Shock remanent magnetization measurement using the superconducting quantum interference device microscope

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Knowledge of the evolution of magnetic field intensity is key to understanding the past evolution of planets. However, magnetic field paleointensity data of terrestrial planets such as Mars and Moon have been poorly obtained because of the lack of appropriate rock samples. To address the problem, we focus on shock remanent magnetization (SRM). There are many impact craters on surface of the terrestrial planets, and the magnetic field originated from the SRM of planetary crust can be measured by spacecraft magnetometer. The magnetic field paleointensity could be estimated using the magnetic field data observed over the impact craters.

In order to estimate the magnetic field paleointensity from the observed magnetic field data, it is crucial to know a structure of the SRM, while the structure remains unclear due to the difficulty in experimental techniques. In this study, to reveal the structure of SRM, we conducted SRM acquisition experiments and magnetic imaging of the SRM sample using the superconducting quantum interference device (SQUID) microscope.

Natural basalt samples with cylindrical form of 10 cm in diameter and 10 cm in length (FURNITURE STONE) were used as a target. Before the SRM acquisition experiments, the basalt samples were subjected to alternating field demagnetization at 80 mT. The two-stage light gas gun at the Institute of Space and Astronautical Science (ISAS) of Japan Aerospace and Exploration Agency (JAXA) was used for the SRM acquisition experiments. A magnetically shielded cylinder of 32 cm in diameter and 100 cm in length was set in a vacuum experimental chamber of the two-stage light gas gun. The magnetically shielded cylinder was constructed with three μ-metal layers, and the residual field in the cylinder was <0.3 μT. A solenoid coil of 26 cm in diameter was set in the magnetically shielded cylinder. The basalt sample was placed at the center of the solenoid coil. The applied field was set to be 0–100 μT, and direction of the applied field was parallel to the cylindrical axis of the basalt samples. An aluminum sphere of 2 mm in diameter was used as the projectile. A nylon slit sabot was used to accelerate the projectile. The impact velocity was ~7 km/s, and the impact angle was fixed at 90° from the horizontal.

Using the SQUID microscope at Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), magnetic imaging of the basalt samples were conducted after the SRM acquisition experiments. The basalt cylinder was placed on non-magnetic xyz-sample table. The distance between a surface of the basalt cylinder and the SQUID microscope was set to be ~1 cm, and a vertical component of magnetic field over the basalt sample was measured for 6 cm ×6 cm region.

The sample imparted SRM in zero-field showed decrease in the magnetic field at center of the crater, corresponding to the increase in sample to sensor distance. On the other hand, the sample imparted SRM in a 100 μT field showed increase in the magnetic field at center of the crater. These results suggest that the basalt samples acquired remanent magnetization as the SRM. In this talk, we will discuss the structure of SRM based on the results of SQUID microscope measurements.

Keywords: Shock remanent magnetization, SQUID microscope

