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Mildenhall, Dallas (2008):

### **Civil and criminal investigations. The use of spores and pollen**

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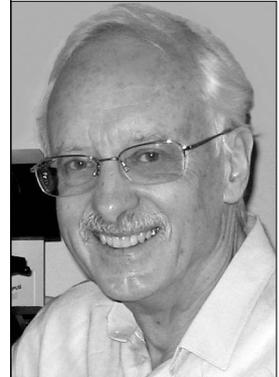
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## *Civil and criminal investigations*

# The use of spores and pollen<sup>1</sup>

Even though forensic palynology has been successfully used as a crime fighting tool for over 50 years it is still not universally used in either civil or criminal cases except in a few select countries. The usefulness of spores and pollen is a result of their small size of 7–200µm (20–60 micrometers on average), dispersal mechanisms, resistance to biological, chemical and mechanical attack, and complex morphology allowing many to be identified back to a parent plant and therefore to a known ecology or source environment. Spores and pollen are so small that they cannot be seen by the naked eye and criminals do not know that they have collected and taken away from the crime scene. In spite of this latter fact such material is not usually actively collected as forensic evidence. Spores and pollen are almost universal in their distribution but do not spread evenly over surfaces because of eddying air currents and numerous obstacles. This leads to even small geographic areas containing unique spore and pollen combinations. Crime scene and alibi scenes only metres apart can be distinguished. Recent courses in forensic palynology at the University of Vienna are a start in reintroducing forensic palynology to Austria after the pioneering work in this field by the Austrian palynologist Wilhelm Klaus over 50 years ago. However, forensic palynology should be regarded as just one tool in an arsenal of ecological tools that could be used to fight crime. It is recommended that a multidisciplinary forensic ecological unit be considered as an important element in Austria's on-going fight against crime.



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### 1. INTRODUCTION

The first recorded case of the use of spores and pollen to solve a serious crime (forensic palynology) was in Austria over 50 years ago. A man on a journey down the Danube River disappeared near Vienna, but his body could not be found. Another man, with a motive for killing him, was arrested and charged with his murder. Without a confession or a body the prosecutor's case seemed likely to fail. As the investigation proceeded, mud from a pair of the defendant's shoes was given for analysis to the palynologist Wilhelm Klaus of the Department of Palaeobotany, University of Vienna. Klaus determined that the mud

contained modern spruce, willow, and alder pollen, as well as 20 million year old fossil hickory pollen grains, which had eroded from exposed sediment of Miocene age. Only one small area 20 km north of Vienna, along the Danube River, had soil developed on the required Miocene rocks and a forest consisting primarily of spruce, willow and alder. When the defendant was confronted with the identity of this locality he confessed his crime and led authorities to the precise site where he had buried the body. This region was in the area pin-pointed by Klaus.

In spite of this excellent beginning the science of forensic palynology did not gain

### VOCABULARY

**palynology:**  
*Pollenforschung*

**eddy:**  
*Strudel, Wirbel*

**spruce, willow and alder:**  
*Fichte, Weide und Erle*

## VOCABULARY

**rustling:**  
Viehdiebstahl

**anther:**  
Staubbeutel

**stigma:**  
Narbe

**sporangium:**  
Bildungsstätte von Sporen

**liverwort:**  
Lebermoos

**lycopod:**  
Bärlapp

**hornwort:**  
Hornmoos

**lichen:**  
Flechte

**moss:**  
Moos

**germination:**  
Keimung

**to burrow:**  
sich verkriechen

**decomposition:**  
Zersetzung

acceptance in Austria or worldwide until relatively recently. Forensic palynology has been a key element in a large number of criminal investigations in Great Britain, New Zealand and Australia, mainly in investigations of homicide, genocide, violent assault, rape, terrorism, suspected terrorism and in multinational criminal activity including counterfeiting of bank notes.

In New Zealand forensic palynology has been used in all types of crime where a suspected exchange of soil or plant material has taken place, and where other clues seem to be rare or subject to debate. These cases include arson, assault, breaking and entering, burglary, counterfeiting (particularly of pharmaceuticals), forgery, hit and run, illegal fishing, possession and manufacture of illicit drugs, rustling, smuggling, theft, and the violent crimes.

***Forensic palynology can also be used to focus a line of inquiry for the Police without actually leading to the provision of concrete evidence able to be presented in court.***

A number of case histories and scientific papers have been published outlining the successful applications of forensic palynology to the solution of criminal activities. A list of twenty selected papers is presented<sup>2</sup> to give the interested reader an introduction into the science behind various forensic palynological techniques and more details of the range of civil and criminal investigations forensic palynology has been used in.

## 2. WHAT CAN FORENSIC PALYNOLOGY DO?

Spores and pollen, often collectively identified as pollen, are used as a means of dispersal and reproduction by plants. Pollen are produced within anthers in flowers

(from flowering plants) or highly modified leaves within cones (from conifers) and carry the male sex cells from one plant to the female part of the flower (stigma) or the female cone of a different plant (more often) in the same species for fertilisation and seed production. Spores are produced in sporangia and other specialist organs and are the means of either sexual or asexual dispersal of lower plants and plant allies including algae, ferns, fungi, liverworts, lycopods, hornworts, lichens and mosses. These spores and pollen grains depend on outside factors, like animals, wind or water, to get from the parent plant to a suitable environment for germination (spores) or fertilisation (pollen).

### 2.1. ADVANTAGES OF USING POLLEN AS A FORENSIC TOOL

Spores and pollen have distinct advantages over many other biological and geological sources of forensic evidence. Pollen grains are so small, between 7–200 micrometers (avg. 20–60µm), that they cannot individually be seen by the naked eye, thus criminals cannot tell that they have collected them from the crime scene. They adhere to almost any surface and can become firmly attached and even burrow into clothing if they still contain active pulsating cytoplasm surrounding the male sex cells. Normal washing in domestic detergent will always extract some grains but sufficient pollen grains still remain embedded to retain the potential to be directly related back to a crime scene.

A second distinct advantage is that pollen are extremely resistant to decomposition. They have a multi-layered cell wall composed of cellulose and one of the most chemically resistant organic molecules known, sporopollenin. Pollen walls can be preserved for hundreds of million years given the right dry depositional conditions. In forensic cases pollen can

survive for many years to provide evidence well after the event under investigation.

