Developing traditional forensic science exploitation of contaminated exhibits recovered from a nuclear security event

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Abstract. Forensic scientific support to a nuclear security event involving the malicious use of nuclear or other radioactive material outside regulatory control, will aim to maximise the information that can be obtained utilising nuclear forensic analysis and traditional forensic sciences. The latter is potentially challenging to achieve as traditional forensic science laboratories are not designed or designated to handle exhibits contaminated with nuclear or other radioactive material. Equally, analytical laboratories designated to support nuclear forensic analyses are not equipped with the instrumentation or the trained staff to undertake traditional forensic science examinations. The United Kingdom, in response to this technical challenge, has established a purpose-built facility, the Conventional Forensic Analysis Capability (CFAC) at a nuclear licensed site to enable the examination of items contaminated with nuclear and other radioactive material using a range of traditional forensic science examination techniques. The current activities within the CFAC laboratory are focussing on adapting and validating methods and procedures to be used in forensic science examinations in support of a nuclear security event.

1. Introduction

Since the early 1990s, nuclear forensic science has become increasingly recognised as an additional discipline to provide scientific support to law enforcement or equivalent investigations [1]. The development of the discipline was partly in response to illicit trafficking incidents involving nuclear or other radioactive material outside regulatory control, [2] and the potential asymmetric threat of the malicious use of such materials in a terrorism related incident [3]. Nuclear forensic science focuses on the analyses that provide elemental, chemical, isotopic and physical characteristics (e.g. morphology) to aid in the interpretation of the seized “questioned” nuclear or other radioactive material in support of the investigation. Equally important is the information that can provide the classical broader associative, investigative and event/incident reconstruction links of individual(s) to places, events and processes [4]. The ability to undertake traditional forensic science examinations would aid in these interpretations [5]. Nevertheless it may not be possible to conduct routine examinations in a standard forensic laboratory environment safely, due to the items being contaminated with the nuclear or other radioactive material. As a result in the United Kingdom, the Office for Security and Counter-Terrorism (OSCT) within the Home Office funded the construction of a specialist laboratory at the Atomic Weapons Establishment (AWE).

This paper provides an overview of the method development and validation studies that have been undertaken in the Conventional Forensic Analysis Capability (CFAC) laboratory at AWE, for the safe handling and processing of exhibits or items recovered from a scene of crime involving nuclear or other radioactive material outside regulatory control.

2. An overview of the CFAC laboratory

The CFAC laboratory was designed around the concept that forensic scientists and practitioners from a traditional Forensic Science Service Provider (FSP), Police and other specialist forensic science laboratories, having undertaken suitable training, would perform the examinations on the exhibits contaminated with nuclear or other radioactive material with technical (i.e. glove box operations), radiological monitoring and protection advice provided by AWE specialists.

To ensure that the CFAC laboratory was designed to meet the required technical specification of the various traditional forensic science disciplines, forensic scientists and practitioners from the organisations who would operate in the CFAC laboratory (e.g. Forensic Access Ltd and the Forensic Services Directorate within the Metropolitan Police Service) were involved in the design phase [6]. The housing of multiple disciplines in a single environment generated a number of challenges, such as ensuring that adequate examination capability was provided for each, whilst acknowledging limitations due to the size of the laboratory. For example, there are a number of techniques that can be utilised to aid in the development of a fingerprint, from vacuum metal deposition to using chemical dyes (e.g. SOLVENT BLACK 3 [7]) however, it would not be possible to incorporate all of these techniques into the CFAC laboratory. As a result, and based on technical advice from the forensic science practitioners, it was determined that the CFAC laboratory should be able to enable fluorescence examination, cyanoacrylate vapour, ninhydrin and 1,8-Diazafluoren-9-one (DFO) treatments of exhibits as a minimum.

Two purpose-built glove box units form the main examination capability within the CFAC laboratory. This follows a similar approach to other nations who have developed support to traditional forensic science examinations [8]. The CFAC glove box units have incorporated a dedicated chamber for cyanoacrylate vapour treatment, a digital microscope, fluorescence illumination using a Coherent® TracER 532nm (green) wavelength laser or a 577nm (yellow) wavelength laser depending on which glove box is used, and the ability to download data from cellular devices, Fig 1.

The CFAC laboratory at AWE incorporates the traditional forensic examination requirements for: record photography; fingerprint development; digital data recovery from cellular and other electronic devices; DNA sampling; trace evidence recovery and characterisation; questioned document analysis and physical investigations for explosive-related examination. This is done whilst ensuring that there is no compromise in terms of the radiological safety and operating requirements for a designated radiological controlled laboratory on a nuclear licensed site, Fig. 2.

FIG 1. One of the glove box units housed within the CFAC laboratory. The digital microscope for imaging and the integrated Coherent® TracER laser system used to support fingerprint development are visible in the image. Insert shows the integrated chamber for the cyanoacrylate (CNA) vapour treatment.

