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PHYTOPLANKTON OF THE PALEOCENE FLYSCH DEPOSITS BEOTIA/GREECE

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A B S T R A C T

The dinoflagellate assemblages from the paleocene flysch deposits of the Ptoon-mountains, Beotia, Greece, are described. They consist of 11 genera (with 1-2 species). Palaeoecological reflections refer to a warm pelagic palaeoenvironment. Most of the species are known in the European Paleocene.

INTRODUCTION

In the course of stratigraphical and structural new investigations of the Helicon-Mountains, Beotia, Greece (JUX et al.1987), a paleocene flysch section (Upper Akraifnion-Member, KONERTZ 1987) has been investigated (microfacies, stable isotopes $\delta^{13}C_{carb.}$, $\delta^{18}O$, $\delta^{13}C_{org.}$; BEILSTEIN 1987, KONERTZ 1987). This study supplements the present results concerning this member by a description of the phytoplancton.

Other paleocene sections are beeing worked out now, but new results are not yet advanced enough, to be taken into consideration in this study.

BIOSTRATIGRAPHIC COMPARISONS

The identified species are distinguished by a relatively large biostratigraphic range and palaeogeographic distribution. About 60% of the identified species are known in the North-American Paleocene (*Achomosphaera ramulifera*, *Areoligera senonensis*, *Cyclonephelium distinctum*, *Heterosphaeridium heteracanthum*, *Spinidinium densispinatum*, *Spiniferites ramosus* var. *multibrevis*, *Spiniferites pseudofurcatus*). Two species are known in the Australian Paleocene (*Achomosphaera ramulifera*, *Heterosphaeridium heteracantum*). *Achomosphaera ramulifera* is known in the Indian Eocene, *Spiniferites*

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pseudofurcatus is known in the Eocene of South-America and the USSR (HARKER & SARJEANT 1975).

DESCRIPTION OF THE SECTION (FIG.3)

The investigated sequence of the Upper Akraifniom Member (named by KONERTZ 1987), is located about 500m westwards from the monastery of Ag. Pelagia near Akraifnion (Figs.1, 2). Its thickness is 83m. The section beginns with platy grey limestones (echinoderms) and yellow-grey marls (0-4m). It is followed by dark grey and dark green siltstones and claystones (5-53m). They succeed into dark green siltstones and yellow-grey marls (54-58m), which are overlayed by yellow-green marls (59-79m). The section terminates with ochre and dark grey siltstones (80-83m).

DISTRIBUTION OF DINOCYSTS AND POLLEN IN THE SECTION

Alltogether 11 dinoflagellate genera with 14 species and 1 pollen genera with 7 species were encountered. However, the number of specimens within each sample was small, with the exception of samples S9, S15 and S23. Often only 10-20 specimens were found in 100 grams of sample material. From 29 samples 19 included phytoplancton or sporomorphs. 16 samples included bisaccate pollen of conifers, 6 samples included dinoflagellate-cysts and three samples included both. Sample S15 included all the seven pollen species. The limestones contained neither dinoflagellate-cysts nor pollen.

BIOSTRATIGRAPHIC SIGNIFICATION OF THE DINOCYSTS (FIG.3)

Within the section there are two peaks marking a higher distribution of the dinoflagellate species and number of specimens. These are the samples S9, which includes 9 species and sample S23, including 5 of the 14 dinoflagellate species. Only one species (*Spiniferites ramosus* var.*multibrevis*; occurence: Early Cret.to recent) is included in both samples S9 and S23. The last occurence of *Cyclonephelium distinctum* is the Early Paleocene after DRUGG (1967), which corresponds well with its occurence in the lowest parts of the Upper Akraifnion-Member (S4, S9), thus indicating the Early Paleocene. The upper parts of the Akraifnion-Member, especially represented by the sample S23 belong to the Late Paleocene, indicated by the association of *Thalassiphora delicata sensu* MANUM, *Spiniferites pseudofurcatus*, *Spinidinium densispinatum*.

PALAEOECOLOGICAL ASPECTS OF DINOFLAGELLATE ASSOCIATIONS

The question of applicability of dinoflagellate-cysts concerning palaeoecology has been the subject of numerous studies. The classification of dinocysts into associations stood in the foreground (DAVEY 1971). After DOWNIE et al.(1971), some existing Paleocene/Eocene associations are:

The *Spiniferites* -association: marked by the genera *Spiniferites*, *Hystrichosphaeridium*, *Achomosphaera*, *Cordosphaeridium*

the *Areoligera*-association: marked by the genera *Areoligera*, *Cyclonephelium*.

