

# ON MEGASPORES, CHAROPHYTA FRUITS AND SOME OTHER SMALL FOSSILS FROM THE CRETACEOUS

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## ABSTRACT

Megaspores found in boring IJsselmonde, I, the Netherlands, have been compared with the spore content of some other borings in the Netherlands and of boring Kingsleke, Great Britain, which are Wealden in age. Convincingly it could be proved that the samples studied from boring IJsselmonde must belong to the Wealden. Some new specimens were noticed, of which *Triletes gryensis* has been found by Dr. Gry in the Lower Wealden from Bornholm, Denmark, by which fact the age of boring IJsselmonde, I, may belong to the Lower Wealden. Moreover, a number of non-calcified Charophyte fruits have been found in that boring.

Some new records of borings in Belgium, the Netherlands and Egypt have been mentioned. The most interesting result may be that *Pyrobolospira lobata* does not only occur in the Senonian, but also in the Palaeocene, whereas its horizontal spreading is also very wide (from W. Europe to Egypt). Finally, this spore is closely related, probably identical with *Rodeites dakshini* from India.

## INTRODUCTION

**D**URING the last few years some deep borings have been made in the so-called Peelveld, north of Heerlen, the Netherlands. So far there are no coalmines in that field. These borings are connected with the exploration of collieries. Besides the study of the Carboniferous from the cores, that of the overlying strata is very important. They consist of some marine and two freshwater strata, namely the Palaeocene and the Aachenian (Senonian, Cretaceous). In both the strata megaspores and other small fossils have been found by which it was possible to determine exactly the age of these strata. The results of the Palaeocene will be published in a separate paper. Most megaspores from the Aachenian have already been described (DIJKSTRA, 1949; VANGEROW, 1954), but still some problems remain, and moreover some new fossils were noticed.

Besides these cores, we received some samples of the N.A.M. (Dutch Oil Co.) from boring IJsselmonde, I, which is situated more in the centre of the Netherlands. They appeared to contain Wealden megaspores.

Most of them are well-known species, (DIJKSTRA, 1951), but also some new species and fruits of Charophyta were noticed.

Finally, we shall discuss some data of borings made in Egypt, namely at Hurgada; the age of its cores was unknown.

The results of these three groups of borings will be discussed in this paper, but before doing this we shall first give some data of the practical significance of spores and other small fossils, and a short survey of the development of the study of these fossils from the overlying strata in which they have been found.

The beginning of this study was merely of scientific and not of applied interest. It was by chance that a co-worker asked us whether an Aachenian sample given by him might contain megaspores. It appeared to be very rich in them and some other small fossils (*Chrysotheca*) by which it became very characteristic and quite different from the Carboniferous. Continued research disclosed that numerous samples of the Aachenian contain such megaspores. It was then that this knowledge got practical significance for the mining industry. The Aachenian is namely found over a great surface immediately over the Carboniferous in South Limburg. When making new galleries in a coalmine near the surface of the Carboniferous, upwards borings are made at certain distances, with the purpose to determine the thickness of the overlying Carboniferous. This is connected with the safety of the mine, because the overlying strata may contain much water. It is sometimes very difficult to distinguish the Aachenian clay or sand from the partly weathered upper layer of the Carboniferous, the so-called 'baggert' which is also often clayey, especially from cores with a small diameter. All such samples are minutely studied and spores or other small fossils are determined.

By the discovery of megaspores in boring samples from a stage the age of which was unknown, but probably belonging to the

Wealden, and by comparing them with spores from the Wealden of Great Britain, the age of this stage was determined as Wealden (DIJKSTRA, 1951). A more detailed study of the Wealden of Great Britain was made by Hughes (1955). Some of these species have also been found by Gry, who is working out the Wealden and the Jura of the Isle Bornholm, Denmark. His study has not yet been published. Some of these Wealden spores have also been found in boring IJsselmonde, I.

A great number of cores of several borings from Egypt were studied by Jongmans and Van der Heide (1955) in which they found a number of plant and animal fossils belonging to the Lower Carboniferous. In samples from borings at Hurghada, however, only some badly preserved plant fossils could be noticed, and on the ground of fossils from the other borings it was assumed that the age of Hurghada was also Lower Carboniferous. Just at that time we received rest of these cores, and succeeded in finding a great number of megaspores in them belonging to the Lower Carboniferous (DIJKSTRA, 1957). The microfossils found in the cores from Hurghada appeared to be quite different from them, and cannot belong to the Lower Carboniferous, but to the Cretaceous.

In general it can be said that spores have a great practical significance. They are very important as a result of their considerable horizontal spreading. Many investigators have accentuated this for Carboniferous spores. It was convincingly proved by Piérart (1958) who read on the 4th International Congress on Carboniferous Stratigraphy and Geology at Heerlen a paper in which he communicated that he had found megaspores in Katanga (Congo) which are identical with specimens described by Dijkstra (1955) from Brazil and India. The similarity of these spores with those from Brazil is remarkable. These species from Gondwana beds are not only identical, but also their quantitative representation and even their preservation are the same.

