ΓΕΩΛΟΓΙΑ.— **Upper Eocene Radiolaria in Cyprus,** *by Michael Mantis* *. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Ἰω. Τρικκαλινοῦ.


ABSTRACT

Twenty eight radiolarian species are recorded, for the first time, from the massive chalks and marls of the Lefkara group. These radiolarian species represent among others a unique faunal assemblage restricted within the Upper Eocene *Hantkenina alabamensis* Zone. They form a mixed radiolarian and foraminiferal assemblage which is restricted within the massive chalk horizon of the Lefkara group.

The species identified are compared with the faunal assemblages described from California, Barbados, Saipan Mariana islands, U.S.S.R. and from the deep sea sediments drilled by the Deep Sea Drilling Project.

The radiolarian assemblage is under systematic study and new species are also present. The up to now identified species are photographed and illustrated in plates I and II. A map showing the localities sampled and a distribution chart of the Radiolarian species in the massive chalks are also provided.


## INTRODUCTION

Our present knowledge on radiolaria and especially on their stratigraphic value is so scant and therefore the record of any new assemblage is significant and contributes to our knowledge as to their stratigraphic significance and geographical distribution.

The great majority of the described fossil radiolaria belong to Cenozoic formations and these are mainly from Upper Eocene formations. The Eocene marls, chalks and silicified limestones are very rich in radiolaria. No radiolaria faunas were earlier described from the Eocene sediments of Cyprus.

The present study deals with the radiolarian assemblage present in Upper Eocene sediments bordering the Troodos mountains of Cyprus

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and compares them with those previously recorded from California, Saipan islands, U.S.S.R. and from deep sea sediments.

The radiolarian species herein recorded were found in material studied from several outcrops and boreholes samples drilled for groundwater and from samples collected during geological mapping. The radiolarian assemblage has been mainly recorded from material studied from the following boreholes 3/65 at Alethrico, Larnaca District, 17/67 near Ayios Theodoros and 18/67 near Psematismenos, MR 20/68 and MR 25/68 in Mitsero area. They have been also recorded in material studied from the Cement Factory quaries, from Pyla area samples no. PL 64 - PL 70, from Kilani and Perapedhi village areas samples no. PL 726 - PL 735 and in material studied from Yerovassa area and from Trimiklini and Limnatis village areas.

In all material studied the original siliceous material of the radiolarian tests is well preserved and even the finer details of the species can be observed. It must be emphasized that by no means all of the radiolaria species present in the Upper Eocene sediments of Cyprus are here recorded. All the forms herein recorded are identical with, or similar to, species already described from Upper Eocene sediments elsewhere (see references sited).

## STRATIGRAPHIC POSITION OF THE RADIOLARIAN ASSEMBLAGE

The radiolarian bearing horizon is within two well defined foraminiferal zones. The underlying sediments are characterised by a rich planktonic foraminiferal assemblage consisting mainly of keeled Globorotalias and Globigerina which are within the Globorotalia rex-aragonensis Zone of Lower Eocene age. Lithologically consists of chalk, cherts and marls and form part of the Pano Lefkara Formation (Mantis, 1970) no Middle Eocene sediments have until now been recorded underlying the Radiolarian bearing horizon. In most cases the radiolarian species are abundant and foraminifera are very rare or are absent from the samples while in certain cases a rich foraminiferal assemblage is present. Among the species present are :

*Hantkenina alamabensis* Cushman
*Hantkenina primitiva* Cushman and Jarvis
*Globigerina tripartita tripartita* Koch
*Globorotalia renzi* Bolli
*Globigerina praebulloides praebulloides* Blow
*Globigerinita martini martini* Blow and Banner
*Globigerapsis index* (Finlay)

This foraminiferal assemblage is well known from the Upper Eocene of many places (Eames et al. 1962). The coexistence of this foraminiferal assemblage and the herein recorded radiolarian species denote beyond any doubt the age of the radiolarian bearing horizon. It is of interest to note that the radiolarian bearing horizon constitutes part of the Hantkenina bearing horizon. The Hantkenina species are rare and the stratigraphic evaluation of the radiolarian assemblage is significant especially in drilling projects.

