

Predicting Modal Mineralogy at Scale Using Drill Core Data

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In the mining and exploration industry, mineralogy is typically characterized using methods such as optical petrography, scanning electron microscopy (SEM), and X-ray diffraction (XRD), applied to samples that range from thin sections to bulk, multi-meter samples. While these techniques produce reliable mineralogical data, they are often impractical for routine use at the deposit scale. However, geochemical data already collected from drill cores at the multi-meter scale, combined with industry-standard physical response and mineralogical datasets, offer a promising opportunity to predict mineralogy more efficiently.

Rather than relying on direct modal mineral abundance measurements, we utilize a linear programming (LP) approach (Matoušek and Gärtner, 2007) to invert multi-element geochemical data into mineralogical predictions. This method leverages a dynamic, user-defined base mineral library of expected minerals with idealized mineral compositions from Deer et al. (2013) as a starting point. The library can be customized to reflect the specific mineral chemistry of a deposit, particularly if high-precision analysis (e.g., electron microprobe) is available.

Geological rules derived from domain knowledge are incorporated into the model to ensure geologically reasonable, fit-for-purpose predictions. By leveraging various input datasets, minerals are dynamically added to the LP library on an interval-by-interval basis, helping constrain the mineral predictions. For example, if a sample shows a strong magnetic susceptibility, magnetite is selected, or if a sample has a strong HCl acid response, calcite is added. Shortwave infrared (SWIR) mineralogical data, particularly useful for phyllosilicate, sulfate, and carbonate minerals, helps prevent the overestimation of chemically similar minerals, especially phyllosilicates.

In this study, we validate the method by comparing LP-predicted modal mineralogy to quantified XRD mineralogy for the same sample. We then demonstrate the upscaling potential of the proposed workflow using drill core datasets from two porphyry copper-gold deposits in British Columbia, Canada. One dataset integrates industry-standard, multi-element four-acid drill core assays with co-registered portable X-ray fluorescence (pXRF) Si values and SWIR mineralogy. The other dataset combines co-registered SWIR and XRF major element data from multi-sensor core imaging technology. The ability to predict mineralogy across a deposit has broad applications in exploration, rock mass characterization, and tailings management.