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UPPER PLIOCENE DIATOMS AND SILICOFLAGELLATES FROM SECTION FORTESSA, CENTRAL CRETE, GREECE

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ABSTRACT

A rich siliceous phytoplankton assemblage of early Piacenzian age, containing marine diatoms and silicoflagellates, was found northern in fine laminated diatomite beds in the section Fortessa from the northern central part of the Crete island (Province of Heraklion), which belongs to the Stavromenos formation.

The diatom association belongs to the new local *Thalassiosira leptopus* Acme subzone, whereas the silicoflagellates belong to the Acme subzones *Dictyocha brevispina brevispina* and *Dictyocha* cf. *neonautica* respectively. Both groups of the siliceous phytoplankton indicates more or less a subtropical paleoenvironment.

KEY WORDS: Diatoms-Silicoflagellates-Diatomites-Neogene-Piacenzian-Mediterranean area-Crete Island-Biostratigraphy-Acme subzone-Quantitative data.

1. INTRODUCTION

In Crete island two sedimentation cycles are distinguished, which range correspond to the Upper Miocene and Pliocene time respectively (CRISTODOULOU, 1963). The Miocene and Pliocene macrofossils of Central Crete have been investigated by PAPAPETROU-ZAMANI (1965), SYMEONIDES & KONSTANDINIDES (1970), DERMITZAKIS (1979), GEORGIADOU-DIKEOULIA (1979). Other biostratigraphical studies concerning the marine successions on Crete are based on zonation of bentonic foraminifera (FREUDENTHAL 1969; MEULENKAMP 1969), ostracodes (SISSINGH, 1972; TSAPRALIS, 1976), calcareous nannoplankton (SCHMIDT, 1973; THEODORIDIS, 1984; DRIEVER, 1988), planktonic foraminifera (ZACHARIASSE, 1975) and silicoflagellates (FRYDAS, 1985, 1990, 1994, 1996).

The correlation of the marine zones with the succession of sporomorph associations was given by BENDA & MEULENKAMP (1979), while the first mastodont from Crete was described by BENDA at al., (1968). Date provided by BRUIJN & ZACHARIASSE (1979) make it possible to correlate mammal associations with marine microfossil zones and sporomorphs.

2. THE FORTESSA SECTION

The Neogene sediments of the northern Heraklion district consist of homogenous marls, grey clays with brownish interbeds, fossiliferous yellowish marls and diatomites with a total thickenss of more than 100m. The present paper concerns exclusively the investigation of diatom and silicoflagellate associations for establishing useful local stratigrpahical diatoms zones which could be correlated with the zones of silicoflagellates and calcareous nannofossils FRYDAS (1985, 1990, 1994, 1996) DRIEVER (1988).

The Fortessa section (fig. 1a, b) belongs to the Stavromenos formation (ZACHARIASSE 1975;

