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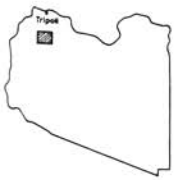
UPPER SENONIAN AND PALAEOCENE BIOSTRATIGRAPHY AND PALAEOGEOGRAPHIC DEVELOPMENT OF AL QARYAT AL GHARBĪYAH AREA (HAMMĀDAH AL HAMRĀ', LIBYA)

(Figs. 5, Pls. 4)



A b s t r a c t: The stratigraphic division and palaeogeographical development of the Campanian—Palaeocene of the Hammádah al Hamrá' basin (Al Qaryat al Gharbíyah area, Tripolitania, Libya) is presented in this work.

Р е з ю м е: Предложено стратиграфическое расчленение и палеогеографическое развитие кампан — палеоцена впадины Гамадаг аль Гамра (Аль Карнат аль Гарбия области, Триполитания, Либия).

Introduction

The Upper Senonian and Palaeocene sediments of the studied area of Al Qaryat al Gharbíyah belong to the sedimentation basin of Hammádah al Hamrá' (see Fig. 1), situated in the NW part of Libya.

Early Palaeozoic, Triassic and Jurassic sediments occur in the area of Jeffara of southern Tunisia and northern Tripolitania (B u s s o n, 1967 a, 1967 b, G l i n t z b o e c k e l and R a b a t é, 1964; B a i r d, 1967; B i s h o p, 1975). The Jeffara area situated north of the Nefúsah Uplift belongs, from geotectonical viewpoint, to the southern part of the East Tunisian Platform, which is part of the Pelagian Block (B u r o l l e t et al., 1978). The Palaeozoic—Mesozoic to Palaeocene-Lower Eocene Hammádah al Hamrá' sedimentation basin south of the Nufúsah Uplift, also with its crystalline basement, is already part of the Saharan Platform.

In the uppermost Jurassic to Lower Cretaceous distinct regression and sedimentation of prevailingly Upper Jurassic lagoonar and continental Lower Cretaceous sediments of the Chicla Formation took place in the Hammádah al Hamrá' and Jeffara areas (D e s i o, 1971).

A distinct transgression from north to south took place in the Cenomanian. The Upper Cretaceous and Palaeocene distinctly shallow-water, shelf to lagoonar carbonate sediments are formed by various types of limestones, calcareous dolomites to dolomites with layers of clays and marls, very often gypsiferous. The Cenomanian to Campanian p. p. sediments belonging to Nefúsah and Tigrinnah Formations and Mazúzah Member, found to the north and beyond the studied area in the Mizdah sheet area, were not subject of study and are described in detail by A n t o n o v i ć (1977), we refer to his work. The studied Campanian to Maastrichtian and Palaeocene sediments occurring in the wider

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surroundings of Al Qaryat al Gharbíyah were mapped by team in the years 1977 to 1978 in the frame of investigation tasks of I.R.C. Tripoli (see sheet 1 : 250 000 Al Qaryat al Gharbíyah NH-35, J. Salaj, 1979). Concerned is the NE part of Hammádah al Hamrá', approximately 300 km S of Tripoli. The sediments occuring there belong to Thala, Lower Tár, Upper Tár, Hád, Bú Ra's and Qaltah Members and were defined and described by Jordi and Lonfat (1963) and their last member was defined by Burollet et al. (1960). The stratigraphic nomenclature of these formations has been studied in the light of new observations by Megerisi and Mamgain (1980).

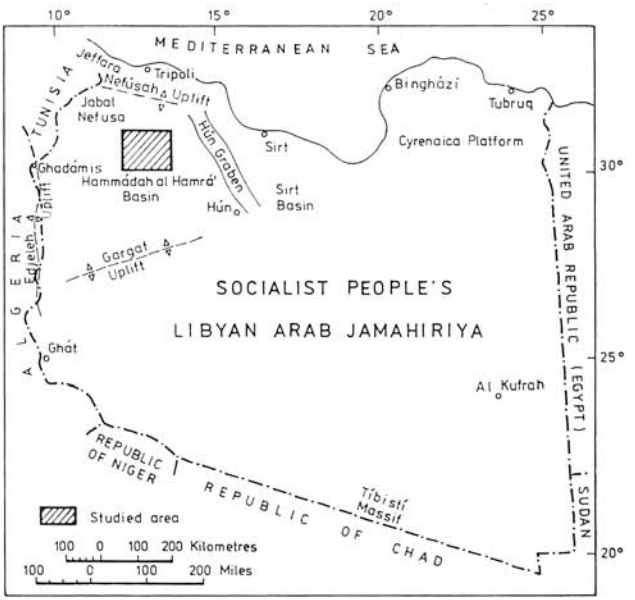


Fig. 1. Location map

Lithology and stratigraphy

1. The Thala Member defined by Jordi and Lonfat (1963) and described in detail by Antonović (1977) is represented by regressive sediments and belong to the upper part of the Mizdah Formation (Jordi and Lonfat, 1963). Lithologically the Thala Member (40 to 45 m in thickness) is characterized mainly by gypsiferous marl with sporadically occurring agglutinated foraminifers of the genus *Haplophragmoides* (cf. *Haplophragmoides glabrans* CUSHMAN) observed in its lower part, inmediatelly at the contact with dolomitized limestones of the underlying Mazúzah Member (lower part of the Mizdah Formation, defined by Jordi and Lonfat, 1963). From the macrofauna determined by Záruba, the species *Lopha (Actinostreon) morgani* (DOUVILLÉ) is present only, quite abundantly.

Plate 1

Fig. 1 a. The marls of the Lower Tár Formation, The Upper Campanian level with *Lopha (Actinostreon) dichotoma* (BAYLE) loc. Lawd Wudayytát al Kurumb, no. 1786-I-D-19/1.
Fig. 1 b. The marls of the Lower Tár Formation, The Lower Maastrichtian level with *Amphidonte overwegi* (von BUCH), loc. Lawd al Bahríyah, no. 1786-I-B-3/3.

In the Upper part of the Thala Member calcarenites and calcilutites, often silicified and laminated, testify to the calm evolution of sedimentation. The sediments of the Thala Member were accumulated in the subtidal environment with low energy. That is confirmed also by the presence of one level with recrystallized corals. The top of the Thala Member (60 cm in thickness) is represented by calcilutite with very characteristic bioturbation corresponding to the supratidal environment.

Microfaunistically the Thala Member in its upper part represented by three types of microfauna assemblages:

a) Foraminiferal assemblage with preponderance of the species *Pararotalia hammi* KOCH associated with *Gavelinopsis bartensteini* HOFKER, *Neoflabellina rugosa rugosa* (ORBIGNY) and *Pararotalia tuberculifera* (REUSS).

b) The Ostracod assemblage with the prevailing species *Ovocytheridea nuda* GREKOFF. Other ostracod species present are: *Brachycythere ekpo* REYMENT, *Cythereis* aff. *deltaensis* REYMENT, *Cytherella (Cytherella) kunradensis* VAN VEEN and *Ovocytheridea apiformis* REYMENT. These two assemblages are bound to the marl facies.

c) In the calcareous clays, calcilutites and partly in calcarenites too, *Rhapydiomina* sp., *Peneroplis* sp. and *Dicyclina schlumbergeri* MUNIER and CHALMAS are present, studied in thin sections only.

