MICROFLORA OF THE GRAND CANYON

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Introduction

About two years ago, I made a study of the micro-fossils of the Chinle formation (Mezozoic) in the Petrified Forest area, Arizona. The remarkable variety of spores found there has been reported by Roadifer et al.[1]

Since the resistance of the outer or exine layer of pollen grains gives them a stability in time (geologically speaking comparable to that of diatoms, foraminifera and other minute siliceous animal bodies), the study of palynology has become, rather rapidly, of great importance in determining the flora of the past.

Recent reports of finding fossil Angiosperm pollen in the Cambrian (Leclercq[2]) led to the suggestion that a study of the micro-fossils of the various Grand Canyon formations might prove of interest. Several trips into the canyon were made, the last one on November 18, 1965, with Harold Slusher, geophysicist of Texas Western College, El Paso, Texas.

The following is a report on the various types of spores found in various formations.

The micro-fossil slides are available in my collection for reference, and will be deposited in whatever museum the Creation Research Society declares as their official source location for material published in their journal.

Acknowledgments

The author wishes to express his indebtedness to the University of Arizona for use of laboratory facilities during part of this study. My original training in palynology was under the direction of Dr. Gerhardt Kremp, who first interested me in this phase of Paleobotany. The observations and conclusions reported in this paper, however, in no way reflect the thinking of the Paleobotany department of the University of Arizona, or that of Dr. Kremp. I also wish to express my appreciation to Harold Slusher, who made my last trip into the canyon possible, and to Dr. Walter E. Lammerts for his careful evaluation of the manuscript, botanical descriptions and general pertinence of the data submitted.

Material and Methods.

The maceration technique, though somewhat similar to that used by Roadifer et al, is one which I have especially perfected. Contamination by modern spores would seriously confuse results, so all samples were collected with great care. New plastic bags were peeled off a new pack, the surface of which was protected from exposure to the air during the trip. Exposed weathered rock was carefully chipped away until fresh unfractured rock was available. Then samples were cut and placed in the bags, labeled and securely tied. The sealed bags were taken to the laboratory for maceration, and the rock was crushed in the bags. The following is both a general description of sampling technique and my own modification of technique previously used.

Maceration Technique

Whatever instruments are used for grinding the rock samples must be thoroughly clean. After use all equipment is carefully washed with detergent.

The chemical technique will vary with the type of sample. Coal or peat requires boiling with K-O-H or Schultz solution to dissolve the carbonaceous material, nitric acid and potassium chlorate. For modern pollen the acetolysis method is used where the pollen and plant fractions are preserved in glacial acetic acid until time for treatment.

The chemical method has been the most commonly used technique for the maceration of spores and pollen. Sulfides are removed with concentrated nitric acid, and carbonates with hydrochloric acid. Much of the rock is composed of silica, which can only be dissolved with hydroflouric acid. This acid is highly toxic when it comes in contact with the skin, or when the fumes are breathed. Therefore, it is necessary to use this acid under the ventilated hood, and with the operator wearing goggles and rubber gloves.

While the exine of the spores is not easily destroyed with acids, there is always danger of some damage. The writer has therefore been employing a more simplified method, as follows:

1. Clean the specimens. The sample should be well cleaned to remove all contamination, with brush under running water.

2. Disaggregation. If a mortar and pestle are used to break up the rock, they should first be well scrubbed with brush and abrasive cleanser, then dried with compressed air before use. Break up the rock until it passes a 1 mm. screen; if ground much finer the spores may split.

3. Place about 1 gram of sample in a 100 ml. lusteroid centrifuge tube.

4. Add enough Varsol or other cleansing solvent to cover the sample, making sure it is wet all through.

5. Add 5 to 10 drops of a non-ionic detergent (such as Lux or Joy) and stir.

6. Fill tube with distilled water, shake thoroughly, then place in transducer tank of ultrasonic generator for about ten minutes. Stir occasionally if standing open, or shake if tube is stoppered. This greatly speeds up disaggregation of particles.

7. Remove tube from tank, stir or shake, and place in rotating drum for several hours to complete the disaggregation.

8. Centrifuge for 2-3 minutes at 1,500 r.p.m. and decant.

9. Fill with 10% hydrochloric acid solution, stir, then centrifuge and decant, Wash and centrifuge 2-3 times to get rid of hydrochloric acid. The acid will keep solution from clouding.

10. After decanting, fill with zinc bromide heavy liquid of 2.2 specific gravity. Stir or shake manually or with machine for a few minutes.

11. Pour into double plastic tubes inserted into larger centrifuge tubes. Place in centrifuge and rotate at 1500 r.p.m. for 2-3 minutes.

13. The sediment goes to the bottom and the spores float. The plastic tubes are pinched off just below the float and the top is decanted into smaller tubes. The residue may be saved for rechecking later to see how good a separation took place.

14. Since the spores have a specific gravity of about 1.5, they will float in the heavy liquid. The tubes are now filled with distilled water, which reduces the specific gravity below 1.5; thus the spores will sink.

15. Stir or shake, centrifuge and decant. Fill again with distilled water, centrifuge and repeat washing until heavy liquid is gone. The residue is now mixed with glycerine and centrifuged to get rid of most of water,

16. The small amount of residue containing the spores is now drained off into small vials for storage after labeling.

17. A small amount of glycerine jelly is placed on a glass slide and heated until it melts; to which is added a like amount of the spore residue, After mixing, a cover glass is placed over it and after drying, is sealed with some type of sealer such as fingernail polish. The slide is labeled and filed away, or placed under the microscope for examination.

