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Simultaneous cathodoluminescence hyperspectral imaging and X-ray microanalysis

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Technique

A facility has been developed to acquire hyperspectral cathodoluminescence (CL) images simultaneously with X-ray composition data. Based around an electron microprobe, the system uses a built-in Cassegrain microscope to efficiently couple emitted light directly into the entrance slit of an optical spectrograph. A cooled array detector allows the parallel acquisition of CL spectra, which are then built up into a multidimensional data-cube containing the full set of spectrally- and spatially-resolved information for later analysis. This setup has the advantage of allowing wavelength-dispersive X-ray (WDX) data to be recorded concurrently, providing a powerful technique for the direct comparison of luminescent and compositional properties of materials. The combination of beam and sample scanning thus allows the correlation of composition and luminescence inhomogeneities on length scales ranging from a few cm to sub-micron.

Applications and discussion

We will present examples of applying this technique to a number of zoned geological materials, including calcite (Lee *et al.* 2005) and zircons. These results show how the hyperspectral CL technique can be used to readily identify spatially-varying spectral features in a way not possible using flood electron gun or monochromatic CL imaging systems. We will describe our use of techniques, such as correlation plots, to investigate co-dependencies between individual spectral features and trace element WDX maps. We will also discuss the applicability and limitations of established multivariate statistical techniques in the analysis of hyperspectral CL data.

Reference

Lee M.R., Martin R.W., Trager-Cowan C. and Edwards P.R. (2005) *Journal of Sedimentary Research A* (in press).

Applications of cathodoluminescence in forensic geology

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Cathodoluminescence (CL) can be observed in many materials encountered in the forensic analysis of trace evidence including: soils, sand, dust, brick, concrete, slag, glass coatings and paint. In many cases, the major components of these heterogeneous materials are minerals such as quartz, feldspars and carbonates. Traditionally these minerals have been difficult to use for forensic discrimination or sourcing information due to their presence in nearly all samples. However, the variation of CL in a given mineral as a function of the source environment and subsequent sample history provides a new prospect for improving the value of mineralogical evidence, particularly for the some of the most commonly occurring minerals. Applications of CL to forensic evidence that will be presented include the following:

Identification: In soil and sand samples, many of the most abundant minerals luminesce. For these minerals, CL provides a quick method to identify the minerals present (*e.g.*, the class of feldspar), determine if multiple populations of a given mineral exist (*e.g.*, quartz) and estimate the relative abundances of the light minerals in a sample. In forensic paint samples, the pigment size (<1 μm) is too small for rapid identification using light microscopy, but CL provides a way quickly identify inorganic pigments and relative abundances.

Discrimination: Differences in the concentration of activator and quenching ions in a given mineral from different locations, as well as structural defects, will lead to variations in the resulting CL image and spectrum. Analogous to the way in which trace elements can be applied to group minerals from similar origins, CL provides a fast and relatively non-destructive means to discriminate among samples from different sources or environments.

Provenance: For certain minerals, the color of luminescence or pattern of zoning can be used to constrain the type of environment from which a particular grain originated (*e.g.*, quartz, zircon). This information can be extremely useful in helping to establish the geographic source of an unknown sample. Due to the complexity of environmental factors that can influence the CL properties of a given mineral, specific constraints are, at present, difficult to apply. However, as the relationships between diagenetic environments and CL in various minerals become better understood, the use of CL as a provenance tool will improve.