

Voluminous silicic magma formation for the 30 ka Aira catastrophic caldera-forming eruption: contributions of crust-derived mafic and felsic magmas

*Ayumu Nishihara¹, Yoshiyuki Tatsumi^{2,1}, Keiko Suzuki-Kamata^{2,1}, Katsuya Kaneko^{1,2}, Jun-Ichi Kimura³, Qing Chang³, Hironobu Hinata⁴, Takashi Miyazaki³, Bogdan Stefanov Vaglarov³

1. Department of Planetology, Graduate School of Science, Kobe University, 2. Kobe Ocean-Bottom Exploration Center, 3. Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 4. Kobe Municipal Tarumi Junior High School

Aira catastrophic caldera-forming (CCF) eruption occurred at 30 ka and discharged voluminous silicic magma with a small amount of less silicic magma. In order to understand the genesis of magmas in the Aira CCF eruption, petrological and geochemical characteristics of the juvenile clasts and plagioclase phenocrysts in them were investigated. Important petrological and geochemical features of the Aira ejecta and related rocks are described as follows:

1. Juvenile ejecta discharged by the Aira CCF eruption consist of three types of clasts; white pumice, dark pumice, and scoria clasts. Whole-rock chemical compositions of the dark pumices are less SiO₂ contents (67.5-75.7 wt.%) than those of the white pumices (74.3-77.2 wt.%). The scoria shows andesitic composition (SiO₂=59.0 wt.%).
2. In whole-rock characteristics, the SiO₂-poor juvenile clasts have higher ⁸⁷Sr/⁸⁶Sr (0.70856±0.00001 of the dark pumice and 0.70738±0.00001 of the scoria) than the white pumice (0.70597±0.00001).
3. An-contents of plagioclase cores in the white and dark pumices show bimodal distributions with peaks of An₄₅ and An₈₀, while the scoria contains solely high-An (>An₆₅) plagioclase.
4. In plagioclase phenocrysts of the Aira juvenile clasts, Sr isotopic ratios of the high- and low-An plagioclase cores are different (0.70680±0.00117 and 0.70575±0.00040, respectively).
5. Basement rocks beneath the Aira caldera consist of Shimanto sediments and Miocene granites. These materials have much higher ⁸⁷Sr/⁸⁶Sr (Shimanto sediments: >0.70965; Miocene granites: >0.70885) than the Aira juvenile clasts.
6. Pre-caldera basaltic lavas, which are the most SiO₂-poor ejecta around the Aira caldera, have lower ⁸⁷Sr/⁸⁶Sr (0.70425-0.70469) than the Aira juvenile clasts.

The above features suggest that voluminous silicic magma bearing the white pumices in the Aira CCF eruption was produced by mixing between low-⁸⁷Sr/⁸⁶Sr felsic and high-⁸⁷Sr/⁸⁶Sr mafic magmas, crystallizing the low- and high-An plagioclase, respectively. The low-⁸⁷Sr/⁸⁶Sr felsic magma was distinguished from both the upper crust and pre-caldera basaltic materials in ⁸⁷Sr/⁸⁶Sr characteristics. If the basaltic materials show the mantle signature, the low-⁸⁷Sr/⁸⁶Sr felsic magma was derived from a lower crust material. The geochemical signature of the high-⁸⁷Sr/⁸⁶Sr mafic magma can be explained by assimilation of high ⁸⁷Sr/⁸⁶Sr upper crust materials. The lowest ⁸⁷Sr/⁸⁶Sr recorded in the high-An plagioclase is higher than the whole-rock ⁸⁷Sr/⁸⁶Sr of the pre-caldera basalts, suggesting the mafic end-member magma for the Aira CCF eruption was the lower crust origin. A frequency ratio of the low- to high-An plagioclase in the white pumice proposed that the mixing ratio of the felsic and mafic magmas was estimated at a ratio of ~8:2, which is consistent with whole-rock ⁸⁷Sr/⁸⁶Sr variations of the white pumice. In conclusion, the crust-derived low-⁸⁷Sr/⁸⁶Sr felsic and high-⁸⁷Sr/⁸⁶Sr mafic magmas had contributed to the formation of voluminous magma discharged by the Aira CCF eruption.

Keywords: Aira caldera, caldera-forming eruption, Sr isotope ratio, magma mixing, crustal assimilation