Classification of Suijoki-hunka (steam eruption)

*Tsukasa Ohba[1]

1.Faculty of International Resource Science, Akita University

The Japanese word "Suijoki hunka" and its English equivalents are usually defined by the phenomena including transformation from groundwater into steam, whereas the actual eruption is determined as Suijoki hunka based on absence of juvenile material from volcanic ash. The inequality sometimes hinders understanding of the eruption mechanism and prediction of subsequent volcanic activity. This paper represents a new classification of non-juvenile eruptions based on the reviews on three literatures: Sterns and MacDonald (1944), Mastin (1995), and Browne and Lawless (2001). Subaerial eruptions are classified according to relevance to phase transition of external water. Eruptions unrelated to phase change of external H_2O consist of magmatic eruption and gas eruption that is a kind of non-juvenile eruptions. Gas eruption is an explosive eruption derived from pressurized volcanic gas accumulated underground. Eruptions relevant to the phase change (hydro-eruptions or hydro-explosion) are further subdivided into five types: phreatic, phreatomagmatic, hydrothermal, magmatic-hydrothermal, and mixing eruptions. Phreatic eruption occurs when a cold aquifer is heated by newly injected hot magma to explode, and if the explosion involves the hot magma, the eruption is phreatomagmatic. Hydrothermal eruptions and magmatic-hydrothermal eruptions occur in geothermal fields and volcanoes underlain by underground hydrothermal systems. Hot hydrothermal fluid can explode itself by sudden phase change from water to steam without external heat influx (hydrothermal eruption). When the hot hydrothermal fluid is injected by hot magma that supplies additional thermal energy for explosion, the eruption is magmatic-hydrothermal. Mixing between groundwater and hot rock such as solidified new lava results in an explosive eruption that is a mixing eruption. As thermal regimes within volcanic edifices determine the eruption types, three types of regimes are assumed here. A volcano with a low temperature regime (type P hereinafter) contains a cold aquifer that can be the source of phreatic and phreatomagmatic eruptions when a batch of new magma injects. In a volcano with a high temperature regime (type G), hydro-eruption hardly occurs because liquid water can not exist in the heated volcanic edifice. Magmatic and gas eruptions are common to type G volcanoes. A volcano with an intermediate thermal regime (type H) includes a sub-volcanic hydrothermal system containing hot water (often boiling water and steam). The hydrothermal fluid in the type H volcano is the source of hydrothermal and magmatic-hydrothermal eruptions. It is noteworthy that hydrothermal eruption can occur without injection of or heating by new magma as the hot hydrothermal fluid can explode itself by releasing thermal energy of the fluid when it is decompressed. These thermal regimes can easily change each other in response to change of magmatic activity; types H and P change into type G when magmatic activity intensifies. To evaluate subsequent volcanic activity when a non-juvenile eruption occurs, it is crucial to realize the internal thermal condition of the volcano beforehand by means of geophysical, geochemical, and geological investigations.

Keywords: Gas eruption, Phreatic eruption, Phreatomagmatic eruption, Mixing eruption, Hydrothermal eruption, Magmatic-hydrothermal eruption

The geothermal structure in the southwestern Hokkaido

*Midori Hayakawa[1]

1.Hokkaido University, Graduate school of science

Quaternary volcanoes, Hokkaido Komagatake and Esan in the southern part, and Karibayama in the northern part, are situated in Oshima Peninsula, southwestern Hokkaido. Even though recent volcanic activity is not seen in the central part, geothermal gradient is high. The geological structure of this region is dominated by the movement of basement blocks aligning in the north-south, and folds and fractures have developed. Many hot springs and geothermal manifestations are seen in this region where called “Yakumo-Nigorikawa geothermal zone.” The Mori geothermal power plant is operating in the Nigorikawa caldera formed about 12,000 years ago. Nigorikawa and Yakumo, Kumaishi part have been thought as promising geothermal areas, so the geothermal development research (New Energy and Industrial Technology Development Organization, 1990, 1999) have been executed in various ways.

In this study, based on the investigations in Yakumo and Kumaishi area, we discussed the feature of the geothermal structure of this “Yakumo-Nigorikawa zone”. In addition, I estimated the resistivity structure of Yakumo area by Magnetotelluric method (MT). With created resistivity model, we thought about the hot water circulation system in Yakumo area. And comparing with the feature of other areas, we discussed the feature of the geothermal structure of the southwestern Hokkaido.

