Complexiopollis Pollen Lineage in Mississippi Embayment Rocks

GEOLOGICAL SURVEY PROFESSIONAL PAPER 743-C

Work done in cooperation with the Kentucky Geological Survey

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By ROBERT H. TSCHUDY

CONTRIBUTIONS TO PALEONTOLOGY

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Stratigraphic ranges of new species belonging to the genera Complexiopollis *and* Choanopollenites

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ABSTRACT

Complexiopollis Krutzsch 1959, a genus proposed for fossil pollen grains and originally described from Europe, is represented in the Mississippi Embayment by four new species herein named and described. *Choanopollenites* Stover 1966 is a fossil pollen genus somewhat similar morphologically to *Complexiopollis* and by evolution is considered to be derived from it. Four new species of *Choanopollenites* are named and described and one species, reported previously, is included as a new combination.

The range zones of the species of *Complexiopollis* and *Choanopollenites* discussed in this paper are delineated, and the relationships between the species are suggested.

INTRODUCTION

The genus *Complexiopollis*, originally described from Europe by Krutzsch (1959), is a member of a complex of genera composing the group Normapolles of Pflug (1953). Pollen grains assigned to genera of the Normapolles group are commonly triangular, short axial, and morphologically highly differentiated, and they possess complex, and sometimes bizarre, apertures. So far as is known, these genera are extinct, and their relationship to modern families and genera is as yet unknown. Normapolles is a group of convenience and no genetic relationships among all the included genera are implied. *Complexiopollis* is one of the earliest, if not the earliest, genus of the Normapolles group to appear in the fossil record. In Europe it appears in the basal Cenomanian and persists at least into the basal Campanian.

Krutzsch (in Góczán and others, 1967) restudied genera belonging to the Normapolles group, erected several new genera, but of more importance, clarified the morphological details of wall and aperture structures of the several genera. He redescribed *Complexiopollis* and placed his genera *Latipollis* Krutzsch 1959 and *Turonipollis* Krutzsch 1959 in synonymy with *Complexiopollis*.

Several species were found in reference material from formations in the Mississippi Embayment and tentatively assigned to the genus *Complexiopollis*. The present work is the outcome of more careful examination of these species in preparation for providing descriptions and names for the undescribed new species.

The genus *Complexiopollis* (including *Latipollis*) has been reported from North American rocks by Leopold and Pakiser (1964) from the pre-Selma Cretaceous of Alabama, by Groot and Groot (1962) from the Paleocene of Maryland, by Gray and Groot (1966) from the Upper Cretaceous of Delaware and New Jersey, by Doyle (1969) from the Raritan and Magothy Formations of the Atlantic Coastal Plain, and by Wolfe and Pakiser (1971) from the Magothy and Raritan Formations of New Jersey and Maryland. Except for the papers by Groot and Groot (1962) and Gray and Groot (1966) none of these contributions provides species names or descriptions.

The material on hand from some Mississippi Embayment Upper Cretaceous and Tertiary formations has been ample for the description of nine species, eight new and one new combination, assignable to the *Complexiopollis* lineage. Furthermore, when the ranges of the several species are considered in stratigraphic sequence, evolutionary development of the pollen *Complexiopollis* to *Choanopollenites* with the retention of the basic morphologic features of *Complexiopollis* becomes evident.

The stratigraphic distribution of the several species and the evolutionary lineage that developed in North America is presented. The morphological features that characterize the genus *Complexiopollis* and that are present in modified form in the genus *Choanopollenites* Stover 1966 are demonstrated. *Choanopollenites* is here considered as belonging to the *Complexiopollis* lineage.

ACKNOWLEDGMENTS

I thank the following people for providing some of the reference samples: Jack Wolfe of the U.S. Geological Survey for matrix material from collections of E. W. Berry in the U.S. National Museum, E. M. Cushing and W. W. Olive of the U.S. Geological Survey for the Clayton Formation and McNairy Sand samples studied, W. W. Fairchild of Standard Oil Company of Texas for the sample from the Naborton Formation, C. W. Copeland of the Geological Survey of Alabama for a sample from the Naheola Formation, and H. T. Ames of Pennsylvania State University for the sample from the Coal Bluff Marl Member of the Naheola Formation. Kathryn Dieterich and Sharon Van Loenen assisted in the preparation of the samples and the photography of specimens.

METHODS

The methods employed for processing rock samples and preparing slides are standard for this laboratory and have been reported previously (Tschudy, 1970).

I set an arbitrary minimum of 10 good specimens as the basis for assigning a name to a new species. Several potentially new species are mentioned but because of insufficient specimens are not named.

TYPE SPECIMENS

All specimens illustrated in this report are preserved on slides deposited in the paleobotanical collections of the U.S. Geological Survey, Denver, Colo. All illustrated specimens are within black-inked circles marked directly on the slides; they may also be located on the slides by the mechanical-stage coordinates given in the plate explanations. In order that other workers may convert their mechanical-stage readings to those recorded for specimens included in this report, the coordinates for the center point of a 1- by 3-inch standard microscope slide are 108.0 and 12.3 mm (designated as 108.0×12.3). The method of accurately locating the center of a standard microscope slide is described by Tschudy (1966, p. D78). If the slide label is placed to the left, the vertical coordinates decrease toward the near edge of the slide and the horizontal coordinates decrease toward the right edge of the slide.

FOSSIL POLLEN LOCALITIES

The fossil pollen grains used in this study are cataloged by the appropriate U.S. Geological Survey localities and by slide numbers. The rock samples used for obtaining reference material from formations within the Mississippi Embayment are from the localities shown in figure 1. Twenty-six samples from 15 collecting localities in Louisiana, Missouri, Kentucky, Tennessee, Alabama, Georgia, and Mississippi were examined in detail.

The following descriptions of sampling localities are given in approximate stratigraphic order, oldest to youngest.

USGS paleobotany loc. No.	Locality	Stratigraphic unit
D3415	Outcrop at an altitude of 510 feet on the south side of U.S. Highway 78, NW¼ sec. 34, T. 3 S., R. 15 W., Colbert County, Ala. Collected by W. W. Olive, U.S. Geological Survey, and indicated by him (writen commun., 1964) as being "probably from unit 4 described by Stevenson and Monroe, 1940, p. 46."	Tuscaloosa Formation.
D3265	E. W. Barry field No. 6474. Collected at Broken Arrow Bend of the Chattahoochee River about 13 miles below Columbus, Chattahoochee County, Ga. Matrix material from leaf locality collected by E. W. Berry, U.S. Geological Survey, 1909. Matrix submitted by Jack Wolfe, U.S. Geological Survey, 1963.	Eutaw Formation.
D3260	E. W. Berry field No. 6471. Collected at the junction of Cowickee Creek and Chattahoochee River, Barbour County, Ala. Matrix material from leaf locality collected by E. W. Berry, U.S. Geological Survey, 1909. Matrix submitted by Jack Wolfe, U.S. Geological Survey, 1963.	Cusseta Sand Member, Ripley Formation.
D3412	Type locality, near middle. Elev. 440 feet along bluff on left bank Tennessee River 0.3 miles downstream from mile 185 and 0.9 mile east of crossroads north of Coffee Landing, Hardin County, Tenn. Collected by W. W. Olive, U.S. Geological Survey, 1964.	Coffee Sand.
D3413	From roadcut along east side Tennessee Highway 22, 0.8 mile north of intersection with Tennessee Highway 100, Henderson County, Tenn. Collected by W. W. Olive, U.S. Geological Survey, 1964.	Coon Creek Tongue of Ripley Formation.
D1967	Type locality of McNairy Sand Member. West end of big cut in Southern RR., east of Dismal Swamp and Tuscumbia River. Base is approximately same elevation as track and 40 feet northwest of railroad crossing. South center NW¼SW¼, Chewala quad., McNairy County, Tenn. Collected by E. M. Cushing, U.S. Geological Survey, 1962.	McNairy Sand Member of Ripley Formation.
D1967–A	0–14 in. above bottom of sequence.	Do.
B	14–26 in. above bottom of sequence.	Do.
C	26–38 in. above bottom of sequence.	Do.
D3416	6 feet below unconformable contact with Owl Creek Formation; NW¼NW¼ sec. 10, T. 27 N., R. 11 E., Advance 7½-min quad., Stoddard County, Mo. Collected by W. W. Olive, U.S. Geological Survey, 1964.	Upper part McNairy Sand.
D3410	Type locality. From right bank of Owl Creek, 2.5 miles northeast of Ripley, Miss., E½ sec. 7, T. 4 S., R. 4 E., Tippah County, Miss. Collected by W. W. Olive, U.S. Geological Survey, 1964.	Owl Creek Formation.

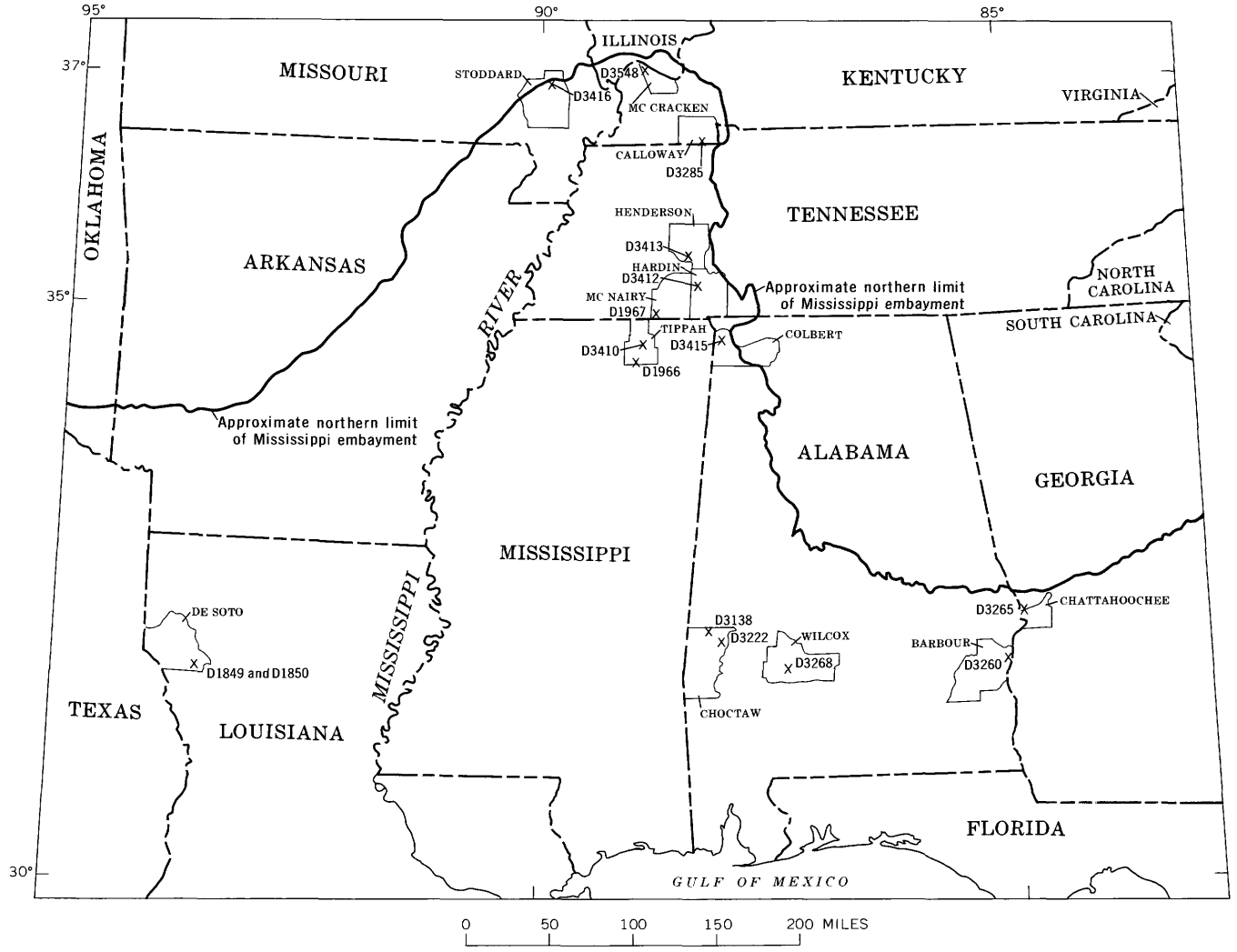

FIGURE 1.—Map of Mississippi Embayment showing fossil localities and USGS paleobotany locality numbers. Selected counties are delineated within each State.

