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CALCAREOUS NANNOPLANKTON AND PROBLEMATIC
MICROORGANISMS FOUND IN THE
LATE PALAEOZOIC LIMESTONES

by

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(with 5 plates, 2 text-figures and 1 table)

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Abstract

Two species of calcareous nannoplankton belonging to genus *Thoracosphaera* found in the Upper Pennsylvanian limestones of Kansas, U.S.A., are systematically described. Two other calcareous microorganisms of uncertain affinity are also described. These two forms occur in the Upper Pennsylvanian limestones and some Lower Permian limestones.

Introduction

During the last ten years the senior author has been engaged in petrographic investigation of carbonate rocks using electron microscope. Some of the results were reported already (Honjo and Minoura, 1968; Minoura, 1974). In course of electron microscopic observation he recognized a few types of calcareous microorganisms, in which two of them could be related to calcareous nannoplankton. At first these microorganisms were recognized in the Upper Pennsylvanian limestones of Eastern Kansas, U.S.A. Later, similar microfossils but no calcareous nannoplankton were confirmed in several Lower Permian limestones of the same area.

Recently the authors have been jointly devoting to an extensive petrographic investigation of the Late Palaeozoic limestones widely distributing in the Southern Kitakami Mountains, Northeastern Japan. Naturally such microorganism as found in the Kansas material were expected to be found, at least to some extent. However, no such microorganism has been ascertained at present in the Japanese material. The senior author, thus, decided to describe first these microorganisms found in the Kansas material in cooperation with the junior author.

Although two types of organisms could be referred to such calcareous nannoplankton as *Thoracosphaera*, two other types, in which one is most frequently found, could not be related to any known calcareous microfossil, and their affinity is uncertain. Definite occurrence of Pre-Mesozoic calcareous nannoplankton has been extremely rare (Noël, 1961; Pirini Radrizzani, 1971; Gartner and Gentile, 1972) though it has been often quoted since Gümbel (1870).

Thoracosphaera herein described is associated with no "ordinary" coccolithophyceae. The authors wish to describe these microorganisms rather for open discussion than for claiming the occurrence of definite calcareous nannoplanktons in the Upper Pennsylvanian,

