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Dinoflagellate cysts and pollen in pelagic sediments of the northern part of the Philippin Sea

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Abstract

Pelagic assemblage of dinoflagellate cysts from the bottom sediments in the Philippin Sea shows the characteristic of an adundant occurrence of *Impagidinium* and lack or scarcity of *Spiniferites* and *Operculodinium*. Pollen and spores are also very rare and composed of only wind-pollinated taxa. Accumuration processes of these palynomorphs are discussed in comparison with the other trench assemblage.

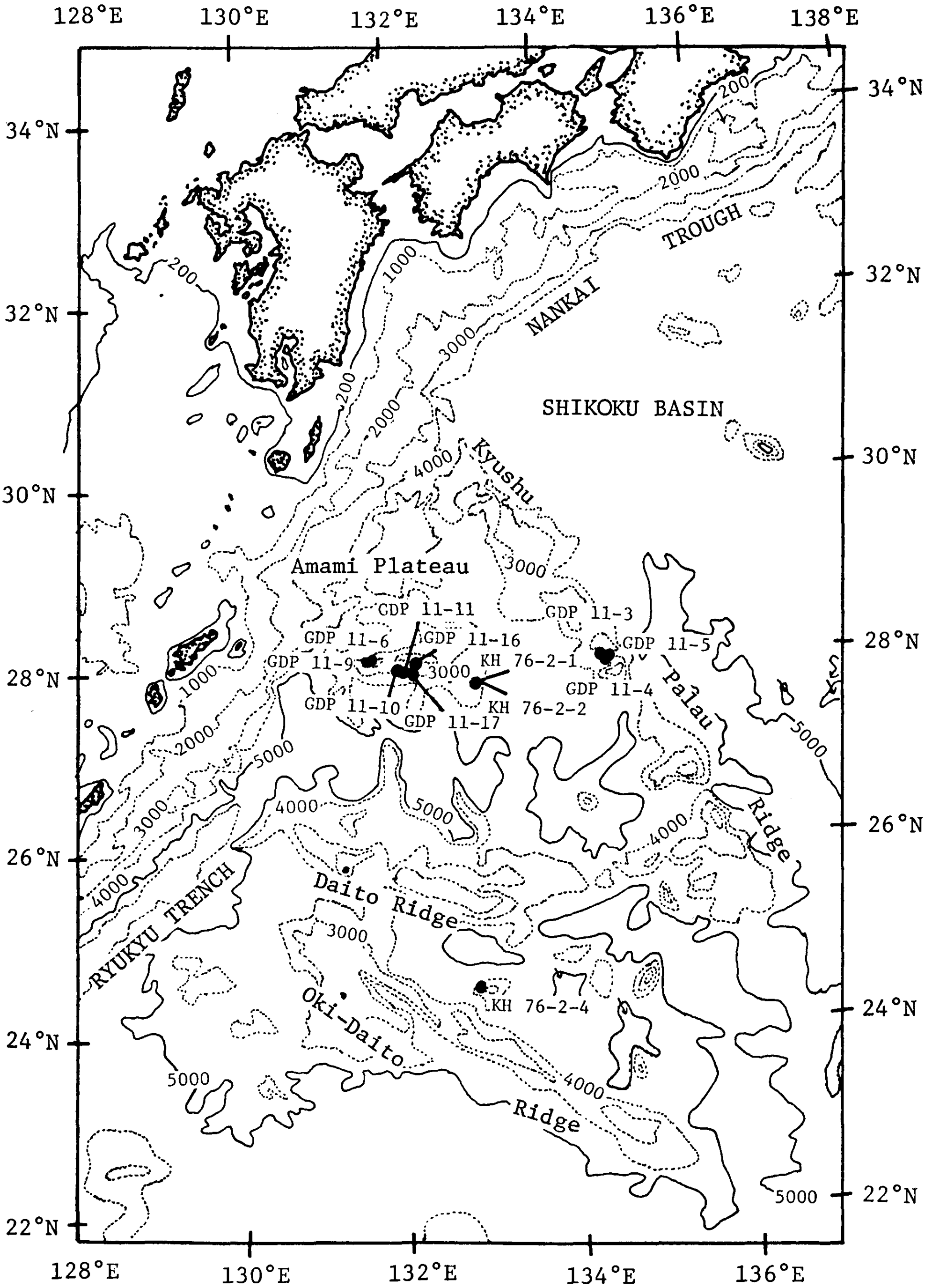
Introduction

According to recent progress in dinoflagellate biology, it is made clear that most fossil dinoflagellates are hypnozygotes, namely oöcysts, and produced by sexual reproduction in the life cycle (Von STOSCH, 1973; MANUM, 1976; DALE, 1977). On the other hand, all of modern dinoflagellates are not known to produce the cysts (WALL, 1974). These members are observed in some parts of *Protoperidinium*, *Ceratium*, *Gonyaulax* and other genera. Therefore, the distridution of modern dinoflagellate cysts preserved in sediments is not wholly concordant with that of planktonic thecate forms living in the surface water.

For understanding a paleoenvironmental condition by using dinoflagellate cysts as well as other microfossils, it needs to make clear that the recent distribution of these cysts independently. For this purpose, several works on the recent distribution of dinoflagellate cysts in the Atlantic and its relative areas have been done by DAVEY (1970), WILLIAMS (1971), REID and HARLAND (1974), DAVEY and ROGERS (1974), and WALL *et al.* (1977). In the western Pacific, there are only a few reports on its subject (HARADA, 1974 MS.; MATSUOKA, 1976). These works clarified the characteristics of dinoflagellate cyst assemblage in the neritic to littoral area of Northeastern Honshu. But the pelagic assemblage has been scarcely investigated. The purpose of this paper is to make clear the asseblage of dinoflagellate cysts and other palynomorphs in the typically pelagic and tropical area in the western Pacific.