USGS paleobotany loc. No.	Locality	Stratigraphic unit
D1966	1.5 miles south-southwest of Cotton Plant, Miss., southwest wall of tributary to Guyton Creek along country road. S½NW¼ sec. 8, T. 6 S., R. 3 E., Tippah County, Miss. Collected by E. M. Cushing, U.S. Geological Survey, 1962.	Clayton Formation.
D1966-A	6 feet above basal limestone.	Do.
B	9 feet above basal limestone.	Do.
C	14 feet above basal limestone.	Do.
D	15 feet above basal limestone.	Do.
E	17 feet above basal limestone.	Do.
F	20–23 feet above basal limestone.	Do.
D3548	Auger hole J. 12, about 1 mile from southwest corner Joppa 7½-min quad.; Kentucky coordinates, south zone: E. 1,094,590 feet; N. 308,200 feet, McCracken County, Ky. Collected by W. W. Olive, U.S. Geological Survey, 1965.	Do.
D3548-A	Depth 93–98 feet.	Do.
B	Depth 77–93 feet.	Porters Creek Clay.
C	Depth 62–77 feet.	Do.
D	Depth 52–62 feet.	Do.
D3285	Channel of McCullough Fork, 300 feet north Kentucky-Tennessee State line. Kentucky coordinates, south zone: E. 1,263,500 feet; N. 70,250 feet. Hazel quad., Calloway County, Ky. Collected by W. W. Olive, U.S Geological Survey, 1963.	Porters Creek Clay.
D1849 and D1850.	NW¼SW¼ sec. 6, T. 11 N., R. 11 W., De Soto Parish, La. Sample provided by W. W. Fairchild, Standard Oil Company of Texas, 1962.	Naborton Formation.
D3138	Upper half Naheola Formation from along Alabama Highway 17 in SE¼NW¼ sec. 3, T. 15 N., R. 2 W., Choctaw County, Ala. Sample provided by C. W. Copeland, Geological Survey of Alabama, 1963.	Naheola Formation.
D3268	Type locality. From Coal Bluff on Alabama River, sec. 7, T. 11 N., R. 7 E., Wilcox County, Ala. Sample provided by H. T. Ames, Pennsylvania State University, 1963.	Coal Bluff Marl Member, Naheola Formation.

USGS paleobotany loc. No.	Locality	Stratigraphic unit
D3222 -------	0.2 mile east of bridge across Tucabum River on Lavaca-Pennington Road, south side new roadcut; sec. 22, T. 14, N., R. 1 W., Choctaw County, Ala. (See F. S. MacNeil, 1946) Collected by W. W. Olive and R. H. Tschudy, U.S. Geological Survey, 1963.	Nanafalia Formation.

SYSTEMATIC DESCRIPTIONS

Genus Complexiopollis Krutzsch, 1959, emend.

Latipollis Krutzsch 1959, Palaeontographica sec. B, v. 105, p. 128.

Turonipollis Krutzsch 1959, Palaeontographica sec. B, v. 105, p. 133.

Type species.—*Complexiopollis praeatumescens* Krutzsch 1959.

Diagnosis.—Pollen grains triangular flat lens shaped, rarely thick lens shaped; many triplanoid, range to typically triplane. Equatorial contour concave to extremely concave and twisted triangular, rarely convex triangular with bizarre, elongated angles (germinals). Contour sometimes interrupted, sometimes almost uninterrupted. Length of the polar axis differing greatly among the individual form-species, depending upon the shape, outline and triplane aspect of the grains. Wall thin, multilayered; in some species layers are distinct, in others appearing as a wall-complex. Endexine as thick as ektexine or slightly thicker. Surface smooth to weakly sculptured. Structure of germinals is complex. Exogerminal with a vertical (poleward directed) slit-shaped outer opening, two layered, the outer part without structure, the inner with radially projecting tightly packed bacula. Toward the roots of the exogerminals the bacula may be less densely packed, appearing as separate rods or narrow spines. Vestibulum small, in most grains not prominent. Mesogerminal consists of two flaplike structures separated by an equatorially directed slitlike opening at right angle to the exogerminal opening. An annuluslike thickening often present at the exterior extremities of the flaplike aperture. Centripetal to the mesogerminal, additional wall lamellae with atriate openings are developed. The inner wall layers at the root of the germinal are almost without structure. Secondary folding is incidental, particularly in the delicate triplane forms. No oculus or interloculum is present. Typical regular plicae are absent; however, some species may have delicate endexinal arci. The pollen species range in size from about 15μ (microns) to about 40μ.

Remarks.—Krutzsch (in Góczán and others, 1967) reviewed the morphology of the genera *Latipollis* Krutzsch 1959 and *Turonipollis* Krutzsch 1959 and concluded that these two genera should be suppressed. He placed pollen species previously assigned to them in the revised genus *Complexiopollis* Krutzsch. In his revised generic diagnosis of *Complexiopollis*, Krutzsch stated that arci are absent. Several of the new species from Mississippi Embayment rocks possess delicate threadlike endexinal arci. The morphological features of these species are otherwise identical to those found in other species of *Complexiopollis*. I have, therefore, emended the genus *Complexiopollis* to include arci rather than erecting a new genus for these new species.

Forms which have a somewhat rigid rhombic equatorial outline (typically triplane forms) and which were previously assigned to the genus *Latipollis* may owe their shape, in part at least, to the presence of a somewhat rigid thickened part of the endexine that extends from pore to pore (the arci). A typical example of this triplane form is seen in *Complexiopollis* (formerly *Latipollis*) *normis*. The new species *C. funiculus* possesses much more prominent cordlike thickenings or arci extending from pore to pore. When compressed laterally this species assumes the typical triplane form.

The genus *Atlantopollis* Krutzsch 1967 is morphologically somewhat similar to *Complexiopollis*. Krutzsch (in Góczán and others, 1967, p. 446) distinguishes *Atlantopollis* from *Complexiopollis* by the prominent sculpture and the presence of a columella layer in *Atlantopollis*. However, Krutzsch does not mention in his diagnosis the presence of mesogerminal flaps or equatorially oriented mesogerminal openings, nor does he show these features in his diagrammatic representation of *Atlantopollis*. Consequently, for the present, I am excluding *Atlantopollis* from the *Complexiopollis* lineage.

Complexiopollis funiculus n. sp.

Plate 1, figures 1–29; text figure 2

Holotype.—USGS paleobotany loc. D3415, slide 3, coordinates 107.8×9.5, plate 1, figures 1–7.

Paratype.—USGS paleobotany loc. D3415, slide 1, coordinates 78.9×21.4, plate 1, figures 8, 9.

Paratype.—USGS paleobotany loc. D3415, slide 2, coordinates 108.5×16.9, plate 1, figures 11–15.

Diagnosis.—Shape of pollen grains triangular to strongly concave in polar view, triplane in equatorial view and twisted into a partial triplanoid attitude. Size range, based on more than 100 specimens, equatorial diameter 23–36μ, polar 17–21μ. Wall made

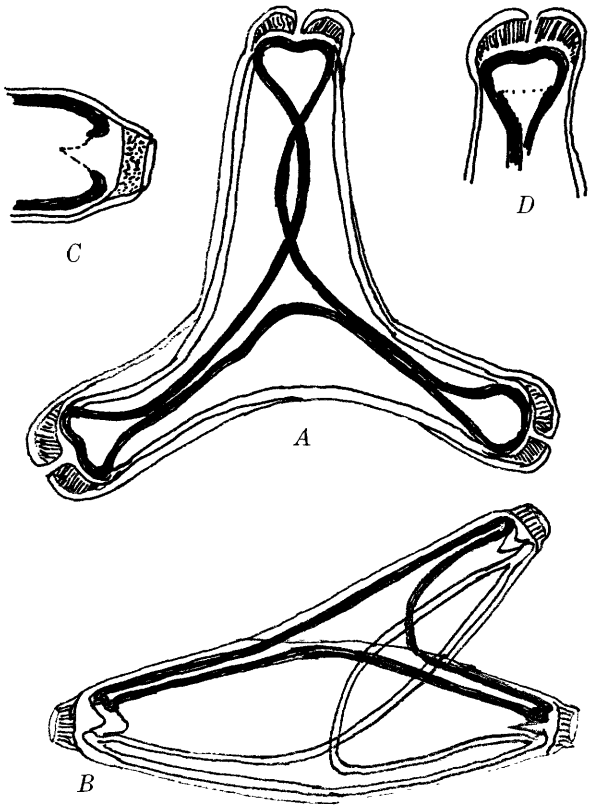

FIGURE 2.—*Complexiopollis funiculus*, ca. × 2000. *A*, Polar view showing arci. The upper cordlike endexinal thickenings have been shaded; the lower are shown in outline. *B*, Lateral or equatorial triplane view. Upper arci shaded. *C*, Equatorial view of aperture showing vertical outer slit and horizontal V-shaped inner aperture bordered by flaps. *D*, Polar view of aperture showing additional lamella centripetal to the endexinal flaps.

up of at least two layers, the inner layer usually exhibiting evidence of several lamellae. Ektexine and endexine thin, their combined thickness less than 2μ. Surface of ektexine psilate to scabrate. Exogerminals 3.5–5μ wide (polar view) with a vertical slit-shaped outer opening. Exogerminal two layered, the outer thin and without internal structure, the inner consisting of radially directed tightly packed bacula. The thickened part of the ektexine in germinal area less than 5μ long in radial direction. Mesogerminal consisting of two fairly broad flaps on opposite sides of an equatorially elongated opening at right angle to the opening of the exogerminal. Cordlike endexinal thickenings extend from the sides of the mesogerminal openings to adjacent apertures. These form slight annuluslike thickenings at the outer margins of the flaps. In equatorial (or triplane) view the mesogerminal lamella is thickened above and below at the apertures. A radially directed V-shaped opening separates the flaps. A very narrow vestibulum separates the exogerminal from the mesogerminal. Additional lamellae centripetal to the mesogerminal are distinguishable in a few specimens.

Stratigraphic distribution.—Tuscaloosa and Eutaw Formations.

Remarks.—*Complexiopollis funiculus* can be distinguished from most other species of *Complexiopollis* by its threadlike arci. *Complexopollis microverrucosus* sp. nov., although possessing arci, has a prominent verrucate surface sculpture; its apertures are larger in polar diameter; and its baculate layer is distinctly larger and more prominent. *Complexiopollis abditus* sp. nov. also possesses arci, but it is much smaller and its shape is triangular rather than concave triangular.

The specimen in triplane equatorial view (pl. 1, figs. 20–22) shows the upper aperture as it appears in polar view and the other two apertures in equatorial view. The specimen on plate 1, figures 23 and 24 exhibits the arci in equatorial view, as drawn in text figure 2*B*.

Complexiopollis microverrucosus n. sp.

Plate 2, figures 1–23; text figure 3

Holotype.—USGS paleobotany loc. D3412, slide 3, coordinates 105.2×7.4, plate 2, figures 1–8.

Paratype.—USGS paleobotany loc. D3412, slide 1, coordinates 82.7×16.3, plate 2, figures 9–11.

Paratype.—USGS paleobotany loc. D3412, slide 1, coordinates 75.5×5.7, plate 2, figures 12–14.

Diagnosis.—Shape of pollen grains triangular to strongly concave triangular in polar view, triplane in equatorial view, often twisted into a partial triplane attitude. Size, based on 25 specimens, 25–39μ in equatorial diameter. Wall thin, flexible; ektexine and endexine of about equal thickness, in combination less than 2μ thick. Ektexine verrucate with low relief. Exogerminal 8–10μ in polar diameter with a vertical slit-shaped outer opening; two layered, the outer thin without internal structure, the inner with radially projecting tightly packed bacula. Length of bacula shorter toward the root of the exogerminal. Mesogerminal consisting of two rounded flaps separated by a V-shaped opening. Mesogerminal opening equatorially directed and at right angle to the exogerminal opening. A narrow annulus is present at the extremities of the flaps, appearing as a loop or partial loop when seen in oblique view, and continuing as arci connecting the three apertures. Vestibulum between exogerminal and endogerminal somewhat prominent. At least one additional lamella

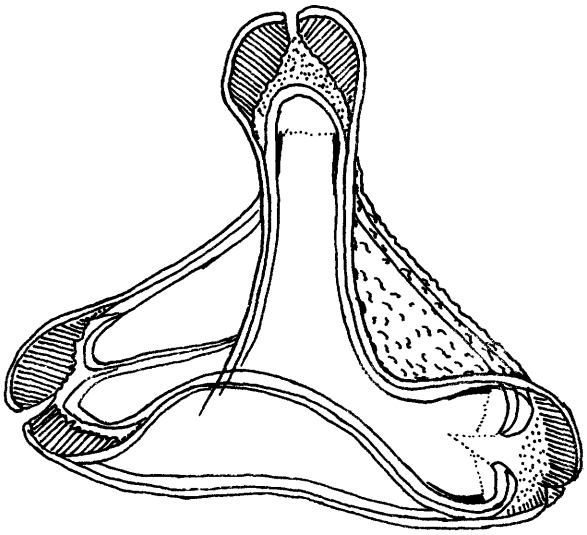

FIGURE 3. — *Complexiopollis microverrucosus*, ca. × 2000. The upper aperture shows a typical polar view, the one to the right an equatorial view, and the one to the left an intermediate view showing the loop-forming thickenings at the extremities of the mesogerminal flaps. Lamella forming atriate endogerminal shown in right aperture.

is present centripetal to the mesogerminal and forms an atriate endogerminal.