Stratigraphical assignment of this member to the Campanian is performed on the basis of the described microfauna and of fact that in the map sheet Shawa' the underlying Mazúzah Member sequence contains Campanian orbitoid foraminifers found and quoted by Chaloupský (1979).

2. The Lower Tár Member already belonging to the Zimám Formation, is determined at its base by a basal transgressive conglomerate lumachelle macrofacies (0.30—0.60 cm) and calcirudite transgressive lithofacies (0.8 m to 3 m in thickness), with triaxon needles and bryozoans only.

Gypsiferous clays and marls with layers of gypsum, glauconite calcarenites and marls are overlying them. In the uppermost layers of this sequence, mainly in the NW part of the area, Upper Campanian orbitoid foraminifers, represented by mass occurence of the species *Orbitoides media* (ARCHIAC), are found. The macrofauna is represented by mass occurrence of the bivalves (see Pl. 1, photo 1.), from which the following species were determined by Záruba: *Lopha (Actinostreon) villei* (COQUAND), *Lopha (Actinostreon) dichotoma* (BAYLE), *Pycnodonte (Phygraea) vesicularis* (LAMARCK) and *Ceratostreon spinosum* (MATHERON). The last named species of them does not exceed the Campanian boundary in its range.

The overlying sequence of the uppermost Campanian to basal part of the Maastrichtian is lithologically variable in the area studied. Essentially it is represented by three lithological types:

1. In the NW area are thick-banked calcirudites, forming a sequence about 25 m thick, with abundant fragments of inoceram shells and with *Inoceramus (Cataceramus) goldfusianus* ORBIGNY. In the uppermost part are brecciated calcilutites with a conglomerate layer and disintegrating chalky calcarenites to calcilutites 1—2 m thick with *Agerostrea ungulata* (SCHLOTHEIM), which already indicates a Maastrichtian age of this part of the sequence (see Fig. 3).

2. In the NE part of the area studied may be recognized:

Vertical range of important microfossils in the pelagical facies of the Lower Tár Member Loc.: 5.5 km NE of Bi'r az Zamílah no 1986-II-B-7/1-9	UPPER CAMPANIAN					LOWER MAASTRICHTIAN			
	Globotruncana arca rugosa Zone					Globotruncana falsostuarti zone			
	1	2	3	4	5	6	7	8	9
Spiroplectammina laevis ROEMER	+						+	+	+
Lenticulina (Robulus) pseudovortex (MARIE)	+					+	+		+
Bolivina incrassata crassa VAS & MYATLIUK	+		+						
Bolivina incrassata incrassata REUSS	+	+	+	+	+			+	
Bolivinoides watersi CUSHMAN	+	+							
Bolivinita eleyi (CUSHMAN)	+								
Neoflabellina rugosa rugosa (ORBIGNY)	+								
Neoflabellina rugosa leptodisca (WEDEKIND)	+								
Gavelinella umbilicatiformis HOFKER	+								
Dentalina marcki REUSS		+					+		+
Marginulina trilobata (REUSS)				+			+		+
Gavelinopsis pseudoacuta NAKKADY		+		+	+	+		+	+
Gavelinopsis bartensteini HOFKER			+						
Cibicides voltziana (ORBIGNY)				+			+	+	
Tritaxia pyramidata REUSS					+		+	+	
Gyroidina globosa HAGENOW							+		
Gyroidina umbilicata (ORBIGNY)							+	+	
Praebulimina carseyae (PLUMMER)							+	+	
Praebulimina laevis (BEISSEL)							+	+	
Marginulina bullata REUSS							+	+	
Dentalina angusticostata CUSHMAN							+	+	+
Bolivina incrassata gigantea WICHER							+	+	
Afrobolivina afra REYMENT							+	+	+
Ortokarstenia clarki (CUSHMAN & CAMPBELL)							+	+	+
Frondicularia aff. biformis MARSSON							+		
Neoflabellina cf. efferata (WEDEKIND)							+		
Neoflabellina aff. permutata KOCH							+		
Pseudovigerina cristata (MARSSON)							+		
Cibicides beaumontiana (MARIE)							+		
Cibicides excavatus BROTZEN							+		
Tritaxia dubia REUSS								+	+
Frondicularia sepiolaris MARIE								+	
Heterohelix globulosa (EHRENBERG)	+	+	+	+	+		+	+	+
Heterohelix ultimatumida (WHITE)	+	+			+				
Pseudoguembelina costulata (CUSHMAN)	+		+			+			
Globotruncana arca arca (CUSHMAN)	+	+			+	+	+	+	+
Globotruncana arca rugosa (MARIE)	+			+	+	+	+	+	+
Globotruncana bulloides (VOGLER)	+	+		+			+		
Globotruncana fornicata fornicata (PLUMMER)	+						+	+	
Globotruncana ventricosa (WHITE)	+					+	+	+	
Rugoglobigerina rugosa (PLUMMER)	+		+		+				+
Rugoglobigerina macrocephala (BROENNIMANN)		+							
Pseudoguembelina excolata (CUSHMAN)		+			+	+	+	+	
Globotruncana rosetta rosseta (CARSEY)		+							+
Globigerinelloides rosebudensis (SMITH & PESSAGNO)		+		+					
Hedbergella monmouthensis (OLSSON)		+							
Heterohelix striata (EHRENBERG)			+	+	+		+	+	+
Platystophyla brazoensis (MARTIN)				+					
Globotruncana rosetta insignis GANDOLFI						+	+		+
Globotruncana subcircumnodifer (GANDOLFI)						+		+	
Globotruncana falsostuarti SIGAL									+

Fig. 2.

a) coquinoid calcarenites to calcirudites with layers of marls and scarcely also with intercalations of chalk and chalky calcilutite (about 15—25 m thick) with a rich Upper Campanian macrofauna containing the following species determined by Z á r u b a: *Lopha (Actinostreon) dichotoma* (BAYLE), *Nicaisolopha nicaisei* (COQUAND), *Pycnodonte (Phygraea) vesicularis* (LAMARCK)

