

CATHODOLUMINESCENCE OF MOLDAVITES. B. Fritzsche¹, J. Götze² and J.-M. Lange³, ¹Institut für Mineralogie, TU Bergakademie Freiberg, Brennhausgasse 14, D-09599 Freiberg, Saxony, Germany, fritzke@mailer.tu-freiberg.de (bjoernfri@web.de), ²Institut für Mineralogie, TU Bergakademie Freiberg, Brennhausgasse 14, D-09599 Freiberg, Saxony, Germany, goetze@mailserver.tu-freiberg.de, ³Sektion Petrographie, Senckenberg Naturhistorische Sammlungen Dresden, Königsbrücker Landstraße 159, D-01109 Dresden, Saxony, Germany, jan-michael.lange@senckenberg.de.

Introduction: Moldavites are tektites, which originate from an initial phase of the Ries meteorite impact. Although already several investigations on moldavites have been carried out, there are no luminescence studies on tektites of the Central European Field despite one thermoluminescence analysis [1]. The present study provides first results of cathodoluminescence (CL) microscopy and spectroscopy of moldavites from different occurrences. Luminescence is the transformation of diverse kinds of energy into visible light due to an emissive transition of anions, molecules, or a crystal from excited electronic states to the ground state or a state with lower energy. Because luminescence of solids is dominated by defect luminescence, CL enables visualization of the real (defect) structure of materials.

Materials and Methods: The aim of the study was focused on general luminescence properties of moldavites, and the possible differentiation of tektites from different occurrences based on their CL properties. Furthermore, the potential of CL for the revelation of internal textures and heterogeneities within the tektites was tested. The material investigated comprises moldavite samples from the Southern Bohemia (MB), Moravia (MM) and Lausatia (ML) regions as well as the Cheb (MBC) and Radomilice (MBR) area. Thick sections of the samples were analyzed by polarizing microscopy, CL microscopy and spectroscopy and scanning electron microscopy (SEM). CL studies were performed using a hot-cathod luminescence microscope HC1-LM coupled with a peltier-cooled digital camera (OLYMPUS DP 72) and an Acton Research SP-2356 digital triple-grating spectrograph with a Princeton Spec-10 CCD detector.

Results and Discussion: CL microscopy clearly revealed internal textures and heterogeneities in the tektites, which were partly not discernable by optical microscopy (Figure 1). Two different types of CL could be distinguished. The matrix of the moldavites mainly luminesces in different shades of greenish-yellow. Streaks are clearly visible due to variations of the CL colours, which are probably also related to slight changes in chemical composition (Figure 1). Depending on the chemistry (basic or acidic), the streaks appear brighter or darker compared to the surrounding glass matrix. Inclusions of lechatelierite are clearly detectable due to their bright blue CL colour (Figure 2).

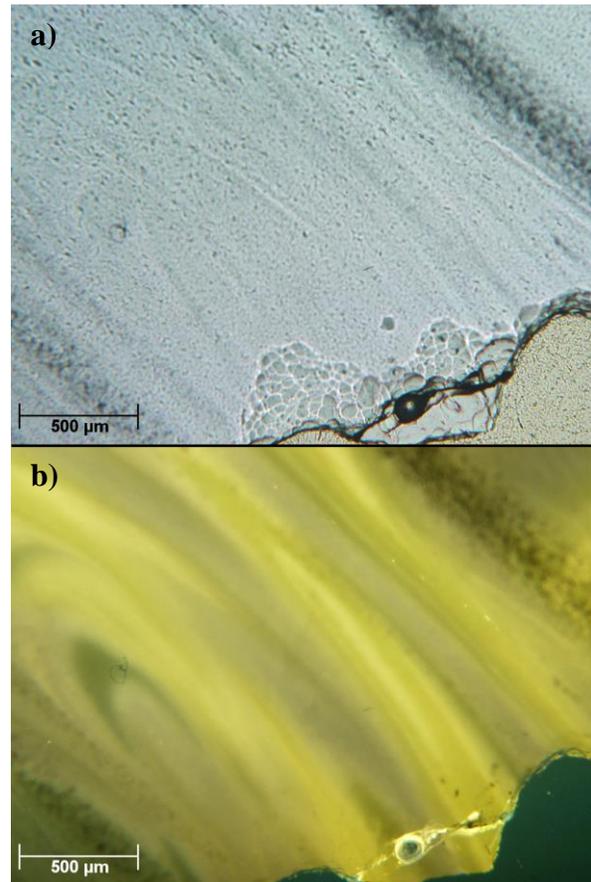


Figure 1: Internal textures of streaks in the sample MBR-RDM1. Difficult to observe by optical microscopy (a), and high-contrast by CL microscopy (b).

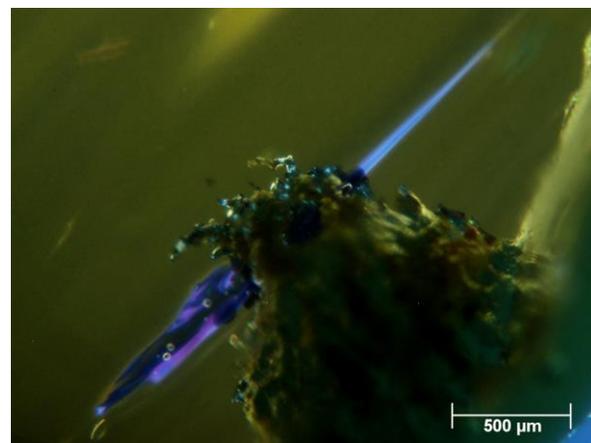


Figure 2: Lechatelierite inclusion with visible blue CL emission in the sample MB-JKV17.

