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M. KEDVES

# INTRODUCTION TO THE PALYNOLOGY OF PRE-QUATERNARY DEPOSITS

## PART I

AKADÉMIAI KIADÓ
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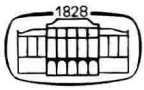
by

M. KEDVES

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# FOREWORD

The author has performed regular palynological research since 1959. As a teacher in József Attila University, Szeged, he lectured until 1975 on various themes in botany. As research professor to the same University he has been devoting his energies to palynological research since 1975. In addition, he delivered special courses to students concerned with the subject of palynology. The present work is based on many years of experience in teaching and research work. The writer is dedicating his book to the youth and to scientists who, though engaged in other fields, are interested in palynology. A great number of fellow professionals has helped the author to bring the book to completion. First of all, he should like to acknowledge the contributions by MME. DR. M. VAN CAMPO (E. P. H. E., Laboratoire de Palynologie, Montpellier, France) and by his master, late professor DR. P. GREGUSS. Thanks are also due to foreign palynologists for the ready help they were so kind to provide the author.

Szeged, 10 October, 1979 MIKLÓS KEDVES

# I. INTRODUCTION

Progress in the study of modern and fossil spores and pollen grains (generally referred to as sporomorphs) has quickened in the last decades. This is clearly indicated by the appearance of several summarizing works (e.g. FAEGRI and IVERSEN 1950, ERDTMAN 1954, ANDREEVA, et al. 1966, ERDTMAN 1969, TSCHUDY and SCOTT (ed.) 1970, CHATEAUNEUF and REYRE 1974, STANLEY and LINSKENS 1974), and by a number of papers on the connections of palynology. In the latter context the paper of VISHNU-MITTRE (1962) is reviewed.

The object, the spores and pollen grains, belongs to the domain of botany. With its special fundamentals, palynology has penetrated numerous branches of botany (taxonomy, cytology, ecology, phytogeography, genetics, evolution). The connection with botanical taxonomy is evident from the works of a good number of palynologists. A few books (WODEHOUSE 1935, ERDTMAN 1952, 1957, IKUSE 1956) and many monographs have recently been published. Large-scale pollen morphological studies may help us to solve the problems of botanical taxonomy, though the limitations of pollen morphology cannot be disregarded either. Pollen dimorphism, variations in size, sculpture and germinal aperture are features by which palynology contacts the fields of cytology and cytogenetics. Palynological results may be of help to geneticists in their choice of genera and species suitable for hybridization. Sporoderm stratification, ornamentation and germinal aperture have served as a basis for the initiation of morphogenetic tests. The evolution of the germinal aperture, germination, belongs to the subject of physiology. The same holds true of the research into the protoplasm and enzymes. Palynology is particularly significant for studies in evolution and plant phylogeny. In case of both lower and higher plants, comparative studies of the various orders, genera and species give a general portrayal of the evolution of their morphological features. WODEHOUSE's suggesting the germinal aperture to be a primitive feature is a palynological contribution to phylogeny. Palynology is one of the major methods of paleobotany, an important tool in solving the problems of evolution in the kingdom of plants, the history or origin of the floras, their distribution in space and time, their migration and immigration, etc. Pollen analysis encompasses the studies on Cenozoic