The hot water in the Nigorikawa area is high chlorine density water and is subjected to the reaction of volcanic gas. The heat source is considered to be residual heat of volcanic activity in the Nigorikawa caldera. On the other hand, in Kumaishi and Yakumo area, from the result of the drilling survey, it is thought that the ground temperature is increased by the thermal conduction from deep heat source. In addition, the chemical componential analysis of the hot spring water and hot water of the well indicated that hot water in this area is thought to be high chlorine density water subjected to the reaction of volcanic gas and rainwater are mixed. These features are similar in Yakumo and Kumaishi area. But considering new resistivity models, there are no remarkable low resistivity bodies to continue over both areas. And comparing resistivity model and geological columnar section, the hot water in Yakumo-Kumaishi area is rising along the faults which run through the granite and sedimentary rocks. The heat source of geothermal system in Yakumo-Kumaishi area is thought as the residual heat of past magma activity, that is the heat source unlike other area where geothermal gradient is high.

Keywords: geothermal area, Yakumo, Kumaishi, Nigorikawa, resistivity structure, Magnetotelluric method

A Magnetotelluric Exploration for Crustal Electrical Conductivity Distribution beneath around Azuma Volcano, Northeastern Japan

*Masahiro Ichiki[1], Toshiki Kaida[1], Takashi NAKAYAMA[1]

1.Graduate School of Science, Tohoku University

A magnetotelluric (MT) observation was carried out to explore electrical conductivity distribution in the crust beneath around Azuma Volcano, northeastern Japan. We expanded 16 MT observation sites in 20 X 20 km^2 area of which Oana-Crater lay in the center. Electromagnetic field variation during 3 days with 32 Hz sampling and during 30 hours with 1024 Hz sampling were acquired at each site. The MT response function has been calculated using procMT software (Metronix Inc.). The phase tensor attitude indicates high dimensionality around this area. To obtain three-dimensional conductivity model, we will have used WSINV3DMT (e.g. Siripunvaraporn et al., 2009), and will be discussing magma/hydrotherm transportation from deep crust in this presentation.
Acknowledgment: We thank Geothermal Energe Research Development Co. Ltd. and Nittetsu Mining Cosultant Co. Ltd. for providing the magnetotelluric remote-reference data.

Keywords: electrical conductivity

Introduction of fumarole temperature observation in the Tateyama Jigokudani valley

*Toshiya Tanbo[1], Yoshihiro Matsuda[2]

1.Tateyama Caldera Sabo Museum, Toyama Prefecture, 2.Tateyama Guide Council

A molten sulfur flows has occurred infrequently in fumarole field of Tateyama Jigokudani valley. The cause of active molten sulfur flow in Jigokudani valley is not known well. In recently, the Jigokudani valley fumarole gas properties such as component, temperature and concentration have shown large changes. So that raise of fumarole gas temperature might have dissolved sulfur deposit of ground surface, or the sulfur plumes might have ascent from the reservoir of shallow hydrothermal fluids.
This paper mainly reports the results of an investigation about time variations of the fumarole gas temperature, and distribution of surface temperature in the Tateyama Jigokudani valley. We thought the geothermal observation in the fumarole field may be an index of hydrothermal fluids activity. At the moment, the obtained data only shows the extrinsic factor change resulting from a weather. We carried out the long-term continuously observation and investigate whether the change of datum is associated with such as earthquakes and crustal movement.
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Keywords: Tateyama Jigokudani valley, fumarole gas, fumarole temperature

Resistivity structure around the Kuju volcanic group

*Taro Shiotani[1], Mitsuru Utsugi[5], Koki Aizawa[2], Makoto Uyeshima[3], Takao Koyama[3], Wataru Kanda[4], Tsuneomi Kagiyama[5]

1.Graduate School of Science, Kyoto University, 2. Institute of Seismology and Volcanology, Kyushu University, 3.Earthquake Research Institute, Tokyo University,Japan, 4.Volcanic Fluid Research Center, Tokyo Tech.,Japan, 5.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 6.Technical Division Graduate School of Science, Kyoto University

