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SCANNING ELECTRON-MICROSCOPICAL INVESTIGATIONS INTO THE SPOROMORPHES OF THE COAL LAYERS IN THE DOROG BASIN

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Abstract

In this paper, the results of the scanning electron-microscopic investigations of the sporomorphous types — that are particularly characteristic of the layers of the lower coalification cycle of the brown-coal bed in Dorog — are summarized. On the surface of the investigated spores (*Leiotriletes adriennis, L. dorogensis, Cicatricosisporites dorogensis* subfsp. *dorogensis, C. dorogensis* subfsp. *dorogensis* fvar. *rugulatearis, Polypodiaceoisporites speciosus, Microfoveolatosporis pseudos dentatus*), with the exception of Microfoveolatosporis pseudodentatus, some characteristics could be demonstrated which could not be recognized with light microscopes. In case of Leiotriletes fgen., these formations seem to be of taxonomical value. *Psosphosphaera intrapuctata*, on the basis of its submicroscopical formations on the surface, is not similar to recent Gymnospermatophyta pollen grains. The matter in question is, probably, a died out taxon. It is very well separated by its surface formations from other fossil and recent inaperturate forms. From among the pollen grains which are very characteristic of coal layers, on the surface of *Monocolpopollenites tranquillus*, there is a well definable verrucate-rugulate sculpture. On the basis of the results of the investigations into several specimens, these formations are of changing size.

Introduction

Concerning the light-microscopic palynological investigation into the lower coalification cycle of the coal-basin at Dorog, several literary data are available for us (e.g.; POTONIÉ & GELLETICH, 1933; KEDVES, 1960, 1961, 1962, 1969; RÁKOSI, 1973). The total of brown coal is, on the basis of these, rich in sporomorphes. The number of the separated form-species is, however, comparatively low. Among the Angiospermae the palms have a special importance in the vegetation forming these layers.

The intensive scanning electron-microscopical palynological investigations, starting in the second half of the past decade, yielded several new results at the fossil sporomorphes, as well. These investigations, particularly in case of pollen grains, apart from improving on the earlier statements concerning the surface formations, have thrown a new light, in a number of cases, upon the taxonomical phylogenetical connections, too. It is interesting that the application to the Palaeo- and Mesozoic sediments has become much more general than to the sporomohes of the younger, Tertiary layers. STANLEY and KEDVES (1975) also referred to this problem of the fossil pollen grains of Angiospermatophyta.

There are known about the scanning electron-microscopical investigation into the fossil sporomorphes in Hungary so far but a few data (STANLEY & KEDVES, 1975; KEDVES & STANLEY, 1976a, b; KEDVES & RADVÁNSZKI, 1975; KEDVES, 1974).

The continuation of these investigations in the interest of the more perfect evaluability of the home sporomorphes coming from the Palaeogene period, well-known by the light-microscopical method, is also supported by the results until now. Several authors referred to the importance of the method, e.g., MARTIN (1969), TAYLOR & MILLAY (1969), JARDINÉ & RAYNAUD (1972), CERCEAU, HIDEUX, LACHKAR, MASURE, RENAULT-MISKOWSKI, ROLAND, TANGOURDEAU-LANTZ & YBERT (1976).

This paper renders account of the result of the first scanning electron-microscopical examination of the important enough sporomorphes in the habitat in Hungary which, at any rate, is counted among the classical ones even in international relation.

Materials and Methods

The material of investigation originates from boring N–33 in the Nagysáp area in the Dorog basin, from the depth-gaps 465.0–465.4 and 466.2–466.8 m of the total brown-coal bed of the lower coalification cycle. The dry matter was carried, by means of a glass-needle, on a glass-plate covered with a polyvinylchloride adhesive and then evaporated with a gold-palladium binary alloy. The investigations were carried out with a JSM 50-A electron microscope, with tilting in an angle of 45 degrees, in the Electron-Microscopical Laboratory, placed in the Department of Zoology of the Lorand Eötvös University. For the kind help I express my special thanks, in this way too, to the Head of the Department, Dr. J. KOVÁCS and to J. BAGI, technician.

