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**Depositional environment of the Nfail Formation in Karbala-
Najaf area**

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اقرار المشرف

أشهد بان موضوع البحث الموسوم

(Depositional environment of the Nfail Formation in Karbala-Najaf area)

والمنجز من قبل الطالبة (بنين محمود مخيف راجح) قد اجري تحت اشرافنا في قسم علم الارض كلية العلوم جامعة بابل كمتطلب جزئي لنيل شهادة البكلوريوس في علوم الارض وذلك

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(يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ
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الإهداء

وصلت رحلتي الجامعية إلى نهايتها بعد تعب ومشقة... وها أنا ذا أختتم بحث تخرجي بكل همّة ونشاط . وأمتن لكل من كان له فضل في مسيرتي وساعدني ولو باليسير إلى من أفضّلها على نفسي، ولم لا؛ فلقد ضحّت من أجلي ولم تدخّر جهداً في سبيل إسعادي على الدوام (أمي الحبيبة) نسير في دروب الحياة، ويبقى من يسيطر على أذهاننا في كل مسلك نسلكه صاحب الوجه الطيب، والأفعال الحسنة. فلم يبخل علي طيلة حياته (والدي العزيز) إلى أصدقائي، وجميع من وقفوا بجواري وساعدوني بكل ما يملكون، وفي أصعدة كثيرة (أقدم لكم هذا البحث، وأتمنى أن يحوز على رضاكم .

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ABSTRACT

Field work and petrographic study on Miocene sediments of the Nfayil Formation in the Karbala-Najaf area, indicate that the exposed Miocene sediments in the area are in an upward sequence. The microfacies of the Nfayil Formation show intraclastic mudstone -wackestone at Karbala with quartz (sand silt size) clastic influx, intraclastic wackestone -packstone, Ooid wackestone-packstone, Intraclastic packstone- grainstone and marl lithofacies. Nfayil Formation that is marine and consists of marls interbedded with limestone. The Nfayil Formation was deposited in restricted marine, reef, and shoal environments. The Miocene succession in the study area was developed in an area of low subsidence, which reflects the major effect of eustasy as the main controlling factor in sequence development.

Content list

Page	Subject
1	Chapter One : Introduction
2	1-1 Preface
2	1-2 Aim of the Study
2	1-3 Methodology
2	1-4 Location of study area
2	1-5 Stratigraphy and Tectonic Setting
5	1-6 Preview Studies
7	Chapter Two : Microfacies Analysis
8	2-1 Preface
8	2-2-1 Grains
9	2-2-1-1 Skeletal grains
8	2-2-1-2 Non skeletal grains
12	2-2-2 Ground mass

16	Chapter three : Microfacies Analysis and Deposition Environment
17	3-1 Preface
17	3-2 Deposition Environment
17	3-2-1 Peritidal Environment
18	3-2-2 Shoal Environment
18	3-2-3 Restricted Environment
19	3-2-4 Deep Environment

Chapter One

Introduction

Chapter One

Introduction

1-1 Preface

The Miocene succession in Al_Qadissiya area is represented by, Nfayil Formation; The Nfayil Formation consists of marls interbedded with limestones and marly limestone.

1-2 Aim of the Study

1-study detailed petrographic.

2-Investigate the diagenesis processes that affect the Formation .

3-Microfacies analysis and deposition environment interpretation aimed towards a better understand.

1-3 Methodology

To conduct the current study through the following strategies are used:

-Study thin section and fossils content in studies formation.

-Determining the Microfacies analysis of the Formation .