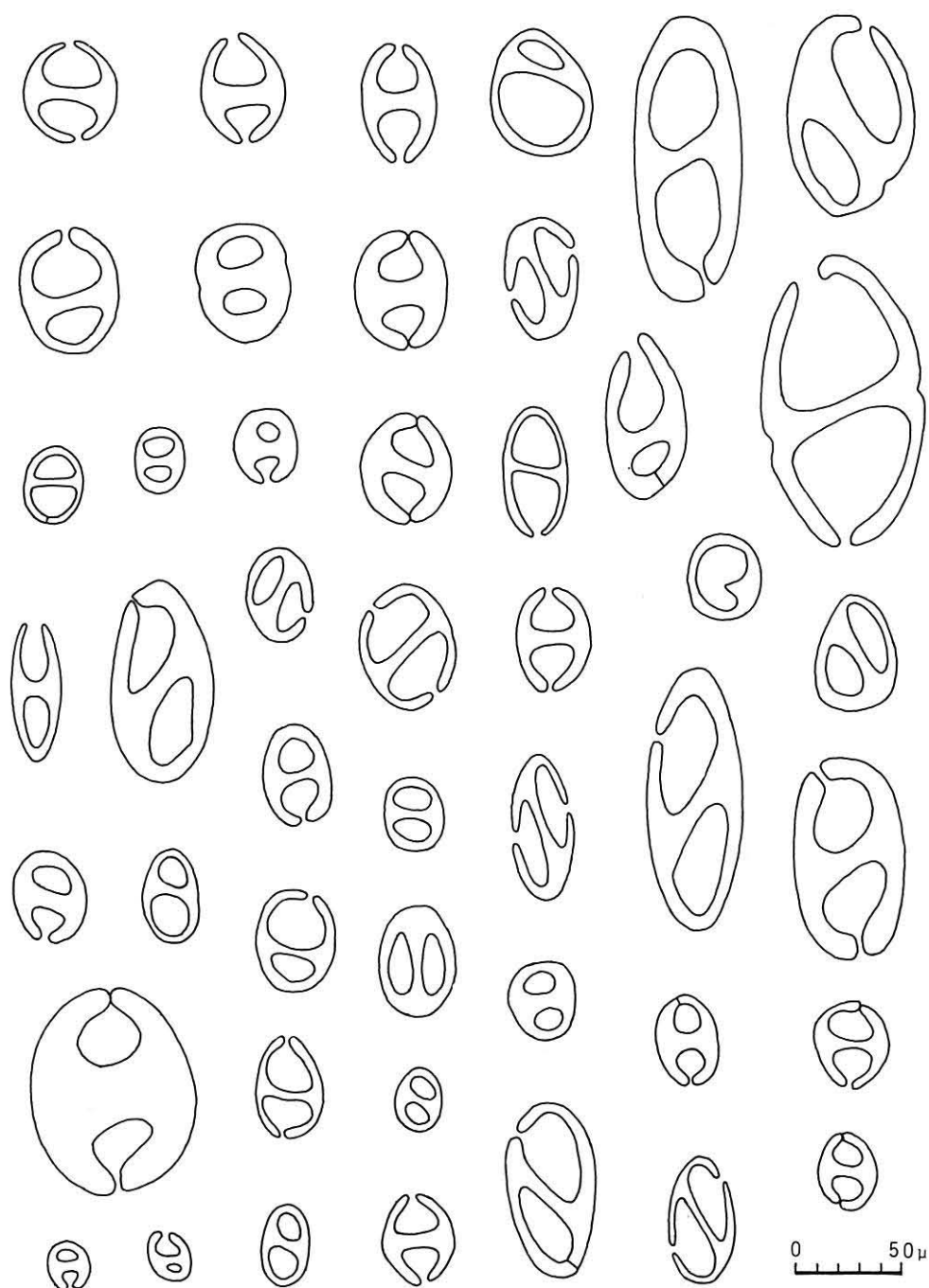


Fig. 1 Simplified sketches of cross sections of *Ovummurus duoportio* gen. et sp. nov. Variation of the shape is mainly due to the direction of section. Schematic reconstruction (Fig. 2) is made mainly based on many sketches in addition to electronmicrographs.

Table 1 List of the limestones containing relatively abundant microorganisms described.

Th. cf. de. Th. sp. Ov. du. De. no.	Smp. No. P-	Member	Locality	
x	149	Wreford ls.	CEN sec. 30, T 11 S, R 11 E, Wabawnee County	L. Permian
x	148	Cottonwood ls.	CEN sec. 25, T 11 S, R 11 E, Wabawnee County	
x	147			
x	146	Hughes Creek ls.		
x x	145	Americus ls.		
x x	144	Falls City ls.	SWSW sec. 28, T 11 S, R 12 E, Wabawnee County	Upper Pennsylvanian
x x	138	Brownville ls.	SWSW sec. 26, T 11 S, R 12 E, Wabawnee County	
x	137			
x	123	Jim Creek ls.	NWNWSE sec. 18, T 16 S, R 13 E, Lyon County	
x	122	Grandhaven ls.		
x	121			
x x	99	Maple Hill ls.	CSLSW sec. 29, T 11 S, R 14 E, Shawnee County	
x	98			
x	116	Elmont ls.	NE sec. 35, T 13 S, R 14 E, Shawnee County	
x	94	Wakarusa ls.	C sec. 31, T 11 S, R 15 E, Shawnee County	
x x	93			
x	70	Ervine Creek ls.	NENWNW sec. 22, T 12 S, R 18 E, Douglas County	
x	87	Avoca ls.	E2 sec. 1, T 12 S, R 17 E, Douglas County	
x x x x	86			
x x	62	Beil ls.	NWNW sec. 24, T 12 S, R 18 E, Douglas County	
x	60	Big Spring ls.		
x	59			
x x	58	Spring Branch ls.		
x	57			
x	88	Clay Creek ls.	E2 sec. 10, T 12 S, R 18 E, Douglas County	
x	134	Plattsmouth ls.	C sec. 11, T 28 S, R 12 E, Greenwood County	
x	78		SE sec. 35, T 11 S, R 18 E, Douglas County	
x	77			
x	130	Leavenworth ls.	E sec. 2, T 26 S, R 12 E, Greenwood County	
x x	52		NE sec. 20, T 12 S, R 19 E, Douglas County	
x x	229	Argentine ls.	SWSW sec. 25, T 11 S, R 23 E, Johnson County	
x	228			
x	219	Paola ls.	C sec. 23, T 11 S, R 24 E, Wyandotte County	
x	218			
x	214	Dewey ls.	SW sec. 23, T 11 S, R 24 E, Wyandotte County	
x	213			
x	209	Westerville ls.	SE sec. 22, T 11 S, R 24 E, Wyandotte County	
x	208	Block ls.		
x	207	Westerville ls.		
x	204			
x x	201			
x x	200			
x x	199			
x	191	Bethany Falls ls.		
x	190			
x	182	Sniabar ls.	C sec. 31, T 20 S, R 25 E, Linn County	
x	179			
x	177	Critzer ls.		

though nannoplankton reported by Noël (1961) and by Gartner and Gentile (1972) occurred in the Pennsylvanian nearby. Therefore taxonomic problems of calcareous nannoplankton is not treated. The authors simply follow Jafar's (1974) classification system for calcareous nannoplankton since it deals with thoracosphaeraceae extensively.

Material

The microorganisms herein described were recognized at first in Upper Pennsylvanian limestones collected in Eastern Kansas, U.S.A., when these limestones were observed by an electron microscope for petrographic investigation. More than one third of 180 Upper Pennsylvanian limestones thoroughly investigated (Minoura 1974) were ascertained containing variable number of certain microorganisms, after a 1 × 1 cm peeled area of the polished and etched surface of the limestones were thoroughly observed by light microscope. Usually several specimens are counted in the observed area, but some limestones contain more than 40 individuals in the same area. Those limestones containing more than 10 individuals of any type of microfossil are listed, with its locality, in Table 1. Although not so thoroughly investigated, at least several Lower Permian limestones of Kansas also were confirmed to contain certain types of microorganisms but no calcareous nannoplankton. Thus, these Permian limestones containing more than 10 individuals are also included in Table 1.

Systematic Description

Class Coccolithophyceae Rothmaler, 1951

Order Heliolithae Deflandre in Grasse, 1952

Family Thoracosphaeraceae Deflandre in Grasse, 1952

Genus *Thoracosphaera* Kamptner, 1927

Type species: Thoracosphaera pelagica Kamptner, 1927, p.180

Thoracosphaera cf. *deflandrei* Kamptner 1956

(pl.1, figs.1-4)

1956 *Thoracosphaera deflandrei* Kamptner, p.448, figs.1-4.