A third advantage of pollen is that, in spite of their small size, they have quite a complex morphology that allows many of them to be identified back to parent plants and to an unseen ecological and environmental setting. The ability to determine what sort of environment particular combinations of spores and pollen came from allows palynologists to identify and describe an unseen location or locations where a crime may have taken place solely on the basis of an analysis of very small evidential samples.

***A distinct advantage pollen have is that many plants produce pollen in great abundance and disperse that pollen through the air.***

Pollen is not evenly spread over a large area at any one time because there are numerous obstacles that get in the way. Eddies, updrafts, downdrafts, and turbulent airflow concentrate or eliminate specific pollen types from given areas. Obstacles like vegetation, especially leaves, act as effective pollen filters. Most pollen falls within about 2 km of its source and in many cases within 100 m. Ground hugging plants disperse most of their pollen over even shorter distances. This highly variable dispersal effect produces large differences in pollen recovery over very short distances – even within a few metres – and has been of great significance in a number of forensic cases.

## 2.2. POLLEN DISPERSAL

Most pollen picked up in forensic samples come from plants that disperse their pollen by air. Plants that do this tend to be the taller trees like alders, beeches, birches, elms, firs, oaks, pines and sycamores and

herbaceous plants like many of the grasses, daisies, docks, and plantains.

Another dispersal agent is water but pollen produced by plants that depend on this dispersal mechanism tend to be small, unornamented, thin-walled types that are often hard to identify. If recovered in an evidential forensic sample they would indicate a wetland source.

Some plants use animals for dispersal. These plants usually produce relatively few pollen grains because their choice of disperser is far more effective than wind or water. Such plants include clover (*Trifolium*), flowering cherry (*Prunus*), orchids (many different genera), many proteas, and sunflower (*Helianthus*). The pollen are often large, thick walled, sticky and highly ornamented to enhance their ability to cling to the outside of the animal or insect they use. A wide range of insects and other animals are known to be active pollinators. When such pollen grains are found the source plant is usually close by and if found in some numbers in an evidential sample it usually means that the item sampled has been in close contact with the flowering parent plant or with soil from immediately beneath the plant.

***Another important source of pollen is from older sediments. In a small number of forensic cases the identification of fossil pollen, eroded out of old rocks and recycled into younger soils caught up in a crime, has been important.***

The Austrian “murder on the Danube” case is a good example. Often the presence of fossil pollen can pin-point an unknown locality with greater precision than modern pollen alone and provide conclusive evidence of a connection between perpetrator and crime scene.

## VOCABULARY

**updraft:**  
*Aufwind*

**ground hugging:**  
*bodennah*

**herbaceous:**  
*krautartig*

**dock:**  
*Ampfer*

**plantain:**  
*Wegerich*

**wetland:**  
*Feuchtgebiet*

## VOCABULARY

*comparator sample:*  
Vergleichsprobe

*pinch sample:*  
Einzelauflistung

*cardinal point:*  
Himmelsrichtung

Thus forensic palynology can perform a range of tasks that most forensic techniques in combination endeavour to cover.

### 3. WHAT AND HOW TO COLLECT FORENSIC SAMPLES FOR POLLEN

Papers listed below<sup>3</sup> will give readers an idea of what to look out for during the collection of evidential and comparator samples, and the problems that must be appreciated.

***It is important that samples be collected with the full knowledge of why they are being collected and what the problems are that their collection is designed to solve.***

To get the best results in an investigation it is highly preferable if the forensic palynologists do their own collecting from scenes of major crimes as soon as possible. This will allow for time to plan the most appropriate sampling strategy for the particular case and avoid possible destruction or contamination of pollen evidence. However, for criminal activity of lower priority it may not be practical or cost efficient to send for the forensic palynologist, or such a person may not be available at short notice. Therefore, the scene of crime police officers (SOCOs) or other forensic scientists will need to collect pollen samples. Consequently they need to know what and how to collect to avoid loss of important evidence and thus will need training by experienced forensic palynologists.

It is not intended to go into great detail about how to collect because it seems that every crime scene is different and collecting must take into account the circumstances at each crime scene. More detailed information can be obtained from the articles listed below.<sup>4</sup>

### 3.1. COLLECTION OF COMPARATOR SAMPLES

Accurately sited, timely and relevant comparator samples need to be collected from crime scenes to be compared with evidential samples. Random material from near crime scenes is not good enough for comparison with evidential samples from specific localities. Since pollen percentages can be quite different over short distances (of a metre or less), comparator samples need to be taken as close as possible to where evidential samples were taken. It will also be necessary to take a range of samples from the site so that the variation in pollen at the crime scene can be determined. This provides a better chance of establishing a closer comparison between evidential and comparator samples.

Samples can be collected in a number of ways determined by the nature of the crime scene. Random pinch samples can be taken from loose material on the ground and bagged separately or preferably combined into one sample to give an averaged representation of the pollen assemblage from a suspected crime scene. Alternatively, all loose material can be collected together from an area defined by the crime. The crime scene can be divided into segments of decreasing priority and targeted samples taken evenly over the surface of each segment to get an averaged pollen profile per segment. Another method is to collect several samples from each cardinal point around the crime scene. A full sampling regime must be undertaken at each crime scene to determine the full range of variation present because each sample represents a site unique in its spore and pollen content. You can never collect too many samples. An example of a case in which such averaged pollen percentages were calculated from two crime scenes is given in section 5.2.

Comparator samples should not be collected from any deeper into the ground than the suspect at the scene is likely to have penetrated. Normally no comparator sample would be more than 1.0 mm deep and more often it is surface dust that is collected, especially when the perpetrator has only walked over the area under investigation. Comparator samples need to be collected along paths, tracks or other entry or exit points into and out of a crime scene and can often provide the only pollen evidence of a suspect being at or near a scene.

Pollen profiles at crime scenes are highly variable and sufficient samples must be taken to fully encompass those variations. This taphonomic variability, defined by Patricia Wiltshire, Britain's most experienced forensic palynologist, as "all the factors that influence whether a palynomorph (pollen, spore, or other microscopic entity) will be found at a specific place at a specific time", needs to be expected and tested. Each crime scene presents a series of unique pollen profiles applicable only to that specific scene and those profiles must be sampled so that the full range of variability is documented. A lot of palynological data from surface samples may be required to answer all questions that arise in a criminal investigation and subsequent trial.

Other sources of comparator samples need to be considered, these include shoes, clothing, walls, ropes, shovels, and many other items, and all require their own special techniques which can be learnt by only by reference to experienced forensic palynologists. In general comparator samples should match evidential samples as closely as possible, bearing in mind that often comparator samples are collected before evidential samples are located.

