Automated mineralogy as efficient tool for provenance analysis of stream sediments and mineral exploration

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Introduction

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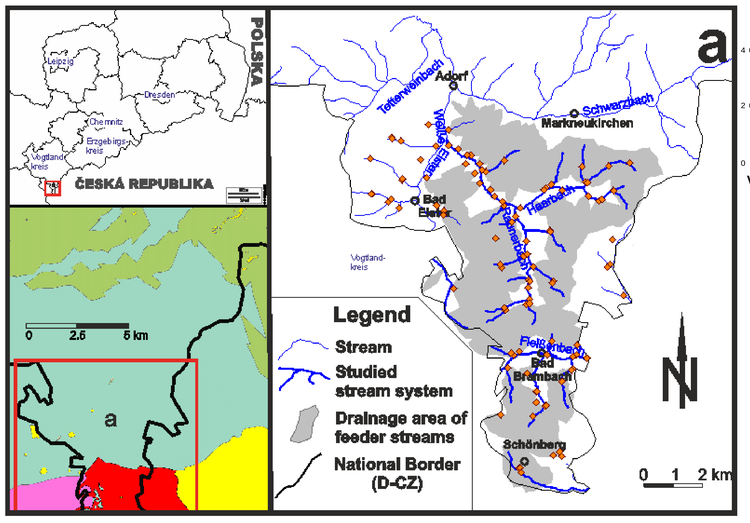
The Erzgebirge and neighbouring Vogtland are well known for the occurrence of granite-related mineral systems, represented as polymetallic skarn-, vein-, stockwork- and greisen-type deposits. Some of the deposits currently explored have been exploited for centuries for their remarkable amounts of Sn, In and Li – others have been known for decades. The regional and local geological setting (especially the magmatic and metamorphic lithological units) of these deposits is very well understood. Therefore, the Erzgebirge and Vogtland are excellent study areas to test innovative exploration methods, such as the use of quantitative mineralogical data from modern stream sediments as a proxy for granite-related mineralization. The present study aims to provide such proxies of provenance and transport mechanisms by using automated SEM-based images analysis. The approach includes a grain-size window as wide as possible and at the same time optimizes the statistical evaluation of both bulk sediment composition and single grain analysis.

Sampling strategy

Samples were collected from the main streams, as well as the associated lower order streams, in the Bergen-granite and Fichtelgebirgs-granite districts. In both areas main streams were sampled with constant distance (300-600m). The Fichtelgebirgs-granite district is characterized by clearly differentiated lithological units, which provide obvious signals within the sediments. This study is used for initial adjustment of the measurements and calculations.

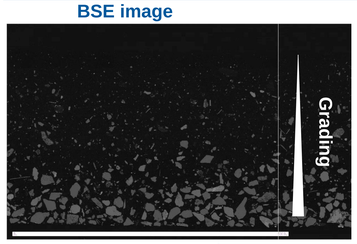


Method

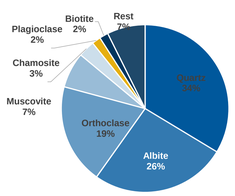
Mineral liberation analysis combines the information of Backscattered Electron (BSE) Images and Energy Dispersive X-ray-Spectrometry (EDS). In order to provide a holistic grain size window the samples are prepared with respect on gravitational processes. Cutting and re-preparation of grain mounts to represent grading-related grainsize varieties of the sample.

Key information provided by MLA

BSE image



Modal mineralogy



False color image

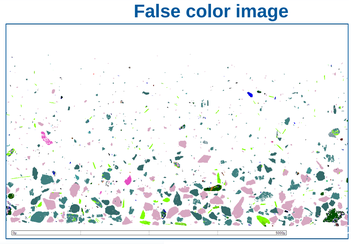


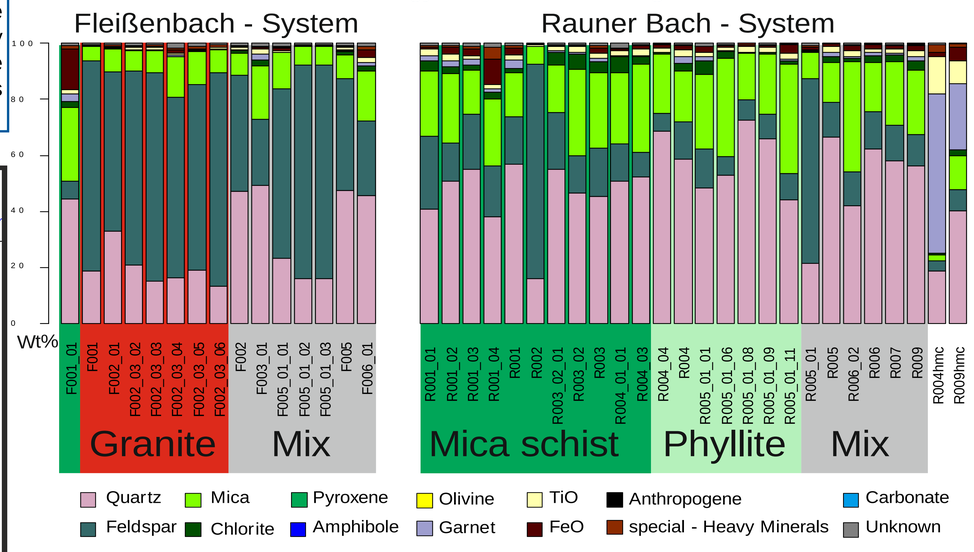
Image analysis

Combination BSE and false colour images, highlighting provenance factors such as: Indicator mineral identification, single grain analyses, detection of anthropogenic contamination.