Stratigraphic distribution.—Coffee Sand and Coon Creek Tongue of Ripley Formation.

Remarks.—This species differs from *Complexiopollis funiculus* by its more verrucate surface sculpture, larger germinals and larger, more prominent baculate areas and more prominent loop-forming thickenings as extensions of the arci across the terminal portions of the mesogerminals. The looplike thickenings on the extremities of the mesogerminal flaps are similar to those figured for *Turonipollis turonis* (now *Complexiopollis turonis*) by Krutzsch (1959). However, Krutzsch presented photographs of but one specimen. In Krutzsch's photographs arci are not clearly evident, and the outer surface of his specimen has a smooth appearance.

The looplike appearance of the extremities of the mesogerminal flaps is shown particularly well on plate 2, figures 10, 12, and 14. Plate 2, figures 15–17 and 21–23 shows this species in typical triplane attitude.

Complexiopollis patulus n. sp.

Plate 3, figures 1–18; text figure 4

Holotype.—USGS paleobotany loc. D3265, slide 2, coordinates 97.0×15.5, plate 3, figures 1–3.

Paratype.—USGS paleobotany loc. D3265, slide 3, coordinates 83.2×6.7, plate, 3, figures 6–9.

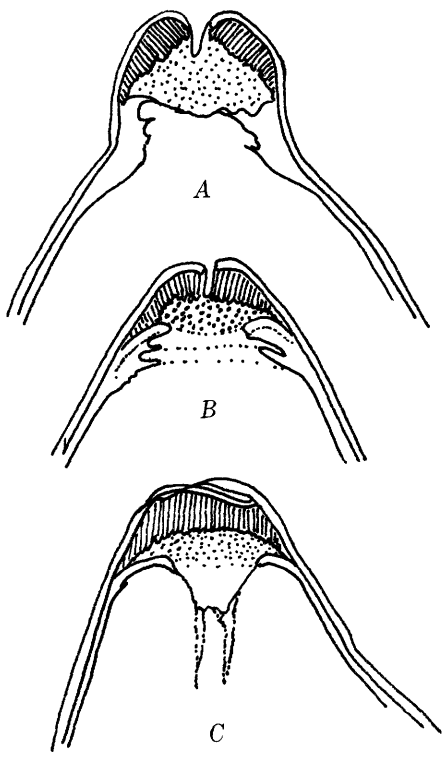

FIGURE 4.—*Complexiopollis patulus*, ca. × 2000. *A* and *B*, Apertures in polar view showing variation in shape of germinals and the prominent lamellae forming endogerminal atria. *C*, Equatorial view of aperture showing V-shaped notch between flaps and the short, incomplete arci.

Diagnosis.—Pollen shape triangular to slightly convex-triangular in polar view, germinal areas commonly protruding. In equatorial view rhomboidal triplane. Size 24–37μ in equatorial diameter (20 specimens) and 22–28μ in polar diameter (eight specimens). Wall thin; ektexine and endexine difficult to distinguish, combined thickness about 1μ in the interapertural areas. Surface psilate to microscabrate. Exogerminal a vertical slit-shaped opening surrounded by a two-layered thickening of the ektexine. Outer layer of ektexine without structure, inner layer made up of radially directed elongate tightly packed bacula. Wall thickness at exogerminal about 3μ. Vestibulum prominent; in equatorial view ends of bacula appear as punctae. Endexine thin, except in vicinity of mesogerminal where short incomplete arcuslike thickenings are commonly present. Mesogerminal consisting of two delicate flaps. Opening between flaps equatorially directed—at right angle to the exogerminal opening. In equatorial orientation a V-shaped notch is visible between the tips of the flaps. Additional lamellae centripetal to

the mesogerminal form atriate endogerminals. Endogerminal lamellae often prominent.

Stratigraphic distribution.—Tuscaloosa and Eutaw Formations. Many specimens present in Eutaw sample.

Remarks.—*Complexiopollis patulus* can be distinguished from all other species of *Complexiopollis* by its incomplete or interrupted arci.

The incomplete arci are shown on plate 3, figures 6–11. The triplane attitude of this species is shown on plate 3, figures 12–18.

Complexiopollis abditus n. sp.

Plate 4, figures 1–25; text figure 5

Holotype.—USGS paleobotany loc. D3412, slide 3, coordinates 87.1×2.9, plate 4, figures 1–6.

Paratype.—USGS paleobotany loc. D3412, slide 1, coordinates 101.2×16.3, plate 4, figures 7–10.

Diagnosis.—Pollen small, rigid triangular in polar view, with slight bulges at the angles (apertural areas); thick lens shaped in equatorial view, although seldom found in this attitude. Size 15–21μ in equatorial diameter, based on 35 specimens. Wall thin, about 1μ thick in interapertural areas. Ektexine and endexine of about equal thickness. Ektexine psilate, rarely slightly microverrucate. Exogerminal in the form of a short vertical slit. Lips of exogerminal two layered; the outer ektexinal layer slightly thicker in apertural areas than in interapertural areas, without structure, the inner layer consisting of very short radially projecting bacula. Paired endexinal thickenings or plicae lying one above the other in polar view extend from aperture to aperture. Mesogerminal consisting of two, somewhat rounded, thin flaps separated by a shallow V-shaped notch. Mesogerminal opening horizontally directed at right angle to exogerminal opening. Endexinal thickenings do not traverse extremities of the flaps to form an annulus. Vestibulum between exogerminal and mesogerminal narrow. At least one additional lamella centripetal to the mesogerminal, forming a submesogerminal atriate opening. This lamella or lamellar complex is usually prominent.

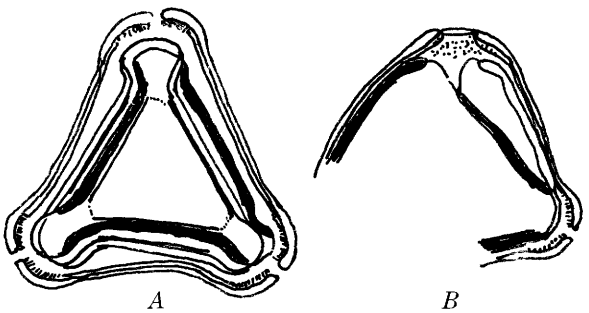

FIGURE 5.—*Complexiopollis abditus*, ca. × 2000. *A*, Polar view of pollen grain. Upper arci shown as solid heavy line; lower arci in outline. *B*, Distorted, partial triplane or equatorial view (upper aperture) showing relationship of flaps and lower and upper arci.

Stratigraphic distribution. — Eutaw Formation and Coffee Sand. Many specimens observed in the Coffee Sand sample.

Remarks.—*Complexiopollis abditus* can be distinguished from other species that possess arci by its rigid triangular shape and small size. The paired arci lying one above the other are shown on plate 4, figures 13–22, and are shown less clearly on plate 4, figures 23–25.

Complexiopollis sp. A

Plate 4, figures 26–35

Illustrated specimens.—

USGS paleobotany loc. D3415, slide 3, coordinates 112.4×13.7, plate 4, figures 26–29.

USGS paleobotany loc. D3265, slide 4, coordinates 87.87×11.0, plate 4, figures 30–33.

USGS paleobotany loc. D3265, slide 1, coordinates 84.3×21.4, plate 4, figures 34–35.

Discussion.—This pollen species was not given a specific epithet because too few specimens were observed (four only). In size (18–20μ) and shape, pollen of this species is virtually the same as *Complexopollis abditus*. It appears to differ from the latter by a continuation of the endexinal thickenings across the mesogerminal flaps in the form of a pronounced annular thickening. This feature is absent from *C. abditus*.

Stratigraphic distribution.—Tuscaloosa and Eutaw Formations.

Genus Choanopollenites Stover, 1966

Pollen of the genera *Complexiopollis* Krutzsch 1959 and *Choanopollenites* Stover 1966 are very similar in basic structure, yet the morphological attributes of the type species of the two genera are strikingly different. This similarity is perhaps accentuated by several pollen species found in Mississippi Embayment rocks that show somewhat transitional characteristics. It is my conviction that both genera belong to the same lineage and that *Choanopollenites* is an evolutionary variant of the *Complexiopollis* group. Pollen of both genera possess vertical (polar-directed) exogerminals bordered by distinct ektexinal thickenings. Both possess inner germinals with equatorially directed openings at right angles to the exogerminal openings and both

possess flap or valvelike lips on either side of the inner germinal.

Choanopollenites pollen differs from that of *Complexiopollis* by possessing a relatively thick wall, in which the ektexine is distinctly thicker than the endexine. In *Complexiopollis* the walls of the pollen grains are thin, and the endexine is thinner than the ektexine or is of approximately the same thickness. In some species of *Complexiopollis* the wall is so thin that the two wall layers are difficult to recognize. In equatorial view the pollen of *Choanopollenites* species is oval and is in contrast to the triplane rhomboidal shape of *Complexiopollis* species in the same view. *Choanopollenites* pollen further differs from that of *Complexiopollis* by lacking atriate endogerminals. *Complexiopollis* is described as having, in addition to the flap-shaped mesogerminals, one or more endogerminals with atriate apertures centripetal to the mesogerminals. Owing to the small size and thin walls of many species, the several wall layers are often difficult to differentiate. If sufficient specimens of a species are available, the distinguishing wall layers—particularly those that make up the endogerminals—can usually be found. This type of atriate endogerminal has not been observed in any of the species assigned to *Choanopollenites*. The single species of *Choanopollenites* previously described is from the lower Eocene. It is probably an evolutionarily advanced form of the genus, and appears near the stratigraphic level where the genus becomes extinct. No representatives of the genus have been observed in rocks younger than early Eocene age.

Choanopollenites eximius Stover, 1966

Text figure 6

Type species.—*Choanopollenites eximius* Stover 1966 (in Stover and others, 1966), Kansas Univ., Paleontological Contributions, Paper 5, p. 8, pl. 4, figs. 1a–1h.

Diagnosis.—Stover (in Stover and others, 1966) stated "Pollen isopolar triaperturate with radial symmetry. Outline subtriangular 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."

Species description not repeated here.

Stratigraphic distribution.—Lower Eocene Wilcox Group (Stover, in Stover and others, 1966).

Remarks.—In the description of the species *Choanopollenites eximius*, Stover mentions that the outer

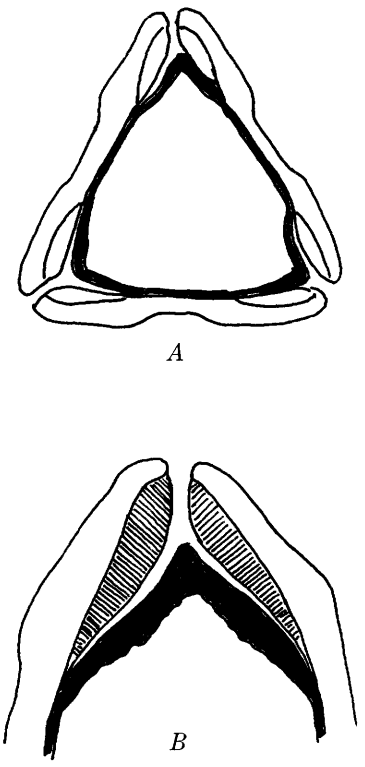

FIGURE 6.—*Choanopollenites eximius*. *A*, Pollen grain showing shape, ca. × 500. *B*, Aperture, ca. × 1000.

apertures are "elongate poleward," and that the inner apertures are "broadly elliptical" and "elongate equatorially." *Choanopollenites eximius* has not been observed in our reference samples.

Choanopollenites consanguineus n. sp.

Plate 5, figures 1–27; text figure 7

Holotype.—USGS paleobotany loc. D3413, slide 1, coordinates 107.1×17.4, plate 5, figures 1–6.

Paratype.—USGS paleobotany loc. D3413, slide 1, coordinates 90.0×19.3, plate 5, figures 7–9.

Diagnosis.—Shape of pollen grains triangular, sometimes slightly concave triangular in polar view, oval in equatorial view. Size 16–24μ in equatorial diameter (24 specimens), 13–16μ in polar diameter (five specimens). Wall 2–3μ thick in interapertural areas, thicker adjacent to the germinals. Ektexine more than twice as thick as endexine in interapertural areas. Ektexine psilate, sometimes slightly microverrucate particularly in interapertural and polar areas. Pore canal index less than 0.3. Exogerminal vertical slit shaped surrounded by a thickened, rarely slightly bulging two-layered ektexine; outer layer structureless, inner layer thin, consisting of tightly packed radially directed bacula. Vestibulum prominent. Inner germinal consisting of two flaps

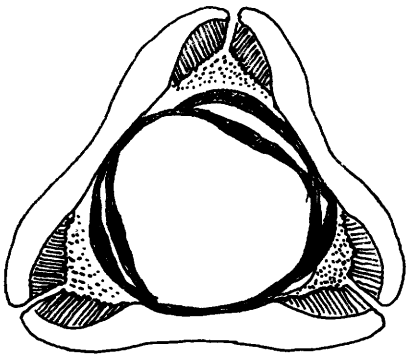

FIGURE 7. — *Choanopollenites consanguineus*, ca. × 2000. The wide endexinal apertures bordered by thickened endexinal flaps subtend the ektexinal apertures.

with the opening between the flaps at right angle to the exogerminal. Extremities of the flaps semicircular and usually slightly thickened; in equatorial view aperture between the flaps U-shaped.

