Stratigraphic Distribution of Species of the Megaspore Genus *Minerisporites* in North America

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By ROBERT H. TSCHUDY

CONTRIBUTIONS TO PALEONTOLOGY

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Taxonomy, stratigraphic ranges, and facies significance of Minerisporites *megaspores*

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By Robert H. Tschudy

ABSTRACT

Five species of megaspores assignable to the genus *Minerisporites* were found in samples from the Rocky Mountain region of the United States. One of these species had been reported previously from Alberta, Canada, and one from Montana. Of the three species previously unreported from North America, one is a new combination, and two are proposed as new species. These megaspores range in age from Albian to Paleocene. The stratigraphic ranges of all species of the genus reported from North America are also provided. A discussion of the significance of megaspores and their facies representation is presented.

NEW SPECIES OF MINERISPORITES

Two new megaspore species assignable to the genus *Minerisporites* were found in Paleocene and Cretaceous rocks of the Rocky Mountain region of the United States. A third species, previously unreported from North America, was found in Paleocene rocks of Montana. This species, previously reported from the Paleocene of the Netherlands by Dijkstra (1961) as *Triletes mirabilis* forma *glossoferus* and later transferred to the genus *Minerisporites* by Potonié (1966), is herein designated as a new combination—*Minerisporites glossoferus.* These three species are described and illustrated in the present report.

A fourth species, which I consider to be conspecific with *Minerisporites mirabilis* (Miner) Pot. and which was previously reported by Miner (1935) from Montana, was also found, as were specimens of *Minerisporites pseudorichardsonii*[1] Gunther and Hills and of three unnamed new species.

The discovery of numerous specimens of three species new to North America of one megaspore genus was somewhat surprising in view of the apparent rarity of megaspores suggested by the scarce reports in the literature. Previous to the present work only 11 species of *Minerisporites* had been reported from North America. That this apparent rarity is probably more illusory than true will be discussed in the following section.

[1]Original spelling *pseudorichardsoni.* See recommendation 73c, International code of botanical nomenclature, p. 61 (Lanjouw and others, 1966).

STRATIGRAPHIC DISTRIBUTION

The stratigraphic distribution of all species of *Minerisporites* reported from North America is shown in figure 1.

Minerisporites mirabilis (al. *Selaginellites mirabilis*), the type of the genus, was reported by Miner (1935) from the Paleocene of Montana. I found specimens that I consider to be conspecific with *Minerisporites mirabilis* in the Paleocene of Wyoming. Hall (1963) reported the presence of *M. mirabilis* in the Dakota Formation (Cenomanian) of Iowa, Hall and Peake (1968) reported *M. mirabilis* in the Windrow Formation of Minnesota (Cenomanian), and Agasie (1969) found specimens that he assigned to *M. mirabilis* in the Dakota Formation (Cenomanian) of Arizona. The specimen figured by Agasie is probably a specimen assignable to *M. dissimilis*, n. sp., as herein proposed. Hall's specimen may belong to the same species, but his figure, photographed by reflected light, does not show the detail necessary to allow one to be sure of such a designation. The specimen figured by Hall and Peake is not conspecific with *M. mirabilis.*

Elsik (Stover and others, 1966) reported a form similar to *Minerisporites mirabilis* from the upper part of the Paleocene (or lower Eocene) of Texas. He named this fossil *Minerisporites mirabiloides.* Elsik proposed this species on the basis of five specimens, none of which appears to be complete (and unbroken).

Miner (1932) described the species *Minerisporites borealis* under the genus *Selaginellites borealis* from the Upper Cretaceous rocks of Greenland. Singh (1964, 1971) found three species of *Minerisporites* from the Albian of Canada—*M. macroreticulatus, M. marginatus,* and *M. venustus.* The species *M. macroreticulatus,* and *M. venustus* were new; *M.marginatus* had previously been reported from Upper Jurassic and Lower Cretaceous localities in Europe and Australia. (See table 1.)

The work of Gunther and Hills (1972 is particularly significant because they found seven species of *Minerisporites* in the Brazeau Formation of Alberta, Canada. This formation ranges in age from middle Campanian through middle Maestrichtian. Two of the species, *M.*

