

## SOME FOSSIL "LIVING COCCOLITHOPHORID" SPECIES

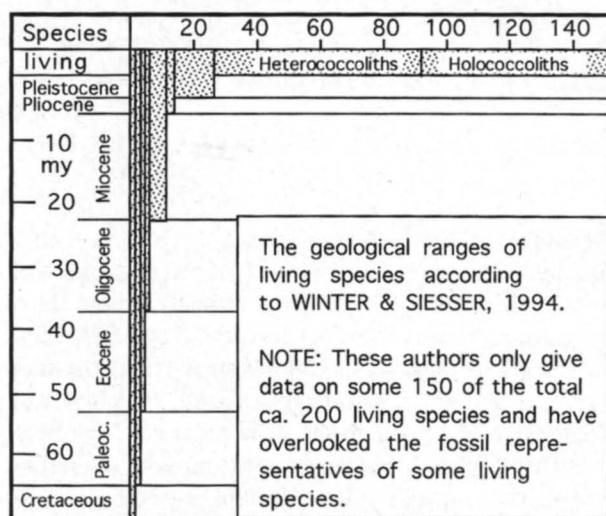
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**Abstract:** Fossil representatives of the following living coccolithophorids never or rarely reported from the fossil record are illustrated: *Coronosphaera binodata*, *Helicosphaera pavimentum*, *Poricalyptus gaarderae*, *Poricalyptus isselii*, *Syracolithus confusus*, *Syracosphaera anthos*, *Syracosphaera pirus*, *Tetralithoides quadrilaminata*, *Umbilicosphaera angustiforamen*. This significantly increases the number of living species with an illustrated ancestor. In addition, one new species, *Pontosphaera decorata* is described, from the Pliocene

## Introduction

Winter & Siesser (1994) provide us with a useful atlas of the living coccolithophorid species. For the specialist interested in fossil coccolithophorids they provide a long wished-for overview of what the result of over 200 million years of calcareous nannoplankton evolution looks like in the form of living species.

In the atlas the authors also make statements about the known geological ranges of some 150 of the nearly 200 presently known, living species. According to this information only 25, (i.e. 17%) of the living species have a fossil record (Fig. 1). The authors warn, that "this information is presented with caution, as comparatively little is yet known about the range/distribution of many species".



While we have known for a long time that not all living species survive transport to the seafloor (Honjo, 1976) and so are not found in the underlying sediments, the non-fossilising percentage of only 17% comes as something of a surprise. Partial explanations may be that nearly 40% of the coccoliths in Winter & Siesser's (1994) atlas are holococcoliths which have a very low fossilisation potential, and that the authors were not specially interested in providing ancestors for the living coccolithophorids. But there also must be a lack of interest from the "palaeontological community", to make an effort to find and report ancestors of living species in the sediment. None of the authors who have presented overviews of the evolution of the calcareous nannoplankton have addressed this problem in earnest or attempted a concentrated search for such species (Haq, 1983; Roth, 1987; Perch-Nielsen, 1986; Bown et al., 1993).

This is an highly unsatisfactory state of affairs

when we want to investigate rates of species appearances and extinctions, or the longevity of species and compare them with other groups of phyto- and zooplankton. Triggered by the realisation, that more must be known than has been reported, I had another look at my TEM and SEM pictures collected over the past quarter of a century. This yielded the Neogene forms discussed in this paper. They are illustrated here in order to illuminate the ranges given by Winter & Siesser (1994). In addition, a first attempt to search the literature also furnished a few Palaeogene species that may be ancestors of living forms.

I hope this presentation will initiate friendly co-operation among colleagues who also have such "corpses" in their EM-collections of calcareous nannofossils, and lead to a better understanding of nannoplankton evolution.