Lipman (1950) described similar radiolarian fauna from the Upper Eocene of Western Siberia lowland, from Kyzyl-Kum and Turkomania. Among the species recorded are *Sethocyrtis elegans* Lipman *Astrophacus annularius* Lipman *Cenosphaera valentinae* Lipman etc. While Clark and Campbell (1942) described *Lithochytris cheopsis* from the Upper Eocene of California and Riedel (1957) described a closely related radiolarian fauna from the Eocene succession of Saipan Islands. Riedel and Sanfilippo (1970) and Dumitrica P. (1973) record similar radiolarian species from the deep sea sediments from the Deep Sea Drilling project in the deep ocean basins.

The overlying succession has not yet been satisfactorily studied and research is still in progress. Available evidence from drilling in the Psematismenos-Anglisidhes area show that the radiolarian bearing horizon is underlying Oligocene strata while evidence obtained from Perapedhi-Kilani area suggests that this radiolarian assemblage in within the Hantkenina horizon. The value of radiolarians for local and general correlations has already been widely accepted. All species are pelagic and have a wide geographic distribution. This factor together with the high degree of complexity that species might attain are of special value in establishing local and general correlation systems.

RADIOLARIAN SPECIES

1) *Sethocyrtis elegans* Lipman
2) *Sethocyrtis principii valgrandensis* Clark and Campbell
3) *Sethocyrtis minimus* Lipman
4) *Podocyrtis mitra* Ehrenberg
5) *Podocyrtis pedicellaria* Haeckel
6) *Podocyrtis angus* Ehrenberg
7) *Podocyrtis fasciata* Clark and Campbell
8) *Phormocyrtis lingulata* Clark and Campbell
9) *Phormocyrtis striata* Brandt
10) *Dictyocephalus lipogaster* Clark and Campbell
11) *Dictyophimus babylonis* Clark and Campbell
12) *Lithochyrtis cheopsis* Clark and Campbell
13) *Theocotyle ficus* Ehrenberg
14) *Ellipsoxiphus chabakovi* Lipman
15) *Cenodiscus akojensis* Lipman
16) *Lychnocanium bellum* Clark and Campbell
17) *Astrophacus annularius* Lipman
18) *Anthocyrtium byronense* Clark and Campbell
19) *Calocycloma ampulla* (Ehrenberg)
20) *Calocyclas litos* Clark and Campbell
21) *Galocyclas rachiphora* Clark and Campbell
22) *Calocyclas semipolita* Campbell
23) *Clathrocyclas universa nova* (Clark and Campbell)
24) *Sethamphora mongolfieri* (Ehrenberg)
25) *Archicorys bella* Clark and Campbell
26) *Cenosphaera politepora* Lipman
27) *Cenosphaera valentinae* Lipman
28) *Heliodiscus heliastericus* Clark and Campbell

DEVELOPMENT OF THE CYPRUS FAUNA

The sudden appearance and disappearance of this distinct radiolarian assemblage is of great importance. The silica enrichment of the Eocene sea of Cyprus may only be explained by a probably short volcanic

activity in the vicinity since volcanic erruptions in Cyprus ceased since Upper Cretaceous Campanian times. The enrichment of silica favoured the development of the radiolarian fauna. It is well known Campbell (1964) that much of the reproductive activity of the Radiolaria seems to be in epidemic form, after local, temporary enrichment of the sea in silica. This may explain the vast number of specimens in the material studied.

The systematic descriptions of the species hereim recorded will appear in another publication.

## ΠΕΡΙΛΗΨΙΣ

Ἡ παροῦσα ἀνακοίνωσις ἀφορᾷ τὰ Ἀκτινόζωα ποὺ ἀπαντοῦν ἐν πληθώρᾳ εἰς τὰ Ἄνω Ἠωκαινικὰ ἰζηματογενῆ πετρώματα τῆς νήσου Κύπρου. Ἀπὸ ἀρκετὸν χρόνον ἔχομεν συλλέξει ὑλικὸν πρὸς μελέτην τούτων ἀπὸ διαφόρους ἐμφανίσεις τῆς νήσου κυρίως ἀπὸ τὰς πέριξ τῆς ὀροσειρᾶς τοῦ Τροόδους ἀναπτυσσομένας συμπαγεῖς κρητίδας μετὰ μαργῶν, αἵτινες εἶναι εὐρέως διαδεδομέναι. Τὸ μελετηθὲν ὑλικὸν προέρχεται τόσον ἀπὸ γεωτρήσεις ὅσον καὶ ἀπὸ τὰς ἡμετέρας συστηματικὰς ἐπιφανειακὰς δειγματοληψίας.