Results

Fgen.: *Leiotriletes* (NAUMOVA 1937) R. POT. et KRP. 1954.

1. *Leiotriletes adriennis* (R. POT. et GELL. 1933) W. KR. 1959.

In respect of its light-microscopic taxonomy, the publications of POTONIÉ & GELLETICH (1933), THOMSON & PFLUG (1953), KRUTZSCH (1954, 1959), KEDVES (1961), KEDVES & KEREPECZKY (1966) may be mentioned.

The usual picture of lesser magnifying (×2000: Plate I, 1) did not demonstrate any important new datum about the expressly sculptureless surface, only so much that the spore wall somewhat emerges beside the tetrad-mark. But the picture of ×10000 magnifying (Plate I, 2) resulted in a definitely granular surface. The size of the ornamental elements is generally about 0.1 μ, they take place densely or sometimes in a distance of maximum 0.2 μ. They anastomose but rarely and then a fine rugulate ornametation comes about.

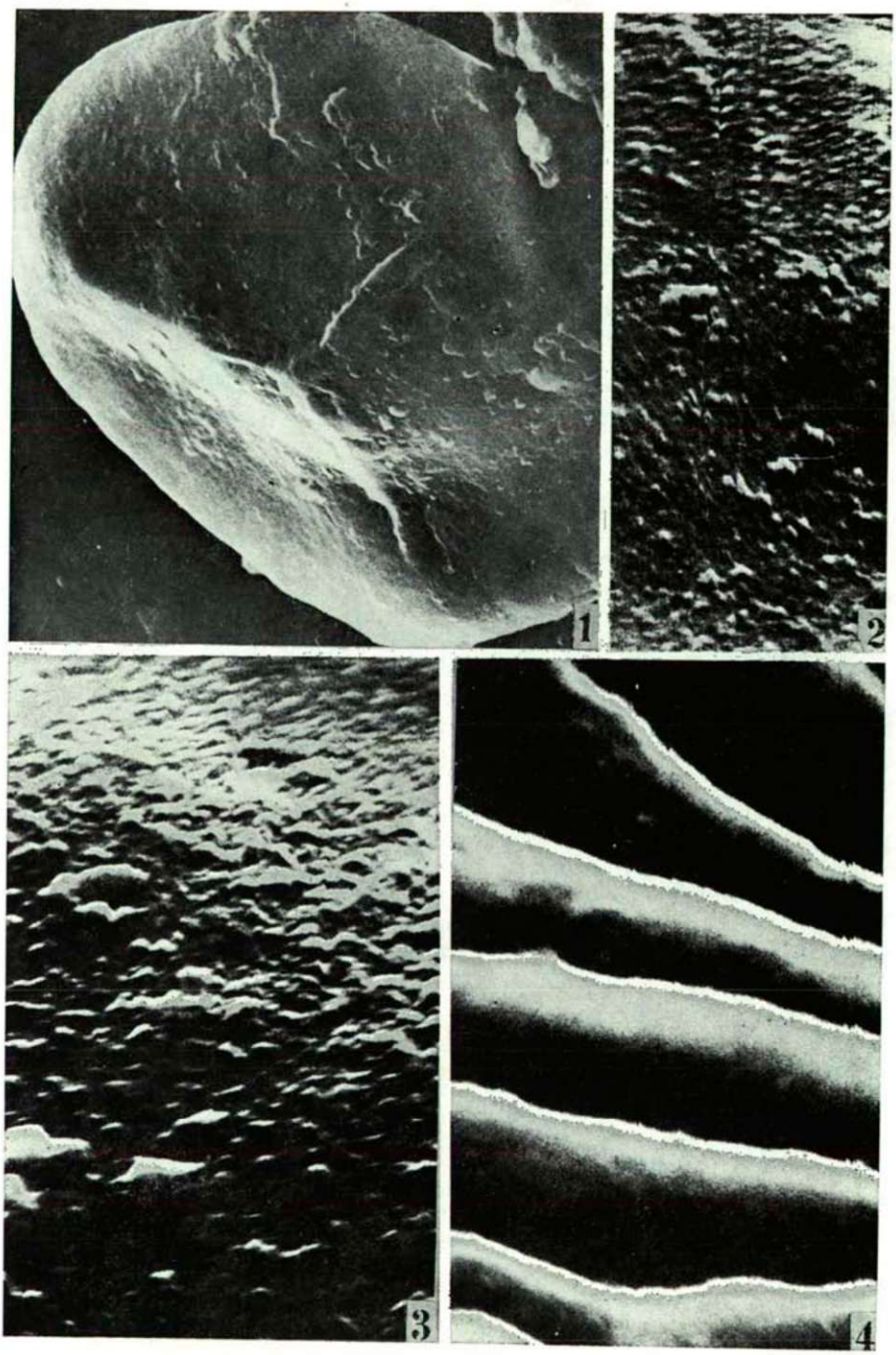
2. *Leiotriletes dorogensis* (KDS. 1960) KDS. 1961.