Another example of considerable horizontal spreading of Cretaceous spores is the fact that Miss Cookson and Dettmann (1958) found spores in samples from Australian Lower Cretaceous which are identical with some Wealden species from W. Europe.

Finally, these small fossils are preferable in some respects to large fossils for practical purposes in consequence of their preservation

and large numbers. For instance, in the very intensively studied Wealden of Europe, in England, France, Belgium and Germany, by a number of investigators only one heterosporous plant was found, whereas the fact that in a rather short time in a number of samples from three borings 26 megaspore species were noticed (DIJKSTRA, 1951), and some in large numbers, speaks well for the importance of megaspores in aid of the stratigraphy, the more so as the same observation has been made by other investigators in other formations.

#### THE TAXONOMIC VALUE OF THE SPORE

There is still another interesting question, namely, How great is the taxonomic value of the gametophyte, especially that of the spore, with respect to that of the sporophyte? In general it must be said that the habit of the sporophyte has, as a primary basis for systematic arrangement, very real and practical value, and therefore it has been used by all taxonomists up to the present time.

In fern classification the characters of the sporangia (sori) are used (Filices-Eusporangiatae and Leptosporangiatae). Later on, the character of the venation of the leaves, the number of the vascular bundles in the leafstalk and the stele theory were adopted in the classification. Theoretically, all possible features should be regarded as criteria of comparison and used in drawing conclusions as to the relationship and descent (BOWER, 1923, p. 59) but he did not venture to propose a new classification in place of that of Diels in Engler and Prantl (1902). Spores in ferns are tetrahedral or wedge-shaped (monolete), with two flattened sides. The Marattiaceae and the Schizaceae include both forms. The spore-form is consequently (after BOWER, 1923, p. 259) an uncertain guide to affinity. Some present-day genera have large sporangia with a few large spores and smaller sporangia that contain many spores which are smaller. These facts suggest initial heterospory. In Marsiliaceae and Salviniaceae real heterospory occurs. Nevertheless, the spores or pollen of some fossil groups are very similar in shape, for instance, of Medulloseae and Pteridosperms (FLORIN, 1937).

The primary division of *Equisetum* is based on the arrangement and shape of the stomata and the guard-cells. Their isospores are spherical and have a thin spore coat without

any sculpture; they are surrounded by elaters built from the perispore. The spores contain much chlorophyll and are, therefore, green. *Equisetites suecicus* and *E. nathorsti* (HALLE, 1908) from the Rhaetic and Lias of Schonen have similar spores; moreover, they are provided with a triradiate mark, whereas elaters are lacking. The spores of Calamariaceae are homo- or heterosporous; they have the same shape, are thin-walled and provided with a triradiate mark (HARTUNG, 1933). Isolated spores of Calamariaceae belong to the spore genus *Calamospora*; they have the same shape. To this genus also belong the spores of *Noeggerathia* (HALLE, 1954), and *Discinities* (NEMEJC, 1941). However, some spores of *Discinities* must belong to another spore genus.

The primary division of the Lycopodinae is based on the presence or absence of a ligule (Eligulatae and Ligulatae), the former is homosporous, the latter heterosporous. The classification of the Lycopodiaceae by Walton and Alston (1938) is based on the habit of the sporophyte. Knox (1950), studying the microspores, concluded that it appears that in *Lycopodium* the spore morphology adds supporting evidence to the taxonomy of the genus.

The habit of the sporophyte of Selaginellaceae has also been the base in the classification by Walton and Alston (1938; leaves and sporophylls uniform or dimorphous). Knox (1950), studying their microspores, concluded: it cannot be maintained that the spore sculpturing accords with the classification in *Selaginella*, and, in fact, there is no noticeable relationship between spore morphology and any of the taxonomic arrangements suggested. The megaspores of *Selaginella* show, besides variation in sculpture, variation in the number of spores per sporangium. It contains typically four spores, but in some species reduction takes place with different results: (1) inequality of spore size (three large and one small spore, or two large and two small spores); (2) reduction to three equal spores; (3) reduction to two equal spores; and (4) reduction to one megaspore of correspondingly large size (MITCHELL, 1910). Some spores of *Selaginellites* are very similar in shape: *S. suissei* (ZEILLER, 1906), *S. primaevus* (HALLE, 1907), *S. dawsoni* (SEWARD, 1913), and *S. crassicinctus* (HOSKINS & ARBOTT, 1956); they are, with the exception of the megaspores of *S. elongatus* (HALLE, 1907), comparable

with *Triletes triangulatus* (ZERNDT, 1930). Of the megaspores assigned to *Selaginellites* by Miner (1932) only *S. borealis* is comparable with the former, but it is very questionable whether these isolated spores of Miner really belong to *Selaginellites*.

