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Palynologic investigation of Late Eocene to Early Oligocene lignites from Fayum Oasis, Egypt

By

Kiyoshi TAKAHASHI* and Ulrich JUX**

(Received October 21, 1988)

Abstract

In the fluviomarine Qasr El Sagha Formation, which is exposed in the Fayum Oasis of Egypt, a noticeable horizon composed of lignitic clays, carbonaceous and peaty marls, was palynologically investigated. The biostratigraphic age of the formation is confined to Late Eocene and Early Oligocene due to calcareous nannoplankton [e. g. *Ericsonia eupelagica* (Bramlette & Riedel) Roth, *Chiasmolithus oamaruensis* (Deflandre) Hay, Mohler & Wade], furthermore the full marine Birket El Qarun Formation below contains reliable index fossils of the Late Eocene and the fluviatile Gabel Qatrani Formation above has some reputation because of its richness in Early Oligocene vertebrates.

A total of 86 different species of dispersed palynomorphs were identified with the following 18 newly described forms: *Undulatisporites fayumensis* n. sp., *Laevigatosporites aegyptiacus* n. sp., *L. undulatus* n. sp., *Latosporites rotundus* n. sp., *Verrucatosporites minutiverrucatus* n. sp., *Extrapunctatosporis pseudomiocaenicus* n. sp., *E. fayumensis* n. sp., *Cupressacites africanus* n. sp., *Triatriopollenites fayumensis* n. sp., *Monosulcites aegyptianus* n. sp., *Quercoidites punctatus* n. sp., *Tricolpopollenites chagrenatus* n. sp., *T. aequatoripunctatus* n. sp., *T. lanceolatus* n. sp., *T. pseudoasper* n. sp., *Rutaceopollenites subtropicus* n. sp., *Rhoipites rotundus* n. sp. and *Tetracolporopollenites globosus* n. sp.

Several species had to be described and provisionally named in open nomenclature: *Extrapunctatosporis* sp. a, *E. sp. b, E. sp. c, Graminidites* sp. a, *G. sp. b, Cycadopites* sp. a, *C. sp. b, Tricolpites* sp. a, *T. sp. b, T. sp. c, Polycolpites* sp. a, *P. sp. b, Rhoipites* sp. a, *R. sp. b and R. sp. c.

From the rest of the assemblage 34 species could be referred to previously described taxa supporting a Late Eocene to Early Oligocene age as it was already concluded from the remains of calcareous nannoplankton as well as fossil invertebrates and vertebrates.

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A good deal of the identified palynomorphs relates to known plant families and in some cases even to the genera. From this and more geologic evidence a former vegetation in the vicinity and reaches of a prograding delta front, either growing on the natural levees or in back swamps and marshes, could be delineated.

**Introduction**

Fayum Oasis, a large circular depression, is situated near to the Nile Valley at the northeastern edge of the Western Desert (Fig. 1). The lowest parts of this region are occupied by Birket Qarun (45m below sea level), the modern El Rayan lakes and cultivated land. Along the escarpments which form the boundary to the plains of the open desert, and in Wadi Rayan, a thick sequence of Tertiary to Quaternary sediments is exposed. Paleogene rocks are either marine calcareous units of Middle Eocene age in the southwest or clastic fluviomarine to continental accumulations of the Late Eocene and Early Oligocene, which are capped by basaltic flows, in the north of Birket Qarun (Fig. 1).

For more than a century the exposures along the northern boundary of the oasis attracted paleontologists and fossil collectors due to the occurrence of spectacular...
remains of Late Eocene and Oligocene vertebrates. A detailed description of both the local geological features and the stratigraphical sequence, still a valuable source of information, dates back to the beginning of this century (Beadnell, 1905).

In the northern part of the depression the base of the outcropping Tertiary section is formed by the Birket El Qarun Formation (ca. 50 m) overlying the limestones of the Middle Mokattam Formation with *Nummulites gizehensis* (Forsk.) and consisting of fossiliferous sandstone, marl, clay and a few layers of impure limestone. The marine environment of sedimentation can be recognized by numerous invertebrate fossils (*Nummulites beaumontii* d'Arch. & H., *Operculina cf. discoides* Schwag., *Ostrea reili* Fraas, *Caralia placunoides* Cantr.), cetacean bones (*Prozeuglodon isis* Andr.) and fish teeth, underlining a Late Eocene age (Beadnell, 1905; El Khashab, 1974).

The Qasr El Sagha Formation (ca. 150 m), shaly in its lower and sandy in its upper part (Fig. 2), is of fluviomarine origin, as shown by marine molluscs (*Turritella angulata* Sow., *Gisortia gigantea* Münst., *Spondylus aegyptiacus* Bull. & Newt., *Aletronyia clotbeyi* Bellardi, *Caralia placunoides* Cantr.) and echinoids (*Echinolampas crameri* Loriol) as well as plant remains in carbonaceous shale, crocodile and mammalian bones. Among the latter cetacean (*Dorudon osiris* Dames), sirenians (*Etheroides libyca* Andr.) and last not least ancestral proboscideans (*Moeritherium lyonsi* Andr.) may be mentioned.

![Field sketch of Gabal Sagha, type locality of Qasr El Sagha Formation.](image)
An Early Oligocene age is assigned to the fluviatile and in parts perhaps lacustrine Gabal Qatrani Formation (Beadnell, 1905; El Khashab, 1974), conformably terminating the Paleogene section and being composed of clastic deposits (variegated sands, calcareous crusts and shales). Two horizons are conspicuous because of an abundance of large silicified logs and associated bone beds yielding crocodiles, turtles, embrithopods (*Palaeomastodon beadnelli* Andr., *Phiomia serridens* Andr. & Beadn., *Geniohyus mirus* Andr., *Bunohyrax major* Andr., *Megalohyrax eocaenus* Andr., *Titanohyrax palaeotheroides* Schloss.), artiodactylans (*Brachydus pars* Andr.), primates (*Propliopithecus haecckeli* Schloss., *Aegytopithecus zeuxis* Sim.), hyaenodontians (*Apterodon macrognathus* Andr., *Pterodon africanus* Andr., *Hyacodon brachycephalus* Osb.) and rodentians (*Phiomys andrewsi* Osb., *Meta-

Depositional environments

During the Late Eocene rather inconsistent paleogeographic boundaries are reflected in all the Fayum sections. This is quite evident when the clastic components in the sediments together with the apparent change from a marine to a continental biofacies are considered. Marine coastal environments of sedimentation, such as bioturbated planar laminated beds, longshore bars and subtidal lagoonal deposits are commonly preserved within the Birket El Qarun Formation, thus giving record of the dynamics at a variety of shore faces.

A rapidly prograded delta front surrounded by calm coastal waters may well explain the combined incorporation of both continental and marine fossils in a sequence of interbedded clay, silt and sand within the Qasr El Sagha Formation (Vondra, 1974). This would also agree with typical structures of sedimentation (ripple marks) and a fining upward sequence, which most likely appears to have passed into deposits of
tidal flats and flood plains. Channel fill of intraformational conglomerates which contain reworked shells and commonly abraded bones grade into cross-bedded quartz sands with intercalated carbonaceous siltstone and clay. This is referred to lag, levee and backslope accumulations of deltaic distributaries (Vondre, 1974).

During the Oligocene, when the sea had retreated to the north of Egypt (Bowen & Jux, 1987), a big river flew west of the present Nile Valley (Blanckenhorn, 1902) as can be concluded from both remote sensing and the composition of the Gabal Qatrani Formation in the Fayum Depression. This river system may have drained a large lake in northern Sudan (Bowen & Vondra, 1974). The section of the Gabal Qatrani Formation is characterized by two depositional cycles, each of them starting with fluvial erosion and the accumulation of coarse clastics in channel cuts. These events were followed by periods of aggradation caused by braided rivers on alluvial plains and ended with the deposition of silt and clay in former ponds or shallow lakes (Khashab, 1974). From the abundant logs, especially in the Lower and Upper Fossil Wood Zones it was deduced that dense gallery forests grew along the streams and lined the bays. Nevertheless, the predominance of herbivores among the fossil mammals and their modes of preservation suggested that savannahs and a profuse vegetation around fresh water lakes may also have existed in the upstream areas (Bowen & Vondra, 1974).

**Lignitic clays in the Qasr El Sagha Formation**

In clay beds of the Qasr El Sagha Formation Beadnell (1905) noticed already impressions of plants, lignitic masses of vegetation including solid twigs and some bands which approximate to an impure brown coal. In a section which he published from the exposures in the northeast of Qasr El Sagha (Fig. 2) the marginal marine facies was already clearly recognized by him. In this connection it is therefore referred to a sandy limestone (ca. 40 m below top), mainly composed of *Carolia placunoides* Cantr. and oysters, overlying a sequence of purplish clays and cross-bedded sands. Interbedded highly carbonaceous bands contained lignitic streaks and lumps, the latter resembling natural charcoal, whereas the sands yielded remains of aquatic and amphibic mammals (*Zeuglodon, Eosiren, Moeritherium*) together with abundant coprolites or the bones of crocodiles and fishes. Carbonized plants, especially leaves, are by far the most common fossils in the gypsiferous claystones and were therefore taken as an indication for a dense vegetation along the course of distributaries (Moustafa, 1974). In fact, the sequence of "gypsiferous and carbonaceous laminated claystone and siltstone facies" may include beds up to 0.5 m thick, which are composed entirely of partially to complete carbonized leaves (Von-
Fig. 3  Articulated skeleton of cyprinoid fish (? Leuciscus Klein) in carbonaceous and peaty marl of Qasr El Sagha Formation. This layer contains also calcareous nannoplankton.

dra, 1974). Such lignitic paper shales are not easily interpreted as river deposits but rather as an accumulation under very low energy conditions. This is the case near the landward side of lagoons where broad leaved plants have had their habitat (Vondra, 1974). Such environments of sedimentation could easily explain the regular laminations of the claystone, the intercalated beds with sand filled calianassid burrows, the mutual fossilization of terrestrial plants (leaves) and aquatic animals (Fig. 3) and even the gypsum in the desiccation cracks.

Materials

From the Qasr El Sagha Formation ("laminated claystone and siltstone facies") two samples were available for the present palynological investigation. One of these is a black and rather fragile, lignitic cobble, woody in part, with bands (1 – 2 cm thick) of a shiny gagate alternating with a dull, laminated brown coal, the latter showing a fine granulate texture. This material is mainly a lignite which ranks among the group of “Glanzbraunkohlen” (Rmax = 0.58). In comparison to this, the other sample represents a well bedded, brown carbonaceous in parts peaty marl with fine plantal debris and the articulated remains of a small cyprinoid fish (? Leuciscus Klein).

From both these samples the proportion of combustible components as well as
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The $\delta^{13}$C composition were determined.

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<th>$\delta^{13}$C (‰ PDB)</th>
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<td>Brown coal, dull with streaks of gagate</td>
<td>44.1</td>
</tr>
<tr>
<td>Carbonaceous shale</td>
<td>5.2</td>
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The relative enrichment of ‘light’ carbon in the coal is due to isotopic fractionation during growth periods of the plants and corresponds well with $\delta$-values which were measured from other Tertiary lignites.

The carbonaceous or even peaty marl is summed up by the following properties:

- **Granulometric characteristics:** coarse sand (1.2%), fine sand (5%), coarse silt (6.8%), medium silt (25.9%), fine silt (31.4%) and clay (26.8%).
- **Mineralogical composition:** calcite, quartz, apatite.
- **Main elements (EDAX):** Al, Si, Cl, K, Ca, Fe.

Al, Si and K result from clay minerals whereas Ca traces back to thin intercalated lenses with rather abundant coccoliths.

### Previous palynological studies

Although phytogene components were early observed in deposits which mark the termination of the Paleogene marine cycle in Upper Egypt, dispersed palynomorphs derived from the Qasr El Sagha Formation were neither systematically described nor even mentioned. Evidently there is a considerable lack of knowledge as regards the palynology of the Late Eocene and Early Oligocene all over the Near East.

There are some papers on Paleogene palynomorphs in Egypt (Kedves, 1971, 1984, 1985; El-Beialy & Kora, 1987). Kedves (1984) summarized the palynological assemblage of the Danian stage from Egypt. Normapolles pollen is infrequent, but two genera occurred: *Trudopollis* and *Minorpollis*. The monosulcate pollen grains are the most important. These palynomorphs range from the Upper Maastrichtian of Egypt.

Although no detailed datum on Eocene palynomorphs from Egypt seems to be at hand, an assemblage from the Paleocene Kurkur Formation was reported (El-Beialy & Kora, 1987). An association which derived from Darb El Arbaïn (Southern Egypt) and consisted of *Monoporites annulatus* v. d. Hammen, *Cupuliferoipollenites pusillus* Pot., *Casuarinidites granilabratus* (Stanley) Srivast., *Chenpodium* sp. with associated dinoflagellate cysts may of course indicate fluviomarine environments of sedimentation, possibly not far away from open grasslands.

Spores and pollen grains were recorded in Oligocene layers from Abu Rawash and the Moqattam Plateau near Cairo and from this paleoecologic similarities (Taxo-
diaceae-Cupressaceae swamp forest) as well as differences (prairie with Gramineae and Chenopidaceae) were outlined when compared with synchronous associations of Europe (Kedves, 1985). Besides, the occurrences of Pentapollenites laevigatus Kr. laevigatus and Normapolles pollen (Minorpollis gallicus Kds., Plicapollis pseudoexcelsus (Kr.) Kr. pseudoexcelsus, P. pseudoexcelsus (Kr.) Kr. turgidus Pf., P. pseudoexcelsus (Kr.) Kr. semiturgidus Pf.) are very interesting from a standpoint of paleophytogeography.

Previous Pre-Tertiary and Neogene palynological studies in Egypt are not referred in this paper.

**Geologic age**

Most of the spectacular fossils which came to light in the Fayum Depression were recovered from exposures of the Gabal Qatrani Formation, the Early Oligocene age of which is generally considered (Ansary, 1955) and refers to remains of continental mammalians. This designation is not directly comparable with the biostratigraphy of marine index fossils, although, the facies of the Qasr El Sagha Formation has a transitional fluviomarine character.

At first these rocks were placed into Middle Eocene (Beadnell, 1905). However, an abundance of indicative fossils in certain horizons, such as Nummulites striatus (Brug.), Plicatula bellardi Mayer-Eym., Carolia placunoides Cantr., Ostrea clotbeyi Bellardi, Exogyra fraasi Mayer-Eym., Echinolampas crameri Loriol or Dorudon osiris Dames underlines a Late Eocene (= Late Bartonian) age (Cuvillier, 1930), which is furthermore supported by the composition of the foraminiferal fauna (Ansary, 1955) and by other biostratigraphic evidence (Strougo, 1979).

In this connection it is referred to the abundant coccoliths which were observed in the sample of the peaty marl with the fossil fish (Fig. 3). The minute calcites plates, produced by the non-motile resting stages of only a few genera of the Coccolithophoridae are lumped together in enormous quantities (pl. 14, fig. 1) and the almost monospecific assemblage indicates an ecologically rather restricted environment, perhaps in a bay or estuarine river mouth. Many of the placoliths are either somewhat disaggregated or show more or less the effects of diagenetic solutions (pl. 14, figs. 2, 3, 6).

The assemblage of calcareous nannofossils is dominated by the stratigraphically rather indistinct species Ericsonia eopelagica (Bramlette & Riedel) Roth, although the species (pl. 14, figs. 1, 3, 4), the synonymy of which has been outlined by Roth et al. (1971), is known to occur in the Lower Oligocene quite abundantly (Martini, 1971). The rare specimens of Chiasmolithus oamaruensis (Deflandre) Hay,
Mohler & Wade (pl. 14, fig. 8) are, however, much more indicative in this concern and definitely confine a Late Eocene to Early Oligocene age (NP-Zones 18–22; Martini, 1971; Roth, Baumann & Bertolino, 1971; Perch-Nielsen, 1985) to the carbonaceous marl. In addition one or two badly preserved *Neococcolithes cf. dubius* (Deflandre) Black (pl. 14, figs. 2, 5), *Neochiastozygus* sp. (pl. 14, fig. 6), *Discoaster aff. gemmeus* Stradner (pl. 14, fig. 7) as well as doubtful *Toracosphaera* sp. and rhabdosphaeracean fragments give further evidence for a short and rather concealed marine interval during the sedimentation of the fluviomarine Qasr El Sagha Formation.

**Systematic description of palynomorphs**

*Anteturma Sporites* H. Potonié 1893.


*Subturma Azonotriletes* Luber 1935.


Type species: *Leiotriletes spheroatriangulus* (Loose 1932) Potonié & Kremp 1954.

*Leiotriletes apheles* (Hunger) Krutzsch

Pl. 1, fig. 4.

1962 *Leiotriletes apheles* (Hg. 1952) Kr. 1959b, Atlas, Lfg. I, S. 22, Taf. 4, Fig. 1–10.

**Diagnostic characters:** Trilete, laevigate spore of circular outline. Exospore twolayered, 1 μm thick. Trilete laesurae straight, almost reaching the equatorial margin.

**Dimension:** 47 X 41 μm in diameter.

**Stratigraphic range:** Miocene in Middle Europe.

Germany: Early Miocene (Sachsen: Tanndorf-Seidewitz); Middle Miocene (Weisswasser-Rietschen).

**Remarks:** The specimen observed is identical with *Leiotriletes apheles* (Hunger) Krutzsch from the Miocene of Germany.

