Abstract

INTEGRATED REMOTE SENSING AND GEOCHEMICAL TECHNIQUES FOR IDENTIFICATION AND MAPPING OF METALLIC AND CARBONATE MINERAL-RICH ZONES IN MOHMAND AND SURROUNDING AREA, PAKISTAN.

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This research investigates the delineation and characterization of metallic and carbonate mineral-rich zones in the Mohmand district and adjacent regions in northwestern Khyber Pakhtunkhwa, Pakistan. Utilizing an integrative, multidisciplinary methodology, the study employs advanced remote sensing techniques, field-based spectral analysis, and laboratory-based mineralogical and geochemical evaluations to identify mineralization zones and assess their economic viability.

Remote sensing analyses leveraged ASTER and Landsat 8 satellite imagery to detect spectral signatures indicative of metallic and carbonate minerals. Advanced image processing techniques, including the Spectral Angle Mapper (SAM), band ratio analysis, and Minimum Noise Fraction (MNF) transformations, were utilized to enhance the identification of mineral signatures while minimizing spectral noise and ambiguities. These remote sensing findings were systematically validated through extensive field surveys, during which a spectroradiometer was employed to record the spectral signatures of rock samples in situ. Subsequent laboratory investigations

included X-ray diffraction (XRD), atomic absorption spectrometry (AAS), and petrographic analyses to refine the mineralogical and geochemical characterization of collected samples. This comprehensive approach enabled cross-validation of remote sensing-derived data with ground-truth observations. The study primarily focuses on economically significant metallic minerals such as chromite, manganese, and iron, along with carbonate mineral assemblages commonly associated with ophiolitic complexes and the Main Mantle Thrust (MMT) zone. The integration of remote sensing, field, and laboratory datasets within a GIS framework facilitated the generation of high-resolution mineral potential maps, delineating zones of significant mineral enrichment. The findings underscore the role of serpentinization and tectonic settings in influencing mineralization processes, thereby advancing the understanding of geological controls in the study area.

This research holds practical implications for resource management, mine planning, and mineral exploration. It contributes to scientific advancements in economic geology, remote sensing applications, and geochemistry, providing a methodological framework adaptable to similar geological contexts globally. Furthermore, the study supports initiatives by the Geological Survey of Pakistan (GSP) and the Mineral Development Department (MDD) KP, fostering informed decision-making in mineral resource management and exploration.