



# Patterns produced when soil is transferred to bras by placing and dragging actions: The application of digital photography and image processing to support visible observations



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## ABSTRACT

A series of soil transference experiments (STEs) were undertaken to determine whether patterns identified in laboratory experiments could also be recognised at a simulated crime scene in the field. A clothed 55 kg human rescue dummy dressed in a padded bra was either dragged or merely placed on a soil surface at sites with natural and anthropogenic soil types under both wet and dry soil conditions. Transfer patterns produced by dragging compared favourably with those of laboratory experiments. Twelve patterns were identified when a clothed human rescue dummy was dragged across the two soil types in the field. This expanded the original set of eight soil transfer patterns identified from dragging weighted fabric across soil samples in the laboratory.

Soil transferred by placing the human rescue dummy resulted in a set of six transfer patterns that were different to those produced by dragging. By comparing trace soil patterns transferred to bras using each transfer method, it was revealed that certain transfer patterns on bras could indicate how the fabric had made contact with a soil surface. A photographic method was developed for crime scene examiners to capture this often subtle soil evidence before a body is transported or the clothing removed.

This improved understanding of the dynamics of soil transference to bras and related clothing fabric may assist forensic investigators reconstruct the circumstances of a variety of forensic events.

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## 1. Introduction

Forensic soil examination has a wide range of advanced analytical methods available to compare soil with likely localities of origin [1–10]. These methods are generally defined as biological, chemical or physical. However, the way in which soil transferred by actions such as dragging has received little attention, apart from the early work of Locard in 1930 [11]. All other laboratory-based investigations have focused on the transfer of human-made manufactured materials such as textile fibres, glass, fluorescent powder, lighter flint particles and metal particles (glitter) [12–21].

This gap in forensic soil knowledge was an important issue in the interpretation of soil evidence in an Australian murder case [22,23]. A deceased female was found buried in park land. There was no evidence of violence at the burial site and it was deduced that the initial attack had occurred at a second location.

Traces of brick dust and soil on the victim compared closely with a brick driveway and soil from the victim's front yard indicating that this was the location of the attack. A trace amount of red brick dust, combined with natural soil objects, were lodged against the buckles and fasteners of the victim's bra. Similar trace soil evidence was embedded in scratches in her boots. Hard quartz particles had acted like 'glacial till'; gouging out brick dust from the red brick pavers [22]. A series of parallel scratches could be clearly seen with the unaided eye across metal buckles on one bra shoulder-strap [24]. The combination of soil, brick particles and scratches suggested that the victim had been dragged across the brick paving dusted with soil.

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Evidence relating to soil origin was accepted by the Judge that the initial attack on the victim occurred in the front yard of her home. However, the Judge disallowed interpretation of trace soil marks on clothing being used as an indication of the circumstances of the attack. He suggested that soil evidence on her clothes may have been the result of normal daily activities; or possibly carried by the wind into her clothes whilst they were drying on a clothes line. The Defendant was acquitted and Corryn Rayney's murder remains unsolved.

The circumstances in this case highlighted the lack of published research that would allow interpretation of trace soil patterns on clothed victims. Murray et al. [25] conducted a series of systematic laboratory-based experiments where weighted bras were dragged across various soil types. Analysis of the physical elements of transferred soil particles (colour, size, mineralogy) during these experiments showed that there was a range of indicators for dragging.

Image processing software was used to provide an objective assessment of the soil distribution on the fabric, referred to in this paper as 'trace soil patterns'; and Munsell colour classification of the soil that had been deposited. The software was also able to construct rose diagrams from the image data, which provided evidence of the direction from where the fabric was dragged. Relationships between the observed pattern and the soil type and particle size, clay mineralogy and soil moisture content were demonstrated. Using this methodology to systematically record and analyse the physical elements of trace soil patterns, before soil is removed for forensic analyses, may indicate whether a victim was dragged or placed upon a soil surface.

The objective of this paper is to report on the extension of the previous laboratory-based work to field-based experiments using a clothed human rescue dummy to simulate a victim. Methods of soil transfer were extended to include two distinct methods of soil transfer to fabric; dragging across both dry and wet anthroposol and natural soil surfaces and placement of the human rescue dummy upon the same soil surfaces. The effectiveness of the image

processing technology to objectively interpret the transfer patterns was also investigated.

## 2. Material and methods

### 2.1. Experimental design: 'placing' and 'dragging' as methods of soil transfer onto bras

The objective of these experiments was to extend the soil transfer method simulated in previous laboratory experiments [25]; whilst confirming that trace soil patterns documented in the laboratory could also be identified in the field. To minimise external factors that might influence results or effect the reproducibility of these experiments, similar controls on soil transfer method had to be placed on 'dragging' soil transfer experiments (STEs) to mimic the soil transfer method previously tested in the laboratory.

Soil transfer methods were limited to testing either the 'dragging' or 'placing' of a semi-clad female body on different natural and HAHT soil surfaces because these were the most contentious issues involving forensic soil evidence during the Rayney murder trial. The lack of published literature testing even these most simple of soil transfer methods provided the incentive to field-test these two methods first. Resulting soil transfer patterns contained herein cannot be used to definitively prove a combination of these soil transfer methods or other situations not yet tested.

These experiments were designed to be the first step in providing forensic investigators with a methodology and classification system capable of interpreting the transfer method of trace soil evidence on clothing at crime scenes. To create a pristine record of trace soil patterns on clothing, photographs were taken immediately after the simulated victim's body was moved and before any clothing was removed.

This series of soil placing and dragging experiments dressed a human rescue dummy in a bra to:



**Fig. 1.** Photograph of the clothed 55 kg human rescue dummy wearing: (i) waterproof overalls, (ii) plastic clip-lock bags over its hands and head and (iii) a clean bra complete with "breast implants". The rescue dummy in the photograph is seen placed on a dry soil on the rose garden path during a 2 min "placement" soil transference experiment.

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