ADHESION AND CLUSTERING OF DIELECTRIC PARTICLES IN THE SPACE ENVIRONMENT

1. Electric Dipole Character of Lunar Soil Grains

G. Arrhenius and S. K. Asunmaa, University of California, San Diego, Scripps Institution of Oceanography, La Jolla, California 92037

Introduction. Exposure to space environment causes the lunar soil surface particles to adhere to each other forming grain clusters with low bulk density. This phenomenon is likely to be of general importance for aggregation of grains in space now and in the preplanetary history of the solar system. Our previous investigations have shown the adhesion forces to be electrostatic and due to persistent internal polarization (1, 2).

The purpose of the present research is to clarify experimentally the detailed nature of this phenomenon, to measure the magnitude of the attractive force between individual grains and to interpret the results in terms of particle behavior on the Moon. During exposure to corpuscular radiation primarily from the Sun, the grains have been subjected to structural disordering and charge along the tracks of penetrating ions and to deposition of mass impurities and charge at the end of the paths of implanted ions. Local charge accumulations so obtained are likely to become polarized even in low intensity fields such as the Moon's sunlit side.

Comparison of the electrostatic adhesion in top and bottom strata of the Apollo 12 double core where the age relationships are approximately known show that the adhesion although perceptibly decayed, still persists after burial times estimated to be of the order of 10^7 years (1).

Objectives and achievements. The primary objectives of the present investigation have been:

1) to determine magnitude of dipole moments of individual grains.

2) to compare the dipole characteristics before and after removal of mobile surface charges in order to distinguish between surface polarization and internal dipole.

3) to establish dependence of dipole strength on parameters such as mass, composition and structure of the grains.

4) to examine changes in dipole strength induced by stepwise removal of the surface layer of irradiated grains.

Techniques have been developed for two independent approaches for measurement of dipole moments. First, using a dynamic technique, grains in free fall in vacuum were subjected to electrostatic attraction in an axisymmetric field. In the other technique, the volume polarization of the lunar dust was examined under static conditions. The dielectric constant of powder samples is being determined in a paraffin matrix under two conditions a) grains in random orientation; b) the grains electrically aligned with respect to field lines in an homogeneous electric field. New experimental devices have been constructed for both techniques.

Two independent techniques have also been used for elimination of surface charges. In one approach thermally stimulated discharging by infrared heating was employed. As a complementary technique, the most heavily irradiated surface layer was removed by treatment with dielectric solvents.

Adhesion and Clustering of Dielectric Grains; I. Electric Dipole..

Arrhenius, G. and Asunmaa, S.K.

The effect on the dipole strength of the removal of a 500-1000 Å layer was examined in individual grains as well as in bulk powder samples.

The axisymmetric electric field for measurement of dipole moments. The principal components of the device for examination of grain behavior in free fall in a non-homogeneous electric field are a central wire electrode (10μm diameter) at potentials up to 2000 volt and a field limiting brass cylinder at ground potential (Fig. 1). The potential distribution in the field is shown in Fig. 2. The grains are introduced into the field through an aperture at a distance of 0.3 cm from the field axis. The device is operated in a vacuum of 10^{-5} Torr with external contacts for the high voltage and a vibrator in contact with the grain supply funnel. Optical and scanning electron microscope techniques were employed for identification and measurement of grain dimensions and locations on the wire electrode at sites of contact where the grains remain adhered. Figure 3 shows a section of the collector electrode. Several grains stand on end displaying small contact areas.

The behavior of Apollo 17 soil grains in the electric field was compared with that of terrestrial augite of similar particle size.

Dipole moments of lunar grains in Apollo 17 soil. The logarithmic correlation between dipole moment and grain mass in sample 78501.14 is shown in Figure 4. The dipole moments range from 10^9 to 10^{13} Debye ($1D = 10^{-18}$ esu). Similar distributions are found for samples 75081.63, 72501.14 and 75810.53.

The scatter of dipole moments around the least square average curve AB is probably due to differences in grain composition, structure, irradiation history and geometry. The estimated experimental errors are small compared to this scatter. The experimental data are discussed in a companion paper (4).

REFERENCES

1. Arrhenius, G., Asunmaa, S. K. and Fitzgerald, R. (1972). "Electrostatic properties of lunar regolith" in Lunar Science III, ed. Watkins, p. 30-32.

