SUMMARY OF BELLCOMM REPORT entitled "Photometry and Polarimetry of the Moon and Their Relationship to the Physical Properties of the Lunar Surface"

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This report is a review of the large body of experimental and theoretical information relating to the photometry of the moon, written, primarily, for those who have a direct interest in the subject matter. This summary is intended for those with a less detailed interest and attempts to present the more important observations, conclusions and recommendations.

In the report an attempt is made to display the salient lunar light reflecting properties which are controlled by the exact nature of the lunar surface microrelief. This summary presents a brief discussion of a currently favored model of the lunar surface covering layer and compares this model with the conclusions necessitated by photometric data. Subsequently a listing is given of factors excluded from the study and finally conclusions and recommendations are presented.

Description of the Lunar Covering Surface

From a consideration of the experimental lunar photometric and polarimetric data, laboratory experiments and theoretical models, the following lunar surface properties are necessitated:

(A) Nearly the entire lunar surface must have a uniform cover layer made up of nearly opaque material. This cover layer must have low surface reflectivity and possess an extremely porous and interconnected structure giving it complex shadow-casting properties in order to exhibit the characteristic lunar photometric behavior.

(B) In addition to these properties the layer-vacuum interface must be made up of highly irregular granule agglomerations, having mean dimensions of the order of a tenth of a millimeter and similar spacings in order that it exhibit the lunar polarization characteristics, especially the correct so-called negative polarization behavior.

Laboratory studies, at atmospheric pressures, have shown that it is possible to form a surface composed of complex overlapping dendritic structures of opaque grains having average dimensions of about 1/50 mm (if larger grain sizes are used to form the structure, consolidation results). This surface has been found experimentally to closely approximate the photometric properties of the lunar surface; however, this artificial surface does not display the same polarimetric behavior as the lunar surface.

A complex low-density matrix results when the bonding forces between the contact faces of grains are larger than the gravitational body forces acting on the grains. When the bonding forces are small, consolidation or a tight packing of grains results. On the moon, the bonding forces between grains may result from a cementing process, where such a process could be due to the grains being sprayed with hot vapors from micrometeorite explosions on the surface, volatile materials being slowly evolved from the lunar interior, or sputtering. The intergranular bonding forces also may result simply from ultra-clean grain faces being in close proximity. The density as a function of depth and the bearing strength properties of such a poorly organized matrix will depend primarily upon the exact nature of the bonding forces.

Information Not Obtainable From Present Study

It should be stressed that certain types of information cannot be obtained from an analysis of lunar photometric, polarimetric, and colorimetric data:

(1) Essentially no information relating to the correlation distances of lunar surface irregularities smaller than about 660 feet can be obtained since this is the lower limit of earth-based telescopic resolution.

(2) No information concerning the nature of the underlying structure of the lunar surface can be obtained, since visible light can penetrate at most a few millimeters into even a quite porous surface layer.

(3) Although the reflection coefficients of terrestrial materials are helpful in determining terrestrial material types, this has not been found to be true in the case of the moon.

(4) Even though different lunar regions have slight color differences, these small differences have been of little value in searching for terrestrial analogues of lunar materials. Furthermore, any original color of lunar materials probably has been drastically modified due to bombardment by solar x-rays, solar flare protons, the solar wind, micrometeoroids, etc.

(5) No information concerning albedo differences on a scale less than about 660 feet (lower limit on telescopic resolving power) can be obtained. Hence, the lunar photometric function does not take into account local albedo differences or gross shadowing.

Conclusions

One can reasonably conclude, on the basis of the previous considerations, that the lunar surface is not covered with loose dust, in any ordinary sense, but in fact is covered, to at least millimeter depths, with an intricate matrix made up of small adhesive grains, probably resulting from pulverization of lunar surface material by micrometeoroid bombardment. The strength properties of such a matrix on the lunar environment can only be poorly estimated at this time.

Recommendations

It is recommended that serious attempts be made to simulate, under ultra-high vacuum conditions (10^{-11} mm of Hg), an artificial surface matrix having lunar photometric and polarimetric properties.

Such an artificial surface layer would be of great value to Project Apollo in two ways:

(A) Lunar surface lighting condition simulators could be made more realistic.

(B) The bearing strength properties of such a layer could be analyzed in detail, both experimentally and theoretically.