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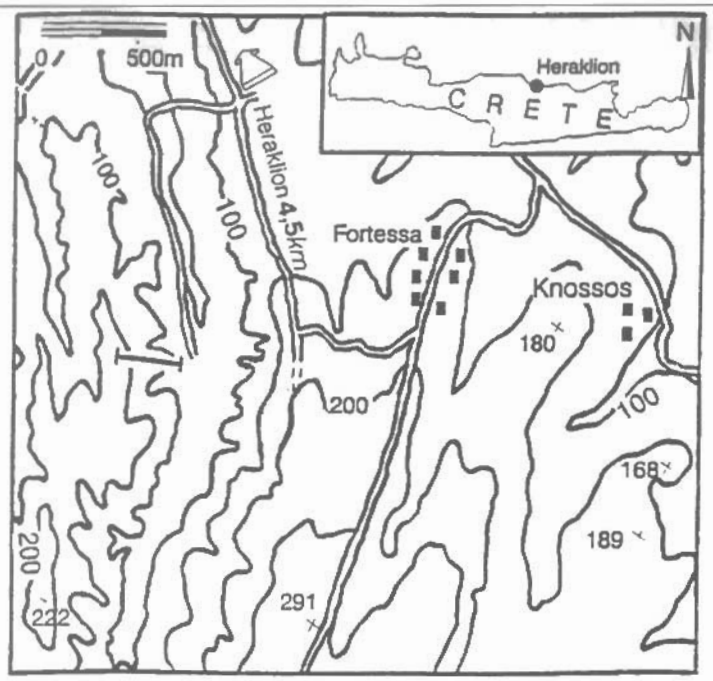
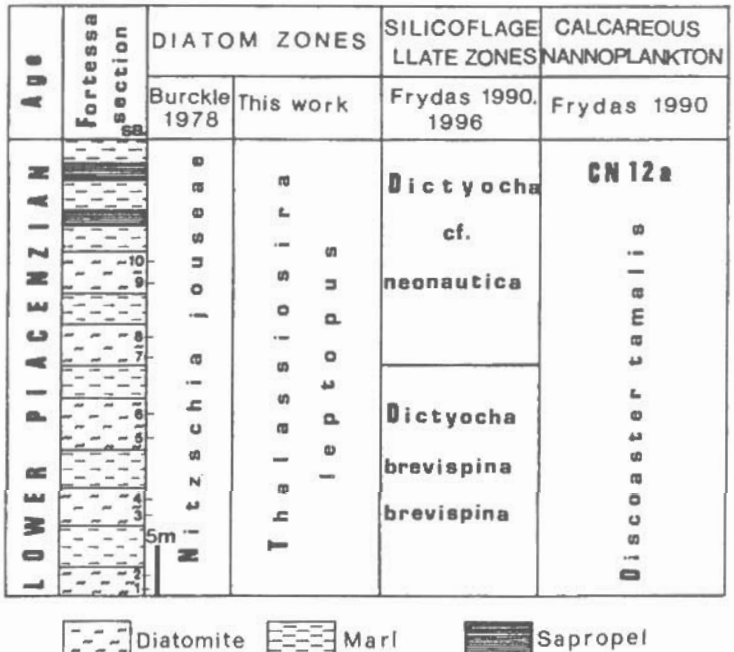


Fig. 1: Location of Fortessa section (modified from Jonkers, 1984).

Fig. 2: Correlations of the diatom, silicoflagellate and calcareous nannoplankton acme-Zonation used here (Frydas 1990, 1996) with the diatom zonation of Burckle 1978.



JONKERS 1984). The Neogene deposits of the sections are transgressively lying on the Tripolis limestones. They consist of an alternation of yellowish-grey homogenous marls, sapropel and white-greyish laminated diatomite beds, which generally appear in the upper part of the section.

3. BIOSTRATIGRAPHY

The present diatom Acme subzone *Thalassiosira leptorus* from the section Fortessa is correlated with the well known tropical/subtropical zonation from several DSDP, ODP and other publications (HUSTEDT 1930-1966; HAJOS 1968, 1973; BUKRY & FOSTER 1973; KOIZUMI 1973, 1986, 1992; SCHRADER & GERSONDE 1978; BURCKLE & TRAINER 1979; BALDAUF & IWAI 1995; BARRON 1985; SIMS et al. 1989; GERSONDE & VELITZELOS 1977; SIMS et al. 1989) and is based on low latitude species. For the percentages variation of diatoms the following symbols have been used. A: Abundant (>20%), C:Common (11-20%), F:Frequent (4-10%), R:Rare (1-3%).

The percentage distribution of the diatom association is given in tab. 1. They consist of centric-(60% to 90%), meroplanktic- and benthic diatom species. The diatoms of the section are placed in an Acme subzone where *Thalassiosira leptopus* is frequent to abundant. It corresponds to the low latitude *Nitzschia jouseae* zone (sensu BURCKLE 1978; BARRON 1985; FRYDAS 1998).

Actinocyclus octonarius Coscinodiscus oculus iridis and *Thalassiosira leptopus* belong to the group of species characterized by labiate processes arranged on the valve (pl. 1, figs. 5,6). According to MEDLIN et al. (1986) movement is reported for the first time in a centric diatom. This movement supports the proposal that motility is achieved by the production of mucopolysaccharides through the labiate processes.

a: Silicoflagellates.

Determination is effectueded according to PERCH-NIELSEN (1985) and FRYDAS (1990, 1993, 1994). Following species are found in the diatomite of the section Fortessa in the same samples as the diatoms. *Cannopilus major* (Frenguelli) (F to C), *Dictyocha brevispina ausonia* (Deflandre) Bukry (F), *D. Brevispina brevispina* (Lemmermann) (C), *D. fibula* Ehrenberg (A), *D.* cf. *neonautica* Bukry (C) (first appearence in the sa.no.7), *D. stapedia aspinosa* Bukry (F), *Distephanus binoculus* (Ehrenberg) (R to F), *Ds. boliviensis boliviensis* (Frenquelli) (F to C), *Ds. quinquangellus* Bukry & Foster (F), *Ds. septenarius* (Ehrenberg) (R), *Ds. speculum quintus* (Bukry & Foster) (R), *Ds. speculum speculum* (Ehrenberg) (C to A) and *Mesocena (Paradioctyocha) circulum* Ehrenberg (F).

