

ELECTROSTATIC SEPARATION AND SIZING OF ILMENITE IN LUNAR SOIL SIMULANTS AND SAMPLES.
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The advantages of developing lunar oxygen sources as fuel and atmosphere for lunar base and space operations has spurred a program at NASA JSC in the concentration of industrially useful materials in lunar soil. Ilmenite, the most abundant oxide in lunar soil, is approximately 58 wt% FeO, and is considered a prime candidate as a lunar oxygen source. As a result, Lockheed Engineering and Management Services Co. has undertaken a study at JSC to electrostatically concentrate and size lunar ilmenite using mineral electrostatic separators based on commercial designs (1).

Electrostatic separation performance has been evaluated using lunar soil simulant mixtures of comminuted terrestrial anorthite (An_{90}), ilmenite (Quebec), olivine (Fe_{91}), and pyroxene ($Wo_{50}En_{33}$) in the weight ratio (4/1/1/4) as well as a sample of the .09-.15mm size fraction of lunar soil 10084. Ilmenite in the .09-.15mm size fraction of the simulant has been concentrated from 10 wt% to approximately 95 wt% with 68% of total sample ilmenite recovered in the concentrate after one pass in air through the separator with a maximum electric field strength of 2.7 kV/cm and feed temperature of approximately 150°C. Elevated sample feed temperature was used to drive off moisture and enhance the conductivity and hence the charge contrast in the separator between ilmenite, a semiconductor, and the other species which are essentially nonconductors.

Prior to electrostatic separation of the 10084 lunar sample, agglutinates and soil metal amounting to 37 wt% were removed with a hand magnet. Virtually all the soil ilmenite was retained in the nonmagnetic fraction. The lunar ilmenite was then concentrated electrostatically from approximately 10 volume % to 54 volume % with 45% recovery after one pass in nitrogen through the separator with a maximum electric field of 5kV/cm and feed temperature of approximately 190°C. Ilmenite concentrations in both terrestrial and lunar separates were estimated by optical microscope count. The lower yields of the lunar sample resulted in part from the polyphase character of many of the grains.

To elucidate behavior of mineral species in the electrostatic separator which employs aluminum electrodes, contact charging on aluminum of 5 mg aliquots of the four terrestrial mineral components in the three size ranges, .09-.15mm, .15-.25mm and .25-.5mm, was measured at approximately 70°C in a Faraday well connected to the Keithley electrometer model 610C. Charge polarity of the nonconductor species was the same as deduced from their behavior in the separator (An_{-01+}, Px_{-}) (1). In all size ranges, charge magnitude became increasingly negative in the order olivine, ilmenite, pyroxene, anorthite, the same order as increasing percent bridging oxygens in the crystal structures of the species. Increasing covalency and hence strength of the oxygen bonds in that order may be the reason for the negative charge trend. Log log plots of the 5 mg sample charges vs log normal mean diameter of the three size ranges (.116mm, .194mm, .353mm respectively) are plotted in Fig.1. In all four species, sample charge increases with decreasing grain size as l^m where l is the log normal mean grain diameter and $-1 > m > -2$. If m were -1, contact charge of the 5 mg aliquots would vary directly with surface area of the samples. Since charge increases even more rapidly than surface area with decreasing grain size, these measurements suggest the four species can be successfully sized electrostatically. That is not likely to be the case with magnetic separation techniques, for example, because the magnetic force is volume dependent ($m = 0$).

Electrostatic sizing of terrestrial ilmenite was subsequently tested by dropping mixtures of the above three size ranges into an electric field of approximately 1.4 kV/cm in air and observing the horizontal deflection in each size range. Figs. 2&3 show typical results of trials at 23°C and 150°C respectively. Weight distributions of the three size ranges extend over 6 horizontal bins, each 3.5 cm wide. Medians of the distributions are expressed in units of bin number and increase with increasing horizontal deflection. At room temperature, the medians of the three size ranges increase monotonically with decreasing grain size. At 150°C, the fine size median falls off with respect to the mid size median. That can be accounted for by a 30% increase in air viscosity at the higher temperature which most strongly inhibits the deflection of the fine size fraction. These results suggest that electrostatic sizing of all the above minerals, as well as lunar soil, is feasible and would be enhanced in vacuum ambient where the blurring effects of increasing atmospheric resistance with decreasing grain size would be eliminated. Electrostatic soil sizing may be particularly advantageous in the lunar environment as a step in extraction of solar wind hydrogen from lunar fines (2). A preliminary vacuum version of the mineral electrostatic separator and sizer has been built and is being evaluated.