**Botanical affinity:** Unknown.


Type species: *Monoleiotriletes angustus* Krutzsch 1959.
Monoleiotriletes angustus Krutzsch
Pl. 1, figs. 1–3, 5–7; pl. 2, fig. 1 (cf.).

1959 Monoleiotriletes angustus Krutzsch, Geologie, Jrg. 8, Beih. 21/22, S. 65, Taf. 4, Fig. 23.

Diagnostic characters: Trilete, laevigate spore; equatorial contour triangular with convex or somewhat concave sides and rounded corners. Exospore one-layered, 0.5–1 \( \mu \)m thick, smooth. Trilete laesurae distinct, straight, extending to a half or two-thirds of the distance to the equatorial corners, mostly with thin lip.

Dimensions: 53–66 \( \mu \)m X 47–65 \( \mu \)m in equatorial diameter.

Previous record: Middle Eocene in Germany (Geiseltal).

Remarks: The present specimens match in all diagnostic features Monoleiotriletes angustus from the Middle Eocene of the Geiseltal (G.D.R.).

Botanical affinity: Unknown.

Type species: Deltoidospora hallii Miner 1935.

Deltoidospora sp.
Pl. 2, fig. 2.

Description: Trilete spore subtriangular to deltoid in equatorial outline. Trilete laesurae distinct, straight, with prominent lips, extending over two-thirds to three-quarters of the distance to the periphery. Corners either broadly or rather narrow rounded. Exospore smooth, 0.5 \( \mu \)m thick; one face of the spore is conspicuously concave.

Dimension: 47 X 40 \( \mu \)m in equatorial diameter.


Botanical affinity: Possibly Adiantaceae, Adiantum.

Genus Concavisporites Pflug 1953.
Type species: Concavisporites rugulatus Pflug 1953.

? Concavisporites sp.
Pl. 2, fig. 3.
Description: Trilete spore of triangular contour with extremely concave sides in polar view. Exospore thin, 0.5 μm thick, smooth, noticeable crumpled during fossilization. Y-mark slender, curved, almost reaching the equatorial corners.

Dimension: 50 X 49 μm in equatorial diameter.

Remarks: Whether the present specimen belongs to the genus *Concavisporites* or not, is quite questionable as it lacks a torus.

Botanical affinity: Unknown.

Genus *Undulatisporites* Pflug 1953.
Type species: *Undulatisporites microcutis* Pflug 1953.

*Undulatisporites fayumensis* n. sp.

Pl. 2, figs. 4–7; pl. 3, figs. 1–8.

Diagnosis: Trilete spore of triangular to subtriangular outline with convex or slightly concave sides and rounded corners in polar sight. The trilete laesurae is conspicuous and strongly undulated, 1 ±μm wide, extending to a half or two-thirds of the distance to the equatorial periphery. Exospore single layered, laevigate to chagrenate, 0.5–1 μm thick. No torus.

Dimensions: 43–72 μm X 43–70 μm in equatorial diameter.

Holotype: Pl. 2, fig. 6; 58 X 53 μm in equatorial diameter; exine 0.5±μm thick, laevigate; Y-mark sinuous; no. of specimen: Fayum 1–18 (GN 5318).

Derivation of name: After the Fayum Oasis.

Remarks: The new species differs from all the other of the genus *Undulatisporites* in respect to its shape, thickness and ornamentation of its exine, and the mode of its Y-mark.

Botanical affinity: Unknown.

*Undulatisporites* sp.

Pl. 3, fig. 9.

Description: Trilete spore of triangular contour with straight sides and rounded corners in equatorial outline. Trilete laesurae distinct, slender, sinuous, extending to a half of the distance to the equator. Exine one-layered, 1.5 μm thick, chagrenate.

Dimension: 33 μm in equatorial diameter.

Remarks: There is no doubt that the specimen belongs to the genus *Undulatisporites*, however, specific identification is not yet possible.

Botanical affinity: Unknown.
Laevigatosporites aegyptiacus n. sp.
Pl. 4, figs. 3 – 12.

Diagnosis: Monolete spores of oval shape in equatorial and proximal views. Monolete furrow is rather short, very slender, straight or curved and does not extend to the periphery (14 – 25 μm long). Exine very thin, 0.5 μm thick, laevigate, with secondary folds due to fossilization.

Dimensions: 41 – 58 μm in length.
32 – 44 μm in width.
Width / length ratio: 0.67 – 0.81.

Holotype: Pl. 4, fig. 6; 48 X 37 μm in size; exine laevigate, 0.5 μm thick; monolete dehiscence slightly curved, 18 μm long; width / length ratio = 0.77; no. of specimen: Fayum 1 – 18 (GN 5318).

Name derivation: After Egypt.

Remarks: Previously described species of Laevigatosporites exhibiting a stout shape are as follows: Laevigatosporites haardti (R. Pot. & Ven.) Th. & Pf. haardtioides Kr., L. nitidus (Manc.) Kr. nitidus, L. pseudodiscordatus Kr., L. discordatus Kr., L. adiscordatus Kr., L. josensis Tak. & Jux, L. oviformis Tak. & Jux, L. ovatus Wilson & Webster, L. gigantiformis Tak., L. ovoideus Tak., L. probatus Tak., etc. The new species resembles L. ovoideus Tak. (1961, pp. 288 – 289, pl. 16, figs. 9 – 14) from the Early and Middle Miocene of Sasebo, Kyushu, Japan and L. probatus Tak. (1964, pp. 214 – 215, pl. 29, fig. 8) from the Campanian and Maastrichtian of Ooyubari, Hokkaido, Japan, but differs from both in the slender dehiscence furrow; furthermore the first has swollen lips and the second a thicker exine.

Botanical affinity: Polypodiaceae.

Laevigatosporites undulatus n. sp.
Pl. 5, figs. 3 – 12; pl. 6, fig. 3 (cf.).

Diagnosis: Monolete spores, reniform in lateral (equatorial) view. Dehiscence furrow slender, more or less sinuous, 19 – 26 μm long, not reaching the margin and commonly with weak lips. Exine very thin, less than 0.5 μm thick, laevigate but crumpled
during fossilization. Proximal side with dehiscence of variable contour (convex, concave or straight).

**Dimensions:** 35–45 μm in equatorial axis.
25–32 μm in polar axis.

Width / length ratio: 0.65–0.82.

**Holotype:** Pl. 5, fig. 10; 40 X 27 μm in size; exine less than 0.5 μm thick, laevigate; dehiscence furrow slender, sinuous, 22 μm long, with weak lips; proximal side straight; no. of sample: Fayum 1–17 (GN 5317).

**Derivation of name:** undulatus (lat.) = having a wavy form.

**Remarks:** The new species can be distinguished from others by its slender and sinuous dehiscence furrow and its delicate exine.

**Botanical affinity:** Peranemataceae, Acrophorus.

**Laevigatosporites dehiscens** Takahashi

Pl. 5, figs. 13–15.


1964 *Laevigatosporites dehiscens* Takahashi, Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol., vol. XIV, no. 3, p. 215, Taf. Fig. 9–13; Taf. 40, Fig. 13–15.

1979 *Laevigatosporites dehiscens* Takahashi, Takahashi & Kim, Palaeontographica, B, 170, Lfg. 1–3, pp. 23–24, pi. 1, figs. 10–11.


**Diagnostic characters:** Monolete spores. Figura bean-shaped in lateral (equatorial) view. Dehiscence furrow slender, straight or somewhat curved. Exine very thin, 0.5 μm or less than 0.5 μm thick, laevigate, with secondary folds due to fossilization.

**Dimensions:** 30–36 μm X 21–27 μm in size.

Width / length ratio: 0.7–0.75.

**Stratigraphic range:** Late Cretaceous to Miocene in the Far East.

Japan: Late Cretaceous (Hokkaido, Futaba); Paleogene and Miocene (Hokkaido, Jooban, Kyushu).

Korea: Early-Middle Miocene (Changgi, Yonil).

**Remarks:** *Laevigatosporites dehiscens* closely resembles both *L. gracilis* Wilson & Webster from the Paleocene Fort Union Formation of Montana (USA) and the Middle Oligocene to Early Pleistocene of Middle Europe and *L. haardti* (R. Pot. & Ven.) Th. & Pf. haardti from the Eocene to Plio-Pleistocene of Middle Europe, but differs from them in its thinner exine and besides that from *L. gracilis* in its larger size.
Botanical affinity: Polypodiaceae.

*Laevigatosporites ovoideus* Takahashi

Pl. 5, fig. 16; pl. 6, fig. 2.


1979 *Laevigatosporites ovoideus* Takahashi, Takahashi & Kim, Palaeontographica, B, 170, Lfg. 1–3, p. 24, pl. 1, figs. 12–16; pl. 2, fig. 2.


Diagnostic characters: Monolete spores of a broad-elliptical outline in proximal view. Monolete relatively short, slightly curved, 14 μm long and not reaching the periphery. Exine thin, 0.5 μm thick, smooth.

Dimensions: 30 X 27.5 μm in size.

Width / length ratio: 0.916.

Stratigraphic range: Late Cretaceous to Miocene in the Far East.

Japan: Late Cretaceous (Futaba, Hida); Early Miocene (Sasebo); Middle Miocene (Iki, Korea strait).

Korea: Early and Middle Miocene (Changgi, Yonil).

Remarks: L. ovoideus is very similar to L. ovatus Wilson & Webster, but differs in its thinner and one-layered exine.

Botanical affinity: Polypodiaceae.

Genus *Latosporites* Potonié & Kremp 1954.

Type species: *Latosporites latus* (Kosanke 1950) Potonié & Kremp 1954.

*Latosporites rotundus* n. sp.

Pl. 4, figs. 1–2; pl. 5, figs. 1–2.

Diagnosis: Monolete spores. Outline circular to subcircular in equatorial view. Monolete furrow slender and slightly curved, moderately long, 15–29 μm long, not reaching the margin. Exine very thin, 0.5–0.7 μm thick, laevigate, somewhat crumpled by folds. In lateral view the distal as well as the proximal surface are conspicuously convex.

39–51 μm in polar axis.
Width / length ratio: 0.87–1.0.

Holotype: Pl. 5, fig. 1; 53 X 51 μm in size; exine 0.5 μm thick, laevigate; dehiscence furrow slightly curved, 29 μm long; distal and proximal faces rounded; width / length ratio = 0.96; no. of specimen: Fayum 1–19 (GN 5319).

Name derivation: rotundus (lat.) = rounded.

Remarks: The genus Latosporites was introduced by Potonié & Kremp (1954) for Paleozoic monolete iso- or microspores with broadly oval to approximately circular outlines and distal distensions. Latosporites rotundus n. sp. is comparable with L. latus (Kosanke) Pot. & Kr. from the Pennsylvanian of Illinois (USA), but differs from the latter in having both a longer monolete mark and a thinner exine.

Botanical affinity: Unknown.

Latosporites sp.
Pl. 6, fig. 1.

Description: Monolete spore of subcircular or tetragonal contour in lateral (equatorial) view. Monolete furrow slender, slightly sinuous, 17 μm long. Exine very thin, 0.5 μm thick, smooth, with secondary folds due to fossilization. In lateral view the distal side exhibits a rather rounded curvature whereas the proximal side is straight.

Dimensions: 26 X 25 μm in size.
Width / length ratio: 0.96.

Remarks: The only specimen observed belongs to the genus Latosporites rather than the genus Laevigatosporites.

Botanical affinity: Unknown.

Infraturma Sculptatomoenoleti Dybova & Jachowitz 1957.

Verrucatosporites cf. tenellis (Krutzsch) Krutzsch
Pl. 6, fig. 4.

1959 Reticulidosporites (Polypodiisporites) tenellis Krutzsch, Geologie, Jrg. 8, Beih. 21/22, S. 218, Taf. 44, Fig. 486.
1967 Verrucatosporites tenellis (Krutzsch) Krutzsch, Atlas, Lfg. IV & V, S. 190, Taf. 71, Fig. 4–19.

**Diagnostic characters:** Monolete spore of subcircular or oval outline in lateral (equatorial) view. Dehiscence straight, 20 μm long, slightly opened. Exine weakly verrucate, 0.5 μm thick, strongly folded during fossilization; surface of the exine appears to be somewhat reticulated. In lateral view distal side is semicircularly expanded whereas the proximal side is slightly convex.

**Dimensions:** 44 X 39 μm in size.

**Width / length ratio:** 0.89.

**Stratigraphic range:** Eocene to Miocene in Middle Europe.

- Germany: Middle Eocene (Geiseltal); Middle Oligocene (Brg. Delitzsch-Nord 1, Torgau, Brg. Seyda 1, Brg. Wassermannsdorf 2); Miocene (Brg. Kasekow, Wolfshain, Ville).
- Hungary: Early Eocene (Southern Bakony: Úrkút).

**Remarks:** The only specimen found is much wider than Krutzsch's original material.

**Botanical affinity:** Polypodiaceae.

*Verrucatosporites minutiverrucatus* n. sp.

Pl. 6, figs. 5 – 8.

**Diagnosis:** Monolete spores of reniform contour in lateral (equatorial) view. List of dehiscence slender, sinuous, moderately long (23–30 μm). Exine weakly verrucate, less than 0.6 μm thick; verrucae form a network on the outer surface of the exine. In lateral sight the proximal side may appear concave or straight.

**Dimensions:** 38–49 μm in equatorial axis.

23–31 μm in polar axis.

**Width / length ratio:** 0.61–0.76.

**Holotype:** Pl. 6, fig. 7; bean-shaped; 46 X 29 μm in size; exine weakly verrucate, less than 0.5 μm thick; dehiscence furrow undulate, 30 μm long; proximal side concave; no. of specimen: Fayum 1–18 (GN 5318).

**Name derivation:** minutus (lat.) = small; verrucatus (lat.) = warty.

**Remarks:** The new species is similar to *Verrucatosporites tenellis* (Kr.) Kr., but differs in its sinuous dehiscence.

**Botanical affinity:** Polypodiaceae.

*Verrucatosporites* sp.

Pl. 6, fig. 18.
**Description:** Monolete spore of triangular outline in lateral (equatorial) view. Monolete furrow slender, narrow, straight, 12 μm long. Exine very thin, 0.5 μm thick, weakly verrucate. In lateral view the proximal side appears to be more or less concave whereas the distal is remarkably curved.

**Dimensions:** 28 X 21 μm in size.

- Width / length ratio: 0.75.

**Remarks:** The single specimen which was observed, was not specifically identifiable.

**Botanical affinity:** Polypodiaceae.

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**Genus Extrapunctatosporis Krutzsch 1959.**

Type species: *Extrapunctatosporis extrapunctoides* Krutzsch 1959.

*Extrapunctatosporis pseudomiocaenicus* n. sp.

Pl. 6, figs. 9-12 (cf.).

**Diagnosis:** Monolete spores. Figura elliptical in lateral (equatorial) view. Monolete furrow slender, curved or slightly sinuous, 15-20 μm long, in most specimens exposing narrow lips. Exine thin, less than 1 μm thick, finely granulate on proximal side and finely verrucate on distal side. Proximal side convex in lateral view.

**Dimensions:** 35-41 μm in equatorial axis.

- 27-32 μm in polar axis.

- Width / length ratio: 0.69-0.82.

**Holotype:** Pl. 6, fig. 9: 39 X 27 μm in size; exine thin, finely granulate on proximal and central sides and finely verrucate on distal side; dehiscence furrow slender, slightly curved; no. of specimen: Fayum 1-18 (GN 5318).

**Name derivation:** *pseudes* (gr.) = false; *miocaenicus* = from the stratigraphic term Miocene.

**Remarks:** The new species can be distinguished from others of the genus *Extrapunctatosporis* by its unusual ornamentation. *Extrapunctatosporis miocaenicus* Krutzsch has an extrapunctate sculpture on its proximal and a verrucate-granulate on its other sides.

**Botanical affinity:** Athyriaceae, *Athyrium*.

*Extrapunctatosporis fayumensis* n. sp.

Pl. 6, figs. 13-15; pl. 7, figs. 2-3 (cf.).

**Diagnosis:** Monolete spores of subcircular to broad-elliptical contour in approximate-
ly polar sight. Monolete mark of slender, narrow composition, slightly curved, 14–19 \( \mu m \) long. Exospore weakly granulate, 0.5–1 \( \mu m \) thick, with secondary folds due to fossilization.

**Dimensions:** 33–48 \( \mu m \) in equatorial axis (length).

\[
26–39 \mu m \text{ in width.}
\]

Width / length ratio: 0.79–0.95.

**Holotype:** Pl. 6, fig. 15; 48 X 39 \( \mu m \) in size; exine delicately granulated, less than 0.5 \( \mu m \) thick; dehiscence furrow slender, slightly curved, 15 \( \mu m \) long; width / length ratio = 0.81; no. of specimen: Fayum 1–18 (GN 5318).

**Derivation of name:** After the Fayum Oasis.

**Remarks:** The new species is almost alike *Extrapunctatosporis pseudomiocaenicus* n. sp., but differs in its more expanded form and its throughout fine-granulated sculpture.

**Botanical affinity:** Athyriaceae, *Athyrium*.

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**Extrapunctatosporis sp. a**

Pl. 6, fig. 16.

**Description:** Monolete spore of elliptical or oval outline in polar view. The dehiscence fissure is again slender but straight, 12 \( \mu m \) long. Exine very thin, less than 0.5 \( \mu m \) thick, very weakly granulate and crumpled by folds caused by fossilization.

**Dimensions:** 30 X 24 \( \mu m \) in size.

Width / length ratio: 0.8.

