Measurements of gaseous elemental mercury discharge rates from soil around active craters

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Gaseous mercury emissions from ground surface at active volcanoes suggest thermal activities such as hydrothermal system. Mercury contained in geothermal hot water or hydrothermally altered rocks is released with an increase in temperature. Gaseous mercury separated from hydrothermal reservoirs is transported to the surface along relatively high permeable zone. Thus, a distribution of gaseous mercury emission rates from ground surface is one of a clue used to detect localities of geothermal reservoirs, fluid paths and permeable zones such as faults. Furthermore, changes in flux of gaseous mercury may reflect temperature changes in a hydrothermal reservoir although mercury flux from ground surface is affected by environmental factors including air temperature, soil moisture content and organic carbon.

Recently, portable apparatuses allowing to measure concentrations of gaseous elementary mercury (GEM) have been developed. We apply the NIC (R) EMP-2 portable GEM analyzer which is low power consumption and light weight. The GEM analyzer is easy to operate because special carrier gas is not required. Combining an Au amalgam method, the GEM analyzer automatically detect trace gaseous mercury of around 2.0 ng/m^3. However, over 600 seconds are required to measure GEM concentrations of each site on the basis of a standard empirical procedure. To estimate GEM flux of each site, we have developed a simple numerical model of the empirical procedure. Our model suggests that a GEM concentration which is proportional to GEM flux at the site can be measured within 600 seconds. Measurement time changes depending on a ratio of a GEM concentration of ambient air to a GEM flux of a site.

We have measured GEM concentration at Owakudani geothermal area of Hakone volcano in order to reveal a distribution of GEM flux in September 2016. Owakudani is the most active thermal area at central cones of Hakone caldera in terms of emissions of a large amount of volatiles and hot springs. A phreatic eruption which produced a hundred tonnne of highly altered materials occurred at Owakudani in 2015. To utilize hot springs of Hakone volcano safely, a hydrothermal system beneath central cones has been investigated in detail, and conceptual models have been proposed.

GEM concentrations obtained in this study show a correlation with ambient temperatures as known in previous reports. Applying an empirical method of a correction for temperatures, we obtain a GEM flux distribution based on GEM concentration around Owakudani. GEM fluxes decrease with a distance from the center of Owakudani. At a region more than 1.5-2 km from Owakudani, GEM concentrations show roughly constant values of around 4 ng/m^3 which indicates the value of background at Hakone Caldera.

These results suggest that GEM fluxes around Owakudani are enhanced by hydrothermal water. In the northeastward direction from Owakudani, values of GEM fluxes are slightly larger than these values measured at the same distance from Owakudani. Such a GEM anomaly may be caused by an underlying hydrothermal water, or depositions of mercury in volcanic gas which was drifted from fumaroles in Owakudani.

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