These are typical pelagic associations (DAVEY 1971). Most of the identified cysts of this study can be arranged into these two associations aswell.

PALAEOECOLOGICAL SIGNIFICANCE OF THE SHAPE OF THE PROCESSES

DAVEY (1970), DAVEY & ROGERS (1975) and MARHEINECKE (1986) worked out, that the major cyst types show the first indication of the living milieu of dinoflagellates, which means, that chorate cysts (ratio of radius of endocoel/radius overall ≈ 0,6) are dominant in warm water environments.

Fig.1: The study area in Greece

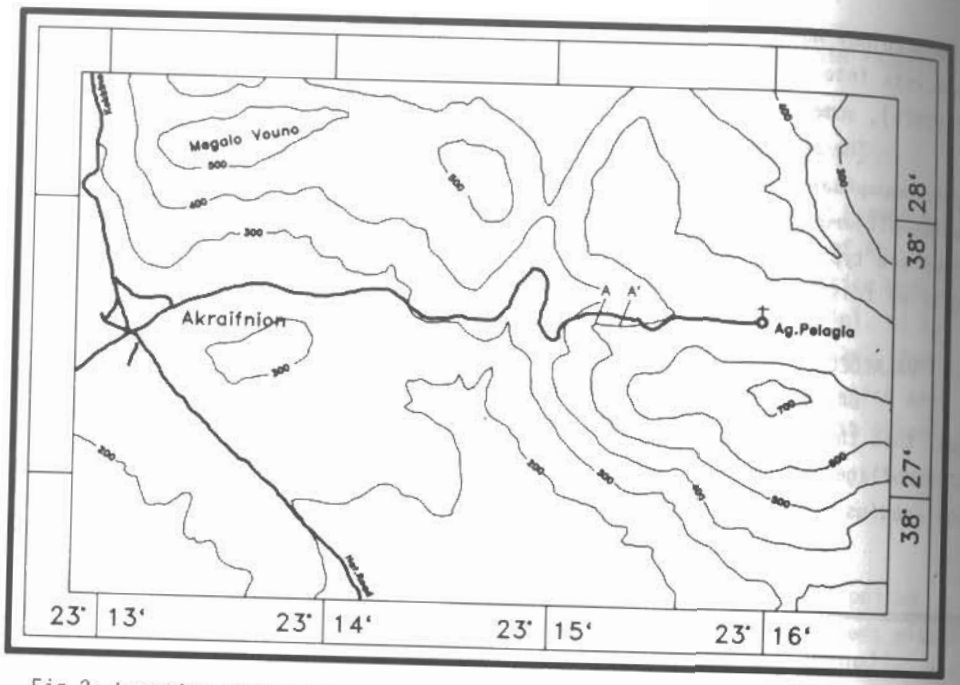

Fig.2: Location of the investigated section

Nearly all the identified species in this study are of the chorate or proximochorate major cyst type, too. They are characterized either by numerous (*Cleistosphaeridium polytrichum, Cyclonephelium distinctum)*, very long processes or bizarre branched tips (*Achomosphaera sp., Areoligera cf. coronata, Areoligera senonensis, Exochosphaeridium sp., Hystrichosphaeridium salpingophorum, Spiniferites pseudofurcatus*). Therefore the palaeoenvironment of the dinoflagellates described here is a relatively warm-water open ocean. The occurence of bisaccate pollen of conifers (genus *Pityosporites*) shows an untypical association of paleocene sporomorphs. These elements found here are allochthonous.

SYSTEMATIC PALYNOLOGY

The palaeontological cyst-taxonomy is descriptive, based on features that play a subordinate role in recent cyst biology. There is no taxonomy based on phylogenetic reference (BELOW 1987). Therefore the authors use different suprageneric classifications. In this study the cyst-classification proposed by NORRIS (1978) is used.

