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The facies analysis of the Cenomanian –Turonian succession of Surdash –Shaqlawa area, NE. Iraq

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Abstract:
Three formations were studied from seven outcrops extend from Surdash to Shaqlawa (Cenomanian – Santonian), they comprise Dokan, Gulneri and Kometan Formations. Four microfacies and eight submicrfacies are identified depending on this microfacies, we determine the depositional environments. Dokan Formation is deposited in open-marine deep shelf environment; it could be deposited at deeper shelf to slope and basinal settings. While Gulneri Formation deposited in open sea shelf, as well as at outer shelf settings, the sediments consist of organic–carbon rich black shale and consider a record of the ocean anoxic event 2, Kometan Formation represent pelagic sediments characterize the deep-marine basins in open marine.

Keywords: Cretaceous, Kometan, Gulneri, Dokan, microfacies, Iraq.

التحليل السحني للتتابع الطباقي من السينومانين – التوروني من منطقة سورداش الى شقلاوة ، شمال شرق العراق

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الخلاصة
تم دراسة السحنات الدقيقة لثلاثة تكاوين هي دوكان وكولنيري وكوميتان (سينوماني–السنتوني) من سبعة مكاشف سطحية امتدت من سورداش الى شقلاوة حددت اربع سحنات رئيسة وثمان ثانوية حددت البيئة الترسيبية لكل تكوين اعتمادا على السحنات الدقيقة وقد تبين بان تكوين دوكان ترسب في بيئة الرف المفتوح العميق واحيانا بيئة المنزلق والحوضية، اما تكوين كولنيري ;قد ترسب في البيئة البحرية العميقة مصحوبا بنقص في الاوكسجين وهذا يطابق الضروف الترسيبية التي مرت بها الفترة بنقص في الاوكسجين بشكل عالمي على فترات نقص اوكسجين عالمية اما تكوين كوميتان فقد ترسب في بيئة حوضية عميقة بيلاجية ويمكن تقسيمها الى بيئات ثانوية وبينت الدراسة ان جميع التكاوين ترسبت في بيئات عميقة متفاوتة بالعمق.

الكلمات المفتاحية: الكريتاسي، كوميتان، كولنيري، دوكان، سحنات دقيقة، العراق.

Introduction

The Cretaceous successions have special importance within the geological column because they include formations, which are the most productive in the country. The significance of Cretaceous in Iraq is due to their high production of oil and gas from many Cretaceous reservoirs. The Cenomanian

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–Turonian sequence of the Kurdistan region (NE/ Iraq) is of importance, owing to lack of through investigation. The present study includes microfacies analysis of succession, namely Dokan, Gulneri, and Kometan Formations, that aims to investigate and analyze the sedimentary environments as well as the stratigraphic setting.

Location of study Area

The present stud is situated in the Northeast part of Iraq, extending from Surdash to Shaqlawa regions, seven sections have been chosen, surrounding between Longitude lines 44° 26′ -44° 10′ and latitude circles 35° 50′-36° 30′.

These sections are Surdash, Khalikan, Qallat, Hezope, Sektan, Degala and Shaqlawa. Figure-1, Table-1, most of these sections is studied for first time and determines their boundaries accurately.

Stratigraphy of studied formation:

The study is focused on the vertical and lateral microfacies distribution and the relationships between grain composition and depositional environments.

Dokan Formation was formerly included in the Kometan Formation, the type locality is on site of Dokan Dam in NE Iraq [1], it comprises 4 -11 m of light brown coloured grey and white limestone. This characterized the colour that separates it from the rest of the formation. It is not well bedded and finely crystalline. The Gulneri Formation is a thin, highly condensed unit, which is locally preserved at the top of Cenomanian –E. Turonian sequence; it consists of 1.2 m of black, bituminous, finely laminated, calcareous shale, reflecting euxinic environment, just Degala section comprises of 4 m approximately to black marly limestone, Surrounded by two unconformity boundaries that carried some of glauconite.

The Kometan Formation comprises 80 - 120 m of light grey, thin bedded, Fossiliferous limestone, locally silicified, Bioturbation and Glauconite, the fossil content indicate Turonian age. The bottom is well bedded and then change to thick bedded, both the lower and upper contacts of the formation are unconformable it changed to sharp contact by Shiranish formation which represented by fossiliferous marly limestone.

