Минно-геоложки университет "Св. Иван Рилски"
Годишник, том 47, свитък I, Геология и геофизика, София, 2004, стр. 233-236

GRANITE REFLECTANCE SPECTRA BEHAVIOUR DEPENDS TO ITS ROCK-FORMING MINERALS

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РЕЗЮМЕ. Измерванията на отражателните спектри могат да се използват като допълнително средство за получаване на важна информация в областта на петрографията и минералогията. Целта на настоящата работа е да се изследва вида на получаваните спектрални характеристики на гранити в зависимост от основните скалообразуващи ги минерали. Проведените многоспектрални измервания са осъществени в лабораторни условия в диапазона 0.55-1.1 μm. В съответствие с поставената задача са анализирани получените спектрални характеристики на множество петрографски образци, за което са приложени различни методи за анализ: декомпозиция на спектрални смеси, базова скална линия, наклон на спектралните криви, индекси-отношения.

ПОВЕДЕНИЕ НА ОТРАЖАТЕЛНАТА СПОСОБНОСТ НА ГРАНИТА В ЗАВИСИМОСТ ОТ НЕГОВИТЕ СКАЛООБРАЗУВАЩИ МИНЕРАЛИ

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ABSTRACT. Reflectance spectrometric measurements could be used as an additional opportunity to derive significant information about petrography and mineralogy. The goal of present paper is the study of granite reflectance spectra behaviour depends to their rock-forming minerals. For this purpose laboratory multispectral measurements are performed in the range 0.55-1.1 μm. According to main experimental problem obtained reflectance spectra of various granite samples are analysed and different approaches are applied: spectral mixture decomposition, rock baseline, reflectance curves inclination angles, spectral transformation.

Introduction

Spectrometric measurements are a part of remote sensing and they could be used as an additional opportunity to derive significant information about petrography and mineralogy. Real land covers are mixtures of materials and the theory of mixed spectral classes (Mishev, 1986) is an efficient method to study various rocks and minerals. Granites are two sub-classes of one and the same class (group) of granite and rhyolite (Маринов, 1989). For remote sensing the granites are mixed class of their rock-forming minerals.

The goal of present paper is the study of granite reflectance spectra behaviour depends to their rock-forming minerals.

Materials and methods

It is known that the specific reflectance, absorption and emission of solar radiation by land covers are the basis of remote sensing, of spectrometric measurements in particular (Мишев *и др.*, 1987; Clark, 1999).

In the reflected by the object radiation contains mineralogical information. This information is carried by the reflectance coefficients $r(\lambda_i)$. These coefficients form the reflectance spectra $R\{r(\lambda_i)\}$ and they are spectral informational features of the studied object.

The parameters of studied object using measured spectral reflectance $R\{r(\lambda_i)\}$ are defined. The dependence of reflectance signatures behaviour to type and rock-forming minerals of the granites provides a basis for the purpose.

Mineral content of the studied objects is of particular importance. It determines the distribution of reflected from surface radiation. The amount of reflected light is dependent on mineral content (Clark and Roush, 1984; Hapke, 1993; Spiridonov *et al.*, 1980). As the rock-forming minerals darker, more light is absorbed and the reflectance drops. The reflectance increases as the salic minerals increase.

Made literature review shows that previous investigations aim to analysed mineral samples and in some papers rock samples are investigated (Spiridonov *et al.*, 1980; Spiridonov *et al.*, 1983). In present paper granites as mixed class of their rock-forming minerals are examined and obtained results are analysed. For analysis different approaches are applied: spectral mixture decomposition, rock baseline, reflectance curves inclination angles, ratio indices.

The studied petrographic samples of granites are with different proportion of mafic (biotite, amphibole) and salic (quartz, potassic felspar, plagioclase felspar, muscovite) rock-forming minerals in total mixture.

If a priori information is not enough it could be bring a lot of omissions in interpretation. It is important to know technical parameters of used device and experimental conditions.

