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Characterization of magnetic impurities extracted from hectorite clay

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Hectorite is a phyllosilicate of the smectite group with the approximate formula $Na_{0.33}(Mg,Li)_3Si_4O_{10}$ $(F,OH)_2$. Both the properties of the clay itself and the nature of its impurities carry information about its geological origin. Both are also important in evaluating new areas of application. Although much less common than montmorillonite, hectorite has gained interest as a potential component of organic-inorganic nanocomposites. Such nanocomposites have improved gas barrier and mechanical properties, and are studied as carriers of biological macromolecules. Here we present measurements of the bulk magnetization and ^{1}H NMR spectra measurements of hectorite SHCa-1 as received (San Bernardino County, California, USA), magnetically purified hectorite, and a characterization of magnetic impurities extracted from this clay.

Hectorite as received shows weak ferromagneticlike properties at 300 K. After magnetic purification, hectorite has mostly diamagnetic properties which well agree with changes in the ^{1}H NMR spectra and with the ferromagneticlike properties of the extracted particles. The significant contribution that small impurities can make to the physical properties of clays, demonstrate the necessity for a detailed characterization of impurities. The most common natural mineral that could account for the magnetic properties of the extracted particles is magnetite. An SEM survey showed some particles of roughly octahedral outline among the extracted material, but since the grains were coated with silicates no definite identification was possible. Therefore a polished grain mount was prepared for electron probe microanalysis (EPMA). A variety of min-

erals was identified in this sample, including magnetite, a second Fe oxide assumed to be FeO(OH), two alkali feldspars (one almost pure K feldspar, the other with Na>K), SiO_2, $CaCO_3$, amphibole, ilmenite, and the lanthanides-rich mineral allanite.

Although the available sample of impurities was too small to determine the relative proportions of minerals, a magnetite abundance of $\sim$5% of the extracted material (or $\sim$0.1% of the original hectorite sample) is consistent with both the magnetic properties and the grain mount data. Magnetite occurs as individual grains of up to $\sim$100 μm as well as <1 μm inclusions in some silicates, particularly K-spar. Adherence of very small magnetite inclusions to grain surfaces is also the probable cause that non-magnetic minerals such as SiO_2 and $CaCO_3$ stick to the magnet used for magnetic separation. At least some of the mineral impurities are apparently detrital in origin. The mineralogical diversity suggests that more than one source is responsible.