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TRANSMISSION ELECTRON MICROSCOPIC (TEM) INVESTIGATIONS ON UPPER CRETACEOUS SPORES FROM VILA FLOR (PORTUGAL)

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Summary

TEM investigations were performed on spores of the Upper Cenomanian sediments of Vila Flor. It was found that 1. The wall matrix of three species of the form-genus (fgenus) *Leiotriletes* is homogeneous. In the inner part of the wall there are channells or cavities running more or less parallel with the surface. In the case of one form-species (fsp) the cavities continue in radial channels in the exospore. The diameter of the channels parallel with the surface has a taxonomical value. 2. The exospore of two species from the fgenera *Cicatricosisporites* and *Polypodiaceosporites* is completely homogeneous without channels. 3. The exospore of *Ariadnaesporites* is not completely homogeneous. Ultrastructure of the perispore and that of the acrolamellae are identical; they are composed of irregular sporopollenin particles while the ultrastructure of the elaters is homogeneous. The exospore of the fsp from the fgenus Microfoveolatosporis is homogeneous as well.

Introduction

TEM investigations were performed on spores of palaeozoic forms (PETTIT, 1966) and on spores of heterosporic plants (KEMPF, 1969a, 1969b, 1971; KEDVES 1978). There are relatively few data known about wall ultrastructure of fossile isosporic plants (KEDVES and PÁRDUTZ, 1973).

Ample palynological investigations are in progress on Upper Cretaceous sediments in Portugal. The first step of these investigations covers the angiospermous pollens e.g. DINIZ, KEDVES and SIMONCSICS (1974/1977), KEDVES and HEGEDŰS (1975), KEDVES and PITTAU (1979). After the investigation of the angiospermous pollens, the results on spores and on the pollens of Gymnospermatophyta will be presumably published in a monograph. Before this new data are necessary for the description of several new taxa. At present such data can be obtained by TEM method. Present work summarizes the introductory part of authors' investigations on the Upper Cenomanian sediments of Vila Flor.

Materials and Methods

A geological survey of the site of Vila Flor is published by DINIZ, KEDVES and SIMONCSICS (1974/1977). The methods are described by KEDVES and PÁRDUTZ (1970). This time the spores embedded in blocks were photographed again by light microscope. Only the short description of these pictures is to be published here because in a subsequent taxonomic work all the fossile spores will

be identified and published. From the main spore types of the Portuguese Upper Cretaceous the spores of fgenera *Leiotriletes*, *Cicatricosisporites*, *Ariadnaesporites* and *Microfoveolatosporis* were investigated by the TEM method.

Results

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

1. *Leiotriletes* fsp XV./1 (Table I, 1,2)

Light microscopic characters: The outline is triangular with convex sides. The exospore is 2—3 μm thick. Laesurae of the square mark do not reach the equator, r=3/4—4/5; diameter 73 μm.

TEM characters: The wall is homogeneous, no layers with different electron-affinity can be distinguished, but in the inner third part cavities or channels running parallel with the surface occur. Exceptionally, these may reach the middle of the wall. Their diameter is variable: 0.17—0.5 μm; mostly about 0.3 μm.

2. *Leiotriletes* fsp XIV./1 (Table I, 3, 4)

Light microscopic characters: It is a triplanoid form. The outline is triangular with convex sides. The exospore is 2—2.5 μm thick. Laesurae of the square mark do not reach the equator, r—3/4; diameter=70 μm.

TEM characters: The wall is homogeneous permeated by two kinds of channels. In the inner third part of the wall channels running irregularly or parallel with the surface occur. One part of these channels lead into channels radially oriented and reaching the surface. The diameter of the radial channels is 0.05 μm, the irregular inner channels has a diameter of 0.04—0.14 μm, mostly about 0.07 μm.

3. *Leiotriletes* fsp XIV./3 (Table II, 1—3)

Light microscopic characters: The outline is triangular with straight on concave sides. The wall is 2—3 μm thick. The laesurae of the square mark reach the equatorial contour (or nearly so), r=4/5—5/5; the diameter is 75 μm.

TEM characters: The wall is homogeneous. In the inner part channels and cavities running parallel with the surface occur, relatively densely. They reach about the middle of the wall but they occur only in the inner third part densely. Their diameter is variable: 0.02—0.2 μm, mostly 0.5—0.7 μm.

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

1. *Cicatricosisporites* fsp XIII./2 (Table II, 4,5, Table III, 1,2)

Light microscopic characters: It is a triplan form, the width of four striae and muri is 20 μm. The longitudinal axis is 44 μm long.

