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Forensic Palynology and the Ruidoso, New Mexico Plane Crash—The Pollen Evidence II

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ABSTRACT: The crash of a private plane near Ruidoso, New Mexico in 1989 resulted in an investigation of a small mass of biological material isolated from a tubular component of the fuel assembly. Part of the biological material consisted of a small pellet of pollen. The pollen grains were glistening, bright yellow in color, and surrounded by a moist hyaline substance that formed thin strands connecting the individual grains. If the grains had accumulated over time, some would have been subjected to an air temperature of about 500° F (190°C) for the operational life of the fuel component. If they were present before the crash, they also would have been exposed to a post-crash fire that distorted aluminum parts and melted resin/fiberglass construction material. Experiments with fresh pollen demonstrated that the grains darkened significantly with moderate heating for short periods, and that the connecting strands disappeared. The conclusion, consistent with other biological, chemical, and soil evidence, was that the biological mass was a post-crash accumulation unrelated to the accident.

KEYWORDS: forensic science, December, 1989 Ruidoso, NM plane crash, forensic botany, palynology, airplane crash, New Mexico

Forensic palynology is the study of pollen and spores with reference to criminal investigations and judicial proceedings. Although the method has been used occasionally in other countries (e.g., New Zealand, (1)), there are fewer examples of its application in the United States (2,3). The principal restraint is the special set of circumstances that must prevail before these microscopic entities can be used with confidence for investigative purposes. If plant remains are involved (drugs, baskets, rope, and packing material) these either must have originally contained pollen and spores; the object under investigation must have been in contact with material that contained such assemblages (soil, mud); or there must have been opportunity for these particles to settle on the object from the atmosphere. The time interval between the event, collection of the evidence, and analysis, and the method of treatment and storage, must allow preservation of the pollen and spores. Many are destroyed or altered by biodegradation, oxidation, exposure to solutions that are basic in Ph, mechanical degradation (e.g., erosion), and crystallization of the surrounding matrix. The object (bodies, clothing, tools, utensils, and weapons) must be gathered, handled, and stored in a manner to prevent contamination. For many uses, the assemblage must be diagnostic for a particular time interval (e.g., season), or place (domestic or foreign country; woods, grassland, weedy field, and swamp). In most cases, the morphology of the pollen and spores must allow relatively precise identification. Many can be recognized to genus (e.g., *Quercus,* oak) but less commonly to species (viz., the particular kind of oak). In some instances they can only be referred to family (e.g., Gramineae, grasses) or even a group of families (Chenopodiaceae-Amaranthaceae; or certain members of the fern families Blechnaceae-Polypodiaceae-Pteridaceae). Even with these limitations, however, there are instances in which palynology has provided useful and even primary evidence in establishing cause or guilt (4–7).

A prominent example is recounted by Erdtman (8) from an investigation made by Wilhelm Klaus of the University of Vienna:

> "A man disappeared during a trip along the Danube in the vicinity of Vienna. Despite dragging, searching by helicopter, etc., his body could not be found. A person suspected of having killed the missing man was arrested, but denied having anything to do with the case. On pollen-analytical investigation of soil from the arrested man's shoes much alder and pine pollen was found. Moreover, some early Tertiary (Oligocene) [fossil] pollen grains were encountered. This unique combination of pollen types pointed, according to geological and phytogeographical maps, to a place south of Vienna, where alder and pine grow together on Oligocene strata."

When the arrested man was confronted with this information, and being unaware of other evidence that might connect him to the crime, he agreed to cooperate and the police located the body near pine-alder woods along the Danube.

Another instance in which palynology proved useful as an investigative tool involved the nature of "yellow rain" (9), purported to document chemical warfare in southeast Asia by trichothecene mycotoxins. Spots of a yellow residue were collected from the surface of rocks and leaves at alleged sites of chemical attack. The residues were all found to contain pollen, and they shared the following characteristics: 1) No two samples had the same pollen composition, suggesting they were not a manufactured agent used for culturing or delivering toxins; 2) plants producing all the pollen types are common in southeast Asia; 3) some of the pollen types were also found on the bee *Apis cerana,* and several others were present in honey from Thailand; 4) some were present in feces of *A. cerana* and *A. dorsata* on leaves from near Poona, India; 5) the spots on these leaves resembled those of the "yellow rain"; 6) some samples contained bee setae (hairs); and 7) there were reports from the People's Republic of China of "yellow rain" events not associated with alleged chemical attack. The palynological evidence suggested the "yellow rain" was derived from the activity of bees and, indeed, mass cleansing flights of *A. melifera* that result in similar spots are well known (9).