The taxonomy of *Isoetes* by Pfeiffer (1922) is based on the structure of the megaspores. On the other hand, the megaspores of this genus show a variation in shape and sculpture to such a degree that if they should have been fossilized, they would have been divided over at least three spore genera (DIJKSTRA, 1958). An earlier classification by Baker (1887) is based upon the geographical distribution. The groups in which Knox (1950) has arranged the microspores bear no apparent relationship to the sections defined by Pfeiffer. Of course, any correlation of the sculpture of the microspores with that of the megaspores need not exist. Evolution does not synchronously develop all organs of one species in the same way. Some of them may remain primitive, whereas others fully develop. Remarkable is that the shape of the microspores of *Isoetes* may be ovoid in outline with one ridge (monolete) or tetrahedral with three ridges (trilete). Moreover, Knox could not find any connection between the spore structure and the varied ecological conditions in which the plant lives (the classification of Baker). On the other hand, the explanation of a peculiar shape of a spore shape or of its ornament has always been speculative.

Concerning fossil Lycopodinae some investigators suppose that the megaspores of *Sigillariostrobus* should belong to the *Aphanozonati*, whereas those of *Lepidostrobus* must be accounted to the *Lageniculae*. If this should be always the case, then the spore shape should be a base in the classification of these strobili; but Dijkstra (1958), however, gave some exceptions to this rule. The spores of *Spencerites*, a lycopodiaceous plant, probably have taxonomic value (see CHALONER, 1951); the same can be said of the spores of *Lepidocarpon* (CHALONER, 1952).

At last in the morphographical classification of Potonié and Kremp (1956, III, pp. 87-88) in which mega- and microspores are arranged, especially in the microspores, little connection can be found between their spore genera and the plant groups which have produced them.

Summing up, it can be said that the shape and sculpture of spores of Pteridophyta have taxonomic value in many cases.

Spore genera have been treated as other organ genera like roots, stems, leaves, twigs, etc. However, a spore is the most important stage of the gametophyte, the other stages: prothallium, archegonium, egg cell (antheridium, spermatozoid, resp.) are small or reduced. Roots, stems, leaves, twigs, etc., are together the most important stage of the sporophyte. The systematic value of the spore is theoretically comparable with that of the whole habit of the sporophyte (the sexual stages excepted), and not with one of its organ genera only. Of course, it would not be practical to base the classification of the Pteridophyta mainly on their spores. On the other hand, the systematic value of the other form genera may be doubtful too, compared to the thousands of specific names which have been assigned to fern leaves, a small minority of which only is attributable to true ferns. In one respect spore genera are above the other organ genera, namely in consequence of their small dimensions, their good preservation and their abundance, it is generally not difficult to find a great number of undamaged specimens belonging to one species in a small sample.

#### METHODS, MATERIAL AND CLASSIFICATION

The material of all boring samples was treated in the ordinary way. First, the cores were broken into small pieces with a diameter of about 1 cm. and were dried. Then they were put into a boiling solution of soda (about one spoonful of  $\text{Na}_2\text{CO}_3$  to half a litre of water), in which they were boiled thoroughly for about a quarter of an hour. Afterwards the material was poured out on a sieve with a mesh size of 0.1 mm., and cleaned by running water. Finally, the remains on the sieve were dried and examined under a stereoscopic binocular microscope with a magnification of  $32\times$ , and the microfossils were picked out. The fossils were put in slides made of cardboard and closed with a cover glass. The spores were not mounted in the slide, and by this it was possible to turn them with a needle to study them from both sides.

The fossils found in this way consist of megaspores, fruits of Charophyta and *Chrysotheca*, cuticles, pieces of wood, *incertae sedis*, etc. Our point of view concerning the classification of megaspores is known (see DIJKSTRA, 1957, p. 7).

The Charophyta constitute a group of non-marine aquatic plants that range from the Lower Devonian to the Recent. Generally only their fruits are known. The fruit, consisting of the egg cell, is surrounded by generally 5 enveloping cells, that spiral to the left. The upper part of the distal end of the enveloping cells calcifies and can be fossilized, whereas their outer part and the coronula are less resistant and so disintegrate. Generally only the calcified part of the enveloping cells is found; these fossils are provided with the specific name *Gyrogonites*. The vegetative parts of the Charophyta also contain a little calcium carbonate, but this may not retain their structure on the death of the plants and, therefore, few records or descriptions of them have been made.

The Charophyta fruits found in the Wealden samples from boring IJsselmonde, I, consist only of the uncalcified part of the enveloping cells, a coronula could not be noticed and the egg cell has also been lost. Its cavity is filled up by sediment or pyrite. Most fruits show some degree of distortion attributable to the compaction of the sediment. We have sent some microphotographs of them to Dr. Mädlar, asking him for advice. His opinion is that the calcified parts may have been dissolved in an acid. This must have happened very soon after their death, because in the other case the uncalcified parts would have rotted away. There is still another possibility, namely some Charophyta species, *Nitella* for instance, never form calcified fruits, they are laterally compressed, rarely preserved, and are known from the Pleistocene to Recent. Those of *Tolypella* are calcified a little, and are known from the Triassic to Recent (MÄDLER, 1953). Under the circumstances in which spores were preserved, uncalcified fruits of Charophyta could also be fossilized (they have been found together in the same samples). *Chara sausari* was found in a block of chert by Sahni and Rao (1943) that also contained *Azolla intertrappea*. As this *Chara* bears a coronula and is attached to a branchlet, parts which generally are not fossilized, we may assume that it has lived together with *Azolla*.

