CASE REPORT

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The Combined Use of Pollen and Soil Analyses in a Search and Subsequent Murder Investigation*

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ABSTRACT: This case report shows how soil analyses (particularly petrology) can be used in conjunction with pollen in order to refine or strengthen an association. Soil samples from a car believed to have been used by the suspect in a missing persons case was subjected to soil and pollen analyses. The soil characteristics and petrology were used to redefine the search area using geology and soils maps, the pollen and vegetative remains were used to target woodlands with a particular species mix. As a result two bodies were located and the environmental evidence was used in the subsequent trial. In this case the history of the vehicle was well known and the wheel arches and footwells provided reliable soil traps. The advantage of combining the techniques is that soil evidence (both mineralogy and other inclusions) provides a geological/soils match while the pollen provides independent evidence of vegetation type providing a combination that may be rare or unique.

KEYWORDS: forensic science, soil analyses, forensic palynology, vehicle history, legal evidence

The use of soil, rocks, and biological materials in legal evidence has a long history. Forensic palynology, the science of deriving legal evidence from pollen and spores has a history dating back over 60 years as described by Erdtman (1). Pollen evidence has been used in a wide variety of cases by Mildenhall (2), Bryant et al. (3), Stanley (4), and according to Horrocks and Walsh (5), it is used routinely in New Zealand. Its main forensic value lies in providing associative evidence that may assist in proving or disproving a link between people or objects with places or with other people or objects. The analyses of soil or a foreign body (e.g., brick) can also be used in a similar manner. Soil is analyzed using X-ray diffraction (XRD), which identifies the principal mineral content. This technique was preferred to polarized-light microscopy because of the small sample sizes and time taken for impregnation cutting and analyses. Mineralogical characterization is preferred over other soil characteristics because the mineralogy is largely non-transient and closely related to the geology on which the soil has developed and the results are highly reproducible. This report describes the way these data types were combined in order to redirect a search and provide circumstantial evidence in court. The reason for combining the analyses is to both validate and strengthen palynological evidence and to increase the associative power of the analytical process. The likelihood ratio as described by Horrocks and Walsh (5) provides the conceptual basis for combining different and independent environmental parameters as the combination of soil and vegetation type will be less common than either in isolation and may be rare or unique.

The Crime

On Nov. 18 concerns were raised about the disappearance of a retired couple that had not been seen for over a week. On visiting the couple's bungalow that sits on the Hambleton peninsular (Fig. 1), surrounded by Rutland Water, the police noticed disturbed soil, and on Nov. 19 the bungalow was searched. In the bathroom blood was located and a forensic scientist determined that "a significant event" had taken place. Blood was also found in the couples' car, a blue Rover. The car was soiled and yet the couple were known to be fastidiously neat and tidy. In an attempt to establish the recent history of the vehicle, soil samples were taken from the wheel arches and footwells. Detailed examination of the micro-stratigraphy and distribution of the mud suggested the mud had been accumulated off-road over a short period of time and recently (arch samples included green leaf fragments in the mud). As described earlier a multi-component analysis was performed on all samples that included: soil type using standard soil description, mineralogy using XRD, low-power microscopy for inclusions, plant macrofossils, and pollen analysis.

Both the soil description, which used appropriate characteristics from the UK soil classification system (color, texture, structure, organic matter) and the mineralogical analysis showed the samples to be of a similar type. The coarse fraction was dominated by quartz and calcite, and ironstone along with chert (probably from a drive/track surface) and coated road stone. The coarse and fine mineralogy and presence of calcite ooids (identified from low-power microscopy) indicated that the soil was derived from soil on the Lincolnshire Limestone, which outcrops in East Leicestershire. Also found was monofilament nylon of the sort used for fishing line. The macroscopic plant constituents included small grass sp, oak, alder and hawthorn leaves, and the moss *Eurynchium swartzii*. More unusually, a spangle gall of oak was found in the front offside wheel

