# PROGRESS REPORT ON GRAND CANYON PALYNOLOGY†

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*During 1964 and 1965, while I was doing work in the Department of Geochronology at the University of Arizona (with special application to paleobotany and palynology), we did a research project in the Petrified Forest of Arizona. We had especially good results with fine microphotographs of many species of Chinle formation conifers. Thus encouraged, Dr. Kremp next initiated some research in the Grand Canyon in palynology.*

*Considering the wide sections of Paleozoic Era Periods visible of the geologic column, there are all too scanty arrays of macrofossils to demonstrate the evolutionary succession of life. Since microfossils, that is pollen and spores are many times more numerous, it was a well conceived enterprise to check the fossil plant life by means of the spores.*

*Samples were taken by the instructor and turned over to this author to process in the laboratory. The schistose formations from the Permian, the Mississippian, the Cambrian, and the younger Precambrian produced a variety of spores, but the predominant type of spore from all the ages tested was the vesiculate conifer. Such results were deemed by some as out of order, according to current paleontological thought.*

*Accordingly the Creation Research Society sponsored a repeat research project in the Grand Canyon, and also encouraged a corollary project sponsored by Loma Linda University of California. Samples processed by the University of Arizona produced negative results, due to defective technique. On a tour of the canyon sponsored by the Bible-Science Association, Drs. Bullis, and Arthur Chadwick of Loma Linda took rock samples and processed them in their Loma Linda laboratories.*

*At this writing their results practically duplicate the work formerly done by Burdick.[1]*

## Introduction

The study of fossil spores and pollen; i.e., palynology, is comparatively recent as compared with the study of macrofossils, but is developing into a very valuable tool in the study of ancient plant life. Darwin complained about the scarcity of fossils; but for every tree in the forest we find many spores or pollen grains. Therefore if we can learn to identify the tree or plant by its spore we have a thousand times as rich a fossil picture. This is a great aid in ascertaining the distribution of plant life in the geologic record.

Since some formations were named in the past on the basis of scanty fossil evidence, it would not be at all surprising if upon securing fuller evidence from fossil spores, we might find it necessary to rearrange some of the former hypotheses, and even to modify the geologic column.

Spores make ideal fossils for study, inasmuch as they are covered with a very tough coat called exine, which does not weather easily and which is not affected by most acids.

Most of the laboratory work with spores in the past involved treating macerated rock samples with strong acids such as hydroflouric acid which dissolves the quartz, and hydrochloric acid which dissolves the carbonates. However such acids can be a health hazard. We were able to develop a method without acids that worked very well. This method was outlined in the paper by Burdick[2] in the 1966 Annual of the Creation Research society.

In the past where results appear anomalous, researchers tend to condemn the findings as "contaminations." It is often suggested that spores or pollen floated in from contemporary plants at the time the samples were being taken and got mixed up with the rock. Such fears might be understandable from someone who is not too familiar with palynology, for they perhaps confuse pollen contamination with bacterial contamination.

Naturally great care must be taken to avoid contamination. But when we get extremely large numbers of a single type of spore in a sample, the mathematical odds are aganist it being due to contaminations. Not only at the Grand Canyon, but also from the Arizona Petrified Forest, I have processed multitudes of samples with no spores that showed up, not even contaminations.

Great care must be exercised when taking rock samples. No weathered rock should be included in the sample. Fresh unweathered rock

†The author is grateful to the Creation Research Society for providing funds to extend former work in the Grand Canyon. Thanks are also due to Pastor Walter Lang and the Bible-Science Association for conducting a tour in the Grand Canyon by means of which a geologist from the University of Arizona, Dean Delavan, accompanied the tour and collected samples of rock to be tested at the University of Arizona Palynology Laboratories.

I am also grateful for the time and work expended by Drs. Bullis and Chadwick, biologists from Loma Linda University, California, for taking separate samples, and for the laboratory work of Dr. Arthur Chadwick in obtaining clear photographs of both Gymnosperm and Angiosperm pollen from the Precambrian and Cambrian samples thus far tested.