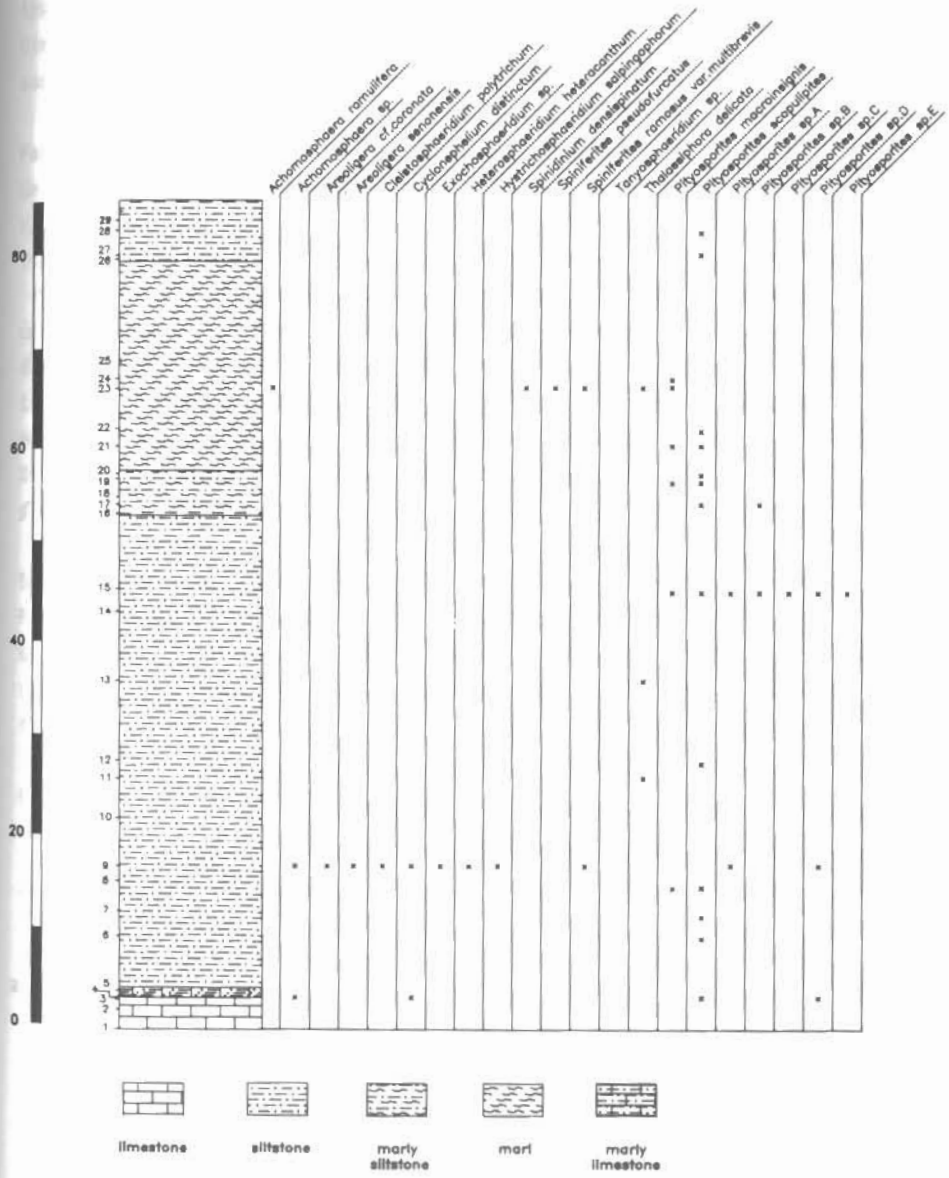

Fig.3: Distribution of Dinocysts and pollen within the section

COMMENTS TO THE DINOFLAGELLATE SPECIES

Division *Pyrrhophyta* PASCHER 1914
Class *Dinophyceae* FRITSCH 1929
Order *Peridiniales* HAECKEL 1896
Family *Spiniferitaceae* SARJEANT 1970, emend.NORRIS 1978
Genus *Achomosphaera* Evitt 1963
Achomosphaera ramulifera (DEFLANDRE 1937) EVITT 1962
1986 *Achomosphaera ramulifera* (DEFLANDRE), MARHEINECKE, p.17, pl.9, fig.2, pl.10, fig.4.