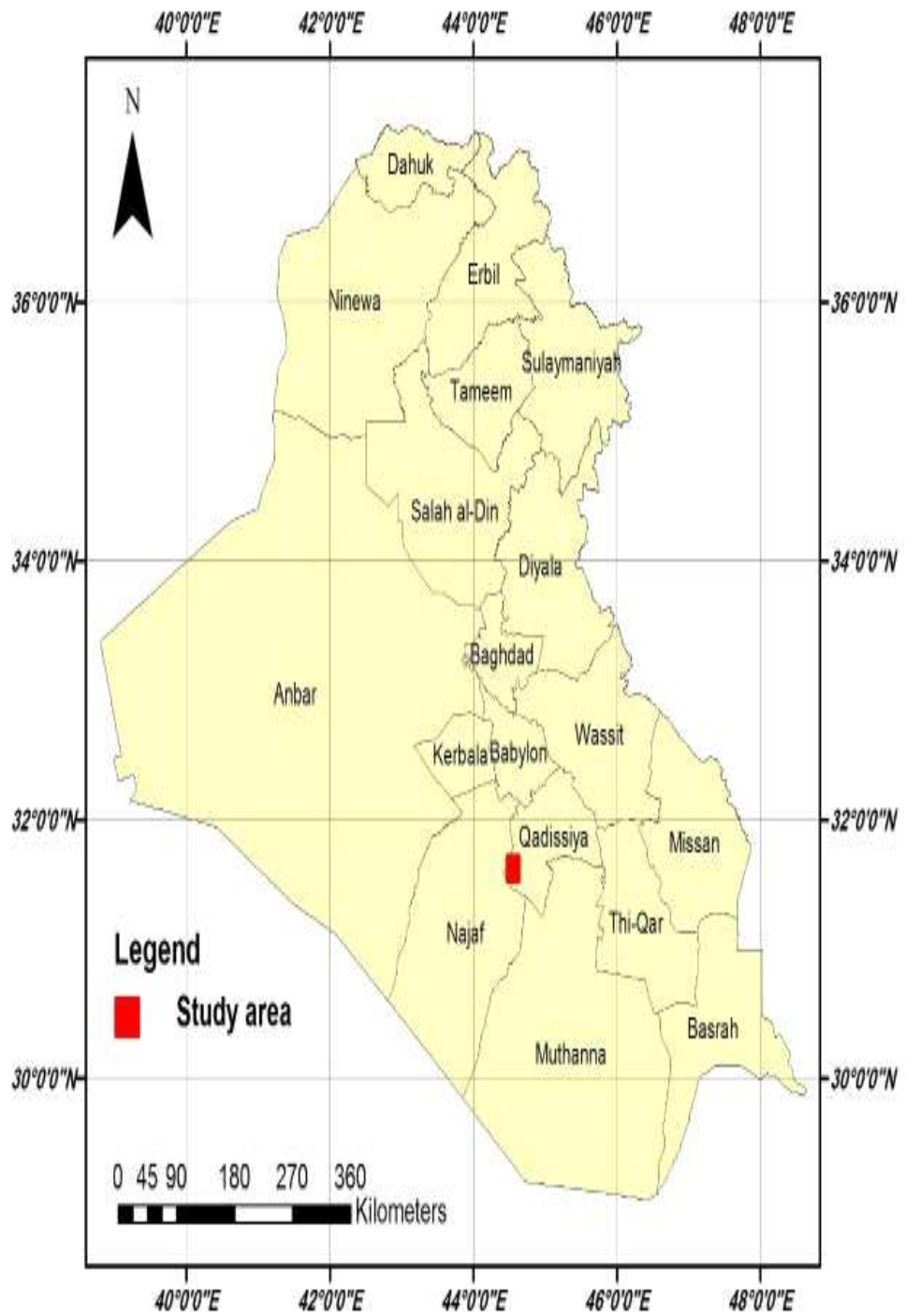
1-4 Location of study area

The study area is located within the Al-Qadissiya Governorates .

1-5 Stratigraphy and Tectonic Setting

The studied succession was referred to middle Miocene Nfayil formation .The study area is located between the stable shelf of the western desert and unstable shelf of the Mesopotamian zone, within Abu-jir fault zone, Nfayil Formation is subdivided into two members: Lower carbonate Member composed of three cycles of limestone and marl intercalations and Upper clastic Member of sandstone and claystone with thin layers of limestone

(Sissakian, 1999). Nfayil Formation is equivalent of Fatha Formation .The cycle as whole is characterized by the folding and uplift of the Eugeosynclinal area and by the continuation of the sedimentation in the Miogeosynclinal trough and on the shelf area, (Buday, 1980). The sedimentation in the shelf area was mostly calcareous - evaporitic. The cycle can be divided into two subcycles, the lower subcycle is characterized by a very slight subsidence and with prevalently calcareous sedimentation. It ended by a lagoonal episode during which evaporates were laid down, (Buday, 1980). The upper cycle is partly transgressive but its sediments might develop in the center of the main foredeep basin gradationally from the lower one. It is marked by calcareous (or calcareous-conglomeratic) sedimentation at its beginning and then by calcareous evaporitic sedimentation. Al-Sayyib and Valek in 1968 mentioned that the basement rocks are shallow ranging in depth between (3-5) km., consisting of granitic rock or may be of metamorphic type, (Buday 1973), recorded in the tectonic map one direction of fault which is north-south corresponding with A bu-jir fault which separate the stable shelf from the unstable shelf. The long and short linements of NW-SE direction are typical for this subzone parallel to the Euphrates fault zone, probably partly shifted by faults of approximately NE-SW and NS trends. (AL-Ameri, 1983).



