



BIOSTRATIGRAPHY OF BEKHME FORMATION (UPPER CRETACEOUS) IN SELECTED SECTIONS, KURDISTAN REGION, NORTHEAST IRAQ

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Received: 24/ 07/ 2016, Accepted: 15/ 12/ 2016

Key words: Bekhme, Biostratigraphy, Biozones, Khanzad, Iraq

ABSTRACT

The Bekhme Formation belongs to the Late Campanian – Early Maastrichtian cycle. The formation consists mainly of thick and massive bedded limestone and dolomitic limestone. The main objective of this study is to determine the microfossil and the age of Bekhme Formation.

Forty four species of benthonic and planktonic foraminifera have been recognized including one species described for the first time in Iraq.

Depending on the assemblage of different groups of foraminifera, two biozones of benthonic foraminifera were determined, namely:

1. *Murciella cuvillieri* Range Zone.
2. *Omphalocyclus macropours-Orbitoides apiculatus-Siderolites calcitrapoides* Assemblage Zone.

According to the identified biozones the age of Bekhme Formation is estimated as Late Campanian – Maastrichtian at Shaqlawa, Bekhme and Khanzad sections.

دراسة الطباقية الحياتية لتكوين بخمة (الطباشيري الأعلى) في مقاطع مختارة في إقليم كردستان، شمال شرق العراق

سلام إسماعيل الدليمي و رؤى علاء الدين العبيدي

المستخلص

درست الطباقية الصخرية والحياتية للوحدات الصخرية لتكوين بخمة في ثلاث مقاطع مختارة في شمال شرق العراق. يعود عمر تكوين بخمة الى دورة الكامباني المتأخر – الماسترختي المبكر. ويتألف التكوين من طبقات صلبة من الحجر الجيري والدولوميتي. أن الهدف الرئيسي من هذه الدراسة هو تحديد المتحجرات لتكوين بخمة وتحديد عمر التكوين اعتماداً على المحتوى الحياتي.

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تم تمييز 44 نوعاً من الفورامينيفيرا القاعية و الطافية ومن ضمنها نوع واحد وصف لأول مرة في العراق، واعتماداً على هذا التجمع فقد تم تحديد نطاقان حياتيان يعودان للفورامينيفيرا القاعية وهي حسب الظهور:

1. *Murciella cuvillieri* Range Zone.
2. *Omphalocyclus macropours-Orbitoides apiculatus-Siderolites calcitrapoides* Assemblage Zone.

وتم تقدير عمر التكوين بأنه الكامباني المتأخر – الماسترختي في مقاطع شقلاوة وبخمة وخانزاد اعتماداً على الانطقة الحياتية المذكورة أعلاه إضافة إلى المتحجرات المصاحبة لها.

INTRODUCTION

The Bekhme Formation belongs to the Late Campanian – Maastrichtian cycle. The cycle begins with a widespread transgression which occurred after the termination of the unrest caused by the middle Cretaceous orogenies and almost covered the whole country. The cycle is terminated by another uplift and regression, caused by the paroxysmal phases of the Laramide Orogeny around the Cretaceous-Tertiary boundary. The Bekhme Formation lies amongst seven other formations, namely Hartha, Tayarat, Aqra, Shiranish, Tanjero, Hadina, and Digma formations (Buday, 1980). This formation consists mainly of thick and massive bedded limestone and dolomitic limestone.

In this research, three outcrop sections are selected for the biostratigraphic study of Bekhme Formation; they are Bekhme, Khanzad and Shaqlawa sections. The biostratigraphic study depends mainly on the occurrence of benthic foraminifera.

The Campanian – Early Maastrichtian age was accepted for Bekhme Formation (Bellen *et al.*, 1959). It is widely exposed in the study area. The formation consists of well bedded limestone and dolomitic limestone, locally bituminous, very hard, light grey in color (Sissakian, 1998). The Bekhme Formation was defined by Wetzel in Bellen *et al.*, 1950 from the Bekhme Gorge of the Greater Zab River in the High Folded Zone as bituminous secondary dolomite, replacing organic detrital limestones in its upper part, and reef detrital limestones, alternating with reef shoal limestones in the middle part, with basal breccia and conglomerate in the lower part (Jassim and Goff, 2006). The Bekhme Formation in its type sections can be divided into units depending on lithology, bedding and fossils content.

The main objectives of this study are to determine the microfossils especially benthonic foraminifera of Bekhme Formation and age of the formation depending on fossils content.

The study area lies in the northeast part of Iraq at Erbil Governorate. It lies between (44° 14' 00" – 44° 26' 00" E) and (36° 08' 00" – 36° 44' 00" N) (Fig.1) (Table 1). It lies within the High Folded Zone (HFZ), which is a part of the unstable shelf of Arabian Plate (Buday and Jassim, 1984). The Bekhme Formation (Upper Campanian – Maastrichtian) was studied at two separate areas within north and north east part of Iraq.