Laboratory spectral reflectance measurements in range (0.55 - 1.1 μm) with $\Delta\lambda$=10 nm of granites (15 samples) are performed. It is used spectrometric system for remote sensing SPM-1, made in STIL-BAS (Илиев, 2000).

Results and discusion

Figure 1 shows granite reflectance spectra. Reflectance feature of coarse-grained granites is almost horizontal or with a small angle ((0-15), of medium-grained the angle is 15-30 and of fine-grained the slope is over 30 (Borisova, 2003). For lighter granites which content of salic minerals is more than content of mafic minerals reflectance values are higher.

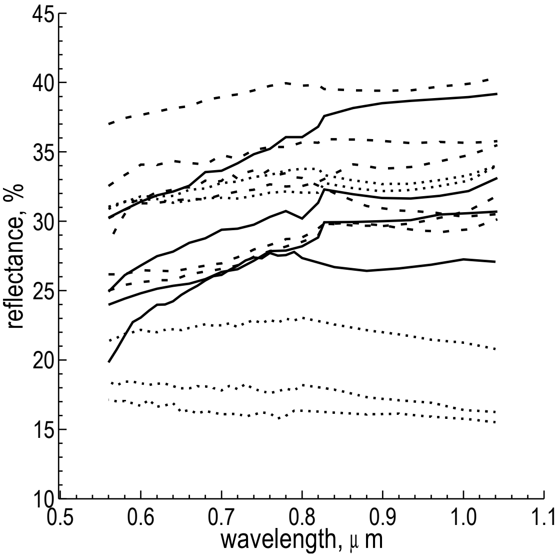

Fig. 1. Spectral reflectance of granites

Plot of NIR = 1.00 μm versus red = 0.62 μm reflectance for laboratory reflectance spectra are presented in Figure 2. The rock baseline is established with linear regression:
NIR = 1.077 (red) + -0.52, R-squared = 0.97, n=15.

If using only the red and NIR reflectance all granites fall on a well-defined rock line.

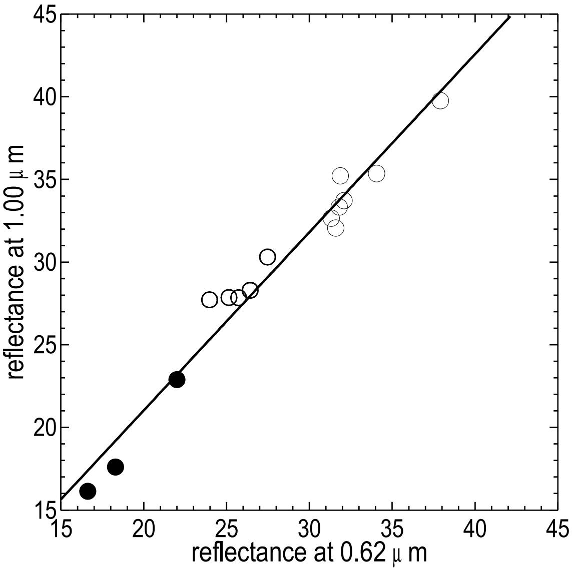

Fig. 2. Plot of NIR vs. red reflectance

The granites are divided into three groups based in a visual assessment of their mineral content. In Figure 2 it can be seen three clusters (marked with fill, thick and thin points) for three groups of salic or mafic mineral content.

In Table 1 description of the studied granites and of the content of salic and mafic minerals are presented.

Table 1.
Content of salic and mafic minerals in granites

N	Name	Salic minerals	Mafic minerals
1	Granite	90	10
2	Porphyry granite	75	25
3	Porphyry granite	85	15
4	Two-mica granite	95	5
5	Porphyry granodiorite	60	40
6	Granite	83	17
7	Granite	75	25
8	Granite	90	10
9	Granite	80	20
10	Granite	75	25
11	Alkalic granite	40	60
12	Granite	75	25
13	Granite	70	30
14	Granite	85	15
15	Granodiorite	40	60

In Figure 3a and Figure 3b dependence between the content of salic and mafic minerals in the granites and the reflectance at 0.76 μm are shown. It can be seen when salic minerals increase reflectance increase and when mafic minerals are more reflectance values decrease.