TEM characters: The exine is completely homogeneous. In some places an inner thin layer shows higher electron affinity (Table II, 4, Table III, 2); this is the artefact of the preparation. From serial cuttings it can be established that the proximal part is nearly smooth. The caniculate sculpture of the distal part is variable on the different parts of the spore; there are partly stocky and wide muri and on the other hand occur high protuberances too. These can be properly seen on all the four photos (Table II, 4, 5, Table III, 1, 2).

Fgenus *Polypodiaceoisporites* R. POT. 1956 non 1951

1. *Polypodiaceoisporites* fsp XI./2 (Table IV, 1, 2)

Light microscopic characters: The equatorial contour is triangular with slightly convex or concave sides. The cingulum is 4.5 μm wide. The laesurae of the square

Table I

1, 2 *Leiotriletes* fsp XV/1, exospore cross section, x20000
3, 4 *Leiotriletes* fsp XIV/1, exospre cross section, x20000

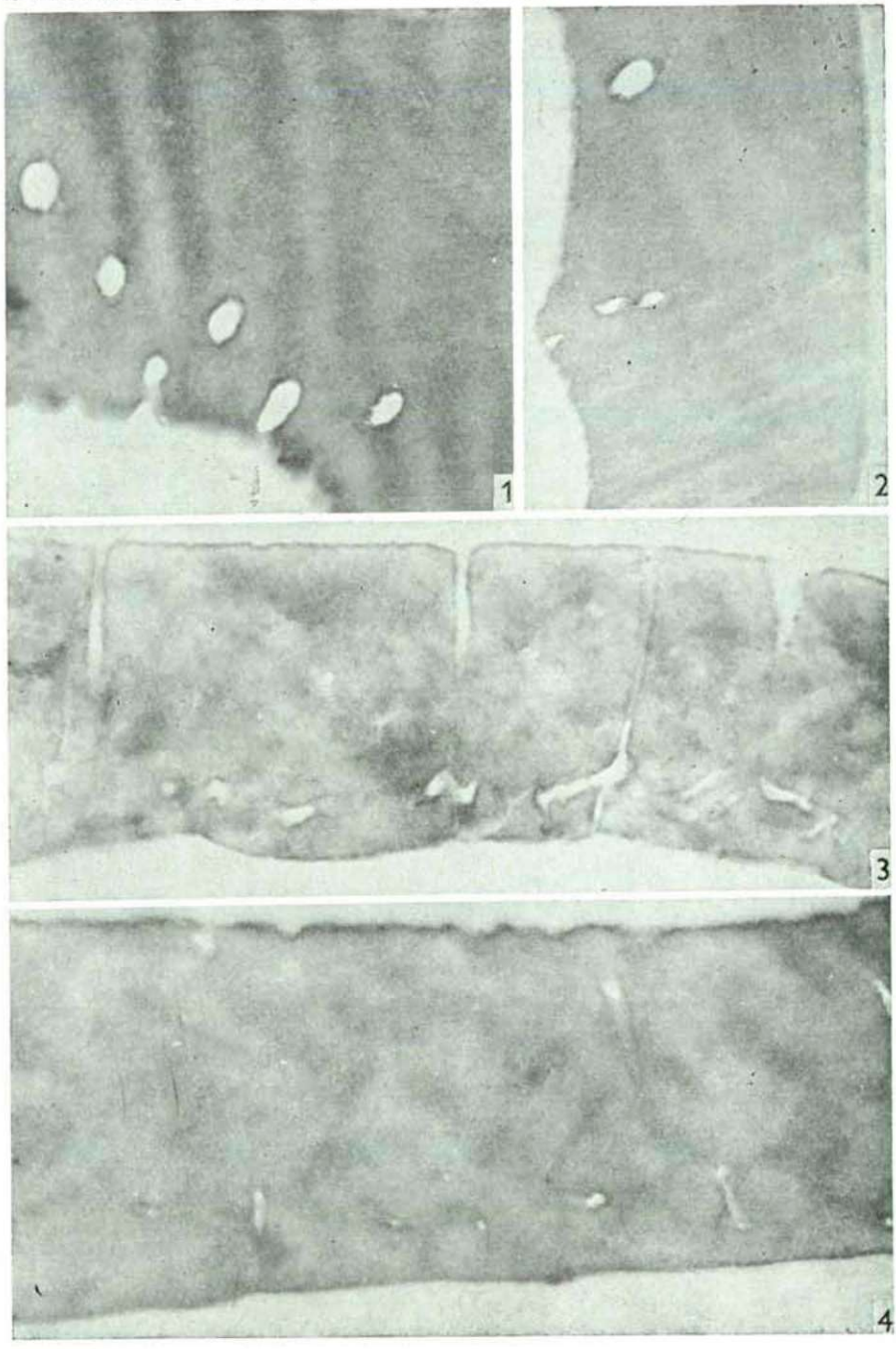


Table II

1—3, *Leiotriletes* fsp XIV/3; 1, 2 exospore cross section x20000, 3 exospore cross section x10000
4, 5, *Cicatricosisporites* fsp XIII/2 spore cross section, x5400

