Magma-plumbing system and doming processes of dacite volcano Usu (2)

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In order to make a successful long-term prediction or to predict time developments of volcanic eruption, we need to understand particular processes operating in magma-plumbing system. Until recently, very few observational data are available for the long-term precursors except of a few active volcanoes. Recently, we have detected a quasi-continuous re-inflation of Izu-Oshima and Miyakejima volcanoes, in addition to the case of Mauna Loa. These observations suggest that basaltic volcanoes, which erupt every several tens of years, might be fed continuously from depths. Concerning andesitic and dacitic volcanoes, which also repeat eruptions every several tens of years, very few observational data are available on the style of magma supply. In this paper we propose a possible model for the magma-plumbing system and the mechanisms of doming activity of Usu volcano, by integrating the extensive observation of its recent activities in 1977-82 and 2000.

After the cessation of doming activity of Usu volcano in 1984, the seismic activity around the volcano was low. Since 1995, however, we have observed a gradual increase in the annual number of earthquakes and the temperature elevation of fumaroles on the Meiji-shinzan cryptodome at the northern foot. Hernandez et al (2001) also detected the temporal increase in CO2 flux from the ground around the summit area during the period of 1998-1999. On the contrary, they observed no remarkable inflation of the volcano. These were the long-term precursors to the 2000 eruption of Usu volcano.

During the precursory period of remarkable seismic swarm activity from March 28-31, we observed the volcano inflation originating from the depth of 2km beneath the west part of the summit, and also the wide-area deflation originating from the 10km deep source. After the eruption on March 31, the local doming activity continued at the eruption site, while both the summit inflation and wide-area deflation stopped. These observational data give us two essential evidences for the magma- plumbing system and the mechanisms of doming activity. The first evidence is that the intrusion of magma to the shallow depth beneath the west summit was accompanied (not preceded) by the deep deflation that suggested the intrusion of basalt magma from the deep source to the shallow source. This is in contrast to the precursory quasi-continuous inflation observed at basaltic volcanoes. The second important evidence is that the local doming activity around the eruption sites continued even after the cessation of both of the precursory shallow inflation and deep deflation. This suggests that the doming activity might be caused by the volume increase of magma (due to bubble growth) that intruded to the shallow depth beneath the summit. The rate of doming uplift followed exponential decay curves with two distinct time constants (14 and 120 days). In the initial period with a time constant of 14 days, Yamamoto et al. (2002) observed peculiar low frequency seismic events of a period of 12s and supposed as generated by magma flow. The shorter time constant can be explained by delayed bubble growth in magma. The longer decay constant might be caused by the saturation of water associated with magma crystallization. During the 1977-82 doming activity, we had also observed two distinct time constants of the order of 10 and 100 days (Watanabe, 1984). It was also noted that the doming activity, in 1977-82 and 2000, quickly stopped after the uplift velocity decreased to a value of 1 cm/day. This might be caused by the rheological properties of dacite magma, and a helpful evidence for the prediction of the final stage of doming activity.