The silicoflagellate associations of the section belong to the *Dictyocha brevispina brevispina* and *Dictyocha* cf. *neonautica* Acme subzones (*sensu* FRYDAS, 1996). These acme-subzone correspond to the subzone CN12a (*Discoaster tamalis*) of calcareous nannoplankton and to the *Globorotalia bononiensis* zone of planktonic foraminifera (FRYDAS, 1990).

b: Diatoms.

The percentage variation of the diatom species reflects the conditions of a subtropical paleoenvironment through the common presence of the warm-water species *Azpeitia curvatulus*, A. *nodulifer, Hemidiscus cuneiformis. Nitzschia marina. Thalassionema nitzschioides, Thalassiosira leptopus* and *Triceratium balearicum* fa. *biquadrata*. Also, the dominance of the silicoflagellates species *Dictyocha brevispina brevispina* and *Dictyocha* cf. *neonautica* indicates a warm-water paleoenvironment (FRYDAS 1996).

Table 1.Percentage variation of diatoms in the Fortessa section. In each sample 300 valves were counted.

F01	F02	F03	F04	F05	F06	F07	F08	F09	F 10	Diatoms from the section Fortessa (F0) (p): planktonic, (m):meroplanktic, (b): benthic species.
4	6	2	1	2	5	6	8	8	5	*Actinocyclus octonarius* Ehrenberg (m)
6	7	<1					2	4	<1	*A. octonarius* var. *tenellus* (Breb.) Hendey (m)
5	3	<1					3	2	1	*Actinoptychus senarius* (Ehr.) Ehrenberg (m)
4	2	1		<1		2	<1	9	7	*Azpeitia curvatulus* (Grunow) (p)
7	4	8	6	<1	<1	3	2			*Az. nodulifer* (A. Schmidt) (p)
<1	<1	5	4	<1		2	3	2	2	*Az.vetustissima* (Pantocsek) (p)
1	<1		<1			2	4			*Bacteriastrum comosum* Pavillard (m)
<1	<1	<1				3	4	1		*Biddulphia tuomeyi* (Bailey) Roper (b)
3	4			6	4	3	4	6	7	*Chaetoceros gastridium* (Ehr.) Brightwell (p)
9	6	16	11	8	10	7	9	8	6	*Coscinodiscus asteromphalus* Ehrenberg (p)
		1	<1	1	<1	2	2		<1	*C. obscurus* A. Schmidt (p)
24	29	37	33	41	34	36	21	22	34	*C. oculus-iridis* Ehrenberg (p)
	<1				3	5	4	3	4	*C. radiatus* Ehrenberg (p)
7	9	11	14	18	17	3	4	8	5	*Hemidiscus cuneiformis* Wallich (p)
	<1	<1	<1		2			2	<1	*Navicula hennedyi* Cleve (b)
2	4			3	4	<1		2	<1	*Nitzschia jouseae* Burckle (p)
	<1		1			2		<1		*N. marina* Grunow (p)
						<1		<1		*Rhabdonema adriaticum* Kutzing (b)
				<1					2	*Rhizosolenia barboi* (Brun) Tempere & Peragallo (p)
4	6	1	2	3	2	1	4	6	4	*Stephanopyxis turris* (Greville & Arnott) Ralfs (m)
	<1				1			<1		*Surirella ovata* Kutzing (b)
	<1			4	3	1	<1		2	*Thalassionema nitzschioides* (Grun.) Hustedt (p)
1	<1	<1						<1		*Thalassiosira eccentrica* (Ehrenberg) Cleve (p)
21	15	13	26	10	13	20	24	14	18	*Th. leptopus* (Grunow) (p)
		1				1				*Thalassiothrix* cf. *longissima* Cleve & Grunow (p)
<1		1		<1	<1		<1	<1		*Triceratium balearicum* Cl. & Gru. fa. *biquadrata* (Janisch) Hustedt (b)

