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Paleoecology of Albian – Santonian succession of Surdash to Shaqlawa area, NE Iraq

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Abstract:

Three formations to be studied along Surdash, Qallat, Khalakan, Hezob, Sektan, Degala and Shaqlawa areas in the Sulaimaniya and Erbil governorates, NE Iraq. These are: Dokan, Gulneri and Kometan formations. The paleoecology and depositional environment of these formations are determined by studying the ecology of the planktonic and benthic foraminifera.

The depositional environment of are ranged from the continental shelf to the abyssal, and the paleotemperature, salinity and paleoclimate were discriminated in each section along the study area.

Keywords: Paleoecology, Foraminifera, Albian, Santonian, Dokan, Gulneri, Kometan

البيئة القديمة لتتابع الالبيان – سانتونيان من منطقة سورداش الى شقلاوة ، شمال شرق العراق

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الخلاصة:

تم في هذا البحث دراسة البيئة القديمة لثلاثة تكاوين في مناطق سورداش ، قلات ، خله كان ، هيزوب ، سيكتان ، ديكله و شقلاوة، هذه التكاوين هي: تكوين دوكان وتكوين كلنيري وتكوين كوميتان . البيئة القديمة والبيئات الترسيبية لهذه التكاوين جرى تحديدها من خلال دراسة بيئات معيشة الفورامنيفرا الطافية والقاعية.

البيئات الترسيبية تراوحت بين بيئة الرف القاري حتى بيئة الأعماق السحيقة كذلك تم تحديد درجة الحرارة القديمة ، الملوحة والمناخ القديم في كل مقطع على امتداد منطقة الدراسة.

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Introduction

Paleoecology uses the fossil record to reconstruct the life habits of past organisms, their association in communities and their relationship to the environments in which they lived. Traditionally, studies have concentrated on case histories using an array of fossil assemblages to reconstruct past ecosystems [1].

The lithology of Dokan Formation along Surdash to Shaqlawa areas is crystalline grayish brown, thick bedded limestone. The lithology of the Gulneri Formation is hard black shale. The lithology of the Kometan Formation is grayish brown to yellowish brown, hard, stylolitic, well bedded limestone. The stylolites are occurred along bedding planes of Kometan Formation throughout. The chert nodules are occurred near the upper part of the formation.

Previous work:

Dokan Formation

The Dokan was first described as separate formation by Lancaster and Jones [2]. It consists of 4 m of light colored grey and white oligosteginal limestone, locally rubbly, with glauconitic coatings of the pebble-like masses.

- The depositional environment of Dokan Formation is open sea condition [3].

- TheDokan Formation is range in thickness from 4 to 150 m. It's consists of light-colored, grey with white locally rubbly, oligosteginal limestone. It is bounded by unconformities above and below [4].

- The Dokan formation was studied [5] in Zewa and Azmer, NE Iraq and she gave the Late Cenomanian age to the formation according the presence of *Rotaliporacushmani*(Morrow) *Rotaliporagreenhornensis*(Morrow) range zone and the deep marine as depositional environment according to the presence of oligostegina and *Rotalipora*species.

- The Dokan Formation was restudied [6] in Kirkuk 116, Kirkuk 243, Jambur 18, Jambur 40, Bai Hassan 81, and Bi Hassan 86 boreholes in north Iraq and she said that the lithology of the Dokan Formation is oligosteginalmarly limestone deposited in the outer shelf – upper slope. The age of the Dokan Formation is Late Early Cenomanian – Late Cenomanian.

Gulneri Formation

- The Gulneri Formation was first described by Lancaster [2] from the site of the Dokan Dam in the High Folded Zone, NNE of Sulaimaniya, where it consists of about 2 m of black bituminous, finely laminated, calcareous shale with some glauconite in the lower part.

- *Rotalipora* cf.*appenninica*, *Globotruncanahelvetica,* minute globigerinids, fish detritus, small bicarinate*Globotruncana* was described and indicates early Turonian age [2].

- The Gulneri Formation was studied [7] in the Dokan area NE Iraq. They found that the formation consists mainly of marl and marly limestone with no more than 20% of laminated shale. Thin section study showed that the shale is highly deformed, which has foliation-like texture. Therefore, most probably the previously described shale is originally marl, which is changed to laminated shale-like rock, by. They suggest combining it with Kometan Formation because the formation occurs only in Dokan dam site and it does not exist in near by surrounding areas.

- The Gulneri Formation was studied [5] in Zewa and Azmer, NE Iraq and she gave the Turonian age to the formation according the presence of *Helvetoglobotruncanahelvetica*range zone and the deep marine water as depositional environment of the formation.

- The Dokan Formation was restudied [6] in Kirkuk 116, Kirkuk 243, Jambur 18, Jambur 40, Bai Hassan 81, and Bi Hassan 86 boreholes in north Iraq and she said that the lithology of the GulneriFormation is

shaly limestone rich in organic matter deposited in middle-lower slope. The age of the Gulneri Formation is Middle Turonian.

Kometan Formation

- The Kometan Formation was first described [2] from the Kometan village near Endezah in NE Iraq. The formation comprises 36 m of light grey, Thin bedded, Glolobigerinal-oligosteginal limestone, with a glauconitic bed at the base.

- *Globotruncanarenzi* indicate that the basal beds of the formation are of Turonian age [2] and that the overlying beds are of Santonian age.

- The Kometan Formation was studied [8] in north Iraq; he gave the age Turonian-Santonian to the formation and off-shelf to bathyal as depositional environments.

- The Biostratigraphy of Kometan Formation was divided [9] into four biostratigraphicforaminiferal Zones, these are: *Globotruncanarenzi – Glt. sigali*zone*, Glt. concavata*zone*, Glt. Fornicate* zone and *Glt. fornicate – Glt. elevate – Glt. Stuartiformis* assemblage zone.

- Five new species were found [10] which belong to the Kometan Formation;these are*Spiroplectamminasayyabi, S. rectangularis,Gaudryinellakometanensis*, *G. triqaudratus* and *Osangulariaabnormis*.

- The contact between Kometan and Shiranish Formations was re-studied [7] in Sulaimaniyah Governorate and laboratory and divided the contact into three types: obvious gradational, burrowed and glauconitic and sharp contacts.

- The Kometan Formation was studied [5] in Zewa and Azmer, NE Iraq and she gave the Coniacian - Campanian age to the formation according the presence of *Dicarinellaprimitiva*(DALBIEZ) *Dicarinellaconcavata(BROTZEN)* range zone and *Globotruncanaelevata*(BROTZEN) range zone. The deep marine is the depositional environment of the formation.

- The Kometan Formation was restudied [6] in Kirkuk 116, Kirkuk 243, Jambur 18, Jambur 40, Bai Hassan 81, and Bi Hassan 86 boreholes in north Iraq and she said that the lower unit of the Kometan Formation represents the proper Kometan Formation. The shaly succession in the middle unit of the Kometan Formation may be represents the Tanuma Formation. The upper unit of the Kometan Formation is suggested to represents a new rock unit. The proper Kometan Formation deposited in upper slope shifting to outer shelf at top and its age is Late Turonian. The shaly succession in the middle unit of the Kometan Formation deposited in the upper slope and its age is Coniacian. The upper unit of the Kometan Formation deposited in upper slope – outer shelf and its age is Santonian.

Tectonic setting

All selected sections is distributed in the High Folded Zone and located in northeastern part of the Arabian plate on the Unstable Shelf [11].

