

Integration of Spaceborne Imaging and Laboratory Spectroscopy for Mineral Characterization of Oxidized Zn Orebodies: Implications for Mineral Exploration

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High-grade deposits of oxidized Zn mineralization (nonsulfides or in mixtures with sulfides) represent attractive targets for mineral exploration. While these deposits exhibit large alteration footprints at the surface, spaceborne spectral imaging has seen limited use for their exploration. In this study, we investigate the spectral behavior of several Zn-bearing minerals collected from different deposit types worldwide, including supergene oxidized mineralization at Skorpion (Namibia), Accha, Yanque, Mina Grande and Cristal (Peru) and Reaphook (Australia), and the hypogene willemite-rich deposit at Beltana (Australia).

High-resolution spectral reflectance imaging and point spectroscopy were conducted on representative hand samples, over the Visible Near-Infrared (VNIR) to Shortwave Infrared (SWIR) range, coupled with analytical geochemistry (i.e., XRPD and FESEM-EDS) and spaceborne imaging spectroscopy. A large suite of ore and alteration minerals, exhibiting well-developed absorption features, was detected, including Fe oxy-hydroxides (hematite, goethite), carbonates (dolomite, calcite, smithsonite), silicates (willemite, hemimorphite, fraipontite, micas, kaolinite, smectite), and phosphates (scholzite, tarbuttite).

At district scale, Skorpion and Beltana were selected as case studies to map the spatial distribution of hydrothermal alteration and supergene weathering by using EnMAP hyperspectral and ASTER multispectral satellite data, respectively covering the VNIR-SWIR and longwave infrared (LWIR) wavelength ranges. EnMAP covers the range between 420 and 2450 nm with 224 contiguous spectral bands at 30m spatial resolution and ASTER TIR bands cover the range between 8000 to 12000 nm with 5 spectral bands at 90 m resolution.

The abundance, composition, and crystallinity of the target minerals were estimated by applying a multiple-feature extraction workflow based on polynomial fitting and band rationing methods in reflectance and emittance data.

The mapping products highlights the significance of reflectance spectroscopy in exploration targeting and demonstrates the capability of EnMAP and ASTER-TIR data in identifying distinct alteration footprints of oxidized Zn deposits, providing district-scale vectors to support mineral exploration.