**Remarks:** Only one specimen was observed.

**Botanical affinity:** Athyriaceae.

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**Extrapunctatosporis sp. b**

Pl. 6, fig. 17.

**Description:** Monolete spore of bean-shaped contour in lateral (equatorial) view. Monolete mark somewhat sinuous, 20 \( \mu m \) long. Exospore thin, 0.5 \( \mu m \) thick, granulate near to the dehiscence, folded during fossilization. Proximal side slightly convex.

**Dimensions:** 38 X 25 \( \mu m \) in size.

Width / length ratio: 0.66.

**Remarks:** Only one specimen was discovered.

**Botanical affinity:** (?), Athyriaceae.
Extrapunctatosporis sp. c
Pl. 7, fig. 1.

Description: Monolete spore; bean-shaped in lateral (equatorial) view. Dehiscence rather short (11 μm), with swollen lips (2 μm wide). Spore face with dehiscence concave. Exospore 1 μm thick; sculpture granulate on the distal, however, very weakly granulate (?) on the proximal side; crumpled diagenetically.

Dimensions: 40 X 28 μm in size.

Width / length ratio: 0.7.

Remarks: A single specimen was encountered.

Botanical affinity: Athyriaceae.

Anteturma Pollenites R. Potonie 1931.
Turma Aletes Ibrahim 1933.
Infroturma Psilanapiti Erdtman 1947.

Type species: Inaperturopollenites dubius (Potonie & Venitz 1934) Thomson & Pflug 1953.

Inaperturopollenites dubius (Potonie & Venitz) Thomson & Pflug
Pl. 7, figs. 4, 6 - 7.

1953 Inaperturopollenites dubius (Potonie & Venitz) Thomson & Pflug, Palaeontographica, B, 94, S. 65, Taf. 4, Fig. 89; Taf. 5, Fig. 1 - 13.
1957 Inaperturopollenites pseudodubius Takahashi, Mem. Fac. Sci., Kyushu Univ., Ser. D. Geol., vol. 5, no. 4, p. 216, Taf. 38, Fig. 11-17; Taf. 39, Fig. 13-14.
1964 Inaperturopollenites pseudodubius Takahashi, Mem. Fac. Sci., Kyushu Univ., Ser. D. Geol., vol. 14, no. 3, p. 222, Taf. 33, Fig. 16-24; Taf. 41, Fig. 5.
1979 Inaperturopollenites pseudodubius Takahashi, Takahashi & Kim, Palaeontographica, B, 170, Lfg. 1 - 3, p. 33, pl. 7, figs. 3, 5 - 8, 10 - 13; pl. 8, fig. 8.
1984 Inaperturopollenites dubius (R. Potonie & Venitz 1934) Thomson & Pflug 1953, Mohr,
Diagnostic characters: Inaperturate pollen grains. Figula circular in outline. Exine thin (0.5 µm), chagrenate to finely punctate, with secondary folds due to fossilization.

Dimensions: 19—26 µm X 18—22 µm in diameter.

Stratigraphic range: Paleocene to Pliocene in Middle Europe and Late Cretaceous to Miocene in the Far East.

Germany: Paleocene (Sarstedt); Paleocene-Early Eocene (Helmstedt); Late Eocene-Early Oligocene (Borken, Burghasungen); Middle Oligocene (Bergisch Gladbach); Middle Oligocene-Early Miocene (Friedendorf); Late Oligocene (St. Augustin); Late Oligocene-Early Miocene (Eschweiler): Middle-Late Pliocene (Wallensen).

Japan: Late Cretaceous (Hokkaido, Jooban); Eocene-Miocene (Hokkaido, Jooban, Kyushu).

Korea: Early-Middle Miocene (Changgi, Yonil).

Remarks: Inaperturopollenites pseudodubius Takahashi is identical with I. dubius (Potonie & Venitz) Thomson & Pflug.

Botanical affinity: Taxodiaceae – Cupressaceae.

Inaperturopollenites laevigatus Takahashi

Pl. 7, figs. 8 (cf.), 18—19.
**Diagnostic characters:** Inaperturate pollen of circular to subcircular outline. Exine thin, one-layered, less than 0.5 µm thick, laevigate, crumpled diagenetically.

**Dimensions:** 24–37 µm X 19–34 µm in diameter.

**Stratigraphic range:** Late Cretaceous to Miocene in the Far East and Oligocene in Middle Europe.

- Japan: Late Cretaceous (Jooban); Paleogene (Jooban, Ube, Kyushu); Miocene (Iki, Sasebo).
- Korea: Early and Middle Miocene (Changgi, Yonil).
- Germany: Middle Oligocene (Bergisch Gladbach); Late Oligocene (St. Augustin).

**Remarks:** *Inaperturopollenites laevigatus*, which is furnished with a laevigate exine, should not be mixed with *I. hiatus* (R. Pot.) Thomson & Pflug of Europe, which can be distinguished because of its one-layered and thinner exine.

**Botanical affinity:** Taxodiaceae – Cupressaceae.

*Inaperturopollenites minimus* Takahashi & Jux

Pl. 7, figs. 9–12.


**Diagnostic characters:** Inaperturate pollen grains of circular to subcircular or oval outline. Exine very thin, finely punctate to smooth and crumpled by secondary folds due to fossilization.

**Dimensions:** 12–16 µm X 12–13 µm in diameter.

**Previous record:** Middle Tertiary (Jos) of Nigeria.

**Remarks:** *Inaperturopollenites minimus* is the smallest representative of the genus *Inaperturopollenites* so far known and identical with specimens from the Jos Plateau in Nigeria.

**Botanical affinity:** Unknown.

Genus *Psophosphaera* Naumova 1937 ex Bolchovitina 1953.

Type species: *Psophosphaera tenuis* Naumova ex Bolchovitina 1953.

*Psophosphaera aggereloides* (Maljavkina) Chlonova

Pl. 7, figs. 13–17.

1949 *Bullulina aggereloides f. glabrescens* Maljavkina, Trudy VNIGRI, no. 33, p. 133, pl.
Diagnostic characters: Inaperturate pollen of circular to subcircular or oval outline. Exine less than 1 μm thick, laevigate, diagenetically crumpled.


Previous records: Late Cretaceous to Early Paleogene in the USSR (Chulym-kemi and Eniseisk districts, West Siberia) and Latest Cretaceous in Japan (Hida).

Remarks: The specimens from the Fayum Oasis match in all diagnostic features the Late Cretaceous Psophosphaera aggereloides (Maljavkina) Chlonova of Siberia.

Botanical affinity: Larix or Pseudotsuga.

Genus Cupressacites Bolchovitina 1956.

Type species: Cupressacites russus Bolchovitina 1956.

Cupressacites cf. bockwitzensis Krutzsch

Pl. 7, fig. 5; pl. 8, fig. 13.

1984 Cupressacites bockwitzensis Krutzsch. 1971, Kirchner, Palaeontographica, B, 192, S. 102, Taf. 4, Fig. 5.

Diagnostic characters: Inaperturate pollen grains. Figura circular or oval in outline; commonly in so-called hiatus preservation. Exine two-layered, 1–2.5 μm thick, finely punctate.

Dimensions: 31–34 μm in diameter.

Stratigraphic range: Eocene to Pliocene in Middle Europe.

Germany: Late Oligocene (St. Augustin, oberbayerische Faltenmolasse, Borna-Bockwitz).

Hungary: Early Eocene (Northern Bakony: Olaszfalen; southern Bakony: Úrkút); Middle Eocene (Northern Bakony: Dudar, Balinka); Late Oligocene (Northern Bakony: Dudar; Mór Graben; Vértes); Miocene-Pliocene (Eger, Szászvár, Hidas).
Remarks: The two specimens which recognized are quite certainly identified with *Cupressacites bockwitzensis* Krutzsch.

*Botanical affinity:* Cupressaceae.

*Cupressacites africanus* n. sp.

Pl. 8, figs. 3–14 (cf.).

*Diagnosis:* Inaperturate pollen grains. Figura circular to subcircular in outline. Exine two-layered, delicately punctated or sometimes granulate; columellae or baculate muri 0.5–2 µm high; endexine 0.5–0.7 µm thick or somewhat less.

*Dimensions:* 22–38 µm X 18–32 µm in diameter.

*Holotype:* Pl. 8, fig. 8; 32 X 31 µm in diameter; exine punctate; muri less than 0.5 µm long; endexine thinner than 0.5 µm; no. of specimen: Fayum 1–18 (GN 5318).

*Derivation of name:* After Africa.

Remarks: The new species is rather similar to both *Cupressacites cuspidataeformis* (Zaklinskaja) Krutzsch and *C. bockwitzensis* Krutzsch, but can easily be distinguished by its columellae or baculate muri on the ectexine.

*Botanical affinity:* Cupressaceae.


Genus *Potamogetonacidites* Sah 1967.

Type species: *Potamogetonacidites cenozoicus* Sah 1967.

*Potamogetonacidites paluster* (Manten) Mohr

Pl. 8, figs. 1–2.


1984 *Potamogetonacidites paluster* (Manten) Mohr, Palaeontographica, B, 191, Lfg. 1–4, S. 60–61, Taf. 7, Fig. 12.1 und 12.2.

*Diagnostic characters:* Inaperturate pollen grains. Figura subcircular to oval in outline. Exine finely reticulate but crumpled during fossilization; lumina 0.5–1.5 µm in diameter; muri baculate, 0.5 µm long.

*Dimensions:* 23–26 µm X 18–19 µm in diameter.

*Previous records:* Miocene in the Netherlands (Haanrade) and Miocene and Pliocene in West Germany (Frechen).

*Remarks:* Due to a reticulum which exhibits smaller lumina than that of *Potamogetonacidites difficilis* Takahashi the specimens are referable to *P. paluster* (Manten)
Mohr.

*Botanical affinity:* Potamogetonaceae, *Potamogeton.*

**Turma Poroses Naumova 1937 emend. Potonié 1960.**
Type species: *Graminidites media* Cookson 1947 ex Potonié 1960.

*Graminidites subtiliglobosus* (Trevisan) Krutzsch

**Pl. 8, fig. 15.**

1967 *Monoporopollenites subtiliglobosus* Trevisan, Palaeontographica Italica, 62 (N. S. 32), p. 49, 63, pl. 33, figs. 6a-f.

*Diagnostic characters:* Monoporate pollen grain of circular outline. Exine 1 \(\mu m\) thick, finely punctate. Pore subcircular, 5 \(\mu m\) in diameter with a weak annulus of 1.5 \(\mu m\) width.

*Dimensions:* 34 X 32 \(\mu m\) in diameter.

*Stratigraphic range:* Late Oligocene to Plio-Pleistocene in Middle Europe.

- Germany: Late Oligocene (St. Augustin, oberbayerische Faltenmolasse); Middle Miocene (Klettewitz); Miocene-Pliocene (Rhine land); Pliocene (Elbe, Wetterau); Plio-Pleistocene (Buchenau).
- Poland: Late Miocene (Rypin).
- Italy: Late Miocene (Gabbro/Toscana).
- South Bohemia: Pliocene.

*Remarks:* The single specimen encountered has a weak annulus around its pore.

*Botanical affinity:* Gramineae.

*Graminidites laevigatus* Krutzsch

**Pl. 8, fig. 17.**

1970 *Graminidites laevigatus* Krutzsch, Atlas, Lfg. VII, S. 60, Taf. 5, Fig. 1-12.
1986 *Graminidites laevigatus* Krutzsch, Takahashi & Jux, Bull. Fac. Liberal Arts, Nagasaki Univ., Nat. Sci., vol. 26, no. 2, pp. 178-179, Taf. 21, Fig. 22a-b, 23.
Diagnostic characters: Monoporate pollen of globular shape. Pore circular, 3 \( \mu \text{m} \) in diameter and furnished with a strong annulus (6.5 \( \mu \text{m} \) in diameter). Exine 0.5 \( \mu \text{m} \) thick, chagrenate, with secondary folds due to fossilization.

Dimensions: 31 X 29 \( \mu \text{m} \) in diameter.

Stratigraphic range: Late Oligocene to Pliocene in Middle Europe.

- Germany: Late Oligocene (St. Augustin); Early Miocene (Wiesa/OL); Middle Miocene (Niederlausitz).
- Poland: Late Miocene (Konin).
- South Bohemia: Miocene (Mydlovary).
- Hungary: Pliocene (Matra Mts.).

Remarks: Graminidites laevigatus differs from all other species of the genus in the structure as well as the sculpture of the exine.

Botanical affinity: Gramineae.

Graminidites sp. a
Pl. 8, fig. 16.

Description: Monoporate pollen grain of subcircular outline. Exine thin, 0.5 \( \mu \text{m} \) thick, finely punctate, weakly intrabaculate and deformed by secondary folds. Pore small, circular, 1.7 \( \mu \text{m} \) in diameter, without annulus.

Dimensions: 18 X 18 \( \mu \text{m} \) in diameter.

Remarks: Only one specimen was observed.

Botanical affinity: Gramineae.

Graminidites sp. b
Pl. 8, fig. 18.

Description: Monoporate pollen grain most likely of originally globular shape. Pore small, circular 1.5 \( \mu \text{m} \) in diameter, without annulus. Exine thin and one-layered (0.6 \( \mu \text{m} \) thick) smooth, highly folded during fossilization.

Dimensions: 31 X 29 \( \mu \text{m} \) in diameter.

Remarks: Only one specimen was found.

Botanical affinity: Gramineae.


Type species: Psilodiporites hammenii Varma & Rawat 1963.
Psilodiporites minimus v. d. Hammen & Wymstra
Pl. 8, figs. 19–24.


Diagnostic characters: Diporate pollen of circular to subcircular contour. Exine thin, 0.5 μm thick, chagrenate. Two small pores 2–4 μm in diameter, neither with labrum, annulus or atrium.
Dimensions: 12–15 μm X 12–14 μm in diameter.
Previous records: Early Miocene in South America (British Guiana, near George town) and Middle Tertiary in West Africa (Nigeria, Jos Plateau).
Remarks: The specimens are alike Psilodiporites minimus v. d. Hammen & Wymstra from the Early Miocene of British Guiana on the one hand and the Middle Tertiary of Nigeria on the other.

Cricotriporites nigerianus Takahashi & Jux
Pl. 9, figs. 1–6 (cf.).


Diagnostic characters: Triporate pollen of circular to subcircular outline. Exine two-layered, 0.5–1 μm thick, delicately punctate. Pores oval (2.5–4 μm in diameter) with a weak annulus and costae pori; annulus 5–6 μm in diameter; one or two pores are placed subequatorially.
Dimensions: 23–29 μm X 18–27 μm in diameter.
Previous record: Middle Tertiary of Nigeria (Jos Plateau).
Remarks: The present specimens are referred to Cricotriporites nigerianus Takahashi & Jux notwithstanding that the holotype has somewhat thicker exine.
Botanical affinity: Unknown.
Genus *Triatriopollenites* Pflug 1953.
Type species: *Triatriopollenites rurensis* Pflug & Thomson 1953.

*Triatriopollenites fayumensis* n. sp.
Pl. 9, figs. 7–11.

*Diagnosis:* Triporate pollen of a circular to subcircular equatorial contour. Exine 1—1.5 μm thick midway between the pores, however, 1.5—2.5 μm thick near to them, with weak tumescence and atrium; surface of exine chagrenate to finely punctate; ectexine weakly intrabaculate; endexine smooth. The three pores are relatively small, 1—2 μm wide and depressed to 1.5—2 μm.


*Holotype:* Pl. 9, fig. 10; 28 X 27 μm in equatorial diameter; exine chagrenate, finely punctate near to the pores; wall weakly intrabaculate, 1 μm thick midway between pores and 2.5 μm thick around the pores; no. of sample: Fayum 1–19 (GN 5319).

*Derivation of name:* After the Fayum Oasis.

*Remarks:* The new species is almost alike *Triatriopollenites josensis* Takahashi & Jux from the Middle Tertiary of Nigeria (Jos Plateau), but differs on its thinner exine and delicate ornamentation.

*Botanical affinity:* Unknown.

Genus *Subtriporopollenites* Pflug & Thomson 1953.
Type species: *Subtriporopollenites anulatus* Pflug & Thomson 1953 subsp. *anulatus*.

*Subtriporopollenites* sp.
Pl. 9, fig. 12.

*Description:* Triporate pollen of subcircular contour in equatorial view. Exine thin, chagrenate, somewhat crumpled by secondary folds. The three pores are placed subequatorially, small, 1—2 μm in diameter.

*Dimensions:* 15 X 12 μm in equatorial diameter.

*Remarks:* A single specimen was encountered. This is a rather small variety of *Subtriporopollenites*.

*Botanical affinity:* Unknown.

? *Subtriporopollenites* sp.
Pl. 12, fig. 23.
Description: Triporate pollen of oval outline. Exine two-layered, 1.8 μm thick, laevigate, but crumpled by diagenetic folds. The three pores are subequatorially placed, 2.5–3 μm in diameter.
Dimensions: 22 X 16 μm in diameter.
Remarks: A single specimen was observed.
Botanical affinity: Unknown.

Genus Subtriporopollis Sah 1967.
Type species: Subtriporopollis tenuis Sah 1967.

Subtriporopollis sp.
Pl. 9, figs. 16a-b.

