SPECTROSCOPY OF LUNAR AND TERRESTRIAL BASALTS

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Reflectance spectroscopy is a rapidly growing science that could be used to derive significant information about mineralogy. Absorption bands in telescopic spectral reflectance of the moon and other solar system objects are potential for obtaining mineralogical and chemical information. Real land and solar bodies' covers are mixtures of materials and the theory of mixed spectral classes is an efficient method to study various rocks and minerals. Laboratory spectral measurements of basalt samples have been performed in the visible, near infrared and thermal infrared bands with multi-channel radiometers. Basalts are mixed classes of their rock-forming minerals and the data obtained have been used to illustrate the application of spectral mixture analysis for mineralogical and chemical differentiation.

Since the earliest days of spectroscopic remote sensing [1] of the lunar surface electronic transition bands exhibited by lunar soils and rocks in the visible and near-infrared regions of the spectrum are used to determine mineralogical composition [2]. Much less is known about the spectral behaviour of lunar rocks in the thermal infrared.

The interpretation of reflectance spectra of unknown materials requires an understanding of how the reflectance of different components combines into a single curve. An efficient method for spectrometric data processing is the mixed classes' theory [3]. The real land cover is a mixture of materials at just about any scale we view it. Rocks are mixture of their rock-forming minerals. Of particular interest are iron-containing rock-forming minerals because they are widespread.

Description of measured basalt samples:

1) Terrestrial samples are light grey porphyritic rocks with green olivine phenocrysts; dark grey slightly vesicular rocks consisting of black and light green phenocrysts; vesicular rocks with small phenocrysts.

2) Lunar samples are mare regolith.

In this investigation laboratory spectral measurements of the basalt samples is performed in the visible, near infrared and thermal infrared (TIR) bands with multi-channel radiometers – SPM-1 [4,5] and IR-1 [6].

Figure 1 and Figure 2 present reflectance spectra of lunar and terrestrial basalts in different spectral ranges.

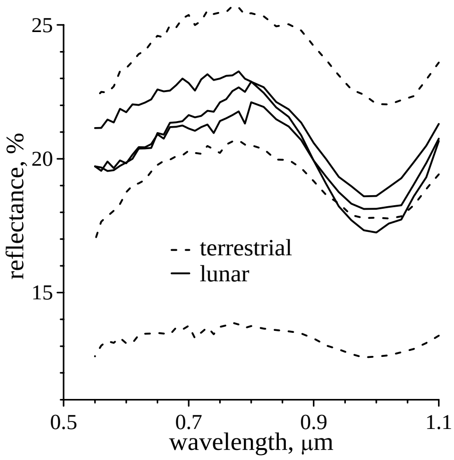

Fig. 1. Reflectance spectra of basalts (measured with SPM-1)

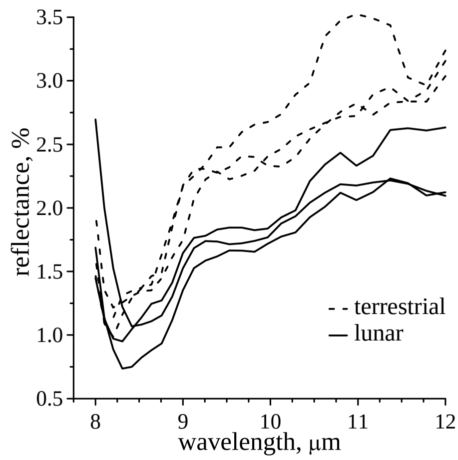

Fig. 2. Reflectance spectra of basalts (measured with IR-1)

The typical for the iron reflectance minimum at about 1 μm is observed in the spectral behaviour of all curves (Figure 1). The absorption at 1.0 μm varies depending on the iron content and is more pronounced for the lunar samples because of the higher iron content compared to the terrestrial basalts. In the TIR range (Figure 2) the lunar samples reflectance is lower than the reflectance of the terrestrial ones. Besides, the reflectance curves inclination of the terrestrial samples is steeper. This is used in the further spectral data analysis for rock mineral assessment.