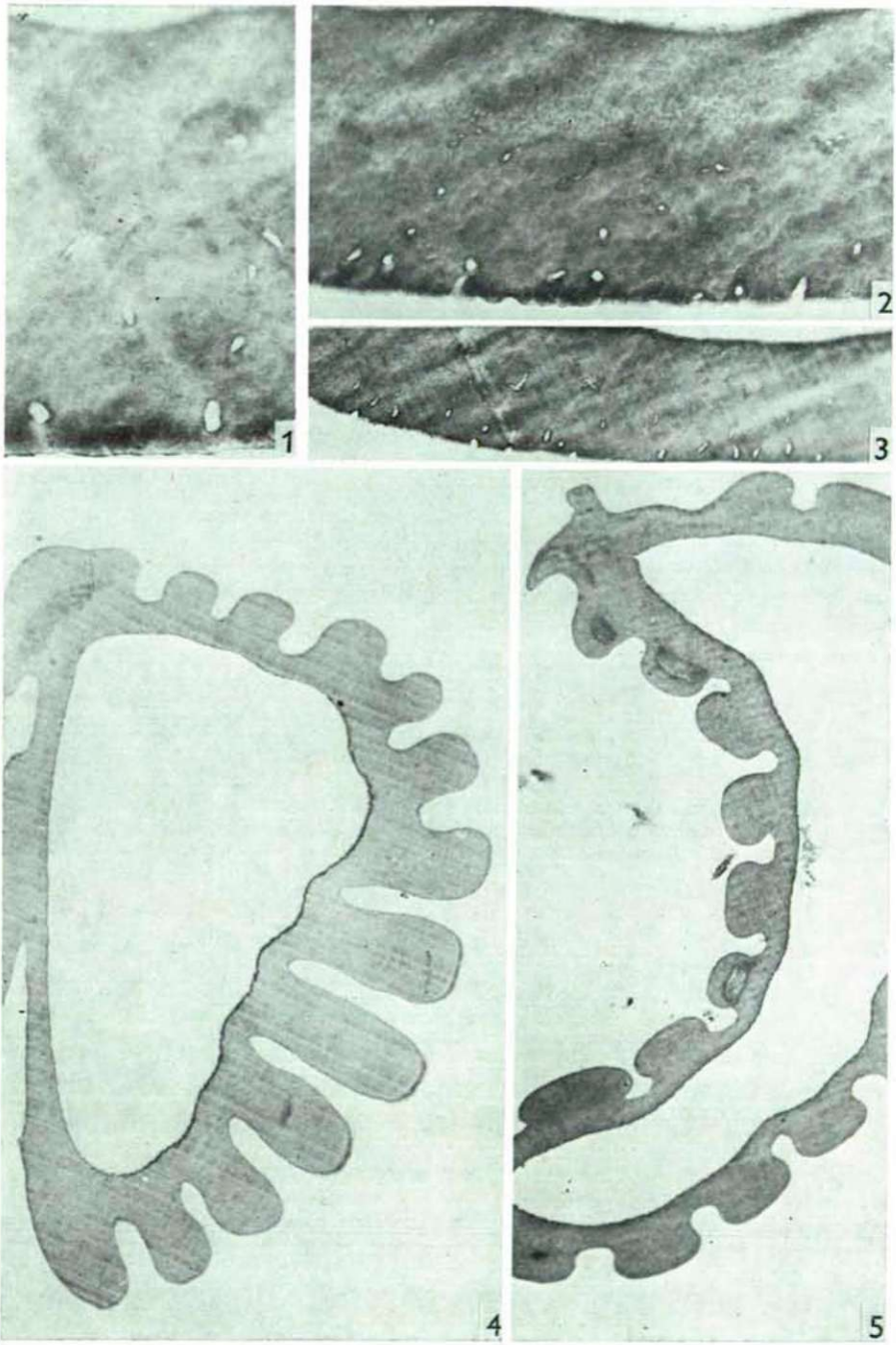
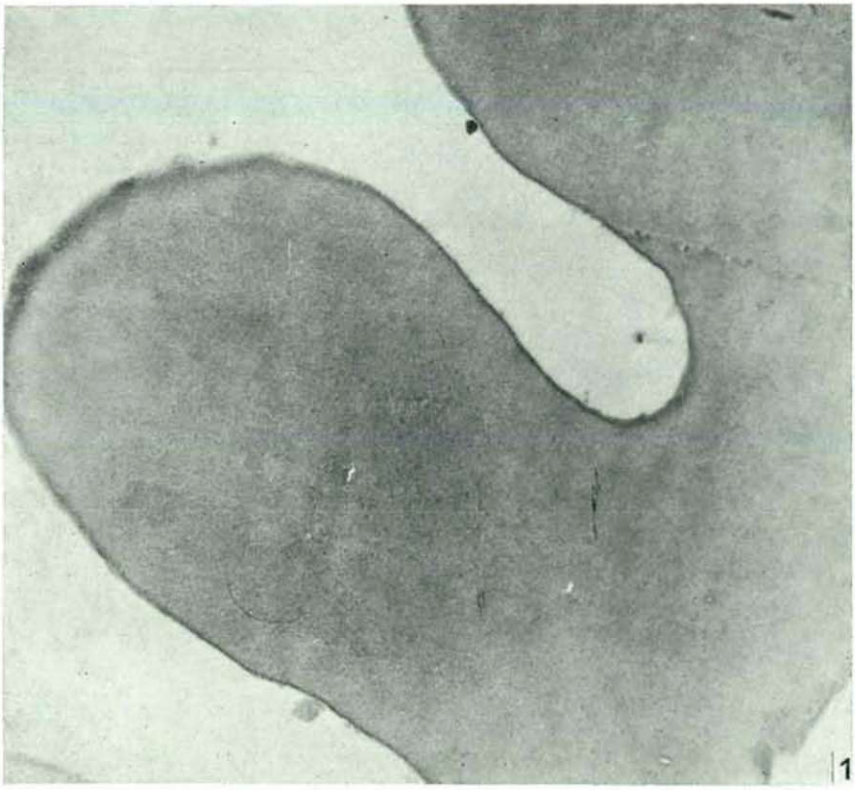


