Variations in a zoned magma chamber and its eruption processes: Case study on active volcanoes from southwestern Hokkaido, Japan

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Magma mixing is the common process, which is derived from compositionally zoned magma chamber. In many cases, mafic magma injects into felsic magma chamber to form a zoned chamber. Considering density difference between the two magmas, the mafic magma spreads beneath the felsic one. In addition, magma mixing usually occurs between the two magmas to form hybrid layer between the two magmas. We have developed systematic studies on active volcanoes from southwestern Hokkaido. We show variations in structure of a zoned magma chamber, due to physical properties of magma, and also emphasize that the variations would reflect eruption feature of each volcano.

Three active volcanoes from southwestern Hokkaido, Komagatake, Usu and Tarumai volcanoes, have repeated explosive eruptions, such as plinian eruption, since 17th centuries. These eruptions mainly produced felsic magma with dacitic to rhyolitic melt. In each volcano, mafic magma injected into felsic magma before the intial eruption. Felsic magmas of Komagatake and Tarumai volcanoes contained phenocrystic minerals with 20 - 50 %. Thus, whereas whole-rock chemistry of these felsic magmas are felsic andesite, these magmatic densities are relatively high. In the case of Tarumai volcano, injected mafic magma is also porphyritic. Thus, the mafic magma is denser than the porphyritic felsic magma. However, the mafic magma of Komagatake was nearly aphyric, and less denser than the porpyritic felsic magma. These density difference between mafi and felsic magmas could reflect structures in a zoned magma chamber. The zoned chamber beneath Tarumai volcano would consist of upper felsic and lowe mafic magma. This chamber is a compositionally normal zoned chamber. In contrast, the chamber beneath Komagatake volcano is a compositionally reverse zoned chamber, which consists of upper mafic and lower felsic magmas. Both volcanoes have erupted mixed magma between mafic and felsic magmas since the second eruption. Thus, hybrid layer was formed beween the mafic and felsic magmas. In addition, whereas mafic injection has repeated in each eruption of tarumai volcano, it seems that mafic injection has not occurred since the second eruption of Komagatake volcano.

These differences in the zoned chamber of the two volcanoes are consistent with the temporal variations in juvenile materials during each eruption. In all the eruptions of Komagatake volcano, mafic magma erupted first, followed by felsic magma. In contrast, mainly felsic magma erupted first in Tarumai volcano. In addition to the structure of the zoned chambers, variety of precursor activity and eruption sequence would depend on whether mafic injection occurred just before eruption. Poor precursor activity of 1929 Komagatake volcano would depend on absence of mafic injection.

In the case of 1663 Usu eruption, the intial stage of the eruption effused mixed magma between felsic and mafic magmas, followed by felsic magma. This sequence has been observed in many eruptions, such as 1991 Pinatubo eruption. In order to explain the sequence, the convective entrainment has been discussed (Snyder and Tait, 1996). If mafic magma with high temperature injected into felsic magma with lower temperature, thermal convection would occur in the felsic magma to entrain the mafic magma to form mixed magma. In the case of Usu volcano, the similar process would occur to form hybrid layer on the top of the felsic magma. Density of the hybrid layer is similar to the aphric felsic magma of Usu volcano, because temperature of the layer was much higher than that of the felsic one. Thus, the hybrid layer could settle at the top of the chamber, resulting to form a composionally reverse chamber.