Two New Pollen Genera (Late Cretaceous and Paleocene) With Possible Affinity to the Illiciaceae

GEOLOGICAL SURVEY PROFESSIONAL PAPER 643-F

Work done in cooperation with the Kentucky Geological Survey

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By ROBERT H. TSCHUDY

CONTRIBUTIONS TO PALEONTOLOGY

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Two new genera Terscissus *and* Trisectoris *are described, and the stratigraphic ranges of the species are delineated*

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CONTENTS

ILLUSTRATIONS

[Plates follow index]

TABLE

CONTRIBUTIONS TO PALEONTOLOGY

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By ROBERT H. TSCHUDY

ABSTRACT

Palynological examination of Upper Cretaceous and Paleocene samples disclosed several pollen species that are commonly found as isolated thirds, rather than complete specimens. Two new fossil pollen genera, *Terscissus* and *Trisectoris*, are described for these pollen species. Three new species are included in the genus *Terscissus* and two new species are assigned to the genus *Trisectoris*. Four unnamed species belonging to the genus *Terscissus* and two to the genus *Trisectoris* are discussed and figured. Comparison is made with some species of the modern genus *Illicium*, which also possess the tendency to separate into three isolated segments.

All the species in these two genera are from rocks of Late Cretaceous and Paleocene age. The stratigraphic range of each species is shown.

INTRODUCTION

During the investigation of Cretaceous and Tertiary pollen and spore assemblages from the Mississippi embayment region, several species of morphologically distinctive palynomorphs were noted from samples immediately above and below the Cretaceous-Tertiary boundary. Much later, the discovery of complete specimens proved that these distinctive palynomorphs were, in fact, separate thirds of pollen grains. The discovery of complete grains reminded me that I had found similar-appearing forms while examining samples from Venezuela. A reexamination of the Venezuelan material confirmed that some of the Venezuelan fossils closely resembled one of the species from the Mississippi embayment region.

A comparison of these new fossil pollen grains with grains of modern pollen led to the conclusion that the morphologic features of the fossils most closely resembled some features of pollen grains of the modern genus *Illicium* in the Illiciaceae. *Illicium* is a member of the most primitive order of angiosperms, the Ranales (Stebbins, 1950, p. 471).

The principal feature shared by modern pollen of some species of *Illicium* and the fossil pollen described below is the tendency to split into thirds along the syncolpate suture lines. I know of no other genus of modern plants in which this occurs.

The modern genus *Illicium* includes species with two different types of pollen, the syncolpate type with colpi bordered by ridges or thickenings (margos) and the tricolpate type, morphologically almost identical with the syncolpate type, in which the colpi do not quite reach the poles. The pollen grains of *Schizandra* and *Kadsura*, also belonging to the Ranales, though not syncolpate, are somewhat similar morphologically to the pollen of *Illicium*, but *Illicium* is unique in the possession of syncolpate pollen grains that split into thirds.

Two new genera have been erected to accommodate the new species described in this paper. These species are useful fossils of comparatively narrow stratigraphic range.

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METHODS OF PROCESSING SAMPLES AND PREPARING SLIDES

Rock samples were treated in a conventional manner by use of hydrofluoric acid to disaggregate and partly dissolve the inorganic matrix. The residue was then oxidized with Schulze solution ($HNO_3 + NaClO_3$), and the solubilized humates were removed by a short exposure to 10-percent NaOH solution. Pollen and spores were concentrated from the residue by flotation by use of zinc bromide (specific gravity about 2) and were then "panned" by means of the technique suggested by Funkhouser and Evitt (1959).

In most of the preparations the palynomorphs were mixed with Vinylite AYAF in 90-percent alcohol (polyvinyl acetate plastic, refractive index 1.466). Several drops of the mixture were placed on a cover glass, and another cover glass placed on the mixture thus forming a sandwich. After the plastic had spread evenly to the margins, the cover glasses were separated by sliding them in opposite directions lengthwise in much the same manner as a blood smear is made. This method provided a thin, evenly distributed film of pollen and spores in a mountant of favorable refractive index. After the mixture on the cover glasses had dried for a few minutes on a warming plate, the cover glasses were inverted and mounted on slides in Permount. This method serves to anchor all the fossils close to the cover glass so that they can be examined conveniently, even under high-power oil-immersion lenses. The use of Vinylite was suggested by Alfred Traverse (written commun., 1958). Some of the preparations were mounted in canada balsam, and a few of the earlier preparations of Venezuelan material were mounted in glycerine jelly.

SOURCE OF MATERIAL

MODERN POLLEN

The photographs of modern *Illicium* pollen included in this report are of pollen from permanent slides on file in the palynological laboratory of the U.S. Geological Survey in Denver, Colo. For the most part the modern pollen was obtained from flowers on herbarium sheets. Anthers from these flowers were acetylated by means of Erdtman's (1943) method to remove cellulosic tissue and the cell contents of the pollen grains. The pollen was then mounted on slides in AYAF plastic, as outlined above. Each preparation was given an accession number with the prefix P; for example, P2855 *Illicium floridanum* Ellis. This number is referred in the accession book to the herbarium sheet from which it was obtained. Multiple slides from the same preparation are indicated thus: P2855, slide 1; P2855, slide 3.

FOSSIL POLLEN LOCALITIES

The fossil pollen grains from the United States used in this study are cataloged under the appropriate U.S. Geological Survey locality and slide numbers; for example, D3000, slide 7. Those from Venezuela are listed under preparation and slide numbers; for example, TS–200, slide 3.

The rock samples that yielded specimens of the new genera *Terscissus* and *Trisectoris* are from four general localities: The Mississippi embayment region, the coastal plain of Maryland and New Jersey, northern New Mexico, and western Venezuela (fig. 1). Specimens used in this study, including those shown on the plates, are from the following specific localities.

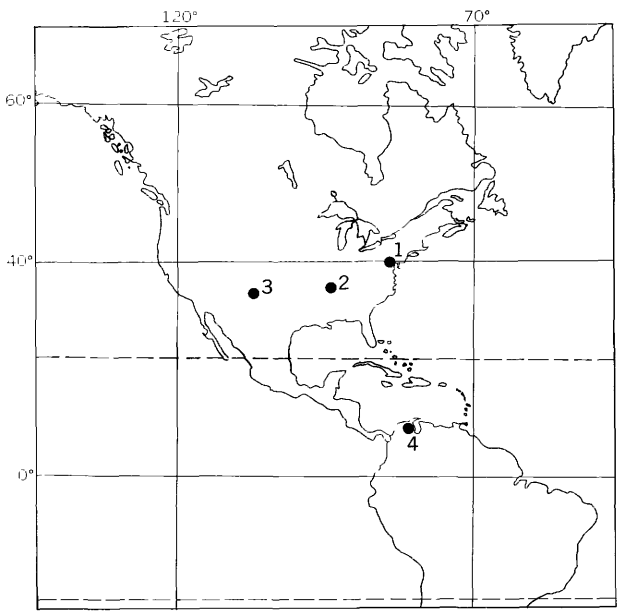

FIGURE 1.—Fossil localities in Maryland and New Jersey (1), the Mississippi embayment region (2), northern New Mexico (3), and western Venezuela (4).

United States specimens: USGS paleobotany loc. Nos.	*Locality*	*Stratigraphic unit*
D1322_____	Type locality. 2.25 miles S. of Lakeshore, Md., on North Ferry Point, adjacent to and on N. bank of Magothy River, Anne Arundel County, Md.	Magothy Formation.
D1846_____	Type locality of Bayou Lennan Member. NW¼SW¼ sec. 12, T. 6 N., R. 13 W., Sabine Parish, La. Elev 165 ft (Andersen, 1960, p. 75).	Bayou Lennan Member, Pendleton Formation of Andersen (1960) in Wilcox Group.

United States specimens: USGS paleobotany loc. Nos.	*Locality*	*Stratigraphic unit*
D1864	On abandoned lane 900 ft S. of Independence School; Kentucky coordinates, South zone, E. 1,267,650 ft; N. 144,650 ft, Hico 7½-min quad., Calloway County, Ky.	McNairy Sand.
D1867	1,000 ft SE. of Independence School; eastward cut in right wall of stream; Kentucky coordinates, South zone, E. 1,268,500 ft; N. 145,000 ft, Hico 7½-min quad., Calloway County, Ky.	Clayton Formation.
D1967–A	Type locality of McNairy Sand Member. W. end of big cut in Southern RR. E. of Dismal Swamp and Tuscumbia River. Base is approximately same elevation as track and 40 ft NW. of railroad crossing. South center NW¼SW¼, Chewala quad., McNairy County, Tenn.	McNairy Sand Member of Ripley Formation.
D3000	1,850 ft ENE. of Roberts cemetery, 2.1 miles ESE. of Shiloh, stream channel of headwater drainage of Sugar Creek; Kentucky coordinates, South zone, E. 1,289,050 ft; N. 135,150 ft, Hico 7½-min quad., Calloway County, Ky.	McNairy Sand.
D3001	6,500 ft SSW. of Shiloh in channel of tributary of Jonathan Creek; Kentucky coordinates, South zone, E. 1,272,250 ft; N. 132,050 ft, Hico 7½-min quad., Calloway County, Ky.	McNairy Sand.
D3143–B	Right bank of Clarks River, 0.25 mile W. of Cold Spring; Kentucky coordinates, South zone, E. 1,186,550 ft; N. 251,450 ft, Symsonia quad., McCracken County, Ky.	Clayton Formation.
D3210	N. side of Ohio River near water level (elev 291.5 ft); about 1,000 ft downstream from statue in Massac Park; Kentucky coordinates, South zone, E. 1,135,800 ft; N. 307,700 ft, Metropolis quad., Massac County, Ill.	McNairy Sand.
D3378	Drill hole PW–14 in Noble Park, Kentucky coordinates, South zone, E. 1,158,150 ft; N. 287,700 ft, Paducah West 7½-min quad., McCracken County, Ky.	McNairy Sand.
D3410	Type locality. From right bank of Owl Creek, 2.5 miles NE. of Ripley, Miss., E½ sec. 7, T. 4 S., R. 4 E., Tippah County, Miss.	Owl Creek Formation.
D3410–B	14 ft above stream level	Owl Creek Formation.
D3410–C	22 ft above stream level	Owl Creek Formation.
D3412	Type locality, near middle. Elev 440 ft along bluff on left bank Tennessee River 0.3 mile downstream from mile 185 and 0.9 mile E. of crossroads N. of Coffee Landing, Hardin County, Tenn.	Coffee Sand.
D3416	6 ft below unconformable contact with Owl Creek Formation; NW¼NW¼ sec. 10, T. 27 N., R. 11 E., Advance 7½ min quad., Stoddard County, Mo.	Upper part, McNairy Sand.
D3420	1.15 miles NNE. of Thomson Chapel; 550 ft N., 75 ft E. of road junction E. side of U.S. Highway 60; 0.9 mile S. of N. edge Little Cypress 7½-min quad.; Kentucky coordinates, South zone, E. 1,227,200 ft; N. 292,400 ft, Livingston County, Ky.	McNairy Sand.
D3507	0.5 mile S. of Reidland High School, elev 320 ft; small tributary of Clarks River; Kentucky coordinates, South zone, E. 1,186,500 ft; N. 258,300 ft, Paducah East 7½-min quad., McCracken County, Ky.	Clayton Formation.
D3522	600 ft SE. Independence School; Kentucky coordinates, South zone, E. 1,268,350 ft; N. 145,100 ft, Hico 7½-min quad., Calloway County, Ky.	McNairy Sand.
D3522–A	4–5 ft below stream	McNairy Sand.
D3523	0.9 mile SW. of Shiloh, elev 145 ft; Kentucky coordinates, South zone, E. 1,272,900 ft; N. 136,600 ft, Hico 7½-min quad., Calloway County, Ky.	McNairy Sand.
D3524	0.75 mile SW. of Shiloh, elev 125–130 ft; Kentucky coordinates, South zone, E 1,275,650 ft; N. 134,100 ft, Hico 7½-min quad., Calloway County, Ky.	McNairy Sand.