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arch. Pollen concentrations were high in all samples (10,000 + grains mL), indicating a topsoil and relatively undisturbed source. All the samples, except one wheel arch, had an almost identical spectra dominated by grass (Poaceae, 52% total land pollen) along with high, oak (*Quercus*) and lesser amounts of pine (*Pinus*), ash (*Fraxinus*), lime (*Tilia*), sycamore/maple (*Acer*), alder (*Alnus*), hawthorn (*Cretaegus*), willow (*Salix*), hazel (*Corylus*), birch (*Betula*), sloe (*Prunus* t.), holly (*Ilex*), hogweed/cow parsnip (Umbelliferae), goosefoot family (Chenopodiaceae), dandelions (Lactuceae), cereals, and most importantly horse chestnut (*Aesculus hippocastanum*) (Fig. 2). Horse chestnut pollen was present in all the samples at around 1–2 %, which is highly significant as it is not a native tree to Britain, is relatively uncommon and is insect pollinated with pollen that does not travel far from the tree. All 23 samples were processed, using standard chemical procedures, and each counted to over 500 land pollen using standard keys and a reference collection. Since the location from which the mud originated was not known, the pollen and the petrological data were used to predict possible source areas. Taking into consideration the varied productivity and transportability of pollen, the mineralogy and foreign bodies, it was predicted that the soil had originated from "a road verge or parking place by water (used by fishermen) in, or adjacent to, woodland with a significant proportion of oak, horse chestnut, ash and lime. The wood edge also bordering arable fields and pasture, and located on, or adjacent to, soils derived from Lincolnshire Limestone." Areas of suitable geology existed only on the Hambleton peninsular, and to the north or east of Rutland water. Combining this information with local ecological information provided by the Leicestershire Wildlife Trust, a list of five woodlands of suitable type and on the correct geology was drawn up, Exton and Hambleton-Armley Woods were regarded as the most likely.

Since Nov. 19 a search for the couple had been taking place. By late November the garden and environs of the bungalow had been exhaustively (fingertip and geophysics) searched, a helicopter and sonar search of the edges of Rutland water was in progress and police divers were faced with the daunting prospect of dragging the edges of Rutland Water (the largest man-made lake in Europe) and other local water-bodies. The predicted soil source lead to a re-focusing of the search on the specified peninsular woodlands and within two days on Dec. 1, the couple's bodies were found in Armley Wood, which is the closest of the suitable sites to their home. The bodies, although buried, were not in an excavated grave. Instead a pre-existing crescent shaped mound (used as a car park edge) had been used with the bodies placed on the woodland floor and buried by stones, tiles (later identified as from the couple's garage), soil, a gravel layer, and woodland debris. The bodies lay 20 m downslope from a line of mature Horse chestnut trees and underlying them, horse chestnut fruits (conkers) were found. The

