Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SVC49-P01 Room:Convention Hall Time:May 25 18:15-19:30

Near surface structure of a Crater on mountain side of Mt. Shiretokoiozan and its mechanism of molten sulfur eruption

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Mt. Shiretokoiozan, located in the middle of the Shiretoko Peninsula in Hokkaido Japan, is famous as molten sulfur eruption. Since 1857, Mt. Shiretokoiozan has erupted with molten sulfur four times. At the last eruption from February through October in 1936, approximately 200,000 tons of molten sulfur welled out of the Crater I, located on the northwestern mountain side, and the brown liquid sulfur flowed into the Kamuiwakka Creek. The eruption was closely observed and documented for ten days in September by Watanabe. He presumed the underground structure and possible existence of a molten sulfur reservoir under the crater based on the periodic activity.

Since 2005 we have implemented further researches to find out the near-surface underground structure of the Crater I for discussing the mechanism of molten sulfur eruption. The methods are various; geological survey, DC resistivity survey, self-potential exploration, and chemical analysis of gas and hot spring.

As a result, we found that the crater had been created by depression due to hydrothermally altering of andesite lava sheet and the following running-off of material. We suggest that there is a chamber under the crater and molten sulfur is supplied from the aquifer at the eruption where the sulfur had been generated during the inter-eruption period by chemical reactions of volcanic gasses.

The geology of the Crater I and its vicinity is mostly composed of hydrothermally altered clay, gravel and onion structured floats. Originally this area was composed of several-meters-thick sheet lava layers of andesite, which had flowed from the summit of mountain. The volcanic gasses, mostly hydrogen sulfide and carbon dioxide, come out through fumaroles and craters located directionally along conjugate faults cutting through this area. Original andesite rocks suffered weathering by the reaction with those acid gasses into onion structured boulders and seems to change to white gravels and clay. Because the small clay particles and the gravel at ground surface have been drained, large boulders in several meters were left on the ground and they covered most of this area.

In the cross section around the Crater I, we conclude that the crater is a depression hole opening in the hydrothermally altered lava. An aquifer among sheet lava goes under the Crater I and hot spring wells in the crater. At the higher elevation than the Crater I, there is a small creek called the Io Creek. And at the lower altitude, the Kamuiwakka Creek is located. We interpret that the underground water comes from the Io Creek and flows through lava-sheet aquifer, and upwells at the Crater I as well as hot springs in the Kamuiwakka Creek.

Volcanic gasses, hydrogen sulfide and sulfur dioxide, dissolve into the underground water, and were involved in the chemical reaction to generate the accumulation of sulfur in the aquifer. At the fumarole in the Crater I, water soluble sulfur dioxide is just barely detected. At the same time, the gas temperature has never been higher than boiling point of water. These are the evidences that most of volcanic gas passed through underground water.

We suggest that the sulfur in the aquifer melts and flows into the chamber under the Crater I at the active term of volcano, and may eject molten sulfur periodically. The amount of the molten sulfur erupted in 1936 was approximately 200,000 tons. If the chamber had reserved all amount of sulfur erupted in 1936, its volume might have been as much as 100,000 cubic meters. We suppose the possible chamber size is much smaller than the estimation. It is concluded that the aquifer supplied the molten sulfur continuously to the chamber, while the chamber made a periodic eruptions.

Keywords: Molten sulfur eruption, Hydrothermal alteration, Shiretokoiozan, The Crater I, DC resistivity survey, Hot springs in the Kamuiwakka Creek

SVC49-P02 Room:Convention Hall Time:May 25 18:15-19:30

Mineralogical study of non-juvenile material in volcanic products at Tokachidake volcano, Japan

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Temperatures, depths, and fluid chemistry of sub-volcanic hydrothermal system were estimated based on mineralogical analysis of eruptive products of the 1926 and the 4.7-3.3ka eruptions at Tokachidake volcano, Japan. The deposit of the 1926 eruption can be divided into three layers according to volcanic phenomena; the lower debris avalanche deposit, the middle hydrothermal surge deposit and the upper debris avalanche deposit. The deposits of the 4.7-3.3 ka eruption can be divided into four pyroclastic flow deposits layers; one from the 4.7 ka eruption and other three from the 3.3 ka eruption. Every deposit contains abundant hydrothermally-altered lithic fragments. Three layers of the 1926 eruption exclusively consist of altered lithic fragments without any juvenile fragments. Minerals identified in the bulk sample of the 1926 eruption deposit are cristobalite, smectite, sericite, kaolinite, alunite, gypsum and pyrite, and those in the deposits of the 4.7-3.3ka eruptions are cristbalite, tridymite, quartz, sericite, pyrophyllite, alunite, plagioclase and hyperthene. Mineral assemblages of individual fragments were also determined with combination of SEM-EDS and XRD. The 1926 eruption product is characterized by the coexistence of cristobalite, alunite and/or smectite in the fragments, whereas the 4.7-3.3 ka eruption product is characterized by the coexistence of pyrophyllite and quartz. The mineralogical contrast implies difference in hydrothermal condition between the 4.7-3.3 ka and the 1926 eruptions. The former eruptions were derived from hotter ($>$230 C) and deep (1-2 km) hydrothermal systems and the latter from a colder ($<$100 C) and shallow (near-surface) hydrothermal system, although both volcanic products are characterized by sulfuric acid fluid which is typical in hydrothermal systems at volcanic centres.