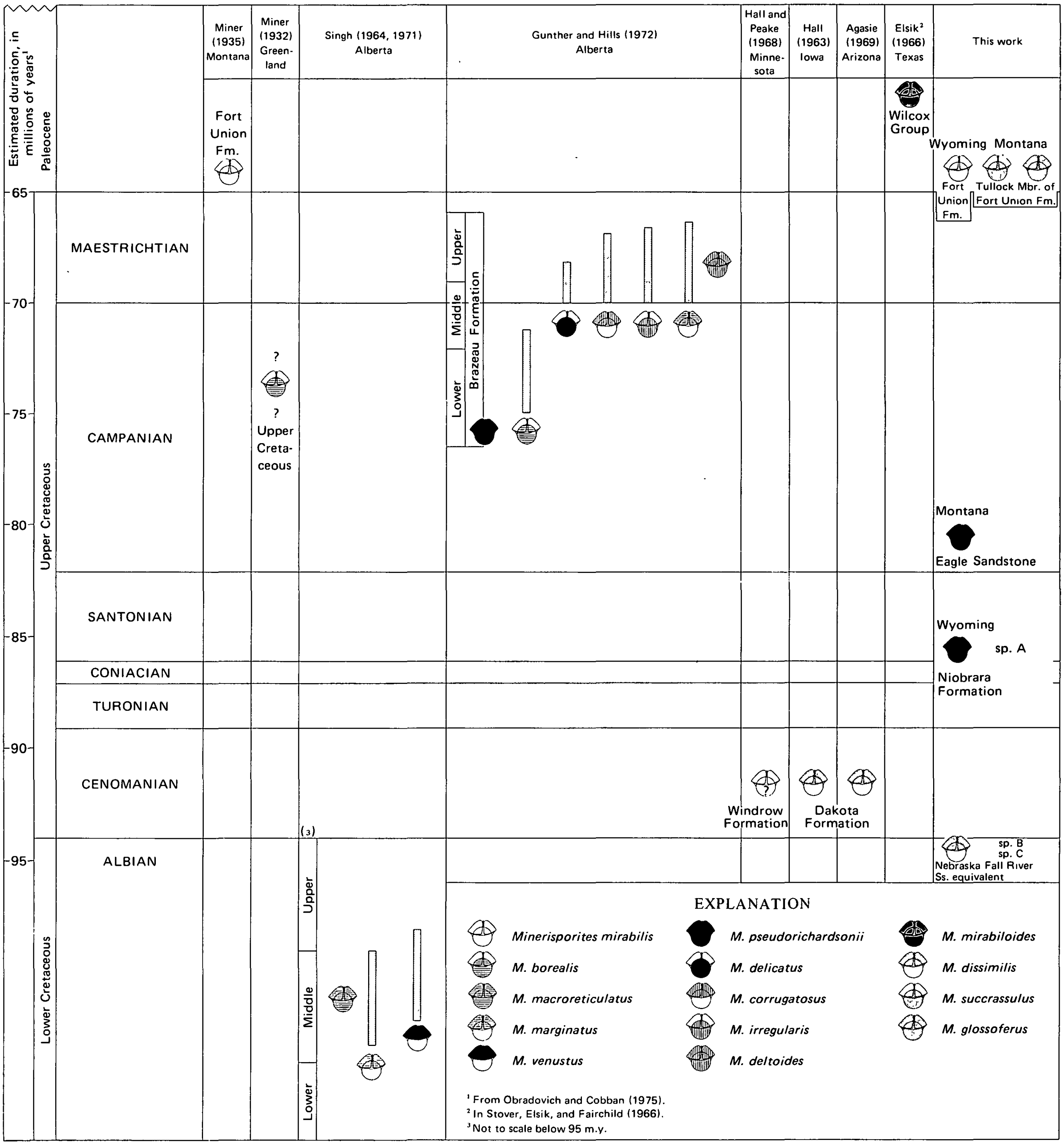

FIGURE 1.—Stratigraphic distribution of species of *Minerisporites* reported from North America, including Greenland.

borealis and *M. marginatus*, had been reported previously. They considered the species *M. pseudorichardsonii*, *M. delicatus*, *M. corrugatosus*, *M. irregularis*, and *M. deltoides* to be new.

In addition to the species *Minerisporites mirabilis* mentioned earlier, I have found specimens in the Paleocene of Montana which I consider to be conspecific with Dijkstra's (1961) forma *glossoferus* and have altered

TABLE 1.—*Species of* Minerisporites *reported from localities outside of North America*

Species	Country	Age	Reported by
Minerisporites mirabilis (al. *Triletes mirabilis* Dijkstra, 1961) Pot., 1966.	The Netherlands	Paleocene	Dijkstra (1961).
M. mirabilis forma *glossoferus* (al. *Triletes mirabilis* forma *glossoferus* Dijkstra, 1961) Pot., 1966.	...do	...do	Do.
M. mirabilissimus (al. *Triletes mirabilissimus* Dijkstra, 1961) Pot., 1966.	Belgium	...do	Do.
M. marginatus (Dijkstra, 1951) Pot., 1956.	The Netherlands	Wealden (Early Cretaceous)	Dijkstra (1951).
	England	...do	Batten (1969).
	Denmark	Late Jurassic	Gry (1969).
	England	Late Jurassic, Early Cretaceous.	Hughes (1958).
	Australia	Early Cretaceous (probably Albian).	Cookson and Dettmann (1958).
	Belgium	Wealden (Early Cretaceous)	Delcourt and Sprumont (1955).
M. richardsonii (Murray, 1939) Pot., 1956.	England	Middle Jurassic	Murray (1939).
M. alius Batten, 1969	...do	Wealden (Early Cretaceous)	Batten (1969).
M. volucris Marcinkiewicz, 1960	Poland	Jurassic	Marcinkiewicz (1960).
	Denmark	...do	Gry (1969).
M. institus Marcinkiewicz, 1960	Poland	...do	Marcinkiewicz (1960).
M. gryensis (al. *Triletes gryensis*) Dijkstra, 1959 (not transferred).[1]	The Netherlands	Wealden (Early Cretaceous)	Dijkstra (1959).

[1]Original description indicates that *Triletes gryensis* should be transferred to *Minerisporites gryensis*. However, the photograph of the type does not show enough detail to permit transfer without examination of the original specimens.

the designation to *Minerisporites glossoferus*, n. comb. (See section entitled "Systematics.") In addition, I found specimens assignable to the proposed new species *M. sucrassulus* and *M. dissimilis*—the former from the Paleocene of Montana, and the latter from the Albian of Nebraska. I found specimens identical with the species *M. pseudorichardsonii,* named by Gunther and Hills (1972) from the Brazeau Formation of Canada, in the Eagle Sandstone (lower Campanian) of Montana and in the Niobrara Formation (Santonian-Coniacian) of Wyoming. Two new unnamed species were found in the Fall River Sandstone equivalent of Nebraska (upper Albian), and one new unnamed species was found in the Niobrara Formation of Wyoming (Santonian-Coniacian).

A literature search of the 17 species of *Minerisporites* included in the genus prior to the present work revealed that 11 had been found in samples from North American rocks. Species reported from other regions of the world are listed in table 1.

Of the species listed in table 1, only *Minerisporites mirabilis* and *M. marginatus* have heretofore been mentioned from North America. The present work adds the species *M. glossoferus,* n. comb., to that list. The remaining species are from European Jurassic or Lower Cretaceous rocks. Rocks (particularly those of Jurassic age) that are likely to yield magaspores because of their nonmarine nonoxidized carbonaceous characteristics are uncommon in North America and, therefore, have not been examined for megaspores. Also, Lower Cretaceous rocks, and, to a lesser degree, Upper Cretaceous rocks form North America have not been routinely examined for the presence of megaspores.

SIGNIFICANCE OF MEGASPORES

I am convinced that once megaspores have been routinely searched for in continental Mesozoic rocks they, and the smaller palynomorphs accompanying them, will provide for the stratigraphic subdivision of nonmarine rocks as effectively as ammonites and baculites now serve to subdivide marine-rock sequences. The stratigraphic utility of megaspores is already well established for the Paleozoic (Zerndt, 1930, 1937, 1938; Dijkstra and Vierssen Trip, 1946; Dijkstra, 1952, 1955, 1957; Winslow, 1959; Chaloner, 1959; and many other authors). Present knowledge of megaspores from Mesozoic rocks suggests that these fossils will become as stratigraphically valuable as those from the Paleozoic.

Representatives of the genus *Minerisporites* have been found sporadically throughout the Jurassic, Cretaceous, and Paleocene. Present knowledge of species belonging to this genus strongly suggests that most of the species have a comparatively short stratigraphic range. Admittedly, much more work is required to delineate the geographic and stratigraphic ranges of species of *Minerisporites* in particular and of megaspores in general. The facts that

Gunther and Hills (1972) found seven species of *Minerisporites* in the Brazeau Formation of Canada, that Singh (1964, 1971) found three species in the Albian of Canada, and that I found five species (plus three unnamed species) during the present study suggest that the presence of megaspores in nonmarine Cretaceous and Paleocene deposits is much more common than published reports indicate. Also pertinent is the suggestion that more megaspores would be found if assiduously sought.

The potential stratigraphic usefulness of megaspores in general is brought sharply into focus by the work of Gunther and Hills (1972). They found 15 genera and 33 species of megaspores in a series of samples from a single formation—the Brazeau Formation of Alberta, Canada. A compilation of the more important reports dealing with megaspore assemblages is presented chronologically in table 2. The data presented indicate clearly that megaspores are significant fossils.

In addition to the reports listed in table 2, there are several papers by various authors dealing with only one or two species rather than assemblages of megaspores.