Ἔχομεν προσδιορίσει εἴκοσι ὀκτὼ εἴδη ἀκτινοζώων καὶ ταῦτα ἀνακοινώνονται καὶ καταγράφονται διὰ πρώτη φορὰν ἀπὸ τὰ Ἄνω Ἠωκαινικὰ πετρώματα τῆς νήσου Κύπρου, ἅτινα κατατάσσονται εἰς τὴν Ὁμάδα τῶν Λευκάρων.

Τὰ ἀκτινόζωα αὐτὰ ἀποτελοῦν ἰδιαιτέραν πανίδα, ἥτις περιορίζεται καὶ ἀναπτύσσεται μόνον ἐντὸς τῶν Ἄνω Ἠωκαινικῶν πετρωμάτων, ἅτινα χαρακτηρίζονται ἀπὸ τὴν ζώνην τοῦ τρηματοφόρου *Hantkenina alabamensis*. Ἀποτελοῦν μίαν ἀνάμικτον μικροπανίδα ἀκτινοζώων καὶ πλαγκτονικῶν τρηματοφόρων, ἥτις ἀπαντᾷ μόνον ἐντὸς τῶν συμπαγῶν κρητίδων καὶ μαργῶν τῆς ὁμάδος τῶν Λευκάρων καὶ εἶναι χαρακτηριστικὰ ἀπολιθώματα τῶν πετρωμάτων αὐτῶν.

Τὰ προσδιορισθέντα εἴδη ἀκτινοζώων συγκρίνονται μετὰ τῶν ἤδη περιγραφεισῶν πανίδων ἐκ διαφόρων ἀπομεμακρυσμένων περιοχῶν, ὡς ἡ Καλιφόρνια, νῆσοι Μαριάνα, Παρπάδος, ὡς καὶ μετὰ τῶν ἀναφερομένων πανίδων ἐκ τῶν δειγμάτων ἀπὸ γεωτρήσεις ἐντὸς τῶν βαθειῶν θαλασσῶν.

Λόγῳ τῆς περιωρισμένης ἐρεύνης εἰς τὴν ὁμάδα αὐτὴν αἱ γνώσεις μας ὡς πρὸς τὴν στρωματογραφικὴν ἀξίαν τῶν ἀκτινοζώων εἶναι λίαν περιωρισμέναι. Οὕτω κάθε ἀναφορὰ οἱασδήποτε νέας περιγραφῆς πανίδος ἀκτινοζώων εἶναι λίαν

σημαντικὴ καὶ προσφέρει τὰ μέγιστα ὡς πρὸς τὴν στρωματογραφικὴν θέσιν καὶ γεωγραφικὴν ἐξάπλωσιν τούτων διὰ σκοποὺς παραλληλισμοῦ.

