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LATE MAASTRICHTIAN AND PALEOCENE CALCAREOUS NANNOFOSSILS FROM AIN DABADIB SECTION, NW KHARGA OASIS, EGYPT

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Key Words: Maastrichtian, Paleocene, Nannofossils, NW Kharga, Egypt.

ABSTRACT

On terms of calcareous nannofossils, the late Maastrichtian and Paleocene sediments were subdivided into several biozones. The Cretaceous-Tertiary boundary is marked by a hiatus concerning the latest Maastrichtian and the early Danian.

To predict the surface water paleotemperature during the late Maastrichtian-Paleocene interval, the warm-water/cool-water; the *Micula staurophora/Watznaueria barnesae*, and *Discoaster/Chiasmolithus* ratios were calculated for each studied samples.

There is some nannofossil evidence to suggest that the paleotemperature was already declining in the late Maastrichtian. A slight cooling in the surface-water temperature has occurred at the end of Danian. However, the late Paleocene (Thanetian) is characterized by the predominance of warm-water forms and also by an increased value of the *Discoaster/Chiasmolithus* ratio. This suggested an increase of the surface-water paleotemperature during this time interval.

INTRODUCTION

The Upper Cretaceous-Lower Tertiary succession exposed in Kharga and Dakhla Oases has been studied by many workers (Zittel, 1983; Ball, 1900; Beadnell, 1901, 1909; Hassan, 1953; Nakkady, 1959; Said, 1962; Hermina, 1967; Issawi, 1972).

Issawi *et al* (1978), studied the geology of the Abu Tartur Plateau and classified the Upper Cretaceous-Paleocene rocks into different rock units. They are from base upwards: Nubia Formation, Duwi Formation, Dakhla Formation, Kurkur Formation and Garra Formation.

The planktonic and benthic foraminifers and the Ostracods and the nannoplankton of the Upper Cretaceous-Paleocene rocks in the Ain Amur section were studied and identified by Faris (1982). The sequence was subdivided into a number of planktonic foraminiferal and nannofossil zones.

No adequate attention has been paid so far to the study of nannofloras in the Ain Dabadib section.

The investigated section, at Ain Dabadib, lies in the Northwestern part of the Kharga Oasis (Longitude 30^0 26′ E and Latitude 25^0 44′ N, Fig. 1).

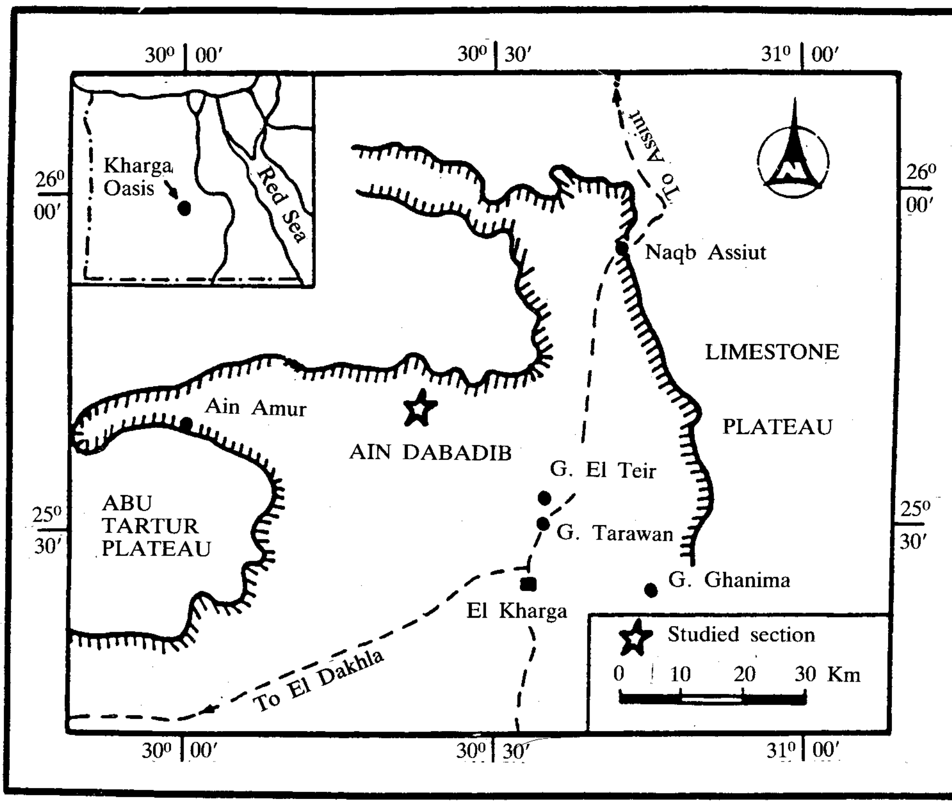

Fig. 1: Location Map

The stratigraphic sequence exposed in the NW Kharga Oasis is subdivided into several rock units, namely from base to top: Nubia sandstone, Duwi Formation, Dakhla Shale and Tarawan Chalk. The first two formations as well as the lowermost part of the Dakhla Shale are completely barren in nannofossils in the Ain Dabadib section.