18. The best spores or pollen are photographed if the microscope is equipped with a photographic camera.

Geography and Geology of the Grand Canyon.

Though well known to most everyone in a general way, a brief description of the various formations in descending order will help to clarify results obtained. The formations are identified in the usual way, but without attaching to them the usual time significance assumed by most modern geologists. For the geologist and non-geologist alike the vast chasm of the Grand Canyon with its multicolored rocks is truly one of the greatest spectacles in the world.

On the south rim of the canyon you stand on a whitish marine limestone of the Permian period and Paleozoic era. It is called Kaibab limestone and is an accumulation of lime and sandstone with fossils of corals, sea shells and sponges.

Immediately below the Kaibab and Toroweap (also Permian) come the Permian white cliff forming sandstone with cross bedded sandstone formed by wind causing dune formations. Tracks of lizard-like creatures are found in this formation called the Coconino sandstone.

Hermit shale is next below the Coconino sandstone and is considered by paleontologists as still part of the Permian formation even though lithologically radically different from the sandstone above. It is an accumulation of mud and sandy sediments, evidently formed by the flow of sediment-laden, slow moving waters from the northeast. Trails of worms, salamanders, and impressions of ferns are preserved. About 35 species of fern and cone bearing plants have been found.

The Supai formation, also Permian, is next below the Hermit shale and is the thickest seen from Grand Canyon Village, measuring about 800 feet thick. It consists of altered layers of hard sandstone and soft shale or hardened mud. Some twelve to fifteen notable alternations can be seen when viewed from a distance, and many more when examined at close range.

Since the Supai is a non-marine formation, some combination of river and flood action must be postulated to explain this interbedding or cyclic sedimentation. A rapidly changing provenance or source area for the origin of this series of deposits is also necessary. No adequate tectonic agent has thus far been suggested. This formation is notable for its flaming red color which also colors the Redwall limestone below. Large tracks of some four-footed animal as well as tracks of smaller creatures have been found.

The Redwall limestone next is a great cliff-forming rock, mostly red and about 550 feet thick. It contains many kinds of marine fossil life sea shells, corals, and sections of crinoids. This formation is Mississippian in age, and thus distinct paleobotanically from the various formations above. The iron containing sediments of the overlying Supai are fire-brick red, and the descending water has carried this color to the Redwall below. When not overlaid by the Supai, the "Redwall" is not red, but whitish like the Kaibab. This is quite evident as one descends the Kaibab trail, but to date I have not seen any report on the significance of this phenomenon. Later I will discuss this in relation to the proper interpretation of what we are really seeing here.

The Devonian period is not well represented at this part of the canyon. A small section of lavender colored rock, immediately below the Redwall, containing fish scales is the extent of that period. The lower Devonian, Ordovician, and Silurian are missing altogether. This represents an hiatus of over 100,000,000 million years according to usually accepted theory as presented in the "standard" geological column. The Mississippian Redwall limestone rests apparently conformably on the Cambrian. This is called **paraconformity,** and presumably represents a long period of time when neither erosion nor deposition of sediments occurred in this area. All physical evidence for this gap in deposition of strata is lacking. No angular discordance or erosion surface can be found.

The Muav limestone lies next below the Mississippian Redwall at most places in the canyon. At a distance it actually appears as a continuation of it. However it is of Cambrian age, was deposited beneath a sea, and contains fossils of sea life, typically Cambrian as regards species and genera.

The Bright Angel shale lies next below the Muav limestone and also is classified as Cambrian. Lithologically it is very different and a striking greenish grey color. It contrasts more sharply with the Muav limestone than the Muav contrasts with the Redwall limestone, even though both are Cambrian in distinction from the Mississippian Redwall. The Bright Angel shale ranges 450 to 650 feet in thickness and the fossils are all marine.

The Tapeats sandstone lies below the shale and is 225 foot thick and brown in color. This is the bottom stratum of the Cambrian and likewise the Paleozoic era. It rests on an erosion surface of Pre-Cambrian. The Tapeats forms a great, nearly flat platform known as the Tonto platform. North and south, normal vertical faults cut across the canyon, slicing the Pre-Cambrian so that in places the Tapeats rests on or contacts Shinumo quartzite, in other places the Tapeats lies over the Hakati shale, Bass limestone and even the older pre-Cambrian Vishnu schist or intrusive granite.

The only life so far reported in the Pre-Cambrian is fungi and algae, very simple plants structurally speaking, without a vascular system. The Colorado River has cut a deep gorge of about 1000 feet into the pre-Cambrian Vishnu schist.

Such, in brief, is the order of formations seen as one descends into the Grand Canyon and some of the structural problems in need of explanation.

Present Grand Canyon Vegetation.

The Canadian zone does not generally typify the vegetation even at the top. However in the colder parts typical Canadian zone Douglas fir, Engelman spruce, Colorado blue spruce and quaking aspen are found. Mostly the top of the canyon which is 7000 feet high is typically transition zone or the yellow pine belt. Here are found, where water is available, the juniper, some pinion pine, cedar, scrub oak, manzanita, brittle brush, cottonwood, willow, long-stemmed grasses, and various asters. Desert types such as the burro brush catclaw, mesquite, and narrow leaf yucca are also found. Down lower we come to the Sonoran zone characterized by the box elder, Wilcox live Oak and the redbud or Judas tree. The Morman tea is one of the few remaining members of the ancient joint-fir family and is found in the lower Sonoran zone.

