Spectral signatures of mineral associations as a proxy in the prospecting of Cu, Ni, and Co in the Sierra de Aramo (Asturias)

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INTRODUCCTION

The existence of Cu, Ni, and Co mineralization in the Sierra de Aramo, south of Oviedo, has been known for over a century, with small historical mining operations exploiting the mineralization though underground galleries which were later abandoned in the 1950s. This is an epithermal style of mineralization developed in relation to the circulation of fluids rich in these elements affecting Carboniferous carbonate rocks via faults and related fractures. Several processes affecting the sedimentary limestones have been identified, with widespread dolomitization of the pre-existing limestone. The mineralization is found in veins where chalcopyrite, cuprite, malachite, azurite, tetrahedrite, tennantite, asbolane, and hematite, among others, are commonly present.

On the other hand, the use of reflectance spectroscopy in the visible to shortwave infrared wavelength range (VNIR-SWIR) has been increasing significantly in recent years, both from data obtained by remote sensing and from proximal or laboratory measurements. Generally, spectra are used to identify economically relevant minerals or those associated with mineralization, and these techniques are commonly employed to detect alteration halos where minerals such as phyllosilicates or sulfates appear, which have a strong spectral response in this wavelength range.

This paper presents work which involved a study using VNIR-SWIR spectroscopy on both rock and soil samples from the Sierra de Aramo. The primary objective of the study is to establish spectral signatures for later application in the interpretation of satellite images and data obtained from a hyperspectral sensor during a flight conducted over the study area.

MATERIALS AND METHODS

A total of 166 samples were examined, including 115 rock outcrop samples and 51 soil samples from the Aramo Plateau study area. These samples were analyzed through chemical analysis, VNIR-SWIR reflectance spectroscopy, and X-ray diffraction (XRD).

The XRD analyses were performed on total powdered rock using a Bruker D8 Advance ECO system with Cu Kα radiation, operating at a speed of 0.05° 2θ/s. For the semi-quantification of the samples, EVA software and the PDF (Powder Diffraction FilesTM) database were utilized. The initial exploration chemical analysis was conducted by ALS Laboratories in Ireland using the analytical method ME-ICP-61 33 element 4-acid digestion. The VNIR-SWIR spectra of the studied samples were obtained with a high-resolution portable spectroradiometer from ASD, model FieldSpec 4 Hi-Res, equipped with a contact probe. The equipment includes three detectors—one for the visible range and two for the infrared—covering wavelengths from 350 nm to 2500 nm, with a spectral resolution of 3 nm in the visible and 6 nm in the infrared ranges, respectively. The spectral analysis was carried out using the SpecView and Spectragryph softwares (Menges, 2016).

The combined statistical analysis of the mineralogical, chemical, and spectral data, including their mathematical preprocessing (first and second derivatives), was performed using Past V4.09 and SPSS V12 software.

RESULTS AND DISCUSSION

The main minerals identified in the rock samples are calcite and dolomite, with occasional occurrences of quartz, gibbsite, goethite, malachite, and azurite. In the soil samples studied, the predominant minerals are quartz, illite, and complex phyllosilicates corresponding to interstratified vermiculite-chlorite, with occasional identification of talc and calcite, as well as possible HIMs (2:1 phyllosilicates with interlayer hydroxides). Based on the mineralogical identification results from XRD, 11 mineral associations have been established. Statistical analysis of the data revealed two mineral associations that are most likely to contain elevated concentrations of Cu, Co, and Ni.

For each mineral association, after confirming that the morphology of the spectra in the infrared region is similar and that no samples exhibit significant differences in the identified absorption features, the average spectrum was obtained, representing the characteristic spectral signature of that mineral association (Fig. 1). The spectral signature SSO3-4 corresponds to two different mineral associations that have indistinguishable spectral signatures; the same applies to the signature SSS1-2. Consequently, a total of 9 distinct spectral signatures have been defined: 7 for rock samples and 2 for soil samples. The spectral signatures of the associations with the highest likelihood of containing Co, Ni, and Cu are SSO6 and SSO8 (Fig. 1).
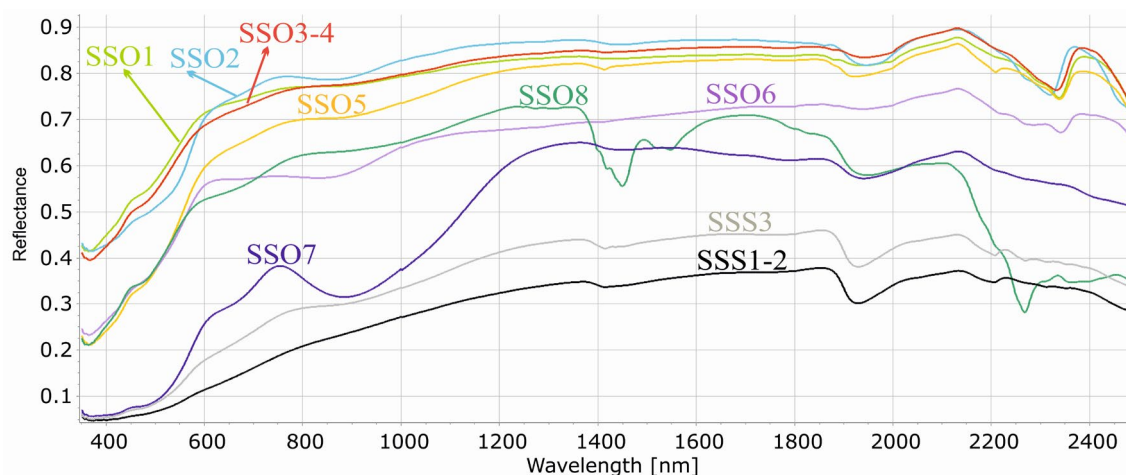
Fig 1. *Spectral signatures derived from the mineral associations are presented here. Signatures beginning with the code SSO correspond to rock samples, whereas those starting with SSS refer to soil samples.*

CONCLUSIONS

Two mineral associations have been identified as having the highest probabilities of containing greater amounts of the elements of interest, with their spectral signatures potentially serving as criteria that can be applied to field exploration. The 9 calculated spectral signatures, representative of distinct mineral associations detectable via VNIR-SWIR, can therefore be utilized as endmembers for lithological mapping through remote sensing.

REFERENCES

Menges, F. (2016): Spectragryph-Optical Spectroscopy Software (Version 1.2.15). http://www.effemm2.de/spectragryph/ [accessed on: October 5 2024].

ACKNOWLEDGMENTS