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Microfacies Analysis and Depositional Environment of Bekhme Formation (Late Campanian- Early Maastrichtian) in Selected Outcrops, North and Northeastern Iraq

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ABSTRACT

The present study deals with the microfacies analysis and the sedimentary environment of the Bekhme Formation (Late Campanian-Early Maastrichtian) in two sections, the first (Badi section) in the Duhok city and the second (Khoran section) in the Shaqlawa city. The lithology of the formation and the microfacies of each section were studied and described, and the sedimentary environment of the formation was deduced by relying on microfacies analysis of each sections, as three main microfacies (lime mudstone , lime wackestone , lime packstone microfacies) were diagnosed divided into (12) submicrofacies, and it was found that the sedimentary environment of the formation at Badi section was represented by the upper bathyal to the middle bathyal, while the microfacies diagnosed in the formation at Khoran section reflected the middle shelf to outer shelf environments. The reason for the difference in the sedimentary environment is due to the nature of the sedimentary basin for each section and the tectonic factors in that period, which formed normal faults in the (Back- Bulge) basin, as the Badi section is located within the (Deep Back- Bulge) area, while the Khoran section is close to the shallow Back- Bulge area less deep.

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تحليل السحنات الدقيقة والبيئة الترسيبية لتكوين بخمة (الكامبانيان المتأخر–الماسترختيان المبكر) في مكاشف مختارة شمال وشمال شرقي العراق

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الملخص

يتناول البحث الحالي التحليل السحني والبيئة الترسيبية لتكوين بخمة (الكامبانيان المتأخر–الماسترختيان المبكر) في مقطعين، الاول (مقطع بادي) في منطقة دهوك الثاني (مقطع خوران) في منطقة شقلاوة. تم خلال البحث دراسة و وصف صخارية التكوين والسحنات الدقيقة لكل مقطع، كما تم استباط البيئة الترسيبية للتكوين وذلك من خلال الاعتماد على التحليل السحني الدقيق، اذ تم تشخيص ثلاثة سحنات دقيقة (الحجر الجيري الطيني و الواكي و المرصوص) رئيسية قسمت الى (12) سحنة ثانوية، و تبين ان البيئة الترسيبية للتكوين لمقطع بادي كانت ممثلة ببيئة المنحدر الكاربوني ضمن منطقة الباثيال الاعلى (Upper Bathyal) الى الباثيال الاوسط (Middle Bathyal)، بينما عكست السحنات الدقيقة المشخصة للتكوين في مقطع خوران بيئة الرصيف الاوسط (Middle Shelf) الى الرصيف الخارجي (Outer Shelf)، حيث يرجع سبب اختلاف البيئة الترسيبية الى طبيعة الحوض الترسيبي لكل مقطع والعوامل التكتونية في تلك الفترة التي كونت فوالق اعتيادية في حوض (Back- Bulge) اذ يقع مقطع بادي ضمن منطقة (Deep Back- Bulge) , بينما يقترب مقطع خوران من منطقة (Shallow Back- Bulge) الاقل عمقا.

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Introduction

The sedimentation cycle of the upper Cretaceous (Late Campanian - Maastrichtian) was characterized by its wide spread in different locations in Northern Iraq, which includes many formations, as Bekhme, Shiranish, Tanjiro, Aqra and Hadina. The sediments of this cycle were affected by many factors, including local and regional tectonic factors related to the emergence and development of the Forland basin, in addition to the sea level change, where it's also played an influential role in the variation of thicknesses and the lithology of the formations of this cycle vary from location to another (Buday, 1980).

The events of this cycle began with the beginning of the closure of the Neo-Tethys and this closure was followed by a wide marine progressive that included all the Iraq except the Rutba High (Jassim and Karim, 1984).

Where the stage of obduction the ophiolite of the New Tethys crust above the edge of the Arab-Nubian plate and its prominence above sea level reached its peak during the late Campanian, as a result of the continued movement of the Arab-Nubian plate towards the Northeast, this led to an increase in the downward amplitude of the flexion wave, i.e. an increase in the subsidence of the Fore-deep basin, coincided with the increase in the rise of the fore-bulge, and this wave helped to activate the normal basic faults behind the Fore-bulge, which led to the development of the Deep Back- Bulge. During this period, the Forland-Zagros basin began to form at a stage without filling on the continental crust of the

Arab-Nubian plate (Jassim and Goff, 2006), and at the end of the Cretaceous to the beginning of the Paleocene the rise of the ophiolite was interrupted due to the collision of the Hassan Bek Ophiolite arch with the Northeastern continental edge of the Arab-Nubian plate (Ali et al., 2012).

The Bekhme Formation was first studied by (Wetzel ,1946 in Bellen et al., 1959) and identified its type section at the Northern end of the Bekhme Gorge with a thickness of (315) meters, Northeast of Iraq. The formation is divided in its type section into three parts, the lower part consisting of conglomerate and limestone containing foraminifera, and the middle part consists of reefal limestones, while the upper part consists of dolomite rocks, and the age of the of formation was determined in late Campanian to early Maastrichtian.

Kassab et al. (1974) studied the Bekhme Formation in the Kani Masi area of the Amadiya in Northern Iraq, and pointed out that the deposits of the formation consist of grey, hard dolomitic limestone containing conglomerate in some parts, and that the age of the formation is the late Campanian- early Maastrichtian.

Abdul Muniem and Said (1979); Sissakian and Youkhana, (1979) refers that the Bekhme Formation facies refer to the deposition of the formation in the reef, fore reef environments, depending on the presence of different genera of benthic and planktonic foraminifera.

(Al–Alawi, 1980) during his study of the Bikhir anticline mentioned that the Bekhme Formation consists of limestone with thick bedded in its upper parts which alternate with marl and marly limestone, while its lower parts consist of fine-crystallized limestone.

Al–Mutwali et al. (2008) conducted a biostratigraphical and sedimentological study of the Bekhme Formation in the Dohuk city, and determined the age of the formation based on the biozone of the late Campanian, and that the environmental deposition of the formation is the upper bathyal.

(Ali, 2010) studied the sedimentary and stratigraphy of the Bekhme Formation in selected areas in Northern Iraq, where the formation was divided into four units depending on the lithology, bedding and the content of the fossils and that the formation has been subjected to many diagenetic processes such as compaction, dissolution, cementation, and dolomitization.

(Al-Shireedah and Al-Ghrear, 2022) also studied the sedimentary changes and the facies analysis of the lower part only of the Bekhme Formation in the Dohuk region, where the section was divided into three facies, and the researchers indicated that the sedimentation environment of the formation is the carbonate slopes.