### 3.2. COLLECTION OF REFERENCE VEGETATION SAMPLES

Cones, flowers, fruit, galls, seeds or leaves may need to be collected from a crime scene to help the palynologist, especially if direct contact between perpetrator and the vegetation (whether flowering or not) is suspected. It is easier and quicker for the palynologist to identify pollen in forensic samples by comparison with pollen processed from plants nearby than it is to work without knowledge of what is present and flowering at the time or shortly before. Living vegetation will need to be stored in paper envelopes or between newspapers that are frequently changed as the vegetation should dry out, preferably in a drying oven.

***Fresh vegetation should never be stored in plastic containers as this promotes growth of fungal and bacterial activity which may destroy evidence very quickly.***

However, anthers from flowers can be stored in plastic containers and preserved in alcohol until processed for identification. If colour is important then this should be recorded and compared with standard colour charts.

A full photographic or video coverage of the crime scene and surrounding vegetation should also be taken. This may help the palynologist to better relate individual trees to the crime scene. Direct video contact with a forensic palynologist in the laboratory providing ongoing advice can also help SOCOs during their collection of evidential and comparator samples.

### 3.3. COLLECTION OF EVIDENTIAL SAMPLES

In most cases the evidential samples turn out to be very small in comparison with

## VOCABULARY

*map:*  
abbilden

*cuff:*  
Stulpe

*grooves and crevices:*  
Rillen und Spalten

*track shoes:*  
Turnschuhe

comparator samples. Almost everything has the potential to provide pollen evidence given the right circumstances. Since pollen grains readily attach to surfaces, they are found on and cling to almost anything. Nearly all but the most highly refined food and drug products contain pollen.

When collecting evidential samples from clothing it is important from very early on to know if pollen samples need to be collected to map pollen distribution. For example, it may be important to know whether someone has hidden under a tree and has received a lot of pollen on their shoulders, and less pollen elsewhere. It may be important to know whether clothing, worn by someone walking through a field, contains pollen that has become attached to the cuffs or base of their trousers (maybe just on one side), or higher up depending on the height of the vegetation. Plants do not need to be in flower at the time. It may also be important to know if someone had knelt, sat or rolled on the ground and pollen can be mapped on clothing to demonstrate this.

A good source of pollen evidence is from shoes. Even cleaned shoes constantly used for weeks or months after being worn at a crime scene could retain pollen that relates back to that scene. One reason is that shoes contain grooves and crevices that store pollen, especially the modern track shoes with their deeply grooved soles, and polishing and washing will not get into all of these areas.

Multiple pollen samples from cars are also important to collect because they may contain the only evidence of a presence at or near a scene. Again how, what and where to collect will be based on the forensic palynologist's experience and the questions that need to be answered.

#### 4. ENVIRONMENTAL PROFILING UNITS

Since forensic palynologists are usually trained in only one aspect of environmental science, the ideal is for law enforcement agencies to consider establishing forensic ecology or environmental profiling units to cover the full range of forensic environmental analyses.

Because of the large range of specialist equipment, databases, and reference collections in the many disciplines involved most of the experts will need to be closely associated with a specialist grouping, either in a university or stand alone institute. Therefore, the environmental profiling unit would act more in a co-ordination role than consisting of active forensic ecology scientists.

***A full geological and biological environmental analysis of any relevant crime scene will always provide much more useful information than any single discipline on its own.***

This small specialist forensic ecology unit would build up access to the numerous environmental skill sets required and know when they would be of most benefit, creating a powerful cost effective tool in the combat against crime. This unit would be able to ensure that liaison between the criminal investigation team, other scene-of-crime personnel, pathologists, and forensic scientists, is maintained. The only part of the world where such units presently exist is Great Britain where an Environmental and Forensic Ecology Unit within the British Forensic Science Service is developing.

#### 5. EXAMPLES OF THE USE OF FORENSIC PALYNOLOGY

Many hundreds of cases around the world have now successfully used forensic paly-

nology as a tool against crime. Six previously documented case histories are presented here to illustrate the numerous ways that palynology has been used in forensics.

### 5.1. INVESTIGATION OF WAR CRIMES<sup>5</sup>

This investigation is a classic case of detailed environmental profiling using palynology as one of the major tools.

In July 1995 a massacre of civilians followed the fall of Srebrenica with resultant burial in seven mass graves. Three months later the bodies were exhumed and transported to a number of new burial sites in an attempt to conceal evidence of the massacre and to deflect blame. Could palynology help in relating the secondary burial sites with the original primary burial sites and thereby more closely link

the massacre to known or suspected perpetrators? Re-exhumation was commenced by the United Nations International Criminal Tribunal for the former Yugoslavia (ICTY) in 1997.

The objective of the palynological and associated soil analyses was to determine the environmental profile of the original burial sites and to try and find a connection with the secondary sites where different environmental profiles existed. These analyses were done independently of all other forensic investigations being undertaken at the same time to ensure credibility. Five of the original sites and 19 secondary sites were investigated in detail. Analyses indicated that the original mass graves each had a different geological and botanical profile which easily separated each site. Samples from all sites were taken from the fill of the graves close to

