Cathodoluminescence Microscopy of HP- and UHP-metamorphic minerals: New avenues to understanding petrological processes

Hans-Peter Schertl

Institute of Geology, Mineralogy and Geophysics, Faculty of Geosciences, Ruhr-University Bochum, 44780 Bochum, Germany

During the last 50 years, the technique of cathodoluminescence (CL) microscopy has become a standard tool in mineralogy, particularly well-known for studying sedimentary rocks and internal structures of zircon prior to age dating using in-situ ion-probe and laser-ablation methods. Within the last 20 years, this technique has also been applied to various other minerals in metamorphic and magmatic rocks.

In this contribution the significant advantages of a “hot-cathode” CL microscope will be demonstrated, especially in conjunction with EMP, mineral-inclusion, age-dating and oxygen-isotope studies of HP- and UHP-metamorphic rocks, using just standard polished thin sections. The compilation of data presented include samples from the Dora-Maira Massif (Italy), the Kokchetav Massif (Kazakhstan), Sulu and Dabie Mountains (China), the Western Gneiss Region (Norway), Pohorje (Slovenia), Erzgebirge (Germany), Isla Margarita (Venezuela), the Rio San Juan Complex (Dominican Republic), and the Motagua Valley (Guatemala).

A special focus will be on (1) regular and irregular (in some cases very complex) growth structures of garnet, jadeite, omphacite, zoisite/clinozoisite, kyanite, carbonates, and clinopyroxenes; (2) oscillatory zoning patterns of garnet, jadeitic clinopyroxenes, kyanite, and zircon; (3) exsolution patterns of K-feldspar in clinopyroxene and dolomite in calcite. Further documented studies involve the change of crystal morphology during growth (e.g., in garnet, jadeitite, diopside), as well as dissolution and deformational effects (garnet). Distinguishing features of different silica phases like coesite (bluish-green luminescence), quartz (dark red to violet), chalcedony (yellow), as well as those of aragonite (green), calcite (yellow), Mg-calcite (orange), and dolomite (red) will be presented, as well as the characteristics of different quartz and carbonate generations. Such CL-investigations also contribute to a better understanding of mineral reactions, in particular in considering the formation of pseudomorphs and symplectites. Additional studies will focus on interstitial phases, different annealed crack systems of rock matrices and the influence of radioactive damage. Accessory luminescent minerals like greenish-blue diamond, blue zircon, green apatite and bearthite are easily identified in thin section, even if they occur in small abundances only.

Moreover, CL-microscopy is far from being only a simple descriptive method. Using high-resolution spectroscopy of the CL-emission, it is possible to evaluate the spectra of different minerals. Narrow bands of, for instance Cr^{3+}, Dy^{3+}, Sm^{3+}, Tb^{3+}, and broad bands like Mn^{2+} can be easily distinguished, even in different zones of the same mineral (e.g., in garnet, clinopyroxene, kyanite, carbonates).

In essence, CL enables colour images of important but otherwise not visible growth structures of minerals to be obtained easily, inexpensively and quickly. A knowledge of the detailed structural characteristics of rock-forming minerals has an invaluable impact on deriving more precise and detailed PT-paths and thus allows the evolution of geodynamic processes within metamorphic rocks to be better understood. Thus it is proposed that the CL-technique should be used more intensively for routine investigations of thin sections, in particular as a pathfinder prior to possible further characterization using other techniques.