THE UNIVERSITY OF KANSAS

PALEONTOLOGICAL CONTRIBUTIONS

May 23, 1966 Paper 5

NEW GENERA AND SPECIES OF EARLY TERTIARY PALYNOMORPHS FROM GULF COAST

By Lewis E. Stover, William C. Elsik, and William W. Fairchild

Esso Production Research Company, Houston, Texas

ABSTRACT

Ten new genera and 13 new species of Paleocene and Eocene pollen and spores belonging to an equal number of genera are described and illustrated. The specimens were found in palynomorph assemblages recovered from samples collected in Texas, Louisiana, and Alabama.

INTRODUCTION

A considerable amount of information on European Early Tertiary spore and pollen assemblages is available through the efforts of numerous European palynologists over the past 35 years. In contrast, relatively little has been published on Paleocene and Eocene palynomorphs from the North American Gulf Coastal area. Most recently, ENGELHARDT (1964a) illustrated and discussed spores and pollen from the middle Eocene Cockfield Formation of Mississippi and in the same year proposed a new species of *Gothanipollis* KRUTZSCH, also from the Cockfield Formation (ENGELHARDT, 1964b). Prior to ENGELHARDT's papers, GRAY (1960) had discussed the ecological implications of spores and pollen from the Gosport Formation (middle Eocene) of Alabama and KRUTSCH (1960) had described and illustrated the distinctive species, *Thomsonipollis magnificus*. A sharp palynological hiatus between the Midway (Paleocene) and Wilcox (lower Eocene) in south-central Arkansas was demonstrated by JONES (1962).

The purpose of this paper is to augment the knowledge of Early Tertiary spore and pollen types by describing and illustrating several new, morphologically distinct palynomorphs recovered from Gulf Coast strata. Specimens shown on the accompanying plates, or otherwise used in this study, were recovered from the following localities.

LOCALITIES

Locality 1.—Lignite of the Wilcox Group (lower Eocene) exposed 0.25 mile west of state highway 43 and 9.5 miles southwest of Marshall, Harrison County, Texas.

Locality 2.—Lignite of the Wilcox Group (lower Eocene) exposed 3.3 miles west of U.S. highway 77 and 8.7 miles southwest of Rockdale, Milam County, Texas.

Locality 3.—Marquez Shale Member of the Reklaw Formation (middle Eocene) exposed in the stream bed and banks of Twomile Creek, 1.25 miles south-southwest of Brazos River bridge on U.S. highway 79, five miles southwest of Hearne, Robertson County, Texas (Stop 2 of SMITH, 1959).

Locality 4.—Porters Creek Formation (Paleocene) exposed along state highway 100, two miles north of Oakhill, Wilcox County, Alabama.

Locality 5.—Chemard Lake lignite lentil of the Naborton Formation (Paleocene) exposed at the head of a gully in the NE ¼ of the SW ¼, section 6, T 11 N, R 11 W, 1.25 miles east of Grove Hill Church, DeSoto Parish, Louisiana. (Locality 7 of MEAGHER & AYCOCK, 1942.)

Occurrences are reported as rare (1 to 9 specimens), sparse (10 to 24 specimens), common (25

to 50 specimens) or abundant (more than 50 specimens).

Type specimens will be deposited in the Division of Paleobotany, United States National Museum, Washington, D.C. The coordinate locations of specimens on slides are given in millimeters measured from a reference mark (an x scratched near the lower left corner of the coverglass): the first coordinate gives the horizontal and the second coordinate the vertical distance from the reference mark.

SYSTEMATIC DESCRIPTIONS

Genus CALAMUSPOLLENITES Elsik, n. gen.

Diagnosis.—Pollen anisopolar, bilateral, monosulcate. Outline elliptical in apertural view. Nexine and sexine distinct. Sexine punctate, punctae aligned in irregular to wavy rows and separated by low, irregular ridges of sexinous material. Monotypic.

Type Species.—Calamuspollenites pertusus Elsik, n.sp.
Occurrence.—Lower Eocene.

CALAMUSPOLLENITES PERTUSUS Elsik, n. sp.

Description.—Anisopolar, bilateral, monosulcate pollen. Sulcus extends full length of grain; margins of sulcus slightly opened, tightly closed or overlapped. Sulcus generally open at one end, due to oblique compression of specimens. Exine presumably continuous across furrow. Edge of furrow appears torn on one specimen (Pl. 1, figs. 1a-c), which is compressed on end. Exine punctate to microreticulate under bright-field microscopy. Phase contrast reveals thin nexine overlain by punctate sexine. Endosexine obscure, appears baculate. Ectosexine formed of low ridges generally separated by irregular rows of punctae, resulting in pseudovermiculate or scrobiculate pattern.

Discussion.—Nine specimens measured 23 to 27 μ wide, 20 to 24 μ in depth, and 32 to 40 μ long. Sulcus is tightly closed to 1 μ wide, closed to slightly flaring on ends; sulcus in some specimens several μ wide at one end owing to oblique compression of the grain. Wall about 1 μ thick, sexine as thick as or slightly thicker than nexine. Punctae about 0.5 μ in diameter. Intervening ridges between rows of punctate 1 to 2 μ wide.

Comparison.—The pattern of the exine sculpture is unique for this species. Monosulcate pollen with regularly punctate or reticulate exines would be placed in *Arecipites* (Wodehouse, 1933) according to Anderson (1960, p. 18) who placed an arbitrary maximum of 0.5 μ for the lumina of *Arecipites*. Furthermore, it appears that *Arecipites* is limited to species having regularly punctate or distinctly reticulate exines, with the lumina generally as wide as or wider than the muri. The separation of punctate by spaces wider than the punctae and the tendency of the punctae to be aligned into rows distinguishes *Calamuspollenites* from other monosulcate form genera.

Affinities.—The exine pattern of *Calamuspollenites pertusus* is basically the same as that found in *Calamus guruba* and *Calamus microcarpus* (Palmae) and *Liriodendron tulipifera* (Magnoliaceae). *C. microcarpus* and *L. tulipifera* are generally monosulcate but the ectosexine between the rows of punctae is swollen into verrucae or low rugulae. *C. guruba* has a sculpture pattern and wall thickness identical to *C. pertusus*, but *C. guruba* is normally bisulculate. Pollen similar to *C. pertusus* are found in the extant families Palmae and Magnoliaceae, and possibly in other families as well. It is evident that *Calamuspollenites* should be treated strictly as a form genus.

Holotype.—Plate 1, figures 2a-e. Measurements, 28 by 38 μ.

Occurrence.—Wilcox Group, lower Eocene, type locality 2, rare.

Illustrations.—Plate 1, figures 1, 2.——1. Paratype, USNM 41632, slide S400(3), coordinates 27.7, + 3.2; 1a, bright field; 1b,c, phase contrast at median and low focus levels, all $\times$1,000.——2. Holotype, USNM 41633, slide S400(3), coordinates 33.1, + 8.3; 2a-c, phase contrast at high (2a), median (2b), and low (2c) focus levels; 2d,2e, bright field at two slightly different focus levels, all $\times$1,000.

Genus MONULCIPOLLENITES Fairchild, n. gen.

Diagnosis.—Pollen isopolar, monoaperturate, lenticular. Outline circular in polar view. Aperture consists of relatively small, more or less circu-

lar, annulate ulcus located at or near center of grain. Exine thin; sexine and nexine closely appressed, of approximately equal thickness. Sexine of type species foveolate. Monotypic.

Type Species.—*Monulcipollenites confossus* FAIRCHILD, n. sp.

Occurrence.—Middle Eocene.

MONULCIPOLLENITES CONFOSSUS Fairchild, n. sp.

Description.—Monoaperturate lenticular pollen having circular outline. Aperture consists of more or less circular m. distalipolar annulate ulcus 2.5 to 5 μ in diameter, located at or near the center of grain. Width of annulus about 2.5 μ. Exine about 1 μ thick, sexine and nexine closely appressed and of approximately equal thickness. Sexine foveolate, diameter of circular pits less than 1 μ at surface. Nexine psilate. Size range: 30 to 44 μ in diameter, based on 14 specimens.

Discussion.—The foveolate exine and single annulate ulcus are distinctive characters. The original shape of the grain appears to have been lenticular rather than spheroidal, since in almost every specimen the ulcus is located at or very close to the center of the grain. Several specimens were found in which the annulate ulcus could only be seen under phase contrast (Pl. 1, fig. 5b), and such specimens could easily be mistaken for inaperturate forms.

