J13 The Examination of Crossed Lines for the Determination of Sequence of Strokes Using Laser Ablation-Inductively Coupled Plasma/Mass Spectrometry (LA-ICP/MS) and X-Ray Fluorescence (XRF)

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Learning Overview: The goal of this presentation is to provide information about a novel approach to the determination of sequence of stroke for crossed ink lines.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by adding to the present knowledge base concerning the determination of sequence of strokes for crossed ink lines.

During the course of forensic examinations of documents, the question of sequence of strokes is common. Determining which ink or printed line was produced first, second, third, etc. may play an important role in answering questions about the genuineness or veracity of the document or its content. Furthermore, this problem is growing in scope as the number of writing instrument types, ink formulations, and printing devices and media expands. Forensic Document Examiners (FDEs) may be presented with line crossings of any kind, and so need in their arsenal the best fit analysis for the possible mixed-media before them.

Over the years, many destructive and non-destructive techniques have been developed for or applied to the examination of crossed lines; Rodrigues e Brito et al. have published a comprehensive review of the research to date in this regard.[1] The methods outlined in this compendium include microscopy, lifting techniques, the use of electrostatic detection devices, chemical analyses, chemometric, and advanced imaging techniques. While this presentation outlines the use of XRF techniques to resolve problems of crossed lines, there is little research on the application of LA-ICP/MS.

This research explores the use of LA-ICP/MS and XRF as semi-destructive and non-destructive techniques, respectively. LA-ICP/MS is a highly sensitive analytical chemistry technique used to determine the trace element concentration and elemental distribution of a wide range of solid samples. This technique can be considered semi- or micro-destructive in that, with an appropriate stage, a document need not be cut or otherwise destructively manipulated. However, the technique uses a laser to directly ablate, or burn, the sample surface for a total volume of <1ug, thereby ensuring the integrity of the sample and allowing for other measurements using different techniques. XRF is a non-destructive analytical technique in which a primary X-ray beam is used to excite fluorescent radiation from the sample, yielding an elemental map of the region of interest.

Twenty-five writing instruments of various ink formulations were used to create intersecting lines with printed matter from five devices and with paper designed for use with the printing devices (e.g., inkjet, photocopy, laser papers). The crossed lines were created such that the sequence was cataloged and blinded from the rest of the study team. The samples were imaged, observed microscopically and macroscopically, then run using both techniques. The resultant analytical output and crossed lines were examined by 5 FDEs and 20 non-examiners to determine if: (1) the individuals could easily and reliably determine the sequence of strokes based on the output, and (2) there was a difference between the results from the FDEs and laypeople. Notwithstanding the complexity of intersecting line problems, this study adds to the body of research to determine reliable techniques for use by FDEs in casework.

Reference(s):

1. Livia Rodrigues e Brito, Angelica Rocha Martins, Andre Braz, Amanda Belem Chaves, Jez William Braga, Maria Fernanda Pimentel. Critical Review and Trends in Forensic Investigations of Crossing Ink Lines. *Trends in Analytical Chemistry* 94 (2017): 54-69.

Questioned Documents, Forensic Chemistry, Crossed Line Intersections