Magnetic separation of ordinary solid particles using a pokcet size magnetic circuit

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An ensemble of heterogeneous solid particles, composed namely of bismuth, enstatite (Myanmar), olivine (San Carlos), gold and graphite, are separated into fractions of different materials by small magnetic circuit composed of two NdFeB plates (4.0×4.0×1.0cm).[1] The abovementioned separation & identification followed a recently-reported principle [2][3] that acceleration of a particle, induced by magnetic volume force in an area of field gradient, is uniquely determined by intrinsic susceptibility of material, and its acceleration was independent to mass of particle. The small magnetic circuit produced a field distribution that monotonically decreased along a x-axis that was located between the two plates (0.4 cm in width [1]. The mixture of the particles was maintained at the bottom of a half-piped scape (0.2 cm in depth). An orifice (diameter: 0.07 cm) was located at the bottom of the halfpipe, which was set just above the circuit gap. An area with a height of 4cm was located below the circuit, and a cross-sectional paper was horizontally set at the bottom of this area to collect the translating particles. The horizontal separation, x, of the individual particles with respect to the position of the orifice were measured after they were collected on the plate. The particles were manually pushed towards the orifice position one by one using a thin copper wire and were dropped from the orifice with small initial velocity. Among the separated materials, graphite is known to have the smallest diamagnetic susceptibility of popular materials; whereas, the paramagnetic susceptibility observed in many of the rock forming minerals are smaller than that of San Carlos Olivine. Accordingly, the susceptibilities reported for the most existing materials in nature overlap with the values of the abovementioned five materials.

The efficiency of the proposed material separation is improved by increasing the variance of horizontal velocity between the two particles, because it directly increases the separation of the particles observed on collecting plate. The velocity can be enhanced by increasing the field-gradient of the magnetic circuit. A circuit having a compact size suitable for on-site researches (edge length: ~10 cm, weight: ~1.5 x10^3g) was previously designed and developed. The field gradient produced by the circuit was as large as 6250 G/cm, which could increase the field-induced velocity of particle by an order of magnitude.

It is presently considered that most solid particles, composed of diamagnetic or weak paramagnetic materials, are magnetically inert; the conventional magnetic separators were not used to extract these materials. Hence the new method proposed in the present study may extend to an effective technique of pre-treatment in analysing aggregates, because such technique is desired in various research fields of science; it may play a role of a "chromatography technique" conventionally used in the analysis of organic molecules. The portable and low-cost system may provide a breakthrough for on-site research in industrial and medical fields as well as in resource explorations in nature.

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