The rock succession treated in this work is mainly composed of two lithostratigraphic units: the middle and upper parts of the Dakhla Shale and the Tarawan Chalk. The Tarawan Chalk in the Ain Dabadib section is stratigraphically equivalent to the Abu Tartur Formation in the North Ain Amur section.

BIOSTRATIGRAPHY

In the present study, the scheme proposed by Perch-Nielsen *et al* (1982) was adopted for the late Cretaceous and that of Martini (1971) for the Paleocene nannofossils except for Zones NP7 and NP8; the definition used by Romein (1979) is adopted.

Biostratigraphic analyses of the collected samples were performed at polarizing optical microscope on semar slides. Most samples contained nannofossils, although with variable abundance.

The recorded nannofossil zones and their relevance to those of the planktonic foraminifers recorded by Anan and Sharabi (1988) for the same study sequence are shown on Fig. 2.

The most significant nannofloral assemblages are reported on Figs. 3 and 4. Barren samples have been omitted. Some selected nannoplankton species and genera are illustrated on Plate 1.

The identified nannoplankton zones are discussed herein briefly:

LATE MAASTRICHTIAN

1. *Micula murus* Zone: Martini (1969). emend Perch-Nielsen, (1981).

The zone is recorded here for the first time in the studied section. The *M. murus* (*M. mura* for many authors) is probably restricted to tropical regions, while *Nephrolithus frequens* is common in the boreal regions (Worsley and Martini, 1970). In our sediments *N. frequens* was not found, but *M. murus* is present.

The Cretaceous/Tertiary Boundary:

Hassan (1953), studied the Cretaceous-Tertiary succession at Gebel El Teir and Gebel Um El-Ghanayem in the Kharga Oasis. He proposed a "Danian-Montian" stage as "Transitional Zone" between the Maastrichtian and Paleocene.

El Deftar *et al* (1970), studied the geology of Abu Tartur and adjacent areas. They recorded an unconformity between the Maastrichtian and the Danian sediments reaching its climax in the central part of the area.

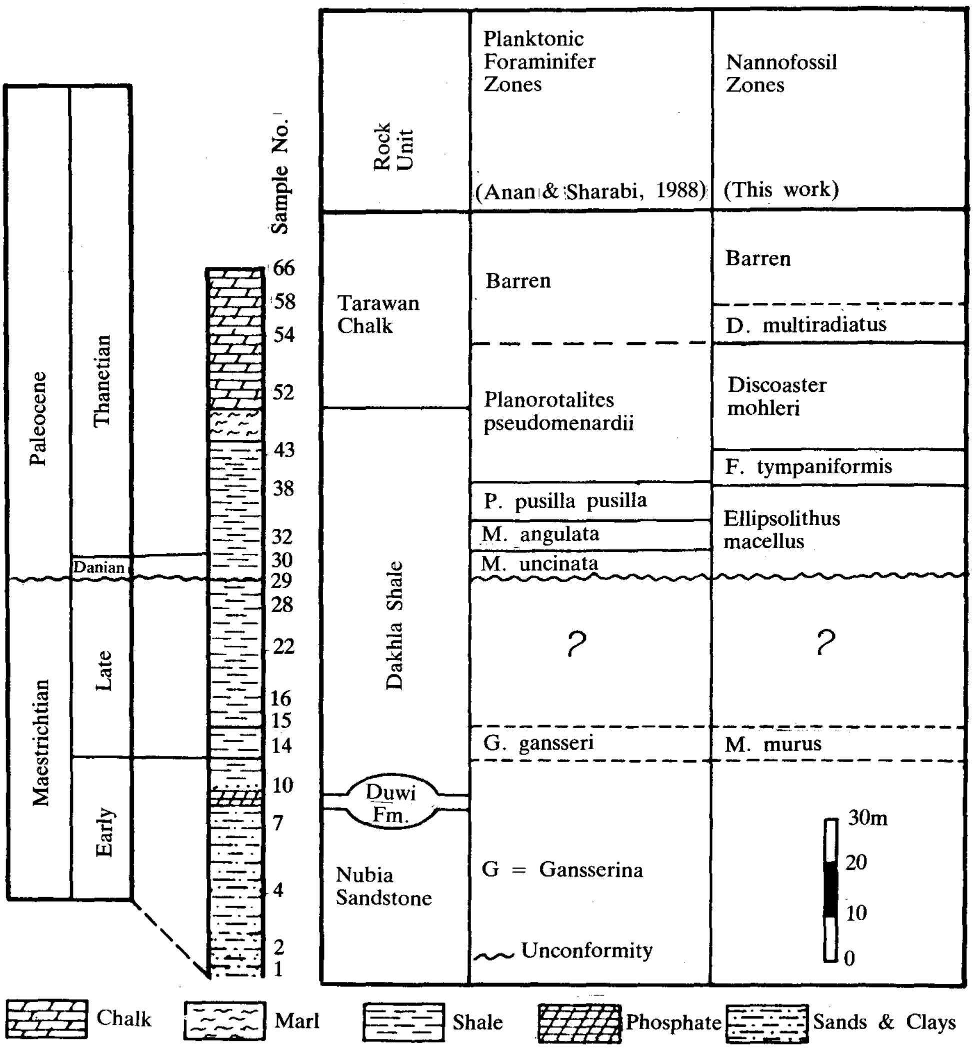

Fig. 2: Lithostratigraphy and biostratigraphy of the late Cretaceous-Paleocene in the Ain Dabadib section (Lithology after Anan and Sharabi, 1988).