Table III

1, 2 *Cicatricosisporites* fsp XIII/2, exospore cross section, x20000



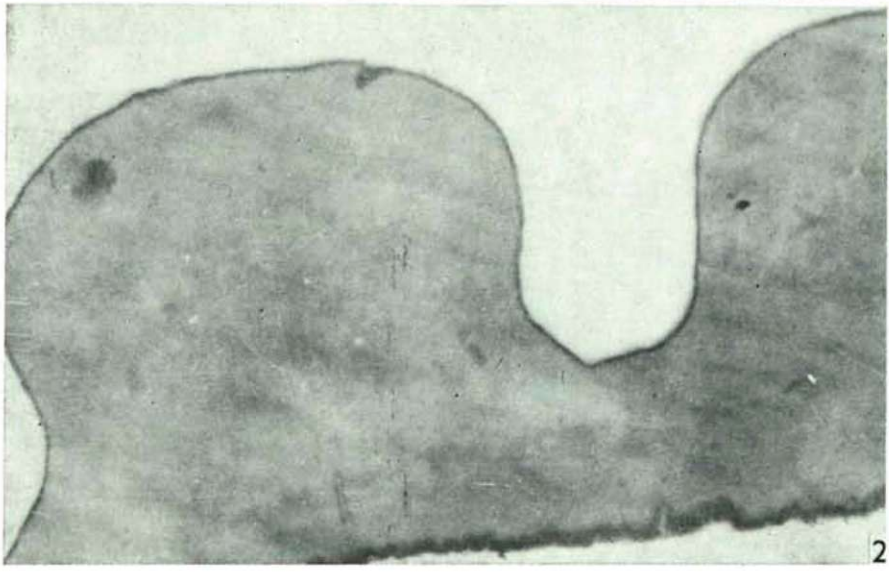


Table IV

1 *Polypodiaceoisporites* fsp XI/2, spore cross section, x5400
2 *Polypodiaceoisporites* fsp XI/2, spore cross section, x6600
3 *Ariadnaesporites* fsp XIII/3, exospore and perispore cross section, x10000
4 *Ariadnaesporites* fsp XIII/3, perispore cross section with elaters, x10000