Karim et al. (2022) also studied the Aqra and Bakhama Formations (Upper Cretaceous) and the Govanda Formation (Middle Miocene), where they deduced the sedimentary environments of each formation in addition to separating the Bekhme formation from the Aqra formation and indicated that the age of the Bekhme formation is equivalent to the Kometan Formation (Torunian – Early Campanian).

The present study focused on the stratigraphy and the microfacies analysis of the Bekhme Formation in two different sections and the aim of the study was to infer the sedimentary environment of the formation and draw the sedimentary model based on the results of the microfacies analysis of the limestone succession.

Geological Setting

The two outcrops of the present study are located within the High Folded Zone of the Unstable Shelf, and are located within the Back- Bulge according to divisions of Znad (Znad et al., 2020).

Geographically, the two study areas are located in Northern Iraq, specifically in the governorates of Erbil and Dohuk, where the first section (Badi) is located (8 km) Northeast of the Duhok city on the Northern end of the Bikhir anticline at longitude (43° 05` 13`E) and latitude (36° 54` 27' N), and the second section (Khoran) is located in the Erbil city, at a distance of (10 km) South of the Shaqlawa city on the Southern end of the Sefeen anticline at longitude (44° 86` 26 E) and latitude (36° 71` 17` N) .

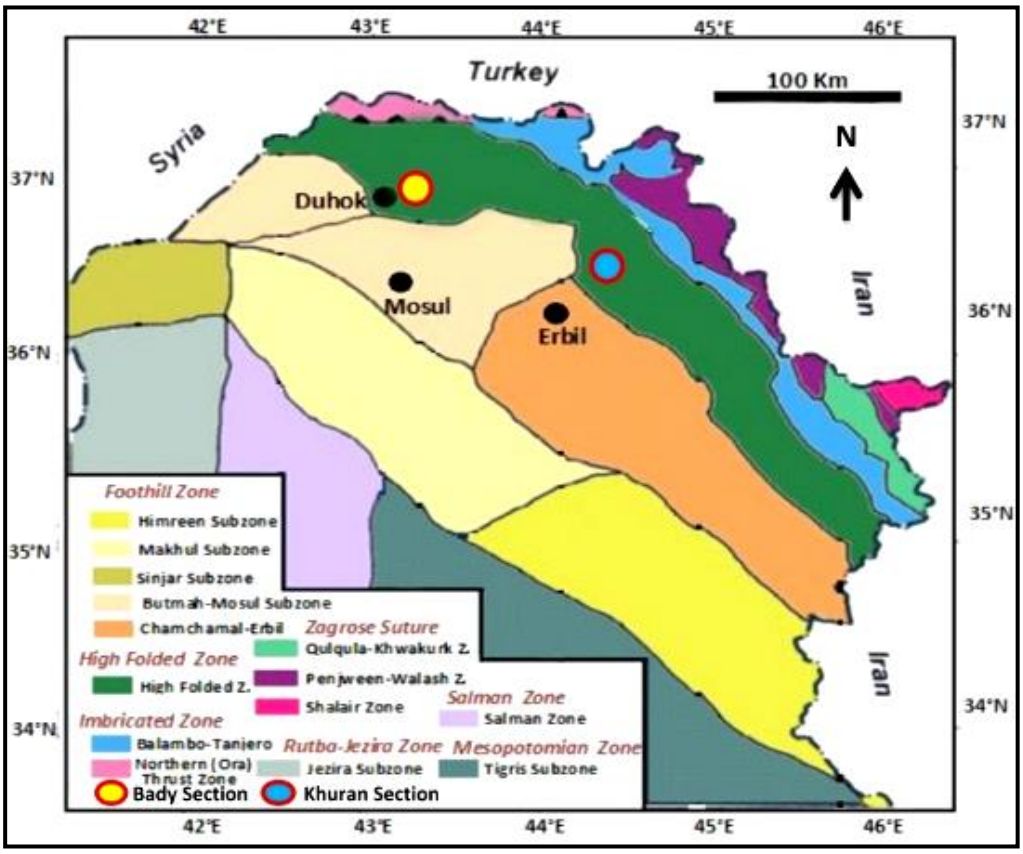

Fig. 1. Map of tectonic divisions of the Northeastern Iraq showing the study areas.

(after; Jassim and Goff , 2006)

Methods and Materials

Accomplish of the current study relied on several methods, including field work and laboratory work. The field work included field tours in order to determine the best outcrops in which the formation is exposed and then to describe the lithology of the formation and take sampling according to changes in the lithology. 27 samples were taken from Badi section and 40 samples from Khoran section.

As for the laboratory work, it included the preparation of 67 thin section from the two sections in the workshop of the Department of Earth Sciences at the University of Mosul for the purpose of studying them petrographically and then determining the microfacies to reach the conclusion of the sedimentary environment.

The thickness of the exposed part of the Bekhme formation is approximately 80 meters in the Badi section. The limestone prevails significantly along the length of the section of the formation with overlaps of marly limestone beds, which exist from the beginning of the section intermittently and disappear in the center part of the formation to reappear again in end of the formation (Fig. 2).

The lower boundary of the formation in Badi section is unexposed, while the upper boundary is determined by the first appearance of marl beds representing the Shiranish formation. Most of the previous studies have pointed to the conformable nature between the Bekhme and the Shiranish above it. as Henson (1940 in Bellen et al., 1959) confirmed this through his study to Shiranish Formation in its type section to the conformable nature of this surface. Among the studies that have indicated compatibility of this surface are (Kassab, 1979) and (Al–Alawi, 1980).

As for the Khoran section, the thickness of the formation is approximately 140 meters and the lower part of it consists of limestone beds, which contains in some parts beds bearing large fossils, while the middle part and the upper part consists of dolomitic limestone which extends to the end of the formation (Figure 2). The lower boundary of the Bekhme Formation in the Khoran section is unconformable with the Qamchuqa Formation due to the presence of some field evidence such as Breccia. The upper contact of the Bekhme formation with the Shiranish Formation above it appears as a conformable surface.