## Material

The following samples yielded the forms illustrated on Plate 1:

- KvS 645 from the "Mio-Pliocene" of Rio Gurabo, St. Domingo (Saunders et al., 1986). The assemblage includes *Reticulofenestra pseudumbilicus*, *Helicosphaera carteri*, *Sphenolithus abies*, *Scapholithus fossilis* and the species shown here. The presence of *Reticulofenestra pseudumbilicus* indicates the presence of NN15 or below (early Pliocene or older). Since discoasters are very rare and no ceratoliths were found, the absence or presence of the marker species of this interval can not be used to allow for a more precise age assignment. Other details of the samples are given by Saunders et al. (1986).

- DSDP Site 119-26; (Perch-Nielsen, 1971)
- DSDP Site 354- 2cc; (Perch-Nielsen, 1977)
- DSDP Site 355-2-4, 70cm; (Perch-Nielsen, 1977)
- DSDP Site 357-5-4, 135cm; (Perch-Nielsen, 1977)

## Systematic descriptions

CLASS PRYMNESIOPHYCEAE HIBBERD, 1976  
Family *Calyptosphaeraceae* Boudreaux & Hay, 1969  
(*Holococcoliths*)

*Poricalyptus isselii* (Borsetti & Cati, 1976) Kleijne,  
1991  
Pl. 1, Fig. 2

**Remarks:** This holococcolith features usually four, sometimes also more or fewer pores and sometimes a central horn, like the Pliocene form illustrated here.

**Occurrence:** living (Winter & Siesser, 1994); Early Pliocene, Rio Gurabo, Dominican Republic.

*Poricalyptra gaarderae* (Borsetti & Cati, 1972)

Kleijne, 1991

Pl. 1, Fig. 1

**Remarks:** The characteristics of this species are the two pores, one on either side of the central bridge with or without a central process. The fossil form illustrated has the same characteristics.

**Occurrence:** living (Winter & Siesser, 1994); Early Pliocene, Rio Gurabo, Dominican Republic.

*Syracolithus confusus* Kleijne 1991

Pl. 1, Figs 4, 5

**OR** *Calyptrolithina multipora* (Gaarder, 1980) Norris 1985

**OR** *Helladosphaera dalmatica* (Kamptner, 1927) Okada & McIntyre, 1977 (in Steinmetz, 1991).

**Remarks:** *S. confusus* is characterised by 5-8 cavities according to the original description. Kleijne (1991) however, illustrates a paratype (pl. VI, fig. 4) with more than the "allowed" 8 cavities, since there are already 7-8 visible on half a coccolith. In the specimens illustrated here from the Pliocene, there are from 10 to more than 20 cavities. Thus although the two Pliocene specimens illustrated here are similar to recent forms a precise assignment is difficult. Nevertheless if we assume, that these specimens belong to one of the possible candidates this increases the number of living species with an illustrated ancestor by another species.

Note the different states of preservation shown in the detail Pl. 1, Fig. 5. Here the small size of the crystals in the well preserved wall of the specimen can be observed next to somewhat larger units in the distal, dome-shaped part of the coccolith. The wall includes, however, also heavily overgrown zones where the originally discrete crystals fuse into larger blocks, as is usually the case in older holococcoliths.

Similar but larger specimens from the upper Palaeocene, which were described by Perch-Nielsen (1971) as *Semihololithus biskayae* also have more than 5-8 cavities (Pl. 1, Fig. 6).

**Occurrence:** Living (Winter & Siesser, 1994); Early Pliocene, Rio Gurabo, Dominican Republic; probably also in the Late Palaeocene of the Bay of Biscay (Perch-Nielsen, 1971).

"In search of a descendant??"

Pl. 1, Figs 7, 8

**Remarks:** The two holococcoliths illustrated here have no obvious descendant among the living holococcoliths. The form shown in Pl. 1, Fig. 7 is polygonal and features a central cavity, while Fig. 8 has an elliptical outline. The latter might correspond to the proximal view of several species, while there seems to be no correspondent living form to the former.

**Occurrence:** Early Pliocene, Rio Gurabo, Dominican Republic.

**Family Coccolithaceae Poche, 1913**

*Geminilithella rotula* Kamptner (1956) Backman 1980  
Pl. 1, Fig. 14.