Stratigraphic distribution.—Coffee Sand, Coon Creek Tongue and McNairy Sand Member of Ripley Formation.

Remarks.—*Choanopollenites consanguineus* differs from all other species of *Choanopollenites* except *C. transitus* by its small size. It differs from *C. transitus* in having a more rigid triangular shape, a generally thicker wall, smaller baculate areas in the pore canal areas, and shorter pore canals, and by having a slight thickening at the extremities of the endexinal flaps.

Choanopollenites transitus n. sp.

Plate 6, figures 1–24; text figure 8

Holotype.—USGS paleobotany loc. D3416, slide 2, coordinates 95.4×19.5, plate 6, figures 1–4.

Paratype.—USGS paleobotany loc. D3416, slide 2, coordinates 103.9×6.8, plate 6, figures 5–8.

Diagnosis.—Shape of pollen grains triangular, mostly concave triangular in polar view, oval in equatorial view, germinals at apices often slightly bulging; size 20–28μ in equatorial diameter (20 specimens) and 13–15μ in polar diameter (two specimens). Wall about 2μ thick in interapertural areas, much thicker adjacent to germinals. Ektexine at least twice as thick as endexine in interapertural areas and about 5μ thick adjacent to germinals. Ektexine psilate. Pore canal elongate; pore canal index about 0.3. Exogerminal in the form of a vertical slit surrounded by a distinctly thickened two-layered ektexine; outer layer structureless, inner layer prominent, consisting of long, radially directed bacula. Bacula in baculate layer becoming progressively shorter toward the base of the germinals, and very short in the interapertural areas. A prominent, though narrow, vestibulum is present between the exogerminals and endogerminals. Endogerminal opening equatorially oriented, at right angle to the exogerminal. Aperture bordered above and below by two semicircular endexinal flaps. Additional lamellae centripetal to the endogerminal (as found in *Complexiopollis*) not evident.

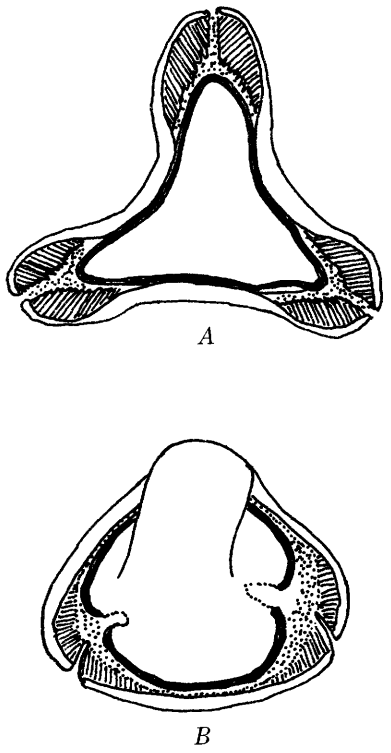

FIGURE 8.—*Choanopollenites transitus*, ca. × 2000. *A*, Polar view. *B*, Equatorial, partially triplane view.

Stratigraphic distribution.—Coffee Sand, Coon Creek Tongue of Ripley Formation, McNairy Sand Member of Ripley Formation, Clayton Formation, and Porters Creek Clay.

Remarks.—*Choanopollenites transitus* can be distinguished from other species by its small size, concave triangular shape, and proportionately large baculate area. It can be distinguished from *C. consanguineus* by its shape, elongate pore canal, and prominent baculate areas. The endexinal flaps show well on plate 6, figures 5, 8, 14–17, and 21. Plate 6, figures 20–24, shows specimens in triplane attitude.

Choanopollenites discipulus n. sp.

Plate 7, figures 1–14; text figure 9

Holotype.—USGS paleobotany loc. D3548–A, slide 2, coordinates 97.0×21.4, plate 7, figures 1–5.

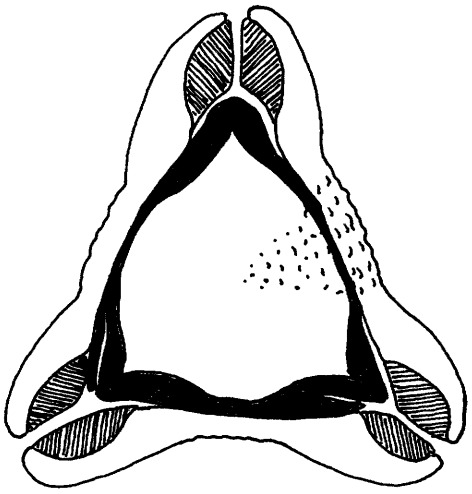

FIGURE 9.—*Choanopollenites discipulus*, ca. × 2000.

Paratype.—USGS paleobotany loc. D3548–A, slide 2, coordinates 83.9×20.4, plate 7, figures 6–9.

Diagnosis.—Shape of pollen grains triangular to slightly concave triangular and bulging at the angles (apertures). Size 24–34μ in equatorial diameter (13 specimens). Wall about 2–3μ thick in interapertural areas, much thicker at germinals. Ektexine at least twice as thick as endexine in interapertural areas. Surface smooth at germinals, slightly scabrate to verrucate in interapertural and polar areas. Exogerminal vertical slit shaped, surrounded by a two-layered, often bulging ektexine. Outer layer structureless, smooth, and thicker at base of germinal than at apex; inner layer of tightly packed, radially projecting bacula. Vestibulum between exogerminals and endogerminals very narrow. Endogerminal consisting of two triangular flaps, with the openings between the flaps at right angle to the exogerminal opening. Endogerminal flaps thickened in the form of an inverted V. Endexine conspicuously thinner in interapertural areas than in germinal areas.

Stratigraphic distribution.—Clayton Formation and Porters Creek Clay.

Remarks. — *Choanopollenites discipulus* differs from *C. transitus* and *C. consanguineus* in its larger size, thickened extremities of the endexinal flaps, and pointed triangular shape of the flaps. It differs from *C. eximius*, *C. conspicuus*, and *C. patricius* principally by its much smaller size.

Choanopollenites sp. A

Plate 7, figures 15–18

Illustrated specimen.—USGS paleobotany loc. D1966–A, slide 1, coordinates 106.4×14.0.

Discussion.—Only one specimen of this pollen species was found, consequently no specific epithet was assigned. This species, 40μ in diameter, is intermediate in size between *Choanopollenites discipulus* (24–34μ) and *C. eximius* (71–82μ). It differs from *C. consanguineus* by possessing less robust apertural areas and a thinner ektexine. Morphologically, it resembles *C. discipulus* and may be conspecific with the latter species.

Occurrence.—Clayton Formation.

Choanopollenites sp. B

Plate 6, figures 25, 26

Illustrated specimen.—USGS paleobotany loc. D1849, slide 1, coordinates 99.2×23.1.

Discussion.—Only two specimens of this pollen species were observed. No specific epithet was assigned. This species is about 30μ in equatorial diameter and may be characterized by greatly elongated pore canals. The exterior wall in the apertural areas is very thin, the baculate area occupying most of the area of the exogerminal.

Occurrence.—Naborton Formation.

Choanopollenites conspicuus (Groot and Groot 1962) Tschudy n. comb.

Plate 8, figures 1–16; text figure 10

Latipollis conspicuus Groot and Groot 1962, Palaeontographica, sec. B., v. 111, p. 169, pl. 30, figs. 35, 36; pl. 31, figs. 1–3.

Extratriporopollenites sp. Groot and Groot 1962, Palaeontographica, sec. B, v. 111, p. 170, pl. 31, fig. 7.

Extratriporopollenites sp. Tschudy 1971, in Geol. Soc. America Spec. Paper 127, p. 98, figs. 9, 10.

Holotype.—*Latipollis conspicuus* Groot and Groot 1962.

Description.—Groot and Groot (1962, p. 169) state: "Triplanar pollen grains with three germinal apertures which are rather narrow, elongated openings without annulus; the exine consists of an endexine, which curves toward the center of the grain near the apertures, and an ektexine, which is about 2μ thick and distinctly scabrate; diameter of the grain is about 55μ, height about 35μ."

Emended diagnosis.—Shape of pollen grains rigid triangular to concave triangular in polar view, broadly oval in equatorial view. Size (based on 19 specimens) 35–57μ, average 46μ, in equatorial diameter (17 specimens), 22–30μ in polar diameter (two specimens). Ektexine thicker than endexine, with psilate to scabrate surface sculpture. Ektexine 3–4μ thick in the interapertural areas, and as much as 8μ thick at the apertures. Ektexine adjacent to exogerminal three layered; outer layer thin (less than 1μ thick), scabrate with low relief, maculae present

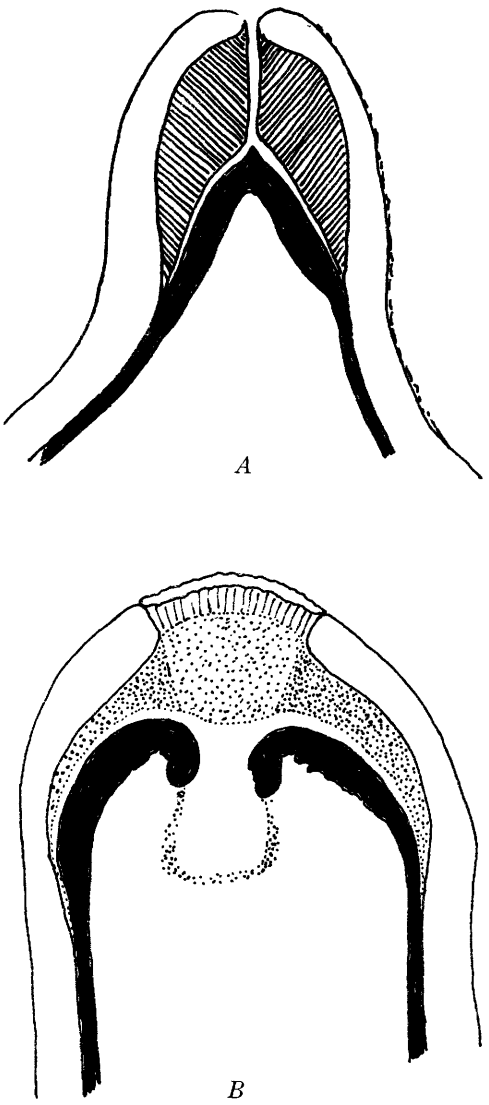

FIGURE 10.—*Choanopollenites conspicuus*, ca. × 2000. *A*, Polar view of apertural region. *B*, Equatorial view of apertural region.

over entire surface of most grains; middle layer structureless, 2–3μ thick; the inner layer consisting of densely packed, radially oriented bacula. Baculate area is somewhat comma shaped, bacula distinctly shorter toward the inner part of the aperture. A layer of very short bacula separates the endexine from the ektexine throughout all areas of the grains. Exogerminal aperture a vertical slit-shaped opening, in equatorial view funnel shaped, tapered centripetally. Vestibulum very narrow. Endogerminal consisting of two somewhat triangular flaps; opening between the flaps at right angle to the exogerminal slit. Extremities of flaps thickened to as much as 3μ. In equatorial view mesogerminal opening prominent, U-shaped, up to 10μ deep. Lamellae centripetal to mesogerminal not evident.

Stratigraphic distribution.—Porters Creek Clay, Naheola Formation, and Brightseat Formation (Paleocene) of Maryland (Groot and Groot, 1962).

Remarks.—*Choanopollenites conspicuus* can be distinguished from *C. transitus, C. consanguineus,* and *C. discipulus* by its larger size. It can be distinguished from *C. eximius* by the rounded rather than angular shape of the germinals in polar view, and from *C. patricius* by the convex triangular outline and the more delicate and triangular shape of the endexinal flaps.

Groot and Groot (1962) named this species *Latipollis conspicuus* from a specimen in equatorial view and figured specimens of *L. conspicuus* in partial triplane attitude (pl. 31, figs. 1–3) that demonstrate an intermediate view between polar and equatorial. These illustrations are similar to those shown on plate 8, figures 11–16. They figured a specimen in polar view as *Extratriporopollenites* sp. (pl. 31, fig. 7). for which they provided the following description: "Triporate, pores equatorial and extremely protruding, long pore canals; exine consisting of endexine and ektexine, the former thickening toward the pore opening, and the latter of constant thickness; pore structure 18μ long and 15μ in diameter; equatorial diameter of grain 50μ." From an examination of specimens in polar, equatorial, and distorted triplane views, I am certain that the specimens mentioned above are conspecific and also are conspecific with my material. Krutzsch (in Góczán and others, 1967) reexamined *Latipollis* Krutzsch 1959 and placed the type species into synonymy with *Complexiopollis.*

The holotype of *Latipollis conspicuus* was designated by Groot and Groot (1962, p. 169) as "Slide 50311–B, grain 5, 105.6×20.8." However, they did not designate the holotype specimen of *L. conspicuus* on their plate description. Because they presented two and possibly three different specimens on their plates, I am assuming that the first one presented is the holotype (pl. 30, figs. 35–36).