United States specimens: USGS paleobotany loc. Nos.	*Locality*	*Stratigraphic unit*
D3546_____	Auger hole 600 ft SE. of Independence School, Kentucky; Kentucky coordinates, South zone, E. 1,268,350 ft; N. 145,100 ft, Hico 7½-min quad., Calloway County, Ky.	
D3546–B__	2½ ft above base of lignitic clay_	McNairy Sand.
D3546–C__	3½ ft above base of lignitic clay_	Clayton Formation.
D3546–D__	4½ ft above base of lignitic clay_	Clayton Formation.
D3546–E__	5½ ft above base of lignitic clay_	Clayton Formation.
D3546–F__	6½ ft above base of lignitic clay_	Clayton Formation.
D3574–B__	Well T–1–F, S. of State Highway 59, 1.1 miles SE. of Braden, Fayette County, Tenn., depth 734 ft.	Upper part, Wilcox Group.
D3910_____	P[6]–1 corehole, C. sec. 33, T. 31 N., R. 19 E., in York Canyon, Colfax County, N. Mex.	Raton Formation.
D3910–C__	Depth 857 ft_____	Raton Formation.
11056_____	Garbage dump 0.75 mile S. of Melvins Creek, lat 40°26.55′ N.; long 74°17.5′ W., South Amboy quad., Middlesex County, N.J.	Amboy stoneware clay of Kümmel and Knapp (1904) in the Magothy Formation.
11057_____	About 0.5 mile SW. of garbage dump, 0.75 mile S. of Melvins Creek, lat 40°26′ N.; long 74°17.70′ W., South Amboy quad., Middlesex County, N.J.	Magothy Formation.
11062–B___	Lat 39°59.17′ N.; long 75°1.5′ W., Camden quad., Camden County, N.J.	Upper part, Magothy Formation.
Venezuela specimens: loc. Nos.		
RT–178V__	Well CR–4 (Shell-Rosario field S. of Alturitas, Venezuela). Maracaibo coordinates, S. 161,378.98 m; W. 105,116.25 m. Greenwich long 72°36′; lat 9°11′. Depth 11,200–11,230 ft.	Mito Juan Formation.
RT–180V__	Well CR–4. Depth 10,510–10,540 ft.	Guasare Formation.
RT–179V__	Well CR–4. Depth 11,020–11,050 ft.	Catatumbo Formation.
TS–200____	Well CR–4. Depth 11,200–11,230 ft.	Mito Juan Formation.
TS–230____	Well CR–4. Depth 11,230–11,260 ft.	Mito Juan Formation.
Venezuela specimens: loc. Nos.	*Locality*	*Stratigraphic unit*
Z390V_____	Rosalia 1 well (Mobil wildcat in Barinas near Apure River, Venezuela). Maracaibo coordinates, S. 332,367.44 m; E. 116,781.00 m. Greenwich lat 7°39′; long 70°34′. Depth 9,260–9,270 ft.	Eocene.

THE MODERN GENUS *ILLICIUM*

Illicium is a genus of aromatic shrubs or small trees. With the exception of several species found in Southern United States, its distribution is primarily confined to Southeast Asia (Japan, Malaysia, Philippine Republic, China, and India). About 20 species were attributed to the genus by Wodehouse (1935). As many as 42 species were placed in the genus by A. C. Smith (1947). Pollen grains of all species heretofore reported are from 28μ (microns) to 35μ in diameter. Descriptions of the pollen of only four species are available to me. The descriptions are included here.

Illicium floridanum Ellis

Illustrated specimens from colln. W. H. Duncan USNH 14879, Geneva County, Ala., March 29, 1953. Modern pollen preparation P2855. Plate 1, figures 1–4.

Pollen described by Wodehouse (1935), Pokrovskaia (1950), and Erdtman (1952). Following description from Wodehouse (1935, p. 335): "Grains uniform, spheroidal, about 28.5μ in diameter; tricolpate, occasionally dicolpate. Furrows long and slender, meeting at both poles, without germ pores. Exine completely covered by a system of anastomosing ridges bounding angular lacunae and ending with closed and somewhat smaller lacunae along the furrows, the ridges coalescing to form a sort of rim; mesh of the reticulum somewhat finer than in the grains of *Drimys winteri*, otherwise similar."

Remarks.—Pokrovskaia (1950) listed the size range as 21μ–30μ. Pollen of this species is syncolpate.

Illicium religiosum (*I. anisatum* (L.) Sieb. and Zucc.) Shikimi

Pollen described by Wodehouse (1935) and Pokrovskaia (1950). Following description from Wodehouse (1935, p. 336): "Grains indistinguishable from those of the preceding species. [*I. floridanum*]."

Remarks.—Pokrovskaia gave the size range as 24μ to 30μ and mentioned that the lacunae of the reticulum are smaller in *I. religiosum* than in *I. floridanum*.

Illicium yunnanense Franchet

The following description from Wodehouse (1935, p. 336): "Grains uniform, oblately flattened and more or less three-lobed in outline, about 30.8μ in diameter, tricolpate, with furrows long and tapering but not quite meeting at either pole, deeply sunken, imparting to the grain its three-lobed appearance. Furrow membrane marked with median linear thickenings throughout their length but with no indication of germ pores. Exine of the general surface uniformly reticulate, similar to that of grains of *Schizandra* (pl. 5, fig. 10) but of heavier ridges and smaller and less angular lacunae."

Remarks.—All the species of *Illicium* that I have examined possess the median linear thickening throughout the lengths of the colpi. This feature is not present in the new fossil genera discussed in this report.

Illicium anisatum Linn

Illustrated specimens Colln. Avalonne Kosanke, from the Denver Botanic Gardens. Modern pollen preparation P3382. Plate 1, figures 13–17.

Following description from Erdtman (1952, p. 254): "Grains 3-colp(oid)ate [longicolp(oid)ate], suboblate (about 29×35μ). Sexine reticulate (or provided with an undulating tegillum?). Muri cf. dupli-tribaculate, carinate."

Remarks.—The specimen (pl. 1, figs. 13 and 14) shows the presence of the median linear colpal thickenings in polar view.

Pollen from two additional species of *Illicium* was obtained from flowers supplied through the courtesy of Mr. Eyde of the Smithsonian Institution. Descriptions of these species follow:

Illicium simonsii Maxim

Colln. J. F. Rork USNH 11725 Yunan (China), March 1924. Modern pollen preparation P2856. Plate 1, figures 9–12.

Grains spheroidal, often slightly prolate, 31μ–36μ in diameter; tricolpate. Colpi long and slender, approaching but not meeting at either pole. Colpi membranes possessing median linear thickenings throughout their entire length. Exine coarsely reticulate, lacunae distinctly larger in the equatorial region than at the poles and along the colpi, muri coarse, duplibaculate to multibaculate. Colpi bordered by thickened exine made up of anastomosed muri. Separate segments (thirds) rarely found after acetylation.

Illicium henryi Diels var. *typicum* A. C. Smith

Colln. E. H. Wilson USNH 3087 Hupeh (China). Modern pollen preparation P2857. Plate 1, figures 5–8.

Grains spheroidal, 28μ–34μ in diameter, syncolpate, colpi long and slender, meeting at both poles. Colpal membranes with median linear thickenings. Exine uniformly reticulate except along the colpi, lacunae irregular in outline, muri narrow, similar to those in *I. anisatum*. Separate segments (thirds) common after acetylation.

Remarks.—The separation of pollen grains of *Illicium* into segments is mentioned by Pokrovskaia (1950): "The exine [of *Illicium*] of the furrows is thin. Also, as a result of alkali treatment, the membrane of the furrows splits easily in such a manner that the pollen is found divided into three parts in the form of split sections of an orange, whenever the furrows approach the poles."

THE NEW FOSSIL GENERA, *TERSCISSUS* AND *TRISECTORIS*

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

In addition to slides of the illustrated specimens, color photographs of the new genera and species described in this report are available from the U.S. Geological Survey laboratory, Denver, Colo., on a limited-time loan basis.

SYSTEMATIC DESCRIPTIONS

Genus TERSCISSUS n. gen.

Type species.—*Terscissus grandis* n. sp.

Diagnosis.—Pollen grains radially symmetrical; outline circular, rounded triangular or slightly three lobed; inaperturate, syncolpate, or syncolpoidate; divided into three segments by prominent grooves (colpi) bordered by prominent margos or lips, grooves joining at both poles. Complete grains usually rare,

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more often occurring as isolated thirds. Ornamentation various, reticulate, clavate, or baculate.

Terscissus grandis n. sp.

Plate 2, figures 1–4; plate 3, figures 1–6

Holotype.—D3546–C, slide 5, coordinates 98.0 × 11.5, plate 2, figures 1, 2.

Paratype.—D3546–C, slide 5, coordinates 88.3 × 21.3, plate 2, figure 3.

Paratype.—D1867, slide 8, coordinates 91.3 × 18.3, plate 2, figure 4.

Diagnosis.—Large syncolpate pollen grains, with prominent margos; surface ornamentation of regularly distributed islands made up of several clavae fused at their tips; areas devoid of clavae with short, densely packed verrucae.

Description.—Complete specimens are rounded triangular to slightly trilobed in outline. Based on 20 complete specimens and over 100 isolated segments, the diameter has been determined to range from 125μ to 185μ. Dimensions of isolated thirds are 58μ × 78μ (lateral) and 106μ × 124μ (radial). Three colpi, extending from pole to pole (syncolpate), divide the surface into three well-defined areas. Commonly the fossils are found as isolated segments or thirds, which indicate that the colpus or furrow membranes are thinner than the remainder of the exine. The colpi are bordered by prominent margos, which are separated from the remainder of the surface by thinner areas or channels. The wall is 12μ–18μ thick, including the sculpture. The endexine is 3μ–5μ thick. The clavae of the ektexine are about 8μ–13μ long and irregularly fused at their tips forming an incomplete tectum. Areas devoid of clavae and, in particular, areas in channels separating the margos from the remainder of the heavily sculptured areas possess short, densely packed verrucae.

Discussion.—The shape of isolated segments is roughly deltoid in polar view and circular where found in equatorial view. Several isolated segments are shown on plate 3 (figs. 2–5). Such segments are much more common in palynological preparations than are complete specimens. Interference contrast photographs (pl. 3, fig. 1) provide a view of the surface relief and clearly show the small verrucae at the base of the larger sculptural elements and in the channels adjacent to the prominent margos.

Sparse broken pieces of the margos are found (pl. 3, fig. 6). These provide excellent sections of the wall in the vicinity of the colpi and show the apical fusion of the large clavae.

All specimens from the Owl Creek Formation appear to differ from specimens from the Clayton Formation by possessing slightly larger clavae. Some clavae are fused at their apices to form an incomplete tectum (pl. 3, figs. 4, 5). Some Owl Creek specimens display a tendency to have an incomplete banding arrangement of the coarse sculptural elements centrifugal to the channel which separates the margo from the remainder of the surface. This tendency is not apparent in all specimens. Because of the absence of complete specimens from the Owl Creek and the fact that all Owl Creek specimens do not show the tendency to banding, it seems inappropriate at this time to erect a new species for Owl Creek specimens on the basis of the slightly larger size of the surface clavae—the only feature that differentiates these forms from *Terscissus grandis*.

Affinity.—A similarity to the modern genus *Illicium* is suggested by the gross morphology of the pollen grains and the tendency of the grains to split into thirds. The fossils assigned to *Terscissus grandis*, however, are many times larger than pollen of any known species of modern *Illicium*. Affinity with the Illiciaceae is postulated.

Occurrence.—*Terscissus grandis* has been found in the Clayton Formation of Paleocene age. One specimen was found in the upper part of the Upper Cretaceous McNairy Sand, and many specimens of a slightly variant form were found in the Owl Creek Formation of Late Cretaceous age. All these rocks are present in the upper part of the Mississippi embayment region.

Terscissus canalis n. sp.

Plate 4, figures 1–6

Holotype.—RT–178V, slide alpha, coordinates 106.3 × 7.9, plate 4, figure 1.

Paratype.—RT–178V, slide alpha, coordinates 95.0 × 13.0, plate 4, figure 2.

Paratype.—RT–178V, slide alpha, coordinates 107.0 × 19.4, plate 4, figure 3.

Paratype.—RT–178V, slide beta, coordinates 97.2 × 15.1, plate 4, figure 4.

Diagnosis.—Large syncolpate pollen grains, with prominent margos; each third with three channels separating the densely packed clavae into a margo, two annular segments, and one circular segment.

Description.—Complete specimens are probably rounded triangular to slightly trilobed in outline. The one complete specimen is distorted. The dimensions of the one complete specimen are 140μ × 184μ. On the basis of 20 isolated segments (thirds), the dimensions of the segments have been determined to range from 74μ to 160μ (lateral) and 80μ to 100μ (radial). Three colpi, extending from pole to pole (syncolpate), divide the surface into three well-defined areas. The membranes of the colpi or furrows are relatively thin, per-

mitting easy separation of the pollen grain into three segments. The colpi are bordered by prominent margos or lips. The margo is separated from the remainder of the heavily sculptured surface by a narrow channel. Two additional continuous channels divide each segment into three annular bands plus a circular central portion. The wall is 11μ–18μ thick, including the sculpture. The endexine is 3μ–5μ thick and the ektexine ranges in thickness from 8μ to 14μ. The surface, except in the channels, is densely covered with robust clavae; some clavae are fused at their tips with adjacent clavae. Short verrucae or granulae are present in the floor of the channels but are difficult to see except in abnormally expanded specimens. This species differs from *Terscissus grandis* by possessing a wall separated into annual segments, by the much greater density of the large surface clavae, and by the lack of readily visible verrucae between the large clavae.