As the picture of lesser magnifying has brought nothing that is essentially new in respect of the earlier knowledge, we publish here only a picture of ×10000 magnifying (Plate I, 3). The ornamentation of the surface is primarily rugulate, here

Plate I

1. *Leiotriletes adriennis* (R. POT. et GELL. 1933) W. KR. 1959, Schizaeaceae, cf. *Lygodium*; a comprehensive view over the surface of the spore, x2000.
2. *Leiotriletes adriennis* (R. POT et GELL. 1933) W. KR 1959, Schizaeaceae, cf. *Lygodium*; a detail of the submicroscopical sculpture of the surface, x10 000.
3. *Leiotriletes dorogensis* (KDS. 1960) KDS. 1961, Schizaeaceae, cf. *Lygodium*; a detail of the submicroscopical sculpture of the surface, x10 000.
4. *Cicatricosisporites dorogensis* R. POT. et GELL. 1933 subfsp. *dorogensis*, Schizaeaceae, *Anemia*; a part of the sculpture of the distal side, x10 000.

Plate I



and there verrucate. The verrucae are of 0.5–0.3 μ diameter, the width of the rugulate ornamentation is generally 0.2 μ, its length is changing, about 0.3–0.7 μ.

Fgen.: *Cicatricosisporites* R. POT. et GELL. 1933.

1. *Cicatricosisporites dorogensis* R. POT. et GELL. 1933 subfsp. *dorogensis*.

A scanning electron-microscopical picture about the spore was made by SRIVASTAVA (1972) at first. The pictures of ×1000 magnifying brought nothing that is new, as compared with with the results of light microscopes. In our picture of ×10000 magnifying (Plate I, 4) we have succeeded to recognize flat granule-like but not expressed formations on the surface of muri, on a surface that light-microscopically seemed to be smooth.

2. *Cicatricosisporites dorogensis* R. POT. et GELL. 1933 subfsp. *dorogensis* fvar. *rugulatearis* KDS. 1961.

The transition of the canaliculate sculpture into a sporadically rugulate ornamentation is very obvious in the picture of ×2000 magnifying (Plate II, 1). It is interesting that even at a magnification like this, the tiny granule-like formations, located sparsely on the large sculpture elements, can be observed well.

Fgen.: *Polypodiaceoisporites* R. POT. 1956.

1. *Polypodiaceoisporites speciosus* (R. POT. 1934) R. POT. 1956.

On the proximal side, a further fine ornamentation of the sculpture elements can be observed; a similare and more express one on the rugulate elements of the distal sculpture (Plate II, 2, 4). This is a fine granulate-rugulate ornamentation. The surface of the zone is not smooth, either, but finely granular, the size of granules being maximum 0.1 μ (Plate II, 3).

Fgen.: *Microfoveolatosporis* W. KR. 1959.

1. *Microfoveolatosporis pseudodentatus* W. KR. 1959.

The scanning electron-microscopical results only support the light-microscopical observations although on the muri a further granular structure is visible; this, however, is not convincing, according to the foregoing (Plate II, 5, 6).

Fgen.: *Psophosphaera* NAUMOVA 1937 ex BOLCHOVITINA 1953.

1. *Psophosphaera intrapunctata* (KDS. 1961) n.comb.