Comments: Sutural ridges are unclearly defined. Basically the processes are connected sporadically by low crests, but not in the same way as in *Spiniferites*. The processes are solid, closed distally and bi- or trifurcate (up to 5μ).
Dimensions: length : 32-40μ, width: 37μ, processes: 12-15μ
sample: S23

Achomosphaera sp.
fig.1

Comments: The processes are solid, possessing bulbous bases. Their triangular form is conspicuous. They are closed distally and differ from *A. ramulifera* in that they are branched in a very bizarre way.
Dimensions: length: 50-75μ, width: 22-36μ, processes: 15-40μ
samples: S4, S9

Genus *Spiniferites* MANTELL 1850 emend.SARJEANT 1970
Spiniferites pseudofurcatus (Klumpp 1953) SARJEANT 1970
1976 *Spiniferites pseudofurcatus* (KLUMPP), EATON, p.283, pl.14, figs.12, 13

Comments: The processes are connected by proximal crests, which are sometimes fenestrate. The tips are funnel-shaped (diameter up to 15μ). Sometimes the tips are recurvate.
Dimensions: central body: 52-75μ, processes: 22-27μ
sample: S23

Spiniferites ramosus (EHRENBERG 1838) MANTELL 1854
Spiniferites ramosus var. *multibrevis* DAVEY & WILLIAMS, DAVEY et al.1966
1974 *Spiniferites ramosus* var.*multibrevis* (DAVEY & WILLIAMS), COOKSON & EISENACK, p.56, pl.21, fig.7.

Comments: A variety of *S.ramosus* with an oval central body and short processes. The gonal processes are trifurcate, sutural ones are bifurcate. Both types of processes are bifid. The sutural crests are well developed.
Dimensions: length: 35-37μ, width: 25-27μ, processes: 10-15μ
samples: S9, S23

Family *Lingulodiniaceae* SARJEANT & DOWNIE 1974
Genus *Exochosphaeridium* DAVEY et al.in DAVEY et al.1966
Exochosphaeridium sp.
fig.3

Comments: Numerous simple processes cover the central body and are concentrated to apical- and antapical regions. Processes vary considerably in diameter length (2-8μ, increasing towards apical- and antapical pole). Sometimes the processes are branched. The tips are closed, recurvate. The pole processes are branched in a bizarre way. An archeopyle is not observed.
Dimensions: length: 35μ, width: 20μ, processes: 15-20μ
sample:S9

Suborder *Hystrichosphaeridiinae* NORRIS 1978
Family *Hystrichosphaeridiaceae* EVITT 1963 emend.NORRIS 1978
Genus *Hystrichosphaeridium* DEFL.1937 emend.DAVEY & Williams in DAVEY et al.1966
Hystrichosphaeridium salpingophorum (DEFLANDRE 1935), DAVEY et al.1966
fig.4
1966 *Hystrichosphaeridium salpingophorum* (DEFLANDRE), DAVEY & WILLIAMS in DAVEY et al., p.61, pl.10, fig.6.

Comments: The processes are tubiforme. Medially they reach a diameter of 10μ and expand towards their sub-quadrate openings, which are up to 20μ. The processes may split at their medial length into two strong branches. An archeopyle is not observed.
Dimensions: diameter of central body: 40-70μ, processes: 20-25μ
sample: S9

Genus *Tanyosphaeridium* DAVEY & WILLIAMS 1966
Tanyosphaeridium sp.
1972 *Tanyosphaeridium paradoxum* (BROSIUS), BENEDEK, p.35, pl.9, fig.12

The big ellipsoidal central body has a granular surface. The processes are concentrated in the pole regions, where they reach their maximum length (40μ). They are arranged in a circular manner around the central body. [illegible] they expand in a funnel-shaped way.

Dimensions: length: 95µ, width: 50µ, processes: 35-40µ
samples: S11, S13

Family *Cleistosphaeridiaceae* SARJEANT & DOWNIE 1966
Genus *Cleistosphaeridium* DAVEY et al.1966
Cleistosphaeridium polytrichum (VALENSI 1947) DAVEY & DOWNIE 1966
fig.5
1986*Cleistosphaeridium polytrichum* (VALENSI), ASHRAF & ERBEN, p.147, pl. 12, fig.3

Comments: The ellipsoidal cyst is covered by numerous (≈ 50) distally closed processes up to 15µ. Within the species the processes vary in length, but they are of uniform length for any given specimen. No distal branches. Archeopyles are not observed.
Dimensions: length: 42-55µ, width: 25-35µ, processes: 7-15µ
samples: S9, S11

Family *Areoligeraceae* EVITT 1963 emend.SARJEANT & DOWNIE 1966
Genus *Areoligera* LEJEUNE-CARPENTIER 1938
Areoligera cf.coronata (O.WETZEL 1933) LEJEUNE-CARPENTIER 1938
fig.6
1985 *Areoligera coronata* (O.WETZEL), ROBASZYNSKI et al., p.91, pl.11, figs.6-10

Comments: All three types of processes of the genus - soleate, annulate and linear - occur. Proximally there can be fenestrate or non fenestrate membranes with the processes arising from the distal margin of these membranes.