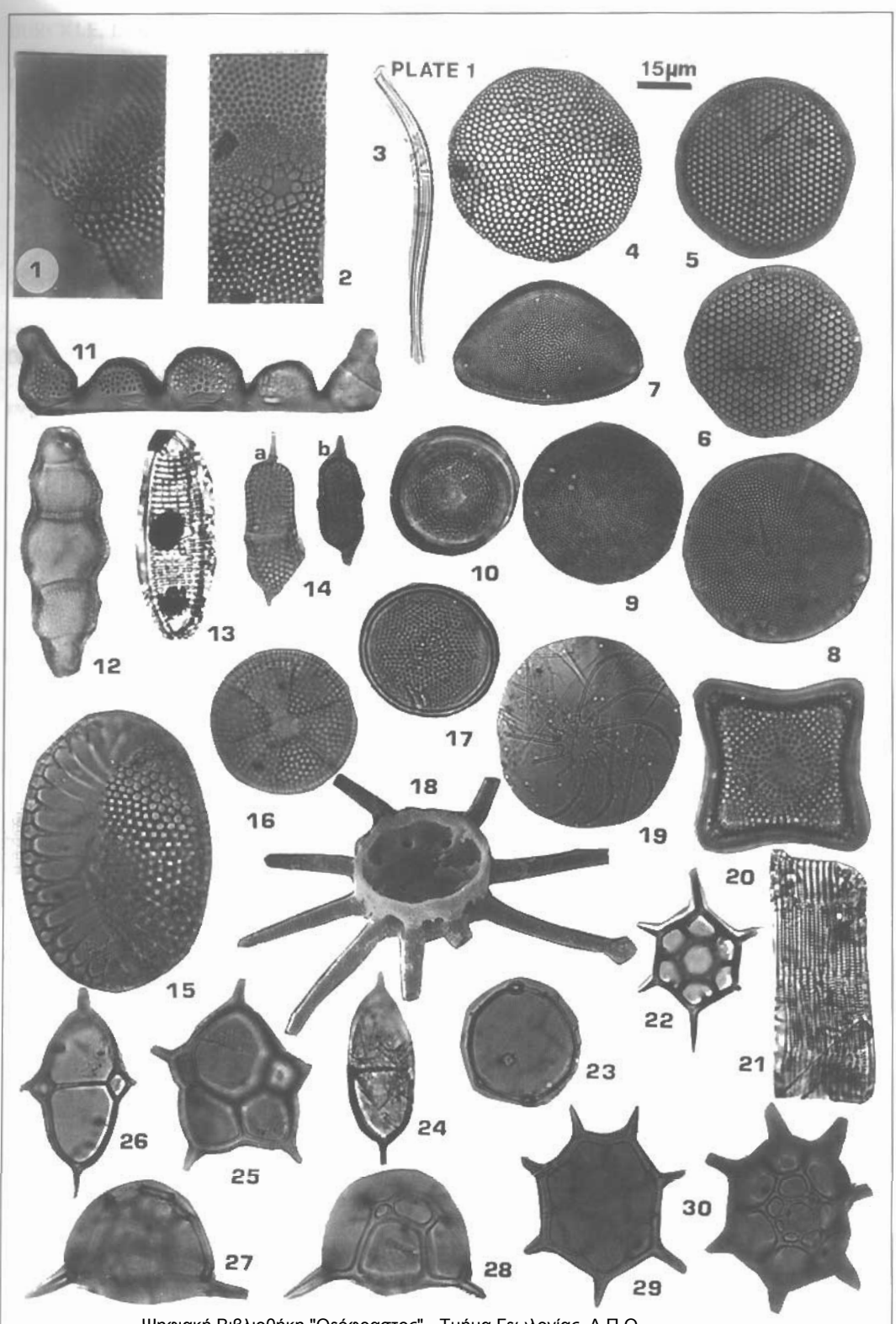


PLATE 1

Diatom and silicoflagellate photomicrographs magnification x 650

Figs. 1 to 21: Diatoms

Fig. 1: *Coscinodiscus asteromphalus* Ehrenberg, sample F03

Fig. 2: *Coscinodiscus obscurus* A. Schmidt, sa. Fo3

Fig. 3: *Rhizosolenia barboi* (Brun) Tempere & Peragallo, sa. Fo10.

Fig. 4: *Coscinodiscus oculus-iridis* Ehrenberg, sa. Fo3.