deposits. The investigation of lacustrine sediments and marshes as exposed in vertical sections enables us to reconstruct the history of vegetation, thus being linked to phytoecology and phytogeography. To understand the climatic requirements of present-day vegetation as manifested in the relation of palynology to climatology, one must be familiar with past changes in vegetation and climate. VON POST (1916) was the first to propose pollen curves for a climatic classification of the postglacial period. Later authors used selected species, of *Viscum, Hedera* and *Ilex* (IVERSEN 1944), *Corylus avellana* (ANDERSON 1902) and some arctic alpine species (DAHL 1953) as climatic indices. As a good example for the connection of palynology and climatology the temperature gradient from Denmark up to the northern and western coasts of Britain can be quoted as evidenced by statistical data concerning the pollen grains of *Hedera helix* (GODWIN 1956, VISHNU-MITTRE 1959). In addition to this example, most works dealing with pre-Quaternary sporomorphs include a climatic interpretation as well. The works of SAKS et al (1973) may be mentioned as summarizing treatises. The connection of palynology and geology will be obvious when, for instance, the controversial views about the saline deposits of Punjab are considered. Dated as Precambrian by geologists, these would be of Eocene age according to palynological results. Similar examples can be encountered all over the world. Enabling the correlation of oil-bearing deposits, palynology is one of the indispensable tools of oil exploration. Furthermore, palynological research is efficient in monitoring such geological phenomena as the changes in the Ice Age, the glacials, soil movement, frost-affected soils and loess genesis. The ties between palynology and crop production are manifested in comparative studies of prehistoric plants and the pollen of honey as well as in those of pollen grains and seed production. This latter is of importance for forestry as well. Prehistoric man's influence on vegetation was first supposed by IVERSEN (1941) on the basis of pollen diagrams and subsequently, in 1949, the problem was elaborated by the same author. Numerous pollen diagrams helped him identify prehistoric agriculture in many countries. The study of the pollen content of honey is so significant that a special term, melittopalynology, has been coined for it. Melittopalynology detects the geographic origin of honey, it identifies the plants suitable for the bees, specifies the nutritive and medicinal value of honey and renders eventual mixtures and adulterations recognizable. The Scottish heath (*Erica*) honey, the Australian *Eucalyptus* honey and the American red clover honey have been standardized on a palynological basis. The connection of palynology to archeology is manifested in its yielding direct information on the environment in which prehistoric man lived. On top of that, the beginnings of crop production and the crops produced by early man can be identified. Heyfever and asthma due to the pollen content of the air in the U.S.A. and a number of European countries have brought about links between palynology and medicine (HYDE 1954). The medical

significance of palynology has attired the attention of biochemists and physicists, too. Using the methods of electrophoresis, ultracentrifuging, diffusion, chromatography and chemical analysis they managed to determine the composition or just simply the presence of organic (proteins, amino-acids, carbohydrates, vitamines, hormones, enzymes and pigments) and inorganic components (K, Mg, Ca, Cu, Fe, Si, P, S, Cl). They observed that pollinized food retarded the appearance of mamillary cancer in mice. Immunologists observed similar antigens in pollen grains as in bacterial cells.

*Subdivisions of palynology*. The fields distinguishable within palynology were classified by ERDTMAN (1963). His classification was adopted as a basis for further work and, apart from some modification, it will be followed by the present writer as well.

First of all, it is pertinent to distinguish between two main branches: investigation of terrestrial and extra-terrestrial plant microfossils, even though "palynology outside the Earth" is at present restricted to often disputable organic remains recovered exclusively from meteorites. With progressing space exploration, however, vast prospects will be opened up for extra-terrestrial paleontology, micropaleontology and phylogeny. In the wake of STAPLIN (1962) and NAGY (1967) there are now even summarizing works on investigation of organic matter from meteorites. Relatively few of the known meteorites have been subject to research as yet. So the Orgueil, Ivuna, Alais, Mighei, Mokaia, Haripura and Cold Bokkeveld meteorites were investigated (CLAUS and NAGY 1961, CLAUS and HENNESSY 1962, BRIGGS and MAMIKUNIAN 1963, TIMOFEEV 1963). The detected parts are morphologically similar to certain biological or abiological artificial products. Some authors confirmed these finds (PALIK 1962, STAPLIN 1962, PAPP 1963), while others (DEFLANDRE 1962, MUELLER 1962, FITCH and ANDERS 1963) declared them to be problematic, for the microstructures may represent, at least in part, terrestrial microbiological impurities or artificial mineralogical products. CLAUS and NAGY (1961) introduced the term "organized elements" for microstructures recovered from meteorites. Although the organized elements were discovered in meteorites, the morphological criterion is insufficient for the determination of their origin. For this reason, the use of ultramicrotechniques has had to be resorted to: X-ray analysis, UV and visible ultra-microspectrometry, and electron microscopy.

1. Electron probe *X-ray micro-analysis* showed all the organized elements to have been partly mineralized. The samples contain some acid-insoluble residue that may be a carbonaceous matter.

2. The absorption of the insoluble residue is in the 260 to 280 m$\mu$ *UV range* which may be due, for instance, to purine or pyrimidine—the base of nucleic acids. In spite of this, the method is not satisfactory for the determination of the chemical nature of the organized elements.

3. *Electron microscopy*. Sections of meteorite fragments, slides of mounted ground material or insoluble residue showed intriguing structures. The nature of these objects cannot be evaluated unambiguously. They may represent terrestrial impurities, mineral or electron-microscopic artifical products or genuine extra-terrestrial microstructures.