Illustrated specimens.—

USGS paleobotany loc. D3285, slide 1, coordinates 91.7×17.5, plate 8, figures 1–3.

USGS paleobotany loc. D3285, slide 1, coordinates 101.7×1.8, plate 8, figures 4–7.

USGS paleobotany loc. D1966–F, slide 7, coordinates 89.3×13.7, plate 8, figures 8–10.

USGS paleobotany loc. D1966–F, slide 1, coordinates 106.1×9.3, plate 8, figures 11–13.

USGS paleobotany loc. D1966–F, slide 7, coordinates 99.4×7.4, plate 8, figures 14–16.

Choanopollenites patricius n. sp.

Plate 9, figures 1–11; text figure 11

Holotype.—USGS paleobotany loc. D3222, slide 3, coordinates 80.7×7.2, plate 9, figures 1–5.

Paratype.—USGS paleobotany loc. D3222, slide 5, coordinates 83.1×20.9, plate 9, figures 6, 7.

Diagnosis.—Pollen rounded triangular in polar view, enlarged at angles (apertures), oval in equatorial view. Apertural areas hemispheric at angles, separated by a narrow concave area along the sides of the grains midway between the apertural areas. Size 39–47μ in equatorial diameter (15 specimens) and 28–33μ in polar diameter (2 specimens). Wall about 3μ thick in interapertural areas, much thicker at the apertures. Ektexine about three times as thick as endexine. Exogerminal apertures short, vertical slit-shaped. Ektexine adjacent to exogerminal three layered; outer layer thin (less than 1μ thick), scabrate to microverrucate, middle layer structureless, 6–8μ thick at the root of the exogerminal, inner layer of radially directed tightly packed bacula. Baculate layer difficult to see owing to the surface maculae. Endogerminal opening elongate equatorially, much larger than exogerminal opening and at right angle to it. Endogerminal with two very prominent valvelike thickened flaps. Terminal portion of flaps about 4μ thick in both equatorial and polar views. In equatorial view the extremities of the valvelike flaps are reflexed inward; opening between flaps broad U-shaped. Vestibulum narrow but prominent.

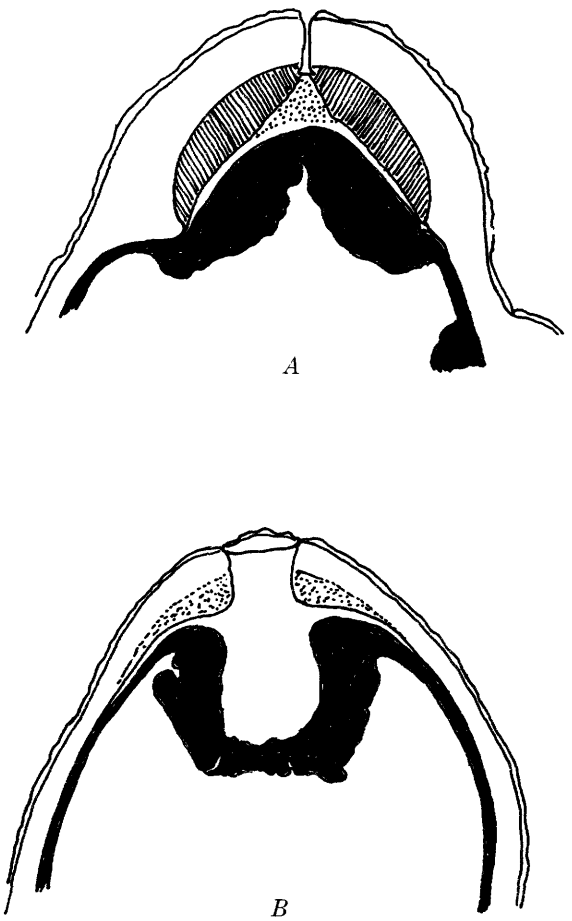

FIGURE 11.—*Choanopollenites patricius*, ca. × 2000. *A*, Polar view of apertural area. *B*, Equatorial view of apertural area.

Stratigraphic distribution.—Nanafalia Formation.

Remarks.—*Choanopollenites patricius* can be distinguished from all other species of *Choanopollenites* by its shape, and the thick hemispherical endexinal thickenings adjacent to the endogerminal. A pollen grain that appears to be conspecific with *C. patricius* was illustrated by Kuyl, Muller, and Waterbolk (1955, p. 68, pl. 3, fig. 9) from the "Eocene U.S.A."; and Fairchild and Elsik (1969, p. 85, fig. 55) figured a specimen from the Wilcox that also appears conspecific with *C. patricius*.

SUGGESTED RELATIONSHIPS OF SPECIES INCLUDED IN THE *COMPLEXIOPOLLIS* LINEAGE

The relationships suggested below can be only tentative. Too few samples from Campanian and older Cretaceous rocks have been examined from the Mississippi Embayment. Consequently it is anticipated that additional species of the *Complexiopollis* lineage will appear as more Cretaceous rocks from this area are examined.

In Europe the stratigraphic range of the genus *Complexiopollis* is from basal Cenomanian through the basal part of the Campanian, with questionable specimens found in the upper Maestrichtian (Góczán and others, 1967). This range is shown by the heavy bar in figure 12. The genus *Choanopollenites* has not been reported from Europe. The observed stratigraphic ranges of species of *Complexiopollis* and *Choanopollenites* found in Mississippi Embayment rocks are also shown on figure 12.

Complexiopollis funiculus, *C. patulus*, and *C.* sp. A were observed in samples from the Tuscaloosa and Eutaw Formations. The Tuscaloosa sample was taken from some distance above the base of the formation and also from some distance above the base of the Cenomanian. All three species may have been derived from a common older ancestor, or *C. funiculus* or *C. patulus* could have been the first species of this genus to appear in embayment rocks.

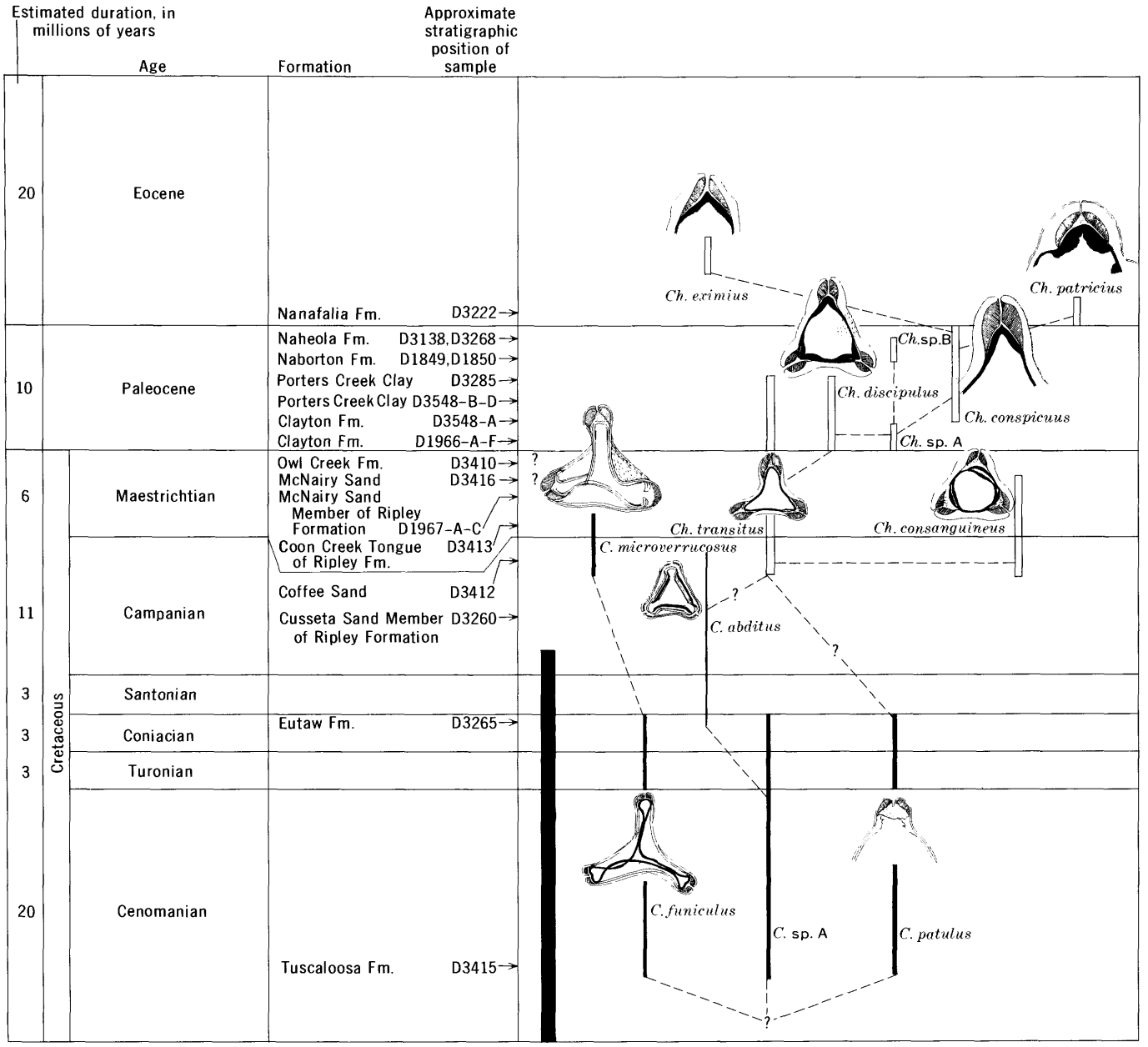

FIGURE 12.—Suggested relationships of species of *Complexiopollis* and *Choanopollenites* in Mississippi Embayment. Estimated duration, in millions of years, modified from Kulp (1961), Holmes (1965), and Gill and Cobban (1966). Heavy bar represents stratigraphic range of *Complexiopollis* in Europe; light solid bars, ranges of *Complexiopollis species;* open bars, ranges of *Choanopollenites* species.

The species *C. abditus* is morphologically so similar to *C.* sp. A. that the latter must have been derived from this stem. *C. microverrucosus* is the youngest species of *Complexiopollis* observed. It probably was derived from the older *C. funiculus* stock.

As has been mentioned previously, the genus *Choanopollenites* is similar structurally to the genus *Complexiopollis.* The oldest species observed in Mississippi Embayment rocks are *Choanopollenites transitus* and *C. consanguineus.* The former has the greater stratigraphic range—from upper Campanian through middle Paleocene; the range of the latter is limited to upper Campanian and Maestrichtian rocks. The species *Choanopollenites discipulus, C.* sp. A, *C.* sp. B, and *C. conspicuus* are progressively larger variants of the *Choanopollenites transitus* type. For the most part these larger species occur also in progressively younger rocks. The species *Choanopollenites conspicuus* has been reported previously from the Paleocene Brightseat Forma-

tion of Maryland; and in Mississippi Embayment rocks this species is also confined to the Paleocene.

The morphologically more complex species of *Choanopollenites, C. patricius,* was observed in our material only in Nanafalia Formation rocks although many younger samples of Eocene age were examined.

The type species of *Choanopollenites, C. eximius,* was not observed in our reference material. Stover (in Stover and others, 1966) reported this species from the lower Eocene Wilcox Group from Milam County, Tex. On the basis of morphological criteria I believe that *C. eximius* probably was derived from the older *C. conspicuus-discipulus* complex.

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INDEX

[Italic page numbers indicate major references]

PLATES 1-9

Contact photographs of the plates in this report are available, at cost, from U.S. Geological Survey Library, Federal Center, Denver, Colorado 80225.

PLATE 1

[Magnification × 1000 unless otherwise indicated]

FIGURES 1–29. *Complexiopollis funiculus* n. sp.

1–7. Holotype, USGS paleobotany loc. D3415, slide 3, coordinates 107.8 × 9.5. 6, 7, Holotype × 2000.

8, 9. Paratype, USGS paleobotany loc. D3415, slide 1, coordinates 78.9 × 21.4. 9, Paratype × 2000.

10. USGS paleobotany loc. D3265, slide 1, coordinates 106.3 × 16.0.

11–15. Paratype, USGS paleobotany loc. D3415, slide 2, coordinates 108.5 × 16.9.

