

Age of the Toya caldera eruption

*Akihiko Tomiya¹, Isoji Miyagi¹

1. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology

1. Introduction

Toya caldera eruption is one of the largest eruptions in Japan, producing Toya ignimbrite ($>36.8 \text{ km}^3$; Goto *et al.*, 2018) and Toya ash (Toya; $>150 \text{ km}^3$; Machida *et al.*, 1987; Takarada, 2019). Toya ash is one of the most useful marker tephras in Japan. The age of Toya eruption, estimated by radiometric and stratigraphic dating, is about 0.11 Ma (see later). However, when looking closer, there is some confusion because the eruption age used differ from researcher to researcher. Precise age determination is valuable since Toya ash is a critical time marker of 0.11 Ma or Marine Isotope Stage (MIS) 5d (5.4) (e.g., Kudo, 2018). Therefore, we compiled and evaluated the reported ages to propose an appropriate age (Tomiya and Miyagi, 2020).

2. Absolute age

Early studies to measure the ^{14}C age (e.g., Minato, 1966) failed because of the much shorter half-life of ^{14}C than the eruption age. There is no K-Ar age reported because of the much longer half-life of ^{40}Ar . The first reported eruption age is $0.13 \pm 0.03 \text{ Ma}$ by zircon FT (fission track) dating (Okumura and Sangawa, 1984). Then, Takashima *et al.* (1992) reported TL (thermoluminescence) ages of 0.103 to 0.134 Ma with an error of 30%. Ganzawa *et al.* (2007) reported SAR-RTL ages of 113 ± 13 to $132 \pm 15 \text{ ka}$, and Ganzawa and Ike (2011) revised them to be 104 ± 15 to $118 \pm 15 \text{ ka}$. Recently, Ito (2014) reported U-Pb and U-Th ages of $0.11 \pm 0.01 \text{ Ma}$ and $108 \pm 19 \text{ ka}$, respectively, using laser ablation ICP-MS. Thus, the absolute age is about 0.11 Ma with an error of 0.01-0.02 Ma.

3. Relative age and its conversion

Toya ash overlies the MIS 5e (5.5) terrace and underlies the MIS 5c (5.3) one, indicating that it deposited in the MIS 5d (5.4) (Machida *et al.*, 1987; Machida and Arai, 2003). Combining with the information from deep-sea cores (Shirai, 2001; see later), Machida and Arai (2003) proposed the eruption age to be 112-115 ka.

Shirai *et al.* (1997) and Shirai (2001) studied Toya ash in the sediments recovered from ODP Site 794 (Sea of Japan). They estimated the eruption age to be 112 ka based on the correlation of dark and light layers with a nearby site where oxygen isotope record was available. To convert the stratigraphic position to the absolute age, they applied the oxygen isotope curve by Bassinot *et al.* (1994), where the peak of MIS 5.4 was 106 ka. Matsu'ura *et al.* (2014) studied Toya ash in the Chikyu C9001C cores (Pacific Ocean), where oxygen isotope record was available (Domitsu *et al.*, 2010, 2011). They clearly showed that the Toya ash deposited in the MIS 5.4. They adopted 106 ka as the eruption age because they considered it to be corresponding to the peak of MIS 5.4 by Bassinot *et al.* (1994) (Matsu'ura, personal comm.).

4. Reexamination of the age

The stratigraphic position of Toya ash is actually above the peak of MIS 5.4, according to the oxygen isotope record at C9001C. The eruption age, therefore, must be younger than that peak. Bioturbation is negligible at this site because the sedimentation rate is high (Domitsu, personal comm.). Furthermore, pollen analysis shows that Toya ash deposited after an extreme cold and dry period corresponding to the peak of MIS 5.4 (Ooi *et al.*, 1997).

Besides, the oxygen isotope curve by Bassinot *et al.* (1994) is not precise for $<300 \text{ ka}$ (Waelbroeck *et al.*,

2002). Recently, Lisiecki and Raymo (2005) and Thompson and Goldstein (2006) have proposed that the peak of MIS 5.4 is 109 ka, which we consider better.

Considering that the stratigraphic position of Toya is between the peaks of MIS 5.4 and MIS 5.3, we propose that the age of Toya eruption is ca. 106 ka. Even if the stratigraphic position is considered to be merely around the peak of MIS 5.4, the eruption age should be $109 \pm \text{ca.} 3$ ka. These values well agreed to the absolute ages mentioned above.

For detail: Tomiya and Miyagi (2020) Age of the Toya eruption. *Bull. Volcanol. Soc. Japan*, 65(1), in press.

Keywords: Toya caldera, ignimbrite, Toya ash, MIS 5d (5.4), absolute age, relative age