SPECTROMETRIC MEASUREMENTS OF TERRESTRIAL AND LUNAR BASALTS

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ABSTRACT. 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.

СПЕКТРОМЕТРИРАНЕ НА ЗЕМНИ И ЛУННИ БАЗАЛТИ

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РЕЗЮМЕ. Спектрометрирането намира приложение във все повече области на науката и практиката и успешно се използва за получаване на важна информация в минералогията. Получените данни в резултат на спектрометрирането на Луната и други обекти в Слънчевата система съдържат потенциална информация за химичния и минералния им състав. Реалните повърхности представляват смеси от материали. Теорията за смесените класове е един ефикасен метод за изучаване на скали и минерали. В настоящата работа са проведени лабораторни спектрометрични измервания на базалти във видимия, близкия инфрачервен и топлинния инфрачервен диапазони с многоканални радиометри. Базалтите се разглеждат като смесени класове от основните им скалообразуващи минерали. Получените данни илюстрират едно приложение на анализа на спектрални смеси за оценка на минералния състав.

Since the earliest days of spectroscopic remote sensing (Spiridonov et al., 1983) 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 (Adams, 1974). 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 (Mishev, 1986). 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. A special case for remote sensing is iron-containing rock-forming minerals because they are widespread.

Description of measured basalt samples: 1 – terrestrial samples are light grey porphyritic rock with green olivine phenocrysts; a dark grey slightly vesicular rock consisting of black and light green phenocrysts; vesicular sample with small phenocrysts; 2 – lunar samples are mare regolith. In the present investigations laboratory spectral measurements of basalt samples are performed in the visible and near infrared bands with multi-channel radiometer SPS-1, designed and assembled in STIL-BAS (Илиев, 2000; Mishev, Iliev, 1992).

Figure 1 presents reflectance spectra of lunar and terrestrial basalts. For both type curves (Fig. 1a) it is seen typical of the iron minimum to about 1 μm. The iron absorption at 1.0 μm is reduced in depth according to it content and it is deeper for lunar samples because of more iron content compared to terrestrial ones. This advantage spectral data analysis is necessary for further rock and mineral detection.

Another spectral range is thermal one (8-12 μm) which is very interesting for mineral and rock investigations. But it is too hard to stabilize radiometer systems in measuring. In STIL-BAS in collaboration with IE-BAS the IR-1 (infrared radiometer) is constructed (Ferdinandov, Tsanev, 1993). The obtained results as spectral curves are presented in Fig. 1b.

Plot of NIR=0.8 μm versus Red=0.62 μm reflectance are presented in Figure 2. It is clearly seen that terrestrial and lunar basalts fall on a well-defined rock line. This dependence is successfully applied for establishing rock baseline (Elvidge, Lyon, 1985).

Figure 3a shows relationship between the iron content as FeO and reflectance ratio 0.8 μm/1.0 μm. Lunar and terrestrial basalts are almost the same in mineral composition but with different iron content in samples. It can be clearly seen two clusters forming by lunar and terrestrial basalts. This relation based on content of widespread iron in rock-forming minerals could be used for detection of various iron-containing minerals and rocks.

