PRISMA Hyperspectral Discrimination of Alteration and Lithology across Vein, Red-bed and MVT-Type Pb–Ba Deposits (Upper Moulouya, Morocco)

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Hyperspectral remote sensing is a well-established tool for geological mapping and mineral exploration, from early airborne campaigns to the current spaceborne missions such as PRISMA [1], [2]. Despite their economic importance, lead and barium deposits (such as those in the Upper Moulouya district) remain particularly challenging targets to map because they do not display diagnostic absorption features in the VNIR-SWIR range[3]. Exploration must therefore rely on mapping their associated hydrothermal alteration and the surrounding host-rock lithologies[3], [4]. Most remote sensing studies conducted in the Upper Moulouya district have relied on multispectral sensors such as Landsat-8 OLI, ASTER, and Sentinel-2A [5]. With only a few broad spectral bands, these sensors miss much of the diagnostic information that can only be resolved using numerous narrow bands of hyperspectral data. We therefore assess the contribution of PRISMA hyperspectral imagery in this district.

As part of this study, we used PRISMA hyperspectral imagery to determine whether a single processing protocol could characterize three genetically distinct types of Pb-Ba deposits in the Upper Moulouya district: the vein-type deposit of Aouli, hosted in Paleozoic schists and granites; the Mississippi Valley-Type (MVT) deposit of Mibladen, a stratabound mineralization hosted in Jurassic carbonates; and the red-bed deposit of Zeida, hosted in Triassic conglomerates and arkoses[4].

We used two PRISMA Level-2D scenes: one covering Aouli and Mibladen, and one covering Zeida. Both scenes were preprocessed to ENVI format, with bands affected by water-vapour absorption and low SNR removed, followed by spectral smoothing. We then applied a Minimum Noise Fraction transform and Pixel Purity Index to extract endmembers, which we matched against the USGS spectral library. Following the feature-based approach of Chirico [3], band ratio indices were calculated for each deposit and combined into false-colour RGB composites, validated against lithological boundaries digitized from published geological maps [5].

The three composites revealed distinct, deposit-specific spectral signatures. At Aouli, the sericite schists and muscovite granite were highlighted by the white-mica composite, consistent with the sericitic alteration accompanying the Paleozoic-hosted veins. At Zeida, iron-oxide indices mark the hematite-rich Triassic red beds. At Mibladen, a dolomite-calcite discrimination allows the Liassic carbonate formations and their dolomitized zones to be distinguished, with lithological factors playing a key role in MVT mineralization. In all cases, the spectral boundaries agree with the digitized geology, and the results are reproducible across the two independent PRISMA acquisitions.

The results show that a single PRISMA-based protocol could discriminate the alteration and host-lithology signatures of three genetically distinct Pb-Ba deposit types within the same district. This approach could be transferable to other semi-arid base-metal exploration settings. A field campaign is currently ongoing to validate our spectral interpretation.

References

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