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Editorial

Forensic palynology: Why do it and how it works

Abstract

Forensic palynology has been a law enforcement tool for over 50 years. Forensic palynology is the application of pollen and spores in solving legal issues, either civil or criminal. Pollen and spores can be obtained from an extremely wide range of items, including bodies. Pollen and spores provide clues as to the source of the items and the characteristics of the environments from which the material on them is sourced. Their usefulness lies in a combination of their abundance, dispersal mechanisms, resistance to mechanical and chemical destruction, microscopic size, and morphology. Their often complex morphology allows identification to an individual parent plant taxon that can be related to a specific ecological habitat or a specific scene. Pollen and spore assemblages characterise different environments and scenes and can easily be picked up and transported away from scenes of interest without providing any visual clue to a suspect as to what has occurred.

With so many publications and high-profile cases involving forensic palynology and environmental analysis now receiving publicity, the future of this branch of forensic science is assured. Furthermore, with the development of multi-disciplinary approaches to environmental analyses of crime scenes, far more detailed information is now available to law enforcement agencies, enabling them to determine with greater accuracy what may have happened during the commission of criminal activities.

Keywords: Forensic science; Forensic palynology; Pollen; Spores; Environmental analysis; Trace evidence

1. Introduction

Forensic palynology is the study of modern and fossil spores, pollen and other acid resistant micro-plant remains in a legal context. It is not a new science; as a forensic tool, it has been sparingly used since at least the 1950s [1–3] and probably well before that, but without documentation or publicity. More recently, forensic palynology has been used regularly as evidence in criminal trials in Australia [4], New Zealand [5], and the United Kingdom [6], in particular, and probably far more sparingly elsewhere [7–9]. Not only are modern pollen used, but in a number of cases, the presence of fossil pollen in association with a criminal action has also been useful in determining what happened and where it occurred [1,7].

Over the last decade or so, a number of papers on various aspects of forensic palynology have been published. Many have given advice on the collection of forensic palynological samples [5,9–13], on how to interpret variations in pollen distribution in soil [14–17], on how various materials, including clothing, retain pollen [18–20], on assessing the value of the palynological evidence [21,22], and even on determining when the murder occurred [8]. A number of case histories have now been published [23–25] demonstrating the various ways in which forensic palynology can be used towards establishing the truth behind a criminal or civil action, only some of which are given in the references. However, it is our hope that researchers wishing to follow up on forensic palynology will be able to access additional literature by reference to those papers listed, and to take care in who they follow on internet sites now appearing in increasing frequency.

These published case histories demonstrate the use of forensic palynology in cases as broad as forgery, rape, homicide, genocide, terrorism, drug dealing, assault and robbery, arson, hit and run, counterfeiting, and illegal importation, as well as civil cases involving geopreservation, illegal fishing, and pollution [26]. In general, palynology can be used to [5,13]:

- relate a suspect to the scene of a crime or discovery scene,
- relate an item left at the crime scene or discovery scene to a suspect,
- relate an item at the discovery scene to the crime scene,
- prove or disprove alibis,
- narrow down a list of suspects,
- determine the travel history of items, including drugs [27],
- provide information as to the environment that an item has come from,
- provide information as to the geographic source of items,
- aid police in their lines of inquiry,
- help locate clandestine graves and human remains [8,28],
- help determine the peri-mortem fate of a victim [29], and
- help to determine the deposition period of human remains.

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The complexity of forensic palynology and the associated necessity of needing to train in all aspects of environmental analysis at the trace level means that skilled practitioners are needed and these people are few and far between. In New Zealand and the United Kingdom forensic palynology is an accepted technique, but still it is not always being used as routinely as it should be nor in as timely a fashion. It has yet to be fully accepted elsewhere.

