Fusion of Hyperspectral and High-Resolution Mineralogical Data in a Machine Learning Framework for Drill-Core Mineral Mapping

I. Cecilia Contreras, Mahdi Khodadadzadeh, Laura Tusa and Richard Gloaguen

Helmholtz-Zentrum Dresden-Rossendorf, Helmholtz Institute Freiberg for Resource Technology, Division "Exploration Technology", Chemnitzer Straße 40, 09599 Freiberg, Germany;
i.contreras@hzdr.de; m.khodadadzadeh@hzdr.de; l.tusa@hzdr.de; r.gloaguen@hzdr.de.

Drilling is an important stage in sub-surface exploration campaigns to extract indicative mineralization information and evaluate geological mineral deposits. This activity has been steadily increasing in the last years due to the growing demand in the raw material sector. In 2019, a total of 38,958 drill holes were reported worldwide belonging to 1,093 projects.

Traditionally, visual drill-core logging is performed by different geologists on-site to determine e.g., the lithology, structures, mineralogy, and alteration zones. Such qualitative logging relies on the geologist's interpretations and is extremely time-consuming. To complement and automate drill-core logging, hyperspectral imaging is becoming an increasingly popular tool. The mineralogical information extracted from drill-core hyperspectral data allows geologists to rapidly characterize a large number of drill-cores in a nondestructive and noninvasive manner. Drill-core hyperspectral data have been commonly processed following basic and established tools in commercial software, which require a large amount of expert interaction. This motivated us to explore the use of machine learning techniques to improve drill-core analysis. Particularly, we explore the use of supervised machine learning techniques for the task of mineral mapping. Although these techniques require confident training data, they are highly accurate and reliable.

Defining meaningful classes and collecting representative samples for training a supervised classifier is not straight-forward in drill-core samples. In this work, we suggest the use of the Scanning Electron Microscopy (SEM) instrument integrated with the Mineral Liberation Analysis (MLA) software to generate the training data from small surfaces of the drill-core samples that are fully representative. SEM-MLA is a modern tool that provides high-resolution mineralogical information from small polished thin sections. For a successful fusion of both the SEM-MLA and hyperspectral data, we first resample the SEM-MLA data to the resolution of the hyperspectral data and carefully coregister them. Then, we generate the training set from the resampled SEM-MLA data and we apply the generated training set in a machine learning classification system. We suggest using Random Forest and Support Vector Machines since they can handle high-dimensional data with a limited number of training samples.

Our proposed machine learning framework is an effective approach to fuse these two techniques that are being used in the mining industry. This fusion framework shows to exceed the mapping capabilities of the traditional methods and provide the means to up-scale the detailed mineralogical information from small portions of the drill-cores to entire drill-core samples with classification accuracies of above 70%. Hence, our proposed logging system not only accurately map alteration patterns, such as veins, but also well characterize the mineralogical variations along the cores.

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