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Experimental forensic studies of the preservation of pollen in vehicle fires

R.M. Morgan [a,b,*], J. Flynn [c], V. Sena [c], P.A. Bull [c]

[a] UCL Department of Security and Crime Science, Jill Dando Institute, 35 Tavistock Square, London, WC1H 9EZ, United Kingdom
[b] UCL JDI Centre for the Forensic Sciences, 35 Tavistock Square, London, WC1H 9EZ, United Kingdom
[c] Oxford University Centre for the Environment, South Parks Road, Oxford, OX1 3QY, United Kingdom

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ABSTRACT

The implications of the recent recommendations of the Law Commission regarding the use of admissibility tests have the potential to be far reaching for forensic disciplines that rely on the expertise of highly qualified expert witnesses. These disciplines will need a concomitant body of peer-reviewed experiments that provides a basis for the interpretations of such evidence presented in court. This paper therefore, presents such results from two experiments which were undertaken to address specific issues that were raised in cases presented in the British courtroom. These studies demonstrate that there is a variability in the persistence of Lily, Daffodil and Tulip pollen when exposed to high temperatures between 0.5 min and 1440 min (24 h). It was possible to identify all three pollen types after 30 min of exposure to 400 °C, and after shorter time frames the threshold for successful identification was 700 °C after 0.5 min for all pollen types tested and 500 °C for Daffodil and Lily after 5 min of heat exposure. Over longer time periods (18 h (1080 min)) the different pollen types were found to persist in a viable form for identification at 300 °C (Lily), 200 °C (Daffodil) and 50 °C (Tulip). These findings, albeit from a small sample of pollen types, provide empirical contextual information that would contribute to such evidence having sufficient scientific weight to meet admissibility criteria and be viable evidence for a court. These studies demonstrate the value in seeking pollen evidence from even such extreme crime scenes as encountered in vehicular fires.

1. Introduction

The UK has experienced rapid and significant changes in the structure of the practice of the forensic sciences in the last 20 years. These changes have included the closure of the Forensic Science Service (FSS) as well as the introduction of competitive tendering for forensic analysis and the establishment of the Forensic Regulator's Office. Whilst it was recognised that Forensic Science is critical to the efficiency and effectiveness of the criminal justice system by the House of Commons 'Science on Trial' report in 2005 [1], it was also acknowledged that there are significant areas of research and development in this discipline that need to be addressed more fully to ensure that the forensic sciences are in a position to provide strategic solutions for the future of crime detection. Most recently, the Law Commission's 2011 paper addressed the admissibility of expert evidence in criminal proceedings in England and Wales [2] and these findings have the potential to have far reaching implications for the future changes in legislation in England and Wales relating to the provision and admissibility of forensic evidence in a court. Indeed such a change has the potential to change the means of presenting forensic evidence by expert witnesses and has serious ramifications for the collection, analysis and presentation of trace evidence such as geoforensic materials including soils, minerals and pollen.

Perhaps the area that will be most significantly affected will be the forensic disciplines that rely on the expertise of highly experienced and qualified expert witnesses but where there is a lack of an extensive corpus of peer reviewed, experimental work to provide the foundations of the discipline in a form that will be recognised by a reliability test. Forensic palynology is known to be a highly valuable, accurate and effective means of forensic reconstruction which has been used by a number of experienced scientists in the last 30 years to provide forensic intelligence and evidence in selected legislatures [3–5]. There is however a disproportionately small body of forensic palynology literature in comparison to the value and reliability of the technique in practice, and the majority of the literature that has been published provides case study examples of where and how palynology was able to aid forensic investigations [3,6–9]. Should the recommendations of the Law Commission be adopted in the England and Wales legal system there is the potential for helpful, accurate and insightful forensic evidence to be ruled inadmissible if it is not accompanied by experimental work that establishes the nature and behaviour of different forms of trace evidence in forensically relevant situations in a manner that meets the criteria for admissibility of

* Corresponding author at: UCL Department of Security and Crime Science, Jill Dando Institute, 35 Tavistock Square, London, WC1H 9EZ, United Kingdom. Tel.: +44 20 3108 3037.
E-mail address: ruth.morgan@ucl.ac.uk (R.M. Morgan).

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evidence. The challenge is to ensure that disciplines that are applied in the forensic arena have the concomitant experimental (and forensically relevant) research base to ensure that their admissibility is assured in the British courtroom and valuable evidence is not lost simply because the accrued expertise and knowledge of the experts is not available in a format required by the court.

This paper therefore, seeks to demonstrate the value of even the most simple experimental studies in forensic palynology for addressing admissibility tests in the UK courts. A case is presented where pollen evidence was considered to be important at trial. The key question in an investigation often relates to the behaviour of a trace material in a specific forensic situation and over a particular time frame. Whilst much can be gleaned from the traditional palynological literature as to the behaviour of pollen under different natural situations and through different means of dispersal, in criminal investigations it is vital for the interpretation and presentation of the evidence for the specific variables impinging on the case to be taken into account. In a criminal prosecution in England in 1998, the defence argued that particulate evidence recovered from within a car which had been set on fire would have been affected and modified by the subsequent fire to render the evidence unusable and therefore sought to exclude the particulate evidence (which included soil and pollen). The mineral evidence was still presented to the court as the subsequent analysis demonstrated the particulates not to have been altered enough to render them unusable. However, if a Daubert-style test had been required at the time, all of this evidence may well have been excluded as inadmissible. Due to the vehicle fire, the pollen evidence was not deemed to be viable and no analysis was undertaken. We present here experimental studies in a forensic context that provide the preliminary evidence that counters the defence argument that pollen and soil particulates would have been destroyed by the vehicle fire.