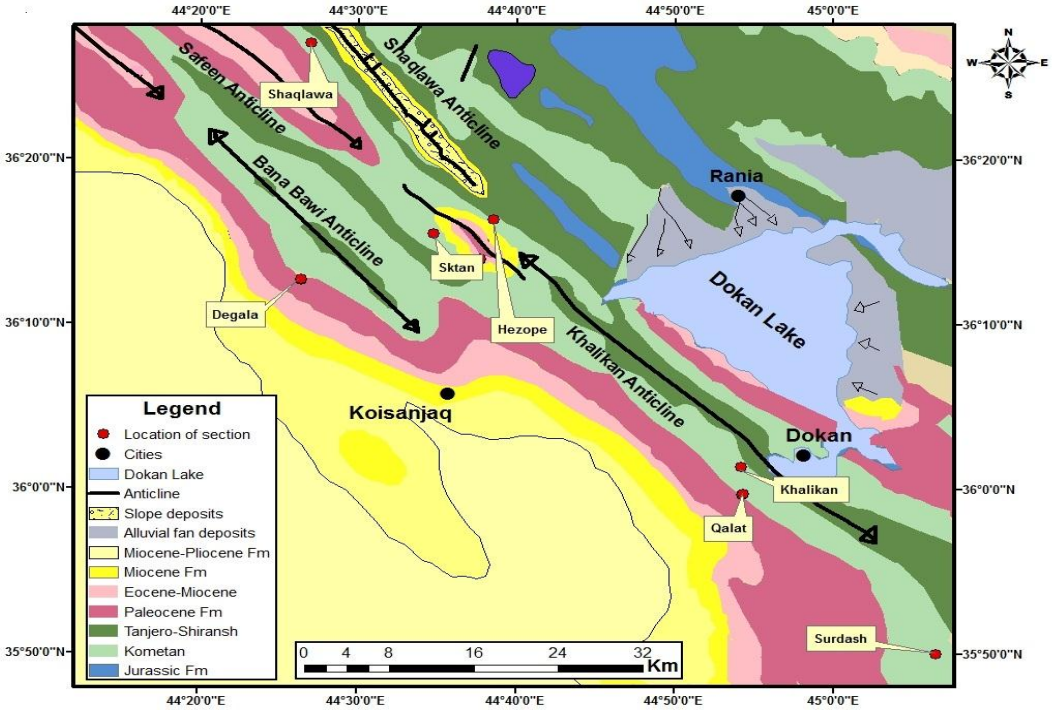

Figure 1- Geological and location map of studied area

Table 1-the thicknesses and microfacies for studied sections with appearance or disappearance for formations in the surface sections.

Fm	**Kometan**		**Gulneri**		**Dokan**	
Sections	thick(m)	microfacies	thick(m)	microfacies	thick(m)	microfacies
Degala	30	2-B, 3-A	4	2-C, 3-B,3-C	5	2-A, 3-D
Qallat	82	2-B,3-A,3-C	1.2	2-C, 3-B,3-C	absent	
Khalikan	1.5	2-B,3-A,3-C	2.2	2-C, 3-B, 3-C, 4-A	2.5	1-A, 2-A, 3-D
Surdash	81	2-B,3-A	absent		11	1-A, 2-A
Hezope	29	2-B,3-A	absent		absent	
Shaqlawa	16	3-A	absent		absent	
Sektan	absent		absent		4	1-A, 2-A, 3-D

Microfacies

The microfacies and lithology for the studied section are characterized by no variation in facies, may change slightly, but the overall setting remains constant for every formation, there are two types of lithology, clastic and carbonate.

Four main types of facies and nine submicrofacies are determined depending to [2-5].

1- Bioclast lime mudstone to Wackestone submicrofacies

This facies is characterized by particles between 8-15%. The particles are mostly skeletal components such as planktonic foraminifera and calcispheres, with a few amounts of extraclast and small gastropods. The groundmass is either micrite or microspar effective in neomorphism. It exists only at the top of Dokan Formation in Sektan, Khalikan, and Surdash sections.

This facies is equivalent to the SMF 9 in FZ.2 depending on model of [3, 5] which represent deep outer shelf (Pl.1-1).

2- Lime Wackestone microfacies: It is divided into three submicrofacies

A- Calcispheric Wackestone Submicrofacies

This facies is characterized by the predominance of skeletal grains (about 10-50% from rocks component) and high distribution of calcispheres about 70% of skeletal grains, calcispheres tests are well preserved, the other grains are planktonic foraminifera such as *Globigerinelloides, Rotalipora, Ticinella,* and other associated skeletal fragment of pelecypods. This facies represent the bottom of Dokan Formation. The groundmass is dark brown sometimes light.

The calcispheric wackestone Submicrofacies resembles SMF 3 in FZ 3 which given by [3] and modified by [5]. It represent deep shelf margin. (Pl.1-2).

