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Potential of ICP-OES for determination of halogens and sulfur species dissolved in volcanic geothermal fluids

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The water in active crater lakes and volcanic hot springs are important monitoring targets for understanding a volcano's subsurface hydrothermal system and evaluating its activity. Halogens and sulfur species related to magma volatiles are important to determine in chemical monitoring using these targets. Both halogen and sulfur species are the subject of anion analysis, and ion chromatography and ion-selective electrodes are widely used for this analysis. In this study, we investigated the possibility of using ICP-OES instead of ion chromatography and ion-selective electrodes to determine halogen and sulfur species contents in active crater lakes and volcanic hot springs.

Chlorine, bromine, iodine, and sulfur have emission spectra in the vacuum ultraviolet wavelength range, and it is possible to detect these elements using ICP-OES equipped with a vacuum spectrometer. On the other hand, fluorine cannot be detected by a standard ICP-OES system with argon plasma due to its high excitation energy. Therefore, fluorine is excluded from the target of this study. We attempted to quantitatively analyze the dissolved chlorine, bromine, iodine, and sulfur species in the lake water of an active crater lake (Yugama Crater, Kusatsu-Shirane Volcano, Japan) and in volcanic hot spring water (Kusatsu Hot Springs, Japan) using an ICP optical emission spectrometer with a vacuum system (SPS3520UV-DD, SII NanoTechnology Inc.). As a result, it was found that ICP-OES was sufficiently applicable to the quantitative analysis of chlorine, bromine, iodine, and sulfur in the order of mg/L, and in particular, the lower limit of quantification for bromine and iodine are the order of sub-mg/L. Concerning sulfur species, pre-separating each species into fractions using anion exchange made it possible to easily separate and quantify sulfate, thiosulfate, and polythionate ions. Depending on the analytical objective and the solution conditions of the sample to be analyzed, it is thought that the ICP-OES method, which is an elemental analysis, can obtain more reliable analytical values than ion chromatography or ion-selective electrodes, which analyze chemical species.