Samples and mothod

Thirteen samples provided for the study were taken during two research cruises,



Text-fig. 1 : Sample location map

GDP-11 and KH-76-2 Cruises. The GDP-11 Cruise was carried out in 1974 by R/V Tokaidaigaku-maru II of Tokai University. The other, KH-76-2 cruise, was performed in 1976 by R/V Hakuho-maru of Ocean Research Institute of the University of Tokyo.

The surveied area of both cruises was situated around the Daito Ridge and the Amami Plateau in the northern part of the Philippen Sea. All samples were dredged from the slope of sea mounts and the ocean bottom. Table 1 shows the location, water depth, lithology and estimated geologic age of each sample. Some samples have been investigated on calcareous nannoplankton by NISHIDA (unpublished data). *Emiliania huxleyi* and *Gephyrocapsa oceanica* occur together in most of them. From calcareous nannoplankton biostratigraphy, the samples containing *Emiliania huxleyi* are late Pleistocene to Holocene (0.3 Ma. to Recent) in age. The age of other samples lacking these nannoplanktons are exactly unknown. However, their dinoflagellate cyst assemblages are very similar to those of late Pleistocene to Holocene samples.

Table 1 : Some basic data of analized samples

Sample no.	Latitude	Longitude	Depth	Lithology	Age
GDP 11-3	28°05.5'E	134°37.5°E	620m	coarse sand	Late Pleist.- Hol.*
GDP 11-4	28°03.8'N	134°33.0'E	1900m	medium sand	Late Pleist.- Hol.*
GDP 11-5	28°04.1'N	134.32.0'E	3000m	semi-consoridated mud	Late Pleist.- Hol.
GDP 11-6	28°01.9'N	131°41.0'E	1955m	brownish gray hard sandy mud	Late Pleist.- Hol.*
GDP 11-9	28°04.0'N	131°37.8'E	1350m	coarse sand	Late Pleist.- Hol.
GDP 11-10	27°55.5'N	132°05.0'E	2140m	semi-consoridated fine sand	Late Pleist.- Hol.
GDP 11-11	27°55.2'N	132°05.3'E	2135m	light gray, soft sand	Late Pleist.- Hol.
GDP 11-16	28°04.7'N	132°01.2'E	2100m	brown mud	Late Pleist.- Hol.
GDP 11-17	28°05.0'N	132°01.4'E	1800m	gray silt	Late Pleist.- Hol.
KH 76-2-1	27°51.0'N	132°58.6'E	2740m	brown silt	Late Pleist.- Hol.
KH 76-2-2	27°51.0'N	132°58.6'E	2740m	milky white sand	Late Pleist.- Hol.
KH 76-2-4	24°31.5'N	133°06.8'E	2600m	gray sand	Late Pleist.- Hol.