This is included as a prime example of a common, but relatively poorly known, fossil coccolith whose descendants are unclear.

**Occurrence:** Early Miocene to Late Pliocene.

*Umbilicosphaera angustiforamen* Okada & McIntyre, 1977

Pl. 1, Fig. 15

**Remarks:** The two shields are typically equal in size in this genus and species, a feature that can also be observed in the distal view illustrated here. The angular plates described from the holotype are not preserved in the fossil specimen illustrated here. Another living species of *Umbilicosphaera* with a wide open central area, *U. maceria*, is smaller and has only some 30 elements, while *U. angustiforamen* has more than 40 elements.

**Occurrence:** living (Winter & Siesser, 1994); Early Pliocene, Rio Gurabo, Dominican Republic.

**Family Helicosphaeraceae Black, 1971***Helicosphaera pavementum* Okada & McIntyre 1977

Pl. 1, Fig. 12

**Remarks:** Like most living species, *H. pavementum* is usually illustrated in distal view. This shows a form with a central area that is formed of a pavement of minute laths arranged  $\pm$  parallel to the long axis of the coccolith which, at around 5  $\mu$ m long, is considerably smaller than the more common *H. carteri/kamptneri/wallichii*, which is well known from the fossil record. The proximal view illustrated here shows a broken specimen featuring a suture-line  $\pm$  along the long axis of the coccolith.

**Occurrence:** Living -- Late Pleistocene (Winter & Siesser, 1994); Early Pliocene, Rio Gurabo, Dominican Republic; probably widespread but not generally reported.

**Family Pleurochrysidaceae Fresnel & Billard, 1991**

*Tetralithoides quadrilaminata* (Okada & McIntyre, 1977) Jordan et al. (1993)

Pl. 1, Figs 9, 10

**Remarks:** *T. quadrilaminata* is characterised by a very thin rim and a very wide central area covered by four thin plates. In the forms illustrated here the thin rim and wide central area are well developed, but the exact structure of the central area in the form of a plate, plates or other is not clearly visible due to overgrowth and other particles overlying the central area. This species is listed by Winter & Siesser (1994) as *Cricosphaera quadrilaminata*, with



no known fossil record. Subsequent work has revealed its identity with *Tetralithoides symeondesii* (Theodoridis 1984) and so given it a lengthy fossil range (Jordan *et al.* 1993).

**Occurrence:** Living (Winter & Siesser, 1994); DSDP Site 372 in the western Mediterranean, the Atlantic and Indian Oceans in the Miocene (NN 2- NN 11) according to Theodoridis (1984); Quaternary of the Philippine Sea (Matsuoka & Okada, 1989) and DSDP Site 354 on Ceara Rise north of Brazil, samples from NN 16 & NN19.

**Family Pontosphaeraceae Lemmermann, 1908**

*Pontosphaera decorata* n.sp.

Pl. 1, Fig. 13

**Holotype:** Pl. 1, Fig. 13. Negative No. 6/3412-5; deposited at the Museum of Natural History, Basel.

**Locus typicus:** Rio Gurabo, Dominican Republic.

**Stratum typicum:** NN 15 or below, Early Pliocene or older.

**Diagnosis:** Flat species of *Pontosphaera* with a narrow wall surrounding a distal area composed of  $\pm$  tangentially oriented laths pierced by very small holes/depressions. More than four small blocks about 1  $\mu$ m high are arranged around the central area pierced by the holes/depressions.

**Remarks:** No other flat species of *Pontosphaera* has small blocks arranged around the pierced part of the central area.

**Range:** Forms similar to *P. decorata* have not been reported from living or fossil assemblages so far. NN 15 or below.