Comparison.—*Monulcipollenites* differs from *Graminidites* COOKSON (1947) in having a foveolate exine and in its lenticular rather than spheroidal shape. *Inaperturopollenites incertus foveolatus* PFLUG & THOMPSON (1953, p. 66, pl. 5, fig. 31-35) is similar to *M. confossus* in shape and exine construction, but no mention is made of a germinal opening in its description, and none is apparent on the figured specimens. KRUTZSCH (1957, p. 521, pl. 10, figs. 40-45) illustrated but did not describe a group of monoaperturate forms, some of which may be conspecific with *M. confossus*. The specimen figured by JONES (1962, pl. 2, fig. 12) from the Eocene Saline Formation of Arkansas may also represent *M. confossus*.

Holotype.—Plate 1, figures 5a,b. Equatorial diameter of holotype, 31 μ.

Occurrence.—Reklaw Formation, middle Eocene, type locality 3, sparse.

Affinities.—Unknown; the annulate ulcus on *Monulcipollenites confossus* resembles that on *Staberhoa cernua* as figured by ERDTMAN (1952, p. 376, fig. 220B), although the exine construction of *M. confossus* is more like that of *Hypolaena lateriflora* (ibid., fig. 220A). The new species is only superficially similar to *Thamnocortus fruticosus* and *Meeboldina denmarkica*, two additional species of the Restionaceae with which it has been compared. Modern grains of the Restionaceae appear to be spheroidal rather than lenticular and their apertures are not restricted to the center of the grain, thus even a provisional assignment of the new species to this family seems unwarranted.

Illustrations.—Plate 1, figures 3-6.——3. Paratype, USNM 41634, slide 160-18a, coordinates 24.9, + 4.8, ×1,000.——4. Paratype, USNM 41635, slide 160-18a, coordinates 26.6, + 16.8, ×1,000.——5. Holotype, USNM 41636, slide F-716, coordinates 12.3, + 14.8; 5a, bright field; 5b, phase contrast, both ×1,000.——6. Paratype, USNM 41637, slide 160-18a, coordinates 16.4, + 15.9, ×1,000.

Genus SERNAPOLLENITES Stover, n. gen.

Diagnosis.—Pollen isopolar, tricolpoidate, equatorial outline circular with apertures shallowly incised. Apertures apical, equatorial, simple. Exine stratification imperfect; nexine complete, sexine interrupted and formed of spinate projections. Monotypic.

Type Species.—*Sernapollenites duratus* STOVER, n. sp.

Occurrence.—Lower Eocene.

SERNAPOLLENITES DURATUS Stover, n. sp.

Description.—Triaperturate, isopolar pollen having circular or subcircular equatorial outline. Apices indistinct, sides moderately convex on unsplit specimens. Colpoid apertures equatorial, shallowly incised, generally poorly defined and with rapped edges. Pollen wall composed of thin (less than 1 μ) nexine supporting closely spaced spinate projections with broad bases, concave sides and sharp tips. Basal part of spines contains 3 or 4 columellae; upper part is solid. In plan view, outline at bases of spines is triangular. Projections arranged as circular clusters with each rosette havings 6 to 8 spines or as individual spines between clusters. Areas between or surrounded by projections lack columellae. Length of spines varies from 1.5 to 2.5 μ; overall diameter of grains is 28 to 35 μ as determined from 11 specimens.

Discussion.—The distinguishing features of *Sernapollenites duratus* include its poorly defined colpoid apertures, organization of the spines in rosettes and absence of a sexinous layer between projections. In random preparations, specimens show no preferred orientation and a majority of the 17 individuals used in this study are torn. The clarity of the rosettes varies; usually, the circular clusters are clearest in the polar areas, gradually become less well defined toward the equatorial area and are least well defined adjacent to the apertures. Unfavorably oriented specimens or those in which the apertural indentations are not evident may be mistaken for inaperturate grains.

Comparison.—Echinate specimens illustrated by KRUTZSCH (1957, pl. 10, fig. 34-37) have the ornamentation arranged in rosettes. These individuals may be conspecific with *Sernapollenites duratus* provided the spines are constructed the same.

Holotype.—Plate 1, figures 7a-d. Diameter of holotype, 34 μ.

Occurrence.—Lower Eocene, type locality 2, sparse.

Affinities.—Unknown.

Illustrations.—Plate 1, figures 7, 8.——7. Holotype, USNM 41638, slide 1051(52), coordinates 18.8, + 12.3; 7a, bright field; 7b, phase contrast; 7c, optical section in phase contrast showing wall and spine structure; 7d, phase contrast showing columellae, all ×1,000.——8. Paratype, USNM 41639, slide 1051(46), coordinates 14.2, + 5.8, ×1,000.

Genus TRIATRIOPOLLENITES (Pflug) Thomson & Pflug, 1953

Type Species.—Triatriopollenites rurensis PFLUG & THOMSON, 1953 (p. 76, pl. 7, fig. 95).

Occurrence.—Paleocene.

TRIATRIOPOLLENITES DILATUS Fairchild, n. sp.

Description.—Pollen isopolar, brevaxial, triatriate. Outline slightly convex-deltoid, with distinctly expanded and broadly rounded apices. Exine less than one μ thick, nexine slightly thinner than sexine. Sexine minutely granulate. Atria elliptical, distinct in well-preserved specimens. Pores equatorial, apical, circular, diameter 1 or 2 μ. Size range 17 to 25 μ, based on 10 specimens.

Discussion.—The minute granulation on the sexine of *Triatriopollenites dilatus* is apparently only on very well-preserved specimens. The atria often are not distinguishable in badly corroded grains, but the broadly rounded and expanded apical areas make it possible to recognize the species under almost all conditions of preservation.

Comparison.—The poorly preserved *Triatriopollenites sp.* illustrated by JONES (1962, pl. 1, fig. 12) from the Porters Creek Clay of south-central Arkansas may represent *T. dilatus.* No additional published reports of similar pollen have been noted.

Holotype.—Plate 1, figures 9a-c. Equatorial dimension of holotype, 20 μ.

Occurrence.—Porters Creek Formation, Paleocene, type locality 4, sparse.

Affinities.—Unknown.

Illustrations.—Plate 1, figures 9, 10.——9. Holotype, USNM 41640, slide S364-2, coordinates 27.1, + 11.4; 9a, bright field; 9bc, phase contrast at high (9a) and median (9b) focus levels, all ×1,000.——10. Paratype, USNM 41641, slide S364-2, coordinates 7.2, + 17.5, ×1,000.

Genus MYOCOLPOPOLLENITES Elsik, n. gen.

Diagnosis.—Pollen isopolar, spherical to prolate, tricolpate. Colpi margins are thickened and crenulate, generally tightly appressed. Colpi do not extend to poles but marginate sexinous material, with some modification, passes over poles, which results in formation of pseudosyncolpate crests distinct from rest of ectosexine. Monotypic.

Type Species.—Myocolpopollenites reticulatus ELSIK n. sp.

Occurrence.—Lower Eocene.

MYOCOLPOPOLLENITES RETICULATUS Elsik, n. sp.

Description.—Isopolar, spherical to prolate, reticulate pollen. Colpi as slits, not folds, which do not extend to poles; margins thickened and crenulate, tightly appressed or slightly opened, especially at ends. Marginate sexinous material extends past ends of colpi to poles where they join to form pseudosyncolpate triradiate crests. Ectosexine of crests and body both reticulate; crests set off from rest of sexine by narrow grooves. Nexine thin and imperforate. Sexine with distinct bacula supporting smooth muri. Bacula regularly to irregularly spaced. Sexinous elements much coarser over poles. Lumina irregular in size and shape, narrower and deeper

over poles. Wall thickness uniform except over poles where it is thickened. Dimensions of five specimens: width 35 to 48 μ; length 42 to 49 μ; colpi 24 to 26 μ long; wall thickness 2 to 8 μ at equator, 7 to 10 μ at the poles; nexine about 0.5 μ thick; muri 0.5 to 1.5 μ wide; bacula 0.5 μ in diameter; and lumina less than 0.5 to 5.8 μ wide; 6 to 12 μ long.

Holotype.—Plate 2, figures 1a-c. Measurements, 35 by 47 μ.

Occurrence.—Lower Eocene, type locality 2, rare.

Affinities.—Unknown. The presence of triradiate crests is distinctive for this genus. The crests of *Myocolpopollenites* are somewhat similar to the well-developed meridional crests of extant *Trapa* (Erdtman, 1952, p. 207; Ikuse, 1956, pl. 28, fig. 1) of the family Hydrocaryaceae. There is no similarity, however, in exine stratification or sculpture.