Vertical range of Macrofaune in the Lower Tár Member (sheet 1:250.000 Al Qaryat al Gharbíyah – NH 33-5)	UPPER CAMPANIAN		MAASTRICHTIAN	
	Northwestern area	Northeastern and Eastern areas	Nortwestern area	Northeastern and Eastern areas
Lopha (Actinostreon) dichotoma (BAYLE)	+	+	+	+
Lopha (Actinostreon) morgani (DOUVILLÉ)		+		
Lopha (Actinostreon) villei (COQUAND)	+	+	+	
Pycnodonte (Phygraea) vesicularis (LAMARCK)	+	+		+
Curvostrea thomasi (PERON)		+		
Ceratostreon spinosum (MATHERON)	+		+	+
Nicaisolopha nicaisei (COQUAND)		+		
Tudicla bussoni COLLIGNON		+		
Plicatula numidica COQUAND		+		
Inoceramus (Cataceramus) goldfussianus ORBIGNY	+			
Inoceramus (Cataceramus) crispi var. radiosus QUAAS			+	
Inoceramus (Cataceramus) regularis ORBIGNY				+
Plicatula hirsuta var. sparsicosta PERVINQUIÈRE			+	+
Exogyra (Costagyra) paronai MAXIA			+	+
Agerostrea ungulata (SCHLOTHEIM)			+	+
Amphidonte overwegi (v. BUCH)			+	+
Pecten (Chlamys) dujardini ROEMER			+	+
Acutostrea incurva (NILSSON)				+
Meretrix tripolitensis (BARONI)				+
Ostrea lameraciana COQUAND				+
Plicatula flattersi COQUAND				+
Trigonoarca schweinfurthi (ZITTEL)				+
Trigonoarca cf. thevestensis (COQUAND)				+
Arca (Nemodon) sacodryensis BASSE				+
Venus immersa SOWERBY				+
Dentalium decemcostatum QUAAS			+	
Baculites anceps LAMARCK				+
Indoceras cf. afikpoense REYMENT			+	
Indoceras ismaeli var. libycum SORRENTINO			+	
Echinobrissus markovi FAS			+	
Hemiaster chargensis WANNER			+	
Hemiaster texanus ROEMER			+	

Fig. 3.

and *Tudicla bussoni* COLLIGNON. The microfauna has not been found in this sequence.

About 2 m above this sequence the species *Amphidonte overwegi* (VON BUCH) occurs sporadically first, surely determining the base of the Maastrichtian and so the Campanian-Maastrichtian boundary.

b) The further lithological development, of least areal extension, is represented by chalky calcilutides and chalk (15 to 18 m thickness) with rich planktonic and benthonic microfauna of the Upper Campanian *Globotruncana arca rugosa* Zone to Lower Maastrichtian *Globotruncana falsostuarti* Zone (see Fig. 2. 5).

Vertical range of important Upper Maastrichtian microfossils of the Lower Tár Member in the NE area Loc.: 5.5 km NE of Bi'r az Zamílah no 1986 - II - B - 7 / 10 - 21	UPPER MAASTRICHTIAN Lewel with Omphalocyclus macroporus and Cytherella (Cytherelloidea) araromiensis						
	10	13	14	16	17	18	21
Tritaxia aff. pyramidata REUSS	+						
Marginulina trilobata REUSS	+		+				
Omphalocyclus macroporus (LAMARCK)	+		+	+	+		
Heterohelix glabrans (CUSHMAN)	+						
Heterohelix punctulata (CUSHMAN)	+						
Rugoglobigerina rugosa (PLUMMER)	+		+				
Globotruncana patelliformis GANDOLFI	+						
Globotruncana cesarensis (GANDOLFI)	+						
Globotruncana subcircumnodifer (GANDOLFI)	+	+					
Globotruncana fornicata (PLUMMER)	+						
Rosalina binkhorsti REUSS		+					
Cibicides bosquetti REUSS			+	+	+		
Brachycythere aff. oguni REYMENT			+				
Cytherella (Cytherelloidea) araromiensis REYMENT			+		+		
Haplophragmoides excavata CUSHMAN & WATERS				+		+	
Marssonella oxycoma (REUSS)				+			
Pullenia americana CUSHMAN				+			
Heterohelix striata (EHRENBERG)				+	+		
Gavelinopsis bartensteini HOFKER					+		
Gavelinopsis umbilicatiformis HOFKER					+		
Pararotalia tuberculifera (REUSS)					+		
Pseudovalvulineria moniformis (REUSS)					+		
Globigerinelloides volutus (WHITE)					+		
Bairdia decumana VAN VEEN					+		
Cytherella (Cytherella) kunradensis VAN VEEN					+		
Brachycythere armata REYMENT					+		
Veenia aff. reticulocostata REYMENT					+		
Haplophragmoides walteri (GRZYBOWSKI)						+	
Rugotruncana gansseri (BOLLI)							+

Fig. 4.

It is the pelagic facies of the Lower Tár. The boundary with the underlying more or less lagoonar development of gypsiferous and nonfossiliferous clays and marls is sharp. The distinct submarine erosional boundary (S a l a j and M e g e r i s i, 1978) is caused by rapid change of sedimentary conditions. Rapid deepening on the one hand and short sedimentation in the barrier zone with high energy gave rise to scours in marls and so an uneven surface formed in their top part and on the other hand, in the basal layer, 10—30 cm, thick, of pelagic development, is much detritus of thinwalled lamellibranch shells together with *Pycnodonte (Phygraea) vesicularis* (LAMARCK) and *Curvostrea thomasi* (PERON).

In the uppermost part of this sequence (sample 7/5), belonging to the basal part of the *Globotruncana falsostuarti* Zone, the macrofauna of *Amphidonte overwegi* (VON BUCH), *Agerostrea ungulata* (SCHLOTHEIM) and *Baculites anceps* LAMARCK is found first, also determining the Maastrichtian age of the sequence considered (Fig. 5). In this part of the sequence the marls with very abundant foraminifers are also present (Fig. 2).

We remark that at the Campanian — Maastrichtian boundary represented by the facies of chalky limestone and chalk a rich nannoplankton was found. In this part belonging to the Late Campanian we determined so far: *Reinhardtites* aff. *authophorus* (DEFLANDRE), *Stephanolithion laffitei* NOEL, *Cribrocorona gallica* (STRADNER), *Cribrosphaerella* cf. *circula* RISSATI, *Praediscosphaera cretacea* (ARKHANGELSKI) and *Cribrosphaera ehrenbergi* ARKHANGELSKI.

In the Early Maastrichtian part of this sequence as well as of the overlying grey marls [sample 7 (7)] the following species were determined. *Gartnerago obliquum* STRADNER, *Deflandrius intercisus* (DEFLANDRE), *Praediscosphaera spinosa* (BRAMLETTE and MARTINI), *Bidiscus rotatorius* BUKRY, *Praediscosphaera cretacea* (ARKHANGELSKI) and *Markalius circumradiatus* (STOWER) PERCH-NIELSEN.

After deposition of these sediments a distinct regional regression took place, to which also formation of the phosphate horizon with 2 to 5 % P_2O_5 is bound. The overlying Maastrichtian part of the Lower Tár Member is mainly represented by clays and marls burred by *Amphidonte overwegi* (VON BUCH) (see Pl. 1, photo 2), varicoloured in the NW part, with layers of calcarenites and calcirudites. Layers of coquinoid calcirudite are abundat, calcirudites are represented subordinately here. The top of these sequences is formed by calcarenite, locally by arenite, both with cross bedding, 10 to 20 m in thickness. The variegated, mainly red colouring, is obviously caused by supply of terrigenous material from emerged zones where sedimentation of variegated continental sediments coloured with Fe-oxides took place, which are known from southern areas, mainly from Nigeria and were studied by K o g b e (1980) in the last time.