Table 1: Geographic coordinate of the studied sections

Section	Coordinate	Locality
Shaqlawa	E 44° 26' 13" N 36° 13' 22"	Permum Anticline
Khanzad	E 44° 23' 27" N 36° 31' 48"	Hareer Anticline
Bekhme Gorge	E 44° 14' 16" N 36° 39' 50"	Perat Anticline

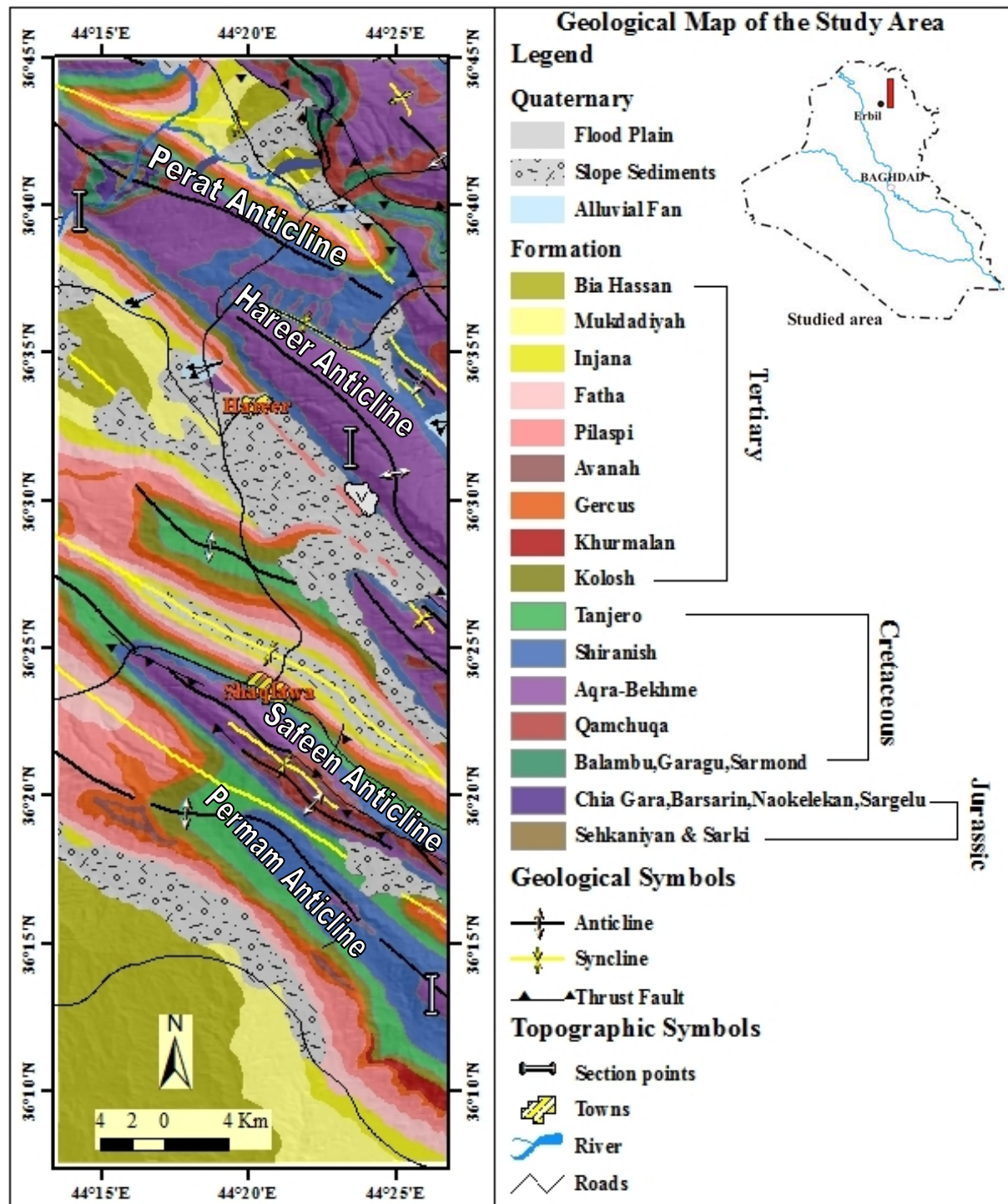


Fig.1: Geological and location map of the three studied sections, Shaqlawa, Bekhme and Khanzad (after Sissakian, 1998)

■ Previous Works

- Dunnington (1947), studied the fossils of the Bekhme Formation in its type locality and recognized rudist and various species of planktonic and benthonic foraminifera.
- McCarthy *et al.*, (1958), pointed out that generally Bekhme Formation consists of tough dolomitic limestone, finely crystalline and brown in colour.