## DESCRIPTION

*Triletes occultatus* sp. nov.

Pl. 1, Fig. 6; holotype Fig. 6

Spore subtriangular in outline, flattened in proximal-distal direction, diameter being 270, 280 and 320  $\mu$ . Triradiate ridges nearly as long as the radius of the spore, 7-10  $\mu$  wide, 12-15  $\mu$  high; there where they meet the arcuate ridges the widest. Equatorial ridge 8  $\mu$  wide. Contact faces and distal area rough to finely punctate, exceptionally the equatorial ridge bears some globules, 15  $\mu$  in diameter. Spore coat black.

*Discussion and Comparison* — This very rare species, of which three specimens have been found among numerous specimens of well-known Aachenian spores, cannot be changed with any species described until now.

*Occurrence* — Sample No. 1628, boring No. XLVII from 496.0 to 499.5 m., the Netherlands; age Aachenian (Senonian).

*Triletes imitatus* sp. nov.

Pl. 1, Figs. 1a, 1b, 2; holotype Fig. 1

Spore discus-like, rounded to oval in outline. Diameter varies from 820 to 970  $\mu$  (two specimens). Triradiate ridges 300  $\mu$  long, 25  $\mu$  wide, 30  $\mu$  high. The arcuate ridge is not distinguishable. Spore coat, the contact faces excepted, densely covered with red globules, 30-60  $\mu$  in diameter, on a distance of 5-30  $\mu$ ; in the direction of the contact faces smaller, 5-30  $\mu$ , where they touch each other. The contact faces are rough and grooved. Spore wall 30-40  $\mu$  thick.

*Discussion and Comparison* — In some broken specimens, found in another sample of the same boring, the distance of the globules is greater, 20-80  $\mu$ . Probably, these specimens must be referred to *T. imitatus*. This species most resembles *T. carbunculus* (DIJKSTRA, 1949, 1951). It can easily be distinguished from it because the shape of *T. carbunculus* is spherical, its triradiate ridges much wider (50  $\mu$ ), and its cover more irregular.

*Occurrence* — In two samples of boring IJsselmonde, I, the Netherlands; age Wealden.

*Triletes sulcatus* Dijkstra

Pl. 1, Figs. 15a, 15b

1951. *Triletes sulcatus* DIJKSTRA. MEDED. GEOL. STICHT., N.S., 5, p. 11, PL. 2, FIG. 3

*Discussion* — The preservation of the specimens found in boring IJsselmonde, I, is better

than that of those described in 1951. We mentioned that this species has a top area which is provided with dorso-ventral running rims which are merged at the basal area in granules. It is more correct to say that the coat is reticulate, the diameter of the reticules is about 50  $\mu$ . The rims of the reticules are up to 30  $\mu$  high, rather sharp, and sometimes covered with a transparent substance. The rims of the reticules are in tangential direction not so high, and may be lacking.

*Occurrence* — In several samples of boring IJsselmonde, I, the Netherlands; age Wealden.

*Triletes lanatus* Dijkstra

Pl. 1, Fig. 9

1951. *Triletes lanatus* DIJKSTRA. MEDED. GEOL. STICHT., N.S., 5, p. 11, PL. II, FIG. 22

*Triletes gryensis* sp. nov.

Pl. 1, Fig. 14; holotype Fig. 14

Spore generally flattened in proximal-distal direction, subtriangular in outline. Diameter 250-360  $\mu$  (the mean being 306  $\mu$ ; 18 specimens measured). Triradiate ridges wavy, continuing to the periphery, 60-90  $\mu$  high, 15  $\mu$  wide. Ridges formed by a transparent substance, strengthened by 6-8 bars which are 2-3  $\mu$  wide and run in proximal-distal direction. The outline of the ridges (the crest) is wavy too. Arcuate ridges about 7  $\mu$  wide and the same in height. There where they meet the triradiate ridges, triangular earlobe-like processes occur. Processes 120  $\mu$  wide (in tangential direction), 60-90  $\mu$  in radial direction; they are generally obscured by the triradiate ridges. Spore coat reticulate, about 10  $\mu$  thick; reticules 5-10  $\mu$  in diameter.

*Discussion* — This species resembles in some respects *T. divisus*, *T. samarus*, *T. midas* and *T. pseudotenellus* (DIJKSTRA, 1951), but in all these species the triradiate ridges are provided with long, hair-like appendages. Dr. Gry, during his visit to Heerlen, told us that he has found the same species in the Lower Wealden from Bornholm. In honour of him we have given the species this name.

*Occurrence* — In some samples of boring IJsselmonde, I, the Netherlands; Isle of Bornholm, Denmark; age Lower Wealden.