The transversal blocks affect the area and it was intermittently uplifted in Cretaceous and Paleogene time and strongly deformed in the Late Tertiary. The High Folded Zone covers most of the Iraqi Kurdistan region. This area comprises harmonic folds with Mesozoic limestone in their cores and Paleogene and Neogene limestone and clastics on their flanks [11]. The strata suffered from intense deformations especially those that are located within the axis of synclines due to imposed stress of Iranian Plate. The stresses generated many thrust faults and transverse in the area. Most of the gorges are developed along transversal normal and strike slip faults.

Location of the study area:

The study area is located in the High Folded Zone in Northeastern Iraq (Sulaimaniya and Erbil) Figure-1. It's bordered from the northeastern by the Thrust Zone and from the southeastern by the Low Folded Zone. It's bounded by longitudes (44° 15′ - 45° 06′ E) and latitudes (35° 50′ – 36° 25′ N). The seven selected sections are shown in the table 1 below:

Table 1-The coordinates of the study sections and number of slides for each section

Section name		Longitude	Latitude	Altitude	Number of slides
Sulaimaniya	Surdash	45° 06′ 26″	35° 50′ 01″	770 m	86
	Qallat	44° 54′ 26″	35° 58′ 10″	634 m	134
	Khalakan	44° 54′ 18″	35° 59′ 45″	921 m	94
	Hezob	44° 41′ 17″	36° 10′ 08″	552 m	56
	Sektan	44° 37′ 42″	36° 13′ 59″	702 m	36
Erbil	Degala	44° 26′ 23″	36° 12′ 43″	856 m	102
	Shaqlawa	44° 15′ 58″	36° 25′ 14″	891 m	42

Aim of the study:

This study aims to determine the paleoecology of the Dokan, Gulneri and Kometan Formations.

Material used and Methodology:

There are 277 samples collected from seven outcrops belonging to Sulaimaniya and Erbil Governorates; of which 550 slides were prepared in the workshop of department of Geology- College of Science- University of Baghdad. The slides were examined under microscope to discriminate the paleoenvironment of the fossils.

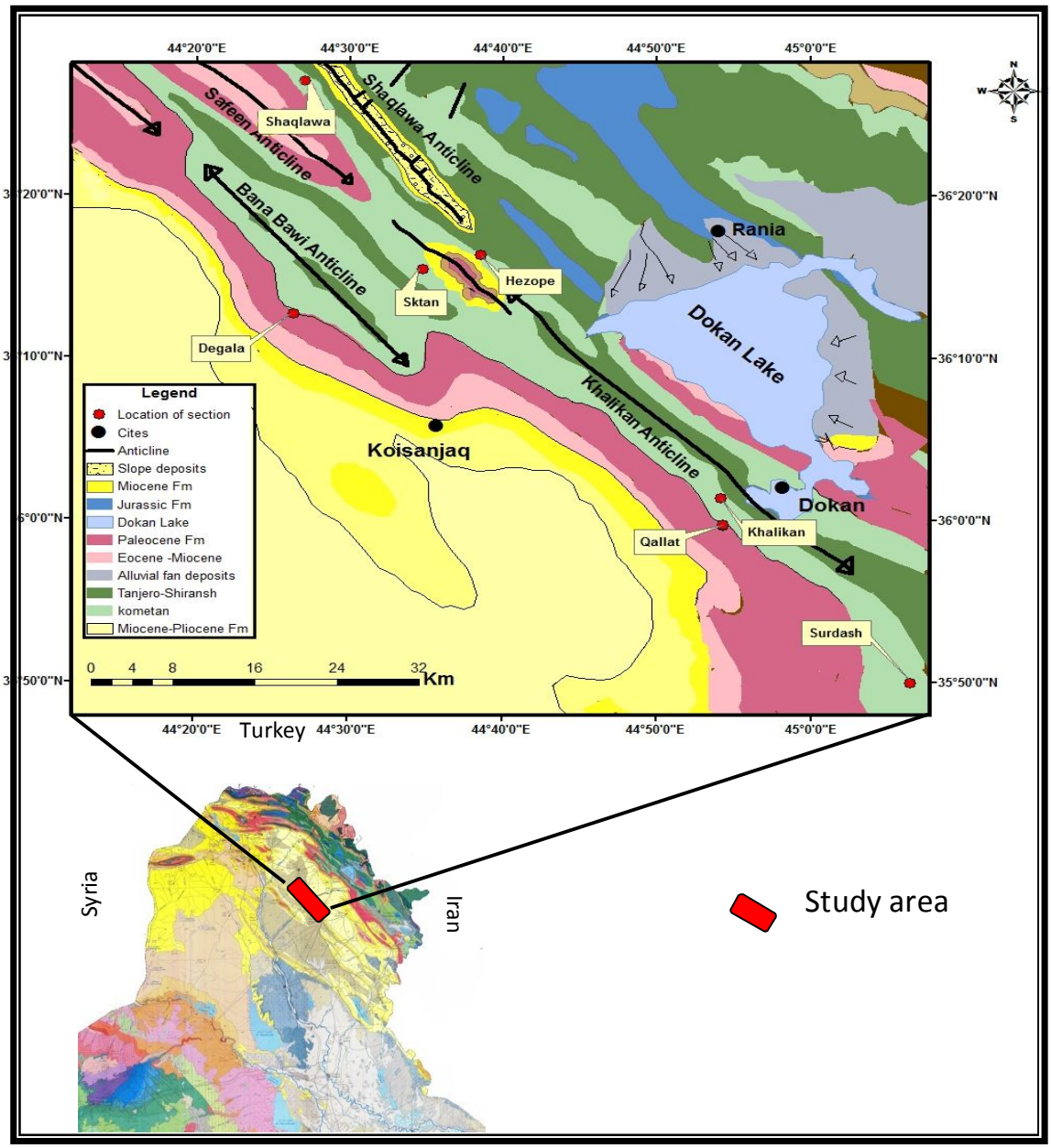


Figure1-Location map of the study area

Results and Discussion:

In order to discuss the foraminiferal paleoecology with the depositional environment of each formation, a model of oceanic divisions is depended in present study [12], these divisions are:

1- Continental Shelf: from (0-200 m.) in depth, and it is divided into:

- Inner Shelf: (0-30 m.)
- Middle Shelf: (30-100 m.)
- Outer Shelf: (100-200 m.)

2- Continental Slope (Bathyal Zone): from (200-2000 m.) in depth, and it is divided into:

- Upper Bathyal: (200-600 m.)
- Middle Bathyal: (600-1000 m.)
- Outer Bathyal: (1000-2000 m.)

3- Abyssal Zone: from (2000-5000 m.) in depth, and it is divided into:

- Upper Abyssal; (2000-3000 m.)
- Lower Abyssal: (3000-5000 m.)

4- Hadal Zone: more than (5000 m.) in depth.

Surdash section

Dokan Formation:

Dokan Formation in Surdash section (Figure-2) is represented by the only occurrence of the species *Ticinellaprimula*, plate (1, 1). *Ticinella*characterizes the low latitude environments and indicate shallow water fauna of less than 100 m [13], while the oligostegina (plate 1, 8) indicates deep marine environment [14] and [15]; and they are adapted to more open marine conditions [16].But in this section, two individuals of *Ticinellaprimula* are recorded and indicate that these fauna was transported from the shallow environment to deep marine environment.

By using the oligostegina as environmental indicator, it can be concluded that the Dokan Formation in this section was deposited under deep marine environment in tropical–subtropical abyssal conditions.

Kometan Formation:

The Heterohelicids and the simple globigerine-shaped Hedbergellids dominated Cretaceous shallow water environments [17] and [18] as they constitute the first planktonic species to colonize new seaways and also the last to disappear.