An abundance of wild flowers are in bloom on the Tonto plateau in late April and May. Pollen of these were not found as fossils.

The Angiosperm Pollen Grain.

Since many of the non-botanical members of our society are unfamiliar with the structure of pollen grains and spores a brief description is in order.

The Angiosperm pollen grain is built up of three concentric layers. The center is the living cell, which germinates on the stigma and forms the pollen tube that penetrates the style, and brings the fertilizing nuclei down to the ovum. The middle layer is the *intine,* the composition of which is at present not well known, but it is thought that part of it consists of cellulose. These two parts of the pollen or spore are quite easily destroyed.

The *exine* is formed of one of the most extraordinarily resistant materials known in the organic world. It is the exine which survives ages of decay processes and is relatively unchanged after lengthy chemical treatment. This remarkable durability is the basis of palynology. Its resistance to destructive forces is due to its unusual chemical composition. The exine of pollen, as well as spores, contains a highly polymerized, cyclic alcohol termed *sporopollenin* by

Wyssling. It is related to suberine and cutin but is more resistant than either.

The exine is structurally complex, with at least two layers. The inner layer, the *endexine*, is a continuous homogeneous membrane. The outer layer, the *ektexine*, is composed of numerous small elements whose development and distribution produce great variability in structure. If the outer elements of the exine do not form a continuous covering, the type is called *intectate*. On the other hand, if the covering is continuous, the type is *tectate*.

Most pollen grains possess openings or thin areas of the exine through which the pollen tube emerges at germination. Two general types of apertures exist, known as the *furrows* and *pores*. Furrows are boat-shaped depressions in the exine, while the pores are tiny holes in the exine. One-furrowed grains are common in monocotyledonous and gymnospermous plants. Three furrows or pores are typical of dicotyledonous plants.

If the pollen is divided into lobes longitudinally, they are known as *dicolpate* or *tricolpate*, according to whether there are two or three lobes. These occur mainly in the dicotyledons.

Spore Morphology

Since the pollen are specialized types of spores, the above description of pollen also covers spores in a general way. Spores are usually elongate instead of spherical in shape, with three contact faces and radial symmetry. The universal distinction between the two fundamental spore types is the tetrad scar. It is usually well defined and easily discernible as *monolete* or *trilete*.

Regarding size, spores are divided into two classes, the *megaspores*, or large female spores, and the *microspore*, or small male spores. The latter are much more numerous, and include the pollens. The spores belong to the algae, ferns, lycopods, the Psilophyta, the Arthrophyta, and non-seeding plants. Spores and pollen vary in size from 5 microns to 200 microns or more.

Pollen is usually produced in large quantities and the pollen dispersed to the ground is known as *pollen rain*. The wind has been known to have dispersed pine pollen as far as 60 miles from the nearest pine forest. Pine pollen is equipped with wings or bladders which help them float afar, so that the presence of pine pollen in soil or rock does not necessarily mean that pine trees grew in that exact location. The spores and algae and water plants are carried by water largely. It has been estimated that a single anther of *Canabis sativa* produces as many as 70,000 grains. Since only a comparatively small percentage of polen grains will ever fulfill the purpose for which they grew, their production is very prolific.

Results of Examination of Slides from Maceration of Rocks from Various Formations.

The following identifications are only tentative, but at least are indicative of the type of spores found in various formations, and usually are certain at least to the genus unless otherwise indicated.

The Supai Formation (Permian)

The shaly members of this lowest of the Permian series are relatively thin and are the ones sampled. One slide showed about 20 vesiculate pollen grains of Conifers. This was not unexpected since the Permian is not very far from or below the Triassic, which, in the Chinle formation at the Petrified Forest, produced so many fossil conifer pollen grains. There were also about half a dozen pollen grains of various Angiosperms, both polyplicate and disaccate.

Technical Description

Genus *Podocarpitis* Cookson

Diagnosis: Disaccate pollen grains with the equatorial outline of the central body oval to polygonal; marginal crest usually visible; sacci large, pendent distally; length of the sacci always greater than that of the central body.

***Podocarpitis* species. (Plate I, Figure 2)**

These grains because of their marginal crest and large sacci are provisionally compared to the genus *Podocarpitis*. The ornamentation of the sacci is radial; body granulose. The pollen grains average 110 microns in breadth. Found in about the center of the Supai formation vertically speaking. These grains also have a resemblance to *Picea complantoformis*.

Plate I, Figure 1 shows a tiny bit of bark that somewhat resembles a lycopod, showing the characteristic leaf cushions pattern on scar left from the fallen leaf stems. These were found commonly in coal measures and are an arborescent type of plant. The rock samples were taken 30 feet west of the Kaibab trail, about 5 miles east of Grand Canyon Station on O'Neill Butte flats. They are from a prominent 6 foot thick seam of shale between sandstone layers.