***Triletes pseudotenellus* Dijkstra**

Pl. 1, Figs. 12, 13

1951. *Triletes pseudotenellus* DIJKSTRA. MEDED. GEOL. STICHT., N.S., 5, p. 12, PL. III, FIGS. 9, 10

*Occurrence* — In some samples of boring IJsselmonde, I, the Netherlands.

***Triletes pyriformis* Dijkstra**

Pl. 1, Figs. 10, 11

1951. *Triletes pyriformis* DIJKSTRA. MEDED. GEOL. STICHT., N.S., 5, p. 14, PL. II, FIG. 9

*Discussion* — The specimens found in a boring in the Netherlands in 1951 are very uniform in size and shape; they are smaller and different from *T. argus* (DIJKSTRA, 1951) from boring Kingscleke No. 1, Great Britain. The former species was also found by Hughes (1955). His specimens are more variable in size, and after Hughes *T. argus* is not considered to be a separate species. As the specimens from boring IJsselmonde are also more variable, Hughes may be right.

*Occurrence* — In several samples of boring IJsselmonde, I, the Netherlands; age Wealden.

***Triletes galericulatus* Dijkstra**

Pl. 1, Figs. 7, 8

1951. *Triletes galericulatus* DIJKSTRA. MEDED. GEOL. STICHT., N.S., 5, p. 14, PL. II, FIG. 16; PL. III, FIG. 5

1955. *Triletes galericulatus* HUGHES. WEALDEN PLANT MICROFOSSILS, GEOL. MAG., XCII (3), p. 212, PL. XII, FIGS. 1, 2

*Occurrence* — In one sample of boring IJsselmonde, I, the Netherlands; age Wealden.

***Triletes pileatus* sp. nov.**

Pl. 1, Figs. 16-19; holotype Fig. 16

Spore generally flattened in lateral direction, body of the spore ovoid, provided with a neck-like projection. Length of the spore body 240-370  $\mu$  (the mean being 264  $\mu$ ; 32 spec. measured), width 190-310  $\mu$  (the mean being 259  $\mu$ ). Neck-like projection 110-170  $\mu$  long, 130-190  $\mu$  wide. Triradiate ridges 70  $\mu$  long, 50  $\mu$  wide, 80  $\mu$  high, but generally obscured by an irregularly lobed

substance, being granulate, nearly foamy, transparent and 90-200  $\mu$  large. Arcuate ridges not distinguishable. Spore coat about 8  $\mu$  thick, reticulate; reticules 10-15  $\mu$  in diameter.

*Discussion* — In most of the specimens the coat of the spore is bare, but very rarely it is covered with very thin transparent blades, 30  $\mu$  high, which are attached to the rims of the reticules. In some respects, for instance by its lobed substance, this species resembles the sterile form of some *Cystosporites* species, but it can be easily distinguished from them by its striking and wide triradiate ridges (after the lobed substance has disappeared) and by its reticulate coat.

*Occurrence* — In some samples of boring IJsselmonde, I, the Netherlands; age Wealden.

***Triletes squamosus* sp. nov.**

Pl. 2, Fig. 34; Fig. 33?; holotype Fig. 34

Spore body spherical, provided with a neck-like projection. Diameter of body 320  $\mu$ , neck-like projection 130  $\mu$  high, 140  $\mu$  wide, rounded in outline. Triradiate ridges 100  $\mu$  long; arcuate ridges not distinguishable. Contact area about 100-150  $\mu$  large. Neck-like projection and contact area covered with a granulate transparent substance; granules about 5  $\mu$  in diameter. Body of the spore reticulate; reticules about 10  $\mu$  in diameter; rims of the reticules about 15  $\mu$  high, very thin and transparent.

*Discussion* — Only one single specimen could be found. The spore is characterized by its reticules over the whole surface, projection and contact faces excepted. These reticules are very remarkable; their rims gave an impression of very thin scales or blades which are perpendicularly attached to the wall of the spore, but sometimes of bar-shaped appendages. Another specimen, probably belonging to the same species, was noticed. It has lost its cover, and its whole coat is provided with pointed papillae, about 8  $\mu$  high. These papillae may be the points of attachment of the reticules.

*Occurrence* — Boring IJsselmonde, I, the Netherlands; age Wealden.

***Pyrobolospora lobata* (Dijkstra) Hughes**

Pl. 1, Figs. 3-5

1949. *Triletes lobatus* DIJKSTRA. MEDED. GEOL. STICHT., N.S., 3, p. 25, PL. II, FIG. 9

1954. *Triletes lobatus* DIJKSTRA. VANGEROW, PALAEOONTOGR., LXLVI, p. 28, Pl. 14, FIG. 22
1955. *Pyrobolospora lobata* (DIJKSTRA) HUGHES. GEOL. MAG., XCII, 3, p. 211
1957. *Triletes lobatus* DIJKSTRA. MEDED. GEOL. STICHT., N.S., 10, p. 5

*Discussion* — In sample No. 1962, Shaft Beringen from 271.65 to 275.45 m., and in sample No. 2013, boring No. LXXVI, at 515 m., among Palaeocene megaspores a number of specimens were found belonging to *Pyrobolospora lobata*, a species known until now only from the Aachenian (Senonian), where it occurs rather commonly. At first we believed that the only possibility is that these specimens have been derived from the Senonian. Derivation of megaspores from older deposits into younger can occur. The other possibility that *P. lobata* did not extinguish after Senonian time is not so obvious. The following facts, however, speak for this last supposition. In all Palaeocene samples studied only *P. lobata* was found, other Senonian megaspores could not be observed in them, although some are very abundant. Finally, it has also been found in some boring samples from Egypt.