- Bolton (1958), described the formation in Ranya area northeast Iraq and described it as thick bedded and massive containing various fossils forming fore-reef limestone, and shoal (reefal) limestone.
- Chatton and Hart (1961), clarifies that it is difficult to separate Aqra Formation from Bekhme Formation and they use Aqra-Bekhme Formation term.
- Yassin (1973), in SW of Halwa Nasara area (North Iraq), used two species *Loftusia* sp. and *Omphalocycus macroporus* (LAMARK) to separate Bekhme Formation from Aqra Formation.
- Abdul Muniem and Said (1979), point out that rocks of Bekhme Formation indicate facies of reef and shallow fore-reef depending on the presence of various species of planktonic and benthonic fossils.
- Sissakian and Youkhana (1979), recognized reefal limestone consisting of rudist which represents Bekhme Formation. They separated three types of microfacies, and considered the sedimentary environment of the formation to be shallow marine, reef and fore-reef limestone.
- Buday (1980), used the name Aqra-Bekhme Formation and said that separation between Bekhme and Aqra formations is very difficult.
- Al-Karadakh (1989), studied the Bekhme Formation from three outcrops in north and northeast Iraq including the type locality section at Bekhme Gorge, in addition to Shiranish Islam and Shaqlawa sections. The lower part of Bekhme Formation at the type locality and Shiranish Islam section are well-bedding fossiliferous limestone. The middle and upper parts consist of massive, dolomitized and thick bedded limestone. The Shaqlawa section is composed wholly of massive dolomitized rocks indicating deposition in three environments including back-reef, reef and fore-reef, in addition to the intertidal environment which occurred at the initial phase of the formation. The Bekhme Formation is conformably underlying Shiranish Formation, and unconformably overlying the Qumchuqa and/ or Mergi formations at the type locality and Shiranish Islam area respectively. The lower contact at Shaqlawa section is found to be occupied by lentical shaped beds of marl.
- Ameen and Karim (2008), claimed that basal conglomerate or erosional surface occurs between Qumchuqa Formation and Bekhme Formation. They point out that the contact is most possibly conformable and shows no subaerial erosion. The conglomerate like structures that are found in the boundary zone is secondary (diagenetic) in origin as they were formed by stress of overburden or tectonics during burial and their ball-like shape is enhanced by weathering.
- Al-Mutwali *et al.* (2008), studied an incomplete but well exposed section in NE Dohuk City and believed that Bekhme Formation represents the lower part of a regional Upper Cretaceous (Campanian – Maastrichtian) succession that was deposited over most of Iraq and adjacent regions. The formation unconformably overlies the Qumchuqa Formation and is overlain by Shiranish Formation. They distinguished three main microfacies throughout the Formation, representing middle-shelf, outer shelf and upper-bathyal environment.
- Ali (2010), studied the Bekhme Formation from seven sections in the area between 36° 15' 00" N, 44° 30' 00" E and 37° 00' 00" N 42° 45' 00" E. He distinguishes six microfacies indicating that the Bekhme Formation was deposited as reef, fore-reef, and back-reef in an isolated platform.

METHODOLOGY

In this study, (139) samples are collected from three outcrops representing Bekhme Formation. The samples were collected according to lithology, color and fossil content and their variations. These samples include (42) samples from Shaqlawa section, (47) from Khanzad section and (50) from Bekhme section. The field work comprises description of lithology of the three sections. The laboratory work included making two to three thin sections for each sample. Alizarin red solution is used for discriminating calcite from dolomite of the carbonate samples according to Dickson's method (Tucker, 1988). In addition, transverse cross section were made for fossil samples, besides an average of two to three thin sections were made for each fossil shell to describe the microstructures. The thin sections were examined using the polarized microscope to differentiate the various types of microfossils and microfacies. The digital camera DCE-2 was used to photo the thin sections. Various references were used to recognize and differentiate the foraminifera genus and species.

GEOLOGY OF THE STUDY AREA

The outcrop sections of the study area (Shaqlawa, Khanzad and Bekhme Gorge) lie within three anticlines. These are Permian, Hareer and Perat anticlines, respectively. According to Ibrahim *et al.* (1984); Sissakian (1998); Jassim and Goff (2006) and Al-Ma'amar (2015) these anticlines are double plunging and asymmetrical. Their southwestern limbs are steeper than their northeastern limbs (Fig.1). Generally, they are trending NW – SE coinciding with the High Folded Zone and Zagros-Taurus belts. The cores of the anticlines are represented by sub-horizontal beds, while the top become inclined to vertical and overturned at the southern limbs. These anticlines are affected by several types of faults and joints with a number of minor folds that occur within the less competent strata. The topography of the high folded zone within the study area reflects the feature of the tectonic structures (folds and faults), as well as the lithology. The higher topography is occupied by massive limestone (Bekhme Formation) while the lower elevation is occupied by soft sediment of Tertiary age. The drainage pattern on the anticline is of dendritic and parallel types (Zebari, 2010).