*: samples including reworked fossils of nannoplankton

The preparation method was generally based on following procedure. The original samples were taken into 200cc beaker, then added 10% mixed solution of nitric and hydrochloric acids ($HCl : HNO_3 : H_2O = 1 : 1 : 1$) for removing calcium carbonate material mainly consisting foraminifer, nannoplankton and other mineral consistuents. The dissolved material was repeatedly washed out with pure water. Then, hydrofluoric acid was provided for taking away fine silicate minerals. The organic residure was filterated through 120μm and 20μm mesh screene. The remnant materials on the 20μm mesh screen was concentrated by a centrifuge. The material containing dinoflagellate cysts and other palynomorphs were mounted with glycerine jelly on slide, and cover slipes were sealed with transparent nail enamel.

As the materials provided for analysis were limitted amount, sufficient dinoflagellate cysts were not obtained enough to discuss on the assemblage quantitatively.

Observation

Present observation was carried out under optical microscope with ordinary light and sometimes with interference contrast.

The organic-walled microfossil assemblages in the samples are composed of dinoflagellate eysts, statospores of the Chrysophyceae, foraminifera with only chitinous inner test, pollen, spores and acritarchs. Among them, dinoflagellate cysts mostly dominated and are followed by foraminifera and pollen.

1) Dinoflagellate cyst

Cysts assigned to representative thecate families, the Gonyaulacaceae and the Peridiniaceae are very dominant in the samples from the northern part of the Philippin Sea. The *Gonyaulax* group are composed of *Impagidinium*, *Operculodinium*, *Lingulodinium* and *Spiniferites* in addition to *Nematosphaeropsis*. Most samples are dominated by *Impagidinium* including several species, *I. patulum*, *I. aculiatum*, *I. strialatum*, *I.* sp. A and *I.* sp. B, and last two of which are probably new cyst species. In the samples of GDP–

Table 2 : Result of palynological investigation on dinoflagellate cysts, pollen and spores. Numerical figures indicate absolut count.

Palynomorphs \ samples	GDP 11-3	GDP 11-4	GDP 11-5	GDP 11-6	GDP 11-9	GDP 11-10	GDP 11-11	GDP 11-16	GDP 11-17	KH 76 2-1	KH 76 2-2	KH 76 2-4
Gonyaulax Lineage												
Impagidinium aculeatum											7	7
Impagidinium paradoxum										6	12	35
Impagidinium patulum	33	64	6	54	8	23	41	4	7		1	
Impagidinium strialatum										2	10	15
Impagidinium sp. A		2	2	7						3	7	13
Impagidinium sp. B											3	13
*Hystrichokolpoma rigaudiae**											1	
Lingulodinium cf. *machaerophorum*	16	7	1	4	4	3	7	2				
Nematosphaeropsis labyrinthea	1											4
Operculodinium centrocarpum	1	1		7			1	3	2		4	
Operculodinium israelianum	1	1		2		1		2	1			
Spiniferites cf. *bentori*											1	2
Spiniferites bulloideus	8	8	3	43		5	12	17	14			
Spiniferites mirabilis	5	1		32		4	1	5	4		7	2
Spiniferites ramosus											9	13
Spiniferites sp. indet.	3			11	1	1	2	2	4	3	27	2
Peridinioid Lineage												
Brigantedinium spp.	12	17	8	14	4	9	21	3	16			
Multispinula quanta	2	3					1					
Quinquecuspis concretum				2			1					
Stelladinium stellatum							1					
Trinovantedinium capitatum	2			1								
Votadinium calvum							1					
Gen. et sp. indet.												2
Tuberculodinium Lineage												
Tuberculodinium vancampoae				2		1						
Total number of dinoflagellates	84	104	20	185	17	48	89	38	50	14	89	106
Pollen												
Abies	3			4					1			
Pinus	4	8	6	13	1	5	5	5	7	7	3	3
Tsuga	2	1	1	9		1		1	2			
others			1	1			1					
Spore			1						1			
Total number of pollen and spore	9	9	7	26	1	6	6	6	10	7	3	3

11-6, 16 and 17, *Spiniferites* is the most dominant group. This group mainly consists of cosmolopitan species, namely *S. bulloideus* and *S. mirabilis* as previously suggested by WALL *et al.* (1977). Other species are very rare through all samples. It is noteworthy that no specimens of *Spiniferites elongatus* and *S. membranaceus* ornamented with membraneous parasuture and processes occurred in any samples. *Operculodinium centrocarpum* and *O. israelianum* are also rare in all samples. *Lingulodinium* sp. cf. *machaerophorum*, which are different from *L. machaerophorum* in having a very coarse granulate surface of the periphragm, are of a small amount.