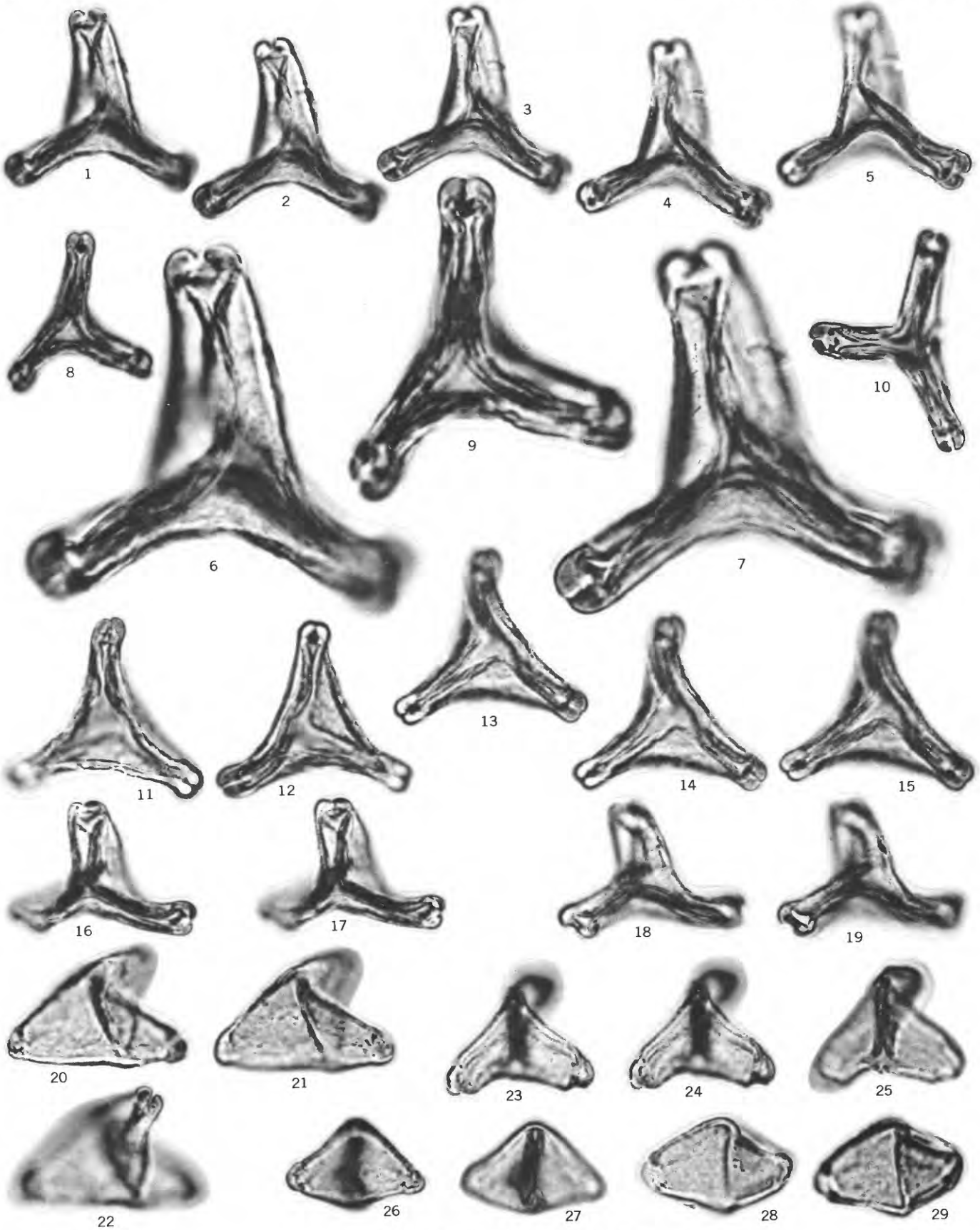
16–19. USGS paleobotany loc. D3415, slide 2, coordinates 99.0 × 16.0.

20–22. USGS paleobotany loc. D3415, slide 1, coordinates 89.8 × 22.5

23–25. USGS paleobotany loc. D3415, slide 2, coordinates 96.0 × 6.4.

26, 27. USGS paleobotany loc. D3415, slide 1, coordinates 104.6 × 8.2.

28, 29. USGS paleobotany loc. D3415, slide 1, coordinates 89.9 × 21.9.



COMPLEXIOPOLLIS FUNICULUS

PLATE 2

[Magnification × 1000 unless otherwise indicated]

FIGURES 1–23. *Complexiopollis microverrucosus* n. sp.

1–8. Holotype, USGS paleobotany loc. D3412, slide 3, coordinates 105.2 × 7.4. 7, 8, Holotype × 2000.

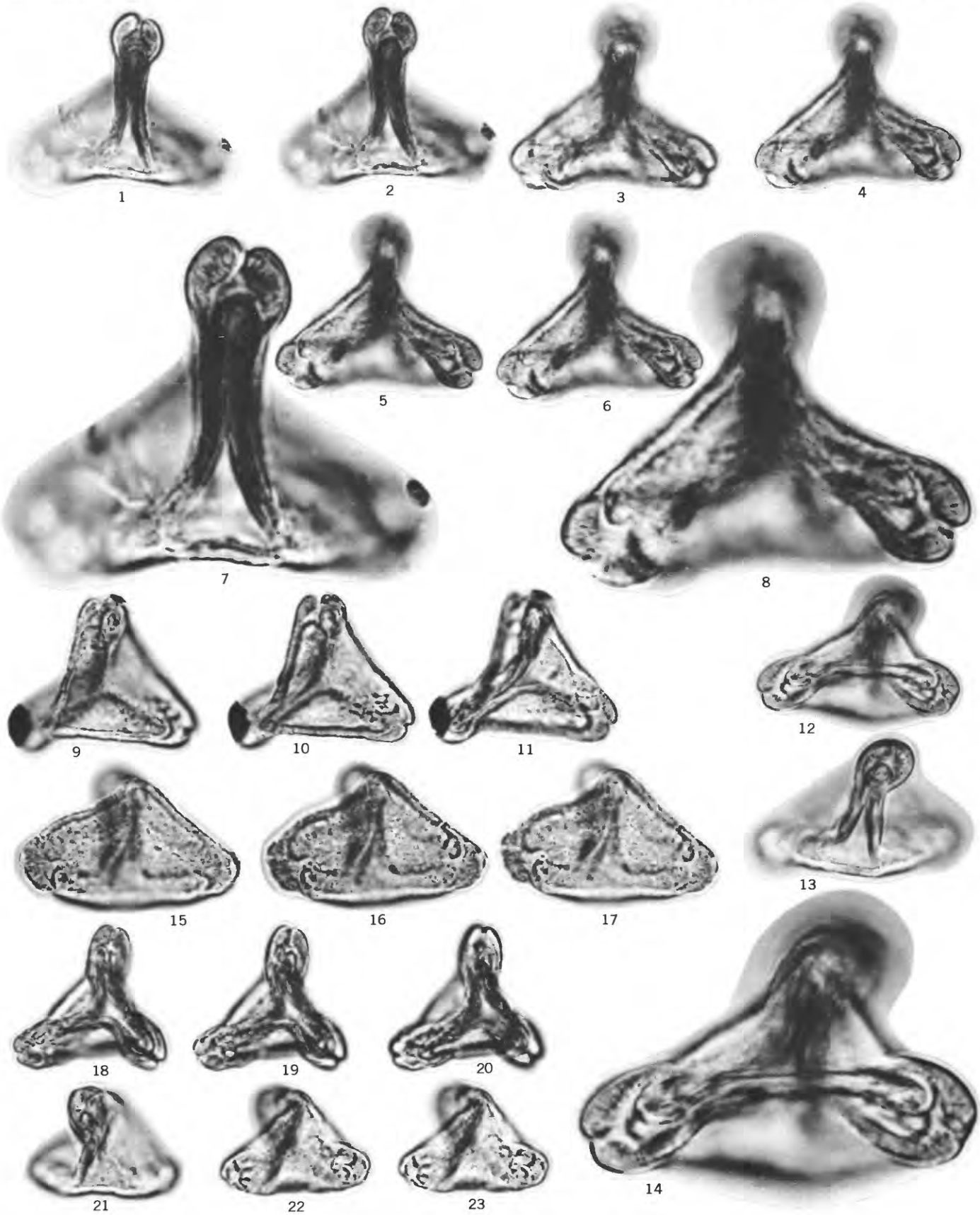
9–11. Paratype, USGS paleobotany loc. D3412, slide 1, coordinates 82.7 × 16.3.

12–14. Paratype, USGS paleobotany loc. D3412, slide 1, coordinates 75.5 × 5.7. 14, Paratype × 2000.

15–17. USGS paleobotany loc. D3412, slide 1, coordinates 93.4 × 6.4

18–20. USGS paleobotany loc. D3412, slide 2, coordinates 97.8 × 15.6.

21–23. USGS paleobotany loc. D3412, slide 2, coordinates 78.1 × 3.5.



COMPLEXIOPOLLIS MICROVERRUCOSUS

PLATE 3

[Magnification × 1000 unless otherwise indicated]

FIGURES 1–18. *Complexiopollis patulus* n. sp.

1–3. Holotype, USGS paleobotany loc. D3265, slide 2, coordinates 97.0 × 15.5. 3, Holotype × 2000.

4, 5. USGS paleobotany loc. D3265, slide 4, coordinates 93.5 × 7.6.

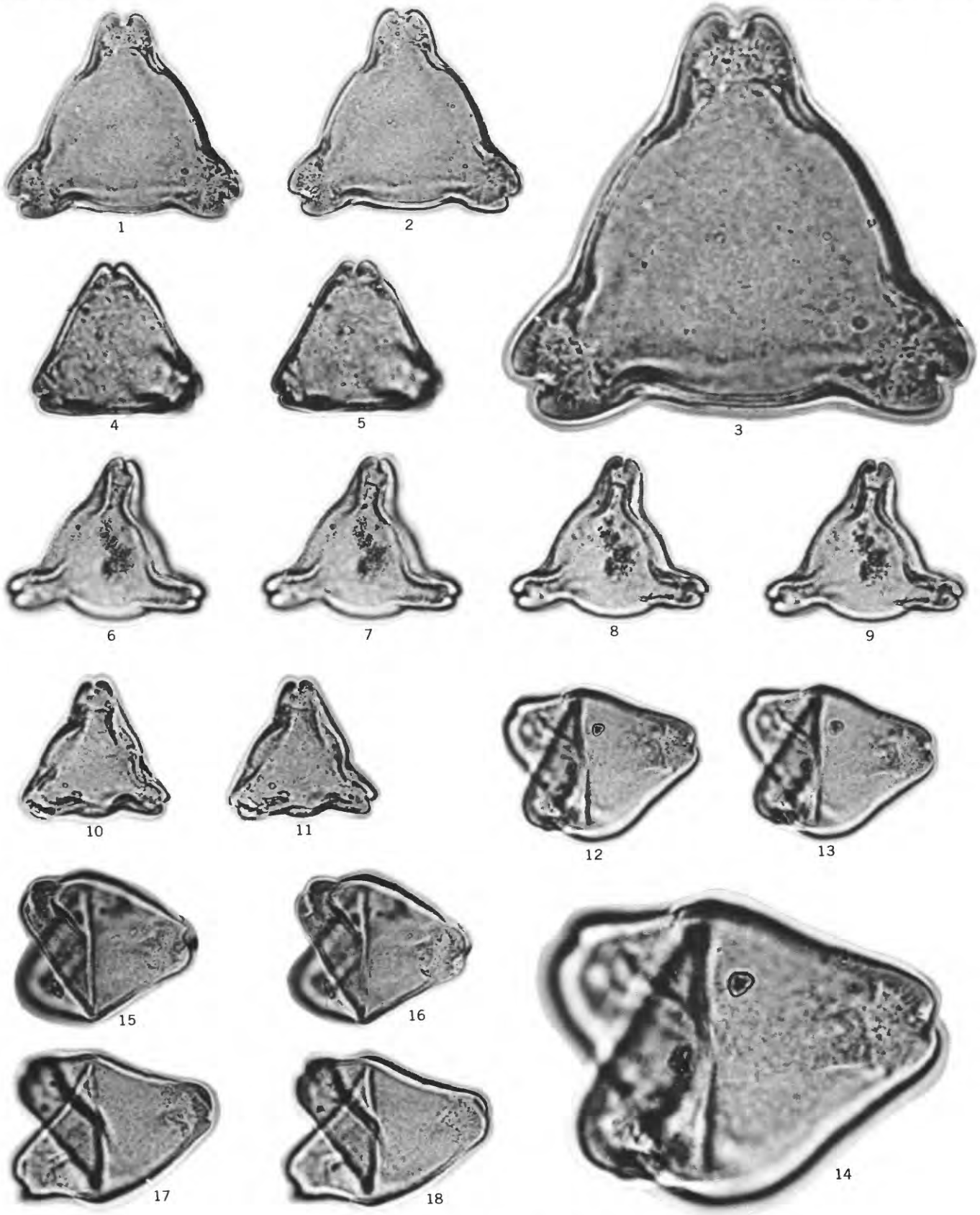
6–9. Paratype, USGS paleobotany loc. D3265, slide 3, coordinates 83.2 × 6.7.