Illustrations.—Plate 2, figures 1,2.——1. Holotype, USNM 41643, slide S400(2), coordinates 31.5, + 15.8; 1a-c, phase contrast at high focus (1a), between high and median focus (1b), and at median focus (1c); all ×1,000.——2. Paratype, USNM 41644, slide S400(2), coordinates 27.8, + 14.5, phase contrast at median focus; ×1,000.

Genus TRICOLPITES Cookson in Couper, 1953

Type Species.—Tricolpites reticulatus Cookson, 1947 (p. 134, pl. 15, fig. 45; original designation by Couper, 1953, p. 61).

Occurrence.—Eocene.

TRICOLPITES CIRCUMSTRIATUS Fairchild, n. sp.

Description.—Pollen isopolar, slightly prolate, spheroidal. Colpi long, extending almost to the poles. Exine less than 1 μ thick, layering not distinguishable. Colpi margins slightly thickened in the equatorial area, in some with rudimentary transverse furrow. Sculpture consists of minute irregular striations more or less parallel to equatorial plane. In polar view striations appear roughly concentric around pole. Size range; equatorial diameter, 14 to 16 μ; length, 18 to 22 μ, based on 21 specimens.

Discussion.—Tricolpites circumstriatus is a common constituent of assemblages from the Rockdale lignite. It can be distinguished from the numerous other species of tricolpate and tricolporate pollen present by its thin exine, extremely long colpi, and its distinctive striate sculpture. The occasional presence of a rudimentary transverse furrow suggests that the species may be tricolporate, but in no case has it been possible to distinguish a definite pore within the furrows.

Comparison.—Published data afford no record of fossil tricolpate pollen with latitudinal striations comparable to those of *Tricolpites circumstriatus*.

Holotype.—Plate 2, figures 3a-c. Equatorial diameter of holotype, 20 μ.

Occurrence.—Lower Eocene, type locality 2, common.

Affinities.—Tricolpites circumstriatus has been compared with modern pollen of three species of *Acer* (*A. rubrum, A. platanoides,* and *A. pennsylvanicum*). The grains of modern *Acer* pollen are considerably larger than those of *T. circumstriatus*, and have a thicker exine with definite separation into layers. The striate surface pattern common to the three species is almost identical to that of *T. circumstriatus* in appearance, but in these species as well as in others of the genus the striations are aligned more or less longitudinally rather than parallel to the equatorial plane. No published descriptions or illustrations of modern pollen with latitudinally oriented striations similar to *T. circumstriatus* have been found.

Illustrations.—Plate 2, figures 3-7.——3. Holotype, USNM 41645, slide S400(3), coordinates 31.9, + 12.7; 3a-c, bright field at high (3a), median (3b) and low focus levels (3c); all ×1,000.——4. Paratype, USNM 41646, slide S400(3), coordinates 20.3, 20.3, + 17.5; 4a-c, phase contrast at median (4a), slightly lower (4b), and slightly higher (4c) focus levels; all ×1,000.——5. Paratype, USNM 41647, slide S400(3), coordinates 13.0, + 18.5; 5a,b, bright field at high (5a) and median (5b) focus levels; 5c, phase contrast at median focus level; all ×1,000.——6. Paratype, USNM 41648, slide S400(3), coordinates 20.7, + 15.5; phase contrast at high focus level, ×1,000.——7. Paratype, USNM 41649, slide S400(3), coordinates 8.4, + 7.6; 7a, b, phase contrast at median (7a) and high (7b) focus levels; both ×1,000.

Genus HOLKOPOLLENITES Fairchild, n. gen.

Diagnosis.—Pollen isopolar, tricolporate, oblate spheroidal. Outline in polar view deltoid with broadly rounded apices. Colpi long, deeply

incised, with definite margos extending full length of colpi. Margos interrupted at equator by transverse furrows. Exine relatively thick, nexine thicker than sexine except adjacent to colpi, where it thins abruptly. Nexine incised by inner irregular channels more or less parallel to sides of grain in polar view. Monotypic.

Type Species.—*Holkopollenites chemardensis* FAIRCHILD, n. sp.

Occurrence.—Paleocene.

HOLKOPOLLENITES CHEMARDENSIS Fairchild, n. sp.

Description.—Pollen isopolar, tricolporate, oblate spheroidal. Outline in polar view deltoid, with straight or very slightly concave sides, and broadly rounded apices. Colpi long, deeply incised, with margos one to two μ wide, extending full length of colpi. Transverse furrows interrupt margos at equator. Sexine composed of very close-spaced bacula which fuse together near margins of colpi. Nexine thicker than sexine except adjacent to colpi, where it thins abruptly and two layers are about equal in thickness. Nexine of polar and interapical areas incised by irregular channels more or less parallel to three sides of grain as seen in polar view. Size range 31 to 40 μ, based on 15 specimens.

Discussion.—Characteristic features of *Holkopollenites chemardensis* are its straight-sided outline, thickened and deeply incised colpi, and channeling of nexine. Size of areas adjacent to colpi in which nexine is thin and not channeled seems to be variable. Several specimens were noted in which nexinous channels were very weakly developed. These specimens were smaller than those with well-developed channels and may represent immature forms.

Comparison.—Judging from the drawing of the type species of *Nyssapollenites* THIERGART, 1937 (POTONIE, 1960, pl. 6, fig. 117, 118), *Holkopollenites* differs from that genus in several respects: 1) *Nyssapollenites* appears to have a distinct, round or oval equatorial pore around which the margos diverge, whereas the pores of *Holkopollenites* are indistinct and marked only by a minor interruption of the margos at the equator; 2) the margos of *Nyssapollenites* seem to be thickest near the equator and quite thin or absent at the polar ends of the colpi, however, the margos of *Holkopollenites* are uniformly thick throughout the length of the colpi; and 3) no indication of nexinous channeling appears in the drawing of the holotype of *Nyassapollenites* or in the illustrations of species subsequently assigned to the genus.

Holotype.—Plate 2, figures 8a-d. Equatorial diameter of holotype, 37 μ.

Occurrence.—Naborton Formation, Paleocene, type locality 5, common.

Affinity.—Unknown.

Illustrations.—Plate 1, figure 11; Plate 2, figures 8,9.——**1,** 11. Paratype, USNM 41642, slide F113(2), coordinates 23.0, + 15.6, apertural view, ×1,000.——**2,** 8. Holotype, USNM 41650, slide F113(2), coordinates 27.5, + 7.6; 8a-c, bright field at high (8a), high median (8b), and low median (8c) focus levels; 8d, phase contrast at median focus, all ×1,000.——**2,** 9. Paratype, USNM 41651, slide F113(2), coordinates 20.9, + 7.9; 9a, bright field at median focus, 9b, phase contrast at slightly lower focus, both ×1,000.

Genus KYANDOPOLLENITES Stover, n. gen.

Diagnosis.—Pollen isopolar, triaperturate; apertures aspidate, equatorial, compound. Outer aperture circular or nearly so, inner aperture elliptical, elongate. Grains circular in polar view, oblate in equatorial view. Exine relatively thick (5 to 8 μ), sexine thicker than nexine; endosexine lacking or very thin around apertures. Surface granulate on type species. Monotypic.

Type Species.—*Kyandopollenites anneratus* STOVER, n. sp.

Occurrence.—Lower Eocene.

KYANDOPOLLENITES ANNERATUS Stover, n. sp.

Description.—Triaperturate pollen having circular outline in polar view; apices slightly protrusive, sides moderately convex. Equatorial apertures aspidate, compound; outer aperture circular or nearly so, inner aperture elliptical, elongate poleward. Exine clearly stratified; ectosexine 2 to 2.5 μ thick over most of grain, thickening to nearly 6 μ around apertures; endosexine about 1 μ thick, except adjacent to the apertures where it is less than 0.5 μ in thickness or lacking. Nexine 2 to 2.5 μ thick, usually thickest around apertures. Outer surface more or less evenly granular, individual granules less than 1 μ in diameter, spaces between granules about half granule diameter. Size range, 47.5 to 54 μ, based on 20 specimens.

Discussion.—Characteristic features of *Kyandopollenites anneratus* include 1) nearly circular outline in polar view, 2) relatively thick exine, 3) thinning or absence of the endosexine around the apertures and 4), slightly aspidate apertures. Little variability in size, shape, exine thickness, and ornamentation was observed among the 42 specimens used in this study. The shape of the inner aperture varies from narrowly to broadly elliptical; this variation may be due to compression. On some specimens the endosexine appears columellar, especially around the apertures. Fistulate openings, like those observed in the exine on *Choanopollenites eximius*, also occur on some individuals of *K. anneratus*.