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must be dug out and sealed immediately in new sterile plastic bags.

Another diagnostic clue is quite reliable, especially when the spores are dug out of red shales, like Hakati. The red iron stains the spore so that it appears redder under the microscope than modern spores that have not been buried in the rocks.

In most cases the fossil spores obtained from the macerations were extinct species or genera; they did not compare with slides of extant types on file in the palynology laboratory.

### Previous Work

The discovery of pollen analysis came at a time when important problems in the history of vegetation and climate as well as in archeology were without solution. To Swedish scientists belongs the credit for early pioneering in the branch of paleobotany known as palynology. To another Swedish scientist of another age also belongs the credit for modern nomenclature, Linneaus perhaps the most famous in that line since Adam named the animals.

Pre-Quarternary fossil pollen grains were first observed by Goppert (1836) and Ehrenberg (1838). The first to utilize the occurrence of pollen grains in Post-Glacial deposits were Geinitz (1887) and C. A. Weber (1893).

The real potentialities of the new science of palynology were not realized until Lennart von Post,[3] a state geologist, took it up with Langerheim as his micromorphological instructor. Von Post presented the first modern percentage pollen analysis in a lecture at Oslo and also at Stockholm.

From the middle twenties pollen analysis has been the dominant method for investigation of late Quarternary development of vegetation and climate and has been perfected into a very refined instrument of research, giving intimate glimpses into the conditions of life during earlier periods. Erdtman[4] gave a general survey of the taxonomic systems.

The science of palynology finally "spilled" over into the new world, and such pioneers as Dr. S. A. Cain and Dr. P. B. Sears[5] and Dr. Waksman did much to expand the work in this country; but perhaps Dr. R. P. Wodehouse[6] has done more than anyone to promote interest in pollen research in the New World.

Most recently Dr. Gerhart Kremp[7] has published an up-to-date library in several volumes on pollen analysis.

In 1966 the Creation Research Society published the first palynology study in the Grand Canyon by Burdick[8] (1966). This study indicated that gymnosperms (conifers) were a dominant type of plant or tree in the Permian, Mississippian, Cambrian, and younger Precambrian.

This work has been challenged because it was somewhat anomalous by standards of procedure; therefore, encouragement was given to further work in the Grand Canyon by scientists not connected with the former project.

### Current Research Project

This repeat project was sponsored in part by the Creation Research Society of Ann Arbor, Michigan, and the Bible-Science Association of Caldwell, Idaho. A geologist, Dean Delavan from the geology department of the University of Arizona, accompanied a field trip in the Grand Canyon which was organized by the Bible-Science Association, in June of 1970.

Mr. Delavan took rock samples from the schistose strata of the Permian period, namely the Hermit Shale and the Supai formations. These were from fresh unweathered exposures and immediately sealed in sterile plastic bags. Samples were also taken from the shaly layers in the Mississippian Redwall formation. Further samples were cut from Cambrian formations, chiefly the Bright Angel shale. Getting down into the Precambrian, the Proterozoic, samples were taken from the Hakati Shale and the Bass limestone.

Mr. Delavan then turned the samples over to Mr. Morgan, a palynologist from the geochronology department of the University of Arizona for processing. Mr. Morgan used the acid technique, which has been the vogue in the past. When the spore residue was placed on slides and examined through the university microscopes, they were so clouded with undissolved rock silt that if spores were present they were completely obscured. Therefore I would conclude that the University of Arizona phase of the investigation was inconclusive. However sufficient samples were available for a repeat performance but Mr. Morgan has been too busy to repeat the analyses.

The announced tour of Grand Canyon had been rather widely advertised by the Bible-Science Association, and two scientists, Drs. Bullas and Arthur Chadwick, were sent along to also take samples, which they did from the same rocks where Mr. Delavan sampled. They too followed specific procedures to avoid contamination.

Loma Linda University has recently outfitted a laboratory especially designed for spore and pollen analysis, and Dr. Chadwick and graduate students have taken special instruction in palynology. They have studied the technique of processing and the maceration of rock samples for the extraction of the spores.