1967 *Thoracosphaera* cf. *deflandrei* Kamptner – Fischer, Honjo and Garrison, p.35, fig.22.

1974 *Thoracosphaera deflandrei* Kamptner – Jafar, p.82, pl.14, figs.3, 4.

Description: Hollow spherical test consists of prismatic equidimensional calcite. Each calcite is imperforated. The test has no aperture nor lid covering the aperture. Diameter of the test ranges 13.3 – 20.8 μ . Thickness of the test wall ranges 0.9 – 1.8 μ . Size of the calcite element is 0.5 – 2.8 μ . The outer surface of the spheric test is smooth, inner surface appears quite smooth also.

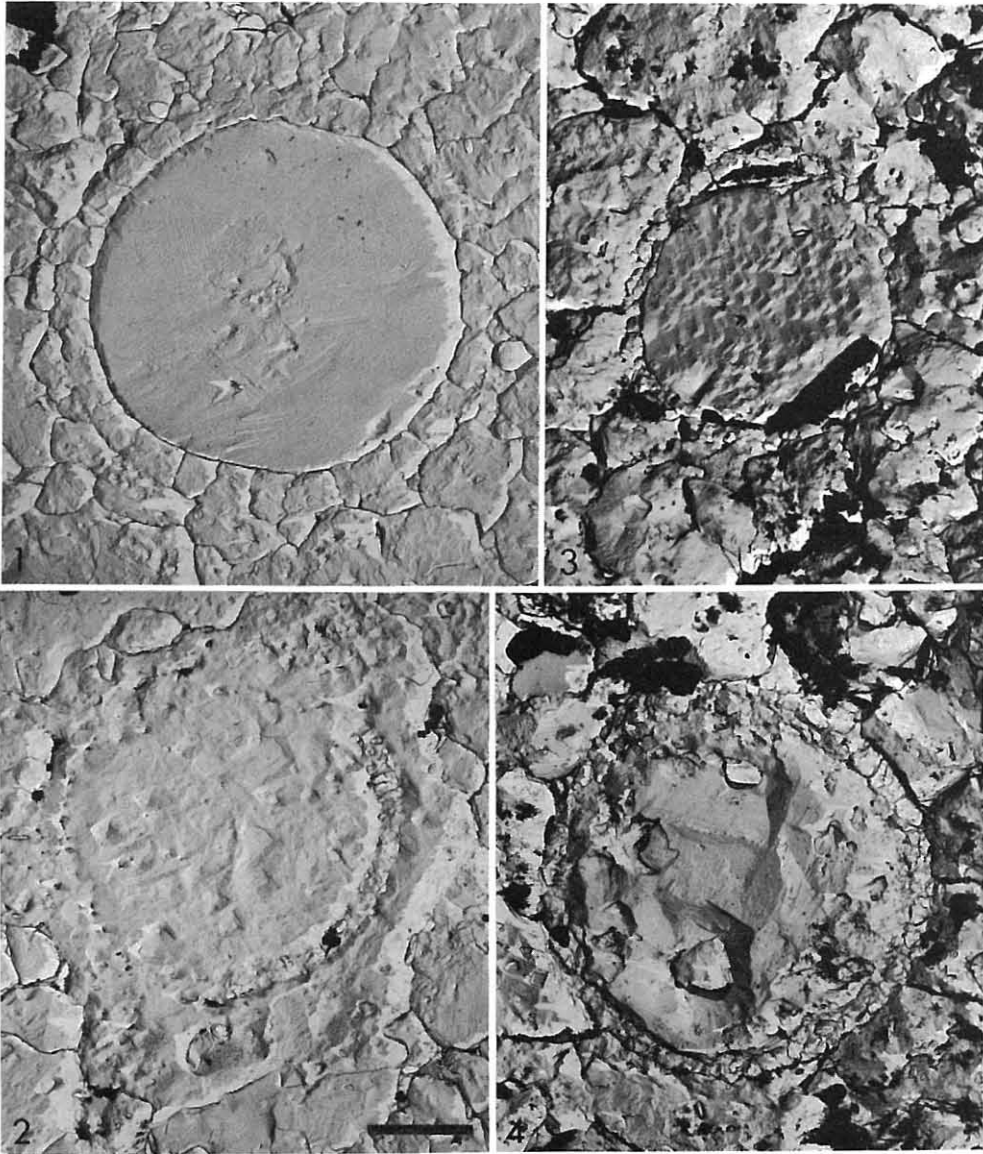
Discussion: This species is well characterized by extremely smooth outer and inner surfaces

Explanation of Plate 1

(Fig. 1–4. Electronmicrographs of polished-etched surface. Scale-bar is 5 μ for all).

Figs. 1–4 *Thoracosphaera* cf. *deflandrei*.

- 1: Essentially centered section of an exceptionally well preserved specimen. N-388, P-243.
- 2: Nearly centered section of a severely obliterated specimen. N-310, P-223.
- 3: Nearly centered section revealing fine calcite elements and partial obliteration by recrystallization. N-ad4-1, P-85.
- 4: Essentially centered section of an well preserved specimen. N-ad4-2, P-85.



of the spheric test which is composed of imperforated, fine, usually less than 1μ , calcite elements. The specimen shown as fig. 1 is somewhat different in having rather larger (2.8μ max.) calcite elements. However this is the only exceptional case having such large element in the studied specimens. The authors, therefore tentatively included this specimen into *Th. cf. deflandrei*. Although other specimens are more or less obscured by recrystallization, fine calcite elements and extremely smooth surface are evident.

