Spectral and Structural Analysis of Satellite Imagery for Lithium Pegmatite Exploration in Northwestern Somalia

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Lithium (Li) is a critical element in the production of rechargeable Li-ion batteries, with growing demand driven by the rapid expansion of the electric vehicle industry. This demand has intensified global exploration for economically viable Li deposits. Key lithium-bearing minerals of economic importance include spodumene ($LiAlSi_2O_6$), lepidolite ($K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$), and petalite ($LiAlSi_4O_{10}$), typically hosted in pegmatites. This study employed spectral and structural analysis of moderate- to high-resolution satellite imagery data to identify potential pegmatite-hosted Li mineralization in northwestern Somalia, a region with partial vegetation cover. The remote sensing approach focused on detecting diagnostic Li-indicator minerals, including spodumene, white micas (e.g., lepidolite, muscovite), clay alteration minerals (e.g., smectite, illite, kaolinite), ferric iron oxides, formed as weathering products of Li-bearing minerals, and silica, which helps distinguish silica-rich granites and pegmatites from surrounding rocks. Image processing targeted distinct spectral features across key electromagnetic spectrum regions of Shortwave Infrared (SWIR, 1.4 to 1.6 µm and 2.1–2.3 µm), indicative of OH^-, Al^{3+}, Li^+, and Mg^{2+} components, Visible and Near Infrared (VNIR, 0.490–0.665 µm) associated with ferric iron oxides, and Thermal Infrared (TIR, 8.65–9.10 µm) representing Si–O stretching vibrations. The Spectral Angle Mapper classification algorithm was applied to multispectral ASTER and hyperspectral PRISMA imagery using reference spectra from the USGS spectral library to identify Li-bearing minerals and associated clays. Ferric iron oxides were mapped using red/blue band ratios from high-resolution WorldView-2 and Sentinel-2A VNIR data. Silica-rich lithologies were delineated using the Band 11/Band 12 ratio from ASTER TIR data. Additionally, structural analysis identified favorable open-space settings such as fold hinges and axial planes within an E–W trending metamorphic unit that likely facilitated the intrusion of Li-rich pegmatites/granites. These features, extracted from WorldView-2 and Sentinel-2A data, were integrated with the mapped mineral indicators and delineated first- and second-priority Li potential targets for field validation.