Εἶναι γεγονὸς ὅτι εἰς τὴν σχετικῶς περιωρισμένην βιβλιογραφίαν τῶν ἀκτινοζώων αἱ περισσότεραι ἀναφοραὶ ἀφοροῦν ἀκτινόζωα τοῦ Ἠωκαίνου. Ἐν Κύπρῳ ἡ παρουσία τῆς ἐν λόγῳ πανίδος ἐνέχει μεγάλην σημασίαν εἰς τὴν γεωλογικὴν ἐπισκόπησιν τῆς νήσου, καθ' ὅτι καθορίζει σαφῶς τὴν στρωματογραφικὴν θέσιν ἑνὸς σημαντικοῦ γεωλογικοῦ ὁρίζοντος. Συμβάλλει κυρίως εἰς τὴν μελέτην καὶ παραλληλισμὸν τῶν γεωτρήσεων, ὅταν δὲν συνυπάρχουν τὰ καλῶς γνωστὰ χαρακτηριστικὰ τρηματοφόρα. Ἡ παρουσία τῶν ἀκτινοζώων αὐτῶν εἶναι ἀρκετὴ ἔνδειξις διὰ τὸν προσδιορισμὸν τῆς Ἄνω Ἠωκαινικῆς ἡλικίας τῶν πετρωμάτων. Ἡ στρωματογραφικὴ ἀξία τῶν ἀκτινοζώων διὰ σκοποὺς τοπικοῦ παραλληλισμοῦ εἶναι εὐρέως ἀποδεκτή, καθ' ὅτι ὅλα τὰ εἴδη εἶναι πλαγκτονικὰ καὶ ὡς ἐκ τούτου ἔχουν εὐρεῖαν γεωγραφικὴν ἐξάπλωσιν. Ὁ παράγων αὐτὸς μετὰ τῶν πολυπλόκων χαρακτήρων πολλῶν εἰδῶν προσλαμβάνουν ὅλον καὶ μεγαλύτερον ἐνδιαφέρον ὡς πρὸς τὴν δημιουργίαν συστήματος ζωνώσεως τῶν ἱζηματογενῶν πετρωμάτων, ὡς ἔχει ἤδη γίνει καὶ μὲ ἄλλας ὁμάδας μικρο-ἀπολιθωμάτων, ὡς τρηματοφόρων καὶ κοκκολίθων καὶ ἄλλων. Ὁ μεγάλος ἀριθμὸς εἰδῶν καὶ ἡ στρωματογραφικὴ των ἀξιοποίησις ἐπιτρέπει τὸν ἀκριβῆ προσδιορισμὸν τῆς ἡλικίας τῶν πετρωμάτων εἰς ἅτινα ἀπαντοῦν, καὶ ἡ δημιουργία ζωνώσεως τῶν Ἄνω Ἠωκαινικῶν πετρωμάτων βάσει τῆς πλουσίας αὐτῆς μικροπανίδος τῶν ἀκτινοζώων πρὸς πληρέστερον ἔλεγχον, ὡς καὶ ἡ συστηματικὴ περιγραφὴ τῶν εἰδῶν, ἀποτελεῖ ἰδιαιτέραν μελέτην ἥτις συνεχίζεται.

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Map of Cyprus showing the localities (●PL64) and Borehole sites (●MR/3/65)