Occurrence: This species is known in Eocene (Kamptner, 1956; Fischer, Honjo and Garrison, 1967; Jafar, 1974) and believed to occur in Cretaceous (Jafar, 1974). In the studied material, this species occur solely in Upper Pennsylvanian limestones, though doubtful spheric organism obscured by recrystallization is very rarely recognized in some Permian material. Relatively abundant occurrence of this species in the studied material is tabulated in Table 1, though about 30 limestones were confirmed to contain this species.

Thoracosphaera sp.

(pl.2, figs.3, 5, 6 and 9)

1971 *Thoracosphaera* sp. —Pirini Radrizzani, pl.3, figs.1, 2.

Description: Spherical to slightly ellipsoidal test consists of fairly large, short prismatic calcite. Each calcite prism is imperforated. Sometimes the test is faintly appeared to be two-layered (figs. 3 and 5). Probable aperture is apparent in a specimen (fig. 3). Both outer and inner surface of the test may be smooth. The size of the spheric test is rather uniform, measures $25.0 \times 23.1\mu$ (fig. 3) and $24.7 \times 24.4\mu$ (fig. 5). The thickness of the test ranges $5.0 - 7.5\mu$, though slightly variable at the position measured, suggesting slight elliptical shape.

Discussion: This species is distinctly different from any known *Thoracosphaera*, having extremely thick test compared to its diameter, though *Th.* having such thick test is not uncommon. This form can be related to *Thoracosphaera* sp. (Fischer, Honjo and Garrison 1967, p. 34, figs. 69 and 70) or to *Thoracosphaera* sp. figured by Pirini Radrizzani, 1971 (p. 995, plate, 3, figs. 1 and 2). Although this form can be related to transverse section of *Nannoconus*, no longitudinal section of the latter has been recognized in the studied material.

Occurrence: In the studied material this species occurs solely in the Upper Pennsylvanian limestones as *Th. cf. deflandrei*. Several of these limestones contain up to 30 or more specimens in a 1×1 cm area examined. Limestones containing more than 10 specimens are

Explanation of Plate 2

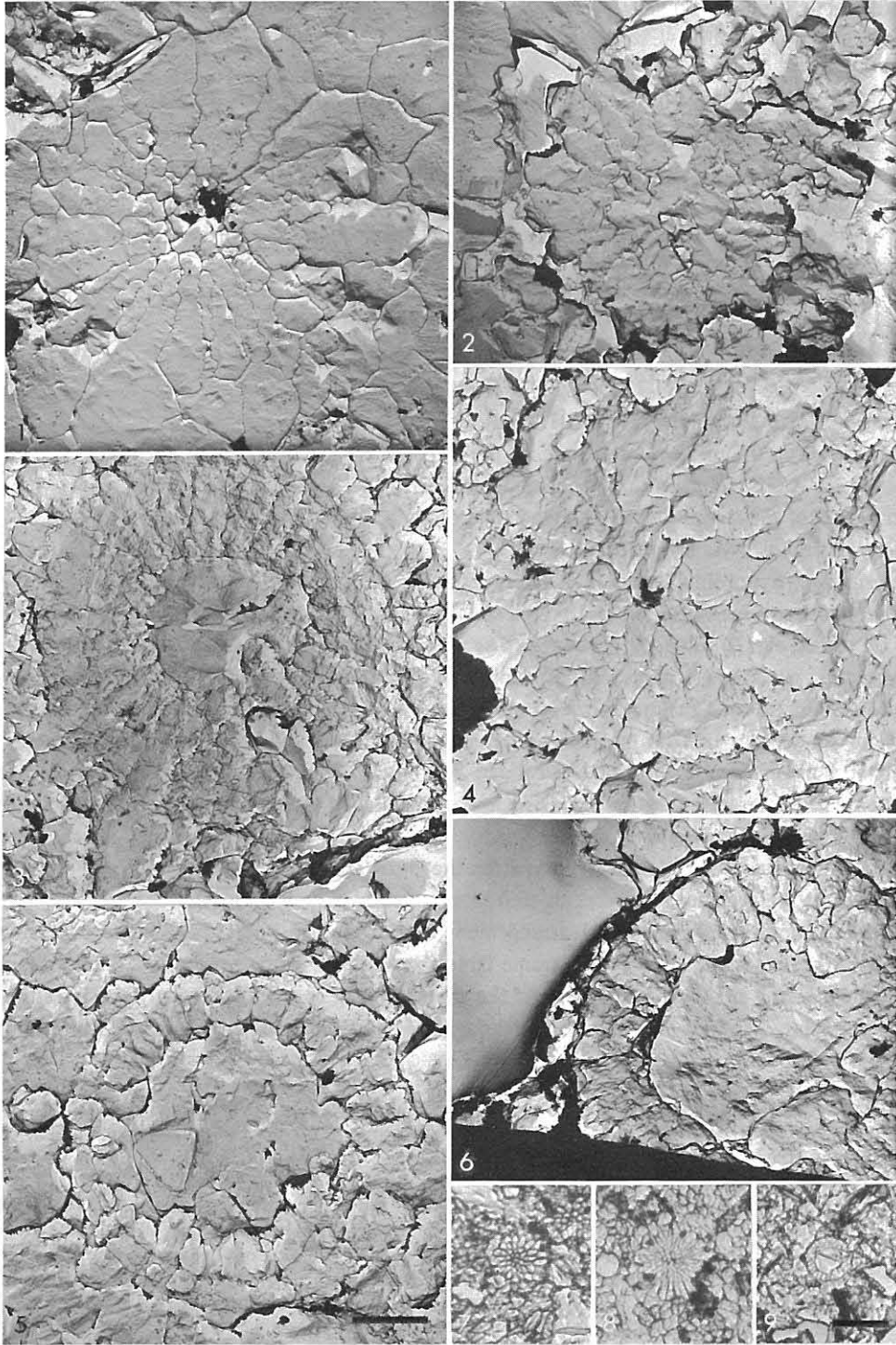
(Figs. 1–6: Electronmicrographs of polished-etched surface. Fig. 7–8: Lightmicrographs of acetate peels. Scale-bars are 5μ and 30μ for the electronmicrographs and for the lightmicrographs, respectively.)

