Article

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Internal Structure of Kuttara Caldera, Hokkaido, Japan

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A controlled-source audio-frequency magnetotelluric (CSAMT) survey was conducted across the caldera of Kuttara volcano, Hokkaido, Japan, to investigate its subsurface structure. The caldera is 3 km in diameter and contains a circular lake (Lake Kuttara) 2.5 km across. The CSAMT survey was conducted along a 12-km-long east–west-trending transect that crossed the volcano and passed over the caldera. A total of 23 receiver stations were distributed along the survey line, including 7 stations in the caldera. Unique on-boat measurements were obtained at the surface of Lake Kuttara. A two-dimensional inversion of the CSAMT data, which revealed the resistivity structure to depths of up to 1000 m beneath the caldera, suggested the existence of a low-resistivity region ($<30\,\Omega\cdot$m) beneath the eastern caldera floor, extending subvertically for >1000 m and with a width of 1300−1500 m. The structure is interpreted to be a region filled with lava blocks and pyroclasts, which subsided during collapse of the caldera and which has been affected by hydrothermal alteration. The location of the low-resistivity region corresponds to an oval basin in the eastern part of the lake, implying that caldera subsidence occurred mainly beneath this basin. The western part of the caldera floor tilts gently to the east and has a rugged surface, suggesting that the western caldera rim was significantly enlarged as a result of landsliding during caldera formation. We thus infer that the Kuttara caldera was produced by asymmetric caldera collapse, which is attributed to the geological heterogeneity of the Kuttara volcano, with an eastern part comprised mainly of andesitic lavas and a western part comprised mainly of dacitic pyroclastic deposits.

Key words: resistivity survey, CSAMT method, caldera, internal structure, Kuttara volcano

1. Introduction

The Kuttara caldera (3 km in diameter), Kuttara volcano, southwestern Hokkaido, Japan, is one of the smallest Quaternary calderas in Japan (Fig. 1). The caldera contains a remarkably circular freshwater lake, Lake Kuttara (Fig. 2A). Subsurface geological structures of the caldera have been previously studied by a gravity survey (Yokoyama *et al.*, 1967), but details of the structures remain poorly constrained. We conducted a controlled-source audio-frequency magnetotelluric (CSAMT) resistivity survey (Milsom, 2003; Sandberg and Hohmann, 1982) to investigate its internal structure. As the Kuttara caldera contains a lake, we obtained unique on-boat CSAMT measurements from the lake surface. A two-dimensional inversion of the CSAMT data revealed the resistivity structure at depths of up to 1000 m beneath the caldera. We here present the results of the resistivity survey, and discuss the nature of the subsurface geological structures beneath the caldera.

2. Kuttara caldera

The Kuttara caldera is located at the summit of Kuttara volcano (Fig. 2). Volcanic activity on Kuttara volcano, which occurred from 80 to 40 ka, included an early period of silicic explosive activity followed by the construction of an andesitic stratovolcano (Katsui *et al.*, 1988; Moriizumi, 1998; Moriya, 2003; Yamagata, 1994). The stratovolcano (elevation, 549 m above sea level; base diameter, 9 km) consists mainly of andesitic lavas and scoria, and associated dacitic pyroclastic deposits (Katsui *et al.*, 1988). The andesitic lavas and scoria are distributed on the northern, eastern, and southern parts of the stratovolcano, whereas the dacitic pyroclastic deposits are distributed on the western part (Fig. 2B).

The Kuttara caldera is subcircular (diameter, 3 km) and retains its primary morphological features, such as a caldera rim and inner caldera wall (Fig. 2A). The caldera formed during violent and explosive silicic eruptions at *ca.* 40 ka (Moriizumi, 1998; Yamagata, 1994) that resulted in a large-volume dacitic pyroclastic fall and flow deposits around the caldera (Kt-1 tephra; Yamagata, 1994). Lake Kuttara is 2.5 km in diameter with a maximum depth of 148 m (water level, 258 m above sea level). The lake water is clear and transparent to a depth of 22 m, as measured in 1991 (Environment Agency of Japan, 1993). The caldera has never been drilled, and its subsurface geology is poorly known. Gravity data (Yokoyama *et al*., 1967) show that

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