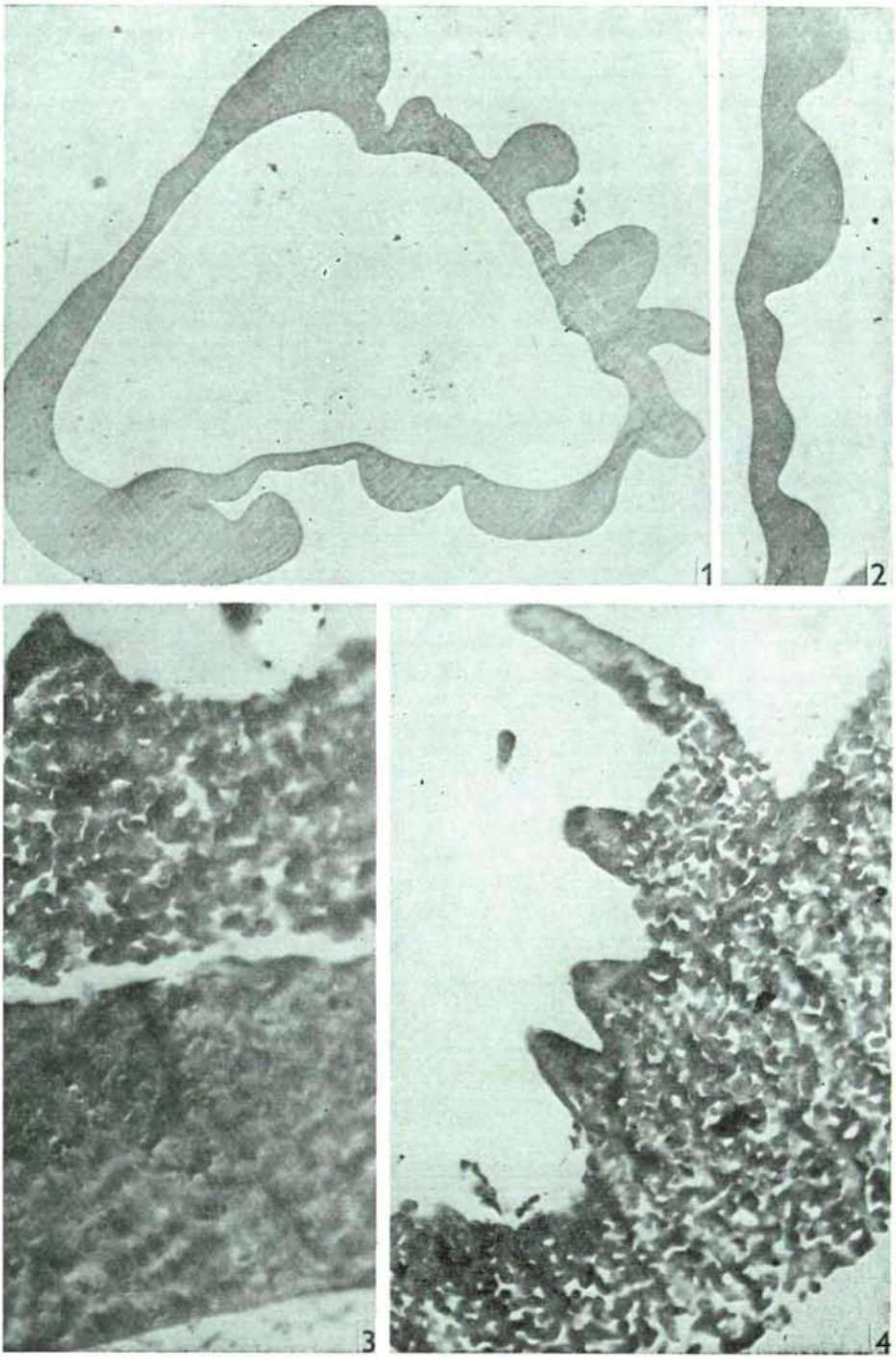


Table V
Ariadnaesporites, exospore and perispore cross