Figs. 1, 2, 4, 7 and 8 *Densosphaeralis nodosus* gen. et sp. nov.

1: Essentially centered section. Holotype, N-334, P-229, UHR 30381. 2: Slightly off-centered section. Paratype, N-227, P-201, UHR 30382. 4: Slightly off-centered section revealing imbricated structure of calcite prisms, N-51-4, P-61. 7: Off-centered section. P-144. 8: Essentially centered section. P-52.

Figs. 3, 5, 6 and 9 *Thoracosphaera* sp.

3: Essentially centered section revealing probable aperture at lower right portion. N-183-3, P-183. 5: Essentially centered section. N-127-1, P-130. 6: Essentially centered section of an obliterated specimen. N-151-3, P-129. 9: Essentially centered section. P-88.



tabulated in Table 1.

Incertae Sedis

Genus *Densosphaeralis* gen. nov.

Type species: Densosphaeralis nodosus sp. nov.

Generic diagnosis: Free calcareous microorganism of spheroidal shape. Consists of radially oriented lod-like calcite so closely and densely packed as to leave no internal void chamber. The outer surface of the spheroid may be rough due to bluntly pointed calcites constitute the spheroid.

Densosphaeralis nodosus gen. et sp. nov.

(pl.2, figs.1, 2, 4, 7 and 8)

Holotype: Plate 2, fig.1, N-334, P-229, UHR 30381

Paratype: Plate 2, fig.2, N-227, P-201, UHR 30382

Type locality: 0.5 m above the base of the Argentine Ls. Mbr. (P-229), at SWSW sec. 25, T125, R23E, Johnson County, Kansas, U.S.A.

Derivation of the name: Densely packed spheroid with noded surface.

Specific diagnosis: As for genus.

Description: Spheroidal calcareous microorganism of unknown affinity. Diameter of the spheroidal body measured on sections close to the centre is 24.0μ (pl. 2, fig. 1) and is $20.0 \times 25.0\mu$ (pl. 2, fig. 4). Slightly off-centered section (pl. 2, fig. 2) measures $20.6 \times 16.1\mu$. Thus slight elliptical shape is suggested. The spheroidal body is composed of outwardly tapered, bluntly pointed large prismatic calcite of about $4 \times 12\mu$. This large prismatic calcite radially packed so densely that no internal void chamber exists, though small (about 5μ diameter) central portion seen in holotype specimen possibly is a void chamber filled with calcite cement. In centered section calcite prism appears as bladed shape, while off-centered section reveals imbricated wide and shorter blades. Thus, under light microscope, off-centered section appears as a tiny dandelion seen from the above (pl. 2, fig. 7).