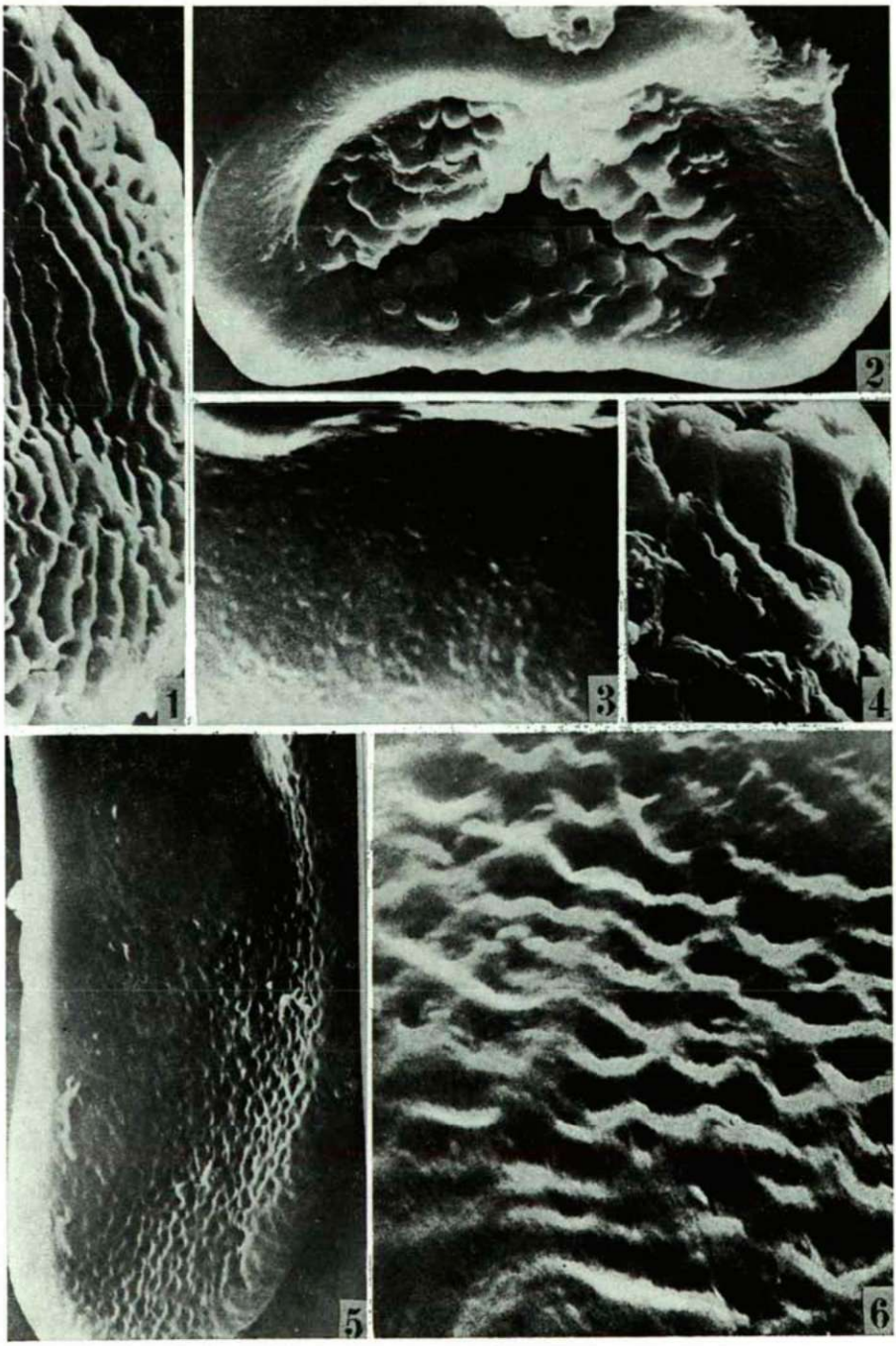
Syn.: KEDVES 1961 — *Laevigatasporites intrapunctatus* n.fsp.