Discussion.—The shape of isolated segments is identical with that of segments of *Terscissus grandis*. Because only one complete specimen was found and because the species can easily be identified from isolated thirds, isolated thirds were chosen as paratypes. One of the paratypes shown (pl. 4, fig. 3) lacks the margo but is otherwise a complete segment. As in the type species, isolated fragments only of the margo are found. One of these fragments, which provides a cross section of the wall of the margo, is shown on plate 4, figure 6. The thick endexine and the clavae whose enlarged tips are fused into a tectum are shown. The tightly packed clavae and the surface relief are seen in another picture (pl. 4, fig. 5) taken using interference contrast.

Affinity.—Possibly with the Illiciaceae.

Occurrence.—This species has so far been found only in the Mito Juan Formation of Maestrichtian age in western Venezuela.

Terscissus crassus n. sp.

Plate 5, figures 1–6

Holotype.—RT–179V, slide 6, coordinates 90.0 × 16.9, plate 5, figure 1.

Paratype.—RT–179V, slide 8, coordinates 94.8 × 13.7, plate 5, figure 2.

Paratype.—RT–179V, slide 10, coordinates 105.2 × 19.3, plate 5, figure 3.

Paratype.—RT–179V, slide 10, coordinates 88.4 × 9.4, plate 5, figure 4.

Paratype.—RT–179V, slide 9 (single grain), coordinates 105.0 × 12.0, plate 5, figure 5.

Diagnosis.—Large syncolpate pollen grains with prominent margos; coarse clavae mushroom shaped and a few fused with adjacent clavae at their tips; no visible verrucae between large clavae.

Description.—No complete grains were found. On the basis of 33 segments and many fragments, the dimensions of the individual thirds have been determined to range from 90μ to 100μ (lateral) and 120μ to 140μ (radial). The holotype, though broken and incomplete, shows clearly the three-segment characteristic of the genus. Three colpi, extending from pole to pole (syncolpate), divide the grains into three well-defined areas. The colpi or furrow membranes are thinner than the remainder of the exine, facilitating the separation of the segments. The colpi are bordered by very prominent margos. The wall is 10μ–16μ thick, including the sculpture. The endexine is 3μ–5μ thick. Clavae are 7μ–11μ long, enlarged, mushroom shaped at the tips, and often fused at the tips with one to several adjacent clavae. Clavae are robust and densely packed, thus giving the appearance of a coarsely verrucate surface. Some specimens have a tendency toward channeling and annular arrangement of fused clavae. This species differs from *T. grandis* and *T. canalis* by having coarser, more densely packed structural elements in the ektexine and by lacking visible small verrucae between the coarse clavae.

Discussion.—The colpal margos of this species, like those of *T. canalis* and *T. grandis*, are made up of fused clavae. The fusion is such that the margos are noticeably smoother than the margos of the previously described species. The mushroom shape of the clavae can be seen on the specimen on plate 5, figure 3. Two adjacent fused clavae are shown on plate 5, figure 4.

Affinity.—Possibly with the Illiciaceae.

Occurrence.—This species has been found only in the Catatumbo Formation of early Paleocene age in western Venezuela.

Other Terscissus *species.*—During the examination of Venezuelan samples, several additional species were found. All of these are characterized by a reticulate sculpture. Sufficient specimens to adequately circumscribe these species were not available. Consequently, these species have not been given specific epithets. They are included here as records of additional members of the genus *Terscissus*.

Terscissus sp. 1

Plate 6, figures 1, 2

Discussion.—This species possesses such prominent and distinctive morphology that it cannot be confused with any other taxon. Only one complete specimen and one isolated segment were found. The complete specimen is rounded triangular to slightly trilobed in outline (polar view). Three colpi join at the poles to form a syncolpate grain. The colpi are bordered by margos, and the endexine is thickened adjacent to the colpi. This

thickening is shown on plate 6, figure 1, on the part of the grain from which the reticulate ektexine has been removed. The wall is 16μ–19μ thick, including the sculpture. The endexine is 3μ–5μ thick, except along the margins of the colpi where it is thicker. The ektexine is made up of pillars 3μ–5μ in diameter and 6μ–10μ long that support a coarse reticulum made up of cylindrical elements 3μ–4μ in diameter. The reticulum in surface view is vermiculate; the endexine surface is granulate.

The specimen photographed (pl. 6, fig. 1) has had the reticulate tectum removed from part of the surface, thus clarifying the structure of the ektexine. The isolated segment (third) on plate 6, figure 2, shows clearly the irregular nature of the lacunae of the reticulum.

Affinity.—Possibly with the Illiciaceae.

Occurrence.—This species has been found only in the Guasare Formation of Paleocene age of western Venezuela.

Terscissus sp. 2

Plate 6, figures 3–6

Discussion.—Two specimens (thirds) whose morphology appears very similar to that of *T.* sp. 1 were found. These specimens are distinctly smaller, and the elements of the reticulum are smaller, than those in *T.* sp. 1. A vermiculate irregular reticulum supported by comparatively robust pillars is present in this species also (pl. 6, fig. 4). This same specimen shows the torn inner thickening of the endexine along the colpi. It is postulated that this condition is approximated in *T.* sp. 1.

Affinity.—Possibly with the Illiciaceae.

Occurrence.—These specimens are from the Upper Cretaceous Mito Juan Formation of western Venezuela.

Terscissus sp. 3

Plate 6, figures 7–9

Discussion.—Several specimens (thirds) of this species were found. The general morphology is similar to that of *T.* sp. 1 and *T.* sp. 2. This species is distinguished by a more regular reticulum and a reticulum whose lacunae are more numerous and smaller.

Affinity.—Possibly with the Illiciaceae.

Occurrence.—These specimens are from the Upper Cretaceous Mito Juan Formation of western Venezuela.

Terscissus sp. 4

Plate 7, figures 1, 2

Discussion.—A single complete specimen was found. It is rounded triangular in polar view and has a dense reticulum of fairly heavy muri and smaller irregular lacunae. It has prominent thickened margos adjacent to the colpi. The colpi extend from pole to pole, forming a syncolpate grain. The wall is about 8μ thick (16μ thick along the colpi).

Affinity.—Possibly with the Illiciaceae.

Occurrence.—This specimen is from the Catatumbo Formation of early Paleocene age of western Venezuela.

Genus TRISECTORIS n. gen.

Type species.—*Trisectoris costatus* n. sp.

Diagnosis. Pollen grains spherical or nearly so; syncolpate or syncolpoidate; divided into three segments that commonly separate; complete grains rare; ektexine of prominent longitudinal costae; costae separated from endexine by prominent baculae.

Trisectoris costatus n. sp.

Plate 7, figures 3–14

Holotype.—D3001, slide 1, coordinates 83.3×7.6, plate 7, figure 3.

Paratype.—D3001, slide 3, coordinates 82.0×20.7, plate 7, figure 4.

Paratype.—D1867, slide 1, coordinates 96.5×18.8, plate 7, figures 5, 6.

Paratype.—D1967–A, slide 2, coordinates 92.7×2.4, plate 7, figures 7, 8.

Paratype.—D1864, slide 5, coordinates 76.4×4.5, plate 7, figures 9, 10.

Diagnosis.—Syncolpate pollen grains with prominent longitudinal costae that extend from pole to pole.

Discription.—Pollen grains spherical or spheroidal and syncolpate. On the basis of 12 complete specimens and over 100 isolated thirds, the diameter has been determined to range from 32μ to 49μ. Dimensions of isolated thirds range from 21μ to 28μ (polar) and 31μ to 37μ (lateral). After separation the thirds commonly contract in their polar axis, forming distinctly cupped segments. Longitudinal costae range in number from 7 to 12 per segment. Costae adjacent to the colpi are continuous over the poles, thus forming a complete circle. Individual costae are 2μ–4μ wide equatorially, tapering toward the poles where they tend to fuse with adjacent costae. Costae are subtended on their inner face by ± two rows of prominent baculae. In equatorial view baculae are easily seen through the costae. Ektexine including baculae is 3μ–5μ thick, and baculae are as much as 2μ long. The endexine is very thin, about 1μ thick, and membranous. The costae and attached baculae are easily separable from the endexine.

Discussion.—Isolated thirds of *Trisectoris costatus* are shown on plate 7, figures 7–14. In figures 7 and 9, the supporting baculae are clearly shown. An enlarged view of a broken segment showing comblike "teeth" or baculae, which separate the costae from the endexine, is

seen in figures 12 and 13. The thin endexine and the continuous circular costa adjacent to the colpi are shown in figure 11. The tapering of the costae at the poles and their fusion at the extremities is displayed in figure 14.

Affinity.—The marked tendency to split into thirds suggests the possibility of affinity to the Illiciaceae.

Occurrence.—*Trisectoris costatus* has been found in the Upper Cretaceous Coffee, McNairy, and Owl Creek Formations. A single specimen has been found just above the Cretaceous-Tertiary boundary in the Clayton Formation of Paleocene age.

Trisectoris stoveri n. sp.

Plate 8, figure 1–6

Holotype.—11062–B, slide 2, coordinates 91.7×4.6, plate 8, figure 1.

Paratype.—D1322, slide 1, coordinates 95.9×17.4 (2 joined segments), plate 8, figure 2.

Paratype.—D1322, slide 1, coordinates 101.1×14.3 (one segment), plate 8, figure 3.

Diagnosis—Syncolpate pollen grains with prominent longitudinal costae; many costae interrupted or do not extend from pole to pole.

Description.—Pollen grains spherical or nearly so. On the basis of five complete specimens and 25 isolated segments (thirds), the diameter is determined to range from 41μ to 57μ. Dimensions of isolated thirds range from 29μ to 52μ in polar dimension and 21μ to 51μ in equatorial dimension (average 40.8μ polar × 31.4μ equatorial). The number of costae at the equator ranges from 9 to 14. Some costae reach from pole to pole; others are interrupted. Costae are 2μ–5μ wide—widest about midway of their length and tapering slightly to their blunt ends. Costae adjacent to the colpi are continuous over the poles, thus forming a complete circle. Costae are subtended on their inner faces by ± two rows of prominent baculae. Ektexine, including baculae, is 3μ–5μ thick; baculae are as much as 2μ long. The endexine is 1μ–2μ thick. This species differs from *Trisectoris costatus* by its slightly larger size and by the fact that many of the costae do not reach from pole to pole.

Discussion.—The interrupted nature of many of the costae is demonstrated particularly well in plate 8, figures 2 and 3. Figure 6 of plate 8 pictures an isolated third, which shows that the costa adjacent to the colpi passes over the pole without interruption, thus forming a complete circular costa. This species is named for Lewis E. Stover (1964), who first reported it as pollen type A from the Magothy Formation of Maryland. He indicated (written commun., 1969) that in his material the diameter of complete grains reaches 78μ. This size is appreciably larger than that of specimens in my material from the same formation.

Affinity.—The marked tendency to split into thirds suggests the possibility of affinity to the Illiciaceae.

Occurrence.—*Trisectoris stoveri* has been found in the lower, middle, and upper parts of the Magothy Formation of Late Cretaceous age. At present (1969), its range is limited to the Magothy.

Other Trisectoris *species.*—Two additional species that clearly belong to the genus *Trisectoris* were found. Only a few specimens were found; these were considered too few to provide adequate species circumscriptions, and consequently these species have not been named. They are included as additional records of the genus *Trisectoris.*

Trisectoris sp. 1

Plate 8, figures 7–9

Discussion.—No complete specimens were found, and only two isolated thirds serve to characterize this species. This species, with longitudinal costae and ± two rows of prominent baculae which separate the costae from the endexine, clearly belongs to the genus *Trisectoris.* It differs from all other species by having prominent reticulate margos adjacent to the colpi. Plate 8, figure 7, shows this feature particularly well. Plate 8, figures 8 and 9, show that some of the costae do not reach from pole to pole; this condition approximates that observed in *Trisectoris stoveri.* Plate 8, figure 9, is an isolated segment cupped in the polar axis. The reticulate ornamentation is seen only at the pole and along the margo to the left. The dimensions of isolated segments are about the same as those of *Trisectoris stoveri.* (See plate descriptions.)

Affinity.—Possibly with the Illiciaceae.

Occurrence.—Only in the Amboy stoneware clay, of Kümmel and Knapp (1904) in the Magothy Formation of Late Cretaceous age.