***Ephedra* species. (Plate I, Figure 3)**

These grains measure 35 x 52 microns and are prolate to sub-prolate, They have about thirteen longitudinal ridges separated by well defined grooves. When the pollen grains germinate, the exine dehisces, splitting into two or more parts through the grooves. Wodehouse has observed

PLATE I

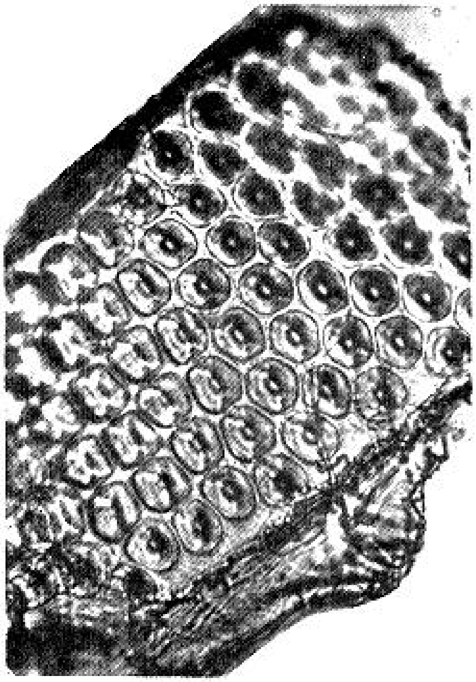

Figure 1

Figure 2

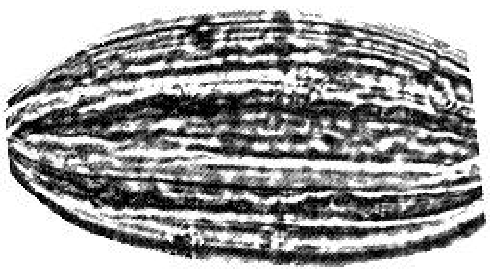

Figure 3

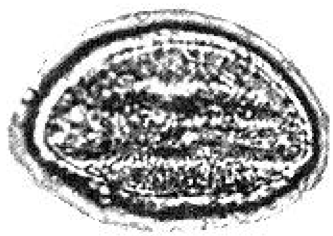

Figure 4

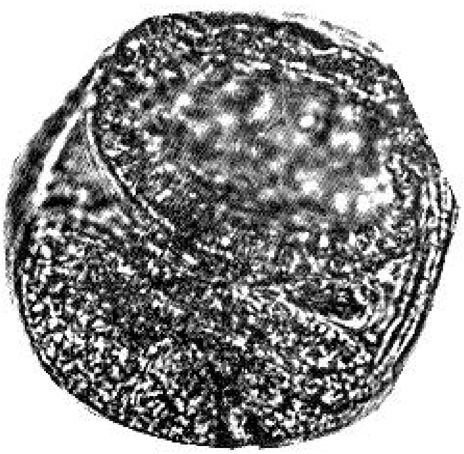

Figure 5

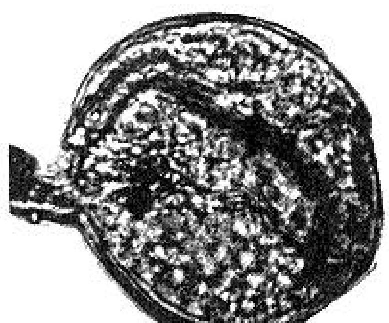

Figure 6

this kind of dehiscence in the grains of *Ephedra intermedia.*

The same phenomena has been recorded by Stapf (1879) for other species. His figures show a grain split that way with the protoplasm emerging from the split end. The exact species cannot be determined but comparison indicates close resemblance to *Ephedra eccenipitis.* This genus is a Gymnosperm and is commonly found in the Eccene Green River formation, an oil bearing shale. This specimen is from the same rock sample as described above.

Gymnosperm as yet unidentified (Plate I, Figure 4)

This is a small pollen grain about 30 microns in length and is evidently monoculpate or monosulcate. It is either a Gymnosperm or a monocotyledon spore which often have only one furrow.

Genus *Alisporites* (Daugherty) Potenie and Kremp.

Diagnosis: Disaccate grains; proximal outline including sacci more or less oval; longest axis of the oval central body about as long as bladder bases; distally a distinct relatively narrow germinal groove with thin exine, bordered by the parallel straight bladder bases. The bladders are only slightly pendant and crescent shaped.

***Alisporites opii,* Daugherty (Plate I, Figure 5)**

These pollen grains are identified as being identical to those reported by Daugherty from the type locality in the Petrified Forest so are undoubtedly of this species. (Compare with Daugherty's Figure 1, proximal view.) Diameter 110 microns.

Unidentified spores (Plate I, Figure 6)

A definite identifiation of these spores is not possible. There are three fossil spores described which come close to maching it. Phlug[3] illustrates one he calls *Shizoplanites bipolaris* Phlug. It also resembles Bolhovitina's[4] *Selagenella reclusa.* Another possibility is *Azonaletes.* All three genera are typical of the Cretaceous, or are Mezozoic in the literature so far available. The spores average 110 microns in diameter. They are possibly dicotyledonous plants with tricolpate pollen grains.

The Redwall Formation

This Mississipppian formation lies under the Supai and measures about 550 feet in thickness near the Grand Canyon Station. Samples were not taken of the limestone but from some of the numerous shaly seams interbedded with the limestone in the Redwal. Reddish colored oblate spores were found of unknown origin as well as some vesiculate coniferous ones. The samples described were taken from a shaly seam sandwiched between limestone strata in the back of a prominent cave on the south side of the Kaibab trail, 100 feet from the Redwall-Supai contact down the trail vertically. This was at a point where the trail passes from the west to the east side of the rock exposure.