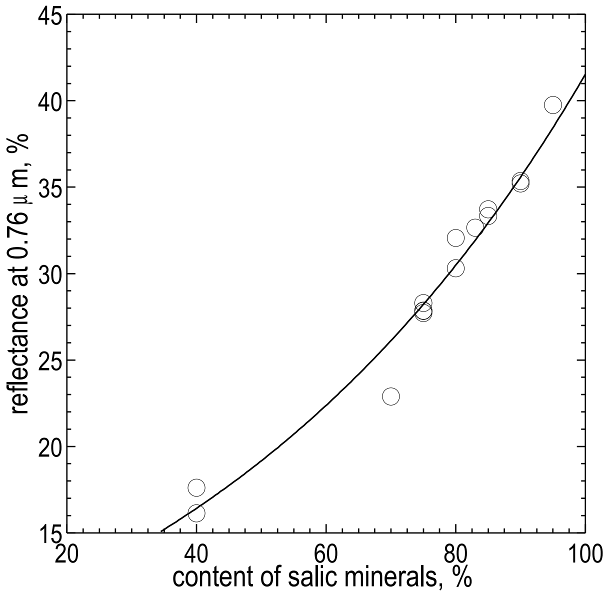

Fig. 3 a. Relationships between content of salic minerals in granites and reflectance for 0.76 μm

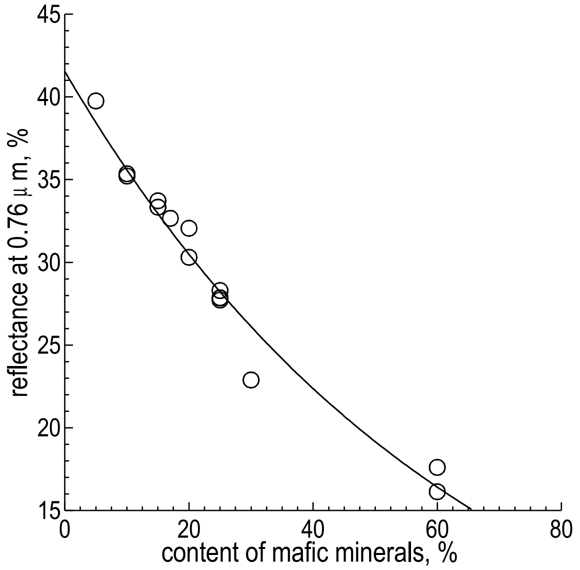

Fig. 3 b. Relationships between content of mafic minerals in granites and reflectance for 0.76 μm