Kuju volcanic group is located at a boundary of Kumamoto Prefecture and Oita Prefecture, Kyushu, Japan. Iwo-yama is active fumarolic activity area at central part of the volcanic group. Yoshikawa et al.(2005) derived the subsurface seismic velocity structure of this volcanic group and pointed out the possibility of the existence of magma chamber at 11 km depth beneath Iwo-yama. Mizutani et al.(1968) showed that volcanic fluid is supplied to surface. But it is not cleard where volcanic fluid ascends to surface. .The purpose of this study is to infer the volcanic fluid path. We carried out campaign survey using the wide-band MT (Magneto-Telluric) around Kuju volcanic group in Sep. to Oct., 2014. From the data obtained by this survey, we investigated the detailed 2D subsurface resistivity structure by the inversion method of Ogawa and Uchida (1996). In this presentation, we will show the resistivity structure along two observation lines which is passing Iwo-yama and east side of it. We found the following common features in the resultant resistivity models along these two observation lines.Near the surface, there is a low resistivity layer. This layer can be interpreted as the aquifer that consists of the underground water containing volcanic gases.There is high resistivity area beneath the volcanic group from 1km to 6km depth. This high resistivity area is surrounded by low resistivity area. The high resistivity body is related with high Vp and Vs religion that was found by Yoshikawa et al. (2005).Two low resistivity areas correspond with low Vp and Vs religion that was found by Yoshikawa et al. (2005). We are considering that high resistivity body reflects an instructive rock and that low resistivity bodies may indicates geothermal fluid.

Repeated survey of ground temperature and hot springs around Iwo-yama, Kirishima Volcanic Group

*Tsuneomi Kagiyama[1], Shin Yoshikawa[1], Shinji Ohsawa[1], Taketoshi Mishima[1], Yu-Chih Huang[1]

1.Graduate School of Science, Kyoto University

Iwo-yama Volcano is located in the northwest of Karaguni-dake Volcano, central part of Kirishima Volcanic Group. This area had intense fumarolic activity before 1990's. After 1990's, fumarolic activity disappeared but hot spring activity has continued. However, volcanic tremors occurred frequently after 2014. And fumarolic activity appeared again at the summit of Iwo-yama in December 2015. The authors have carried out repeated measurements of electrical conductivity of hot spring waters; Western and Northeastern Flank of Iwo-yama and Ashiyu hot spring. Chemical composition was also analyzed.
Repeated measurements of electrical conductivity of spring water indicate EC of the W&NE springs are affected by rain water, but EC of Ashiyu water shows a significant change; 225 mS/m in 2008, 235-245 mS/m after the eruption of Shinmoe-dake in 2011, 256 mS/min December 2015. According to the chemical analysis, SO4 ion increased from 1060 mg/l to 1130 mg/l in Ashiyu, while the ratio of Cl/SO4 changed from 0.12 to 0.09. On the other hand, Cl/SO4 increased from 0.002 to 0.014 in the W Flank of Iwo-yama. This means SO4 ion increased in Ashiyu after the beginning of volcanic tremor in August 2014, but in W Flank of Iwo-yama, both SO4 ion and Cl ion increased.
Ground temperature at 1m depth has been observed at the central part of Ebino Heights. High temperature about 40C was detected in this area by the 1980's. But no anomalous temperature was detected. This means geothermal activity is limited within the summit area now.

Keywords: Kirishima Volcanic Group, Iwo-yama, Geothermal activity, Electrical conductivity, Volcanic actiovity

Gravity surveys in southwestern part of the Kirishima volacnic area

*Yasuhiro Fujimitsu[1], Jun Nishijima[1]

1.Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University

Laboratory of Geothermics, Kyushu University conducted gravity surveys in the hot springs area, mainly the Maruo and Hayashida hot springs, in southwestern part of the Kirishima volcanic area in order to reveal the shallow subsurface structure of the hot springs area. And we drew a Bouguer anomaly map of this area by using the measured gravity values and the data of the gravity database (AIST, 2013).
The Bouguer anomaly map shows a gravitational steep incline, which has a strike of NE-SW direction, near the Kirishima Rehabilitation Center of Kagoshima University in the Maruo hot springs. It is explained that this steep incline indicates a fault structure. And a low Bouguer anomaly area exists at the western part of the steep incline. So it is inferred that this is a depression structure filled with some low density layers and can be a hot spring aquifer.We are grateful to Mr. Yusaku Yonekura who had progressed this study.
AIST (2013) Gravity Database of Japan, DVD.

Keywords: Kirishima volcanic area, gravity survey, hot springs, subsurface structure