**Family Syracosphaeraceae (Lohmann)  
Lemmermann, 1903**

This family includes coccoliths of widely varying construction. What the specialists of living coccolithophorids call "caneoliths" would, by some authors specialised in fossil forms be called coccoliths with a zeugoid wall and  $\pm$  open central area. In the fossil realm, such forms are assigned to the recent families Pontosphaeraceae, Calcosoleniaceae and the Syracosphaeraceae and the following fossil families:

- the **Chiastozygaceae** which feature wall(s) of vertical or oblique elements and a central area spanned by a X or more elaborate central arrangement of elongated elements. Such forms disappear with the extinction of *Isthmolithus recurvus* in the Oligocene, some 32 million years ago.

- the **Stephanolithiaceae** which include forms of varying outline, a wall of vertical elements and a central area spanned by a great variation of usually  $\pm$  radially oriented elements topped or not with a central process. The family

is considered to have become extinct at the Cretaceous-Tertiary boundary, with the extinction of the Maastrichtian species of *Rotelapillus*, *R. munitus*, some 65 my ago. Some of the forms assigned to the recent family Syracosphaeraceae however, might well be descendants of forms that would be assigned to the Stephanolithiaceae in the fossil realm.

? *Coronosphaera binodata* (Kamptner 1937) Gaarder & Heimdal, 1977 or

? *Coronosphaera mediterranea* (Lohmann 1902)  
Gaarder, 1977  
Pl. 1, Figs 17, 18

**Remarks:** *C. binodata* as illustrated in Steinmetz (1991) has a wall of imbricated elements and a central area featuring a floor of  $\pm$  radially arranged elements topped by two thick nodes. *C. mediterranea*, on the other hand, features a central, elongated boss along the longaxis surmounted or not by a central process. Coccoliths with such a wall are also found in the fossil record. The central area in the forms illustrated here is empty. Forms with nodes have, however, been observed in several samples with the light microscope. In the Cretaceous, such simple rings as those illustrated here would be assigned to the Cretaceous species *Loxolithus armilla*, of which no specimen with a filled central area has been illustrated to date.

**Occurrence:** living (Winter & Siesser, 1994); Early Pliocene, Rio Gurabo, Dominican Republic.

*Syracosphaera anthos* (Lohmann 1912) Janin, 1987  
*S. variabilis* Halldal & Markali, 1955  
*Deutschlandia gaarderae* Perch-Nielsen, 1980

**Remarks:** Perch-Nielsen (1980) described *D. gaarderae* from the middle Pliocene. It has since been suggested that the differences used by Perch-Nielsen (1980) to distinguish the fossil specimens from the recent ones -- the nearly double size and the higher central cone in the fossil form -- are insufficient to characterise a new species different from the living one.

**Occurrence:** living (Winter & Siesser, 1994) ; Early Pliocene (NN 15) of DSDP Site 357 (Perch-Nielsen, 1980).

*Syracosphaera ?pirus* Halldal & Markali, 1955  
Pl. 1, Fig. 16

**Remarks:** *S. pirus* as illustrated in Steinmetz (1991) is characterised by its lenticular shape, its wall of two cycles of vertically standing elements surrounding a central area bridged by radially oriented laths that bear a central process of vertically standing, long parallel laths. In the specimen illustrated here the wall also consists of vertical elements. It is, however, not clear beyond doubt that there are two cycles of elements, since overgrowth has affected the fossil coccolith. The central stem is shorter than in the living form, a feature probably due to breakage. Its struc-

ture is not discernible. The radial laths of the floor are present.

Similar forms lacking any remains of the central area are not uncommon in some samples. Their relationship with the Palaeocene species *Nodosella? franzii* from the Lower Palaeocene of Tunisia (Perch-Nielsen, 1981, pl. 1, figs 4,5, 7-9) will have to be investigated further. Similar forms with a wall of  $\pm$  vertical elements are also known from the Mesozoic family Stephanolithiaceae (see above).

The identification is given as *S?pirus* since most illustrations of *S.pirus* and *S.prolongata* (a closely associated form), show three distinct flanges around the coccolith (see e.g. figs in Winter & Siesser, 1993 or INA Newsletter 14/1:40), so it is not certain that the form illustrated by Steinmetz was correctly identified.