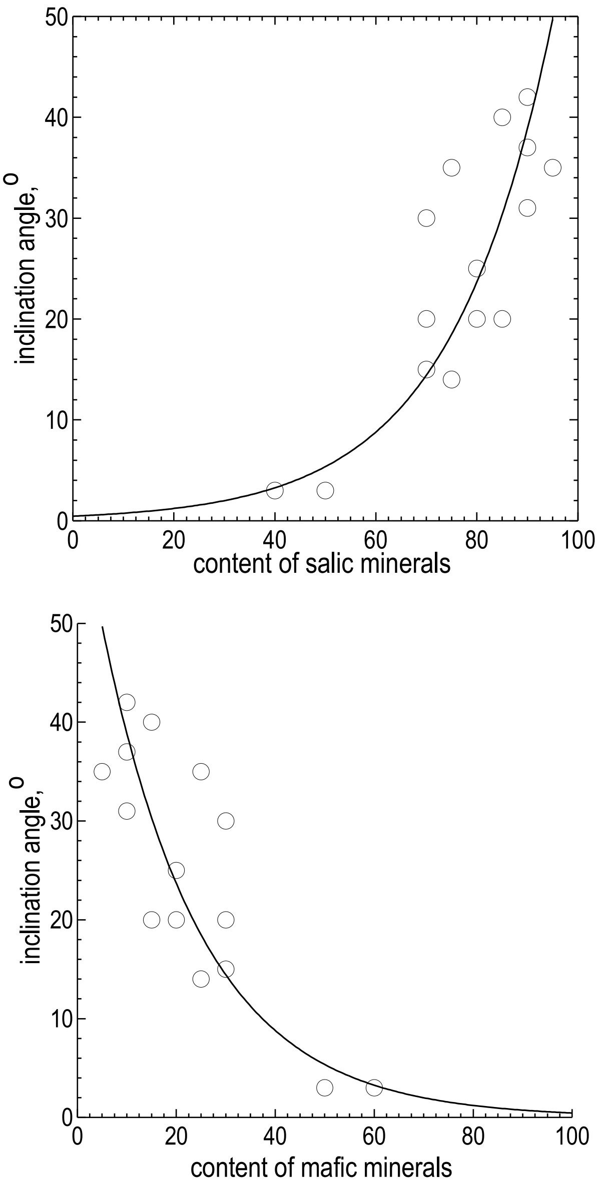

Fig. 4. Relationships between content of salic and mafic minerals in granites and reflectance curves inclination

Figure 4 demonstrates relation of the content of salic and mafic minerals in granites to reflectance spectra inclination angles. The larger quantity of salic rock-forming minerals enhances the inclination of reflectance signatures. If the mafic rock-forming minerals predominate over salic ones the reflectance does not increase and spectra angle is very small.

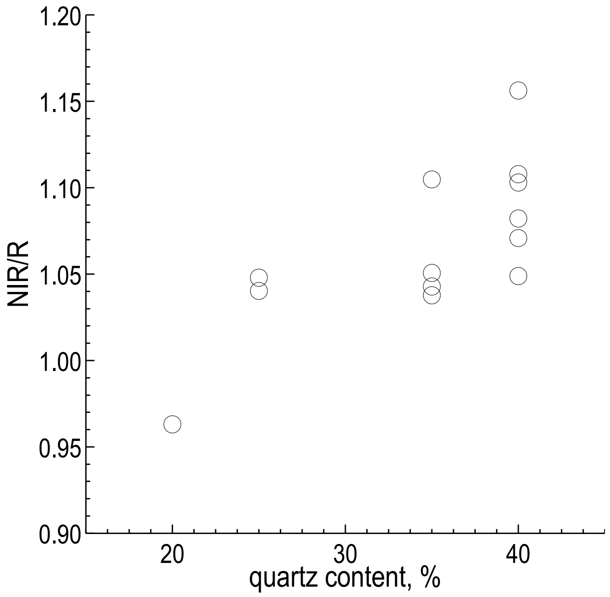

Fig. 5. Relations between quartz content and spectral index NIR/R

Figure 5 shows relationships between spectral transformation (index) NIR (λ = 0.76 μm)/R (λ = 0.62 μm) and quartz content as one of salic minerals. It can be seen that the content of quartz increases and the index values increase.