As a result of a critical evaluation UREY (1966) came to the conclusion that if terrestrial objects are found in meteorites they should be considered biological ones. KREMP (1968) regards as possible the vegetal origin of the objects observed in the Orgueil meteorite. They may represent a "prelife form" or coacervate coagulated into a cell similarly to the case of the bluish-green algae. Regarding the hexagonal structure of the afore-mentioned meteorite, L. A. NAGY, KREMP and B. NAGY (1969) ascertained that it could not be an impurity, but they could not find out its origin.

It is obvious from all these circumstances that there are still many problems to be cleared, but it is also evident that the relevant research should be attributed top priority and we are looking forward with keen interest toward further achievements.

## 1. FUNDAMENTAL RESEARCH

1.1. *Pollen and spore morphology*. A special subject in the context of the morphology of pollen and spores includes the stratification and terminology of the exine. Subsequent to initial studies with the optical microscope, the examination of ultra-thin sections with electron microscope led to the solution of many problems. Lately an ever increasing number of publications on ontogenetic studies has been appearing since the mid-1960's. The scanning electron microscopic method has provided new possibilities for the exact exploration of the finest morphological features. Phase contrast optics, polarization and fluorescence microscopy, UV microscopic results, etc. help to solve special problems of both modern and fossil sporomorphs.

Mention should be made of experimental palynology also, the subject of which is represented primarily by the germination of pollen grains and the exploration of the factors influencing it. Many papers have appeared in recent years especially on studies concerning the mechanism of action of gibberellin.

1.2. Theoretical bearings of applied palynology—production and dispersion, etc. *Aeropalynology* is of particularly good service for applied research work. In this context special mention should be made of the determination of the pollen content of glacier ice as a quite specific field of research. Palynology and meteorology represent a vast field in which we do not wish to go into details. The principal question is dispersion emerging from palynological works. SCHMIDT (1967)

published a good summary in which he pointed out the significance of diffusion and outwash prior to the redeposition and final settling of the sporomorphs and he distinguished three mechanical effects. Atmospheric diffusion due to irregular flow patterns was shown to be of particular significance.

1.3. *Systematic palynology* (=*palynotaxonomy*). Hosts of references to the taxonomic value of the sporomorphs are found in classical handbooks on botanical taxonomy already. Of course, like any feature, the sporomorphs cannot decide, by themselves, the taxonomic relations, but they can contribute considerably to the solution of problems.

## 2. APPLIED PALYNOLOGY

2.1. *Geo- or paleopalynology*. Within geo- or paleopalynology first of all the domain of research into associated and disperse sporomorphs should be separated and eventually the study of the Quaternary deposits is distinguished, even regarding the objective and the method involved, from that of the pre-Quaternary ones. The former serve as a basis properly for genetic phytogeography, while pre-Quaternary palynology cannot dispense with the phylogeny of the plant kingdom for an up-to-date evaluation of the results (cf. POTONIÉ 1973). Naturally, several trends are distinguished here too:

a) Investigation of megaspores developed especially for the solution of the problems of local stratigraphy of carbonaceous beds of Carboniferous age.

b) Electron microscopic investigation of spores and pollen grains in ultra-thin sections on the one hand and the use of scanning electron microscopy for the exploration of the ultrastructure. Phylogenetic evaluation of the ultrastructure enables to disclose quite new relationships, in addition to its being badly needed, coupled with optical microscopy, for the assessment of the morphological features in an exact way. It should be noted that the papers presenting results of this kind are unfortunately very rare, a fact that may be probably explained by the difficulties involved in the use of the method or by other causes. In this connection the school of TAKHTADJAN ought to be mentioned.