BIOSTRATIGRAPHY

The biostratigraphy of the Bekhme Formation is studied from three outcrops as given below:

▪ Shaqlawa Section

The thickness of the Bekhme Formation in this section is about 76 m. The following microfauna are identified in the sediments of Bekhme Formation at this section (Fig.2):

Bolivina incrassata REUSS, *Cibicides Cuneolina cylindrica* HENSON (Fig.3), *Elphidiella* sp., *Heterohelix* sp., *Lenticulina* sp., *Lepidorbitoides* sp., *Loftusia* sp., *Loftusia minor* COX, *Loftusia persica* BRADY (Fig.4), *Marginulinopsis* sp., *Murciella cuvillieri* FOURCADE, *Nodosira* sp., *Nummofallotia* sp., *Orbitoides apiculatus* SCHLUMBERGER (Fig.5), *Orbitoides gensacicus* LEYMERIE (Fig.6), *Orbitoides medius* (d'Archiac), *Orbitoides tissoti* SCHLUMBERGER, *Omphalocyclus macroporus* (LAMARCK), *Omphalocyclus (Torreina) torrei* PALMER, *Orthokarstenia* sp., *Pyrgo* sp., *Rotalia* sp., *Rugoglobigerina* sp., *Siderolites calcitrapoides* LAMARCK, *Sulcoperculina globosa* (de Cizancourt), *Triloculina* sp., *Valvulineria cretacea* CARSEY (Fig.7), algae, gastropoda, ostracoda, pelecypoda and rudist.