Fig(1-1): Location map of the study area

1-6 Preview Studies:

The Formation's type locality lies near the "Garat AL-Nfayil" (AL-Nfayil village) which is 23 km., west of Haditha town. This Formation is divided into two members (Sissakian, 1999).

a- The lower member consists of three cycles, each cycle consists of marl and limestone. The marl is olive green, soft, papery or massive, concoidally fractured, fractures are filled with secondary gypsum. The thickness of marl beds range from (0.5-5.0) meters, the limestone is yellowish white to greenish grey, fractured, jointed, locally undulated and deformed slightly oolitic, partly recrystallized and Shelly, shells are mainly pelecypods, gastropods, and oysters, oysters found only in the second cycle its a good marker over the whole exposed area of the Nfayil Formation.

b- Upper member is exposed in the extreme western part of the exposed area in AL-Kherish vicinity a long the Iraq-Syrian border. It consists of claystone and limestone. The claystone is reddish, bedded, and calcareous, whereas the limestone is pinkish with quartz grains, bedded and hard. The top of the upper member is always capped by splintery limestone and very hard, the thickness in the type locality ranges from (10-50) meters.

The Nfayil Formation is deposited in shallow to very shallow marine environment with normal to high saline water, with clear oscillation in the sea level. The upper part of the upper member may indicate near shore environment, with some deltaic influences, as indicated by the type of the clastics, fining upward of the uppermost part of the Nfayil Formation, (Sissakian, 1999).

Different authors named the Nfayil Formation as follows: -

1. AL-Mubarak, (1972) named the sequence “unit C” of the Euphrates Formation in AL-Qaim vicinity.
2. AL-Jumaily, (1974) named the sequence as “the unite B” of the second Miocene sedimentary cycle.
3. Tyracek and Youbert, (1975) adopted the same terminology, in Haditha.
4. Hamza, (1975) named the sequence as “unit of alternating of limestone and green marl”.
5. AL-Mehaidi et. al., (1975) named the sequence as “Limestone and marl unit” in shithath vicinity”.
6. AL-Mubarak and Amin, (1983) named the sequence as “ unit C” of the Euphrates Formation in west of Najaf and Karbla vicinities.
7. Jassim et. al., (1984) named the sequence with the overlying sediments as “Kherish Beds” and “Najaf and Habbaniyan Bads”.
8. Mahdi et. al., (1985) named the sequence as “Nfayil unit” in Haditha.
9. Fouad et. al., (1986) adopted the name after Mahdi et. al., (1985).
10. Sissakian and Salin, (1994) named the upper member as “Nfayil member” of the Fatha Formation in Hadine vicinity.
11. Sissakian and Salin, (1995) named the upper member as “clastic member” of Fatha Formation in Ramadi vicinity.

The age of the Nfayil Formation according to the fossil assemblages is middle Miocene. (Sissakian, 1999).

The lower contact between the Nfayil Formation and the underlying Euphrates Formation is conformable. The upper contact of the Nfayil Formation with the Injana Formation is conformable and aggradational.

Chapter Two

Microfacies

Analysis

Chapter Two

Microfacies Analysis

2-1 preface

The aim of this chapter is to diagnose the petrography characteristic of fifteen thin sections in order to delineate the microfacies of the Eocene-Miocene studied sections. Thin sections were classified on the bases of Dunham's classifications (1962). Study reveals that the carbonate grains represented within the Eocene-Miocene successions are both skeletal and non-skeletal grains. The main components of the skeletal grains are benthonic foraminifera, Molluscs (pelecypoda), ostracoda, while non-skeletal grains are represented by peloids, Ooids, graptolite, and lithoclastes. The Eocene-Miocene succession is represented in this study by the Nfayil Formation ..