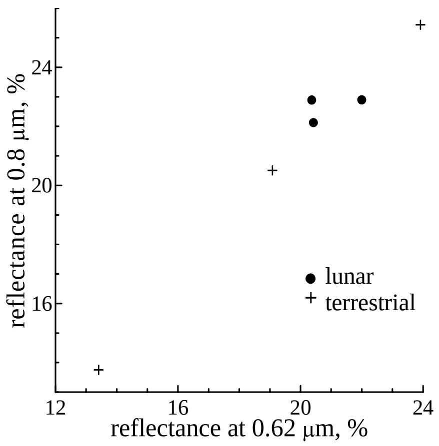

Fig. 3. NIR (0.8 μm) vs. Red (0.62 μm) reflectance of basalts

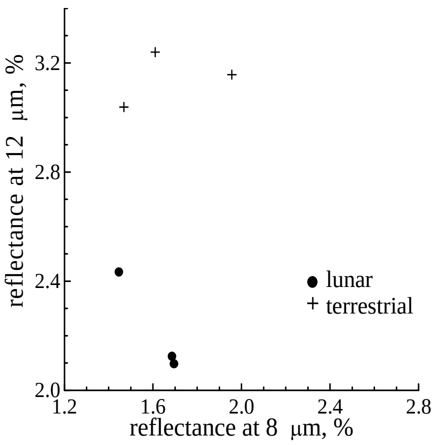

Fig. 4. TIR (12 μm vs. 8 μm) reflectance of basalts

The plot of NIR = 0.8 μm versus Red = 0.62 μm reflectance is presented in Figure 3. It is seen that terrestrial and lunar basalts lie on a well-defined rock line analogously to the soil baseline [7]. However, although closely grouped lunar basalts cannot be reliably distinguished from the terrestrial in this wavelength range (see also Fig.1). In Figure 4 TIR (12 μm versus 8 μm) reflectance of the basalts is shown. In this case the lunar and terrestrial samples form clearly separated unoverlaping clusters.

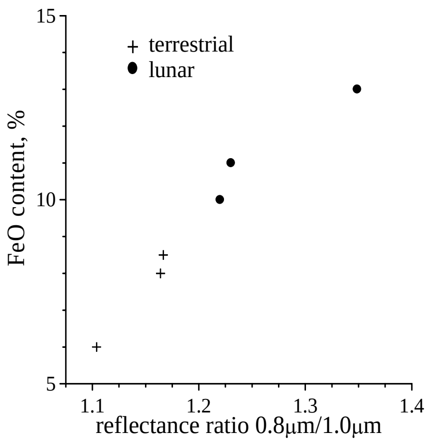

Fig. 5. Relationship between the iron content (as FeO) and basalts reflectance ratio 0.8 μm/1.0 μm

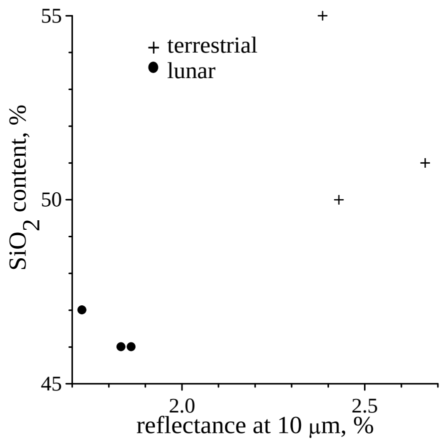

Fig. 6. Relationship between the quartz content and basalts reflectance at 10 μm.

Figure 5 presents the relationship between the iron content as FeO and the reflectance ratio 0.8 μm/1.0 μm. The lunar and terrestrial samples have almost the same mineral composition but different FeO content. As a result they form two clusters in Fig.5. This dependence can be used for detection of various iron-containing minerals and distinguishing between rocks of different origin.

The same refers to the relationship between basalts quartz content and spectral reflectance at 10 μm displayed in Figure 6. The fundamental Si-O stretching vibration bands of silicates are greatly diminished in intensity for lunar samples.

Detailed spectral data analysis including the theory of mixed classes and other methods (ratio indices, continuum removal) to isolate specific reflection and absorption features could certainly improve the success of distinguishing rocks and minerals.

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Reference

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