TRENDS AND PROBLEMS OF THE RESEARCHES OF FOSSIL SPORES AND POLLEN GRAINS

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Abstract

This paper summarizes the most important fields of researches and problems of the investigations of fossil sporomorphs. The synthesis of TEM data of the fossil spore-pollen wall is first published here. The chemistry and molecular structure of the biopolymer units of the sporopollenin, and the importance of the biogeochemistry in the investigation of the fossil palynomorphs is emphasized.

Introduction

The methodical study of fossil sporomorphs started in the thirties of this century. In contrast, the investigations of the spores and pollen grains of the recent taxa began till to the XVIII century. In this way the results got on the recent taxa necessarily have an effect on Paleopalynology, but its special characteristic features, namely the geological uses in the researches of the raw material, became an important influential factor of this field of research.

The peculiar, interdisciplinar position of the researches of the fossil sporomorphs happened in consequence of this reason.

The classical light-microscope method is important in the solution of the following problems:

1. The geological age may be determined by the data of well preserved spore-pollen assemblages.

2. It yields opportunity to get data for the circumstances of the sedimentation processes.

3. Quantitative palynological data are useful for local stratigraphic correlations.

4. The rebedding of the sediments may be established by palynological methods, too.

5. The continental movements may also be followed by the regional distribution of the fossil sporomorphs.

The morphological and taxonomical knowledge of the new fossil spore and pollen types isolated from the sediments of different geological ages influenced the general palynological concepts, which were based exclusively on data of the recent taxa, and modified the attitude of this branch of research. From this point of view the following may be worth of mentioning:

1. Among the fossil sporomorphs a number of new types were also found, which occured not at the recent taxa. E. g.: some spores of the paleozoic ferns; *Emphanisporites*, *Reinschospora*, the monosaccate gymnosperm pollen types from the Upper Permian.

2. Trough evaluation of the different spore and pollen types in the chronological order of the geological time table the evolutionary significance of the sporomorphs, and of their morphological characteristic features may be established. For example the trilete spore is earlier than the monolete one. From among Angiospermatophyta pollen grains, Longaxones are more primitive rather than Brevaxones. The augmentation of the number of the aperture is also a sign of the evolution. The pore, as aperture is more developed than the furrow. The history of the air bladded gymnosperm pollen grains is interesting, too.

3. The spore-pollen data are important in the researches of plant phylogeny.

4. Paleoecology, Paleophytogeography and Paleoclimatology are largely cultivated fields of researches based on palynological data.

The reciprocal effect developed in this way between the researches of the recent and fossil sporomorphs, in optimal case is stimulating for both fields of researches.

In connection with the study by the LM method, one sometimes negligated point of view must be mentioned. It is desirable that the investigations were extended to the full microremnants assemblage in the literatural sense of the word to the following too:

1. Algal remnants (*Botryococcus*, *Pediastrum*, Hystrichosphaeridae, etc.), Mycophyta spores.

2. Epidermis, xylem and other kind of tissue remnants.

3. Organic walled, microscopical animal remnants, e. g.: chitinous Foraminiferae shells, Thecamoeba.

In some cases, the tissue remnants, occurring in the spore-pollen assemblages have a primary role in the solution of the problem investigated. E. g.; the transport of the radioactive material may be carried out by xylem remnants too, connected to aromatic lignin derivates. From the point of view of Geochemistry, the cellulose (parenchym cell walls) and cutin (epidermis) occurring in the coal layers are also important.

The scanning electron-microscope method is important firstly in the taxonomic spore-pollen researches. Connected TEM and SEM characteristic features from phylogenetic point of view were established at the early brevaxonate angiosperm pollen grains, The earliest Brevaxones; Probrevaxones have a columellar infratectum, the surface ornamentation is relatively diversified. The ultrastructure of the infratectum of the developed Normapolles and Postnormapolles taxa is granular and there are submicroscopic coni on the surface of the tectum. The basis diameter and the number of coni per 1 square micron, have taxonomical value.