2-2-1 Grains

Grain is an important component in establishing the textural kinds of rocks and depositional circumstances in the Nfayil Formation. Skeletal grain and non-skeletal grain are the two categories of grains, with skeletal grains include entire or shattered fossils. According to (Selly, 2000), they're frequently sand-sized or larger .

2-2-1-1 Skeletal grains

Nfayil Formation consists mainly of various skeletal grains as foraminifera and other bioclasts.

a- Foraminifera

Benthic foraminifera occur in different environments (from near shore to the deep sea), they are the most abundant in marine sediments and important as paleoecologic indicators (Boudagher-Fadel,2008) . In Nfayil Formation benthic foraminifera consider the most dominant skeletal grains and they indicate a shallow marine environment. In the studied area , miliolid ,*Dendritina* sp. , rotalid , *Ammonia beccarii* (Plt 1.1) . Nfayil Formation composite section miliolid was profound from 1.5 – 2.5 meter . Generally the last appearance of *Miogypsina* sp. is used to delineate the top of the Euphrates Formation , but in the current study , the occurrence of *Miogypsina* sp is recorded at the lower part of the Nfayil Formation (Plt.1-2) . It is important to denote that the green marl unit forms the contact between Nfayil and Euphrates formation (Sissakian,1999) .

b- bioclasts

Molluscs represent the most dominant skeletal component within the Nfayil Fomation , and found generally as shell fragments which resulted from the effect of tides or currents activation or high energy environment .Molluscs are recognized

as whole shells at 8.75-9.5 meters at Samawa composite section (Plt 1.3) . It may also be as coquina , rare occurrence of algae (Dasycladacea), Ostracoda , echinodermata fragments and shell fragments are found in the Nfayil Formation .

2-2-1-2 Non-skeletal grains

a- Peloids

Peloids are inclusive description term include polygenetic group of grains comprise of crypto - and microcrystalline carbonate .

peloids are commonly internally structure less but it may have fine-grained of skeletal remains in addition to the other grains. Generally, the typical sedimentation of fine grained peloidal limestones are, low-energy, (Flugel, 2010)

The most common sizes of peloids range from 0.05 mm to 0.20 mm. They may occur in cluster and they are commonly well sorted, (Boggs. 2009). Peloids are generally spherical, ellipsoidal rounded or sub rounded, to irregular in shape and commonly has high organic contents. Fecal pellets produced by deposit-feeding animals, (Tucker and Wright, 2002). The biological disintegration or micritization of other carbonate grains (mainly bioclasts or ooids) form peloids that may retain slight traces of their original internal structure, (Scholle, and D.Scholle, 2003, 2003).show (Fig.2-2) illustrates the origin of peloids. Peloids can be observed in the Nfayil Formation

b-Ooids

Ooids are ovoid and spherical of carbonate and have a nucleus covered by an external cortex. The diameter of the majority of ooids are ooids that are smaller than 2 mm in diameter, with many ooids ranging from 0.51 to 1 mm in diameter. (Flugel, 2010).

The nucleus may be a peloid, smaller ooid, skeletal fragment, or even a clastic grain such as a quartz grain. According to (Boggs, 2009). Ooids can be deposited in a wide variety of environments, but Commonly, ooids deposit in shallow carbonate platforms.

c- Intraclasts and Extraclast

Intraclasts are partly lithified or completely lithified sediments of carbonate fragment, forming by the erosion of adjacent of pen contemporaneous sediments from Extra-, Intra- and Lithoclasts within the basin then re- deposited in the same area .

The extraclasts are a carbonate rock fragment forming by the deterioration of exposed ancient rocks of limestone and come from somewhere other than the depositional basin where it is found .

There are a difficulties in the segregation of the two types in thin sections, so the term lithoclasts had been used by many authors (Flugel, 2010).

2-2-2 Ground mass

According to (Flügel, 2010) the groundmass or matrix denotes the interstitial material between larger grains. In Nfayil Formation the groundmass is composed of micrite and/or Microspar which formed by neomorphism.

a- Micrite

Carbonate mud is termed micrite, (Selley, 2000), and it is the abbreviation of 'microcrystalline calcite'. In fact, 'micrite' is proposed by (Folk 1959) referring to the lime mud deposits that mechanically lithified, (Flügel, 2010).

