Lacustrine sediments and subaqueous geothermal activity of the Nakadake crater lake, Aso Volcano, Japan

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Nakadake, Aso Volcano is one of the most active volcanoes in Japan, and has maintained a high heat discharge rate of approximately 220 MW even in calm periods (Terada *et al.*, 2008). The active Nakadake crater is occupied by a hyperacid crater lake during its dormant periods. Recently, precise remote monitoring of water volume and temperature has been carried out (Terada *et al.*, 2008). For geochemical and isotopic analyses, lake water samplings were taken several times (Ohsawa *et al.*, 2003). However, sampling of lacustrine sediments is extremely difficult because the crater, which is 200 m in diameter, is surrounded by steep crater walls of over 120 m in height and SO_2 gas emission of 200-600 tonne/day.

The sampling of lake sediments from the Nakadake first crater on 8 July 2008 was conducted by the following method. We first stretched a 400-m polypropylene rope (8 mm diameter, 7 g/m weight) between crater rims (hereafter we call main rope) because the Nakadake crater lake is inaccessible. A mud sampler (total weight 0.6 kg) and an attached weight (1 kg) suspended beneath two pulleys were descended to the lake bottom under gravity along the main rope. The attached weight was tied to the sampler using paper string that dissolved in the lake water. This system enabled the rapid descent of the sampler from the crater rim to the lake, the automatic detachment of the weight from the sampler once the system reached the lake, and the easy manual retrieval of the sampling system from the lake to the crater rim.

Lacustrine sediments sampled from Nakadake crater lake are characterized by an extremely high content (74 wt.%) of total sulfur, which exits as elemental sulfur, gypsum and anhydrite. The abundance of sulfur is believed to result from precipitation due to the reaction of SO_2 and H_2S in the lake water. Based on the sulfur content of sediments and measurements of elevation change of the crater bottom (Terada *et al.*, 2008; Hashimoto *et al.*, 2003), the sulfur accumulation rate at the Nakadake crater lake was calculated at approximately 250 tonne/day. This suggests that a considerable amount of SO_2 is absorbed in lake water relative to total amount of SO_2 emission (200-600 tonne/day; JMA data) from the Nakadake crater. The sediments include a small amount (9 %) of apparently clear glass shards that are barely altered, although they were easily altered by hyperacid lake water. This finding suggests that the clear glass shards originating from the underlying magma emit constantly from fumaroles on the bottom of crater lake even in calm periods. The present work emphasizes that sampling and chemical analyses of lacustrine sediments enable quantitatively evaluation of geothermal activity through active crater lakes.