MAGMA AND VOLATILE EVOLUTION OF THE POST-CALDERA MAGMA CHAMBER OF SATSUMA-IWOJIMA VOLCANO.

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Geochemical and petrological studies of volcanic rocks and melt inclusions of Satsuma-Iwojima volcano were carried out to investigate the evolution of the magma system during the post-caldera stage. Satsuma-Iwojima is a volcanic island (6x4 km), which is located on the rim of the largely submerged Kikai caldera (20x17 km), south-west Japan. The latest caldera-forming eruptions (ca. 6300y.B.P.) were followed by formation of Iwodake rhyolitic dome (>500y ago), a basaltic cone of Inamuradake (3000y ago) and a small nearby rhyolitic island (Showa-Iwojima) formed in 1934. Intense fumarolic activity at the summit of Iwodake has continued for >800y. Total volume of the magma erupted during the post-caldera stage was estimated to be more than 45 km^3 by the topography. The high magma effusion rate (~7.5 km^3/1000y) suggests existence of a large magma chamber beneath the caldera during the post-caldera stage.

The volcanic rocks of the caldera-forming and post-caldera stages show a bimodal whole-rock chemistry ranging from basalt (SiO_2:52-55wt.%) to rhyolite (SiO_2:70-72 wt.%), lacking intermediate compositions. Abundant quenched mafic inclusions are observed in the Showa-Iwojima rhyolitic lava. They are spherical to oblate and are up to 20 cm in long dimension. They are fine-grained with diktytaxitic groundmass and vesicles of up to 5 mm in diameter in the cores. The inclusions with similar texture are found in Iwodake volcanic bombs but are less common than the Showa-Iwojima lava. The mafic inclusions have the following petrological characteristics; 1) Showa-Iwojima mafic inclusions have andesitic composition and the Iwodake mafic inclusions have basaltic compositions. The major and trace element compositions of the Showa-Iwojima mafic inclusions are along mixing lines between the Inamuradake basalt and its host rhyolite. 2) Plagioclase phenocrysts in the inclusions have a large variation in core chemical compositions ranging from 42 to 96 for Ca/(Ca+Na)x100, indicating these are both basaltic and rhyolitic magmas in origin. These plagioclase phenocrysts have various zoning profiles and reaction textures, suggesting they had coexisted with melts ranging from basaltic to rhyolitic compositions. These results suggest that the Showa-Iwojima mafic inclusions were formed by mixing of the Inamuradake basalt and the rhyolite. The bimodal whole-rock chemistry, contemporaneous activities of basaltic and rhyolitic magmas in a small area and the petrological characteristic of the mafic inclusions suggest the existence of a stratified magma chamber beneath the volcano, which consists of a lower basaltic layer, upper rhyolitic layer and episodically-present, thin middle-andesitic layer. Change of the chemistry from the Iwodake mafic inclusions to Showa-Iwojima mafic inclusions suggest that the mixing of the basalt and rhyolite has been ongoing since the time of the Iwodake eruptions. Pyroxene geothermometry indicates that the post-caldera rhyolitic magmas has high temperature of 970°C , which is close to that of the Inamuradake basalt (1080°C). The high temperature of the rhyolites might be due to heat supply from the underlying basalt to the upper rhyolite.

Chemical analyses of thirty melt inclusions in plagioclase and pyroxene phenocrysts in caldera-forming and post-caldera volcanic rocks were carried out to investigate volatile evolution in the magma chamber during the post-caldera stage. Large variations in volatile concentrations of melts were observed; 1) Water concentration of rhyolitic melts decreases with time; 3-4.6 wt.% at the time of latest caldera-forming eruption of Takeshima pyroclastic flow deposit, 3 wt.% for small pyroclastic flow of Iwodake rhyolitic dome, and 0.7-1.4 wt.% for Showa-Iwojima lava eruption in 1934. 2) Rhyolitic melts of the Takeshima and Iwodake eruptions contained CO_2 of less than 40 ppm, while the Showa-Iwojima melt has higher CO_2 concentration of up to 140 ppm. 3) Water and CO_2 concentrations of basaltic to andesitic melt of Inamuradake, a post-caldera basaltic scoria cone, are 1.2-2.8 wt.% and ≤290 ppm, respectively. Volatile evolution in the magma chamber is interpreted as follows; 1) the rhyolitic magma at the time of the latest caldera-forming was gas-saturated due to pressure variation in the magma chamber because the large variation in water concentration of the melt was attributed to exsolution of volatile in the magma prior to the eruption. Iwodake eruption (ca. 1300 y.B.P.) was caused by a remnant of the caldera-forming rhyolitic magma, suggested from the similarity of major element composition between these magmas. 2) Volatile composition of the Showa-Iwojima rhyolitic melt agrees with that of magmatic gases presently discharging from a summit of Iwodake, indicating the low pressure degassing condition. 3) The degassing of the magma chamber by magma convection in a conduit of Iwodake during non-eruptive but active degassing period for longer than 800 years decreased water concentration of the rhyolitic magma. 4) Addition of CO_2 from the underlying basaltic magma in the stratified magma chamber to the upper gas-undersaturated (degassed) rhyolitic magma increased CO_2 concentration of the rhyolitic magma.