Experimental work, of an allied nature, has demonstrated that it is possible to recover quartz grains for forensic surface texture analysis after exposure of up to 1200 °C (or 900 °C in the presence of salts) [10] and also fingerprints with sufficient ridge detail for analysis [11]. Therefore, an experiment was designed to establish whether pollen grains can be recovered for subsequent successful forensic analysis after their exposure to extreme heat/fire conditions and thus have evidential value in a forensic investigation. It is of course well known in the field of archaeology that pollen can persist for hundreds or thousands of years and withstand domestic fires and can therefore provide valuable insight in the use and age of particular sites of interest [12]. It is also well documented in the geological literature (micropalaeontology) that pollen can persist for tens of thousands or millions of years and is often found in association with charcoal and other evidence of natural fires [13,14]. Although the heat attained by geological processes affects pollen grains, it does not have the same oxidative potential that a fire would. There is a parallel however, in that pollen in the geological record does show different reactivity to geologically imposed heat according to species type and this may suggest that different pollen types will respond differently to fire as well [15–17]. However, in forensic investigations, exposure to fire and its heat is often comparatively brief and the questions asked of the samples are rather different to those posed in palaeoarchaeological and palaeontological investigations.

This present study aims to assess the threshold temperature at which pollen grains are sufficiently morphologically intact for forensic identification, and the degree to which that threshold varies over time and provide some insight into whether or not the pollen recovered from the sediment samples from the vehicle exposed to fire and heat in the 1998 case mentioned previously could have been viable evidence. The importance of such a study is not only found in assessing the viability of the trace evidence and thus influencing the collection and analysis stages of the investigations, but also in providing a scientific, experimental basis that provides the evidence base necessary for such evidence to meet a reliability test in the style of Daubert.

2. Experimental work

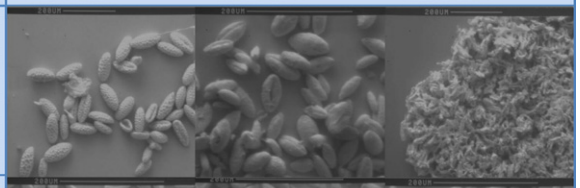
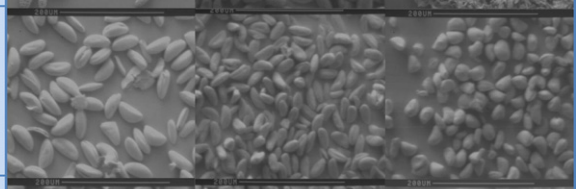
Three types of pollen were selected; Lily (*Lillium*), Daffodil (*Narcissus*) and Tulip (*Tulipa*) due to their relative abundance and their ease of accessibility for domestic decoration within dwellings in the UK. The flowers were allowed to mature and were then dried at room temperature before the pollen was extracted and transferred to sealed containers. A small quantity of pollen was placed into a ceramic crucible and put in a pre-heated furnace. Given the preliminary nature of this study, only the effects of furnace heat were considered. Future work could helpfully include the effects of direct flame contact and the extent to which these two conditions elicit different responses of the pollen that would affect morphological identification.

In experiment 1, discrete samples of pollen was exposed to different temperatures of 100–1000 °C (at 100 °C increments) for 5, 10, 15, 30, 60 and 120 minute intervals ($n = 66$). This temperature range was chosen after the work of Putori and McElroy [18] that demonstrates the temperature ranges typically found in house fires and the work of Morgan et al. [10] that demonstrated the typical temperatures experienced in vehicle fires. The samples were then allowed to cool in the crucible and subsequently analysed using binocular light microscopy and scanning electron microscopy (SEM). Pollen grains were grouped into four categories according to the degree to which the species of pollen could be identified through comparison with a control sample. Pollen grains were classified as follows:

1. Pollen grains retain their shape (*identifiable*)
2. Pollen grains show signs of thermal stress (*identifiable*)
3. Pollen grains become severely misshapen and/or conglomerated (*unidentifiable*)
4. Pollen destroyed (*unidentifiable*)

In classifications 1 and 2 the pollen species were identifiable and could be used for forensic analysis. As Table 1 illustrates, in classification 1 the pollen grains retained their shape and showed no adverse effects as a result of heating. In classification 2 the pollen grains were still identifiable, but showed some signs of thermal stress, such as a reduction in grain size or a partial distortion in shape. In classification 3, pollen grains were severely distorted in shape and size and were likely to have conglomerated. In classification 4 the pollen was completely destroyed (no sample recovered). It was deemed that when pollen grains were classified as 3 and 4 that the pollen was unidentifiable and therefore unsuitable for forensic analysis.

Table 1
Classification of pollen grains.

Pollen type	Classification 1	Classification 2	Classification 3
Lily			
Daffodil			
Tulip