Paleomagnetic Applications in the Field: Case Study in the Unzen Volcano

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Lavas and welded tuffs have a remanence aligned to the ambient geomagnetic field in the time of their formation, which is called thermoremanent magnetization (TRM). Non-welded pyroclastic flows have a TRM or partial TRM according to how high the formation temperature was. This gives us an opportunity to estimate the emplacement temperature of pyroclastic flows. On the other hand, geomagnetic field fluctuates in direction and intensity, and the temporal variation of direction usually amounts to 2 to 8 deg. per 100 years. Hence, remanence directions of volcanic rocks give a tool to identify flows whether there is some amount of time lag among them beyond the limit of dating method. However, this basic idea often fails due to complicated rock magnetism such as secondary components of viscous origin. This is the reason why we need to follow a usual experimental procedure of paleomagnetism such as progressive demagnetization rather than just to measure bulk remanence called natural remanent magnetization (NRM). This study reports a case study of paleomagnetic applications in the Unzen Volcano, and some instructions in the experiments will be discussed.

Paleomagnetic measurements for two pyroclastic flows from Mayu Yama gave a cautionary case to judge the thermal origin of the flow. It is highly confident that both flows are block and ash flows. Nevertheless, remanence directions are well grouped at one flow while very scattered at the other. This puzzling fact is reconciled by supposing that the flow with inconsistent remanence directions was generated during the lava dome was endogenously growing, which is after the model by Ui et al. (1999). When the lava dome is endogenously growing, temperature of the dome wall could be lower than 300-400 deg.C. In that case, the TRM acquisition must have completed at the summit because the blocking temperature (Tb) of the flow is higher than 400 deg.C. This is supported by much more reddish color of the blocks from this flow, suggesting long term presence at the summit.

One intriguing results about the lava identification were obtained from 100ka Fukkoshi Lava in which samples were collected at two and three sites from northern and eastern flows. Within flow paleodirections are very consistent while those for between flow are much different, indicating that there are two flows which erupted with some amount of time lag. Lava identification by paleomagnetism relies on accuracy of sample orientation and measurements of remanence. Orientation by sun compass adopted in this study makes the former very accurate and small circles of 95% confidence around the mean direction proves accuracy of the latter.

This study includes several other case studies in which there are some complicated and difficult examples as well as very straightforward ones. Some instructions will be discussed for effective application of paleomagnetic measurements in volcanic fields.