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PETROGRAPHICAL AND MICROFACIES STUDY OF JERIBE FORMATION (M. MIOCENE) IN ASHDAGH MOUNTAIN, KURDISTAN REGION, IRAQ

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ABSTRACT

This study deals with the Middle Miocene Jeribe Formation in the Ashdagh Anticline in Darzila Village near Sangaw in Sulaimani Governorate, Iraq. Stratigraphic analysis has shown that Jeribe Formation consists of recrystallized and dolomitized, mostly limestone which, as a whole, supported its reservoir potential. Petrography has provided a diversity of fauna such as large benthic foraminifera, *Astrotrillina sp.*, Miliolid in addition to *Borelis melo curdica*, which for a long time has been considered an index fossil for this formation. Other fauna includs several types of mollusks. The Jeribe carbonates were subjected to various diagenetic processes ranging from micritization, dolomitization, cementation, compaction, dissolution, and others. The formation consists of three major limestone microfacies: mudstone, wackestone, and packstone/ grainstone. The evidence from petrography and facies analysis support that the Jeribe Formation was deposited in restricted marine environment.

دراسة مجهرية و سحنية دقيقة للتكوين الجيريبي (المايوسيني الأوسط) في جبل أشداغ، في منطقة كوردستان، العراق

رزگار عبدالكريم عبدالله، محمد سعدي نورمحمدي، گيلان رشيد، و نبرد صالح

المستخلص

تتناول هذه الدراسة التكوين الجيريبي المايوسيني الأوسط في طية أشداغ قرية درزيلة بالقرب من سنگاو في محافظة السليمانية/ العراق. وأظهر التحليل الطبقي أن تكوين الجريبي يحتوي على صخور جيرية معادة التبلور والمدملة بشكل عام والتي تدعم بكل إمكاناتها الكامنة لتصبح صخورا خازنة. وقد وضح التحليل المجهري مجموعة متنوعة من الحيوانات مثل فوراميينيفيرا القاعية الكبيرة نوع أستروتيلينا، وميليوليد، بالإضافة إلى بورليس ميلو كورديكا، والتي تعد منذ مدة طويلة المؤشرالأحفوري لهذا التكوين. وتضمنت الحيوانات الأخرى، أنواعا عديدة من الرخويات. وتم إخضاع كربونات الجيريبي لمختلف العمليات التحويرية التي تتكون من تكسير، الدلمتة، والاسمنت، والانضغاط، والتحلل، وغيرها. ويتألف التكوين من ثلاث أنواع من السحنات الدقيقة للحجر الجيري الرئيسية: مدستون، واكستون، و باكستون/ گرينستون. والأدلة التي ظهرت من التحليل المجهري والسحني تبين أنها تدعم التكوين الجريبي وقد ترسبت في البيئة البحرية المقيدة.

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INTRODUCTION

The Jeribe Formation was first described by Damesin (1936, in Bellen *et al*., 1959), but later was defined by Bellen (1957, in Bellen *et al*., 1959) from the type locality near Jaddala Village in Jebel Sinjar Anticline and assumed to be of Early Miocene age. Al-Kharsan (1970) studied Lower Oligocene and Lower Miocene stratigraphy of the eastern area of Khanaqin, Iraq. In Syria the formation, according to Ponikarov *et al*. (1967), occurs in the Jezira Basin; where the formation has transgressive character and is conglomeratic at its base. In Iraq, it could be broadly correlated with the Govanda Limestone but older than facies and paleogeographic position in Iran; equivalents of the formation are the Kalhur Limestones (Buday, 1980). The formation may be similar to the upper part of the Middle Asmari and the Upper Asmari of Iran, as defined by James and Wynd (1965).

Mohammed (1983) studied biostratigraphy of Kirkuk Group formations in Kirkuk and Bai Hassan areas and described the lower boundary of Jeribe Formation as unconformable. Al-Hashimi and Amer (1985) studied the Tertiary microfacies of Iraq which included the Miocene microfacies too. The Jeribe Formation is an important reservoir in many of Iraq's important oilfields (Aqrawi *et al*., 2010) such as Kirkuk and Tawki oil fields (Ahmed, 2007; Abdula, 2010).