The chemical composition of the spore-pollen wall interested the researchers for ages. The first data were published by JOHN (1814). Later ZETZSCHE and KÄLIN (1931), ZETZSCHE et al. described several characteristic features of the sporopollenin, among these we emphasize the autoxydation. The first period of the knowledge of the chemistry of the sporopollenin was summarized by TOMSOVIC (1960). On the basis of previous results it was concluded that the sporopollenin is a high polymerized terpene derivate, similar to the cutin. The new results of SHAW and YEADON (1964, 1966), BROOKS and SHAW (1968, 1971, 1978), fundamentally changed this first concept of the sporopollenin. They established that the precursors of the sporopollenin are ß caroten and esters of carotenoids. The stability of these elementary base molecules is assured by aromatic lignin derivates; MANSKAYA, KODINA and GENERALOVA (1973). Following POTONIÉ and REHNELT (1971) in the course of coalification the aliphatic part of the sporopollenin becomes more and more aromatised. For this matter, they introduced the term "sporin" (POTONIÉ and REHNELT, 1969).

On the basis of the results on the exine of recent Epacridaceae FORD (1971) established the following: the outer layer, the ectexine is composed of sporopollenin, the endexine has a high lignin content, and the material of the intine is cellulose. On the surface of the pollen exine thorium and other kind of metals were discovered by ROWLEY (1971). FAEGRI (1971) concerning the enzymatic destruction of the sporopollenin emphasized that our knowledge is poor regarding the enzymes which may be degraded the sporopollenin. As regards the microbial destruction the publications of ELSIK (1966) and ERDTMAN (1971) are important.

Summarizing the results concerning the chemistry of the sporopollenin it may be concluded, that there are several questions to solve, moreover there are several problems which were not be mentioned here.

The higher level of the knowledge of the chemistry of the sporopollenin is themolecular structure of the biopolymers. The most important fields of research of this problem are as follows:

The twofold refraction of light of the exine was studied by SITTE (1959, 1960, 1963) and by FREYTAG (1964). Based on the results they supposed that the sporopollenin is composed of globular units arranged in fibrillar order. In contrast to this, ROWLEY (1962) emphasized the fibrillar units of the sporopollenin. By the TEM study of degraded fossil exines KEDVES, STANLEY and ROJIK (1974) published pictures from the biopolymer units of the sporopollenin, and probably from the polymers of the aromatic lignin derivates. All observed particles have globular morphology. ROWLEY (1975) established that in the exine there are lipopolysaccharide filaments. These filaments may be solved in 2-amino-ethanol, and the higher biopolymer units of the sporopollenin may be studied by the transmission electron microscope. Rowley, with several co-workers published a number of papers concerning this problem, and the helical sub-units of the exine was described. My own enzymatic, and oxidizing experiments combined with the TEM method resulted globular biopolymer units. In this paper it is necessary to emphasize that the globular biopolymer units may be the basic elements of the helical structures. During our TEM study of the plant microfossils of the manganese ore layers, helical structures were also found.

Finally it is necessary to emphasize the opportunity of the methods, and results of Biogeochemistry and of Biophysics, in the researches of the organic remnants. It established the remnants of several biologically important compounds from sedimentary rocks. BREGER (1960), JONES and VALLENTYNE (1960) respectively reviewed the earlier results, following these publications, in 1944, FOX, UPDEGRAF and NOVELLI published carotenoids, and chlorophyll-like pigment remnants from marine sediments. It may be hoped to get data for the evolution of the chemistry of the sporopollenin and for the molecular structure of the sporoderm.

It may be concluded from the formerly mentioned facts that the effectual co-operation of the researches of the different fields (Biology, Geochemistry, Paleobiology, Geology) may be resulted in a very valuable synthesis.