Keywords: sub-volcanic hydrothermal system, hydrothermally-altered lithic fragment, Tokachidake volcano, eruption products in 1926, pyoroclastic flow deposits in 4.7-3.3 ka

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Resistivity structure of geothermal area at south area of Yakedake Volcano

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Resistivity structure of geothermal system at south area of Yakedake Volcano

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Some hot-springs and fumaroles are seen around the Yakedake Volcano. High temperature hot springs such as Nakanoyu and Shirahone hot springs are located at the south area of the Yakedake volcano, but the relations between the volcano and geothermal system have not been clarified yet. Geophysical studies concerning the structure of geothermal fluid reservoir and heat source of the hot springs have never been performed in this area.

Hokkaido University carried out a MT survey to clarify the subsurface structure at six sites between Sirahone hot spring and Sawando area in 2013 and indicated distribution of geothermal fluid reservoir beneath Shirahone hot springs and Sawando area (Yamaya et al., 2014). But they did not clarify the extent of geothermal fluid reservoir under these area. We installed two additional MT sites each at outside of the previous survey area in 2014 to investigate extension of these reservoirs.

We recorded MT signals for about 48 hours at each site, and obtained the apparent resistivity and phase at a frequency range of 0.03-100Hz. We applied the remote magnetic reference (Gamble et al., 1979) and manual data editing by MTEDITOR to remove local electromagnetic noises.

The magnetotelluric phase tensors (Caldwell et al., 2004) and induction vectors were calculated to verify structural dimensionality and to determine the 2D strike direction for the 2D inversion. According to the phase tensor ellipse and induction vector at the lower frequency range, the deeper layer have 2D structure and we decided that 2D strike direction is N60W in this area.

We performed two types of 2D inversion, which used the TM mode and TE+TM modes, respectively. We used the inversion code proposed by Ogawa and Uchida (1996), which minimized ABIC as convergent criterion in the iteration process. The ABIC criterion includes smoothness, least square mean error and static shift correction.

As a result, we indicate that geothermal fluid reservoir correspond with low resistivity is extending at directly under the Shirahone hot spring area, and it ranges in the limestone body. Dissolved limestone is origin of milky hot spring that characterizing the Shirahone hot spring. The low resistivity zone was also found at the depths of 500m down in the Sawando area. Although no geothermal manifestation is recognized at the surface of the Sawando area, but this low resistivity zone probably indicates a geothermal reservoir.

Furthermore, these two low resistivity structures corresponding each geothermal fluid reservoir join together at the depths of 2 km below. The columnar low resistivity zone extends to deep. Comparing the geology, the Sakaitouge fault runs through at the columnar low resistivity zone. The resistivity structure suggests that geothermal fluid ascends from deeper zone along the Sakaitouge fault. Based on this result, we can propose two possibilities of the heat source of geothermal fluid. One possibility is that hot volcanic fluid flows out from the Yakedake volcano along the fault. The other is that heating water is ascending along the fault from the hot rock area extending in the Japanese Northern Alps area.

Keywords: Geothermal area, Resistivity structure, Yakedake

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Conductivity distribution of the surface layer around volcanic area in central Kyushu

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Kagiyama and Morita (2008) indicated magma degassing is one of the important factors to control magma ascending. Discharge rate of volatiles from magmas through a crater has been estimated by direct observations of CO2 and SO2 gases, such as COSPEC and DOAS, and by geochemical methods. However, discharge rate of volatiles through a volcanic aquifer has not been clarified because of difficulty of obtaining geochemical samples spatially from deeper part of volcanic aquifer. Electrical conductivity of ground strongly depends on the conductivity of pore water, and VLF-MT survey is a powerful tool to clarify the distribution of hydrothermal water in the shallow depth. On this aspect, the authors carried out VLF-MT survey around volcanoes in central Kyushu, Japan.

Aso Caldera: Aso Caldera has acid crater lake in Nakadake Volcano, which is one of the post caldera cones, and has many hot springs within the caldera such as Uchinomaki, Jigoku & Tarutama. 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 have lower conductivity (<3mS/m), except active geothermal fields around Naka-dake Craters and western part of post caldera cones (>30mS/m). Just north and south of Naka-dake Craters, high conductivity (3-10mS/m) was identified. This suggests down flow of hydrothermal water from Naka-dake Craters to the flank of post caldera cones. 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 (>30mS/m) was found at several areas in the caldera floor. These high conductive zones and Naka-dake are located along the NNW-SSE line. Hydrothermal water may be supplied along this tectonic line.

Kuju volcanic group: Central cones have lower conductivity (<3mS/m), except active geothermal fields around Iwo-yama (>30mS/m). Around volcanic cones, high conductivity zone was identified. This suggests down flow of hydrothermal water from volcanic cones to the flank. On the other hand, another high conductivity zone is identified along the tectonic line; Oita-Kumamoto tectonic line, Yufuin Fault, etc. Hydrothermal water may be supplied along this tectonic line.

Tsurumi&Garan volcanoes (Beppu geothermal area): Many lava domes show low conductivity (<3mS/m), except active geothermal spots in Tsurumi and Garan domes. High conductivity zones are identified along some tectonic faults; E-W trend from Garan crater to Kan'nawa hot spring, along Asamigawa Fault, etc. The area size of high conductive (>30mS/m) zone around northern Beppu hot springs (320MW) is estimated about 4 km2.

These results suggest Geothermal activity dominant volcanoes have wide high conductivity area related with degassing from magma. And VLF-MT survey will be effective method to identify tectonic line around volcanic and geothermal field.

Keywords: Active volcano, Electrical conductivity, Central Kyushu, Geothermal activity