論　説

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有珠火山1663年噴火のマグマ供給系の再検討

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Re-examination of the Magma Plumbing System beneath Usu Volcano, Hokkaido, Japan, during the 1663 Eruption

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The 1663 Usu eruption was the first and largest of all its historic eruptive activities after ca. 7000 years' dormancy. Our recent study divided the 1663 eruption into three stages in following ascending order: Stage I, small scale of plinian and phreatomagmatic eruptions; Stage II, climactic plinian eruption (pumice fall as so-called Us-b fall); and Stage III, vigorous phreatomagmatic eruptions. Previous petrological studies mainly focused on the Stage II event.

The 1663 juvenile materials are composed of three types, white (from all the stage), banded pumices (Stage I and II) and gray essential lithic fragment (Stage I). Major phenocrystic minerals (i.e. plagioclase and orthopyroxene) show nearly bimodal compositional distributions, and can be divided into two types: Type A, iron-rich orthopyroxene (Mg#～46) and sodic plagioclase (An～42); and Type B, magnesian orthopyroxene (Mg #～70) and calcic plagioclase (An～87). This observation suggests that the juvenile materials were mixing products between mafic and felsic magmas. This observation is also consistent with linear trends in all the oxide variation diagrams for whole-rock chemistry. Based on Wo (Ca/(Ca＋Mg＋Fe)) content in orthopyroxene, An and FeO* contents in plagioclase, however, the Type A phenocrysts can be further subdivided into two types: Type A_1 (lower Wo, An and FeO* contents) and Type A_2 (higher Wo, An and FeO* contents). Moreover, the Type A_2 phenocrysts are common in the juvenile materials of Stage I (gray essential lithic fragment) as well as in the Stage-II. Based on phenocryst size, composition and whole-rock chemistry, it can be concluded that the Type A_2 phenocrysts crystallized from the mixed magma between the mafic and felsic ones, and had grown for several years before the 1663 eruption.

Considering the eruption sequence and the types of erupted magma, the mixed magma was erupted during the initial, weak eruption (Stage I), as well as the climactic, explosive eruption (Stage II). This indicates that the mixed magma of Stage I event would not stagnate between mafic and felsic magmas, as is common in a normal zoned magma chamber, but the top of the chamber. This could be explained by convective entrainment as follows. The injection of the high temperature (＞1000℃) mafic magma into the lower temperature (＜800℃) felsic magma could cause thermal convection to entrain the former into the latter. This entrainment would form the mixed magma, which could rise to the top of the chamber. In effect, the upper part of the chamber would be gravitationally stable until the eruption, because the mixed magma could be lighter than the felsic one. Our petrological analysis concludes that the 1663 eruption was derived from a compositionally reverse zoned chamber that the mixed magma had existed above the normal zoned magma, and that mafic injection had occurred not just before the eruption.

Key words: Usu volcano, the 1663 eruption, zoned magma chamber, eruption sequence

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