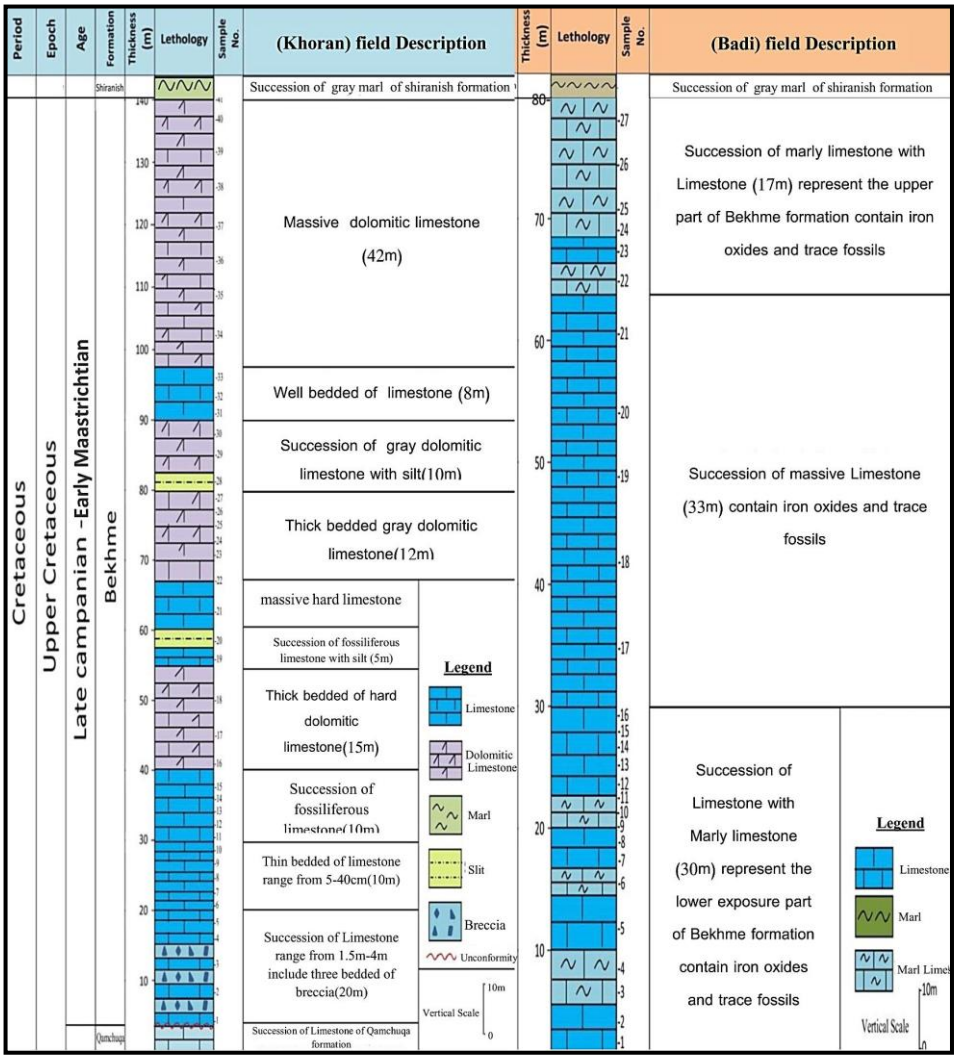

Fig. 2. lithological description of the Bekhme Formation in the both sections Badi and Khoran.

Results

The results of the microfacies analysis showed that the Bekhme Formation contain a wide range of microfacies, and for the purpose of diagnosing the microfacies, the classification of (Dunham, 1962) was relied upon. By comparing the diagnosed microfacies with the (SMF) placed by (Flugel, 2010), the facies zone (FZ) was diagnosed. The Bekhme Formation in the two sections consists of (3) main microfacies, later divided into (12) submicrofacies, according to their content of allochems (Figure 3.)

Microfacies	Submicrofacies	badi Section	khoran Section	SMF
1. Mudstone (M)	Bioclast lim mudstone (M1)		●	9,19,18,24
	Ostracodal lim mudstone (M2)		●	
	Orbitolina lim mudstone (M3)		●	
	Lithoclast lim mudstone (M4)		●	
2. Wackestone (W)	Algal lim wackestone (W1)		●	18,9,3,4
	Bioclast lim wackestone (W2)	●	●	
	Planktonic foramineferal lim wackestone(W3)	●		
	Lithoclast lim wackestone (W4)	●		
3. Packstone (P)	Orbitolina lim packstone (P1)		●	18,4,3,16
	Bioclast lim packstone (P2)	●		
	Planktonic foramineferal lim packstone(P3)	●		
	Peloidal lim packstone (P4)	●		

Fig. 3. shows the comparison of the microfacies of the study sections with the standard microfacies of Flugel, 2010.

Microfacies analysis of Bekhme Formation

The main microfacies and submicrofacies recognized in the Bekhme Formation are the following:

1. Lime Mudstone Microfacies (M)

This microfacies is widespread in the Khoran section only, and it consists mainly of a small percentage of carbonate grains not exceeding (10%) of the proportion of the

components of the rock as a whole and a large percentage of micrite, which appears in light brown. This microfacies included the bioclasts, ostracoda and benthic foraminifera (Orbitolina) in addition to the lithoclasts.

this microfacies was divided into four submicrofacies, depending on the type of granules prevailing in it, as shown as follows:

Bioclast Lime Mudstone Submicrofacies (M1)

This microfacies is represented by beds of limestone and dolomitic limestone (5-2.5 m. thick) and spread in the middle and upper part of the formation in Khoran section. The percentage of the allochems less than (10%) of the total number of components, and consisted of bioclasts (5%), some of which belong to the pelecypods (Plate 1. a). The lithoclasts made up 2% of the other components, with micritic matrix. The matrix is affected in some parts by the recrystallization, chemical compaction (Plate 2. -f), cementation (Drusy cement), dolomitization (Fogged, Spotted and Micro Suture texture) according to the classification of (Randazzo and Zachos, 1984).

The general characteristics of this microfacies were compared with the general characteristics of the standard microfacies of (Flugel, 2010) and found that they are similar to the standard microfacies (SMF9), deposited within the (FZ7), which is represented by (Platform interior) within the semi-isolated lagoon environment.

Ostracodal Lime Mudstone Submicrofacies (M2)

This microfacies is represented by beds of limestone (3 m. thick) at the bottom of the formation. The percentage of the carbonate grains about (8%) of the total of its components, consist of well-preserved Ostracoda shells, in micritic matrix. (Plate 1.-b). The microfacies affected by compaction, cementation (Drusy cement).

The general characteristics of this microfacies were compared with the general characteristics of the standard microfacies of (Flugel, 2010) and found to be similar to the standard microfacies (SMF19) deposited within the (FZ8) which represents a platform interior restricted.

Orbitolina Lime Mudstone Submicrofacies (M3)

This microfacies was located in the lower part of the Bekhme formation, where it is represented by thick beds of limestone (6m.), the percentage of granules in this microfacies was about (9%), it consisted mainly of the large benthic foraminifera (Orbitolina (5%), Ostracoda shells (2%) and a few bioclasts and echinoderms, where the ground mass represents by micrite (Plate 1.-c). this microfacies affected by compaction, as well as presence of some iron oxides.

