Fumarolic gases sampled at Ebino-Iwoyama and Shinmoedake volcanoes, Kirishima, Japan

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Introduction

New fumaroles have appeared at Mt Ebino-Iwoyama volcano Kirishima Japan in Dec 2015. After the appearance, volcanic earthquakes and tremor have been observed, suggesting the activation of volcanic activity. At Mt Shinmoedake volcano Kirishima Japan, a magmatic eruption happened in 2011. Until Jan 2017, the volcanic activity has decreased and the activity is almost dormant. In general, fumarolic gases contain magmatic components. In this study, we have sampled fumarolic gas at Ebino-Iwoyama and Shinmoedake volcanoes. The chemical and isotopic composition of fumarolic gases will give us the useful information for the evaluation of activity at the both volcanoes.

Fumarolic gas

We have sampled fumarolic gases at the fixed position on the summit area of both Ebino-Iwoyama and Shinmoedake volcanoes. The temperature of fumarolic gas, at the outlet of fumarole, was close to the boiling temperature of water under the local atmospheric pressure. The momentum of discharging fumarolic gases was low at the both volcanoes, producing no big sound.

Result and Discussion

(Ebino-Iwoyama volcano)

The CO2/H2O ratio of fumarolic gas had increased until May 2016 followed by a continuous drop after Jul 2016. In general, CO2 gas originates in the degassing magma. The recent decrease of CO2/H2O ratio suggest the suppressed degassing activity of magma. The apparent equilibrium temperature (AET) can be calculated by use of the concentration of H2O, H2S, SO2 and H2 in fumarolic gas. The calculated AET was 232C in Dec 2015. It increased to 313C in Feb 2016, followed by a stabilized temperature. In Dec 2015, the 18O/16O ratio of H2O in fumarolic gas was low. It increased significantly in Feb 2016 followed by a gradual increase. The changes in AET and 18O/16O ratio suggest an invasion by hot magmatic fluid within the shallow hydrothermal system beneath fumaroles.

(Shinmoedake volcano)

One conspicuous feature of fumarolic gas composition was the high CO2 concentration extending to 5 to 7%. The concentration is much higher than the value of fumarolic gas sampled in 1991 and 1994, which was 1.4 to 1.9%. On the other hand, H2S concentration was only 0.01 to 0.04%, much depleted relative to the gas in 1991 and 1994 such as 0.2 to 0.6%. The recent chemical composition of Shinmoedake volcano suggests the sustained degassing of CO2 rich magma with the process removing H2S gas working along the channel of volcanic fluid between magma and fumarole.

Keywords: Kirishima Ebino Iwoyama Shinmoedake, Volcanic gas, magma

A hydrothermal system of Kusatsu-Shirane volcano inferred from Cl concentrations and stable isotope ratios of Yugama crater lake water

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Kusastu-Shirane volcano exhibits geothermal features such as hot springs that have almost the same SO_4^{2-}/Cl^- ratio of water. These hot springs are derived from common parental fluid (Pf) which is produced by a mixing of magmatic high temperature volcanic gas and local meteoric water. The Pf is diluted by hot waters containing low concentration sulfate as waters flow under the ground surface (Yamamoto et al., 1997; Hirabayashi, 1999). A relation between Cl^- concentrations and stable isotope ratios of water requires an existence of vapor-liquid reservoir. The liquid phase of the reservoir is highly condensed in Cl^- produced by a boiling of the Pf. The vapor-liquid reservoir supplies hot water to Kagusa and Jyofu hot springs, located near the top of Kusatsu-Shirane volcano (Ohba et al., 2000).

Shirane pyroclastic cone, located at the summit of Kusatsu-Shirane volcano, has three crater lakes. The largest crater lake, locally called Yugama, has over 0.5 million m^3 of water with a temperature between 0 and 30 degree Celsius which is 10 degree Celsius higher than an ambient temperature. Phreatic eruptions have repeatedly occurred around the cone during the last 130 years. During the recent calm periods, subaqueous fumaroles of Yugama crater lake continue to supply hot water containing high concentration of H^+, Cl^- and SO_4^{2-} to lake. Stable isotope ratios of lake water have values that are larger than that of the local meteoric water due to additions of magmatic fluids from the lake bottom.

We can easily collect lake water on the lake shore in order to monitor changes in concentrations of lake water. However, we cannot directly evaluate chemical features of fluid emitting from subaqueous fumaroles, because lake water experiences somewhat complex processes including isotropic fractionations during evaporation, condensation, seepage through the lake bottom and meteoric input.