They are extremely problematical forms. At this form species we have, therefore, examined several specimens which led to an identical result. The submicroscopical ornamentation of the surface bearing light-microscopically no definite sculpture is double. On the one hand, the surface is uniformly covered by very small granules

Plate II

1. *Cicatricosisporites dorogensis* R. POT. et GELL. 1933 subfsp. *dorogensis* fvar. *rugulatearis* KDS. 1961, Schizaeaceae, *Anemia*; a detail of the ornamentation of the spore, x2000.
2. *Polypodiaceoisporites speciosus* (R. POT. 1934) R. POT. 1956, Pteridaceae; a comprehensive view over the proximal surface of the spore, x2000.
3. *Polypodiaceoisporites speciosus* (R. POT. 1934) R. POT. 1956, Pteridaceae; a detail of the submicroscopical ornamentation of the proximal side of the cingulum, x10 000.
4. *Polypodiaceoisporites speciosus* (R. POT. 1934) R. POT. 1956, Pteridaceae; a detail of the sculpture of the distal side, x2000.
5. *Microfoveolatosporis pseudodentatus* W. KR. 1959, Psilotaceae; a detail of the surface ornamentation of the spore, x2000.
6. *Microfoveolatosporis pseudodentatus* W. KR. 1959, Psilotaceae; a detail of the sculpture of the surface, x10 000.

Plate II



below 0.1 μ which sometimes look like coni (Plate III, 2). Apart from this, there is a characteristically stried ornamentation, as well. This is irregular, ramifying, in the middle of the striation there are often some hollows, as well, and only its both edges emerge (Plate III, 1, 2). This surface ornamentalness may raise the idea that above the solider muri there is also a formation, similar to a thin perisporium.

Fgen.: *Monocolpopollenites* TH. et PF. 1953.

1. *Monocolpopollenites tranquillus* (R. POT. 1934) TH. et PF. 1953 subfsp. *tranquillus*.

From the point of view of the knowledge of the vegetation, having formed the brown coal-bed layers from the lower Tertiary, this pollen is particularly considerable, first of all at the brown-coal bed layers of Dorog type.

The express sculpture is very obvious in but less magnified scanning pictures, as well (Plate III, 3, 5). Six specimens got under scanning electron-microscopical investigation. These led qualitatively to an identical result but as to the sizes of ornamentation, variation is large enough. The sculpture is rugulate-verrucate. The size of the rugulate ornamental elements is highly changing: 0.5–1.2 μ (Plate III, 4, 6).

Fgen.: *Arecipites* WODEHOUSE 1933.

1. *Arecipites granulatus* (KDS. 1961) L. RÁKOSI 1973.

The fine reticulate ornamentation can be observed very well with the scanning electron-microscopical method (Plate III, 7, 8). It is essentially new that the surface is identical in the germinal and extragerminal regions, too. This could not be demonstrated, so far, with the light-microscopical method.