Comparison.—Because of its extremely thick exine, *Kyandopollenites* appear similar to *Emscheripollis* KRUTZSCH (1959) and *Papillopollis* PFLUG (1953). The new genus differs from these genera in having more convex sides, slightly aspidate apertures and less clearly differentiated wall layering. *Kyandopollenites* also differs from *Emscheripollis* in lacking tori and from *Papillopollis* in not having a vestibulum.

Holotype.—Plate 3, figures 1a-e. Diameter of holotype, 51 μ.

Occurrence.—Wilcox Group, lower Eocene, type locality 1, common.

Affinity.—Unknown.

Illustrations.—Plate 3, figures 1,2.——1. Holotype, USNM 41652, slide 995(74), coordinates 5.7, + 6.0; 1a-d, bright field photomicrographs at successively lower focus levels, 1a highest, 1d lowest; 1e,f, exine sculpture pattern at slightly different focus levels, 1e lower than 1f, all $\times$1,000. ——2. Paratype, USNM 41653, slide 995(72), coordinates 2.7, + 6.0; 2a-c, bright field photomicrographs at successively lower focus levels from slightly below pole to equator, 2a highest, 2c lowest, all $\times$1,000.

Genus GALLAPORTAPOLLENITES Elsik, n. gen.

Diagnosis.—Oblate, tri(col?)porate pollen. Pollen wall thin, stratification indistinct. Sexine(?) thickened and bulbous around apertures. Apertures indistinct; as irregular pores or cross-shaped openings. Monotypic.

Type Species.—*Gallaportapollenites aspera* ELSIK, n. sp.

Occurrence.—Lower Eocene.

GALLAPORTAPOLLENITES ASPERA Elsik, n. sp.

Description.—Oblate, tri(col?)porate pollen with sexinous(?) thickenings around apertures. Exine, except for apertural thickenings, thin; layering indistinct. Ornament finely granulose, scabrate, or pitted. Sexine(?) swollen and glabrous around apertures. Apertures as small irregular pores or cross-shaped openings. Apertural swellings are cavate on inside of grain. Margins of apertural swellings smooth to rough; occasional islets of sexinous(?) material along borders. Dimensions of 12 specimens are: equatorial width 15 to 22 μ; polar length (measured from one specimen), 11 μ; exine about 0.5 μ thick; apertural swellings, 4 to 6 μ thick; equatorial width, 10 to 14 μ, polar length, 8 to 10 μ.

Discussion.—Several Lower Tertiary form genera are characterized by exinous swellings around the apertures. *Gallaportapollenites* is distinct in that the swellings are generally solid and glabrous, and constitute the bulk of the pollen grain. The aperture is constricted and irregular. There are irregular polar folds in the exine generally parallel to the margins of the apertural swellings. The exine may be ruptured along these folded areas or along the margin of the swollen exine; perhaps these are alternate germination routes. Isolated apertural swellings are common in the residue.

Holotype.—Plate 3, figures 3a, b. Equatorial dimensions, 18 by 20 μ.

Occurrence.—Wilcox Group, middle Eocene, type locality 2, sparse.

Affinities.—Unknown.

Illustrations.—Plate 3, figures 3-7.——3. Holotype, USNM 41654, slide S400(3), coordinates 0.8, + 13.9; 3ab, bright field photomicrographs at high (3a) and median (3b) focus levels, both $\times$1,000.——4. Paratype, USNM 41655, slide S400(3), coordinates 26.4, + 18.1; 4a-c, bright field photomicrographs at high (4a), midway between high and median focus levels (4b) and at median focus (4c), all $\times$1,000.——5. Paratype, USNM 41656, slide S400(3), coordinates 25.1, + 17.9; 5a-c, bright field photomicrographs at same focus levels as 4a-c, $\times$1,000.——6. Photomicrographs of two detached "apertural swellings" as viewed toward the inner surface, $\times$1,000. ——7. Detached "apertural swellings" at different focus levels (7a,b), $\times$1,000.

Genus CHOANOPOLLENITES Stover, n. gen.

Diagnosis.—Pollen isopolar, triaperturate with radial symmetry. Outline subangular in polar view; oval in equatorial view. Apertures apical, equatorial, and compound. Exine stratification conspicuous, sexine thicker than nexine; endosexine greatly thickened adjacent to apertures. Surface smooth, indistinctly roughened or punctate. Monotypic.

Type Species.—*Choanopollenites eximius* Stover, n. sp.
Occurrence.—Lower Eocene.

CHOANOPOLLENITES EXIMIUS Stover, n. sp.

Description.—Triaperturate pollen having subangular outline in polar view; apices narrowly rounded, sides slightly convex, generally with slight or pronounced concavity midway between apices. Outer opertures narrowly elliptical, elongate poleward, confined to sexine; inner opertures broadly elliptical, elongate equatorially, confined to nexine and much larger than outer apertures. Exine layering distinct; ectosexine 3 to 4 μ thick, usually slightly thinner next to apertures; endosexine (columellae layer) less than 1 μ thick over most of the grain, however, at apertures and for 20 to 23 μ on both sides of apertures in equatorial direction, endosexine thickens to 4 to 5 μ. Nexine uniform, about 2.5 μ thick. Outer surface of pollen smooth, vaguely roughened or punctate; punctate unevenly distributed, more or less circular, one μ or less in diameter and 2 to 2.5 μ deep. Sparse, fistulate openings, larger in diameter than punctae, penetrate pollen wall either partly or completely. Diameter in polar view, 71 to 82 μ, based on 25 specimens.

Discussion.—The distinguishing features of *Choanopollenites eximius* include its relatively large size, the thick sexine—especially the pronounced thickening of the endosexine adjacent to the outer apertures—and the larger inner apertures. Of the 58 complete specimens observed in strewn preparations, nearly all were seen in polar view. The greatest variability appears to be in surface ornamentation and in the disposition and number of fistulate openings. A majority of specimens have an irregularly punctate surface ornamentation, others are smooth or have slightly roughened exteriors. The punctae vary in outline from circular to oval and they tend to be concentrated along the flanks of the pollen and between apices. On each pole, a poorly defined, narrow, triradiate area has a lighter coloration than the rest of the grain. The fistulate openings are randomly distributed, and have a variable depth of penetration.

Comparison.—The new species, although considerably larger, bears a resemblance to many of the "normapolles" from the Upper Cretaceous and Lower Tertiary of Europe, especially those assigned by Weyland & Krieger (1953) and by Pflug (*in* Thomson & Pflug, 1953), to *Trudopollis* Pflug, *Basopollis* Pflug, and *Oculopollis* Pflug. *Choanopollenites* appears to be most similar to the *T. protrudens*-type of "normapolle," but differs in having endexine greatly thickened in apertural areas and in lacking nexine layer in close proximity to outer aperture. *Basopollis* has vestibulum and *Oculopolis* has greatly expanded apertural areas; *Choanopollenites* lacks both of these features.

Direct comparison with most described "normapolles" is precluded owing to the paucity or lack of detailed morphologic information pertaining to wall and germinal structures.

Holotype.—Plate 4, figures 1a-h. Diameter of holotype, 80 μ.

Occurrence.—Wilcox Group, lower Eocene, type locality 2, abundant.

Affinities.—Unknown.

Illustrations.—Plate 4, figure 1.——Holotype, USNM 41657, slide 1051(54), coordinates 22.4, + 14.5; 1a-c, bright field photomicrographs of complete specimen at high (1a), intermediate (b) and median (1c) focus levels, all ×500; 1d-h, detail of wall and apertures at successively lower focus levels from about midway between pole and equator (1d) to slightly below equator, all ×1,000.

Genus QUADRAPOLLENITES Stover, n. gen.

Diagnosis.—Pollen isopolar, tetra-aperturate; outline circular or nearly so in polar and equatorial views. Apertures equatorial, colporate. Exine stratification faint, nexine absent or indistinct equatorially, sexine thickened adjacent to colpi. Ora circular or elliptical, relatively large. Outer surface smooth on type species. Monotypic.

Type Species.—Quadrapollenites vagus Stover, n. sp.
Occurrence.—Lower Eocene.

QUADRAPOLLENITES VAGUS Stover, n. sp.

