MIDDLE TRIASSIC POLLEN AND SPORES FROM THE LOWER MUSCHELKALK OF WINTERSWIJK (THE NETHERLANDS)

BY

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SOMMAIRE. — Ce travail consiste en l'analyse palynologique d'échantillons de calcaires marneux provenant du Muschelkalk inférieur de Winterswijk (Pays-Bas). Les résultats qualitatifs montrent une ressemblance avec les associations sporo-polliniques du Grès bigarré (Röt) ; cependant on a pu constater des différences quantitatives. Grâce à l'étude des pollens et spores on a obtenu quelques données nouvelles en ce qui concerne la composition de la flore du Trias Moyen européen.

Introduction.

In the eastern Netherlands the Lower Muschelkalk (« Wellenkalk ») consists of alternating marly limestones, dolomites, clayey marls, and dolomitic clay layers. A section of 26 m is exposed in three quarries situated east of the town of Winterswijk (Province of Gelderland). The lowermost part of this section probably belongs to the Upper Bunter (reddish pelites of the Röt Group) ; because of a gradual transition the boundary between Bunter and Muschelkalk cannot be drawn with accuracy. The stratigraphic position of the Winterswijk sequence is palaeontologically determined by scarce bivalves, viz. *Gervilleia socialis* SCHLOTHEIM and *Myophoria vulgaris* SCHLOTHEIM (cf. FABER, 1959).

Numerous samples of different lithological composition were investigated palynologically ; however, only samples taken from the compact marly limestone of the upper part of the main quarry appeared to be rich in pollen and spores (1). The saccate pollen in particular is often badly preserved ; this may be due to the effects of secondary dolomitisation processes. A sufficient number of rather well-preserved pollen grains, however, allowed at least a qualitative palynological analysis. Localy hystrichosphaerids are abundant (species of *Micrhystridium*, *Baltisphaeridium*, *Veryhachium*, etc.) ; these will be discussed elsewhere.

Our investigations have been carried out at the Department of Palaeobotany of the Botanical Museum and Herbarium, Utrecht, under the direction of Prof. Dr. F. P. JONKER.

The figured specimens of pollen grains and spores are mounted in single-grain slides, numbered WW-01, WW-02, etc... ; these have been deposited in the palynological collections of the above-mentioned institute.

Analysis and Comparisons.

The palynological assemblage encountered in the samples investigated is referable to a relatively small number of both spore- and pollen genera. With one exception (*Aratrisporites quadriiuga*), here presented without taxonomic comments, the following forms were recognized :

Sporites.

Punctatisporites sp. (Plate III, fig. 1).

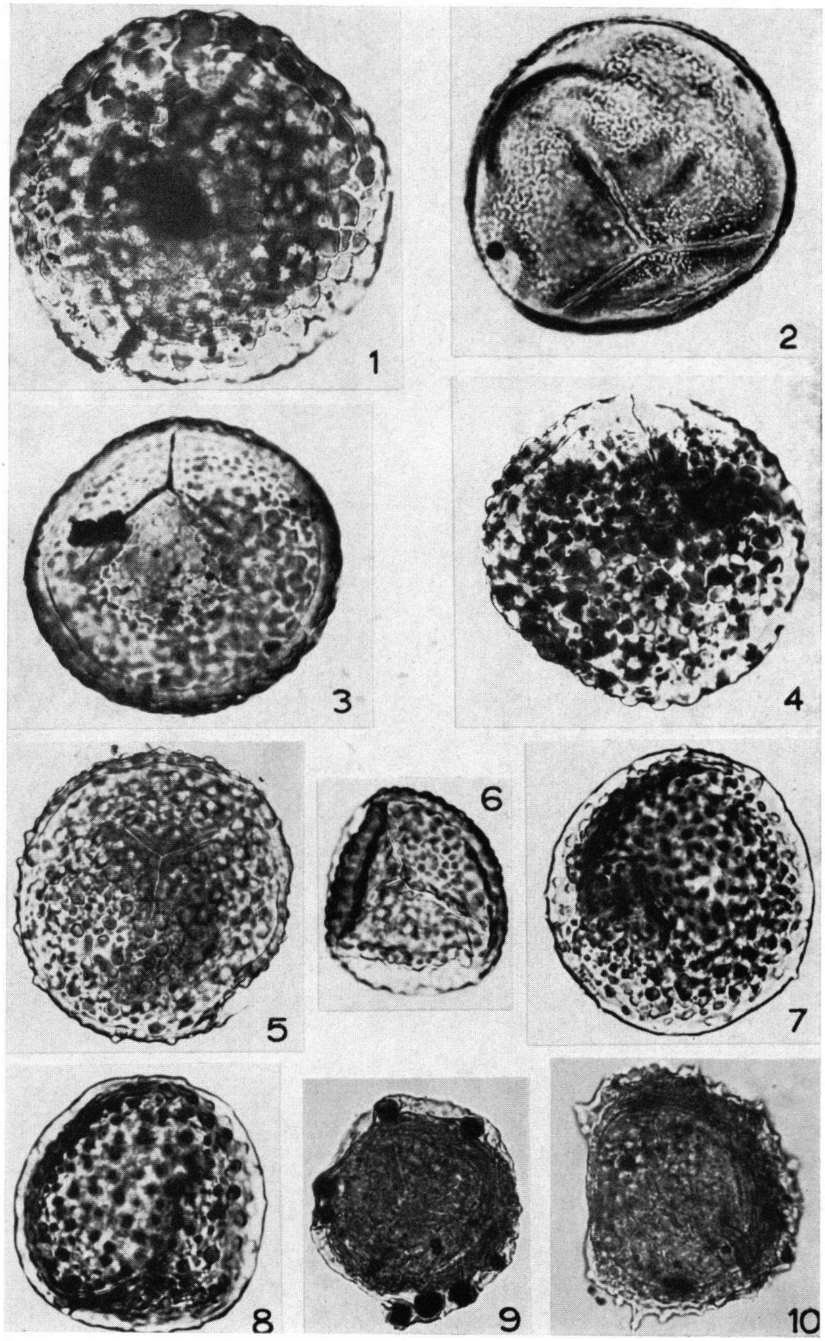
cf. *Cyclogranisporites arenosus* MÄDLER, 1964 (Plate II, figs. 7, 8, 11).

