Evaluation on the Durations of Large-scale caldera-forming Eruptions Based on Paleomagnetic Method: Examples from Aira caldera, Japan and Mamaku/Ohakuri Ignimbrites, New Zealand

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(Introduction)
The durations of caldera-forming eruptions producing large volumes of pyroclastic ejecta (VEI=7 or more) are poorly understood due to absence of direct observations. However, clarifying the timescale of these eruptions is still important for risk evaluation and disaster mitigation for future hazardous events. We already reported several cases indicating considerable time gaps (> tens of years) within geologically successive ignimbrites from Japanese calderas, such as Kikai and Shikotsu, based on paleomagnetic directions and secular variation [1],[2]. In this study, the 30 ka Aira caldera products (Japan) and 240 ka sequence of eruptives including the Mamaku and Ohakuri ignimbrites[3] (New Zealand) are investigated to evaluate the time scales of eruption durations based on our paleomagnetic method.

(Method)
We carried out oriented sampling for each unit from Aira caldera products: Osumi pumice fall (OS), Tarumizu ignimbrite (TM), and Ito ignimbrite (IT: largest unit) in ascending order (Total volume > 400 km^3), and Mamaku-Ohakuri ignimbrites (> 250 km^3), Taupo Volcanic Zone, New Zealand. The Mamaku-Ohakuri sequence consists of interfingering units (Unit 1 to Unit 6) including the caldera-forming ignimbrites (Mamak and Ohakuri) from Rotorua and Ohakuri calderas, respectively. There is no soil layer within the sequential units of Aira and Mamaku/Ohakuri products. Although welded tuffs were drilled, soft ashes were collected by a method we have developed for accurate orientation of an aluminum sampling cube and an apparatus for precisely guiding the cube into the outcrop. More than 8 cubes were sampled from each unit (except Mamaku-Ohakuri sequence units 2 and 3 due to presence of coarse lapilli) and paleomagnetic directions were measured by spinner magnetometer with thermal and/or alternating current demagnetization. The mean for paleomagnetic directions we obtained for each unit falls within a 95% confidence limit (2 to 10 degrees).

(Results)
Aira: Mean paleomagnetic directions of OS and TM are undistinguishable (Dec/Inc=5~13°/47~52°) indicating no time gap between these units. IT (welded tuff) from six locations indicate the range of mean directions as Dec=10 to 15°/Inc=45 to 52° (including referenced data from [4]) except for the IT2 site which shows a slightly different inclination (Inc: 43°). Although there are still possibilities of tilting (after cooling) or a different flow unit for the IT2, it seems that the Aira caldera-forming eruption occurred successively without remarkable (> tens of years) time breaks.
Mamaku/Ohakuri: Paleomagnetic directions of all samples plot away from the geocentric axial dipole, suggesting the eruption occurred during a geomagnetic excursion as reported by [5]. We detected remarkable differences in directions (> 15°) between Unit 1 and Unit 4 (Mamaku ignimbrite), and also between Unit 4 and Unit 6 (Ohakuri ignimbrite). A geomagnetic excursion is a brief event that generally

lasts for less than 2-3 thousand years with a faster rate of magnetic pole wandering (> 0.1 to 0.2°/year). Based on these assumptions, the time gaps between these units can be calculated as 100 to 200 years. Our paleomagnetic studies suggest that we can determine the duration of large-scale caldera-forming eruptions, but that these durations can range from < 10 years to >100 years. Similar durations have been suggested in previous caldera studies based on geologic field evidence, but our method provides a unique quantitative assessment. We are trying to increase the case studies for understanding the eruption timescales and associated volumes, styles and the link to underlying silicic magma systems of caldera volcanoes.

(References)
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