This microfacies compared with the standard microfacies of (Flugel, 2010) and found to be similar to the (SMF18), deposited within the (FZ8) representing a platform interior restricted.

Lithoclastic Lime Mudstone Submicrofacies (M4)

This microfacies existed in the middle part of the formation, where it is represented by thick beds of limestone (5 m.), the granules are about (5%) consisted of lithoclasts, in micritic matrix. The facies were affected in some parts by the process of recrystallization of micrite to microspar (Plate 1.-d), in addition to presence of compaction, dolomitization, dissolution (channel and vuggy porosity), dolomitization (Fogged texture), and the presence of iron

oxides represented by pyrite metal. The data of this microfacies showed a match with the (SMF24) deposited within the (FZ8) and representing the (Platform interior) environment.

2. Lime Wackestone Microfacies (W)

This microfacies appears as hard limestone beds in both sections, and it consists mainly of carbonate clasts no more than (50%) of the percentage of rock components within a micritic matrix. The grains were represented of green algae, bioclasts, planktonic and benthonic foraminifera and some lithoclasts. This microfacies is divided into four submicrofacies depending on its granule content, as follow:

Algal Lime Wackestone Submicrofacies (W1)

The existence of this microfacies was limited to the Khoran section only, where it is represented by limestone beds (20m. thick) present at the bottom part of the formation. The facies consist of clasts (25%) consisted mainly of green algae (*Permocalculus iranae),* and bioclast of Pelecypods, a few Ostracoda shells as well as little benthic foraminifera (*Triloculina)* were present (Plate 1. - e), in micritic matrix. The microfacies affected by dissolution (vug and intraparticle porosity), compaction, cementation (Drusy cement). The general characteristics of this microfacies were similar to the (SMF19) deposited within the (FZ8-9) representing the protect part of platform (tidal environment).

Bioclastic Lime Wackestone Submicrofacies (W2)

This microfacies was present in both sections, where it is represented by limestone beds (3-20m. thick) spread at the top of the two sections. The percentage of carbonate grains in this microfacies was about (40%) and consisted mainly of bioclast (30%), planktonic foraminifera and peloid (10%), in micritic matrix, as well as the presence of a little benthic foraminifera (*Spiroloculina, Quinqueloculin, Textularia*, Orbitolinid, Fusilinids), echinoderms and green algae (Plate 1.-f). The facies affected by dissolution (Vuggy porosity), dolomitization (sieve texture), compaction, cementation, bioturbation.

This microfacies similar to the (SMF9) deposited within the two facies zone (FZ 7), Which represents the protect part of platform, open marine environment (Flugel 2010).

Planktonic Foraminiferal Lime Wackestone Submicrofacies (W3)

This microfacies was found in the Badi section only, where it spread at the lower and the upper of the formation, and its thickness ranges from (3-5) meters. The granules of this facies are about (45%) consisting mainly of planktonic foraminifera (35%), (*Heterohelix, Pseudotextularia Globigerinelloides, Rogoglobegerina, Globotruncana, Globotruncanita*), as well as benthic formenifra (5%) (*Nodosaria, Dentalina, Dorothia, Bolivina*), and a few bioclasts of Ostracoda and echinoderms, in micritic matrix (Plate 1.-g). The facies affected by dissolution and compaction.

The general characteristics of this microfacies were compared with the general characteristics of the standard microfacies of (Flugel, 2010) and found that they are similar to the (SMF3) deposited within the (FZ3) which represents the environment of the upper carbonate slope.

Lithoclastic Lime Wackestone Submicrofacies (W4)

The existence of this microfacies was limited to Badi section only, where it is represented by hard, massive limestone (3-18m. thick) scattered in the middle part of the formation. The allochems consist of lithoclasts (15%), and large benthonic foraminifera tests

(Orbitolites) and a few echinoderms, with micritic matrix (Plate 1.-h). The microfacies affected by compaction, cementation (Blocky cement). The general characteristics of this microfacies were similar to the (SMF4) deposited within the facies zone (FZ3) toe of slope.

3. Lime Packstone Microfacies (P)

This microfacies is present in both sections, composed of carbonate grains which ranges between (50-80%) in a micritic matrix. The grains consist of benthic foraminifera (Orbitolina), planktonic foraminifera bioclasts. This microfacies was divided into four submicrofacies depending on the content of the grains, namely:

Orbitolina Lime Packstone Submicrofacies (P1)

The microfacies presence in the Khoran section only, represented by limestone beds (4 m. thick) scattered at the bottom of the formation. It consists of skeketal grains (70%), of benthic foraminifera (*Orbitolina sp.*), which have large size with good preservation by approximately (50%), and of Pelecypodal bioclast (20%) (Plate 2.-a). The facies affected by compaction, with presence of fractures, as well as iron oxides (pyrite) (plate 2-e).

The abundance of *Orbitolina* sp. indicates the deposition of this microfacies in shallow waters of the lagoon environment (Boudagher and Fadel, 2008). This microfacies is similar to (SMF18) deposited within the FZ8 which represents restricted marine environment.

Bioclast Lime Packstone Submicrofacies (P2)

The presence of this microfacies was limited in the middle part of the Bekhme Formation as hard limestone beds (5m. thick).

This microfacies consists mainly of a high percentage of carbonate grains ranging between (70-80%) of the proportion of rock components, consisted mainly of bioclasts (40%) mostly belong to the pelecypods, lithoclasts (20%), benthic foraminifera (15%) such as (*Lepidocyclina sp., Orbitoide*) and a few echinoderms and a little of Ostracoda and echinoderm. Compaction, dissolution and dolomitization (Suture mosaic dolomite) (plate 2-h) were present (Plate 2.-b). The general characteristics of this microfacies were compared with the general characteristics of the standard microfacies of (Flugel, 2010) and showed that it is similar to the (SMF4) deposited within the (FZ 3) in the open marine environment.