This present paper is based primarily upon the first results of their investigation, that is, results from the aforementioned Cambrian and Precambrian samples. Work is presently continuing on the samples from the higher strata stratigraphically, up through the Permian.

The Loma Linda biologists report that great care has been exercised to avoid contamination, and they are convinced that the results obtained represent a true picture of plant life corresponding to the age of the strata or periods sampled.

As the readers will observe, the Loma Linda results largely follow the same pattern of the palynology investigation as performed by Burdick in 1964 and 1965, while doing research for the University of Arizona. If there is any divergence in results it would appear that Loma Linda secured a slightly greater proportion of Angiosperms.

In a recent personal communication, Lanny Fisk, a graduate student, reports that they are now finding about the same type of Gymnosperm and Angiosperm fossil spores in the Redwall and the Hermit Shale, the latter being one of the higher formations of the Permian Period. These results also correspond with Burdick's results.

## Parallel Research Report

Every spring the Arizona Academy of Science has a science seminar at one of the three state universities in Arizona. Students and members of the Academy are invited to submit abstracts for presentations at the meetings. Those selected are printed in an advance booklet and sent to members and universities with invitations to attend the convention.

Abstract No. 93 was titled: "A river level pollen transect in the Grand Canyon of the Colorado River"; by James E. King[9], who is taking work in the geochronology department of the University of Arizona. This was a speech, and presumably not otherwise published except for the abstract.

Mr. King's work had nothing to do with fossil spores except the very recent ones coming into the canyon as "pollen rain." The plants that produced the pollen are growing near the place where the pollen was deposited, or at least the same species are. This branch of palynology at the University is under the direction of Dr. Paul Martin, while the fossil spore department of palynology is managed by Dr. Gerhard Kremp.

The meeting of the Arizona Academy of Science is also held in conjunction with sessions of the local branch of the American Association for the Advancement of Science. Since Mr. King's work involved work in palynology in the Grand Canyon, it may be well to quote the entire King abstract:

> A transect of 22 surface samples collected through the Grand Canyon at river level between Lee's Ferry and Diamond Creek has been analyzed for the modern pollen rain. The results show the pollen spectra varying with both changing vegetation and geomorphology of the Grand Canyon. *Pinus* pollen averages 20% through the transect, all of it drifting in from the canyon rims; *Quercus* pollen also drifting in, is generally less than 10%. *Juniperus*, which does occur occasionally at river level, accounts for 10% to 20% of the total pollen rain. Other arboreal pollen types which occur occasionally throughout the transect include *Rhamnus, Betula, Picea,* and *Abies.*
>
> The pollen of *Torreyana* - type *Ephedra*, is common in the upper half of the Canyon, while that of *Ephedra* Nevadensis-viridus type is dominant in the lower portion. This shift approximates the distributions of Ephedra species within the inner gorge. Of the non arboreal pollen, *Franseria-Ambrosia* type Compositae are very abundant in the Lower canyon, while *Chenopodiaceae-Amaranthaceae* pollen varies with the degree of disturbance and the amount of suitable habitat available.

## Means of Identification

As a rule no one publication was sufficient for complete identificatoin, but the following four texts were used:

1. Textbook of Pollen Analysis, 1950. Knut Faegri,[10] Johs Iversen, and H. T. Waterbolk, Hafner Publishing Co., New York.

2. An Introduction to Pollen Analysis; G. Erdtman, 1943, The Ronald Press Company, New York. (Reference 4).

3. Synopsis of Spores, Four volumes, 1958-1962,[11] Robert Potonie, Hanover Germany.

4. Catalog of Fossil Spores and Pollen, Gerhart Kremp, and Spakman and H. T. Ames. 1956- to present. Penn State University, Department of Geology, University Park, Penn. (Reference 7).