Micrite is the fine-grained component of carbonate grains as well as Carbonate rocks' fine-grained matrix. The size of micrite crystal range from cryptocrystalline (can't be resolvable under the petrographic microscope) to microcrystalline. Generally, the existence of micrite give assign of low-energy depositional environments in both of deep and shallow marine, (Flügel, 2010)..

Micrite may be replaced to form microspar by diagenetic alteration through aggrading neomorphism, (Tucker, 2001),).

b- Microspar

Genetically sparite is carbonate cement (orthosparite) or product of recrystallization. Folk (1959) used rang size from 5 to more than 20 μm in diameter and Bathurst (1975) used rang size 5–50 μm , (Flügel, 2010) .

The term (microsparite) is a calcite matrix with identical crystal shape and size.

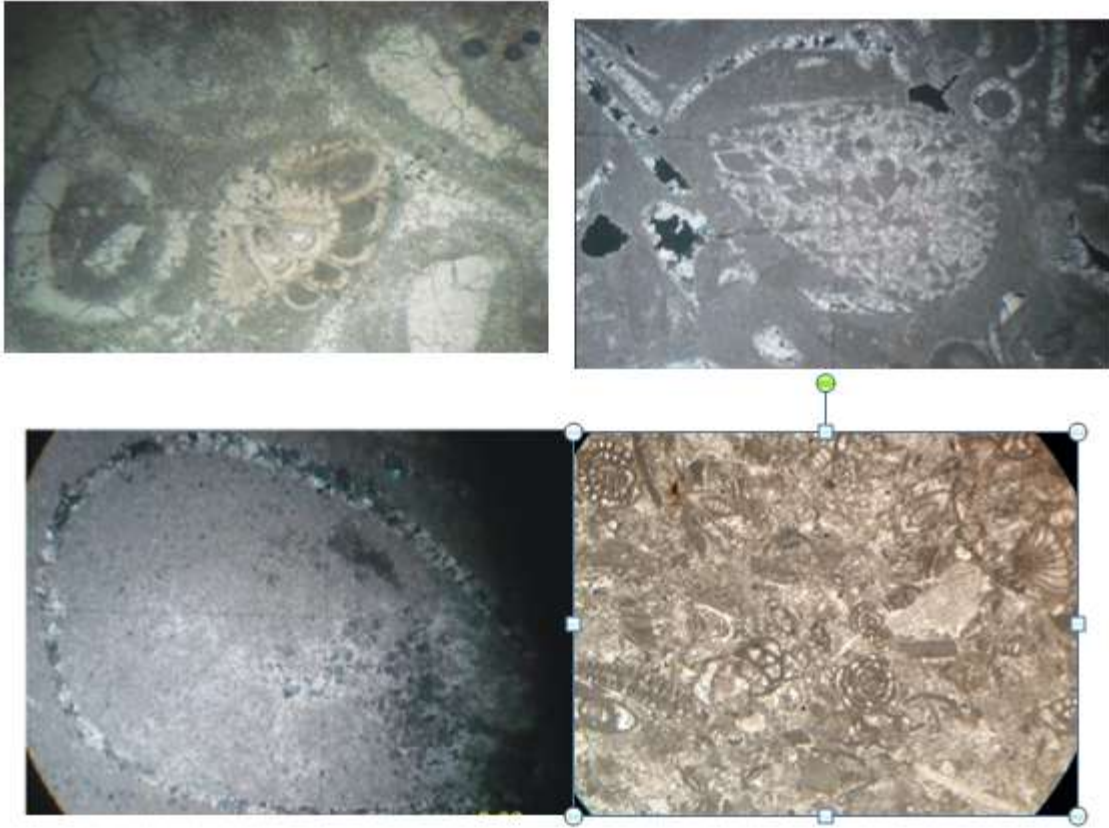
Two ways form microsparite:

1)The aggrading neomorphism (Recrystallization) created by transforming smaller High-Mg calcite crystals into bigger calcite crystals.

The clay content is an important factor and may hinder recrystallization if it being less than 2%.

