2.2.5 ELECTROSTATIC DISRUPTION OF LUNAR DUST PARTICLES

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An investigation has been made to study a possibility that dust particles might catastrophically explode on the lunar surface due to electrostatic charging. It is shown that for the dark side along the terminator zone, dust balls and compact stony particles of micron and submicron sizes will be blown up if their surface potential is as low as a kilovolt negative. This mechanism will not operate on the sunlit side because the potential is only 3.5 ~ 20 volts positive. Some of these fragments may possibly levitate in the vicinity of the terminator.

One aspect of the lunar environment which has created much interest and discussion is the method of formation and transportation of dust particles. Several investigators studied various mechanisms (Gold, 1955; Singer and Walker, 1962; Gold, 1962; Rennilson and Criswell, 1974). The lunar surface is covered with dust. It is expected that surface dust particles do have certain electric charge due to the solar wind and solar radiation. Accordingly, the electromagnetic field carried in the solar wind will exert a Lorentz force on the charged dust particles. Very likely the moon as a solid body is charged positively on the sunlit side (Singer and Walker, 1962; Gold, 1962; Rhee, 1972). The magnitude of this field is rather difficult to estimate, but the currently accepted value seems to range from +3.5 to +20 volts. On the dark side of the moon Knott (1973) recently predicted an equilibrium surface potential of a few kilovolts negative. It is also demonstrated that for the dark side along the terminator the potential can be as low as -1.2×10^3 volts (Rhee, 1974). On the basis of the Apollo ALSEP/SIDE experiment Freeman et al. (1974) have determined that the surface potential at the lunar nightside ranges from -250 to -750 volts in the solar wind.

It is the objective of this note to show that in this range of surface potential micron and submicron size surface dust particles might break up due to the large electrostatic stress which is greater than the tensile strength of the material.

The internal disrupting stress F due to electrostatic repulsive force acting on a sphere of radius r and surface potential ϕ (Öpik, 1956) is given by

$$F = \epsilon_0 \phi^2 / r^2 \qquad (1)$$

where ϵ_0 is the permittivity. Equation (1) can be rewritten as

$$F = 8.85 \times 10^{-7} \phi^2 / r^2 \tag{2}$$

where F is the tensile strength in dyne/cm², ϕ is in volts and r is in cm.

Table 1 shows diameter of dust particles for various materials of different tensile strengths computed as a function of surface potential. Loosely bound and fluffy dust balls have a low strength of about 10^4 dyne/cm² and $10^{-3} \sim 10^{-2}$ cm size dustballs will fragment due to electrostatic tension if the surface potential ranges from -10^2 to about -10^3 volts. A typical tektite glass requires a much higher potential to be electrostatically broken up. For a compact stone charged to about -10^3 volts, the break-up diameter is about two microns.

Table 1

Relation between material strength and break-up diameter

Material	Tensile strength (dyne/cm²)	particle diameter (micron)			
		-100 volts	-300 volts	-500 volts	-1000 volts
dust ball	10^4	19	57	95	190
compact stone	10^8	0.19	0.57	0.95	1.90
tektite	6.9×10^9	0.02	0.06	0.10	0.20
iron	2×10^{10}	0.01	0.03	0.05	0.10

In the absence of any pertinent laboratory data on the electrostatic explosion of dust particles, it is very difficult to explain the dynamics of these resulting fragments. Nevertheless one might consider a specific case in order to find out just how far and high these fragments might travel on the lunar surface. A compact stone of radius 1 micron and charged to -10^3 volts carries an electrostatic energy of 1.1×10^{-3} erg. In the event that an electrostatic explosion takes place and creates a fragment of mass 10^{-14} gram and if about 10% of this energy is imparted to this fragment, it will have an ejection speed of about 1.05 km/sec. Assuming an ejection angle of 45° and considering lunar gravity only, it can travel a distance of 728 km and reach a maximum altitude of 208 km on the lunar surface.

Evidence for the transportation of dust on the lunar surface has been reported from Surveyor 3 observations. LUNOKHOD-II observation of a post-sunset brightness of the lunar sky, astronaut observations of streamers associated with sunrise and sunset as seen from lunar orbit, and results from the Apollo 17 LEAM experiment (Berg et al., 1974) indicate strong evidence of lunar soil transport associated with the terminators. The impact data from the Apollo 17 LEAM experiment strongly suggest electrostatic levitation and horizontal soil transport as postulated by Gold (1955); Singer and Walker (1962), and others. More recently Rennilson and Criswell (1974) have proposed electrostatic levitation as an explanation for the sunset horizon glow observed from the Surveyor missions.

The mechanism of electrostatic disruption proposed here is effective only in the vicinity of the terminator zone on the dark side. At the lunar terminator and on the dark side adjacent to it, dust particles are expected to assume a very low negative potential and, depending on their material strength, they may explode if the electrostatic stress exceeds the tensile strength.

It is impossible at the present time to invoke dust charging as a possible mechanism to explain the differences between the near and far side of the moon because of the uncertainties in the physical parameters on the dark side.

In summary, an attempt has been made to investigate the possibility that dust particles might catastrophically explode on the lunar surface, even though it is extremely difficult to attack the problem satisfactorily. It is pointed out that for the dark side along the terminator zone, dust balls and stony particles of micron and submicron sizes will explode if the surface potential is as low as a kilovolt negative. Some of these fragments may conceivably levitate in the vicinity of the terminator. It is unlikely that the entire dark side of the moon would assume a negative potential as low as a few kilovolts because of the presence of the plasma cavity behind the moon.

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