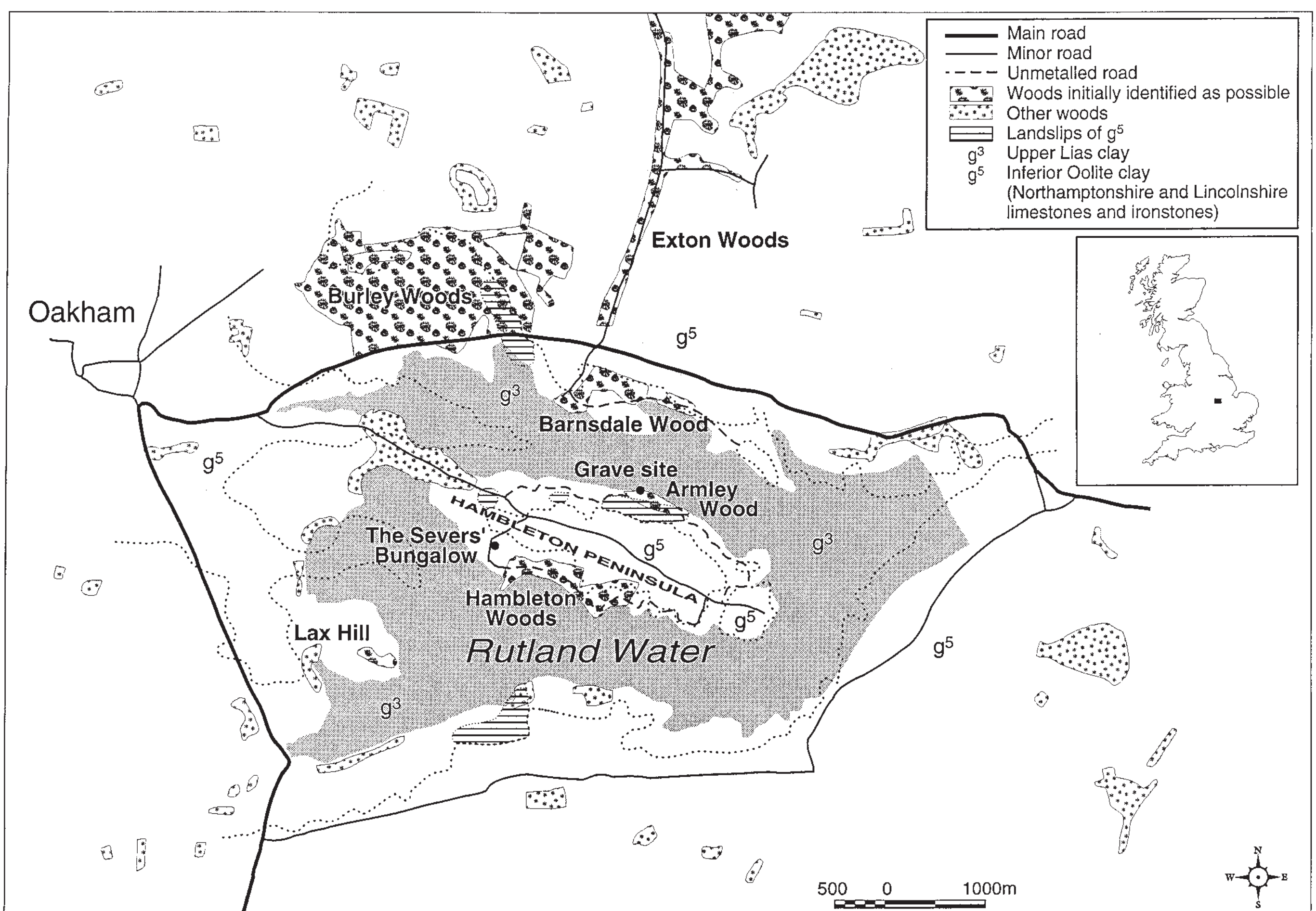

FIG. 1—*A map of the Hambleton area with the deceased couple's bungalow and the burial location.*

