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Preface

Recent developments in microbeam cathodoluminescence with applications to mineralogy

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This thematic set contains a series of papers arising from a symposium of the same name at the 15th Annual Goldschmidt Conference, held at the University of Moscow, Idaho, in May of 2005. Although luminescence (the ability of materials to emit light upon excitation with various kinds of energy) is a well-established technique in physics and the material sciences, its present widespread use in the geosciences was stimulated forty years ago by the introduction of the technique of cathodoluminescence (CL) to image the internal structure of minerals (Smith and Stenstrom 1965; Long and Agrell 1965). Many minerals exhibit the phenomenon of CL as a result of electron-beam interaction, a trait that can successfully be applied to the study and interpretation of zoning patterns in minerals and/or cementation in rocks (e.g., Mariano 1988). The state of the technique of CL, up to the end of the last millennium, had been laid out in a comprehensive book by Pagel et al. (2000) and this meeting was designed to explore developments and applications at the dawn of the 21st century.

The last decade has seen numerous advances in the application of microbeam-induced CL in the field of mineralogy, primarily related to improvements in instrumentation, software, and the ease of collection of imagery and emission spectra. Accordingly, this session sought to highlight and capitalize on many of these advances, and aimed to foster collaboration and discussion between various groups of geoscientists, mineral physicists, and chemists. It proved to be very successful, with a wide range of papers being presented. The following four papers are representative of the material presented, with a similar bias towards the use of hyperspectral CL imaging.

The extreme sensitivity of CL to tiny changes in composition or structure within minerals allows this technique to reveal fine-scale features that are not resolvable from samples studied by other methods (e.g., back-scattered electron imagery, optical microscopy; Rae et al. 1996). However, understanding the properties of the material that give rise to luminescence, such as defects, trace elements, etc., can often make the interpretation of CL in minerals very difficult. As such, this set of papers looks into some of the important questions that relate to the origin of CL in minerals while also highlighting advances in CL methods. These include the ability to collect and record full CL spectrum at each point in a scan using an scanning electron microscope based CL system, which results in the accumulation of a multidimensional data set, or "hyperspectral image" (Christen et al. 1991), and the ability to acquire data from different signals simultaneously during a single scan, the so-called "multimode" functionality (Edwards et al. 2003; Lee et al. 2005).

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Edwards et al. (2007) describe the use of combined cathodoluminescence hyperspectral imaging and wavelength dispersive X-ray analysis of minerals, coupled with multivariate statistical analysis that facilitates the identification and characterization of zoning within minerals, such as calcite and zircon. They demonstrate that this novel combination of microanalytical techniques significantly increases the effectiveness of CL as a diagnostic tool.

Lee et al. (2007) also visit the topic of hyperspectral CL imaging, describing a study of alkali feldspar of Proterozoic age from South Greenland. Here, they apply the technique of Edwards et al. (2007) to resolving long-standing questions concerning the activation of the blue emission band in cryptoperthitic alkali feldspar. From a combination of high spatial resolution electron probe microanalysis and CL spectroscopy, they demonstrate that the blue band is activated by the presence of Ti, while the red band relates to Fe activation. Thus, their study is a good example of applying these new techniques to obtain a quantitative understanding of luminescence activation.

Moving away from electron-microscope based CL work, to modifications of CL imagery obtained on the earliest type of petrological microscope-based CL systems, Barwood (2007) presents a paper that applies digital imaging techniques, particularly in the near infrared, to the study of CL images of minerals and rocks.

The final paper by Fris et al. (2007), while not strictly dealing with CL, describes the use of the closely related technique of ion beam-induced luminescence together with electron spin resonance to investigate the mineral leucophanite.

The Goldschmidt meeting provided a useful forum for discussion of these issues and it is certain that the debate will continue at future meetings. Editorial responsibility for the papers was taken by Ian Coulson, Paul Edwards, and Martin Lee. The following people contributed by reviewing papers in the thematic set, and are gratefully thanked for their assistance: Jocelyn Barbarand, Henry Barwood, Michael Gaft, Ulrich Glasmacher, Nigel Poolton, Timothy Rose, and David Wark. We also thank the editorial staff at the Mineralogical Society of America, for their cooperation and assistance in publishing these contributions.

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