Planktonic foraminifers, more scarcely found, mainly in the lower part of the sequence, are represented by the species: *Globotruncana rosetta insignis* GANDOLFI, *Globotruncana falsostuarti* SIGAL and *Globotruncana aegyptiaca* NAKKADY. Bentonic foraminifers are mostly represented (see Fig. 4), among which the species *Omphalocyclus macroporus* (LAMARCK) and *Siderolites cal-*

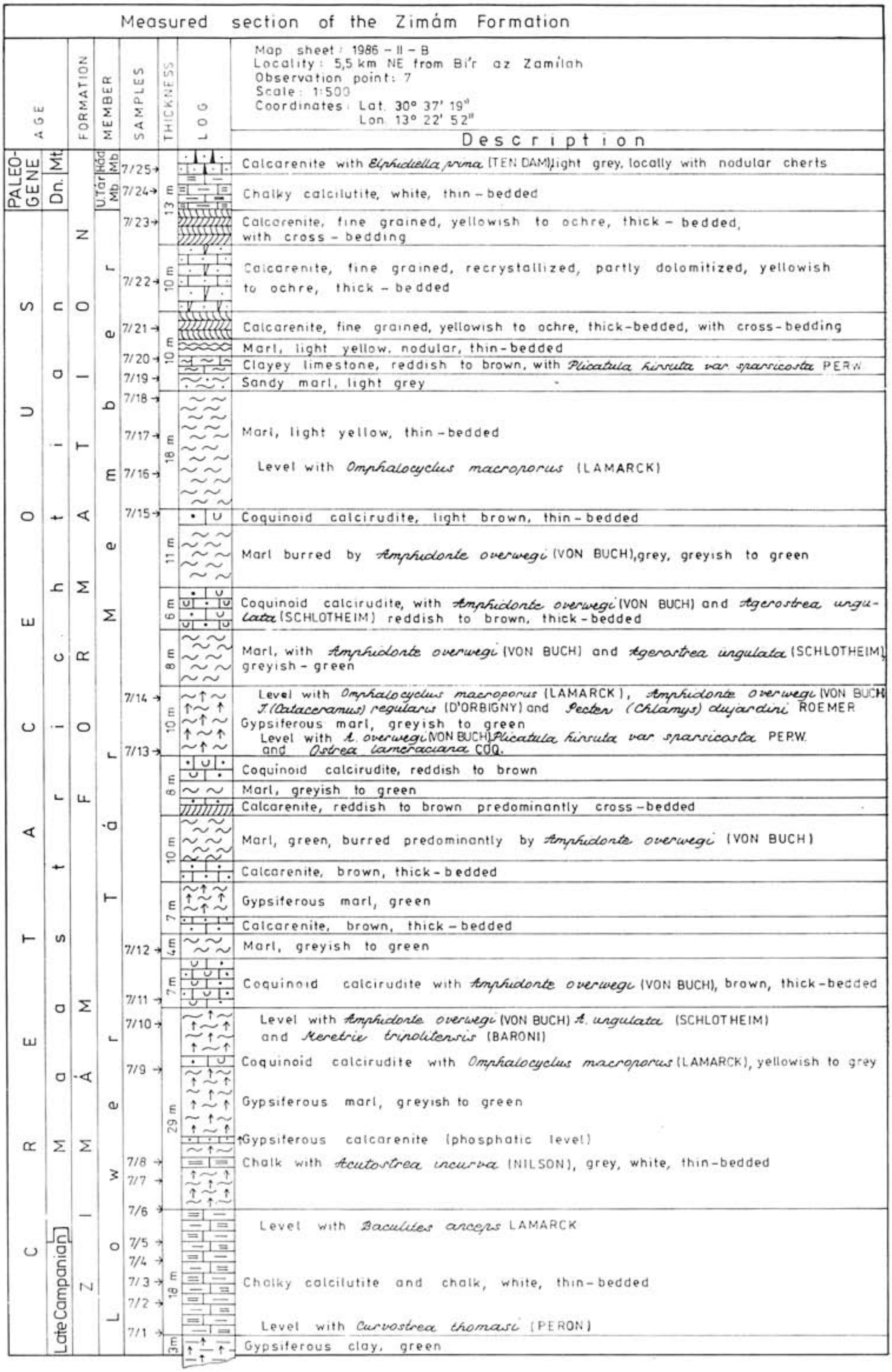

Measured section of the Zimám Formation
AGE
FORMATION
MEMBER
SAMPLES
THICKNESS
LOG
Map sheet: 1986 – II – B
Locality: 5,5 km NE from Bi'r az Zamilah
Observation point: 7
Scale: 1:500
Coordinates: Lat. 30° 37' 19"
Lon. 13° 22' 52"
Description
PALEOGENE
Dn. Mt.
Hdd Mb
U. Tar Mb
CRETACEOUS
Late Campanian – Maastrichtian
ZIMÁM FORMATION
Tar Member
Thalith Member
7/25 Calcarenite with Elphidiella prima (TEN DAM), light grey, locally with nodular cherts
7/24 13 m Chalky calcilutite, white, thin-bedded
7/23 Calcarenite, fine grained, yellowish to ochre, thick-bedded, with cross-bedding
7/22 10 m Calcarenite, fine grained, recrystallized, partly dolomitized, yellowish to ochre, thick-bedded
7/21 Calcarenite, fine grained, yellowish to ochre, thick-bedded, with cross-bedding
10 m Marl, light yellow, nodular, thin-bedded
7/20 Clayey limestone, reddish to brown, with Plicatula hirsuta var sparsicosta PERW.
7/19 Sandy marl, light grey
7/18
7/17 18 m Marl, light yellow, thin-bedded
7/16 Level with Omphalocyclus macroporus (LAMARCK)
7/15 Coquinoid calcirudite, light brown, thin-bedded
11 m Marl burred by Amphidonte overwegi (VON BUCH), grey, greyish to green
6 m Coquinoid calcirudite, with Amphidonte overwegi (VON BUCH) and Agerostrea ungulata (SCHLOTHEIM) reddish to brown, thick-bedded
8 m Marl, with Amphidonte overwegi (VON BUCH) and Agerostrea ungulata (SCHLOTHEIM) greyish-green
7/14 10 m Level with Omphalocyclus macroporus (LAMARCK), Amphidonte overwegi (VON BUCH) I. (Cataceramus) regularis (D'ORBIGNY) and Pecten (Chlamys) dujardini ROEMER
Gypsiferous marl, greyish to green
7/13 Level with A. overwegi (VON BUCH) Plicatula hirsuta var sparsicosta PERW. and Ostrea lameraciana COQ.
Coquinoid calcirudite, reddish to brown
8 m Marl, greyish to green
Calcarenite, reddish to brown predominantly cross-bedded
10 m Marl, green, burred predominantly by Amphidonte overwegi (VON BUCH)
Calcarenite, brown, thick-bedded
7 m Gypsiferous marl, green
Calcarenite, brown, thick-bedded
7/12 4 m Marl, greyish to green
7 m Coquinoid calcirudite with Amphidonte overwegi (VON BUCH), brown, thick-bedded
7/11
7/10 Level with Amphidonte overwegi (VON BUCH) A. ungulata (SCHLOTHEIM) and Meretrix tripolitensis (BARONI)
7/9 Coquinoid calcirudite with Omphalocyclus macroporus (LAMARCK), yellowish to grey
29 m Gypsiferous marl, greyish to green
Gypsiferous calcarenite (phosphatic level)
7/8 Chalk with Acutostrea incurva (NILSON), grey, white, thin-bedded
7/7
7/6 Level with Baculites anceps LAMARCK
7/5
7/4
7/3 18 m Chalky calcilutite and chalk, white, thin-bedded
7/2
7/1 Level with Curvostrea thomasi (PERON)
3 m Gypsiferous clay, green

Fig. 5.

citrapoides LAMARCK are of most importance for Upper Maastrichtian stratigraphy.

