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Coexistent titanohematite and titanomagnetite in obsidian from Takanoobane lava of Aso Volcano, Japan

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Volcanic glass contains abundant superparamagnetic and single-domain grains carrying stable remanence and has been served as an accurate paleomagnetic field recorder. Obsidian, a sort of volcanic glass of rhyolitic composition, is potentially a rich source of reliable paleomagnetic information. Also rock magnetic properties of volcanic glass provide key clues to identify and correlate a particular tephra layer related to an explosive volcanic eruption.

Here we report magnetic characterization of both titanohematite and titanomagnetite from borehole cores penetrated into Takanoobane rhyolitic lava of Aso Volcano, Japan. Crystalline rhyolite comprises a inner part of the lava and is bounded by upper and lower obsidian layers. We collected samples from an upper obsidian layer of one hole and from lower obsidian layers of three holes. Collected obsidian blocks are often mixtures of cloudy glass and crystalline spherules so that we carefully picked up glassy grains and rinsed with a ultrasonic cleaning. We performed high-temperature thermomagnetic analyses, low-temperature AC susceptibility measurements and low-temperature demagnetizations.

Most remarkable feature in these measurement results is ubiquitous 160 K peaks in AC susceptibility variations seen for almost all samples. This points to the Neel temperature of titanium-rich titanohematite ($y = 0.9$). On the other hand, Curie temperatures above 500degC are always observed from high-temperature measurements. Sometimes two Curie points ($>$500degC) can be seen in a single single, suggesting that dual low-titanium titanomagnetite phases ($x < 0.1$) are present. In addition, we found a kink at about 50 K in low-temperature demagnetization curves and also frequency dependence of AC susceptibility around 50 K in both in-phase and out-of-phase components. This indicates extremely fine grains are contained in obsidians. Low-temperature frequency dependence was most obviously seen for a lowermost part of a lower obsidian layer, where clear glassy obsidian can be seen.

We could identify a complex mineralogy and grain-size distribution of iron-titanium oxides. Titanomagnetite is a common oxide in igneous rocks and readily recognized by using room- or high-temperature techniques like three-axis IRM demagnetization. In contrast high-titanium titanohematite is usually missed in ordinary magnetic measurements because of its low Neel temperature, whereas low-temperature magnetic measurement is able to detect a very low concentration of titanohematite. Detailed grain-size distribution can give a clue to resolve cooling history of a rhyolitic lava.

Keywords: rock magnetism, obsidian, superparamagnetic grains, low-temperature magnetometry, frequency dependence of susceptibility