Trisectoris sp. 2

Plate 8, figures 10–13

Discussion.—I did not find any complete specimens or a sufficient number of separate segments to justify formal naming of this species. The few specimens found in the uppermost Cretaceous sample of the Raton Formation from northern New Mexico have fewer, more robust costae and a slightly larger size range than *T. costatus. T.* sp. 2, on the basis of six separate "thirds," one "two-thirds," and about 20 broken fragments, is determined to have a size range of 26μ to 38μ (polar) and 37μ to 41μ (equatorial). One of the segments has nine costae, one has seven and the remainder have eight. This species has the same general morphology as *Trisectoris costatus* and clearly belongs to the genus. A photograph of two-thirds of a complete specimen is shown on plate 8,

figure 10. One segment, which is contracted and cupped in the polar axis, is shown on plate 8, figure 11. The type and arrangement of supporting baculae are shown on plate 8, figures 12 and 13. This species differs from *T. costatus* by possessing fewer, wider, and thicker costae and by being slightly larger.

Affinity.—Possibly with the Illiciaceae.

Occurrence.—To date (1969), this species has been found only in the uppermost Cretaceous part of the Raton Formation.

MORPHOLOGIC SYNOPSIS OF THE GENERA *ILLICIUM, TERSCISSUS,* AND *TRISECTORIS*

A summary of significant similarities and differences between the modern genus *Illicium* and the fossil genera *Terscissus* and *Trisectoris* can be expressed best in tabular form (table 1).

The presence of a median linear thickening of the colpal membrane is a morphologic character confined to species of the genus *Illicium*. The comparatively large size of species in the genus *Terscissus* (greater than 66μ) serves to differentiate this genus from *Illicium* and *Trisectoris;* and the presence of prominent longitudinal costae with supporting baculae serves to separate the genus *Trisectoris* from the other two genera.

TABLE 1.—*Comparison of some morphologic features of the genera* Illicium, Terscissus, *and* Trisectoris

Selected morphologic features	*Illicium*	*Terscissus*	*Trisectoris*
Tricolpate pollen form	Some species	No species	No species.
Syncolpate or syncolpoidate pollen form.	do	All species	All species.
Splitting readily into segments (thirds).	do	do[1]	Do.
Reticulate sculpture	All species	Some species	No species.[2]
Longitudinal costae	No species	No species	All species.
Median linear thickening of colpal membrane.	All species	do	No species.
Prominent colpal margos	Some species	All species	All species.
Diameter (range, in microns)	20–35	66–185[3]	32–57.[4]

[1] Except *Terscissus* sp. 1.

[2] *Trisectoris* sp. 1 does not possess a reticulate surface sculpture but has a reticulate fringe on the colpal margos.

[3] Minimum diameter of "thirds" of *Terscissus* sp. 2. Complete specimens of this species not found.

[4] *Trisectoris stoveri* reported as having a diameter as much as 78μ by L. E. Stover (written commun., 1969).

OTHER POSSIBLY RELATED GENERA

Many fossil pollen species possess morphological similarities to some species of *Illicium;* in particular, tricolpate reticulate species and "pseudosyncolpate" reticulate species show this similarity, because *Illicium* species are either tricolpate or syncolpate, and they have the reticulate surface sculpture. However, modern tricolpate reticulate pollen is known from several other families such as the Ranunculaceae, Cruciferae, and Haloragaceae. Most reticulate syncolpate and reticulate tricolpate fossil species cannot at present be referred with any degree of confidence to any of these extant families; consequently, they are placed provisionally in a form genus. The form genus erected by Elsik (in Stover and others, 1966) for pseudosyncolpate reticulate forms is *Myocolpopollenites.* Elsik's species *M. reticulatus* was found in Mississippi embayment rocks.

MYOCOLPOPOLLENITES

Myocolpopollenites reticulatus Elsik, 1966

Plate 9, figures 1–6

Discussion.—This genus and species of pollen is described in part as follows: "Marginate sexinous material extends past ends of colpi to poles where they join to form pseudosyncolpate triradiate crests" (Elsik, in Stover and others, 1966, p. 4). This species is included here for comparison with the species of *Terscissus* and *Trisectoris*, because *Myocolpopollenites reticulatus* is also found as isolated thirds. Separation occurs along the colpi often enough that individual segments are common in our material. Interference contrast photographs of an equatorial view (pl. 9, figs. 3, 4) show the character of the reticulum and the polar crests. An isolated segment (third) is shown on plate 9, figures 5 and 6.

Affinity.—Elsik states that the affinity of this taxon is unknown. That this taxon has affinity with the Illiciaceae is not beyond the realm of possibility.

Occurrence.—Lower Eocene (Elsik, in Stover and others, 1966). Wilcox Group, lower Eocene, USGS sample localities D1846, D3574–B.

TRICOLPITES

Tricolpate reticulate species are commonly placed in the form genus *Tricolpites.* Three *Tricolpites* species are briefly discussed below:

Tricolpites sp. 1

Plate 9, figures 7–9

Discussion.—The colpi extend nearly to the poles and are bordered by very prominent margos. Some specimens occur as separated or isolated fragments, as shown on plate 9, figure 9. This feature is shared by the genera *Illicium, Terscissus,* and *Trisectoris.*

Occurrence.—This tricolpate species was found in the Eocene of Venezuela.

Tricolpites sp. 2

Plate 9, figures 10, 11 and 14

Discussion.—This tricolpate reticulate species is slightly trilobed. The colpi extend almost to the poles and are bordered by fairly prominent margos. Figure 14, plate 9, shows the development of heavy margos to the extent that this specimen may represent a different species from that shown in figures 10 and 11. Sufficient specimens to clarify this possibility were unavailable.

Occurrence.—McNairy Sand.

Tricolpites sp. 3

Plate 9, figures 12, 13

Discussion.—This tricolpate reticulate species is almost spherical but is smaller than the other pictured species of *Tricolpites*. It has colpi bordered by distinct margos. The colpi extend almost to the poles. The lacunae are distinctly larger than those seen in the other figured species of *Tricolpites*.

Occurrence.—McNairy Sand.

These few examples are included here merely to demonstrate some of the morphological variations found in fossil tricolpate and pseudosyncolpate pollen grains. Some of these morphological types may be related to the Illiciaceae, others probably have no relationship whatsoever. The genus *Tricolpites* undoubtedly accommodates species from several distinct families.

If the hypothesis of affinity of the genera *Terscissus*, *Trisectoris*, and possibly *Myocolpopollenites* to the Illiciaceae proves valid, then it will be evident from the number of new species belonging to these genera that have been found that this segment of the Ranales was undergoing rapid evolution in Late Cretaceous and early Paleocene time. It may be true, with the advent of a reticulate surface sculpture, as seen in *Terscissus* species 1–4, that this character became fixed, and that the modern species of *Illicium* descended from this ancestral stock. Perhaps the nonreticulate genera and species, such as *Terscissus grandis* and *Trisectoris*, possessed fewer characteristics of survival value and thus became extinct.

STRATIGRAPHIC DISTRIBUTION OF THE GENERA *TERSCISSUS* AND *TRISECTORIS*

The species of *Terscissus* and *Trisectoris* mentioned in this report are all limited to the Late Cretaceous and Paleocene. The recognition of so many species of these hitherto unknown fossils does not necessarily mean that they have not been seen. Indeed, Stover (1964) figured a species of *Trisectoris* but did not give it a name. The lack of published palynological work, particularly from the Mississippi embayment area and from Venezuela, may partly explain this lack of reporting. Further, the fact that most specimens occur as isolated thirds delayed my recognition of them as pollen grains and may have deterred others from describing them.

The speciation demonstrated in the Late Cretaceous and early Tertiary certainly suggests that these genera originated in the Cretaceous and were eliminated from the floras or were evolutionarily modified by Eocene time. In Venezuela, literally thousands of samples from Eocene and Oligocene rocks have been examined, and none of these genera were seen. In the Mississippi embayment, hundreds of post-Paleocene samples have failed to yield any members of these genera. These facts are particularly striking in relation to the genus *Terscissus*. Species belonging to this genus are extremely large for pollen grains and are not easily overlooked. Even species evolutionarily reduced to the size of modern *Illicium*, because of their distinctive morphology, would not be disregarded. Specimens of some of these genera, in limited parts of the section, are sufficiently numerous to indicate that their parent plants were significant elements of the fossil floras. The modern genus *Illicium*, a member of a primitive order of angiosperms, may have been derived from genera similar to the ones described here. Although species of the genus *Illicium* are now living in the southern part of the United States, they are not numerous elements of the floras of the region. The presence of modern *Illicium* in the area of the Mississippi embayment suggests that the genus should be represented by fossil pollen in the same area. The fact that modern *Illicium* pollen has not been definitely recognized suggests that the plants were too few in number to produce sufficient pollen so that it would be likely to be found as fossils. The presence of a few plants in a region does not insure that these plants will produce enough pollen to provide a fossil record. It may be that after Paleocene time, the plants that produced pollen with an *Illicium*-, *Terscissus*-, or *Trisectoris*-like morphology were so reduced in number that they did not leave an as-yet-recognized fossil record. This record may eventually be found in species placed in the genus *Tricolpites*.

THE GENUS *TERSCISSUS*

Known ranges of species of *Terscissus* and *Trisectoris* are shown in figure 2. *Terscissus grandis* ranges from the upper part of the Upper Cretaceous McNairy Sand, through the Owl Creek Formation, and into the Paleocene Clayton Formation. A slight variant, which cannot always be distinguished, may be limited to the Owl Creek Formation. A morphologically somewhat similar species *Terscissus canalis* has so far (1969) been found only in the uppermost Cretaceous Mito Juan Formation of western Venezuela.

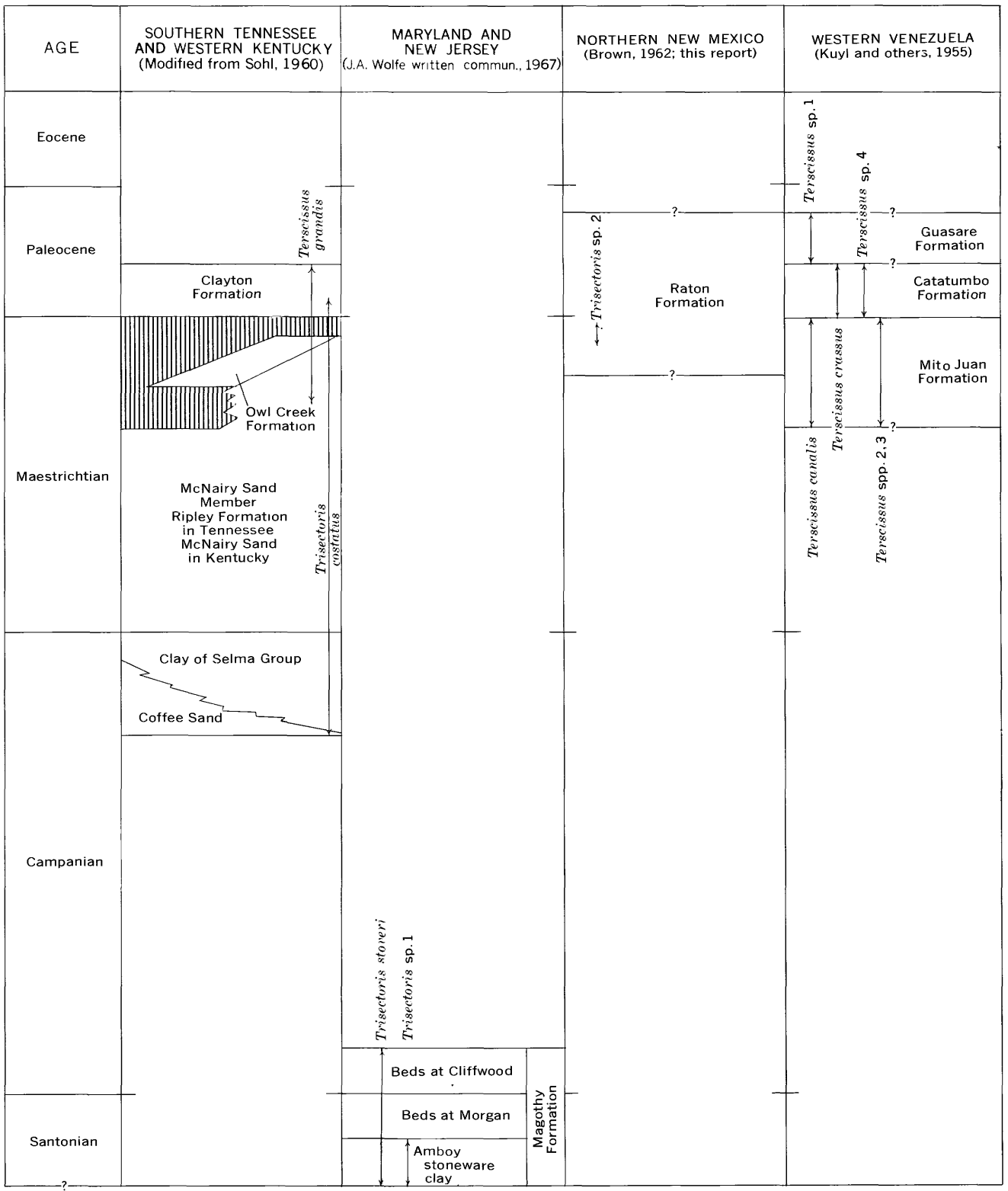

FIGURE 2.—Stratigraphic ranges of species of the genera *Terscissus* and *Trisectoris*.

