From luminoscope to SEM-based hyperspectral imaging: An evolution of CL technology

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Introduction

Cathodoluminescence (CL)-based geological studies initially employed an electron flood source, a low vacuum chamber, and a light microscope. The "luminoscope," developed about 40 years ago, produces images on the scale of millimeters to centimeters, captured on film *via* a microscope-mounted camera. Roughly fifteen years ago, color filtered imaging and spectroscopy were added by combining fiber-optic and CCD capabilities. Scanning electron microscope (SEM)-based CL was developed several decades ago, primarily for optoelectronic applications [1], but was not widely used by earth scientists until the 1990s. SEM-based systems can capture CL down to micrometer-scale resolution. CL was once collected primarily by photomultiplier tube (PMT) technology. However, many "non-luminescent" materials luminesce in the red, outside the typical PMT wavelength range. In addition, in the absence of filters, PMT images capture only the total intensity of a sample's CL, integrating all wavelengths. (During the past decade, technological advances have overcome this problem.) Our present study is based upon CL imaging and spectroscopy employing three different detection systems.

Approach

Guatemalan jadeite and Archean zircon were imaged and their spectra collected using: 1) A SpectrMedix ELM-3R luminoscope equipped with a high sensitivity color CCD (Optronics magnafire) and a solid state (SBG ST) detector with a McPherson monochromator; 2) An SEM-mounted Gatan MonoCL 3+, which consists of a high efficiency collection mirror, RGB filters, a high sensitivity photomultiplier tube, and multiple gratings for spectroscopy; 3) A Gatan XiCLone array detector for parallel detection of spectra capable of hyperspectral imaging. By combining CL with other microchemical methods (e.g. EPMA and SIMS) we hope to constrain the processes recorded by CL contrast in the specimens.

References

[1] Holt D.B. (1992), *Scanning Microscopy* **26,** 135–143.

CL in support of interpreting gem deposits

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Cathodoluminescence is an extremely valuable technique for examining zoning in minerals and can lead to fundamental interpretations about how they formed. This technique is being applied to the origin of gem deposits which often suffer from poor sampling, inaccessibility, and various sample problems. CL of jadeite in jadeitites (jade) has proven critical to the interpretation that they formed by direct crystallization from hydrous subduction-related fluids in fractured serpentinizing peridotite. Microtextures and spectral analysis are being used to enhance study of jadeitites worldwide and to elucidate paragenesis of rubies, sapphires, painite, and other gems particularly from the marble-hosted deposits in Myanmar.

Jadeitites from the two distinct occurrences in Guatemala have been examined with a CL spectrophotometer on a SEM: Jadeite from a jadeite-phengite rock (MVE02-8-6) *south* of the Motagua Fault Zone (MFZ) shows ~2 broad emission peaks – major at 480 nm, associated with grain cores and inner rhythmic-banded overgrowths, and minor at 270 nm from cores only. Zircon in this rock shows ~4 peaks – major at 505 nm, semi-major at 410 nm, broad or doublet at 315, minor at 245 nm and very weak at 685 nm, with μm-scale banding involving all peaks equally and indicating zircon grew in place. The zircon CL is roughly equivalent to that from zircon in a lawsonite eclogite hosted in the same area of serpentinite mélange.

Jadeite from a coarse jadeitite (MVJ84-9B) *north* of the MFZ shows a stronger peak at 700 nm from grain cores and two smaller peaks at 560 and 480 nm correlated with fine banding. Zircon in this rock shows 4 peaks – a major one at 547 nm, smaller equal-intensity ones at 342, 279, 270 nm; each varies in intensity in different growth zones.

Reconnaissance CL on fluorescent corundum (ruby) from Myanmar shows both subtle growth banding on ditrigonal or scalenohedral faces and bright healing on fractures. Myanmar painite CL shows both planar and irregular growth zoning on a scale of <10 μm banding. These data support growth influenced by pulses of fluid in the marble host.