A rock magnetic study of Aso volcanic ashes to assess the eruption processes

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Magnetic minerals have potentials for prediction of volcanic eruptive processes. All of the volcanic products include a large volume of magnetic minerals mainly as magnetite-ulvospinel (titanomagnetite: $Fe_{3-x}Ti_xO_4$) and/or hematite-ilmenite (titanohematite: $Fe^{2+}_y Fe^{3+}_{2-2y}Ti^{4+}_yO^{2-}_3$) series. These minerals should record the magma condition of each stage in the eruptive processes. For example, the titanomagnetite and titanohematite system is considered to contribute estimating the temperature of magma at the conduit. We applied some rock magnetic analyses to the volcanic ashes collected on the Aso Nakadake eruption beginning from late April, 2019, to assess the correlation between magnetic characteristics and eruptive processes and to detect the branching conditions from ash eruption toward strombolian eruption.
The volcanic ashes are collected from several points of different distances and directions from the Nakadake 1st crater. This paper focuses on two sampling points, Kako-fuchi(KAF) and Sakanashi (SAK) whose distances and directions from the crater are about 250m WSW and 7000m NE, respectively. Continuous eruption of the Nakadake from April 2019 to the present allows us collecting the volcanic ashes in chronological order. We examined the samples collected from KAF and SAK in arbitrary frequency after August 2019. In addition, a volcanic ash of strombolian eruption accumulated on 26th November 2014, at 450m SSW from Nakadake first crater is also studied.
The results of thermo-magnetic analyses show that the ashes have three characteristic Curie temperature (*Tc*). All samples have a component of Tc = 250-270°C. This *Tc* range is characteristic of nonstoichiometric titanomagnetite (x=0.47 to 0.49). Ti substitution (x) is calculated using the best fit equation: $Tc=575-552.7x-213.3x^2$ (Hunt et al., 1995) with measured *Tc*. Some samples have multiple *Tc*, in addition to the above, low temperature (*Tc*=around 170°C) and/or high temperature (*Tc*=around 490°C) components. As the low Tc component corresponds to iron-oxyhydroxides, these ashes involve some goethite (αFeOOH) and/or lepidocrocite (γFeOOH). Meanwhile, as the high *Tc* component is Ti poor titanomagnetite (x=0.15), the high-temperature oxidation occurred at more than 490°C to the samples. The 2014 ash sample also have three different *Tc* (around 170, 250, 490°C), although a proportion of high *Tc* component (x=0.15) is higher than the present volcanic ashes.
These results suggest that the high *Tc* magnetic minerals occur more when the eruptive activity progresses from incipient eruption. Interestingly, the high and/or low *Tc* signals at SAK are significant only before observation of gas plume glowing in the crater, although the signals cannot be confirmed at closer KAF site. The fine grain size of magnetic minerals are considered to acquire a high-stability magnetization under the high-temperature oxidation, therefore, the high *Tc* signal seems to appear earlier on a farther site with wind effect. The difference of oxidation states by grain size may carry the information of different places of the conduit.

Keywords: Aso Nakadake, Rock magnetism