On the other hand, the *Peridinium* group was made up several cyst genera such as *Brigantedinium, Multispinula, Quinquecuspis, Stelladinium, Trinovantedinium* and *Votadinium.* But they are unimportant members in these pelagic samples. The *Tuberculodinium* group consists of only *T. vancampoae* and occurs rarely.

2) Pollen and spores

Pollen and spores occupy a small portion in the total palynomorph assemblage. Furthermore, all component of the pollen assemblage are wind-pollinated taxa such as *Abies, Pinus* and *Tsuga.* Other pollen taxa are very rare.

Discussion

In the western Pacific, BOULOUARD and DELAUZE (1966) reported on some dinoflagellate cysts with many other palynomorphs from bottom sediments in the Japan Trench. According to my re-examination of their photographs (BOULOUARD and DELAUZE, 1966, pl.1, figs. 19, 20 and 27, pl.2, figs. 32 and 33), a few species of *Impagidinium* are recognized. However, they did not record those relative frequencies among the dinoflagellate cyst assemblage. HARADA (1974, MS.) quantitatively investigated on dinoflagellate cysts and acritarchs in many bottom sediments off Northeastern Honshu. Unfortunately, he identified those cysts and acritarchs only on generic level. However, he illustrated several species of *Impagidinium* accompanied with *Spiniferites* and other forms in pelagic sediments collected near the Izu-Ogasawara Trench, and concluded that the genus *Leptodinium* (=*Impagidinium*) has a strictly oceanic hebitat as previously proposed by WILLIAMS (1971).

In the present samples, it is difficult to know the absolute frequency on each dinoflagellate cyst species and other palynomorph, because all samples were not analized quantitatively. Judging from insufficient data on some samples of which original wet weight were made clear, the absolute frequency of the palynomorphs was much less than that of neritic and littoral fine sediments. This is a distinctive characteristic in offshore pelagic palynomorph assemblage as previously pointed out by DAVEY (1971), HARADA (1974, MS.) and WALL *et al.* (1977).

The genus *Impagidinium* including several species is a dominant taxon, and makes up fifteen to fifty percent in each dinoflagellate cyst assemblage. This genus is well known to be a minor element in near-shore sediments where *Tuberculodinium, Lingulodinium* and *Operculodinium* dominate commonly (WILLIAMS, 1971; WALL *et al.*, 1977). The present dinoflagellate cyst assemblages are characterized by an abundance of

Impagidinium and rarity of *Tuberculodinium*, *Operculodinium* and others. This characteristic is also common to other pelagic sediments in the Atlantic. Because the investigated area is situated in warm water region, this feature of dinoflagellate cyst assemllage, also, supports that the genus *Impagidinium* is a typically tropical to subtropical element as clarified by WALL *et al.* (1977) in the Atlantic.

Impagidinium aculiatum is the most dominant species in the Atlantic pelagic sediments (WILLIAMS, 1971; WALL *et al.*, 1977). In the western Pacific, BOULOUARD and DELAUZE (1966) and HARADA (1974, MS.) reported the occurrence of *Impagidinium aculiatum*, *I. paradoxum*, *I. patulum*, *I. strialatum* and other species. But their relative frequencies were not indicated. In the northern part of the Philippin Sea, *Impagidinium* consists of several species with two new forms as previously mentioned. Among them, *Impagidinium patulum* is most dominant. This difference, that is components and dominant species of *Impagidinium* different between the Atlantic and the western Pacific, is an intersting problem. It suggests that each species of this genus might have a somewhat different habitat ecologically, or histrical background.

The present palynomorph assemblage shows another intersting characteristic. Pollen and spores are very rare in all samples. In contrast, the Japan Trench sediments yeilded many pollen and spores which consisted of *Pinus*, *Tsuga*, *Cryptcmeria*, *Carpinus*, *Alnus*, *Quercus*, and others (BOULOUARD and DELAUZE, 1966). The component difference of pollen assemblage of the Japan Trench and the present pelagic area is very distinctive. This fact shows that the accumulation process of palynomorphs may differ between the trench and the pelagic areas. It is tentatively explained by following process. Most of terrestrial material composed of both organic and inorganic particles once settle near river mouth and shore line. Then, they are transported to an off-shore basin such as a trough, trench and others mainly by turbidity current with shallow water material including many marine organisms, and these materials mixed together are trapped in a deep trench and trough. They, therefore, are not provided to a further oceanic floor. The present pollen assemblage consists of *Abies*, *Pinus* and *Tsuga*, all of which have air sacs and are wind-pollinate. These pollen grains might be transported by not turbidity current but wind.