In this study we have developed a numerical model which takes factors associated with variations of Cl^- and stable isotope ratios into account. Applying the model to observation data including water level, temperature, Cl^- concentrations and stable isotope ratios of hydrogen and oxygen, we estimate mass flux, enthalpy, Cl^- concentration and stable isotope ratios of water emitting from the lake bottom. During a calm period in 2012 - 2013, a relation between Cl^- concentrations and stable isotope ratios of water indicates that the hydrothermal reservoir beneath Yugama crater lake is a mixture of magmatic high temperature volcanic gas and the local meteoric waters.

Intense micro earthquake swarms and ground deformations occurred around Shirane pyroclastic cone in 2014, which are accompanied by changes in water temperature, Cl^- concentration and stable isotope ratios. Our model reveals an increase in supply of magmatic high temperature volcanic gas to the hydrothermal reservoir located beneath Yugama crater lake. However, the relation between Cl^- concentrations and stable isotope ratios of water cannot be explained by a mixing. We believe that enhanced boilings have occurred in the reservoir leading fractionations of stable isotope ratios.

In order to reveal the locality of the hydrothermal reservoir, which is an origin of water of Yugama crater

lake, hypocenters of micro earthquakes are precisely relocated by the DD technique. We identify two groups of hypocenters on the basis of its depth and time sequences. Attenuations of seismic waves indicate that the reservoir locates between the shallow and the deep groups of hypocenters, corresponding to an altitude of around 900 m a.s.l. The depth is consistent with the altitude of undersurface of an impermeable layer suggested by MT surveys (Ogawa, in prep.).

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Keywords: Kusatsu-Shirane volcano, Crater lake, Chloride ion, Stable isotope ratio of water, Micro earthquake

Volcanic fluids-rock interaction inferred from characteristics of altered minerals in volcanic products at Tokachidake volcano, central Hokkaido, Japan.

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Altered volcanic products from Tokachidake were mineralogically observed to interpret interaction between volcanic fluids and rock, by using XRD, Raman spectroscopy, and SEM-EDS. We collected samples from the 4.7 ka pyroclastic flow deposit (Gfl-0), lower and upper units of the 3.3 ka pyroclastic flow deposit (Gfl-1 and Gfl-2), and the 1926AD eruption deposits consisting of the lower debris avalanche deposit (Unit A), the middle hydrothermal surge deposit (Unit B), and the upper debris avalanche deposit (Unit C). Each product contains unaltered ash grains consisting of primary igneous minerals and volcanic glass, weakly-altered ash grains in which unaltered part coexists with altered minerals, and intensely-altered ash grains consisting only of altered minerals. Individual ash grains have one of three types of altered mineral assemblages: silica mineral (silica type), silica mineral-alunite±kaolin (alunite type), and silica mineral-kaolin (kaolin mineral type). Most ash grains in Gfl-0 have undergone alteration that produces the alunite type. The samples from Gfl-1 contain abundant kaolin mineral type ash, subordinate alunite type ash, and minor unaltered ash grains. Alteration types in the Gfl-2 deposit are similar to those of Gfl-1, but unaltered ash grains are more abundant in Gfl-1. Most of the ash grains in the 1926AD products underwent alteration which produced mainly silica and alunite types. These mineral assemblages in every product indicate only acidic alteration. The presence of unaltered parts in the most abundant weakly-altered ash indicates rock alteration by a brief, incomplete chemical reaction. For such brief and incomplete reaction, the followed two fluid-rock interactions can be available. One is water-rock interaction which acid hydrothermal water reacts with rocks. Another is vapor-rock interaction which volcanic vapor separated from magma reacts with rocks. Thus, the presence of weakly-altered ash suggests that rock alteration occurred by the brief, incomplete fluid-rock interactions was undergoing an acid-hydrothermal system and/or a volcanic vapor-dominated system developed under the crater when a magma intrudes and degasses. This concluded that the conditions of rock alteration at Tokachidake volcano can be controlled by a magma intrusion.

Keywords: Volcanic fluids, Fluid-Rock interaction, altered minerals

Geochemical simulation for hydrothermal activity

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The estimation of geochemcal change in volcanic and geothermal process is important. And the geochemical calculator (simulator), for example, Solveq-Chiller, is useful tool to calculate of fluid change. Especially, in Hijiori EGS field, calcite precipite with CO_2 gas release with pH increasing from hot water fluid due to rapidly super-saturated as calcite calculated by Solveq-Chiller.
And we calculated in the case of reaction between CO_2 gas and fluid, mass balance and case study of CO_2 gas injection simulation using Hijiori EGS system.
And the phase balance have to be considered in other volacanic and geothermal system and we will show other field examples.