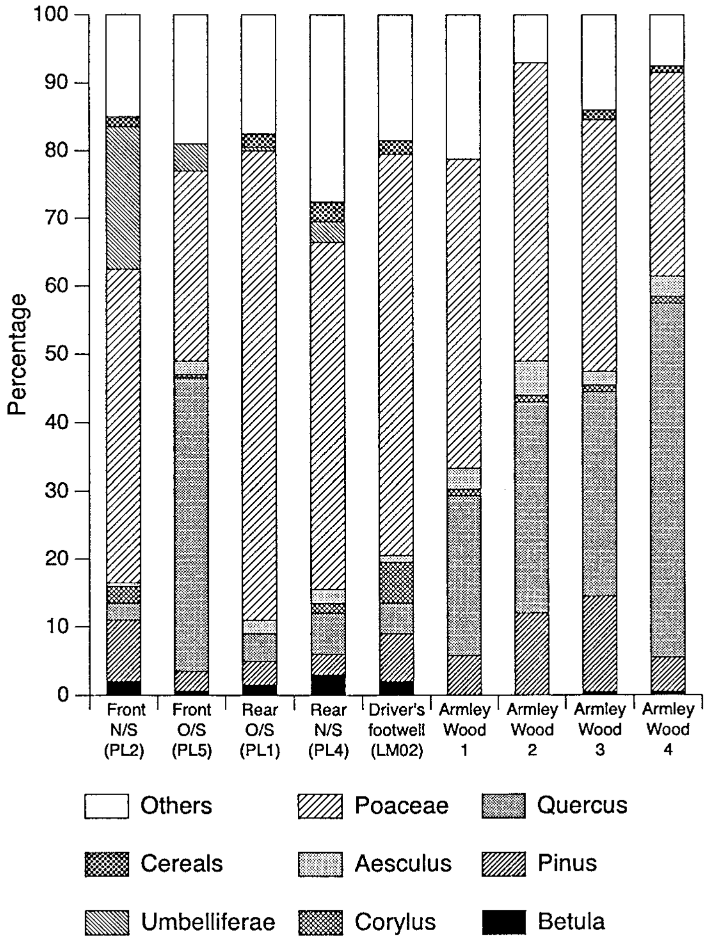

FIG. 2—Pollen type spectra from the car and the wood (from the scene further into the wood). The first five samples are from the car (N/S nearside, O/S offside wheel arches) and the last four samples are 10 m apart along a transect from the edge of the car park into the wood.

bodies were excavated in a controlled fashion using standard archaeological techniques, this allowed each layer of soil to be accurately recorded, and it could be seen that the layers were constructed from the car park side of the mound. The soil used in the mound did not match the local soil but did match with the soil from the Bungalow, which is derived from weathered Upper Lias clay. A further match was made by the presence of a rare variety of potato found in both the grave fill and the deceased's garden. Samples were taken from the drivers' footwell (LM02), woodland, burial mound, and the garden of the bungalow. Although some attempt had been made to clean the drivers footwell, small aggregates of soil were found which were homogenous and could be sampled. Both the suite of woodland pollen types, including the presence of *Aesculus* and the spectra from three of the wheel arches were a strong match. The control samples from the wood were taken from the grave site at the edge of the parking area along a transect into the wood (Armley wood 1–4, Fig. 3) and as shown in Fig. 3, although the suite of types remained very similar, the ratios change as *Quercus* replaces Poaceae. As Brown (6) has demonstrated small woodlands have strong edge effect that can penetrate over 50 m into the wood.

Examination of the gravesite also revealed that one of the wheels of the car must have been adjacent to an oak tree. This explained an anomaly in the original analyses. The front off-side wheel arch contained the same pollen types but far higher oak than the other wheel arches, it also had contained the spangle gall. It is known that due to the flow of rainwater down the trunk of trees, there can be a dramatic increase in pollen around the base of trees. This suggested that the Rover (front wheel drive) had been backed into the parking space and onto the mound, which was consistent with the relative weights of the suspect and deceased (140 kg), and the construction of the mound.

In this case, the match between the crime samples and the scene was strong, however, the assemblage is not uncommon given a number of similar woodlands in the area and taken on its own would only have provided "support"[*sensu* 5] for an association. However, with the restricted number of appropriate woods of the source geology, this provided at least "strong support" for an association.

Conclusions

In the case described above, the combination of pollen and soil characteristics had suggested the most likely source locations, thus saving search time; it also provided a link between the car and the grave site (and also in this case, the murder site) which formed a significant part of the prosecution evidence, and it had provided supplementary evidence of the positioning of the car at a crime