In the Upper Maastrichtian, besides the above mentioned macrofauna, are also found by the authors: *Inoceramus (Cataceramus) cripsi* var. *radiosus* QUASS, *Indoceras ismaeli* var. *libycum* SORRENTINO, *Indoceras* cf. *afikpoense* REYMENT, *Echinobrissus markovi* FAS, *Hemiaster chargensis* WANNER and *Hemiaster texanus* ROEMER (see Fig. 3).

Besides foraminifers, also ostracods take a considerable part in microfauna assemblages, mainly represented by the species: *Veenia ughelli* REYMENT, *Veenia deltaensis* REYMENT, *Mehesella* aff. *paleobiafrensis* REYMENT, *Cytherella (Cytherelloidea) araromiensis* REYMENT and *Brachycythere ogumi* REYMENT (see Fig. 4). They are species displaying conspicuous identity with species described from Nigeria (Reyment, 1960), also fully confirmed by Prof. Dr. R. Benson (letter from September 18 th, 1978). This fact also fully confirms the Trans-Saharan (Late Campanian) transgression (Reyment and Reyment, 1980; Salaj, 1979) and communication of the Atlantic region with the Tethyan Mediterranean realm in the Late Campanian to Maastrichtian.

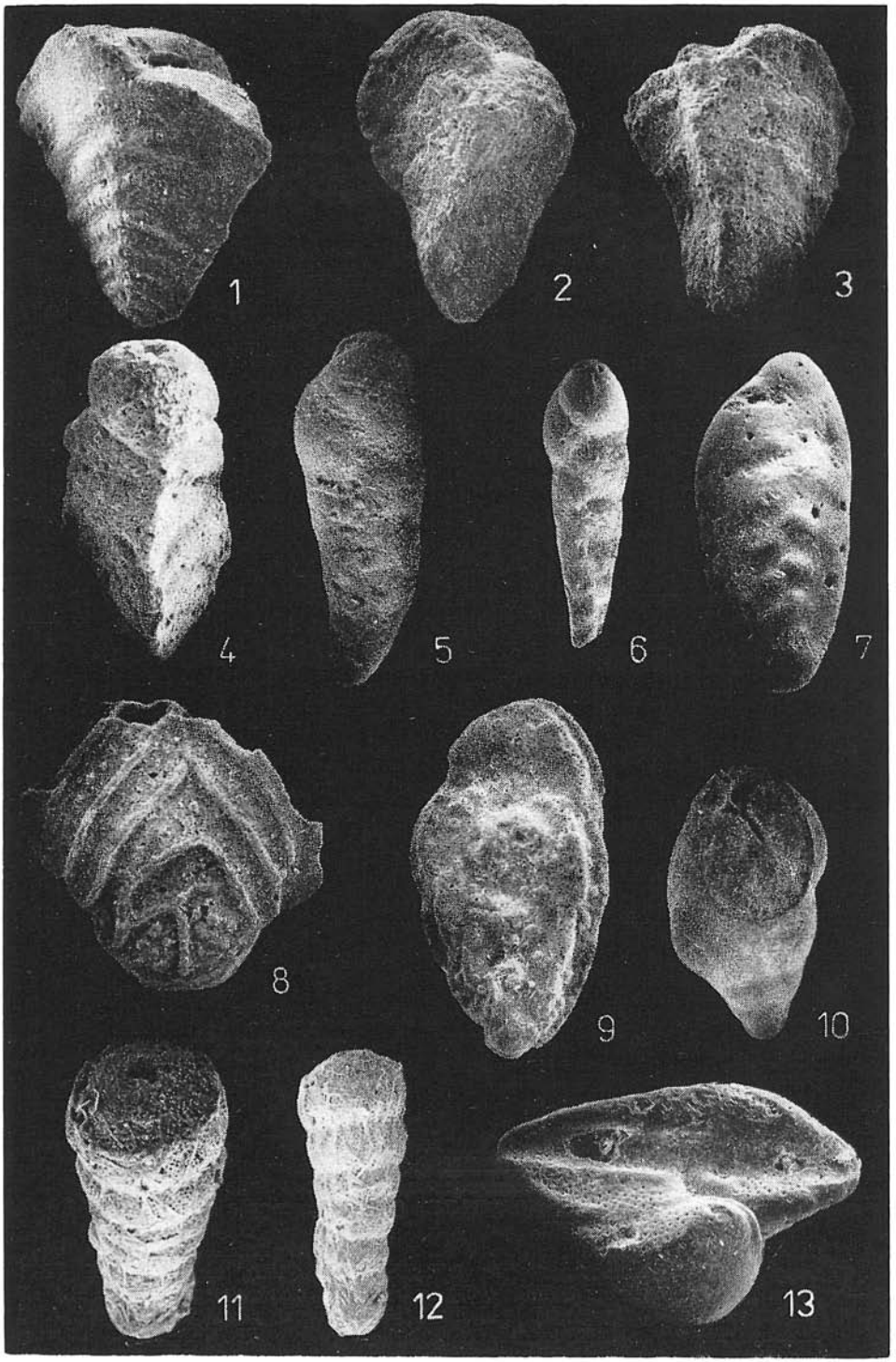
3. The Upper Tár Member (5 to 7 m in thickness) as he middle member of the Zimám Formation is lithologicaly represented mainly by calcilutite, partly dolomitized and marls.

Its Danian age is determined by the following foraminifers: *Lenticulina (Lenticulina) turbinata* (PLUMMER), *Conorbina conula* BROTZEN, *Discorbis pseudoscopus* BROENNIMANN, *Rosalina binkhorsti* REUSS, *Ammonia beccarii* (LINNÉ), *Nonion graniferum* BROTZEN, *Protoelphidium hofkeri* HAYNES, *Protoelphidium rolshauseni* BANDY, *Elphidiella prima* (TEN DAM), *Lockartia roestae* HOFKER, *Globigerina* aff. *eugubina* LUTERBACHER and PREMOLI SILVA, *Globigerina* cf. *pseudobulloides* PLUMMER and *Chiloguembelina* sp.

