REMOTE SENSING OF TiO_2 ON PLANETS AND SATELLITES

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Remote sensing of Titanium (Ti) at the surface of the Moon, Mercury, asteroids and satellites is of importance because Ti though being a metal (Z=22, A=48), has similarities with Si and C as being tetravalent and hexacoordinated. Its atomic radius 0.64 Å is close to those of Al and Fe substitutions in cristalline lattices are frequent, for example in $FeTiO_3$ ilmenite. Its cosmological abundance locates it immediately after the group of the eight major elements ans as the first of the minor elements. It is concentrated in magmatic minerals and rocks and particularly in the pyroxenes and the basalts, gabbros and other mafic rocks.

Optically, Titanium is responsible for strong absorption bands which are observed spectroscopically on the greatest majority of rocks and silicate surfaces. These absorption bands are produced by crystal fields and by charge transfer from one ion to another between Ti and Fe with O. Computations upon these bands were developed by Burns et al (1973), Lœffler et al (1974, 1975), Mao and Bell (1973), Bell and Mao (1976), etc... using transition spectra, crystal field and molecular orbits theories.

A correlation was derived by Charette et al (1974) between the slope of the reflection spectra between 4000 and 5600 Å measured at the telescope around the Apollo landing sites and the mean amount of TiO_2 deduced from the analysis of the Apollo samples available from the same sites.

This empirical calibration was then used to extend abundance determination of TiO_2 to other lunar regions on the basis of telescopic reflectance spectra (Pieters and McCord, 1976). On the basis of this calibration, Johnson et al (1977 a and b) computed also 3800/5600 ratios between filtered telescopic pictures and they derived a mosaic map of TiO_2 abundance on the northern lunar maria.

Our present purpose is to reanalyse and extend the empirical relationship between TiO_2 abundance and spectral signature, using reflectance spectra from 6500 to 2000 Å on a large variety of lunar samples returned from the Apollo and Luna missions for which the TiO_2 content is directly available. Reflectance spectra were taken at normal incidence with emergence at 5° and compared with MgO standard surface to derive the geometric albedo p for phase angle 5°.

In fig. 1, we plot (dots and circles) the ratio $[p(6500)-p(2300)]/p(6500)$ with the wavelengths used by Charette, but directly for 10 lunar mare samples and 4 highland samples. For comparison, we plot also rectangles the telescopic measurements of Charette et al (1974).

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REMOTE SENSING OF TiO_2 ON PLANETS AND SATELLITES

Dollfus A. et al

The relationship is apparently improved when we plot, in fig. 2, the ratio extended to 2300 Å as $[p(6500)-p(2300)]/p(6500)$. Then, the mare and highlands split more clearly into two groups easy to discriminate by their albedo p(6500 Å); the mare calibration is steeper and the highlands exhibit also a correlation of negative slope which, if confirmed by new measurements might permit to extend abundance determinations to lunar terrae.

Thus, on the basis of this calibration, which evidently can still be improved, the abundance of Ti could be deduced remotely from spacecrafts or orbiters preferentially by extending the spectral range to 2300 Å.

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Figs. 1 and 2 : see next page

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REMOTE SENSING OF TiO_2 ON PLANETS AND SATELLITES