In the case that forms the basis for these symposium papers, the palynological study involved a minute pellet of pollen about 1 mm in diameter. The pellet consisted of several hundred to a

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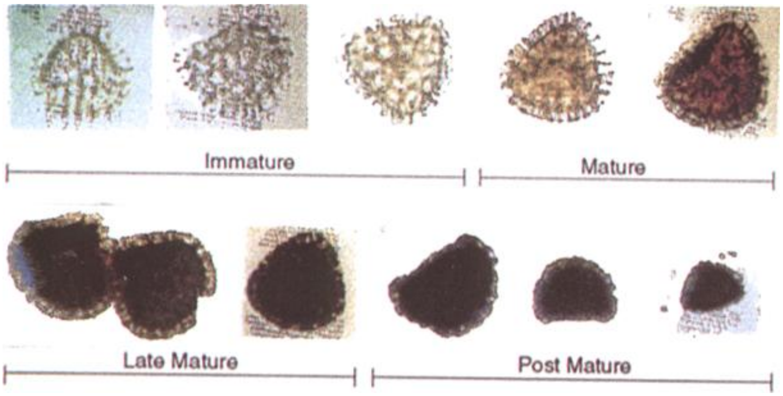

FIG. 1—*Color change of* Lycopodium *spores with increasing heat. The range is from fresh (upper left) to 100°–300° C (lower right) at 25° C intervals. Prepared by Sukla Sengupta, 1978, privately circulated.*

few thousand pollen grains that were part of a mass of biological material about 4 mm in diameter. This mass had been isolated from a metal tube of about the same diameter that formed part of the fuel component of a private aircraft that had crashed in New Mexico. The task was to determine if the mass was a factor in the accident. Analysis of the pollen by Lewis (this series) had shown that most of it resembled *Grindelia* (gumweed, family Compositae; 62.3%), *Melilotus* (sweet clover, Leguminosae; 36.6%), *Sphaeralcea* (globe mallow, Malvaceae; 0.8%), and other Compositae (0.3%). These are all insect-pollinated types, none are present in any sustained quantity in the atmosphere (10,11), and all were found growing in fields adjacent to the outdoor area where the disassembled engines had been stored. No mechanism could be envisioned whereby these pollen types could be drawn into the fuel component and accumulate to the exclusion of prominent wind-dispersed pollen such as *Pinus* (pine; <0.1%), *Juniperus* (juniper, cedar), *Gramineae* (grasses), *Acer* (maple), *Alnus* (alder), *Ambrosia* (ragweed), *Artemisia* (sagebrush), *Celtis* (hackberry), Chenopodiaceae-Amaranthaceae, *Fraxinus* (ash), *Morus* (mulberry), *Quercus* (oak), *Salix* (willow), and others. This evidence strongly suggested that the pollen pellet had been introduced into the line by means other than a differential sifting from the atmosphere.