(1) Sample-digestion technique employed : treatments with dilute HCl and with 45 % HF ; in some cases gravity separation (solution of $ZnBr_2$ in 10 % HCl).

LEGEND OF PLATE I.

Magnification × 585.

FIG. 1. — *Verrucosisporites krempii* MÄDLER. Slide WW-121.
FIG. 2. — *Microreticulatisporites* sp. Slide WW-119.
FIG. 3. *Guttatisporites guttatus* VISSCHER. Slide WW-142.
FIG. 4. — *Verrucosisporites* cf. *remyanus* MÄDLER. Slide WW-120.
FIG. 5. — cf. *Cyclotriletes triassicus* MÄDLER. Slide WW-118.
FIG. 6. — *Converrucosisporites* sp. Slide WW-143.
FIG. 7. — cf. *Cyclotriletes triassicus* MÄDLER. Slide WW-122.
FIG. 8. — cf. *Cyclotriletes triassicus* MÄDLER. Slide WW-124.
FIG. 9. — *Aequitriradites minor* MÄDLER. Slide WW-106.
FIG. 10. — *Kraeuselisporites* sp. Slide WW-107.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Apiculatasporites plicatus VISSCHER, 1966 (Plate II, figs. 3-6).

cf. *Cyclotriletes pustulatus* MÄDLER, 1964 (Plate II, figs. 9,12).

cf. *Cyclotriletes triassicus* MÄDLER, 1964 (Plate I, figs. 5, 7, 8).

Verrucosisporites jenensis REINHARDT et SCHMITZ in REINHARDT, 1964 (Plate II, fig. 10).

Verrucosisporites cf. *applanatus* MÄDLER, 1964 (Plate II, fig. 1).

Verrucosisporites krempii MÄDLER, 1964 (Plate I, fig. 1).

Verrucosisporites cf. remyanus MÄDLER, 1964 (Plate I, fig. 4).

Verrucosisporites thuringiacus MÄDLER, 1964 (Plate II, fig. 2).

Converrucosisporites sp. (Plate I, fig. 6).

cf. *Trilites tuberculiformis* COOKSON, as figured by KLAUS, 1960 (Plate III, fig. 4).

Guttatisporites guttatus VISSCHER, 1964 (Plate I, fig. 3).

Microreticulatisporites sp. (Plate I, fig. 2).

Aequitriradites minor MÄDLER, 1964 (Plate I, fig. 9).

Kraeuselisporites sp. (Plate I, fig. 10).

cf. microspores of *Pleuromeia rossica* NEUBERG, as figured by KIUNTZEL, 1966 (Plate III, fig. 9).

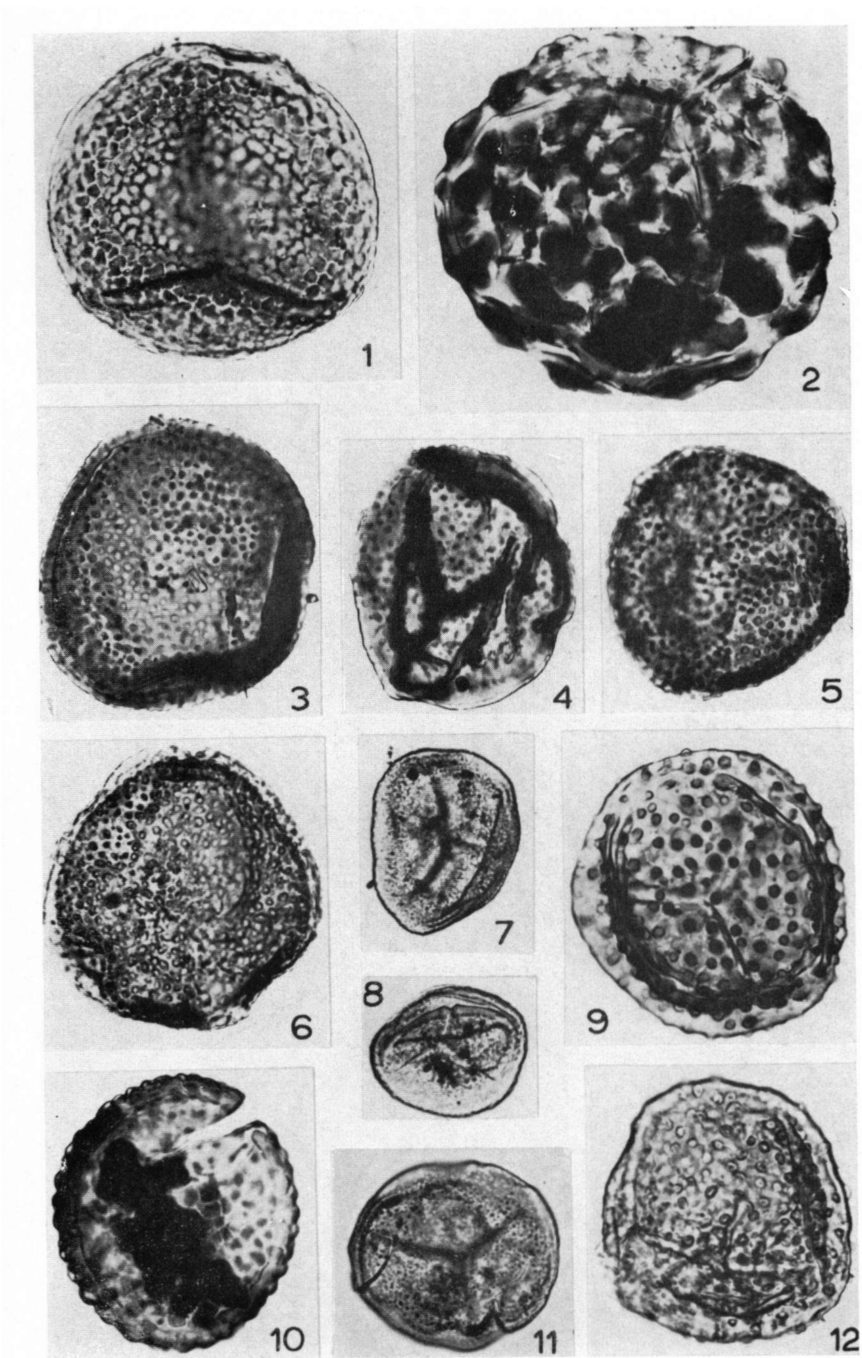
Aratrisporites sp. (Plate III, figs. 11, 12).

