# REMOTE SENSING AND FIELD-BASED CHARACTERIZATION OF THE PALEOGENE DEPOSITIONAL SEQUENCES, KOHAT PLATEAU, PAKISTAN

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**Abstract**

The advanced remote sensing tools and techniques are widely adopted in the field of geology, especially for mineral identification and lithological mapping. The spectral response of minerals and mineral mixtures captured by the spaceborne multi and hyperspectral sensors hold the capacity to identify and map the abundance of heterogeneous mineral assemblages at surface. The spectral analysis of the field spectra is a cheap and non-destructive proxy for the identification of major mineralogy and associated trace minerals & impurities. The Paleogene stratigraphy exposed in north-eastern Kohat Plateau is selected for integrated remote sensing and field base mapping. The spectral analysis of the mapped lithologies is performed to evaluate the effects of major and trace minerals, supported by the petrography and geochemical analysis.

The Advance Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data, due to its wider spectral and moderate spatial coverage, successfully categorized and map the rocks in four major lithological classes. The lithologies are categorized based on the major mineralogy and sedimentary rock type that includes the Carbonates (limestone beds of Kohat and Shekhan formations), Red Clastic Beds (red sandstone/shales), Green Clastic Beds (green sandstone/shales, and Evaporites (Jatta Gypsum) The reflectance composite from SWIR, and image transformation (including Principal Component Analysis-PCA & Band Rationing-BR) proves effective for highlighting the surface exposures of litho-classes. The field spectrometry and spectral comparison

of field spectra with ASTER pixel's spectra shows strong correlation. The Spectral Angle Mapper-SAM algorithm produced a seamless map of lithological classes, where the pixel's spectra as reference proved more suitable in comparison to end member field spectra.

The hyperspectral scene of Environmental Mapping and Analysis Program-EnMap satellite is experimented to test its capability to detect and map the different litho/spectral facies of Paleogene carbonates and shales. The EnMap scene captures the two limestones' facies i.e., Shekhan SF-2 & Kohat SF-1formations, and two shales units i.e., Panoba SF-4 & Kuldana SF-3. The spectral variation of these different limestone and shale beds in visible-near infrared (VNIR) and short-wave infrared (SWIR) spectrum highlights the effects of compositional variation (caused by associated minerals and impurities). The interpretation of reflectance composites and mixture tuned match filtering (MTMF) algorithm proved effective for visualizing the spectral variation in hyperspectral scene. The SAM algorithm is run over the EnMap reflectance data to create a detailed litho/spectral facie map, with the HSI pixels spectra as reference. The accuracy of the final litho/spectral facies map is evaluated, based on field data points, which shows the overall accuracy of ~80% and kappa coefficient value of 0.733.

The spectral analysis of field spectral data is performed to interpret the mineralogy of mapped geological units. The petrography and geochemistry of representative field samples is performed to identify the possible reason that creates the spectral variation among carbonates and shales in the mapped facies. The spectral variation in Shekhan and Kohat formation's limestone is marked by comparatively high intensity of ferric minerals effects (from 450-980 nm) in Shekhan Formations. For shales, the addition of carbonate (~2.3µm) and illite clay (~2.1µm) spectral signatures in Panoba shales define the spectral difference between Panoba and Kuldana formations. Furthermore, the observation of Jatta Gypsum's spectral behavior suggests the

dominancy of gypsum mineral, with association of trace anhydrate. The petrography of limestones beds also highlights the abundance of calcareous frame work bioclasts & lime mud, and the dominancy of gypsum crystals along with secondary anhydrates in Jatta Gypsum. The analysis of geochemistry reveals the dominancy of CaO (~50%), and SiO2&Al2O (~15-25%) in limestones and shales, supports the abundance of carbonates and clay group minerals respectively. The relatively higher percentage of iron oxide-FeO (~≥1.20 %) in Shekhan Formation corresponds to the spectral intensity of ferric minerals. The higher CaO percentage (~25 %) in Panoba Formation supports the existence of carbonate absorption around 2.3µm. The greater CaO percentage (~32%) and the LOI of about 35% in Jatta Gypsum also coincides with the chemical composition of gypsum minerals, whereas the trace amount other oxides (i.e., Na, K, Mg, Al, Si) represent the silicate impurities.