Size Distribution of Lunar Soil

WHEN Duke *et al.*[1] measured the size of lunar soil returned by Apollo 11, they found a size distribution similar to that of glacial till and other terrestrial soil, except that the lunar soil is noticeably deficient in material finer than 15 μm. They feel that a partial explanation for this deficiency is that it is caused by melting and consequent consolidation into clumps of finer particles on the Moon. We wish to suggest another partial explanation, derived from wear theory—it is that the finer particles are missing in lunar soil because materials in a lunar environment have a higher surface energy.

Particles produced by wear during sliding have a diameter, d, given by a relationship which can be expressed most simply as

$$d = 60{,}000\ W_{ab}/p \qquad (1)$$

where W_{ab} is the surface energy of adhesion of the two rubbing bodies a and b, and p is the penetration hardness (Vickers or Knoop) of the body from which the particle is formed[2]. The theoretical basis for this relationship is an energy balance between the surface energy of a contact and the volume elastic energy of the material in the vicinity of a contact. The same equation gives the least size of particles formed by attrition during ball milling[3], and it is possible that it also governs lunar attritious processes.

For typical rock materials on the Moon, p is about 600 kg/mm^2, and for a pair of such materials *in vacuo* W_{ab} can be estimated to be 1,000 erg/cm^2. Thus d in equation (1) has a value of 10 μm, in good agreement with the observed value.

In a terrestrial dry air environment, W_{ab} is reduced by about a factor of two from the value I have given, while in a high humidity environment or in the presence of liquid water, further substantial reductions in W_{ab} take place. Corresponding reductions can be anticipated in the least sizes of particles formed on Earth by attritious processes.

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[2] Rabinowicz, E., *Friction and Wear of Materials*, ch. 6 (Wiley, New York, 1965).

[3] Rabinowicz, E., *Wear*, **7**, 9 (1964).

Coupling between Aerials used for measuring Ionospheric Drifts

AN important consideration when designing an array of aerials to sample the diffraction pattern of a radio wave reflected from the ionosphere is to ensure that the results are not affected by mutual coupling. Signals reradiated from one aerial may be received by another, and this could affect the measured characteristics of the diffraction pattern. Any subsequent measurements (for example, of ionospheric drifts) would also be affected.

A simple check for the effects of such coupling is to look for differences in the cross correlation between records from different aerials. If coupling is important, the values of the cross correlation at zero shift between separated aerials may be expected to show consistent differences depending on their relative orientation. In particular, it may be expected that the correlation for aerials aligned parallel to each other may be different from the correlation for aerials which are mutually perpendicular, and that this effect should be greater for smaller separations.

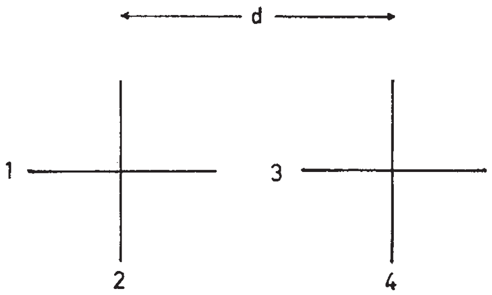

Fig. 1. The aerial configuration.

Such an experiment was carried out using the array of 178 dipole aerials at Buckland Park near Adelaide, South Australia[1]. Pairs of mutually orthogonal half wavelength dipoles (1·98 MHz) with their centres at the same pole were chosen from within the array as shown in Fig. 1. Separate receivers and a four channel pen recorder were used to record the amplitude fluctuations of circularly polarized radio waves reflected from the ionosphere at vertical incidence. From the four records obtained the cross correlation at zero shift for each of the six possible combinations was calculated. Two of these values represent the correlation between signals obtained by orthogonal dipoles at the same site (ρ_{12}, ρ_{34}), two represent the correlation between separated orthogonal dipoles (ρ_{14}, ρ_{23}), one the correlation between dipoles aligned end to end (ρ_{13}) and one represents the correlation between dipoles parallel to each other (ρ_{24}).

The effects are most likely to be seen when the correlation between the fading at adjacent dipoles is low. Partial reflexions from near 95 km were therefore used as these have been observed to give the smallest pattern scale among echoes returned from the ionosphere. In order to eliminate any possible effects due to the receivers or recording apparatus, the connexions between each dipole and the receiver/pen recorder combination were rotated between each record. The records were digitized using eighty levels.

Table 1. VALUES OF THE CROSS CORRELATION AT ZERO SHIFT BETWEEN FADING AT PAIRS OF AERIALS

	Local time (h)	ρ_{12}	ρ_{34}	ρ_{14}	ρ_{23}	ρ_{24}	ρ_{13}
d=91 m	1148	0·95	0·94	0·73	0·76	0·79	0·66
	1152	0·94	0·95	0·70	0·68	0·71	0·69
	1155	0·94	0·89	0·71	0·72	0·66	0·71
	1158	0·93	0·94	0·48	0·63	0·57	0·56
	1205	0·91	0·92	0·64	0·56	0·59	0·59
	1209	0·93	0·94	0·61	0·51	0·60	0·54
	1212	0·94	0·85	0·34	0·48	0·48	0·34
	1215	0·93	0·92	0·54	0·68	0·62	0·65
	1412	0·96	0·88	0·65	0·70	0·68	0·63
	1414	0·90	0·91	0·52	0·44	0·50	0·49
	1417	0·94	0·90	0·61	0·50	0·52	0·58
	1419	0·91	0·92	0·43	0·41	0·39	0·48
	Average	0·92		0·58		0·59	0·58
d=183 m	1219	0·92	0·94	0·15	0·07	0·14	0·09
	1224	0·93	0·92	0·20	0·24	0·23	0·18
	1231	0·90	0·95	0·19	0·18	0·19	0·16
	1239	0·93	0·95	0·40	0·45	0·39	0·44
	1249	0·90	0·84	0·10	0·08	0·13	—
	1252	0·94	0·92	0·17	0·23	0·22	0·21
	Average	0·92		0·21		0·22	0·22
d=274 m	1326	0·92	0·94	0·16	0·18	0·20	0·18
	1329	0·90	0·93	−0·17	−0·05	−0·13	−0·08
	1334	0·93	0·91	0·07	0·09	0·08	0·08
	1337	0·92	0·94	0·26	0·40	0·37	0·29
	1340	0·92	0·89	0·03	0·01	0·03	0·00
	1346	0·93	0·87	0·09	0·14	0·13	0·10
	1350	0·93	0·96	−0·08	−0·07	−0·07	−0·10
	Average	0·92		0·08		0·09	0·07

95 km echo. March 3, 1970.

The results for twenty-five records representing three different separations (d) between the crossed dipoles are given in Table 1. Each record is identified by a time, and each value of cross correlation is listed in the appropriate column. The variations with time do not represent