### VOCABULARY

*deflect:*  
*ablenken*

Quelle: Pal Dat

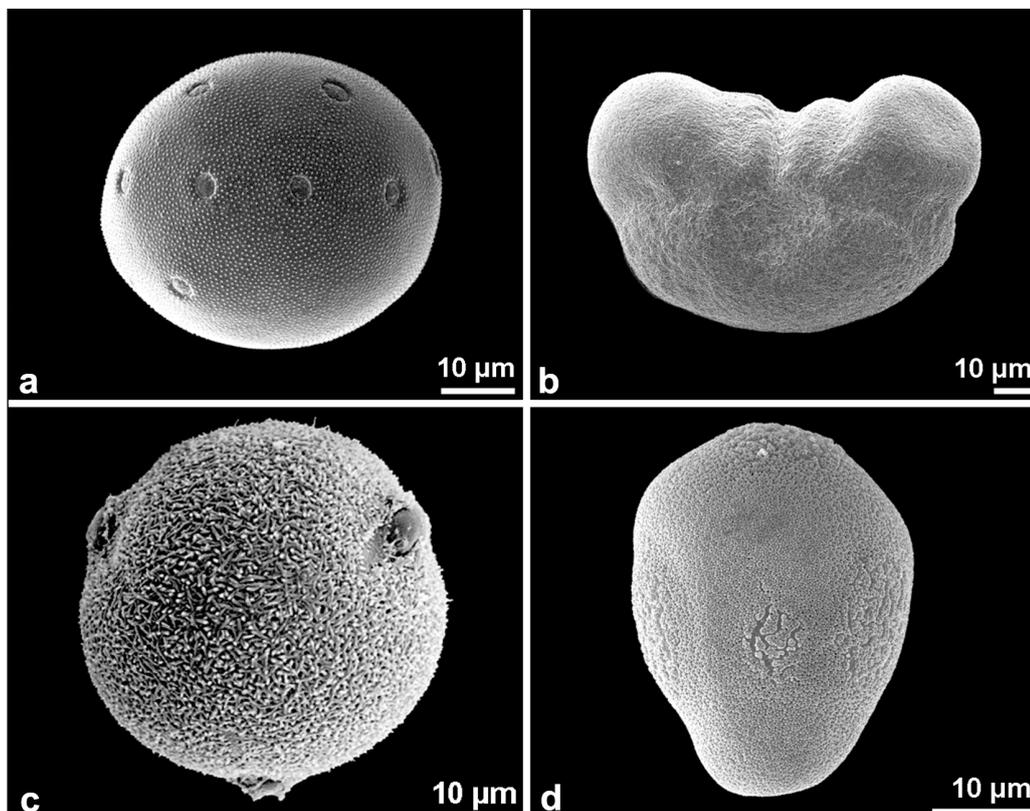


Abb. 1: SEM photographs of pollen. 1a: Juglans (walnut); 1b. Picea (spruce); 1c. Fagus (beech); 1d. Carix (sedge)

and from varying distances away from bodies or body parts and from sediment surrounding the mass graves. Over 240 comparator samples were collected from various sources to determine the background pollen profile of each site, the local vegetation was recorded and abundance of major species determined.

Results showed that sediments and associated spores and pollen from the original mass graves had indeed been transferred along with the bodies to the numerous secondary burial sites and that even some botanical evidence at the primary burial sites pointed to the original execution site or sites. Pollen found at the original burial sites consisted of cultivated grasses (cereals including wheat and maize), wild grasses (Poaceae), pines (Pinus), spruces (Picea), sedges (Cyperaceae), beeches (Fagus) and walnut (Juglans). Various combinations of these pollen types, plus many others, were subsequently found in exotic material sampled from within the graves at the secondary burial sites, proving a link between the original and subsequent burial sites.

The accuracy of the evidence provided by the pollen was confirmed by other types of forensic evidence and presented in court. The investigation showed the importance of being able to differentiate

between imported and local fill used at grave scenes. This was probably the first time that environmental profiling was used systematically in a war crimes investigation.

### 5.2. INVESTIGATION OF THE MURDER OF LEANNE TIERNAN<sup>6</sup>

This case illustrates how accurately the environment of an unknown crime scene can be described solely by pollen analysis of small amounts of evidential material taken from the scene.

Lianne Tiernan had been missing for ten months. In August, 2001 she was eventually found wrapped in a floral bed spread inside plastic bin liners. The area where she was found was an acidic grassland with vegetation dominated by gorse (Ulex europeus), heather (Calluna vulgaris and Erica species), bracken (Pteridium aquilinum), many other herbs, and exotic planted trees, including larches (Larix decidua). No suspect had been identified at the time the pollen analysis was undertaken and it was hoped that this analysis would lead to some environment being determined where she may have been other than at known grave, home and abduction sites.

A vegetation survey and pollen analyses of comparator samples taken from around

#### VOCABULARY

**sedge:**  
Riedgras

**floral bed spread:**  
geblühter Bettüberzug

**bin liner:**  
Müllsack

**gorse:**  
Stechginster

**bracken:**  
Farnkraut

**larch:**  
Lärche

Quelle: Pal Dat

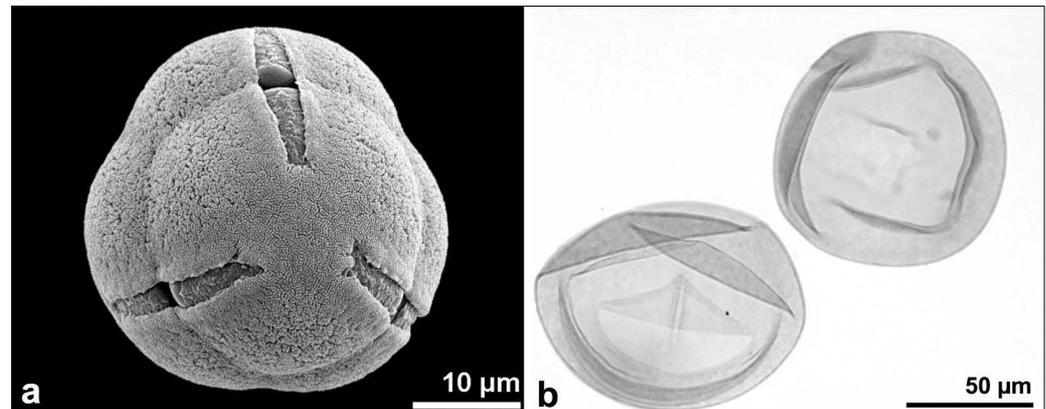


Abb 2: Light microscope and SEM photographs of pollen. 2a. Erica (heather); 2b. Larix (larch)

the grave site, inside and outside of the bed spread and from the victim's hair was undertaken. It was known that the victim washed her hair every other day but her hair had clearly been in contact with soil and/or vegetation. Because the hair and the bed spread would have received pollen from the grave site, and possibly also from her home and abduction sites, the pollen analysis of the hair and bed spread excluded those pollen types found at these known sites.

The hair contained abundant pollen and microscopic charcoal fragments with recognisable large, macroscopic, charred wood fragments and numerous fungal spores in tetrads (groups of four). The abundance of the larger elements was such that the hair must have been in contact with burnt ground for considerable time. Not only that but the large size of many of the charcoal fragments was such that they were unlikely to have been wind dispersed and so her hair must have been in almost direct contact with the burnt out area. None of the known sites contained burnt areas likely to have contaminated the victim's hair. Pollen from the bed spread was similar to that of the victim's hair and both were different from the previously known sites.