The age of the formation was determined originally as being Lower Miocene (Bellen *et al*., 1959). However, the *Borelis melo curdica* found in the formation in Lebanon, together with Middle Miocene fossils (Bellen *et al*., 1959), and the results of the works of the Geological Survey (Karim and Prazak, 1973 in Buday, 1980), found evidence of the genus *Orbulina* which clearly identifies the Middle Miocene as the age of the formation. Al-Zaidy (2013) studied Neogene formations in the northeastern Iraq. He stated that during the Early Burdigalian, the Jeribe Formation was deposited through another sea level rise that covered the area except the Chemchemal – Arbil and Butmah – Mosul subzones which represent the uplifted area. Kharajiany (2014) studied Early – Middle Miocene formations in Ashdagh Mountain and stated that the Jeribe Formation consists of grey limestone, which is slightly marly, about 2 m thick and contains *Borelis melo curdica*.

The aim of the present work is to study the microfacies, depositional environment and diagenetic processes of Early – Middle Miocene Jeribe Formation in the Ashdagh Anticline near Darzila Village.

- **Study Area**

The Jeribe Formation outcrops in Darzila Village on the Ashdagh Anticline which is dissected by Awa Spi Valley (Fig.1).

Ashdagh Mountain is located at the south of Sangaw District in Sulaimani Governorate, between the High Folded and the Low Folded zones. The studied section is located about 1.5 Km south of Hazar Kani Village with longitude 45°17'59" and latitude 35º09'58" (Fig.1).

- **Methodology**

This study is achieved through field and laboratory work. Extensive field work was done in the Ashdagh Mountain in order to study general geology and choose the appropriate outcrop of Jeribe Formation. The work included selection of suitable outcrop section for sampling and description. After removing the weathered parts, eight fresh samples were carefully collected from the section. The petrographic description was made by polarized microscope in Department of Petroleum Geosciences, Soran University.

