A35 Ion Beam-Induced Luminescence as a Forensic Tool

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The goal of this presentation is to introduce the principles and practice of ion beam-induced luminescence with a specific focus on the spectroscopic information that can be obtained from forensic samples and the applicability of IBIL to cases of comparison, authentication, and provenance.

This presentation will impact the forensic community by demonstrating how the ion beam - induced Luminescence (IBIL) is a new technique that is applicable to a range of questions involving the forensic analysis of trace evidence. The spectroscopic information provided by IBIL can aid in comparison, authentication, and provenance examinations of forensic materials including soil, building materials, paints, and glass.

Recent studies have demonstrated the potential for cathodoluminescence (CL) to be an important forensic tool in the discrimination and potential sourcing of trace materials that luminesce. CL is the emission of visible or near visible light from a sample that has been bombarded by an electron beam. An ion beam-induced luminescence (IBIL) method that can be used to discriminate between different minerals by bombarding them with an accelerated proton or alpha beam has been developed. Since all luminescence results from the alteration of band-gap energies due to the presence of trace elements or structural defects in crystalline materials such as minerals, both IBIL and CL produce similar UV-Vis-NIR spectra. This emission is characteristic of either the geological environment of formation of the mineral or, for a synthetic luminescent material, the manufacturing process. Luminescence is observed in many materials routinely encountered as trace evidence, including soils and rocks, building materials, glass, and pigments. The variation in luminescence for a particular mineral can therefore be used to discriminate among samples from different sources or, in certain cases, provide information about the provenance of a sample.

Many of the most abundant minerals (e.g., quartz, feldspar, and carbonate minerals) are luminescent. Due to their ubiquitous nature, these mineral components have typically been underutilized for forensic discrimination. However, the variation in luminescence within a given mineral type provides additional discrimination among sources and offers the potential for improving the significance of geological evidence. Prior research has demonstrated that cold cathode CL with light microscopy provides a relatively fast method to screen soil samples through visual identification of luminescent minerals. In addition to visual observation, high-resolution spectroscopy can offer more detailed information about specific activators (defects and trace elements responsible for luminescence) in a given mineral. For example, 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 and quantified with high resolution spectroscopy. 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.

IBIL provides another method to measure luminescent characteristics of minerals and it has two additional features: ion microprobe analysis can be used to excite single mineral grains (on the order of 10 microns) and the system can simultaneously measure luminescent signatures and perform elemental x-ray analysis. The ability to irradiate only one mineral grain at a time prevents quenching of an entire forensic sample during examination and the addition of simultaneous particle-induced x-ray emission (PIXE) spectrometry provides additional information for forensic source attribution. This presentation will provide an introduction to the principles and practice of IBIL with a specific focus on the spectroscopic information that can be obtained from geological samples and the applicability and limitations of IBIL in cases of comparison, authentication, and geographic sourcing. Spectroscopic information will be compared with prior data collected using cathodoluminescence imaging to assess the degree of additional discrimination and value to provenance determination.

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