Description.—Tetracolporate, isopolar, nearly spherical pollen—some specimens are slightly prolate, others slightly oblate. Apertures equatorial, colpi 22 to 26 μ long, 2 to 2.5 μ wide and with rounded ends. Narrow band, about 2.5 μ wide, surrounds colpi except in equatorial area. Ora circular or elliptical in outline, elongate equatorially, inconspicuous. Exine stratification usually indistinct, sexine and nexine about equal in thickness and both reduced in thickness at apertures in equatorial area; columellae layer is weakly defined and apparently lacking adjacent to apertures. Maximum exine thickness about 2 μ in interapertural areas. Outer surface smooth, commonly wrinkled on flattened specimens. Equatorial diameter 36 to 41 μ, based on 12 specimens.

Discussion.—The relatively wide U-shaped narrow bands next to the colpi, the poorly defined wall layering and the smooth exine are characteristic of *Quadrapollenites vagus*. Of the 40 specimens observed in random preparations, only 12 were seen in polar view. Except for size differences, little variability was observed in the morphology of the species.

Comparison.—*Quadrapollenites* differs from *Sapotaceoidaepollenites* Potonie, Thomson, & Thiergart (1950) in having a nearly spherical form, U-shaped thickenings next to the colpi except in the equatorial area, less prominent ora and in lacking obvious nexinous thickenings around the ora.

Holotype.—Plate 4, figures 3a,b. Diameter of holotype, 38 μ.

Occurrence.—Wilcox Group, lower Eocene, type locali 2, common.

Affinities.—Unknown.

Illustrations.—Plate 4, figures 2-5.——2. Paratype, USNM 41658, slide 1051(51), coordinates 8.2, + 16.0; specimen with weakly-developed thickenings and clearly defined ora, ×1,000.——3. Holotype, USNM 41659, slide 1051(50), coordinates 1.6, + 9.4; 3a, bright field, 3b, phase contrast, both ×1,000.——4. Paratype USNM 41660, slide 1051(46), coordinates 14.6, + 2.1, equatorial view of prolate form, ×1,000.——5. Paratype, USNM 41661, slide 1051(51), coordinates 9.7, + 13.0, × 1,000.

Genus OACOLPOPOLLENITES Elsik, n. gen.

Diagnosis.—Tricol(por?)ate pollen with distinct margos and variable sculpture. Distinct nexine. Sexine baculate; ectosexine smooth to punctate or granulate, verrucate, pistillate, vermiculate, or rugulate, singly or in any combination. Pore(?) suggested by equatorial separation of nexine or sexine in polar view or thinning of margo in equatorial view. Monotypic.

Type Species.—*Oacolpopollenites variabilis* Elsik, n. sp.
Occurrence.—Lower Eocene.

OACOLPOPOLLENITES VARIABILIS Elsik, n. sp.

Description.—Isopolar, tricol(por?)ate pollen with distinct margos. Shape various, generally spherical to subspherical. Colpate apertures closed to randomly opened on compressed specimens. Equatorial pores are suggested by divergence of nexine and sexine in that area along colpi in polar views; by apparent thinnings in sexinous margo in equatorial views (Pl. 5, figs. 2b,c). Colpi approach but do not reach the poles. Nexine thin. Endosexine very thin and baculate. Ectosexine variously ornamented—smooth to punctate, or granulate, verrucate, pistillate, vermiculate, or rugulate. Several ornamentation types may be encountered on one grain. Ectosexine always distinct at colpi margins. Dimensions based on 18 specimens are: equatorial dimensions, 21 to 31 by 18 to 32 μ; polar length, 20 to 25 μ; colpi approach to within 3 to 5 μ of each other at poles; width of margos, 2 to 3 μ; exine, 1.5 to 3 μ thick; nexine, 0.5 to 1 μ thick; endosexine, less than 0.5 μ thick; extosexine, 1.5 to 2 μ thick.

Comparison.—Ornamentation of this species is extremely variable. Some pistillate forms resemble *Pistillipollenites* Rouse (1962). However, the distinctly marginate colpi differentiate *Oacolpopollenites* from *Pistillipollenites*.

Holotype.—Plate 5, figures 1a-e. The holotype is 25 μ in diameter.

Occurrence.—Wilcox Group, lower Eocene, type locality 2, sparse.

Affinities.—Unknown.

Illustrations.—Plate 5, figures 1-6.——1. Holotype, USNM 41662, slide S400(3), coordinates 0.6, + 12.0; bright field photomicrographs at successively lower focus levels, 1a at high focus, 1e at low focus, all ×1,000.——2. Paratype, USNM 41663, slide S400(3), coordinates 24.4,

+ 14.8; bright field photomicrographs at high (2a), median (2b), and low focus (2c), all ×1,000.——3. Paratype, USNM 41664, slide S400(3), coordinates 26.3, + 18.2; equatorial view at high focus of specimen exhibiting closed colpi and pattern of thickened sexine, bright field, ×1,000.——4. Paratype, USNM 41665, slide S400(3), coordinates 22.9, + 10.2; phase contrast, ×1,000.——5. Paratype, USNM 41666, slide S400(3), coordinates 32.6, + 19.4; specimen exhibiting very little development of coarse ornamentation; phase contrast at high (5a) and median focus (5b); bright field at median focus (5c), all ×1,000.——6. Paratype, USNM 41667, slide S400(3), coordinates 24.5, + 10.7; specimen exhibiting irregularity of thickened sexine elements, phase contract at low focus, ×1,000.

Genus MINERISPORITES Potonié, 1956

Type Species.—*Selaginellites mirabilis* Miner, 1935.

MINERISPORITES MIRABILOIDES Elsik, n. sp.

Description.—Trilete megaspore. Central body subcircular to circular in outline. Equatorial zona present to absent, most strongly developed at apices where triradiate lamellae strengthen structure. Trilete evidently reaches equator of body, bounded by high triradiate lamellae. Triradiate lamellae extend to and in some specimens beyond equatorial zona at apices; most well developed over apices. Gross ornamentation reticulate, with broad, low and rounded muri and shallow lumina; muri not sharply defined. Reticulation limited to distal surface and in some along equator in interapical areas proximally. Equatorial zona and triradiate lamellae never reticulate, muri fade out towards those areas. Torn fragments exhibit pseudolamellar structure of spore wall. Wall appears to be punctate, fibrous, or finely granulate; spongy. Dimensions were measured from five specimens. Polar length 406 to 460 μ; equatorial diameter 452 to 664 μ; equatorial zona may be absent for as much as one-third of interapical distance, or if present, may be as much as 10 μ wide interapically. Apically equatorial zona are 70 to 180 μ wide. Triradiate lamellae are 70 to 180 μ high at apices, 70 to 100 μ over proximal pole, and up to 40 μ wide on each side of trilete. Proximal wall, 14 to 16 μ thick; equatorial wall, 12 to 14 μ thick; distal wall, 10 to 38 μ thick, inclusive of muri. Muri height, 2 to 10 μ; muri width, 6 to 30 μ; lumina width, 10 to 30 by 16 to 46 μ.