Maastrichtian			Age	
Early	L.			
Dakhla Shale			Rock Unit	
10 - 14	15	16 - 29	Sample No	
	A		Abundance	
	G		Preservation	
	M. murus		Nannofossil Zone	
	F		Watznaueria barnesae	Warm-water
	R		Micula murus	Warm-water
	R		Thoracosphaera operculata	Warm-water
	R		Pharhabdolithus splendens	Warm-water
	F		Micula staurophora	Cool-water forms
	R		Lithraphidites carniolensis	Cool-water forms
	A		Arkhangelskiella cymbiformis	Cool-water forms
	R		Ahmuellerella octoradiata	Cool-water forms
	R		Cribrocorona gillica	Cool-water forms
	C		Kamptnerius magnificus	Cool-water forms
	R		Lithraphidites praequadratus	Cool-water forms
	R		Lithraphidites quadratus	Cool-water forms
	C		Prediscosphaera cretacea	Non-characteristic forms
	C		Prediscosphaera spinosa	Non-characteristic forms
	A		Cribrosphaerella ehrenbergii	Non-characteristic forms
	C		Eiffellithus turriseiffelii	Non-characteristic forms
	C		Eiffellithus parallelus	Non-characteristic forms
	R		Microrhabdulus decoratus	Non-characteristic forms
	R		Prediscosphaera grandis	Non-characteristic forms
	R		Manivitella pemmatoidea	Non-characteristic forms
	R		Vekshinella crux	Non-characteristic forms
	R		Zygodiscus spiralis	Non-characteristic forms
	R		Parhabdolithus embergeri	Non-characteristic forms
	R		Zygodiscus diplogrammatus	Non-characteristic forms
	R		Cretarhabdus conicus	Non-characteristic forms
	R		Pharhabdolithus angustus	Non-characteristic forms
	C		Kamptnerius puncatus	Non-characteristic forms

A = Abundant
F = Frequent
C = Common
R = Rare

G = Good

Fig. 3a: Distribution of warm-water, cool-water and non-characteristic species in the studied samples (Maastrichtian)

Age	Paleocene																					
	Dan.		Thanetian																			
Rock unit	Dakhla Shale																					
Sample No	30	31	32	33	34	35	37	38	39	40	41	42	43	44	46	47	48	51	52	54	58	
Abundance	A	A	A	F	C	C	F	C	A	R	A	C	R	F	R	R	R	R	R	R	R	
Preservation	G	G	G		M	M	M	M	G	M	M	M	M	M	M	M	M	M	M	M	M	
Nannofossil Zone	E. macellus							F. tympaniformis					D. mohleri								D. multi.	
Ericsonia subpertusa	C	C	C	C	R	R	C	R	C	R	R	R	C	F	R	R	F	R	C	R	R	Warm-water species
Braarudosphaera bigelowii	R			R	R	R				R	R											
Zygrhablithus bijugatus	R	C		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R		
Micrantholithus vesper		R	C	R	R	R	R	R	R	R	C											
Fasciculithus ulii						R				R	R	R	F	F								
Sphenolithus anarrhopus								R		R	R	R										
Fasciculithus bitectus								R	R	R	R	R	R	R								
Pontosphaera multipora								R	R													
Fasciculithus tympaniformis								R	R	R	R	C	C	C	R	R	R	R	R		R	
Fasciculithus pileatus										R	R											
Sphenolithus moriformis											R				R	R	R		R	R		
Discoaster mohleri													R	R	R	R	R	R	R	R	R	
Fasciculithus alanii														R	R	R			R	R	R	
Fasciculithus clinatus																	R					
Sphenolithus primus																	R					
Fasciculithus billii																					R	
Discoaster nobilis																					R	
Discoaster lenticularis																					R	
Fasciculithus janii																					R	
Fasciculithus bobii																			R			
Coccolithus pelagicus	F	F	F	C	R	R	R	R	C	R	R	R	R	R	R	R	R	R	R	R	R	Cool-water species
Chiasmolithus danicus	C	C	R	R	R	R	R	R	R	R	R								R			
Coccolithus eopelagicus												R	R	R		R				R		
Chiasmolithus bidens													R	R	R	R	R				R	
Chiasmolithus frequens																					R	
Placozygus sigmoides	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R						Non-characteristic species
Ellipsolithus macellus	R	C	C	R	R	R	R		R	R	R			R	R							
Neochiastozyqus imbrie																						
Neochiastozygus modestus					R	R	R															
Neochiastozygus saepes						R	R															
Neochiastozygus perfectus													R	R	R	R	R	R			R	
Neochiastozygus cearae													R	R			R				R	
Heliolithus cantabrie																					R	
Zygodiscus plectopons																					R	
Zygodiscus adamas																					R	
Neochiastozyaus distentus																					R	

Abundance A = Abundant
F = Frequent
C = Common
R = Rare

Preservation
G = Good
M = Moderate

Fig. 3b: Distribution of warm-water, cool-water and non-characteristic species in the studied samples (Paleocene)

