Magnetic petrology of lava domes at Unzen volcano, Japan, part 2: deuteric oxidation processes accompanied with dome growth

Takeshi Saito[1]; Naoto Ishikawa[2]; Hiroki Kamata[3]

[1] Institute for Geothermal Sciences, Kyoto University; [2] Graduate School of Human and Environmental Studies, Kyoto Univ.; [3] Dept Earth Dynamics, Grad School Human Environ, Kyoto Univ

Since the 1990-1995 eruption of Unzen volcano, Japan, non-explosive lava dome eruption has attracted many researchers' interests. In particular, to clarify the physical and chemical phenomena in lava dome have been demanded because block-and-ash flows, which are the most dangerous during eruption, are generated from collapse of lava dome. However, the quantitative understandings of generation mechanisms of block-and-ash flows have not advanced yet, although some models were proposed on the basis of visual observations of the lava dome just before generating a block-and-ash flow (Sato et al., 1992; Nakada and Fujii, 1993; Ui et al., 1999). This is not only because steep topography of lava domes prevents us from surveying and sampling at will but also because silicate minerals, which most petrologists use, do not record the conditions in the dome.

Iron-titanium oxide minerals are very useful for studying lava domes. They are oxidized in such circumstances as lava dome and transformed into composite multiphase grains whose phases have distinct chemical compositions. In addition, two solid solution series, titanomagnetite and titanohematite, show magnetic properties and acquire thermoremanent magnetization during cooling from above the Curie temperature or Neel temperature, although the pseudobrookite series are all paramagnetic. Their magnetic properties depend on compositions, grain sizes and amount of oxide minerals. Therefore, if we identify iron-titanium oxides and determine their properties, we can estimate the oxidation process of iron-titanium oxides during cooling in the lava dome. Such a method of study has been recently graced with a formal name Magnetic petrology (Wasilewski and Warner, 1988) and was introduced by Frost (1991b).

In order to understand the redox state in lava domes, we have carried out magnetic petrological study on lava samples from the lava domes of Unzen volcano. As a result, we found that lava samples were oxidized in various degrees. Considering with geological occurrence, redox state is mainly concerned with the position of the sample in the dome and with growing mechanism. The lava dome grew endogenously when the effusion rate was low and cooling rate was high, while the lava dome grew exogenously when the effusion rate was high and cooling rate was low (Nakada et al., 1995). Endogenous dome grew by internal accretion in the dome. The surface of the dome was fragmentated and abundant lava blocks covered the dome surface. These blocks were oxidized concentrically due to the hot lava intruded within the dome and surface of the blocks were reached to type C. Block-and-ash flows generated from endogenous dome were converted from rock falls of such oxidized blocks (Ui et al., 1999). Therefore block-and-ash-flow deposits generated from endogenous dome contained abundant lava oxidized to various degrees.

On the other hand, exogenous dome grew by successive extrusion of new lava at the dome surface. Therefore the dome was composed from much fresh lava and was less oxidized than endogenous dome was. Exogenous dome near the vent site was waving and its direction was parallel to the flow direction. There are vesiculated and oxidized parts at the ridge of the waving lava. Such oxidized and weakened parts may be cracked and local explosion generates block-and-ash flows, which consisted much fresh lava.