Time scales of magmatic evolution from parental basalt to andesite at Rishiri Volcano: constraints from U-Th disequilibria

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Rates and processes of magmatic evolution occurring in cooling magma chambers have been a main research target of igneous petrology. In a few decades, time scales of magma chamber processes have been studied extensively with constraints of 233U-230Th-226Ra disequilibria. Unfortunately, however, there is still a shortage of good timescale data that are useful to test physical models.

In this study, we investigate rates of magmatic evolution of the Kutsugata and Tanetomi lavas, an alkali basalt-dacite suite erupted sequentially from Rishiri Volcano, northern Japan, using constraints of 238U-230Th disequilibria. The Kutsugata and Tanetomi lavas have been the subject of detailed petrologic and geochemical studies (Kuritani, 1998, 1999a, 1999b, 2001), and it has been shown that these lavas represent a series of magmas evolved with assimilation and fractional crystallization in the same magma reservoir (Kuritani et al., 2005). No evidence of magma replenishment is found during the magmatic evolution, except for the replenishment to trigger the eruption of the Tanetomi lava (Kuritani, 2001). They therefore provide an excellent opportunity to investigate the timescale of magmatic evolution in a single stage of cooling of the magma chamber.

Eruption age of the Tanetomi lava was determined using whole-rock isochron, that was produced by selective fractionation of U by degassing after lava emplacement. The isochron yields the eruption age of about 20200 yBP. Unfortunately, on the other hand, eruption age of the Kutsugata lava cannot be obtained by isochron. Therefore, eruption age was estimated using a model age. Assuming that (230Th/232Th) is basically constant at a given volcano, we obtained eruption age of about 42000 yBP. We have also measured (230Th/232Th) and U/Th ratio for whole-rock samples of the Kutsugata and Tanetomi lavas. These compositions vary systematically with whole-rock SiO2 contents, and the variations can basically be explained by AFC process and ageing effect. This reconfirms that magma replenishment did not occur during evolution from basaltic to andesitic compositions in the magma chamber.

From these results, it is clear that it took at least 20000 years for the basaltic magma to have evolved to andesitic magma beneath Rishiri Volcano. Even if conductive cooling is assumed, the size of the magma chamber could have been a few kilometers.