopted because Iwakura et al. (2000) indicated that the carbon dioxide of the carbonated water from Nagayu Hot Springs was volcanic. The volcanic carbon dioxide emission from Nagayu Hot Springs was estimated at about 5.0 t/day by using the data of the hot water discharge rate and the average carbon dioxide concentration in the carbonated water. These results show that the volcanic carbon dioxide emissions by the plumes from the fumaroles and by the carbonated water from a hot springs area are dominant in Kuju Volcano.

Araragi, K. et al. (2008) Measurement of Soil Carbon Dioxide Concentration in Kuju Volcano, Central Kyushu, Japan, and Comparison with Results in Merapi, Merbabu and Ungaran Volcano, Central Java, Indonesia. Abstracts and Programs of 2008 Annual Meeting Geothermal Research Society of Japan, P15. (in Japanese)

Ehara, S. et al. (1981) Hydrothermal System and the Origin of the Volcanic Gas of Kuju Iwoyama Volcano, Japan, Deduced from Heat Discharge, Water Discharge and Volcanic Gas Emission Data. Bulletin of the Volcanological Society of Japan, Vol.26, No.1, pp.35-56. (in Japanese with English abstract)

Itoi, R. (1993) Soil Gas Survey in Kuju Volcano. Report on Grants-in-Aid for Scientific Research (No.01420038), pp.104-113. (in Japanese)

Iwakura, K. et al. (2000) Origin of Carbon Dioxide Discharged from Nagayu Hot Spring, Oita Prefecture, Japan. Journal of Hot Spring Sciences, Vol.50, No.2, pp.86-93. (in Japanese with English abstract)

Keywords: Kuju Volcano, carbon dioxide, emission rate