**Commentary for ‘Emerging Technologies for the Analysis of Forensic Traces’**

**Dr Stephen Bleay, Senior Lecturer, London South Bank University (formerly Senior Technical Specialist, Forensics & Identity, Home Office Centre for Applied Science and Technology)**

The application of advanced analytical techniques to the examination of fingermarks has generated much recent media interest because of the wealth of information that can potentially be obtained from such forensic traces. As one of the few types of trace evidence that can be used to identify an individual, fingermarks remain an important tool in the investigation of crime and still account for appreciably more criminal identifications worldwide than DNA. Because fingermarks have been used for more than 100 years, it is a common perception that there are few advances that can be made in the field. However, the potential to go beyond the traditional use of fingermarks for identification and to add contextual information to an investigation is why advanced analytical techniques have become of such interest to both researchers and practitioners. In this respect fingermarks are a rich source of chemical information that mass spectrometry techniques are ideal tools to exploit.

The combination of features that makes mass spectrometry techniques such as MALDI, SIMS, DESI (and certain other non-mass spectrometry techniques such as ATR-FTIR) of such interest for fingermark analysis is the ability to obtain chemical information from the fingermark, and the ability to map the distribution of the constituents at a resolution sufficient to distinguish fingermark ridge detail.

Even if the actual classification of the chemicals present in the fingermark is not of interest, the ability to map the distribution of unknown chemicals that are abundant in the fingermark may be capable of providing additional detections for the criminal justice system. This is because fingermark visualisation processes are optimised to target constituents expected to be abundant in fingermarks, such as the amino acids in eccrine sweat or fatty acids in sebaceous sweat. If the fingermark is rich in another unrelated contaminant that has been picked up on the finger, it may not be particularly well developed by a conventional reagent. However, the use of a chemical mapping technique may ‘fill in’ missing ridge detail and turn a fragment of a fingermark into a criminal identification, which clearly has operational benefits. Both MALDI and SIMS techniques have demonstrated their feasibility for use in revealing additional ridge detail after use of conventional enhancement processes.

Similarly, the ability to produce chemical maps may be useful in the long-standing issue of separating overlapping fingermarks. If such marks have been deposited by different people, and each contain different chemicals, it may be possible to produce chemical maps that are unique to each fingerprint donor and allow identifiable fingermarks to be seen in isolation, as has been demonstrated using the MALDI process. By separation of the fingermarks, their subsequent comparison by fingerprint identification experts becomes much easier.

Both the above examples describe circumstances where new analytical techniques provide added opportunity to use fingermarks in their traditional ‘source level’ application of identification. However, there is a greater potential to utilise such techniques in provision of contextual ‘activity level’ information that may be relevant to a case. Although this has, to date, been little exploited operationally, the growing range of information that can be obtained and the growing awareness of this capability means that this is likely change in future.

It has been shown that the advanced mass spectrometry techniques now being researched can provide a wealth of information about the lifestyle of the depositor of the fingermark. Even if a contact mark does not contain sufficient ridge detail to identify an individual, it may be possible to obtain supporting contextual information from the chemicals present such as gender, diet and medication that may enable the narrowing down of a field of suspects. If the contact mark is smudged, or not of sufficient quality to be identifiable, all of the techniques described in this chapter become applicable to subsequent analysis. If ridge detail is present, and needs to be imaged and/or preserved, the number of feasible techniques is reduced to SIMS, MALDI and DESI.

Of equal importance is the ability to identify exogeneous substances picked up on the fingers during handling. If a particular substance is relevant to the investigation, the presence of it in a fingermark could be used to link a suspect to a specific location or source material. The mapping capability of the technique can also add context to the distribution of the substance on the finger, possibly enabling the investigator to distinguish between deliberate and accidental contact. Although the majority of studies reported to date relate to detection and mapping of drugs, this capability is equally relevant to detection of substances associated with violent crime such as residues of explosives and their precursors, or gun shot residues. Of the techniques investigated to date MALDI and SIMS show most potential in the application. Although DESI may offer similar potential, it has not been as widely researched or reported in this role.