Aratrisporites quadriiuga (VISSCHER) nov. comb. (Plate III, figs. 5-8, 10). Described as *Paralundbladispora quadriiuga* by VISSCHER (1966). Both the better preserved tetrads and the single specimens show clearly a monolete mark (cf. Plate III, fig. 5b) and are now considered as a species of *Aratrisporites* (synonyms : *Paralundbladispora vieta* VISSCHER, 1966 ; probably also *Saturnisporites praevius* VISSCHER, 1966).

LEGEND OF PLATE II.

Magnification × 585.

FIG. 1. — *Verrucosisporites* cf. *applanatus* MÄDLER. Slide WW-123.
FIG. 2. — *Verrucosisporites thuringiacus* MÄDLER. Slide WW-103.
FIG. 3. — *Apiculatasporites plicatus* VISSCHER. Slide WW-151.
FIG. 4. — *Apiculatasporites plicatus* VISSCHER. Slide WW-145.
FIG. 5. — *Apiculatasporites plicatus* VISSCHER. Slide WW-147.
FIG. 6. — *Apiculatasporites plicatus* VISSCHER. Slide WW-146.
FIG. 7. — cf. *Cyclogranisporites arenosus* MÄDLER. Slide WW-135.
FIG. 8. — cf. *Cyclogranisporites arenosus* MÄDLER. Slide WW-136.
FIG. 9. — cf. *Cyclotriletes pustulatus* MÄDLER. Slide WW-125.
FIG. 10. — *Verrucosisporites jenensis* REINHARDT et SCHMITZ. Slide WW-141.
FIG. 11. — cf. *Cyclogranisporites arenosus* MÄDLER. Slide WW-134.
FIG. 12. — cf. *Cyclotriletes pustulatus* MÄDLER. Slide WW-126.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Pollenites.

Alisporites grauvogeli KLAUS, 1964 (Plate V, figs. 6, 7, 11, 12).

Voltziaceaesporites heteromorpha KLAUS, 1964 (Plate IV, figs. 12-14).

Colpectopollis ellipsoideus VISSCHER, 1966 (Plate VII, fig. 10).

Vesicaspora (?) (Plate VI, fig. 9).

Angustisulcites klausii FREUDENTHAL, 1964 (Plate VI, figs. 4-8, 10).

Angustisulcites gorpii VISSCHER, 1966 (Plate V, figs. 8, 10).

Angustisulcites grandis (FREUDENTHAL) VISSCHER, 1966 (Plate VI, fig. 1).

Triadispora crassa KLAUS, 1964 (Plate IV, figs. 2-6, 8, 9).

Triadispora plicata KLAUS, 1964 (Plate IV, figs. 1, 7).

Triadispora muelleri (REINHARDT et SCHMITZ) VISSCHER, 1966 (Plate IV, figs. 10, 11).

Dacrycarpites europaeus MÄDLER, 1964 (Plate VII, figs. 6, 8, 9).

cf. *Patinasporites obulus* REINHARDT, 1964 (Plate VII, fig. 4).

cf. *Sulcatisporites raticulatus* MÄDLER, 1964 (Plate VII, fig. 1).

Protosacculina germanica MÄDLER, 1964 (Plate V, figs. 1, 2, 5).

Microcachryidites sittleri KLAUS, 1964 (Plate VII, fig. 5).

Microcachryidites fastidioides (JANSONIUS) KLAUS, 1964 (Plate VII, figs. 2, 3).

Vitreisporites pallidus (REISSINGER) NILSSON, 1958 (Plate VI, fig. 3).