Heterohelix species are interpreted as opportunistic and low-oxygen tolerant based on Late Cretaceous and Cenozoic [19].

*Heterohelix*is occupied surface waters above shallow and deep-water areas [20]. A high percentage of *Globotruncana*would be indicative of slope and deeper waters, whereas a dominance of Heterohelicids and Globigerinellids would indicate shelf seas [8].

Keeled bathypelagic are typical genera of low latitudes, and indicate continental slope palaeodepth [21].

Benthic foraminifera indicate an upper bathyal (200-500 meter), and the occurrence of *Hedbergella*(plate 1,5) and *Globigerinelloides*(plate 1, 6)which existed in present study indicate shallow continental margin and \ or high fertility surface waters [22].

Planktonic foraminifera have limited range of salinity (Stenohaline) and that includes the fauna of modern and ancient foraminifera, for that reason [23] suggested that planktonic foraminifera of the Cretaceous have range of salinity between (34-37 ‰).

Hedbergelladelrioensis and *Hd. planispira* are indicate a paleotemperature between (27-28 ◦c); and the presence of *Heterohelixglobulosa* which existed in present study indicates a paleotemperature about (32 ◦c), and the presence of *Globigerinelloides* sp. indicates a paleotemperature about (30.3 ◦c) [24].

The Kometan formation in Surdash section is rich in Keeled (*Globotruncana* (plate 1, 2) and *Dicarinella* plate 1, 3) species and less percentage of *Heterohelix*(plate 1, 4) with occurrence of benthic

foraminifera along the section which indicate a tropical–subtropical, continental slope (Bathyal Zone) upper to outer as a depositional environment and paleotemperature between (30-32 ˚c) and salinity between (34-37 ‰), Figure-2.
The p/b percentage is high along the Surdash section which indicates sea level rise [25].

Qallat section
Gulneri Formation:

Black shale is a dark-colored mud rock containing organic matter and silt- and clay-size mineral grains that accumulated together [26].

Classification of a shale as having been deposited in a shelf setting probably would vary from one person to another. All the deposits included here can be viewed broadly as being transgressive.

Depositional environment of black shale

The range of depositional environments in which black shale may accumulate can be described by the continental shelf model (Figure-3).
Organic material is recycled in the photic zone to a lesser extent because of more rapid settling to the bottom. The concentration of oxygen in the water may remain large down to the top of the accumulating sediment because of circulation and the production of oxygen in the photic zone. In this setting also, the sediments become anoxic a very short distance beneath the surface because of bacterial processes.
This kind of depositional environment has been deduced for several transgressive black shales in North America, such as those in cyclothems of Pennsylvanian age [26].

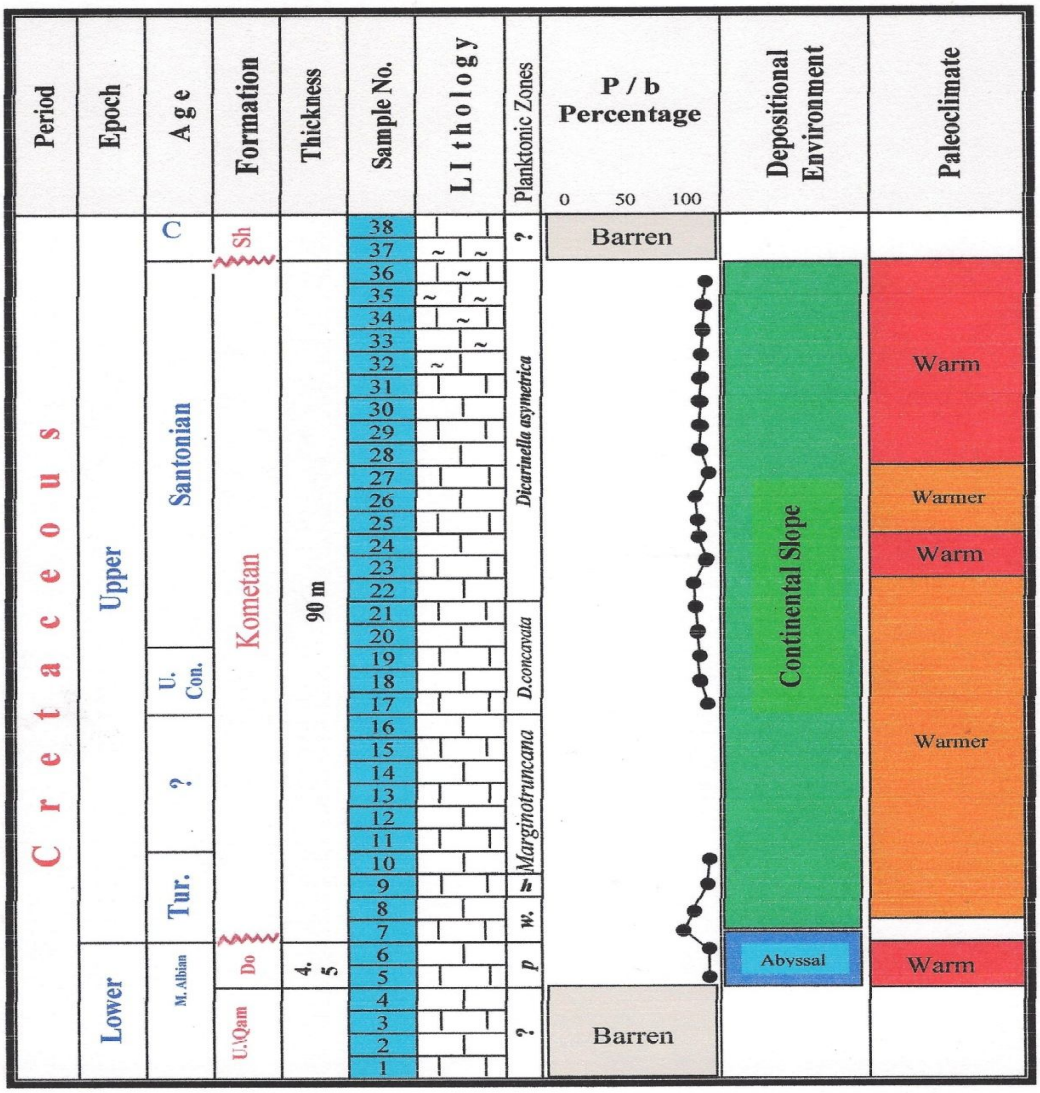
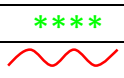


Figure2- Depositional environment, Paleoclimate and Planktonic to benthic ratio of foraminifera (P\b) of Surdash section. (Not to scale)

Legend of the figures

No.	Symbol	Explanation	No.	Symbol	Explanation
1.		Stylolite	2.		limestone
3.		Marly limestone	4.		shale
5.		Glauconite Unconformity	6.		Chert nodules
7.		Bioturbation	8.		marl
9.	Cmp	Campanian	10.	Sh.	Shiranish Formation
11.	M.A.	Middle Albian	12.	Do.	Dokan Formation
13.	L.	Lower	14.	Qam	Qamchuqa Formation
15.	Cen.	Cenomanian	16.	Gul.	Gulneri Formation
17.	Tur.	Turonian	18.	Alb	Albian
19.	San.	Santonian	20.	Con.	Coniacian
21.	*W.*	*Whiteinella*	22.	*Ti.*	*Ticinella*
22.	*M.*	*Marginotruncana*	23.	*Glt.*	*Globotruncana*
24.	*co.*	*Concavata*	25.	*Gu.*	*Guembelitria*
27.	*Hd.*	*Hedbergella*	28.	*D.*	*Dicarinella*
29.	*R.*	*Rotalipora*	30	*L.*	*Luxostomum*
31.	*Ht.*	*Helvetoglobotruncana*	32.	*G.*	*Gavelinella*

