Field-Based Mineral Chemistry Using Portable Laser-Induced Breakdown Spectroscopy (pLIBS) for Exploration and Mineral Processing

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There is a growing demand for real-time, cost-effective tools in mineral exploration and extraction. Accurately interpreting the trace element chemistry of alteration minerals can provide powerful vectors to mineralization, improving discovery efficiency and reducing exploration costs. In production settings, understanding trace element distributions in valuable by-products or deleterious elements is equally important. Traditional techniques such as laser ablation ICP-MS (LA-ICP-MS) and scanning electron microscopy (SEM) are lab-based, time-consuming, and require sample preparation, limiting their utility in field campaigns and mineral processing assessments. As a result, insufficient mineralogy and mineral chemistry often leads to missed or delayed opportunities in discovery and recovery. Laser-induced breakdown spectroscopy (LIBS) is an atomic emission technique that enables rapid, low-cost chemical analysis with minimal sample preparation. Portable LIBS (pLIBS) systems allow in-situ, high-resolution elemental mapping and can detect a wide range of elements, including low atomic number elements like Li, Na, and Mg which are difficult to analyze with most other portable instruments. Using a 16×16 analysis grid (~2.4×2.4 mm), pLIBS spectra are collected and processed mathematically to extract relative elemental intensities. These are compared against a user-defined mineral library using cosine similarity, providing the probability of mineral phases at each shot location. Mineral scores are spatially assigned, generating mm-scale maps that can be interrogated by mineral species to visualize intra-mineral trace element chemistry.

This approach enables real-time, field-based assessments of mineralogy and geochemistry, supporting vectoring toward mineralization and identification of by-products or deleterious elements. While the precision of pLIBS is lower than that of lab-based methods like LA-ICP-MS, its speed, portability, and broad elemental detection range make it ideal for rapid field deployment. This capability allows large volumes of mineral chemistry data to be generated in real time, supporting faster discovery and improved evaluation of recovery opportunities.