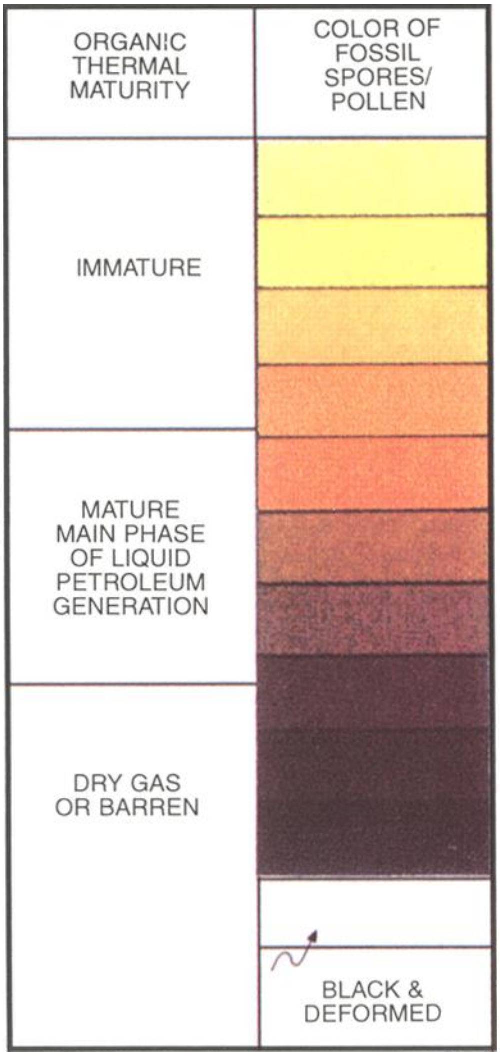

FIG. 2—*Generalized color change in pollen with thermal maturity. Prepared by D. L. Pearson, 1984, Phillips Petroleum Company, privately circulated. See also Traverse, 1988, p. 417.*

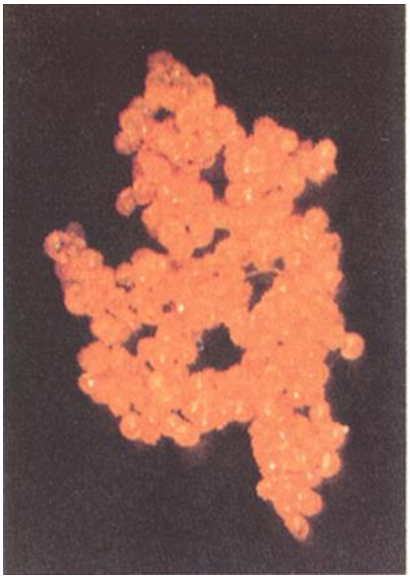

FIG. 3—*Fresh pollen of* Hibiscus rosa-sinensis *(Malvaceae). Note the glistening, bright yellow color of the grains. Hyaline strands connected several of the grains.*

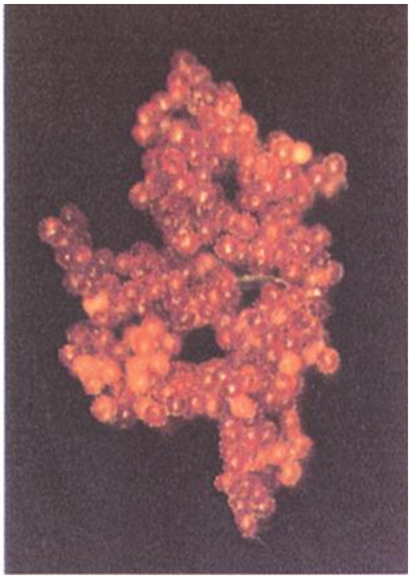

FIG. 4—*Pollen of* Hibiscus rosa-sinensis *after 4 h of heating at 80° C. Note the darker color. Hyaline strands were absent after heating.*

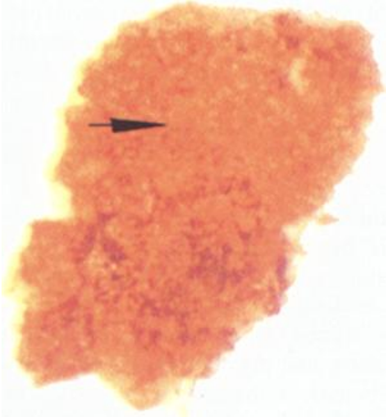

FIG. 5—*Part of the pollen pellet from the biological mass isolated from the fuel component of the plane that crashed. Compare color of grains away from the dark underlying matrix (vicinity of the arrow) with those in Figs. 3 and 4. There were hyaline strands connecting the grains when originally examined at SEAL Laboratories in Los Angeles in 1992.*

The biological mass was examined at the SEAL Laboratories in Los Angeles in April, 1992. Upon first seeing the pollen, two relevant facts were immediately apparent. One was that the grains were glistening and bright yellow. The other was that a hyaline substance formed a partial matrix and extended as thin strands between the grains. At the time, the chemical nature of the strands and the surrounding matrix was not known. The pollen pellet was divided between the plaintiffs and defense experts, and a portion was brought to the palynology laboratory at Kent State University.

