Cycles of magma activities leading to catastrophic eruptions in aira caldera in Kyushu, Japan

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Aira pyroclastic eruption (29 ka; 450 km^3), one of the largest caldera-forming events in Japan, was proceeded by continuous tephra eruptions (100–30 ka), and provides a unique opportunity to examine transition of magma reservoir compositions leading to the caldera-forming eruption. We report magma compositions between 100 ka and the present, and propose cycles of magma activities in which the mafic magma activity marks early stage and the felsic one marks late stage, ending with catastrophic eruption. We classified one mafic magma group and two felsic magma groups on the basis of mineral assemblages, group-M (under 59 wt.% SiO_2; <95 ka) containing plagioclase, two pyroxenes and rare olivine, group-F1 (63–70 wt.% SiO_2; 95–85 ka) containing plagioclase, two pyroxenes and hornblende and group-F2 (73–78wt.% SiO_2; 60–30 ka) containing plagioclase, orthopyroxene and quartz. Products of Aira pyroclastic eruption, belong to Group-F2 magma.

Patterns of transition of magma compositions during 100 ky at Aira revealed that Group-M mafic magmas were active before felsic magmas (F1 and F2). Aira pyroclastic eruption marks the final eruptive event of Group-F2 activity. Fukuyama pumice fall eruption, which is the largest eruptive event (about 40 km^3) before Aira event (29 ka), marks the final eruptive event of group-F1 magma activity. Incompatible trace element compositions show that Group-M magma and Group-F2 magma do not represent parent-daughter relationship. Contents of incompatible elements of Group-F2 magma increase with time (SiO_2: 2–4 wt.%; Rb: 5–20 ppm) from 60 ka to 30 ka, to the composition similar to that of Aira pyroclastic eruption. Compositional variations observed among Group-F2 magma are explained by crystal fractionation of the mineral phases contained in the parent magma. Felsic magma similar in composition to Aira pyroclastic products appeared 1,000 years before the event.

Volcanic products from Sakurajima volcano (25.5 ka–the present), show binary magma mixing between basalt and dacite. Their mafic end member is compositionally similar to the Group-M magma which appeared in the first and the second cycles. Neither F1 nor F2 magmas are possible candidates of felsic end member of mixing. It is implied that different felsic end member magma, i.e. F3, exists in magma reservoir beneath the present Aira caldera. Magma activities of Sakurajima volcano, probably forms the felsic stage of the new cycle.