A third species of *Terscissus*, *T. crassus*, is limited to the lower Paleocene Catatumbo Formation of western Venezuela. Morphologically, it is similar and probably closely related to the two previous species.

Several distinctly different species of *Terscissus* with reticulate surface sculpture were found in the Upper Cretaceous and lower Paleocene of Venezuela. A large species, *Terscissus* sp. 1, is confined to the Guasare Formation of Paleocene age. Another large reticulate species, *Terscissus* sp. 4, was found in the lower Paleocene Catatumbo Formation. Smaller reticulate species, *Terscissus* sp. 2 and *Terscissus* sp. 3, are limited to the Upper Cretaceous Mito Juan Formation of western Venezuela. These unnamed species particularly, owing to the fact that few specimens were recovered, may in the future be found to have slightly greater stratigraphic ranges.

THE GENUS *TRISECTORIS*

The geographic distribution of this genus, so far as known, is confined to rocks from the United States. Specimens of the type species *Trisectoris costatus* have been found in the Coffee Sand, the McNairy Sand, and the Owl Creek Formation, all of Late Cretaceous age, and in the Clayton Formation of Paleocene age. These formations are in the northern part of the Mississippi embayment area. The range extends from upper Campanian, through the Maestrichtian, and into the lower Paleocene. A very similar but distinct species, *Trisectoris stoveri*, is represented in the Magothy Formation of Santonian and basal Campanian age. No specimens of this genus have been found in rocks from the Santonian and lower Campanian of the Mississippi embayment, but then, comparatively few samples have as yet been examined from this interval.

Trisectoris sp. 1, differing from *Trisectoris stoveri* by possessing reticulate margos along the colpi, is found at present only in the Amboy stoneware clay of Kümmel and Knapp (1904), the basal clay of the Magothy Formation.

Another species, *Trisectoris* sp. 2, is present in the uppermost Cretaceous part of the Raton Formation of northern New Mexico. Brown (1962) placed at least the lower 50 feet of the Raton Formation in the Cretaceous, on the basis of finding the Upper Cretaceous plant *Paleoaster inquirenda* Knowlton at this level. More recent palynological work on a core which penetrated the Raton Formation in northern New Mexico reveals that the lower 265 feet of the Raton Formation is Cretaceous and that the remainder is Paleocene. *Trisectoris* sp. 2 is not present in the Paleocene part of the Raton Formation. Further work in this area may extend the range and provide enough additional specimens to permit description and naming of this species.

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PLATES 1–9

PLATE 1

[All figures × 1,000]

FIGURES 1–4. *Illicium floridanum.*

1. P2855, slide 1, coordinates 85.4 × 9.4, diameter 30μ. Beginning of equatorial splitting.
2. P2855, slide 1, coordinates 81.6 × 20.7, diameter 31μ. Beginning of polar splitting, high focus.
3. P2855, slide 1. Same specimen as fig. 2, low focus.
4. P2855, slide 2, coordinates 93.4 × 12.6. Separate segments, polar view.

5–8. *Illicium henryi* var. *typicum.*

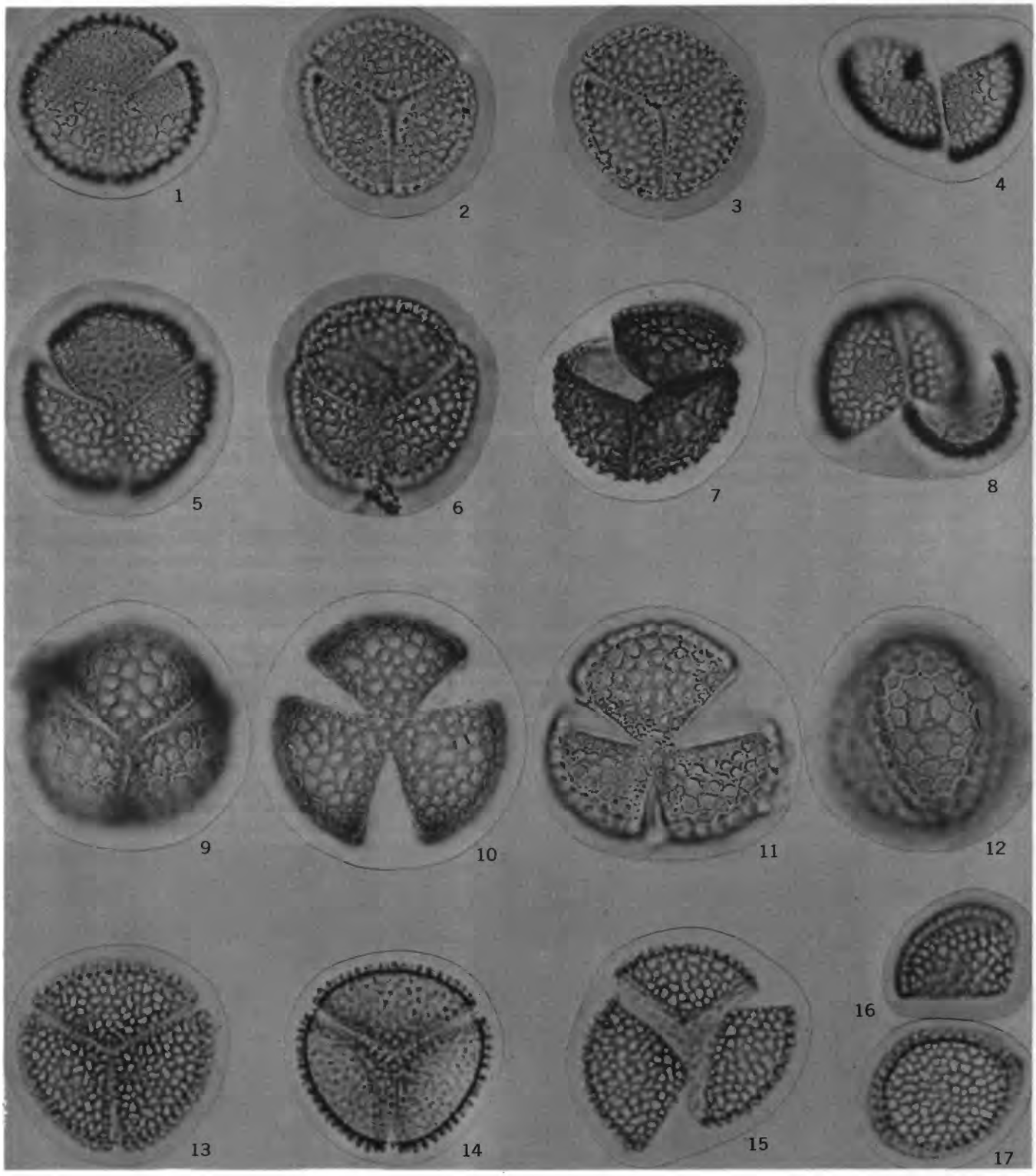
5. P2857, slide 1, coordinates 95.9 × 14.5, diameter 31μ.
6. P2857, slide 1, coordinates 93.6 × 6.3, diameter 32μ.
7. P2857, slide 1, coordinates 82.7 × 20.1, diameter 33μ. One segment disattached at one pole.
8. P2857, slide 1, coordinates 87.4 × 20.0, diameter 30μ. One segment completely disattached.

9–12. *Illicium simonsii.*

9. P2856, slide 1, coordinates 92.7 × 7.6, diameter 36μ. Polar view of spherical grain.
10. P2856, slide 1, coordinates 84.3 × 14.2, flattened grain, diameter 40μ. Note partially detached median linear thickening of furrow membrane.
11. P2856, slide 3, coordinates 98.5 × 8.5, partially flattened grain, diameter 40μ. Note gradation in size of reticulum from pole to equator.
12. P2856, slide 1, coordinates 92.3 × 14.5, polar diameter 34μ. Note large size of equatorial lacunae.

13–17. *Illicium anisatum.*

13. P3382, slide 3, coordinates 80.3 × 10.0, diameter 33μ, high focus.
14. Same specimen as fig. 13, low focus. Note median linear thickenings of furrow membrane.
15. P3382, slide 5, coordinates 102.1 × 17.8, segments detached at one pole.
16. P3382, slide 3, coordinates 82.0 × 10.2, isolated segment in polar view.
17. P3382, slide 5, coordinates 111.5 × 14.4 isolated segment, equatorial view.



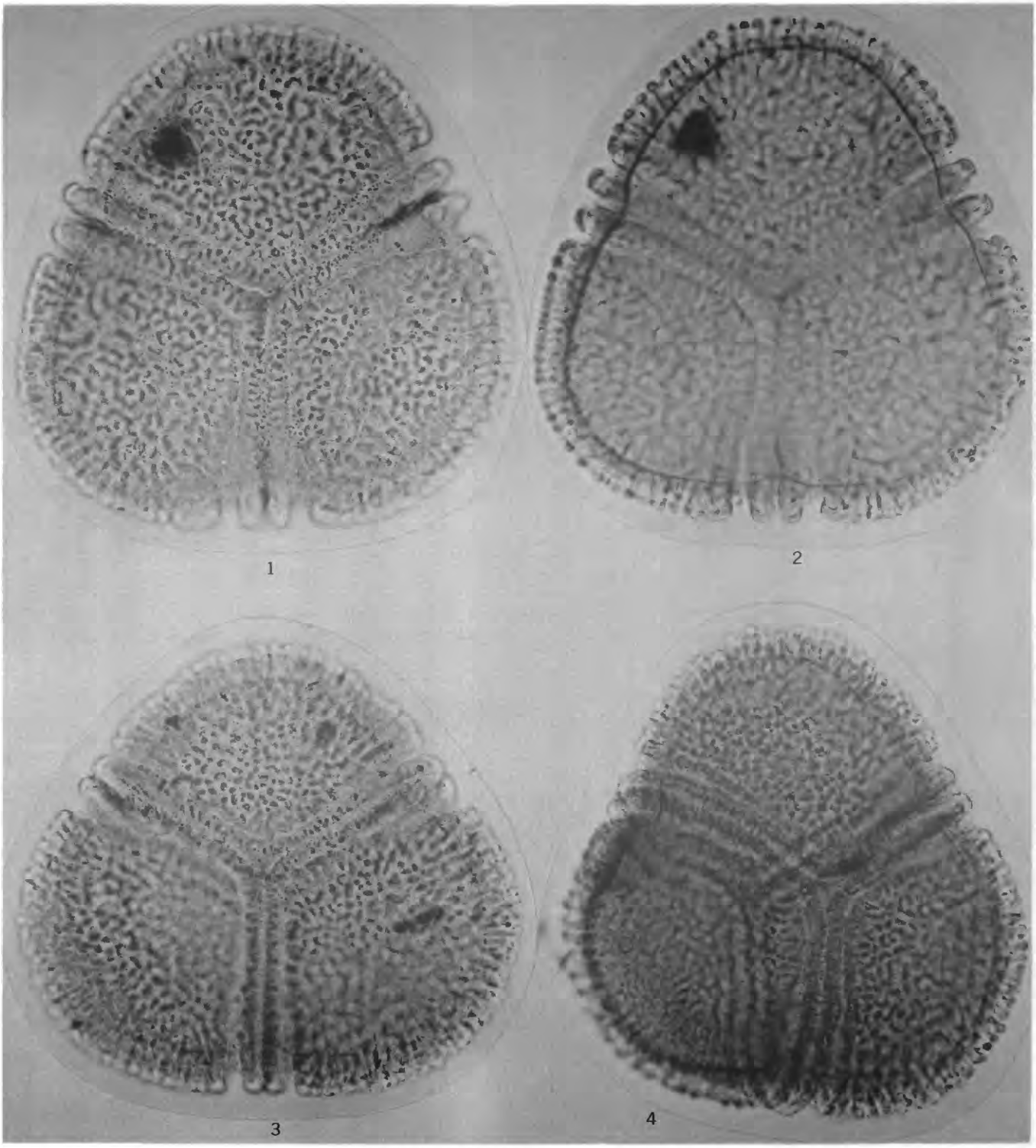
MODERN *ILLICIUM* SPECIES

PLATE 2

[All figures × 500]

FIGURES 1–4. *Terscissus grandis* n. gen. and sp.

1. Holotype, USGS paleobotany loc. D3546–C, slide 5, coordinates 98.0 × 11.5, 176μ × 182μ.
2. Same specimen as fig. 1 but focussed on the margin to show detail of the baculae and thickening of endexine at colpi.
3. Paratype, USGS paleobotany loc. D3546–C, slide 5, coordinates 88.3 × 21.3, 163μ × 167μ.
4. Paratype, USGS paleobotany loc. D1867, slide 8, coordinates 91.3 × 18.3, 145μ × 168μ. The colpi can be seen extending completely around this specimen, dividing the spheroid into three segments.