Of particular interest was the bright yellow color of the grains from the fuel component. This color is typical of many pollen types in the fresh condition. It is also a reflection of the temperature to which the grains have been exposed. In the petroleum industry pollen and spore color is standardly used as a measure of thermal maturity. When organic matter (kerogen) in sedimentary rocks is exposed to heat and pressure, there comes a point, called the window of petroleum formation, where droplets of oil begin to form and are expressed from the kerogen. For economic and other reasons, it is useful to know the degree of thermal maturity at various points along the drill core in order to estimate the depth of oil formation and balance this against the cost of drilling. A widely used marker is pollen and spore color. Charts have been developed for the primary purpose of determining thermal maturity, but these also document that pollen and spores darken with heat. One such chart is shown in Fig. 1 which depicts the color change in spores of *Lycopodium* (ground pine) when exposed to increasing temperatures (prepared by Sukla Sengupta in 1978). Another is shown in Fig. 2 and is a generalized representation of color in relation to temperature and thermal maturity (prepared by D. L. Pearson, Phillips Petroleum Company in 1984; see also (12).

A general estimate of the temperature to which pollen, if present in the fuel component, would have been exposed during operation of the plane is about 190°C (Brunk, this series; Valquesney, personal communication, 1992). If it is assumed that the biological mass accumulated over time, some of the pollen would have been subjected to these temperatures for several to many hours. After the crash the plane caught fire and was subjected to intense heat. Aluminum parts were distorted and resin around the fiberglass body melted. Aluminum used in the plane melts at 500°–600°C and the resin/fiberglass melts at 400°C (Valquesney, personal communication, 1992).

To further test the extent of color change with heat, fresh pollen from the plant family Malvaceae (*Hibiscus rosa-sinensis;* Fig. 3) was heated to 80°C for 4 h. Even this mild treatment for a brief time produced a notable darkening (Fig. 4). A comparison was made of the pollen from the fuel component (Fig. 5) with the fresh and heated Malvaceae pollen. It should be noted that pollen from the fuel component in the photograph is mixed with and underlain by dark organic material that proved to be, in part, finely macerated leaf tissue of *Sphaeralcea* (Liddell, this series). The pollen itself, free of this material, is shown at the arrow in Fig. 5. From this comparison of color, it is evident that pollen in the fuel component could not have been subjected to even moderate temperatures for even a few hours, and certainly not to those of the air passing through the component over the lifetime of its operation, and ensuing after the plane crashed.

A second comparison involved the hyaline strands connecting and mixed with the grains in the fuel component (Liddell, this series). This material was also present in the fresh Malvaceae pollen, but disappeared with heating. Thus, the mass was composed of essentially fresh pollen, macerated leaves of *Sphaeralcea,* trichomes (plant hairs) of the type found on *Sphaeralcea* (Bates, this series), and an amorphous thick-liquid material.

If it is untenable to maintain that the pollen accumulated over time, and experienced both fuel component and post-crash temperatures essentially unaltered, there remains the question of the origin of the mass, and how it got into the fuel line. That explanation is provided by Rozen and Eickwort (this series).

If the mass of biological material recovered from the fuel component was not a factor in the accident, then a remaining alternative is that the cause was soil that was present throughout the disassembled engines and in the fuel line. It should be noted that after examination of the engines in Canada, they were returned to New Mexico for storage at an airport near Ruidoso where they lay in an open weedy enclosure for several months, and soil was placed over part of the wreckage. Indeed, at the time of our visit in May, 1992, they were partially embedded in dust and soil. For the soil alternative to have validity, it would have to be demonstrated that the mineral matter from the fuel component did not come from the storage site, and that it was diagnostic of the specific area(s) where the plane had previously landed, flown over, or had been stored between flights. This possibility is addressed by Daugherty (this series).

The most parsimonious conclusion from the palynological evidence, consistent with results from the other lines of inquiry, is that the pollen component of the mass was a post-crash accumulation unrelated to the cause of the accident.

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