B132 The Sub-Particle Composition and Morphology of Gunshot Residues (GSR)

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After attending this presentation, attendees will have a more developed understanding of the variation in sub-particle composition and morphology of different types of GSR and its significance to GSR evidence evaluation.

This presentation will impact the forensic science community by reporting on work that has been conducted in the sectioning and sub-particle analysis of GSR from different types of ammunition and firearms, allowing for a more thorough understanding of the variation in and differentiation of GSR particles that can be demonstrated at this level.

This presentation explores the key hypothesis that GSR particles are not homogeneous and their sub-structure carries valuable information that can be exploited in GSR examination.

Complex interactions in the moments after firing result in the formation of GSR particles.[1] Incorporation of key elements is thought to come principally from the ammunition's primer; however, inclusions from the projectile, casing, and barrel of the firearm are not uncommon.[2] When it comes to the assessment of GSR evidence, the usual standard technique, Scanning Electron Microscopy with Energy-Dispersive X-Ray Microanalysis (SEM/EDS), operates on a whole particle analysis level. While this has been useful in providing a qualitative assessment of the presence of particles characteristic of GSR, detailed characterization and differentiation of particles originating from different ammunition types has been elusive.

Recently, there has been research to suggest that the complexity of GSR formation results in distinct differences in both the sub-particle composition and morphology. Prior studies have indicated that beyond the external morphology and composition, sub-surface morphological differences can be used as a means of identifying particles from different ammunition types.[3] More recent work has suggested the use of a Focused Ion Beam (FIB) to examine the internal composition and morphology of GSR particles as a means of obtaining more in-depth information about a particle's composition and origin.[4,5] Practically, the casework experience has shown that in some situations three component particles are observed in situations where one component – antimony – is absent from the primer mix but is present in the projectile.[6,7] This is most often the case with .22 caliber ammunition, which is common in Australia. The prospect of being able to assess the origin of different particles, or specific components within them, would provide useful information in forensic investigations and GSR research.

This study applies FIB techniques supported by SEM/EDS and X-ray mapping, as well as Auger Electron Spectroscopy (AES) and Time-of-Flight/Secondary Ion Mass Spectroscopy (TOF/SIMS), to GSR particles originating from different ammunition calibers and types, with a view to demonstrating their sub-surface features and heterogeneity. Specific morphological and compositional features were then evaluated as to their relationship to the origin of the particles, with a view to determining if they originate purely from elements in the primer or of a mixed primer and projectile origin. GSR samples were collected from the hands of shooters, following the discharge of a number of different ammunitions. Characteristic particles were then selected and elemental X-ray maps collected using an SEM/EDS system. These particles were then cross-sectioned or had slices collected from them using a gallium ion FIB. The cross-sectioned face of these particles was re-mapped with SEM/EDS to assess internal morphology, composition, and discrete phases. Slices collected from these particles were analyzed using AES and TOF/SIMS in order to provide further compositional information.

Ultimately, this study has demonstrated that in many cases there are distinct sub-particle compositional and morphological features that clearly demonstrate the non-homogeneous nature of GSR particles. GSR examiners could use these features to improve the probative value of GSR examinations.

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