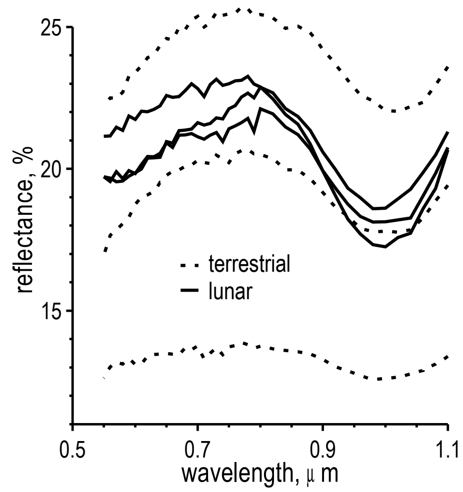

Fig. 1a. Reflectance spectra of basalts measured with SPS-1

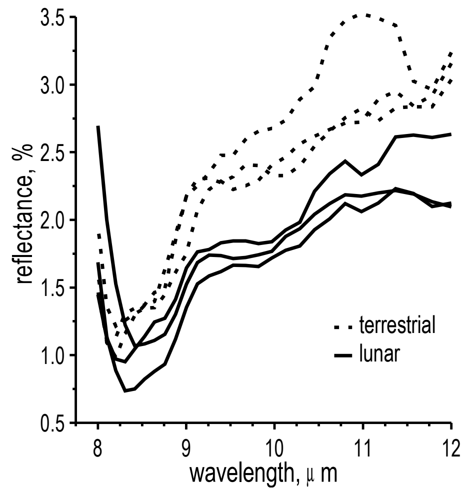

Fig. 1b. Spectra of basalts measured with IR-1

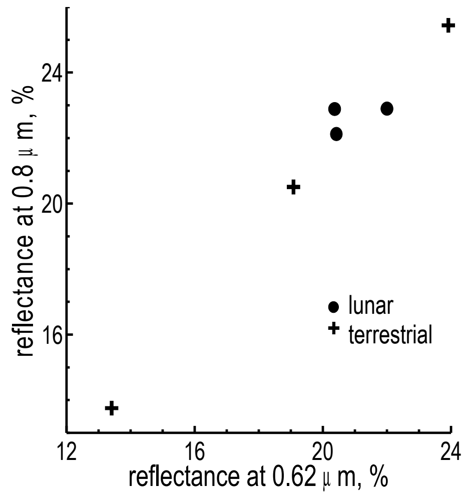

Fig. 2. NIR (0.8 μm) vs. Red (0.62 μm) reflectance of basalts

Relationship between the quartz content and reflectance at 10 μm is displayed in Fig. 3b. The fundamental Si-O stretching vibration bands of silicates are greatly diminished in intensity for lunar samples.

In Fig. 4 the terrestrial and lunar basalts are presented in the 2-D space of different spectral reflectance ratios. The ratios are chosen in relation to the sensitive to iron content range 0.8-1.0 μm (see Fig.1a).

The present study is closely related to many international programs for the investigation of Moon, Mars and other planets of the Earth system.

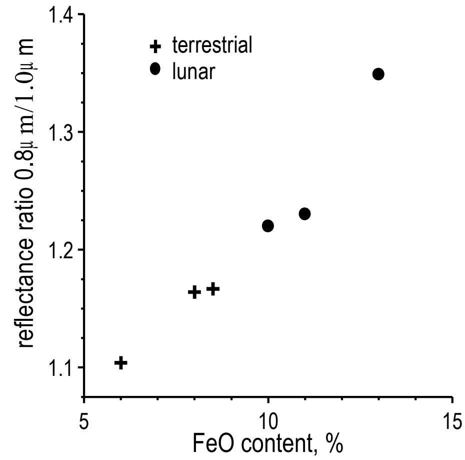

Fig. 3a. Relationship between the iron content as FeO and reflectance ratio 0.8 μm/1.0 μm

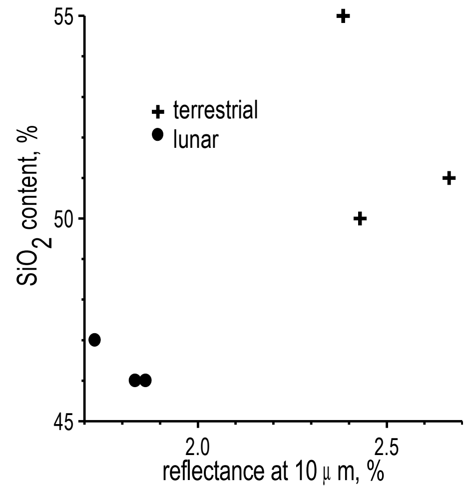

Fig. 3b. Dependence of spectral values at 10 μm and the quartz content

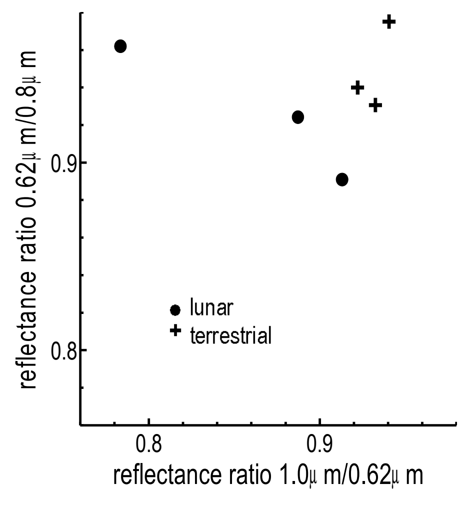

Fig. 4. 2-D space of different spectral reflectance ratios

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

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