Magnetic separation of diamagnetic grians and paramagnetic grains in general

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Magnetic separation is popularity used to extract materials that are either ferromagnetic, ferrimagnetic or strongly paramagnetic grains from an ensemble of heterogeneous grain. It was believed that dynamic motion (i.e. diamagnetic and paramagnetic) of weak magnetic materials generally require ultra-strong field intensities above 10 Tesla. Field-gradient forces was used to realize levitation of diamagnetic materials at high-field laboratories; the levitation was later realized on a human fingertip by using a small NdFeB block. Field-induced translations were reported recently for single weak particles floated in an area of a monotonically decreasing field [1]. It was proposed that the values of magnetic susceptibility X per unit mass assigned to the grain was obtainable from the translation no mater how small the sample may be [2]. In the present study, the translation was simultaneously performed on multiple grains for the first time, and ensemble of grains composed of weak magnetic materials were successfully separated in a simple manner using a hand magnet (*go to* YouTube “Magnetic separation of general solid particles realized by a permanent magnet” *for movie*) [3]. In order to realize the separation, an apparatus that was previously designed to examine the field-induced translation [2] was modified; the short microgravity condition was produced in a drop box (40 cm ×30 cm ×22 cm) which was used in a short shaft. A monotonically decreasing field distribution along the +x-axis was produced by a small NdFeB circuit . At the edge of the translating areas, 2 collecting plates were added to examine the efficiency of separation. The above setup was sealed in a glass tube (inner pressure˜ 100 Pa) to eliminate the effect of air resistance. The motions of the samples were examined by a high-speed camera that was placed outside of the glass tube. The diamagnetic samples were cut from synthetic blocks with purity higher than 99.99 wt%. The two paramagnetic olivines were products of San Carlos, New Mexico and Mogok, Myanmar . Then a weak magnetic grain is released in a monotonically decreasing field with small initial velocity, it follows a motional equation described as $ma = mXB(dB/dx)$. In a common field distribution, acceleration a of particle is determined by intrinsic X value of the grain material, not by mass m of particle. This property realizes the observed magnetic separation. By using the achieved technique, the extraction of new solid phases from a heterogeneous grain ensemble may, which will lead to important discoveries in inorganic materials. In this sense, the potential of this study as an analytical technique may be comparable to that of chromatography separation. The technique is also applicable in separating rare samples such as the particles recovered from the moon or the asteroids, because in principle, the method is capable of thoroughly separating micron-order grains without sample-loss.

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References

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