Fig. 5,6: *Thalassiosira leptopus* (Grunow), sa. Fo3; Arrows indicate the rounded labiate processes on the valve.

Fig. 7: *Hemidiscus cuneiformis* Wallich, sa. Fo7.

Fig. 8: *Azpeitia curvatulus* (Grunow), sa. Fo7.

Fig. 9: *Actinocyclus octonarius* Ehrenberg, sa. Fo2.

Fig. 10: *Actinocyclus octonarius* var. *tenellus* (Brebisson) Hendey, sa. Fo2.

Fig. 11,12: *Biddulphia tuomeyi* (Bailey) Roper sa. Fo7; 11: Girdle view, 12:Valve view.

Fig. 13: *Nitzschia* cf. *jouseae* Burckle, sa. Fo9.

Fig. 14: *Stephanopyxis turris* (Greville & Arnot) Ralfs, sa. Fo2 (a); sa. Fo10 (b).

Fig. 15: *Surirella ovata* Kutzing, sa. Fo9.

Fig. 16: *Actinoptychus senarius* (Ehrenberg) Ehrenerg, sa. Fo9.

Fig. 17: *Thalassiosira eccentrica* (Ehrenberg) Cleve, sa. Fo9.

Fig. 18,19: *Bacteriastrum comosum* Pavillard, sa. Fo8; 18: Scaning electron microscope x 1500; 19: Light microscope x 650.

Fig. 20: *Triceratium balearicum* Cleve & Grunow fa. *biquadrata* (janisch) Hustedt, sa. Fo8.

Fig. 21: *Rhabdonema adriaticum* Kutzing, sa. Fo9.

Figs. 22 to 30 Siliciflagellates

Fig. 22: *Distephanus speculum speculum* (Ehrenberg), sa. Fo9.

Fig. 23: *Mesocena (Paradictyocha) circulus* Ehrenberg, sa. Fo9.

Fig. 24: *Dictyocha* cf. *neonautica* Bukry, sa Fo9.

Fig. 25: *Dictyocha brevispina ausonia* (Deflandre) Bukry, sa. Fo2 (aberrant form).

Fig. 26: *Dictyocha brevispina brevispina* (Lemmermann) sa. Fo2.

Fig. 27,28: *Cannopilus major* (Frenguelli), sa. Fo2; Lateral view.

Fig. 29, 30: *Distephanus boliviensis bolieviensis* (Frenguelli); sa. Fo2; 29: Basal ring. 30: Apical ring.

REFERENCES

BALDAUF, J. G. & IWAI, M. 1995. Neogene diatom biostratigraphy for the Eastern Equatorial Pacific Ocean, Leg 138.-In : Pisias, N.G., Mayer, L.A., Janecek, T.R., Palmer-Julson, A. & van Andel, T.H. (Eds.), *Proc. ODP, Sci. Results*, pp. 105-128; College Station TX (Ocean Drilling Program).

BARRON, J.A. 1985. Late Eocene to Holocene diatom biostratigraphy for the equatorial Pacific Ocean, Deep Sea Drilling Project, Leg 85.-*In*: Mayer, L.A. Theyer, F. *et. al., Init. Repts. DSDP*, 85, pp. 413-456; Washington (U,S. Covt. Printing Office).

BENDA, L., HILTERMANN, H., KUSS, S. E.& SYMEONIDES, N.K. 1968. Der erste Mastodontfund der Insel Kreta.- *Ann. Geol. Pays Hellen.*, 21, pp. 167-177; Athenes.

BENDA, L. & MEULENKAMP, J. E. 1979. Biostratigraphic correlation in the eastern Mediterranean Neogene. 5. Calibration of sporomorph associations, marine microfossils and mammal zones, marine and continental stages and the radiometric scale. *Proceed. VIIth. Intern. Congr.* Mediterr. Neogene, Athens 1979, *Ann. Geol. Pays Hellen.*, hors serie 1, pp. 61-70; Athens.

BUKRY, D. & FOSTER, J. H. 1973. Silicoflagellate and diatom stratigraphy, Leg. 16, Deep Sea Drilling Project.- *In*: [illegible]. 815-871; Washington.

BURCKLE, L. H. 1978. Marine diatoms.- In: Haq, B.U. & Boersma, A. (Eds.); Introduction to Marine Micropaleontology, pp. 245-266; Elsevier, New York- Amsterdam-Oxford.