Description: Triporate pollen of subcircular outline. Exine finely reticulate; lumina of reticulum are 0.5–1.5 μm in diameter; muri baculate, 1 μm high. The three pores are subequatorially placed, circular, 3 μm in diameter, with annulus (2 μm wide, 7 μm in diameter).
Dimensions: 26 X 24 μm in diameter.
Remarks: The only specimen, which was observed, has three subequatorial ora and a reticulate exine. The size, composition of the aperture and the ornamentation of the exine is so distinct that the specimen is easily distinguished from the species, which were described either by Thomson & Pflug (1953, pp. 85–87) from the Tertiary of Germany or by Sah (1967, pp. 119–121) from the Late Neogene of Burundi.
Botanical affinity: Unknown.

Genus Tiliaepollenites Potonié 1931 ex Potonié & Venitz 1934.
Type species: Tiliaepollenites instructus Potonié 1931 ex Potonié & Venitz 1934.

Tiliaepollenites sp.
Pl. 9, fig. 17.

Description: Triporate pollen of almost circular contour in polar view. The three germinals are circular (semi-circular in polar view), relatively small (1 μm wide) and slightly protruded; they are furnished with a postvestibulum. Exine finely reticulate; the lumina of the reticulum are slightly larger in marginal areas, however, fine in the centrals.
Dimensions: 20 X 18 μm in equatorial diameter.
Remarks: The small specimen from the Jos Plateau is comparable with Tiliaepol-
*Tiliaepollenites* Takahashi, *Tiliaepollenites* cf. *punctulosus* Takahashi, and *? Tiliaepollenites* sp. (Takahashi, 1982, pp. 322–323) which have been described from the Eocene of Java. It can be distinguished from *T. tropicus* in the size and the germinal pores, from *T. cf. punctulosus* in both size and ornamentation, and from *? T. sp.* in the number of the pores as well as its ornamentation.

**Botanical affinity:** Tiliaceae.


Genus *Ulmipollenites* Wolff 1934.

Type species: *Ulmipollenites undulosus* Wolff 1934.

*Ulmipollenites semiundulosus* Takahashi & Jux

Pl. 9, fig. 13.


**Diagnostic characters:** Polyporate (4) pollen of oval contour with convex sides. The four pores are shaped circularly, neither with labrum nor atrium; an annulus is missing or just faintly indicated; two pores are placed subequatorially.

**Dimensions:** 31 X 24 μm in equatorial diameter.

**Remarks:** The specimen is identified with *Ulmipollenites semiundulosus* Takahashi & Jux from the Middle Tertiary of the Jos Plateau (Nigeria).

**Botanical affinity:** Ulmaceae, Ulmus.

Genus *Alnepollenites* Potonié 1931.

Type species: *Alnepollenites verus* Potonié 1931 ex Potonié 1934.

*Alnepollenites* sp.

Pl. 9, fig. 14.

**Description:** Polyporate pollen of square outline with straight or convex sides. The four pores are placed on the corners of the grain; they are small but furnished with labra and vestibula and interconnected by arched folds of the exine (arcus); this gives the impression of garlands extending from pore to pore on both proximal and distal faces. Exine thin, chagrenate.

**Dimensions:** 17 X 12 μm in diameter.
Remarks: A single specimen was observed.

Botanical affinity: Betulaceae, Alnus.

Type species: Carpinuspolis carpinoides (Pflug 1953) Takahashi 1979.

? Carpinuspolis sp.
Pl. 9, fig. 15.

Description: Polyporate (4) pollen of circular outline in polar view. The four pores are relatively large, 3–4 μm deep and without labrum and annulus. Exine thin, finely punctate but somewhat crumpled by secondary folds.

Dimensions: 35 X 33 μm in diameter.

Remarks: The single specimen which was observed might belong to another genus than Carpinuspolis.

Botanical affinity: Unknown.

Genus Parsonsidites Couper 1960.
Type species: Parsonsidites psilatus Couper 1960.

Parsonsidites psilatus Couper
Pl. 9, fig. 18.


Diagnostic characters: Periporate pollen of subcircular outline. There are nine or ten circular ora, rather large, 4–7 μm in diameter and variably placed. They are furnished with an annulus (1–2 μm wide, 7–9 μm in diameter). Exine 2 μm thick, chagrenate.

Dimensions: 30 X 29 μm in diameter.

Previous record: Middle Oligocene (Waitakian) to Late Pliocene (Waitotaran) in New Zealand.

Remarks: The specimen is identical with Parsonsidites psilatus Couper from the Middle Oligocene and Late Pliocene of New Zealand.

Botanical affinity: Apocynaceae, Parsonsia.
Subturma Monocolpates Iversen & Troels-Smith 1950.
Genus Monocolpopollenites Pflug & Thomson 1953.

Monocolpopollenites intrabaculatus Takahashi
Pl. 9, fig. 20.

1979 Monocolpopollenites intrabaculatus Takahashi & Kim, Palaeontographica, B, 170, Líg. 1–3, p. 35, pl. 8, fig. 24.
1986 Monocolpopollenites intrabaculatus Takahashi & Jux, Bull. Fac. Liberal Arts, Nagasaki Univ., Nat. Sci., vol. 26, no. 2, p. 119, Taf. 20, Fig. 11; Taf. 21, Fig. 15–17.

Diagnostic characters: Monocolpate pollen of lenticular shape, asymmetrical with pointed apices in distal polar view. Exine 1 μm thick, intrabaculate. Colpus straight, ca. 1.5 μm in wide.
Dimensions: 23 X 15 μm in size.
Width / length ratio: 0.65.
Stratigraphic range: Late Oligocene in Middle Europe and Paleogene to Miocene in the Far East.
Germany: Late Oligocene (St. Augustin).
Japan: Paleogene (North and West Kyushu, Ube, Ishizuchi, Jooban).
Korea: Early Miocene (Changgi).
Remarks: A single specimen was observed.
Botanical affinity: Palmae.

Monocolpopollenites sp.
Pl. 9, fig. 19.

Description: Monocolpate pollen grain. Figura lenticular with pointed or weakly rounded apices in distal polar view. Colpus slender, asymmetrical, curved, extending from one apex to the other. Exine thin, chagrenate.
Dimensions: 22 X 11 μm in size.
Width / length ratio: 0.5.
Remarks: One specimen was encountered.
Botanical affinity: Palmae.

Genus *Arecipites* Wodehouse 1933.
Type species: *Arecipites punctatus* Wodehouse 1933.

*Arecipites brandenburgensis* Krutzsch
Pl. 9, figs. 25 (cf.)–26.

1970 *Arecipites brandenburgensis* Krutzsch, Atlas, Lfg. VII, S. 106, Taf. 22, Fig. 8–19.

Diagnostic characters: Monocolpate pollen of elliptical or prolate shape in distal polar view. Colpus slender, curved or sinuous. Exine reticulate; lumina of reticulum polygonal, 0.5–2.5 μm in diameter; muri baculate, 0.5 μm long.
Dimensions: 29 X 18–21 μm in size.
Width / length ratio: 0.62–0.72.
Previous records: Middle Oligocene to Miocene in Germany.
Remarks: Two specimens were observed.

*Arecipites* sp.
Pl. 9, fig. 24.

Description: Monocolpate pollen of elliptical or prolate shape with rounded or pointed apices in distal polar view. Colpus slender, more or less curved. Exine reticulate; lumina very small; muri baculate, 1 μm long.
Dimensions: 19 X 14 μm in size.
Width / length ratio: 0.74.
Remarks: A single specimen was found.

Genus *Cycadopites* Wodehouse 1933 ex Wilson & Webster 1946.
Type species: *Cycadopites follicularis* Wilson & Webster 1946.

*Cycadopites gracilis* Krutzsch
Pl. 9, fig. 21.
1970 *Cycadopites gracilis* Krutzsch, Atlas, Fig. VII, S. 94, Taf. 18, Fig. 1–3.
1986 *Cycadopites gracilis* Krutzsch, Takahashi & Jux, Bull. Fac. Liberal Arts, Nagasaki Univ., Nat. Sci., vol. 26, no. 2, p. 120, Taf. 21, Fig. 12.

**Diagnostic characters:** Monosulcate pollen grain of long-lenticular shape in distal polar view. Prominent colpus curved, extending to the apices. Exine 1 μm thick, somewhat chagrenate.

**Dimensions:** 41 X 17 μm in size.

**Width / length ratio:** 0.4.

**Previous records:** Late Oligocene to Miocene in Germany.

**Remarks:** The specimen refers in all diagnostic features to *Cycadopites gracilis* Krutzsch.

**Botanical affinity:** Cycadaceae.

*Cycadopites* sp. a
Pl. 9, fig. 22.

**Description:** Monocolpate pollen of elliptical or prolate shape with both rounded and pointed apices in distal polar view. Colpus conspicuous, slightly curved and extending to the apices. Exine 0.5 μm thick, laevigate, with secondary folds due to fossilization.

**Dimensions:** 45 X 30 μm in size.

**Width / length ratio:** 0.66.

**Remarks:** A single specimen was observed, which corresponds with the rare occurrence of other species of the genus *Cycadopites* in the Fayum lignite.

**Botanical affinity:** Cycadaceae.

*Cycadopites* sp. b
Pl. 9, fig. 23.

**Description:** Monocolpate pollen, somewhat ship-shaped or prolate with pointed apices in distal polar view. Colpus slender, slightly sinuous, extending from one apex to the other. Exine 0.5 μm thick, laevigate.

**Dimensions:** 55 X 32 μm in size.

**Width / length ratio:** 0.58.

**Remarks:** A single specimen was found.

**Botanical affinity:** Cycadaceae.
Genus *Monosulcites* Cookson 1947 ex Couper 1953.
Type species: *Monosulcites minimus* Cookson 1947.

*Monosulcites aegyptiacus* n. sp.

Pl. 10, figs. 1–16

*Diagnosis:* Monosulcate pollen of circular to elliptical or oval shape with rounded apices in distal polar view. Sulcus indistinct, slender and curved; extending to both apices and sometimes gaping; open sulci 24–27 μm long x 2–7 μm wide. Exine 1–3 μm thick; ectexine as thick as endexine. Ectexine variably composed of baculate, verrucate and clavate elements (0.7–2 μm long) which altogether create a reticulate or rugulate sculpture in surface view.

*Dimensions:* 33–45 μm in length.
24–36 μm in width.

Width / length ratio: 0.62–0.97.

*Holotype:* Pl. 10, fig. 12; 42 X 31 μm in size; exine baculate-clavate-verrucate sculptural elements are 1.2–2 μm long; surface of exine rugulate or reticulate; sulcus slender, curved, broad, 1 μm wide; width / length ratio: 0.74; no. of specimen: Fayum 1–18 (GN 5318).

*Derivation of name:* After Egypt.

*Remarks:* The new species is quite abundantly distributed. It resembles *Monosulcites palisadus* Couper (1953, p. 65, pl. 8, fig. 132) from the Late Cretaceous of the Kaitangata coal field and new Brighton borehole in New Zealand, but differs in its shape and the ornamentation of the exine.

*Botanical affinity:* Liliaceae, Commelinaceae or Araceae are questionable.

Type species: *Longapertites marginatus* van Hoeken-Klinkenberg 1964.

*Longapertites* sp.

Pl. 11, fig. 1.

*Description:* Monosulcate pollen (?) of triangular shape. Aperture (sulcus) quite indistinct, slender, covering ca. two-thirds of the maximal width of the grain. Exine sculptured by verrucate and baculate elements, 1.5 μm long.

*Dimensions:* 31 X 28 μm in diameter.

*Remarks:* Whether the specimen is correctly combined with the genus *Longapertites* or not, is quite uncertain.
Botanical affinity: Unknown.

Subturma Triptyches Naumova 1939.


Type species: *Quercoidites henrici* (Potonie 1931) Potonie 1960.

*Quercoidites microhenrici* (Potonie) Potonie

Pl. 11, figs. 2 (cf.) – 7.

1931 *Pollenites microhenrici* Potonie, Sitz. Ber. Ges. Naturf. Fr., Nr. 1 – 3, S. 26, Taf. 1, Fig. 19c.
1950 *Quercoidites microhenrici* (R. Pot.), Potonie, Thomson & Thiergart, Geol., Jb., 65, S. 55, Taf. B, Fig. 24–25.
1951 *Quercoipoll.* microhenrici R. Pot., Palaeontographica, B, 91, Taf. 20, Fig. 63–64.
1953 *Tricolpopollenites microhenrici* (R. Pot.) Thomson & Pflug, Palaeontographica, B, 94, S. 96, Taf. 11, Fig. 62–110.
1980 *Tricolpopollenites microhenrici* (R. Potonie 1931) Thomson & Pflug 1953, Thiele-Pfeiffer, Palaeontographica, B, 174, S. 142–143, Taf. 11, Fig. 3–7.
1984 *Tricolpopollenites microhenrici* (R. Potonie 1931) Thomson & Pflug 1953, Mohr, Palaeontographica, B, 191, S. 76, Taf. 11, Fig. 10.1–10.2; Taf. 12, Fig. 1.1–1.2.
1984 *Tricolpopollenites microhenrici* (R. Potonie 1931) Thomson & Pflug 1953, Kirchner, Palaeontographica, B, 192, S. 117, Taf. 6, Fig. 12 a-b.

Diagnostic characters: Tricolpate pollen of elliptical or prolate shape in equatorial view. Exine intrabaculate, 0.5–0.8 μm thick; ectexine double as thick as endexine. The three conpli are narrow and extend in radial symmetry, parallel to each other to the apices where they converge.

Dimensions: 20–31 μm in length.
12–18 μm in width.

Width / length ratio: 0.56–0.64.

Stratigraphic range: Paleocene to Pleistocene in Middle Europe and Middle Tertiary in Nigeria.
Remarks: The specimen shown on pl. 11, fig. 2, is somewhat larger than the other ones. *Quercoidites microhenrici* is quite variable in size and widely distributed.

*Botanical affinity: Quercus.*

*Quercoidites punctatus* n. sp.

Pl. 11, figs. 10-12.

**Diagnosis:** Tricolpate pollen grains. Figura ellipsoidal to broad-ellipsoidal or prolate to subprolate in equatorial view. The three slender colpi are conspicuous, placed in radial symmetry; they extend almost to each other to the apices where they converge. Surface of exine punctate; ectexine intrabaculate; endexine smooth; thickness of exine 1 \( \mu m \).

**Dimensions:** 29–32 \( \mu m \) in length.

21–24 \( \mu m \) in width.

Width / length ratio: 0.65–0.83.

**Holotype:** Pl. 11, fig. 10; 32 \( \times \) 21 \( \mu m \) in size; exine punctate, 1 \( \mu m \) thick; ectexine intrabaculate; endexine smooth; width / length ratio = 0.656; no. of specimen: Fayum 1–18 (GN 5318).

**Name derivation:** punctatus (lat.) = marked with dots, punctate.

**Remarks:** The new species resembles both *Quercoidites microdensus* Takahashi & Jux (1982, pp. 42–43, Taf. 5, Fig. 1–7) from the Middle Oligocene of Bergisch Gladbach, W-Germany and *Tricolpopollenites densus* Pflug (Thomson & Pflug, 1953, p. 96, Taf. 11, Fig. 55–58) from the Paleocene to Early Oligocene of Germany, however, it differs from the first in its larger size and otherwise composed structure of the exine, and from the second in the sculpture as well as the structure of the exine.

*Botanical affinity: Probably Cupuliferae.*


*Cupuliferoidaepollenites liblarensis* (Thomson) Potonie

Pl. 11, fig. 8.

1950 *Pollenites liblarensis* Thomson, Potonie, Thomson & Thiergart, Geol. Jb., 65, S. 55, Taf. 5, Fig. 26–27.

1953 *Tricolpopollenites liblarensis* (Thomson) Thomson & Pflug liblarensis (Thomson) Thomson & Pflug, Palaeontographica, B, 94, S. 96–97, Taf. 11, Fig. 111–132.

1960 *Cupuliferoidaepollenites liblarensis* (Thomson) Potonie, Beih. Geol. Jb., 39, S. 92, Taf. 6, Fig. 94.


1984 *Cupuliferaidae pollenites liblarensis* (Thomson) Potonié, Takahashi & Jux, Bull. Fac. Liberal Arts, Nagasaki Univ., Nat. Sci., vol. 26, no. 2, pp. 131–132, Taf. 22 Fig. 22; Taf. 27, Fig. 14.


**Diagnostic characters:** Tricolpate pollen of elliptical or prolate shape in equatorial view. The three slender colpi are quite distinct, symmetrically arranged and parallel to each other. Exine 0.5 μm thick, weakly intrabaculate.

**Dimensions:** 19 X 12 μm in size.

Width / length ratio: 0.63.

**Stratigraphic range:** Early Eocene to Plio-Pleistocene in Middle and Late Paleocene in West Europe.

Germany: Middle Eocene (Niedersachsen); Middle Eocene-Late Eocene (Messel bei Darmstadt); Late Eocene-Early Oligocene (Hessen); Middle Oligocene (Bergisch Gladbach); Oligocene (Hessen); Late Oligocene (St. Augustin, oberbayerische Faltenmolasse); Miocene (Hessen, Rhine land. Oberpfalz); Pliocene (Hessen); Pliocene / Pleistocene (Hessen).

Hungary: Early Eocene (Hlimba); Middle Eocene (Dorog, Dudar); Late Eocene (Budakeszi, Csillaghgy, Mátyás); Miocene-Pliocene (Mecsek. Mts.).

France: Late Paleocene (Menat).

**Remarks:** The single specimen which was encountered is identical with *Cupuliferaidae pollenites liblarensis* (Thomson) Potonié.