***It was predicted that the victim had spent some time on the ground in a weedy garden or waste ground, where a fire had once occurred in which both soft and hard wood had been burnt.***

The body would have lain close to where the fire was. It was also thought that this site had the following plants growing close to where the body had lain – privet (*Ligustrum*), elder (*Sambucus*), brambles (*Rubus*), hawthorn (*Crataegis*), and cherry/plum/sloe (*Prunus*). Other plants likely to

occur nearby included nettles (*Urtica*) and chenopods (*Chenopodiaceae*, goosefoot family).

Subsequent police investigations identified a suspect and when they went to his garden recognised it from the description given to them by the forensic palynologist. All the plants identified and determined to be at the scene were present, as were two large burnt areas in different parts of the garden. Derelict dog kennels occupied one area close to one of the fire sites. Six averaged pollen samples were collected from the garden and while the inter-sample variation was high the presence of so many key pollen and spore indicators was sufficient to show that the body, or more specifically the hair on the body, and the bed spread had lain near to the dog kennels and close to one of the burnt out areas.

The close comparison of the pollen profiles, the fungal remains, the macroscopic and microscopic charcoal found in the garden where the body had been, the victim's hair and the bed spread and the poor comparison of these elements with all other known contact sites demonstrated a close linkage to the garden. The defendant confessed to his crime.

### 5.3. INVESTIGATION OF CRIME AND ALIBI SCENES<sup>7</sup>

This case gives an example of just how close two scenes can be yet the pollen so different that both scenes can be clearly distinguished.

A prostitute was raped in an alleyway between two buildings. The resultant disturbed ground was seven meters from the edge of a driveway where the defendant's car parked after he had taken her to the scene. The defendant denied having raped the prostitute and maintained that he was never more than one meter from where he

### VOCABULARY

**weed:**  
*Unkraut*

**derelict:**  
*verfallen*

**poor:**  
*hier: dürftig*

Quelle: Pal Dat

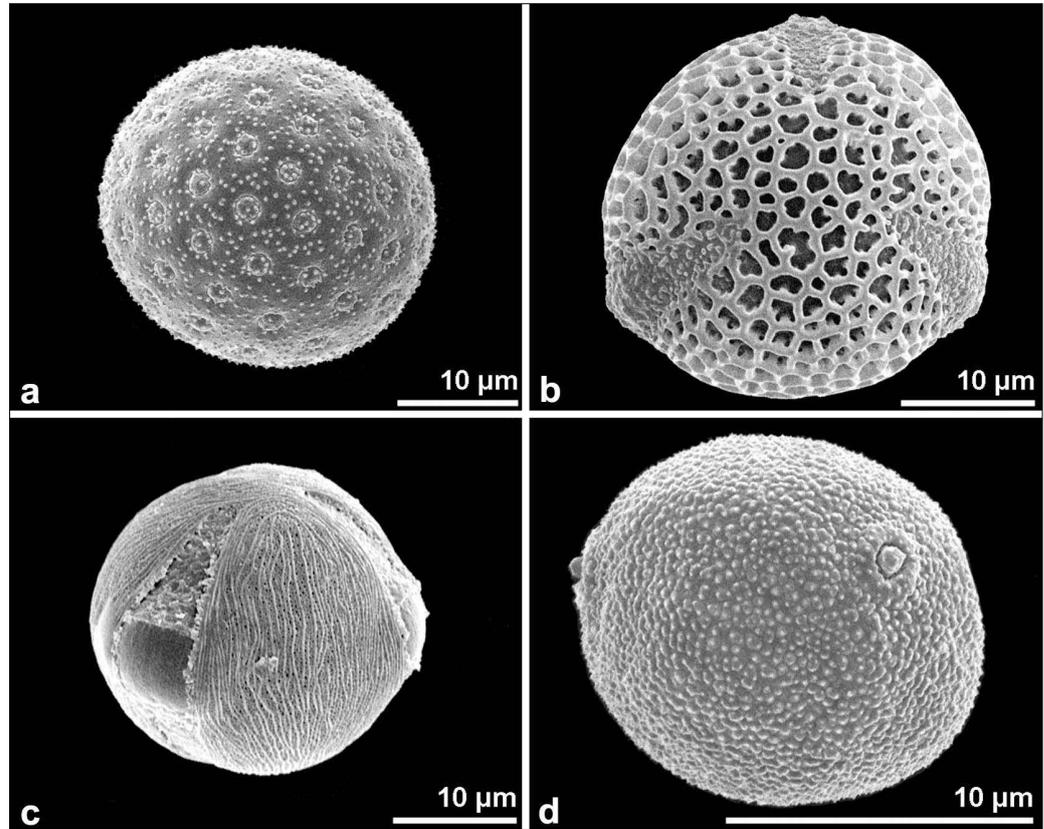


Abb. 3: SEM photographs of pollen. 3a. Chenopodiaceae (goosefoot); 3b. Ligustrum (privet); 3c. Rubus (bramble); 3d. Urtica (nettle)

**VOCABULARY**

*track pants:*  
Trainingshose

*pine:*  
Föhre

parked his car and had only been in casual contact with her. The defendant had soil on his jacket and track pants which he alleged had come from the ground close to his car and not from the area of disturbed ground in the alleyway.

***No physical evidence at either scene linked to the defendant was found.***

Pollen analysis from the defendant's clothing was decided on because petrologic analysis of two apparently uniform scenes so close together was deemed unlikely to provide site differentiation.

Soil samples were taken from the defendant's jacket and the knee of his track pants. Comparator samples were taken from the two scenes – the alleyway and

driveway where the car was parked. The two comparator samples were clearly from the same geographic location containing the same pollen types, but in quite different percentages. The alleyway sample contained a very large amount of pollen from Coprosma, and small amounts of other pollen types. The driveway sample contained far less Coprosma pollen and far more pine and grass pollen. A lot of grass was growing next to the driveway but not in the alleyway.

If the defendant had remained close to his car then his clothing would not contain very many Coprosma pollen grains. Pollen analysis indicated that the clothing contained approximately 80 % Coprosma pollen and very small percentages of other pollen types and matched the alleyway pollen profile very closely. There was virtually

no grass or pine pollen on the clothing, as would be expected if he had been in direct contact with the ground beside his car. The pollen evidence very strongly supported the contention that the soil on the defendant's clothing came from the alleyway.