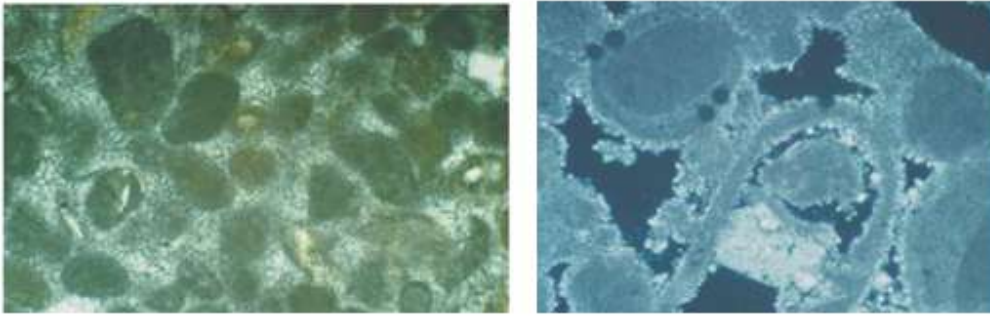
2)Without a micritic step, aragonite-dominated lime mud is transformed into microspar. Further criteria are equal grain shapes and boundaries, mosaic-like micro texture, tarnishes of organic matter or clays among the crystals, pits within the crystals, occasionally a patchy distribution in the micrite, generally loaf-shaped, euhedral and subhedral of calcite crystals. Pseudosparite is a coarse neomorphic fabrics (Calcite crystals is larger than 30 μ m) form by recrystallization, (Flugel, 2010).

Plate 1



- *Ammonia beccarii* in intraclastic bioclastic packstone-grainstone .
- *Miogypsina* sp , *miogypsina* packstone .
- whole pelecypods .
- *Dendiritina* in *Dendiritina* packstone

Plate 2



- 1- Peloids in peloidal packstone .**
- 2- Superficial ooids with vugs in ooids pelecypod packstone .**
- 3-Extraclasts with sand grains in extraclastic wackestone-packstone .**
- 4- Intraclasts in intraclastic packstone-grainstone .**

Chapter three
Microfacies Analysis
and Deposition
Environment

Chapter three

Microfacies Analysis and Deposition Environment

3-1 preface

This chapter includes studying the petrography which is one of the first important steps in Microfacies analysis of Formation .The intercalated limestone beds varies in thickness from about (0.2 - 2.0) meters, they are yellowish to light grey in color and generally highly fossiliferous. The lower part of the Formation is marked by the first appearance of a relatively thick yellowish green marl bed more than (1.0) meter thick. According to many studies, the carbonate grains of the formation are both skeletal and non-skeletal.

3-2 Deposition Environment

The Nfayil microfacies reveal four types of environments using the ramp standard microfacies of (Flugel ,2004).

3.2.1 Peritidal Environment

Peritidal carbonates are shallow-subtidal, intertidal and supratidal sediments found in marginal-marine and shoreline depositional environments. These facies are vertically arranged (regressive) shallowing upward succession consisting of shallow-marine sediment overlain by intertidal and supratidal carbonates that are subject to periods of subaerial exposure (Flugel,2004) .Facies responsible for the designation of this environment is the **intraclastic mudstone -wackestone** at Karbala with quartz (sand – silt size) clastic influx , and **extraclastic wackstone - packstone** at Samawa section at depth 0.0-1.5 meter and **intraclastic wackstone -**

packstone at depth 8.0 meter in same section .Both are matching ramp standard microfacies number 24 (Flugel ,2004) which is intraclast mudstone /wackestone. Microfacies responsible for this environment is not found at Najaf section .

. 3.2.2 Shoal Environment

Carbonate sand shoal sediments are composed of sand to granule –sized loose carbonate material occurs in shallow, high energy areas, these shoal carbonate may be made up of ooids, mixture of broken shelly debris or may be an accumulation of benthonic foraminifera reworked by wave and tidal currents which results in a deposit made up of well-sorted, well rounded material: when lithified these form beds of grainstone or sometimes packstone , (Gary,2009)

Two types of microfacies were recognized for this environment:

A- An Ooid wackestone-packstone, at 0.0-1.5 meter at Najaf section another occurrence is at 5.5-6.5meters in the same section (Plt10.F), with the presence of *Dendiritina* , peloids, grapstones , pelecypods, gastropods, and shell fragments. whereas at Karbala section ,this facies occur at depth 25.5 meter as **Ooid pelecypod packstone**. Ooids are small and of superficial , concentric types , also with grapstones, peloids, and shell fragments (Plt10.B). Corresponds to ramp microfacies 29 (Flugel,2004),ooid grainstone with concentric ooids.