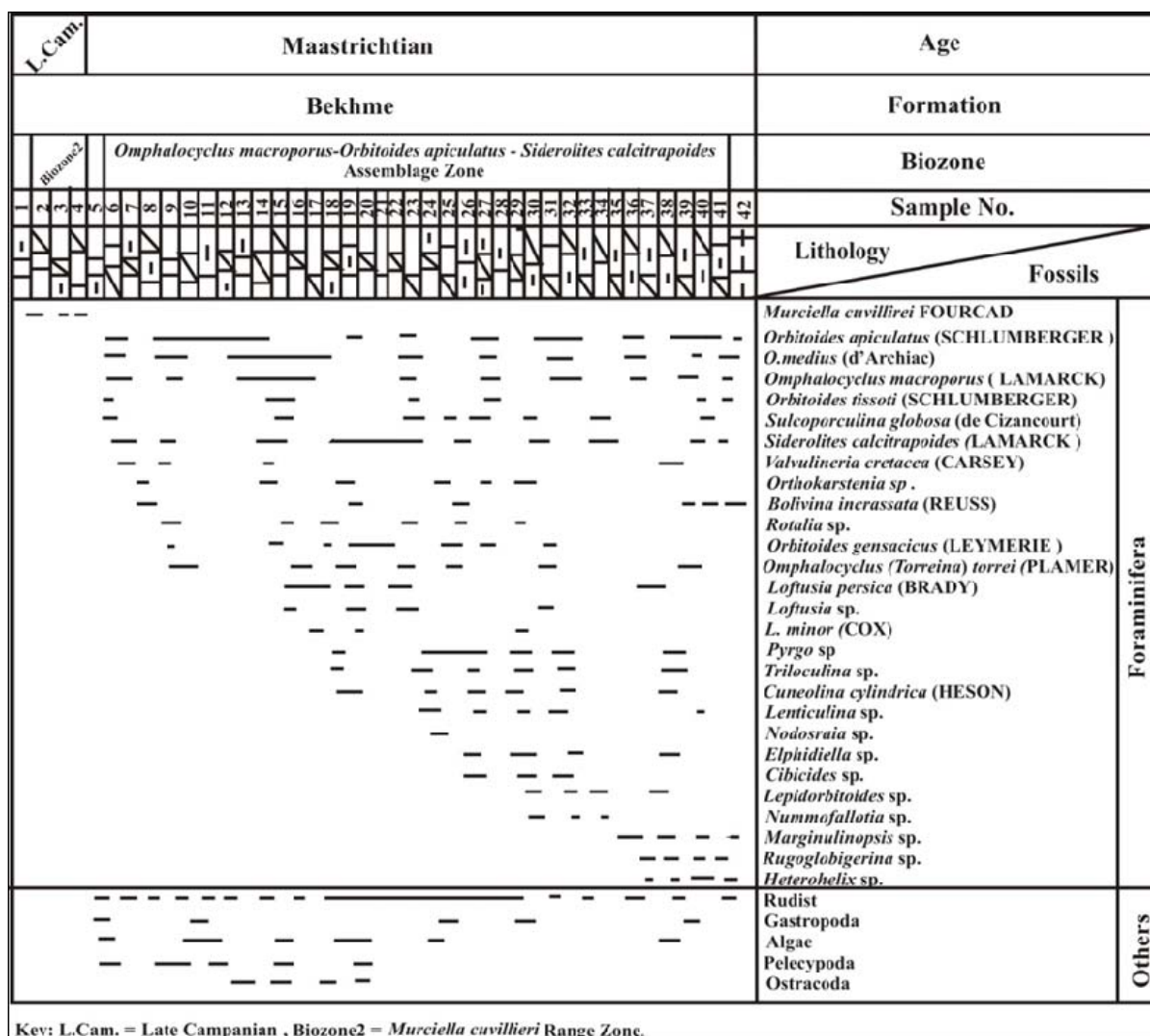


Fig.2: Distribution chart of fossils in Shaqlawa section

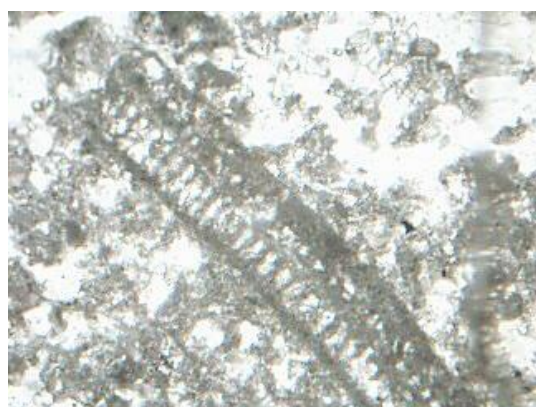


Fig.3: *Cuneolina cylindrica* HENSON, Shaqlawa section, Sample No.23, X5

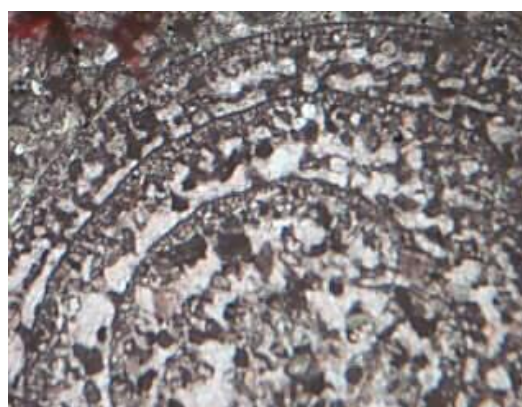


Fig.4: *Loftusia persica* BRADY, Shaqlawa section, Sample No.14, X4

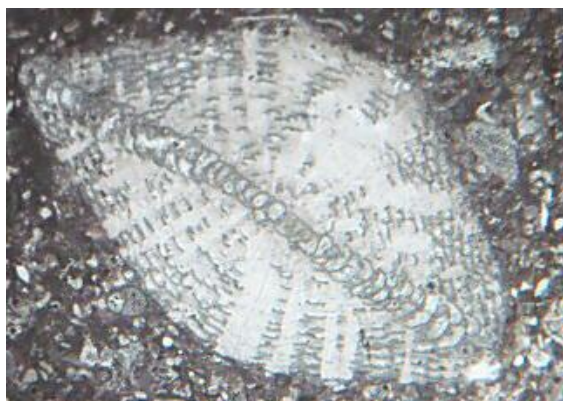


Fig.5: *Orbitoides apiculatus*
SCHLUMBERGER, Shaqlawa section,
Sample No.11, X5

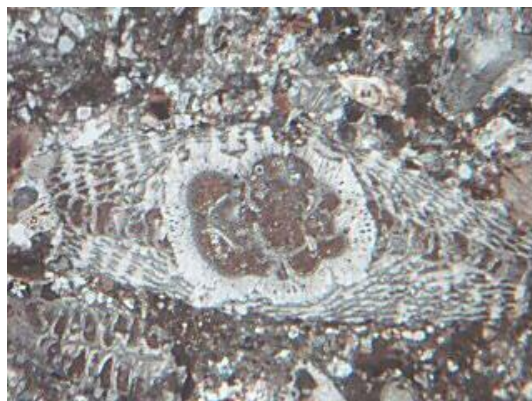


Fig.6: *Orbitoides gensacicus*
(LEYMERIE), Shaqlawa section,
Sample No.20, X5

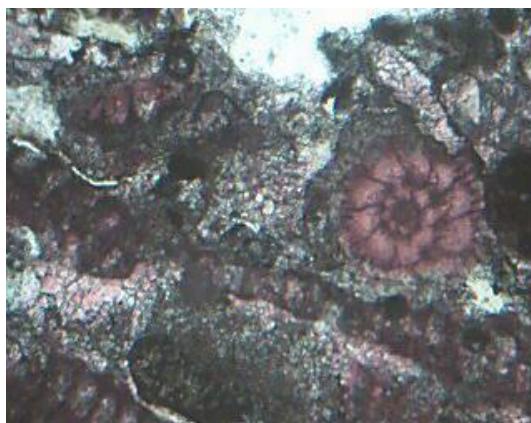


Fig.7: *Valvulinera cretacea* CARSEY,
Shaqlawa section, Sample No.13, X10

▪ Bekhme Section

The thickness of the formation in Bekhme section is about 160 m; the following benthonic and planktonic foraminifera are identified in Bekhme Formation in this section (Fig.8):

Bolivina incrassata REUSS (Fig.9), *Cibicides* sp., *Elphidium* sp., *Gasserina gansseri* (BOLLI), *Globotruncana* sp., *Globotruncana bulloides* VOGLER, *Globigerinellides* sp., *Hedbergella* sp., *Heterohelix striata* EHERENBERG, *Lepidorbitoides* sp., *Loftusia* sp., *Loftusia minor* COX (Fig.10), *Marginulinopsis* sp., *Murciella cuvillieri* FOURCADE, *Nodosraia* sp., *Nummofallotia* sp., *Orbitoides apiculatus* SCHLUMBERGER, *Orbitoides gensacicus* LEYMERIE, *Orbitoides medius* (d'Archiac) (Fig.11), *Orbitoides tissoti* SCHLUMBERGER, *Omphalocyclus* sp., *Omphalocyclus macroporus* (LAMARCK), *Omphalocyclus (Torreina) torrei* PALMER, *Orthokarstenia* sp. (Fig.12), *Pyrgo* sp. (Fig.14), *Rugoglobigerina rugosa* (PLUMMER), *Siderolites calcitrapoides* LAMARCK, *Sulcoperculina globosa* (de Cizancourt), *Textularia* sp., *Triloculina* sp., *Valvulina* sp., algae, gastropoda, pelecypoda and rudist.

