EFFECTS OF MINERAL COMPOSITION, ORGANIC MATTER CONTENT AND TRACE ELEMENT ABUNDANCE ON REFLECTANCE PROPERTIES OF POLY-PHASE MATERIAL OF WASTE ROCK DUMPS

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1. INTRODUCTION

The mineralogical composition of geological material is primarily a determinant of their inherent reflectance properties [1], [2]. However, additional parameters such as organic matter content [3], [4] and trace element abundance [5] are also known to have an influence on soil and sediment reflectance. As long as the effects of sediment composition, organic matter content and trace element abundance can be spectrally distinguished, it might be possible to map these variables at synoptic scales using quantitative methods of image spectroscopy. In mining environments (still active and abandoned mines), mapping the spatial distribution of mineral composition and the additional soil/rock parameters provide unique constraints on both the mineral composition of the allochthonous material as well as the geochemical processes that occur at the site.

2. TEST SITE DESCRIPTION

The Sokolov basin, Czech Republic, containing rocks of Oligocene to Miocene age, is 8 – 9 km wide and up to 36 km long with a total area of about 200 km2. It contains 60% volcanic ejecta originating from fissures and volcanic cones and 40% sediments. Lignite is found only in the western part of the basin, where it occurs in three seams. The Josef coal seam is the lowest overlying the basement rocks. It contains up to 5 wt % sulphur and 60 – 70 ppm arsenic. The younger Anežka seam is developed only in the western part of the basin. The Josef and Anežka seams were exploited in particular in the past. The Antonín seam is currently exploited in the still-active Jiří and Družba open pits and contains up to 0.9 wt % sulphur together with arsenic [6]. Thick (130 – 200 m) overburden is represented by the Cypris Formation (Burdigalian), comprising clays that are dominantly kaolinite at the base, passing to illite and montmorillonite (smectite) towards the top, and a limestone cap.

3. METHODS

Field spectra of more than 250 surface rock samples collected at the Sokolov open-pit lignite mine, were measured using an Analytical Spectral Device (ASD) spectroradiometer during 2007 –2009 field investigations [7], [4]. At the sampling points spectroradiometric measurements were collected in natural illumination conditions using an ASD FieldSpec 3® portable spectroradiometer (in situ spectroscopy measurements). Spectra for each point represented an average calculated from at least three point measurements distributed within petrologically homogenous material.

Furthermore, samples of the surface material (0-2 cm depth) were collected at 50 selected points. They were dried and sieved to < 2 mm, and the abundance of trace elements was measured using a portable Innov-x Alpha RFA spectrometer. Additionally, the 30 samples were further subjected to X-Ray Diffraction analysis, whole-rock chemistry and determination of laboratory pH; sulphur (Stotal wt %) and Total Organic Carbon (TOC_%). The results coming from these analyses became basis for quantitative determination of mineral composition of the studied samples. Besides the laboratory analyses, laboratory spectra were obtained by measuring the analyzed samples in artificial illumination conditions (laboratory spectroscopy measurements).

4. MINERAL SPECTROSCOPY

Firstly, the effect of the diverse mineral phases (e.g., organic matter, iron oxides, sulphates, organic matter, diverse clay minerals) on the reflectance property was studied and quantitative methods of image spectroscopy were used to derive parameters from variations in spectral signal (e.g., absorption depth, area, slope), secondly the relationship between trace element abundance and additional spectral parameters (e.g., asymmetry, allometric growth) were studied in detail.

5. IMAGE SPECTROSCOPY

The possibility to extend the use of the derived parameters to HyMAP hyperspectral image was tested in MATLAB. The HyMAP hyperspectral data were acquired in July 2009 during the HyEUROPE 2009 campaign using the airborne imaging spectrometer HyMAP. Atmospheric correction of HyMAP images was carried out in ATCOR-4. Reflectance signatures of homogenous ground surfaces (reference targets) that were measured in the field simultaneously with the flight campaign were used to verify the image reflectance. The geo-ortorectification (geometric corrections, orthorectification and georeferencing) was performed in PARGE software using six to eight GCP ground control points (GCP) per one flight line. The differences in spectral and spatial resolution between ground/laboratory and image spectra and the possibility of quantitative mapping and the retrieval of metallic cation chemical form (speciation) and heavy metal concentrations from HyMAP images were tested.

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5. REFERENCES

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