**Botanical affinity:** Cupuliferae.
Cupuliferoidaepollenites fallax (Potonié) Potonié

Pl. 11, fig. 9.

1934 Pollenites fallax Potonié, Arb. Inst. Paläbot. Petrogr. Brennst., 4, Taf. 70, Fig. 10.
1951 Cupuliferoidaepollenites fallax Potonié, Palaeontographica, B, 91, Taf. 20, Fig. 66.
1953 Tricolopollenites liblarensis (Thomson) Thomson & Pflug fallax (Potonié) Thomson & Pflug, Palaeontographica, B, 94, S. 97, Taf. 11, Fig. 133–151.
1977 Tricolopollenites fallax (R. Pot. 1934) W. Kr. 1960, Palaeontographica, B, 163, S. 70, Taf. 29, Fig. 36–40.
1979 Cupuliferoidaepollenites fallax (Potonié) Takahashi, Takahashi & Kim, Palaeontographica, B, 170, P. 38, pl. 9, figs. 21 (?), 22–23.
1984 Tricolopollenites liblarensis (Thomson in R. Potonié, Thomson & Thiergart 1950) Thomson & Pflug 1953 ssp. fallax (R. Potonié 1934) Thomson & Pflug 1953, Kirchner, Palaeontographica, B, 192, S. 118, Taf. 6, Fig. 15a-b.
1985 Tricolopollenites liblarensis (Thomson 1950) Th. et Pf. 1953 ssp. fallax (R. Pot. 1934) Th. et Pf. 1953, Nagy, Geol. Hung., Fas. 47, p. 201, pl. CXV, Fig. 5–6
1986 Cupuliferoidaepollenites liblarensis (Potonié) Potonié, Takahashi & Jux, Bull. Fac. Liberal Arts, Nagasaki Univ., Nat. Sci., vol. 26, no. 2, pp. 132–133, Taf. 22, Fig. 21; Taf. 27, Fig. 15–16.

Diagnostic characters: Tricolpate pollen of elliptical or prolate shape in equatorial view. The three slender colpi are arranged in radial symmetry and parallel to each other. Exine thin, laevigate.

Dimensions: 16 X 10 μm in size.

Width / length ratio: 0.625.

Stratigraphic range: Paleocene to Plio-Pleistocene in Middle Europe and Middle Eocene to Miocene in the Far East.

Germany: Paleocene (Wehmingen bei Sarstedt); Middle Eocene-Late Eocene (Messel bei Darmstadt); Middle Eocene (Niedersachsen); Late Eocene-Early Oligocene (Hessen); Middle Oligocene (Bergisch Gladbach); Late Oligocene (St. Augustin, oberbayerische Faltenmolasse); Oligocene (Hessen); Miocene (Hessen, Rhine land. Oberpfalz); Pliocene (Frankfurt-Rödelheim, Wallensen); Pliocene / Pleistocene (Hessen).

Hungary: Middle Miocene (Mecsek Mts.).
Japan: Middle Eocene-Miocene (Kyushu).
Korea: Middle Miocene (Yonil).
Remarks: A single specimen was recognized.
Botanical affinity: Cupuliferae.

Genus Tricolpopollenites Pflug & Thomson 1953
Type species: Tricolpopollenites parmularis (Potonié 1934) Thomson & Pflug 1953.

Tricolpopollenites chagrenatus n. sp.
Pl. 11, figs. 13–15.

Diagnosis: Tricolpate pollen of either elliptical to broad-elliptical or prolate to sub-prolate shape in equatorial view. Three conspicuous colpi are arranged in radial symmetry. The colpi converge at the apices; they may be provided with a geniculus. Exine 1 µm thick, chagrenate.
Dimensions: 23–29 µm in length.
19–23 µm in width.
Width / length ratio: 0.7–0.83.
Holotype: Pl. 11, fig. 14; 23 X 19 µm in size; exine 1 µm thick, chagrenate; ectexine as thick as endexine; width / length ratio = 0.826; no. of specimen: Fayum 1 -17 (GN 5317).
Name derivation: chagrenatus (from chagrin, fr.) = like scarred leather.
Remarks: Tricolpopollenites chagrenatus n. sp. is somewhat alike T. asper Pflug & Thomson (1953, p. 96, Taf. 11, Fig. 43–49) from the Tertiary of Germany, but can be distinguished by the different shapes.
Botanical affinity: Probably Cupuliferae.

Tricolpopollenites aequatoripunctatus n. sp.
Pl. 11, figs. 16–24.

Diagnosis: Tricolpate pollen of elliptical or prolate shape with pointed pole cap in equatorial view. The three colpi appear to be rather narrow, although conspicuous; they are arranged in radial symmetry and converge at the poles. Exine 0.5–1.5 µm thick, chagrenate, noticeable punctate in equatorial zone.
Dimensions: 25–31 µm in length.
14–23 µm in width.
Width / length ratio: 0.466–0.74.
Holotype: Pl. 11, fig. 16; 31 X 22 µm in size; exine chagrenate, 1.5 µm thick,
especially punctated in equatorial zone; width / length ratio = 0.71; no. of specimen: Fayum 1–17 (GN 5317).

*Derivation of name:* *aequator* from aequare (lat.) = equator; *punctatus* (lat.) = marked with dots, punctate.

*Remarks:* *Tricolpopollenites aequatoripunctatus* n. sp. can be distinguished from all species of the genus due to the restriction of its punctate sculpture to the equatorial zone.

*Botanical affinity:* Unknown.

*Tricolpopollenites lanceolatus* n. sp.

Pl. 12, figs. 2–4.

*Diagnosis:* Tricolpate pollen of lanceolate or prolate shape in equatorial view. The three narrow colpi extend in radial symmetry and parallel to each other to the apices, where they converge. Exine finely punctate to chagrenate, 0.5 μm thick.

*Dimensions:* 26–29 μm in length.
10–13 μm in width.

Width / length ratio: 0.385–0.48.

*Holotype:* Pl. 12, fig. 2; 29 X 13 μm in size; exine thin, finely punctate; width / length ratio = 0.45; no. of specimen: Fayum 1–19 (GN 5319).

*Derivation of name:* *lanceolatus* (lat.) = narrow and tapering like the head of a lance, lanceolate.

*Remarks:* *Tricolpopollenites lanceolatus* n. sp. is narrower than any other species of the genus previously described.

*Botanical affinity:* Unknown.

*Tricolpopollenites pseudoasper* n. sp.

Pl. 12, figs. 5–9.

*Diagnosis:* Tricolpate pollen of either elliptical to broad-elliptical or prolate to subprolate shape in equatorial view. Three slender colpi narrow, radially symmetrical and parallel to each other, converge almost at the apices. Exine thin, less than 0.5 μm thick, chagrenate.

*Dimensions:* 17–22 μm in length.
12–17 μm in width.

Width / length ratio: 0.68–0.82.

*Holotype:* Pl. 12, fig. 6; 21 X 17 μm in size; exine 0.5 μm thick, chagrenate; width / length ratio = 0.81; no. of specimen: Fayum 1–18 (GN 5318).
Derivation of name: pseudo (gr.) = false; asper (lat.) = rough.

Remarks: The new species resembles both Tricolpopollenites asper Pflug & Thomson from the Tertiary of Germany and Tricolpopollenites subasper Takahashi from the Eocene of West Japan, but differs from the first in its smaller size as well as the somewhat narrower form and thinner exine and from the second in its larger size, and relatively narrower shape and thinner exine.

Botanical affinity: Probably Cupuliferae.

Tricolpopollenites inamoenus Takahashi

Pl. 11, fig. 26.

Previous records: Eocene to Oligocene in West and North Japan and Late Oligocene in West Germany.

Remarks: The only specimen which was observed is alike Tricolpopollenites inamoenus Takahashi from Japan and from West Germany.

Botanical affinity: Cupuliferae (?).

Tricolpopollenites subasper Takahashi

Pl. 11, fig. 27.
Diagnostic characters: Tricolpate pollen of subcircular shape in polar sight. Three slender colpi gape. Exine thin, chagrenate.

Dimensions: 20 µm in diameter.

Previous records: Eocene in West Japan and Late Oligocene in West Germany.

Remarks: A single specimen was encountered which is undoubtedly Tricolpopollenites subasper Takahashi.

Botanical affinity: Probably Cupuliferae.

*Tricolpopollenites meinohamensis* Takahashi *meinohamensis*

Pl. 11, fig. 25.


Diagnostic characters: Tricolpate pollen grain. Figura broad-elliptical or subprolate in equatorial view. The three slender colpi are arranged in radial symmetry and extend parallel to each other towards the apices where they gradually converge. Exine thin, punctate or chagrenate.

Dimensions: 36 × 28 µm in size.

Width / length ratio: 0.78.

Previous records: Middle Oligocene to Middle Miocene in West Japan and Middle Miocene in Korea.

Remarks: The only specimen detected matches *Tricolpopollenites meinohamensis* Takahashi *meinohamensis* in all diagnostic features.


*Tricolpopollenites sp.*

Pl. 11, fig. 28.

Description: Tricolpate pollen originally of rather circular contour in equatorial view. Three slender colpi gradually converging at the apices. Exine baculate, 1 µm high, highly crumpled during fossilization.

Dimensions: 31 × 23 (?) µm in size.

Remarks: The single specimen which was observed is so badly preserved that identification below generic level appears to be impossible.

Botanical affinity: Unknown.

Type species: *Ranunculacidites communis* Sah 1967.

*Ranunculacidites contaminatus* Takahashi & Jux

Pl. 11, figs. 29–30; pl. 12, figs. 30–32.


*Diagnostic characters:* Tricolpate pollen of globular shape in both equatorial and polar views. Three colpi which are generally disclosed in a plug-like manner; they are radially placed and converge gradually towards the poles; a geniculus may be developed. Exine 0.8–1 μm thick; ectexine intrabaculate; endexine smooth; punctate along the colpi.

*Dimensions:* 26–27 X 24 μm in size.

22–27 μm in equatorial diameter.

Width / length ratio: 0.89–0.92.

*Previous record:* Middle Tertiary in Nigeria (Jos Plateau).

*Remarks:* All the specimens described from Nigeria (Jos Plateau) were figured in polar view, whereas the Fayum specimens are shown in equatorial as well as polar sights. Nevertheless, *Ranunculacidites contaminatus* Takahashi & Jux from Nigeria corresponds quite with the Egyptian specimens.

*Botanical affinity:* Labiatae, Ranunculaceae or Punicaceae.

Genus *Striatopollis* Krutzsch 1959.

Type species: *Striatopollis sarstedtensis* Krutzsch 1959.

*Striatopollis striatellus* (Takahashi) Takahashi

Pl. 12, figs. 10–11.

1961 *Tricolopollenites striatellus* Takahashi, Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol., vol. 11, no. 3, p. 319, Taf. 23, Fig. 50–51.

1979 *Striatopollis striatellus* (Takahashi) Takahashi, Takahashi & Kim, Palaeontographica, B, 170, p. 39, pl. 9, figs. 25–29.

1986 *Striatopollis striatellus* (Takahashi) Takahashi, Takahashi & Jux, Bull. Fac. Liberal Arts, Nagasaki Univ., Nat. Sci., vol. 26, no. 2, p. 145, Taf. 23, Fig. 11–12; Taf. 27, Fig. 13.

**Diagnostic characters:** Tricolpate pollen grains. Figura ellipsoidal or perprolate in equatorial view. Three conspicuous colpi arranged in symmetry and parallel to each other, converging at the apices. Exine two-layered, less than 1 μm thick, very delicately striated.

**Dimensions:** 25–30 μm X 11–14 μm in size.

**Width / length ratio:** 0.44–0.47.

**Previous records:** Eocene to Early Miocene in West Japan, Early and Middle Miocene in Korea, Late Oligocene in West Germany and Middle Tertiary in Nigeria.

**Remarks:** The two specimens from the Fayum are perprolate and refer quite well to *Striatopollis striatellus* (Takahashi) Takahashi.

**Botanical affinity:** Unknown.


Type species: *Tricolpites reticulatus* Cookson 1947 ex Couper 1953.

*Tricolpites retiformis* (Pflug & Thomson) Takahashi & Jux

Pl. 12, figs. 15–16, 18.

1953 *Tricolpoidites retiformis* Pflug & Thomson, Thomson & Pflug, Palaeontographica, B, 94, S. 97, Taf. 11, Fig. 59–61.

1980 *Tricolpoidites retiformis* Thomson & Pflug 1953, Thiele-Pfeiffer, Palaeontographica, B, 174, S. 144–145, Taf. 11, Fig. 19–21.


1984 *Tricolpopollenites retiformis* Thomson & Pflug 1953, Mohr, Palaeontographica, B, 191, S. 77, Taf. 12, Fig. 9.1 u. 9.2.


**Diagnostic characters:** Tricolpate pollen of elliptical or prolate shape with pointed pole cap in equatorial view. Three slender colpi narrow, converging at the poles. Exine finely reticulate; lumina of reticulum very narrow, less than 0.5 μm in diameter; muri baculate, 0.5–1 μm long.

**Dimensions:** 21–23 μm X 12–14 μm in size.

**Width / length ratio:** 0.52–0.67.

**Stratigraphic range:** Early Eocene to Pliocene / Pleistocene in Middle Europe.

Germany: Middle Eocene (Niedersachsen); Late Eocene-Early Oligocene (Hessen); Middle Oligocene (Bergisch Gladbach); Oligocene (Hessen);
Miocene (Hessen, Oberpfalz); Late Miocene-Early Pliocene (Rhine land);
Pliocene (Hessen); Pliocene / Pleistocene (Hessen).

Hungary: Early Eocene (Halimba); Middle Eocene (Dorog, Dudar).

Remarks: *Tricolpites retiformis* (Pflug & Thomson) Takahashi & Jux can easily be recognized from the delicately reticulated and baculate sculptures.

*Botanical affinity: Salicaceae, Salix.*

**Tricolpites minutireticulosus** Takahashi

Pl. 12, fig. 17.

1979 *Tricolpites minutireticulosus* Takahashi, Takahashi & Kim, Palaeontographica, B, 170, Lfg. 1–3, p. 40, pl. 10, figs. 5–8.

*Diagnostic characters:* Tricolpate pollen of oval or subprolate contour in equatorial view. Three conspicuous colpi in parallel arrangement. Exine finely reticulate; in optical section the exine reveals an intrabaculate structure, 0.5 μm thick; lumina of reticulum 0.5 ± μm in diameter.

*Dimensions:* 19 X 15 μm in size.

Width / length ratio: 0.79.

*Previous record:* Early and Middle Miocene in Korea.

*Remarks:* A single specimen was observed.

*Botanical affinity: Salix or Platanus.*

**Tricolpites sp. a**

Pl. 12, fig. 1.

*Description:* Tricolpate pollen grain of oval outline in equatorial sight. Three narrow colpi grouped in radial symmetry and nearly parallel to each other but gradually at the apices. Exine delicately reticulated; lumina of reticulum less than 0.5 μm in diameter; muri of somewhat baculate composition 0.5 μm long.

*Dimensions:* 31 X 24 μm in size.

Width / length ratio: 0.77.

*Remarks:* Only one specimen was found.

*Botanical affinity: Unknown.*

**Tricolpites sp. b**

Pl. 12, figs. 19 a-b.
Description: Tricolpate pollen of subprolate outline in equatorial view. The three slender colpi are deeply engraved and extend parallel to each other to the apices where they gradually converge. Exine finely reticulate; lumina of reticulum 0.5 ± μm in diameter; muri baculate, 0.5 μm long.

Dimensions: 26 X 20 μm in size.

Width / length ratio: 0.77.

Remarks: The single specimen which was observed is rather similar to Tricolpites sp. c (this paper, pl. 12, fig. 20), but differs in the parallel arrangement of its three colpi and its more oval shape.

Botanical affinity: Salix.

Tricolpites sp. c
Pl. 12, fig. 20.

Description: Tricolpate pollen of ellipsoidal or prolate shape exhibiting pointed apices in equatorial view. The three conspicuous colpi are rather narrow; they converge in symmetry towards the poles. Exine finely reticulate; lumina of reticulum 0.5 μm in diameter or even less; muri baculate 0.5 μm long.

Dimensions: 29 X 19 μm in size.

Width / length ratio: 0.66.

Remarks: Only one specimen was found.

Botanical affinity: Salix.

Genus Polycolpites Couper 1953.
Type species: Polycolpites clavatus Couper 1953.

Polycolpites sp. a
Pl. 12, fig. 12.

Description: Tetracolpate pollen grain. Figura ellipsoidal or prolate with hemispherical to subhemispherical pole cap in equatorial view. Four slender colpi rather indistinct, radially symmetrical and extending parallel to each other. Exine intrabaculate, 1.2 μm thick on apocolpia, delicately punctated in the equatorial zone only; endexine thin.

Dimensions: 28 X 20 μm in size.

Width / length ratio: 0.71.

Remarks: Only one specimen is figured.
Botanical affinity: Unknown.

*Polycolpites* sp. b
Pl. 12, figs. 14a-b.

*Description:* Pentacolpate pollen grain. Figura subprolate in equatorial view. The five slender colpi are rather narrow; they extend parallel to each other and converge somewhat towards the poles. Exine chagrenate, 1 \( \mu \text{m} \) thick.

*Dimensions:* 33 X 27 \( \mu \text{m} \) in size.

Width / length ratio: 0.82.

*Remarks:* It appeared to be not reasonable to identify the single specimen which was observed with five colpi below generic level.

Botanical affinity: Unknown.