Spectral CL measurements were realized to get information about the defects responsible for the different CL characteristics. The visible greenish-yellow CL is caused by three emission bands with the main emission at ca. 580 nm (2.14 eV) and two weak bands at 445 nm (2.77 eV) and 484 nm (2.56 eV) (Figure 3). Because of the similarity in chemical composition and CL behaviour with feldspar minerals (plagioclase), the activators for the CL of moldavites might be also comparable to those in plagioclases. Manganese is present in concentrations up to 0.2 wt-% in the investigated tektites, therefore Mn^{2+} substituting Ca^{2+} in the cation site could act as activator for the greenish CL [2]. Another explanation for the 580 nm emission is a possible structural defect (strong local disorder) as it was reported from altered feldspar crystals [3][4]. The blue emission bands at 445 and 485 nm in the green CL can be related to Al-O-Al defects similar to those reported from feldspar minerals [2][5]. The results of the study show that different shades of the tektite CL are the result of varying intensity ratios of the CL emission bands. No other emissions or shifts of the band positions were detected.

The visible blue luminescence of lechatelierite is composed of five emission bands at 652 nm (1.90 eV), 578 nm (2.15 eV), 538 nm (2.30 eV), 468 nm (2.65 eV) and 416 nm (2.98 eV) (Figure 4). Most of these emissions can be related to structural defects in analogy to other SiO_2 minerals [6]. The emission band at 652 nm is related to an NBOHC with different kinds of precursor centers. Defects generated during electron beam irradiation are the self-trapped excitations (STE). The Emission bands at 578 and 538 nm are the products of these STE's. The visible blue CL was most intense at 468 nm, which can be assigned to oxygen deficiency centers. A small band at 416 nm is responsible for a broadening of the 468 nm band and is probably related to a carbon impurity. Some other structural defects are possible as luminescence-centers for these emissions.

Conclusions: Two different types of CL (greenish and bluish) were observed. Differences of the visible colour between streaks and matrix or between lechatelierite rim and core are related to a variation of intensities of the emission bands. The green CL spectrum is generated by 3 emission bands, while the blue CL spectrum shows 5 bands. Most of the CL emissions are related to structural defects of the local network, influenced by the crystal field. Variations of intensity of CL emission between samples from the different localities were observed, but there is no direct correlation between substrewnfields and CL intensities. The optical CL microscopy is a powerful tool for the high-contrast observing of streaks and lechatelierite in the matrix.

A more detailed characterization of the defects could probably help to reconstruct the conditions responsible for the formation of the moldavites, e. g. to answer the question, whether the initial jet was a plasma or a supercritical fluid or to describe the parameters while the jetting phase. The CL can be also used to classify the moldavite strewnfield in further detail.

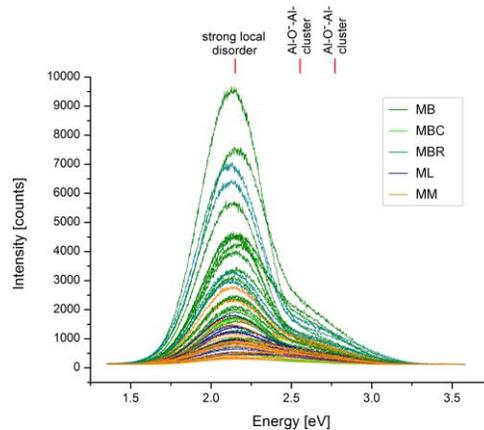


Figure 3: CL emission spectra of the green luminescing matrix of samples from the different substrewnfields.

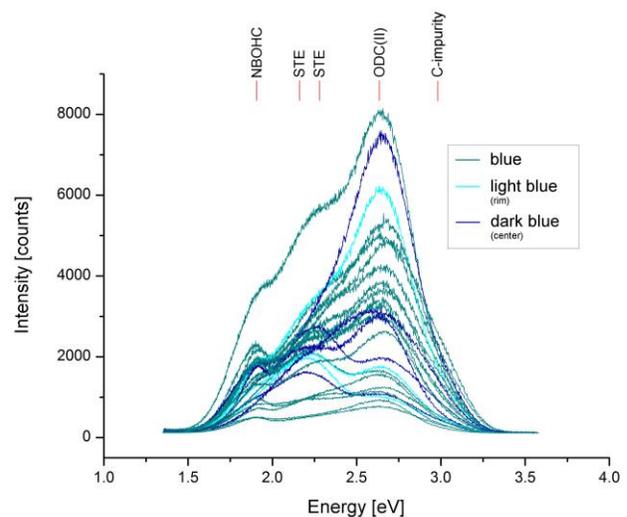


Figure 4: CL emission spectra of the blue luminescing lechatelierite inclusions.

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