REFLECTANCE SPECTROPHOTOMETRY OF SAMPLES EXTENDED TO UV

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The purpose is to assess the return expected from atmosphereless planetary bodies studies from absolute spectrophotometry extended to 2000 Å. Previous works in this field are given in the references. Our results are based upon laboratory measurements of reflectance spectra compared to standard albedo reflectance surfaces from 2000 Å to 8000 Å. We analyzed samples pulverized and sieved from grain size smaller than 25μm including 19 documented rocks and minerals and 27 meteorites, several iron and metallic alloys filed in small grains, 13 natural lunar fines or dust collected when sawing lunar rocks and 7 exposed or fractured surfaces of lunar rocks. Preliminary results were already published by HUA and al (1976).

1°) Rock type classification from UV and red albedos - Fig. 1 shows the plot of the UV albedo p(2300Å) versus the albedo in red p(6500Å). Circled numbers are from the solid surfaces of lunar rocks and breccia; they are not discussed here. All the other samples are fine grained. Basaltic terrestrial samples are confined in a clearly identified domain which is specific. Acidic samples are located in a distinct area well apart, but including also the ultra basic rocks and achondrites. Ordinary chondrites are between these two domains. Carbonaceous chondrites lie isolated in an other characteristic area at the bottom left. Lunar soils show a peculiar behaviour (hached domain); they cover a range of albedo of more than a factor 10 but however follow almost exactly the diagonal of constant ratio p(6500) / p(2300) = 2.5. This is probably because the lunar surface is made of a well defined compositional suite and because the physical texture of the soil is acquired as the result of a saturated process of meteoroid bombardment which is reproducible.

The sample of hand picked lunar agglutinate grains (square) corresponds to a high level of "maturation" by space weathering and the two samples of lunar rocks saw dust (triangles) were not exposed at all to maturation; however, these samples follow the same trends as for the ordinary lunar fines, and it appears that the plot is insensitive to space weathering effects.

Any atmosphereless solar system objects for which the two albedos at 6500 Å and 2300 Å are known can be located in fig. 1 and classified into one of the proper rock types considered here. When only the ratio of the two albedos is known, as in the case of the solar system objects of an unknown diameters, one can at least discriminate lunar soil or carbonaceous surfaces from other meteoritic or lunar type surfaces.

2°) $Si_O2 + Al_2O_3$ determination

SiO_2 and Al_2O_3 are often associated in building up mineral latices. Their percentage is related to albedo p(6500) in fig. 2; for lunar type soils, a clear relationship emerges and the knowledge of albedo in red suffices for a determination of the amount by weight of $Si_O2 + Al_2O_3$ with a 10% accuracy. The same is true for the percentage of Al_2O_3 alone in fig. 3.

This type of relationship is unfortunately not found to be so clear for the non-lunar samples.

3°) Total iron determinations - The percent of total iron is plotted versus p(6500Å) in fig. 4. A striking result in that figs. 2 and 4 are apparently symmetrical owing to the non logarithmic horizontal scale of fig. 2. The meaning is that almost all the control of albedo is given by the iron content which is an opaque phase; in practise, the amount of iron is inversely related to the total amount of the transparent matrix in natural rocks and minerals. The relationship noted for the case of the lunar soil applies still more clearly for the iron content.

An explanation of this trend was suggested to us by M. GAFFEY : As the lunar surface material is basically made of pyroxen, plagioglase and oxydes, an increase of Fe (Fe_{2+} namelly) produces more very opaque oxydes and relatively opaque pyroxen with respect to the less opaque feldspath. If olivin was a major phase, it would increase also but it is less absorbing and hence would produce a higher albedo which would destroy the relationship.

4°) Titanium oxyde determinations - No clear relationships emerge for the plot of TiO_2 percent versus albedo in red as for figs. 2, 3 and 4. In fig. 5, we introduce the UV albedo P(2300 Å) by ploting [p(6500)-p(2300)] / p(6500) versus TiO_2 in %.

A relationship is found for lunar type soil, between the albedo contrast at these two wavelengths and the abundance by weight of TiO_2. This calibration is to be compared with the case of the work by CHARETTE and al (1974) using spectral slope between 400 and 5600 Å; our relationship is extended from dark maria to the lightest highlands; this calibration is still more extended and precise if we include the lunar rocks as was done by DOLLFUS and al (1979) but, because of the difference of surface texture, this extension is provisional.

5°) Remote analysis of solar system planetary bodies - For the Moon, the simple mapping of the albedo in red p(6500) gives a reasonable cartography of the amount of SiO_2 + Al_2O_3 in percent, and also cartographies of the percentage of Fe and of Al_2O_3. The measurement of the UV albedo p(2300) gives a regional determination of the amount of TiO_2.

Now that telescopes in space permit to extend astronomical photometry to UV at 2000Å, asteroids and non icy satellite of known diameters can be located in fig. 1 and there surfaces rocky types can be deduced.

