

The 18–19 ka Andesitic Explosive Eruption at Usu Volcano, Hokkaido, Japan

Yoshihiko GOTO*, Yuko SEKIGUCHI*, Satomi TAKAHASHI*, Hayuru ITO* and Tohru DANHARA**

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Mount Usu is a Quaternary composite volcano located in southwestern Hokkaido, Japan. Here we report on an andesitic pyroclastic fall deposit (the Usu-Kaminagawa [Us-Ka] tephra) erupted during the initial stage of activity at Usu Volcano. The tephra extends from the volcano to the east, and comprises a lower andesitic pumice-fall deposit and an upper ash-fall deposit. The tephra overlies the Nj-Os tephra, which was erupted from the Nakajima Islands, and is overlain by the Usu Somma Lava, which was extruded during the early stages of activity at Usu Volcano. Radiocarbon dating of buried soils located immediately beneath the Us-Ka tephra yields ages of 18–19 cal ka BP. The distribution, stratigraphy, and lithology of the tephra, and the radiocarbon ages of the buried soils beneath the tephra, suggest that an andesitic explosive eruption occurred at Usu Volcano at *ca.* 18–19 ka. This eruption was probably an early manifestation of activity at Usu Volcano.

Key words: Usu Volcano, tephra, stratigraphy, radiocarbon dating, early volcanic activity.

1. Introduction

Mount Usu is a Quaternary basaltic to rhyolitic composite volcano located at the southern rim of Toya Caldera in southwestern Hokkaido, Japan (Fig. 1). Mount Usu is one of the most active volcanoes in Japan, and has experienced at least nine major eruptions since AD 1663 (Katsui *et al.*, 1985; Katsui, 1988; Matsumoto and Nakagawa, 2010; Mimatsu, 1962; Minakami *et al.*, 1951; Nakagawa *et al.*, 2005; Oba, 1966; Soya *et al.*, 2007; Tomiya *et al.*, 2010; Ui *et al.*, 2002; Yokoyama *et al.*, 1973). Understanding the eruptive history of this volcano is essential for mitigation of the volcanic hazards in the region.

This paper presents a study of an andesitic pyroclastic fall deposit (the Usu-Kaminagawa [Us-Ka] tephra; Yamagata and Machida, 1996), inferred to have been erupted during the initial stages of activity at Usu Volcano (Kobayashi and Miyabuchi, 2006). Published geological and geochronological data for the tephra are sparse (Kobayashi and Miyabuchi, 2006; Machida and Yamagata, 1996; Yamagata and Machida, 1996), and further detailed study of the tephra may provide invaluable information with which to constrain the eruptive history of the volcano. Herein, we describe the distribution, stratigraphy, lithology, and radiocarbon ages of the tephra and discuss the early volcanic history of Usu Volcano.

2. Usu Volcano

Usu Volcano rises to an elevation 733 m above sea level, and is a post-caldera cone of Toya Caldera (Fig. 1). The caldera is 10 km × 11 km in size and formed by violent explosive eruptions associated with pyroclastic flows at *ca.* 110 ka (Ganzawa *et al.*, 2007; Machida and Arai, 2003; Okumura and Sangawa, 1984; Takashima *et al.*, 1992; Yokoyama *et al.*, 1973). The Nakajima Islands, located in the central part of the caldera, formed by multiple extrusions of dacitic lavas at 40–45 ka (Takashima *et al.*, 1992). After formation of the Nakajima Islands, Usu Volcano became active (Soya *et al.*, 2007).

Usu Volcano is a basaltic stratovolcano with a parasitic scoria cone, and also includes a number of silicic lava domes and cryptodomes (Fig. 2). According to Yokoyama *et al.* (1973) and Soya *et al.* (2007), the stratovolcano was constructed at *ca.* 10–20 ka by repeated extrusion of basaltic lavas (Usu Somma Lava) and scoria (Fig. 2A). A parasitic scoria cone (Donkoroyama) formed on the northeastern foot of the stratovolcano during this stage (Fig. 2B). At *ca.* 7–8 ka, the summit of the stratovolcano largely collapsed, resulting in generation of a debris avalanche that travelled down to the southwestern foot of the volcano. As a result of this collapse, an amphitheater that is 2 km in diameter formed at the summit of the stratovolcano (Fig. 2B). After the summit collapse, Usu Volcano was dormant for several thousand years, and the

*College of Environmental Technology, Graduate School of Engineering, Muroran Institute of Technology, Mizumoto-cho 27-1, Muroran, Hokkaido 050-8585, 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