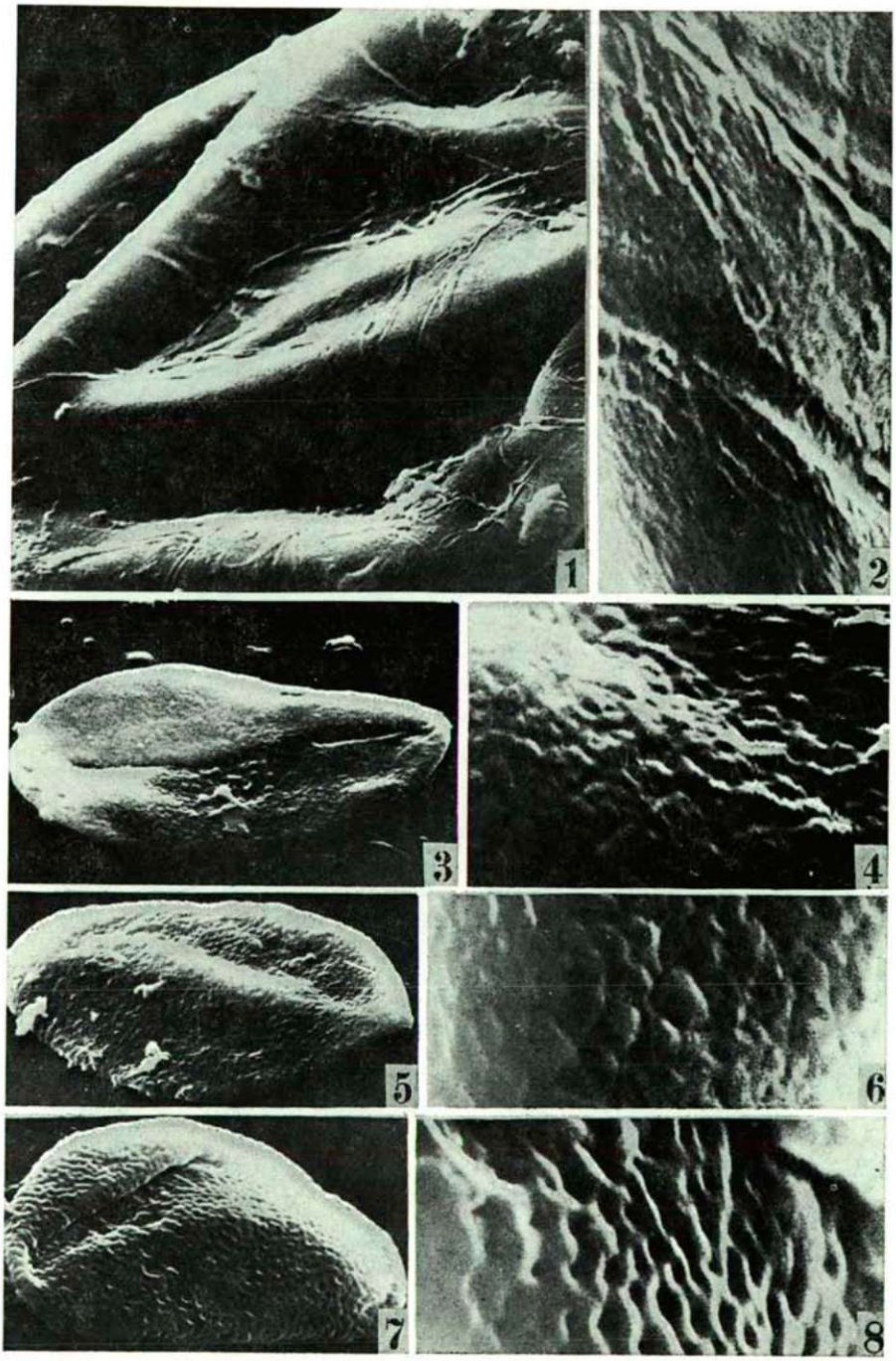
Discussion of results

Sporomorphes of different types have got under a scanning electron-microscopical investigation. Comparing our results in respect of spores with several literary data, we are led to the conclusion that in the future only the results of investigations with a strong magnification can bring something that is even qualitatively new, face to face with the light-microscopical results. On the conspicuous ornamentations which can be recognized with light microscopes, as well other formations may also take place. But primarily the spores with surfaces that seem to be smooth with light microscopes are those at which submicroscopical surface formations of taxonomical value are possible, for which the investigated two *Leiotriletes* fsp. mean a good example. *Polypodiaceoisporites speciosus* is illuminating from this point of view, particularly the express submicroscopical ornamentation of the cingulum which seems to be smooth.

Plate III

1. *Psophosphaera intrapunctata* (KDS. 1961) n. comb.; a detail of the surface x2000.
2. *Psophosphaera intrapunctata* (KDS. 1961) n. comb.; a strongly magnified detail of the surface sculpture, x10 000.
3. 5. *Monocolpopollenites tranquillus* (R. POT. 1934) TH. et PF. 1953 subfsp. *tranquillus*, Palmae; the surface ornamentation of full pollen grains, x2000.
4. 6. *Monocolpollenites tranquillus* (R. POT. 1934) TH. et PF. 1953 subfsp. *tranquillus*, Palmae; a detail of the submicroscopical ornamentation of the surface, x10 000.
7. *Arecipites granulatus* (KDS, 1961) L. RÁKOSI 1973, Palmae; SEM photograph of the pollen grains, x2000.
8. *Arecipites granulatus* (KDS. 1961) L. RÁKOSI 1973, Palmae; a detail of the ornamentation of the surface, x10 000.