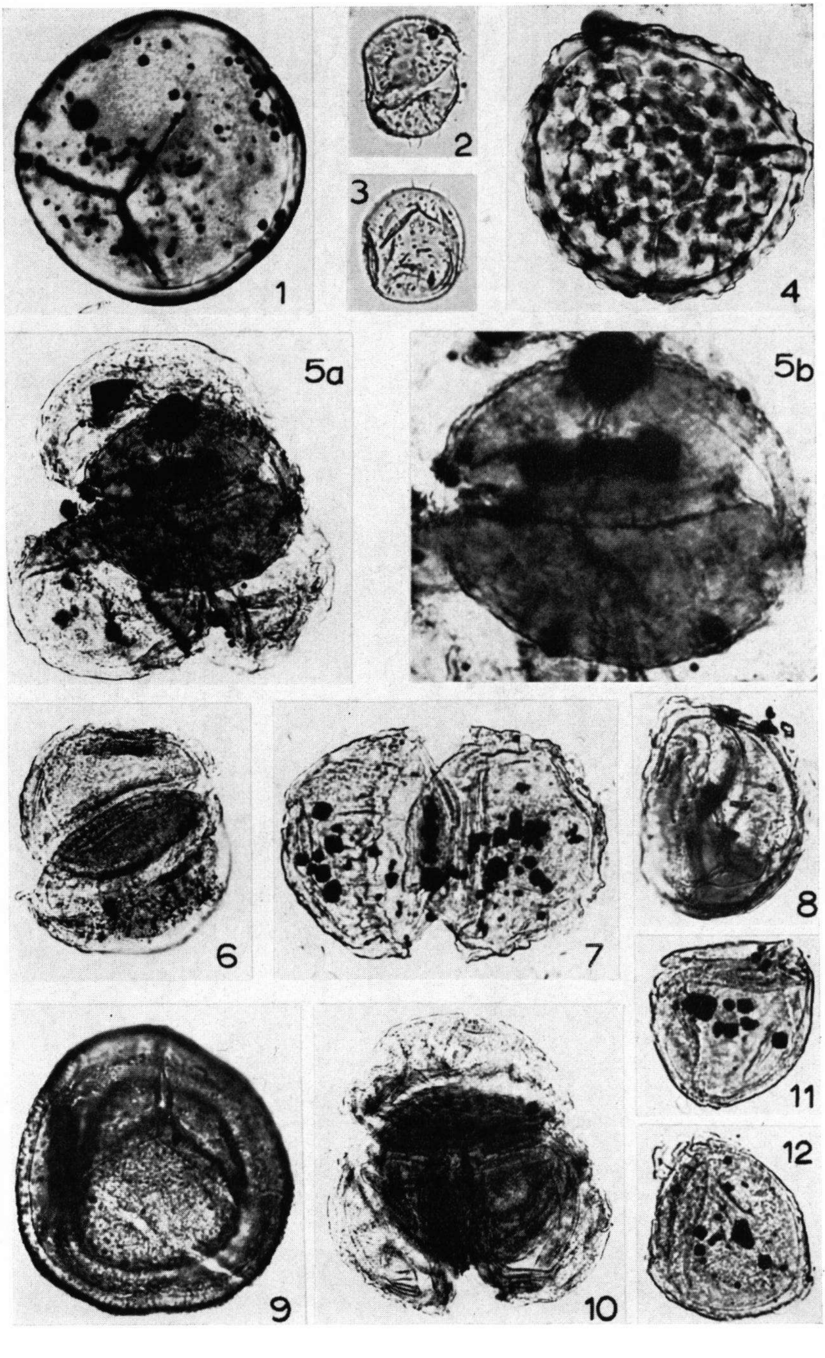
Cycadopites coxii VISSCHER, 1966 (Plate VII, fig. 7).

Cycadopites sp. (Plate VI, fig. 2).

LEGEND OF PLATE III.

Magnification × 585 unless otherwise stated.

FIG. 1. — *Punctatisporites* sp. Slide WW-137.
FIG. 2. — *Baltisphaeridium* sp. Slide WW-151.
FIG. 3. — *Baltisphaeridium* sp. Slide WW-151.
FIG. 4. — cf. *Trilites tuberculiformis* COOKSON. Slide WW-128.
FIG. 5 a. — *Aratrisporites quadriiuga* (VISSCHER) nov. comb. Slide. WW-74.
FIG. 5 b. — Enlarged single specimen of Fig. 5 a, showing the monolete mark magnification × 1000.
FIG. 6. — *Aratrisporites quadriiuga* (VISSCHER) nov. comb. Slide WW-77.
FIG. 7. — *Aratrisporites quadriiuga* (VISSCHER) nov. comb. Slide WW-139.
FIG. 8. — *Aratrisporites quadriiuga* (VISSCHER) nov. comb. Slide WW-151.
FIG. 9. — cf. microspore of *Pleuromeia rossica* NEUBERG. Slide WW-101.
FIG. 10. — *Aratrisporites quadriiuga* (VISSCHER) nov. comb. Slide WW-79.
FIG. 11. — *Aratrisporites* sp. Slide WW-140.
FIG. 12. — *Aratrisporites* sp. Slide WW-140.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Most of the specimens recorded can be identified with species already known from the Upper Bunter or equivalents (cf. KLAUS, 1964, 1965 ; MÄDLER, 1964 ; FREUDENTHAL, 1964 ; DOUBINGER and CHEYLAN, 1964 ; SCHULZ, 1965, 1966 ; REINHARDT, 1964 ; REINHARDT and SCHMITZ, 1965 ; VISSCHER, 1966). As many of these species still occur in Middle Muschelkalk assemblages the existence of index species strictly diagnostic of Lower Muschelkalk is rather speculative. Some spore species in particular may be valuable for detailed stratigraphy but their scarceness in marine sediments as well as taxonomic problems prevent decisive statements at this moment.