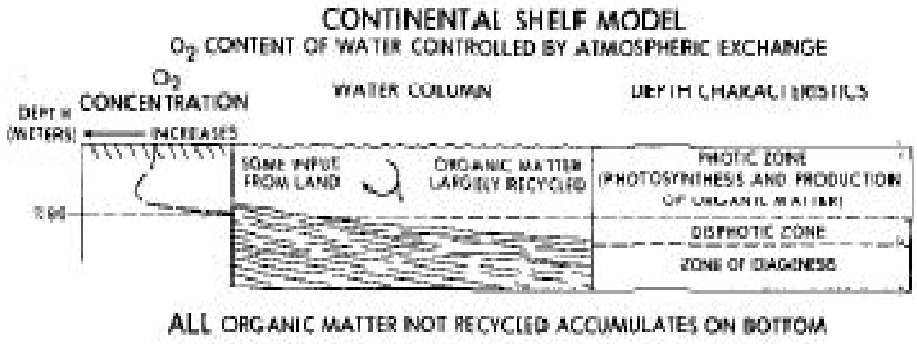


Figure 3- continental shelf model for accumulation of organic-rich sediments

Planispiral forms like *Globigerinelloides*sp. which existed in the Gulneri Formation of present study are increased during warm periods and disappeared during cold periods Frerichs (1971) [26].

Guembelitriacenomana(plate 1, 7) which existed in the Gulneri Formation of present study;thrived in shallow marginal marine environments where they were most abundant in low to middle latitudes and probably tolerant of both salinity and oxygen variations [28].

Guembelitria indicates shallow water fauna of Epicontinental Sea (less than 100 m) [13].

Whiteinella species (recorded in the Gulneri Formation in this section) are typical for the latest Cenomanian Oceanic anoxic events (OAE) [29].

Guembelitria and*Heterohelix* occur in samples with planktonic foraminifera, indicating advantageous conditions for such species in shallow waters (inner shelf) [30].

The Gulneri Formation in Qallat section was deposited in a tropical–subtropical, warm (30.3 ◦c), high fertility surface water in the continental shelf in an anoxic environment, with salinity between (34-37 ‰) Figure-4.

Kometan Formation:

The Kometan formation in Qallat section is rich with keeled *Globotruncana* and *Dicarinella* and less percentage of *Heterohelix*with very low occurrence of benthic foraminifera at the middle and upper part of the section indicating a tropical–subtropical, continental slope (upper to outer bathyal) as a depositional environment and high fertility surface waters with paleotemperature between (30-32 ◦c) and salinity between (34-37 ‰), Figure-4

Khalakan section

Dokan Formation:

The foraminiferal assemblages in Dokan Formation of this section consist of planktonic foraminifera only with the existence of oligostegina, which indicates deep marine conditions, [15].

The Carbonate Compensation Depth (CCD) of the Cretaceous Tethyan province is (2 km) [31] and by comparison with the model of oceanic divisions utilized in this study: the CCD could be sited in the lower part of the bathyal zone.

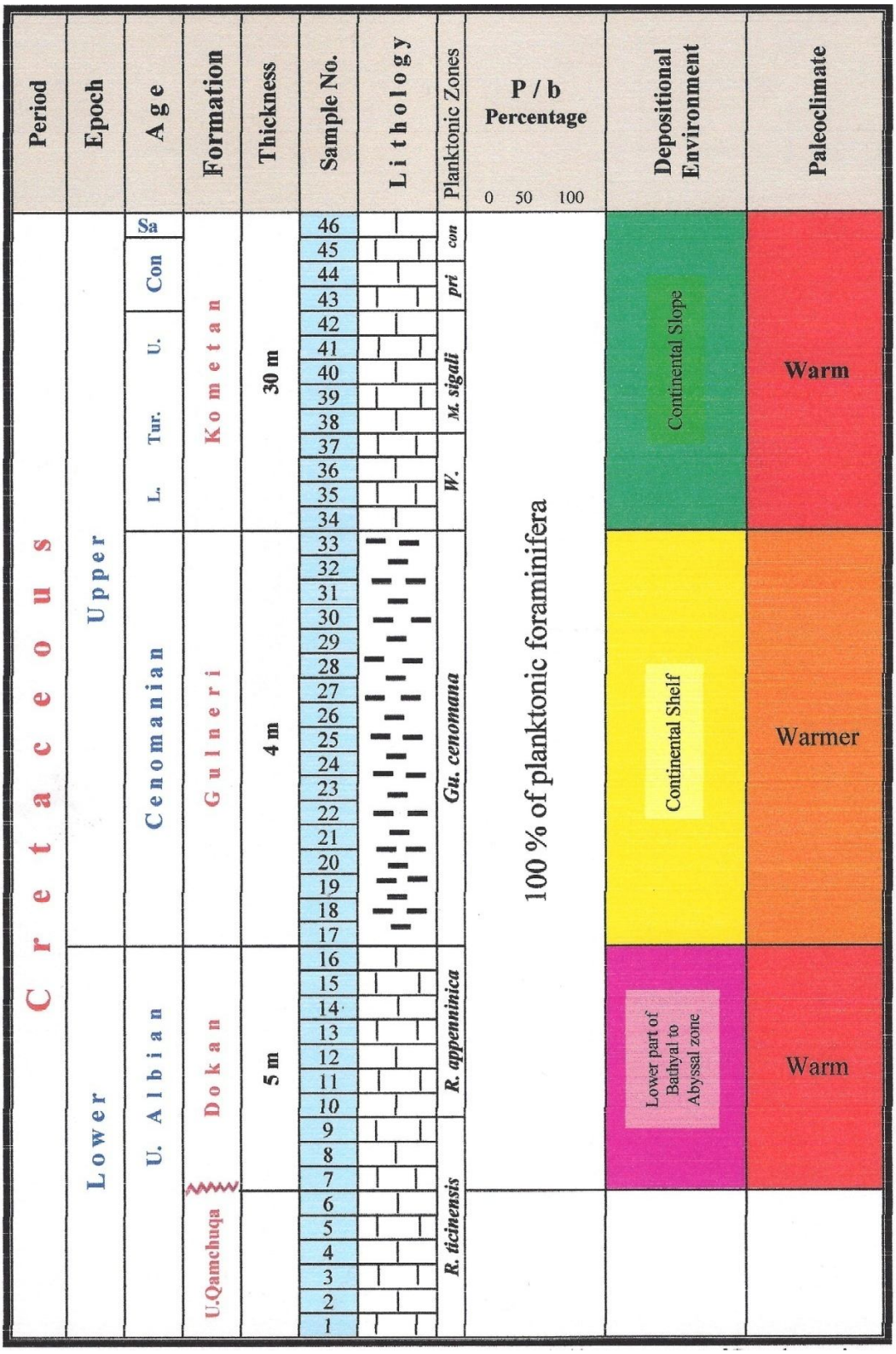


Figure 4- Depositional environment, Paleoclimate and Planktonic to benthic ratio of foraminifera (P\b) of Qallat section.

The presence of partially dissolved and partial ghost of foraminifera (figure-5) indicates the deposition of this formation below the CCD [32].

Rotalipora(plate 1, 9) and *Planomalina*(plate 1, 10) are typical genera of low latitudes, and indicate continental slope palaeodepth, [21].

The Dokan Formation in Khalakan section was deposited in tropical to subtropical, at the lower part of the Outer Bathyal to Abyssal Zone (2000-5000 m.) with a paleosalinity between (34-37 ‰), Figure-6.