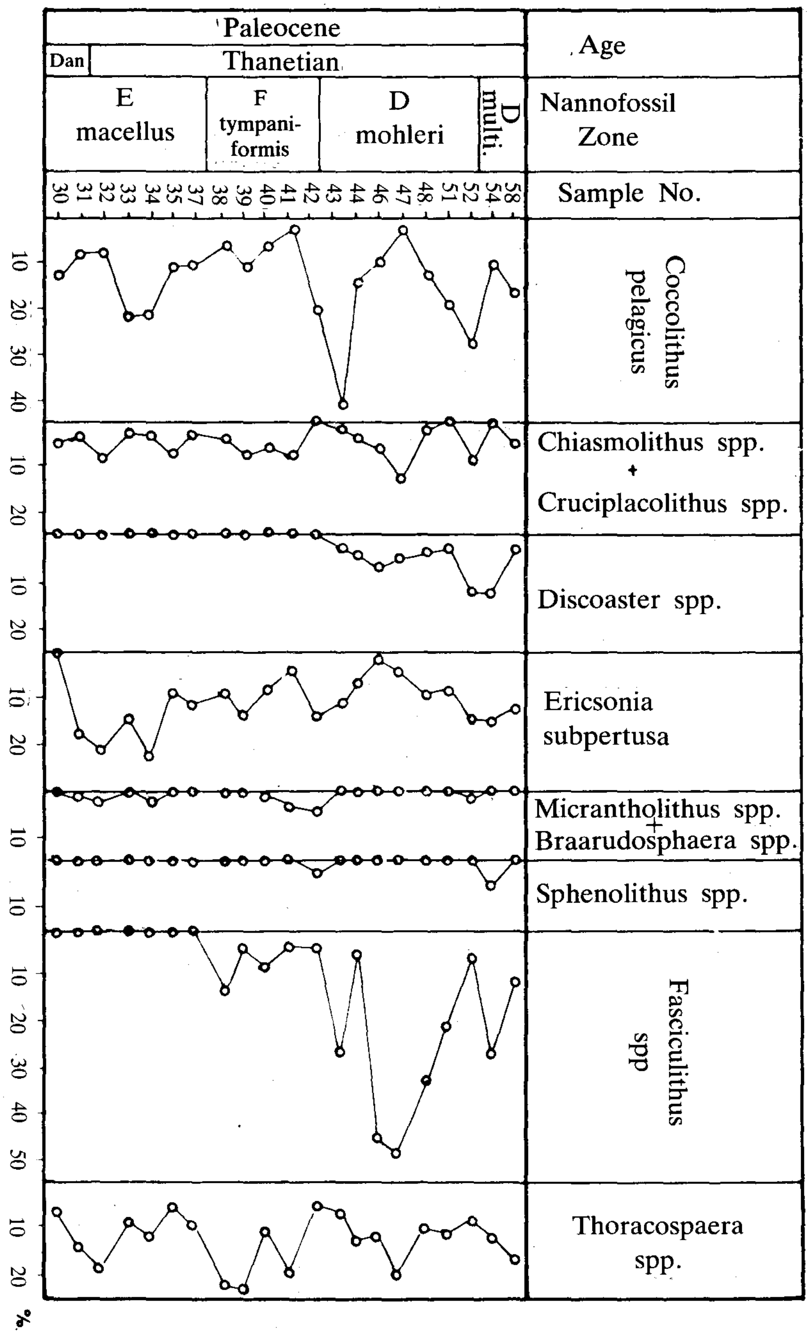

Fig. 4a: Percentage frequency of some selected nannofossil taxa, Ain Dabadib section NW Kharga Oasis.

Age	Paleocene																					
	Dan.		Thanetian																			
Rock unit	Dakhla Shale																					
Sample No	30	31	32	33	34	35	37	38	39	40	41	42	43	44	46	47	48	51	52	54	58	
Abundance	A	A	A	F	C	C	F	C	A	R	A	C	R	F	R	R	R	R	R	R	R	
Preservation	G	G	G		M	M	M	M	G	M	M	M	M	M	M	M	M	M	M	M	M	
Nannofossil Zone	E. macellus							F. tympaniformis					D. mohleri								D. multi.	
Ericsonia subpertusa	C	C	C	C	R	R	C	R	C	R	R	R	C	F	R	R	F	R	C	R	R	Warm-water species
Braarudosphaera bigelowii	R			R	R	R				R	R											Warm-water species
Zygrhablithus bijugatus	R	C		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R		Warm-water species
Micrantholithus vesper		R	C	R	R	R	R	R	R	R	C											Warm-water species
Fasciculithus ulii						R				R	R	R	F	F								Warm-water species
Sphenolithus anarrhopus								R		R	R	R										Warm-water species
Fasciculithus bitectus								R	R	R	R	R	R	R								Warm-water species
Pontosphaera multipora								R	R													Warm-water species
Fasciculithus tympaniformis								R	R	R	R	C	C	C	R	R	R	R	R		R	Warm-water species
Fasciculithus pileatus										R	R											Warm-water species
Sphenolithus moriformis											R				R	R	R		R	R		Warm-water species
Discoaster mohleri													R	R	R	R	R	R	R	R	R	Warm-water species
Fasciculithus alanii														R	R	R			R	R	R	Warm-water species
Fasciculithus clinatus																	R					Warm-water species
Sphenolithus primus																	R					Warm-water species
Fasciculithus billii																					R	Warm-water species
Discoaster nobilis																					R	Warm-water species
Discoaster lenticularis																					R	Warm-water species
Fasciculithus janii																					R	Warm-water species
Fasciculithus bobii																			R			Warm-water species
Coccolithus pelagicus	F	F	F	C	R	R	R	R	C	R	R	R	R	R	R	R	R	R	R	R	R	Cool-water species
Chiasmolithus danicus	C	C	R	R	R	R	R	R	R	R	R								R			Cool-water species
Coccolithus eopelagicus												R	R	R		R				R		Cool-water species
Chiasmolithus bidens													R	R	R	R	R				R	Cool-water species
Chiasmolithus frequens																					R	Cool-water species
Placozygus sigmoides	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R						Non-characteristic species
Ellipsolithus macellus	R	C	C	R	R	R	R		R	R	R			R	R							Non-characteristic species
Neochiastozyqus imbrie																						Non-characteristic species
Neochiastozygus modestus					R	R	R															Non-characteristic species
Neochiastozygus saepes						R	R															Non-characteristic species
Neochiastozygus perfectus													R	R	R	R	R	R			R	Non-characteristic species
Neochiastozygus cearae													R	R			R				R	Non-characteristic species
Heliolithus cantabrie																					R	Non-characteristic species
Zygodiscus plectopons																					R	Non-characteristic species
Zygodiscus adamas																					R	Non-characteristic species
Neochiastozyaus distentus																					R	Non-characteristic species

