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Rock magnetic identification of magnetic minerals in widespread tephra layers in Japan

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As a typical volcanic island, widespread tephra layers are ubiquitously found in various types of Japanese Quaternary sediments. Those tephra layers are having primary importance in correlation and age estimation among Quaternary sediments, where the identification of each tephra has been mainly performed based on refractive index of grass shards and heavy mineral composition. A few rock magnetic attempts in identifying tephra layer have been done, although the results were not always straightforward. Recently, highly comprehensive rock magnetic analysis was applied to an Alaskan tephra by Lagroix et al. (2004). They succeeded to reveal the coexistence of titanohematite and titanomagnetite with low-temperature magnetic methods and appealed an effectiveness of the rock magnetic method.
We applied rock magnetic methods to the several representative tephra layers. High-temperature and low-temperature magnetic measurements and IRM analysis were applied to the samples from following six tephra layers: K-Ah (c. 7 ka), AT (c. 29 ka), DKP (c. 55 ka), Aso4 (c. 90 ka), Ata (c. 110 ka), and SK (c. 115 ka), collected more than 100 localities (e.g., Nakajima and Fujii, 1995). The high-temperature measurement was done with a thermomagnetic balance at KCC to show the Curie temperature (Tc). MPMS was used to show temperature dependence of the low-temperature IRM at OUS with zero-field cooling and field cooling modes. MPMS was also used to give IRMs at 300 K from 1 mT to 5T at 100 points along a logarithmic axis. The IRM acquisition curve was then analyzed with Irmunmix V2.2 (Heslop et al., 2002).
All samples suggest the presence of more than two magnetic constituents. The Curie temperatures were observed at 300-400°C and 500-600°C. While high-temperature tail above 600 °C is sometimes observed, only a few samples indicate Tc around 200°C. The Verwey transition at about 120 K was not always observed, which suggests rather uncommon bearing of stoichiometric magnetite in tephra. As tephra are generally quenched material, exsolution of magnetite through high-temperature oxidation could be restrained during eruption. Large decrease in IRM was sometimes observed at about 50 K, which suggests an occurrence of titanomagnetite. IRM analyses imply tow or more coercivity components. It is noteworthy that extremely high coercive component (>1 T) is often estimated. As goethite is not indicated by thermomagnetic curves, titanohematite can be an alternative answer. These lines of evidences suggest the presence of titanomagnetites with minor titanohematite in the studied tephra.

Keywords: widespread tephra, magnetic minerals, rock magnetism