Dollfus A. et al

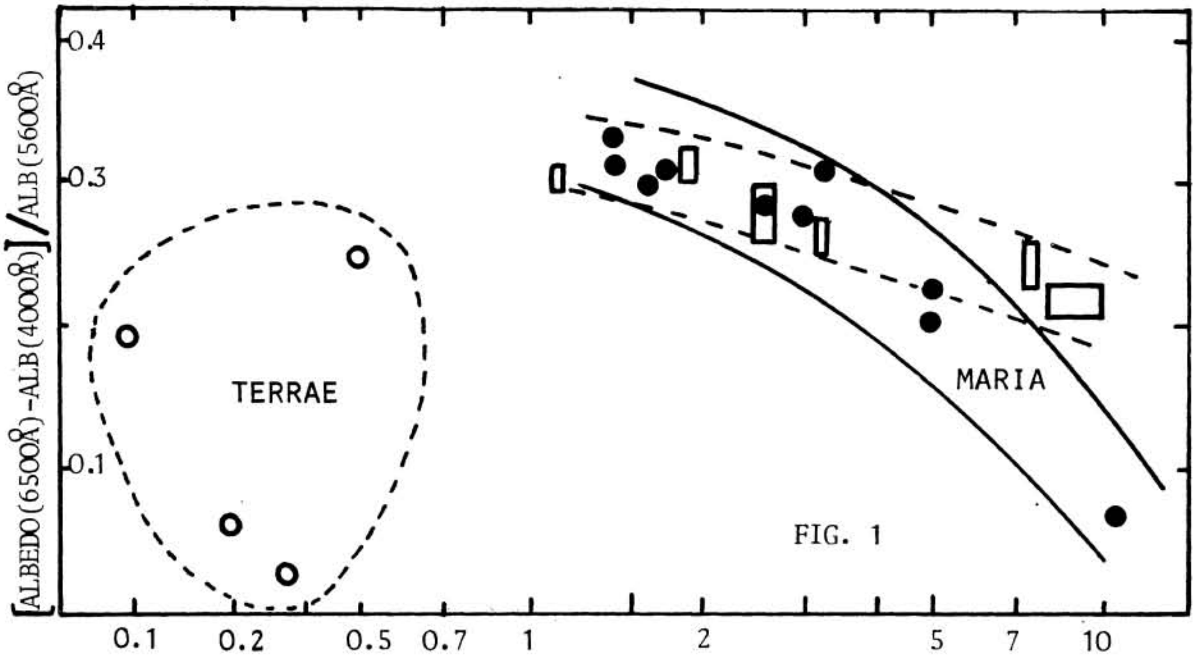

FIG. 1

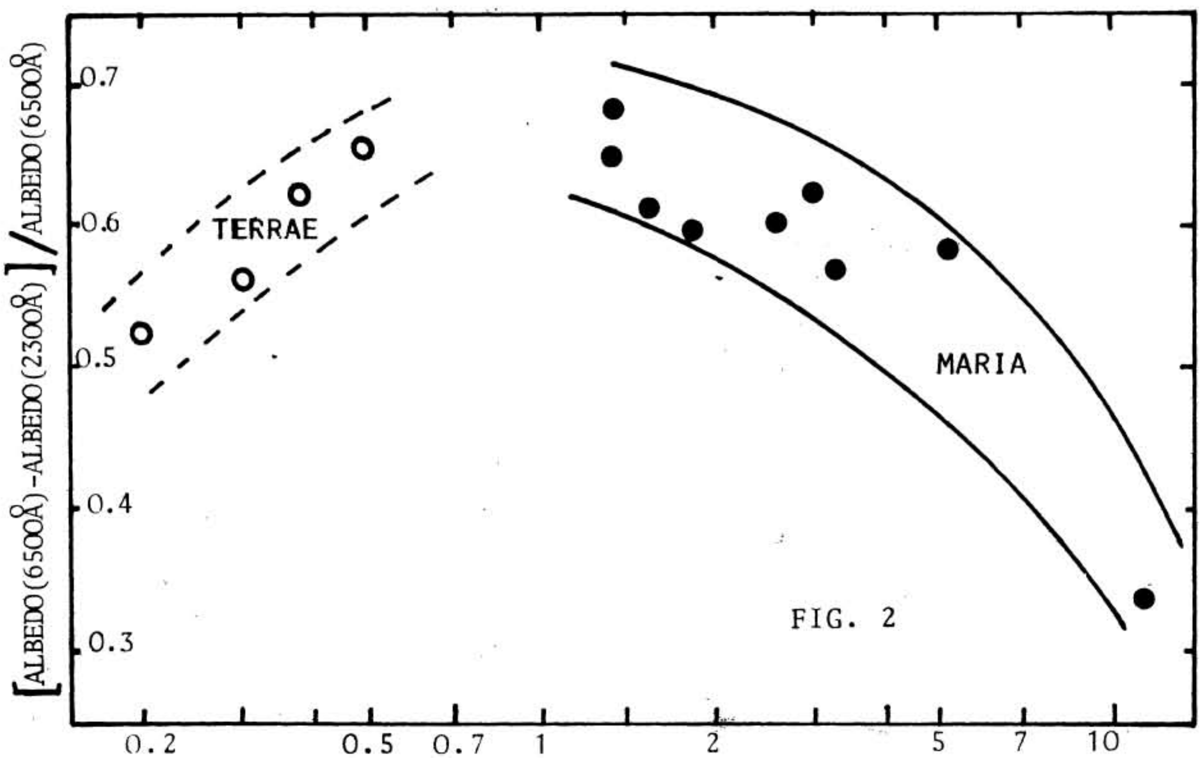

FIG. 2