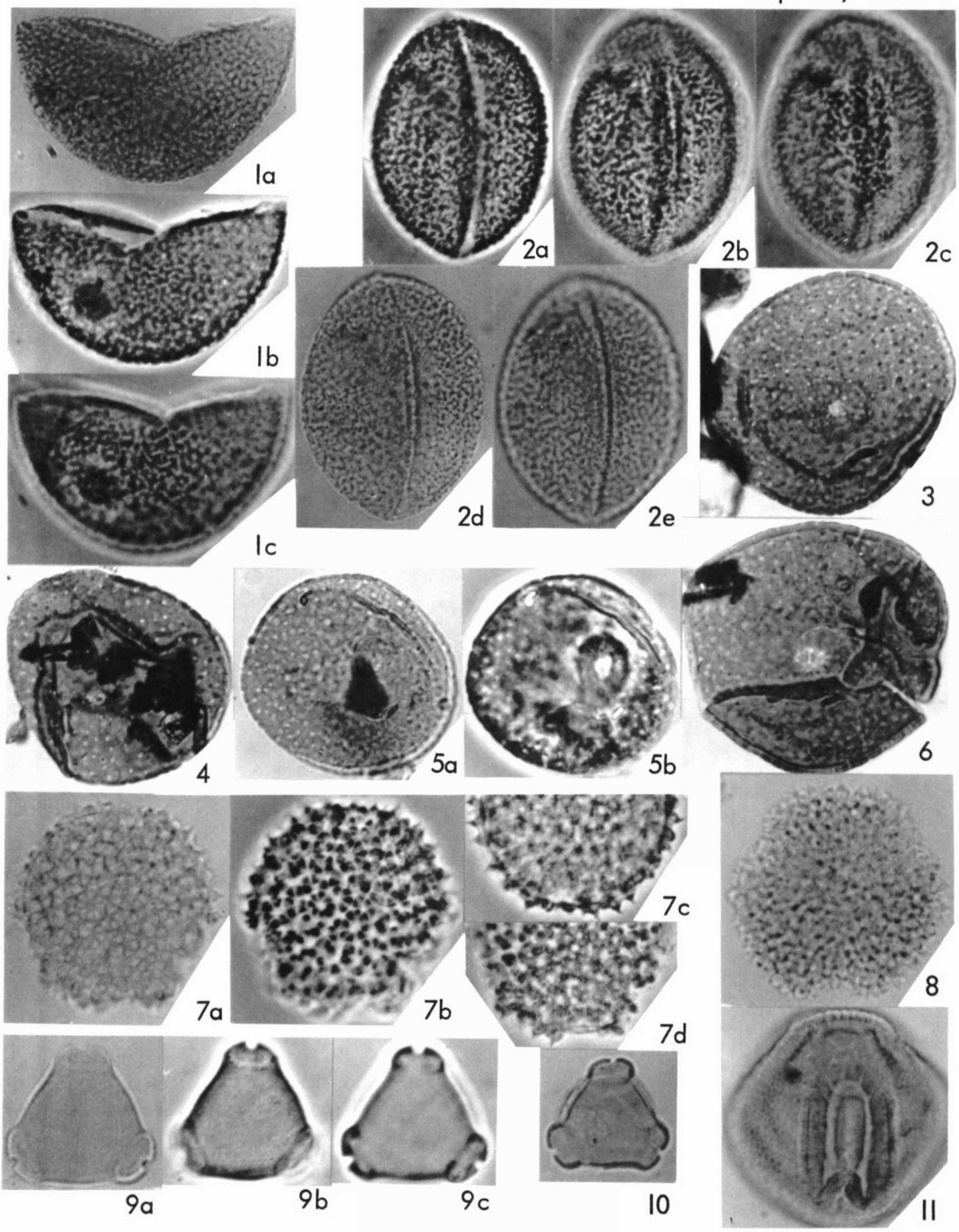
Comparison.—*Minerisporites mirabiloides* differs from *M. mirabilis* (Miner, 935) Potonié, 1956, in not having well-developed reticulation completely over the proximal surface. In addition, *M. mirabilis* possesses marked reticulation over the equatorial zona and up the base of the triradiate lamellae. *M. borealis* (Miner, 1932) Potonié, 1956, has much less distinct muri, appears to be thinner-walled, and the triradiate lamellae are not as prominent. *M. ales* (Harris, 1935) Potonié, 1956, and *M. richardsoni* (Murray, 1939) Potonié, 1956, both appear to possess proximal spines. *M. marginatus* (Dijkstra, 1951) Potonié, 1956 has narrower muri. *M. venustus* Singh (1964) possesses very narrow muri and only a faint reticulation, if any. *M. macroreticulatus* Singh (1964) has hair-like or membranous projections over the thin muri.

Holotype.—Plate 5, figure 7. Polar dimensions, 406 μ. Equatorial diameter, including zona, 499 μ.

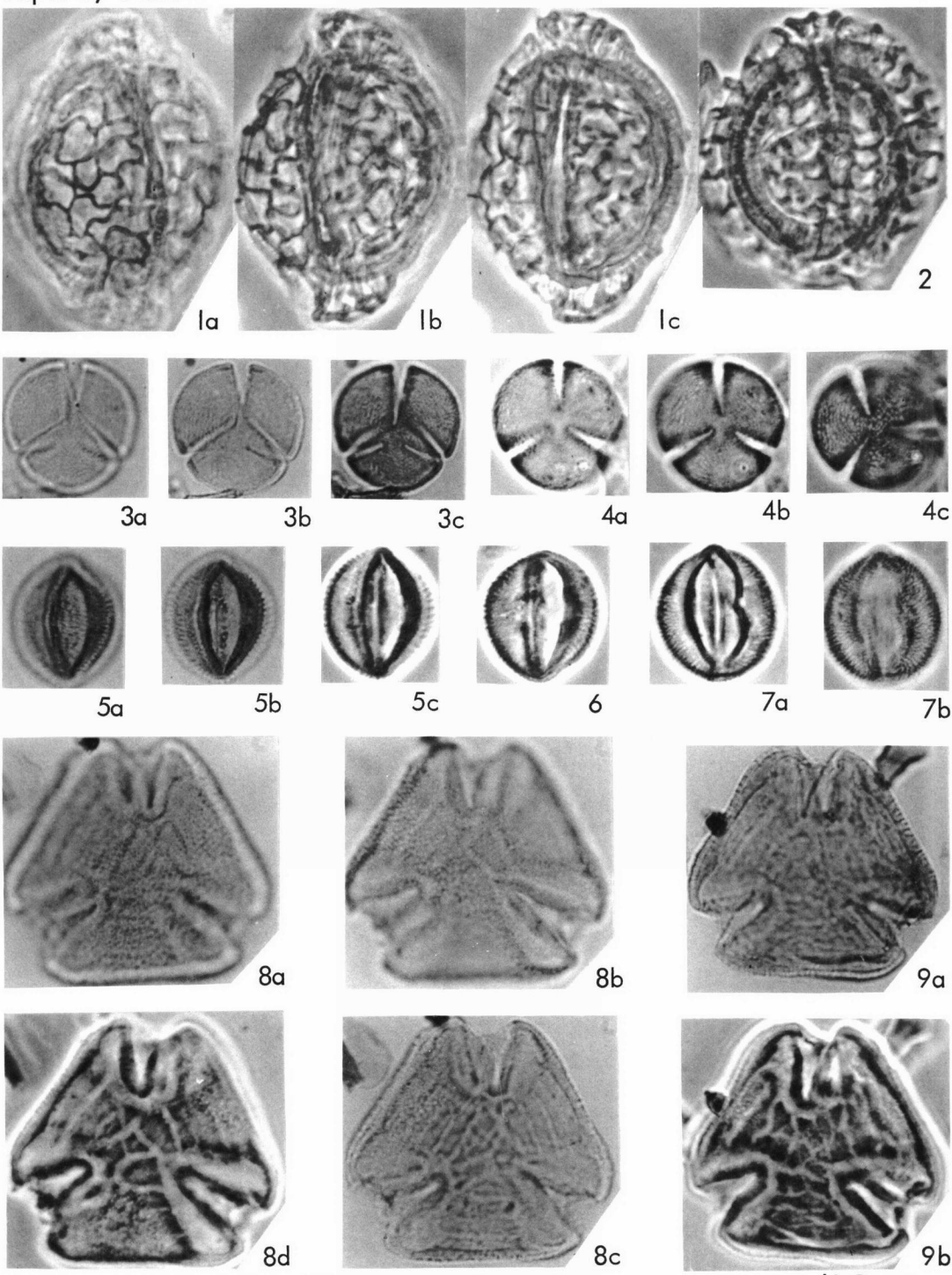
Occurrence.—Wilcox Group, lower Eocene, type locality 2, rare.

Affinities.—Miner (1932, 1935) placed trilete megaspores of this type in the organ genus *Selaginellites*. He stated, however, that "the equatorial ring is quite interesting, as it is present on megaspores of *Isoetes*, but it is not always present or evident on megaspores of *Selaginella*" (1935, p. 618). Singh (1964, p. 157) stated simply that ". . . probable affinity of *Minerisporites* is with the family *Selaginellaceae*." The tendency of the equatorial zona to be less well developed interapically may indeed indicate closer affinities to *Selaginella* than *Isoetes*.