Technical Description

***Selagenella* species (Plate II, Figure 1)**

Here is illustrated what appears to be a tricolpate spore but a definite classification is impossible. Bolkhovitina[4] describes a similar spore or pollen grain of Jurassic age which he classifies as *Selagenella reclusa.* The usual horizon for this spore is middle Mesozoic and mid-Tertiary, yet here we find it in the upper Paleozoic. The spores average 120 microns.

***Alisporitis opii* (Plate II, Figure 2)**

This is a spore 110 microns in diameter shown in proximal view. The spores of this species are described above as one usually found in my Supai formation slides. This spore is also illustrated in Plate I, Figure 5. The smaller size shown in the illustration is due to a lower magnification.

The Bright Angel Shale

This yellow Cambrian formation lies below the Muav limestone, also classified also as Cambrian, which in turn lies unconformably beneath the Redwall limestone. It is a shale formation several hundred feet thick, actually 450 to 650 feet thick at the location where collected. Samples were taken 9 feet south of the Kaibab trail from a vertical exposure where the trail leads westward for a short distance about 200 feet below the Bright Angel-Muav limestone contact line.

Technical Description

***Alisporitis opii* Daugherty (Plate II, Figure 3)**

The similarities and variations in this spore are illustrated by comparison with Plate I, Figure 5 and Plate II, Figure 2. The spore diameter averages about 110 microns.

Tricolpate dicotyledon (Plate II, Figure 4)

This somewhat triangular spore resembles *Shizoplanitis bipolaris* described by Phlug. If so it is a tricolpate dicotyledon. Identification—even to the genus has not yet been made.

Unidentified spore (Plate III, Figure 1)

This spore was 80 microns long. Picture taken at l00x. The spores were reddish in color.

Unidentified spore (Plate III, Figure 2)

This spore was 70 microns in diameter. The picture is at l00x.

PLATE II

Figure 1

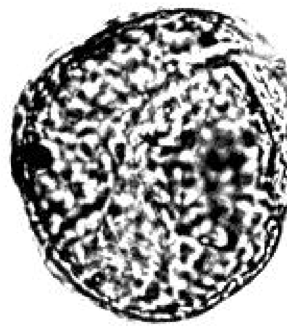

Figure 2

Figure 3

Figure 4

Disaccate spore (Plate III, Figure 3)

This disaccate spore is 40 microns in diameter. Picture taken at l00x. A reticulate structure is shown.

A disaccate Gymnosperm spore (Plate III, Figure 4)

A disaccate spore 100 microns in diameter is shown. The spore was yellow in color, and undoubtedly is a Gymnosperm.

Vesciculate spore (Plate III, Figure 5)

This elongated reddish spore was vesciculate in appearance. It was 120 microns long and the picture is taken at 100x.

Though identifications have not been made on the above spores even to the family they are shown to give some idea of the variety of spores found in the Bright Angel shale.

The Hakati Shale Formation

The Hakati is in a vertical fault block and lies below the Cambrian Tapeats sandstone from which no spores were obtained even though many macerations were made. The Hakati is several hundred feet thick at its exposure on the Kaibab trail and of brick red color. It is a prolific source of spores, Fungi were found as well as tricolpate pollen of Angiosperm plants. Articulate stems were found and also lycopods. The predominant type of pollen was vesiculate characteristic of conifers. Approximately 50% of all spores found were coniferous. The vegetation which contributed these windblown spores was evidently similar to that from which the Permian Supai was derived. All specimens were obtained from a single slab of rock taken ten feet from the Kaibab trail on the east side right at the government marker describing the Hakati shale.

Technical Description

Genus *Podocarpidites* Couper

Diagnosis: This a monad, disaccate, non-aperaturate spore with reticulate ornamentation and a sort of a granular exine covering on the central body. The central body is oval to round. Cookson proposed the sporotype *Podocarpidites* for fossil pollen grains with two air bladders, of the type met with in *Podocarpus*, or when it is not known whether they have been derived from *Podocarpus, Dacrydium* or some extinct member of the family Podocarpaceae. Studies by Cranwell and others have shown that the number of air bladders is relatively unimportant in the separation of generic groups, but the nature of the thickenings of the air bladders is a good diagnostic feature.

Podocarpidites marwickll Couper (Plate IV, Figures 1, 2)

Discussion: Locality usually Mesozoic; in this case Grand Canyon, Arizona. Common to abundant in many localities. This species is characterized by having large air bladders well extended beyond the central body, which is heart-shaped. The line of bladders beyond the central body is slightly cambered. The surface is ornamented, with reticulate granular surface. Length of spore is 140 microns. Specific locality: Hakati shale, Grand Canyon, at the government marker designating the Hakati formation. Figure 2 is a little smaller, about 100 microns, and the specific location is near the top of the Hakati formation. About twelve vesiculate fossil spores were photographed, but space does not permit publishing all of the Hakati specimens here. Color: reddish.

Genus *Parcisporites* Leschik

Diagnosis: Monad, discaccate, nonaperaturate, reticulate ornamentation. The air bladders not well developed, most have two small wings. The bodies are circular with rough, reticulated exine covering.

Parcisporites annectus Leschik (Plate IV, Figure 3)

Discussion: This is the genotype of *Parcisporites* Leschik. Diameter 30 microns, body circular and spore circular except for the rudimentary bladders protruding from each side, Rough, heavily reticulated surface of both body and bladders. The Figure here shown is a double spore, the two still attached after being ejected from the spore mother cell, The coloration is deep red, quite different from the lack of coloration of many recent spores, Thickness of reticulum 2 microns.