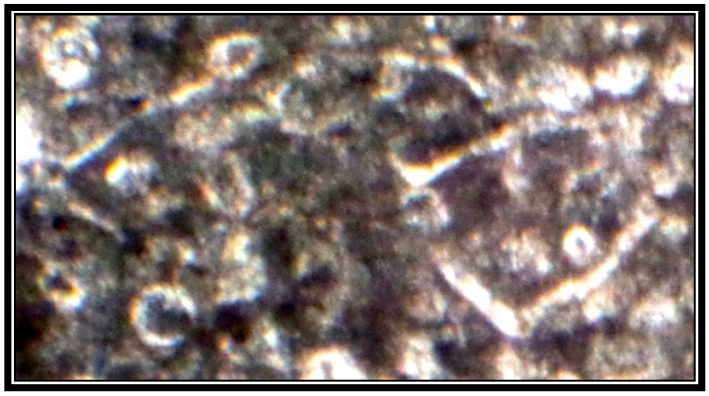


Figure5-Poorly preserved foraminifera within Dokan Formation of Khalakan Section

Gulneri Formation:

The Gulneri Formation in Khalakan section has the same fossils existed in Qallat section which indicates the deposition under marine conditions in warm continental shelf in an anoxic environment, with a salinity between (34-37 ‰).

The occurrence of *Heterohelix*in Gulneri Formation indicates low rate of oxygen, [30].

Heterohelix(biserial form), *Guembelitria*(triserial form), all inhabited the shallow environment waters of less than 100 m [13],Figure-6.

Kometan Formation:

The foraminiferal assemblages in the Kometan Formation of Khalakan section consist of planktonic foraminifera only which indicates open marine conditions and the occurrence of Globotruncanids are an evidence of continental slope environment, [8].

The large number of planktonic foraminifera in the Kometan Formation of this section indicates tropical to subtropical oceanic conditions existing in the Late Cretaceous time, so a tropical \ subtropical, marine, continental slope are suggested as depositional environment. Planktonic foraminifera have limited range of salinity (Stenohaline) between (34-37), [23]

*Hedbergelladelrioensis*existed in Kometan Formation in the present section indicates a paleotemperature between (27-28°c), and reflected surface and subsurface saline environments. In addition, *Heterohelix*, one of the other Cretaceous biserial planktonic foraminifers, was also representative of palaeosalinity changes, [33].

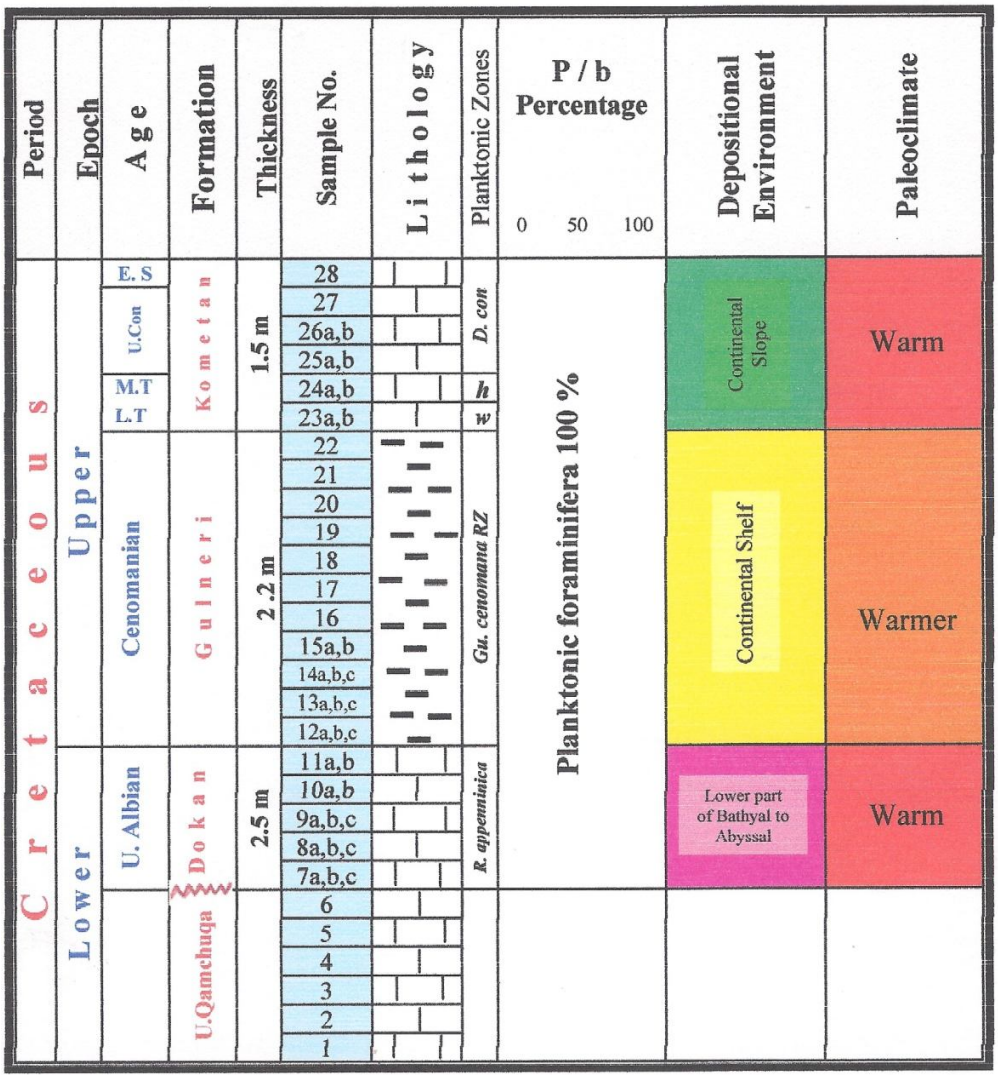


Figure 6- Depositional environment, Paleoclimate and Planktonic to benthic ratio of foraminifera (P\b) of Khalakan section

Hezob section

Kometan Formation:

Planktonic foraminifera of this section outnumber the benthonic foraminifera which means high ratio of (p\b) foraminifera. Also the high occurrence of Globotruncanids indicates continental slope depositional environment, [8].

There is a high diversity and great numbers of planktonic individuals of large tests, which is an evidence for tropical - subtropical oceanic conditions, [8]. The ratio of planktonic foraminifera in thissection exceeds 80 % which reflects depth between 250-1250 m. [9]. If the planktonic foraminifera are more than 50 % the depositional environment is the upper continental slope. [23].

The existing of *Hedbergelladelrioensis* indicates the middle part of the continental slope, [21]. *Hedbergelladelrioensis* is indicating a paleotemperature between (27-28 ◦c); and the presence of *Globigerinelloides* sp. indicates a paleotemperature about (30.3◦c), [24]. So the paleotemperature of

Kometan Formation in Hezob section range between (27-30◦c) and the salinity of the Cretaceous is between (34-37 ‰). [23] Figure-7.

