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Supervised machine learning for the quantification of mineral phases in drill-core hyperspectral data

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Discovery and delineation of new ore deposits require substantial investment into diamond-drilling. Traditionally, the extracted drill-cores are visually analysed by site geologists and subjected to geochemical analyses for metal grade evaluation. Frequently, the geochemical information is insufficient for the evaluation of the mineralization and system morphology, mineralogical data being therefore required. Traditional mineralogical analyses such as optical microscopy, scanning electron microscopy, and X-ray diffraction are time consuming, require extensive sample preparation and deliver non-continuous point information. Due to its fast acquisition time, low sample handling requirements, and non-invasive character hyperspectral drill-core scanning has recently become an efficient tool for lithological / alteration drill core logging. Most commonly used for drill core scanning are visible to near-infrared (VNIR) and short-wave infrared (SWIR) hyperspectral sensors. These sensors allow the identification of mineral groups that show a specific signature as they absorb parts of the incoming light between 400 and 2500 nm. Many of the spectrally active minerals such as white micas, chlorites, epidotes or gypsum play an important role in exploration mapping as they have specific associations with the ore minerals and strong zonality in their distribution within the deposit. They can, therefore, be used as proxies for exploration vectoring and ore deposit modelling. Their compositional analysis and quantification has thus become an important tool for exploration. Commonly used methods for mineral abundance estimation from hyperspectral data consist in unmixing algorithms, which strongly rely on endmember extraction techniques. However, the obtained endmembers consist of mineral mixtures due to the spatial resolution of most hyperspectral sensors; the unmixing results will thus only define abundances of mixed compositions. We propose to overcome this issue by using a supervised machine learning-based methodology. We use the abundance of SWIR active mineral groups in selected representative known areas of the drill-core samples for predicting the mineral compositions at the drill-core scale.

The training data consists of high-resolution scanning electron microscopy-based mineral maps resampled to the resolution of the hyperspectral image. As a result, the resampled image contains the abundance of each selected mineral or mineral group at each pixel. An artificial neural network-based regression is used to upscale the mineral abundances from the training set to the entire drill-core sample. Preliminary results show a great potential for automation and allow for the evaluation of the individual abundance of each mineral or mineral group.