## Spore Morphology

Pollen is formed in the male portion of the flower, the anther. The interior of the anther consists of a sporogeneous tissue from which originate the pollen mother cells. With few exceptions each of these give rise to four pollen grains. The sporogeneous tissue is surrounded by a wall, the structure of which is rather complicated. When the pollen is ripe, this wall breaks down in some way, and the pollen grains are liberated for transfer to the pistil, usually of another flower, where fertilization takes place.

The angiosperm pollen grain is built up of three main concentric layers. The central part is the living cell, which germinates on the stigma and forms the pollen tube which then penetrates the style and brings the fertilizing nuclei down to the ovum.

The middle layer is the *intine.* It is present in all pollen grains and envelops the whole of the grain. Part of the intine consists of cellulose and is not as enduring as the outer *exine.*

The *exine* is one of the most extraordinarily resistant materials known in the organic world. Recent pollen grains can be heated to almost 300 degrees Centigrade, or be treated with concentrated acids or bases with very little effect on the the exine. Thus spores remain as unaltered fossils while the wood that produced them has long since disintegrated. From such criteria one can easily perceive the value of spores as index fossils to illuminate the past.

The following are a few of the more common types of pollen grains according to morphological classification:

1. Vesiculate—that is having bladders such as conifers which have two wings.
2. Polyplicate—Have meridional ridges separated by deep grooves.
3. Inaperaturate—with no distinct aperatures.
4. Monocolpate—aperature elongate.
5. Monoporate—with one circular aperature or pore.
6. Dicolpate—with two furrows.
7. Tricolpate—with three furrows.
8. Dicolporate—with two furrows and also pores.
9. Tricolporate—with three furrows and pores.
10. Diporate—with two pores.
11. Triporate—with three pores.
12. Periporate—pores distributed over the surface.

The first type is typical of gymnosperms, while many of the others are typical of angiosperms. In former work Burdick[12], (1966) about one-half of the spores or pollen recovered from the Hakati shale were Gymnosperms and one-third angiosperm: tricolpate.

### Pollen from Precambrian Hakati Shale—Grand Canyon

**Exhibit A** (Figure 1). The following identifications are not dogmatic, even as to genus, but Exhibit A probably belongs to the monocotyledons, of the Angiosperms. The pollen photographed compares to either *Alismo plantago* or *Sagittaria sagittifolia.* They are small pollen grains with a diameter of about 25 microns. The construction of the pollen from the two genera is similar, having pores and sharp conical spines. The grains are spheroidal, cribellate, and subechinate. They have a faint reticulate texture.

Potonie describes another monocotyledon that also compares to Exhibit A: *Peltandripites woodhouse,* 1933. *Locus typicus* Colorado-Green River formation. Eocene; pores and spines round or elliptical.

**Exhibit B** (Figure 2). Dicolporate, belongs to the angiosperm, dicotyledons. Morphology unmistakable, although in this case, if the spore could be rotated, it might turn out to be a tricolporate, of which there are numerous genera. We could not presume to make a positive identification, which is unnecessary, since we are carrying the identification just far enough to demonstrate that angiosperm dicotyledons apparently lived in the Precambrian. This specimen may represent an extinct genus, but compares somewhat to *Ulmus scabra.* It has many pores, about 30 microns in diameter. The grains are round to suboblate with the exine quite thick.

**Exhibit C** (Figure 3). This grain is typically gymnosperm, vesiculate or disaccate, meaning having two bladders or air sacs. The body is spheroidal or slightly flattened. The exine is especially thick. The germ is between the two bladders. This is some type of conifer. Although this specimen is probably an extinct genus, it might be compared to *Picea excelsa* (spruce) which is biconvex with well-rounded corners. The contours of bladders run smoothly into the contours of body. There is a thick exine with granular texture to body and reticular texture of bladders.

**Exhibit D** (Figure 4). Gymnosperm, vesiculate, two bladders or wings similar to Exhibit C. Different view; body partly hidden by bladders. These are comparatively large spores, measuring from 80 to 140 microns in diameter. If this compares with *Alisporites opii* (Daugherty) the bladders are slightly pendant and crescent shaped. The diameter is 110 microns. These are disaccate grains, similar to the Petrified Forest type.