The field observations and laboratory analysis suggest that the Upper Tár Member was deposited in the praebarrier zone to open sea zone.

Plate 2

Fig. 1. *Spiroplectammina laevis* ROEMER (× 80), sample no 1986-I-7/7 — 5.5 km NE from Bi'r az Zamilah, *Globotruncana falsostuarti* Zone of the Lower Maastrichtian.
Fig. 2. *Gaudryina pyramidata* CUSHMAN (× 65), sample no 1986-II-B-4 — 5 km E from Bi'r az Zamilah, *Globotruncana arca rugosa* Zone (s. l.) of the Upper Campanian.
Fig. 3. *Verneuilina muensteri* REUSS (× 65), sample no 1986-II-B-4.
Fig. 4. *Tritaxia capitosa* (CUSHMAN) (× 50), sample no 1986-II-B-4.
Fig. 5. *Bolivina incrassata crassa* VASILENKO and MYATLIUK (× 90), sample no 1986-II-B-4.
Fig. 6. *Bolivina incrassata incrassata* REUSS (× 60), sample no 1986-II-B-7/7.
Fig. 7. *Bolivina incrassata gigantea* WICHER (× 40), sample no 1986-II-B-7/7.
Fig. 8. *Neoflabellina* cf. *efferata* (WEDEKIND) (× 90), sample no 1986-II-B-7/7.
Fig. 9. *Pseudouvigerina cristata* (MARSSON) (× 130), sample no 1986-II-B-7/7.
Fig. 10. *Praebulimina laevis* (BEISSEL) (× 50), sample no 1986-II-B-7/7.
Fig. 11—12. *Orthokarsteina clarki* (CUSHMAN and CAMPBELL) (× 90, × 60), sample no 1986-II-B-7/7.
Fig. 13. *Cibicides excavatus* BROTZEN (× 80), sample no 1986-II-B-7/7.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4. The Hád Member (30 to 40 m in thickness) represents the upper member of the Zimám Formation. It is formed by siliceous crystalline to microcrystalline limestone and calcilutite, both with cherts and in places dolomitized. The intercalations of breccias are also present.

The microfauna is very poor and recrystallized. Miliolid foraminifers, *Laffitteina bibensis (MARIE) and Elphidinella prima* (TEN DAM) prevail in this sequence. The dasyclads are also very abundant there. The Montian age of these strata is presumed mainly at the base of superposition. That is in agreement with the results of Pożaryska (in: Uberna, 1971).

5. Bú Ra's Member represents the lower member of the Shurfah Formation (Jordi and Lonfat, 1963), lithologically determined mainly by marls, with layers of calcilutite, calcarenite and dolomitic limestone to dolomite and gypsum. Local presence of the basal conglomerate to sandstone confirms the transgressive character of this member. The assemblage of the Landenian foraminifers is represented by the following species: *Rotalia trochidiformis* REUSS, *Elphidiella prima* (TEN DAM) and *Operculina* aff. *heberti* (MUNIER and CHALMAS).

6. Qaltah Member, as the higher member of the Shurfah Formation is simultaneously the highest not completely preserved member. It is represented by thick-banked beds of silicified calcilutite, calcarenite, chalky, endostratic breccia and dolomitic limestone.

This lithological member is very poor in microfauna. On the basis of superposition and the presence of the species *Operculina* aff. *heberti* (MUNIER and CHALMAS) this member may be considered as Landenian (= Thanetian). The uppermost part of the Surfah Formation with *Operculina canalifera sindensis* DAVIES (Fürst, 1964) corresponding to the Late Paleocene is not preserved in this area.

Closing it may be stated that Upper Senonian sediments of Hammádah al Hamrá' are similar to sediments of southern Tunisia in their development and we designate them with the common southern development there (Pervinquière, 1903; Solignac, 1927; Burollet et al., 1978; Salaj, 1978) as well as in the area studied. They are sediments marked by the presence of

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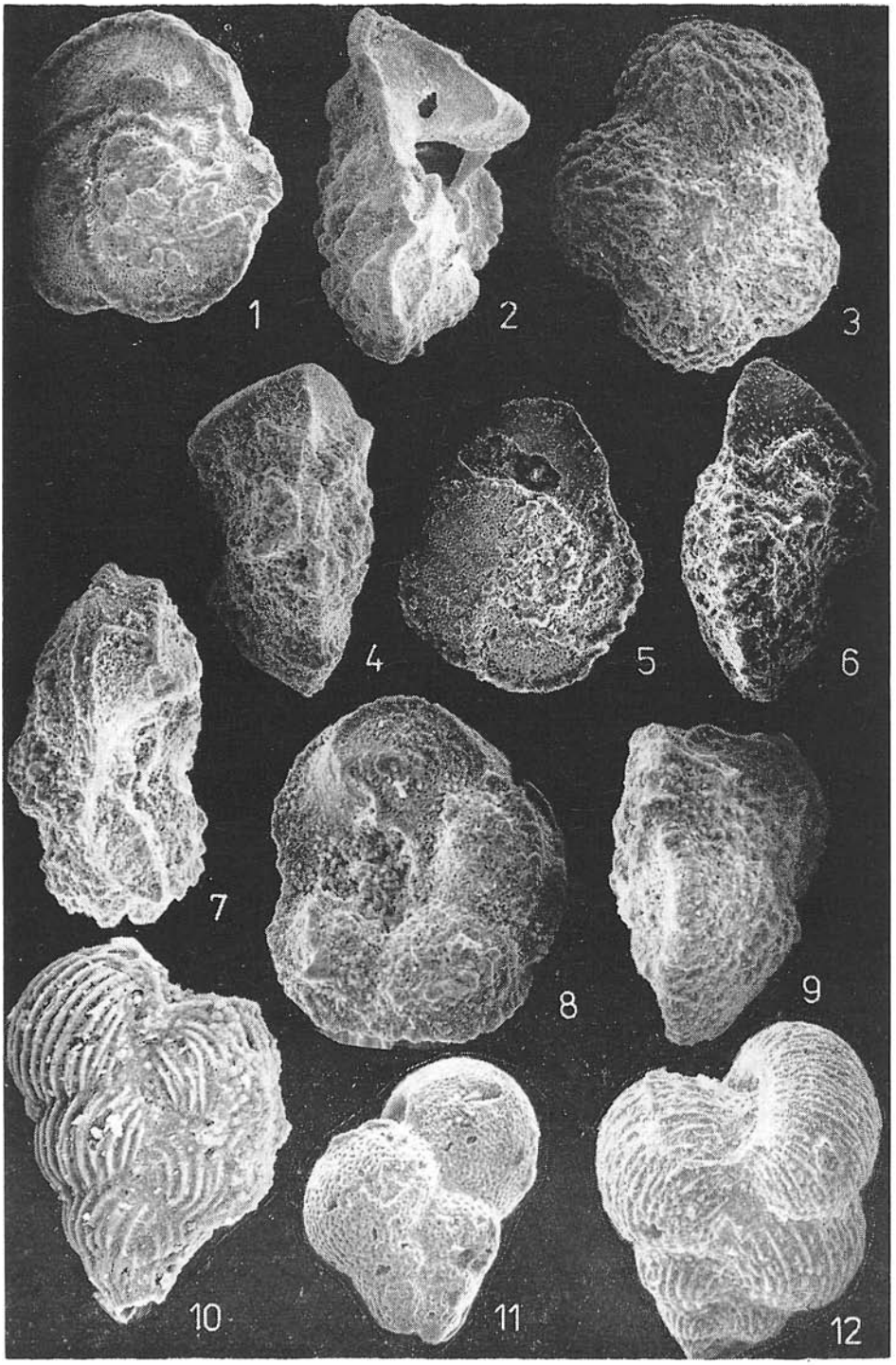
Plate 3