section, x20000

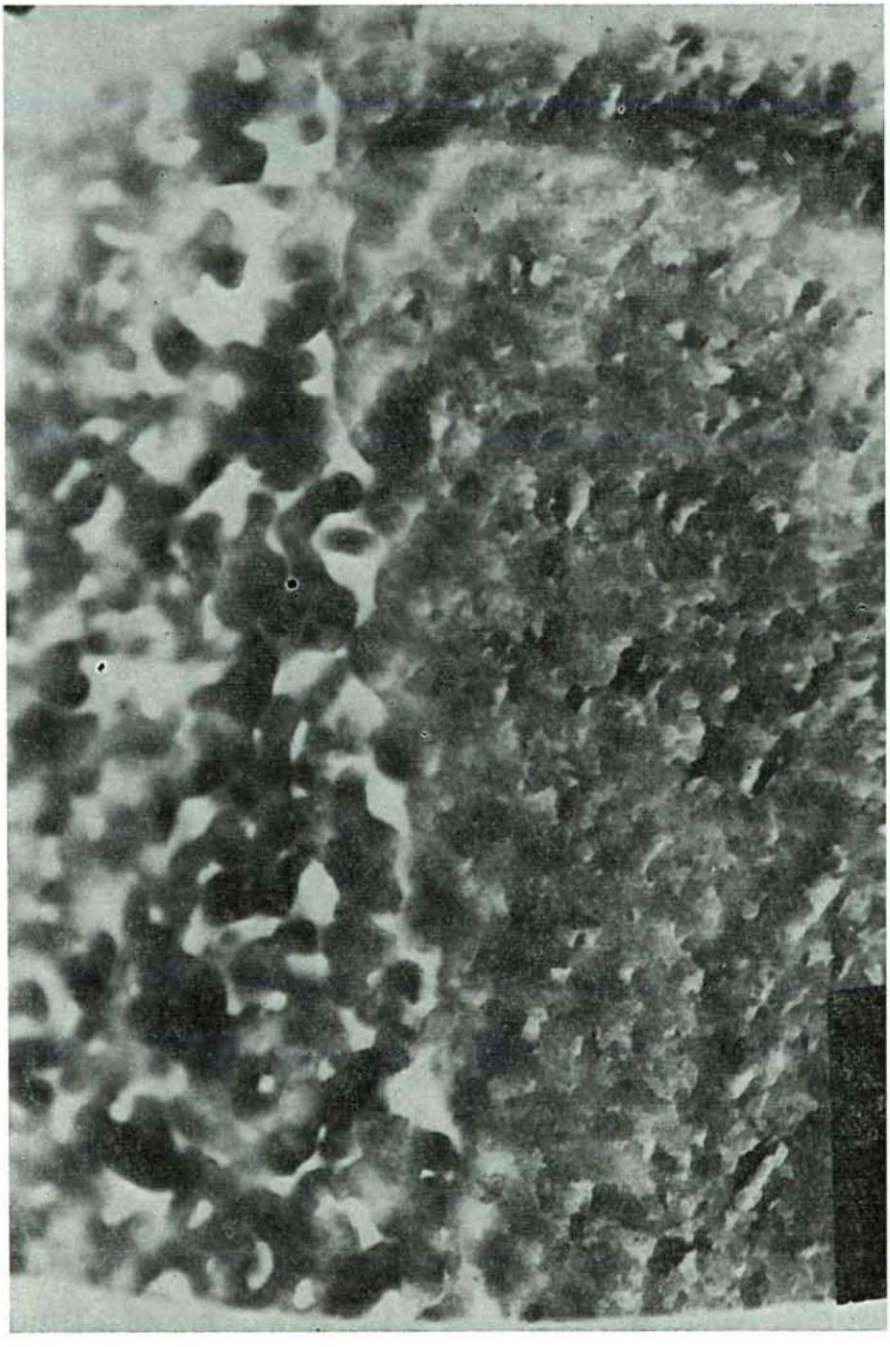
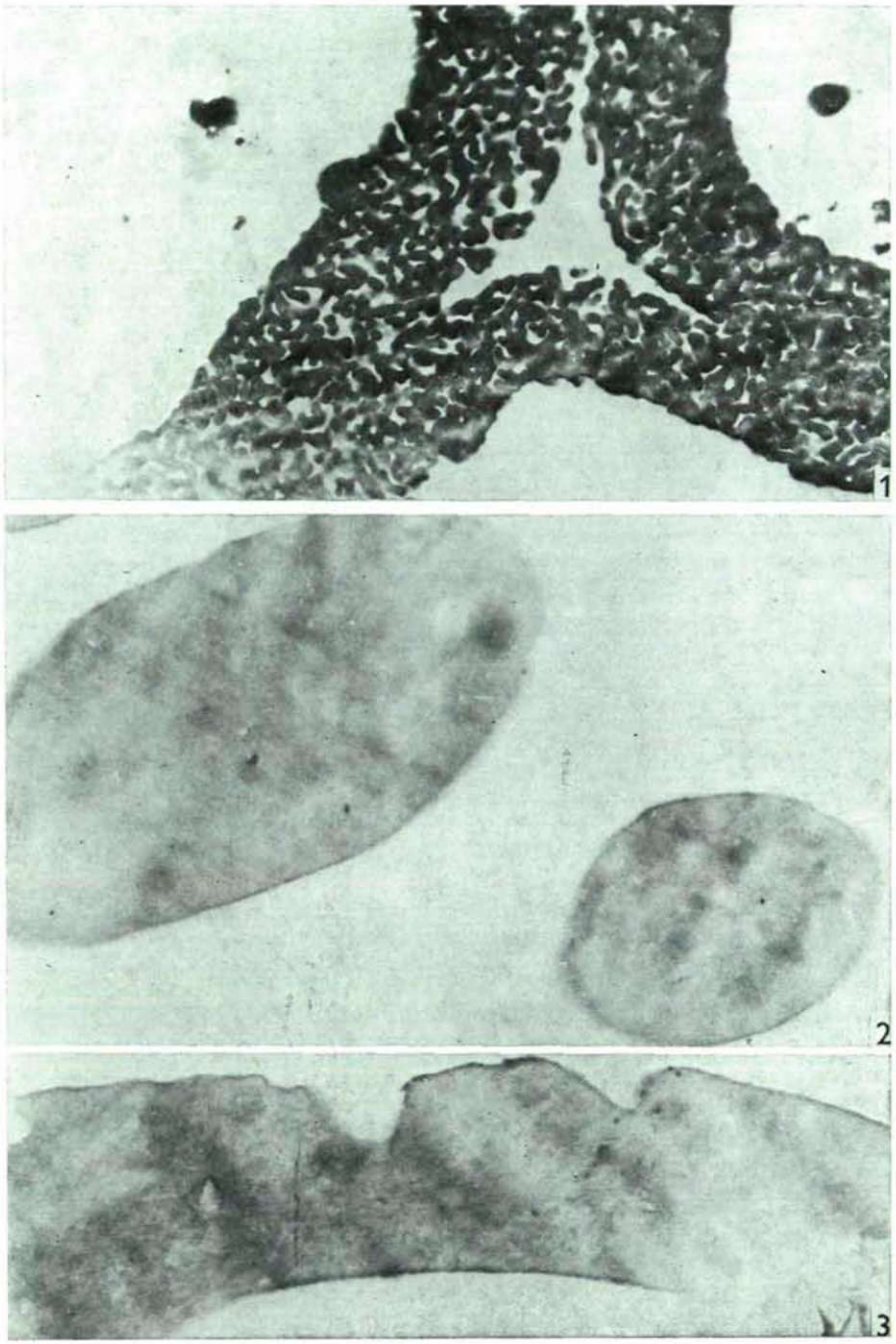


