Continuous Existence and Evolution of Magma Chamber: A case study in Usu Volcano, Japan

Akihiko Tomiya[1]

[1] GSJ, AIST

http://staff.aist.go.jp/a.tomiya/tomiya.html

Continuous existence of the same magma chamber beneath a volcano is generally postulated. It is, however, very difficult to prove. In order to investigate this matter, I made a systematic petrographic analysis of a series of eruptive products for an active volcano, Usu volcano, Japan (e.g., Tomiya and Takahashi, 1995, 2005).

This analysis successfully revealed that all investigated products, erupted in 1663, 1769, 1822, 1853, 1943, 1977 and 2000 A.D., were derived from a continuously existed magma system since 1663 A.D. on the basis of the following observations (Tomiya and Takahashi, 2005): plagioclase phenocrysts with the same sodic core (ca. An43; type-A) or calcic core (ca. An90; type-B) always occur in the rocks, and a similar feature is also found in orthopyroxene; the zoning profiles of the phenocrysts systematically change with time; phenocryst compositions systematically change with time, and so on. This study is probably the first case where zoning profiles of many eruptive products are successfully compared and the continuous existence of the magma chamber is demonstrated. Once we verify the existence of a continuously existed magma chamber, we may make reasonable predictions about future volcanic eruptions, which is our ultimate aim, by studying temporal variations in its characteristics (e.g., temperature, oxygen fugacity, volume, injection of new magma).

I also investigated the evolution of the Usu magma chamber by analyzing temporal change in petrographic characteristics and phenocryst compositions. On the basis of abundance, texture, and size distribution of phenocrysts, I classified the eruptive products into the three groups: (i) nearly aphyric rocks erupted in 1663 with homogeneous phenocrysts; (ii) porphyritic rocks erupted between 1663 and 1977 with inhomogeneous phenocrysts; (iii) nearly aphyric rocks erupted since 1977 with inhomogeneous phenocrysts. This three groups can be explained by different combination of end members of magma mixing that occurred just prior to each eruption, which is revealed by numerous magnetite analysis (Tomiya and Takahashi, 2005). The corresponding three patterns of magma mixing are as follows, accordingly; (i) rhyolite + basaltic andesite; (ii) dacite +- rhyolite; (iii) dacite +- dacite. Thus, this observation reflects the evolution of magma process and magma system beneath Usu volcano; i.e., the Usu magma system significantly changed after 1663 and before 1977 A.D.

I also estimate the change in, for example, temperature and oxygen fugacity of the magma. Further analysis is ongoing in order to quantify the evolution mechanism.

Reference:
Tomiya, A. and Takahashi, E. (1995): J. Petrology, Vol.36, 617-636.
Tomiya, A. and Takahashi, E. (2005): J. Petrology, Vol.46, 2395-2426.