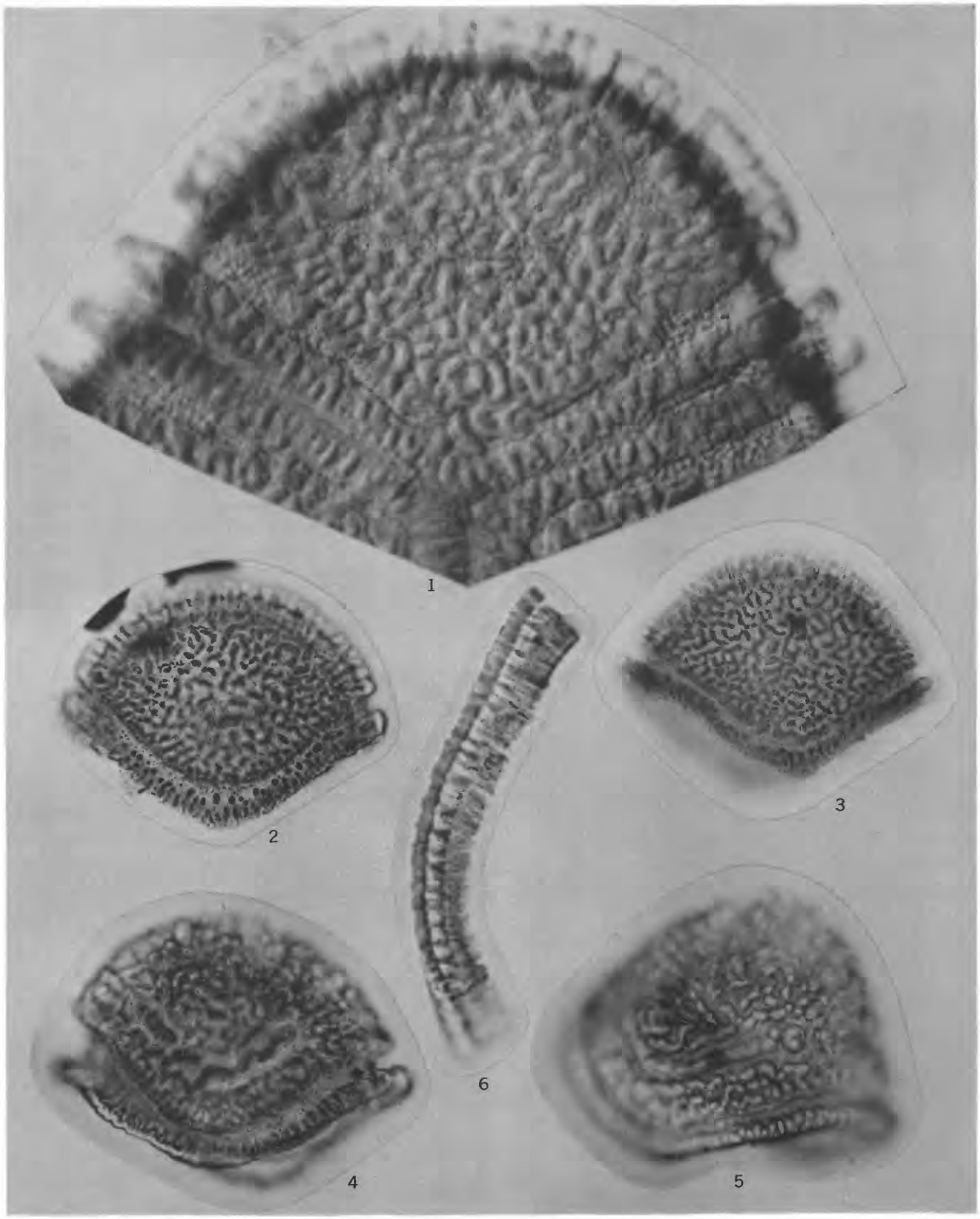
TERSCISSUS GRANDIS HOLOTYPE AND PARATYPES

PLATE 3

[Figures 1 and 6 × 1,000; all others × 500]

FIGURES 1–6. *Terscissus grandis* n. gen. and sp.

1. Segment of holotype photographed using interference contrast. Surface relief and verrucae between the larger surface elements are shown.
2. Isolated segment, USGS paleobotany loc. D1867, slide 8, coordinates 101.4 × 6.4, 114μ × 88μ.
3. Isolated segment, USGS paleobotany loc. D1867, slide 8, coordinates 113.2 × 23.4, 117μ × 90μ.
4. Isolated segment, USGS paleobotany loc. D3410–C, slide zeta, coordinates 79.2 × 18.0, 122μ × 90μ. Specimen from Owl Creek Formation showing slight tendency to form more than one channel parallel to the colpi.
5. Isolated segment, USGS paleobotany loc. D3410–C, slide gamma, coordinates 109.4 × 3.5, 122μ × 109μ. Specimen from Owl Creek Formation showing somewhat larger fused baculae and tendency to form additional incomplete channel.
6. Fragment of colpus margo, USGS paleobotany loc. D1867, slide 7, coordinates 104.7 × 10.5, thickness 12μ–18μ. The upper end of the fragment shows the large baculae fused at the tips that form the margo. The fringelike material to the right is the torn endexine which is thicker at the margins of the colpi.



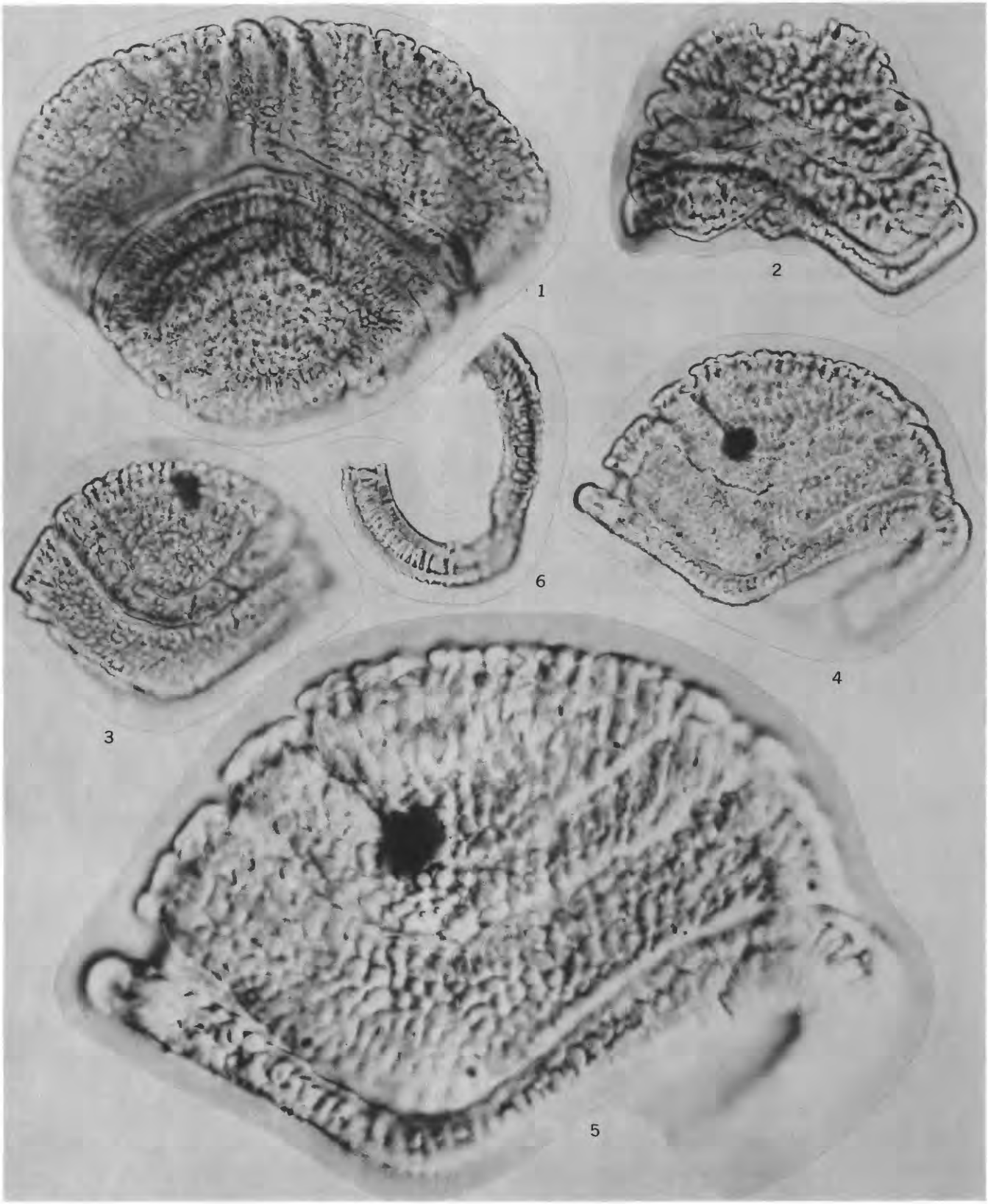
TERSCISSUS GRANDIS ISOLATED SEGMENTS

PLATE 4

[Figures 1, 2, 3, 4 and 6 × 500; figure 5 × 1,000]

FIGURES 1–6. *Terscissus canalis.*

1. Holotype, RT–178V, slide alpha, coordinates 106.3 × 7.9, 140μ × 184μ. This is the only complete specimen.
2. Paratype, RT–178V, slide alpha, coordinates 95.0 × 13.0, 134μ × 104μ. Margo at lower left missing. Note round tipped clavae at apex.
3. Paratype, RT–178V, slide alpha, coordinates 107.0 × 19.4, 121μ × 93μ. Entire margo missing.
4. Paratype, RT–178V, slide beta, coordinates 97.2 × 15.1, segment, 101μ × 146μ.
5. Same specimen as fig. 4, photographed with interference contrast to show surface texture.
6. Fragment of colpus margo, TS–230, slide 6, coordinates 94.8 × 7.7. Cross section of wall showing fused clavae. Wall about 17μ thick; endexine about 5μ thick; ektexine, including clavae, about 12μ thick.



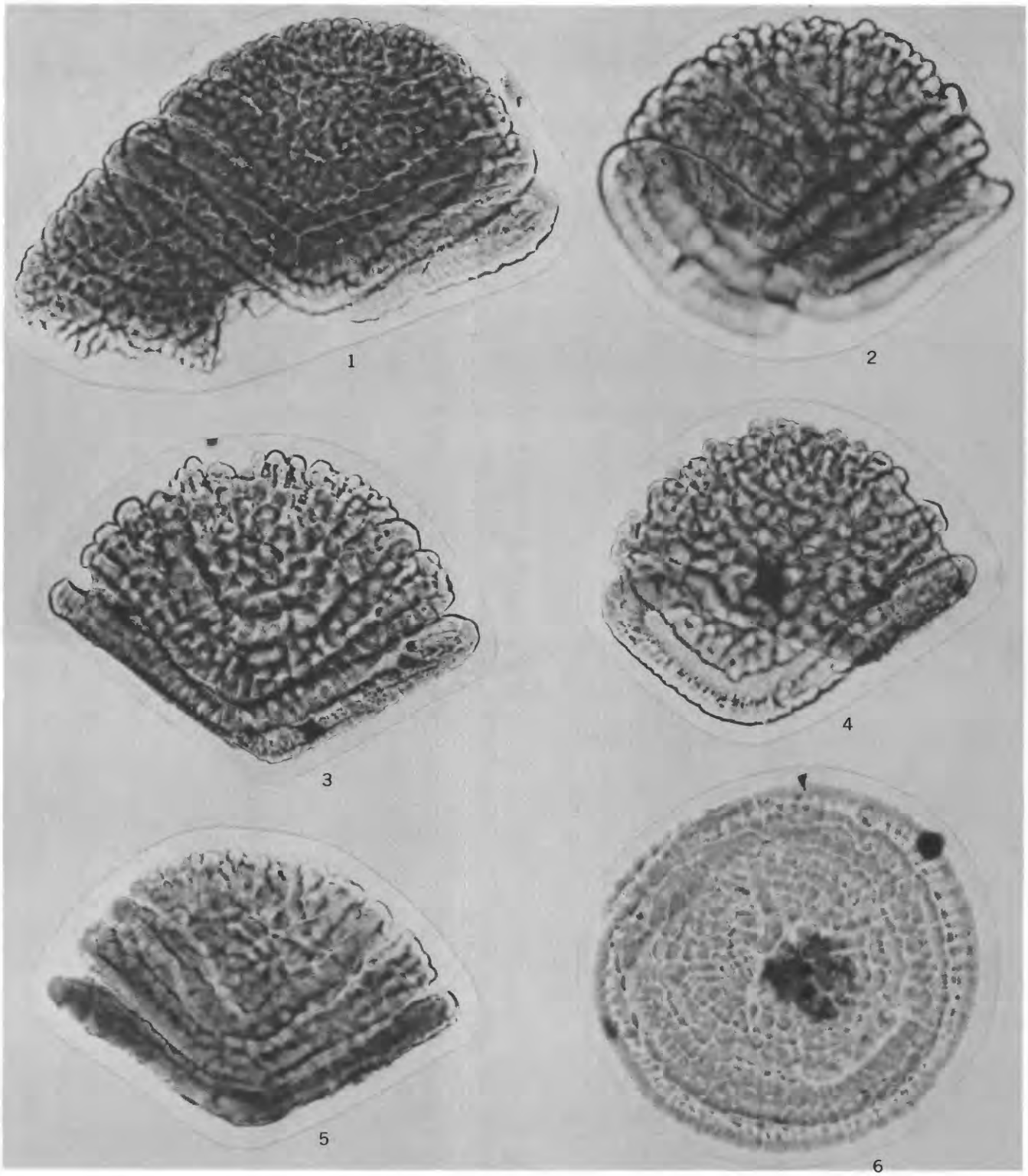
TERSCISSUS CANALIS HOLOTYPE AND PARATYPES