? *Polycolpites* sp.
Pl. 12, figs. 13a-b.

*Description:* Tetracolpate (?) pollen grain. Figura ellipsoidal or prolate with pointed pole cap in equatorial view. The four (?) colpi so strong as they may be are quite obscure; they converge towards the poles, 1.5 \( \mu \text{m} \) wide. Exine two-layered, chagrenate, 1.5 \( \mu \text{m} \) thick; ectexine as thick as endexine.

*Dimensions:* 34 X 22 \( \mu \text{m} \) in size.

Width / length ratio: 0.65.

*Remarks:* As the specimen may be furnished with four colpi, reference to the genus *Polycolpites* is quite doubtful.

Botanical affinity: Unknown.

Subturma Ptychotriporines Naumova 1939.
Infraturma Prolati Erdtman 1934
Type species: *Cupuliferoipollenites pusillus* (Potonié 1934) Potonié 1960.

*Cupuliferoipollenites* cf. *pusillus* (Potonié) Potonié
Pl. 12, figs. 25–26.

1951 *Cupuliferoipollenites pusillus* Potonié, Palaeontographica, B, 91, Taf. 20, Fig. 69.
1953 *Tricolporopollenites cingulum* (Potonii) Thomson & Pflug *pusillus* (Potonii) Thomson & Pflug, Palaeontographica, B, 94, S. 100, Taf. 12, Fig. 28–41.

1960 *Cupuliferoipollenites pusillus* (Potonii) Potonii, Beih. Geol. Jb., 39, S. 98, Taf. 6, Fig. 111.


1982 *Cupuliferoipollenites pusillus* (R. Pot. 1934) R. Pot. 1960, Kedves, Palaeontographica, B, 182, S. 126, Taf. 15, Fig. 5,6.


**Diagnostic characters**: Tricolporate pollen grains. Figura ellipsoidal or prolate with pointed or hemispherical pole cap in equatorial view. The three slender colpi are narrow; they extend in radial symmetry and parallel to each other towards the poles where they appear to converge. Exine two-layered, 1 μm thick, chagrenate. Germinial pores more or less equatorially elongated.

**Dimensions**: 21–22 μm X 12–14 μm in size.

Width / length ratio: 0.54–0.66.

**Stratigraphic range**: Paleocene to Pliocene / Pleistocene in Middle and Late Paleocene in West Europe.

Germany: Paleocene-Early Eocene (Niedersachsen); Middle Eocene (Niedersachsen); Middle Eocene-Late Eocene (Messel bei Darmstadt); Late Eocene-Early Oligocene (Hessen); Middle Oligocene (Bergisch Gladbach); Oligocene (Hessen); Late Oligocene (St. Augustin, oberbayerische Faltenmolasse); Miocene (Hessen, Oberpfalz, Rhine land); Miocene-Pliocene (Rhine land); Pliocene (Hessen); Pliocene / Pleistocene (Hessen).

Hungary: Early Eocene (Halimba); Middle Eocene (Dorog, Dudar, Lábatlan, Tatabánya etc.); Late Eocene (Budakeszi, Csillaghegy, Mátyas); Miocene (Szokolya, Fót, Beremend).

France: Late Paleocene (Menat).

**Remarks**: The species is rather seldom in the Fayum lignite.
Botanical affinity: Fagaceae, Castanopsis.

Genus *Tricolporopollenites* Pflug & Thomson 1953.
Type species: *Tricolporopollenites dolium* (Potonié 1931) Thomson & Pflug 1953.

*Tricolporopollenites microporifer* Takahashi
Pl. 12, figs. 22, 24.

1979 *Tricolporopollenites microporifer* Takahashi, Takahashi & Kim, Palaeontographica, B, 170, Lfg. 1–3, p. 43, pl. 13, fig. 9.

Diagnostic characters: Tricolporate pollen of ellipsoidal or prolate to subprolate shape with pointed or hemispherical pole cap in equatorial view. Three conspicuous colpi radially symmetrical, converging towards the poles. Caverna 2 µm wide. Exine 0.5–2 µm thick, chagренate. Pores small, round.

Dimensions: 23–24 µm X 13–19 µm in size.

Width / length ratio: 0.54–0.83.

Previous records: Paleogene in Japan and Early Miocene in Korea.

Remarks: The specimen figured on pl. 12 (fig. 22) is a broad-ellipsoidal variety and not well preserved.

Botanical affinity: Unknown.


*Intrabaculitricolporites consularis* (Takahashi) Takahashi & Jux
*globularis* (Takahashi) Takahashi & Jux

Pl. 12, fig. 28.

1961 *Tricolporopollenites consularis* Takahashi, Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol., vol. 11, no. 3, p. 323, Taf. 24, Fig. 53–54 (pro parte).
1979 *Tricolporopollenites consularis* Takahashi subsp. *globularis* Takahashi, Takahashi & Kim, Palaeontographica, B, 170, Lfg. 1–3, p. 41, pl. 10, figs. 28–30; pl. 11, figs. 1, 3–10.
Diagnostic characters: Tricolporate pollen grain. Figura broad-ellipsoidal or sub-prolate in equatorial view. Three conspicuous colpi in radial symmetry and parallel to each other; caverna deep. Exine two-layered, intrabaculate, 1.5 μm thick. Ger-minal pores elongated meridionaly.

Dimensions: 28 X 24 μm in size.

Width / length ratio: 0.86.

Previous records: Early Oligocene to Early Miocene in Japan, Middle Miocene in Korea and Middle Tertiary in Nigeria.

Remarks: *Intrabaculitricolporites consularis globularis* is somewhat alike *I. sazveyensis* Pflug n. comb. from the Paleocene to Early Eocene of the Antweiler Graben, F.R.G.

Botanical affinity: Unknown.

*Intrabaculitricolporites cf. affinis* Takahashi & Jux

Pl. 12, fig. 29.


Diagnostic characters: Tricolporate pollen of spheroidal shape in equatorial view. The three slender colpi are quite distinct, yet narrow; they are placed in radial symmetry and converge towards the apices; germinal pores are equatorially elongated. Exine two-layered, intrabaculate, 1 μm thick.

Dimensions: 29 X 26 μm in size.

Width / length ratio: 0.896.

Previous record: Middle Tertiary in Nigeria.

Remarks: The only specimen which was detected is definitely alike *Intrabaculitricolporites affinis* Takahashi & Jux from the Middle Tertiary of Jos, Nigeria.

Botanical affinity: Unknown.


*Rutaceoipollenites subtropicus* n. sp.

Pl. 13, figs. 1-8.

Diagnosis: Tricolporate pollen grains. Figura either ellipsoidal to broadly oval or prolate to subprolate with pointed to hemispherical pole cap in equatorial view. The
three narrow colpi are conspicuous (1 - 3.5 μm wide) and arranged in radial symmetry; they converge towards the poles and are furnished with pores which cross the colpi equatorially; pores 4 - 6 μm long. Exine 0.5 - 2.2 μm thick, chagrenate; ectexine of rather feeble intrabaculate structure; endexine smooth.

**Dimensions:** 31 - 40 μm in length.
24.5 - 28 μm in width.
Width / length ratio: 0.61 - 0.89.

**Holotype:** Pl. 13, fig. 4; 35 X 26.5 μm in size; exine chagrenate, 1.2 μm thick on equatorial faces, 1.7 μm thick on apocolpia; ectexine weakly intrabaculate; pores equatorially elongated, 6 μm long; width / length ratio: 0.76; no of specimen: Fayum 1 - 19 (GN 5319).

**Derivation of name:** sub (lat.) = under; tropicus (lat.) = tropical. Designation for the region bordering the tropical zone.

**Remarks:** Sun (1978) described the genus *Rutaceoipollenites*, without indicating a type species. Therefore, Jansonius & Hills (1979) typified *Rutaceoipollenites zekouensis* Ma. In spite of this, Song & Tsao (1981) attested *Rutaceoipollenites ovatus* Song & Tsao the rank of a type species, although the genus *Rutaceoipollenites* was already valid before their description.

The present specimens are similar to *Rutaceoipollenites ovatus* Song & Tsao from the Oligocene Sanduo Formation of Jiangsu, China, but differ in its larger sizes.

**Botanical affinity:** Rutaceae.

*Rutaceoipollenites* sp.

Pl. 13, fig. 9.

**Description:** Tricolporate pollen of spheroidal shape in equatorial view. The three slender colpi are narrow and indistinct; they are placed parallel to each other and exhibit equatorially elongated pores; pores 5 - 6 μm long. Exine chagrenate, 0.5 μm thick.

**Dimensions:** 36 X 34 μm in size.
Width / length ratio: 0.94.

**Remarks:** The Fayum specimen is comparable with both *Rutaceoipollenites lentiporus* Ke et Shi and *Rutaceoipollenites oblongatus* Sung & Tsao from the Oligocene Sahejie Formation of the coastal region of Bohai, China. It can be distinguished from the first by its thinner exine and from the second by its globular shape as well as its thinner exine.

**Botanical affinity:** Rutaceae.
Genus *Rhoipites* Wodehouse 1933.
Type species: *Rhoipites bradleyi* Wodehouse 1933.

*Rhoipites rotundus* n. sp.
Pl. 13, figs. 15–22.

*Diagnosis:* Tricolporate pollen grains. Figura spheroidal to oval in equatorial and polar views. The three slender colpi are narrow but quite distinct; they are placed in radial symmetry and extend almost parallel to the poles where they may converge. Exine very finely reticulated; lumina of reticulum 0.5–1.5 μm in diameter; muri baculate, 0.5–0.7 μm long. Pores small, round (1–1.5 μm in diameter) and provided with costa pori.

*Dimensions:* 18–20 μm X 16–18 μm in size in equatorial view.
15–22 μm in diameter in polar view.
Width / length ratio: 0.89–1.0.

*Holotype:* Pl. 13, fig. 19; 18 X 18 μm in size; exine very finely reticulate; lumina ca. 0.5 μm in diameter; muri baculate, 0.7 μm long; pores small, round, 1 μm in diameter, with costa pori; width / length ratio = 1.0; no. of specimen: Fayum 1–17 (GN 5317).

*Name derivation:* rotundus (lat.) = round.

*Remarks:* The new species resembles very much *Rhoipites* (al. *Retritricolporites*) *misellus* Takahashi n. comb. from the Early and Middle Miocene of the Yeoungill Bay district in Korea, but differs because of its costa pori.

*Botanical affinity:* Celastraceae, *Celastrus*.

*Rhoipites* sp. a
Pl. 12, fig. 27.

*Description:* Tricolporate pollen of fusiform shape in equatorial sight. The three slender colpi are narrow and symmetrically placed; they converge at the poles. Exine very finely reticulate; lumina of reticulum less than 0.5 μm in diameter; muri 0.5 μm long. Pores very small, round.

*Dimensions:* 19 X 10 μm in size.
Width / length ratio: 0.53.

*Remarks:* A single specimen was discovered.

*Botanical affinity:* Unknown.

*Rhoipites* sp. b
Pl. 13, fig. 13.

Description: Tricolporate pollen grain. Figura ellipsoidal or prolate with pointed pole cap in equatorial view. Three narrow colpi, which are conspicuous, converge near to the poles. Exine reticulate; reticulum polygonal; lumina 0.5—1.5 μm in diameter; muri baculate, 0.5 μm long. Pores round, 3 μm in diameter.
Dimensions: 30 X 20 μm in size.
Width / length ratio: 0.67.
Remarks: The only specimen encountered could not be identified below generic level.
Botanical affinity: Unknown.

Rhoipites sp. c
Pl. 13, fig. 14.

Description: Tricolporate pollen grain. Figura ellipsoidal or prolate with hemispherical pole cap in equatorial view. Three slender colpi are narrowly built, radially symmetrical and converge to the poles. Exine reticulate; reticulum polygonal; lumina 2—2.5 μm in diameter; muri baculate, 1 μm long. Pores meridionally elongated.
Dimensions: 37 X 27 μm in size.
Width / length ratio: 0.73.
Remarks: It appeared to be unreasonable to identify the single specimen specifically.
Botanical affinity: Unknown.

Genus Foveotricolporites Pierce 1961.
Type species: Foveotricolporites rhombohedralis Pierce 1961.

Foveotricolporites sp.
Pl. 13, fig. 12.

Description: Tricolporate pollen grain of oval or subprolate shape in equatorial view. Three narrow colpi which are placed in radial symmetry converge to the poles. Exine foveolate; lumina less than 1 μm in diameter; muri baculate, 0.7 μm long. Pores meridionally elongated.
Dimensions: 19 X 15 μm in size.
Width / length ratio: 0.79.
Remarks: The present specimen is comparable with Foveotricolporites caldensis González Guzmán (1967) from the Early Eocene of Tibu area, Colombia, but differs in
its more delicate reticulum and its thinner exine.

*Botanical affinity:* Unknown.


Genus *Tetracolporopollenites* Pflug & Thomson 1953.

Type species: *Tetracolporopollenites sapotoides* Pflug & Thomson 1953.

*Tetracolporopollenites globosus* n. sp.

Pl. 13, figs. 10–11.

*Diagnosis:* Tetracolporopollenites pollen grains. Figura spheroidal to subprolate in equatorial view. The four colpi are slender and narrow; they are radially symmetrical and parallel to each other, gradually converging towards the apices. Exine two-layered, 0.8–1 μm thick; surface of exine chagrenate. The four germinal pores are lalongated to form slits (5–6 μm long).


*Width / length ratio:* 0.86–0.97.

*Holotype:* Pl. 13, fig. 10; 32 X 31 μm in size; exine chagrenate, 0.8 μm thick; four slender colpi narrow; four lalongate pores forming slits (5–6 μm long); width / length ratio = 0.97; no. of specimen: Fayum 1–18 (GN 5318).

*Derivation of name:* globosus (lat.) = round as a ball.

*Remarks:* The new species is somewhat similar to *Rutaceoipollenites subtropicus*, but can easily be distinguished by the four colpi and ora. Nevertheless, the construction of the geriminal pores is alike. By this, the new species exposes dissimilarities when compared with the sapotoid variety of *Tetracolporopollenites*.

*Botanical affinity:* Rutaceae or ? Sapotaceae.

Genus *Polycolporopollenites* Kedves 1965.

Type species: *Polycolporopollenites ellipticus* Kedves 1965.

*Polycolporopollenites* sp.

Pl. 13, figs. 23a-b.

*Description:* Hexacolporate pollen grain. Figura broad-ellipsoidal or subprolate in equatorial view. There are six narrow colpi, rather conspicuous and converging towards the poles. Exine two-layered, more or less laevigate, 1.3 μm thick; endexine thin. The six pores are small and somewhat equatorially elongated.

*Dimensions:* 37 X 30 μm in size.
Width / length ratio: 0.81.

Remarks: The single specimen which was observed should not yet be indentified below generic level.

Botanical affinity: Unknown.

**Palynomorphs from the Qasr El Sagha Formation in Fayum Oasis**

<table>
<thead>
<tr>
<th>Trilete spores:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Leiotriletes apleles (Hunger) Krutzsch</td>
<td>(v. rare)</td>
</tr>
<tr>
<td>(2) Monoleiotriletes angustus Krutzsch</td>
<td>(few)</td>
</tr>
<tr>
<td>(3) Deltoidospora sp.</td>
<td>(v. rare)</td>
</tr>
<tr>
<td>(4) ? Concavisporites sp.</td>
<td>(rare)</td>
</tr>
<tr>
<td>(5) Undulatisporites fayumensis n. sp.</td>
<td>(few)</td>
</tr>
<tr>
<td>(6) Undulatisporites sp.</td>
<td>(v. rare)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monolete spores:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(7) Laevigatosporites aegyptiacus n. sp.</td>
<td>(abundant)</td>
</tr>
<tr>
<td>(8) Laevigatosporites undulatus n. sp.</td>
<td>(few)</td>
</tr>
<tr>
<td>(9) Laevigatosporites dehiscens Takahashi</td>
<td>(common)</td>
</tr>
<tr>
<td>(10) Laevigatosporites ovoideus Takahashi</td>
<td>(rare)</td>
</tr>
<tr>
<td>(11) Latosporites rotundus n. sp.</td>
<td>(rare)</td>
</tr>
<tr>
<td>(12) Latosporites sp.</td>
<td>(rare)</td>
</tr>
<tr>
<td>(13) Verrucatosporites cf. tenellis (Krutzsch) Krutzsch</td>
<td>(v. rare)</td>
</tr>
<tr>
<td>(14) Verrucatosporites minutiverrucatus n. sp.</td>
<td>(v. rare)</td>
</tr>
<tr>
<td>(15) Verrucatosporites sp.</td>
<td>(v. rare)</td>
</tr>
<tr>
<td>(16) Extrapunctatosporis pseudomiocaenicus n. sp.</td>
<td>(v. rare)</td>
</tr>
<tr>
<td>(17) Extrapunctatosporis fayumensis n. sp.</td>
<td>(v. rare)</td>
</tr>
<tr>
<td>(18) Extrapunctatosporis sp. a</td>
<td>(v. rare)</td>
</tr>
<tr>
<td>(19) Extrapunctatosporis sp. b</td>
<td>(v. rare)</td>
</tr>
<tr>
<td>(20) Extrapunctatosporis sp. c</td>
<td>(v. rare)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inaperturate pollen:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(21) Inaperturopollenites dubius (Potonié &amp; Venitz) Thomson &amp; Pflug</td>
<td>(few)</td>
</tr>
<tr>
<td>(22) Inaperturopollenites laevigatus Takahashi</td>
<td>(few)</td>
</tr>
<tr>
<td>(23) Inaperturopollenites minimus Takahashi &amp; Jux</td>
<td>(few)</td>
</tr>
<tr>
<td>(24) Psophosphaera aggereloides (Maljavkina) Chlonova</td>
<td>(abundant)</td>
</tr>
<tr>
<td>(25) Cupressacites cf. bockwitzensis Krutzsch</td>
<td>(v. rare)</td>
</tr>
<tr>
<td>(26) Cupressacites africanus n. sp.</td>
<td>(few)</td>
</tr>
<tr>
<td>(27) Potamogetonacidae paluster (Manten) Mohr</td>
<td>(few)</td>
</tr>
</tbody>
</table>
Monoporate pollen:
- ➡️ *Graminidites subtiliglobosus* (Trevisan) Krutzsch (v. rare)
- ➡️ *Graminidites laevigatus* Krutzsch (v. rare)
- ➡️ *Graminidites* sp. a (v. rare)
- ➡️ *Graminidites* sp. b (rare)

