OPTICAL POLARIMETRIC AND PHOTOMETRIC STUDIES OF LUNAR SAMPLES

A. Dollfus: Observatoire de Meudon, 92 - Meudon (France)
E. Bowell: Observatoire de Meudon, 92 - Meudon (France)
J.E. Geake: Univ. Manchester Inst. of Sci. and Tech., Manchester (UK)
M. Maurette: Centre de Spectroscopie de Masse, 91 - Orsay (France)

The photometric and polarisation characteristics of three Apollo 14 and one Luna 16 lunar fines samples in the visible and U.V. regions have been investigated using a photoelectric photo-polarimeter; Apollo 14 crystalline rocks and breccia surfaces are also being studied. Optical properties are compared with microscopic structures shown by a scanning electron microscope.

Aims

Study of the structure of planetary, asteroidal, and satellite surfaces has hitherto been confined to remote sensing by photometry, polarimetry and spectroscopy using Earth-based telescopes. Interpretation of the ensuing data has been effected by comparative means using terrestrial minerals, meteorites and returned lunar samples. The polarimetric properties of the lunar surface having already been well established from telescopic observations, the purpose of studying returned samples is threefold: to compare their polarimetric properties with lunar measurements collected at the telescope; by similar means, to investigate the optical properties at other lunar sites so as to be able to predict and account for compositional, microstructural and stratigraphic variations; to accumulate a more numerous and diverse body of data on minerals exposed to space environment, with a view to interpret photometric and polarimetric measurements collected remotely on other atmosphereless celestial bodies.

Special emphasis is given to the last consideration since the remote photometric and polarimetric sensing of Mercury, Mars, some asteroids and planetary satellites will shortly be carried out, not only by telescopic observations but from space-probes (namely the "Grand Tour" mission).
Results

a) Fines: Photo-polarimetric analysis of lunar surface fines from Apollo 11 showed that their polarisation curves (that is, plots of degree of polarisation against phase angle) do not depart sensibly from those obtained from Earth-based telescopic observations of the Mare Tranquillitatis landing site. In contrast, the polarisation curves for Apollo 12, Apollo 14 and Luna 16 surface fines did not agree with remote measurements made on the respective landing sites, for which the telescopic measurements take an average.

The maximum degree of polarisation and the normal albedo, together with their spectral variation, are the parameters which best describe lunar samples. Results for Apollo 11, 12 and 14 fines, and the Luna 16 fines are given in Figs. 1 and 2.

The landing sites of Apollos 12 and 14 provided samples having a great variety of polarimetric properties. However, no individual sample departs from the linear relationship established from telescopic observations characterising a limited range of optical opacity everywhere on the lunar surface (Fig. 1). The range of spectral variation is also limited (Fig. 2), although I2028.98 (core-tube) and I2032 (ray material) depart slightly. Pulverised terrestrial extrusive rocks display greater variety.

b) Rocks and breccia: Measurements were made on several crystalline rocks and breccia, most notably the large breccia I4267 for which different regions of the exposed surface were analysed; these were freshly broken, dust-covered and glass-coated areas. Emphasis was given to the negative branch of polarisation occurring at small phase angles, as it corresponds to the range of phases covered by telescopic observations on planetary satellites and asteroids. Interpretation of the shape of these curves is given in terms of microstructure revealed by a scanning electron microscope.

Conclusion

The variety of lunar material already available is most valuable in improving our understanding of the relationship between optical properties and the nature and texture of material exposed to space. These results are being used to interpret telescopic observations on planetary satellites and asteroids, and will in future serve in the analysis of telemetered data from space-probes investigating many other atmosphereless planetary bodies.
Fig. 1. Normal albedo $A$ versus maximum degree of polarisation $P_m$ (logarithmic scales) for 144 lunar regions and 16 lunar fines samples; low $A$/high $P_m$ is at bottom left of diagram. New data show that lunar region points should be moved up by 0.15 in log $A$.

Fig. 2. Log $A$/log $P_m$ diagram together with spectral variation for 11 lunar samples. Wavelengths used are 3520, 3790, 4350, 5200, 5800 Å (1-5 respectively as for sample h); shorter wavelengths are at the lower left of each line joining sample measurements. Generally, the longer the line the redder is the sample.