PLATE 5

[All figures × 500]

FIGURES 1–6. *Terscissus crassus.*

1. Holotype, RT–179V, slide 6, coordinates 90.0 × 16.9, 106μ × 186μ. The holotype shows the remnants of the three sectors, even though torn and incomplete.
2. Paratype, RT–179V, slide 8, coordinates 94.8 × 13.7, 98μ × 140μ.
3. Paratype, RT–179V, slide 10, coordinates 105.2 × 19.3, 101μ × 150μ. The narrow mushroom shape of the individual clavae is seen in the central part of the upper margin of the photograph.
4. Paratype, RT–179V, slide 10, coordinates 88.4 × 9.4, 127μ × 135μ. Note fusion at tips of two coarse clavae at right margin of photograph.
5. Paratype, RT–179V, slide 9 (single grain preparation), coordinates 105.0 × 12.0, 96μ × 138μ. This specimen and the specimen shown on fig. 3 demonstrate the tendency of some grains to form channels parallel to the colpi.
6. RT–179V, slide 6, coordinates 102.3 × 11.4, 129μ × 137μ. This segment is flattened and viewed from inside.



TERSCISSUS CRASSUS HOLOTYPE AND PARATYPES

PLATE 6

[All figures × 500]

FIGURES 1, 2. *Terscissus* sp. 1.

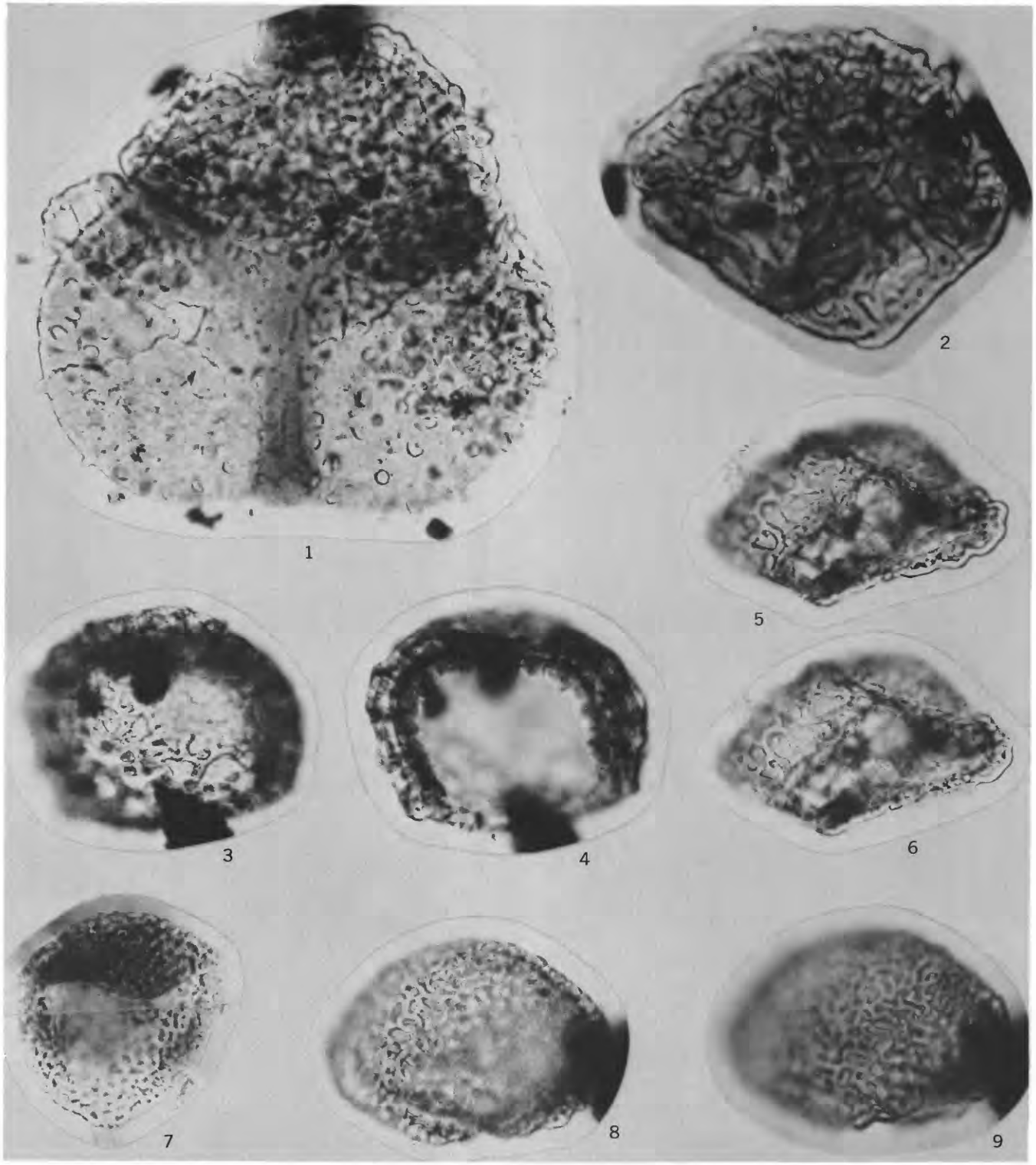
1. RT–180V, slide 1, coordinates 100.5 × 9.0, 180μ × 184μ. This is the only complete specimen of this species that was found. Note the pillarlike baculae supporting the reticulum (on left) and remnants of pillars on surface from which reticulum has been removed.
2. RT–180V, slide 2, coordinates 86.0 × 17.6, 101μ × 135μ. The nature of the reticulum is well shown on this isolated segment.

3–6. *Terscissus* sp. 2.

3. TS–230, slide 11, coordinates 108.0 × 11.7, 77μ × 98μ. Equatorial view of a segment showing coarse reticulum.
4. Same specimen as fig. 3. View of segment from the inside. Colpus margo with pillarlike baculae supporting reticulum is shown.
5. TS–230, slide 12, coordinates 111.2 × 12.8, 59μ × 104μ. Segment showing coarse reticulum, low focus.
6. Same specimen as fig. 5, high focus.

7–9. *Terscissus* sp. 3.

7. TS–200, slide 1, coordinates 109.9 × 22.9, 66μ × 74μ. Cupped segment with fine reticulum.
8. TS–200, slide 4, coordinates 113.5 × 8.3, 68μ × 76μ. Lateral view of segment with fine reticulum, low focus.
9. Same specimen as fig. 8, high focus.



RETICULATE SPECIES OF *TERSCISSUS*

PLATE 7

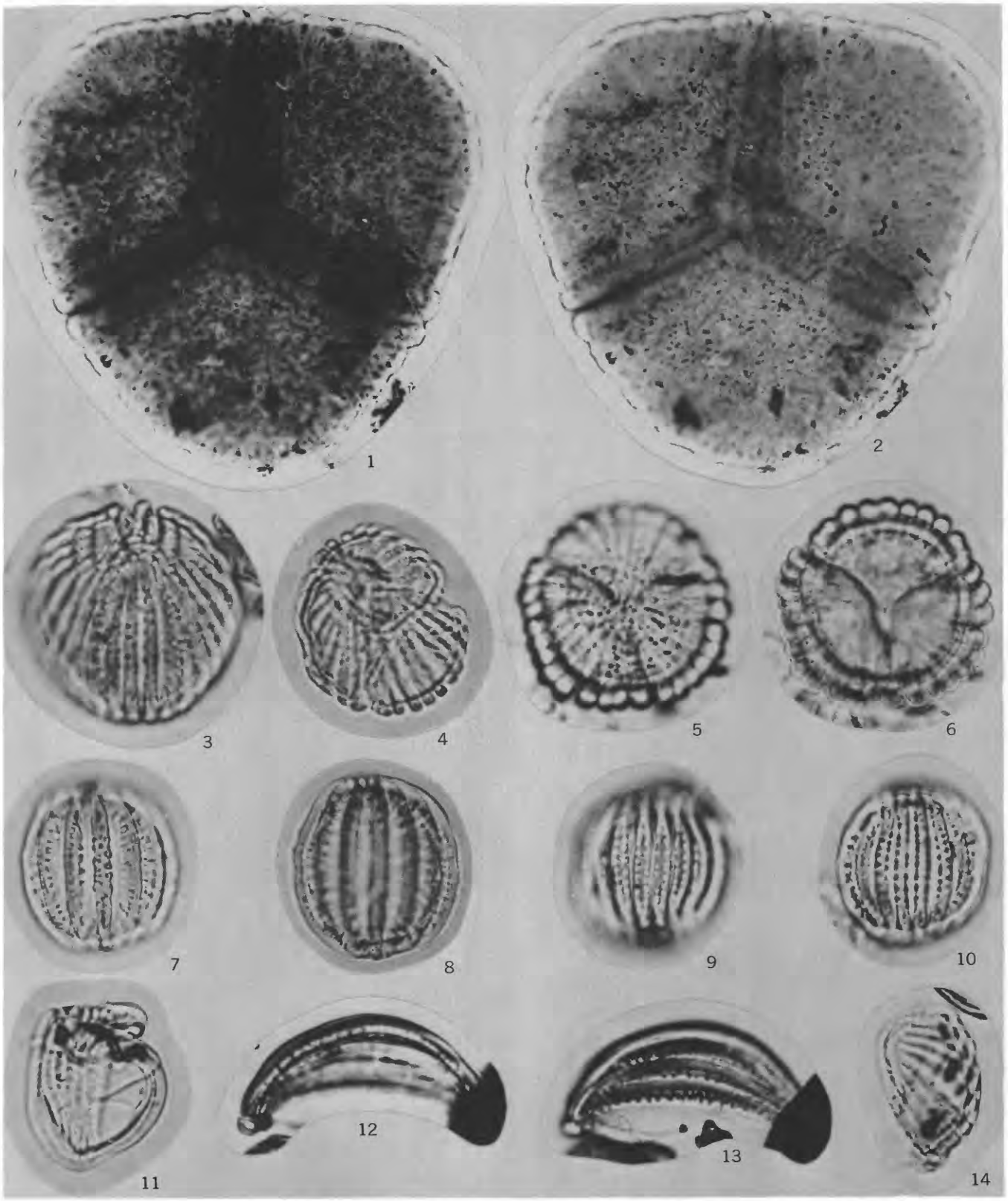
[Figures 1, 2 × 500; figures 3–11 and 14 × 1,000; figures 12 and 13 × 1,500]

FIGURES 1, 2. *Terscissus* sp. 4.

1. RT–179V, slide 13 (single grain preparation), coordinates 101.5 × 10.8, 163μ × 166μ.
2. Same specimen as fig. 1, taken with a red Wratten E–22 filter.

3–14. *Trisectoris costatus* n. gen. and sp.

3. Holotype, USGS paleobotany loc. D3001, slide 1, coordinates 83.3 × 7.6, 37μ × 39μ.
4. Paratype, USGS paleobotany loc. D3001, slide 3, coordinates 82.0 × 20.7, 31μ × 34μ.
5. Paratype, USGS paleobotany loc. D1867, slide 1, coordinates 96.5 × 18.8, 39μ × 41μ, high focus.
6. Same specimen as fig. 5, low focus.
7. Paratype, USGS paleobotany loc. D1967–A, slide 2, coordinates 92.7 × 2.4, 29μ × 33μ, isolated segment (1/3), high focus.
8. Paratype, same specimen as fig. 7, low focus.
9. Paratype, USGS paleobotany loc. D1864, slide 5, coordinates 76.4 × 4.5, 27μ × 28μ, isolated segment (1/3), high focus.
10. Same specimen as fig. 9, median focus.
11. USGS paleobotany loc. D3001, slide 3, coordinates 74.1 × 20.6, 25μ × 31μ. Segment showing circular rim adjacent to colpi and thin (torn) endexine.
12. USGS paleobotany loc. D3001, slide 1, coordinates 83.1 × 9.9, 33μ long. Broken segment showing baculae between endexine and costae, low focus.
13. Same specimen as fig. 12 showing projecting baculae below the costae.
14. USGS paleobotany loc. D3001, slide 1, coordinates 101.7 × 5.3, 20μ × 29μ. Segment (1/3) cupped in polar axis showing tapering of costae at the pole.



