Application of Satellite and Proximal Hyperspectral Sensing to Target Li Mineralization in Volcano-Sedimentary Deposits: The McDermitt Caldera (USA) Case Study

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This study provides satellite and proximal hyperspectral analysis of lithium (Li)-bearing volcano-sedimentary environments aimed at determining the target absorption features of alteration assemblages to be used as exploration vectors towards analogous Li-mineralized systems. The approach was applied to the McDermitt caldera (USA), where Li mineralization occurs in the form of clay minerals forming from the alteration of glass-rich extrusive igneous rocks in endorheic lacustrine basins.

The surface-exposed areas of the caldera were investigated using hyperspectral imagery from the German Environmental Mapping and Analysis Program (EnMAP). Satellite data were validated by analyzing samples from the Jindalee McDermitt Li deposit, using hyperspectral imaging with Headwall Photonics cameras. Complementary mineralogical and geochemical analyses were also conducted on the same samples to further support spectral interpretations.

The creation of hyperspectral feature distribution maps was achieved using band ratio analysis and minimum wavelength techniques, implemented in ENVI 5.6 and the open-source Python package “hylite”. This methodology enabled the detection of various minerals, including amorphous silica, Fe-smectite, Mg(Li)-smectite (hectorite), calcite, and zeolites. The samples, which predominantly contain a Mg(Li)-smectite + amorphous silica assemblage, show distinct absorption features at 2200 nm and 2306 nm, detectable within the EnMAP spectral range. Analysis of the corresponding hyperspectral feature distribution maps and the comparison with ground control samples, compared with ground data, confirmed that the 2200 nm and 2306 nm absorption features can be effectively used as mineralogical-hyperspectral vectors for identifying Li-prospective areas on a caldera-scale. This spectral footprint was applied to the High Rock Caldera Complex, a similar system without Li mineralization. The analysis revealed the absence of the characteristic 2200+2306 nm feature, indicating that these spectral features could be used to target lacustrine sequences with mineralogical characteristics similar to those found in Li-mineralized deposits.