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## Hyperspectral drill-core imaging for ore characterization

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Mineral exploration campaigns represent an essential step in the discovery and evaluation of ore deposits required to fulfil the global demand for raw materials. Thousands of meters of drill-cores are extracted in order to characterize a specific exploration target. Hyperspectral imaging is recently being explored in the mining industry as a tool to complement traditional logging techniques and to provide a rapid and non-invasive analytical method for mineralogical characterization. The method relies on the fact that minerals have different spectral responses in specific portions of the electromagnetic spectrum. Sensors covering the visible to near-infrared (VNIR) and short-wave infrared (SWIR) are commonly used to identify and estimate the relative abundance of minerals such as phyllosilicates, amphiboles, carbonates, iron oxides and hydroxides as well as sulphates (Clark, 1999). The distribution of these mineral phases can frequently be used as a proxy for the distribution of ore minerals such as sulphides. Typical core imaging systems can acquire hyperspectral data from a whole drill-core tray in a matter of seconds. Available sensors record data in several hundreds of contiguous spectral bands at spatial resolutions around 1 mm/pixel.

In this work, we apply a local high-resolution mineralogical analysis, such as SEM-MLA (Kern et al., 2018), for a precise and exhaustive mineral mapping of some selected small samples. We then upscale these mineralogical data acquired from thin sections to drill-core scale by integrating hyperspectral imaging and machine learning techniques. Our proposed method is composed of two main steps. In the first step, after initially co-registering the hyperspectral and high-resolution mineralogical data and making a training set, a machine learning model is trained. In the second step, we apply the learned model to obtain mineral abundance and association maps over entire drill-cores.

The mapping is further used for the calculation of other mineralogical parameters essential to exploration and further mining stages such as modal mineralogy, mineral association, alteration indices, metal grade estimates and hardness. The proposed methodological framework is illustrated on samples collected from a porphyry type deposit, but the procedure is easily adaptable to other ore types. Therefore, this approach can be integrated in the standard core-logging routine, complementing the on-site geologists and can serve as background for the geometallurgical analysis of numerous ore types.

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