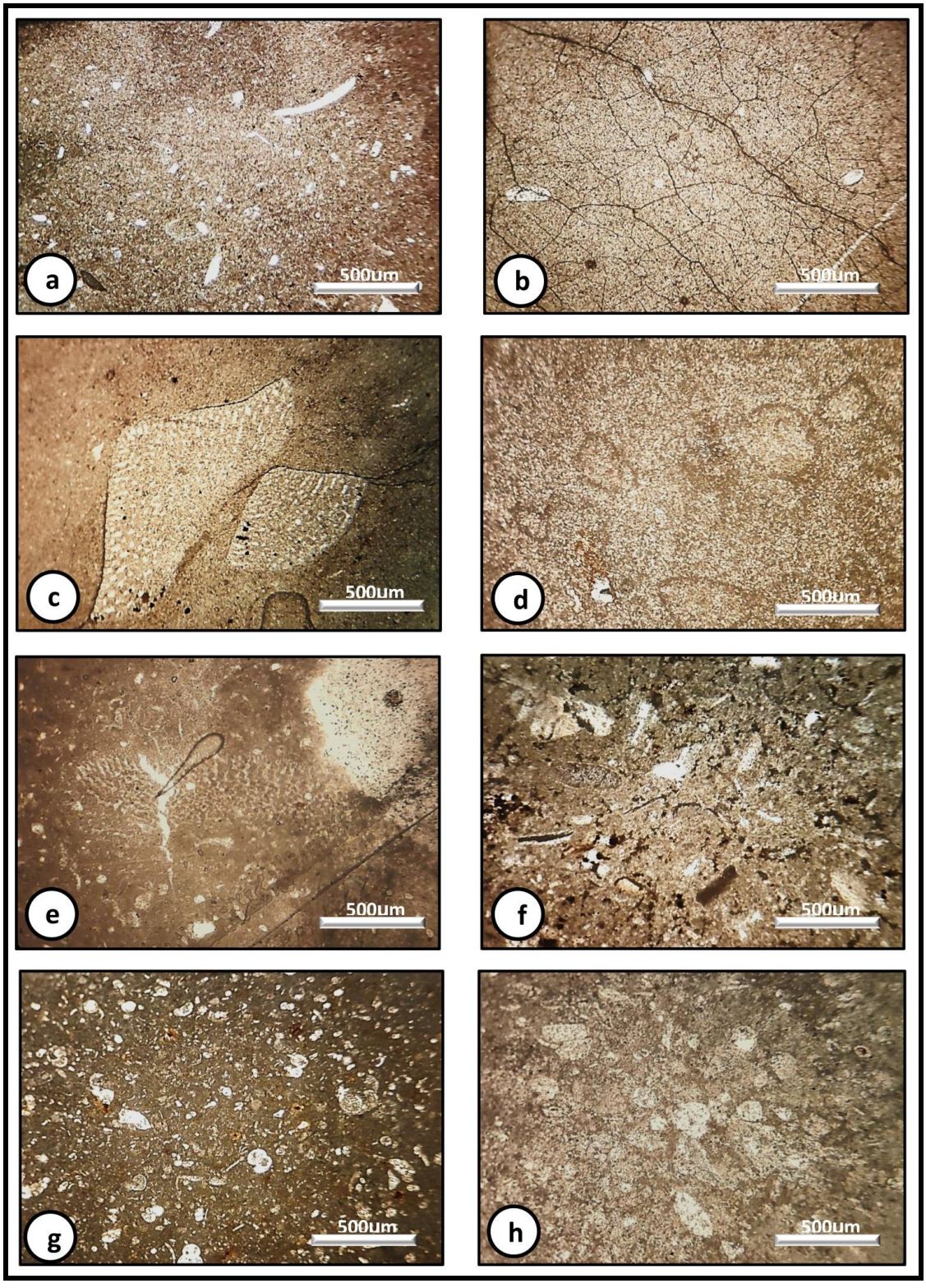

Plate 1. a - Bioclastic lime mudstone submicrofacies (M1), Bekhme Formation, Khoran section, sample 6. b- Ostracodal lime mudstone submicrofacies (M2), Bekhme Formation, Khoran section, sample 10. c- Orbitolina Lime Mudstone Submicrofacies (M3), Bekhme Formation, Khoran section, sample 13. d- Lithoclastic Lime Mudstone Submicrofacies (M4), Bekhme Formation, Khoran section, sample 32. e - Algal Lime Wackestone Submicrofacies (W1), (*Permocalculus iranae*), Bekhme Formation, Khoran section, sample 1. f - Bioclastic Lime Wackestone Submicrofacies (W2), Bekhme Formation, Badi section, sample 20. g - Planktonic Foraminiferal Lime Wackestone Submicrofacies (W3), Bekhme Formation, Badi section, sample 3. h -Lithoclastic Lime Wackestone Submicrofacies (W4), Submicrofacies, Bekhme Formation, Badi section, sample 17.

Planktonic Foraminiferal Lime Packstone Submicrofacies (P3)

This microfacies was found in the Badi section within the Marly limestone beds, where it distributed at the lower and upper part of the formation, and its thickness ranges between (3-15 m.). This microfacies consists mainly of a high percentage of skeletal grains, ranging between (65-75%) of the percentage of rock components. It consisted mainly of planktonic foraminifera (spherical and Keeled species), such as: *Globotruncana, Globotruncanita, Rugotruncana, Globigerinelloides, Rogoglobegerina, Hedbergella.* Bioclasts are present by up to (10%) and most of them belong to the pelecypods shells and gastropods, and a few echinoderms, with little intraclast (5%). The benthonic foraminifera form a percentage (30%) such as genera, *Textularia, orbitoide, Fusulinid* (*Tricites* sp), *Orbitolinopisis*, and a few ostracods shells (Plate 2-c). All these ingredients are embedded in a micritic matrix. The most prominent diageneses processes in this microfacies are compaction, dissolution and cementation.

The general characteristics of this microfacies were compared with the general characteristics of the standard microfacies of (Flugel, 2010) and found to be similar to the (SMF3) deposited within the (FZ3) within the open marine environment (Toe of slope).

Peloidal Lime Packstone Submicrofacies (P4)

This microfacies existed at the lower part of the formation in the section of Badi only, represented by a layer of hard limestone beds (4m. thick). It is consisting mainly of a high percentage of skeletal grains ranging between (70-80%) of the proportion of rock components, consisted mainly of peloids by approximately (60%), Bioclast (15%), benthic foraminifera (miliolid) (10%) (Plate 2- d) in addition to a little planktonic and larger benthic foraminifera represented by the genus *Omphalocyclus omanensis* (Plate 2-g) first described by (Kayğılı *et al*.,2020). This microfacies affected by recrystallization, compaction, dissolution, cementation (Drusy cement) and dolomitization.

The general characteristics of this facie were compared with the general characteristics of the standard microfacies of (Flugel, 2010) and it was found that it is similar to the standard microfacies (SMF16) deposited within (FZ8). Within the restricted marine environment. The figures 6 and 7 show the distribution of the microfacies in the two sections.

