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Sulfur dioxide fluxes from the volcanoes of Hokkaido, Japan

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Abstract

We report here the first measurements of SO_2 emission rates for three volcanoes in Hokkaido. Observations were made by scattered light ultraviolet (UV) spectroscopy using miniature spectrometers carried in vehicles or on foot, or attached to scanners, with data processing following variants on differential optical absorption spectroscopy. The following mean fluxes were calculated for measurements in 2003 (and 2004): 0.032 (0.14), 0.24 (0.28) and 2.4 kg s^{-1} for Meakan-dake, Tarumae, and Tokachi-dake, respectively. These are thought to be the only sites of high temperature volcanic degassing on Hokkaido at present, and thus the modest combined flux of 2.7 kg s^{-1} represents, to first order, the total volcanic emission rate of SO_2 for the island. This represents only a small fraction of the SO_2 output of about 80 kg s^{-1} for Miyakejima volcano in 2003. The apparently low sulfur emission from Hokkaido volcanoes may reflect the scrubbing efficiency of their hydrothermal systems though H_2S emissions remain unquantified. The ability to measure comparatively weak fumarole emissions (e.g., at Meakan-dake and Tarumae) emphasizes the value of walking traverse UV spectroscopy.
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Keywords: SO_2 flux; volcano; Hokkaido; UV spectroscopy; DOAS

1. Introduction

The recent development for volcano applications of commercially available miniature ultraviolet (UV) spectrometers (McGonigle et al., 2002; Galle et al., 2003; Oppenheimer and McGonigle, 2004) has provided a valuable replacement to the correlation spectrometer (COSPEC) for SO_2 emission measurements, bringing a new era of volcanic gas geochemistry. Benefits and opportunities include detection and quantification of additional species such as BrO (Bobrowski et al., 2003; Oppenheimer et al., 2006), H_2S (O'Dwyer et al., 2003) and NO_2 (Oppenheimer et al., 2005), estimation of plume transport speeds (McGonigle et al., 2005; Williams-Jones et al., 2006), and high-time resolution measurements using automated scanning techniques (Edmonds et al., 2003). In addition, the low cost and versatility of this approach to gas sensing provides new opportunities to obtain measurements for many volcanoes that have rarely had their SO_2 fluxes measured, if at all (McGonigle et al., 2004). In

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particular, the portability of instrumentation based on miniature UV spectrometers greatly facilitates collection of plume traverse data on foot (McGonigle et al., 2002; Oppenheimer et al., 2004). This permits measurements of gas fluxes even from very weak emitters such as individual fumaroles, since traverses can be made, where safe, within a few hundred metres of the source.

The aims of this work were to obtain the first measurements of SO_2 fluxes from the volcanoes of Hokkaido, Japan, and to evaluate further the potential of walking traverse methods for sensing of volcanic SO_2 using scattered UV. For this purpose, groups from the Geological Survey of Japan and University of Tokyo (GSJ and UT) were joined by a group from University of Cambridge (UCAM) to carry out a measurement campaign using three systems built around a common UV spectrometer. The volcanoes studied were Tarumae (5 July, 11 November 2003 and 3 July 2004), Tokachi-dake (7 July 2003) and Meakan-dake (9 July 2003 and 29 June 2004). The SO_2 fluxes from Tarumae and Meakan-dake are low, precluding measurements much beyond the upper flanks of both volcanoes.

1.1. Volcanoes investigated

Fig. 1 shows the location of volcanoes on Hokkaido. Close to Tarumae volcano, the direction of Pacific Plate

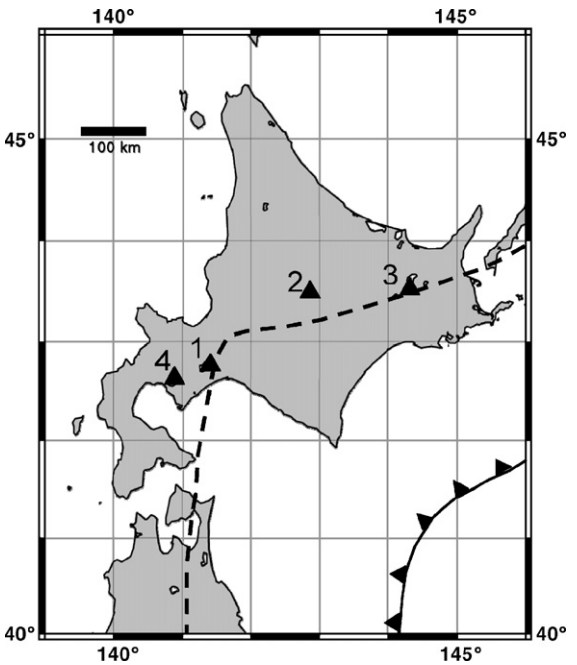

Fig. 1. Map of Hokkaido showing (1) Tarumae, (2) Tokachi-dake, (3) Meakan-dake, and (4) Usu. The dashed line indicates the volcanic front and the toothed line indicates the trench.

Fig. 2. Photograph of walking traverse measurements at Tarumae Site A on 3 July 2004.

subduction changes from N–S along the Japan Trench to WSW–ESE along the Chishima (Kurile-Kamchatka) Trench. Tarumae (1024 m a.s.l.) consists of a 1.5-km-diameter crater formed in 1667 and 1739 and is located on the southeast rim of Shikotsu caldera. It erupted in 1909, emplacing an andesitic lava dome in the summit crater. The dome is 450 m in diameter, 150 m in height, and has a volume of around 0.02 km^3. The last eruption took place in 1981. Strong fumarolic activity persists in the summit area and is focused in two areas: a pit crater on the southeast foot of the lava dome (designated site A here), and on the southern flank of the dome (site B).

Tokachi-dake (2077 m a.s.l.), in central Hokkaido, belongs to the Tokachi volcanic complex. In 1926, its central cone collapsed during a phreatic eruption and lahars inundated and devastated downstream settlements The last eruption took place in 1988–1989, and fumarolic activity prevails in the 62-II crater, located on the northwest flank at around 1740 m a.s.l. Emissions from the 62-I crater, which is about 200 m northwest of the 62-II crater, were sampled between 1984 and 1989, revealing that the gas was equilibrated under a several tens of atmospheric pressure and that there was a secondary sulfur contribution at shallow depth to the deep-originated volcanic gas (Hirabayashi et al., 1990).

Meakan-dake (1499 m a.s.l.), situated on the western edge of Akan Caldera, is an andesitic complex, which erupted frequently between 1955 and 1965. Minor phreatic eruptions occurred in 1996 and 1998 within the Ponmachineshiri crater.

2. Observation methods

We used three spectroscopic systems for SO_2 column measurements during the 2003 campaign, though all

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