Abundance: A = Abundant, F = Frequent, C = Common, R = Rare

Preservation: G = Good, M = Moderate

Fig. 4b: Distribution of warm-water, cool-water and non-characteristic species in the studied samples (Paleocene)

Plate I

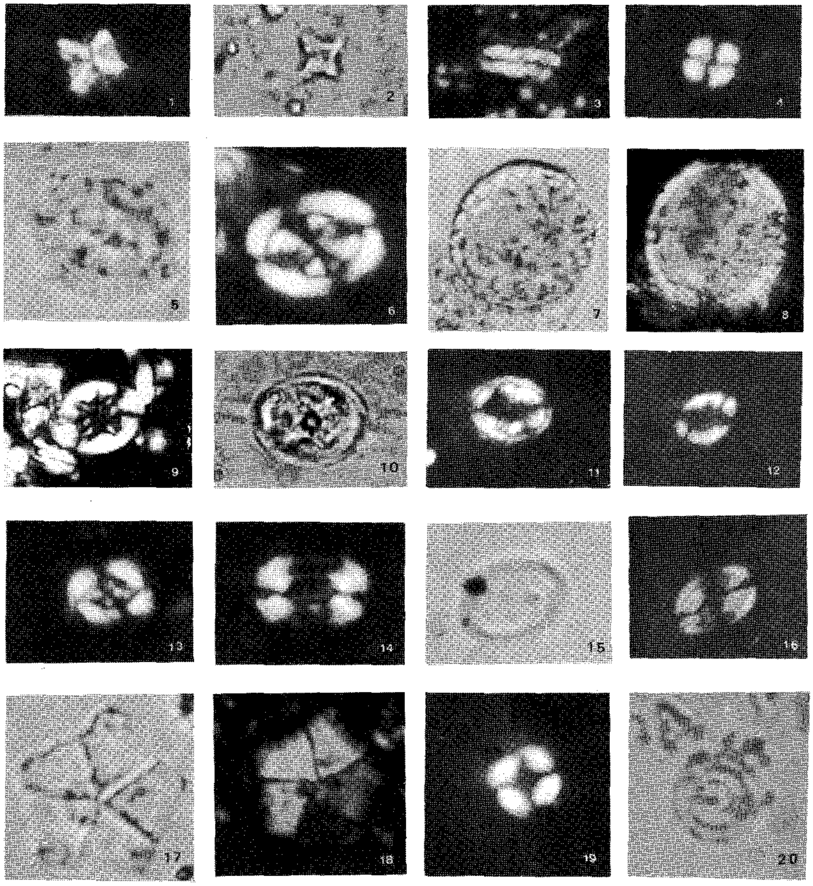

PLATE I
(All Figures X2000)

Figs. 1 & 2: *Micula staurophora* (Gardet), Sample No. 15. Fig. 3: *Zygrhablithus bijugatus* (Deflandre), Sample No. 43. Fig. 4: *Watzaueria barnesae* (Black), Sample No. 15. Figs. 5 & 6: *Arkhangelskiella cymbiformis* Vekshina, Sample No. 15. Figs. 7 & 8: *Thoracosphaera operculata* Bramlette and Martini, Sample No. 48. Figs. 9 & 10: *Eiffellithus parallelus* (Perch-Nielsen), Sample No. 15. Fig. 11: *Placozygus sigmoides* (Bramlette & Sullivan), Sample No. 35. Fig. 12: *Eiffellithus turriseiffeli* (Deflandre), Sample No. 15. Fig. 13: *Chiasmolithus danicus* (Brotzen), Sample No. 30. Fig. 14: *Ellipsolithus macellus* (Bramlette & Sullivan), Sample No. 32. Figs. 15 & 16: *Pontosphaera multipora* (Kamptner), Sample No. 39. Figs. 19 & 20: *Ericsonia subpertusa* (Hay & Mohler), Sample No. 44.