Table VI

1 *Ariadnaesporites* fsp XIII/3, trifolium cross section, x10000
2 *Ariadnaesporites* fsp XIII/3, section of elaters, x16000
3 *Microfoveolatosporis* fsp XIV/2, exospore cross section, x16000



mark nearly reach the inner border of the zone, r=4/5. The central body has verrucate/rugulate ornaments, the size of the ornamental elements is about 3—4 μm. Diameter is 45 μm.

TEM characters: The exospore, including cingulum (Table IV, 1) and the sculptured central body (Table IV, 2) are completely homogeneous

Fgenus: *Ariadnaesporites Potonié* 1956 emend. TSCHUDY 1966

1. *Ariadnaesporites* fsp XIII./3 (Table IV, 3, 4, Table V, Table VI, 1, 2)

Light microscopic characters: The exospore includes a global part, the perispore continues in a trifolium. Numerous 1.5—2 μm wide elaters spring from the later. The diameter is 120 μm.

TEM characters: On the inner wall of the exospore there are granules probably remains of the cytoplasma. No fine structure can be recognized on these fragments (Table IV, the lower part of picture 3). The exospore is inhomogeneous (Table IV, 3, Table V), although this structure may be the consequence of imperfect cutting. The border between the perispore and exospore is sharp (Table IV, 3, Table V). The perispore has an irregular form and a granular, spongy structure (Table IV. 3, 4, Table V). In contrast to this the elaters are completely homogeneous (Table IV, 4, Table VI, 2). The ultrastructure of the trifolium (Table VI, 1) is identical with that of the perispore.

Fgenus: *Microfoveolatosporis* W. KR. 1959

1. *Microfoveolatosporis* fsp XIV./2 (Table VI, 3)

Light microscopic characters: It is a monolete spore, the square mark does not reach the apicis of the spore, r=4/5. The spore wall is 1.5—2 μm thick with a microfoveolate sculpture of 0.5 μm diameter. The diameter is 55 μm.

TEM characters: The exospore is completely homogeneous. The foveae are only superficial hollows, generally reaching only the third part of the thickness of the wall.

Discussion

In the light microscopic description of fossile miospores (not microspores!) it is a constant characteristic that the wall consists of two equal layers or one of the layers is thicker than the other. In authors' first TEM investigations (KEDVES and PÁRDUTZ, 1973) on the basis of different electron affinity two very clearly defined lyaers were demonstrated on Eocenic *Leiotriletes* and *Toroisporis* spores. Less convincing was the demonstration of the presence of layers with different electron affinity on the wall of *Appendicisporites*. Authors' recent data about fgenus *Leiotriletes* shows something totally new. It was demonstrated that the wall is essentially unlayered. At the same time it was also demonstrated that cavities and channels occur only in the inner part of the spore wall and therefore, in consequence of altered refraction, the layer with cavities and/or channels may appear as an independent one.