***Why was there such a difference in the pollen over such a short distance? Most pollen are deposited directly under or within a very short distance of the parent plants.***

The shaded, enclosed alleyway contained predominantly Coprosma bushes (up to 2.5 m high) and patches of bare soil caused by heavy shading. The surrounding buildings and other items stored in the alleyway restricted air circulation. Most Coprosma pollen produced would remain in the alleyway with only a small percentage able to exit the area. The only pollen types that could get into the alleyway came from occasional wind dispersed pollen from the local region. Near the exposed driveway was a grassy, weedy area with plants less than about 0.2 m and no exposed soil for the defendant to pick up on his clothing. Bushes and small trees were nearby, close enough to provide plenty of wind dispersed pollen, especially

pine pollen, to the driveway. The geography of the two scenes enabled a very different pollen assemblage to occur even though the two scenes were just 7 m apart. His alibi was thus proved to be false.

#### 5.4. INVESTIGATION OF AN EXECUTION-STYLE MURDER<sup>8</sup>

This case shows that the season of the year is often of little relevance in forensic cases and that relatively long time intervals between the crime and collection of evidence can also have little importance.

A pig hunter, following an old trail in mountains some distance from Wellington, New Zealand, came across a body of a man shot, execution-style, in the back of the head. Once the man was identified it was realised that he was last seen several months earlier. An 18-month Police investigation resulted in a man being arrested for the murder. This man denied having been in any mountainous area.

Pollen analysis of the victim's clothing and comparator samples from the scene recovered significant numbers of pollen grains of silver beech (*Nothofagus menziesii*), a species common in mountains but absent in Wellington and rare on the outskirts of the city in botanical gardens and planted reserves. Pollen of silver beech is large and does not disperse well

#### VOCABULARY

*beech:*  
*Buche*

Quelle: Pal Dat

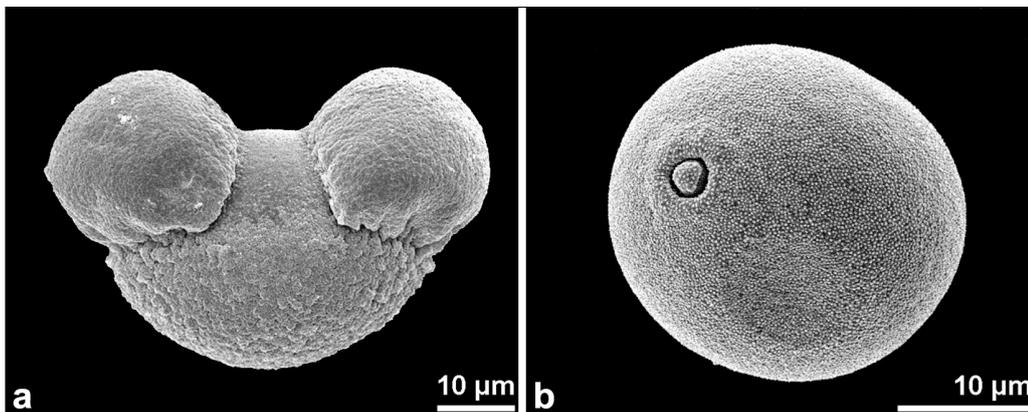


Abb. 4: SEM photographs of pollen. 4a. Pinus (pine); 4b. Poaceae (grass)

in wind so normally most pollen would fall within a few tens of metres of the parent plant. Since the body was found well off the usual tramping and forestry routes in dense forest the murderer was likely to have silver beech and other pollen on his clothing and also on any other items taken to the scene.

***About 60 different items including clothing and tramping gear were obtained from the defendant and his associates.***

The defendant maintained that none of these items had ever been in the mountains. Two of the items seized consisted of a Fairydown jacket and distinctively coloured Rip Curl board shorts. The defendant claimed that the jacket had been purchased overseas and had never left Wellington and that the Rip Curl shorts were purchased after the discovery of the body. Four of the seized items contained significant amounts of silver beech pollen, and eight other items contained enough silver beech pollen to suggest that they also must have been near a parent plant or plants and two of these 12 items were the jacket and shorts.

Pollen analysis of comparator samples from the area around where the defendant, his father, who was at a different address, and his associates lived did not pick up any silver beech pollen. Records of previous modern pollen work in Wellington had also failed to find any silver beech pollen. Investigations showed that no silver beech occurred in the area where the shorts had allegedly been purchased and in fact that particular brand of shorts had never been sold in that area. Inquiries located a witness who reported seeing a man wearing a Fairydown jacket and distinctively coloured Rip Curl shorts with another man, in a car park close to a track

leading into the mountain area at about the same time the victim went missing. No silver beech pollen was found in samples from this car park.

During the trial when the pollen evidence about the shorts and jacket was presented in court the defendant changed his alibi and admitted being in the mountains, but did not admit to the murder.

The murder and subsequent discovery of the body three months later took place well outside the flowering season of silver beech, yet that was the dominant pollen type on the clothes of the victim and although the defendant had only been at the scene a few hours at the most he had enough silver beech pollen (and other pollen from the scene) on him to indicate his presence in the mountains. This case also shows, in spite of a considerable lapse in time between the disappearance of a victim, location of his body and identification of a suspect, that clothing and other items collected for pollen analysis from the suspect still held sufficient pollen derived from the mountains to indicate that they had been there.

### **5.5. INVESTIGATION OF A COLD CASE<sup>9</sup>**

This case shows that even after storage for a number of years evidential items will still hold pollen that may give clues leading the identification and subsequent arrest of a perpetrator.

A series of sexual assaults with the same modus operandi was carried out in Western Australia over a period of five years. Police had DNA evidence but no match, an Identikit picture from several victims, which suggested he was of Australian aboriginal descent, and a pair of track shoes thought to belong to the rapist. After one assault he was involved in an accident in a car he had stolen and in his hurry to get away from the accident scene left his

Quelle: Pal Dat

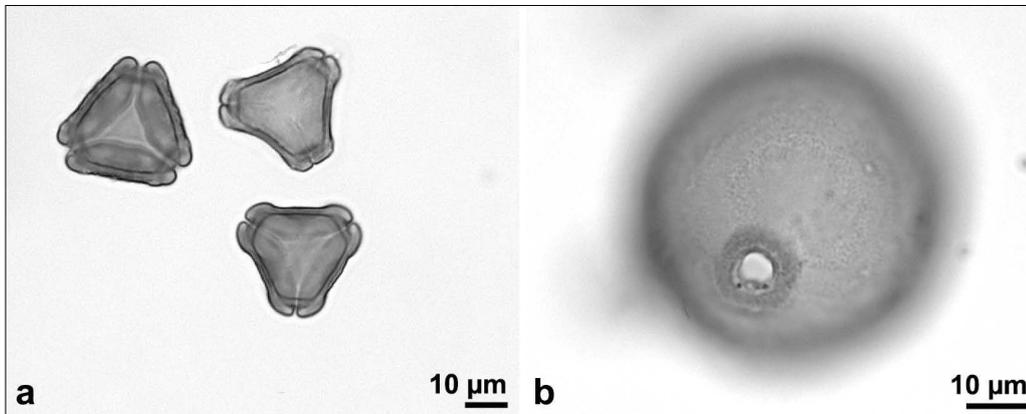


Abb. 5: Light microscope photographs of pollen. 5a. Eucalyptus (gum); 5b. Zea mays (maize)

shoes behind in the car. Police also suspected that the rapist was an itinerant country worker who occasionally visited the city because his assaults were at irregular intervals over a wide geographic area.

