NEW SPECTROPHOTOMETRIC STUDIES OF THE LUNAR SURFACE:
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The reflectance spectra (UV to near IR) of lunar soils are dominantly influenced by elements of the first transition series, particularly by iron- and titanium-ions (1,2). Charge transfer transitions of these ions cause a strong UV-absorption which also determines the slope of the reflectance curve in the visible part of the spectrum, whereas Ti$^{3+}$ and Fe$^{2+}$ crystal field transitions cause distinct absorption features in the visible and near infrared (3). Iron and titanium are highly abundant in lunar soils and exhibit large variations in concentration at different locations; therefore the spectral behaviour of these elements and their ions can be used to analyse the lithologic composition of lunar surface materials.

The spectral characteristics of lunar soil samples have been investigated in order to better determine the relationship between absorption features and the chemical composition. For this purpose we reexamined laboratory measurements (4,5,6) and compared them with our earthbased telescopic observations in the visible part of the spectrum. The laboratory measurements as well as the telescopic measurements may be affected by maturation and therefore by the content of agglutinates and glass. Glass will darken the albedo, redden the spectrum and lower the spectral contrast (6,7,8). In order to get rid of these effects, we have developed a method of relating all reflectance measurements to the same content of agglutinates and glass. Multispectral data of the lunar surface obtained in different filter bands in the visible are usually highly correlated; this means that for the extraction of quantitative information the measured intensities must be transformed in a specific way to calculate the amount of reddening and the spectral contrast. To this end a principal component analysis (9) was applied to the data (spectral intensities) and the second principal component (e. g. the weighted difference of the spectral intensities) was found to be correlated with the content of glass and agglutinates in the samples, whereas the first principal component was found to decrease with increasing maturation. These two new axes (first principal component and second principal component) can be used for removing the effects caused by maturation (glass and agglutinate content) and referring all measurements to the same glass and agglutinate content.

The shape of the reflectance curve in the visible part of the spectrum is influenced by iron and titanium charge transfer transitions and can be understood as the long wavelength wing of these strong absorption features. The spectral characteristics of this part of lunar reflectance spectra can be described firstly by the slope of the curves (which is a measure of the increasing transparency of the material towards longer wavelengths) and secondly by the ratio of the intensities in two bandpasses (in the range $\lambda \approx 0.38 \mu m$ to $0.60 \mu m$). The ratio describes albedo dependent variations of the spectral contrast in the visible or, in other words, the ratio is a measure for the weak absorption features in the visible part of the spectrum and which are mainly due to Ti$^{3+}$ crystal field transitions (see 6,10). For lunar
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soils the amount of total iron is inversely proportional to the albedo at 0.65μm (2); this means, the absorption of light which is needed to reduce the albedo at 0.65 μm is produced pre-dominantly by iron. In the same manner the slope decreases with increasing iron-content or with increasing UV-absorption. Therefore the slope of the reflectance curve in the visible is a measure of the FeO-content in lunar soils.

After removal of all glass- and agglutinate-induced effects on the shape of the reflectance spectrum in the visible, the spectral contrast is strengthened and weak titanium absorptions show up in the spectral characteristics. In accordance with Charette et al. (10) we found the blue to green ratio to be sensitive for the TiO₂-content in lunar soils. While the ratio strongly increases with increasing TiO₂-content, the slope of the reflectance spectrum in the visible, however, is inversely correlated to the FeO-content; this means for soils with low Ti-content (e.g. highlands) that the spectral characteristics are to a first order controlled by the slope of the reflectance spectrum in the visible whereas the spectral characteristics of soils with high Ti-content (e.g. mare) are dominantly controlled by the ratio (in the range λ = 0.38μm to 0.6μm)

Our specific new method of analyzing the spectral characteristics (principal components, slope and ratio) of lunar soils now allows the estimation of iron and titanium abundance both in mare and highland areas from spectral measurements in only two bandpasses (in the range λ = 0.38 μm to 0.6μm).

Detailed results on iron-, titanium -, and glass/agglutinate - content and on the distribution of specific lithologic units for a number of lunar areas will be presented and discussed.

References:

(6) Pieters, C., (1977), Ph.D. Thesis MIT.