Mechanisms of water formation and secular change in water quality of crater lakes of Kusatsu-Shirane volcano, Japan

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Kusatsu-Shirane volcano with three crater lakes, Yugama, Mizugama and Karagama, on its summit is located at the central part of Honshu Island, Japan. Yugama is the largest and the most acidic of the three. Volcanic gas and fluid are supplied constantly to Yugama from its bottom, and thus chemistry of Yugama water reflects the volcanic activity of Kusatsu-Shirane volcano.

In this study, we discuss the mechanisms of water formation and secular changes in water quality of Yugama and Mizugama. Water samples since 1966 were reanalyzed for the present study.

There were five phreatic eruptions at Yugama in 1982-83. A remarkable increase in concentrations of dissolved components of Yugama water was observed after the eruptions, which has been considered to be due to the influx of highly-concentrated fluid into Yugama water.

A spring has been found at the bottom of Yugama that supplies fluid to the lake, which has been thought to control, partially at least, the water chemistry of Yugama. Analysis of the fluid, however, revealed that the chemical compositions of the fluid and Yugama water quite resemble each other. That means that the fluid supplied by the spring is nothing but a part of Yugama water, and suggests that the chemical composition of Yugama water is determined by rocks and mud in direct contact with the water.

Leaching experiments, in which a mud sample collected from the bottom of Yugama was placed in pure water used as leachate at temperatures between room temperature and 100 degrees in Celsius and components dissolved out to the water were analyzed, were carried out. The chemical compositions of the leachates after the experiments resembled that of the present Yugama water. The chemical composition of the Yugama water in 1984 that had been much influenced by the eruptions in 1982-83, was in between the chemical compositions of the leaching experiment at 40 degrees in Celsius and another experiment at 100 degrees in Celsius. These laboratory experiments suggest that the increase in concentrations of dissolved components in Yugama water after the 1982-83 eruptions was due to the temperature increase of the water.

Thus, it may be concluded that there is a fluid reservoir beneath Yugama whose chemical composition is basically the same as that of Yugama water, and the chemistry of Yugama water is controlled by the temperature-dependent equilibrium with surrounding rocks and mud that are in direct contact with Yugama water and fluid in the reservoir.

Secular change in water quality of Mizugama resembles that of Yugama, including the abrupt increase in concentrations of dissolved components after the 1982-83 eruptions, although the absolute concentrations of the former lake are much lower than those of the latter. It was thus possible that the same fluid that was supplied to Yugama was also supplied to Mizugama during the eruptions. The reservoir expected to exist beneath Yugama also supplies fluid to Mizugama.