Magma system dynamics during the AD 1741 eruptions of Oshima-Oshima volcano, SW Hokkaido, Japan

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Oshima-Oshima is a rear-arc stratovolcano located 50 km from the coast of southwestern Hokkaido, which generated a series of explosive eruptions in AD 1741. The climactic eruption occurred on the morning of August 29, and a devastating tsunami was caused by a northward sector collapse of the island’s summit at the same time. A detailed account of the relationships between these hazardous volcanic phenomena has not yet been defined. For this study, we have reconstructed the magma system dynamics preceding, during, and following the cataclysmic event in order to better understand the links between the eruptions, sector collapse, and tsunami.

Whole-rock (WR) and mineral chemical analyses were undertaken for pyroclasts from 11 units emplaced during the AD 1741 eruption sequence. From lower to higher, units 1 to 6 contain clasts with WR SiO_2 and K_2O contents of ~48–49 wt.% and 1.3–1.4 wt.%, respectively. SiO_2 and K_2O contents of clasts gradually increase to ~50 wt.% and 1.6 wt.% from units 7 to 9, and are distinctly higher and variable (52–53 wt.%, 1.9–2.3 wt.%) for unit 10, which represents the climactic eruption. Post-collapse unit 11 comprises clasts with 49 wt.% SiO_2 and 1.5 wt.% K_2O. Variations in WR trace element ratios and Pb-isotopic data for clasts indicate that changes in the magma source composition and mixing between different magma sources occurred throughout the eruption sequence. Mineral chemistry data provide valuable records of the latter process. Olivine forsterite (Fo) and plagioclase anorthite (An) contents generally range from Fo_{90-78} and An_{90-67} in pyroclasts from units 1 to 6, but lowermost Fo and An contents for the rims of normal-zoned crystals steadily decrease toward approximately Fo_{70} and An_{60} in clasts from units 7 to 9. Clasts in unit 10 lack high-Fo olivine, and instead contain a distinctive population of Fo_{72-68} olivine grains, which are un-zoned and have resorbed rims that are overgrown by orthopyroxene. Other similarly un-zoned and low-Fo olivine crystals in unit 10 are instead euhedral and lack the orthopyroxene overgrowths. For plagioclase in unit 10, groundmass microlites and phenocryst rims have An_{50-40}. In post-collapse unit 11, ranges in olivine Fo and plagioclase An contents broadly revert to pre-collapse (unit 9) values.

Eruptions in the AD 1741 sequence appear to have been fed by mafic magma sources that underwent gradually increasing exchange with a more evolved magma in the crust beneath Oshima-Oshima. Despite the evidence of magma mixing in units 1 to 9, crystal zoning patterns in clasts from unit 10 provide no indication that a mafic recharge event occurred immediately prior to the climactic eruption. While these observations do not discount the theory that the sector collapse was initiated by an eruption, the new dataset also does not rule out the hypothesis that the occurrence of the sector collapse instead resulted in the sudden depressurization of a shallow magma body that triggered the climactic eruption.

Keywords: explosive eruption, magma system, Oshima-Oshima, basalt