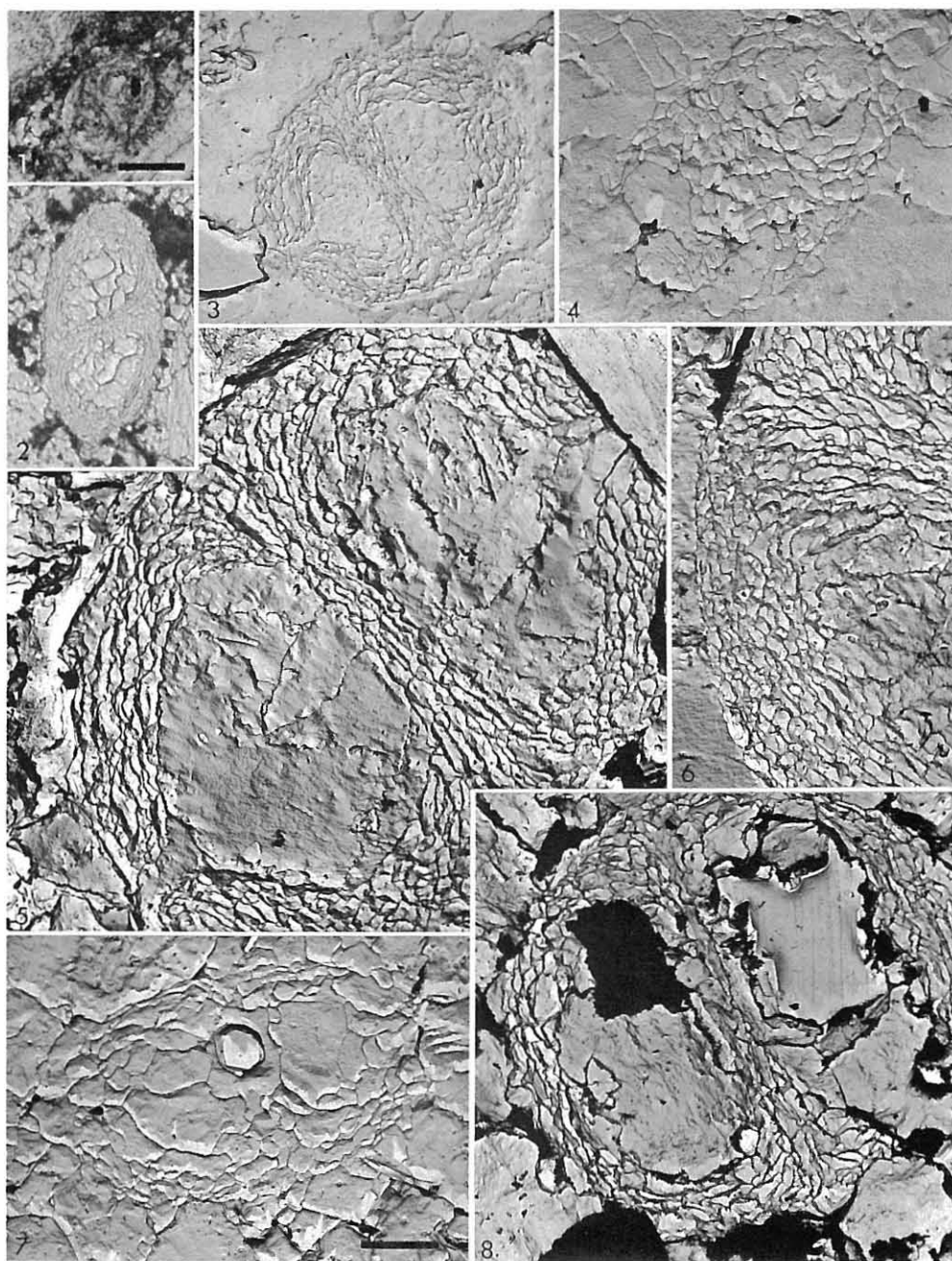
Discussion: At a glance, this species somewhat resembles such discoasteridae as *Discoaster multiradiatus* showing the radial arrangement of the bluntly pointed prismatic calcite in centered cross section. However extreme large size, spheric form, and imbricated structure appearing in the off-centered section of the present form, as a whole strongly indicates that it is not related to coccolithophytheae, though this possibility still remains. As a matter of

Explanation of Plate 3

(Fig. 1: Lightmicrograph of thin section, Fig. 2: Lightmicrograph of acetate peel, Figs. 3-8: Electron-micrographs of polished-etched surfaces. Scale-bars are 30μ and 5μ for the Lightmicrographs and for the electronmicrographs, respectively.)

Fig. 1-8 *Ovummuris duoportio* gen. et sp. nov.

- 1: Slightly tangential transverse section, p-99.
- 2: Nearly longitudinal section of a fairly large specimen, p-99.
- 3: Essentially transverse section, Holotype, N-272, p-213, UHR 30383.
- 4: A specimen obliterated by severe recrystallization, N-437, p-256.
- 5: Essentially transverse section of an well preserved specimen, N-132-2, 3, p-99.
- 6: Part of a fairly large specimen revealing the smooth continuation of microtexture of wall and septum-like structure, N-132-5, p-99.
- 7: Nearly transverse section revealing apertural openings in severely recrystallized specimen, N-312, p-223.
- 8: Nearly transverse section cut close to the end of the longer axis, N-41-1, p-52.



fact, the authors have no idea to what taxon this species belongs, though they more or less inclined to consider its affinity with calcareous algae. During the electron microscopic observation, it was so felt since the microstructure is somehow resembling that of supposed calcareous algae fragments.

Occurrence: In the Upper Pennsylvanian limestones this species sometimes appears as many as 20 or more in a 1 × 1 cm peeled area, though the case that less than 5 specimens in the same area is common. Limestones containing more than 10 specimens are tabulated in Table 1. Several Permian limestones were ascertained to contain this species and also listed in Table 1.

Genus *Ovummurus* n. gen.

Type species: *Ovummurus duoportio* sp. nov.

Generic diagnosis: Free calcareous microorganism consists of ovoid to ellipsoidal shape wall. Oval to elliptical internal chamber is diagonally divided into two equal spaces by a septum-like structure. The test has two narrow slit-like apertures, which extend nearly symmetrically about the center, and diagonally both to the longer and shorter axes of the test. The length of the aperture may reach nearly half of the longer axis. Along this apertures the test slightly elevated and thus may be appearing as slender lips surrounding the apertures.

Ovummurus duoportio n. sp.

(pl.3, figs.1-8; pl.4, figs.1-4; pl.5, figs.1-3)

Holotype: Plate 3, fig.3, N-272, P-213, UHR 30383

Paratype: Plate 4, fig.1, N-ad23, P-148, UHR 30384

Type locality: 0.6 m above the base of the Drum Ls. Fm. (P-213), at SW sec.23, T11S, R24E, Wyandotte County, Kansas, U.S.A.

Derivation of the name: Latin: ovum = egg; murus = wall; duo = two; portio = portion.