TERSCISSUS SPECIES 4 AND *TRISECTORIS COSTATUS* HOLOTYPE AND PARATYPES

PLATE 8

[All figures × 1,000]

FIGURES 1–6. *Trisectoris stoveri.*

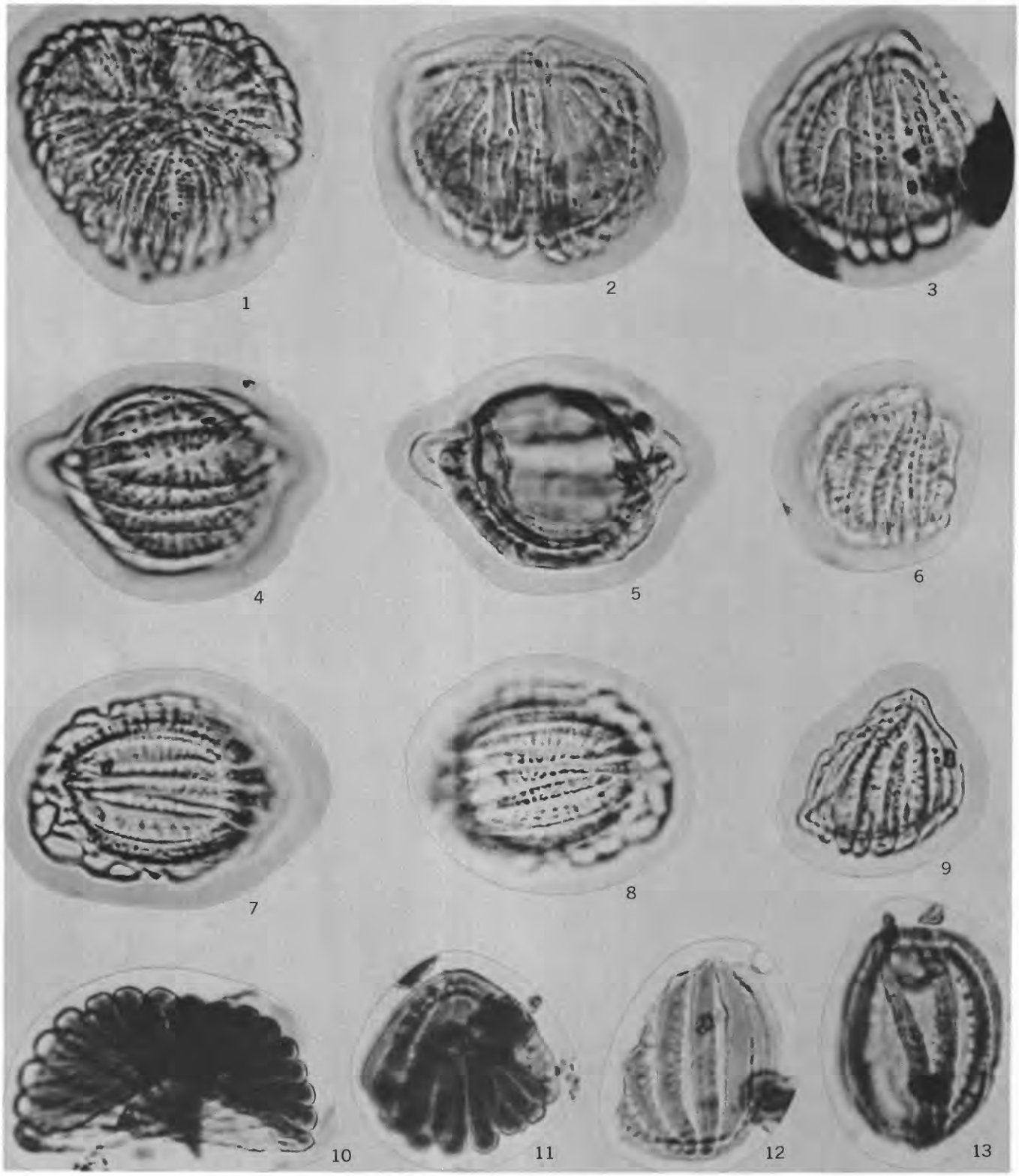
1. Holotype, USGS paleobotany loc. 11062–B, slide 2, coordinates 91.7 × 4.6, 46μ × 49μ.
2. Paratype, USGS paleobotany loc. D1322, slide 1, coordinates 95.9 × 17.4, 41μ × 47μ. Two joined segments (2/3).
3. Paratype, USGS paleobotany loc. D1322, slide 1, coordinates 101.1 × 14.3, 37μ × 41μ. One segment (1/3). In figs. 2 and 3 interrupted costae are seen.
4. USGS paleobotany loc. D1322, slide 3, coordinates 86.8 × 19.4, 33μ × 49μ, high focus.
5. Same specimen as fig. 4. Low focus showing annular ridge or costae adjacent to position of colpi.
6. USGS paleobotany loc. 11057, slide 2, coordinates 104.6 × 14.7, 29μ × 33μ.

7–9. *Trisectoris* sp. 1.

7. USGS paleobotany loc. 11056, slide 1, coordinates 85.2 × 17.1, 35μ × 44μ. Low focus of one segment (1/3). A species similar to *T. stoveri* but possessing a reticulate fringe along the colpi margins.
8. Same specimen as fig. 7, showing an interrupted costa and surface view of baculae.
9. USGS paleobotany loc. 11056, slide 1, coordinates 79.9 × 5.9, 31μ × 33μ. One segment cupped in polar axis. Reticulate fringe on this specimen not nearly so prominent as that seen on fig. 7.

10–13. *Trisectoris* sp. 2.

10. USGS paleobotany loc. D3910–C, slide 4, coordinates 79.9 × 8.5, 28μ × 52μ. Two segments (2/3).
11. USGS paleobotany loc. D3910–C, slide 1, coordinates 79.1 × 20.8, 33μ × 34μ. One segment cupped in the polar axis.
12. USGS paleobotany loc. D3910–C, slide 4, coordinates 110.0 × 4.7, 33μ × 37μ. Broken segment showing baculae below coarse costae.
13. USGS paleobotany loc. D3910–C, slide 1, coordinates 78.2 × 3.6, 28μ × 41μ. Distorted segment (1/3) showing annular costa adjacent to colpi and baculae suspended from costae.



TRISECTORIS STOVERI HOLOTYPE AND PARATYPES AND OTHER SPECIES OF *TRISECTORIS*

PLATE 9

[All figures × 1,000]

FIGURES 1–6. *Myocolpopollenites reticulatus* Elsik.

1. USGS paleobotany loc. D1846, slide 9, coordinates 80.7 × 20.7, 54μ × 44μ, equatorial view.
2. USGS paleobotany loc. D1846, slide 6, coordinates 91.4 × 6.7, diameter 49μ, polar view.
3. USGS paleobotany loc. D1846, slide 10, coordinates 86.6 × 18.8, 39μ × 49μ. Photographed with interference contrast to show reticulum relief.
4. USGS paleobotany loc. D3574–B, slide 2, coordinates 90.4 × 7.1, 43μ × 41μ. Interference contrast showing reticulum and margin of colpus.
5. USGS paleobotany loc. D1846, slide 11, coordinates 93.7 × 17.7, 34μ × 38μ. Segment (1/3), equatorial view.
6. Same specimen as fig. 5. View from inside showing thickness of wall including reticulum.

7–9. *Tricolpites* sp. 1.

7. Z–390V slide, coordinates 92.0 × 16.8, 32μ × 33μ.
8. Z–390V slide, coordinates 98.5 × 8.7, 43μ × 27μ. Two joined segments (2/3).
9. Z–390V slide, coordinates 95.8 × 1.5, 17μ × 20μ. Isolated segment (1/3).

10, 11, 14. *Tricolpites* sp. 2.

10. USGS paleobotany loc. D3000, slide T4, coordinates 86.2 × 8.2, 43μ × 46μ.
11. USGS paleobotany loc. D3000, slide T2, coordinates 91.1 × 12.2, 39μ × 41μ. Showing open colpi and margos.
14. USGS paleobotany loc. D3000, slide T5, coordinates 106.9 × 16.3, 36μ × 41μ. Note heavy margos.

12, 13. *Tricolpites* sp. 3.

12. USGS paleobotany loc. D3000, slide T2, coordinates 94.6 × 11.9, diameter 26μ.
13. Same specimen as fig. 12.

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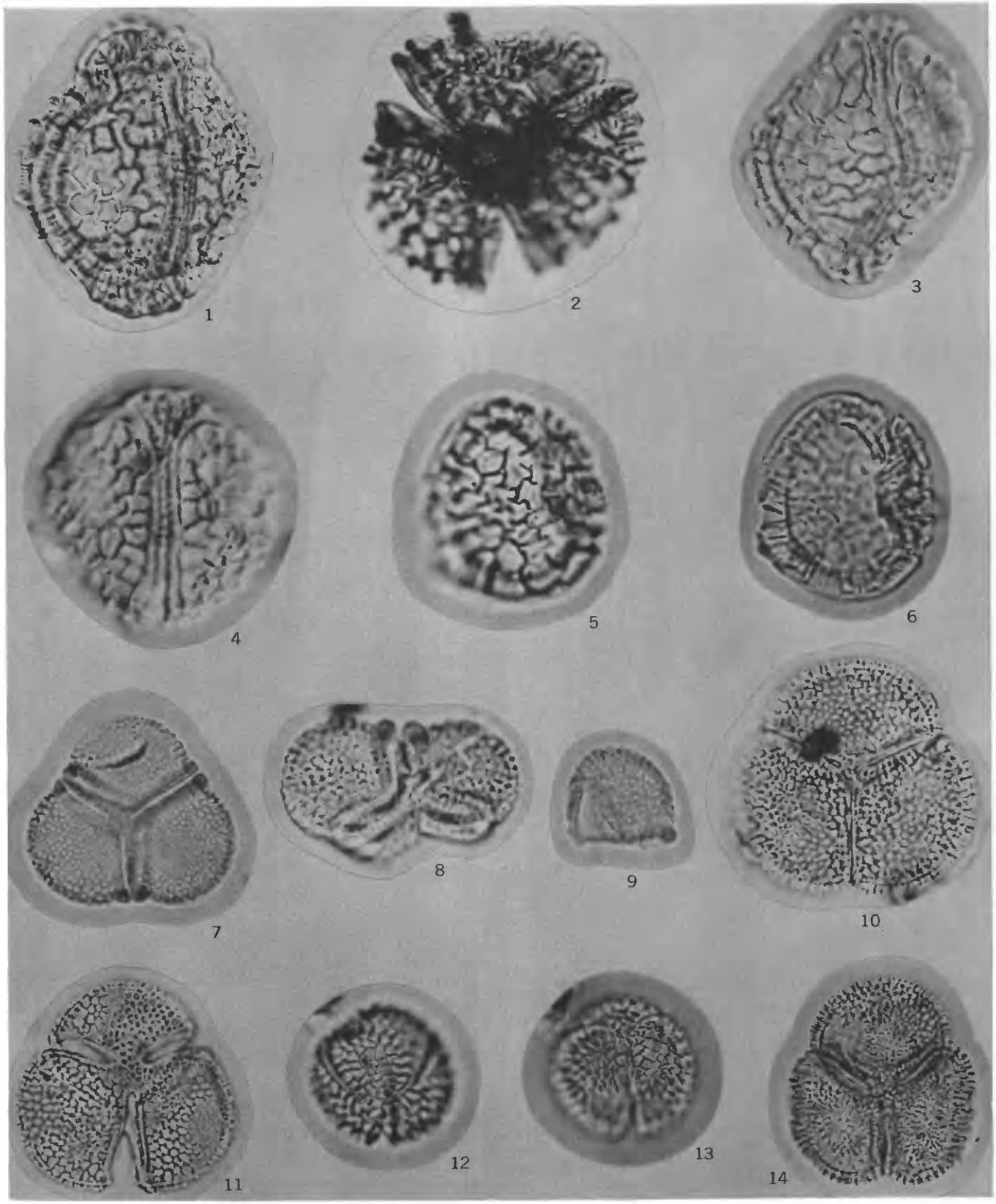

MYOCOLPOPOLLENITES AND *TRICOLPITES*