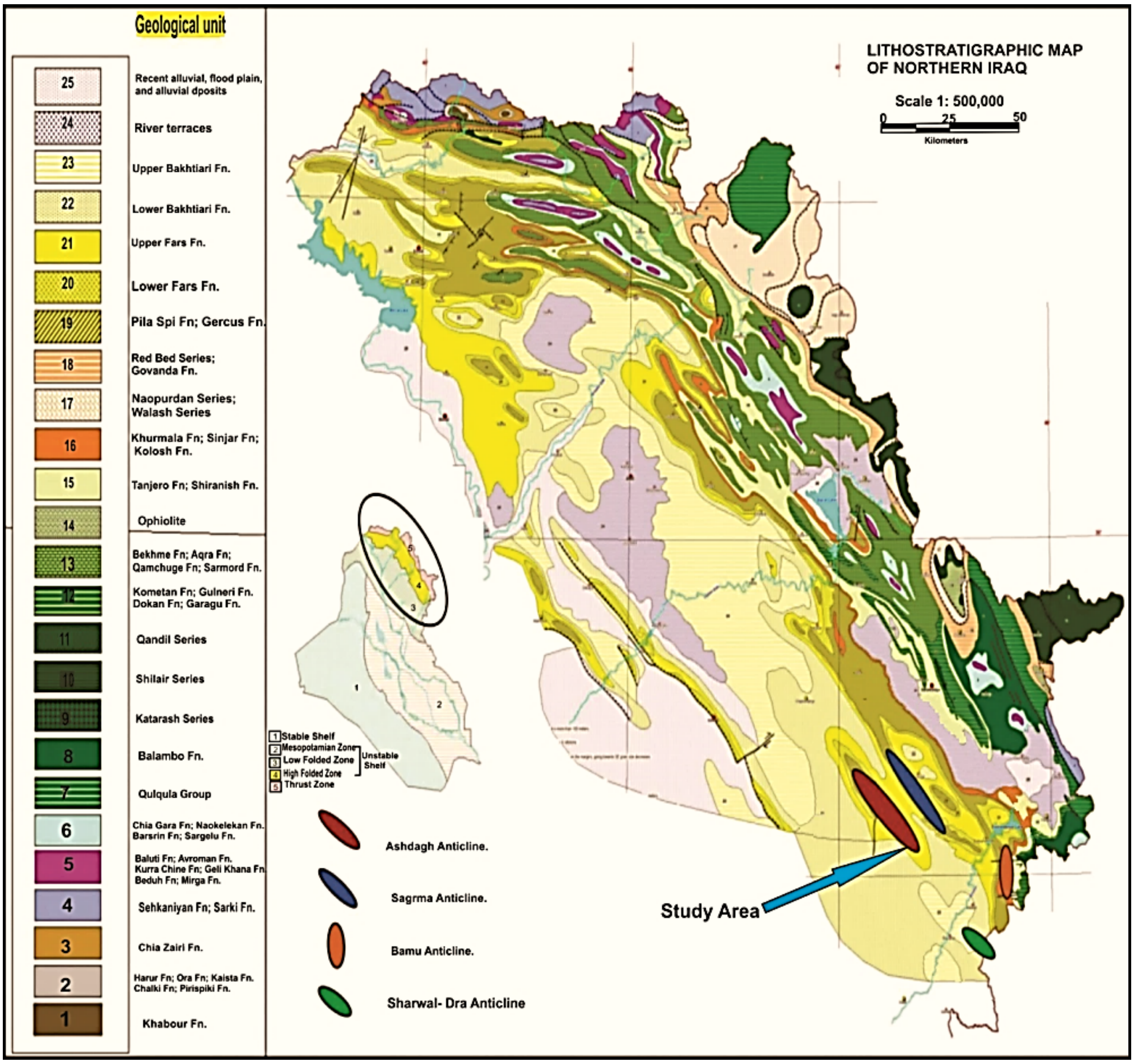

Fig.1: Map showing the distribution of the Early and Middle Miocene rock units in the studied area (after Ghafur, 2012)

GEOLOGICAL SETTING

The northern and northeastern margins of the Arabian Plate are limited by the collisional Taurus- Zagros suture (Beydoun, 1991). At the late Lower Miocene, there were continuous tectonic movements which resulted in the uplift of the southwestern parts of the basin with a resulting subsidence of the northeastern parts of the depositional basin. These events were reflected by the sea regressing from the south western shore and transgressing toward the northeastern parts. Due to the shallowing near the northeastern shore and in the middle parts of the basin, the Dhiban anhydrite was deposited followed by the deposition of limestone beds that was recognized as the Jeribe Limestone (early Middle Miocene) (Al-Dabbas *et al*., 2013).

Tectonically, Ashdagh Anticline is located within the High Fold and Low Fold zones. The rock beds are distributed on limbs and crest of the anticline (Fig.1); the crest is dissected by a valley, which contains milky color sulfuric water that had produced attractive valley and number of caves. The southwestern limb is faulted and thrusted, while the northeastern limb has a gentle slope. Therefore, the best locations to observe the outcrops of Early and Middle

Miocene are the crest and the northeastern limb. These rocks are overlying the Oligocene rocks of Anah and Bajwan formations and underlying the Fatha Formation. The large sinkhole is located directly at the southeastern Ashdagh Mountain about one km northwest of Darzila Village.

- **Stratigraphy**

The definition given by Bellen (1957, in Bellen *et al*., 1959) to the Jeribe Formation is still used, only the age of the unit and its relations to the Fatha Formation have now been changed.

According to Bellen *et al*. (1959), the type locality of Jeribe Formation lies near Jaddala Village, Jebel Sinjar. The formation is composed in its type section of white or grey dolomitized and recrystallized limestones, massive in the lower part and thinner bedded upwards. Dolomitization is strongest in the upper parts (Bellen *et al*., 1959).

Jeribe Formation in Darzila Village is 10 m thick and composed nearly of limestone and dolomitic limestone (Fig.2). The lower contact is unconformable with Anah Formation and upper contact is unconformable with Fatha Formation (Fig.3).

Fig.2: Limestone and dolomitic limestone of Jeribe Formation, NE limb Darzila Village (after Lawa, 2009)

Fig.3: Jeribe Formation underlain unconformably by Anah Formation in the studied area and it is not overlaid by any formations due to erosion (after Lawa, 2009)

- **Areal Distribution**

The Jeribe Formation in the southwest Iraq has in general a lesser areal extent. The boundary of the formation's distribution lies near the Euphrates River, with the exception of the area west of Haditha, where it occurs south of the river as well (Buday, 1980). In the Southern Desert, the investigations are not precise enough to establish the presence or absence of the studied formation (Jassim and Goff, 2006).