2. Arrhenius, G. and Asunmaa, S. K. "Aggregation of grains in space" (1974) Moon 8.

3. Arrhenius, G., Liang, S., Macdougall, D., Wilkening, L. Bhandari, N., Bhat, S., Lal, D., Rajagopalan, G., Tamhane, A. S. and Venkatavaradan, V. S. (1971) The exposure history of the Apollo 12 regolith. Proc. 2nd Lunar Sci. Conf., Vol. 3. The MIT Press, 2583-2598.

4. Arrhenius, G. and Asunmaa, S. K. Adhesion and Clustering of Dielectric Particles in the Space Environment, 2. The electric dipole moments of lunar soil grains. (in this volume).

Adhesion and Clustering of Dielectric Grains;I. Electric Dipole..

Arrhenius,G. and Asunmaa, S.K.

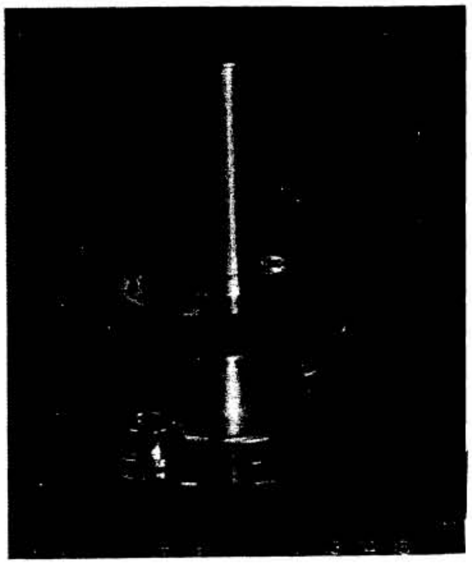

Figure 1. Device for dipole moment determination in an axisymmetric electric field with a central high voltage electrode.

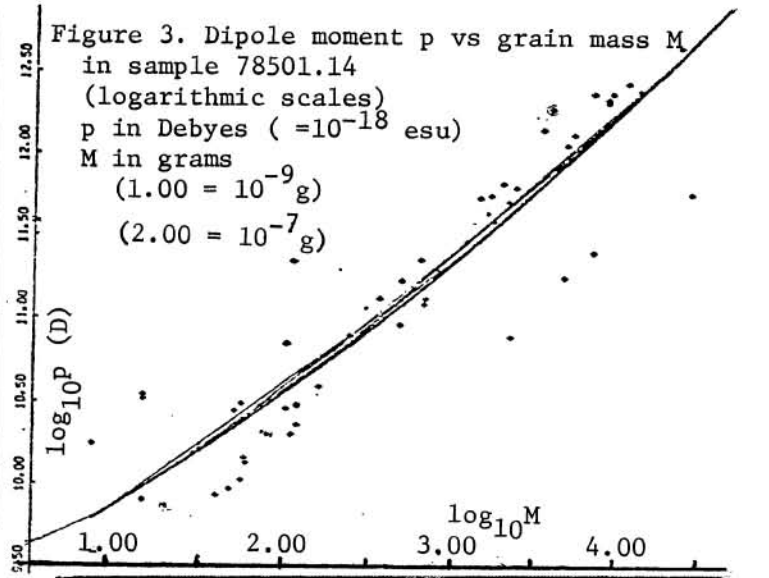

Figure 3. Dipole moment p vs grain mass M in sample 78501.14 (logarithmic scales) p in Debyes ($=10^{-18}$ esu) M in grams ($1.00 = 10^{-9}$g) ($2.00 = 10^{-7}$g)

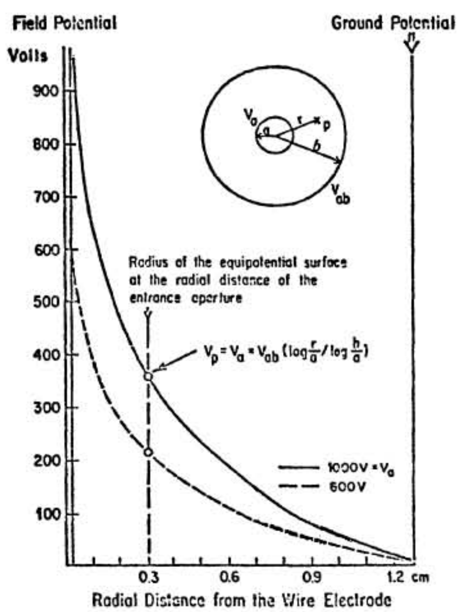

Figure 2. Field potential as a function of axial distance.

Figure 4. Lunar grains adhered on the collector wire electrode. Scanning electron micrograph. Magnification 420x