It is unfamiliar that the diameter of the cavities and channels can have a taxonomical significance because according to the data till now the ultrastructure of the exine is less variable than the light microscopic morphology. The work of LUGARDON (1972. 1974) give a good picture of the ultrastructure of recent Pteropsida spore walls. So radial channels occur in the exospore of *Blechnum spicant, Lygodium japonicum, Gleichenia bancrostii, Cibotium glaucum, Cyathea medullaris, C. cooperi, Dennstaedtia bipinnata, Ceratopteris cornuta, Pteris longifolia, Cryptogramma crispa,, Adiantum capillus-veneris, Athyrium filixfemina, A. alpestre, Cystopteris fragilis, Scolopendrium vulgare, Polypodium serratum, Angiopteris hypoleuca, Marattia fraxinea, Osmunda*

regalis. Cavities occur in the exospore of *Gleichenia bancrostii, G. linearis, G. oceanica, Ophioglossum vulgatum, O. lusitanicum, Botrychium lunaria, Angiopteris hypoleuca, Marattia fraxinea, Osmunda regalis, Leptopteris fraseri*. It is worth mentioning that spore wall ultrastructures similar to the exospores of the fossilia investigated by authors were not found in the literature. It is just possible that Cretaceous spores which may be identified with recent genera on the basis of light mircoscopic investigations have a different ultrastructure and so differ from the recent genera.

More investigations are essential in the fgenus *Cicatricosisporites;* the completely homogeneous ultrastructure of the exospore gives food for thoughts. The same holds, and in an increased degree, in respect of the *Polypodiaceoisporites* fsp because in light microscope the spore wall showes several well defined layers. These are to be considered as refractional phenomena according to authors' present data.

At present detailed nomenclatural investigation of the fgenus *Ariadnaesporites* is not necessary; the taxonomic revision can be easily performed in the light of the descriptions of DINIZ (1967). Authors' TEM data can be compared with the results till now, differences appear only in minor details.

The ultrastructure of the spore wall of *Microfoveolatosporis* corresponds to that observed on *M. pseudodentatus* from the Eocene (KEDVES and PÁRDUTZ, 1973).

References

DINIZ, F. (1967): Spores à flagelles nouvelles pour le Crétacé du Portugal. — Pollen et Spores *9*, 569—577.

DINIZ, F. KEDVES, M. and SIMONCSICS, P. (1974/1977): Les sporomorphes principaux de sédiments crétacés de Vila Flor et de Carrajao, Portugal.-Com. Serv. Geol. Port. *58*, 161—178.

HILLS, L. V. (1967): Ariadnaesporites, Capulisporites or Caudaspora: A discussion. — Pollen et Spores *9*, 553—562.

KEDVES, M. (1978): Ultrastructure investigations into fossil Salviniaceae spores. — Acta Biol. Szeged, *24*, 19—22.

KEDVES, M. and HEGEDŰS, M. (1975): Pollen grains of the Interporopollenites fgen. from sediments of the Upper Cretaceous period in Portugal. — Acta Biol. Szeged. *21*, 43—62.

KEDVES, M. and PÁRDUTZ, Á. (1970): Études palynologiques des couches du Tertiaire inférieur de la Région Parisienne VI. Ultrastructure de quelques pollens d'Angiospermes de l'Ecoène inférieur (Sparnacien). — Pollen et Spores *12*, 553—575.

KEDVES, M. and PÁRDUTZ, Á. (1973): Ultrastructure examination of fossil Pteridophyta spores and Gymnospermatophyta pollens. — Acta Bot. Acad. Sci. Hung. *18*, 304—313.

KEDVES, M. et PITTAU, P. (1979): Contribution à la connaissance des pollens des Normapolles du "groupe papilloide" du Crétacé supérieur du Portugal. — Pollen et Spores *21*, 169—209.

KEMPF, E. K. (1969a): Elektronenmikroskopie der Sporodermis von käinozoischen Megasporen der Wasserfarn-Gattung Azolla. — Paläont. Z. *43*, 95—108.

KEMPF, E. K. (1969b): Elektronenmikroskopie der Megasporen von Azolla tegeliensis aus dem Altpleistozän der Niederlande. — Palaeontographica B, *128*, 167—179.

KEMPF, E. K. (1971): Elektronenmikroskopie der Sporodermis von Mega- und Mikrosporen der Pteridophyten-Gattung Salvinia aus dem Tertiär und Quartär Deutschlands. Palaeontographica B, *136*, 47—70.

KRUTZSCH, W. (1959): Mikropaläontologische (sporenpaläontologische) Untersuchungen in der Braunkohle des Geiseltales. — Geologie 8, BH *21/22*, 1—425.

LUGARDON, B. (1972): La structure fine de l'exospore et de la perispore des Filicinées isosporées I — Généralités. Eusporangiées et Osmundales. — Pollen et Spores *14*, 227—261.

LUGARDON, B. (1974): La structure fine de l'exospore et de la périspore des Filicinées isosporées II. Filicales. Commentaires. — Pollen et Spores *16*, 161—226.
PETTITT, J. M. (1966): Exine structure in some fossil and recent spores as revealed by light and electron microscopy. — Bull. B. M. (N. H.) Geol. *13*, 223—257.
TRYON, A. F. and LUGARDON, B. (1978): Wall structure and mineral content in Selaginella spores. — Pollen et Spores *20*, 315—340.

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