10, 11. USGS paleobotany loc. D3265, slide 2, coordinates 99.8 × 15.7.

12–14. USGS paleobotany loc. D3265, slide 1, coordinates 97.8 × 8.8. 14, Magnification × 2000.

15, 16. USGS paleobotany loc. D3265, slide 2, coordinates 103.4 × 4.5.

17, 18. USGS paleobotany loc. D3265, slide 1, coordinates 82.0 × 6.1.



COMPLEXIOPOLLIS PATULUS

PLATE 4

[Magnification × 1000 unless otherwise indicated]

FIGURES 1–25. *Complexiopollis abditus* n. sp.

1–6. Holotype, USGS paleobotany loc. D3412, slide 3, coordinates 87.1 × 2.9. 6, Holotype × 2000.

7–10. Paratype, USGS paleobotany loc. D3412, slide 1, coordinates 101.2 × 16.3.

11, 12. USGS paleobotany loc. D3412, slide 3, coordinates 98.5 × 5.5.

13–16. USGS paleobotany loc. D3412, slide 1, coordinates 78.7 × 15.7.

17–19. USGS paleobotany loc. D3412, slide 1, coordinates 74.5 × 17.9.

20–22. USGS paleobotany loc. D3412, slide 4, coordinates 79.5 × 18.9.

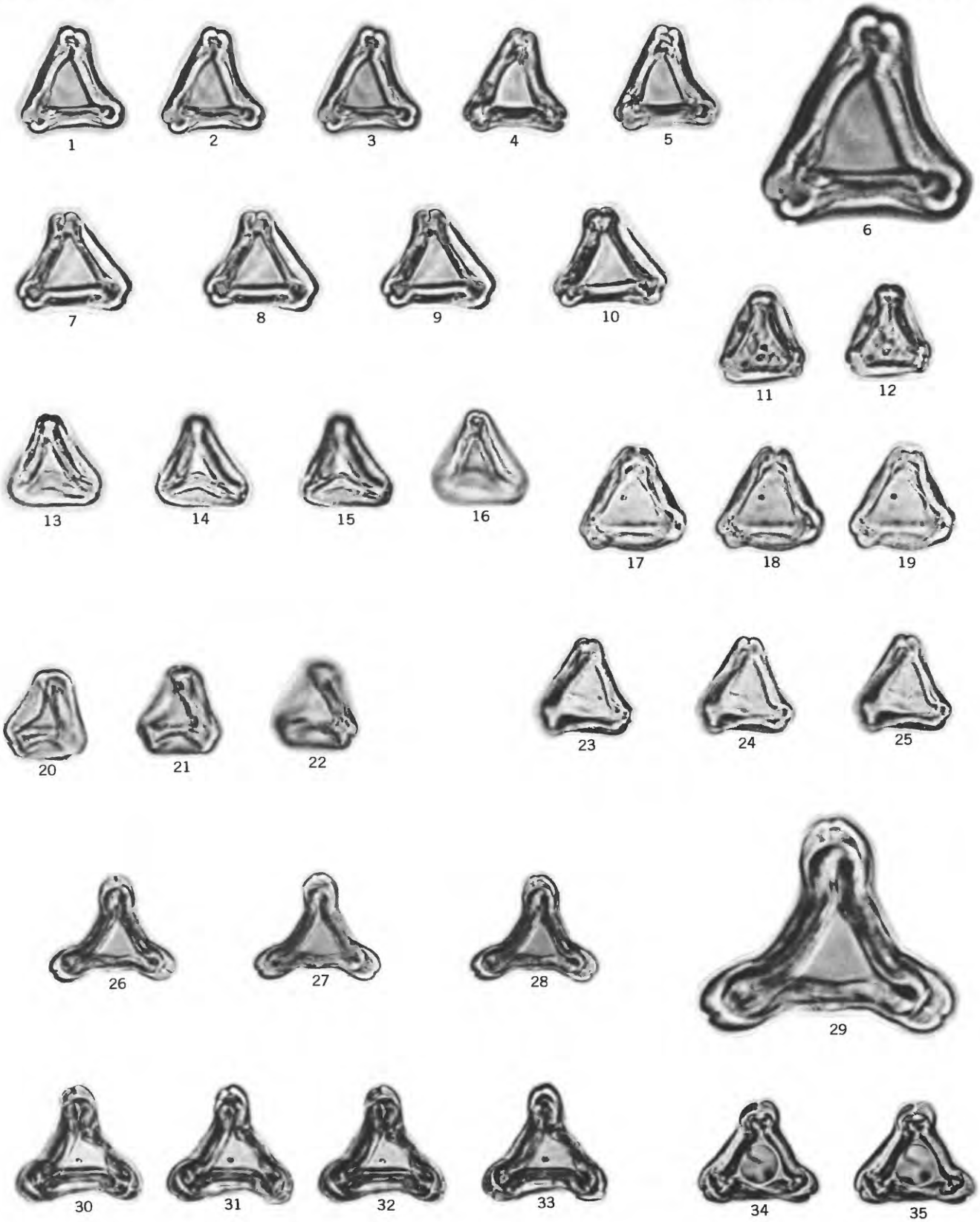
23–25. USGS paleobotany loc. D3412, slide 1, coordinates 82.7 × 5.2.

26–35. *Complexiopollis* sp. A.

26–29. USGS paleobotany loc. D3415, slide 3, coordinates 112.4 × 13.7. 29, Magnification × 2000.

30–33. USGS paleobotany loc. D3265, slide 4, coordinates 87.8 × 11.0.

34, 35. USGS paleobotany loc. D3265, slide 1, coordinates 84.3 × 21.4.



COMPLEXIOPOLLIS ABDITUS AND *COMPLEXIOPOLLIS* SP. A

PLATE 5

[Magnification × 1000 unless otherwise indicated]

FIGURES 1–27. *Choanopollenites consanguineus* n. sp.

1–6. Holotype, USGS paleobotany loc. D3413, slide 1, coordinates 107.1 × 17.4. 6, Holotype × 2000.

7–9. Paratype, USGS paleobotany loc. D3413, slide 1, coordinates 90.0 × 19.3.

10–15. USGS paleobotany loc. D1967–A, slide 6, coordinates 93.3 × 23.3. 15, Magnification × 2000.

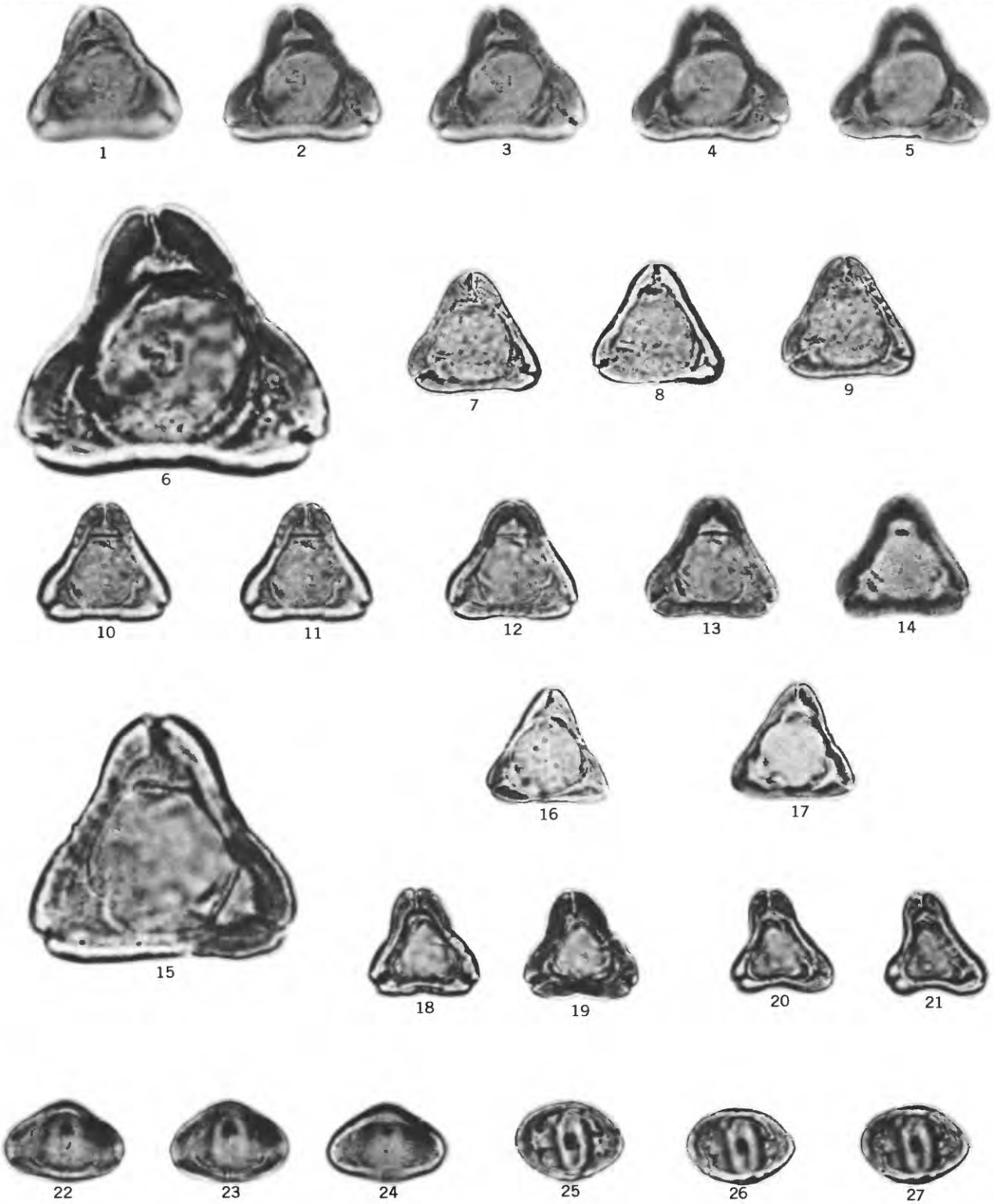
16, 17. USGS paleobotany loc. D1969–C, slide 7, coordinates 114.0 × 1.7.

18, 19. USGS paleobotany loc. D3416, slide 1, coordinates 96.4 × 11.7.

20, 21. USGS paleobotany loc. D3416, slide 1, coordinates 75.3 × 19.8.

22–24. USGS paleobotany loc. D3416, slide 2, coordinates 86.5 × 14.0.

25–27. USGS paleobotany loc. D3413, slide 2, coordinates 105.5 × 6.2.



CHOANOPOLLENITES CONSANGUINEUS

PLATE 6

[Magnification × 1000 unless otherwise indicated]

FIGURES 1–24. *Choanopollenites transitus* n. sp.

1–4. Holotype, USGS paleobotany loc. D3416, slide 2, coordinates 95.4 × 19.5. 4, Holotype × 2000.

5–8. Paratype, USGS paleobotany loc. D3416, slide 2, coordinates 103.9 × 6.8.

9–13. USGS paleobotany loc. D3548–A, slide 1, coordinates 73.0 × 9.1. 13, Magnification × 2000.

