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Generation of Element and Mineral Distribution Maps by Scanning Laser Induced Breakdown Spectroscopy (LIBS)

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Scanning Laser Induced Breakdown Spectroscopy (LIBS) is an upcoming technique, which may provide a fast method for the characterisation of element and mineral distributions on relatively large unpolished surfaces of geomaterials.

LIBS is a type of atomic emission spectroscopy, which uses a highly energetic laser pulse as the excitation source. The laser is focused onto the surface of the sample, ablating a very small amount of material, generating a plasma. At the initially very high temperatures, the ablated material dissociates (breaks down) into excited ionic and atomic species. The characteristic atomic emission lines of the elements can subsequently be observed.

Our LIBS-instruments (from LTB Berlin, Germany) operate with a Nd:YAG 1064 laser and a high resolution broad-range Echelle-spectrograph with a CCD detector. Sample sizes of 1000 x 25 mm at a laser spot size of $\sim$100 μm can be analysed with the LIBS-core-scanner, and sample sizes of 50 x 50 mm at a laser spot size of 60 μm with the LIBS-microscope.

For the elements of interest (metals, e.g. Cu, Pb, Zn, Cr, Ni, Co, Sn, major elements, e.g. Fe, Al, Si, Ca, Mg, Na, K, S, and other elements, e.g. Ba, Sr, Ti, Zr, Ta, Nb, Y), a minimum of two characteristic atom lines were selected in the spectra. The spectra were then automatically processed to calculate integral values over the selected peaks. Ratios between peak values of the same element were used to check and correct for possible peak overlap from neighbouring peaks. The results were used to generate element distribution maps.

Typical classification algorithms (e.g. minimum distance, binary encoding) were used to explore the possibilities to classify the results based on mineralogy. Either the element distribution maps or the reduced spectra were input in the classification algorithm. Previously identified mineral particles were selected as end members.

The present study will first demonstrate the method on homogeneous samples with known composition. Subsequently, the method is demonstrated on well-characterised rock samples (e.g. chromitite layer from Merensky Reef, rock salt, coltan ore, copper shale) and on material from mine tailings. Finally, the advantages and disadvantages of the method are discussed.