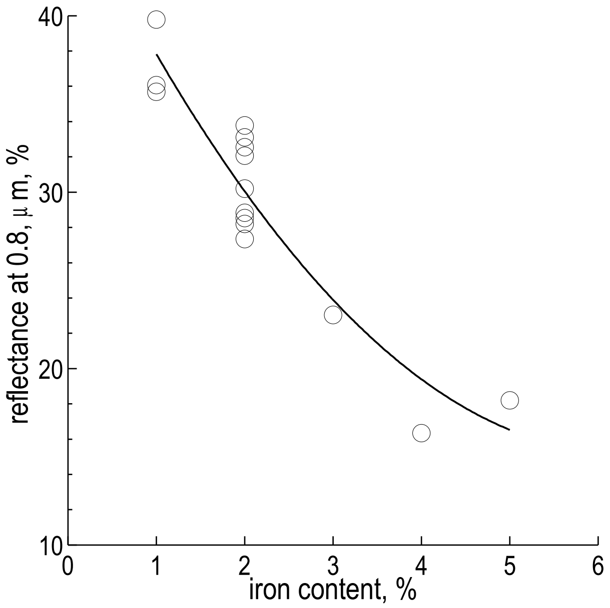

Fig. 6. Relations between iron content and reflectance for 0.8 μm

The iron absorption at 0.8 μm is reduced in depth according to it content. The 0.9-μm-absorption line shifts position with elements substituted for iron. On Figure 6 it can be seen that the reflectance values at 0.8 μm decrease as the content of iron increases. This dependence is based on content of widespread iron in rock-forming minerals and could be used for detection of various rocks.

Conclusions

An advantage of spectrometric investigations is a lot of information including in obtained results. This allowed their use as decode indication for type classification of studied objects.

Analysed relfectance spectra content a complex information. Their type depend on set of factors (color, determined in mixed class granites by proportion of salic and mafic rock-forming minerals; structure and roughness of the samples). It can conclude that granite reflectance spectra behaviour depends to:

- chemical composition of rock-forming minerals;
- color of rock-forming minerals grouped as salic and mafic ones;
- proportion of salic and mafic rock-forming minerals in granites.

Future detailed spectral data analysis including another methods (ratio indices, continuum removal) for studying granites as mixture of rock-forming minerals is intended.

Acknowledgments

The Bulgarian National Science Fund under contract MUNZ-1201/02 supported this study.

The author wishes to acknowledge the help of the assistant Prof. B. Banoushev from Mineralogy and Petrography Department at Mining and Geology University "St. Ivan Rilski".

References

Borisova, D. 2003. Spectrometric Measurements of Granites and Study of Surface Effects. *Annual U M G, 46*, Part I: Geology and Geophysics, 327-329.

Clark, R. 1999. *Chapter 1: Spectroscopy of Rocks and Minerals and Principles of Spectroscopy, Manual of Remote Sensing*, (A.N. Rencz, ed.) John Wiley and Sons, New York, 3-58.

Clark, R., T. Roush. 1984. Reflectance spectroscopy: Quantitative analysis techniques for remote sensing applications, *J.Geophys. Res., vol.89*, 6329-6340.

Clark, R., G. Swayze, A. Gallagher, T. King, W. Calvin. 1993. The U. S. Geological Survey, Digital Spectral Library: Version 1: 0.2 to 3.0 μm, *U.S. Geological Survey, Open File Report 93-592*, 1326.

Hapke, B. 1993. *Introduction to the Theory of Reflectance and Emission Spectroscopy,* Cambridge University Press, New York, 278.

Mishev, D. 1986. *Spectral Characteristics of Natural Objects*. Sofia, Publ. House Bulg. Acad. of Sci., 150.

Spiridonov H., A. Krumov, K. Katzkov, S. Yovchev. 1980. Measurement Results and Conclusions on the Spectral Reflective Coefficients of Volcanites, Granitoides and Gneisses. Remote Sensing and Mineral Exploration, *Pergamon Press, Oxford and New York, 157-163.*

Spiridonov H., A. Krumov, K. Katzkov, S. Yovchev. 1983. Measurement results and conclusions on the spectral reflectance coefficients of volcanites, granitoides and gneisses, *Space Research in. Bulgaria, 4*, 59-69.

Маринов, Т. 1989. *Петрография,* изд. Техника, С., 244.

Мишев, Д., Т. Добрев, Л. Гугов. 1987. *Дистанционни методи в геофизиката и геологията,* изд. Техника, София, 272.

Борисова, Д. 1996. Отражателни характеристики на основните видове скали и тяхното спектрометрично изучаване. *III Нац. конференция с международно участие по съвременни проблеми на слънчево-земните въздействия*, София, 45-47.

Илиев, И. 2000. Спектрометрична система за слънчеви и атмосферни изследвания. *Електротехника и електроника, 3-4*, 43-47.

Препоръчана за публикуване от
катедра "Приложна геофизика", ГПФ