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Zoom meeting A ：11/4 PM1 (13:45-15:30)
13:45～14:00

Optimization of Tsunakawa-Shaw paleointensity measurements for single plagioclase grains

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Measurements on single silicate grains are sometimes useful to retrieve paleomagnetic records from samples that are not suitable for general whole rock measurements. It is powerful for plutonic rocks in which the magnetic carriers are dominated by coarse-grained particles, and volcanic rocks which are vulnerable to thermal alteration. Depending on the forming condition and history of the rock, plagioclase crystal contain magnetically stable tiny exsolved grains of magnetite and/or magnetically unstable coarse-grained magnetic minerals or do not significantly contain magnetite. Plagioclase is contained in various types of rocks, and plagioclase crystals containing tiny exsolved grains are often used in single-crystal paleomagnetic study. On another front, acicular exsolved magnetite preferentially oriented in relation to the crystal lattice of the host plagioclase may cause large magnetic anisotropy, and the measurement results of paleointensity and direction must be interpreted with care. Therefore, to efficiently obtain reliable paleomagnetic data by this method, it is indispensable to select samples suitable for measurement and to adopt an experimental protocol suited to the magnetic characteristics of the sample.

In this study we aim to categorize the magnetic carrier of plagioclase grains from gabbros to set a selection guideline of samples suitable for paleointensity measurements and optimize the Tsunakawa-Shaw paleointensity protocol to measure anisotropic samples. Gabbro samples collected at several localities in Tanzawa, Japan and Pilbara, Australia are studied. We measured the intensity of natural remanent magnetization (NRM) of ˜100 grains per gabbro sample and found that some samples showed NRM intensity distributing with large variability over several orders of magnitude while others had much smaller distribution. Optical microscope observation of selected specimens revealed that the former ones contain large opaque minerals while the later ones were dominated by tiny grains evenly distributed in some region of the plagioclase grain. These results can be interpreted that random capturing of magnetic inclusions with various size and origin during crystal growth of plagioclase can result in large variability in NRM intensity, and without such inclusions exsolved magnetite whose concentration and size distribution controlled by the chemical and thermal condition at the locality can be the main source of magnetization. Therefore, the distribution of NRM intensity can be useful to select magnetically stable samples with exsolved magnetite.

Large magnetic anisotropy biases the results of paleomagnetic measurements by (i) tilting the direction of the remanent magnetization from that of external field toward that parallel to the easy axis, and (ii) varying efficiency of remanent magnetization acquisition by the direction relative to the anisotropy axes. Therefore, we propose to add the following procedures to the Tsunakawa-Shaw protocol in the paleointensity measurement of single plagioclase grains: After stepwise demagnetization of NRM, impart anhysteretic remanent magnetization (ARM) to three orthogonal directions to approximate the degree of anisotropy and estimate the number of specimens required to cancel the anisotropy bias. For samples with large anisotropy for which an unrealistic number of specimens are required, measure ARMs imparted to 6 more orientations to determine the anisotropy tensor precisely. From this tensor and the direction of NRM, calculate the direction of the paleomagnetic field in the sample coordinate system. Impart ARM0 in a DC field parallel to the calculated paleomagnetic field direction to minimize the bias on paleointensity caused by anisotropy. In the presentation, we will discuss the guidelines for applying the above protocol based on the results of anisotropy measurements of some samples.