

Petrological characteristics of Aso-ABCD tephra which erupted before Aso-4 pyroclastic eruption

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Several tephra layers such as Aso-A, B, C, D, , , M, N, α , β , , , η , between Aso-4 (89 ka) and Aso-3 (123 ka) pyroclastic eruptions have been described by Ono et al. (1977). Among them, Aso-ABCD is located at the top of all, and represent a series of continuous eruption events. Nagahashi et al. (2007) estimated their age as 97.7 ka. Ono et al. (1977) estimated the eruption source to be the south of present central cones from the isopach maps. Machida and Arai (1992) estimated their volume to be 3.5 km³. Just before the eruption of Aso-4 event occurred the formation of Omine pyroclastic cone and associated Takayubaru lava flow. This lava flow is overlain by Aso-4 tephra with no intercalated soil. The volume estimate is 2 km³. The most voluminous felsic eruption after Aso-4 event was that of Kusasenri-ga-hama volcano with 1.4 km³ volume (Miyabuchi, 2003). Thus, Aso-ABCD and Omine volcanoes represent voluminous precursory eruptions before caldera-forming Aso-4.

Pumice and volcanic ash was sampled 20 km east of Aso caldera, where the thickness of Aso-ABCD tephra in total is 3 m. The samples were analyzed for XRF bulk-rock chemical analysis, EPMA mineral analyses, FT-IR analyses of melt inclusions. Phenocryst assemblage is plagioclase, clinopyroxene, orthopyroxene, and magnetite, with no hornblende which is common in Aso-4 products. Bulk composition of pumice ranges 63-66 wt. % silica, and mostly plot on Aso-3 trend, and not on Aso-4 trend of Kaneko et al. (2007, 2015). Melt inclusions in plagioclase and pyroxenes also show compositions similar to glass of Aso-3 with silica range mostly in 70-72 wt. %. Compositional range of phenocryst cores are An₄₀₋₆₄ for plagioclase, Mg# =70-74 for orthopyroxene, and Mg#=74-81 for clinopyroxene. Water content was estimated to be 1.0-4.8 wt.% for melt inclusions in host minerals of An₄₀₋₆₄ plagioclase, Mg#=70-74 orthopyroxene, and Mg#=74-81 clinopyroxene.

Equilibrium relationship between melt inclusion and host clinopyroxene provides temperature estimate of 860-950 °C and pressure estimate of 1.1-2.7 kbar (Putirka, 2008). The pressure corresponds to the depth of 3-9 km, comparable to the estimated depth (6 km) of present Kusasenri-ga-hama magma reservoir. Furukawa et al. (2006) showed a gradual change of tephra composition, estimated temperature, estimated water content, and estimated oxygen fugacity from Aso-3 to Aso-4. However, our study showed similarity of magma composition between Aso-ABCD tephra and Aso-3 products. Aso-4 magma reservoir was not yet prepared 9000 years before Aso-4 eruption. Or Aso-4 reservoir at that time was independent from, and had no interaction with, other magma supply system then.

Keywords: Aso, caldera-forming eruption, melt inclusion, Aso-ABCD tephra, Aso-4 pyroclastic eruption