If these accumulation processes are adopted in not only terrestrial pollen and spores but also shallow water palynomorphs, dinoflagellate cysts mainly produced in littoral to neritic area, are possibly trapped in a trench or trough. For this reason, the dinoflagellate cysts found in pelagic sediments seem not to be transported from shallow water areas but to be autoclthonous. It has been generally said that the cyst is resting and benthonic, and that it germinats at a sea floor (eg. WALL and DALE, 1968). But the cyst may be unable to excyst at the pelagic ocean floor, because there is much lower temprature and higher pressure than those in shallow water bottom, and furthermore an aphotic conditon. The general explanation on the cyst behavior as above mentioned is unacceptable in the case of the pelagic forms such as *Impagidinium*. I have already pointed out the possibility of the presence of planktonic cysts on the basis of observation of *Protoperidinium conicoides* (PAULSEN) and its cyst form, *Brigantedinium simplex* (WALL) at off Hachinohe coast, Northeastern Honshu (MATSUOKA, 1976).

Summary

1) Thirteen late Pleistocene to Holocene samples collected from the northern part of the Philippin Sea yielded various palynomorphs such as dinoflagellate cysts, foraminifera, pollen, spores and acritarchs.
2) These dinoflagellate cysts assemblages are characterized by predominance of the genus *Impagidinium*. This characteristic is common to other pelagic and tropical regions.
3) The pollen and spores are poor in both taxonomic variation and abundance. Pollen consists of only wind-pollinated taxa such as *Abies*, *Pinus* and *Tsuga*. This is also a distinctive characteristic in pelagic pollen assemblage.
4) According to abundant occurrence of *Impagidinium* spp. in the present area, these cysts may have a planktonic life mode in the resting period.

Acknowledgement

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Explanation of Plate 1 and 2

Explanation of Plate 1

Figs. 1-4 *Impagidinium paradoxum* (WALL) STOVER and EVITT 1978
1; ventral view, 2; optical section, 3; dorsal view showing a reduced archeopyle, 4; oblique dorsal view. 1-3; Loc. KH-76-2-4, 4; Loc. KH-76-2-2.

Figs. 5-6 *Impagidinium strialatum* (WALL) STOVER and EVITT 1978
5; optical section, 6; oblique dorsal view, Loc. KH-76-2-1.

Figs. 7-8 *Impagidinium aculeatum* (WALL) STOVER and EVITT 1978
7; ventral view, 8; oblique dorsal view, Loc. KH-76-2-2.

Figs. 9-12 *Impagidinium* sp. B
9; ventral view, 10; ventral view showing a parasulcal area, 11; optical section, 12; oblique ventral view, 9; Loc. KH-76-2-2, 10, 11; KH-76-2-4, 12; KH-76-2-4.

Explanation of Plate 2

Figs. 1-2 *Impagidinium paradoxum* (WALL) STOVER and EVITT 1978
1; oblique ventral view showing incomplete reflection of 6c paraplate, 2; lateral view 1; Loc. KH-76-2-2, 2; Loc KH-76-2-4.

Figs. 3-4 *Impagidinium strialatum* (WALL) STOVER and EVITT 1978
1; oblique ventral view, 2; oblique dorsal view, Loc. KH-76-2-4.

Figs. 5-6 *Impagidinium* sp. A
5; oblique dorsal view, 6; oblique dorsal view,
5; Loc. KH-76-2-2, 6; Loc. KH-76-2-2.

Fig. 7 *Spiniferites* sp. cf. *bulloideus* (DEFL. and COOK.) SARJEANT 1970.
optical section, Loc. KH-76-2-1.

Figs. 8-9 *Impagidinium aculeatum* (WALL) STOVER and EVITT 1978
8; apical view, 9; antapical view, Loc. KH-76-2-1.

Fig. 10 *Impagidinium* sp. cf. *patulum* (WALL) STOVER and EVITT 1978
dorsal view, Loc. KH-76-2-2.