**Occurrence:** living (Winter & Siesser, 1994); NN 5 (middle Miocene) DSDP Site 355-2-4,70 (Brazil Basin).

### Conclusions

The additional fossil representatives of living coccolithophorids presented here -- actually also including *Gladiolithus flabellatus* which has been found in Holocene sediments with the light microscope -- add another ten species to the 25 noted by Winter & Siesser (1994) as species with a fossil record. It will need a major effort from the calcareous nannofossil community, to gain a more realistic picture of the history of evolution of the ancestors of the living species of coccolithophorids than the one illustrating the presently acknowledged state (Fig. 1). It will also need co-operation from the authors illustrating living coccolithophorids. From the published pictures it is often impossible to see the structure of the single coccoliths. Thus I have a feeling that some small species may have larger ancestors in the fossil record but that we do not realise this, because we do not have any illustration of those species from which the fine structure is clearly visible. On the other hand species of *Syracosphaera* look rather similar to some forms of the Mesozoic Stephanolithiaceae.

Below is an attempt at assigning some fossil Palaeogene and Jurassic species to living species based on EM-illustrations

<i>Living species</i>	=	<i>Palaeogene fossil species?</i>
<i>Coccolithus neohelis</i>		<i>Cruciaplacolithus tarquinius</i> in Roth, 1970
		<i>Cr. primus</i> P-N 1977 a.o.
<i>Cyrtosphaera cucullata</i>		<i>Cepikiella elongata</i> Roth, 1970
<i>Homozygosphaera wettsteinii</i>		<i>Discolithus solidus</i> Deflandre, 1954 (in Varol, 1989)

<i>Homozygosphaera schilleri</i>	<i>Discolith. macroporus</i> Deflandre, 1954 (in Varol, 1989)
<i>Pontosphaera syracusana</i>	<i>Pontosphaera crucifera</i> Roth, 1970
<i>Syracolithus confusus</i>	<i>Semihololithus biskayee</i> P-N, 1971
<i>Syracolithus quadriperforatus</i>	<i>Zygospaera brytika</i> Roth, 1970
<i>Syracosphaera ossa</i>	<i>Coccolithus joensuui</i> in Hay et al., 1967

<i>Living species</i>	=	<i>Jurassic fossil species?</i>
<i>Calyptrolithina multipora</i>		<i>Anfractus variabilis</i> Medd, 1979
<i>Calyptrolithina divergens</i>		<i>Anfractus harrisonii</i> Medd, 1979
<i>Syracolithus bicorium</i>		<i>'Neococcolithes dubius'</i> Medd, 1979

If we want to make more educated guesses as to longevity and changes in the evolutionary rates over the past 20 my than has up to now been done, we have several ways to do this:

- one person works in splendid isolation for 10 years.

- several people pool their work and embark on intelligent, coordinated investigation of those sections that promise results. These will be sections with exceptionally well preserved assemblages and, at the same time, a good age control.

- everybody works on her/his own, thus probably duplicating a lot of work.

As INA approaches 20 years of "friendly cooperation" I hope to be able to entice INA members to join me in the effort to make a giant step forwards in the "acquisition" of ancestors of living coccolithophorid species. The goal could be to present INA with a "jubilee-gift" for its first 20 years in 1997.

### Acknowledgements

I would like to thank those who gave me the samples which formed the basis of this study: John Saunders, Basel, supplied the samples from the Dominican Republic and the DSDP those from the Atlantic Ocean. Jeremy Young (London) and Ric Jordan (Yamagata) suggested welcome improvements.