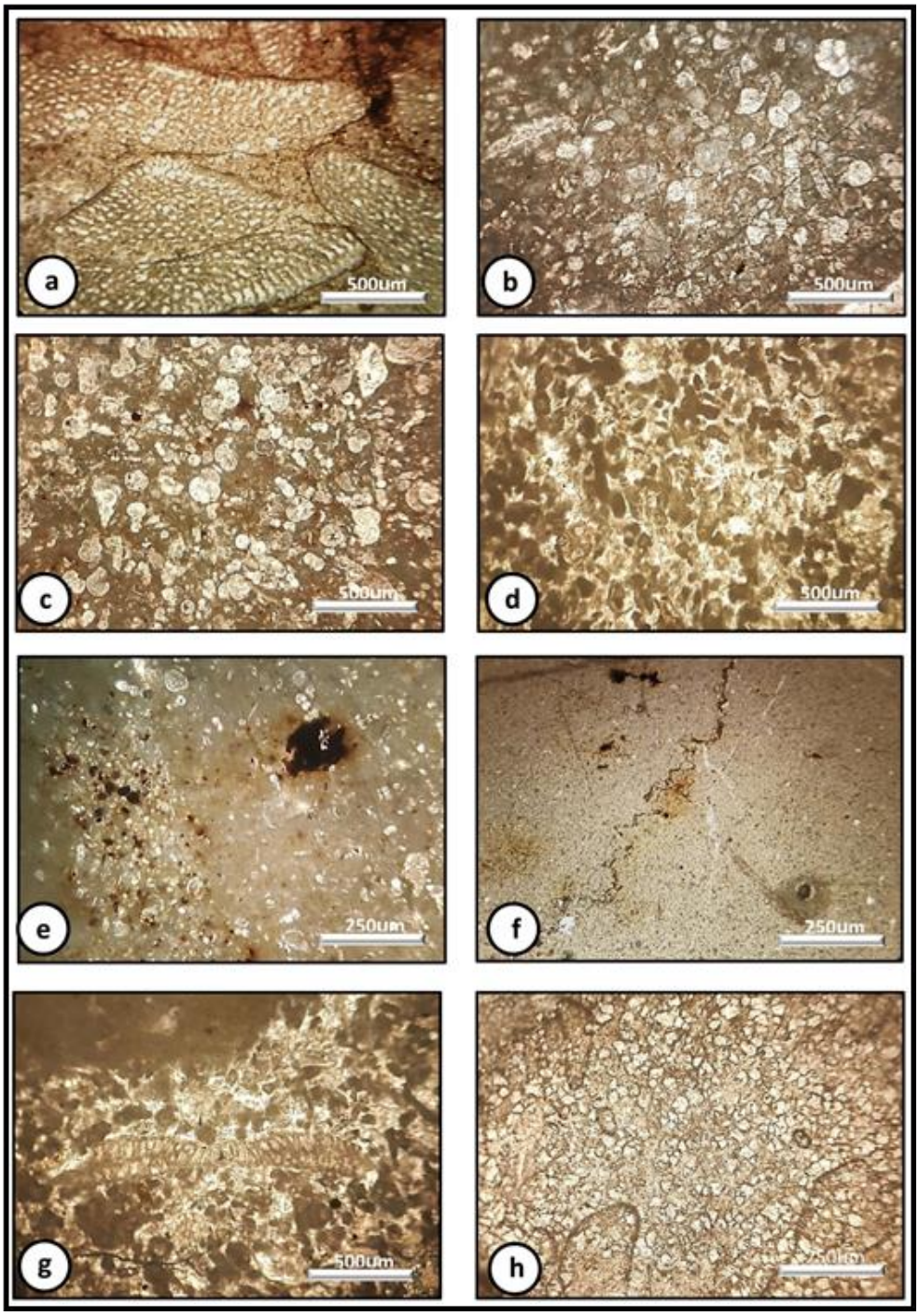

Plate 2. a - Orbitolina Lime Packstone Submicrofacies (P1), Submicrofacies, Bekhme Formation, Badi section, sample 11. b - Bioclast Lime Packstone Submicrofacies (P2), Submicrofacies, Bekhme Formation, Badi section, sample 13. c - Planktonic Foraminiferal Lime Packstone Submicrofacies (P3), Bekhme Formation, Badi section, sample 7. d - Peloidal Lime Packstone Submicrofacies (P4), Bekhme Formation, Badi section, sample 1. e - Iron oxide in micritic matrix, Bekhme Formation, Khoran section, sample 11. f - Chemical compaction (stylolite), Bekhme Formation, Khoran section, sample 16. g - Benthonic foraminifera (*Omphalocyclus omanensis*), Bekhme Formation, Badi section, sample 1. h - Suture mosaic dolomite texture, Bekhme Formation, Badi section, sample 13.