The northeastern boundaries of the Jeribe lie incompletely near the northeastern boundary of the Foothill Zone. The exact boundaries in the northeast where the present study is made and mainly to the northwest of the Greater Zab River remain, however, unknown. The exact boundary of distribution in south of Iraq is to the south of the Awasil-Fallujah area (Ditmar *et al*., 1971). It seems that the southwestern limit of the Jeribe Limestone runs roughly to the southwest of the line connecting Afaq, Musaiyib, and Dujaila (MacLeod, 1961).

- **Lithology**

The lithology of the formation is relatively uniform. In selected section at Darzila Village, Jeribe Formation is composed of limestone and dolomitic limestone. In the lower part, it is white green detrital limestone and in the middle part gray hard dolomitic limestone and white green detrital limestone occurs. In the upper part of the formation massive limestone occurs (Fig.4).

The Jeribe Formation in Ashdagh Anticline is composed of recrystallized and dolomitized, limestone beds of 1 – 2 m thick each, green to white colored. Dolomite in the mudstones at the middle part of the formation indicate mixing-zone diagenesis in intertidal flats as evidenced by the small size of the dolomite crystals. The plannar stromatolite and biotubation appears on the surface of beds at the lower near to the middle part of the formation. According to the classification of Hoffman (1976) planar stromatolites are formed in the intertidal zone (Fig.5).

Fig.4: Stromatolites and bioturbation appears on the surface of Jeribe Formation beds at middle part in Darzila Village, Kurdistan Region, Iraq

