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Experimental Constraints on Magma Storage Conditions of Two Caldera-Forming Eruptions at Towada Volcano, Japan

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Experimental constraints on the pre-eruptive storage conditions of voluminous silicic magma are fundamentally important to assess the risks of serious future volcanic hazards by better interpreting the seismic signals beneath the present caldera volcanoes. Towada volcano is an active volcano in northeast Japan, that caused two large caldera-forming eruptions at 36 ka (episode N) and 15.5 ka (episode L). Eruptive volumes are ~20 km^3 dense rock equivalent in both eruptions. Petrological analyses and phase equilibrium experiments were performed on silicic endmember rhyolitic pumices from these two eruptions to constrain the pre-eruptive magma storage conditions. A common mineral assemblage of plagioclase + orthopyroxene + clinopyroxene + magnetite + ilmenite was observed in both eruptions, whereas amphibole (hornblende) was observed only in the episode L pumice. Mineral thermometers showed temperatures of 832–883°C and 802–870°C for the episode N and L pumices, respectively, with an oxygen fugacity of ~nickel–nickel oxide (NNO) + 1 in log units. The water-saturation pressures evaluated using the plagioclase-melt hygrometer were in the range of ~100–200 MPa. Experiments were conducted at 100–350 MPa and 825–900°C under water-saturated and NNO-buffered conditions using an internally heated pressure vessel with an argon gas pressure medium. The mineral assemblages in both pumices were successfully reproduced, except for magnetite. Further constraints by phase compositions and phase proportions resulted in the preferred storage conditions of 840–850°C and 150–170 MPa for both eruptions. The emergence of hornblende in the episode L magma was likely caused by the higher CaO content compared to the episode N magma and not by the difference in the storage conditions. The storage depths at ~5–7 km coincide with the depth of the low seismic velocity beneath the present Towada volcano, suggesting possible magma accumulation at the same depths as in the past caldera-forming eruptions. This study was supported by the Nuclear Regulation Authority of Japan.