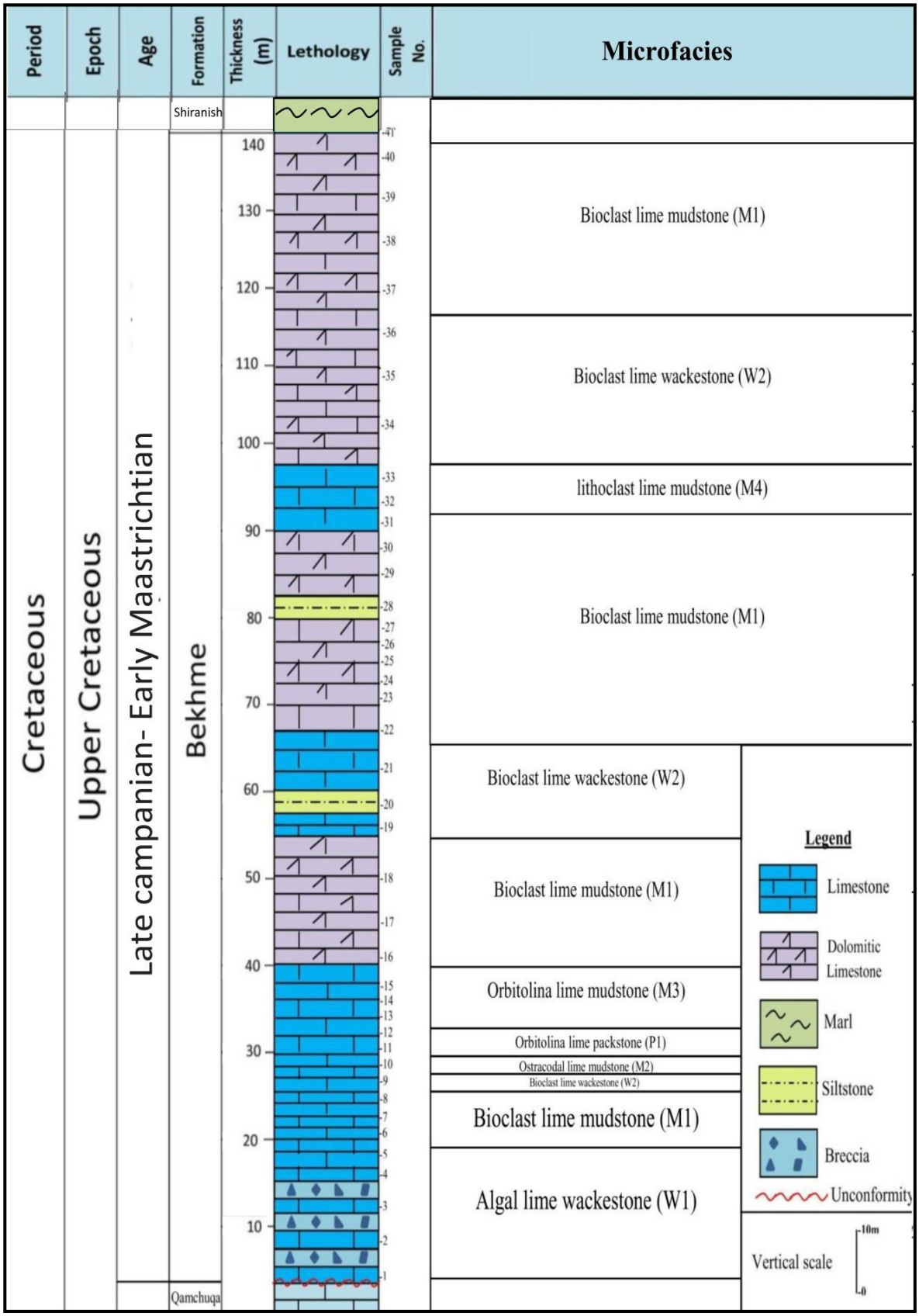

Fig. 4. Distribution of microfacies in Khoran Section

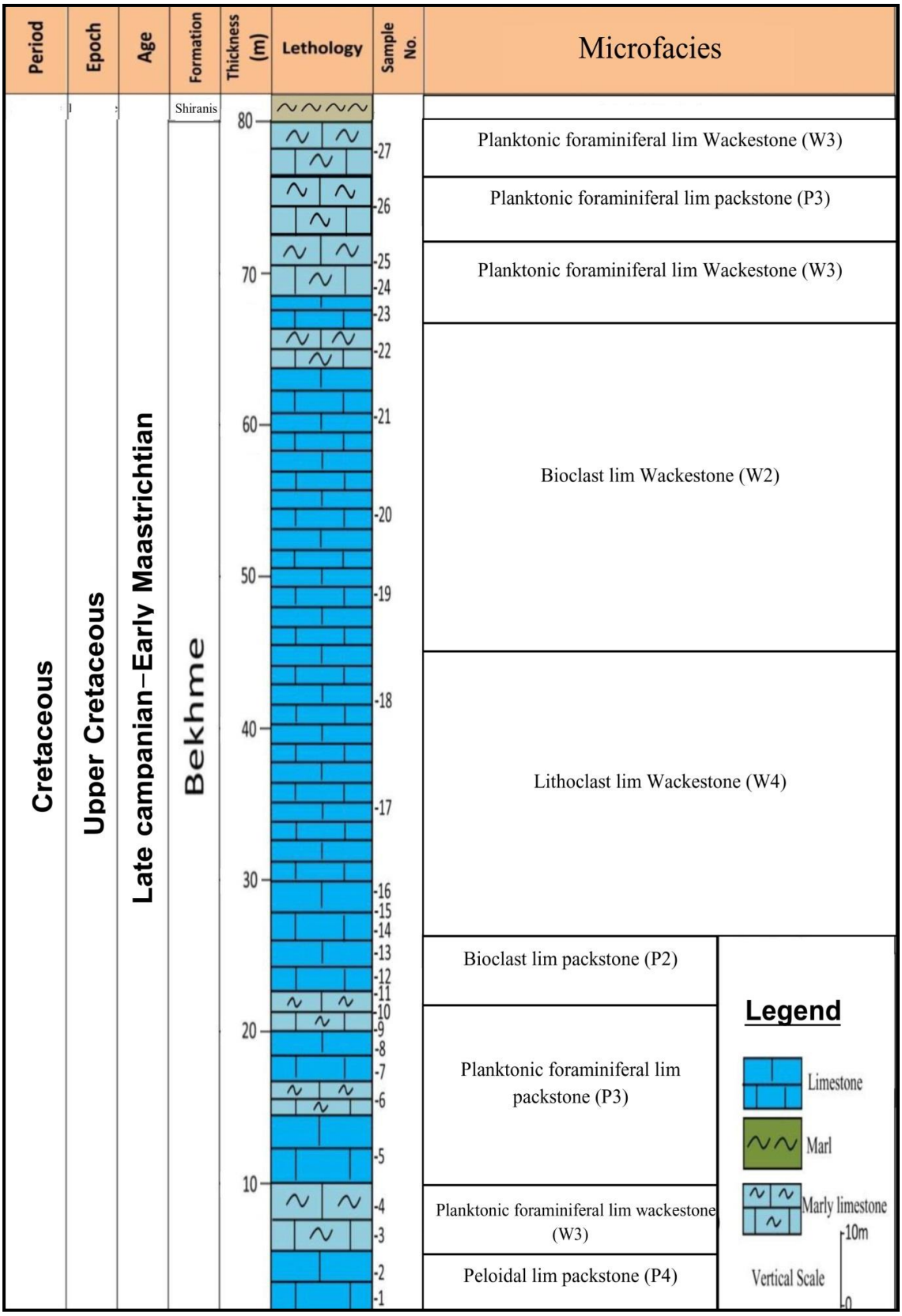

Fig. 5. Distribution of microfacies in a Badi section

Depositional environment

The two sections showed a clear difference in the types of microfacies, as this difference in the microfacies reflects the tectonic situation in that period and the fluctuation in sea level, which is reflected in the variation of the energy of water currents and the

sedimentary depth (Qader, 2020) and the following is a description of the environment of each section:

Badi section

The facies bearing the characteristics of the deep environment prevailed on the Badi section represented by the bioclastic lime wackestone submicrofacies (W2), planktonic foraminiferal lime wackestone submicrofacies (W3) Lithoclastic lime wackestone submicrofacies (W4), where most of the characteristics of these microfacies reflected the environment of the upper Bathyal which corresponds to what was stated in a study (Omana, 2006, Malak et al., 2021) which indicated that the increase in the percentage of planktonic foraminifera in the carbonate succession is evidence of their deposition within the upper Bathyal environment. The section also contained the bioclast lime packstone submicrofacies (P2), planktonic foraminiferal lime packstone submicrofacies (P3) and the peloidal lime packstone submicrofacies (P4), where most of the evidence indicates these microfacies to the deep marine environment represented by the environment of the upper to middle bathyal environments (Malak, et al., 2021), which corresponds to what was stated in the study (Al-Shireedah and Al-Ghrear, 2022), who indicated the presence of the planktonic foraminifera lime wackestone microfacies that reflects the environment of the carbonate slopes (upper - middle Bathyal).