BURCKLE, L.H. & TRAINER, 1979. Middle and Late Pliocene diatom datum levels from the central Pacific.- *Micropaleontology*, 25, no 3, pp. 281-293; New York.

CHRISTODOULOU, G. 1963. Geologic and micropaleontologic research of the Neogene of Crete Island.- *Habilitation*, 157 p., University of Athens (in Greek with English and German abstract); Athens.

DE BRUIJN, H. & ZACHARIASSE, W. J. 1979. The correlation of marine and continental biozones of Kastellios hill reconsidered.- Proceed. VIIht Intern. Congr. Mediterr. Neogene, Athens 1979.- *Ann. Geol. Pays Hellen.* hors serie, 1pp. 219-226; Athens.

DERMITZAKIS, M.D. 1979. Stratigraphy and fauna of the Upper Miocene deposits of Almiri Panaghia (Iraklion province, Crete).-Proceed, VIIth. Intern. Congr. Mediterr. Neogene, Athens 1979.- *Ann. Geol. pays Hellen.*, hors serie, 3, pp. 1321-1331: Athens.

DRIEVER, B. W. M. 1988. Calcareous nannofossil biostratigraphy and paleoenvironmental interpretation on the Mediterranean Pliocene. *Utrecht Micropal. Bull*, 36, 245p., Utrecht.

FREUDENTHAL, T. 1969. Stratigraphy of Neogene deposits in the Khania province, Crete, with special reference to foraminifera of the family Planorbulinidae and the genus *Heterostegina*.- *Utrecht Micropol. Bull.*, 1, 208p; Utrecht.

FRYDAS, D. 1985. Siliceous phytoplankton from a Diatomite near Heraklion, Crete, Greece.- *Newsl. Stratigr.*, 14(3), pp. 142-157; Berlin-Stuttgart.

FRYDAS, D. 1990. Stratigraphie des diatomites du Plaisancien de la Crete centrale (Grece) a l' aide des Silicoflagelles et des nannofossiles calcaires.- *Rev. Micropaleont.*, 33(2), pp. 93-114; Paris.

FRYDAS, D. 1993. Stratigraphie du Neogene de la Crete ouest (Grece) a l' aide des Silicoflagelles et des nannofossiles calcaires.- *Rev. Micropaleont.*, 36 (2), pp. 121-142; Paris.

FRYDAS, D. 1994. Bericht uber ein neues Silicoflagellaten-Vorkomen aus dem Piacenzium von Kreta, Griechenland.- *Berliner geowiss. Abh.*, E13, pp. 483-493; Berlin.

FRYDAS, D. 1996. Silicoflagellate stratigraphy for Neogene to Quaternary marine sediments in Greece.- *Newsl. Stratigr.*, 33(2), pp. 99-116; Berlin-Stuttgart.

FRYDAS, D. 1998. Paleoecology, stratigraphy and taxonomy of the Piacenzian marine diatoms from Central Crete (Greece)-(under review in *Rev. Micropal.*)

GEORGIADES-DIKEOULIA, E. 1979. Paleoenvironmental observations based on the macrofauna of the Pliocene section Pressa, Crete.- Proceed. VIIth Intern. Mediter. Neogene, Athens 1979.- *Ann. Geol. Pays Hellen.*, hors serie, 1 pp. 439-448; Athens.

GERSONDE, R. & VELITZELOS, E. 1977. Diatomeen-Palaookologie im Neogen Becken von Vegora, NW-Mazedonien (Vorlaufige Mitteilung).- Ann. *Geol. Pays Hellen.*, 29, pp. 373-382; Athens.

HAJOS, M. 1968. Die Diatomeen der Miozanen Ablagerungen des Matravorlandes.- *Geologica Hungarica*, Ser. Paleontologica, 37, 402p. Budapest.

HAJOS, M. 1973. The Mediterranean diatoms: *In*: Ryan, W.B.F., Hsu, K.J. *et. al., Init. Repts. DSDP.* 13, pp. 944-969; Washigton.

HUSTEDT, F, 1930-1966. Die Kieselalgen Deutschlands, Osterreichs und der Schweiz mit Berucksichtigung der ubrigen Lander Europas sowie der angrenzenden Meeresgebiete.- *In*: Rabenhorst's L. (Ed.), Kryptogamen Flora, 7, part 1 (1930), 920 p., figs. 1-542; part 2 (1959), 845 p., figs. 543-1179; part 3 (1961-66), 816 p., figs. 1180-1591; Leopold Voss; Leipzig.