Specific diagnosis: as for genus

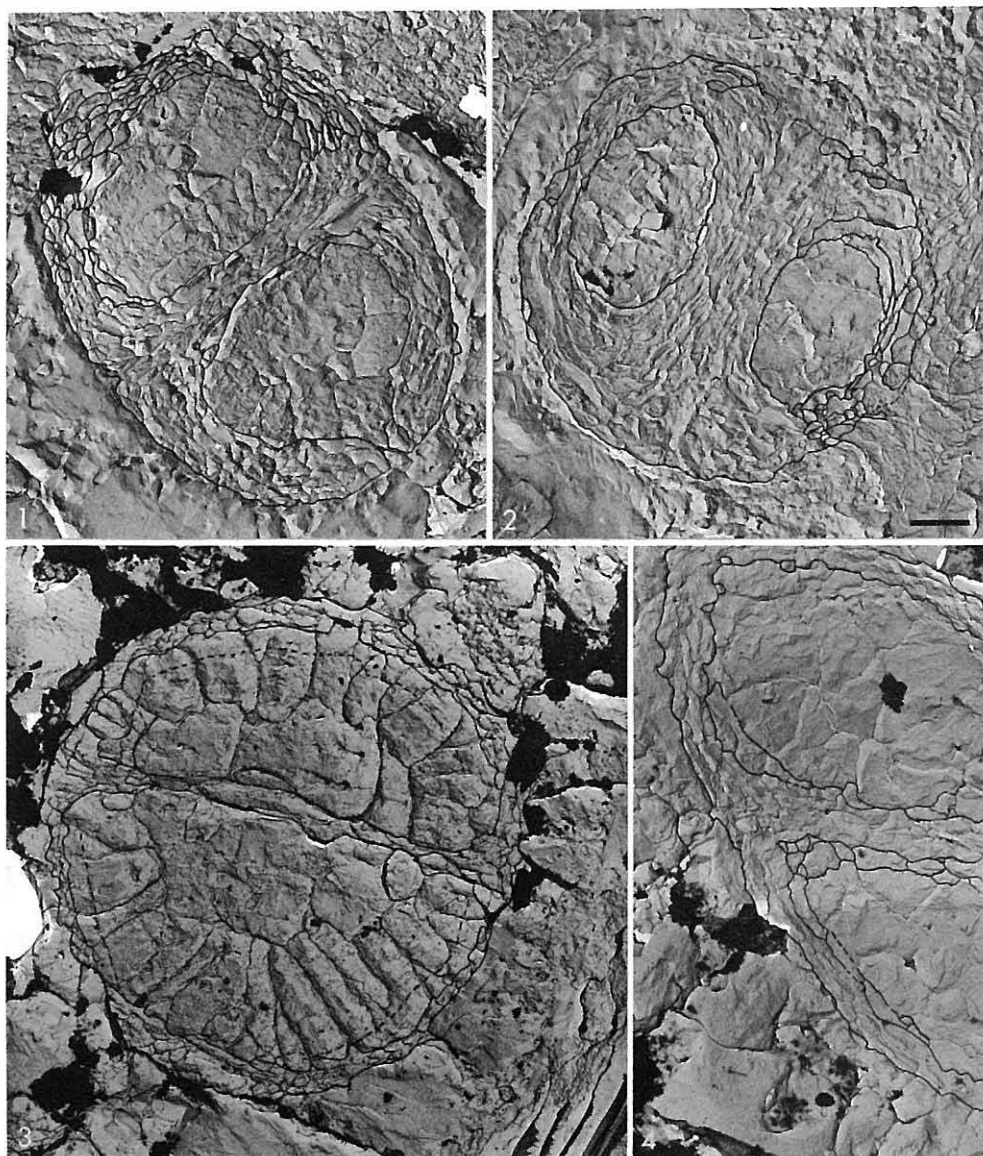
Description: Ovoid to ellipsoidal microorganism of widely variable size is characteristic. The longer diameter ranges 15–120 μ ; specimens with 20–60 μ length are usual. The shorter diameter ranges 10–80 μ ; 15–50 μ are the commonest (Fig. 1). Although the wide variation of the size partly due to the direction of the section, individual variation must be quite wide. The thickness of the wall and septum-like structure appear nearly the same and widely varies being 5–30 μ , mainly due to the direction of the section. Some specimens are appeared as pyriform (pl. 5, fig. 1, Fig. 1). Also some specimens show shallow groove-like depression on the outer surface along the septum at the portion where the septum is connecting to the wall (pl. 4, fig. 1, Fig. 1). Since this microorganism was observed only as section, most possible

Explanation of Plate 4

(Partially retouched electronmicrographs of polished-etched surface. Scale-bar is 5 μ for all).

Figs. 1-4 *Ovummurus duoportio* gen. et. sp. nov.

1: Slightly tangential section. Paratype, N-ad23, p-143, UHR 30384. 2: Transverse section cut close to the pointed end. N-ad22, p-148. 3: Essentially transverse section of a specimen revealing extremely thin wall and septum-like structure. N-ad18, p-93. 4: Part of a specimen seen in nearly longitudinal section. N-56-3, 4, p-58.



schematic reconstruction was tried (Fig. 2) from many electron micrographs and sketches of light microscopic observation. Some of them are illustrated as Fig. 1.

Discussion: At present the authors are uncertain as to the affinity of this species. Apart from the size difference, microtexture of the wall and the septum of this species somehow resembles that of some bryozoa, without wavy structure often seen in the latter (Minoura, 1974). At a glance, the senior author misunderstood this microorganism as tiny bryozoan fragment transversely cut. Existence of long slit-like aperture, and rather regularly arranged microtexture comparing to bryozoa finally made the authors convinced that it was unknown micro-organism, though it could well be a calcareous nannoplankton. This species, however, is extremely different from any known calcareous nannoplankton in microtexture and shape. Also size of this species is far beyond the largest nannoplankton.