The protocols followed in different countries differ dramatically. In Great Britain, the palynologist always collects comparator (control) and evidential samples, visits the crime and associated scenes and undertakes vegetation surveys, and collects vegetation samples. In most, if not all, other countries the samples are more often collected by generalist crime scene examiners such as Scene of Crime Officers (SOCOs) or other law enforcement agents and sent to the palynologist. Vegetation surveys may not be undertaken and the palynologist may never visit the crime scene at all or may visit the scene just before appearing in court. The ideal situation is that occurring in Great Britain. For the palynologist to be able to fully contribute to the development of possible crime scene scenarios, he or she must be deeply involved at the start of the investigation and collect relevant samples as soon as the crime has been discovered. Many of the comments in this introduction are aimed at those law enforcement agencies who do not take advantage of the skilled palynologists available to help them determine what has occurred at crime scenes.

2. Why use spores and pollen?

Following usual convention, when the term pollen is used it also includes spores from ferns and fern allies. Pollen carries the male sex cells of higher cone- and flower-bearing plants from one plant to another of the same species. Spores are the sexual or asexual propagules and reproductive bodies of the lower plants and plant allies, including algae, ferns, fungi, mosses, liverworts, and lichens. Most spores are very small, conservative in morphology, go unnoticed and are difficult to identify and attribute to a specific taxon.

The usefulness of pollen as a forensic tool results from their small size, their resistance to mechanical, biological, and chemical degradation allowing them to be preserved on and within a variety of media, their abundance in the environment, and in their morphology which allows, within limits, identification to specific plant taxa.

The forensic palynologist utilises Locard's Exchange Principle that states whenever two objects come together there is always a transfer of material. It is clear that Locard regarded the exchange of physical evidence to include footprints, and consequently the effects on the plants underfoot, as well as material exchange of mainly dust sized particles [30]. Thus, not only can one demonstrate a connection between two sources of physical evidence but one can also deduce what type of action led to the exchange. Pollen provides one source of commonly transferred material, which often is exchanged within the context of a transfer of soil, mud, and dust particles. However, pollen can also be transferred by direct contact with a part of a plant containing spores or pollen.

2.1. Size

Most wind-dispersed pollen grains fall within a short distance of the parent plant despite their very small size. Their small size, usually between about 20 and 60 μm (some are as small as 7 μm and others are as large as 200 μm) means that often they can be picked up from a scene of interest in clothing, hair, under fingernails, and on other items and transported away from the scene without any visible sign that this has happened. The forensic palynologist is often asked to determine where an item or suspect has been, what they have been in contact with, or whether a particular scene has pollen that characterise that place. They may subsequently want to know if pollen from a point of interest can also be recovered from the clothing or other items directly associated with a suspect. In many cases, there is more than one location involved. For example, a murder may take place at one scene (crime scene), the body taken elsewhere (discovery scene), and the murder weapon disposed of at a third scene, while clothing or other items can be disposed of at other places.

While pollen size is useful in broad terms, it cannot be used as a means of identification. Pollen size can vary within a single anther let alone between species, so over-reliance on size criteria might be imprudent for identification. Many studies confirm that pollen size can also vary with the processing techniques used to extract the pollen from the items under investigation or even the type of mounting media used.

Other morphological features are more useful for identification. These include shape (spherical, ovoid, triangular, etc.); sculpture patterns on the surface of the grains (granules, spines, papillae, reticulation, etc.); aperture type and number (pores, colpi, or both; inaperturate, 1-, 2-, 3-, 4-apertured, or multi-apertured); wall structure (columellae, tectate, perforate, etc.); wall thickness, and variations in thickness around the pollen grain [1,31–34]. Most pollen examinations and identifications will be undertaken using a transmitting light microscope but additional details of the surface sculpture can be obtained, if required, by examination of specific pollen grains using a scanning electron microscope (SEM). However, in most routine criminal cases, SEM is of limited value since whole assemblages of pollen must be identified in mixtures obtained from exhibits.

Forensic palynologists need more than a microscope to identify pollen. They need access to good pollen reference collections, not only of their native taxa but also of other species from all around the world. Preliminary identifications may be made by reference to illustrations (photographs usually, since drawings are too risky to use as they are an individual's interpretation of how a pollen grain appears) in pollen atlases, journal articles, and books or book chapters. Illustrations should only be used as a guide to the appropriate part of the spore/pollen herbarium to look for reference material to compare with the unknown pollen. No one accessible reference collection is totally comprehensive. Many countries have their