TABLE 2.—*Important megaspore assemblages.*

Author and year	Number of genera	Number of species	Remarks
Miner, 1932	1	8	All species have been transferred from the genus *Selaginellites* to other, more appropriate genera.
Harris, 1935	2	22	All species but one were listed under the genus *Triletes*. Most have since been transferred to more appropriate, but less inclusive, genera.
Murray, 1939	1	5	All included in the genus *Triletes*. (See above.)
Mädler, 1955	2	8	Included two species of *Azolla* and six species ot *Thomsonia* (now *Paxillitriletes*).
Vangerow, 1954	1	12	All assigned to the genus *Triletes*. (See above.)
Cookson and Dettmann, 1958	3	6	
Jung, 1960	6	10	
Marcinkiewicz, 1960	11	18	
Dettmann, 1961	5	7	
Dijkstra, 1961	2	6	Two species assigned to the genus *Azolla*, four to the genus *Triletes*.
Marcinkiewicz, 1962	14	25	
Hall, 1963	5	5	
Singh, 1964	10	19	
Kondinskaya, 1966	2	7	
Binda and Srivastava, 1968	5	9	Silicified megaspores.
Hall and Peake, 1968	7	6	
Batten, 1969	3	6	
Gry, 1969	12	16	
Jain and Hall, 1969	3	7	Five species of *Azolla*.
Snead, 1969	2	10	Nine species of *Azolla*.
Jain, 1971	3	4	Two species of *Azolla*.
Kempf, 1971	5	5	
Singh, 1971	7	10	
Gunther and Hills, 1972	15	33	
Bergad, 1973	2	7	Six species of *Balmeisporites*.

FACIES REPRESENTATION

Megaspores of the genus *Minerisporites* are found in continental deposits often interpreted as deltaic. They probably grew within, or adjacent to, freshwater lakes or ponds, sometimes within a delta. This inference is derived from the fact that most reports dealing with the genus *Minerisporites* include mention of other taxa whose ecological tolerances are known. These associated fossil genera include *Azolla, Molaspora, Ariadnaesporites, Balmeisporites, Salvinia,* and *Arcellites*. These genera are all considered to be related to the water ferns, whose habitat is freshwater lakes or ponds. The fossil megaspore species of the modern water fern *Azolla* commonly accompany megaspores of *Minerisporites,* particularly in Campanian and younger rocks. Fossil *Azolla* is not known from pre-Campanian rocks (Hall, 1969). Modern *Azolla* grows in freshwater ponds or lakes. In the older part of the stratigraphic column, particularly in Cenomanian and Albian rocks, specimens of *Minerisporites* are commonly accompanied by specimens of *Arcellites*. A freshwater aquatic habitat has been suggested for *Arcellites* by Dijkstra (1951), Hughes (1955), Cookson and Dettmann (1958), and Ellis and Tschudy (1964). *Arcellites* is very probably closely related to the Hydropteridae, or water ferns, and very possibly to the family Marsiliaceae.

In the present work *Azolla* specimens were found in all of the *Minerisporites*-bearing samples from the Paleocene and in the sample from the Eagle Sandstone (Campanian).

The species *Minerisporites dissimilis,* from the upper part of the Lower Cretaceous, was accompanied by specimens of *Arcellites disciformis*.

It is uncommon to find *Minerisporites* in rocks that yield dinoflagellates, hystrichospheres, or other fossils indicative of marine deposition (Wall and others, 1971). In general, when found, very few marine specimens are present in the preparation, suggesting a very slight marine influence at the time of deposition. Such slight marine influence could have occurred in a deltaic depositional site. I have never found megaspores of *Minerisporites,* nor have I seen reports of *Minerisporites* known to have been *in situ* from rocks deposited in a strictly marine environment.

The large size of the megaspores, always accompanied by abundant small spores or pollen grains, plus the fact that they are commonly found in coals or highly organic shales or siltstones, is further evidence for a low-energy depositional environment, such as might be found in freshwater lakes, swamps, or ponds.

SYSTEMATICS

Fossil megaspores of the type included in the genus *Minerisporites* were first reported by Miner (1932) under the appellation of *Selaginellites borealis.* Later, Miner (1935) described a new species and named it *Selaginellites mirabilis.* Potonié (1956) considered that it is inappropriate to include spores in the organ genus *Selaginellites,* previously erected to accommodate vegetative organs similar in structure to those of modern *Selaginella.* He strengthened his argument by pointing out that the spores discussed by Miner had not been found in organic union in fructifications of *Selaginellites.* He then proposed the genus *Minerisporites* to accommodate these distinctive dispersed megaspores.

Genus MINERISPORITES Potonié, 1956

1935 *Selaginellites mirabilis* Miner, Am. Midland Naturalist, v. 16, p. 618, pl. 23, figs. 1-6.

1956 *Minerisporites mirabilis* (Miner) Potonié, Beih. Geol. Jahrb., v. 23, p. 67, pl. 9, figs. 87, 88.

Type species.—Minerisporites mirabilis (Miner) Pot., 1956.

Lectotype.—Plate 23, fig. 1 of Miner, 1935. Designated by Potonié, 1956.

Diagnosis.—(translated from Potonié, 1956, p. 67). Holotype (including zona) 534 u; trilete megaspores, the equatorial outline of the central body subtriangular to almost circular (not or only weakly inclined toward triangular); in the genotype the outline becomes more triangular through the elongation of the tecta into projecting points at the juncture of the zona, the remainder of the zona being narrower. Y mark extends about to the zona, tecta sometimes strongly erect and having flap, sheet, or board form; meridional outline of the spore body semicircular to circular, from which the erect high tecta towers above. The genotype shows a reticulum with vesicular lumina, and the muri are arched similar to those of the carboniferous species *Triangulatisporites regalis* that we have placed in the Selaginellales.

Minerisporites (al. Selaginellites) mirabilis Miner, 1935
Am. Midland Naturalist v. 16, p. 618, pl. 23, figs. 1-6

Diagnosis.—(from Miner, 1935) "Body of exine round, 332-498 in diameter, the average being 395 μ ; exine covered with irregular reticulate ridges which extend up part way on the wings; triradiate markings extend beyond the periphery; diameter on the radii of the triradiate markings 430-630 μ ; triradiate markings winged, wings 67-150 μ in width, the average being about 90 μ ; equatorial ring present. Bear Creek, Carbon County, Montana; Fort Union Formation."

Discussion.—Dijkstra (1961) found megaspores conspecific with Miner's (1935) *Selaginellites mirabilis* in the Paleocene of the Netherlands. He said (1961, p. 6), "Both descriptions [Dijkstra's and Miner's] have so many points of similarity that it is clear that both spores are identical." Dijkstra included his spores under the name of *Triletes mirabilis* (Miner) S. W. and B. Dijkstra (1961) proposed the new species *Triletes mirabilissimus* for spores significantly larger (630-820 μ m) than, but otherwise identical to, his *Triletes mirabilis.* These species were transferred to *Minerisporites* by Potonie (1966). I do not consider this size distinction of species significant, as his size dimensions overlap. Dijkstra at the same time proposed the new subspecies *Triletes mirabilis* forma *glossoferus,* forma nov. I have found specimens conformable to the figures and descriptions of *Minerisporites mirabilis* (Miner) Pot. from the Paleocene of Wyoming (pl. 1, figs. 1, 2). I have also found specimens apparently identical to the descriptions and figures of Dijkstra's *Triletes mirabilis* forma *glossoferus.* I consider these to constitute a distinct species, which will be discussed later.

