Article

Bull. Volcanol. Soc. Japan
Vol. 60 (2015) No. 1, pp. 17−33

Geology and Evolution of the Nakajima Islands (Toya Caldera, Hokkaido, Japan) Inferred from Aerial Laser Mapping and Geological Field Surveys

Yoshihiko Goto*, Satoru Matsuzuka**, Seiji Kameyama** and Tohru Danhara***

(Received June 12, 2014; Accepted January 10, 2015)

Aerial high-resolution laser-scanner mapping and geological field surveys were performed over the Nakajima Islands within Toya caldera, southwestern Hokkaido, Japan, to study the evolutional history of the islands. The laser-scanner mapping survey covered the entirety of the Nakajima Islands, an area of 3×3 km. A three-dimensional digital map produced from the laser-scanning data revealed detailed topographic features of the islands. Geological field surveys were carried out over the whole area of the Nakajima Islands, to determine how their topography relates to the geological and lithological features. These surveys suggest that the islands consist of a tuff cone, eight lava domes, and a cryptodome. The tuff cone has a low profile and wide crater and consists of dacitic pyroclastic deposits, suggesting that the cone was produced by explosive eruptions resulting from the interaction of dacitic magma and groundwater. The lava domes are conical or pancake-shaped and composed of dacitic to andesitic lavas, suggesting that the domes formed by extrusions of high-viscosity, dacitic to andesitic magmas. The cryptodome consists of coherent dacite overlain by mudstone and sandstone, suggesting that the dome formed by the uplift of caldera-floor deposits following the intrusion of high-viscosity dacitic magma. Mudstones and sandstones are present along the northeastern and southwestern parts of the islands, implying that the caldera floor was uplifted during or prior to the volcanism, forming a bulge (small resurgent dome) at the center of the caldera. We infer that the Nakajima Islands have evolved from caldera resurgence related to the ascent of voluminous dacitic to andesitic magma, followed by subsequent formation of multiple dacitic to andesitic domes and phreatomagmatic eruptions on the resurgent dome.

Key words: laser-scanner mapping, geology, Nakajima Islands, Toya caldera, evolutional history

1. Introduction

LIDAR (light detection and ranging) is a powerful tool for those studying the morphological features of volcanoes (*e.g.*, Chiba *et al*., 2007a, 2007b; Hunter *et al*., 2003; Pesci *et al*., 2007). Three-dimensional digital mapping based on high-resolution laser-scanning data provides invaluable information on the distribution and morphology of craters, lavas, domes, and pyroclastic deposits, as well as reworked deposits. Laser-scanner mapping is particularly useful for surveying topographic features in thickly vegetated areas, for which 'tree-removing' data filtering can be used to reveal the topography of the ground surface (Chiba *et al*., 2007b; Goto *et al*., 2011).

We conducted aerial laser-scanner mapping and geological field surveys over the Nakajima Islands within Toya caldera, southwestern Hokkaido, Japan (Fig. 1), to study the morphological and geological features of the islands. The Nakajima Islands are a silicic volcanic complex produced by post-caldera volcanism (Katsui, 1990; Ota, 1956; Soya *et al*., 2007; Ui *et al*., 2013; Yokoyama *et al*., 1973), but their detailed geology remains unknown because it is obscured by the thick vegetation cover (Fig. 2). Three-dimensional digital mapping based on the laser-scanning data allowed us to study the detailed topographic features of the islands, and use them as the basis for understanding their geology. This paper describes the topographic and geological features of the Nakajima Islands and discusses the evolutional history of the islands.

2. Nakajima Islands

The Nakajima Islands are located in the central part of Toya caldera (Fig. 1). The caldera covers an area of 10×11 km, and was formed by violent silicic eruptions at approximately 110 ka (Ganzawa *et al*., 2007; Machida and Arai, 2003; Okumura and Sangawa, 1984; Takashima *et al*., 1992; Yokoyama *et al*., 1973). The caldera-forming eruptions generated large-volume, rhyolitic, pyroclastic fall (Machida and Arai, 2003), and flow (Yokoyama *et al*.,

* College of Environmental Technology, Graduate School of Engineering, Muroran Institute of Technology, Mizumoto-cho 27−1, Muroran, Hokkaido 050−8585, Japan.
** Tanaka Consultant Co. Ltd, Shinkai-cho 2−1−3, Tomakomai, Hokkaido 053−0052, Japan.
*** Kyoto Fission-Track Co. Ltd, Minamitajiri-cho, Omiya, Kita-ku, Kyoto 603−8832, Japan.

Corresponding author: Yoshihiko Goto
e-mail: ygoto@mmm.muroran-it.ac.jp