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GRANITE AND RELEVANT SOILS SPECTRAL REFLECTANCE AND COLOR FEATURES

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ABSTRACT. Monitoring in risk areas (mines, landslides, etc.) is associated with rock appearance detection. The actual usefulness of the remote sensing methods, applied for this purpose, depends on their accuracy and reliability. Colorimetrical analysis provides means for rock and soil evaluation. The objective of this paper is to study the granite, corresponding soils and their mixture in relation to color features. Experimental data was used to model reflectance and color characteristics of granite and respective soils mixtures. The results provide further confirmation of the potential of spectral mixtures analysis for risk areas monitoring.

СПЕКТРАЛНИ ХАРАКТЕРИСТИКИ НА ГРАНИТИ И СЪОТВЕТНИТЕ ПОЧВИ ВЪВ ВРЪЗКА С ЦВЕТОВИТЕ ИМ ОСОБЕНОСТИ

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РЕЗЮМЕ. Мониторингът на рискови райони (мини, свлачища) се свързва с наблюдението на изнасяне на плодородния почвен слой и разкриването на скалната подложка. Използването на дистанционни методи за тази цел се обуславя от тяхната точност и надеждност. Цветовият анализ е една от възможностите за оценяване на разкритията на скали и разпространението на почвената покривка. Целта на настоящата работа е да разгледа гранитите, съответстващите почви и техните смеси във връзка с цветовите им особености. Експерименталните данни бяха използвани за моделиране на спектралните смеси и цветовите характеристики. Получените обещаващи резултати потвърждават потенциала на анализа на спектрални смеси при мониторирането на рискови райони.

Introduction

Risk areas monitoring by remote sensing is closely connected to vegetation, soil and rock amount estimation. The actual usefulness of the applied methods depends on their accuracy and reliability. A basic problem in data processing and interpretation is spectral mixture decomposition and land cover classification. The objective of this paper is to study the granite, corresponding soils and their mixture in relation to color features. Laboratory and in-situ measurements of the spectral reflectance the granite and soil samples were performed in the visible and near infrared ranges of the electromagnetic spectrum by means of precise multi-channel spectrometers with channel width less than 1 nm. Experimental data was used to model reflectance and color characteristics of mixtures of the granite samples and their respective soils.

Materials and methods

Ground-based in-situ and laboratory reflectance measurements of the granites (10 samples) and relevant soils (brown and red) were performed in the 04-0.8 range of the electromagnetic spectrum using precise multi-channel spectrometers with channel width less than 1 nm (Petkov et al., 2005; Iliev, 2000). The illumination source was a halogen lamp with power P=2000 W. Barium sulphate was used as a reference standard.

The spectral reflectance curves of granite, brown and red soils are given in Fig.1a illustrating the large range of soil reflectance signatures.

The variety of soil and rock fraction cover was modelled from bare soil and rock reflectance using the additive theory (Mishev, 1991):

$$r_{\Sigma}(\lambda) = \sum_i p_i r_i(\lambda) \qquad (1)$$

where $r_{\Sigma}(\lambda)$ are the resulting spectral reflectance signatures of the mixed class, $r_i(\lambda)$ - the reflectance of the components (classes) composing the mixture, p_i - components' relative amounts (fraction cover).

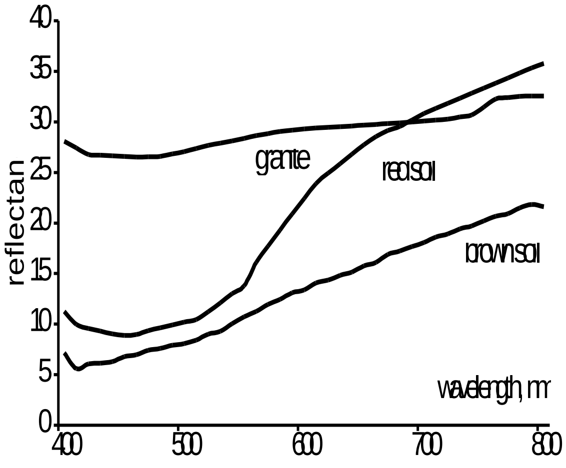

Fig. 1a. Reflectance spectra of granite, brown and red soils

The spectral reflectance curves of modelled rock-soil mixtures are shown in Fig.1b where the impact of the soil type: red (dashed line) and brown soil (solid line) is seen.

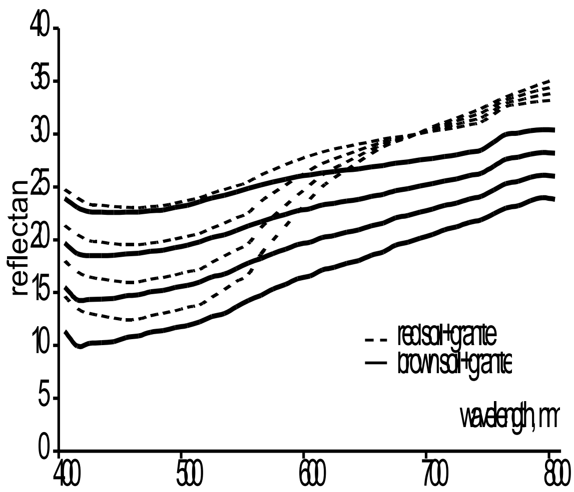

Fig. 1b. Reflectance spectra of rock-soil mixtures with different fraction cover (0.2,, 0.4, 0.6, 0.8) of granite

From each spectral reflectance signature the colorimetric characteristics (tristimulus values *X,Y,Z*, chromaticity coefficients *x,y,z* and dominant wavelength λ_d) of the measured objects and modelled mixtures were computed in the spectral range 450-750 nm according to the CIE 1964 methods and D_{65} light source (Agoston, 1979).

