Roadmap to Multi-scale 3D Geological Modelling from Drill-core Hyperspectral Data

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Drill-core extraction is essential for the characterization of deposits in mineral exploration, but the traditional logging process is fraught by biases and inconsistencies. Hyperspectral drill-core scanning can complement traditional logging techniques by providing continuous, high-resolution mineralogical data over the length of entire boreholes in a fast, reproducible, non-destructive, and cost-effective way. Hyperspectral drill-core scanning is by now widely applied in the mining industry. However, the results are big datasets that are challenging to interpret, validate and incorporate into the traditional workflows. In this contribution we showcase a procedure to increase the value of hyperspectral imaging to an exploration campaign by incorporating the following key elements: I) Automatic pre-processing of large, deposit-scale hyperspectral datasets. II) Unsupervised image processing to attain mineral and alteration maps as well as domains that are consistent across the entire dataset, as a basis for sample selection. III) Supervised classification of hyperspectral data for quantitative mineral abundance predictions along boreholes, using quantitative mineralogical data as training input and dictionary learning, an efficient machine learning technique. IV) Transformation of mineral abundance predictions into multi-scale and geologically meaningful lithological domains via a segmentation algorithm based on a continuous wavelet transform and subsequent classification. Finally, we present a multi-scale approach to correlate these derived domains for 3D geomodelling based on implicit scalar field representations, where the boundaries to be interpolated are identified as marker horizons and are further informed with mineralogical compositional data. In multi-scale modelling, the choice of the scale to work with is made by the user, where domains at larger scales are used for regional modelling, and smaller scale domains are used for modelling with higher resolution within the sub-blocks.