FIG 2. An overview montage image of the CFAC laboratory which includes some of the capabilities that would support the traditional forensic science examinations of exhibits contaminated with nuclear and other radioactive material.

3. Validation studies of traditional forensic science methods to be undertaken in the CFAC laboratory

Although the CFAC laboratory was built around the requirement of traditional forensic scientists and practitioners, it still provides a unique operating environment where it is not possible to directly transfer methods and procedures used in the standard forensic laboratories. Therefore the traditional examination methods require adaptation or simplification for use in the CFAC laboratory. The adaptation could be due to the practical limitations of working in a glove box, such as dexterity. Alternatively it may be safety requirements imposed for working in a radiological controlled environment such as removing the potential for a contaminated wound or cut hazard caused by the use of a sharp-edged tool while undertaking an examination, e.g. tweezers for trace evidence recovery. Once the various methods have been adapted for use in the CFAC laboratory, then they must be validated to enable the production of a series of standard operating procedures that can be accredited and used in support of legal proceedings, Fig. 3.

The range of examination techniques that can be undertaken in the CFAC laboratory, specifically in the glove box units, would normally in a standard forensic facility be undertaken in different laboratory areas. Therefore a significant component of the validation work is to develop and subsequently implement suitable environmental monitoring and laboratory cleaning protocols to reduce the potential for forensic cross-contamination.

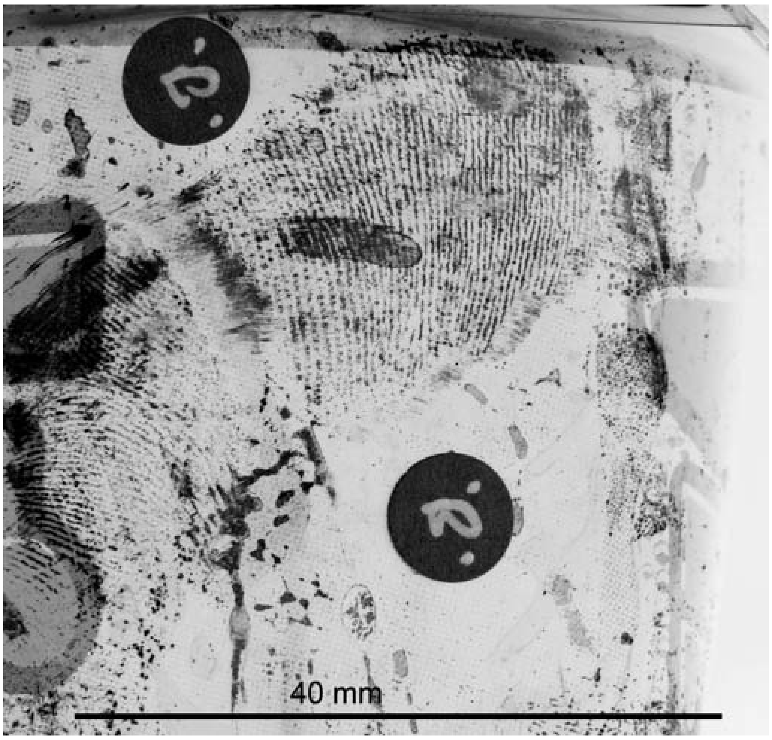

FIG 3. A digital photograph of a fingerprint identified on an exhibit after being processed in the glove box as part of the validation process.

It is likely that a question on the impact of radiation exposure on evidence would be raised during defence council cross-examination of the forensic scientist or practitioner if the investigation leads to a criminal prosecution. Thus an important aspect of the validation studies is to develop an understanding of the potential effects of radiation exposure on forensic evidence, such as the potential colour degradation of hairs or fibres, or the inability to develop a suitable fingerprint from an exhibit [8]. As a result there is a current on-going research effort to study the effects of radiation exposure on evidence, with the initial focus on DNA [9]. Equally important is the need to understand the effects of decontamination [10], which again the current validation studies are exploring, with some preliminary work relating to questioned documents.

In support of the validation studies, the glove box trained forensic scientists and practitioners undertake mock casework examination exercises to demonstrate competence to operate in a radiological controlled environment, Fig. 4. These exercises aim to test the totality of tasks undertaken in the CFAC laboratory, including the application of the validated methods to examine an exhibit; administrative paperwork (such as evidence continuity and the examination strategy / plan); interactions with the radiological protection advisors.

FIG 4. One of the forensic science practitioners trained to operate in the CFAC laboratory demonstrating the ability to perform a taping procedure of an exhibit in one of the glove boxes during a mock casework exercise.