In the present study, the Maastrichtian-Paleocene relationship is an unconformable one and the stratigraphic gap includes the uppermost Maastrichtian *Micula prinsii* Zone as well as the early Paleocene nannofossil zones: *Markalius inversus* (NP1), *Cruciplacolithus tenuis* (NP2) and *Chiasmolithus danicus* (NP3).

The boundary interval is characterized by the presence of a conglomeratic sandy mudstone band containing pebbles of ferruginous mudstone with flint and carbonate nodules. The upper-most part of the Maastrichtian sediments is rich in arenaceous foraminifera and is entirely barren in the planktonic foraminifers and also in calcareous nannofloras. On the other hand, in the Ghanima section, the Cretaceous-Tertiary boundary interval is characterized by the presence of a phosphatic band and shales, containing large numbers of agglutinated foraminifera (Faris, 1985).

PALEOCENE

2. *Ellipsolithus macellus Zone* (NP4): Martini, (1970).

In the study section, the first species of *Sphenolithus,* approximates the first of *Fasciculithus* and thus can be used as a zonal boundary between NP4/NP5 Zones.

3. *Fasciculithus tympaniformis Zone (NP5):* Mohler and Hay, in Hay *et al.* (1967).

In the present area, the *F. tympaniformis* Zone is very easy to recognize.

4. *Discoaster mohleri Zone* (NP7/8): Hay (1964). emend. Romein (1979).

In the present zonation the name *Discoaster mohleri* Zone is used for the combined *D. mohleri* and *Heliolithus riedelii* Zones.

The first representative of the genus *Discoaster* appears in the NP7/8 Zone in the present study.

5. *Discoaster multiradiatus Zone* (NP9): Bramlette and Sullivan (1961) emend. Martini (1971).

The base of the NP9 Zone is sometimes uncertain due to the lacking or the absence of the zonal species. The presence of *Discoaster lenticularis* as a secondary marker, indicates the base of the *D. multiradiatus* Zone (NP9) in the present study.

PALEOTEMPERATURES

The utility of calcareous nannoplankton (Coccolithophores) as water-mass indicators and in determining floral assemblage temperature is well documented.

Nannoplankton are photosynthetic, existing only in the photic zone of the oceans. They should make them ideal candidates for surface paleotemperature and paleonutrient studies.

Wind (1979) recognized latitudinal trends in the relative frequencies of *Micula staurophora* and *Watznaureria barnesae* in the Maastrichtian of the Atlantic and Indian Oceans. He used the ratio of *M. staurophora* to *W. barnesae* (M/W) to delineate water paleotemperature.

Roth (1978) characterized *Micula murus, Quadrum gothicum,* and *Q. trifidum* as warm-water species; *Nephrolithus frequens, Lithraphidites quadratus* and *L. praequadratus* as relatively cold-water species.

Bukry (1971 a-c) proposed that coccolith assemblages with a limited diversity or small size and shape are typical of cool-water.

Siesser (1975) believed that this may also apply to assemblages of *Discoaster* which were associated with warm surface paleotemperature because of their abundance in low latitudes sediments.

Increased numbers of chiasmoliths in high latitude sediments suggest an affinity for cool-surface temperature. This led Bukry (1973 b) to propose the *Discoaster/ Chiasmolithus* ratio for determining surface water temperature. Bukry (1974) describes several paleotemperature events utilizing this technique in samples from Site 242.

The list of cool-water and warm-water species of the late Cretaceous and Paleocene (Tables 1, 2) was compiled by the present authors from data presented by Martini (1970); Bukry (1971a, 1973a); Edwards (1973); Wise (1973); Thierstein (1974), and Doeven (1983).

The percentage of warm water to cool-water species and the ratio between the *Micula staurophora* to *Watznaueria barnesae* and also the ratio between *Discoaster* and *Chiasmolithus* expressed in logarithemic values are demonstrated on Table 3 and Fig. 5.

For the paleotemperature analysis, the studied intervals will be discussed individually below:

warm-water to cool-water species ratios.

The late Paleocene (late Thanetian) (NP7/8 and NP9 Zones) is characterized by the predominance of warm-water species and also by an increased value of the *Discoaster/Chiasmolithus* ratio. This suggested an increase of the surface-water temperature during this time interval.

