

Remote Sensing-Based Identification and Mapping of Mineralized Zones in the Waziristan Ophiolite Complex, Pakistan

Saif Ullah^{1*}, Saad Khan¹, Muhammad Nouman¹, Asad Ullah¹

¹ National Centre of Excellence in Geology University of Peshawar, Peshawar.

*Email: saifullah.dawar994@gmail.com

The Waziristan Ophiolite Complex in northwest Pakistan is being studied for mineralized zones using spectral analysis, X-ray diffraction (XRD), and remote sensing. This geologically complex region has important deposits of iron (Fe) and copper (Cu) as well as mafic-ultramafic rocks. Advanced methods were used to map and explore accurately. The ASTER sensor's multispectral data was used to identify important lithologies and mineralized regions. To bring emphasis on geological characteristics, a variety of image processing techniques were used, including Decorrelation Stretch (DCS), Band Ratios (BR), and False Color Composites (FCC). FCC combinations like (4, 6, 8) and (3, 2, 1), along with DCS (1, 3, 8), proved effective in distinguishing altered zones from the surrounding rock formations. Band Ratios, including $(5/4 + 1/2, 2/1)$ and $(6/4, 4/7, 5/6)$, were employed to further differentiate copper and iron-bearing alteration zones, improving the identification of mineralized areas. Lithological units and related alteration minerals could be identified more precisely because to the integration of Thermal Infrared (TIR), Short-Wave Infrared (SWIR), and Visible and Near Infrared (VNIR) data. XRD analysis confirmed the presence of copper and iron-bearing minerals, validating the spectral findings. The mineral makeup of one of the examined samples showed that 72% of the minerals were goethite, 13% were quartz, 9% were brochantite, and 6% contained arsenic. These findings indicated oxidation and weathering processes, corroborating the alteration zones observed in the remote sensing data. This integrated approach improved the precision of mineral mapping in the Waziristan Ophiolite Complex. The results not only validated the spectral data but also provided a framework for future exploration and potential mining activities in the region, contributing to economic development by guiding targeted exploration efforts.

Keywords: Ophiolites; ultra-mafic; Waziristan; Spectral; remote sensing