Other examples of where advanced analytical processes have been used to provide contextual information are in depth profiling, where it may be possible to determine whether fingermarks have been deposited on documents before writing or printing, or vice versa. This can be an important issue where suspects offer the proposition that documents that are currently of an incriminating nature were blank when handled by them, and there are several cases where this has been used as a defence. The feasibility of using SIMS for this purpose has been demonstrated by several research groups, and the validation of a method to reliably determine order of deposition would be a valuable investigative tool.

Although many of these applications have been demonstrated ‘in principle’ in feasibility studies, there are still barriers that need to be overcome before such techniques find wider use on casework. An important aspect that needs to be addressed is that of validation. Forensic science laboratories worldwide are increasingly adopting the ISO 17025 standard, which requires techniques used within the laboratory to be scientifically validated. For a technique to be used in the Criminal Justice System, several aspects of its performance will need to be addressed. The scientific principles that underpin the method should be well understood and published. Where processes are being used for the detection of trace quantities of substances, the sensitivity and selectivity of the process to its target species should be tested, and any interfering substances that could produce ‘false positives’ or ‘false negatives’ identified.

For the advanced analytical techniques now being reported there is already an understanding of the scientific principles, and a knowledge of sensitivity and selectivity to fingermark constituents and common contaminants is being developed, most particularly for SIMS, MALDI and paper spray mass spectrometry (for situations where ridge detail is not required). What is still required for the processes to be considered sufficiently validated for use in a court room are some larger scale studies, including elements such as repeat experiments, blind testing and the determination of potential effects on other types of forensic evidence. In this respect the techniques that are most advanced are MALDI and SIMS. It has also been shown that both of these techniques can be successfully used after conventional fingermark visualisation processes to reveal addition ridge detail. This makes both methods options that can be considered in serious crime when all other options have been exhausted, and for this reason both techniques are listed in the Fingermark Visualisation Manual produced by the UK Home Office. DESI may be similarly capable, but there is currently no published study to demonstrate whether the process can be used after conventional fingermark enhancement processes.

Another aspect of forensic evidence recovery where advanced analytical techniques could provide future benefits is in the current drive to ‘do more at the crime scene’. Mass spectrometry-based methods could find an important application in providing a confirmatory test for substances of interest at the crime scene, potentially saving both time and money by negating the need to send samples back to a laboratory for analysis. However, this would require a validated database of target substances to be generated and increases the importance of conducting an assessment of the impact of potential interferents. The impact of contamination within the instrument will also need to be considered, together with the potential for cross-contamination between samples. Research will need to establish whether contamination can be easily removed when present, and whether it interferes with normal operation for forensic applications. As indicated in this chapter, although progress has been made towards making some mass spectrometry techniques smaller and more portable, none of the techniques that have most potential for operational use are yet available in a ‘crime scene’ form.

If crime scene use is to become a reality, thought will need to be given to miniaturisation of instrumentation and its portability. Alternatively, protocols for taking evidence back from the crime scene to laboratory for fixed analysis need to be put in place. The use of lifting media (gelatin lifts and adhesive tapes) has already been demonstrated for removing fingermarks from surfaces for analysis by ATR-FTIR and MALDI. However, it may be preferable to directly analyse marks *in situ* on the surface of small portable items, which may limit practical application to processes that can operate at ambient pressure and can accommodate reasonably large samples. MeV SIMS offers the potential for *in situ* analysis, but this is a highly specialised technique that will never be widely available.

Regardless of all the potential operational advantages offered by advanced analytical methods, a question that will always be raised is the cost. It is evident that the cost of such processes will be far higher than the conventional fingermark visualisation and imaging processes used in forensic laboratories, so such methods are unlikely to be used for investigation of volume crime. However, there are circumstances where specific contextual questions need to be answered (e.g.is this mark really in blood? Does the contaminant in the fingermark match a specific substance associated with the crime scene?) and mass spectrometry may provide the answers. For high profile or high priority cases, the additional initial costs of using advanced analytical methods may be justified by providing information vital to a detection, and potentially reducing long terms costs by saved time in criminal investigations. As the research and collation of validation data for these techniques continues, this is likely to be a decision that investigating officers will be increasingly required to make.