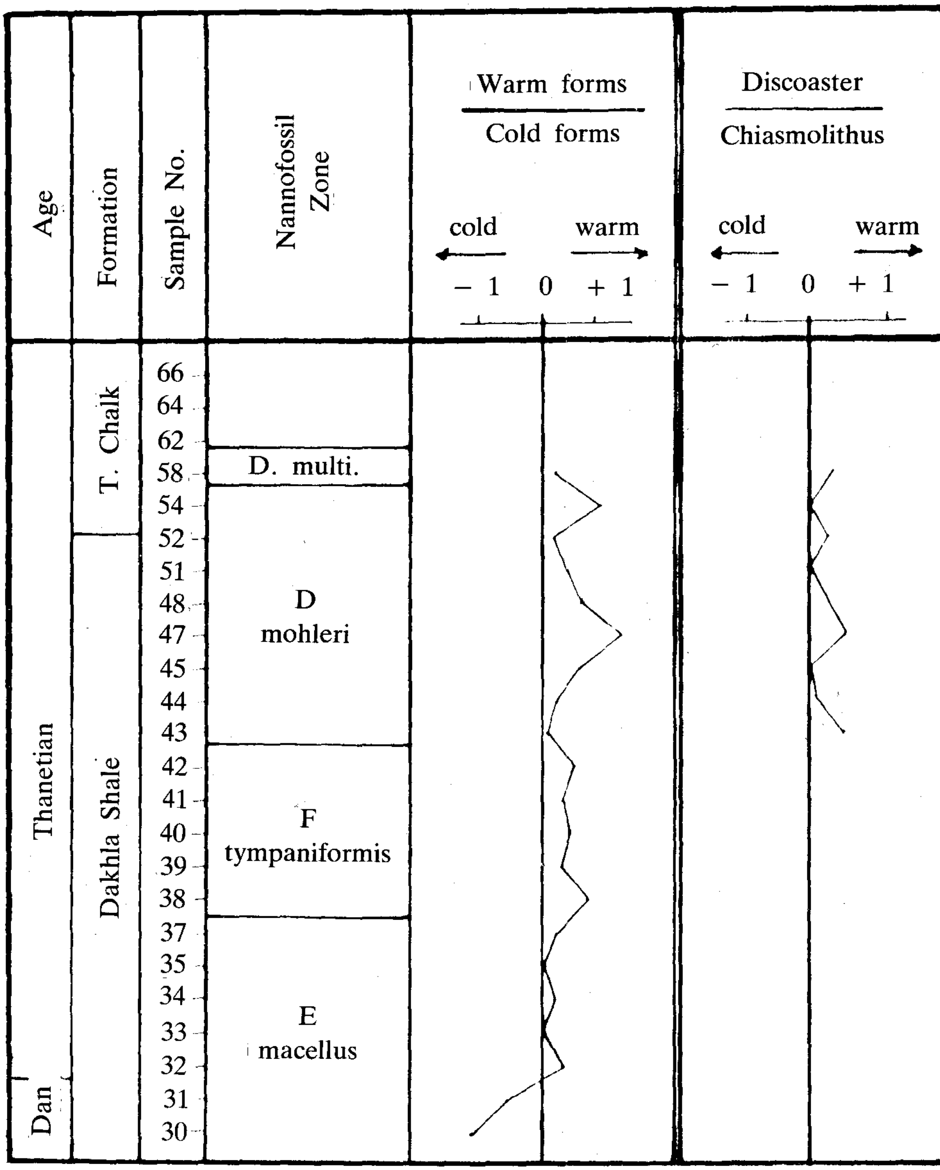

Fig. 5: Relative surface-water paleotemperature during the late Paleocene in Ain-Dabadib section.

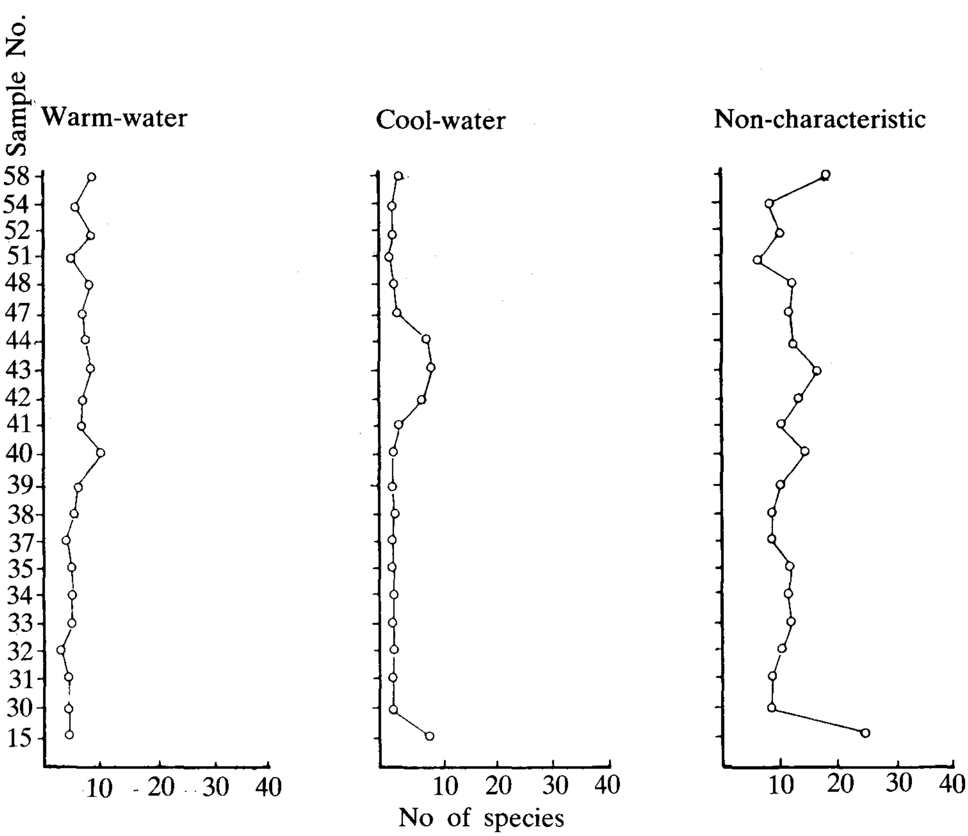

Fig. 6: Number of warm-water species, cool-water species and non-characteristic species in the studied samples.