At present and maybe still for a long time on, optical microscopy is and will remain the most widely used method in the examination of pre-Quaternary fossil sporomorphs. Its regular use in this field now looks back to a history of by and large 40 years. In accordance with the problem to be solved, several kinds of studies are distinguished:

a) Description of fundamental, so-called basic, floras, regular publication of spores and pollen grains from a definite horizon of one or more localities with a comparative evaluation in the light of the earlier literature.

b) Palynological approach to the genesis of coal seams or other kinds of mineral deposits—a field of research judged significant by many scientists. Methodologi-

cally similar to Quaternary palynology, this approach can be used to the purpose of local stratigraphy as well.

c) An express method for the genetic evaluation of both coal and non-coal deposits, used exclusively for industrial purposes, is also known.

d) In addition to local stratigraphy, a kind of paleoecology to some extent, the studies devoted to geological age determination belong to the subject of palynostratigraphy. In this context, some selected sporomorphs that may be regarded as "index fossils" should be attached particular significance, but these cannot be separated from the general character of the sporomorphs composition of the deposit in question. The geological age cannot be determined by spore-pollen analyses, unless a rich literature and comparative material is available. Palynostratigraphy is attached to paleophytogeographic regions identifiable on spore-pollen analytical results elaborated best for the Upper Cretaceous and the Lower Paleogene, though information of this kind concerning the Carboniferous and earlier periods is also available.

e) A fairly good number of papers are dealing with the question of secondary sporomorphs: e.g. CUSHING (1962), WILSON (1964), STANLEY (1966, 1967), KEDVES, ENDRÉDI and SZELEY(1966), MUIR (1967) and VENKATACHALA (1969). The opinion that allochthonous spores and pollen grains are merely harmful, impeding factors in the relevant research work was maintained for a long time. As a result of latest progress in this field, palynology has turned out to be in many cases the only tool to establish the fact of allochthony or to determine the age of the redeposited sediments. Nowadays the method itself is applied to several purposes: 1. Classical method based on a wide, comprehensive knowledge of the sporomorphs characteristic of the different geological ages. 2. Separation of allochthonous sporomorphs by colouring techniques. 3. Use of fluorescence microscopy.

Finally, let us mention the so-called *Palynomixtum*—a special branch dealing with vegetal or animal remains other than spores and pollen grains. Pyrrhophyta, Chlorophyta, Hystrichosphaeridae, Chitinozoa and chitinous foraminiferal tests represent the objects of the major lines of research with a wealth of literature on each.

In terms of ERDTMAN's classification (1963) there are still a few branches of palynology which, distant as they are from the subject of this monograph, will be commented in the briefest form. Here they are:

2.2. *Melittopalynology* deals with the pollen composition of honey.

2.3. *Pharmacopalynology*. The principal subject of pharmacopalynology are tests connected with the adulteration of drogs.

2.4. *Iatropalynology*. The palynological problems associated with allergic diseases belong to iatropalynology.

2.5. *Copropalynology* deals with the analyses of pollen grains recovered from animal droppings—an important contribution to the ecology of feeding habits.

2.6. *Criminological palynology* is a field very poorly known to palynologists, biological or geological backgrounds as they have. In a paper showing the principal fields of palynology, STRAKA (1968) called attention to the interesting research organized by BREITENECKER (EHRENDORFER and CLAUS). In criminological investigations the pollen grains on objects that can be used as evidence may also be useful. LARINA (1973) dealt with the problems of methodology emerging from criminological tests. When examining samples of different weight (50 g, 25 g, 5 g, 1 g, 100 mg, 50 mg) taken from one and the same material, she found out that the method of processing had to be changed (p. 78): "With the decrease of the weight to 50 mg and even to 10 mg it was necessary to make a twofold or even threefold increase in the period of centrifuging."

2.7. *Phytopathological-epidemiological palynology* are disciplines dealing primarily with the spore morphology and physiology of fungi species causing vegetal and animal diseases.

The rapid and ever accelerating growth of scientific information is a general phenomenon in modern natural science. It is valid to the afore-listed branches of palynology as well, which, in accordance with the purpose of the present study, will be used hereinafter in a more strict sense. If wishing to keep pace with modern requirements, scientists engaged in a definite field have to be familiar with the relevant literature and to process it critically before setting to the research proper. Looking back to the situation that existed in the 1950's in paleopalynology and comparing it to the present state, a beginner will find himself, or herself, faced with considerably greater difficulties in research work than it would have been the case with an earlier scientist, owing to the mass of information now available. *Nota bene,* several works may help the scientist to get better oriented in that maze of information. Publications of this kind are the *Bibliographie Palynologique, Supplément à Pollen et Spores,* regularly issued by M. VAN CAMPO et al., KREMP's *Paleo-Data Banks* issues as well as the *Genera File of Fossil Spores* that has been published since 1976 by JANSONIUS and HILLS.

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