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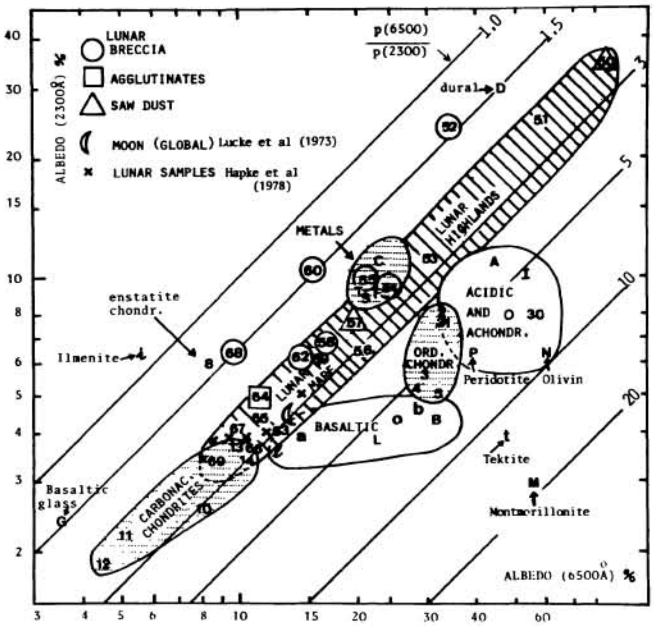
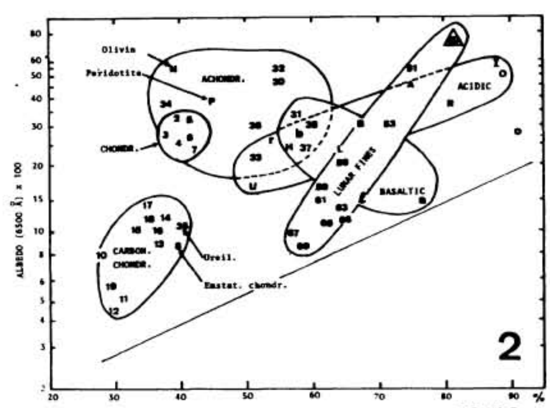
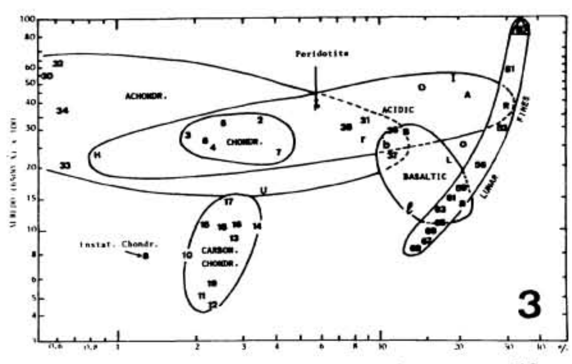
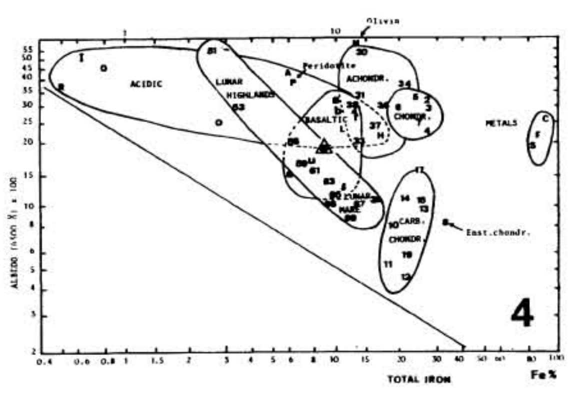
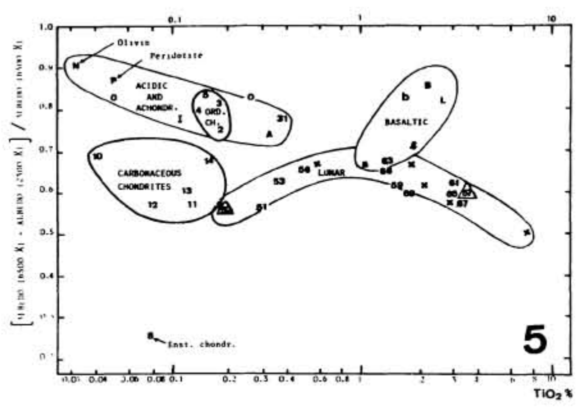

LUNAR BRECCIA
AGGLUTINATES
SAW DUST
MOON (GLOBAL) Lucke et al (1973)
LUNAR SAMPLES Hapke et al (1978)
ALBEDO (2300Å) %
p(6500) / p(2300)
dural
METALS
LUNAR HIGHLANDS
enstatite chondr.
Ilmenite
ACIDIC AND ACHONDR.
ORD. CHONDR
Peridotite
Olivin
LUNAR MARE
BASALTIC
Tektite
Montmorillonite
Basaltic glass
CARBONAC. CHONDRITES
ALBEDO (6500Å) %

1


Olivin
Peridotite
ACHONDR.
ACIDIC
CHONDR.
LUNAR FINES
BASALTIC
CARBON. CHONDR.
Oreil.
Enstat. chondr.
ALBEDO (6500 Å) x 100
SiO₂+Al₂O₃
2


Peridotite
ACHONDR.
ACIDIC
CHONDR.
BASALTIC
LUNAR
FINES
Instat. Chondr.
CARBON. CHONDR.
Al₂O₃
3


Olivin
Peridotite
ACIDIC
LUNAR HIGHLANDS
ACHONDR.
BASALTIC
CHONDR.
METALS
LUNAR MARE
CARB. CHONDR.
Enst.chondr.
TOTAL IRON
Fe %
4


Olivin
Peridotite
ACIDIC AND ACHONDR.
ORD. CH
BASALTIC
CARBONACEOUS CHONDRITES
LUNAR
Enst. chondr.
TiO₂ %
5