

Remote Sensing-based Mapping of Carbonate Lithologies in Northwest Mohmand District, Pakistan, Using Landsat 8 Imagery

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Marble, metamorphic rock rich in calcium carbonate (CaCO_3) and calcium magnesium carbonate (CaMgCO_3), has played a pivotal role in ancient civilizations and continues to be a significant resource for architectural purposes. The 19th-century surge in marble production led to its widespread use, with major quarries emerging in China, India, Italy, and Turkey. However, mapping and identifying marble deposits in remote and inaccessible regions remain challenging. This study introduces an integrated approach employing advanced remote sensing techniques to map carbonate lithologies in the Northwest Mohmand District, Khyber Pakhtunkhwa, Pakistan. Landsat 8 imagery is utilized alongside iterative adaptive reweighted regression (IARR), principal component analysis (PCA), minimum noise fraction (MNF), and spectral angle mapper (SAM) classification techniques. Data processing and analysis are conducted using the Environment for Visualizing Images (ENVI) software, with subsequent spatial analysis using geographic information systems (GIS), ArcMap, and Arc Scene software. Validation of the results is carried out through extensive fieldwork, X-ray diffraction (XRD), and petrographic analysis. The XRD and petrographic data validate the findings derived from the Landsat 8 imagery, confirming significant concentrations of dolomite and calcite, indicative of carbonate deposits. The implications of this study are particularly significant for Pakistan's marble industry, especially in Khyber Pakhtunkhwa, Punjab, and Baluchistan, where an estimated 300 million tons of marble reserves exist. Leveraging Landsat 8 imagery, this research aids in delineating valuable marble resources and provides recommendations for targeted exploration activities in the Mohmand area and beyond.