Late Maastrichtian:

In the studied section, the *Micula staurophora/Watznaueria barnesae* ratio has a negative value (see Table 3). This suggests a decreasing in surface-water paleotemperature during the late Maastrichtian and close to the Cretaceous/ Tertiary boundary interval. On the other hand, an abrupt change in surface temperature has been noted at this boundary in Central Egypt (Abdel-Hameed and Faris, In Press).

Paleocene:

In the current study, the terminal Danian is characterized by a relatively cool-water temperature. This is indicated by the decreased values of the warm-water/ cool-water ratio.

From the middle part of the *Ellipsolithus macellus* Zone (NP4) upsection, the surface-water paleotemperature was warm as marked by higher values of the warm-water to cool-water species ratios.

The late Paleocene (late Thanetian) (NP7/8 and NP9 Zones) is characterized by the predominance of warm-water species and also by an increased value of the *Discoaster/Chiasmolithus* ratio. This suggested an increase of the surface-water temperature during this time interval.

Table 1
Cretaceous "cool" or "warm-water" species
(See text for sources)

"Cool"	**"Warm"**
Lithraphidites quadratus	*Watznaueria barnesae*
Lithraphidites praequadratus	*Parhabdolithus splendens*
Lithraphidites carniolensis	*Thoracosphaera* spp.
Micula staurophora	
Arkhangelskiella cymbiformis	
Kamptnerius magnificus	
Ahmuellerella octoradiata	
Cribrocorona gillica	

Table 2
Paleocene "cool" or "warm-water" species
(See text for sources)

"Cool"	**"Warm"**
Coccolithus pelagicus	*Cyclococcolithus formosus*
Chiasmolithus spp.	*Ericsonia subpertusa*
Neococcolithes dubius	*Fasciculithus* spp.
Prinsius martinii	*Pontosphaera* spp.
Markalius inversus	*Sphenolithus* spp.
Blackites spp.	*Discoaster* spp.
	Thoracosphaera spp.
	Zygrhablithus bijugatus
	Micrantholithus spp.
	Braarudosphaera spp.

Table 3
Percentages of warm-water/cold-water species, *Micula staurophora/Watznaueria barnesae* and *Discoaster/Chiasmolithus* in the studied samples (% expressed in logarithmic values).

Age	Sample No	% warm/cold	Log % warm/cold	% *Micula Watznaueria*	Log % *Micula Watznaueria*	% *Discoaster Chiasmolithus*	Log % *Discoaster Chiasmolithus*
	58	1.84	0.264			0.666	0.17
	54	8.0	0.903			—	—
	52	1.29	0.1106			1.428	0.154
	51	2.416	0.382			—	—
	48	3.888	0.589			1.75	0.243
	17	20.0	1.30			3.0	0.377
	46	4.5	0.653			1.142	0.057
Thanetian	44	1.733	0.238			1.363	0.134
	43	1.264	0.1019			3.0	0.477
	42	3.5	0.544				
	41	2.878	0.459				
	40	2.419	0.383				
	39	2.3214	0.365				
	38	4.2	0.623				
	37	1.653	0.218				
	35	1.085	0.035				
	34	1.2413	0.093				
	33	1.0	0.0				
	32	2.475	0.3935				
Danian	31	0.333	−0.477				
	30	0.0948	−1.022				
Maast.	15	0.285	−0.545	0.9696	−0.0133		

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دراسة أحافير النانوبلانكتون الجيرية في صخور المستخرختيان العلوي والباليوسين في قطاع عين دباديب ـ شمال غرب الواحات الخارجة

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تم تقسيم تتابع المسترختيان العلوي والباليوسين في قطاع عين دباديب بشمال غرب الواحات الخارجية إلى عدة نطق حيوية على أساس ما تحتويه صخوره من أحافير النانوبلانكتون الجيرية .وقد تأكد من دراسة هذه الاحافير بأن الأجزاء العليا من المسترختيان المتأخر وكذا الأجزاء السفلى من الباليوسين المبكر لا تمثل في منطقة الدراسة .

تم دراسة النسبة بين صحبة أنواع المياه الدافئة إلى صحبة أنواع المياه الباردة ، وكذلك النسبة بين Watznaueria Barnesae&MiculaStaurophora بالإضافة إلى النسبة بين أنواع Chiasmolithus & Disoaster والتي أفادت في استنتاج التغيرات النسبية في درجات حرارة المياه السطحية القديمة لرواسب المسترختيان المتأخر والباليوسين بقطاع عين دباديب . ويعتقد أن هذه المياه السطحية كانت باردة نسبياً خلال المسترختيان المتأخر والجزء المبكر منالباليوسين (الدانيان) ، بينما ارتفعت درجة الحرارة النسبية لهذه المياه في الباليوسين المتأخر (التنثيان) .