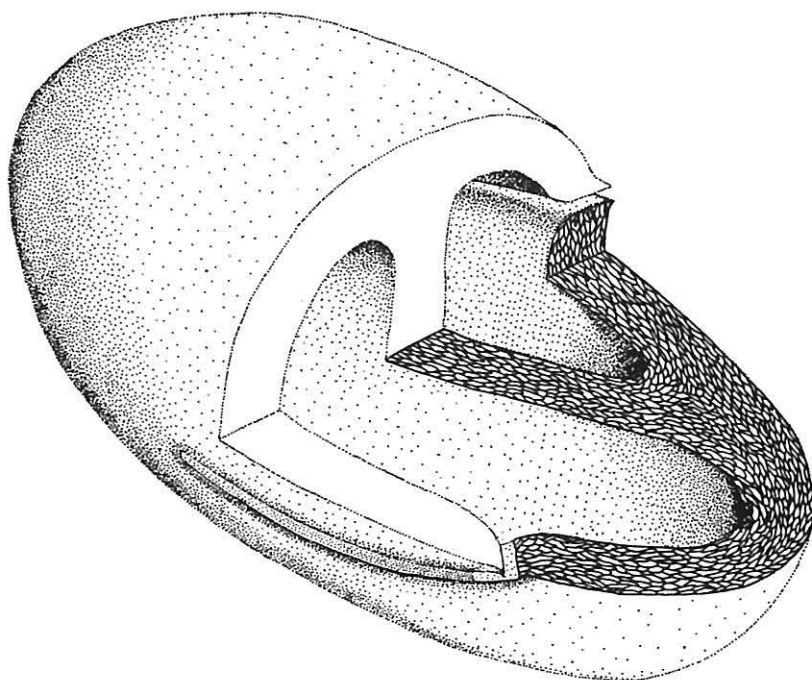


Fig. 2 Probable schematic cut-away reconstruction of *Ovummurus duoportio* gen. et sp. nov.

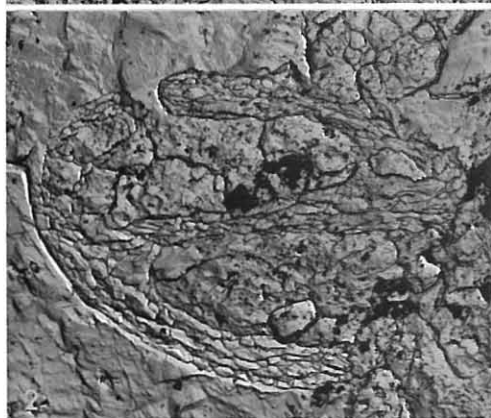
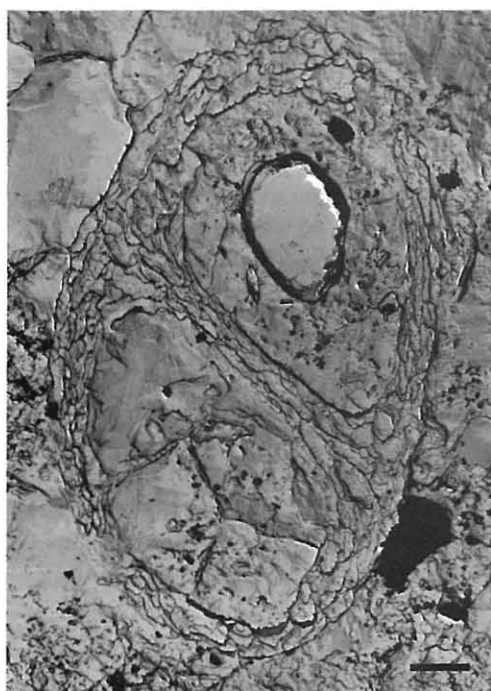
Possibility of this belonging to pollen or spore may be pointed out. But it is not highly probable that pollen or spore is so extensively calcitized as is the present form and that they show such microtexture as revealed in this species. Another possibility is that it is a

Explanation of Plate 5

(Electronmicrographs of polished-etched surfaces. Scale-bar is 5μ for all).

Figs. 1-3 *Ovummurus duoportio* gen et. sp. nov.

- 1: Nearly transverse section of somehow pyriform specimen, N-ad33, p-123.
- 2: Tangential section of a partially broken (lower right portion) specimen. N-ad32, p-123.
- 3: Nearly longitudinal section of a fairly large specimen which reaches 83μ long. N-ad19, 20, p-93.



reproductive organ, ovum, "egg shell" or calcareous spore capsule of certain organism. But this is also highly improbable since the existence of septum-like structure and two slit-like long apertures. It should be noted that this species sometimes contains extremely fine clastic material inside the chamber (pl. 5, fig. 1) or even in the septum-like structure (pl. 3, fig. 7), suggesting possible encrusting growth as certain algae.

Occurrence: This species is most commonly appearing form, comparing to other three species, in the studied limestones. More than one third of 180 Upper Pennsylvanian limestones examined were ascertained containing this species. Sometimes more than 50 individuals of this species occurs in a 1 × 1 cm area of several limestones. Occurrence of this species extends to several Lower Permian limestones. Samples containing more than 10 individuals of this species are listed in Table 1.

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