

Textural and geochemical studies of the 74 ka Youngest Toba Tuff (YTT), Indonesia: Evidence for eruptions from multiple magma chambers

ガブリエラ, ノゴ, レタナニングテイアス, ブンガ, ニーン

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氏 名 : Gabriela Nogo Retnaningtyas Bunga Naen

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(7万4千年前のトバカルデラ噴火火砕物(YTT)の組織学的及び地球化学的研究:多重マグマだまりの証拠)

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論文内容の要旨

The eruption process responsible for the formation of the 74 ka Youngest Toba Tuff (YTT) is still debatable since currently, there are two hypotheses on the magma chamber; one single voluminous chamber or multiple magma chambers. Detailed component analysis of eruption products, comprehensive stratigraphy, mineralogical data, and geochemical signatures of phenocrysts and matrix glass were used to reveal the eruption processes of the YTT super-eruption and to give a constraint to the property of magma chamber. Based on the componentry, mineral assemblages, mineral and glass compositions, and vesicle texture, four distinct pumice types (P1-P4) were identified. The first type (P1) is amphibole-bearing pumice with 77.1 wt % on average of SiO₂ content of glass. This type of pumice is characterized by abundant matrix-vesicles, with plagioclase showing a wide range of anorthite content (from An₂₀ to An₈₀) and disequilibrium texture. The second and third types (P2 and P3) are the most but slightly evolved pumices, with 77.5 and 77.6 wt.% on average of SiO₂ content of glass, respectively. Plagioclases of P2 and P3 pumices commonly have unzoned texture, with low anorthite content (An₃₀ on average). P2 is biotite-bearing, distinctively characterized by abundant pheno-vesicles, while the P3 pumice includes rare pheno-vesicle, skeletal-polyhedral quartz and no biotite. The fourth type of pumice (P4) is quartz- and sanidine-free, shows the less evolved glass composition (76.3 wt.% on average of SiO₂ content of glass), and is characterized by dominant matrix-vesicles and crystal clots of plagioclase, amphibole, pyroxene, and biotite; plagioclase of the P4 pumice shows a hollow texture and high anorthite content (An₅₀₋₆₀). In-situ trace element analysis by LA-ICP-MS for matrix glass of P1, P2, P3 and P4 shows very distinct geochemical signatures, which are clearly correlated with the four pumice types. Plotted on bivariate diagrams of Ba vs. Y, Sr vs. Y and Ba vs. Sr, the P1 pumice is characterized by relatively medium Ba and Sr (400 – 875 ppm, and 41 – 67 ppm, respectively), but variable Y contents (20 – 53 ppm); the P2 and P3 pumices, on the other hand, show low Ba and Sr (8–136 ppm, and 13 – 37 ppm, respectively) and highly variable Y contents (27 – 77 ppm); and P4 pumice is characterized by relatively high Ba and Sr (1173 – 1340 ppm, and 95 – 124 ppm, respectively), but narrow range of Y contents (21 – 31 ppm). The geochemical signatures of matrix glass compositions of distinct pumice types suggest the occurrence of four distinct magma bodies. The number of fractions of distinct glass shards and pumices (ØGP) with the same geochemical signatures represents the volume fraction of each magma type. From the approximate volume of the magma, 5300 DRE km³ after Costa et al. (2014) and the geographical distributions of each pumice type, it is found that a voluminous P1 (ØGP: 0.61~2555 km³), medium P2 (ØGP: 0.28~1170 km³), and smallest P4 (ØGP: 0.03~125 km³) chambers,

located relatively at the northern direction, and small P3 chamber ($\text{OGP: } 0.07\sim 311 \text{ km}^3$) from southern caldera were evacuated during the 74 ka YTT eruption. Eruptions from multiple magma chambers were initiated by a high supersaturation of pheno-vesicle-rich magma (P2 magma). The high supersaturation was caused by the magma buoyancy through the migration of magmatic volatile phase in P1 magma and accumulated in P2 magma, thus triggering the eruption of P1, P2, P3, and P4 magmas simultaneously.

Keywords: Pumices, distinct magma chamber, the Youngest Toba Tuff, super eruption