High-Resolution VNIR-SWIR Core Logging: A Revolutionary New Tool for Exploration, Mining, and Research

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Over the past 25 years, airborne and ground-based spectral analysis of rock samples by short wavelength infrared (SWIR) spectrometry has become a robust and widely used tool for mineral exploration. The technique allows rapid field-based identification of hydrothermal alteration minerals and delineation of alteration zones. Technological advances in the past decade, including increased processing capacity combined with precision robotics in high-resolution spectrometers, have resulted in a new generation of high-speed hyperspectral core logging systems becoming available. The application of these multisensor automated platforms provides a step change in our characterization of ore systems. With a spatial resolution down to 0.5 mm, it is now possible to complete drill core-based, deposit-scale petrographic studies of relevance to exploration, mining, and research.

Huge volumes of data are now produced from a single scanner that integrates reflectance spectroscopy, visual imagery, and 3-D laser profiling. Reflectance spectroscopy can generate over 160,000 spectral pixels per meter from which processed outputs include semiquantitative mineral volume percentages and mineral chemistry determined from characteristic absorption features in the SWIR covering the ~450- to 2,500-nm range. Spectral classification and mineral identification algorithms process each spectral pixel and compare the response to an established mineral library. The identification algorithms classify each pixel and determine the relative abundance (or purity) of the minerals present, which is then used to produce visual mineral abundance maps as well as numerical abundance logs. Chemistry and crystallinity parameters can be calculated for specific mineral groups by analyzing spectral absorption features at particular wavelengths. Inherently, this requires large volumes of data storage and significant processing speeds.

At 500-μm spatial resolution and with ~520 spectral bands, a 1-m length of core will typically generate ~150,000 spectral pixels and consume ~250 Mb of storage (a 500-m drill hole therefore contains ~80 million spectral pixels and 122 Gb storage). Parallel processing algorithms running on multiple CPUs with fast storage arrays allow the data to be processed efficiently and interpretation products to be delivered in a timely manner. Typical processing benchmarks achieve ~1,000 pixels per second per CPU (~6 hours per 500-m drill hole at 4 CPUs). Introduction of on-site 24-hour processing has meant that real-time mineral maps are available to focus the geologist tasked with core logging.

Application of automated scanning technology makes it possible to complete deposit-scale petrographic studies using VNIR + SWIR that complement more traditional cm-scale sampling completed using optical or electron microscope-based observations. High-resolution spectral mapping provides quantifiable outputs that confirm observations commonly made regarding the zonal arrangement of alteration in porphyry, epithermal, and orogenic ore deposits. Deposit-scale petrographic observations can contribute new insights to interpretation of hydrothermal processes, and can assist refinement of exploration models. Application of this technology helps remove subjectivity from geological observations and standardizes the data being collected. More importantly, it refocuses the geologist away from being a data collector to rapidly building their understanding of the deposits being drilled, and provides geologists with the ability to rapidly and accurately define robust geological domains that underpin resource models. The combination of detailed mineralogical and chemical data in three dimensions on orebody scale promises to deliver new insights into the mineralogical and chemical characteristics, 3-D spatial variability, and genesis of orebodies—outcomes of great importance to explorers, miners, and researchers.