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Magnetically-induced free motions of dia- & para-magnetic mineral grain and a novel method of its mineral identification

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The origin of minor mineral phases (including biological remnants) contained in various semimetal and igneous rocks has become one of the major interests in various fields of earth science. The development of a simple and nondestructive method to identify the material of a single fine particle is desired in various research fields that are concerned with micro- and nano-materials. Here, a new method of material identification is proposed which is based on magnetization data; the data is obtained from magnetically induced motions of the single grain that is observed in micro-G condition. Specifically, diamagnetic susceptibility is obtained from translation of the single mineral grain caused by field-gradient force; anisotropy of susceptibility can be obtained from period of rotational oscillation of magnetically stable axis with respect to field direction. According to a data book that compiles published susceptibility values [1], an intrinsic diamagnetic susceptibility and its anisotropy are assigned to almost all the rock forming mineral. Hence identification of a mineral (or material) is possible from the measured values of susceptibility and anisotropy. This attempt does not appear in previous literatures.

Free translation due to field-gradient force was previously reported for various diamagnetic and paramagnetic crystals [2][3]. Rotational oscillation was observed as well for a number of diamagnetic crystals in a homogeneous field located in micro-gravity [4]. The susceptibility and its anisotropy obtained from the above motions agreed well with their published values.

The terminal velocity of the above-mentioned translation at zero field area is observed in the present work. Through these measurements, the field-induced potential at initial position was completely converted to kinetic energy out-side the magnetic field. The mass independent property of terminal velocity, deduced from the above-mentioned energy conservation, is examined in wide range of sample size between 1.0 and 0.005cm in diameter. A compact microgravity system, which is introduced in an ordinary laboratory, was newly developed. This was because the conventional facilities of microgravity were not suitable for a routine analysis such as the present magnetization measurement; a large facility system requires a long machine time, and their running costs are high. In the compact system, length of the drop shaft is 1.5m, and micro-G duration was below 0.7 seconds. The experimental setup was contained in a wooden box (30cm in diameter), which was dropped from the sealing of our laboratory. The micron-sized samples were released in the area of field-gradient; the field was produced by a by a small NdFeB magnetic-circuit (maximum field 0.7 T). The introduction of the small circuit enabled the development of the compact drop system.

The above-mentioned free motion is expected to be a breakthrough to detect susceptibility (& material identification) of limitlessly small particles, because the method is free of both sample holder and mass measurement. Magnetization is measured on any sample irrespective of its size, provided that motion of the sample is observable.

At the first stage of analyzing geological materials, the sample should be separated to a single grain size. Secondly, the material of individual grain will be identified nondestructively by the above-mentioned free motions; then it can be put to various refined analysis based on chemical, isotopic or optical probes, etc. The method is applicable to search biological remnants as well as micro-meteorites from semimetal rocks. It may be effective to identify a new type of exotic grain from primitive meteorites.

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