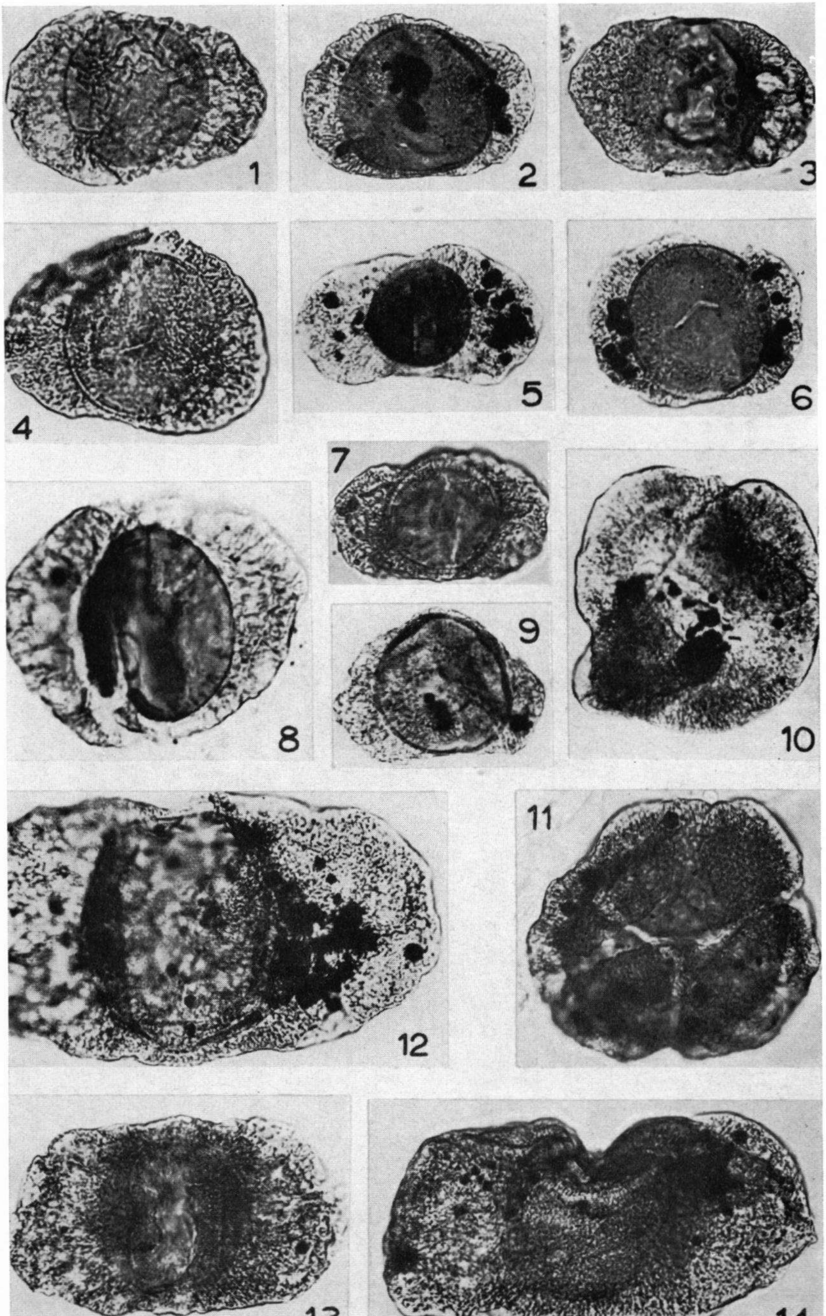
We believe that quantitative palynological analysis may provide useful data with regard to stratigraphy and regional correlation of the European Triassic sequences. Because of the impossibility of a detailed quantitative analysis of the present assemblage, only a general impression of its composition can be given. Leaving out the locally dominant hystrichosphaerids, the assemblage is characterized by the predominance of bisaccate pollen. Among the determinable specimens *Alisporites grauvogeli, Angustisulcites klausii, Voltziaceaesporites heteromorpha, Triadispora crassa, Microcachryidites fastioides,* and *Colpectopollis ellipsoideus* are the most abundant species. All other pollen species are only poorly represented. This also applies to the trilete spore species. The monolete forms assigned to *Aratrisporites,* however, seem to be present in low but constant amounts, often still connected in tetrads.

The composition of the Winterswijk assemblage shows a striking resemblance to that of an assemblage obtained from the transitional calcareous beds between Upper Bunter and Lower Muschelkalk from the « Koninklijke Nederlandsche Zoutindustrie » No. 31

LEGEND OF PLATE IV.

Magnification × 585.

FIG. 1. — *Triadispora plicata* KLAUS. Slide WW-131.
FIG. 2. — *Triadispora crassa* KLAUS. Slide WW-53.
FIG. 3. — *Triadispora crassa* KLAUS. Slide WW-58.
FIG. 4. — *Triadispora crassa* KLAUS. Slide WW-113.
FIG. 5. — *Triadispora crassa* KLAUS. Slide WW-56.
FIG. 6. — *Triadispora crassa* KLAUS. Slide WW-54.
FIG. 7. — *Triadispora plicata* KLAUS. Slide WW-112.
FIG. 8. — *Triadispora crassa* KLAUS. Slide WW-117.
FIG. 9. — *Triadispora crassa* KLAUS. Slide WW-55.
FIG. 10. — *Triadispora muelleri* (REINHARDT et SCHMITZ) VISSCHER. Slide WW-14.
FIG. 11. — *Triadispora muelleri* (REINHARDT et SCHMITZ) VISSCHER. Slide WW-40.
FIG. 12. — *Voltziaceaesporites heteromorpha* KLAUS. Slide WW-64.
FIG. 13. — *Voltziaceaesporites heteromorpha* KLAUS. Slide WW-66.
FIG. 14. — *Voltziaceaesporites heteromorpha* KLAUS. Slide WW-70.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well, situated in the vicinity of Hengelo (cf. VISSCHER, 1966 ; sample 8). The latter assemblage is distinguished from that of the underlying Röt evaporites and associated pelites by increased percentages of *Aratrisporites, Alisporites grauvogeli, Colpectopollis ellipsoideus, Microcachryidites,* and *Angustisulcites klausii* and by decreased percentages of *Voltziaceaesporites heteromorpha* and *Triadispora crassa.*

Lower Muschelkalk pollen and spores from Germany have been previously described by MÄDLER (1964). A detailed comparison, however, is hampered by the poor preservation of MÄDLER's figured specimens of bisaccate pollen grains.

In our opinion the present assemblage has very much in common with an assemblage described by CLARKE (1965) from deposits in England which — although attributed to the Lower Keuper — might represent a continental Muschelkalk equivalent.