Genus *Tricolpites* Cookson, ex Couper

Diagnosis: Cookson described a new sporomorph *Tricolpites reticulates. Tricolpites* is here considered a form genus and is diagnosed as follows: Free, isopolar, tricolpate. Exine variable in thickness and sculpture, Size variable.

Tricolpites matauraensis Couper (Plate IV, Figure 4)

Discussion: Monad, ornamentation, reticulate, non-aperaturate, free, isopolar, tricolpate, colpae long, broad, no trace of ora, grain sub-prolate to prolate. Exine 2 to 3 microns thick, exine 1 micron, sexine 1-2 microns, clavate, baculate, forming a fine-pitted reticulate sculpture in surface view; lumen of reticulum less than 1 micron across. 50 microns polar. Usual range, lower Tertiary.

PLATE III

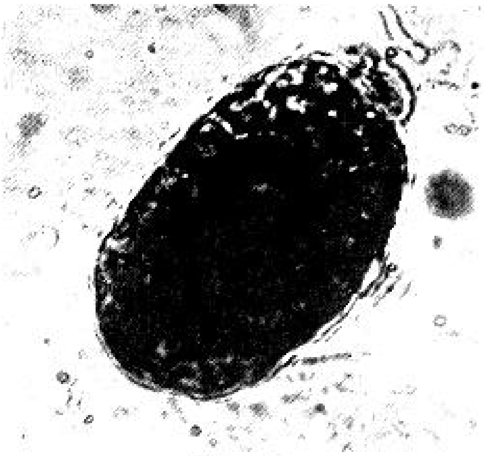

Figure 1

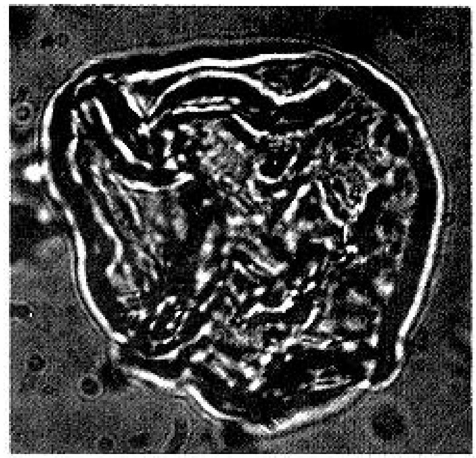

Figure 2

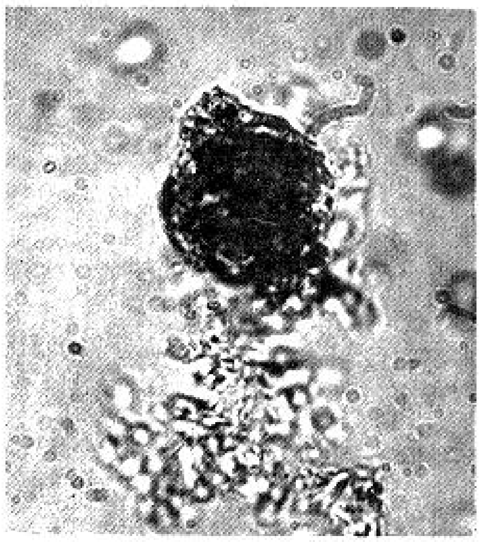

Figure 3

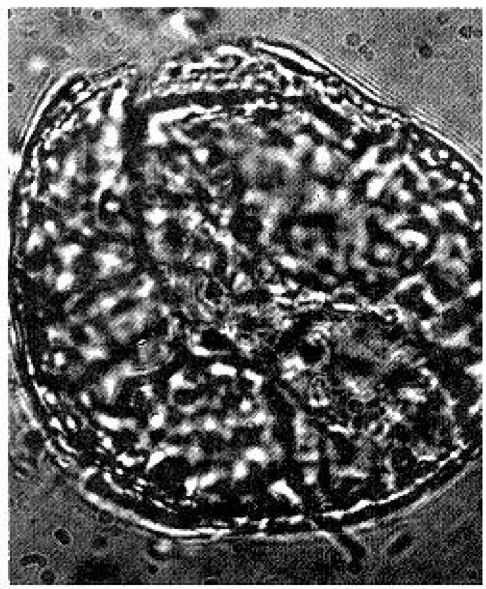

Figure 4

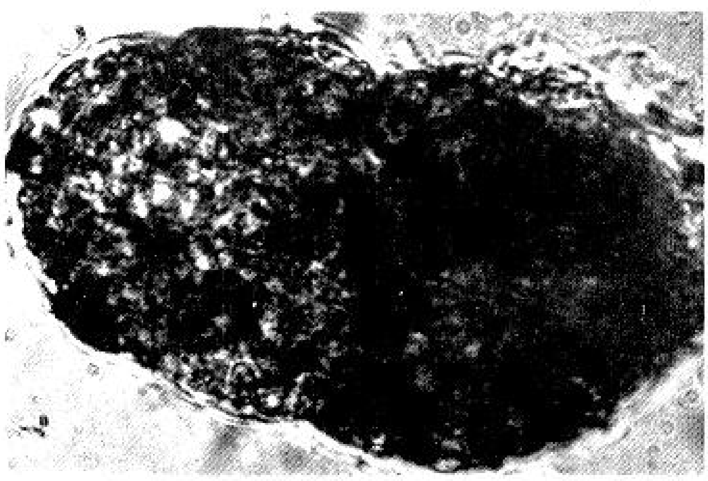

Figure 5

Plate 4, Figure 5 is fossil spore that I will not try to describe with certainty. There appear to be three fossil spores that have been described that come close to matching this fossil spore found in the Hakati near the bottom of the formation. Pflug describes a fossil spore that closely resembles Figure 5 which he calls *Schizoplanites bipolaris* Pflug, 1953. (Cretaceus age) The Russian Bolkhovitina describes a similar fossil spore that closely resembles Figure 5, as *Selagenella reclusa*, Bolkhovitina, 1956. This too is Mesozoic. Another possibility is that it may belong in the genus *Azonaletes,* also Mesozoic.

