Micro-texture and cathodoluminescence (CL) characteristics of high-purity quartz from Russia

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High-purity quartz from ten different localities of Russia was investigated to verify the possibility of using these materials as high-purity silica for industrial applications. The sample material included quartz from pegmatite, hydrothermal vein quartz, tectonically deformed and partially recrystallized hydrothermal quartz as well as quartz from two quartzite occurrences. The samples were investigated by polarizing and CL microscopy as well as CL spectroscopy, to get information about the micro-texture of the samples, mineral and fluid inclusions, and the defect structure of the different quartz types. Additional analytical data were obtained from trace-element analysis, fluid inclusions studies, Fedorovski-table microscopy, low-angle X-ray diffraction and electron back-scattered diffraction (EBSD).

Cathodoluminescence imaging revealed first insights into the micro-structure and homogeneity of the quartz samples. Micro-inclusions of feldspar (bright blue CL), carbonate (orange CL), zircon/monazite (bright radiation halos) and mica (non-luminescent) were clearly detectable by CL. Moreover, features of alteration, recrystallization/reorganization as well as trails of fluid migration could be revealed by CL (Fig. 1). Characteristic luminescence colours of quartz with different geological history and associated spectral CL measurements provided information about the defect structure and incorporated trace elements, primary growth conditions and processes of secondary overprint, which all influence the properties and quality of the potential quartz raw material.

Quartz from hydrothermal veins exhibits a typical short-lived blue CL. The decrease of the main CL emission bands at ~390 and 500 nm during electron irradiation is due to the interaction of the cation-balanced Al-centres with the electron beam and indicates elevated trace element contents (Ramseyer & Mullis, 1990; Götze et al., 2001). Interactions of migrating fluids with the host quartz left their traces in trails of reduced CL intensities. For the first time an orientation-dependent behaviour of the CL during electron irradiation was observed. Sub-grains cut perpendicular to the c-axis (dark in polarized light) show a change of the initial blue CL colour into red (increase of the 650 nm band), whereas sub-grains with other orientations do not show this effect (Fig. 1a–c).

Deformation of hydrothermal quartz resulted in a general decrease of the luminescence intensity and a homogenization of the CL pattern. This fact can probably be related to healing of defects and reduction of trace-element impurities due to recrystallization and reorganization processes of the quartz lattice. On the other hand, deformation twinning (Dauphiné Law) and formation of sub-grains was observed. Reduced CL intensities of sub-grain boundaries are probably caused by migration of fluids from opened inclusions.

Pegmatite quartz shows a homogeneous bluish-green CL with a characteristic CL emission band at ca. 500 nm (Götze et al., 2005; Fig. 1f/g). The transient CL also indicates elevated contents of certain trace elements (e.g., Al, Li). In contrast, quartzite samples are relatively heterogeneous under CL and inherit micro-inclusions originating from the primary source rocks (Fig. 1i).

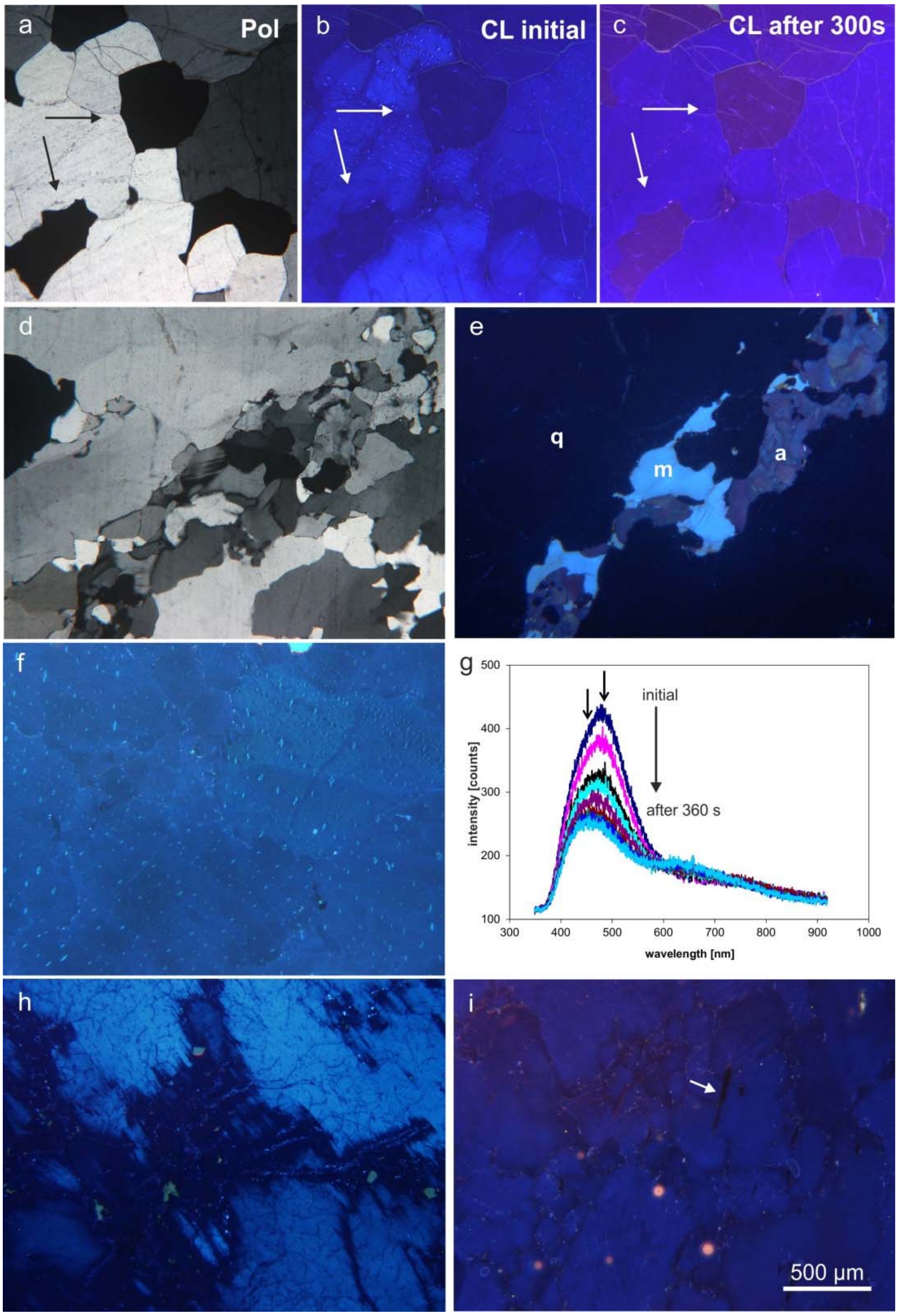

Fig. 1. *Characteristic micro-textures and CL features of investigated high-purity quartz;* ***a–c*** *Orientation dependent CL behaviour of a hydrothermal quartz during electron irradiation; grains cut perpendicular to the c-axis show a change of blue CL to red-violet;* ***d/e*** *Polarized light/CL micrograph pair of a deformed hydrothermal quartz showing vein-like formation of microcline (m) and albite (a) within the dark-luminescent quartz (q) matrix;* ***f/g*** *CL image and related time-dependent CL spectra of pegmatite quartz with a characteristic transient 500 nm emission band;* ***h*** *Hydrothermal quartz with irregular CL patterns due to fluid migration;* ***i*** *Quartzite with inclusions of zircon/monazite (bright radiation halos) and mica (dark CL, see arrow).*

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