B- Intraclastic packstone- grainstone with *Miogypsina* sp. ,others are *Elphidium* , *Ammonia beccarii* , miliolid , rotalid , pelecypods , and shell fragments . At Karbala and Najaf sections this diversified assemblage of fauna similar to ramp microfacies 26 (Flugel,2004) bioclastic packstone-grainstone with divers skeletal grains. Both microfacies never recognized at Samawa section .

3.2.3 Restricted Environment

Four types of microfacies characterize this environment .

A-**Bituminous siltstone** (1.4 meters thick) at depth 14.5 meter at Karbala section , followed by **silty lime mudstone** (7.1 meters thick) interbedded with bituminous siltstone .

B-**Recrystallized lime mudstone** at Najaf and Karbala sections , similar to standard microfacies number 23 which is homogeneous , non-fossiliferous micrite.

C- **Peloidal intraclastic packstone** at the top of Samawa outcrop . Associated fossils are: miliolid , *Dendiritina* matching ramp microfacies number16 (Flugel ,2004) which is mudstone /wackestone with miliolids .

The dominance of family miliolidea as *Dendiritina* , *Articulina* ,and others unidentified miliolds is due to restricted water conditions .

D- **Miogypsina packstone** with miliolid , pelecypods and shell fragments, more restricted conditions are reflected at 8.75 -9.5 meters at Samawa section similar to ramp microfacies number (13) (Flugel,2004) wackestone -packstone with larger foraminifera . C and D microfacies present only at Samawa section.

Miogypsina packstone with miliolid at depth 9.5 meters is designated as restricted at the Samawa section and **intraclastic, bioclastic packstone to grainstone** with presence of *Miogypsina* sp. at depth 25.0 meters in Karbala section as shoal environment , both are located above the olive green marl (the index unit of the Nfayil Formation).