B- Planktonic Foraminiferal Wackestone Submicrofacies

The proportion of grains in this submicrofacies is between 10-60% its components. The planktonic forams represents 80% of these grains and the important genera are: *Globotruncana, Globigerinelloides, Heterohelix, Hedbergela, Ventrberalla,* the remaining components of this submicrofacies are organic matters (10%), calcispheres (5%), and pyrite (5%). In addition to few of ostracods and fish bones are in frequent. The matrix of this submicrofacies is content of the micrite with light brown to dark brown. It is common exists in the middle of Kometan Formation.

Planktonic foraminiferal wackestone Submicrofacies is equivalent to the SMF 8 in FZ.2 which given by [3] and modified by [5]. It represents open sea shelf (Pl.1-3).

C- Globigerinelloides Lime Wackestone submicrofacies

Diversified assemblage of skeletal grains are the main constituents of this microfacies in proportion up to about 70% but the genus Globigerinelloides representS 50% of the total fossils. The other skeletal grains are*: Heterohelix, Ticinella, Bronnimannella*. Most of their tests are calcified and compacted at Gulneri Formation, only at Degala section this submicrofacies is oriented. There are different types of micrite color result of the high percentage of micrite.

Globigerinelloides Lime Wackestone submicrofacies is equivalent to the SMF 1 in Fz.1, 2 which given by [3] and modified by [5]. It is represent basinal deep water with slow sedimentation (Pl.1-4).

3- Lime Packstone microfacies

This is the most common facies in present study. It includes many of the submicrofacies resulting from the variation in the relative components and facies specifications. The submicrofacies are:

A- Planktonic Foraminiferal lime packstone submicrofacies

It is characterized by a high content of planktonic foraminifera (about 80% of the grains), such as *Globotruncana, Hedbergela, Heterohelix, Whiteinella, Bronnimannella, Dicarinella, Ventrberalla.* These assemblages are associated with limited number of molluscan fragments, fish bones, ostracods with rarely benthonic forams, in addition to some other fossils not identified. Also this submicrofacies is contents authogenic minerals such as pyrite and glauconite with special stylolite and hydrocarbon criteria.

This submicrofacies is characteristic to Kometan Formation and few meters faraway towards Shiranish Formation. Planktonic foraminiferal lime packstone submicrofacies is equivalent to the SMF 3 in FZ.1 which given by [3] and modified by [5]. It is represent basin and deep shelf (Pl.1-5).

B- Heterohelixide packstone submicrofacies

Planktonic foraminifera especially *Heterohelix* genus is the overwhelming proportion of the skeletal components of this submicrofacies. It is forming about 70-80% percentage of grain components associated with calcispheres. The carbonate cement fills the chambers of fossils, occasionally oriented. The groundmass is less micrite and effective in neomrphism. It is characterizing the Gulneri Formation.

This Heterohelixide packstone submicrofacies is equivalent to the SMF 10 in FZ.3 which given by [3] and modified by [5]. It is representing Toe-of-slope apron (deep shelf margin) (Pl.1-6).

C- Glauconitic packstone submicrofacies

Glauconite mineral is occupied the vast majority of this submicrofacies, sometimes precipitate inside the shells, It is represent about 80% of grain components. The green colour for glauconite shows clearly to the eye. And under microscope it is take two colors: green and red, the red could be affected in the oxidation processes. These microfacies is included of planktonic foraminifera such as *Heterohelix*, *Globotruncana,* with some broken molluscs shells and extraclast. The groundmass is affected with noemorphism.

In modem oceans glauconite occurs between 50 and 500 m and is abundant in mid-shelf to upper slope settings at depths between 50 and 300 [5]. While [6] though glauconite formation is only restricted to zones of low deposition rate and does not demand a specific water depth. It is generally considered to form as a result of the partial reduction of iron in the sedimentary materials of pellets dropped to the bottom of the sea [7].

This facies lies at the contact between Gulneri - Kometan Formations, and Kometan - Shiranish Formations with uneven thickness between 20 cm to 3 m.

This submicrofacies is equivalent to the SMF-3 that deposited in the Facies zone (FZ-1) is known, according to the model [5], basin and open deep shelf (Pl.1-7).

D- Calcispheric packstone submicrofacies

The calcispheres in this facies is about 85% of the grain components. It is composed the total groundmass, their size is ranging between 30-60 micron, some of the calcispheres fill in micrite but the common in spar. The associated of the skeletal grains are foraminifera and fish bone with disseminated pyrite. The Calcispheric packstone submicrofacies is a frequent microfacies at Dokan Formation, which can be separated it from the other formations.