REFERENCES:

1. Agostio W. N. (1983) Space Manufacturing 1983 Vol. 53, Advances in Astronautical Sci., American Astronautical Soc., AAS 83-231, p. 315-334.
2. Bustin R. et al. (1984) Hydrogen Abundances in Lunar Soils, Proc. Lunar Sci. Conf. 15th.

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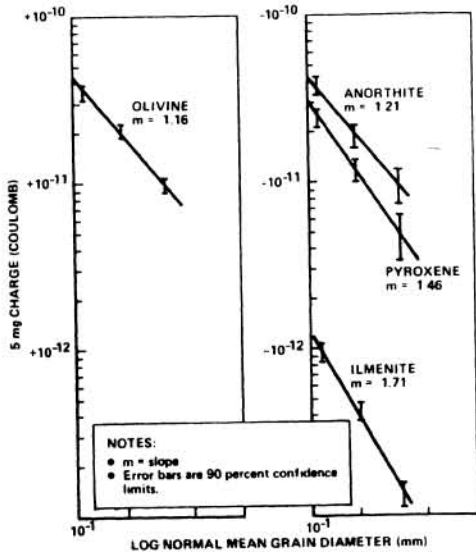


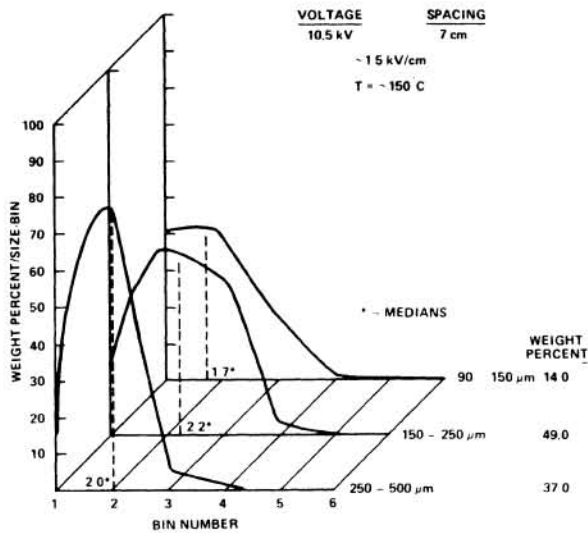
Figure 1.

Contact charge on aluminum of 5 mg aliquots of Ol, An, Px, Il vs grain size in three size ranges. 70°C.

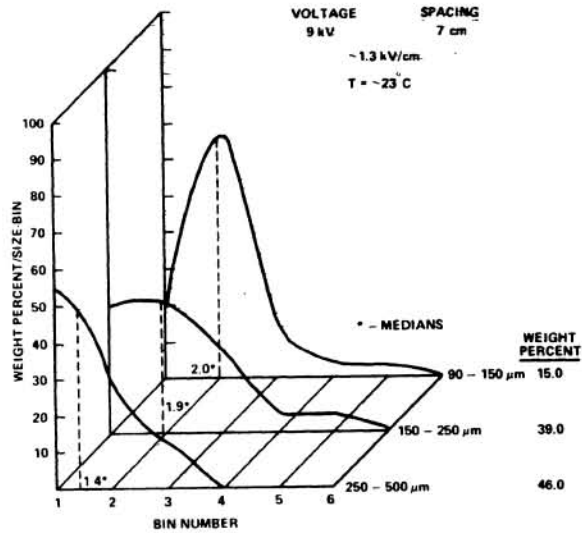
Figure 2. →

Size distribution vs bin number. Room temperature.

ELECTROSTATIC SIZING OF COMMINUTED ILMENITE



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← Figure 3.

Size distribution vs bin number. 150°C.