*P. lobata* shows a great resemblance to the spores of the recent genus *Regnellidium*. Dr. Trivedi drew our attention by letter to the possibility that *P. lobata* may be identical with a spore found by Sahni from the Deccan Intertrappean series, India (age early Tertiary, probably Eocene). This species was described by Sahni and Rao (1943). Megaspores and microspores were found within a single bisporangiate sporocarp. It may be, according to them, identical or closely related to *Regnellidium*. This fossil was referred by Sahni (1943) to the new genus *Rodeites*; this on geographical ground, by the fact of the complete ignorance of the remaining organs and by another small difference with *Regnellidium*.

The megaspore of *Rodeites dakshini* is spherical, about 0.5-0.6 mm. in diameter. Its apical papilla (neck-like elevation) is composed of several radially placed folds showing a slight spiral twist and a basal constriction about 45  $\mu$  thick. Its spore wall is multi-layered: the outermost layer is finely tuberculate, 8-10  $\mu$  thick; the next one, the prismatic layer, 30-40  $\mu$  thick; the inner layer of

the epispore is closely applied and in places indistinguishable from the thin, dark innermost layer, the endospore. The megaspore of *Regnellidium* (CHRYSLER & JOHNSON, 1939) has the same shape and size as *Rodeites*, and its wall the same composition. The wall of the neck-like elevation is only built by the prismatic layer, it has the same structure, but less than half the thickness of it. The space within the elevation (neck chamber, receptaculum) is closed from the spore cavity by the endospore. This thin place in the wall of the spore is round and 0.2 mm. in diameter. The inner layer of the epispore is 4  $\mu$  thick; the endospore 3.2  $\mu$  thick. [See, moreover, the study of Mahabalé (1957) on this subject.]

The diameter of *P. lobata*, (DIJKSTRA, 1949) varies from 200 to 650  $\mu$ . The neck-like elevation completely agrees with *R. dakshini* and *Regnellidium*. We distinguished two layers, an outer granular layer, 40-50  $\mu$  thick, and often a dark brown inner layer about 5  $\mu$  thick. After reading Sahni's paper some transversal sections of the wall have been made. The outermost layer has papillae, about 11  $\mu$  long, 3  $\mu$  wide; the next layer shows a great resemblance to the prismatic layer of *Rodeites* and *Regnellidium* and is about 30-40  $\mu$  thick (thinner walls also occur). The inner layer is about 5  $\mu$  thick; it was not possible to distinguish whether it is composed of two or only one layer. The wall of the neck-like projection is built by the prismatic layer which is much thinner than that of the rest of the spore.

Our conclusion is that *P. lobata* and *R. dakshini* are closely related, probably identical. According to its name, it is not preferable to use the name *Rodeites* as this name is based upon sporocarps. Hughes (1955) created the genus *Pyrobolospora*, to which he has referred *T. lobatus*. The species from this genus are characterized by a prominent neck composed of (usually) six segments. We could not distinguish whether its neck is composed of six segments, but its other characters are sufficient to place it in the genus *Pyrobolospora*.

*Occurrence* — Rather common in the Aachenian of S. Limburg, the Netherlands, and in the adjacent German district; shaft Beringen from 271.65 to 275.45 m., Belgium, and boring No. LXXVI at 515.5 m., the Netherlands, Palaeocene; Hurghada, Egypt: boring No. 132 from 2523 to 2544 ft. in several samples, boring No. 134 from 1789 to 1812 ft.,

and boring No. 135 from 2287 to 2308 ft., probably Cretaceous.

Besides the spores mentioned and figured in this paper, we found *Triletes reticuliferus*, *T. politus* and *T. persimilis* in boring IJsselmonde, I.

***Praechara symmetrica* Peck cf.**

Pl. 2, Figs. 20-23

1957. *Praechara symmetrica* PECK. GEOL. SURV. PROF. PAPER 294-A, P. 39, PL. VII, FIGS. 13-16

Ovoid, generally flattened in lateral direction. Length 530-730  $\mu$  (the mean being 593  $\mu$ ; 10 spec. measured), width 370-550  $\mu$  (the mean being 468  $\mu$ ). Generally 9 (8-11?) spiral ridges in lateral view, width of the flattened spiral cells 30-50  $\mu$ , width of the spiral ridges 15-20  $\mu$ , height 10-15  $\mu$ . The 12  $\mu$  thick spiral cells are not transparent; under reflected light they seem to be punctate.