4. Applying the findings from nuclear forensics analysis to traditional forensic science interpretations

Beyond the traditional forensic science examination techniques that can be applied in the CFAC laboratory, it is equally important to utilise the findings from the nuclear forensic analysis that might provide additional context or interpretation. Particle analysis techniques developed for nuclear safeguards environmental sampling and nuclear forensic science [11] can support the traditional forensic interpretation in a similar way to that used for classical trace forensic science. For example, the identification of firearms discharge residue particles (more commonly referred to as gunshot residue (GSR)) provides potential information to an incident involving the use of a firearm [12]. Using that interpretative philosophy, the linkage of an individual to a scene or activity could be supported by the identification of nuclear or other radioactive particulates sampled from exhibits such as clothing or a disposable glove recovered from a crime scene, Fig. 5.

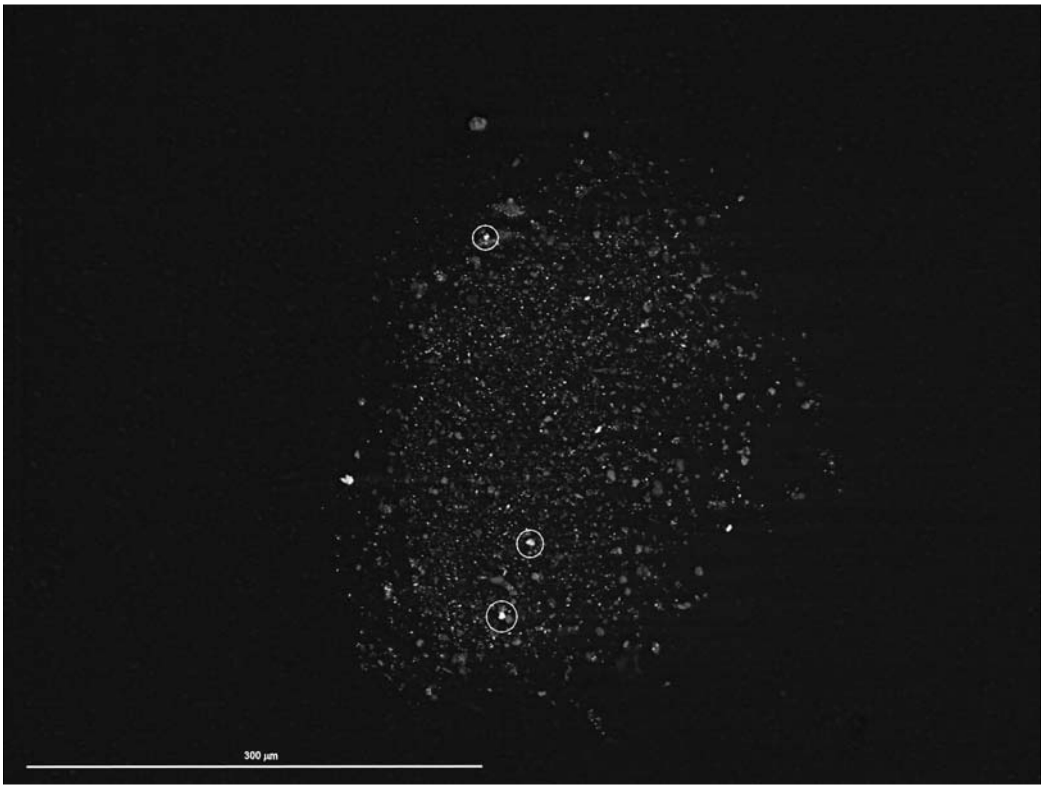

FIG 5. A backscattered electron image of the surface of the carbon adhesive disk mounted aluminium specimen stub that has been used to sample a disposable glove, to mimic potential for particulate transfer if the glove had been worn during an activity or process using nuclear or other radioactive material outside regulatory control. The brightest particles (denoted by the circles) identified in the image would then be subjected to further analysis due to the likely presence of high atomic number elements such as uranium (scale bar is 300 micrometers).

5. Future work

On completion of the validation and method development work for the traditional forensic science procedures to be undertaken in the CFAC laboratory, the next stage will be to gain accreditation to the international standards that apply and are expected to be held by laboratories undertaking forensic science examinations [13]. Furthermore, in the United Kingdom, the Forensic Science Regulator within the Home Office has developed a Code of Practice and Conduct to which, it is expected that FSPs and forensic science practitioners adhere [14].

6. Summary

The scientific support to the investigation following a nuclear security event may include all aspects of forensic science. In addition to the analytical capabilities at AWE for the analyses of the nuclear and other radioactive material [15], the United Kingdom through OSCT within the Home Office has funded the development of a dedicated facility to support traditional forensic science examinations. The CFAC laboratory enables the safe handling and forensic processing of exhibits contaminated with nuclear or other radioactive materials and small quantities of explosive material. The current ongoing method development and validation studies will ensure that the laboratory is able to undertake examinations to the expected standards of the United Kingdom Criminal Justice System.

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