Change of crystal size distribution (CSD) during 300 years in Usu magma chamber

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I studied the change of crystal size distribution (CSD) in a magma chamber of Usu volcano, Japan, which has been well studied petrologically, in order to discuss physical processes ongoing in the silicic magma chamber. Tomiya & Takahashi (1995) has revealed that much microphenocrysts crystallized between 1663 and 1769 A.D. because of an injection of a basaltic magma, which caused the CSD plot to be kinked. On the other hand, according to my new data, the CSD plot does not change significantly between 1769 to 1943 A.D. Neither growth nor settling of the crystals is significant during this period, considering that the position of the kink is almost unchanged. Annealing of microphenocrysts, however, may occur judging from decrease of a slope of the CSD plot for the microphenocrysts.

INTRODUCTION:

Crystal size distribution (CSD; Marsh, 1988, 1998) is a useful tool to investigate physical processes in a magma chamber. CSD is more effective when it is combined with detailed petrologic descriptions. In this study, change of CSD during 300 years is shown for a magma chamber of Usu volcano, Japan, which has been well studied petrologically, in order to discuss physical processes ongoing in the silicic magma chamber.

USU VOLCANO AND ITS PHENOCRYSTS:

Usu volcano started its new activity of silicic magma at 1663 A.D. after a long dormancy. The activity is well studied petrologically by Oba et al. (1983), Tomiya & Takahashi (1995), and so on. Okumura et al. (1981) divided phenocrysts of Usu volcano into three types; type-A, type-B and type-C. It is considered that type-A is from a rhyolitic magma, type-B is from a basaltic magma, and type-C is such as quenched crystals caused by magma mixing between the two magmas (Tomiya & Takahashi, 1995). Most of the phenocrysts are plagioclase. Therefore, only plagioclase is discussed in this study.

The type-A phenocrysts exist in all eruptive products from the 1663 to the 1977 A.D. eruption. They are easily distinguished from other types of phenocrysts by sodic homogeneous core, larger size, and low aspect ratio. We can even see the growth of the phenocrysts during this period (Tomiya, 1995). Thus, type-A phenocrysts are useful "tracers" of Usu magma chamber.

CSD OF PHENOCRYSTS IN USU MAGMA CHAMBER FROM 1663 TO 1769 A.D.:

Tomiya & Takahashi (1995) studied CSD of plagioclase phenocrysts in the 1663 and the 1769 A.D. eruptive products, and revealed the followings: (1) the CSD plot (where logarithm of crystal population density, n, is plotted against size of crystal, L) of the 1663 phenocrysts (most of all is type-A) shows a line with a gentle slope, suggesting a slow cooling; (2) on the other hand, the CSD plot of the 1769 phenocrysts shows a kinked line with a gentle slope (the same as the 1663 phenocrysts) for larger crystals and a steep slope for smaller crystals, suggesting that rapidly formed microphenocrysts (type-C) added to type-A phenocrysts that had existed before the 1663 eruption. This is consistent with a petrologic model for the magma mixing.

CSD OF PHENOCRYSTS IN USU MAGMA CHAMBER FROM 1769 TO 1943 A.D. (This study):

I examined CSD of the 1943 A.D. eruptive product, in order to discuss magmatic processes after 1769 A.D., for example, whether crystal settling of type-A phenocrysts occurred or not, and so on.

Thin sections of the product were scanned by a film scanner (1360 dpi). Digital images by the scanner were processed by a software of "Adobe Photoshop" to trace rims of phenocrysts. The processed images were analyzed using the public domain "NIH Image" program. The resolution is about 20 micron. From the CSD of the 1943 products the following results are obtained: (1) the CSD of the 1943 phenocrysts is essentially the same as that of the 1769 phenocrysts, i.e., a kinked line with similar slopes and the same kink point; (2) the slope of type-C (microphenocrysts) of the 1943 products is a little smaller than that of the 1769 products, suggesting annealing of the microphenocrysts; (3) the amount of type-A phenocrysts does not change, suggesting that crystal settling is not effective; (4) crystal growth is not significant during the period (growth width is up to 100 micron or so, which is consistent with zoning profiles of the phenocrysts).

Using the CSD parameters, such as nucleation density, growth rate and residence time, quantitative discussion for processes in the magma chamber will be done.