Pre-eruptive magmatic processes of upper part of Goshikidake pyroclastic rocks, Zao volcano

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Zao volcano is the active stratovolcano, which has many eruption records before 1940. Precursory phenomena, such as volcanic tremors and earthquakes, have been detected since 2013. Therefore, it is necessary to examine pre-eruptive magmatic processes to understand the current situation of this volcano. In this study, we revealed pre-eruptive magmatic processes on the Okama crater eruption products from 800 years ago to present, by detailed petrologic examination including kinetic modelling of chemical zoning and thermodynamic approach.

Eruption products are pyroclastic surge deposits with periodically existing bomb concentrated layers. The rock samples are basaltic andesite to andesite, including plagioclase, orthopyroxene, clinopyroxene and magnetite as phenocryst. Olivine with reaction rim of clinopyroxene rarely observed. Rocks are classified into medium-K, calc-alkaline series showing liner trends in Harker diagram. Plagioclase: core are An64-86 (peak value: An68, 74), the rim are An_{60-86} ($An_{64, 70, 76}$), and groundmass are An_{57-80} (An_{63}). Orhopyroxene: core are Mg#=60-75 (Mg#=65), the rim are Mg#=64-76 (overgrouth rim is Mg#=65, Mg rich rim is Mg#=71), and groundmass are Mg#=63-67 (Mg#=64). Clinopyroxene: core are Mg#=64-67, and rim are Mg#=64-76. Magnetite: core are Mg/Mn=7-21 (Mg/Mn=12-14), and rim are Mg/Mn=8-18 (Mg/Mn=11, 15). Plagioclase was classified into four types; C-type: homogeneous core with or without normal zoning (core composition An_{70-80}), P-type: patchy-like heterogeneous/oscillatory zoned core (An_{70-75} and An_{60-66}), D-type: having dusty zone (An_{75-90}) on the rim, H-type: honeycomb core (An_{75-85}) and low An rim (An_{60-65}). Orthopyroxene was classified into four types; L-type: low-Mg (Mg#=60-67) core sometimes having normal zoned rim, R-type: low-Mg core having reverse zoned rim. M-type: small phenocryst with medium Mg core sometimes having normal zoned rim. H-type: heterogeneous core with high (Mg#=70-76) and medium parts. R-type is subdivided into subtype-I: thin high-Mg (Mg#=71-76) rim, subtype-II: medium-Mg and Al (Mg#=69-70) broad rim, and subtype-III: medium-Mg and low-Al broad rim. Estimated temperature for low, medium, and high-Mg parts by two-pyroxene geothermometer are 950-1000℃, 1010-1040℃, and 1030-1060℃.

All rocks were formed by mixing between low temperature and high temperature end-member magmas (LT and HT-magmas). The estimated compositions of end-member magmas by using rhyolite-MELTS algorithm were as follows; LT-magma: SiO_2=48.0-50.0 wt.%, T=953-999℃, P=1.5 kbar, H_2O=1.0-2.0 wt.%, HT-magma: SiO_2=59.0-62.0 wt.%, T=1060-1126℃, P=1.5-2.0 kbar, H_2O=1.0-2.0 wt.%. The stable mixed magma (M-magma) where the rim precipitated would be formed in the chamber. We note the Mg-medium and high rim would be formed from Mg-richer mixed magma which would appear from injection of HT-magma to form M-magma. By comparing observed and calculated zoning profiles, we estimated the residence times of orthopyroxene phenocrysts in the M-magma. We assumed the temperature and oxyegen fugacity conditions are 1025℃ and was NNO-buffer. The initial profile of Mg# for orthopyroxene crystal is drawn based on the zoning profile of Al. The estimated residence times of R-type (I) crystals are 0.5 days to 2 years and those of R-type (II) and (III) crystals are 5 to 20 years. In terms of plagioclase phenocrysts, zoning profiles show that several patterns of correlation between MgO and An in core. These would reflect that the multiple magmatic processes in the mixed magma.

Keywords: magma plumbing system, residence time, rhyolite-MELTS, chemical zoning, orthopyroxene, Zao volcano