Schizoplanites is an Angiosperm (or flowering plant) often found in the Cretaceus, and though tentative, I am of the opinion that the spore shown is from a plant closely related to this species. In any event it is a typical Angiosperm type of spore.

Plate 4, Figure 6 illustrates a small tricolpate pollen grain that I also will not try to identify; there are several possibilities. Potonie describes such a pollen as *Pollenites.* Under this genus he describes a host of species but *P. maculites* bears a close resemblance to the one photographed. He gives a Miocene age for this fossil.

The Russian palynologist, Bolkhavitina, 1953, also describes a similar fossil tricolpate pollen as *Sambucus pseudocanadenis.* His horizon for this fossil is Upper Cretaceus.

Discussion

In pre-Pleistocene times before the glacial epochs, there is abundant fossil evidence that not only pines but sub-tropical flowering plants (Angiosperms) ranged much further north than what we now know as the arctic region. This study of the micro-fossils of the Grand Canyon formations is the first one indicating that Conifers and Angiosperms extended backward into what is usually called Cambrian and Pre-Cambrian times. Though variations in percentages of spore types occured, in general the same type of characteristically wind blown pollen was found in **all the formations** from the Permian on down through the Pre-Cambrian. The vesiculate, disaccate spores or pollen (a specialized type of spore really) outnumber all others about two to one.

Spores were not found in the sandstone and limestone rock layers even though many macerations were made. We cannot rule out the possibility that with sufficient work spores from this lithological type of formation might be found. However it does seem significant that of the many macerations made only those from the same lithological type of rock formation, namely shale, yielded spores.

Furthermore, three of the four shales were practically the same color, brick red. The Bright Angel shale is greenish grey to yellow buff. Not all the shale formations yielded spores, since the Hermit shale immediately above the red Supai formation has so far produced nothing from the many macerations made from it.

The Bass limestone lies just below the Hakati shale and according to evolutionary theory contains the oldest life in the Grand Canyon. Many samples were run from this formation, but so far only one small spore was found. It appeared to be from a modern grass, and bore no resemblance to the large reddish vesiculate conifer pollen grains.

It should also be stated that not all macerations even of the spore bearing formations yield spores. Thus one of my associates ran about sixty samples from the Supai before he was able to isolate a single spore. Obviously these wind blown spores are not evenly distributed through the rocks and patience as well as a certain amount of "good luck" is necessary for this sort of "grab bag" study as any palynologist will testify. For this reason negative results are dangerous as far as conclusions are concerned.

However continued lack of success with sandstone and limestone would seem to indicate a relationship between the type of deposition and the chances of spore entrapment. Therefore, the suggestion is made that the cohesive qualities of clay particles together with a relatively quiet phase of fine particle sedimentation are two essentials for spore entrapment and fossilization.

It is important to note also that an entirely **different** type of vegetation is indicated by the fossil spores than that which is now growing in or near the Grand Canyon. Thus *Podocarpidites* simply means a fossil plant resembling the genus *Podocarpus,* a group of species in the yew family or Taxaceae. This genus is found in rather moist areas, such as Japan, and indicates that prior to the deposition of the formations of the Grand Canyon, the climate was not so dry and arid as now.

None of the plants resembling the fossil species or rather genera with the exception of *Ephedra* now live near the Grand Canyon. Thus the pollen grains of the yellow pine, pinion pine, spruce, and Douglas fir do not resemble those found in the various formations. This also indicates that the climate in the past was warmer and less arid than now. In other words these species survived because of their genetic variability potential to adapt to the increasingly arid conditions.