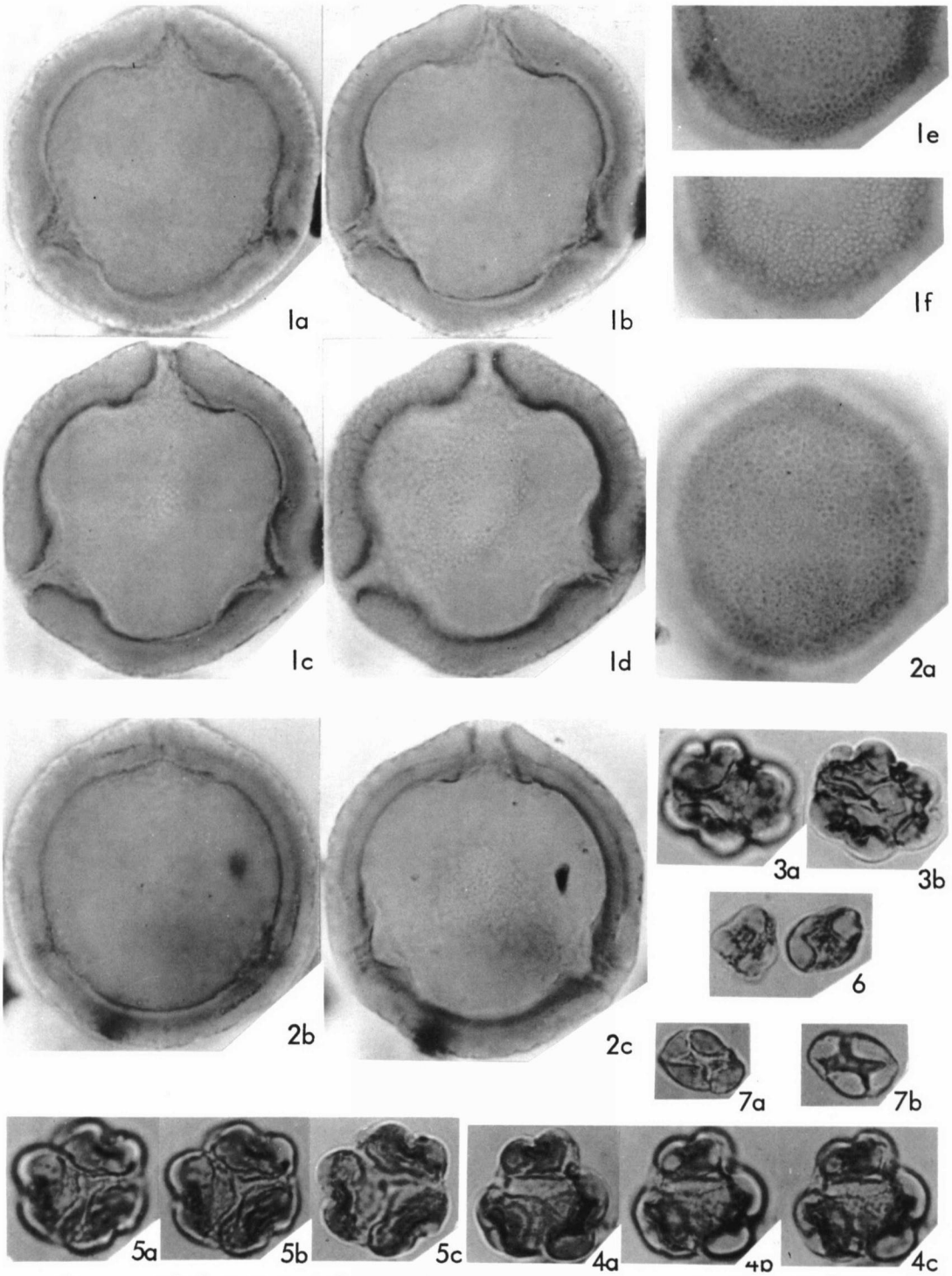
Illustrations.—Plate 5, figures 7-11.——7. Holotype, USNM 41668, slide S400E(4), coordinates 18.8, + 14.3; high (6a) and median focus (6b), both ×100.——8. Paratype, USNM 41669, slide S400E(1), coordinates 24.1, + 6.2, ×100.——9. Paratype, USNM 41670, slide S400E(1), coordinates 32.2, + 0.2, ×100.——10. Detail of sculptured wall, ×200.——11. Detail of reticulate sculpture, ×200.



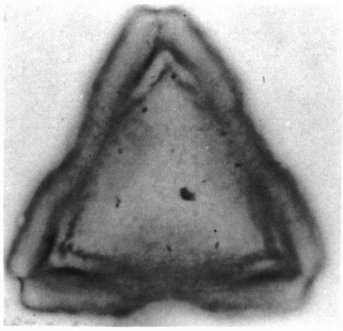
Stover, Elsik & Fairchild--Early Tertiary Palynomorphs from Gulf Coast
Calamuspollenites (1, 2); Monulcopollenites (3-6); Sernapollenites (7-8);
Triatriopollenites (9-10); Holkopollenites (11)



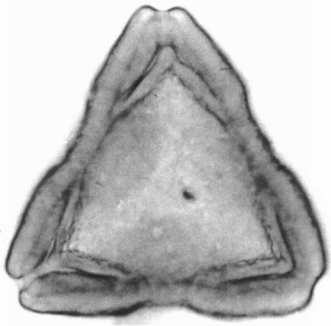
Stover, Elsik & Fairchild--Early Tertiary Palynomorphs from Gulf Coast
Myocolpopollenites (1, 2); Tricolpites (3-7); Holkopollenites (8-9)



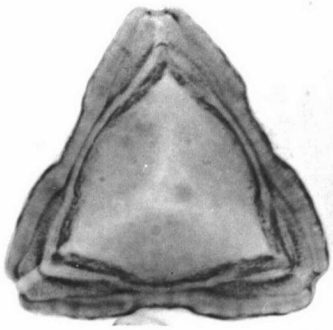
Stover, Elsik & Fairchild--Early Tertiary Palynomorphs from Gulf Coast
Kyandopollenites (1, 2); Gallaportapollenites (3-7)