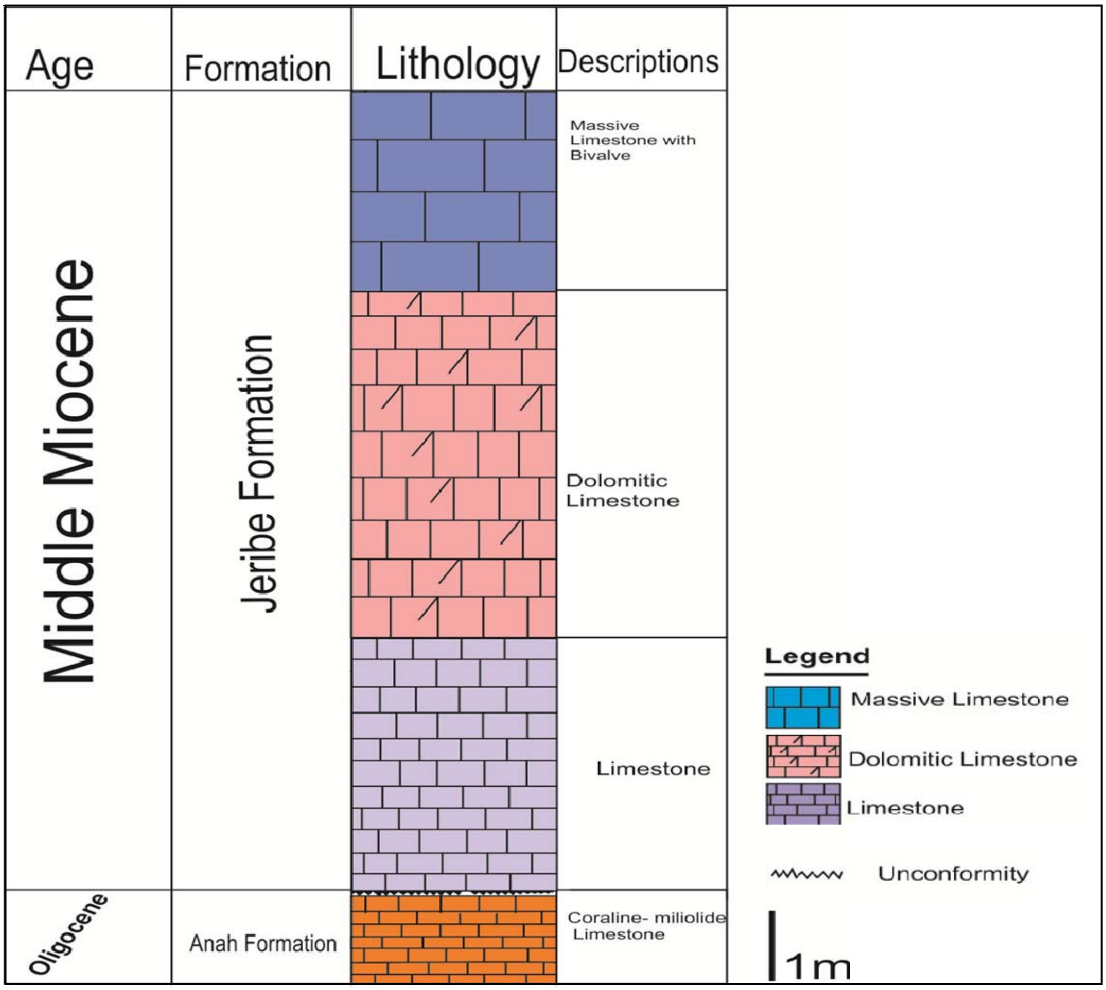

Fig.5: Stratigraphic column of Jeribe Formation at Darzila Village

PETROGRAPHY

Using the polarizing microscope, thin sections of limestone samples were examined to study the petrographic constituents. The limestones consist mainly of groundmass and grains.

- **Groundmass**

– **Micrite:** The *micrite* is the type of carbonate material observed in the studied samples. It a*ppears* as fine-grained carbonate mud and crystalline cement of calcite. Nanocrystals have been observed to form *micrite* in several samples.

– **Sparite:** In the studied samples, the sparite calcite crystals are commonly equant to elongated rhombohedrons, but also a few prismatic crystals were seen. Elongated crystals regularly have sharp tips and stand perpendicular to grain surfaces towards the intergranular pore space.

- **Grains**

– **Skeletal Grains:** Petrographic analysis exposed that the Jeribe Formation comprises generally of different skeletal grains. Below is a detailed description of types of skeletal grains:

Foraminifera: Petrographic study revealed that benthic foraminifera, Miliolid are present within Jeribe Formation in Darzila section (Fig.6.1). Large benthic foraminifera of various sizes are the most common skeletal grains in Jeribe Formation.

During most of the Cenozoic, larger benthic foraminifera (Figs.6.2 and 6.3) contributed much to the carbonate production on tropical shelves (Hallock, 1981; 1997). Peneroplids (large benthic foraminifers) are important sediment formers in modern carbonate shelf deposits, especially in restricted lagoonal settings with variable salinity where they can be the dominant faunal element (Scholle and Scholle, 2003) (Fig.6.4).

Bivalve: Bivalves are present especially at upper part of the Jeribe Formation (Fig.6.4).