Diporate pollen:
- ➡️ *Psilodiporites minimus* van der Hammen & Wymstra (v. rare)

Triporate pollen:
- ➡️ *Cricotriporites nigerianus* Takahashi & Jux (v. rare)
- ➡️ *Triatriopollenites fayumensis* n. sp. (rare)
- ➡️ *Subtriporopollenites* sp. (v. rare)
- ➡️ ? *Subtriporopollenites* sp. (v. rare)
- ➡️ *Subtriporopollis* sp. (v. rare)
- ➡️ *Tiliaepollenites* sp. (v. rare)

Polyporate pollen:
- ➡️ *Ulmipollenites semiundulosus* Takahashi & Jux (v. rare)
- ➡️ *Alnipollenites* sp. (rare)
- ➡️ ? *Carpinuspollis* sp. (v. rare)

Periporate pollen:
- ➡️ *Parsonsidites psilatus* Couper (v. rare)

Monocolpate pollen:
- ➡️ *Monocolpopollenites intrabaculatus* Takahashi (v. rare)
- ➡️ *Monocolpopollenites* sp. (v. rare)
- ➡️ *Arecipites brandenburgensis* Krutzsch (v. rare)
- ➡️ *Arecipites* sp. (rare)
- ➡️ *Cycadopites* cf. *gracilis* Krutzsch (v. rare)
- ➡️ *Cycadopites* sp. a (rare)
- ➡️ *Cycadopites* sp. b (v. rare)
- ➡️ *Monosulcites aegyptiacus* n. sp. (few)
- ➡️ ? *Longapertites* sp. (few)

Tricolpate pollen:
- ➡️ *Quercoidites microhenrici* (Potonié) Potonié (v. rare)
- ➡️ *Quercoidites punctatus* n. sp. (rare)
- ➡️ *Cupuliferoidaepollenites liblarensis* (Thomson) Potonié (v. rare)
- ➡️ *Cupuliferoidaepollenites fallax* (Potonié) Potonié (v. rare)
- ➡️ *Tricolpopollenites chagrenatus* n. sp. (v. rare)
- ➡️ *Tricolpopollenites aequatoripunctatus* n. sp. (rare)
- ➡️ *Tricolpopollenites lanceolatus* n. sp. (v. rare)
Tricolpopollenites pseudasper n. sp. (v. rare)
Tricolpopollenites inamoenus Takahashi (v. rare)
Tricolpopollenites subasper Takahashi (v. rare)
Tricolpopollenites meinohamensis Takahashi meinohamensis (v. rare)
Tricolpopollenites sp. (rare)
Ranunculacidites contaminatus Takahashi & Jux (v. rare)
Striatopollis striatellus (Takahashi) Takahashi (v. rare)
Tricolpites retiformis (Pflug & Thomson) Takahashi & Jux (rare)
Tricolpites minutireticulosus Takahashi (v. rare)
Tricolpites sp. a (v. rare)
Tricolpites sp. b (v. rare)
Tricolpites sp. c (v. rare)
Polycolpate pollen:
Polycolpites sp. a (v. rare)
Polycolpites sp. b (v. rare)
? Polycolpites sp. (v. rare)
Tricolporate pollen:
Cupuliferoipollenites cf. pusillus (Potonié) Potonié (rare)
Tricolporopollenites microporifer Takahashi (few)
Intrabaculitricolporites consularis (Takahashi) Takahashi & Jux globularis (Takahashi) Takahashi & Jux (v. rare)
Intrabaculitricolporites cf. affinis Takahashi & Jux (v. rare)
Rutaceoipollenites subtropicus n. sp. (v. rare)
Rutaceoipollenites sp. (v. rare)
Rhoipites rotundus n. sp. (v. rare)
Rhoipites sp. a (v. rare)
Rhoipites sp. b (v. rare)
Rhoipites sp. c (v. rare)
Foveotricolporites sp. (v. rare)
Polycolporate pollen:
Tetracolporopollenites globosus n. sp. (v. rare)
Polycolporopollenites sp. (v. rare)

abundant: 10 % or more    rare:  1 %
common:  5—9 %          v. rare: 0 % but existing.
few:    2—4 %
Discussion of Qasr El Sagha palynomorphs

In both the lignite and the peaty marl the total assemblage of identified palynomorphs amounts to 86 form-species. Within this microflora nearly 41% (35 species) could be referred to previously described palynomorphs, mainly from Europe but also from Asia or Africa. In this connection it may be noted that 12% of the species were found to occur in lacustrine deposits of Middle Tertiary age in Central Nigeria (Takahashi & Jux, 1989). Due to the lack of reliable monographic presentations of Tertiary palynomorphs from almost allover the Near East, many forms (39%) and particularly those which were either very infrequently recorded within the present assemblage or in an inadequate state of preservation, had yet to be excluded from identification below generic level. At least, a considerable amount of the microfossils (20%) turned out to consist of new species.

Provided that the stratigraphic age of the Qasr El Sagha Formation had to be concluded only from the palynomorphs which were identified in eiter the carbonaceous marl or the lignite, Oligocene or perhaps Middle to Late Oligocene would have appeared to be the most likely answer with reference to the range chart (Tab. 1). However, from the marine fossils (foraminiferids, molluscs, nannoplankton) a considerably higher age, namely Late Eocene to Early Oligocene, is suggested and in fact well founded. As a consequence of this deduction the so far first appearance of several form species, especially the palynomorphs described as new species from the Jos Plateau in Nigeria (Takahashi & Jux, 1989), have to be somewhat predated as done on Tab. 1 by double lines.

Considering the morphological characteristics of the palynomorphs the following grouping occurs:

<table>
<thead>
<tr>
<th>Group</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trilete spores</td>
<td>7%</td>
</tr>
<tr>
<td>Monolete spores</td>
<td>22%</td>
</tr>
<tr>
<td>Inaperturate pollen</td>
<td>56%</td>
</tr>
<tr>
<td>Monoporate pollen</td>
<td>1%</td>
</tr>
<tr>
<td>Diporate pollen</td>
<td>0%</td>
</tr>
<tr>
<td>Triporate pollen</td>
<td>1%</td>
</tr>
<tr>
<td>Polyporate pollen</td>
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<td>Periporate pollen</td>
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<td>monosulcate pollen</td>
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<td>Tetracolpate pollen</td>
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<td>Polyclporate pollen</td>
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1) Pteridophyte

Among the trilete spores, *Monoleiotrilites angustus* Krutzsch, which is known from the Middle Eocene of the Geiseltal, G. D. R., and *Undulatisporites fayumensis* n. sp. are remarkable and of stratigraphic significance. Each of these species ap-
Tab. 1. Range chart of Tertiary palynomorphs noted in the Qasr El Sagha Formation.

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<tr>
<td>Laevigatosporites dehiscens</td>
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<td>Inaperturopoll. laevigatus</td>
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<td>Quercoidites microhenrici</td>
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<td>+Tricolpopollenites inamoenus</td>
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<td>Parsonsidites psilatus</td>
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<td>Arecipites brandenburgensis</td>
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<td>Tricolpopollenites meinohamensis</td>
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<td>Cricotriporites nigerianus</td>
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<td>Ulmi pollenites semiundulosus</td>
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<td>Cycadopites gracilis</td>
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<td>Ranunculacidites contaminatus</td>
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<td>Potamogetonacidites paluster</td>
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peared with 3% within the assemblage. All trilete spores are comparatively large in size and their exospores are extremely thin compared with other species.

Among the monolete spores, *Laevigatosporites aegypticus* n. sp. (Polypodiaceae), *Laevigatosporites undulatus* n. sp. (Peranemataceae), *Laevigatosporites dehiscens* Takahashi (Polypodiaceae), *Latosporites rotundus* n. sp. etc. are characteristic. Besides, *Verrucatosporites* spp. (Polypodiaceae) and *Extrapunctatosporis* spp. (Athyriaceae), which have a verrucate or punctate sculpture, are morphologically remarkable in spite of their restricted number. *Verrucatosporites tenellis* (Krutzsch) Krutzsch is recorded in both the Middle Eocene-Miocene of Germany and the Early Eocene of southern Bakony (Hungary).

All monolete spores have very thin exines.

The association of the spores from the Qasr El Sagha Formation can be called a *Laevigatosporites* — *Monoleiotriletes angustus* — *Undulatisporites fayumensis* group.

2) Gymnosperm pollen

*Psophosphaera aggereloides* (Maljavkina) Chlonova shows the highest ratio of appearance (40%) and comes next to the Taxodiaceae — Cupressaceae (*Inaperturopollenites* — *Cupressacites*) pollen group. Disaccate pollen, by the way, have never been noted in the Mesozoic and Paleogene of Egypt.
One of the characteristic features of the Oligocene vegetation of Egypt is indications of extended Taxodiaceae – Cupressaceae swamp forests, which are reflected by Inaperturopollenites microforatus Krutzsch and Inaperturopollenites concediptes (Wodehouse) Krutzsch (Kedves, 1985). The occurrences of Inaperturopollenites tenuis Kimiyai, and Taxodiaceae pollenites hiatus (Potonie) Kremp in the Paleocene Kur-kur Formation of Egypt (El-Beialy & Kora, 1987) and of Inaperturopollenites concediptes (Wodehouse) Krutzsch and Cupressacites khargaensis Kedves in the Danian of Egypt (Kedves, 1984) may also be a hint that Taxodiaceae – Cupressaceae swamp forests remained rather long in the Paleogene of Egypt.

3 ) Angiosperm pollen

The angiospermous pollen grains from the Qasr El Sagha Formation include many genera and species, but the ratios of abundances are very low.

The following species are remarkable in respect to their morphological features: Psilodiporites minimus v. d. Hammen & Wymstra, Cricotriporites nigerianus Takahashi & Jux, Triatriopollenites fayumensis n. sp., Ulmipollenites semiundulosus Takahashi & Jux, Parsonsidites psilatus Couper, Monosulcites aegyptiacus n. sp., Tricolporopollenites aequatoripunctatus n. sp., Ranunculacidites contaminatus Takahashi & Jux, Rutaceoipollenites subtropicus n. sp. and Tetracolporopollenites globosus n. sp.

The monoporate and periporate pollen groups have very scanty record when compared with their abundances in the Oligocene and Neogene of Egypt.

The monocolpate and monosulcate pollen groups were highly disseminated during the Danian and Neogene in Egypt (Kedves, 1981, 1984). In the Paleocene and Oligocene, however, they are rare (Kedves, 1985; El-Beialy & Kora, 1987). In the Qasr El Sagha Formation, Monosulcites aegyptiacus n. sp. occurs abundantly and is easily recognized because of its morphology, whereas Palmae (Monocolporopollenites) and Cycadaceae (Cycadopites and Arecipites) appear in much lesser amounts.

The tricolpate and tricolporate pollen groups include many genera and species which are of almost European types and in which only four may refer to endemic African or Egyptian populations. These are Tricolporopollenites aequatoripunctatus n. sp., Ranunculacidites contaminatus Takahashi & Jux (Ranunculaceae etc.), Intrabaculitrilocporites affinis Takahashi & Jux, and Rutaceoipollenites subtropicus n. sp. (Rutaceae).

Tetracolporopollenites globosus n. sp. is morphologically similar to Rutaceoipollenites, nevertheless the species is quite distinct because of its four colpi and pores.

An aquatic plant is indicated by Potamogetonacidites paluster (Manten) Mohr. This species, commonly noted in the Miocene-Pliocene of Europe, fits particularly well in the sedimentary paleoenvironments of the Qasr El Sagha Formation.
After all, the assemblage of dispersed pollen identified from the Qasr El Sagha Formation may be called *Psophosphaera* — Taxodiaceae — Cupressaceae — *Monosulcites aegyptiacus* pollen group.

Normapolles, which occurs in the so-called Normapolles palynofloral province of eastern North America and western Eurasia and spreads from Cenomanian to Eocene, appears rather infrequently from the Late Cretaceous to Oligocene of Egypt (Schrank, 1984; Kedves, 1984, 1985; El-Beialy & Kora, 1987). There are in the Campanian (Duwi Formation) *Minorpollis* sp., in the Maastrichtian (Dakhla Formation) *Plicapollis pseudoexcelsus* (Krutzsch) Krutzsch and *Minorpollis* sp., in the Danian *Trudopolis* sp. and *Minorpollis* sp., in the Paleocene (Kur-kur Formation) *Sporopollis* sp. and in the Oligocene *Minorpollis gallicus* Kedves, *Plicapollis pseudoexcelsus* (Krutzsch) Krutzsch *pseudoexcelsus*, *Plicapollis pseudoexcelsus* (Krutzsch) Krutzsch *turgidus* Pflug, *Plicapollis pseudoexcelsus* (Krutzsch) Krutzsch *semiturgidus* Pflug. However, no Normapolles was identified so far in the Qasr El Sagha Formation.

Representatives of the triprojectate pollen group are altogether rare e. g. *Aquilapollenites cf. senegalensis* Jardine & Magloire from the Maastrichtian Dakhla Formation of Southeast Egypt and *Pentapollenites laevigatus* Krutzsch *laevigatus* from the Oligocene cover of the Moqattam Plateau near Cairo. Again, no triprojectate pollen was found in either lignites or carbonaceous clay of the Qasr El Sagha Formation.

In a systematic arrangement the dispersed palynomorphs can be related to the following plant families:

- **Filicales**: Adiantaceae, Polypodiaceae, Peranemataceae, Athyriaceae.
- **Gymnospermae**: ? Cycadaceae, Cupressaceae, Taxodiaceae, Abietoideae.
- **Monocotyledoneae**: Potamogetonaceae, Gramineae, Palmae.
- **Dicotyledoneae**: Salicaceae, Betulaceae, Fagaceae, Ulmaceae, ? Moraceae, Rutaceae, Tiliaceae, Apocynaceae, Labiatae (Ranunculaceae or Punicaceae), Celastraceae.

Most of the palynomorphs with known botanical affinities are attributed to the Fagaceae (21%), next come Polypodiaceae (19%), ? Cycadaceae (10%), Salicaceae (8%) and Gramineae (8%). Such a distribution is not well reflected in the abundances of the populations, for most species were just noted with a few specimens (<1% of the assemblage). Abundantly (>10%) or commonly (5—9%) were only identified the spores of Polypodiaceae (*Laevigatosporites aegyptiacus* n. sp., *L. dehiscens* Takahashi) and the pollen grains of Abietoideae [*Psophosphaera aggereloides* (Maljatkina) Chlonova]. Even 2—4% of the palynomorphs within one slide are only occasionally represented by just one species.
Ecologically the association of palynomorphs and calcareous nannoplankton agrees quite well with the conception of a prograding delta front and both its adjacent calm coastal waters and marshes (Vondra, 1974). This could explain the low-diversity placoliths assemblages in a carbonaceous marl containing also fossils of limnic vertebrates (cyprinoid fish, Fig. 3) and continental plants (wood, leaves, palynomorphs).

From the palynomorphs the near-by vegetation can vaguely be deduced, because the lignites suggest coastal marshes, back swamps, natural levees and the peaty marl an alternating influx of either marine or continental waters. The latter being due to the shifting accumulation centers of fluviomarine sediments. Most likely the levees were wooded by oaks and other cupulifers [e.g. Quercoidites microhenrici (Potonié & Venitz) Thomson & Pflug, Q. punctatus n. sp.], elms (Ulmipollenites semiundulosus Takahashi & Jux), lindens (Tiliaepollenites sp.) and palms (Monocolpopollenites intrabaculatus Takahashi). There were perhaps wooded as well as open places covered by apocynaceans (Parsonsidites psilatus Couper), ferns (e.g. Laevigatosporites aegyptiacus n. sp., L. dehiscens Takahashi, L. undulatus n. sp.) and herbs like labiates (Ranunculacidites contaminatus Takahashi & Jux) or grasses [e.g. Graminidites subtiliglobosus (Trevisan) Krutzsch, G. laevigatus Krutzsch].

The swamps were framed by willows (e.g. Tricompites minutireticulosus Takahashi) and birches (Alnipollenites sp.), whereas the boggy grounds may have given place to cypresses [Inaperturopollenites dubius (Potonié & Venitz) Thomson & Pflug] and the open pools to aquatic plants [Potamogetonacidites paluster (Manten) Mohr]. Psophosphaera aggereloides (Maljavkina) Chlonova, although one of the few species which were abundantly observed, most likely derived by eolian transport from more distant conifers that grew on elevated grounds.