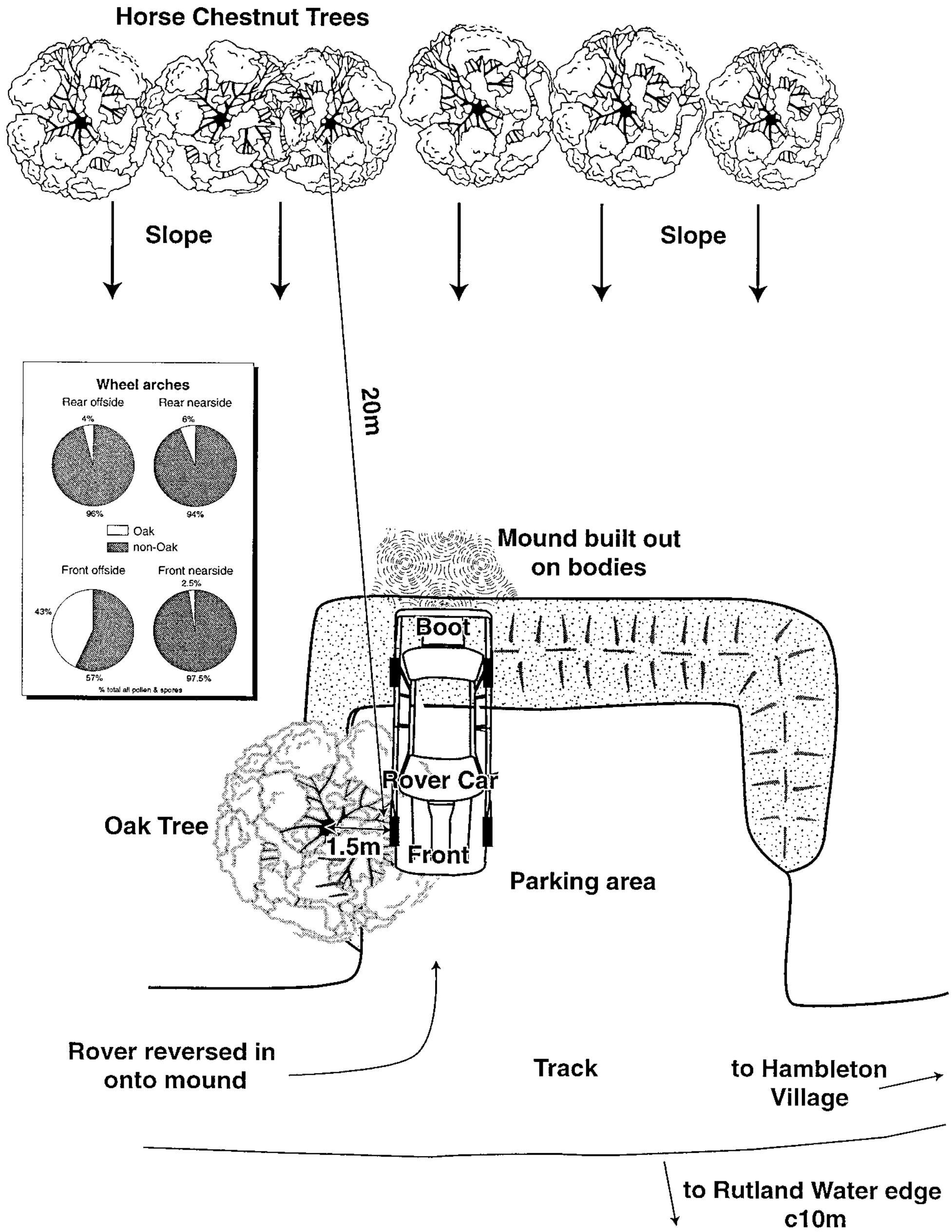

FIG. 3—A plan of the burial location showing the different pollen ratios on the wheel arches.

scene. If their previous history is known, or can be ascertained, and they are impounded early, cars may contain valuable evidence of the location of a crime. The vast majority of cars are rarely taken off-road, however, this often occurs if the car is used for the disposal of a body creating a change in the microstratigraphy of the mud on wheel arches. One of the major advantages of this is that they trap a wide range of grain sizes from small stones and grit (even small fossils) to clay and pollen. Although it is true that soil type is not unique to specific locations, many of its constituents may be, and more significantly, a combination of properties, such as mineral content, fossils, plant debris, and pollen can dramatically reduce the most likely source areas for the soil and/or greatly increase the likelihood of a strong association between the samples and the crime scene. The case study used here is unusually complex and in many cases pollen or mineralogy alone have proved to be sufficient in supporting or rejecting a suspected source for the material (5). However, the greater the number of persistent constituents that can be analyzed in the time available, the smaller the number of likely matches, the more conclusive the analytical conclusions may be.

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