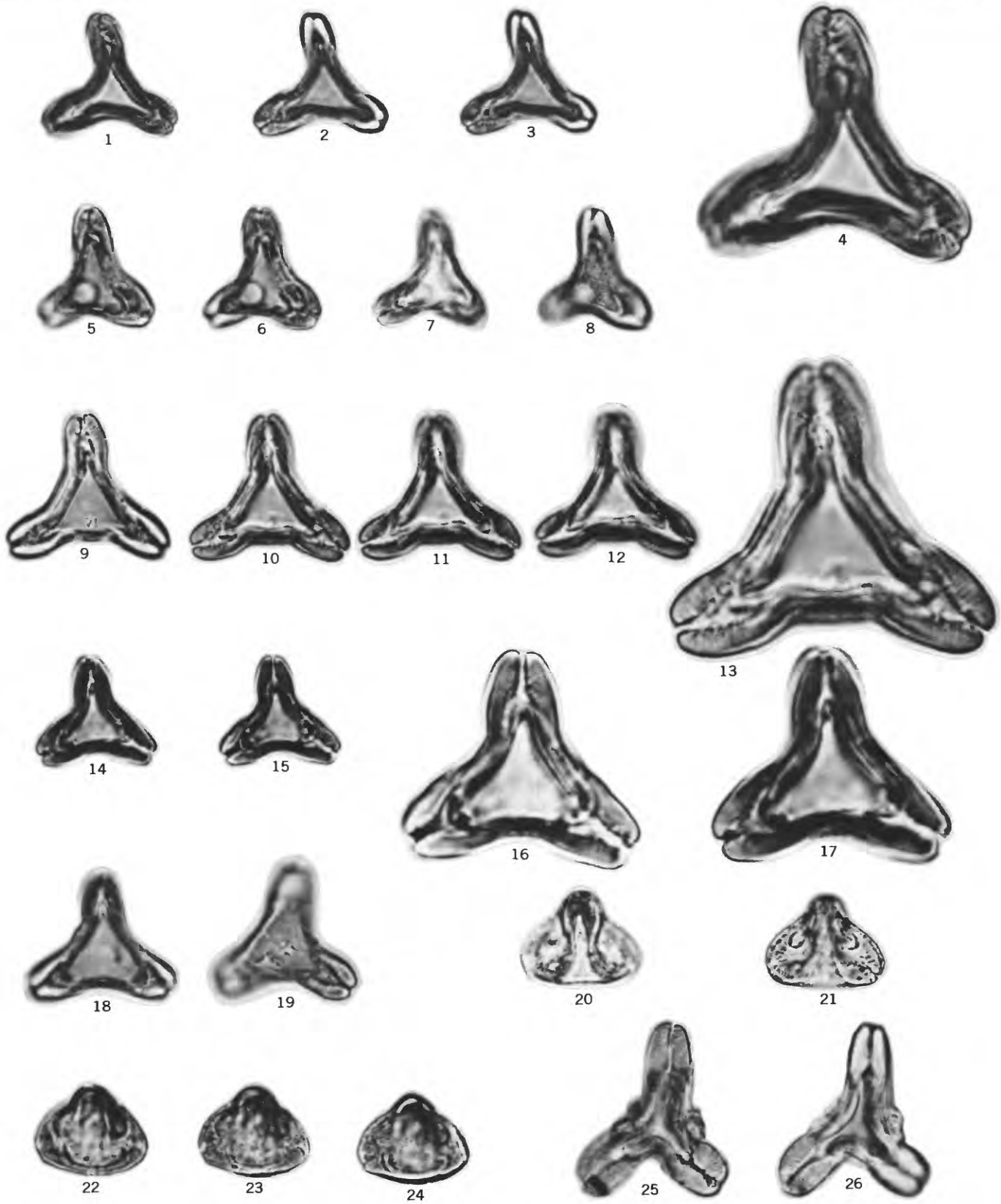
14–17. USGS paleobotany loc. D3413, slide 2, coordinates 96.6 × 8.5. 16, 17 Magnification × 2000.

18, 19. USGS paleobotany loc. D3416, slide 1, coordinates 77.7 × 9.0.

20, 21. USGS paleobotany loc. D3416, slide 2, coordinates 75.2 × 17.3.

22–24. USGS paleobotany loc. D3416, slide 2, coordinates 102.5 × 11.6.

25, 26. *Choanopollenites* sp. B. USGS paleobotany loc. D1849, slide 1, coordinates 99.2 × 23.1.



CHOANOPOLLENITES TRANSITUS AND *CHOANOPOLLENITES* SP. B

PLATE 7

[Magnification × 1000 unless otherwise indicated]

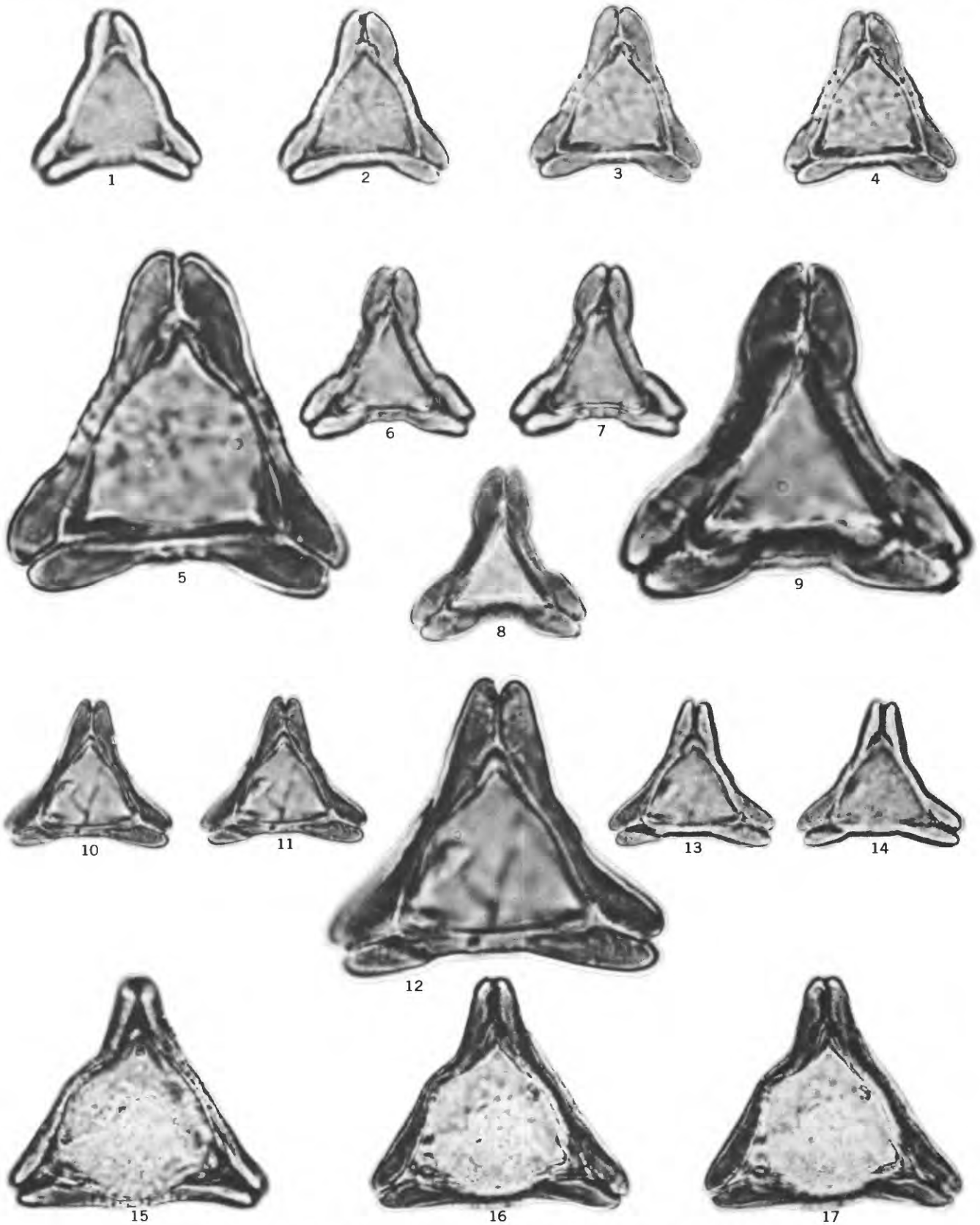
FIGURES 1.–14. *Choanopollenites discipulus* n. sp.

1–5. Holotype, USGS paleobotany loc. D3548–A, slide 2, coordinates 97.0 × 21.4. 5, Holotype × 2000.

6–9. Paratype, USGS paleobotany loc. D3548–A, slide 2, coordinates 83.9 × 20.4. 9, Paratype × 2000.

10–14. USGS paleobotany loc. D1966–F, slide 6, coordinates 87.7 × 15.3. 12, Magnification × 2000.

15–17. *Choanopollenites* sp. A. USGS paleobotany loc. D1966–A, slide 1, coordinates 106.4 × 14.0.



CHOANOPOLLENITES DISCIPULUS AND *CHOANOPOLLENITES* SP. A

PLATE 8

[Magnification × 1000]

FIGURES 1–16. *Choanopollenites conspicuus* (Groot and Groot 1962) Tschudy n. comb.

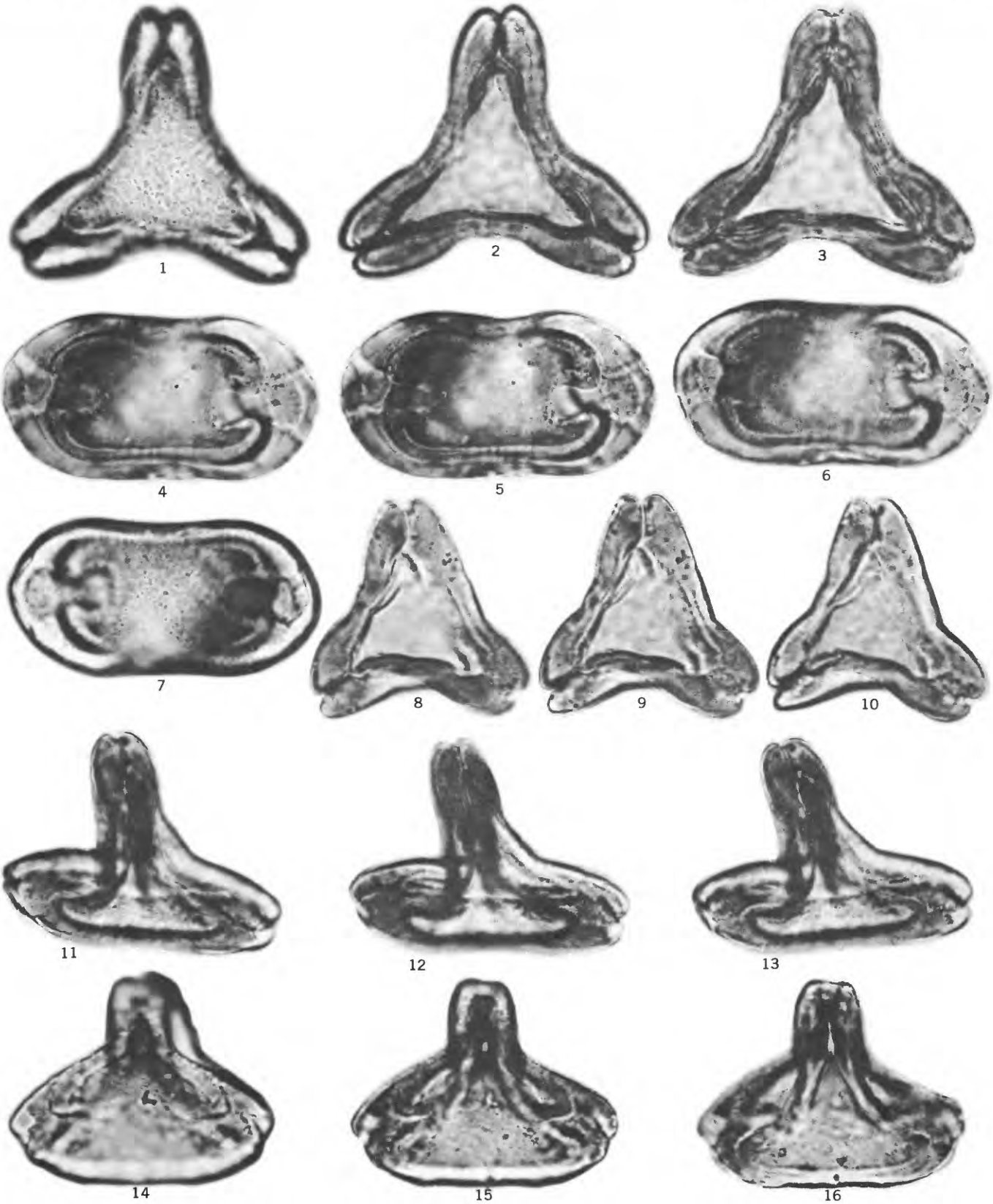
1–3. USGS paleobotany loc. D3285, slide 1, coordinates 91.7 × 17.5.

4–7. USGS paleobotany loc. D3285, slide 1, coordinates 101.7 × 1.8.

8–10. USGS paleobotany loc. D1966–F, slide 7, coordinates 89.3 × 13.7.

11–13. USGS paleobotany loc. D1966–F, slide 1, coordinates 106.1 × 9.3.

14–16. USGS paleobotany loc. D1966–F, slide 7, coordinates 99.4 × 7.4.



CHOANOPOLLENITES CONSPICUUS

PLATE 9

[Magnification × 1000]

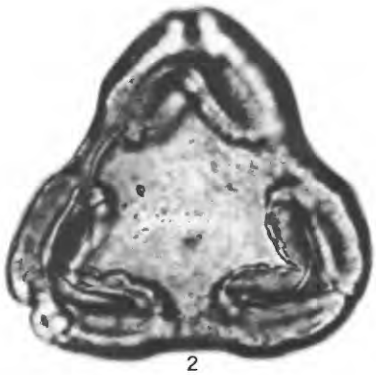
FIGURES 1–11. *Choanopollenites patricius* n. sp.

1–5. Holotype, USGS paleobotany loc. D3222, slide 3, coordinates 80.7 × 7.2.

6, 7. Paratype, USGS paleobotany loc. D3222, slide 5, coordinates 83.1 × 20.9.

8–11. USGS paleobotany loc. D3222, slide 2, coordinates 107.8 × 13.4.


1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CHOANOPOLLENITES PATRICIUS

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