Experimental constraints on magma storage conditions for caldera-forming eruptions of Towada volcano, Japan: a preliminary report

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Towada volcano is an active arc volcano located in the northern part of Northeast Japan and characterized by a large caldera lake with a diameter of ca. 10 km. At this volcano, two extensive eruptions, which are called eruptive episodes N and L, generated Ofudo pyroclastic flow at 36 ka and Hachinohe pyroclastic flow at 15.5 ka, respectively. These eruptions discharged large-volume silicic magma (~20 km^3 dense rock equivalent in each eruption), causing caldera formation. Although the constraints on magma storage conditions for such large-scale eruptions is fundamentally important in terms of risk assessment of future caldera-forming eruptions, precise determination via an experimental approach is still lacking for Towada volcano. From a petrological point of view, amphibole is present in the eruptive product of episode L, but absent in that of episode N. The presence or absence of such hydrous minerals is important because it may reflect the water content in the magma, which controls explosiveness of eruption. However, this has not been understood in terms of the differences in magma storage conditions.

Here we conducted petrological and experimental studies on the silicic endmember pumice from the pyroclastic flow deposits of the eruptive episodes N and L (bulk SiO_2 content: 73.1 wt% for N, 72.0 wt% for L) to understand the magma storage conditions for the caldera-forming eruptions at Towada volcano. The phenocryst mineral assemblages in the silicic endmember pumice of the eruptive episodes N and L are plagioclase (Pl) + orthopyroxene (Opx) + clinopyroxene (Cpx) + Magnetite (Mt) + ilmenite (Ilm) and Pl + Opx + Cpx + Hornblende (Hbl) + Mgt + Ilm, respectively. Magnetite-ilmenite thermo-oxymetry revealed that average temperature and oxygen fugacity of the pre-eruptive silicic endmember magma for the episodes N and L are mostly identical at ~850˚C and ΔNNO (Ni-NiO) = + 1.2.

Phase equilibrium experiments were performed for both episode N and L pumices at 850˚C and 1.5–2.5 kb, and at 875˚C and 2 kb for 5–8 days by using an internally heated pressure vessel (SMC-5000) which has been newly installed at GSJ/AIST. Staring glasses were synthesized by fusing as-is pumice powders at 1250˚C and 2.3 kb for 3 hours. All the phase equilibrium experiments were conducted under a water-saturated condition and oxygen fugacity was buffered with Ni and NiO (i.e., ΔNNO = 0). Magnetite was absent in all the experiments possibly due to the relatively low oxygen fugacity compared to that estimated for the natural magmas. Plagioclase was always present in the L system, but absent at 850˚C and 2.5 kb and 875˚C and 2.0 kb in the N system, which indicates the higher liquidus temperature for plagioclase in the more mafic L system. The assemblage of Pl + Opx + Cpx + Ilm was observed at 850˚C and 1.5 kb (ca. 6 km deep) in both systems; they may correspond to the storage conditions for the episode N magma. Hornblende was crystalized at 850˚C under higher pressures of 2.0 and 2.5 kb in both systems, while it was absent at 875˚C and 2.0 kb. This indicates that hornblende crystallization favors relatively high pressure and low temperature conditions. However, hornblende did not coexist with pyroxenes in all the experiments, implying that further experiments are necessary especially at water-undersaturated conditions to determine the storage conditions for the episode L magma.

This research was supported by the Secretariat of the Nuclear Regulation Authority, Japan.

Keywords: Internally heated pressure vessel, Towada volcano, caldera, phase equilibrium experiment, amphibole

