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Kakioka observatory data contribution to paleomagnetism

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Vigorous paleomagnetic measurements on natural volcanic rocks have revealed fascinating features of the geomagnetic field: for example, present-day field may be about twice the time average for the last 5 Myr (Yamamoto and Tsunakawa, 2005); field intensity was reduced to be about 10 percent of the present-day field during the last geomagnetic reversal (e.g. Mochizuki et al., 2011). They are deduced from thermoremanent magnetization (TRM) of the volcanic rocks, which is acquired when the rocks form.

Neel (1949, 1955) established a theoretical basis for TRM on non-interacting uniaxial single domain (SD) magnetic grain assemblages. For the assemblages, it is demonstrated that (1) TRM direction is parallel to the ambient geomagnetic field and that (2) TRM intensity is in linear proportion to the ambient geomagnetic field. It is expected that paleomagnetic measurements on volcanic rocks allow us to deduce not only the direction but also the intensity of the past geomagnetic field.

However, we have known that majority of natural volcanic rocks more or less suffer from non-ideality: for example, they contain interacting and/or large magnetic grains. To test how reliable paleomagnetic results from volcanic rocks are, we have been working on paleomagnetic measurements on Japanese historical lavas. Historical lavas are ideal ‘standard‘ materials because they formed when the IGRF (international geomagnetic reference field) model was effective: that is, we know the ‘answers‘. The ambient geomagnetic fields at the timing of the lava emplacements can be calculated by the IGRF model, particularly based on the Kakioka observatory data.

So far, we have obtained systematic results from the 1914 and 1946 Sakurajima lavas (Yamamoto and Hoshi, 2008) and the 1986 Izu-Oshima lava (Mochizuki et al., 2004). About the paleointensity (past intensity of the geomagnetic field) estimations, we applied the two different methods of Coe-Thellier (Thellier and Thellier, 1959; Coe, 1967) and Tsunakawa-Shaw (Shaw, 1974; Tsunakawa and Shaw, 1994; Yamamoto et al., 2003). These results indicate that (1) paleomagnetic directions can be deduced within the error (standard deviation) of few degrees and that (2) paleointensities can be estimated within the error of about 10 percent. However, old volcanic rocks usually have been weathered and it makes paleointensity experiments often more difficult.

One hundred years of geomagnetic observations at Kakioka have enabled such assessment of the reliability for paleomagnetic measurements on natural volcanic rocks. The observations at Kakioka contributes not only to geomagnetic study after the 20th century but also to paleomagnetic study back to millions years.