

Multiscale analysis of Lithium-rich pegmatites in Rajasthan (India)

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This study is part of our international collaboration with India on the characterisation and genesis of lithium pegmatite deposits in Rajasthan. The Ajmer region in Rajasthan, part of the Aravalli-Delhi Fold Belt, is characterised by Precambrian metasedimentary, metavolcanic, and intrusive igneous rocks that host extensive pegmatitic and granitic intrusions. The Aravalli-Delhi Fold Belt pegmatites can extend along strike for hundreds of metres and exhibit variable thicknesses ranging from a few metres to nearly 50 metres.

This study aims to identify and characterise lithium-bearing pegmatites using multidisciplinary techniques and data integration tools. Pegmatites identified and sampled via field mapping were analysed for chemistry and mineralogy, and the multiscale hyperspectral data were used to extrapolate the findings from sample to satellite data. The satellite hyperspectral data were further explored to delineate mineral maps that complement sample characterisation and predictive analysis for Li-pegmatite outcrops.

The geochemical and mineralogical characterisation of 11 pegmatite and granite occurrences was conducted using X-ray fluorescence (XRF) and X-ray diffraction (XRD) to provide elemental and mineralogical composition, while Laser-Induced Breakdown Spectroscopy (LIBS) and TESCAN Integrated Mineral Analyzer (TIMA) enabled high-resolution elemental and textural analysis. Minalyze offered continuous core profiling, and hyperspectral techniques, including HyLogger4 and the Hyperspectral Core Imager (HCI), facilitated detailed mineral mapping. The satellite hyperspectral data from PRISMA (ASI) and EMIT (NASA/JPL) sensors were investigated to delineate pegmatite mineralogy and potential vectors towards Li-mineralised pegmatites, with predictive techniques such as the partial least squares (PLS) method being tested.

This integrated approach enhances the understanding of lithium-bearing pegmatites and their geochemical evolution. These include beryl, apatite, tourmaline, albite, lepidolite (Li-rich white mica), and minor spodumene. Geochemical assays have confirmed high lithium oxide concentrations, reaching up to 5 wt%, alongside elevated fractionation indices (K/Rb and K/Cs ratios), indicating advanced pegmatite evolution. This approach highlights the potential of combining ground and sample-based studies with remote sensing to efficiently explore and understand large-scale and complex pegmatite systems.