Three additional reports of the species *Minerisporites mirabilis* are those of Hall (1963) from the Dakota Formation of Iowa (Cenomanian), Hall and Peake (1968) from the Windrow Formation of Minnesota (Cenomanian), and Agasie (1969) from the Dakota Formation of Arizona (Cenomanian).

The photograph presented by Agasie (1969) shows a specimen attributed to *Minerisporites mirabilis* whose acrolamellae appear to be more delicate than is characteristic of those of *M. mirabilis* and more closely approaching the appearance of the acrolamellae of *M. dissimilis,* n. sp., which is found in strata of a slightly older age. Hall (1963) presented a single photograph (reflected light) and no description of his Iowa specimen. The reflected light photograph does not show sufficient detail in the vicinity of the laesurae to permit this specimen to be clearly distinguished from *Minerisporites dissimilis*, n. sp., discussed later. One of the prominent characteristics of *M. mirabilis* is the presence of a singularly massive or robust acrolamella. This feature is clearly evident on Miner's (1935) specimens, on those figured by Dijkstra (1961), and on those here illustrated on plate 1, figures 1 and 2. It would be somewhat surprising to find the species *M. mirabilis* in Cenomanian rocks, then a great hiatus in the record throughout the remainder of the Cretaceous, followed by a reappearance in the Paleocene rocks of both Europe and North America. I think it probable that the specimens mentioned by both Agasie (1969) and Hall (1963) are specimens of *Minerisporites dissimilis.*

The specimen photographed by Hall and Peake (1968) from the Windrow Formation of Minnesota is problematical. It does not show the characteristics of *Minerisporites mirabilis* nor those of *M. dissimilis.* It may represent an abnormally smooth specimen of *M. dissimilis.*

Minerisporites glossoferus (Dijkstra), n. comb.
Plate 1, figures 3-9

1961 *Triletes mirabilis* forma *glossoferus* Dijkstra. Mem. Geol. Foundation. The Netherlands, New Series No. 13, p. 6, pl. 1, figs. 6-8; holotype figs. 7a, 7b.
1966 *Minerisporites mirabilis* forma *glossoferus* Potonié, Beih. Geol. Jahrb. v. 72, p. 95.

Dijkstra (1961 p. 6) distinguished this form from *M. mirabilis* as follows: "From *T. mirabilis* can be distinguished the form *glossoferus* of which a few bars on the distal area have been merged into 100-120 long tongue shaped protuberances. Dimensions and other ornaments of forma *glossoferus* are similar to those of *T. mirabilis.*"

Description.—Trilete megaspores; both equatorial and polar outline of central body circular, outline of entire spore triangular in polar view, owing to extensions of auriculae of zona opposite the laesurae; acrolamellae extending on to the zona, acrolamellae high, membranous at their outer margins, and shorter at the juncture of the laesurae, thereby developing a notch characteristic of other members of the genus. Exine granular, 6-12 μm thick exclusive of sculpture; sculpture consisting of an irregular reticulum, the lumina elongated in the polar direction. Muri 4-8 μm wide, of irregular height; some parts of muri, particularly on the distal surface, extend into tongue-shaped proturberances as much as 120 μm long.

Size ranges based on the measurement of 20 specimens.
Measurements are minima and maxima, () indicates average.
Total equatorial diameter including zona:
Polar view 480(530)584 μm.
Equatorial view 496(522)592 μm.
Diameter of central body 376(396)448 μm.
Width of acrolamellae, polar view 40(62)80 μm.
Height of acrolamellae, equatorial view 72(86)104 μm.
Width of zona alternate to laesurae 20(33)40 μm.
Width of zona (auriculae) opposite laesurae 100(132)160 μm.
Dimensions of lumina 24(34)40×40(59)80 μm.
Protuberances 40(60)120 μm long.

Stratigraphic Distribution.—Paleocene of the Netherlands; Paleocene Tullock Member, Fort Union Formation of Montana, about 86 feet (26.2 m) above the base of the formation.

Remarks.—*Minerisporites glossoferus* is easily distinguished from *M. mirabilis* by the type of surface ornamentation. *M. mirabilis* possesses low muri and more or less circular lumina of approximately uniform size in contrast to *M. glossoferus* which has high irregular muri with projections and irregular lumina elongated parallel to the polar axis. More than 200 specimens of this species were found.

Minerisporites dissimilis, n. sp.
Plate 2, figures 1-6

Type specimens designated on plate explanations.

Diagnosis.—Trilete megaspore, outline of central body circular; in polar view outline of spores rounded triangular to circular; acrolamellae prominent, but thin and membranous with faint striations or incipient reticulations at the bases; acrolamellae characteristically notched at juncture of laesurae and extend on to the narrow zona. Zona narrow, but becomes wider opposite the laesurae by the development of slight auriculae. Exine thin, about 25 μm including sculpture, two-layered, inner layer 2-4 μm thick, outer about 20 μm thick, with irregular reticulate sculpture. Individual reticulations compound—that is, a large lumina with prominent bounding muri surround several secondary smaller lumina with very low muri.

Size range based on the measurement of 40 specimens.
Diameter including zona 408(631)800 μm.
Width of acrolamellae, polar view 16(20)24 μm.
Width of zona alternate to laesurae 10(18)32 μm.
Width of zona (auriculae) opposite laesurae 40(73)104 μm.
Major lumina up to 160 μm, minor 48-56 μm.
Muri 2-8 μm thick (wide).

Remarks.—This species is distinguished from *M. mirabilis* principally by the possession of much narrower acrolamellae. In *M. mirabilis* the acrolamella is heavy and forms a thick heavy boss on the proximal side as much as 100 μm wide. In *M. dissimilis* the width of the acrolamellae averages only 20 μm. The surface ornamentation is also different, and *M dissimilis* has a significantly different stratigraphic occurrence.

Stratigraphic distribution.—Lower Cretaceous Fall River Sandstone equivalent, Sioux County, Nebr., 10 feet (3.05 m) below top of the formation. Probably, the specimens reported by Agasie (1969) and Hall (1963) from the Upper Cretaceous Dakota Formation of Arizona and Iowa, respectively, should also be included here.

Minerisporites succrassulus, n. sp.

Plate 3, figures 1-9

Type specimens designated on plate explanations.

Diagnosis.—Trilete megaspores; outline of central body circular in both equatorial and polar views; acrolamellae prominent, thick, unornamented; characteristically notched at juncture of the laesurae. Acrolamellae extend onto the zona forming prominent auriculae, thereby producing a triangular or rounded triangular spore outline in polar view; zona narrower in interlaesural areas. Exine about 20 μm thick, in distal area provided with a few prominent blunt thickenings or protuberances that may attain a length of as much as 80 μm.