Khoran section

The microfacies bearing the characteristics of the shallow sedimentary environment prevailed in the Khoran section, represented by the bioclast lime mudstone submicrofacies (M1), the ostracodal lime mudstone submicrofacies (M2), the planktonic foraminiferal lime wackestone submicrofacies (M3) and the lithoclastic lime mudstone submicrofacies (M4). Sedimentary evidence and fossils components indicate that these rocks were deposited within intertidal and supratidal environments, which is correspond with the study (Afghah, 2010). The formation also contained the algal lime wackestone submicrofacies (W1). (Burchette and Wright, 1992) indicated the location of the green algae in the part of the sedimentary basin near the coast, represented by isolated or semi-isolated lagoons, rich in fossils due to the abundance of oxygen. All life and sedimentary signs indicate this microfacies is deposited in a relatively shallow environment, specifically a back reef environment with depths of only a few meters (Ioan and Sasaran, 2005). The bioclastic lime wackestone submicrofacies (W2), and the Orbitolina lime packstone submicrofacies (P1), and the abundance of Orbitolina indicates the deposition of this microfacies in confined coastal areas (Boudagher, 2008), as well as (Boudagher and Fadel, 2008). In the sedimentary model of larger benthic foraminifera during Cretaceous, Orbitolina occurs in a back reef environment. A study (Haig and Mc Cartain, 2007) indicated that the facies similar to those diagnosed above were deposited in shallow marine environments and transported by submarine channels to deeper areas within the middle to outer shelf (Figure 6).

From the foregoing, it is clear that the reason for the difference in the sedimentary environment is due to the nature of the sedimentary basin for each section and the tectonic factors affecting that period, which was accompanied by activity in the formation of many normal faults along the back- bulge basin, as the Badi section is located within the deep back-bulge) area, while the Khoran section is close to the shallow Back- Bulge area (Znad et al., 2020).

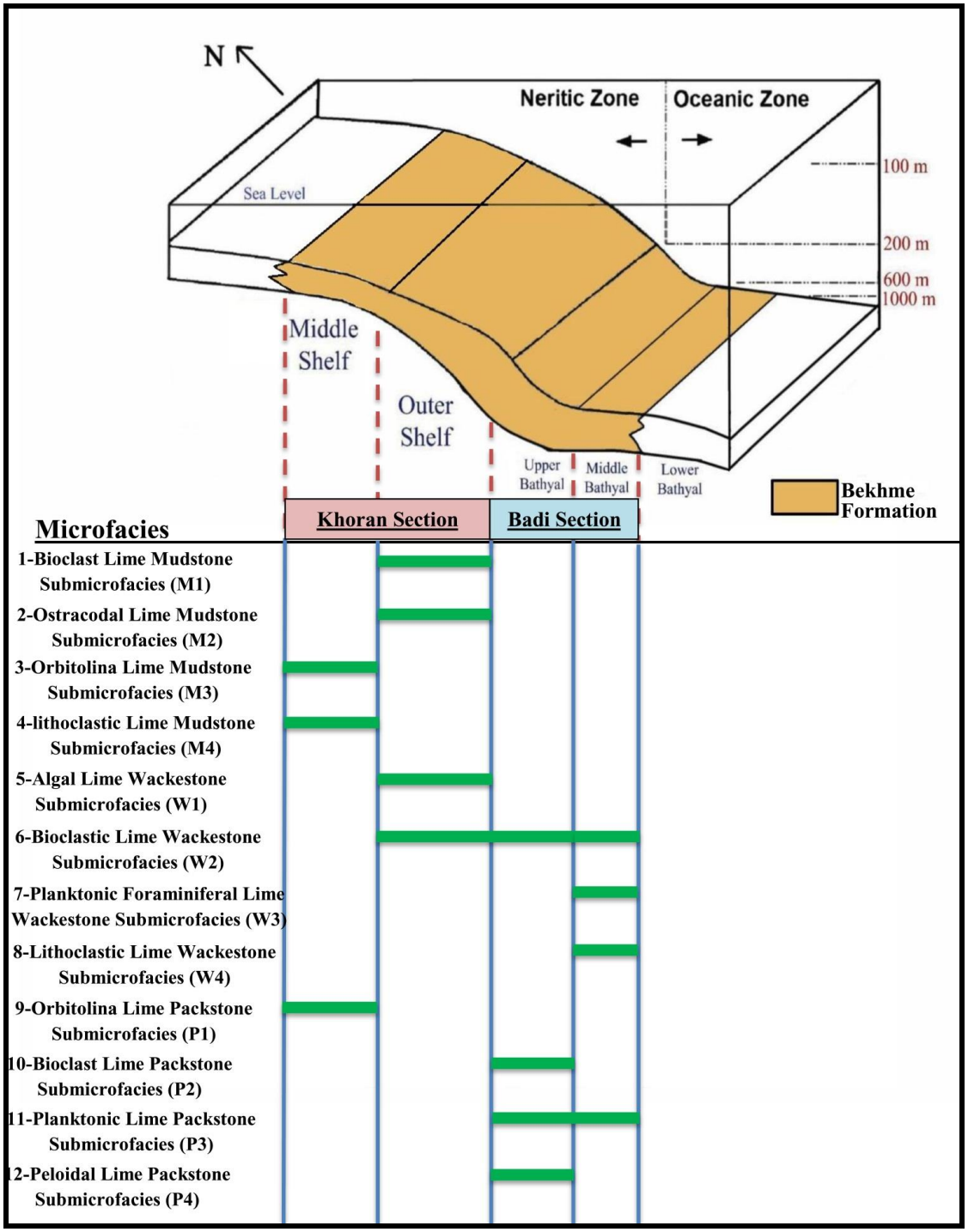

Fig. 6. The sedimentary model of the Bekhme formation in the two sections.

Conclusion

The microfacies analysis of the study sections showed the presence of three main microfacies, namely Lime Mudstone Microfacies (M) Lime Wackestone Microfacies (W) and Lime Packstone Microfacies (P), which in turn were divided into (12) submicrofacies that reflected the deposition of Bekhme Formation within two relatively different environments, where the microfacies of the formation in the Badi section indicated to deposition in a marine environment from the upper bathyal to the middle bathyal, while the formations in Khoran section deposited in a marine environment represented by the middle shelf to the outer shelf.

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