MAGNETISM OF LUNAR SOILS. R. R. Oder, EXPORTech Company, Inc., P. O. Box 588, New Kensington, PA 15068-0588.

BACKGROUND. Recently we reported measurements of the distribution of lithic, mineral and fused soil components magnetically separated from minus 1 mm size fractions of five lunar soils.[1] The work, which continues with lunar rocks, is directed at testing the **feasibility of magnetic beneficiation** of lunar soil for recovery of feedstocks for production of oxygen, refractories, and metals by a variety of methods.[2]

We report determinations of the magnetism of isolates magnetically separated from soils 67511, 65701, 71061, 71501, and 10084. The low susceptibility isolates of immature highland soil 67511 contain concentrated diamagnetic lithic components, the intermediate susceptibility fractions of all the soils contain admixtures of paramagnetic minerals and metallic iron, and the strongly magnetic fractions of all the soils contain concentrated metallic iron. The ratio of magnetic susceptibility to iron oxide, χ/FeO, provides a convenient measure of soil maturity for all the samples studied.[2]

EXPERIMENTAL. Magnetic separations were carried out in fields ranging from a few hundred to 20,000 oersteds. The apparent magnetic susceptibility, $\chi_a = W_p\chi_p + W_f\sigma_f/H$, has been used to determine para- and ferromagnetic components. W_p and W_f are weight fractions and χ_p and σ_f are the paramagnetic susceptibility and ferromagnetic magnetization per gram respectively. A description of the distribution of weight recovered in χ and size intervals has been given elsewhere.[2]

Anorthite: The magnetism of the least magnetic fractions of soil 67511 is related to paramagnetic impurities; $\chi_g = -1.21+0.4296*FeO + 4.9994*Cr_2O_3+113*MnO*10^{-6}$ cc/gm, $r^2=0.9998$.

Using moments for the Cr^{+3} and Mn^{+2} states[3] and their concentrations at zero FeO, one obtains $\chi_g = -0.39*10^{-6}$ cc/gm for the magnetic susceptibility of anorthite, $A_0 = Al_2O_3*(SiO_2)_2*CaO$. Paramagnetic values for A_0 quoted by others[4] may be due to contamination.

Concentrations of anorthite separated from the highland soils are compared in Figure 1. Relatively pure anorthite was separated from soil 67511. The anorthite recovered from soil 65701 was much lower in concentration.

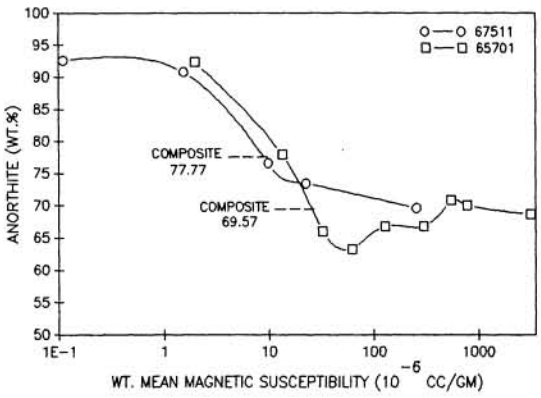

Figure 1.

Paramagnetic and Ferromagnetic Components: Concentrations of ilmenite and pyroxene calculated using chemical data are compared for the mare samples in Figure 2. Ilmenite and pyroxene can be separated from the immature and the submature soils but will be difficult to recover in high concentrations from the mature soil. Ilmenite and pyroxene did not show strong dependencies on particle size.

Metallic iron calculated by difference using the measured apparent magnetic susceptibility and calculations of the paramagnetic susceptibilities of stoichiometric ilmenite,[5] $FeTiO_3$, and stoichiometric iron pyroxene,[6] $FeSiO_3$ are compared for all the soils in Figure 3. Metallic iron concentrates in the most magnetic and finest size fractions and increases with soil maturity.

