Three cycles of magma activities leading to large eruptions as observed in Aira caldera

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Prediction of large caldera-forming eruption is important, however such events are rare and precursory activities are difficult to find. The volcanic products prior to large caldera-forming events, if preserved, record an important transition of magma supply system leading to such a large eruption. Aira pyroclastic eruption (29 ka; 450 km^3), one of the largest caldera-forming events in Japan, formed the present Aira caldera. This eruption was proceeded by continuous tephra eruptions (100-30 ka), providing a unique opportunity to examine transition of magma reservoir compositions leading to the caldera - forming eruption. We report magma compositions between 100 ka and present, and propose three cycles of magma activities which lead to large eruptions as found in Aira caldera.

We classified one mafic magma group and two felsic magma groups on the basis of mineral assemblages, group-M (under 59 wt. % SiO_2; about 100 ka and 70-60 ka) containing plagioclase, two pyroxene and rare olivine, group-F_1 (63-70 wt. % SiO_2; 95-85 ka) containing plagioclase, two pyroxene and hornblende and group-F_2 (73-78wt. % SiO_2; 60-30 ka) containing plagioclase, orthopyroxene and quartz. Products of Aira pyroclastic eruption, belong to Group-F_2 magma.

Patterns of transition of magma compositions during 100 ky at Aira revealed that Group- M mafic magmas were active before felsic (F_1 and F_2). Aira pyroclastic eruption marks the final eruptive event of Group- F_2 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-F_1 magma activity. We propose the two cycles of magma activities, in which the mafic magma activity marks early stage and the felsic one marks late stage. Felsic magma stage ends with large eruption.

Incompatible trace element compositions show that Group-M magma and Group-F_2 magma do not represent parent-daughter relationships.

Contents of incompatible elements of Group-F_2 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. Incompatible trace element compositions of Group-F_2 magma are explained by crystal fractionation of the mineral phases observed in the parent magma. It is suggested that composition of felsic magma leading to Aira pyroclastic eruption appeared 1000 years before the event.

Volcanic products from Sakurajima volcano (25.5 ka and 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 F_1 nor F_2 magmas are possible candidates of felsic end member of mixing. It is implied that different felsic end member magma, i.e. F_3, exists in magma reservoir beneath the present Aira caldera. Magma activities of Sakurajima volcano, probably forms the felsic stage of the third cycle.