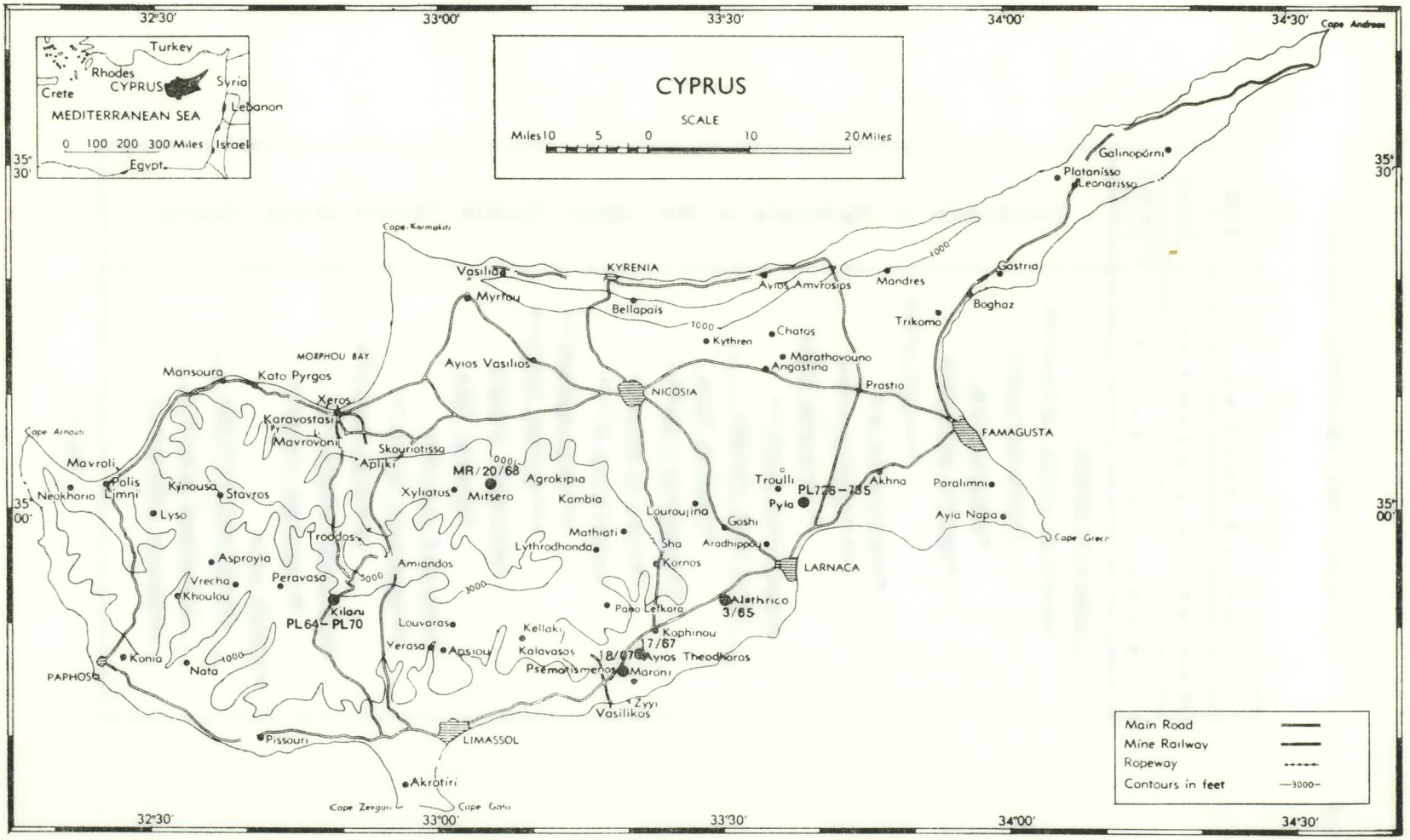



Fig. 1.

| UPPER EOCENE | AGE |
|---|---|
| Hankenina alabamensis | ZONE |
| MASSIVE CHALKS | FORMATION |
| Sethocyrtis elegans<br>Sethocyrtis prinsipii valgrandensis<br>Sethocyrtis minimus<br>Podocyrtis mitra<br>Podocyrtis pedicellaria<br>Podocyrtis angus<br>Podocyrtis fasciata<br>Phormocyrtis lingulata<br>Phormocyrtis striata<br>Dictyophimus babylonis<br>Lithochytris cheopsis<br>Theocotyle ficus<br>Ellipsoxiphus chabakovi<br>Cenodiscus akojensis<br>Lychnocanium bellum<br>Astrophacus annularius<br>Anthocyrtium byronense<br>Calocycloma ampulla<br>Calocyclas litos<br>Calocyclas rachiphora<br>Dictyocephalus lipogaster<br>Calocyclas semipolita<br>Clathrocyclas universa nova<br>Sethamphora mongolfieri<br>Archicoris bella<br>Cenosphaera politepora<br>Cenosphaera valentinae<br>Heliodiscus heliastericus | Distribution of Radiolaria in the Upper Eocene Massive chalks Cyprus |

Fig. 2.