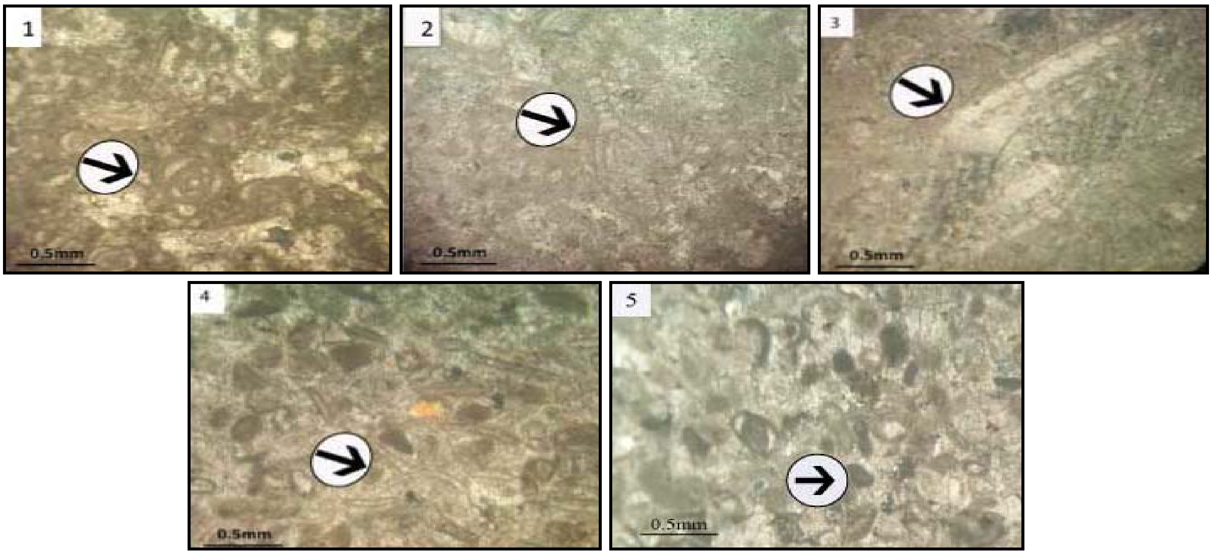

Fig.6: Skeletal and non- skeletal grains (XPL): **1)** skeletal grain, small benthic foraminifera (Miliolid); **2)** skeletal grain, large benthic foraminifera (Peneroplidae); **3)** skeletal grain, large benthonic foraminifera; **4)** skeletal grain (bivalve); and **5)** non-skeletal grains (peloids)

– **Non-Skeletal Grains:** In the current study, non-skeletal grains except peloids (ooids, oncoids, intraclasts, extraclasts) were absent in the limestones of Jeribe Formation. This indicates that Jeribe Formation was dominantly deposited in shallow marine setting (Tucker, 2001).

Peloids: In the Jeribe Formation, peloids are the main non-skeletal grains. They range in size from silt to sand sizes (Fig.6.5). Peloidal carbonate sediments, in general, are sediments of shallow low-energy, restricted marine environments (Tucker and Wright, 1990). By contrast to the abundance of peloids in tropical shallow-marine carbonate, peloids are rare or absent in non-tropical cool water carbonates (Flugel, 2010).

MICROFACIES ANALYSIS

Microfacies are considered as one of the main methods utilized for interpretation of the depositional environments of Jeribe Formation. The types, sizes, shapes, and distributions of skeletal grains are good indicators of the depositional environment (Flugel, 2010). The main microfacies of Jeribe Formation, with their detailed components identified in thin sections upon the petrographic study are as below:

- **Lime Packstone/ Grainstone Microfacies**

This microfacies is principally composed of peloids of various sizes, in addition, benthic foraminifera shell fragments also occur. This microfacies is common in the upper part of Jeribe Formation. The thickness of this microfacies in the formation is about 2 m with the ratio: 1/5 to other microfacies. There are grains more than 50%, Miliolids 35%, penerplids 10%, and bivalve 15%. This microfacies is equivalent to RMF26 (Read, 1985; Flugel, 2010). It is interpreted to indicate shoals and banks with moderate wave agitation at inner ramp environment (Fig.7.1).

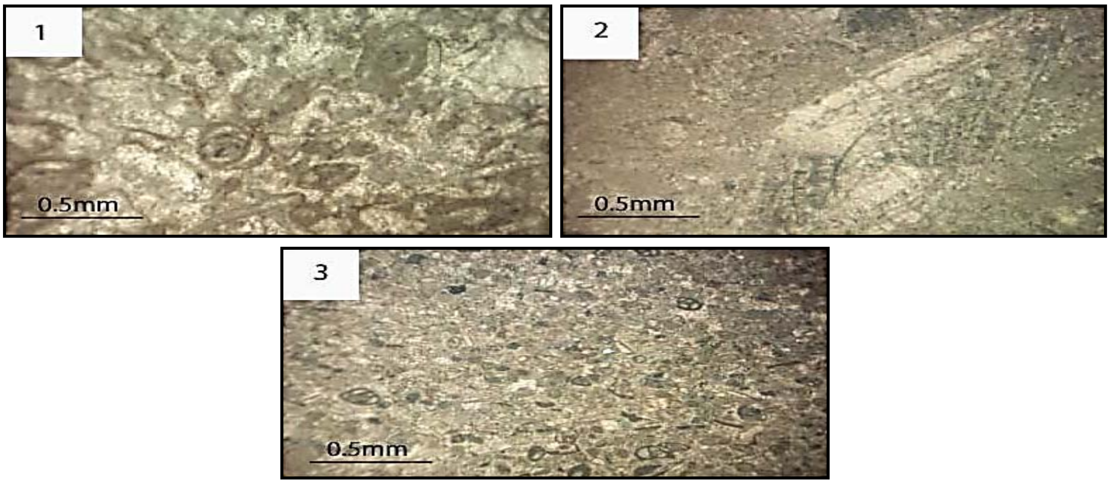

Fig.7: Types of microfacies (XPL): **1)** lime packstone/ grainstone microfacies; **2)** lime mudstone microfacies; and **3)** lime wackestone microfacies