PLATE IV

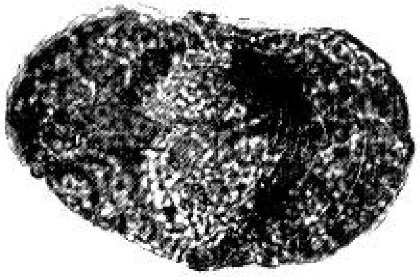

Figure 1

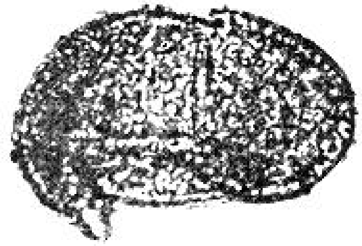

Figure 2

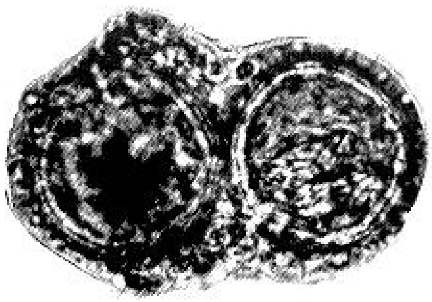

Figure 3

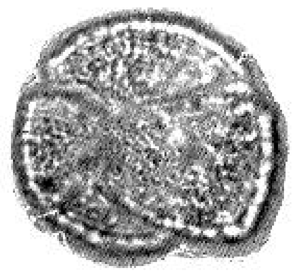

Figure 4

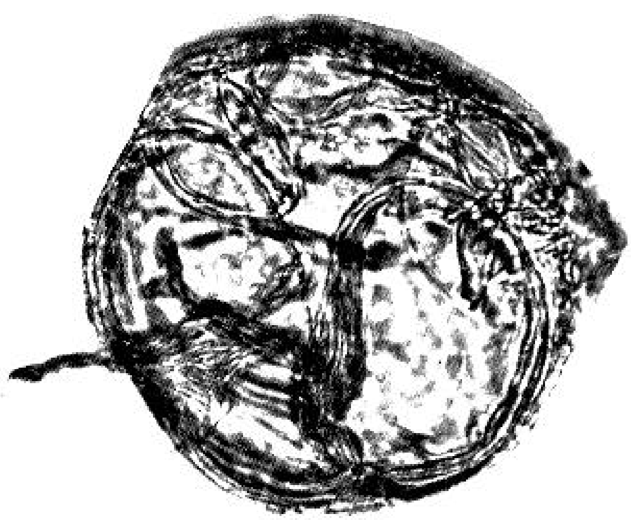

Figure 5

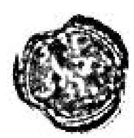

Figure 6

For those who insist on a time significance to the various formations, discovery of both Gymnosperm and Angiosperm pollen grains in the Cambrian and Pre-Cambrian does indeed present problems. A parallel situation in the animal kingdom would be location of mammals in the Pre-Cambrian.

I am inclined to consider retention of the idea of time significance more a matter of faith than science. The unusual fact that **all** formations yielded essentially the same types of spores would seem to indicate that all the formations were formed within a relatively short period of time.

It is really difficult to conceive of Podocarpus-like plants existing for several hundred millions of years **close enough** to the slowly submerging synclines to contribute pollen to the four different shales representing this time span from the Permian to the Pre-Cambrian!

The peculiar fact, that when not overlaid by the Supai, the Redwall formation is **not red** is important. Why did oxidation of the iron in the Supai not occur until all of this Permian formation was eroded away from the surface of that portion of the Redwall which is white? For, when overlaid by the Supai, the Redwall is always red. During at least 198,000,000 years of its existence, the iron was not oxidized, according to the presently accepted practice of attaching a time significance to the various formations.

According to the usually accepted geological time scale, the Supai was deposited on top of the Redwall some 200,000,000 million years ago. Yet, according to usually accepted theory, the erosion of the canyon did not begin until the uplift of the Colorado plateau about ten million years ago. Erosion and cutting of the canyon then continued until all the Supai was removed from portions of the canyon leaving the uncolored “Redwall” exposed.

Let us assume that this was complete by about 2,000,000 years ago. The problem then is, why should about 198,000,000 years of the existence of the Supai pass by without oxidation of the iron, thus leaving the underlying “Redwall” whitish in appearance? For it is the red oxide of iron that makes the Supai so beautifully contrasting with the white Coconino sandstone above. If the iron had been oxidized earlier **all** of the Redwall formation would be red instead of only that covered by the Supai.

As discussed in a previous article (Burdick[5]), the many repetitive lithological alternations present further difficulties in the way of accepting the usual interpretation and explanation of how these strata were formed.

It is not the purpose of this paper to present the many lines of evidence indicating rapid deposition of these and other stratified rocks during a world wide catastrophe of gigantic proportions. I do wish to point out that such facts as the white “Redwall” formation areas are easily explained as the result of very rapid erosion of the relatively soft sediments soon after their deposition during the subsidence period in the centuries following the world wide Flood. Soon is here used in a relative sense as compared with the usual concepts of hundreds of thousands or millions of years.

The presence of a flora liberating pollen followed by entrapment in suitable fine clay particles must be clarified. Destruction by flooding, outpouring of lava and other volcanic activity even miles away would liberate millions of wind blown spores. Even though the plants themselves would no doubt for the most part be destroyed, leaving only occasional areas where fossil stem and other parts could be found, the pollen and spores would be much more wide spread in their distribution.

Whenever currents from the areas in which these plants grew had subsided enough to drop all the heavier sand particles, the remaining finer suspended clay particles would settle out and entrap whatever spores might happen to be present. The limestone was probably from a different or marine source and so would normally not have any pollen. The ebbing and flowing of various currents then built up the formations we now see.

With patience and fortunate chance we can gradually unravel the chain of events at least locally which took place. Little by little these must then be fitted together to give an overall concept of exactly how the complex of events making up the world wide catastrophe actually occurred. The total effect here at the Grand Canyon is indeed one of grandeur.

Summary

1) Evidence is presented indicating that pollen grains of Angiosperms and Gymnosperms are found in four shale formations of the Grand Canyon, beginning with the Permian Supai on down to the Pre-Cambrian Hakati shale.

2) Sandstone formations did not yield any spores even though many maceration were made.

3) Attention is called to the difficulty of explaining the white “Redwall” portions of this formation in terms of the usual concepts giving time significance to the various formations.

4) Finding of spores of plants at least closely related to pines in the Pre-Cambrian makes it

extremely difficult to visualize any evolutionary development of these specialized plants. The undoubted occurance of pollen of flowering plants is even more difficult to explain in usually accepted evolutionary concepts.

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