Relationship between structure of a zoned magma chamber and eruption sequences of Hokkaido-Komagatake volcano

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Eruption sequence of magmas would be affected by structure of a magma chamber. In the case of Hokkaido-Komagatake volcano (hereafter Komagatake volcano), the most mafic ejecta have erupted in the earliest stage of all historic plinian eruptions. Based on petrological features and physical properties of erupted magmas of the volcano, we discussed about a relationship between structure of a zoned magma chamber and eruption sequences.

Plinian eruptions occurred in 1640, 1694, 1856 and 1929, and phreatomagmatic eruption in 1942. The juvenile ejecta are classified into four types, white pumice (SiO_2=59.8~62.4 wt.%), gray pumice (SiO_2=58.2~60.5 wt.%), scoria (SiO_2=57.4~58.9 wt.%) and banded pumice. In the plinian eruptions, the most mafic ejecta erupted first followed by eruption of white pumice.

White pumice shows highly porphyritic feature (24~52 vol.%), whereas scoria is nearly aphyric (~7 vol.%). Gray pumice shows intermediate crystallinity (20~33 vol.%) between them. All of the ejecta contain plagioclase, orthopyroxene, clinopyroxene, and Fe-Ti oxide phenocrysts. Core compositions of phenocrysts are nearly the same among the ejecta. Although compositional zonation of phenocrysts in white pumice is weak, phenocrysts in gray pumice and scoria often show remarkable reverse zonation. These petrological features indicate that gray pumice was formed by mixing between porphyritic white pumice magma (WP magma) and aphyric scoria magma (S magma). Because gray pumice has erupted since 1694, the WP and S magmas formed a zoned magma chamber after the 1640 eruption and the hybrid magma was formed by mixing between them.

Temporal change of crystallinity of white pumice was observed. Crystallinity of the 1640 white pumice ranged from 24 to 42 vol.%. Since the 1694 eruption, on the other hand, crystallinity of white pumice has ranged from 36 to 52 vol.% and most of samples have showed more than 40 vol.%. This temporal change cannot be explained by crystallization processes and suggests existence of a zoned WP magma that is divided into inner melt-rich (25~40 vol.%) and outer crystal-rich zones (40~ vol.%). In the 1640 eruption, the melt-rich WP magma erupted, whereas the crystal-rich WP magma remained in the chamber.

In order to clarify structure of the zoned magma chamber, physical properties of magmas should be evaluated from petrological features of the ejecta. Estimated temperature of the WP magma was about 930C. Melt composition was rhyolitic (SiO_2=74.7~77.4 wt.%) and water content was 3~4 wt.%. Estimated melt density from these petrological data was 2.27~2.31 g/cm3. The density of magmas varies greatly by crystallinity. The WP magma shows highly porphyritic feature. Especially, after the 1640 eruption, crystallinity of the magma became more than 40 vol.%. In this case, the density of the WP magma was larger than 2.55 g/cm3. On the other hand, the temperature and melt water content of the S magma were about 1100C and 2~3 wt.%, respectively. The S magma was aphyric and its density was 2.5~2.54 g/cm3. These indicate that the density of the WP magma was larger than those of the S and hybrid magmas. Therefore, the S magma would be located above the WP magma. Magmatic eruptions may have occurred without injection of the S magma since 1694.

When two magmas form a zoned magma chamber, mafic magma generally stagnates beneath felsic magma because of their densities. In the case of Komagatake volcano, however, the zoned magma chamber showed reverse compositional zonation. This compositionally reverse zoned magma chamber would be common beneath the volcano which erupts porphyritic magma.