Cathodoluminescence analysis of zircons

Zircons (ZrSiO₄) are ubiquitous in the crust of Earth and are a common accessory to trace mineral constituent of most granite and felsic igneous rocks. Zircons have low solubility in most melt and fluid compositions and can survive geological processes such as erosion, transport, or high-grade metamorphism. This makes zircon one of the most important minerals for geochronology. Different types of zircon domains are identified by CL imaging and U-Pb dating is then used to determine ages of different zones within the crystal. This helps to recognize various geological processes recorded during the history of the grain.

Samples and instrumentation

The representative set of about 50 zircon grains were collected during field exploration work in the Zr/Nb-REE deposit Khalzan Bureghtei in North-western Mongolia. The zircon grains were embedded in epoxy block. The analytical surface of the block was polished and coated with 10 nm of carbon. For high resolution imaging MIRA3 field-emission SEM equipped with TESCAN Color CL detector was used. THE EDX mapping was done with a VEGA3 equipped with a thermionic tungsten gun and with a special ultra-fast scintillation BSE detector and the TESCAN panchromatic CL detector.

Results

Most of the grains appeared dark in CL. This indicates a high degree of metamictization (internal radiation damage that leads to degradation of the minerals crystal structure). A few grains showed oscillatory zoning while irregular patchy zoning (overgrowing by the youngest generation of hydrozircon) was more frequent (see Fig. 2 and 3). Those were the youngest generation of zircon grains in the sample. Most inclusions in the grains were identified by EDX mapping as Al silicate and quartz (see Fig. 1). All the zircons were strongly affected by hydrothermal overprint and that is why most of the grains exhibited very typical reprecipitation textures along cracks and fracture fillings.

Fig. 1 a-c: A group of zircons imaged with BSE (1a), CL (1b) and EDX (1c) detectors. In the EDX map regions containing Al (red), Si (green) and Zr (blue), respectively.
Application Example
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Conclusions

Complementary EDX, BSE and CL analyses were used as a foundation for in-depth geochronological study of zircon grains from North-western Mongolia. TESCAN MIRA3 microscope with integrated Color CL detector with very large field of view proved to be an ideal tool for detailed structure study of zircons.

Fig. 2 a-c: CL images provide detailed information about the crystallization and deformation history of each zircon. Concentric oscillatory zoning indicates multiple stages of zircon crystallization in magmatic environments (2a). Irregular, patchy zoning indicates alteration by metamorphism (2b). Different zones are clearly distinct (2c). Images were taken with low accelerating voltage (5kV to 10kV) to resolve fine zoning details.

Fig. 3 a-b: CL (3a) and BSE (3b) image of a zircon grain showing unusual high grade of dissolution, probably due to highly fluorinated fluids. This is indicated by the bright rims of the grain. Red inclusions (e.g. in the left lower part of the grain) are formed by quartz.

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