Dimensions: length: 45-50µ, width: 60-62µ, processes: 20-28µ
sample: S9

Areoligera senonensis LEJEUNE-CARPENTIER 1938
1976 *Areoligera senonensis* (LEJEUNE-CARPENTIER), EATON, p.244, pl.3, fig.1

Comments: The processes are simple and not branched. There may sometimes be basal membranes. An archeopyle is absent.
Dimensions: length: 42-50µ, width: 55-80µ, processes: 10-27µ
sample: S9

Genus *Cyclonephelium* DEFLANDRE & COOKSON 1955
Cyclonephelium distinctum DEFLANDRE & COOKSON 1955
fig.7
1974 *Cyclonephelium distinctum* (DEFL.& COOKSON), COOKSON & EISENACK, p.74 pl.28, fig.6

Comments: The central body is covered by numerous solid, distally closed processes (3-10µ). The tips are aculeate, often recurvate. Archeopyles are not observed. Regions without processes on the ventral- or dorsal surface occur.
Dimensions: length: 50-70µ, width: 40-50µ, processes: 3-10µ
samples: S4, S9

Family *Pseudoceratiaceae* EISENACK 1961 emend.NORRIS 1978
Genus *Heterosphaeridium* COOKSON & EISENACK 1968
Heterosphaeridium heteracanthum (DEFL.& COOKSON) 1955
1974 *Heterosphaeridium heteracanthum* (DEFL.& COOKSON), COOKSON & EISENACK, p.69, pl.29, figs.9, 10.

Comments: The central body is covered by numerous distally closed processes. Either they are tubular with a smaller diameter (1µ) and oblate or they are flattened and broader (5µ). In this case they are branched. Lengths of antapical processes is 20µ. The archeopyle is apical .
Dimensions: diameter of central body: 55µ, processes: 8-20µ
sample: S9

Suborder *Deflandreineae* EISENACK emend.NORRIS 1978
Family *Deflandreaceae* EISENACK 1954 emend.SARJEANT & DOWNIE 1974
Genus *Spinidinium* COOKSON & EISENACK 1962
emend.LENTIN & WILLIAMS 1976
Spinidinium densispinatum STANLEY 1965
1965 *Spinidinium densispinatum* STANLEY, p.226, pl.21, figs.1-5

Comments: Apical - and antapical pole with short, conelike horns (10µ). Cyst body is ornamented with thin processes up to 8µ.
Dimensions: diameter of central body: 35µ, horns: 10µ, processes: 5-8µ
sample: S23

Suborder *Incertae*
Subfamily *Thalassiphoroidae* GOCHT emend.SARJEANT & DOWNIE stat.nov.
Genus *Thalassiphora* EISENACK & GOCHT 1960
Thalassiphora delicata WILLIAMS & DOWNIE 1966 *sensu* MANUM 1976
1985 *Thalassiphora delicata* (WILLIAMS & DOWNIE) *sensu* MANUM (1976).

WILLIAMS & BUJAK in BOLLI et al., p.942, pl.38, fig.16.

Comments: Central body is spherical (diameter 20µ). Surrounded by a distally notched membrane. No keel present. An archeopyle is not observed.

Dimensions: complete diameter: 120µ, diameter of central body: 20µ

sample: S23

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Plate 1. scale 10µ

fig. 1: *Achomosphaera sp.*, fig. 2: *Spiniferites pseudofurcatus*, fig. 3: *Exochosphaeridium sp.*, fig. 4: *Hystrichosphaeridium salpingophorum*, fig. 5: *Cleistosphaeridium polytrichum*, fig. 6: *Areoligera cf. coronata*, fig. 7: *Cyclonephelium distinctum*, fig. 8: *Heterosphaeridium heteracanthum*.