**Exhibit E** (Figure 5). Gymnosperm, but not vesiculate conifer type. Probably belongs to genus *Ephedra,* possibly species *antisphilitica.* The grains are prolate to subprolate, provided with approximately 13 longitudinal ridges which are separated by well defined grooves. When the pollen grains germinate, the exine dehisces, splitting into two or more parts through the grooves. These grains measure 32 X 52 microns. The type location is Eocene Green River formation.

**Exhibit F** (Figure 6). This is also a gymnosperm but of doubtful identification. The bladders are not well developed, but may compare with *Parcisporites annectus* Leschik. There is monad, disaccate, non-aperaturate, reticulate ornamentation. Air bladders not well developed; most have two small wings. The bodies are circular with a rough, reticulated exine covering. The diameter is 30 microns. The bladders are rudimentary, protruding from the sides. There is a rough, heavily reticulated surface of both bladders and body. The spore is dark red from absorption of iron in the rock.

*(Summary on Page 30)*

Figure 1. Exhibit A. Pollen comparable to either *Alismo* or *Sagittaria.*

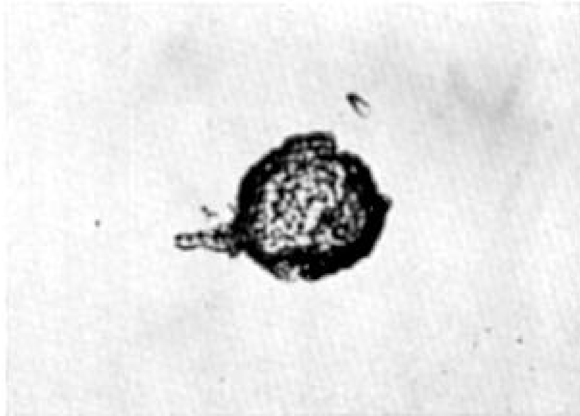

Figure 2. Exhibit B. A dicolporate angiosperm.

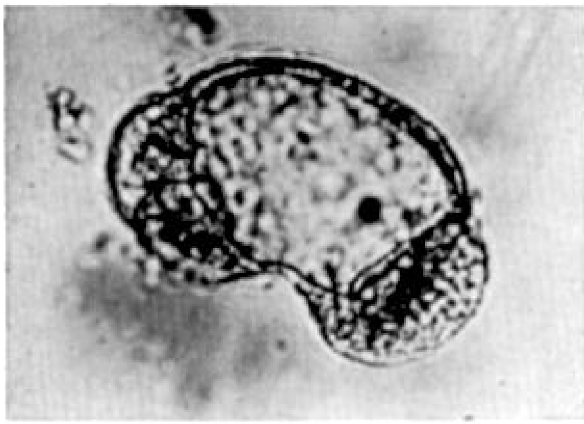

Figure 3. Exhibit C. Typically gymnosperm, vesiculate or disaccate, having two bladders or air sacs.

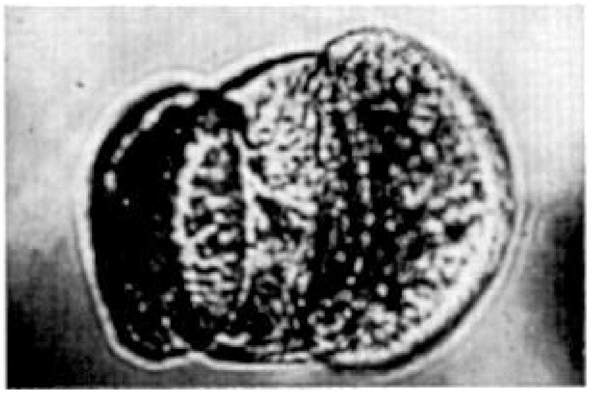

Figure 4. Exhibit D. Gymnosperm, vesiculate. Comparable to *Alisporites opii* (Daugherty).

