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GRAIN-SIZE AND SHAPE CHARACTERISTICS OF LUNAR FINES AND SOME TERRESTIAL COMPARISONS.

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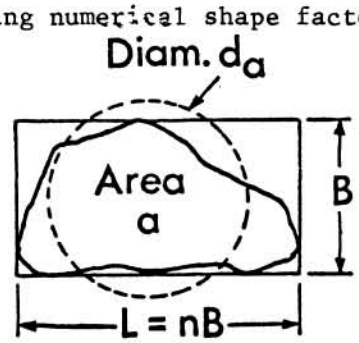
The grain size distribution and shape characteristics have been determined on samples 10 084, 171 and 12 057, 72 returned by Apollo 11 and 12 missions respectively. Some of the characteristics of the latter sample have been described in a previous report, which also explains the procedures adopted for the sizing analyses (1). The only difference in the present procedure is that sieve plates with round hole apertures made by electro-forming were used over the complete size range of 20 to 1000 μm.

Abbreviated sieving analysis

Round hole diam.: μm	Per cent weight passing hole	
	10 084	12 057
500	94	95
200	82	78
100	67	57
50	45	34
20	17	14
Arith. mean. aperture, μm	127	140

Most of the variation between these analyses occurs in the coarsest size fractions. If the material passing 100 μm dia. hole is considered in isolation, then the grain size composition is almost identical. Analysis of the material smaller than 10 μm is being made by centrifugal procedures.

Shape characteristics The theory for defining numerical shape factors has been described in the previous report and may be summarised as follows:- The orthogonal limiting dimensions of a particle are L, B and T in decreasing order of magnitude. The elongation ratio of the profile of a particle is $n = L/B$. If a is the projected area of the profile in the plane of L and B, then a two-dimensional shape factor is the Projected area ratio $\alpha_a = a/BL$ as



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shown in the adjacent figure. A three dimensional shape factor is the volume coefficient $\alpha_{v,a}$ = volume of particles divided by the (projected area diamter)^3. The projected area diameter is the diameter of the circle which encloses the same area as the profile of the particle, namely $d_a = (4\ a/\pi)^{\frac{1}{2}}$.

The sieving procedure used for the determination of grain-size composition produced about 16 closely graded fractions of particles. Determinations of the shape factors n and α_a were made on optical microscope photographs of each of these fractions. A summary of these measurement is given below:

Sample number	Mean value for all fractions	Range of mean values for individual fractions
10 084,171	n = 1.386	1.33 to 1.42
12 057,72	n = 1.376	1.32 to 1.41
10 084,171	α_a = 0.78	0.74 to 0.83
12 057,72	α_a = 0.80	0.75 to 0.84

In general, the finer particles below 100 μm are the most elongated and tend to have a more nearly prismoidal shape, but this variation does not occur uniformly over the complete size range. There are anomolies that indicate variations in the mineralogical composition of the different size fractions but further work is necessary to show whether these variations are random or are significant features in the composition of the lunar fines.

The mean particle volume was measured for the size fractions exceeding 100 μm particle diameter and the following were the mean values of the volume coefficient.

Sample 10 084,171 $\alpha_{v,a}$ = 0.25 Sample 12 057,72 $\alpha_{v,a}$ = 0.22

The general conclusions are that these two samples of lunar fines are very similar, both as regards grain-size composition and particle shape. These shape measurements are being extended by electron microscope photography to particles smaller than 5 microns.

The relative number of glass spherules in the samples is a matter of interest: a precise count has not yet been made but they are present to the number of approximately 10 to 20 per 1000 other particles of the same size in the material larger than 50 μm. However, in the size fractions smaller than 2 μm there appears to be an increase in the relative number of spheres, and the adjacent photograph shows a remarkable cluster of

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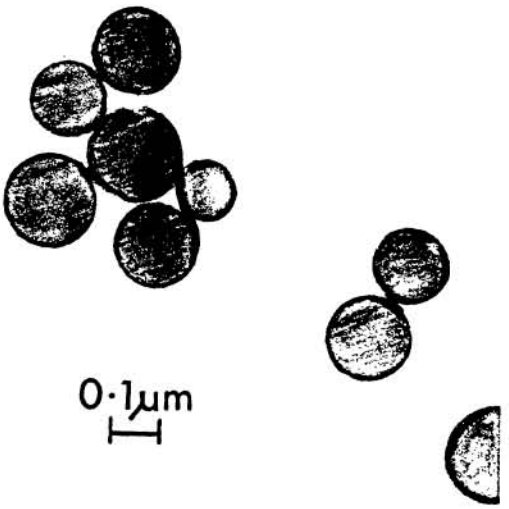
spherules at 60 K magnification in the size range 0.1 to 0.2 μm.



Comparative studies on terrestial particles

Measurements of shape factors are being made on crushed particles of terrestial minerals similar to those found in the lunar fines. Preliminary examination has shown that sharply angular fragments are much more common in the terrestial minerals than in the lunar fines. A study of the mode of formation of glass agglomerates and glass spherules may be promoted by examination of the fused ash particles produced by the combustion of powdered coal. There is an extensive literature on the break-down of liquid drops and a study of these may elucidate the mechanism of spherule and 'dumb-bell' formation in the lunar fines.

Reference

1. Heywood, H. (1971) Particle size and shape distribution for lunar fines sample 12 057,72. Proceedings of the Second Lunar Science Conference, Vol. 3, pp. 1989-2001.