The shoes had been obtained early in the investigation and Police learning of forensic palynology decided to try it on the shoes that had been held in secure storage for over three years. Small samples of soil and dust were recovered from the soles of the track shoes which provided a rich pollen assemblage suggesting derivation from eucalypt woodland containing other plants in the myrtle family, she oaks (*Casuarina*), pines and grass. Unfortunately, this type of woodland is exceedingly common in Western Australia, but it did include the area in which the shoes were found and where the associated assault took place.

On closer examination some of the grass pollen, comprising only 1 % of the total pollen count, were large and clearly from cereals like wheat or maize. Cereal pollen grains are relatively rare as not many grains are produced from these self-fertilising plants, and their pollen is rarely found in soils except immediately under the parent plants. Also caught up in the outer edge of the soles of the shoes were short pieces of straw identical to brittle

straw or stubble left behind on the ground after hay making. Many farmers cut hay for their own use but do not normally employ itinerant workers to help them. Intensive hay making is most common in the chaff-cutting industry, where wheat is grown to be cut and the chaff (the dry protective casings from off seeds of cereal grains or hay or straw cut into very short lengths) is sold as animal feed. These large farms employ mainly itinerant seasonal workers, and such farms occupy a relatively small area some 100 km from Western Australia's capital city, Perth. Police initially approached the largest chaff-cutting farm and asked for a list of their itinerant workers. DNA indicated that the rapist was related to one of the men employed by the farmer. Within a week the rapist was identified and charged, without recourse to any other farm. The rapist had provided general services to the chaff-cutting industry.

## 5.6. INVESTIGATION OF FAKE PHARMACEUTICALS<sup>10</sup>

The criminal fake artesunate trade in SE Asia (Myanmar, Cambodia, Laos, Thailand, Vietnam and Yunnan Province in China) is a thriving trade. This case shows that also fake pharmaceuticals can contain pollen evidence that can lead to the identi-

## VOCABULARY

**stubble:**  
*Stoppeln*

**itinerant worker:**  
*Wanderarbeiter*

**chaff:**  
*Häcksel*

fication of sources and the subsequent arrest of perpetrators.

Malaria is one of the world's most serious health problems causing upwards of one million deaths each year. Many of the established pharmaceuticals used to combat malaria are no longer effective because of a build-up of resistance in the malarial parasite *Plasmodium falciparum*. One drug that is still exceeding useful is artesunate, derived from the plant *Artemisia annua* (sweet wormwood), a native of China. Investigations into the apparent failure of some artesunate drugs discovered that over 53 % of the drugs were counterfeit and that the situation was worsening year by year. In one hospital in Laos all of their artesunate drugs were counterfeit.

An international group of analysts, police, scientists and health workers met to investigate the problem with goals of identifying the source of the counterfeits and seeking out information that could lead to the identification of those responsible. All tasks were undertaken by the analysts and scientists without knowledge of the results from the other working groups so that no possibility of influence affecting the conclusions could occur.

The genuine product is distributed in blister packs in cardboard packages with a leaflet. Holograms were placed on the genuine product to combat counterfeiting, once it was recognised as occurring. Forensic analyses included looking at the forging of the packaging, leaflets, blister packs and holograms, chemical analysis of the air around the tablets in the blister packs and biological and chemical analyses of the tablets themselves. At least 16 different types of hologram were found as the counterfeiters gradually improved their standards of counterfeiting.

Chemical analyses indicated that the fake tablets contained a wide range of che-

micals including banned carcinogenic chemicals, benzene, chloroform, paracetamol, solvents, and precursors of methamphetamines.

***Even worse some tablets-contained sub-therapeutic amounts of the active ingredient artesunate, enough to cause resistance to develop in the parasite if taken consistently.***

The excipient (filler) in the genuine tablet is corn starch but the fake tablets consisted of corn starch, calcite, lactose, talc, and sucrose in various percentages along with traces of other minerals like aragonite, chlorite, dolomite and quartz.

Many of these fake drugs also contained abundant contaminants in the form of insects (including the wide spread mite nymph Dermatophagoides), charcoal, cuticles, other plant cells, fungal material, bryophytes, animal and synthetic fibres, spores and pollen. Some tablets contained only a few pollen grains while others contained a considerable number, indicating production in rather unclean environments. Tablets containing calcite had no pollen at all suggesting that the source of the calcite used in the tablets was not the source of the contamination. The 50 or more different types of pollen and spores recovered from these tablets included *Acacia* (wattle), *Artemisia* (worm wood), other daisies, *Abies* (fir), *Alnus* (alder), *Alsophila* (tree fern), *Carya* (hickory), *Chenopodiaceae*, *Isoetes* (aquatic fern), *Juglans*, *Myrtaceae* (myrtles), *Pinus*, *Poaceae*, *Pterocarya* (wing nut), *Restio* (rush), *Salix* (willow), and *Ulmus* (elm). These spores and pollen could come from the site of manufacture, the source of the ingredients or both. The pollen seemed to agree in terms of flowering times with the dates