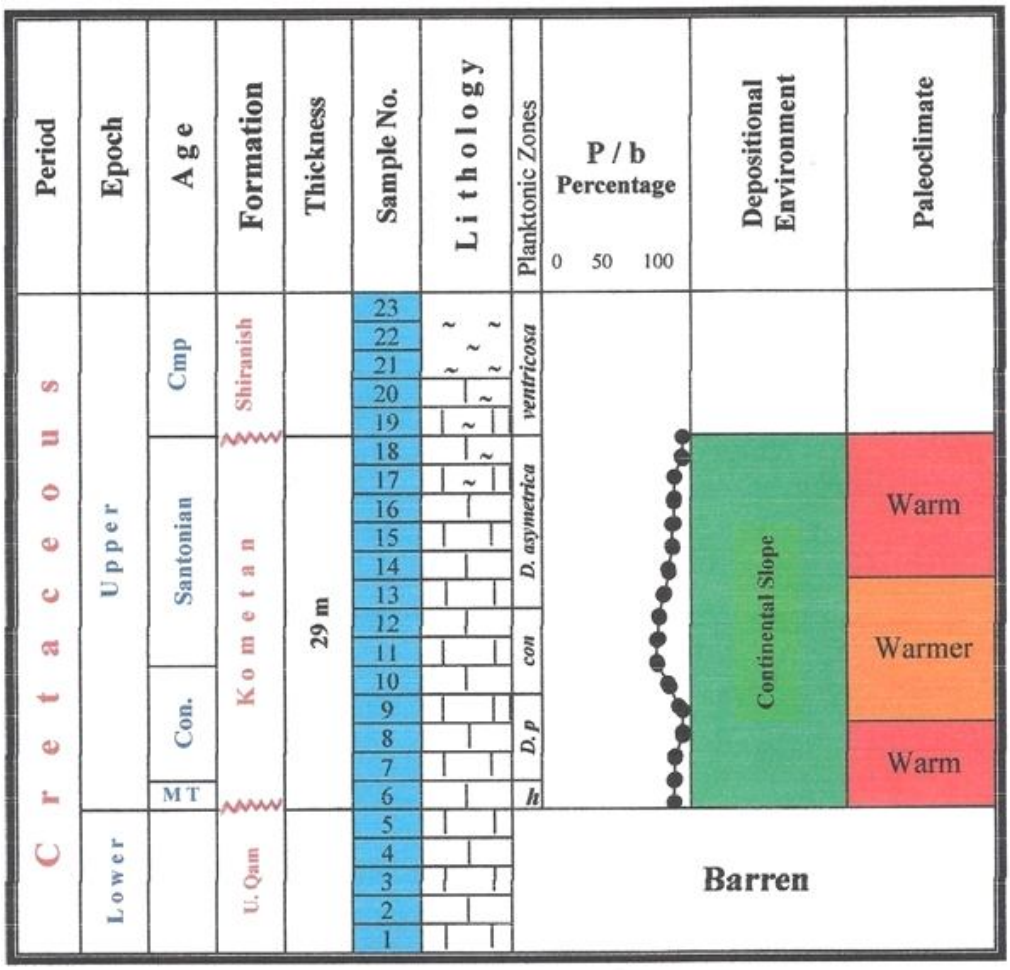


Figure7- Depositional environment, Paleoclimate and Planktonic to benthic ratio of foraminifera (P\b) of Hezob section

Sektan section

Dokan Formation:

The foraminiferal assemblages in Dokan Formation of this section consist only of planktonic fauna which indicates open marine conditions [8].*Rotalipora*and *Planomalina*are typical genera of low latitudes, and indicate continental slope palaeodepth, [21].

Some foraminiferal forms existed in Dokan Formation of this section are poorly preserved (partially dissolved foraminifera, Figure-9 which indicates the deposition below CCD, [32].

The Dokan Formation in Sektan section was deposited under tropical to subtropical conditions at the lower part of the outer bathyal to abyssal zone (2000-5000 m.) and of paleosalinity ranging between (34-37 ‰), Figure-8.

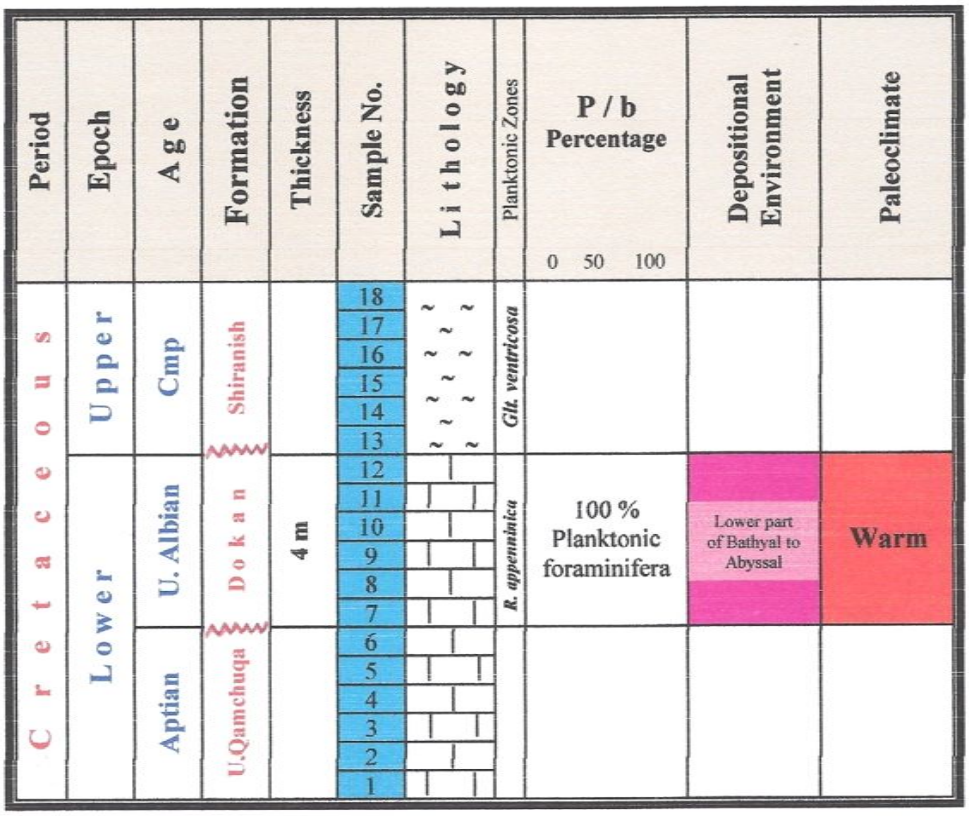


Figure8- Depositional environment, Paleoclimate and Planktonic to benthic ratio of foraminifera (P\b) of Sektan section

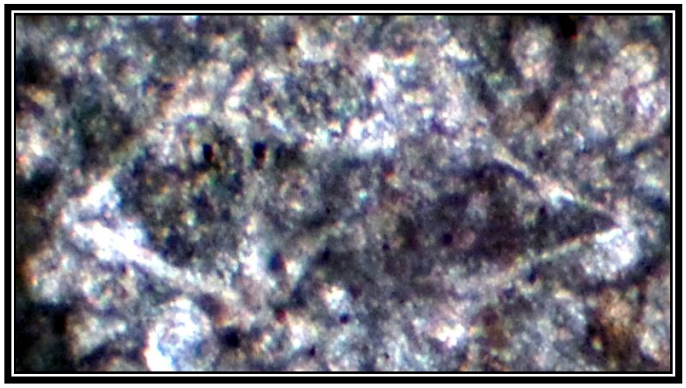


Figure 9-Poorly preserved foraminifera within Dokan Formation in Sektan Section

Degala section

Dokan Formation:

The foraminiferal assemblages in Dokan Formation of this section are the same as in Sektan section; some foraminiferal forms existed here are poor preserved which indicates deposition below CCD, [32].

Microgastropoda (plate 1, 11) is existed only in this section, indicating deep marine conditions, [34].

*Rotalipora*and *Planomalina*are typical genera of low latitudes, and indicate continental slope palaeodepth, [21].