Size range based on measurement of 20 specimens. More than 150 specimens found.

Diameter (not including auriculae), polar view 304(339)360 μm.
Diameter (not including auriculae), equatorial view 240(321)400 μm.
Diameter including auriculae, polar view 376(445)472 μm.
Width of acrolamellae 32(39)48 μm.
Height of acrolamellae 72(87)96 μm.
Width of zona (alternate to laesurae) 20(25)32 μm.
Auriculae 72(107)130 μm.

Stratigraphic distribution.—Paleocene, lower part of Tullock Member, Fort Union Formation in samples D4742-E and D4724-C.

Remarks.—This species of *Minerisporites* is devoid of evidence of reticulation, such as is characteristic of the type species. In all other respects the species conforms to the genus. Singh (1964) proposed the new species *Minerisporites venustus.* This species possessed (1964, p. 159) "some indication of a small-meshed reticulation * * * no sign of reticulation on most specimens." Rather than propose a new genus to include nonreticulate forms, I have included the species *succrassulus* in the genus *Minerisporites.* I believe it to be closely related to other species of *Minerisporites.* The double-walled structure of the acrolamellae (one wall on either side of the proximal aperture) is shown clearly on plate 3, figure 4.

Minerisporites pseudorichardsonii Gunther and Hills (1972)

Plate 4, figures 1-6

Description.—(From Gunther and Hills, 1972) "Trilete megaspore; equatorial outline of the spore triangular; zona (or cingulum) on the equator, widest at the apice; prominent triradiate lamellae on the trilete laesurae, extend to the outer margin of the zona; exine relatively thick and with a reticulate ornament on both proximal and distal surfaces, short spine-like projections often found at the junction of the muri; both triradiate lamellae and zona are striated in a direction perpendicular to the spore body.

Dimensions.—Equatorial diameter

of spore body	390(448)519μ
Holotype	510μ
Radial width of zona	30(60)105μ
Interradial width of zona	12μ
Width of triradiate lamellae	12(14)15μ
Height of triradiate lamellae	90(102)135μ
Lumen diameter	12(18)21μ

(10 specimens)."

Remarks.—The specimens found in our material conform to the description provided and to the photograph of the holotype. The equatorial view presented by some of our specimens clearly demonstrates the presence of a reticulum on the acrolamellae (pl. 4, figs. 1-3). The lumina are somewhat elongate in the polar direction, particularly as the outer extremities of the acrolamellae are approached. A polar view, such as that presented in the photograph of the holotype, shows these reticulations as striae. Shrunken specimens show the short projections at the junctures of the muri to good advantage.

Stratigraphic distribution.—Lower part of the Belly River Formation equivalent in Alberta, middle Campanian. Eagle Sandstone of Montana, lower Campanian, and upper part of Niobrara Formation of Wyoming, Santonian-Coniacian.

Minerisporites sp. A

Plate 4, figures 7-9

Too few specimens (nine, only four of which showed characteristics to good advantage) were found adequately to circumscribe this species. A brief provisional description follows.

Description.—Trilete megaspores; outline of central body circular in polar view, circular to oval in equatorial view; acrolamellae prominent, membranous and extend to the outer margin of the thin membranous zona; zona on the proximal hemisphere, auriculae developed on zona opposite the laesurae; exine thin, about 3 μm thick, commonly wrinkled; surface internally granulate with no evidence of surface reticulation.

Diameter of central body 224(294)360 μm

TABLE 3.—*Fossil megaspore localities*

USGS paleobotany loc. Nos.	Locality	Formation and age
D3159-A	NW¼NW¼ sec. 17, T. 19 N., R. 77 W. (Bengough Hill quadrangle), Carbon County, Wyo.	Hanna Formation, Paleocene.
D3625-F	Road section SE. of Poplar, NE¼ sec. 4, T. 26 N., R. 52 E., Richland County, Mont.	Tullock Member of the Fort Union Formation, Paleocene.
D3718-F	Section measured in tilted fault block in the NW¼NW¼ sec. 13, T. 22 N., R. 17 E., Fergus County, Mont.	Eagle Sandstone, Campanian.
D4724-C	Sec. 33, T. 15 N., R. 56 E., from basal Tullock immediately above the Hell Creek Formation Dawson County, Mont. (Collected by D.A. Russell.)	Tullock Member of the Fort Union Formation, Paleocene.
D4742-E	NW¼ corner sec. 18, T. 15 N., R. 56 E., from immediately above the Hell Creek Formation in the basal Tullock, Dawson County, Mont.	Tullock Member of the Fort Union Formation, Paleocene.
D4766	1,000 ft (305 m) E. of W. line, 2,750 ft (840 m) S. of N. line of sec. 23, T. 45 N., R. 114 W., Teton County, Wyo.	Niobrara Formation equivalent, Santonian-Coniacian.
Tschudy loc. No. RT-194.	California Co. Mann 1 well, SE¼ NE¼NW¼ sec. 27, T. 30 N., R. 56 W., Sioux County, Nebr. Sample from 4,686 ft (1,428 m) depth, Fall River Sandstone equivalent, 10 ft (3.05 m) below top of formation.	Fall River Sandstone equivalent, Albian.

Height of acrolamellae 74(90)109 μm

Width of zona (auriculae) opposite laesurae 56(79)136 μm

Width of zona alternate to laesurae 40(59)70 μm

Remarks.—These specimens bear some resemblance to specimens of *M. venustus* Singh. They differ in being slightly smaller, in possessing much larger, more prominent acrolamellae and zonal membranes, and possessing membranous auriculae in the zona opposite the laesurae.

Stratigraphic Distribution.—Upper part of Niobrara Formation of Wyoming, Santonian-Coniacian.

Minerisporites sp. B
Plate 4, figures 10–11

Too few specimens (five) were found to adequately circumscribe this species; hence, only a brief description is here presented.

Description.—(incomplete) Trilete megaspores; equatorial outline of central body circular; outline of spore including prominent auriculae triangular; acrolamellae thin, membranous, about 50 μm high, extending onto the arcuate lamellae; arcuate lamallae narrow in interlaesural areas, as much as 100 μm wide opposite laesurae. Wall thin, surface having delicate, low reticulum, muri narrow, lumina 10–20 μm in diameter.

Diameter of central body 200–300 μm

Diameter of spore including auricula 320–400 μm

Stratigraphic distribution.—Fall River Sandstone equivalent of Nebraska, upper Albian.

Minerisporites sp. C
Plate 4, figure 12

Only one specimen observed.

Description.—(incomplete) Trilete megaspore; equatorial outline rounded triangular in polar view; central body also rounded triangular; arcuate lamallae widest in interlaesural areas (60 μm); acrolamellae about 30 μm wide and 50 μm high extending onto the arcuate lamellae. Wall thin, surface prominently and irregularly rugulate. Diameter of central body about 500 μm; diameter of spore about 600 μm.