This submicrofacies is equivalent to the SMF 3 in FZ.3 which given by [3] and modified by [5]. It is representing deep shelf margin (Pl.1-8).

3- Silty Sandstone lithofacies:

This lithofacies are only present in the Gulneri Formation and only at Khalikan section. The grain size analysis of Gulneri Formation for 18 clastic samples is revealed two sizes. The common is Silty sand and only two samples represent sandy silt, this facies consists of sandstone, white to light brown, friable to medium, with a thin layer of fissile shale ranging between 10 to15 cm, thickness of this microfacies in study area is ranged between 2-2.2m.

Depositional Environments

Depending on the Standers microfacies of [3, 5], the studied succession started as shallow carbonate basin in inner shelf, lagoon and reef environment that represented by Qamchuqa formation.

Mesozoic calcispheres, pelagic pithonella packstone and SMF 3, that exists in Dokan Formation indicated of open-marine deep shelf environment ,They are found predominantly in sediments of the deeper shelf to slope and basinal settings, sometimes in inner shelf environments [5, 8].

The Dokan limestone represents the deep water maximum flooding surface (MFS), which transgresses of the Qamchuqa shelf carbonate system, the assemblages of calcispheres with planktonic foraminifera in Dokan Formation reinforced these transgression. [9] described it as MFS- K130 within AP8, Plate Setting: passive margin, Late Cretaceous, middle Cenomanian, dated at 95 Ma.

Three facies characterized the Gulneri formation in this sequence, it is a thin, highly condensed unit, which is locally preserved at the top of the Cenomanian-Early Turonian Sequence, the high bitumen content and dwarfed fossils indicate that the formation is deposited in an euxinic environment. As well known there are global events where it registered as Anoxia, and abbreviated OAE (oceanic anoxic events). There were arguably between two and seven OAEs during the mid-Cretaceous[10,11].

Therefore you can consider the sediments of the Gulneri Formation are consist of the ocean anoxic event 2 (OAE2) a cross the Cenomanian–Turonian boundary with agreement of the authors [12-14]. According to [9] the upper Gulneri Shale Formation is represents the K140 MFS: Late Cretaceous, early Turonian, dated at 93 Ma, Plate Setting: AP8, passive margin (post-rift), contains reworked pebbles of the underlying Dokan Formation, and is an extremely condensed, intra-basinal high deposit. These sediments are restricted to a very small area, which probably represents a small graben types basin [15].

Planktonic forms diversity and glauconite are the most important features of Kometan Formation, It is deposited in different environments ranging between shallow shelf, restricted (calcispheres facies) to open marine (globigerinal facies). Pelagic sediments are characterized the deep-marine basins in open-marine and deep shelf settings. Glauconite is usually regarded as an indicator of marine environment, relatively shallow deposition and slow sedimentation. The mineral is often concentrated at discontinuity surfaces that indicating of depositional breaks [7]. According to [16] classification, the type of glauconite in Kometan Formation are: (1) Intrabasinal authigenic glauconites formed in situ that have not undergone transport. (2) Intrabasinal detrital glauconite grains transported from submerged structural highs or derived from in situ reworking processes. (3) Perigenic authigenic glauconites dispersed in an unconsolidated sediment on the sea floor, that have undergone transport from the area where they were formed by tides, storm or turbidity currents. The overlying Kometan Formation is of very similar age to the Gulneri Formation, but is interpreted by [17] to be separated from the Gulneri Formation by an unconformity. It is now understood that such apparent breaks in sedimentation of deep-water marine carbonates may be the consequence of hard ground formation and as such the combined Gulneri-basal Kometan can be treated as the K140 MFS[9].

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Plate1

1. Bioclast lime mudstone to wackestone submicrofacies in Dokan Formation at Sektan section (sample 5).

2. Calcispheric lime wackestone submicrofacies in Dokan Formation at Khalikan section (sample no.4).

3. Planktonic foraminiferal wackestone submicrofacies in Kometan Formation at Qallat section (sample no. 33).

4. Globigerinelloides lime wackestone submicrofacies in Gulneri Formation at Qallat section (sample 22).

5. Planktonic foraminifera lime wackestone / packstone submicrofacies in Kometan Formation - BH-90 well (at depth1488).

6. Heterohelixide lime packstone submicrofacies in Gulneri Formation –Degala section (sample no.28).

7. Glauconitic lime packstone submicrofacies in Kometan Formation – Qallat section (sample no 55).

8. Calcispheric lime packstone submicrofacies in Dokan Formation- Khalikan section (sample no.8)

Plate 1