The depositional environment of Dokan Formation in this section is tropical to subtropical, continental slope (lower part of the outer bathyal to abyssal zone and paleosalinity ranging between (34-37 ‰), Figure- 10.

Gulneri Formation:

The fauna of Gulneri Formation in this section are the same as in previous sections indicating the same depositional environment (marine, warm condition, continental shelf in an anoxic environment, with salinity between (34-37 ‰).

Kometan Formation:

The most common genera of Kometan Formation in this section are *Globotruncana*and *Hedbergelladelrioensis* and both genera indicate continental slope environment, [8].

*Hedbergelladelrioensis*is indicating a paleotemperature between (27-28 ˚c); and the presence of *Globigerinelloides*sp. indicates a paleotemperature about (30.3 ˚c), [24]. So the paleotemperature of Kometan Formation in Degala section was ranging between (27-30˚c).

Bandy [23] suggested that planktonic foraminifera of the Cretaceous have range of salinity between (34-37 ‰).

The depositional environment of Kometan Formation in Degala section is warm, tropical - subtropical continental slope.

Shaqlawa section

Kometan Formation:

The high occurrence of Globotruncanids indicates continental slope depositional environment, [8].

The existing of *Hedbergelladelrioensis*indicates the middle part of the continental slope, [21]and paleotemperature between (27-28 ˚c). While the presence of *Globigerinelloides*sp. indicates a paleotemperature about (30.3 ˚c), [24).

The ratio of planktonic foraminifera in this section exceeds 80 %, which reflects depth between (250-1250 m). [9]; and the salinity of the Cretaceous have range of salinity between (34-37 ‰); [23].

The Kometan Formation in this section was deposited under open marine, tropical - subtropical, warm conditions, in the continental slope, with paleotemperature ranging between (27-30˚c), figure-11.

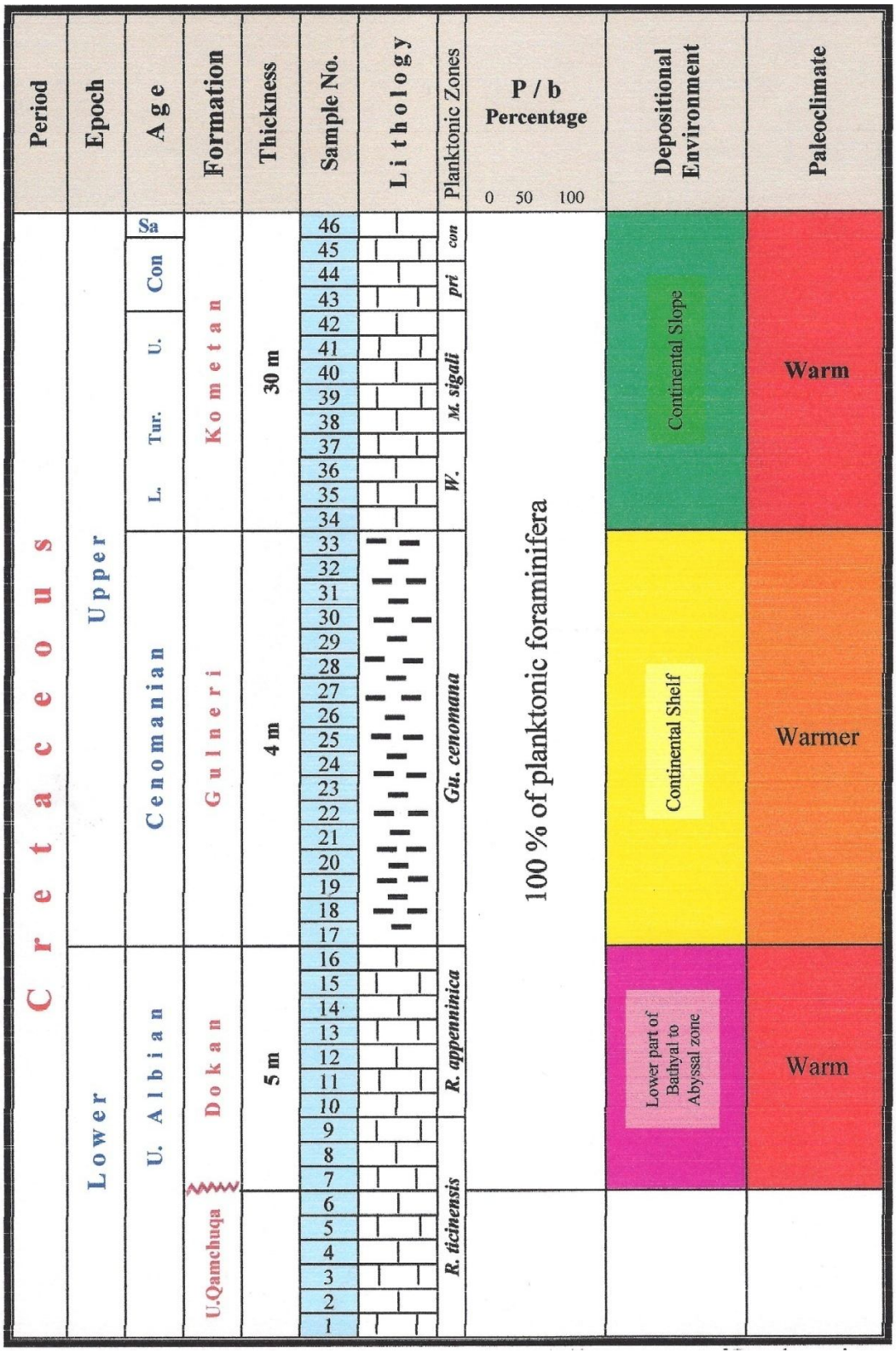


Figure 10-Paleoclimate and Planktonic to benthic ratio of foraminifera (P\b) of Degala section