- **Lime Mudstone Microfacies**

This microfacies occurs at different levels throughout the studied section, but it is most noticeable in the lower part of the formation. The thickness of this microfacies in the formation is about 3.5 m with the ratio > 1/3 to other microfacies. The percent of grains in these microfacies are less than 10% (Peloids 3 – 4 % and Milolid 1 – 2 %). Micrite is the main component in this microfacies. This microfacies is equivalent to RMF19 (Read, 1985; Flugel, 2010). It is related to inner ramp lagoon environment (Fig.7.2).

- **Lime Wackestone Microfacies**

It is the most common microfacies in the Jeribe Formation, and may locally be dominated by a specific type of bioclastic at various levels within the formation succession. The percent of grains in these microfacies are less than 50%. There is skeletal grain more than 10% bivalve 5 – 6 %, peneroplids 10%, Miliolids 15 – 20 %, and peloids 3 – 5 %. Grains of wackestone range between 10 – 50 % in a micritic matrix. The thickness of this microfacies in the formation is about 4.5 m with the ratio of 1/2 to other microfacies. This microfacies is equivalent to RMF13 (Read, 1985; Flugel, 2010). This microfacies are characteristic of restricted-open-marine environments belonging to inner ramp (Fig.7.3).

- **Diagenesis**

Both mechanical and chemical diagenesis occur within Jeribe Formation. Much tectonic deformation, both brittle and ductile, take place within the temperature range of late diagenesis. The late carbonate fracture fill commonly have associated hydrocarbons as stains, fluid inclusions, or solid bitumen, making partial fracture fills (Moore and Druckman, 1981 in Flugel, 2010). The fracturing is present in the Jeribe Formation (Fig.8.1). It is observed that

the Jeribe Formation was commonly affected by both mechanical (Fig.8.2) and chemical compaction. Drusy cement consists of anhedral to subhedral crystals, usually >10 μm crystal size that increases from pore walls to center of cavities (Flugel, 1982). This type is found in shallow and deep marine environments, and also in vadose and phreatic zones (Graf and Lamar, 1950 in Flugel, 1982). Bathurst (1975) believed this type refers to cement filling primary or secondary voids (Fig.8.3). Both diagenetic and tectonic stylolites are present (Fig.8.4). It appears that tectonic stylolites occur more as result of pressure- solution phenomena due to the physical parameters (pressure and temperature) involved than to chemical factors. Cementation process extensively affects the studied formation, and represents the most common of the chemical diagenetic processes. The sparitization (Fig.8.5) processes is evident in the lower part of the Jeribe Formation. Finally, dolomitization has affected these rocks to varying degrees. The general view indicates an increasing dolomitization and desiccation upwards; these variations, may even be noticeable within each lithofacies also.