Figs. 1–2. *Globotruncana rosetta pettersi* GANDOLFI (× 80, × 90), sample no 1986-II-B-7/7 — 5.5 km NE from Bi'r az Zamilah, basal part of the *Globotruncana falsostuarti* Zone.
Fig. 3. *Rugoglobigerina rugosa* (PLUMMER) (× 120), sample no 1986-II-B-4 — 5 km E from Bi'r Zamilah, *Globotruncana arca rugosa* Zone (s. l.) of the Upper Campanian (uppermost part).
Fig .4. *Globotruncana smithi* SALAJ (× 80), sample no 1986-II-B-4.
Figs. 5–6. *Globotruncana bolli* GANDOLFI (× 75, × 100), sample no 1986-II-B-6 — 2.5 km SW from Bi'r az Zamilah, *Globotruncana arca rugosa* Zone (s. l.).
Figs. 7–8. *Globotruncana bulloides* (VOGLER) (× 130), sampple no 1986-II-B-6.
Fig. 9. *Globotruncana ventricosa* (WHITE) (× 130), sample no 1986-II-B-4.
2.5 km SW from Bi'r az Zamilah, *Globotruncana arca rugosa* Zone (s. l.).
Fig. 10. *Pseudoguembelina* aff. *costulata* (CUSHMAN), (× 175), sample no 1986-II-B 7/1 — 5.5 km NE from Bi'r az Zamilah, *Globotruncana arca rugosa* Zone (s. l.).
Fig. 11. *Heterohelix globulosa* (EHRENBERG) (× 90), sample no 1986-II-B-7/7.
Fig. 12. *Heterohelix striata* (EHRENBERG) (× 120), sample no 1986-II-B-4.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abundant macrofauna and orbitoid foraminifers, characteristic of platform sediments of the Saharan Platform developed at the southern margin of the Tethyan sedimentation basin.

An important knowledge is that the Senonian of Tunisian facies, characterized by pelagic sediments of the Pelagian Block (Solignac, 1927; Burollet, 1973; Salaj, 1978), known from the East Tunisian Platform, Sirt Basin and Cyrenaica Platform (northern part), reaches this area. (Late Campanian to Early Maastrichtian chalky calcilutites and chalks are especially concerned).

Palaeocene sediments, prevailingly in carbonate development, are relatively poor in macrofauna and microfauna.

Eocene sediments are not developed in the studied area, obviously as a consequence of the fact that sedimentation was terminated in the Middle Eocene in this area (Desio, 1971).

It is necessary to remark that in the easternmost part of the Hammádah al Hamrá' and mainly in the Hun Graben and Sirt Basin Eocene and younger sediments are found (Fürst; 1964; Klitzsch, 1970; Čepek, 1979).

Conclusions

It is confirmed that the transgression of the Lower Tár Formation in the northern Hammádah al Hamrá' area was taking place in the Upper Campanian. Regarding to the fact that oceanic species of foraminifers as *Globotruncana calcarata* CUSHMAN, *Glbtr. stephensoni* PESSAGNO, *Globotruncanella havanensis* (VORWIJK) and *Rugotruncana kefiana* SALAJ and MAAMOURI are not found here, we had not the possibility to carry out a more detailed subdivision of the *Globotruncana arca rugosa* Zone s. l. For this reason we also can-

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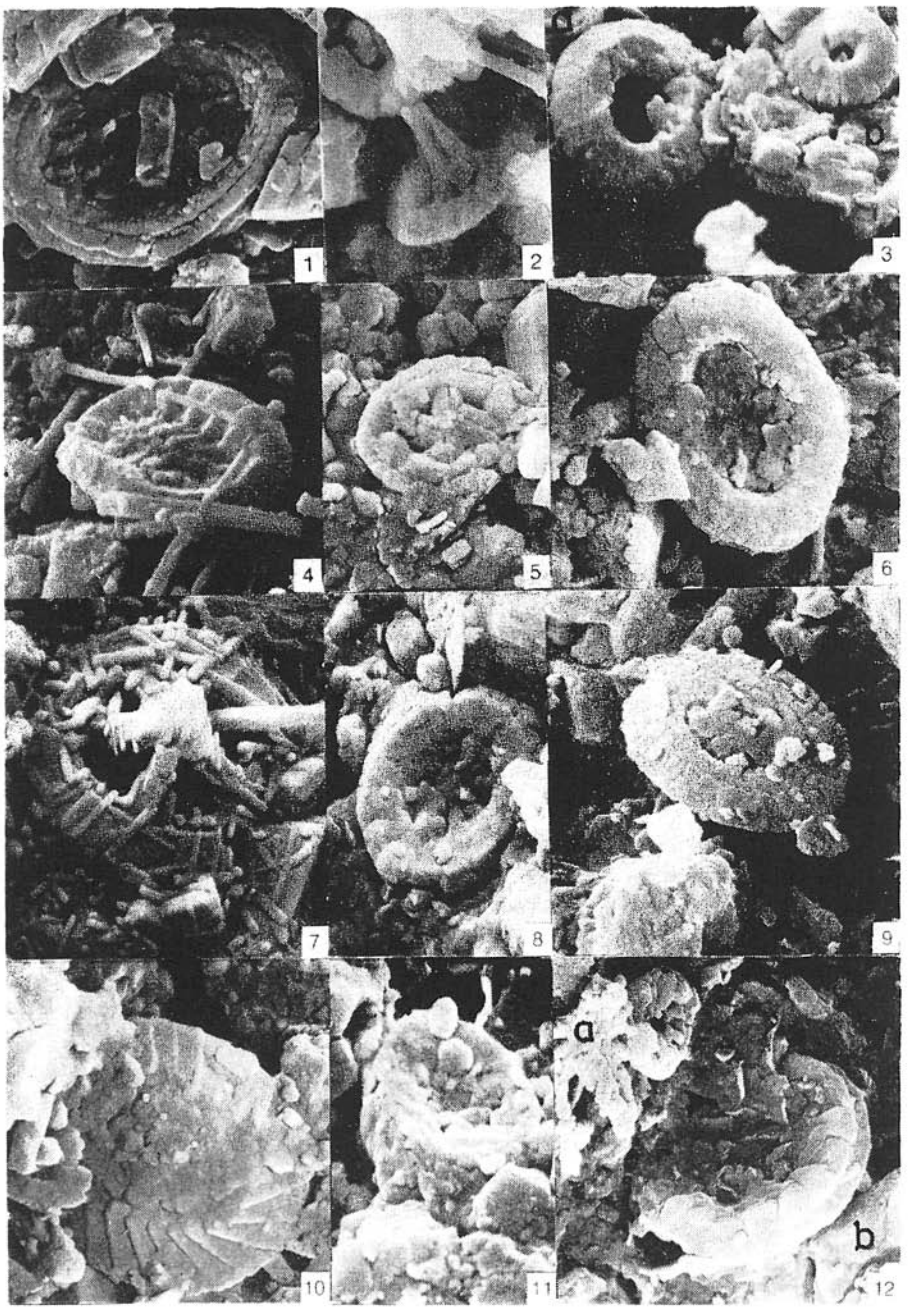
Plate 4