Stratigraphic distribution.—Fall River Sandstone equivalent, upper Albian.

METHODS

The methods employed for processing samples and preparing slides are standard for this laboratory and have been reported previously (Tschudy, 1970). The fossil megaspore localities are listed in table 3.

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 captions. 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.

In addition to slides of illustrated specimens, color photographs are available from the U.S. Geological Survey laboratory, Denver, Colo., on a limited-time loan basis.

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Page numbers in italic type indicate major references]

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PLATES 1–4

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

PLATE 1

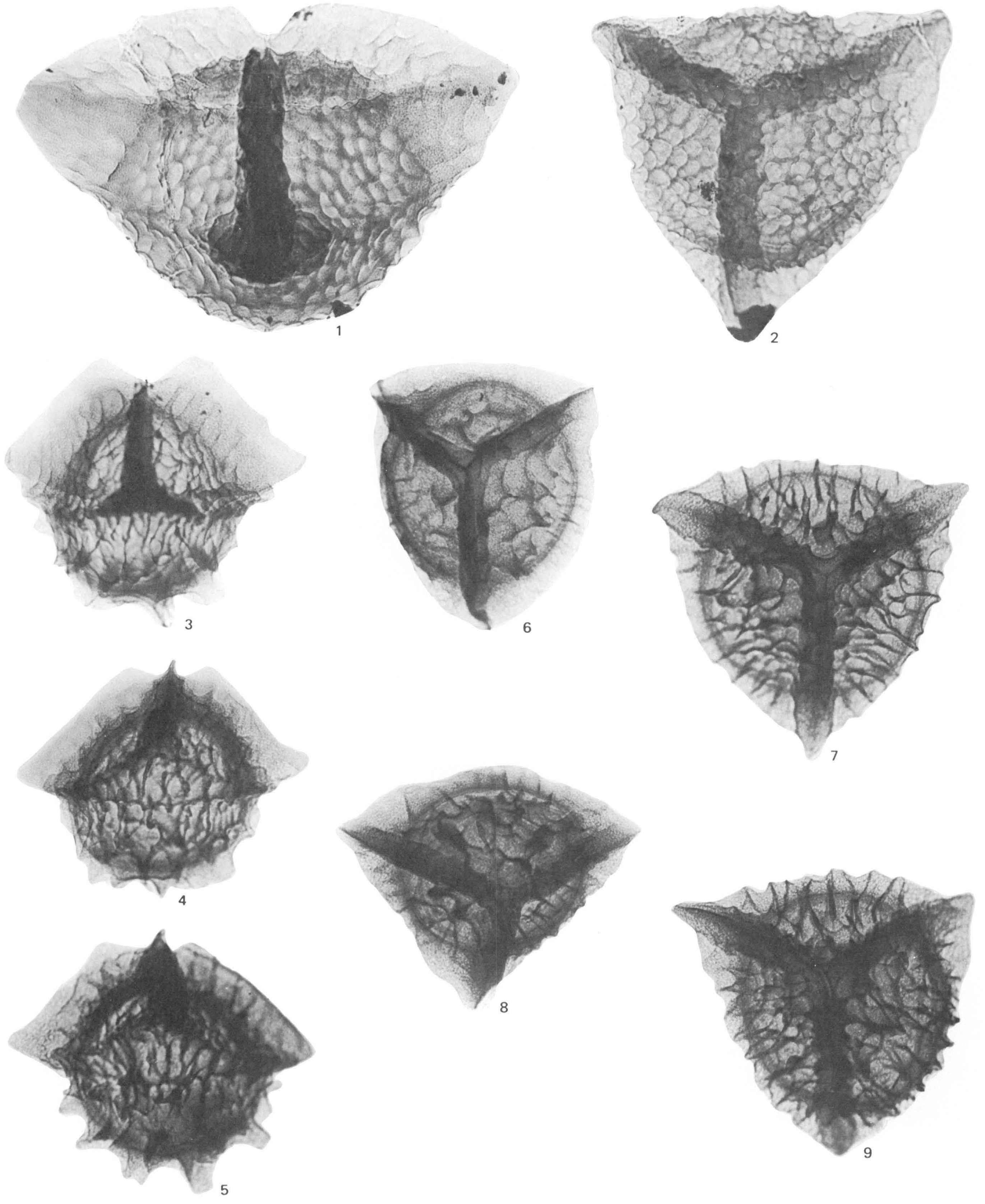
[Magnification X 100]

FIGURES 1–2. *Minerisporites mirabilis* (Miner) Pot., 1956.

1. USGS paleobotany loc. D3159-A, slide Mega 1, coordinates 101.2×12.2. Equatorial view; note characteristic notch in acrolamella.
2. USGS paleobotany loc. D3159-A, slide Mega 1, coordinates 101.0×22.3. Polar view; note robust, thick acrolamellae.

3–9. *Minerisporites glossoferus* (Dijkstra), n. comb.

3. USGS paleobotany loc. D3625-F, slide Mega 6, coordinates 113.5×15.1. Note distal projections.
4. USGS paleobotany loc. D3625-F, slide Mega 1, coordinates 106.0×8.0. Note narrow zona.
5. USGS paleobotany loc. D3625-F, slide Mega 1, coordinates 107.4×17.5. Note distal projections.
6. USGS paleobotany loc. D3625-F, slide Mega 7, coordinates 111.8×16.5. Note large muri on proximal surface.
7. USGS paleobotany loc. D3625-F, slide Mega 1, coordinates 114.3×9.5. Note massive acrolamellae with Y mark at juncture.
8. USGS paleobotany loc. D3625-F, slide Mega 2, coordinates 99.3×12.8. Distal view; note granular structure of zona and auriculae.
9. USGS paleobotany loc. D3625-F, slide Mega 1, coordinates 100.7×14.2.