Late.Cam.	Maastrichtian																														Cam.-Maas.	Age																					
Bekhme																															Sh.	Formation																					
Murciella cuvillieri Range Zone	Omphalocyclus macroporus- Orbitoides apiculatus- Siderolites calcitrapoides Assemblage Zone																															Biozone																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Sample No.			
																																																		Lithology	Fossils		
																																																		Murciella cuvillieri (FOURCADE) Sulcoperculina globosa (de Cizancourt) Orbitoides tissoti (SCHLUMBERGER) Orbitoides apiculatus (SCHLUMBERGER) Orbitoides medius (d' Archiac) Margulinopsis sp. Siderolites calcitrapoides (LAMARCK) Omphalocyclus macroporus (LAMARCK) Valvulina sp. Lepidorbitoides sp. Omphalocyclus (Torreina) torrei (PLAMER) Omphalocyclus sp. Loftusia minor (COX) Cibicides sp. Orbitoides gensacicus (LEYMERIE) Bolivina incrassata (REUSS) Loftusia sp. Nodosraia sp. Nummofallotia sp. Elphidium sp. Textularia sp. Pyrgo sp. Trioculina sp. Orthokarstenia sp. Globotruncana bulloides (VOGLER) Globotruncana sp. Gasserina gansseri (BOLLI) Heterohelix striata (EHERENBERG) Globigerinellides sp. Hedbergell sp. Rugolobigerina rugosa(PLUMMER)		Foraminifera	
																																																		Rudist Gastropoda Algae Pelecypoda		Others	

Key: Late.Cam. = Late Campanian , Sh. = Shiranish Formation. , Cam.-Maas. = Campanian-Maastrichtian.

Fig.8: Distribution chart of fossils in Bekhme section



Fig.9: *Bolivina incrassata* REUSS,
Bekhme section, Sample No.37, X10



Fig.10: *Loftusia minor* COX, Bekhme section, Sample No.16, X5

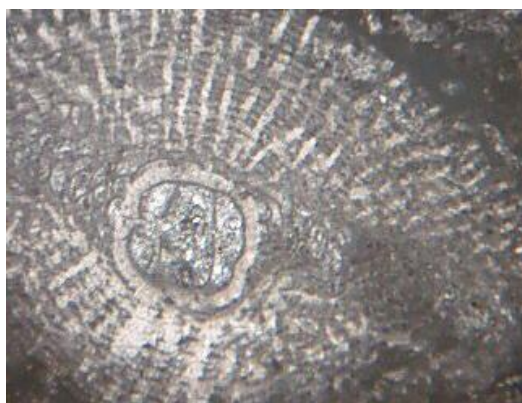


Fig.11: *Orbitoides medius*, (d'Archiac), Bekhme section, Sample No.12, X4



Fig.12: *Orthokarstenia* sp., Bekhme section, Sample No.35, X10

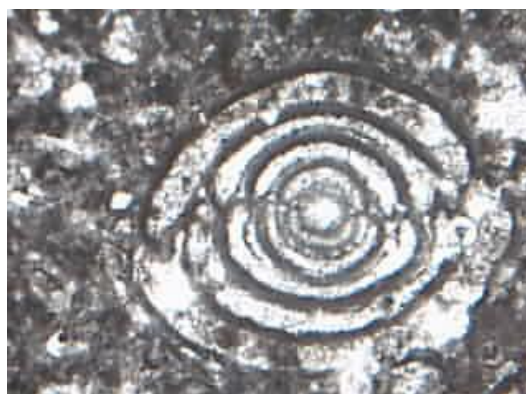


Fig.13: *Pyrgo* sp., Bekhme section, Sample No.25, X5

▪ Khanzad Section

The thickness of the formation in Khanzad section is about 320 m; the following benthonic and planktonic foraminifera are identified in Bekhme Formation at this section (Fig.14):

Bolivina incrassate REUSS, *Cuneolina* sp., *Fabularia* sp., *Globigerinellides* sp., *Heterohelix* sp., *Heterohelix striata* EHERENBERG, *Lepidorbitoides socialis* LEEYMRIE, *Loftusia* sp., *Loftusia minor* COX, *Murciella cuvillieri* FOURCADE (Fig.15), *Nummofallotiasp.*, *Orbitoides apiculatus* SCHLUMBERGER, *Orbitoides medius* (d'Archiac) *Omphalocyclus* sp., *Omphalocyclus macroporus* (LAMARCK) (Fig.16) *Omphalocyclus (Torreina) torrei* PALMER (Fig.17), *Peneroplis* sp., *Pyrgo* sp., *Quinqueloculina* sp., *Rugoglobigerina* sp., *Siderolites* sp., *Siderolites calcitrapoides* LAMARCK (Fig.18), *Sulcoperculina globosa* (de Cizancourt) (Fig.19), *Textularia* sp., *Triloculina* sp., *Valvulina* sp., rudist, ostracoda, gastropoda, pelecypoda and algae fragment that were also recorded.