## EXPLANATION OF PLATES

### PLATE I

1. *Lithochytris cheopsis* Clark and Campbell
2. *Archicorys bella* Clark and Campbell
3. *Podocyrtis angus* Ehrenberg
4. *Phormocyrtis lingulata* Clark and Campbell
5. *Anthocyrtium byronense* Clark and Campbell
6. *Astrophacus annularius* Lipman
7. *Calocycloma ampulla* (Ehrenberg)
8. *Dictyocephalus lipogaster* Clark and Campbell
9. *Sethocyrtis principii valgrandensis* Clark and Campbell
10. *Cenodiscus akojensis* Lipman, 1950
11. *Calocyclas litos* Clark and Campbell
12. *Sethamphora mongolfieri* (Ehrenberg)
13. *Sethocyrtis minimu* Lipman

All Stereoscan Microphotographs × 180

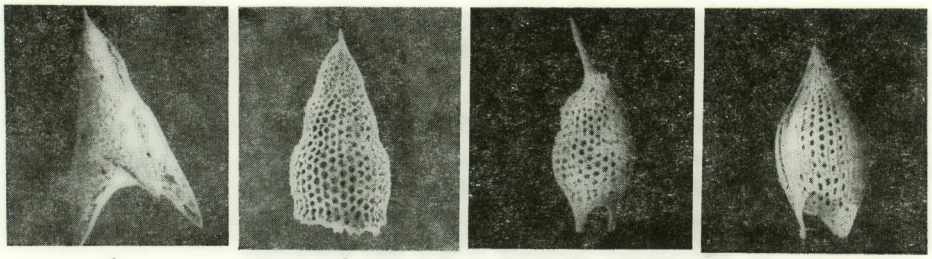
### PLATE II

1. *Podocyrtis mitra* Ehrenberg
2. *Theocotyle ficus* Ehrenberg
3. *Podocyrtis pedicellaria* Haeckel
4. *Phormocyrtis striata* Brandt
5. *Ellipsoxiphus chabakovi* Lipman
6. *Cenosphaera politepora* Lipman
7. *Lychnocanium bellum* Clark and Campbell
8. *Heliodiscus heliatericus* Clark and Campbell
9. *Podocyrtis fasciata* Clark and Campbell
10. *Sethamphora mongolfieri* (Ehrenberg)
11. *Theocotyla ficus* Ehrenberg
12. *Dictyophimus babylonis* Clark and Campbell
13. *Clathrocyclas (?) universa nova* Clark and Campbell
14. *Calocycla rachiphora* Clark and Campbell

All Stereoscan Microphotographs × 180

PLATE I

MICHAEL MANTIS.— UPPER EOCENE RADIOLARIA IN CYPRUS



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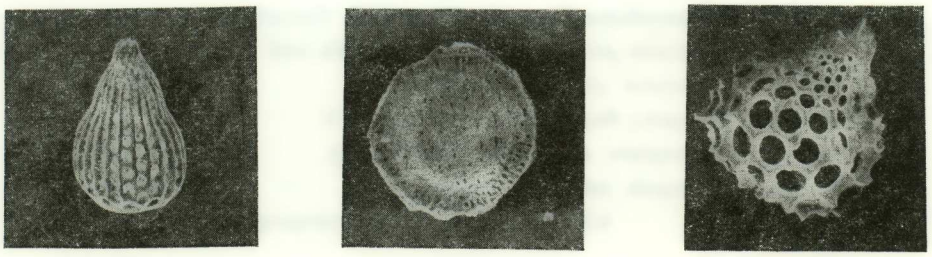

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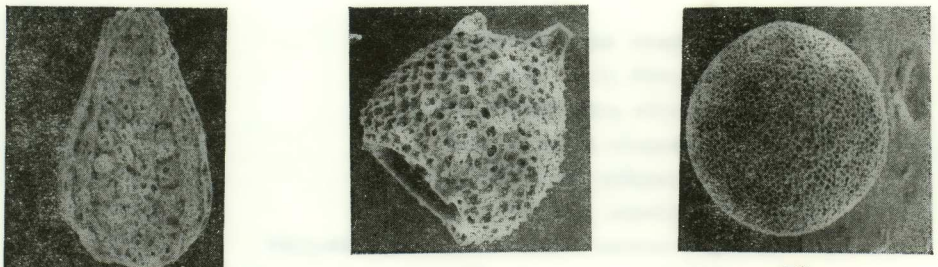