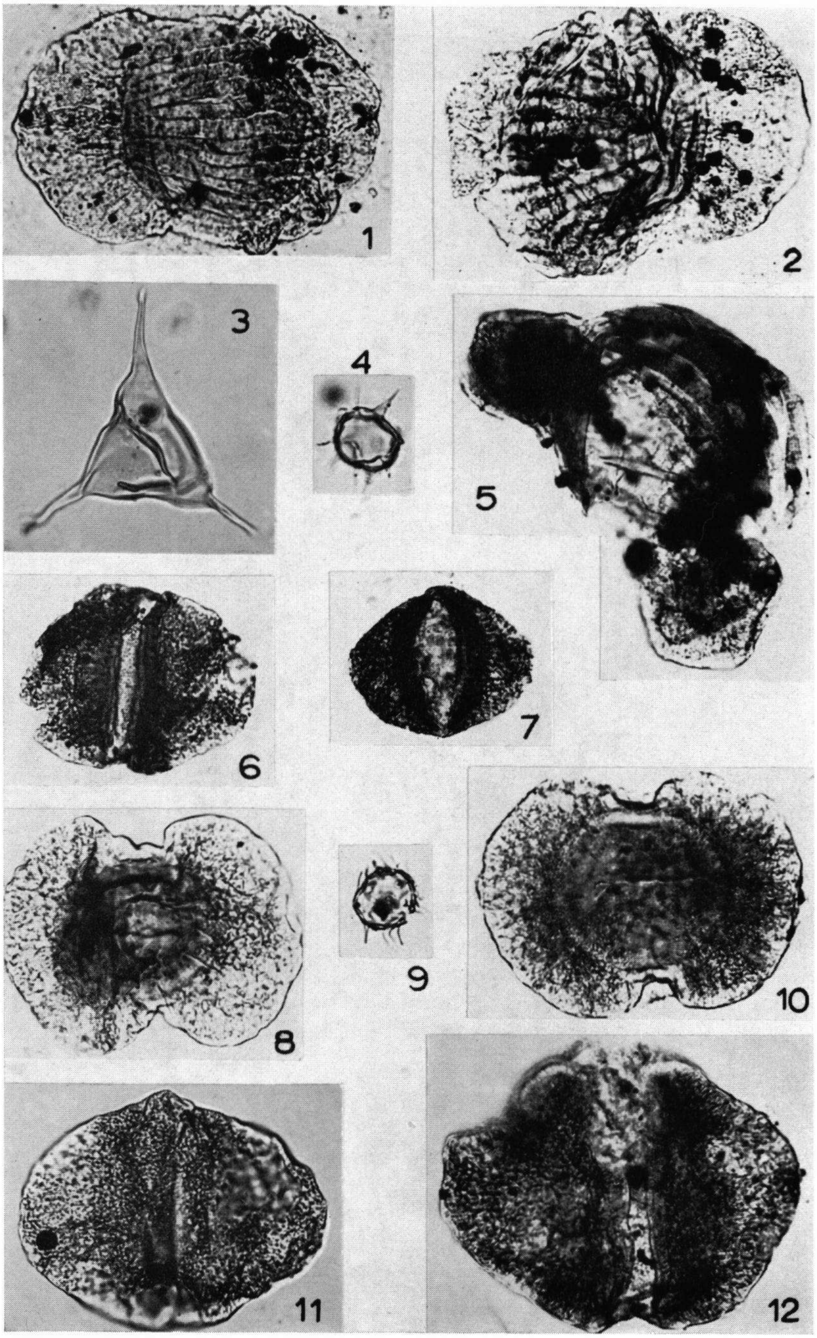
Polaeobotanical Considerations.

The knowledge of the Muschelkalk flora as based on macroscopic plant fossils is extremely meagre and is still mainly restricted to records of stems of ferns (*Adelophyton*) and conifers (*Xenoxylon*). Furthermore rare fronds of the fern *Anomopteris mougeoti* BRONGNIART and fragments of *Equisetites* and *Pleuromeia* are said to be found in the German and/or French Muschelkalk series. The most important data comes from Luxembourg : besides a frond of *Taeniopteris* sp., foliage shoots resembling *Voltzia acutifolia* BRONGNIART and *Voltzia heterophylla* cf. *brevifolia* BRONGNIART were described by CARPENTIER (1950) from Lower- and Upper Muschelkalk deposits respectively. These species may indicate a relionship be-

LEGEND OF PLATE V.

Magnification × 585.

FIG. 1. — *Protosacculina germanica* MÄDLER. Slide WW-44.
FIG. 2. — *Protosacculina germanica* MÄDLER. Slide WW-46.
FIG. 3. — *Veryhachium* sp. Slide. WW-151.
FIG. 4. — *Michrystridium* sp. Slide WW-151.
FIG. 5. — *Protosacculina germanica* MÄDLER. Slide WW-45.
FIG. 6. — *Alisporites grauvogeli* KLAUS. Slide WW-20.
FIG. 7. — *Alisporites grauvogeli* KLAUS. Slide WW-111.
FIG. 8. — *Angustisulcites gorpii* VISSCHER. Slide WW-132.
FIG. 9. — *Micrhystridium* sp. Slide WW-151.
FIG. 10. — *Angustisulcites gorpii* VISSCHER. Slide WW-130.
FIG. 11. — *Alisporites grauvogeli* KLAUS. Slide WW-23.
FIG. 12. — *Alisporites grauvogeli* KLAUS. Slide WW-21.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tween the Muschelkalk flora and the relatively well-known flora of the Upper Bunter, in which conifers (*Albertia, Yuccites,* but especially *Voltzia*) played an important part.

The palynological data from Upper Bunter and Lower Muschelkalk evidences the existence of similar floras in which conifers may have been dominant. The attribution of the saccate pollen species to individual conifer taxa is still very speculative. Pollen of (?) *Voltzia heterophylla* BRONGNIART (= *Masculostrobus willsi* TOWNROW) from the British Lower Keuper (?) (cf. COUPER, 1958, pl. 28, fig. 10 ; TOWNROW, 1962) resembles *Voltziaceaesporites heteromorpha.* A male coniferous cone from the French Upper Bunter, assigned to *Voltzia* by GRAUVOGEL et al. (1967), however, has yielded pollen which seems comparable in shape to that of *Illinites* or *Angustisulcites.*

At least one bisaccate species is non-coniferous. The small pollen grains corresponding to *Vitreisporites pallidus* (Plate VI, fig. 3) probably represent the gymnospermous order of the Caytoniales. Similar pollen has been found in situ in species of *Caytonanthus* (compare, e.g., HARRIS, 1964, fig. 8). Macroscopic remains of Caytoniales have only been demonstrated in Late Triassic and Jurassic floras ; pollen resembling *V. pallidus,* however, ranges from Upper Permian to Cretaceous.