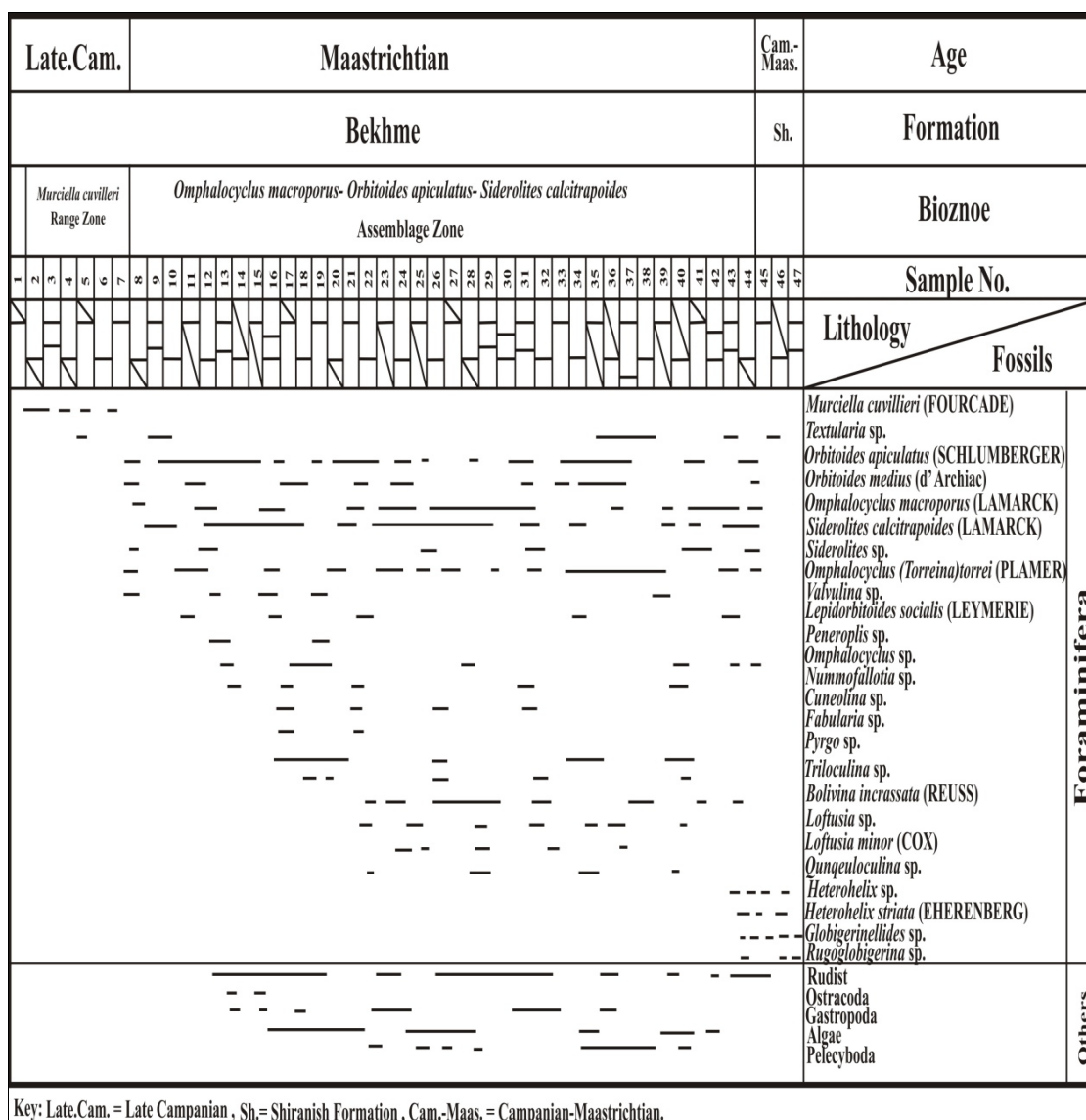


Fig.14: Distribution chart of fossils in Khanzad section



Fig.15: *Murciella cuvillieri*
FOURCADE, Khanzad section, Sample
No.44, X10



Fig.16: *Omphalocyclus macroporus*
LAMARCK, Khanzad section, Sample
No.31, X10



Fig.17: *Omphalocyclus (Torreina) torrei* PALMER, Bekhme section, Sample No.31, X4



Fig.18: *Siderolites calcitrapoides* LAMARC, Khanzad section, Sample No.20, X4



Fig.19: *Sulcoperculina globosa* (de Cizancourt), Khanzad section, Sample No.19, X5

BIOZONE

Through the detailed biostratigraphic study of Bekhme Formation, and depending on the presence of benthonic foraminifera, two biozones are recognized. The thickness and appearance of these biozones vary among the three described sections. The description and discussion of the biozones are given below:

▪ *Murciella cuvillieri* Range Zone

This zone is determined by the first and last appearance of the *Murciella cuvillieri* FOURCADE species which is described for the first time in Iraq. The age of this zone is determined depending on the occurrence of this species within sediments belonging to Upper Campanian age. The thickness of this zone is 15 m at Shaqlawa section, 40 m at Bekhme section and 20 m at Khanzad section. *Murciella cuvillieri* FOURCADE species is identified among strata belonging to Upper Campanian age at Spain, Greece, Yugoslavia and Cuba (Loeblich and Tappan, 1988). In Iraq this species indicate Upper Campanian. According to the identified biozones, the age of the Bekhme Formation belong to Late Campanian – Maastrichtian in Shaqlawa, Bekhme and Khanzad sections.