In the wide-spread case of soil and green vegetation, for instance, considering that $\sum_i p_i = 1$:

$$r_{sv} = p_v r_v + (1 - p_v) r_s \tag{2}$$

$$r_{sv} = p_v (r_v - r_s) + r_s \tag{3}$$

In correspondence with the additive theory (the same being true for *Y, Z* and *W=X+Y+Z*) (Mishev, 1992; Kancheva, 2003):

$$X_{sv} = \sum_{\lambda} D_{65} [p_v (r_v - r_s) + r_s] \bar{x} \Delta\lambda \tag{4}$$

$$X_{sv} = p_v (X_v - X_s) + X_s \tag{5}$$

$$x_{sv} = \frac{p_v (X_v - X_s) + X_s}{p_v (W_v - W_s) + W_s} \tag{6}$$

As seen from (6), the chromaticity coefficients defining the position of soil-vegetation mixtures on the color diagram depend on the relative amounts of the pure classes.

The presented example of “soil-vegetation system” is applied for rock-soil mixture in this paper.

Results and discussion

There are only three important groups of colors from natural objects (Mishev, 1986). Rocks, soils and dry vegetation are within the region of yellow to red-orange (575-590 nm). The color coordinates *(x,y)* of the granite samples, brown and red soils falled into this region. In Fig. 2 is clearly seen the wider band of bare soils location. The wider λ_d range of the soil cluster within the color locus and the narrower one of light-colored granites suppose bigger errors in assessment of rock fraction cover if the soil type are not taken into account.

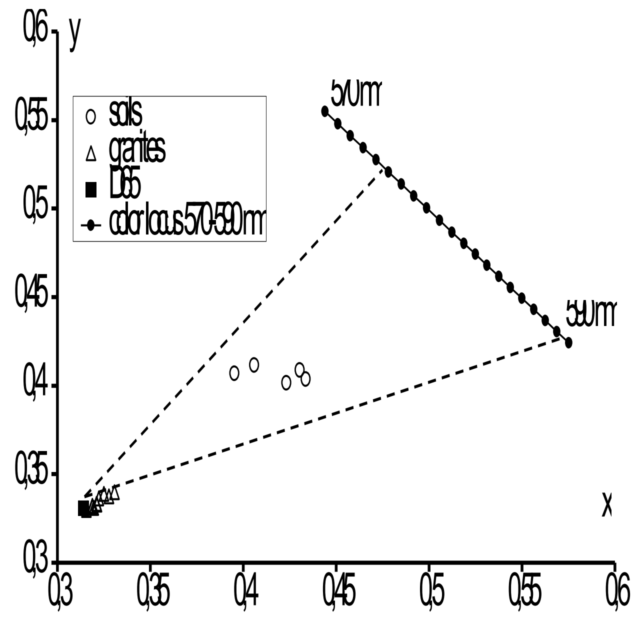

Fig. 2. Dominant wavelengths λ_d of two soil types and granites

In Fig.3 the position on the color locus of two-component mixtures of granite, red and brown soils are presented. The position of chromaticity coefficients of modelled mixtures fall on line connecting pure granites and relevant soils.

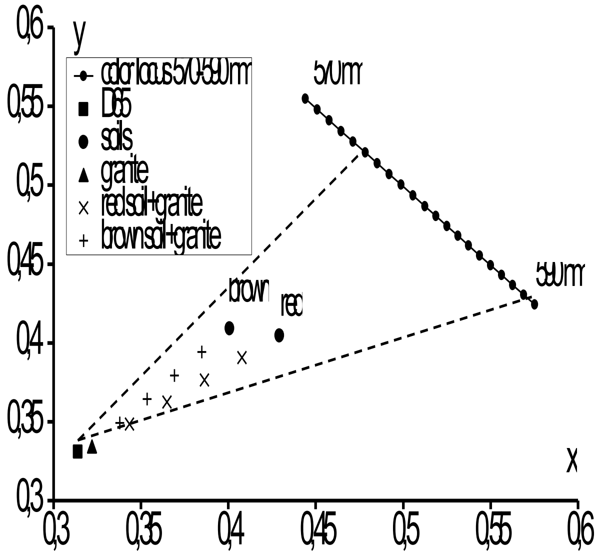

Fig. 3. Dominant wavelengths of 2-component mixtures

Conclusions

The advantage in using color features is that the visible spectral range is closely related to physical and biophysical parameters of the objects and that the whole reflectance curve is used normalized on the spectral distribution of the incident radiation. Besides, λd allows the comparison of slightly differing color stimuli. As a whole the obtained results are an encouraging confirmation of the potential of mixture analysis for risk areas monitoring. Future work is intended in precising the dependences of λd on rock and soil fraction cover by larger experimental data sets as well as their verifying and effective accuracy testing using low-height airborne spectral data.

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