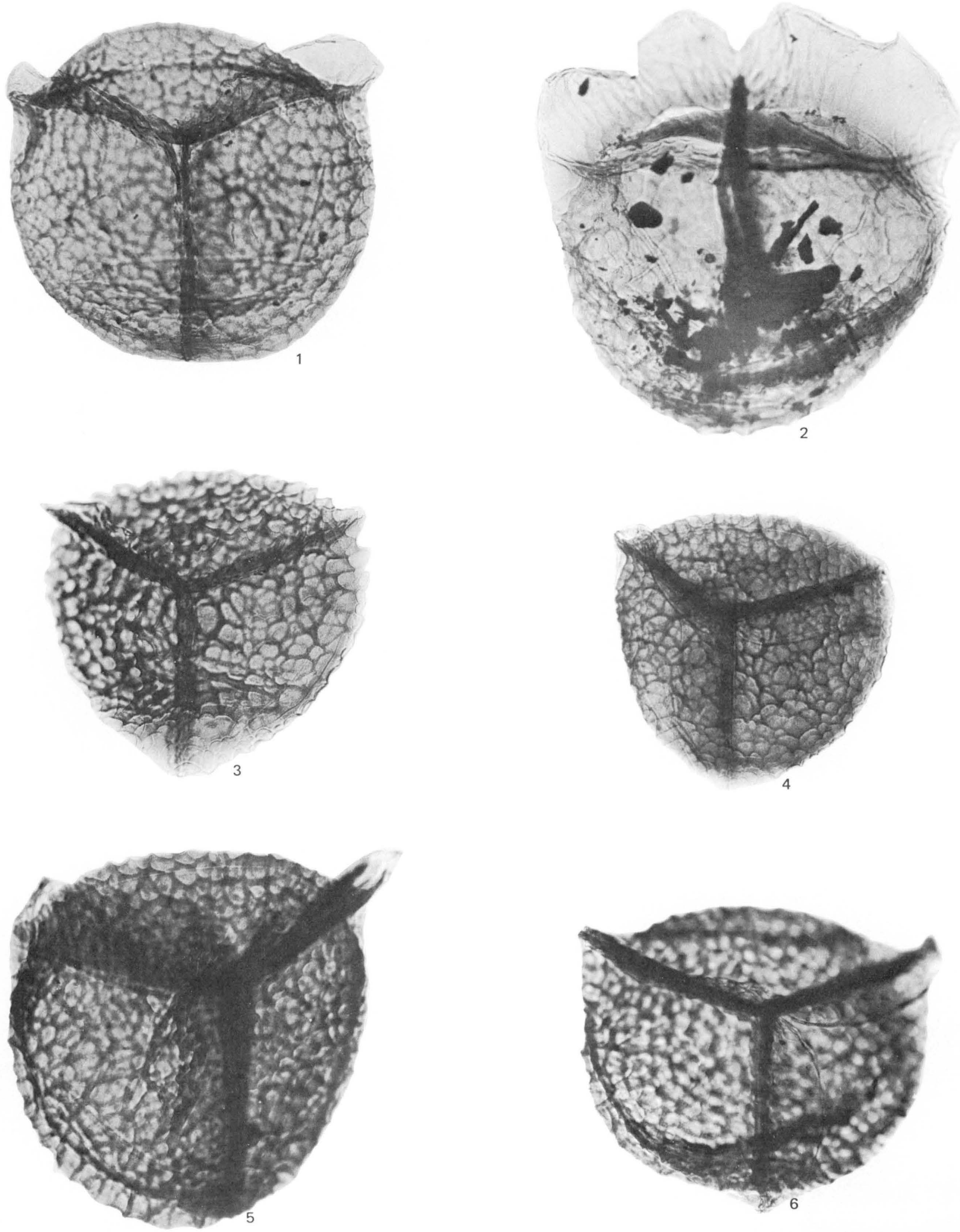
MINERISPORITES MIRABILIS AND *MINERISPORITES GLOSSOFERUS*

PLATE 2

[Magnification × 100]

FIGURES 1–6. *Minerisporites dissimilis*, n. sp.

1. *Holotype.* Sample RT 194, slide F, coordinates 110.7×8.3. Note narrow acrolamellae and aperture at their juncture.
2. *Paratype.* Sample RT 194, slide F, coordinates 114.8×7.1. Note notched acrolamellae and faint reticulations on their bases.
3. *Paratype.* Sample RT 194, slide F, coordinates 101.8×8.2. Note narrow acrolamellae and irregular compound reticulations.
4. *Paratype.* Sample RT 194, slide D, coordinates 103.1×17.0.
5. *Paratype.* Sample RT 194, slide F, coordinates 100.8×8.9. Zona shows at lower left.
6. *Paratype.* Sample RT 194, slide A, coordinates 108.5×7.8. Reticulum appears heavier because focus is on raised acrolamellae.



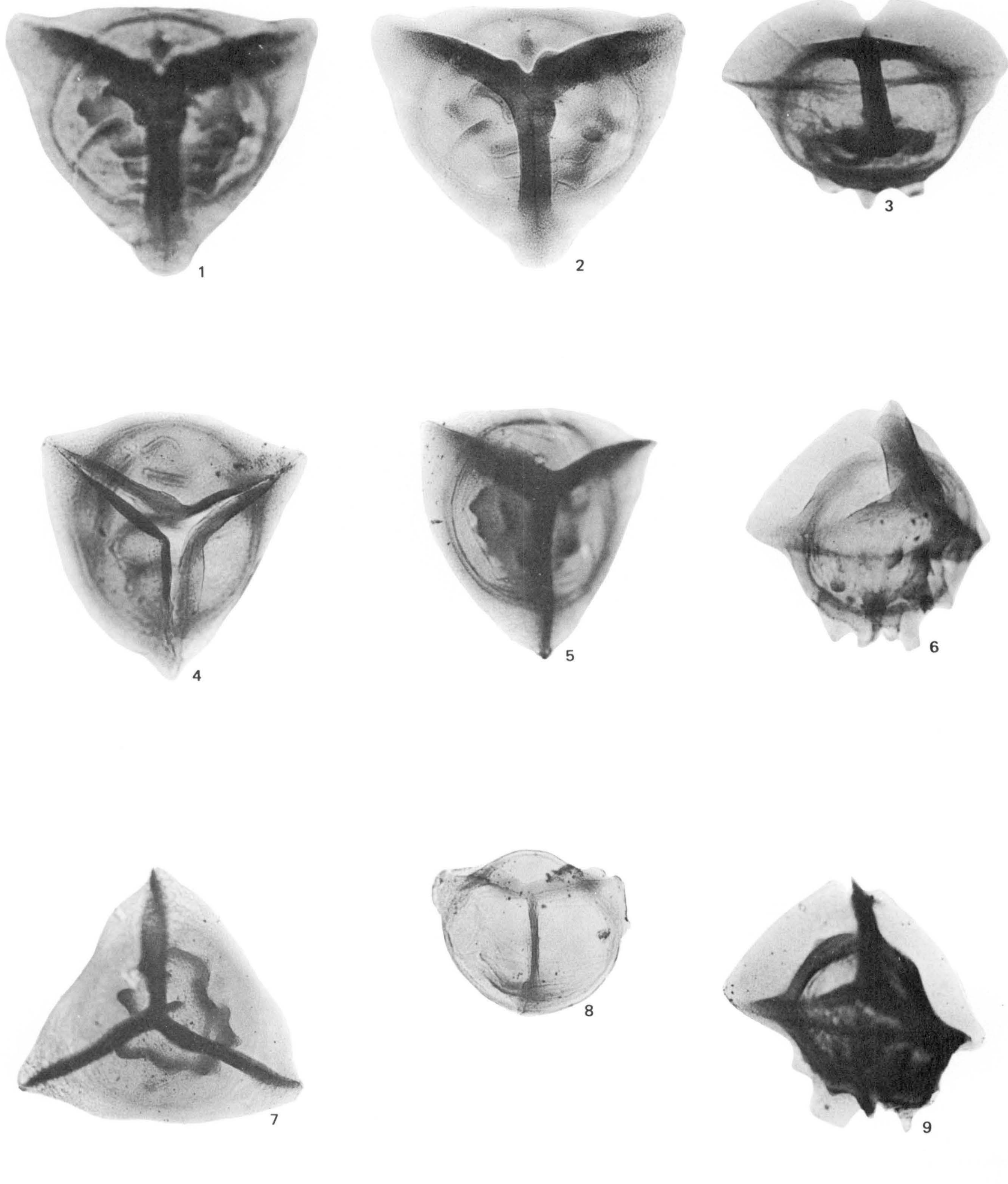
MINERISPORITES DISSIMILIS

PLATE 3

[Magnification × 100]

FIGURES 1–9. *Minerisporites succrassulus*, n. sp.