Keywords: geochemical simulation, chemical composition, degas

Plumbing the depths of Yellowstone's hydrothermal system: preliminary results from a helicopter magnetic and electromagnetic survey

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Although Yellowstone's iconic hydrothermal systems are well mapped at the surface, their groundwater flow systems are almost completely unknown. In order to track the geophysical signatures of geysers, hot springs, mud pots, steam vents, and hydrothermal explosion craters at depths to hundreds of meters, we collected 4900 line-km of helicopter electromagnetic and magnetic (HEM) data. The data cover significant portions of the caldera including a majority of the known thermal areas. HEM data constrain electrical resistivity which is sensitive to groundwater salinity and temperature, phase distribution (liquid-vapor), and clay formed during chemical alteration of rocks. The magnetic data are sensitive to variations in the magnetization of lava flows, faults and hydrothermal alteration. The combination of electromagnetic and magnetic data is ideal for mapping zones of cold fresh water, hot saline water, steam, clay, and altered and unaltered rock. Preliminary inversion of the HEM data indicates low resistivity directly beneath Yellowstone Lake as well as beneath most of the area with mapped hydrothermally altered rocks; the majority of these areas are also associated with magnetic lows. In the northern part of Yellowstone Lake, low resistivity zones intersect with the lake bottom in close correspondence with mapped vents, fractures and hydrothermal explosion craters and are also associated with magnetic lows. Coincident resistivity and magnetic lows unassociated with mapped alteration occur, for example, along the southeast edge of the Mallard Lake dome and along the northeastern edge of Sour Creek Dome, suggesting the presence of buried alteration. Low resistivities unassociated with magnetic lows may relate to hot and/or saline groundwater, to which the magnetic data are insensitive. Resistivity and magnetic lows follow interpreted caldera boundaries in places, yet deviate in others. In the Norris-Mammoth Corridor, NNE-SSW trending linear resistivity and magnetic lows align with mapped faults. This pattern of coincident resistivity and magnetic lows may reflect fractures along which water is flowing. In addition, low resistivities underlie highly resistive and magnetic rhyolite flows, and in several cases, suggest interconnection between the different thermal areas.

Keywords: Yellowstone, geophysics, hydrothermal, electromagnetic, magnetic

Reactive transport modeling in peralkaline salic volcanic complex, caldera-hosted geothermal system; a case of Menengai volcano, Kenya

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Menengai geothermal area is one of high temperature caldera-hosted geothermal systems located in central part of Kenyan rift valley. The caldera together with local rift floor tectono-volcanic axes is considered essential in controlling the local movement of geothermal fluids in the area. Fluid-rock chemical interaction has gained more acceptance in recent years in geothermal application and there has been a growing particular attention in the coupled processes involved in reactive chemical transport in porous media. The current study attempts to develop a 1-D reactive transport model to assess fluid flow conduits and fluid interaction processes of Menengai geothermal field in Kenya. The model incorporates geothermal fluids, modeled from wellhead discharge chemistry to obtain the initial aquifer fluids feeding the reservoir. The resultant fluid was then injected into the model along an ascending porous media as the ‘parent’ fluid. Water chemical data from adjacent water borehole was included as the initial media fluid while pressure and temperature information are taken from well downhole measurements. The reservoir rocks are predominantly peralkaline, silica-oversaturated trachytes, with few lenses of tuffs, rhyolite, and basalt, thus, the initial mineral assemblage of the model taken to be of trachytic composition. The model was calibrated using observed field hydrothermal minerals. The simulation was performed using the parallelized version of TOUGHREACT v3 code that employs a sequential iteration approach that solves the solute transport and reaction equations separately. Flow and transport are based on space discretization by means of integral finite differences. An implicit time-weighting scheme is used for individual components of the model, consisting of flow, transport, and kinetic geochemical reaction. This study demonstrates the relationship between fluid flow, chemical reactions, and mass transport in a peralkaline salic volcanic complex, caldera-hosted geothermal system with a view of explaining the occurrence of hydrothermal minerals in up-flow zones in such systems.

Keywords: Menengai volcano, reactive transport, geochemical modeling, fluid-rock interaction, geothermal fluid