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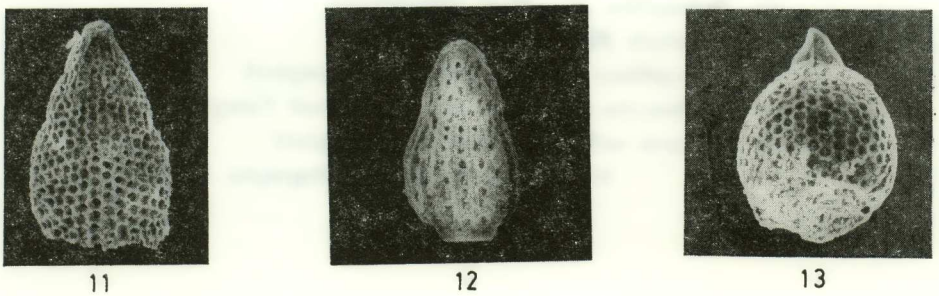

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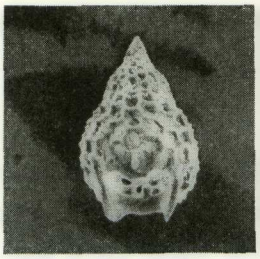
PLASE II

MICHAEL MANTIS.— UPPER EOCENE RADIOLARIA IN CYPRUS



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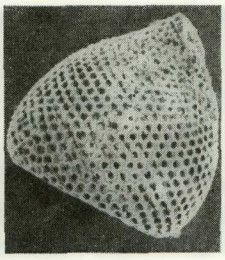

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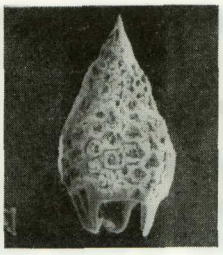

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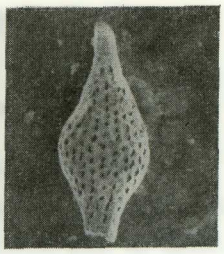

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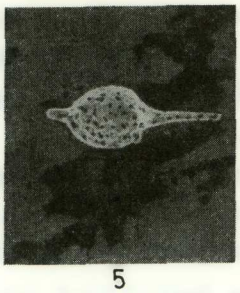

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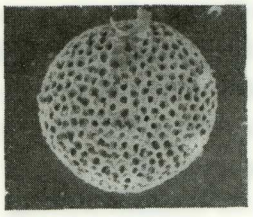

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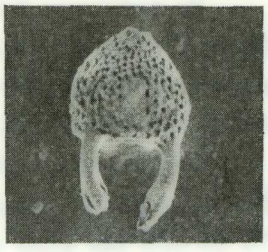

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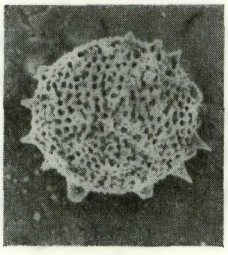

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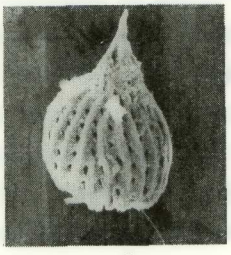

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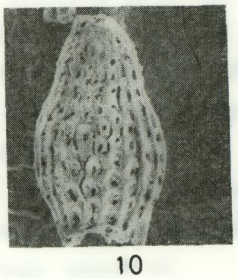

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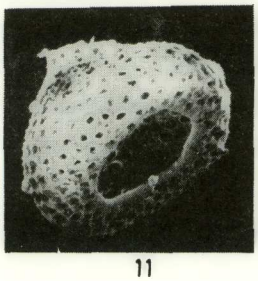

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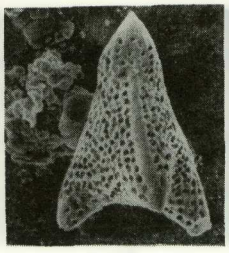

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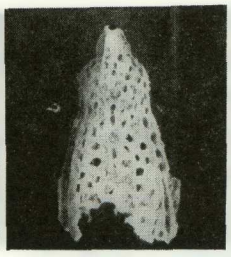

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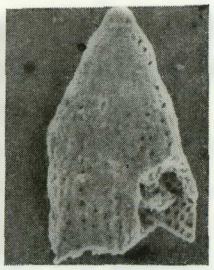

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