1. *Holotype*. Sample D4742–E, slide 3, coordinates 110.5×23.1. Focus on distal projections.
2. *Holotype*. Focus on massive notched acrolamellae.
3. *Paratype*. Sample D4742–E, slide 24, coordinates 97.9×12.2. Note notched acrolamella, zona, distal projections, and lack of other ornamentation.
4. *Paratype*. Sample D4742–E, slide 21, coordinates 99.1×11.4. Note open laesurae bordered by acrolamellae.
5. *Paratype*. Sample D4742–E, slide 21, coordinates 96.7×15.2.
6. *Paratype*. Sample D4742–E, slide 23, coordinates 112.6×19.3.
7. *Paratype*. Sample D4742–E, slide 23, coordinates 102.1×14.9. Distal projection in the form of a ring.
8. Sample D4742–E, slide 7, coordinates 105.3×7.4. Probably an immature spore.
9. *Paratype*. Sample D4742–E, slide 21, coordinates 105.5×20.8.



MINERISPORITES SUCCRASSULUS

PLATE 4

[Magnification × 100 unless otherwise indicated]

FIGURES 1–6. *Minerisporites pseudorichardsonii* Gunther and Hills (1972).

1. Sample D4766, slide 5, coordinates 98.2×15.0.
2. Same specimen as figure 1 except × 200. Magnified to show characteristics of reticulum and faint reticulation of the acrolamellae.
3. Sample D4766, slide 4, coordinates 105.2×7.1. Note prominent reticulation of acrolamellae.
4. Sample D4766, slide 5, coordinates 108.4×2.4. Central body appears shrunken.
5. Sample D4766, slide 4, coordinates 104.9×12.8.
6. Sample D3718–F, slide Mega 8, coordinates 112.3×14.8.

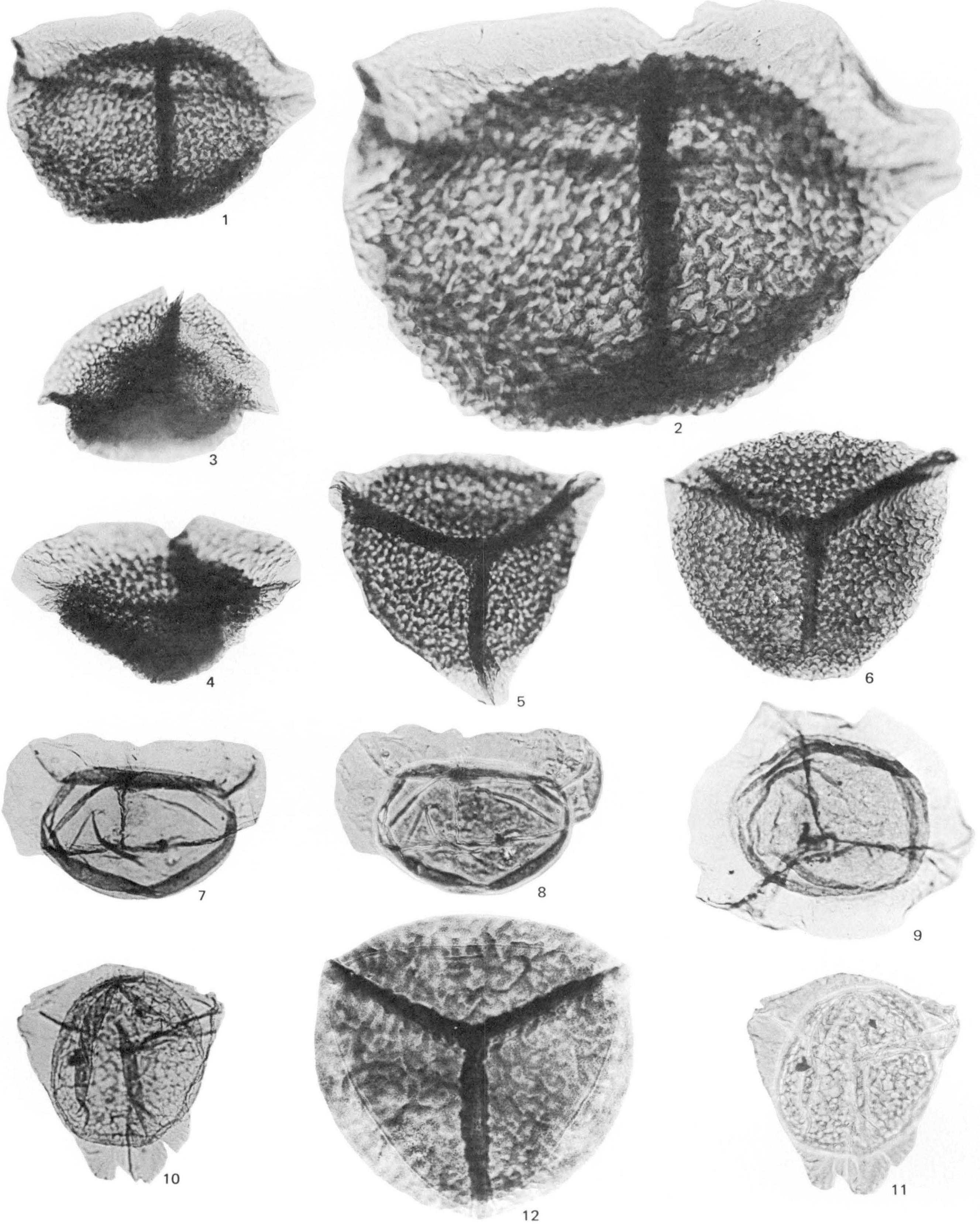
7–9. *Minerisporites* sp. A.

7. Sample D4766, slide 3, coordinates 107.3×13.2.
8. Same specimen as figure 7. Taken with phase contrast.
9. Sample D4766, slide 3, coordinates 112.8×16.8.

10–11. Minerisporites sp. B.

10. Sample RT 194, slide C, coordinates 101.7×9.6.
11. Same specimen as figure 10. Taken with phase contrast. Note delicate reticulum in figures 10 and 11.

12. *Minerisporites* sp. C. Sample RT 194, slide K, coordinates 115.0×11.5.



MINERISPORITES PSEUDORICHARDSONII, M. SP. A, *M.* SP. B, AND *M.* SP. C