*Discussion* — These lateral compressed fruits are generally deformed, especially the summit is damaged. The basis is sometimes well preserved and clearly shows 5 spirals. A basal opening could not be observed, but it may be obscured by the sediment that has filled up the central cavity. Of course, it is possible to dissolve it by HF, but after this treatment this very brittle fossil was broken. As the top area or the basal area was sometimes damaged, the just number of spiral ridges was not always exactly to determine. The top area seems to be closed, and in that case this species must be classified with *Praechara*. Mädlers conclusion, after seeing some microphotographs, is that it may belong to *Praechara symmetrica*. Of course, our specimens show some differences in dimension: the length of *P. symmetrica* varies, after Peck, from 450 to 550  $\mu$ , the width from 375 to 450  $\mu$ . However, if our specimens consist of the outer part of the same fruit of which the gyrogonite *P. symmetrica* is the inner part, then our fossils must be longer and wider than Peck's specimens. Moreover, they are flattened in lateral direction by which the width has been increased. With reservation they belong to *P. symmetrica*.

*Occurrence* — In two samples of boring IJsselmonde, I, the Netherlands; age Wealden.

***Praechara glypta* Peck cf.**

Pl. 2, Fig. 24

1957. *Praechara glypta* PECK. GEOL. SURV. PROF. PAPER 294-A, P. 40, PL. VIII, FIGS. 1, 2

Elliptical in shape, generally flattened in lateral direction. Length 370-470  $\mu$  (the mean being 426  $\mu$ ; 5 spec. measured), width 270-400  $\mu$  (the mean being 337  $\mu$ ). Generally 10 spiral ridges (9-11?) in lateral view. Width of the flattened spiral cells 15-30  $\mu$ . Width of the spiral ridges 10-20  $\mu$ , height 10  $\mu$ . The ridge is sharp.

*Discussion* — Nearly all that has been said of *P. symmetrica* cf. can be mentioned here again. They are smaller than the first described species, and have not been found in the same sample as *P. symmetrica* cf. The spiral ridges are sharp, especially of the flattened specimens. In *P. symmetrica* cf. the ridges are always rounded. It may belong, after Mädlers, to *P. glypta*. The length of Peck's specimens varies from about 350 to 400  $\mu$ ; they are longer than wide. With reservation this specimen can be assigned to *P. glypta*.

*Occurrence* — In one sample of boring IJsselmonde, I, the Netherlands; age Wealden.

***Tolypella mädleri* sp. nov.**

Pl. 2, Figs. 28-32; holotype Fig. 28

Oval in outline, generally a little longer than wide. Length 180-275  $\mu$  (the mean being 239  $\mu$ , 16 spec. measured), width 170-270  $\mu$  (the mean being 212  $\mu$ ). Generally 9 spiral cells (8-10) in lateral view. Width of the flattened spiral cells 20-30  $\mu$ , width of the very sharp spiral ridges 5-8  $\mu$ , height 8  $\mu$ . Coat very thin, transparent, finely punctate.

*Discussion* — The preservation of this species is better than that of the two species first mentioned. Its coat is not brittle; its very narrow spiral ridges give an impression on the outline of the fossil of spines. They are on the upper half of the fossil bent to the summit, on the lower half to its basis. Some specimens are wider than high, but this may be due to the preservation. The equatorial angle is about 35°, but it may be changed by the preservation. Its coat, under transmitted light, is very similar to that of the photomicrographs of Croft (1952, PL. 19, FIGS. 17, 18). According to Mädlers this

species may belong to *Praechara voluta* Peck, but the dimensions of this gyrogonite are much greater. After Peck, its length varies from 300 to 450  $\mu$ , and its width from 200 to 400  $\mu$ . As the non-calcified cover must be larger than the gyrogonite itself, our specimens cannot be referred to *P. voluta*. In dimensions it agrees better with *Obtusochara mädleri* Peck. However, this species is characterized by a very flattened summit area. Probably it can better be classified with *TolyPELLA*. The occurrence of *TolyPELLA* is Triassic to Recent (MÄDLER, 1953). As far as we know, this species has never been described, but there must be many unpublished Charaphyta species in the collections of the Oil Institutes. The specific name is in honour of Dr. Mädler.

*Occurrence* — In a number of samples of boring IJsselmonde, I, the Netherlands, together with *P. symmetrica* cf. or *P. glypta* cf.; age Wealden.

***Dictyothylakos* sp.**

Pl. 2, Figs. 25, 26

Reticulate pieces at least 1.9-0.6 mm., reticules tri- to pentagonal, meshes 20-160  $\mu$  in diameter, bars 15-20  $\mu$  thick.

*Discussion* — Reticulate objects were described by Horst (1954), under the name *Dictyothylakos*, and presumed to be Algae. Hughes (1955) partly interpreted them as separated rests of the perispore of some megasporae. We have found them in some Cretaceous samples, and in some cases they are remaining unrolled parts of the perispore of well-known spore species. However, in the Aachenian some objects have been found which are not referable to a spore. We have studied some hundreds or perhaps thousands of Aachenian samples without finding a spore species to which they may belong. We found them some years before Horst established the genus *Dictyothylakos*, and our conclusion was that they may belong to Algae in some cases.