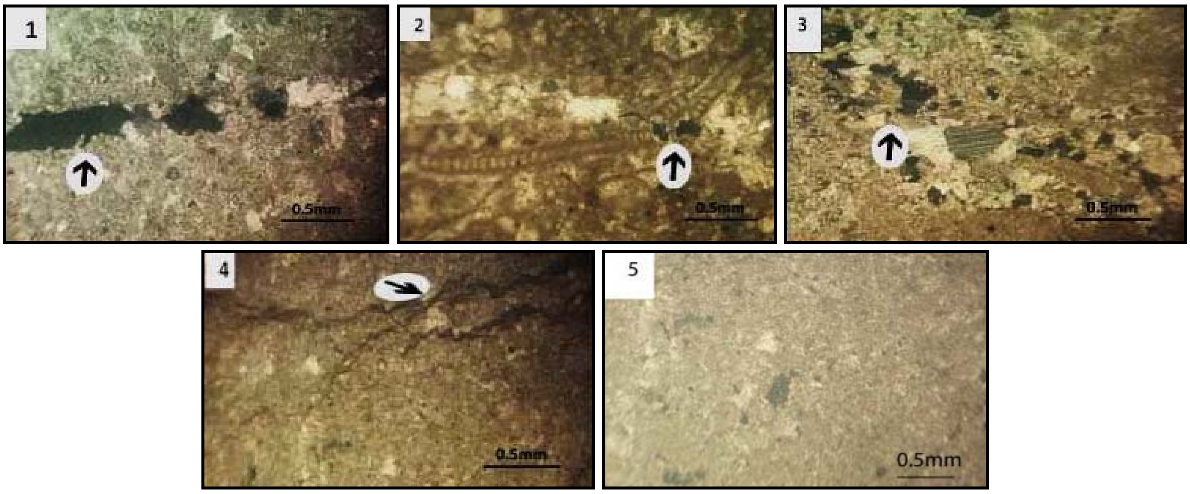

Fig.8: Digenesis process (XPL): **1)** fracture in the lower part of the formation; **2)** mechanical compaction in the lower part of the formation; **3)** drusy cement at the middle part of the formation; **4)** stylolite inside mudstone at the lower part of the formation; and **5)** sparitization processes in the lower part of the Jeribe Formation

SEDIMENTARY ENVIRONMENTS

Since the studied formation is carbonate dominated, it must correspond to one of depositional models (or systems) of carbonate facies that were established to lateral facies relations in ancient carbonate platforms.

The Jeribe microfacies include mudstone, wackestone and packstone/ grainstone. In addition, the fossils of the Jeribe Limestone, such as bivalve, large benthonic foraminifera, *Astrotrillina*, and Miliolid occur. Therefore; the Ramp model represents a widely accepted model for the deposition of Jeribe Formation (Read, 1985). Another reason for this selection can be due to the absence of reef-building community/ organism in Jeribe Formation.

Furthermore, the existence of other fossils such as Peneroplids and Miliolids reflect a lagoonal marine environment with high salinity. The recognition of basal conglomerate (Fig.9) in the lower part of this formation constitutes a good indication for the transgression which is responsible for the deposition of both the basal conglomerate and basinal sediments

rich in foraminifera. An approximate sketch representation of the depositional model of the Jeribe Formation is depicted in Figure 10.

Fig.9: Basal Jeribe conglomerate, nearby the studied section in Hazar Kani Village

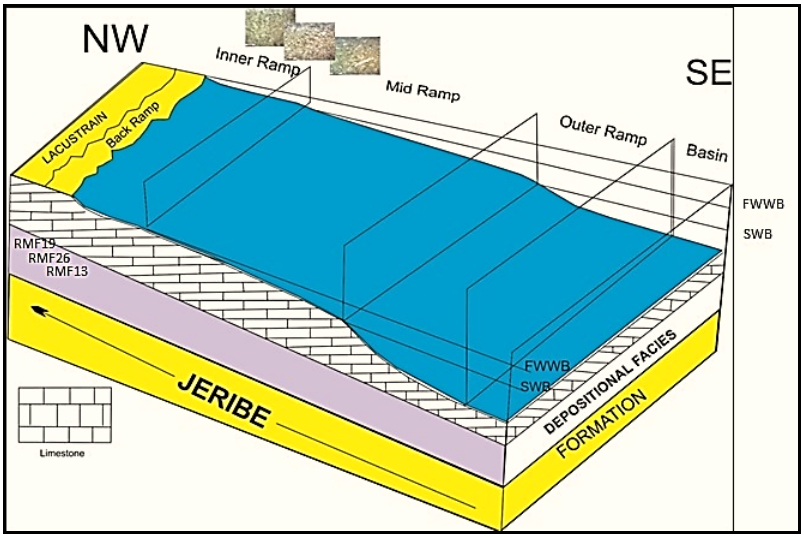

Fig.10: Schematic block diagram representing the ramp depositional model for the various microfacies of the Jeribe Formation

CONCLUSIONS

The following is a summary of the conclusions that have been drawn from this study:

- The most prevailing facies are lime mudstones, wackestone and packstone/ grainstone whereas grainstone is lacking according to Dunham (1962) Classification.
- based on petrographic study and microfacies analysis, the Jeribe Formation was mainly deposited in the ramp environment which represents relatively low energy to high energy.
- The upper contact with Fatha Formation due to erosion does not exist; consequently the Jeribe Formation is not overlaid by any formation in this outcrop section. The lower contact with Anah Formation is unconformable.
- The thickness of the Jeribe Limestone in Darzila Village is about 10 m.

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