

A Multi-Approach Hyperspectral Analysis for the Mineralogical Characterization of Zn-Cu-Pb Vanadate Ores in the Otavi Mountainland (Namibia)

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The Otavi Mountainland (OML) is located in the northernmost part of the Damara fold-thrust belt in northern Namibia. The area is characterized by base metals sulfide and nonsulfide deposits hosted by Neoproterozoic platform carbonates belonging to the Otavi Group. The Zn-Cu-Pb vanadate ores (i.e., descloizite, vanadinite, and mottramite; now mostly exhausted) of supergene origin occur in different styles, like veins or cements in karst breccias and cavities. Country rocks (limestones and dolomites), Fe-oxyhydroxides and V-ore minerals have diagnostic spectral absorptions in the visible-near to the shortwave infrared regions, allowing their identification and mapping through hyperspectral methods. However, the spectral response of V-bearing minerals is poorly described in literature so far.

The objective of this study was to characterize the OML vanadium ores in order to better define the mineralization styles, textures, and minerals' mutual relationships as well as expand the knowledge regarding the spectral behavior of V-bearing minerals by adopting a multi-technique approach based on the integration of laboratory-based hyperspectral bulk spectroscopy (through FieldSpec Pro3) and imaging (using Headwall Photonics Nano- and Micro-Hyperspectral cameras), both covering the 400- to 2,500-nm spectral range. The data processing was performed by applying feature-extraction band ratios and indexes. XRPD mineralogy was used for validating the results. The analyses allowed us to detect Fe-oxyhydroxides based on the Fe³⁺ absorption feature at 900 nm, to recognize vanadate minerals through the peak at 620 nm and double features at 1,990 and ~2400 nm, and to map and distinguish dolomite from calcite depending on the wavelength position of the CO₃ absorption band at 2,317–2,321 to 2,340 nm, respectively.

The use of multi-source high-resolution hyperspectral data represents a powerful tool for mineral exploration and can also be used for supporting satellite-scale hyperspectral remote sensing for mapping the outcropping host rocks and supergene alteration associated with orebodies at the regional scale.