We have also found such structures in boring Hurghada No. 132 from 2418 to 2439 ft. (Pl. 2, FIG. 26), which is very similar to that figured by Hughes (1955, Pl. 11, FIG. 5). Another specimen found in boring IJsselmonde, I (Pl. 2, FIG. 25) seems to have wider meshes.

*Occurrence* — Boring IJsselmonde, I, the Netherlands; age Wealden; boring Hurghada No. 132, Egypt; probably Cretaceous.

***Incertae sedis***

Pl. 2, Fig. 27

In some Aachenian samples unknown objects have been found. They are composed of one single spiral that is turned to the left. This spiral is about 320  $\mu$  wide, hollow and elliptical in diameter; its wall is 20  $\mu$  thick, finely striated lengthwise and transparent. These objects are always broken, the most complete specimens show  $2\frac{1}{2}$  windings. The cavity enclosed by the spiral is about 1 mm. in diameter.

*Occurrence* — Boring No. LXXIV, 555.0 m., the Netherlands; age Aachenian (Senonian).

***Sporangia* sp.**

Pl. 2, Figs. 36, 37

*Occurrence* — In several samples of boring IJsselmonde, I, The Netherlands; age Wealden.

***Scale***

Pl. 2, Fig. 35

*Occurrence* — In one sample of boring IJsselmonde, I, The Netherlands; age Wealden.

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## EXPLANATION OF PLATES

(Photographs by L. R. Funcken)

## PLATE 1

1a, 1b, 2. *Triletes imitatus* sp. nov. — 1a, proximal, 1b, distal area, boring IJsselmonde, I, the Netherlands, Wealden.  $\times 50$ .

3, 4, 5. *Pyrobolospora lobata* (Dijkstra) Hughes, sample No. 1962B, shaft Beringen, 271.65-275.45 m.,

Belgium, Palaeocene. Figs. 3, 4  $\times 50$ ; Fig. 5, transverse section of the wall—A, tuberculate layer; B, prismatic layer, transmitted light.  $\times 1000$ .

6. *Triletes ocellatus* sp. nov., sample No. 1628, boring Sm. XLVII, the Netherlands, Aachenian.  $\times 100$ .

7, 8. *Triletes galericulatus* Dijkstra, boring IJsselmonde, I, the Netherlands, Wealden.  $\times 50$ .

9. *Triletes lanatus* Dijkstra, boring IJsselmonde, I, the Netherlands, Wealden.  $\times 50$ .
- 10, 11. *Triletes pyriformis* Dijkstra, boring IJsselmonde, I, The Netherlands, Wealden.  $\times 50$ .
- 12, 13. *Triletes pseudotenellus* Dijkstra, boring IJsselmonde, I, the Netherlands, Wealden.  $\times 50$ .
14. *Triletes gryensis* sp. nov., boring IJsselmonde, I, the Netherlands, Wealden.  $\times 50$ .
- 15<sup>a</sup>, 15<sup>b</sup>. *Triletes sulcatus* Dijkstra, boring IJsselmonde, I, the Netherlands, Wealden. 15<sup>a</sup> is the proximal area, 15<sup>b</sup> the distal area.  $\times 50$ .
- 16-19. *Triletes pileatus* sp. nov., boring IJsselmonde, I, the Netherlands, Wealden.  $\times 50$ .
24. *Praechara glypta* Peck cf., boring IJsselmonde, I, the Netherlands, Wealden.  $\times 100$ .
25. *Dictyothylakos* sp., boring IJsselmonde, I, the Netherlands, Wealden.  $\times 50$ .
26. *Dictyothylakos* sp., boring Hurghada No. 132, 2418-2439 ft., Egypt, probably Cretaceous.  $\times 50$ .
27. *Incertae sedis*, boring Sm LXXIV at 555.0 m., the Netherlands, Aachenian (Senonian).  $\times 50$ .
- 28-32. *Tolypella mädleri* sp. nov., boring IJsselmonde, I, the Netherlands, Wealden. Fig. 28 transmitted light,  $\times 200$ ; Figs. 29-32  $\times 80$ .
33. *Triletes squamosus* cf., boring IJsselmonde, I, the Netherlands, Wealden.  $\times 75$ .
34. *Triletes squamosus* sp. nov., boring IJsselmonde, I, the Netherlands, Wealden.  $\times 75$ .
35. Scale, boring IJsselmonde, I, the Netherlands, Wealden.  $\times 75$ .
- 36, 37. Sporangia, boring IJsselmonde, I, the Netherlands, Wealden.  $\times 80$ .

## PLATE 2

- 20-23. *Praechara symmetrica* Peck cf., boring IJsselmonde, I, the Netherlands, Wealden. Fig. 22  $\times 100$ ; Figs. 20, 21, 23  $\times 80$ .



