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The forensic analysis of soils and sediment taken from the cast of a footprint

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Abstract

The routine production of a cast of a shoe-print taken in soil provides information other than shoe size and gait. Material adhering to the surface of the cast represents the preservation of the moment of footprint impression. The analysis of the interface between the cast and soil is therefore a potentially lucrative source of information for forensic reconstruction. These principles are demonstrated with reference to a murder case which took place in the English Midlands. The cast of a footprint provided evidence of a two-way transfer of material between the sole of a boot and the soil of a recently ploughed field. Lumps of soil, which had dried on a boot, were deposited on the field as the footprints were made. Pollen analysis of these lumps of soil indicated that the perpetrator of the imprint had been standing recently in a nearby stream. Fibre analysis together with physical and chemical characteristics of the soil suggested a provenance for contamination of this mud prior to deposition of the footprint. Carbon/nitrogen ratios of the water taken from the cast showed that distilled water had been used thus excluding the possibility of contamination of the boot–soil interface. It was possible to reconstruct three phases of previous activity of the wearer of the boot prior to leaving the footprint in the field after the murder had taken place. This analysis shows the power of integrating different independent techniques in the analysis of hitherto unrecognised forensic materials.

Keywords: Footprint cast; Soils and sediment; Forensic geoscience; Pollen; Scanning electron microscopy

1. Introduction

Following Locard's general principle that 'every contact leaves a trace' [1], it would be tempting to consider that the analysis of sediments and soils taken from the soles and uppers of shoes would show much similarity with that of a specific crime site where the person wearing the shoes would be considered to have walked. However, when investigating the similarities or differences of materials found on shoes compared to the comparator site it is clear that the supposed simple relationship is not quite so straightforward [2].

The main problem encountered when analysing and interpreting material from shoes is that the shoes are worn for some designated period of time (often quite a long time) after the crucial event. Thus, materials may well fall off shoes, or indeed be added to by materials from elsewhere during subsequent activity. Compounding this problem is the fact that the shoes may have already had material adhering to them prior to the forensic event. Further, consideration must be given to the representative nature of the sample collected from the shoes and indeed the amount of material available for analysis.

Analytical techniques available to the forensic scientist are numerous if one considers the range of techniques available in geochemistry, sedimentology and botany. A crucial problem here is to employ techniques with forensic rigueur rather than using purely geological procedures of interpretation. So, given that there is enough material available for analysis, and given that the samples analysed are representative both of the material found on the shoe and also representative of the source sample from whence they came, it should be possible to afford a meaningful analysis, comparison and interpretation of results.

Whilst it is possible to provide carefully controlled and repeatable experiments to determine the presence, persistence and final preservation of sediments on different types of shoes, under different climatic conditions, and utilising different geological scenarios [3–5] there is no real substitute for

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analysis of an actual forensic investigation albeit with all the logistical restraints that accompany such a scenario.

2. Case background

A young woman was out walking her dog in the early afternoon on a hot summer's day in a rural area in the midlands of England. The path she took crossed a small bridge which forded a trout stream and ran parallel with the raised embankment of a railway line. The woman was brutally attacked and dragged onto the railway embankment through a patch of thistles and it was assumed that the attacker had attempted to lay her inert body across the railway track. The embankment proved too steep and the young woman was left at the bottom of the slope later to be found barely alive. She was taken to hospital where she died 6 days after admission. Tracker dogs at the scene followed a trail from where the girl was left, across the railway line into a field that had been ploughed on that very morning. Footprints could be seen tracking across the field. Plaster casts were taken of the footprints, primarily to ascertain the size of the suspect's shoes (with the intention of excluding the farmer as being the originator of the footprints. Subsequently, it was shown that the farmer had feet far too small for the footprints).

Suspicion fell upon a man who lived in the area and who was seen a few hours before the attack standing in the trout stream, whilst illegally fishing. When arrested the following day in relation to the attack on the young woman, two pairs of his shoes and his clothes were seized. The investigation centred, in part, on whether materials found on the accused's shoes and clothing were similar or not to the materials found at the crime scene and in the ploughed field (he had burnt some of his clothing the previous evening). He was asked when he had last worn his shoes, and he stated that he had worn one pair of shoes the previous day when he had helped lay a concrete path. He denied having been in the location about the crime scene at any time in the past. Analysis initially centred about a comparison of the materials taken from both pairs of shoes with the crime scene and field from where the tracker dog found the footprints in the recently ploughed soil. Subsequent analysis involved investigation of the footprint casts themselves. Physical, chemical and biological tests were employed during the subsequent laboratory investigation. Finally, a number of samples were taken from 19 surrounding fields to act as exclusion samples and to provide an indication of the variation (if any) in the nature of the soil in the whole of the surrounding area.

3. Results

3.1. Binocular microscopy

Simple low powered binocular microscopy was undertaken on the samples taken from the field, the cast, two pairs of shoes and the 19 exclusion samples. The results are provided in Fig. 1 (samples from both pairs of shoes [1,2] were taken from the left and right shoe, respectively). Perhaps the most striking occurrences identified in this analysis were the presence of very many small fibres of a large number of colours and from a variety of different material types found particularly in the mud sampled at the plaster cast/soil interface (underneath the footprint indent into the soil). Various fibres similar in colour and material type to those found in the cast were also found in the soil from both the left and right of the second pair of shoes. One similar type and colour fibre in the field was also found on the left shoe of shoe 1. Indeed, the cast mud contained 13 different colours of fibre comprising cotton, synthetics and wool.

Animal hair was also identified within the soils of the field, the plaster cast and both pairs of shoes (left and right), although what appears to be unusual is that the hair in the mud from the cast and both pairs of shoes was cut, some at both ends. From the 19 samples taken from surrounding fields no hair (or indeed fibres) were identified.

The visual mineralogy obtained by binocular microscopy showed that the field, cast and both pairs of shoes

Sample	Fibres	Hair	Quartz sand (round)	Quartz silt (angular)	Calcite	Mica	Feldspar	Iron nodules	Shale pellets	Limestone/ oolites
Field 1	6(2)	2(0)	X	X	X	X	X	X		
Cast	13(2)	5(2)	X	X	X	X	X	X		
Shoe 1 L	3(1)	2(1)	X	X	X	X				
Shoe 1 R	3(0)	3(2)	X	X	X	X				
Shoe 2 L	3(1)	5(2)	X	X	X	X	X	X		
Shoe 2 R	6(3)	2(1)	X	X	X	X	X	X		
Exclusion samples (n=19)	Nil	Nil	X	X	X	X	X	X	X	X

Note: Fibres 6(2) indicates 6 different colours of fibre and/or material type, with two similar characteristics.

Hair 2(0) indicates 2 animal hairs identified and neither hair had a cut end

X = present

Fig. 1. Summary table of mineralogical, hair and fibre composition of samples from binocular microscopy.