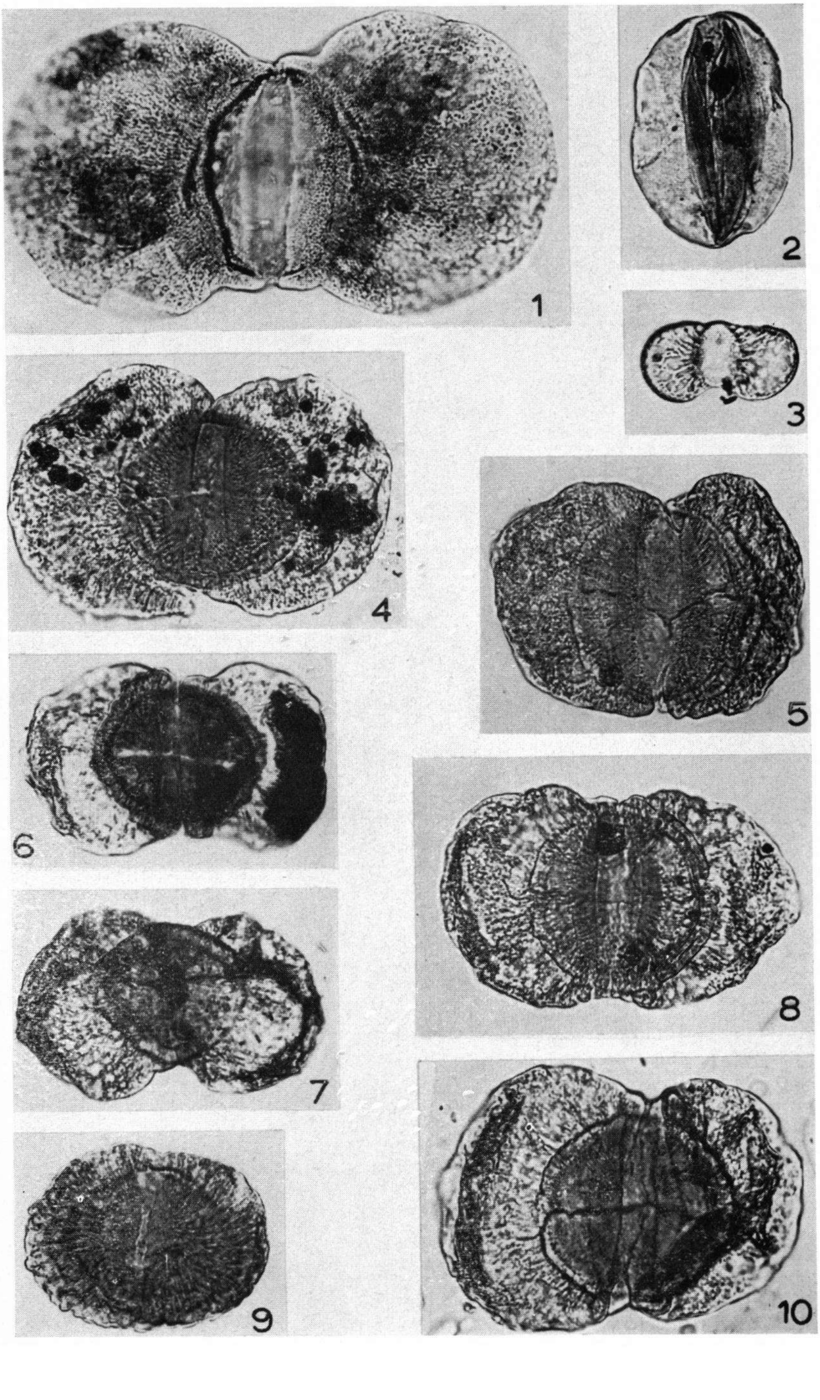
The rare specimens of *Cycadopites* (Plate VI, fig. 2 ; Plate VII, fig. 7) point to the existence of Cycadales and/or Ginkgoales in the Lower Muschelkalk flora. Macrofossils of members of both plant groups are recorded from many Triassic series. In the Lower Muschelkalk *Taeniopteris* may represent the Cycadales ; the Upper Bunter has yielded the cycad *Otozamites vogesiacus* SCHIMPER et MOUGEOT and fragments of *Baiera.*

A single trilete spore resembling the microspores of *Pleuromeia rossica* NEUBERG (cf. KIUNTZEL, 1966) was recognized in the samples investigated (Plate III, fig. 9). Whether *Pleuromeia sternbergi* (MÜNSTER) CORDA (Middle- and Upper Bunter, Upper Muschelkalk) has similar microspores is still uncertain.

LEGEND OF PLATE VI.

Magnification × 585.

FIG. 1. — *Angustisulcites grandis* (FREUDENTHAL) VISSCHER. Slide WW-109.
FIG. 2. — *Cycadopites* sp. Slide WW-104.
FIG. 3. — *Vitreisporites pallidus* (REISSINGER) NILSSON. Slide WW-151.
FIG. 4. — *Angustisulcites klausii* FREUDENTHAL. Slide WW-115.
FIG. 5. — *Angustisulcites klausii* FREUDENTHAL. Slide WW-01.
FIG. 6. — *Angustisulcites klausii* FREUDENTHAL. Slide WW-13.
FIG. 7. — *Angustisulcites klausii* FREUDENTHAL. Slide WW-05.
FIG. 8. — *Angustisulcites klausii* FREUDENTHAL. Slide WW-10.
FIG. 9. — *Vesicaspora* (?) sp. Slide WW-138.
FIG. 10. — *Angustisulcites klausii* FREUDENTHAL. Slide WW-14.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The presence of other (arborescent ?) representatives of Lycopodiophyta in the Lower Muschelkalk flora is palynologically evidenced by the occurrence of *Aratrisporites*. This monolete formgenus ranges from Lower Triassic to Liassic and its species are known from several parts of the world. Its lycopodaceous character was demonstrated by HELBY and MARTIN (1965) who isolated the *Aratrisporites*-like microspores from the Early Triassic cone *Cyclostrobus*. The Rhaeto-Liassic cone *Lycostrobus* NATHORST may also contain similar microspores. No macroscopic remains fo Lycopodiophyta have so far been recognized in Lower Muschelkalk sediments. The German and French Upper Bunter, however, yielded — apart from *Pleuromeia* — several more or less convincing lycopodaceous fossils assigned to genera like *Lepidodendrites* (found together with *Lycostrobus*), *Poecilitostachys*, *Lepidostrobus*, *Knorria*, *Stigmarites*, and *Lesangeana*.