■ ***Omphalocyclus macroporus* – *Orbitoides apiculatus* – *Siderolites calcitrapoides* Assemblage Zone**

This zone is identified depending on the extension of part of the three species. It is recorded in Shaqlawa, Bekhme and Khanzad sections. The lower limit of the zone is identified according to the coexistence of the three species. The upper limit of the zone was determined by the last appearance of the three species and other associated fauna like: *Bolivina incrassata* REUSS, *Cibicides Cuneolina cylindrica* HENSON, *Elphidiella* sp., *Heterohelix* sp., *Lenticulina* sp., *Lepidorbitoides* sp., *Loftusia* sp., *Loftusia minor* COX, *Loftusia persica* BRADY, *Marginulinopsis* sp., *Nodosraia* sp., *Nummofallotia* sp., *Orbitoides gensacicus* LEYMERIE, *Orbitoides medius* (d'Archiac), *Orbitoides tissoti* SCHLUMBERGER, *Omphalocyclus (Torreina) torrei* PLAMER, *Orthokarstenia* sp., *Pyrgo* sp., *Rotalia* sp., *Rugoglobigerina* sp., *Sulcoperculina globosa* (de Cizancourt), *Triloculina* sp., *Valvulineria cretacea* CARSEY.

The age of this zone is determined to be of Maastrichtian, depending on the age of the three species and the age of the accompanying species, in addition to correlation with similar facies found in the neighbouring and other countries. The thickness of this zone is 55 m at Shaqlawa section, 275 m at Bekhme section and 140 m at Khanzad section. The coexistence of the three species together or with other species and genera has been recorded by many researchers from different countries.

In Iraq, Kassab (1979) mentioned these species such as: *Orbitoides* sp.; *Omphalocyclus macroporus* LAMARCK and *Loftusia minor* Cox, indicating early Maastrichtian, *Siderolites calcitrapoides* LAMARCK; *Omphalocyclus macroporus* LAMARCK and *Loftusia minor* Cox, indicate late Maastrichtian.

Al-Kubaysi (2006) and Al-Dulaimi (2011) mentioned the presence of *Omphalocyclus macroporus*, *Orbitoides medius*, *Siderolites calcitrapoides* that indicate Upper Maastrichtian age.

The *Orbitoides apiculatus* SCHLUMBERGER indicating Maastrichtian age in each of the following countries: Switzerland (Renz, 1937), Cuba (Kupper, 1954), Iraq (Lawa, 1983; Al-Kubaysi, 2006; and Al-Dulaimi, 2011).

The species *Omphalocyclus macroporus* LAMARCK was recorded from strata belonging to Maastrichtian age in each of the following countries: Switzerland (Renz, 1937), Netherlands (Drooger, 1952), Cuba (Kupper, 1954), Iran (Khosrow, 1978), Iraq (Lawa, 1983; Al-Kubaysi, 2006; and Al-Dulaimi, 2011).

The *Siderolites calcitropoide* LAMARCK species is identified among strata belonging to Maastrichtian age in Italy, Greece, Romania, Cuba (Loeblich and Tappan, 1988). In Iraq this species indicate Upper Maastrichtian (Al-Kubaysi, 2006).

Schluter *et al.*, 2008, recorded the presence of *Omphalocyclus macroporus* LAMARCK, *Orbitoides apiculatus* SCHLUMBERGER, *Orbitoides medius* (D'ARCHIAC), *Siderolites calcitropides* LAMARCK, *Sulcoperculina* sp., *Lepidorbitoides* sp., *Cuneolina* sp., indicating late Maastrichtian.

CONCLUSIONS

The main conclusions of this study are as follows:

- Lithology of the Bekhme Formation consists mainly of thick and massive bedded limestone and dolomitic limestone which are highly impregnated with bituminous materials.
- Forty four species of the benthonic foraminifera and planktonic foraminifera were recognized in Bekhme Formation at Shaqlawa, Bekhme and Khanzad sections.
- Two biozones of benthonic foraminifera in the Bekhme Formation are determined and described, they include: *Murciella cuvillieri* range zone, which is described for the first time in Iraq and *Omphalocyclus macropours* – *Orbitoides apiculatus* – *Siderolites calcitrapoides* assemblage zone.
- According to the microfossils and by correlation with neighbouring countries, the age of Bekhme Formation is estimated to be Late Campanian – Maastrichtian at Shaqlawa, Bekhme and Khanzad sections.

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