### REFERENCES

**Taxonomic references** that are included in Perch-Nielsen (1985 - nannofossils) or Jordan & Kleijne (1994 - living nannoplankton) are not listed below. They can also be found in the Index and Bibliography of Calcareous Nannoplankton -

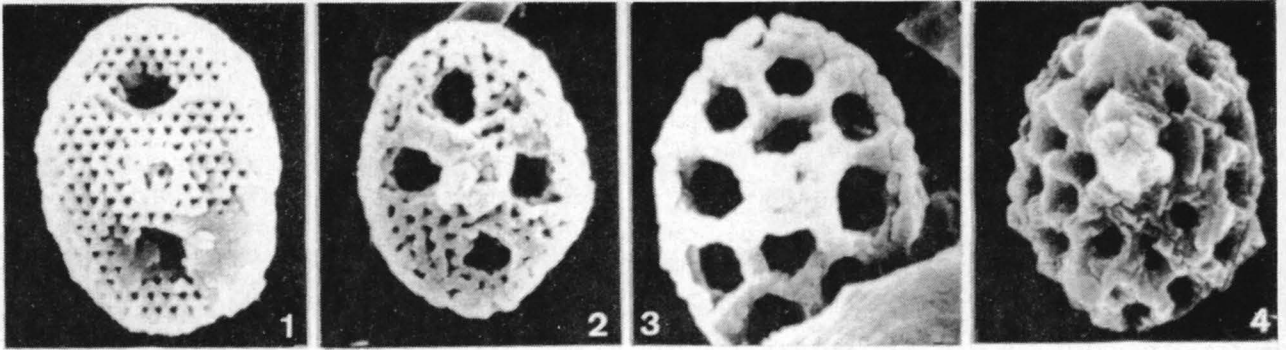
### Magnifications

**Figs 1:** 7.500x; **2:** 15.000x; **3:** 15.000x; **4:** 10.000x; **5:** 9.000x; **6:** 13.000x; **7:** 10.000x; **8:** 13.000x; **9:** ???; **10:** ???; **11:** 10.000x; **12:** 6.500x; **13:** 7.800x; **14:** 7.500x; **16:** 9.000x; **17:** 7.500x; **18:** 10.000x.

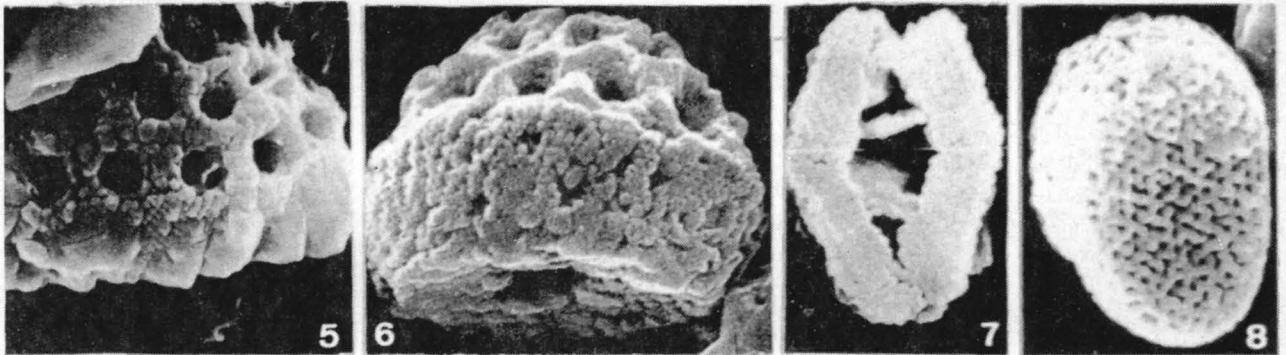
### Localities

**Dominican Republic, Rio Gurabo section;**  $\approx$  NN 15, Early Pliocene: Figs 1, 2, 3, 4, 5, 7, 8, 11, 12, 13, 14, 17, 18. **DSDP Site 119-26, NP 9, Late Palaeocene:** Fig. 6. **DSDP Site 354-2cc, NN 19, Early Pleistocene:** Fig. 9. **DSDP Site 354-3-2, 115cm, NN 16, Late Pliocene:** Fig. 10. **DSDP Site 357-5-4, 135cm,  $\approx$  NN 7, middle Miocene:** Fig. 15. **DSDP Site 355-2-4, 70cm, NN 5, Early Miocene:** Fig. 16.