JONKERS, H.A. 1984. Pliocene bentonic foraminifera from homogenous and laminated marls on Crete.- *Utrecht Micropal. Bull.* 179p.

KOIZUMI, I. 1973. The late Cenozoic diatoms of sites 183-193, Leg. 17, Deep Sea Drilling Project.- *In*: Craeger, J. S., Scholl, D.W., *et. al., Init. Repts. DSDP.* 19, pp. 805-855; Washington.

KOIZUMI, I. 1986. Pliocene and Pleistocene diatom datum levels related with paleoceanography in the northwest Pacific.-*Marine Micropaleontology*, 10(4), pp. 309-325; Amsterdam.

KOIZUMI, I. 1992. Diatomaceous sediments along the Pacific coastal areas of south America and their

evaluation.-*Jour. Fac. Sci.*, Hokkaido Univ., ser. 4, 23(2), pp. 227-245; Hokkaido.

MEDLIN, L.K., CRAWFORD, R.M. & ANDERSEN, R.A. 1986. Histochemical and Ultrastructural Evidence for the Function of the Labiate Process in the Movement of Centric Diatoms.- *Br. phycol. J.*, 21, pp. 297-301;, British Phycological Society, London.

MEULENKAMP, J. E. 1969. Stratigraphy of Neogene deposits in the Rethymnon province, Crete, with special reference to the phylogeny of uniserial *Uvigerina* from the Mediterranean region.- *Utrecht Micropol. Bull.*, 2, 172p.; Utrecht.

PAPAPETROU-ZAMANI, S. 1965. Contribution to the knowledge of the Neogene of Heraklion Province of Crete.- *Ann. Geol. Pays Hellen.*, 16, 207-232; Athenes.

PERCH-NIELSEN, K. 1985. Silicoflagellates.-*In*: Bolli, H.M., Saunders, J.B. & Perch-Nielsen, K. (eds.): Plankton Stratigraphy, pp. 811-846; London, Cambridge Univ. Press.

SCHMIDT, R.R. 1973. A calcareous nannoplankton zonation for Upper Miocene-Pliocene deposits from the southern Aegean area, with a comparison to Mediterranean stratotype localities.- *Proc. Kon. Ned. Akad. Wet.*, ser. B, 76, pp. 287-310; Amsterdam.

SCHRADER, H. -J. & GERSONDE, R. 1978. Diatoms and Silicoflagellates.- *In:* Zachariasse, W. J., Riedel, W. R., Sanfilippo, A. , *et al.*, (eds.): Micropaleontological counting methods and techniques -An exercise at an eight meters section of the Lower Pliocene of Capo Rossello, Sicily. -I. G.C.P. Project no. 1, *Utrecht Micropal. Bull.*, 17, pp. 129-176; Utrecht.

SIMS, P.A. FRYXELL, G.A. & BALDAUF, J.G. 1989. Critical examination of the diatom genus *Azpeitia*: Species useful as stratigraphic markers for the Oligocene and Miocene Epochs.- *Micropaleontology*, 35(4), pp. 293-307; New York.

SISSINGH, W. 1972. Late Cenozoic ostracoda of the south Aegean island arc.- *Utrecht Micropol. Bull.*, 6, 187p; Utrecht.

SYMEONIDIS, N.K. & KONSTANTINIDES, D. 1970. Beobachtungen zu den Neogenablagerungen des Zentralgebietes der Insel Kreta.- *Ann. Geol. Pays Hellen.*, 1. ser., 19 (1968), pp. 657-688; Athenes.

THEODORIDIS, S. 1984. Calcareous nannofossils biozonation of the Miocene and revision of the Helicoliths and Discoasters .- *Utrecht Micropal. Bull.*, 32, 271 p: Utrecht.

TSAPRALIS, V. 1976. Ostracode associations and paleoenvironmental analysis of the Pliocene of section Prassa, Crete, Greece.- *Proc. Kon. Ned. Akad. Wet.*, ser. B, 79 (4) pp. 300-311; Amsterdam.

ZACHARIASSE, W. J. 1975. Planktonic Foraminiferal Biostratigraphy of the late Neogene of Crete (Greece).- *Utrecht Micropal. Bull.*, 11; 171p.; Utrecht.