Remote sensing-based prospects for the exploration of metallic minerals in North Waziristan, Pakistan

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Mineral exploration plays a vital role in a nation's economic growth and sustainability. However, security concerns pose significant challenges to conducting exploration surveys in areas with substantial mineral reserves in Pakistan, particularly in certain regions of Khyber Pakhtunkhwa (KPK) and Baluchistan Provinces. This study focuses on the utilization of remote sensing techniques and GIS tools for the delineation of metallic mineral outcrops in the North Waziristan region of KPK Province. Landsat 8 satellite imagery data was acquired to perform this study and processed using ENVI and ArcGIS software. Radiometric and Atmospheric corrections were applied to the data, followed by various analysis techniques including stacking, band ratio, unsupervised classification, and normalized difference vegetation index (NDVI) in a GIS environment. The study approach based on expert knowledge of distinctive spectral reflectance values to identify different natural surficial materials facilitates the identification of common metallic minerals surface deposits, which exhibit distinctive pale red and red- pinkish color shades compared to other natural materials in the region. Unsupervised classification aided in creating different classes based on reflectance values of the same groups for mineral exploration prospects. Resultant maps indicate surface traces of pyrite, galena, chalcopyrite, hematite, and magnetite as dominant minerals in different parts of the study area. NDVI classification maps and the Hill Shade map assisted in assessing area accessibility and land use, including water bodies, built-up areas, digital terrain, and various vegetation types. The study outcomes show that the Shawal region emerged as a potential area, exhibiting significant metallic mineral diversity, primarily hematite and magnetite. This region is recommended as a suitable training site for conducting field-based mineral exploration surveys in close proximity. Overall, the study results are promising and require ground-truthing which is an

essential aspect of remote sensing-based research. The study emphasizes effectively utilizing remotely sensed data to delineate target areas before commencing comprehensive field-based exploration surveys in such regions. Additionally, the study recommends the use of multiple remote sensing data sources, including ASTER and hyperspectral imageries, for more comprehensive results.