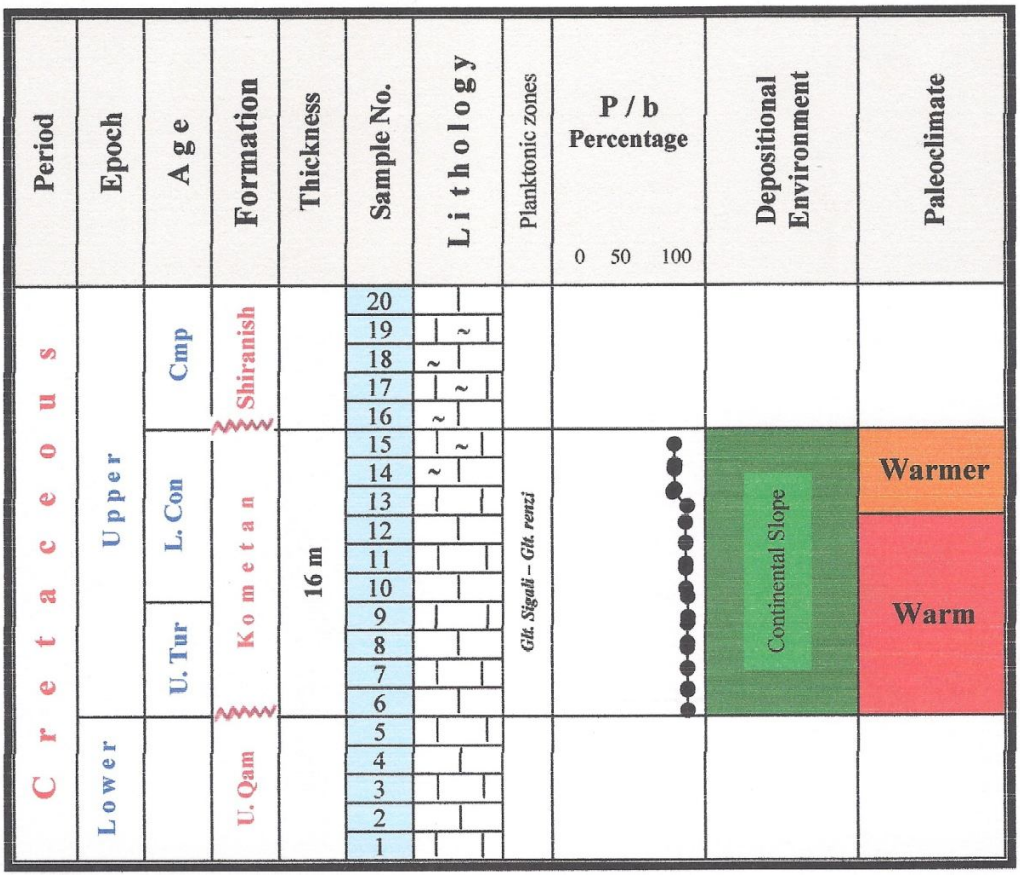


Figure11- Depositional environment, Paleoclimate and Planktonic to benthic ratio of foraminifera (P\b) of Shaqlawa section.

Conclusions:

1- Three depositional environments were distinguished along the studied sections, ranging from the continental shelf to the abyssal.

2- Dokan Formation was deposited in the continental slope (lower part of the outer bathyal to abyssal zone), undertropical to subtropical warm conditions of paleotemperture (30-32 ˚c), and salinity ranging between (34-37 ‰).

3-Gulneri Formation was deposited under tropical to subtropical warm conditions (30.3 ˚c) with high fertility surface water in the continental shelf in an anoxic bottom water environment, with salinity ranging between (34-37 ‰).

4-Kometan Formation is deposited under tropical – subtropical conditions, in the continental slope (upper to outer bathyal) above the CCD line with high fertility surface waters of paleotemperature 30-32 ˚c and salinity ranging between 34-37 ‰.

5- The p/b percentage is high along studied sections which indicating sea level rise.

6- The planktonic foraminiferal assemblages recorded in the present study considered to belong to the Tethyan faunal province.

7- The maximum thickness of Kometan Formation is in Surdash and Qallat sections indicate deposition in the center of the basin and it is thinning laterally toward Shaqlawa section and absent in Sektan section which indicate basin margin.

8- Maximum thickness of Dokan Formation is in Surdash section indicate deposition in the center of the basin and thinning laterally toward NW until it disappears in Shaqlawa section which indicate basin margin.

9- Maximum thickness of Gulneri Formation is in Degala section indicate deposition in the center of the basin and thinning laterally toward Khalakan until it reaches it minimum thickness in Qallat section and absent toward SE and toward NW.

10- The upper contact of Kometan Formation with Shiranish Formation is unconformable along the studied sections and the lower contact of Kometan Formation is unconformable too except in Degala section.

11- The upper contact of Gulneri Formation is unconformable except in Degala section and the lower contact is conformable.

12- The upper contact of Dokan Formation is conformable in Surdash and Khalakan sections and unconformable in Sektan section; and the lower contact is unconformable in Khalakan and Sektan sections and conformable in Surdash section.

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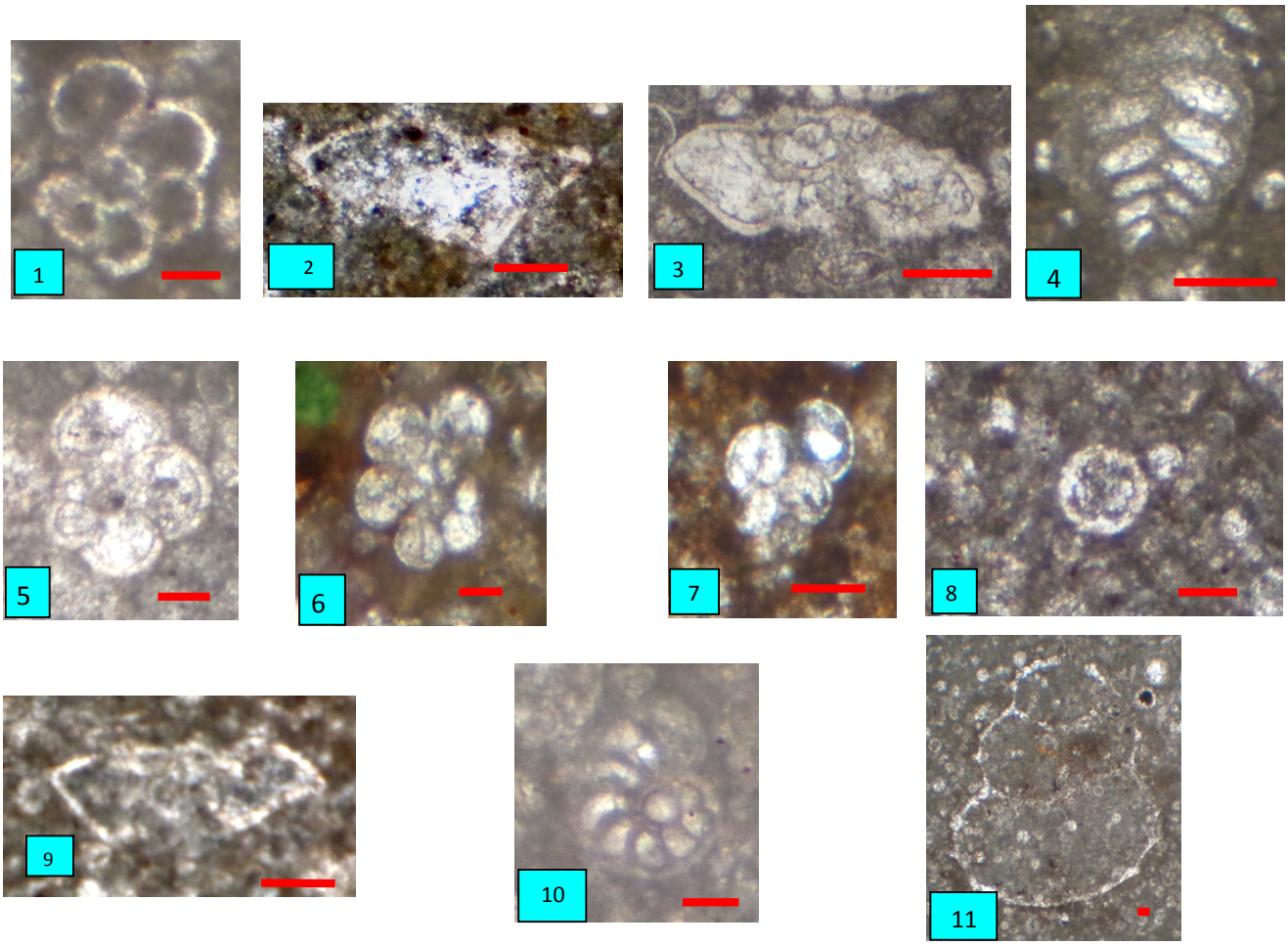
Plate 1



1- *Ticinellaprimula*Luterbacher , 2-*Globotruncanasigali*Reichel 3-*Dicarinellaprimitiva*Dalbiez 4-*Heterohelixreussi* 5-*HedbergelladelrioensisCarsey*
6- *Globigerinelloidesbolli*Pessagno7-*Guembelitriacenomana*Keller
8- Oligostegina 9-*Rotaliporaticinensis*Gandolfi 10-*Planomalinabuxtorfi*Gandolfi 11-Microgastropoda