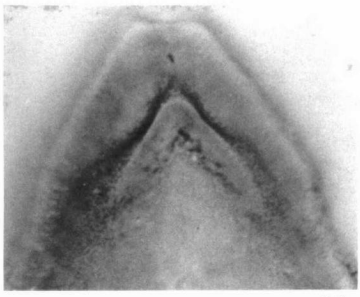
1a



1b

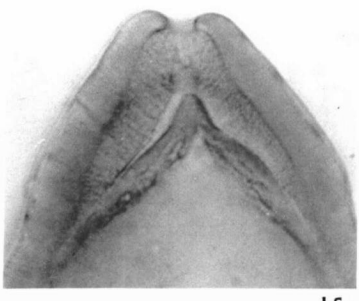


1c

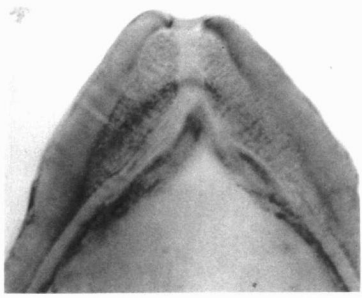


1d

1e

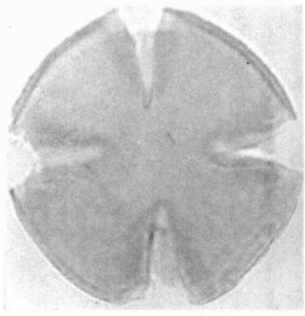


1f

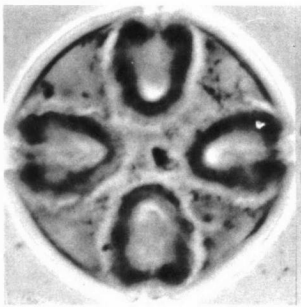


1g

1h

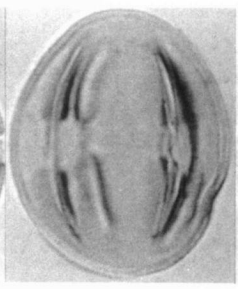


2



3a

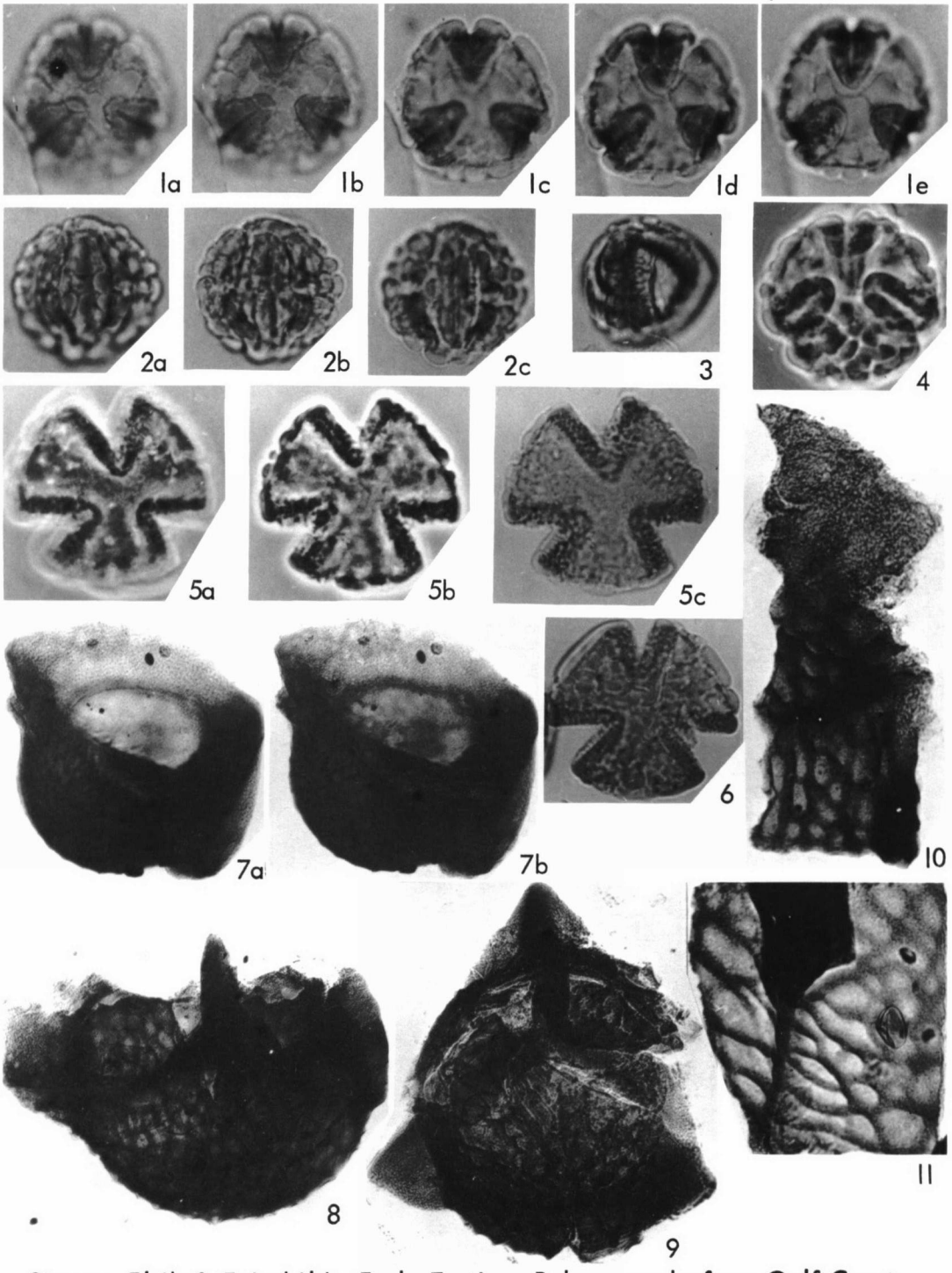
3b



4

5

Stover, Elsik & Fairchild--Early Tertiary Palynomorphs from Gulf Coast
Choanopollenites (1); Quadrapollenites (2-5)



Stover, Elsik & Fairchild--Early Tertiary Palynomorphs from Gulf Coast
Oacolpopollenites (1-6); Minerisporites (7-11)

REFERENCES

ANDERSON, R. Y., 1960, *Cretaceous-Tertiary palynology, eastern side Juan Basin, New Mexico:* New Mexica Inst. Mining and Technology, State Bureau of Mines and Mineral Resources, Mem. 6, 60 p., 12 pl.

COOKSON, I. C., 1947, *Plant microfossils from the lignites of the Kerguelen Archipelago:* B.A.N.Z. Antarctic Research Expedition (1929-31) Rept., ser. A, v. II, pt. 8, p. 129-142, pl. 13-16.

COUPER, R. A., 1953, *Upper Mesozoic and Cainozoic spore and pollen grains from New Zealand:* New Zealand Geol. Survey, Paleont. Bull. 22, 77 p., 9 pl.

ENGELHARDT, D. W., 1964a, *Plant microfossils from the Eocene Cockfield Formation, Hinds County, Mississippi:* Mississippi Geol. Research Papers—1964, Bull. 104, p. 65-96, pl. 1-5.

———, 1964b, *A new species of Gothanipollis Krutzsch from the (Middle Eocene) of Mississippi:* Pollen et Spores, v. 6, no. 2, p. 597-600, 1 pl.

ERDTMAN, GUNNAR, 1952, *Pollen morphology and plant taxonomy. Angiosperms:* Almquist & Wiksell (Stockholm), 539 p., 261 fig.

GRAY, JANE, 1960, *Temperate pollen genera in the Eocene (Claiborne) flora, Alabama:* Science, v. 132, p. 808-810.

IKUSE, MASA, 1956, *Pollen grains of Japan:* Hirokawa (Tokyo), 303 p., 76 pl.

JONES, E. L., 1962, *Palynology of the Midway-Wilcox boundary in south-central Arkansas:* Gulf Coast Assoc. Geol. Socs. Trans., v. 12, p. 285-294, pl. 1-3.

KRUTZSCH, WILFRED, 1957, *Sporen ond Pollengruppen aus der Oberkreide und dem Tertiar Mitteleuropas und ihre stratigraphische Verteilung:* Zeitschr. Angew. Geol., nr. 11/12, p. 509-546, pl. 1-16.

———, 1959, *Einige neue Formgattungen und Arten von Sporen und Pollen aus der Mitteleuropäischen Oberkreide und dem Tertiar:* Palaeontographica, Abt. B, v. 105, pt. 5-6, p. 125-157, pl. 31-35.

———, 1960, *Über Thomsonipollis magnificus (Th. & Pf. 1953) n. gen. n. comb. und Bemerkungen zur regionalen Verbreitung einiger Pollengruppen im alteren Paläocene:* Freiberger Forsch, c86, Paläeontologie, p. 54-65, pl. 1-4.

MEAGHER, D. P. & AYCOCK, L. C., 1942, *Louisiana lignite:* Louisiana Dept. Conserv., Geol. Pamph. 3, 56 p., 2 pl.

MINER, E. L., 1932, *Megaspores ascribed to Selaginellites, from the Upper Cretaceous coals of western Greenland.* Washington Acad. Sci., Jour., v. 22, no. 18-19, p. 497-506, fig. 1-31.

———, 1935, *Paleobotanical examinations of Cretaceous and Tertiary coals.* II. *Cretaceous and Tertiary coals from Montana:* Am. Midland Naturalist, v. 16, p. 616-621, pl. 23, 24.

PFLUG, H. D., 1953, *Zur Entstehung und Entwicklung des angiospermiden Pollens in der Erdgeschichte:* Palaeontographica, Abt. B, v. 95, pt. 4-6, p. 60-171, pl. 15-25.

POTONIÉ, ROBERT, 1956, *Synopsis der Gattungen der Sporae dispersae.* I. Teil: *Sporites:* Beihang, Geol. Jahrb. 23, 103 p., 11 pl.

———, 1960, *Synopsis der Gattungen der Sporae Dispersae.* III. Teil: *Nachtrage Sporites, Fortsetzung Pollenites:* Beih. Geol. Jahrb. 39, 189 p., 9 pl.

———, THOMSON, P. W. & THIERGART, FRIEDRICH, 1950, *Zur Nomenklatur und Klassifikation der neogenen Sporomorphae (Pollen und Sporen):* Geol. Jahrb. 65, p. 35-70, pl. a-c.

ROUSE, G. E., 1962, *Plant microfossils from the Burrard Formation of western British Columbia:* Micropaleontology, v. 8, no. 2, p. 187-218, pl. 1-5.

SINGH, CHAITANYA, 1964, *Microflora of the Lower Cretaceous Mannville Group, east-central Alberta:* Research Council Alberta, Bull. 15, 239 p., 29 pl.

SMITH, F. E., 1959, *Lower Tertiary and Upper Cretaceous of the Brazos River Valley, Texas:* Houston Geol. Soc. and Gulf Coast Sect. SEPM, Guidebook, Ann. Field Trip, p. 1-54, pl. 1-8.

THIERGART, FRIEDRICH, 1937, *Die Pollenflora der niederlausitzer Braunkohle, besonders im Profil der Grube Marga bei Senftenberg:* Jahrb. Preuss. Geol. Landesanst. zu Berlin, v. 59, p. 282-351, pl. 22-30.

THOMSON, P. W. & PFLUG, H. D., 1953, *Pollen und Sporen des mitteleuropäischen Tertiärs:* Pt. II. *Systematik:* Palaeontographica, Abt. B, v. 94, pt. 1-4, p. 48-117, pl. 1-15.

WEYLAND, HERMANN, & KRIEGER, WILHELM, 1953, *Die Sporen und Pollen der Aachener Kreide und ihre Bedeutung fur die Charakterisierung des mittleren Senons:* Palaeontographica, Abt. B, v. 95, p. 1-3, p. 6-29, pl. 1-5.