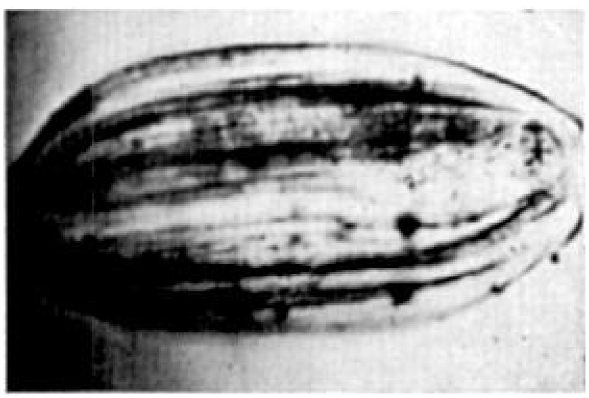

Figure 5. Exhibit E. Gymnosperm, *Ephedra.*

Figure 6. Exhibit F. Gymnosperm.

### Summary

The Loma Linda project largely followed the pattern of the previous work in palynology in the Grand Canyon by Burdick[13], except that the Loma Linda work seemed to produce a slightly larger percentage of angiosperms than the former work. Burdick's work covered the whole series of formations that produced spores from the Permian Supai down to the Precambrian Hakati shale.

### References

[1]Burdick, Clifford L. 1966. A Microflora of the Grand Canyon, *Creation Research Society Annual.*

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[8]Burdick, *Op. cit.*

[9]King, James E. 1971. A river level pollen transect in the Grand Canyon of the Colorado River. Abstract of paper submitted at Arizona Academy of Science and American Association for the Advancement of Science meeting at Arizona State University, Tempe, Arizona.

[10]Faegri, Knut, Johs Iversen, and H. T. Waterbolk, 1950 Textbook of pollen analysis. Hafner Publishing Co., New York.

[11]Potonie, Robert, 1958-1962, Synopsis of spores, Four volumes. Hanover, Germany.

[12]Burdick, *Op. Cit.*

[13]Burdick, *Op. Cit.*

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# A CHRISTIAN BIOLOGIST'S REFLECTIONS ON THE SCIENTIFIC METHOD

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Science is an activity in which we engage in order to gain a more clearly articulated explanation of the phenomena which we experience all around us in life. The Christian does this in obedience to the cultural mandate which God gave to man, and in which He charged man to subdue the earth and to have dominion over all living creatures on the earth. Our purpose in science, then, is to subdue the earth, to help our fellow man, to enrich our life, but above all to glorify God.

In scientific pursuits the analytic function of man is intensified for the purpose of abstracting a part of the total situation under study so that a clearer understanding of this particular part may then enable us better to understand the total situation. As one of the tools of science the scientific method is *consciously* applied so that by systematization of our work we may sooner get to a clearer understanding of a problem or situation.

The scientific method is a pattern or approach which helps to clarify and explain the phenomena and events which we experience in our everyday lives. This approach is most rigorously applied when we are engaged in specific and detailed abstractions in the laboratory. In the scientific method different stages or steps are often distinguished as follows:

a) recognition of a number of data or observations which seem to be related in some way;

b) formulation of a hypothesis whereby this relationship might be explained;

c) collection of data which may have bearing on this relationship, including designed experiments;

d) evaluation of all the amassed data which may result in 1) clear proof that the hypothesis is contradicted by the total evidence gathered, or 2) corroboration of the initial hypothesis which tends to lend more credibility to the hypothesis and which might now be called a theory, until evidence is adduced which clearly contradicts it.

Initial recognition of a possible relationship between certain data or observations is an activity of the whole person and not necessarily the immediate result of his analytic activity. From his entire rich background of many diverse experiences in life the relationship is discerned by the individual, who has some recognition of the structural order of things and events around him.

The hypothesis by means of which the phenomena and their relationships might be explained is, again, rooted in the total experience of the individual, and is definitely correlated with his basic commitments. Because of such commitments, a person will accept or reject certain possible explanations for eligibility under the circumstances of the situation. For example, when enrolled in my master's degree program I

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