Application of Satellite and Airborne Remote Sensing Techniques to Assess Critical Mineral Potential in Trans-Pecos Texas

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ABSTRACT

Demand for rare earth elements (REE) is projected to increase up to 40% by 2040 due to the growing adoption of permanent magnets in electric vehicles and wind turbines as part of the transition to green energy, thus making a secure U.S. REE supply desirable. The Trans-Pecos region of western Texas hosts critical mineral occurrences associated with REE-enriched Paleogene rhyolite and syenite laccoliths intruded into sedimentary strata. The assessment of critical mineral resources in this region is aided by new, high-resolution datasets, including airborne magnetic and radiometric surveys acquired by the U.S. Geological Survey and geologic quadrangle maps with a resolution of 7.5 arc minutes produced by Bureau of Economic Geology researchers. For these reasons, this study integrates existing geologic datasets with geochemical and multi-scale spectral remote sensing data to develop a predictive model for identifying REE deposits in the Trans-Pecos region. Additional datasets include whole rock 60-element geochemistry with corresponding reflectance spectroscopy measurements collected using an ASD FieldSpec 4 spectrometer, as well as multi-source satellite imagery with visible and near-infrared (VNIR) and shortwave-infrared (SWIR) bands.

The spectrometer dataset was processed and analyzed, including noise reduction, data normalization, and lithologic classification. K-means clustering extracted statistically significant spectral profiles from igneous and sedimentary samples. Two optimal clusters within igneous samples exhibited absorption variations in the 705-865 nm range. Additionally, significant correlation (p-value <0.05) was observed with NaO content. Sedimentary samples were reduced to four optimal clusters, showing correlation with CaO and SiO_2 content, indicating distinctions in depositional environment. FieldSpec signatures were applied to satellite band wavelengths, and variance analysis demonstrated that ASTER's SWIR bands, Sentinel's band 12, and Landsat's band 7 were optimal for distinguishing between sedimentary clusters. These bands were put into ratios and plotted in a correlation matrix to identify key ratio pairs.

Preliminary results show distinction between igneous laccoliths and sedimentary map units on satellite imagery. Within sedimentary units, there is a distinction between carbonates and modern alluvial deposits. Additional model inputs will include geospatial datasets related to environmental and social governance, allowing for simultaneous assessment of resource potential from scientific and sustainable perspectives.

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