The application of the transmission electron microscopical method in the Palynology of the recent taxa started in 1952; FERNÁNDEZ–MORÁN and DAHL. The first TEM data on fossil exines were published by EHRLICH and HALL (1959). Later, in particular henceforth in the seventies, the number of publications on the subject of the sporoderm ultrastructure of the fossil dispersed and associated sporomorphs have increased. On the basis of the up-to-date results, the general concepts may be established as follows:

1. During the evolutionary process of the sporoderm fine structure a trend of simplification happened. Irregular submicroscopical units become regularly arranged ultrastructural elements. The wall ultrastructure of the early types is in general more complicated than the evoluted ones. This process may be followed by the decrease of the number of the layers of the sporoderm.

2. The phylogenetical, and taxonomical value of certain sporoderm layers is different.

3. The lamellar ultrastructure is earlier than the granular or homogeneous one.

4. The ultrastructure phylogenetical conclusions based on TEM data of the fossil spores and pollen grains are in each case identical with the most important steps of the sporoderm ontogeny of the recent taxa. E. g.: The development of the nexine – it was established on recent and fossil taxa too that in the first step of development both are of lamellar ultrastructure.

Among the details, the following results can be mentioned. Remark. – These results and conceptions are in the basis of two books by the author, which are under publication.

1. The wall ultrastructure of the earliest spores from the Devonian is composed from ramifying roods of sporopollenin with spongy appearance, or by characteristic lamellar ultrastructure elements.

2. The richness in types of the Carboniferous appear in the wall ultrastructure too, beside the early structures, the developed homogeneous may also occur.

3. In the case of the heterospory, in particular from the Mesozoic it is relatively common that the wall ultrastructure of the megaspore is of an earlier type than those of the microspore. The wall structure of the miospores is often homogeneous, namely the developed type, the wall is sometimes channeled.

4. Henceforth of the Upper Cretaceous the homogeneous wall ultrastructure is common. The fine structure of the perispore of the megaspores is reminiscent to those of the exine of the angiosperm pollen grains – tectum, infratectum, foot layer.

5. The earliest gymnosperm pollen – *Archaeoperisaccus* – from the Devonian (the age may be in question) has a spongy-alveolar ectexine, and a lamellar endexine. This is essentially identical with the ultrastructure of the wall of the earliest spores.

6. Inside the saccate type the charateristic alveolar intratectum ultrastructure appeared in the Carboniferous time, but the ultrastructure of the inner layer of the exine is lamellar.

7. The so-called modern gymnosperm exine ultrastructure appeared in the Trias – Jura period. The submicroscopic structure of the inaperturate gymnosperm pollen types is well known from the Jurassic-Cretaceous period. In contrast to the relatively uniform light-microscope morphology, the fine structure of the exine is heterogeneous.

7.1. The exine ultrastructure of the genus *Balmeiopsis* is of an early type, its ectexine is spongy, the ultrastructure of the endexine is lamellar.

7.2. The exine ultrastructure of the pollen grains of Spheripollenites has angiospermous characteristic features.

7.3. The evolved exine ultrastructure type of the inaperturate gymnosperm pollen grains, which is identical with those of the recent taxa is known until from the Cretaceous period. The endexine is lamellar, the ectexine is granular, but this granular ultrastructure has an angiosperm type.

8. The exine ultrastructure of the Circumpolles Group, which is characteristic for the Trias – Cretaceous period is particularly complicated, but some characteristics are similar to those of the angiosperms.

9. As regards the evolutionary significance of the fossil angiosperm exines, primarily early characteristic feature is the columellar infratectum and the lamellar endexine and/or foot layer.

10. During the differentiation, which started henceforth in the Upper Cretaceous, the phylogenetic value of certain characteristic features may change. Namely, primarily early characteristic may be developed to secondary. E. g.; The columellar infratectum of the Tertiary species of the Postnormapolles, and Eubrevaxones is more developed opposed to the granular structure of the Eunormapolles.

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