

Volcanic activity of Yokodake volcano during the last 4,000 years inferred from eruption age of the latest two lava flows and tephrostratigraphy, northern Yatsugatake volcanoes, Japan

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Yokodake volcano in central Japan, which effused nine lava flows (Y1-Y9), is the only active volcano belonging to Yatsugatake volcanoes. Three tephra deposits (Yt-Pm4, NYk-2, NYk-1), which probably derived from Yokodake volcano, were reported in previous studies (Okuno, 1995; Oishi and Suzuki, 2004; Okuno and Kobayashi, 2010). However, detailed geological occurrence, such as distribution, of the tephra deposits (NYk-2, NYk-1) have not been estimated. In addition, it remains ambiguous whether NYk-1 tephra is a clear tephra layer (Okuno and Kobayashi, 2010). In this study, we re-examined the recent eruptive activity of Yokodake volcano via tephra-stratigraphic study and radiocarbon (¹⁴C) dating, and estimated source vent and erupted volume of each tephra layer.

As a result of geomorphological analysis, three craters (north, south, and 2,350 m crater) were identified around Yokodake summit. North crater, which locates at the summit, is surrounded by slopes with smooth surface topography, differing from rocky surface of the surrounding lava flows. South crater locates immediately adjacent to the southern rim of north crater. 2,350 m crater is elliptical crater opening about 250 m south of the south crater.

As a results of geological survey, scoria layer (named NYk-S tephra) was identified in addition to NYk-2 and NYk-1 tephra. The stratigraphy of the tephra from bottom to top is NYk-2, NYk-S and NYk-1. NYk-2 tephra consists of two units: the lower unit is dark gray lapilli layer and the upper unit is yellowish-brown lapilli layer. This study suggested that NYk-2 tephra derived from the North crater, because the grain size increases toward the North crater. NYk-S tephra is mostly constituted of ash to lapilli size scoria clasts. It was divided into three units, and often observed together with upper NYk-1 tephra. NYk-S tephra has a thickness of 50 cm or more at the southeastern rim of the South crater and the surface around the crater is largely covered by lapilli to bomb size scoria clasts, suggesting the tephra derived from the South crater. NYk-1 tephra was light gray volcanic ash deposit contained volcanic glass. The thickness and grain size increase toward the summit, indicating the tephra derived from Yokodake, although the source vent was not determined.

The ¹⁴C ages of carbonaceous material from yellowish-brown lapilli of NYk-2 tephra and paleosols just below NYk-S and NYk-1 tephra were dated respectively as 2,363-2,323, 791-730 and 518-478 cal yr BP (2 σ ; calendar ¹⁴C age). Our results were almost consistent with ¹⁴C ages of dark gray lapilli of NYk-2 tephra (2,350-2,150 cal yr BP; Okuno and Kobayashi, 2010) and paleosols immediately above the NYk-1 tephra (550-510 cal yr BP; Nitta and Saito, 2019). Therefore, the eruption ages of NYk-2, NYk-S and NYk-1 tephra are, respectively, ca. 2.4, 0.8 and 0.55 ka.

The dense rock equivalent (DRE) volume of the NYk-2 tephra was estimated as about 8.0×10^{-4} km³ by distribution area, and the DRE volumes of NYk-S and NYk-1 tephra were 9.4×10^{-4} , 3.1×10^{-4} DRE km³ calculated by using their isopach data according to the Hayakawa (1985) method.

The magma eruption rate of Yokodake volcano was estimated based upon our results, and earlier data related to age and volume (Kawachi et al., 1978; Oishi and Suzuki, 2004; Oishi, 2015; Nishiki et al., 2011). Magma eruption rates of Yokodake in 34 ky and 3.4 ky were estimated as about $9 \times 10^{-3} \text{ km}^3/\text{ky}$ and $1 \times 10^{-2} \text{ km}^3/\text{ky}$. It suggested that the volcanic activity of Yokodake volcano has been stable during the past 34 ky, although its eruption rate is about one order of magnitude lower than that of the entire volcano group in 50 Ma ($2.8 \times 10^{-1} \text{ km}^3/\text{ky}$).

Our results indicates that the recent eruption rate of Yokodake volcano has not declined, while long-term volcanic activity has weakened. It also revealed that not only effusing lava flow, but explosive eruptions, such as tephra containing scoria, had occurred several times in recent activity.

Keywords: Yatsugatake volcanoes, ^{14}C age, eruptive history, eruption rate