B66 Cathodoluminescence Microscopy in Forensic Science

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The goal of this presentation is to provide an introduction to the prin- ciples and practice of cathodoluminescence with a specific focus on the visual and spectroscopic information that can be obtained from forensic samples and the applicability of CL to cases of comparison, authentication, and provenance.

Cathodoluminescence (CL) is a microscopical technique applicable to a range questions involving the forensic analysis of trace evidence. This presentation will impact the forensic community and/or humanity by pro- viding visual and spectroscopic information provided by CL microscopy which can aid in comparison, authentication, and provenance examinations of soil, building materials, paints, duct tape, and glass.

Cathodoluminescence (CL) refers to the emission of visible (or near visible) light from a sample that has been bombarded by an electron beam. CL is observed in many materials routinely encountered in the forensic analysis of trace evidence (*e.g.*, soil, building materials, glass, pigments, and filler/extenders). CL results from the presence of trace elements or structural defects in materials, which are characteristic of either the geological environment of formation or the manufacturing process (for a syn- thetic luminescent material). The variation in luminescence for a particular mineral can therefore be used to discriminate among samples from dif- ferent sources or, in certain cases, provide information about the prove- nance of a sample. While a multitude of established techniques exist for the analysis of trace evidence, CL offers a widely-applicable alternative tech- nique that provides a unique means for visualization and identification of trace elements and structural defects in a sample.

Within the category of geological evidence (*e.g.*, sand, soil, and con- crete), many of the most abundant minerals are luminescent (*e.g.*, quartz, feldspar, and carbonate minerals). Traditionally, these mineral components have been difficult to use for forensic discrimination or sourcing due to their presence in nearly all samples; however, the variation in luminescence within a given mineral type provides a new prospect for improving the sig- nificance of geological evidence. CL provides a relatively fast method to screen soil samples through visual identification of luminescent minerals (*e.g.*, identification and classification of feldspars), the ability to determine if multiple populations of a given mineral exist (*e.g.*, quartz from different sources) and a means to estimate the relative abundances of luminescent minerals in a sample. Surface information including zoning (*i.e.*, composi- tional changes within a crystal), textures and coatings can provide addi- tional information about the origin of a sample. For example, fragments of biogenic carbonates can be morphologically identified. For other minerals such as quartz, the visible luminescence color can be broadly correlated with a geological formation condition (*e.g.*, metamorphic, volcanic, authi- genic). In addition to visual observation, CL spectroscopy can offer more detailed information about specific activators (defects and trace elements responsible for luminescence) in a given mineral. In feldspar minerals, the chemical composition can be estimated on the basis of the Fe^{3+} emission band. In heavy minerals such as zircon, monazite, and apatite, rare earth element activators, typically present at 1-500 ppm, can be identified spectroscopically. Together, visual and spectroscopic examination of mineral components can be combined to provide a variety of information about soil and sand samples that complement more traditionally used analytical techniques.

Many synthetic or anthropogenically modified minerals such as pigments and filler/extenders also luminesce (*e.g.*, anatase, wollastonite, zincite, and talc). Such minerals are utilized in the manufacturing of a variety of materials commonly encountered as forensic evidence including paint and duct tape. In both materials, CL provides a means to visualize details of the layer structure. In white architectural paints, for example, CL can be used to identify multiple layers that may not be visible by light microscopy. The three main components of duct tape, adhesive, backing and reinforcing fibers (*i.e.*, scrim) all luminesce. Within a given layer of paint or duct tape, CL can also be used to classify the major inorganic filler/extenders and pigments, estimate the size of the inorganic component and observe its distribution in a sample.

This talk will provide an introduction to the principles and practice of CL with a specific focus on the visual and spectroscopic information that can be obtained from geological and anthropogenic samples and the applicability and limitations of CL in cases of comparison, authentication, and geographic sourcing.

Cathodoluminescence, Geology, Soil