Data extraction and statistical analysis

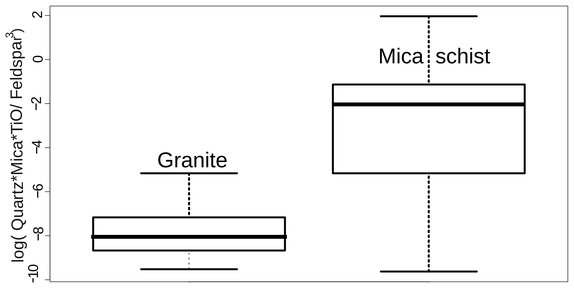
The generated data sources contain grain parameters (i.e. grain size and grain shape) as well as the mineralogical composition and properties (e.g. chemical composition, density) of each grain (20000 to 50000 grains per sample) and the individual sub-grains.

Modal mineralogy related to the lithological units



Statistical analyses

Robust statistical analyses provides the key to maximize the use of the big set of data provided by MLA. Statistical analysis allows prediction and correlation of trends and dependencies recognizable in the sample suit.



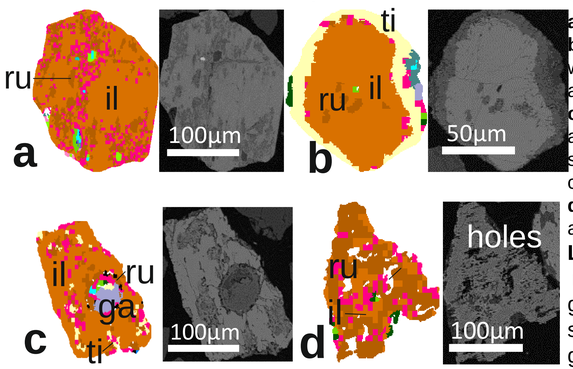
Principal component analyses

Boxplot of the differentiation of granite and mica schist based on the modal mineralogy provided by the MLA measurements. Calculated by the relation between the Quartz and mica to Feldspar content

Single grain analyses

Grains can be easily filtered and separated, independent of the weight percentages retained in the sediment. High resolution of MLA Analysis allows to distinguish detail grain structure, even mineralogical and chemical changes within the grains.

Alteration and transport features on Ilmenite-grains



a: slightly rounded; **b:** slightly rounded, weathering related alteration, il-ru-ti; **c:** alteration prograding along zones of weakness, slightly rounded with initial corrosion remains; **d:** highly corroded and altered grain. **Legend**: il-Ilmenite, ru-rutile; ti-titanite, ga-garnet, pink-mixed spectra, green-phyllosilicates

Anthropogene influx within modern sediment

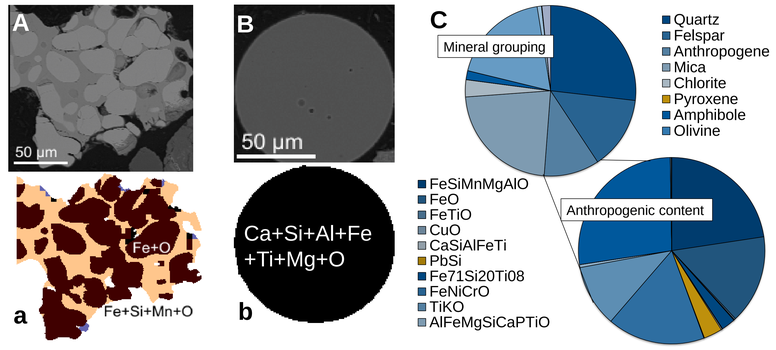


Figure description: Identification anthropogenic phases, to approximate and deduct the anthropogenic contamination. BSE (**A,B**) and false color (**a,b**) pictures of the anthropogenic contamination; chemical composition (provided by EDS). Based on these measurements the composition and amount of the contamination within one Sample can be calculated (**C**).

Conclusions

Current provenance studies rely on standard analytical methods, such as bulk sediment geochemistry, petrographic evaluation (i.e. point counting), indicator mineral and single grain analyses. In this study, we introduce to Mineral Liberation Analysis as a potentially powerful new tool for sediment provenance studies. We also test its potential application to derive vectors for mineral exploration. Results illustrate that the true potential of MLA data for mineral exploration goes far beyond the big database of quantitative data it is able to generate. Rather, it provides the possibility to implement efficient routines that allow discovering and tracking of changes in mineralogy, mineral grain sizes, shapes or mineral associations within a complex system, comparing population of sediment samples.

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