Magnetic Susceptibility of Whole Soils: Magnetic, chemical, and petrographic data for the minus 1 mm fraction of the lunar soils are compared in Table I and Figure 4.

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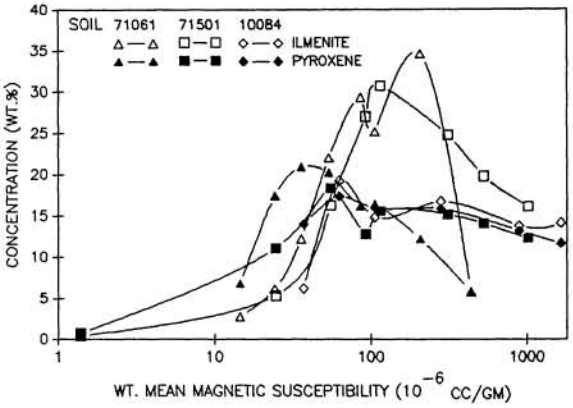

Figure 2.

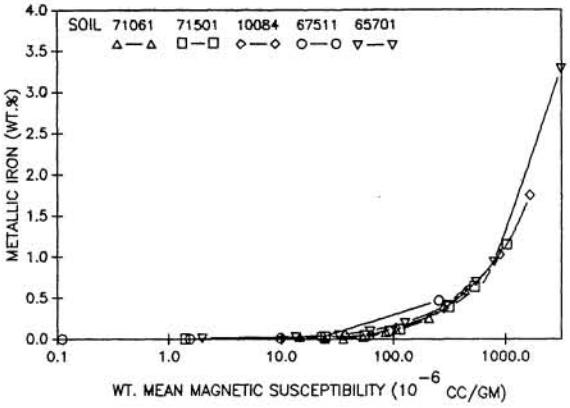

Figure 3.

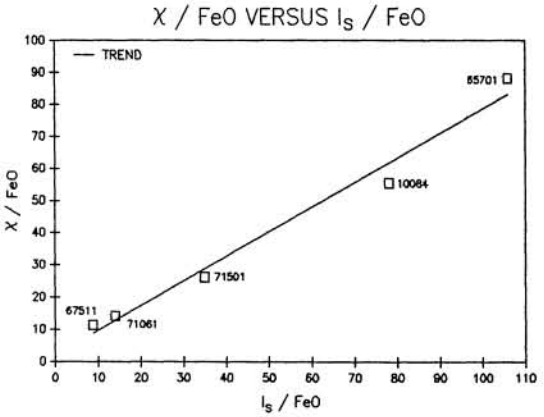

Figure 4.

Table I
Magnetic, Chemical, and Petrographic Parameters for Minus 1 mm Fraction of Lunar Soils

Soil	Magnetic Suscept. (10^{-6} cc/gm)	Iron Oxide (Wt.%)	Metallic Iron (Wt.%)	Agglutinates (Particle %)	I_s/FeO
67511	47.5	4.16	0.08	11.33	8.8
71061	196	13.84	0.24	8.46	14
71501	434	16.54	0.49	15.22	35
10084	786	14.15	0.87	19.2	78
65701	433	4.91	0.55	22.81	106

χ/FeO is convenient for assessing maturity of lunar soils because measurements of whole soil magnetic susceptibility are easy to make and inexpensive instrumentation is readily available.

SUMMARY. The magnetism of lunar soils increases with maturity due to inclusion of disseminated metallic iron. The iron is concentrated in the finest size and highest susceptibility fractions. We have separated feebly paramagnetic material from the highland soils. This can serve as a source of anorthite for manufacture of cement and recovery of metals and oxygen by electrolysis. We have separated intermediate magnetic susceptibility material from hi-titanium mare basalts which can serve as source of ilmenite and pyroxenes for oxygen production by hydrogen reduction. We have separated metallic iron from all soils. Magnetic susceptibility is a convenient measure of soil maturity.

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