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Pre-eruptive conditions and eruptive process of the Tsurumi-dake summit lava; constraints from hornblende phenocrysts

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Textural and chemical analyses were done for hornblende phenocrysts in Tsurumi-dake summit lava to constrain its pre-eruptive conditions and eruption processes. Tsurumi-dake summit lava, the latest lava erupted at 7.3-10.5ka (Fujisawa et al., 2002), is andesitic with ca. 30 vol.% of phenocrysts consisting of plagioclase, hornblende, pyroxenes, quartz, biotite and Fe-Ti oxides. Among 566 grains of hornblende phenocrysts observed, 503 grains are completely decomposed. We quantified degree of hornblende breakdown (DHB) by image analyses of BSE images for remaining 62 grains incompletely decomposed. DHB varies from 18 to 98 %.

Chemical analyses were done for incompletely decomposed hornblende grains by using EPMA (JEOL-8800R) at Earthquake Research Institute, University of Tokyo. Most of hornblende phenocrysts are chemically homogeneous. They are divided into two groups based on AlT [= number of Al per 23 oxygens] with ca. 1.2 and 2.1, respectively. negative correlation is observed between AlT and Si content and DHB increases with Si content. All of analyzed hornblende show Al# [=[6]Al/ AlT] lower than 0.21 and satisfy criterion for applying hornblende geothermobarometer of Ridorfi et al. (2010). Using the geothemobarometer, equilibrium pressure and temperature conditions are estimated for hornblende. The estimated pressures show two separated ranges of ca. 100-200 and ca. 350-450 MPa, corresponding to depths of ca. 2.5-5 and ca. 8.5-11km, respectively. Estimated temperatures are ca. 820-920 and ca. 970-1000 degree C for low-P and high-P hornblende phenocrysts, respectively. DHB tends to increase as estimated temperature decreases.

Present results indicate that there were at least two separated magma reservoirs at depths of 2.5-5 and ca. 8.5-11km. The depth of the deeper reservoir is consistent with that inferred from geothermal study of Furukawa (2009), implying the reservoir has existed at least since ca. 7-10 ka. On the other hand, depth range of the shallower reservoir is consistent with that of aseismic zone beneath Tsurumi volcano reported in Ohkura et al. (2002). The consistency may imply that the shallower reservoir contributed to form the aseismic zone.

Coexistence of hornblende phenocrysts with different P-T conditions is consistent with that the lava was formed by magma mixing as pointed out by Ohta et al. (1990, 1991). Mixing of high-T and low-T magmas derived from deeper and shallower reservoirs induced rapid decomposition of low-P hornblende due to heating, but decomposition of high-P hornblende was insignificant because of mixing-induced cooling. High-P hornblende was decomposed during eruption due to degassing. Absence of low-P hornblende with low DHB indicates that post-mixing crystallization was insignificant and eruption occurred right after magma mixing.

Keywords: hornblende, Tsurumi-dake, geothermobarometry, magma chamber