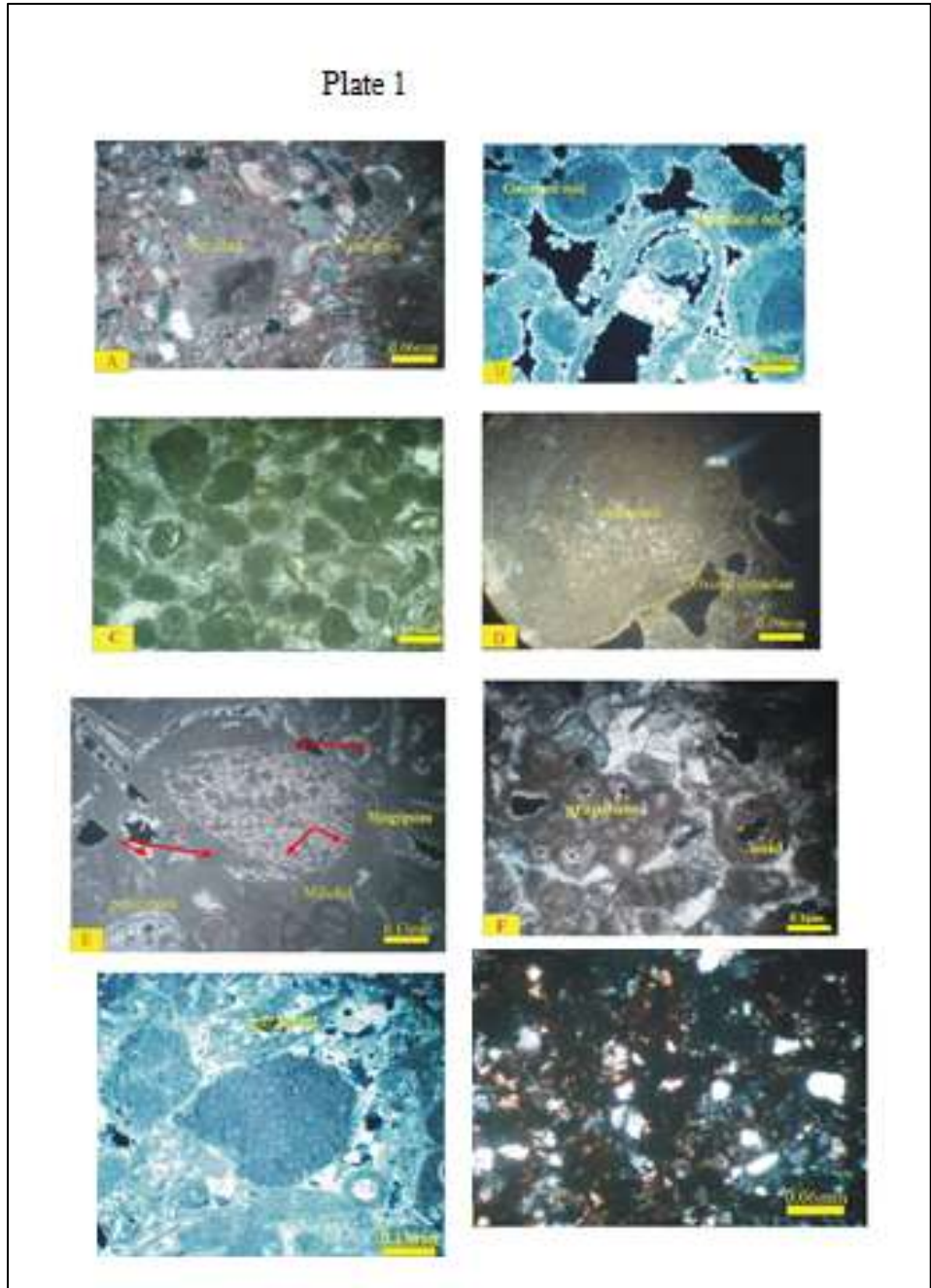
3.2.4 Deep Environment

Deep sediments are medium-bedded, fine grained bioclastic limestone and marls ,often burrowed . Skeletal grains are often worn, echinodermata, mudstone , wackestone , packstone and some grainstone. (Flugel ,2004)

Many layers of marl are found in the succession of the Nfayil Formation .Some are bearing echinodermata fragments ,rotalids , and unidentified fauna, such that at depth 11.0 meters below the top of Najaf outcrop , and at Karbala at depth 24.0

meters . Some layers of marl are olive green color which may indicate deep marine environment .It is present in all three sections. This unit is a characteristic one defining the contact between the Nfayil and the Euphrates Formation (Sissakian,1999) . Other marl unites with fine clastic influx are also present .

Plate 1



- A- Intraclastic mudstone-wackestone , Nfayil Formation .**
- B- Ooids packstone ,Nfayil Formation .**
- C- Peloidal packstone , Nfayil Formation**
- D- Extraclastic wackestone – packstone ,Nfayil Formation**
- E- *Miogypsina* packstone , Nfayil Formation**
- F-Ooid wackestone – packstone , Nfayil Formation**
- G-Intraclastic packstone- grainstone ,Nfayil Formation.**
- K- Bituminous siltstone , Nfayil Formation.**

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الخلاصة

العمل الحقلّي والدراسة البتروغرافية على رواسب الميوسين لتكوين النفايل في منطقة كربلاء- النجف. تشير إلى أن رواسب الميوسين المكشوفة في المنطقة تكون في التتابع تصاعدي. السحانات المجهرية لتكوين النفايل تظهر .

mudstone -wackestone at Karbala with quartz (sand – silt size) clastic influx , intraclastic wackstone -packstone, Ooid wackestone-packstone, - Intraclastic packstone- grainstone ,and marl lithofacies.

تكوين النفايل يترسب في بيئات بحرية اختزالية والريف والبيئات الضحلة . لقد تطور تتابع الميوسين في منطقة الدراسة في منطقة ذات هبوط منخفض، وهو ما يعكس التأثير الكبير للايوسناتيك كعامل رئيسي متحكم في تطور التتابع.



جمهورية العراق

وزارة التعليم العالي والبحث العلمي

جامعة بابل – كلية العلوم

قسم علم الأرض التطبيقي

مشروع بحث تخرج

البيئة الترسيبية لتكوين النفايل في منطقة كربلاء – النجف

للطالبة

بنين محمود مخيف راجح

بكلوريوس علوم علم الارض التطبيقي

العام الدراسي 2023-2024

اشراف

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