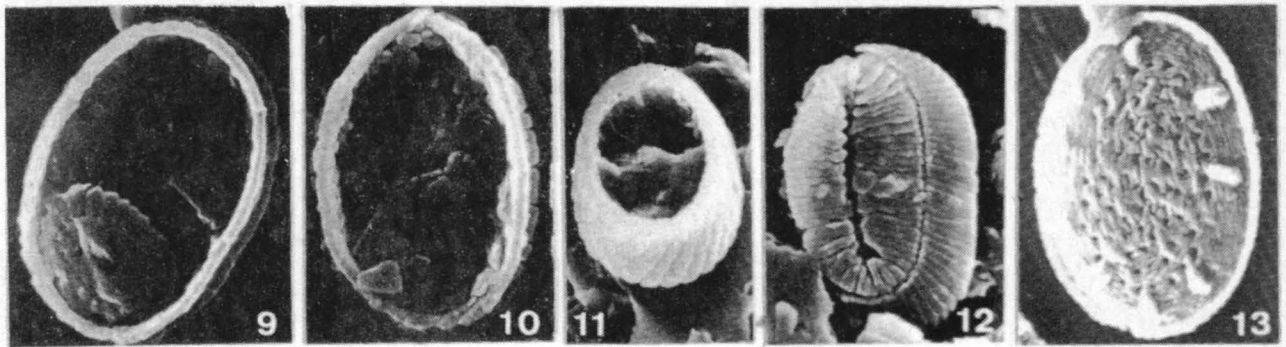




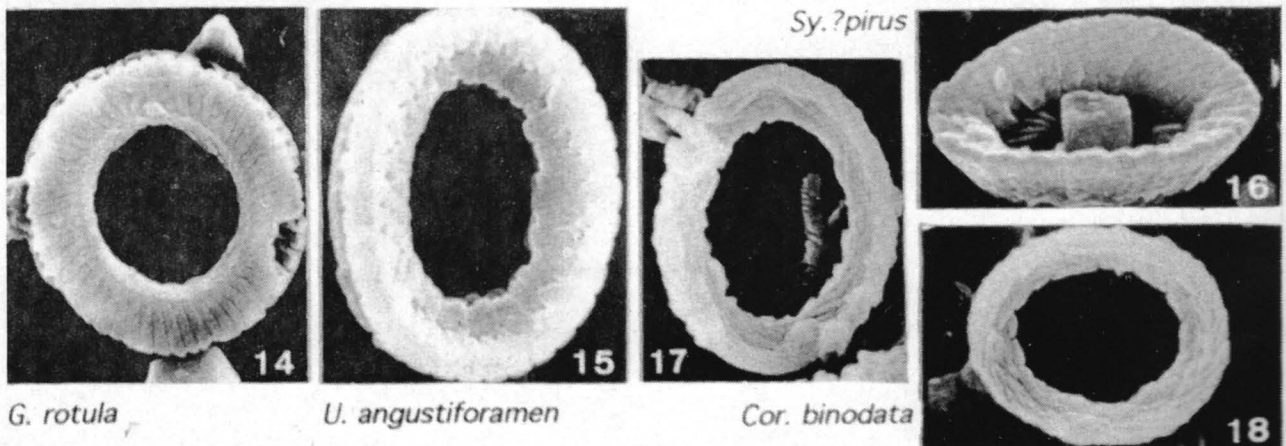
*Poricalyptra gaarderae*    *Poricalyptra isselii*    *Syracolithus confusus*    *Syracolithus confusus*



*Syracolithus confusus*    *Semihol. biscayae* Pal.    *Holococcolith*    *Holococcolith*



*Tetralithoides quadrilaminata*    *Syracosph. ? sp.*    *H. pavementum*    *P. decorata*, HT



*G. rotula*    *U. angustiforamen*    *Cor. binodata*    *Sy. ?pirus*

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