Plate III



Psophosphaera intrapunctata forms a part of our effort, to clear up the taxonomical, phylogenetical connections between the often uncertain, "inaperturate" forms. Our present-day datum presents only an aid to the further steps because on the basis of the demonstrated surface formations the gymnospermous, but also the Pteridophytic origin may be exclused. It may have been the leftover of the fossil Cormophytic taxon but we may think on an algal origin, too. Concerning the scanning data of the recent, resp. fossil inaperturate gymnospermous pollen grains, the works of REYRE (1968, 1973), SRIVASTAVA (1975) afford a very good comparative material.

The knowledge of the submicroscopical surface of the Palmae pollen grains may lead to the determination of the genus. THANIKAIMONI (1966, 1970) performed several investigations into recent Palmae pollen grains, applying both the *TEM* and *SEM* methods. In spite of this, the electron-microscopical knowledge of the recent Palmae pollen grains cannot be considered at all as closed and, owing to the deficiency of the recent comparative SEM data, the identification of the genus could not be carried out. On the other hand, on the basis of the results of the complex researches of AUDRAN and MASURE (1977) into Cycadales pollen grains, the possibility of the belonging of *M. tranquillus* into this group — that on the basis of the light-microscopical morphology, as a possibility, could so far emerge — may now be regarded as precluded.

By POTTER, JR. (1946), the scanning electronmicroscopical picture of cf. *Monocolpopollenites tranquillus* was published from the sediments of the Eocene of Kentucky and Tennessee (Pl. 6, fig. 142). This pollen grain fundamentally differs from those recognized from the Dorog basin, as its tectum is smooth and perforate. In this case, therefore, different species are, at any rate, in question. The question is made interesting by that in Plate II, pictures 12–15 the light-microscopical pictures of *Monocolpopollenites tranquillus* are published by POTTER, JR., on the basis of which no essential difference can be found between the specimens of the Dorog basin and those of North America. The "tranquillus Palmae pollen", the importance of which is indisputable, is from the point of view of the palaeogenous vegetation, on the basis of the recent, already mentioned, light-microscopical data, very problematical. KRUTZSCH (1962) described the subfsp. verrucatus and remarked that the main subfsp. is not entirely smooth but finely sculptured, extrapunctate, granulate but never finely reticulate one. In his opinion, a finer morphological analysis may lead, at these so-called "smooth Palmae pollen grains", to a further division. The author (1968) described, in the course of the palynological investigation into the palaeogenous sediments of the Paris basin, three new subfsp. with light-microscopic method. KEDVES & BOHONY (1966) performed the size-variation-examination of *M. tranquillus tranquillus* and *Arecipites granulatus* (KDS. 1961) L. RÁKOSI 1973 from the Dorog basin. In case of *M. tranquillus tranquillus* has also the idea arisen that it is taxonomically heterogenous as the size-variation curve has three maxima. This is contradicted, in some degree, by that at the comparative recent *Martinezia caryotaefolia* KUNTH two maxima could be observed. This problem is supported by our above-mentioned scanning data, as well.

We shall finally deal with the work of NICHOLS, TATE AMES & TRAVERSE (1973) that continues complicating the question which is anyway in motion. They have investigated with light-microscopical method the question of *Arecipites* WODEH. 1933, *Monocolpopollenites* THOMSON et PFLUG and *M. tranquillus*. In their opinion,

Arecipites are "exine psilate to finely foveolate or scrobiculate"... They have classified into the here described *A. pseudotranquillus* NICHOLS, TATE AMES & TRAVERSE 1973, among others, the data from Hungary, published under the name *M. tranquillus* as well. It is interesting that the exine of the species is "faintly scabrate". About the surface of *M. tranquillus,* they write that it is "psilate scabrate or reticulate but not granulate or verrucate". The problem is, therefore, the separation of the form-genera *Arecipites* and *Monocolpopollenites*. The reexamination of the question with an electron microscope may mean a solution first of all on the original Geiseltal material in this question which is very complicated from taxonomical point of view.

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