Representatives of the Pteridophyta and Equisetophyta were common elements in the Upper Bunter flora ; they probably occurred in the same measure in the Lower Muschelkalk flora. As a result of inability to long-distance transport, their spores are — at least quantitatively — under-represented in the marine sediments of the Upper Bunter and Lower Muschelkalk. Nevertheless the palynological assemblages include a wide diversity in trilete spore species ; it is still impossible to afford evidence of their actual affinities to the different families of ferns.

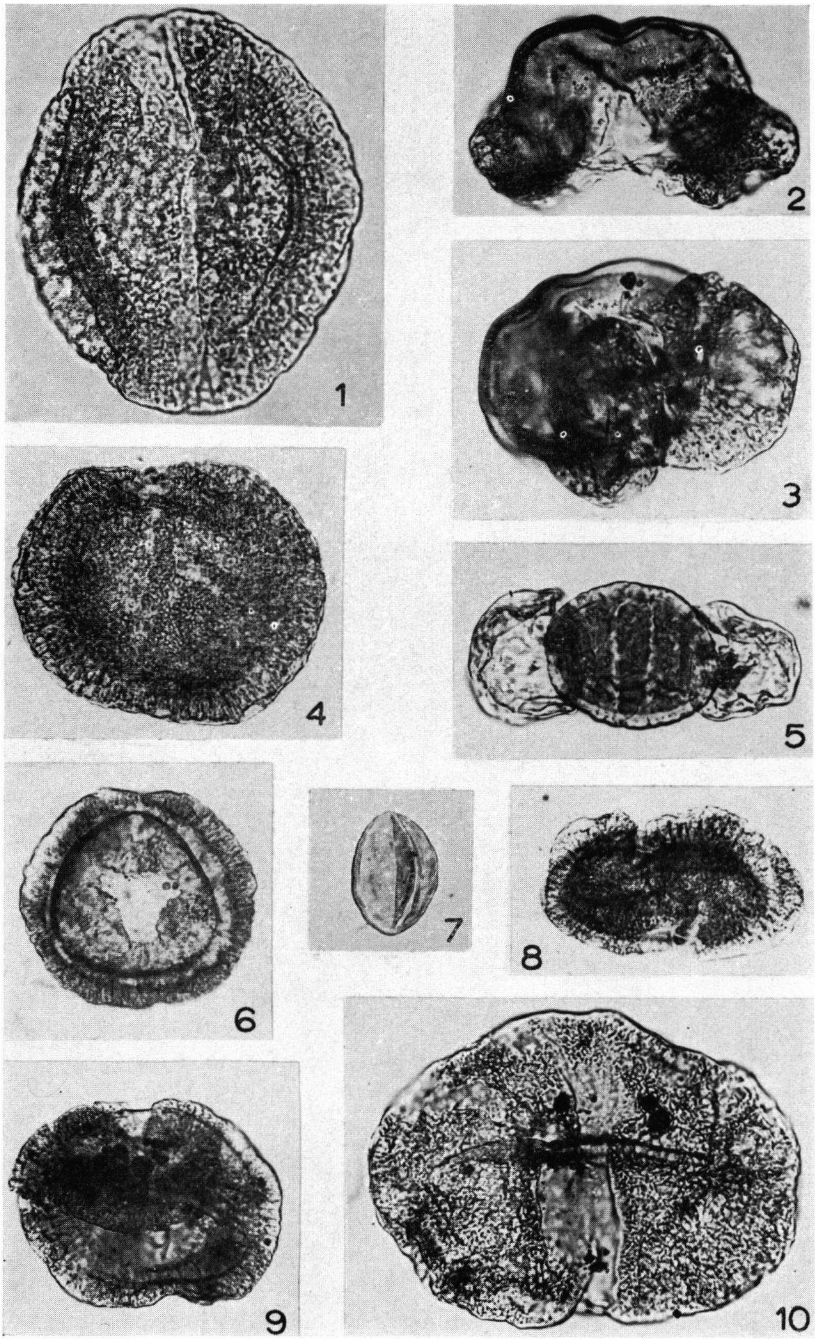
Summary.

A palynological assemblage obtained from marly limestones of the Dutch Lower Muschelkalk is discussed. A qualitative analysis has disclosed its great resemblance to Upper Bunter (Röt) assemblages ; however, differences in quantitative composition were demonstrated. Utilizing palynological data new information can be added to the knowledge of the European Middle Triassic flora.

LEGEND OF PLATE VII.

Magnification × 585.

FIG. 1. — cf. *Sulcatisporites reticulatus* MÄDLER. Slide WW-127.
FIG. 2. — *Microcachryidites fastidioides* (JANSONIUS) KLAUS. Slide WW-114.
FIG. 3. — *Microcachryidites fastidioides* (JANSONIUS) KLAUS. Slide WW-151.
FIG. 4. — cf. *Patinasporites obulus* REINHARDT. Slide WW-129.
FIG. 5. — *Microcachryidites sittleri* KLAUS. Slide WW-30.
FIG. 6. — *Dacrycarpites europaeus* MÄDLER, Slide WW-108.
FIG. 7. — *Cycadopites coxii* VISSCHER, Slide WW-149.
FIG. 8. — *Dacrycarpites europaeus* MÄDLER. Slide WW-105.
FIG. 9. — *Dacrycarpites europaeus* MÄDLER. Slide WW-41.
FIG. 10. — *Colpectopollis ellipsoideus* VISSCHER. Slide WW-26.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