Fig. 1. *Gartnerago obliquum* STRADNER (× 4000), sample no 1986-II-7/7 — 5.5 km NE from Bi'r az Zamilah. *Globotruncana falsostuarti* Zone.
Figs. 2, 5. *Deflandrius intercisus* (DEFLANDRE) (× 4000), sample no 1986-II-B-7/7.
Fig. 3 a. *Praediscophaera spinosa* (BRAMLETTE and MARTINI), Fig. 3 b. *Bidiscus rotatorius* BUKRY (× 4750), sample no 1986-II-B-7/7.
Fig. 4. *Cribrosphaera pelta* GARTNER (× 5000), sample no 1986-II-B-7/7.
Figs. 6, 9. *Reinhardtites* aff. *anthophorus* (DEFLANDRE) (× 5000), sample no 1986-II-B-4 — 5 km E from Bi'r az Zamilah. Uppermost Campanian.
Fig. 7. *Praediscophaera cretacea* (ARKHANGELSKY) (× 5000), sample no 1986-II-B-7/7.
Fig. 8. *Stephanolithion laffitei* NOËL (× 5000), sample no 1986-II-B-4. Uppermost Campanian.
Fig. 10. *Markalius circumradiatus* (STOWER) PERCH-NIELSEN (× 5000), sample no 1986-II-B-7/7.
Fig. 11. *Cribrocorona gallica* (STRADNER) (× 5000), sample no 1986-II-B-4.
Fig. 12 a. *?Russelia* sp., Fig. 12 b. *Cribrosphaerella* sf. *circula* (RISSATI) (× 5000), sample no 1986-II-B-4.

The microphotos, the negatives of which were made by the operators Mr. K. Šebor and M. Švec, were prepared by aid of scanning microscope stereoscan JSM-U3 at the Dionýz Štúr Institute of geology in Bratislava.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not establish nearer the time of onset of this transgression. Basing upon the konwledge from Tunisia (Salaj and Maamouri, 1982), we infer that significant tectonic processes connected with regression, emersion and Trans-Saharan transgression were taking place in the uppermost Campanian s. l. Trans-Saharan transgression became gradually younger, Maastrichtian, toward the south (Jurák, 1978, p. 72; Woller, 1978, p. 86).

The sediments at the Campanian — Maastrichtian boundary in the NE part of the area under study are represented by chalky limestone and chalk (facies characteristic of the more northerly situated Pelagian Block, which penetrated to the region of the Saharan Platform in time of temporary deepening of the sea; Salaj and Megerisi, 1978). The planktonic foraminifers found in this facies are not always the component predominating in the associations, in many cases even benthonic foraminifers predominate over planktonic. Remarkable is, however, the presence of abundant nannoplankton (Tab. 4), to the study of which it will be necessary to pay attention in the future.

The Lower Maastrichtian is characterized by the *Globotruncana falsostuarti* Zone originally defined in the West Carpathians by Salaj and Samuel (1966). In its higher part *Globotruncana conica* WHITE is found very sporadically, the index species of the upper Lower Maastrichtian zone of equal name (Eliagoubi, 1975; Eliagoubi and Powell, 1980). According to Barr (1972) in Libya this species appears first later in the upper part of the *Rugotruncana gansseri* Zone and continues in the *Abathomphalus mayaroensis* Zone.

The associations of the planktonic *Rugotruncana gansseri* and *Abathomphalus mayaroensis* Zones are very impoverished. The species *Rugotruncana gansseri*

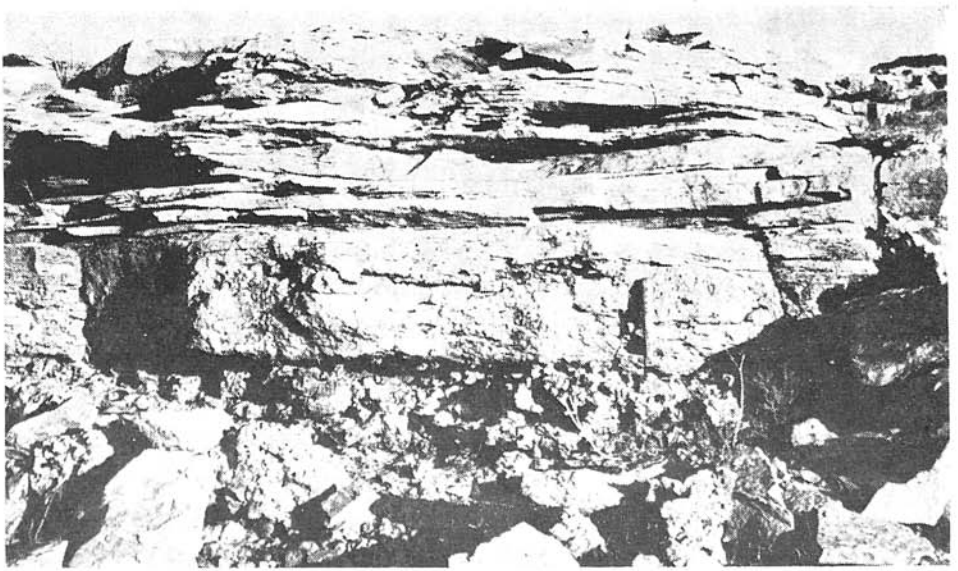

Fig. 6 — The basal transgressive conglomerate lumachelle of the Lower Ta'r Fm and transgressive calcarenites with cross-bedding. Trans-Saharan transgression of the Late Campanian (1986-I-H-2/1b).

(BOLLI) is scarce and the species *Abathomphalus mayaroensis* (BOLLI) has not been proved in the area under study so far.

Equivalent in time to these planktonic zones in the studied area is the zone of orbitoid foraminifers with *Omphalocyclus macroporus* LAMARCK, equally as also the ostracod zone with *Cytherella (Cytherelloidea) araromiensis* REYMENT.

The Paleocene is mainly characterized by the benthonic foraminifers and the flora from the group of dasyclads. The planktonic foraminifers, besides scarce finds in the Danian, have not been proved in the Middle and Upper Palaeocene.

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