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Quantitative mineralogy of chromite ore based on imaging Laser Induced Breakdown Spectroscopy and Spectral Angle Mapper Classification Algorithm

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The chemical, mineralogical and textural investigation of drill cores demands objective and repeatable information unaffected by the human bias to be able to correlate significant features across drillcores. Imaging Laser induced Breakdown Spektroscopy (LIBS) can be applied to large scales at high spatial resolution in relatively short times to obtain detailed chemical, mineralogical and textural information with a minimum of sample preparation. The application of the Spectral Angle Mapper (SAM) algorithm for supervised classification of the LIBS hyperspectral data cubes provides a relatively fast, but easy to handle tool to visualize and quantify variations in the chemical, mineralogical composition of complex ores from the sub-millimetre to the metre scale. The information derived offers novel and barely investigated interpretation opportunities in a very detailed manner which directly can be used for exploration purposes. The investigated Merensky Reef is about 1 m thick. It consists of pegmatoidal pyroxenite framed by the lower and upper thin chromitite seams. The Merensky Reef is one major ore body out of three for platinum-group elements (PGE) within the Bushveld Igneous Complex which is the world's largest known layered intrusion and largest PGE resource on Earth   Detailed LIBS-based imaging measurements with 200µm spotsize were accompanied by space-resolved reference measurements based on SEM/MLA (4µm) and µ-EDXRF (20µm), as well as bulk chemical analyses for multiple core slices. The SAM algorithm was applied for classification of hyperspectral LIBS images as being sensitive for differences in mineral chemistry. Focus was put on the pre-processing of LIBS spectra prior to SAM classification, on the development of the spectral library, and on the validation of the classified data. The SAM classification algorithm, which is solely based on ratios between spectral intensities, was found insensitive to normal shot-to-shot plasma variations and to chemically induced matrix effects. However, the algorithm may become inaccurate at low signal to noise ratios, at the border between different mineral grains (mixed spectra), or when classifying chemically similar phases such as pyrite and pyrrhotite. The extent of mixed spectra depends both on the size of the mineral grains as well as on the spot size of the LIBS laser. The SAM algorithm was successfully applied for classification of several base metal sulphides, rock-forming minerals, accessory minerals, as well as several mixed phases representing the main borders between different mineral grains. The obtained classified LIBS image images the spatial distribution of the different phases, which corresponds very well to the reference measurements based on highly space-resolved EDXRF and SEM/MLA mineral distribution maps. The investigated core piece highlights the extremely heterogeneous distribution of e.g. the sulphide phases. The LIBS-SAM classification image was used to estimate metal concentrations based on point counting. The applicability has been explored for Cu, Ni, S, and Cr. This approach, when applied on sufficiently large surfaces, enables quantification of well-defined mineral phases, as well as the possible detection of trace elements (e.g. Pt, Pd) that occur in very small nuggets.