

Grayfields: Unearthing Geological Knowledge Through AI-Driven Data Integration for Critical Mineral Discovery

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Mineral exploration projects typically fall within two categories: greenfields, where geological knowledge is sparse and discovery risk is high, and brownfields, where infrastructure and data density anchor incremental resource growth. Herein, I propose a third, largely unrecognized category, termed grayfields, defined by deposits and prospective terranes that are neither unknown nor well-understood, but obscured by neglected, fragmented, and inaccessible data. For critical minerals under acute supply pressure, grayfields may represent the most immediate and undervalued exploration frontier.

The challenge is not data scarcity. Geological surveys, mining companies, and academic institutions individually house drillhole records, geochemical analyses, and geophysical line-kilometers, the vast majority of which remain machine-inaccessible, locked in scanned documents, proprietary formats, and gray literature. Advances in artificial intelligence, natural language processing, and cloud-scale spatial infrastructure have recently enabled platforms capable of ingesting, standardizing, and semantically querying these heterogeneous archives, transforming them from static records into dynamic exploration assets.

Here I present case studies of three deposit types 1) nickel laterite prospectivity mapping using legacy soil surveys with modern remote sensing in the Josephine peridotite; 2) reanalysis of tungsten skarn districts in the Basin and Range using reconnaissance geochemical datasets in conjunction with AI-vectorized geologic maps and newly acquired aeromagnetic surveys; and 3) reinterpretation of permissive lithium pegmatite terranes by synthesizing proxy commodity data, legacy geochemistry, and structural datasets at regional scale.

This contribution introduces grayfields as a conceptual and operational framework for AI-driven critical mineral exploration, based on emerging data integration platforms applied to public geoscience archives. The greatest near-term exploration leverage lies not solely in new data acquisition but in achieving interoperability among data already collected. The next significant critical mineral discovery may already exist in the archival record. Can we rediscover it?