This scenario was gradually altered when the delta front prograded further north and a coastal plain had developed in Early Oligocene by the fluviatile deposition of the Gabal Qatrani Formation. The time interval which was filled between the full marine Birket El Qarun Formation of Late Eocene and the fluviatile Gabal Qatrani Formation of Early Oligocene age by the transitional Qasr El Sagha Formation was probably not very extended as the duration of a Cenozoic NP zone is generally assumed to last not longer than ca. 1.1 myr.

Acknowledgements

We are grateful to Prof. Dr. B. Issawi and Mr. T. Defterdar, B. Sc. (Geolgical Survey and Petroleum-Mining Ministry of Egypt) for fruitful discussion and for providing the samples which were used in the course of this investigation.
Mr. W. Mackowiak and Dipl. Geol. A. Klinke (Geol. Inst., Cologne) kindly prepared the SEM-images of coccoliths and the photo of the fish from the carbonaceous marl.

References


Kedves, M. (1971) : Présence de types sporomorphes importants dans les


Explanation of Plates 1–14
Explanation of plate 1
(All figures magnified X 1000 unless otherwise mentioned)

Figs. 1–3, 5–7. *Monoleiotriletes angustus* Krutzsch
Figs. 1–3, 5: Fayum 1–17 (GN 5317); fig. 6: Fayum 1–19 (GN 5319)
fig. 7: Fayum 1–18 (GN 5318); figs. 1b and 3a: X 400.

Fig. 4. *Leiotriteles apheles* (Hunger) Krutzsch Fayum 1–18 (GN 5318).
Explanation of plate 2
(All figures magnified X 1000 unless otherwise mentioned)

Fig. 1. *Monoleiotrites cf. angustus* Krutzsch Fayum 1–17 (GN 5317).
Fig. 2. *Deltoidospora* sp. Fayum 1–18 (GN 5318).
Fig. 3. ? *Concavisporites* sp. Fayum 1–17 (GN 5317).
Figs. 4–7. *Undulatisporites fayumensis* n. sp.
   Figs. 4a, b: Fayum 1–17 (GN 5317) ; fig. 4a: X 400; figs. 5–7: Fayum 1–18 (GN 5318) ; fig. 6: holotype.
Figs. 1–8. *Undulatisporites fayumensis* n. sp.
Figs. 1, 2, 4, 5: Fayum 1–17 (GN 5317); figs. 3, 6, 7: Fayum 1–18 (GN 5318); fig. 8: Fayum 1–19 (GN 5319).

Fig. 9. *Undulatisporites sp.* Fayum 1–18 (GN 5318).
Explanation of plate 4
(All figures magnified X 1000)

Figs. 1–2. *Latosporites rotundus* n. sp.
Fig. 1: Fayum 1–18 (GN 5318); fig. 2: Fayum 1–17 (GN 5317).

Figs. 3–12. *Laevigatosporites aegyptiacus* n. sp.
Figs. 3, 4, 7, 9–12: Fayum 1–17 (GN 5317); figs. 5, 6, 8: Fayum 1–18 (GN 5318); fig. 6: holotype.
Explanation of plate 5
(All figures magnified X 1000)

Figs. 1—2. *Latosporites rotundus* n. sp.
Fig. 1: Fayum 1—19 (GN 5319); holotype; fig. 2: Fayum 1—18 (GN 5318).

Figs. 3—12. *Laevigatosporites undulatus* n. sp.
Figs. 3, 7, 11: Fayum 1—18 (GN 5318); figs. 4, 9: Fayum 1—19 (GN 5319); figs. 5, 6, 8, 10, 12: Fayum 1—17 (GN 5317); fig. 10: holotype.

Figs. 13—15. *Laevigatosporites dehiscens* Takahashi
Fig. 13: Fayum 1—18 (GN 5318); figs. 14, 15: Fayum 1—17 (GN 5317).

Fig. 16. *Laevigatosporites ovoideus* Takahashi Fayum 1—19 (GN 5319).
Explanation of plate 6
(All figures magnified X 1000)

Fig. 1. *Latosporites* sp. Fayum 1–17 (GN 5317).
Fig. 2. *Laevigatosporites ovoides* Takahashi Fayum 1–17 (GN 5317).
Fig. 3. *Laevigatosporites* cf. *undulatus* n. sp. Fayum 1–18 (GN 5318).
Fig. 4. *Verrucatosporites* cf. *tenellis* (Krutzhc) Krutzsch Fayum 1–19 (GN 5319).

Figs. 5–8. *Verrucatosporites minutiverrucatus* n. sp.
Figs. 5, 7, 8: Fayum 1–18 (GN 5318); fig. 7: holotype; fig. 6: Fayum 1–17 (GN 5317).

Figs. 9–12. *Extrapunctatosporis pseudomiocaenicus* n. sp.
Fig. 9: Fayum 1–18 (GN 5318), holotype; figs. 10–12: Fayum 1–17 (GN 5317); fig. 12: cf.

Figs. 13–15. *Extrapunctatosporis fayumensis* n. sp.
Figs. 13, 14: Fayum 1–19 (GN 5319); fig. 15: Fayum 1–18 (GN 5318), holotype.

Fig. 16 *Extrapunctatosporis* sp. a Fayum 1–17 (GN 5317).
Fig. 17 *Extrapunctatosporis* sp. b Fayum 1–17 (GN 5317).
Fig. 18 *Verrucatosporites* sp. Fayum 1–19 (GN 5319).
Extrapunctatosporis sp. c Fayum 1–18 (GN 5318).
Figs. 2–3. Extrapunctatosporis fayumensis n. sp.
Fig. 2: Fayum 1–18 (GN 5318) ; fig. 3: Fayum 1–17 (GN 5317), cf.
Figs. 4, 6–7. Inaperturopollenites dubius (Potonié & Venitz) Thomson & Pflug
Fig. 4: Fayum 1–19 (GN 5319) ; figs. 6, 7: Fayum 1–17 (GN 5317).
Fig. 5. Cupressacites cf. bockwitzensis Krutzsch Fayum 1–18 (GN 5318).
Figs. 8, 18–19. Inaperturopollenites laevigatus Takahashi
Fig. 8, 18: Fayum 1–17 (GN 5317) ; fig. 8: cf.; fig. 19: Fayum 1–18
(GN 5318).
Figs. 9–12. Inaperturopollenites minimus Takahashi & Jux Fayum 1–17 (GN
5317).
Figs. 13–17. Psophosphaera aggereloides (Maljavkina) Chlonova
Figs. 13 15–17: Fayum 1–17 (GN 5317) ; fig. 14: Fayum 1–19 (GN
5319).
Explanations of plate 8
(All figures magnified X 1000)

Figs. 1—2. *Potamogetonacites paluster* (Manten) Mohr, Fayum 1—17 (GN 5317).

Figs. 3—12, 14. *Cupressacites africanus* n. sp.

Figs. 3—5, 7, 9—12, 14: Fayum 1—17 (GN 5317); figs. 6, 8: Fayum 1—18 (GN 5318); fig. 14: cf.; fig. 8: holotype.

Fig. 13. *Cupressacites cf. bockwitzensis* Krutzsch, Fayum 1—17 (GN 5317).

Fig. 15 *Graminidites subtilliglobosus* (Trevisan) Krutzsch, Fayum 1—17 (GN 5317).

Fig. 16 *Graminidites* sp. a, Fayum 1—18 (GN 5318).

Fig. 17 *Graminidites laevigatus* Krutzsch, Fayum 1—17 (GN 5317).

Fig. 18 *Graminidites* sp. b, Fayum 1—17 (GN 5317).

Figs. 19—24. *Psilodipontes minimus* van der Hammen & Wymstra

Fig. 19: Fayum 1—17 (GN 5317); fig. 20: Fayum 1—18 (GN 5318); figs. 21—24: Fayum 1—19 (GN 5319).

Figs. 25a-b. Indeterminable pollen grain, Fayum 1—17 (GN 5317).
Explanation of plate 9
(All figures magnified X 1000)

Figs. 1—6. *Cricotripores nigerianus* Takahashi & Jux
Figs. 1, 2, 4, 6: Fayum 1—18 (GN 5318); figs. 3, 5: Fayum 1—19 (GN 5319); fig 6: cf.

Figs. 7—11. *Triatriopollenites fayumensis* n. sp.
Figs. 7, 9,: Fayum 1—18 (GN 5318); figs. 8, 10: Fayum 1—19 (GN 5319), fig. 10: holotype; fig. 11: Fayum 1—17 (GN 5317).

Fig. 12. *Subtriporopollenites* sp. Fayum 1—19 (GN 5319).

Fig. 13. *Ulmipollenites semiundulosus* Takahashi & Jux Fayum 1—17 (GN 5317).

Fig. 14. *Achnipollenites* sp. Fayum 1—17 (GN 5317).

Fig. 15. *? Carpinuspollis* sp. Fayum 1—18 (GN 5318).

Figs. 16a-b. *Subtriporopollis* sp. Fayum 1—17 (GN 5317).

Fig. 17. *Tiliaepollenites* sp. Fayum 1—18 (GN 5318).

Fig. 18. *Parsonsidites psilatus* Couper Fayum 1—18 (GN 5318).

Fig. 19. *Monocolpopollenites* sp. Fayum 1—19 (GN 5319).

Fig. 20. *Monocolpopollenites intrabaculatus* Takahashi Fayum 1—18 (GN 5318).

Fig. 21. *Cycadopites gracilis* Krutzsch Fayum 1—18 (GN 5318).

Fig. 22. *Cycadopites* sp. a Fayum 1—17 (GN 5317).

Fig. 23. *Cycadopites* sp. b Fayum 1—17 (GN 5317).

Fig. 24. *Arecipites* sp. Fayum 1—17 (GN 5317).

Fig. 25. *Arecipites cf. brandenburgensis* Krutzsch Fayum 1—18 (GN 5318).

Fig. 26. *Arecipites brandenburgensis* Krutzsch Fayum 1—18 (GN 5318).
Explanation of plate 10
(All figures magnified X 1000)

Figs. 1—16. *Monosulcites aegyptiacus* n. sp.
Figs. 1, 4a-b, 7—9, 13a-b, 14: Fayum 1—17 (GN 5317) ; figs. 2, 3, 5, 6, 11, 12, 15, 16: Fayum 1—18 (GN 5318) ; fig. 12: holotype; fig. 10: Fayum 1—19 (GN 5319).
Explanation of plate 11
(All figures magnified X 1000)

Fig. 1.  ? Longapertites sp.  Fayum 1–17 (GN 5317).

Figs. 2–7.  Quercoidites microhenrici (Potonie) Potonie
Figs. 2, 3: Fayum 1–19 (GN 5319); figs. 4–7: Fayum 1–17 (GN 5317).

Fig. 8.  Cupuliferidaepollenites liblarensis (Thomson) Potonie  Fayum 1–19 (GN 5319).

Fig. 9.  Cupuliferidaepollenites fallax (Potonie) Potonie  Fayum 1–18 (GN 5318).

Figs. 10–12.  Quercoidites punctatus n. sp.
Figs. 10, 12: Fayum 1–18 (GN 5318); fig. 10: holotype; fig. 11: Fayum 1–17 (GN 5317).

Figs. 13–15.  Tricolpopollenites chagrenatus n. sp.
Figs. 13, 15: Fayum 1–18 (GN 5318); fig. 14: Fayum 1–17 (GN 5317),
holotype.

Figs. 16–24.  Tricolpopollenites aequatoripunctatus n. sp.
Figs. 16, 20, 24: Fayum 1–17 (GN 5317); fig. 16: holotype; figs. 17, 23:
Fayum 1–19 (GN 5319); figs. 18, 19, 21, 22: Fayum 1–18 (GN 5318).

Fig. 25.  Tricolpopollenites meinohamensis Takahashi meinohamensis  Fayum 1–18
(GN 5318).

Fig. 26.  Tricolpopollenites inamoenus Takahashi  Fayum 1–18 (GN 5318).

Fig. 27.  Tricolpopollenites subasper Takahashi  Fayum 1–19 (GN 5319).

Fig. 28.  Tricolpopollenites sp.  Fayum 1–17 (GN 5317).

Figs. 29–30.  Ranunculacidites contaminatus Takahashi & Jux
Fig. 29: Fayum 1–19 (GN 5319); figs. 30a-b: Fayum 1–18 (GN 5318).
Explanation of plate 12
(All figures magnified X 1000)

Fig. 1. Tricolpites sp. a Fayum 1–17 (GN 5317).
Figs. 2–4. Tricolpopollenites lanceolatus n. sp.
Fig. 2, 3: Fayum 1–19 (GN 5319); fig. 2: holotype; fig. 4: Fayum 1–18
(GN 5318).
Figs. 5–9. Tricolpopollenites pseudoasper n. sp.
Fayum 1–18 (GN 5318); fig. 6: holotype.
Figs. 10–11. Striatopollis striatellus (Takahashi) Takahashi
Fig. 10: Fayum 1–18 (GN 5318); fig. 11: Fayum 1–17 (GN 5317).
Fig. 12. Polycolpites sp. a Fayum 1–18 (GN 5318).
Figs. 13a-b. ? Polycolpites sp. Fayum 1–17 (GN 5317).
Figs. 14a-b. Polycolpites sp. b Fayum 1–19 (GN 5319).
Figs. 15, 16, 18. Tricolpites retiformis (Pflug & Thomson) Takahashi & Jux
Figs. 15, 16: Fayum 1–18 (GN 5318); fig. 18: Fayum 1–17 (GN 5317).
Fig. 17. Tricolpites minutireticulosus Takahashi Fayum 1–17 (GN 5317).
Figs. 19a-b. Tricolpites sp. b Fayum 1–19 (GN 5319).
Fig. 20. Tricolpites sp. c Fayum 1–18 (GN 5318).
Figs. 21, 28. Intrabaculitricolporites consularis (Takahashi) Takahashi & Jux globularis
(Takahashi) Takahashi & Jux Fayum 1–17 (GN 5317).
Figs. 22, 24. Tricolporopollenites microporifer Takahashi Fayum 1–17 (GN 5317).
Fig. 23. ? Subtriporopollenites sp. Fayum 1–17 (GN 5317).
Figs. 25–26. Cupuliferoipollenites cf. pusillus (Potonie) Potonie Fayum 1–17 (GN
5317).
Fig. 27. Rhoitites sp. a Fayum 1–17 (GN 5317).
Fig. 29. Intrabaculitricolporites cf. affinis Takahashi & Jux Fayum 1–18 (GN
5318).
Figs. 30–32. Ranunculacidites contaminatus Takahashi & Jux
Fig. 30: Fayum 1–19 (GN 5319); figs. 31, 32: Fayum 1–18 (GN 5318).
Explanation of plate 13
(All figures magnified X 1000)

Figs. 1–8.  *Rutaceoipollenites subtropicus* n. sp.
Figs. 1, 2, 5, 7, 8: Fayum 1–18 (GN 5318); fig. 3: Fayum 1–17 (GN 5317); figs. 4, 6: Fayum 1–19 (GN 5319); fig. 4: holotype.

Fig. 9. *Rutaceoipollenites* sp.  Fayum 1–19 (GN 5319).

Figs. 10–11.  *Tetracolporopollenites globosus* n. sp.
Fayum 1–18 (GN 5318); fig. 10: holotype.

Fig. 12. *Foveotricolporites* sp.  Fayum 1–17 (GN 5317).

Fig. 13. *Rhoipites* sp. b  Fayum 1–17 (GN 5317).

Fig. 14. *Rhoipites* sp. c  Fayum 1–18 (GN 5318).

Figs. 15–22. *Rhoipites rotundus* n. sp.
Figs. 15, 16, 18, 20: Fayum 1–18 (GN 5318); fig. 17: Fayum 1–19 (GN 5319); figs. 19, 21, 22: Fayum 1–17 (GN 5317); fig. 19: holotype.

Figs. 23a-b. *Polycolporopollenites* sp.  Fayum 1–17 (GN 5317).
Explanation of plate 14

Calcareous nannofossils from a layer of carbonaceous marl (as shown on Fig. 3) in the Qasr El Sagha Formation, Fayum Oasis.

Fig. 1. *Ericsonia eopelagica* (Bramlette & Riedel) Roth; monospecific assemblage of placolitha. Scale = 3 \( \mu \text{m} \).

Fig. 2. *Neococcolithes cf. dubius* (Deflandre) Black; walls and central crosses were prone to partial dissolution. Scale = 1 \( \mu \text{m} \).

Fig. 3. *Ericsonia eopelagica* (Bramlette & Riedel) Roth; proximal as well as connecting tube with distal shield in an advanced state of dissolution and disintegration. Scale = 1 \( \mu \text{m} \).

Fig. 4. *Ericsonia eopelagica* (Bramlette & Riedel) Roth; imbricated petaloid elements of oval distal shield are well preserved. Scale = 1 \( \mu \text{m} \).

Fig. 5. *Neococcolithes cf. dubius* (Deflandre) Black with somewhat bifurcating bars near the single wall. Scale = 3 \( \mu \text{m} \).

Fig. 6. *Neochiasticzygus* sp.; the elliptical coccolith is rather altered but the two walls can still be noted. Scale = 1 \( \mu \text{m} \).

Fig. 7. *Discoaster aff. gemmeus* Stradner; proximal view of well preserved imbricated petaloid rays. Scale = 3 \( \mu \text{m} \).

Fig. 8. *Chiasmolithus oamaruensis* (Deflandre) Hay, Mohler & Wade; oval shield the marginal elements of which from a distinct distal crest around X-shaped central structure. Scale = 3 \( \mu \text{m} \).