Formation and Evolution of Silicic Magma Plumbing System: Petrology of the Historic Activity of Usu Volcano, Japan

Akiko Matsumoto[1]; Mitsuhiro Nakagawa[2]

[1] Earth and Planetary Sci., Hokkaido Univ.; [2] Earth & Planetary Sci., Hokkaido Univ.

Usu volcano, located on southwestern Hokkaido, has erupted nine times since 1663 after 7000 years' dormancy. The previous studies proposed the single magma storage system model based on magmatic temperature (Tomiya and Takahashi, 2005). However, our recent study revealed that the historic juvenile materials could be divided into three groups based on their petrological features, and that the three distinct magma plumbing systems have been active during the historic activity. Because the magma plumbing systems had changed twice for ca. 350 years, it is suggested that three felsic magma chambers had existed beneath Usu volcano. We examined the generation of multiple felsic magmas beneath Usu volcano.

The previous studies discussed the petrogenesis of felsic magmas: e.g., fractionation of basic magma and partial melting of lower crust etc. On Usu volcano, fractional crystallization model of the pre-historic basalts, which were similar to historic juvenile materials on isotopic composition, was proposed (Oba, 1966; Oba et al., 1983, 1985). In this study, we examined whether the fractional crystallization could produce the multiple felsic magmas.

To examine of the generation of Usu felsic magmas, we estimated their features as follows. We substituted the most felsic sample for felsic magma in Group-1 on whole-rock compositions. We also estimated whole-rock compositions of felsic magmas in Group-2 and -3 using the Fe-Mg mineral-melt distribution coefficients for orthopyroxene derived from felsic magmas, to determine whole-rock compositions of felsic magmas. In addition, we could estimate magmatic temperatures using geothermometry for Fe-Ti oxides of Spencer and Lindsley (1981). According to our estimations and eruptive volumes, felsic end-member magmas have become more mafic, hotter and smaller with time.

Firstly, we examined the case of simple fractional crystallization. In this case, felsic magma of Group-1 must produce those of Group-2 and -3 based on their relationships in composition and temperature. According to our examination, this model cannot explain the variations for trace elements although it can do for major elements. Secondly, we carried out the examination the case of assimilation and fractional crystallization, since it is believed that fractional crystallization would occur with assimilation of wall rocks (DePaolo, 1981). In this case, felsic magma of Group-2 and -3 must be also derived from those of Group-1, as the same of simple fractional crystallization. In this model, we substituted the pre-historic basalt as assimilant. However, this model isn' t also consistent with the variations of Usu felsic magmas. It is concluded that Usu felsic magmas were not produced by fractional crystallization of basalt.

The variation of Usu felsic magmas will be probably explained by the partial melting of crustal components in various degrees. In this case, partial melting in lower degree would produce felsic magma of Group-1. According to the thermal conduction within crust, the partial melting in lower degree would occur in wider region to generate large amount of melts. This relationship is consistent with the variation of the eruptive volumes of the three groups.