#### VOCABULARY

**counterfeit:**  
gefälscht

**forging:**  
Nachahmung

**excipient:**  
Füllstoff, Füllmittel

**starch:**  
Stärke

**mite:**  
Milbe

**cuticle:**  
Hautteile

Quelle: Pal Dat

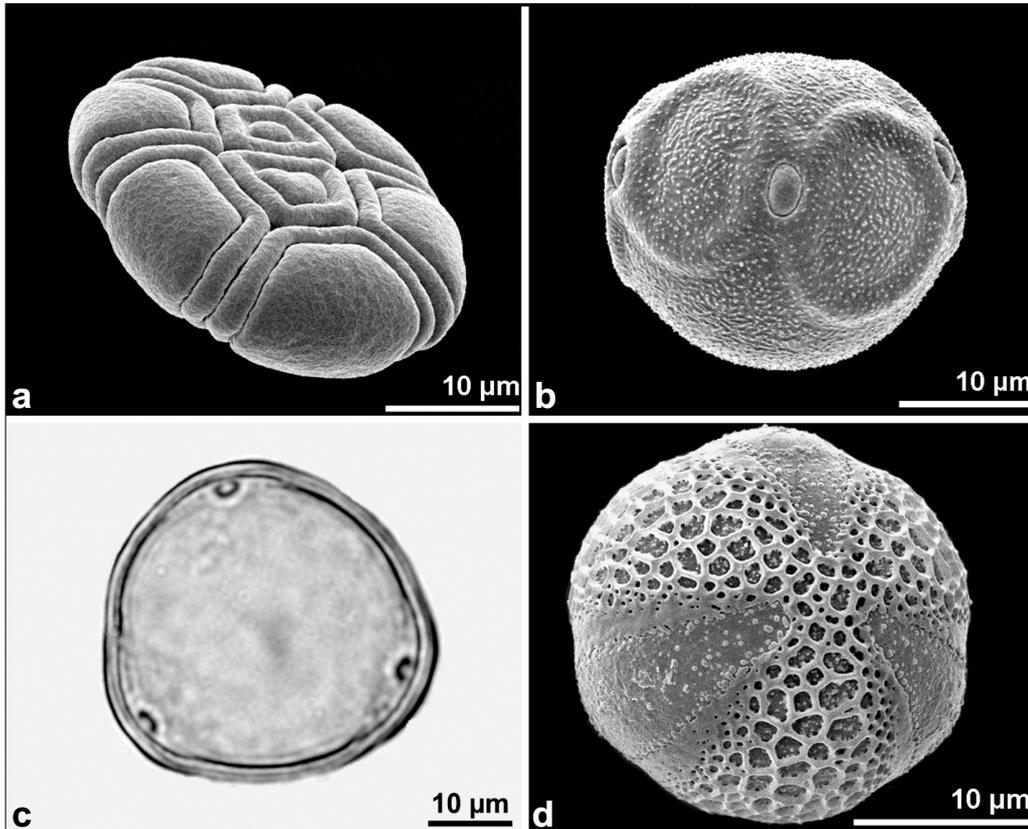


Abb. 6: Light microscope and SEM photographs of pollen. 6a. Acacia (wattle); 6b. Alnus (alder); 6c. Carya (hickory), 6d. Salix (willow)

given on the fake packaging, assuming that the dates were a genuine indication of when the tablets were manufactured.

The pollen assemblages recovered from tablets and their differing diversity suggest that multiple source areas are involved in the manufacture of the counterfeits from the border area between China and Viet Nam, Laos, Thailand and Burma, probably from a seasonally arid area, from near rice fields, and from a more mountainous, humid environment. Confirmation, that at least one source was from the border area between China and Viet Nam, was obtained from analysing carbon and oxygen isotopes of calcite found in fake tablets from Viet Nam. The analysis was very similar, if not identical, to the isotopic signature of high quality hydrothermal calcite mined in China close to the border with Viet Nam.

Information gathered by the investigation team was presented to the Chinese law enforcement authorities who acted quickly to stem the flow of counterfeit artesunate, arresting a number of perpetrators and closing down one of the western Chinese sources of counterfeit drugs.

## 6. FUTURE OF FORENSIC PALYNOLOGY IN AUSTRIA

Students around the world are studying various aspects of forensic palynology as thesis topics as universities sense an increasing demand for forensic palynologists and the science gets investigated in the intensive detail it deserves and needs. More and more high profile court cases where forensic palynology has played an important role are coming to the attention of law enforcement agencies. Thus the demand for this service grows. The gene-

## VOCABULARY

*to stem:*  
*eindämmen*

**VOCABULARY**

*slide:*  
*hier: Präparate*

ral public is also now aware of the technique as a result of articles appearing on the internet, radio, TV, newspapers, magazines, newsletters, and popular books.

Courses in forensic palynology have been run at the Department of Palynology and Structural Botany, University of Vienna for the last few years. These courses provide law, medical and biology students and law enforcement officers with an opportunity to learn about the technique. It can be expected that the courses will encourage some to follow in the footsteps of Wilhelm Klaus and start looking at criminal and civil cases where forensic palynology and environmental analysis could assist in achieving a required outcome.

With the research now being carried out at the Department of Palynology and Structural Botany of the University of Vienna the future development of the science of forensic palynology in Austria now seems assured. The department uses high quality light and scanning electron microscopy and direct access to large databases necessary for this type of work. This

also includes access to modern and fossil pollen reference slides, fossil pollen assemblage slides from sediments of different ages, modern pollen assemblages from different Austrian environments, printed pollen atlases, and internet databases. The gradual upgrading of the online pollen database PalDat, published by the Society for the Promotion of Palynological Research in Austria<sup>11</sup>, is a great asset for future forensic pollen work both within Austria and for those working in this field throughout the world<sup>12</sup>.

It only needs local law enforcement and other agencies, including Police, Customs, and Health in particular, to take advantage of the expertise being created and use this developing forensic palynological knowledge to assist in the detection and resolution of criminal activities. We have here the opportunity to develop a specialist unit in forensic environmental techniques, with the ability to bring in additional expertise when required, that could be accessed nationally and internationally by neighbouring countries.

<sup>1</sup> Summarised from papers published in Mildenhall 2006, 161–248. A recommended read.

<sup>2</sup> See further reading.

<sup>3</sup> See further reading.

<sup>4</sup> See further reading.

<sup>5</sup> Brown 2006, 204–210.

<sup>6</sup> Wiltshire 2006, 241–248.

<sup>7</sup> Horrocks 1999, 417–420.

<sup>8</sup> Milne et al. 2004, 217–252.

<sup>9</sup> Milne et al. 2004, 217–252.

<sup>10</sup> Newton et al. 2008, 32.

<sup>11</sup> <http://www.paldat.org/>.

<sup>12</sup> Currently this database holds descriptions of 1.071 modern and fossil pollen species and over 8.500 photographs and more are constantly being added each year. High quality scanning electron and high-power light microscope photographs of selected pollen types used in this paper were obtained from this database and the personal file of Dr. Martina Weber.

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