Fig. 11 *Nematosphaeropsis labyrinthea* (OST.) REID 1974
optical section, Loc. KH-76-2-4.

Fig. 12 *Spiniferites mirabilis* (ROSS.) SARJEANT 1970
ventral view, Loc. KH-76-2-2.

All figures × ca. 670.

K. MATSUOKA PLATE 1

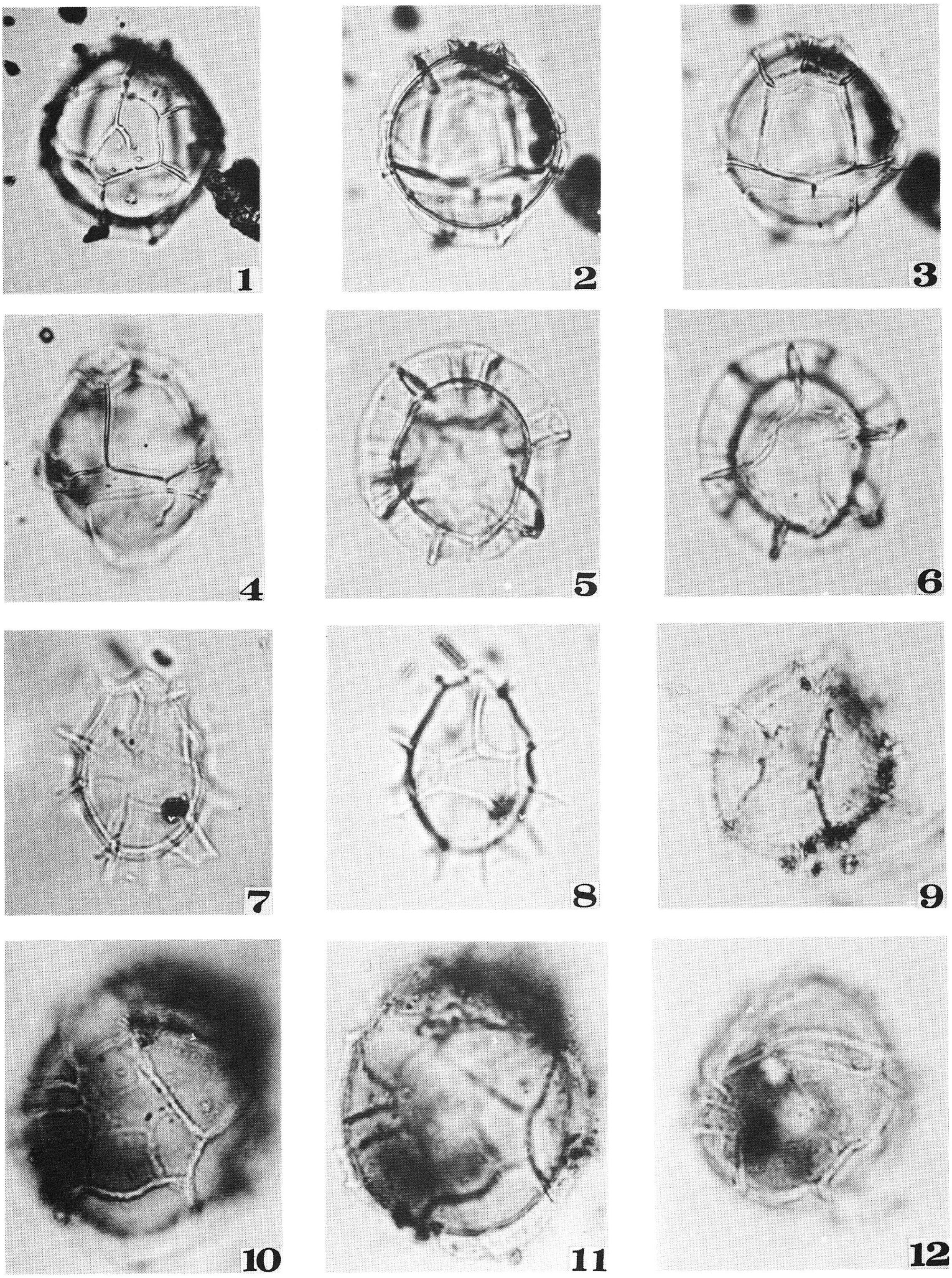

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PLATE 2