The Microfacies Analysis of Mishrif Formation in Gharraf Oil Field

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Abstract
Six main microfacies are identified which are Lime Mudstone, Bioclastic Wackeston, Bioclastic Packstone-Wackestone, Bioclastic Wackestone- Mudestone, Pelagic Mudstone–Wackestone, Bioclastic Packstone -Grainston Microfacies in addition to their associated depositional environment. The diagenesis process have affected the Mishrif rocks and played a role in deteriorating reservoir porosity in well Ga-2 and enhancing it in well Ga1,3.These processes include: cementation, micritization, recrystallization,dissolution,compaction pressure solution and dolomitization.
Keywords: microfacies, mudstone,wackestone, packstone, grainstone.

تحليل السحنات الدقيقة لتكوين المشرف في حقل الغراف النفطي

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الخلاصة:
تم تحديد ست سحنات دقيقة رئيسية وهي سحنة الحجر الجيري الطيني، سحنة الحجر الجيري الواكي الفتاتي العضوي، سحنة الحجر الجيري المرزوم–الواكي الفتاتي العضوي،سحنة الحجر الجيري الواكي–الطيني، سحنة الحجر الجيري الطيني– الواكي البحري وسحنة الحجر الجيري المرزوم–الحبيبي الفتاتي العضوي بالإضافة إلى تحديد بيئاتها الترسيبية. العمليات التحويرية أثرت على صخور المشرف ولعبت دورا في تدمير مسامية المكمن في البئر Ga-2 وتحسينها في البئرين Ga-1,3. هذه العمليات تضمنت السمنتة، المكرتة، إعادة التبلور ،الإذابة،الانضغاط ومحاليل الضغط و الدلمتة.

Introduction

The Mishrif Formation (Cenomanian-Early Turonian) represents a heterogeneous formation originally described as organic detrital limestones, capped by limonitic fresh water limestones [1].The lower contact of the formation is conformable. The underlying unit is Rumaila Formation.The upper contact of the Mishrif Formation is marked by an unconformity of Khasib Formation [5].

Gharraf field is located south of Iraq in Thi Qar province about 85 km north of Nassriya city, figure 1. The Gharraf field is a NW-SE trending anticline with an area of 24 km length and 5 km width Three wells (Ga-1,Ga-2, Ga-3) were drilled in Gharraf field during the years of 1984, 1987, 1988. The main oil accumulation zones in the field are the Mishrif and Yamama Formation. The second accumulation zones are found in the Ratawi and Zubair Formation.

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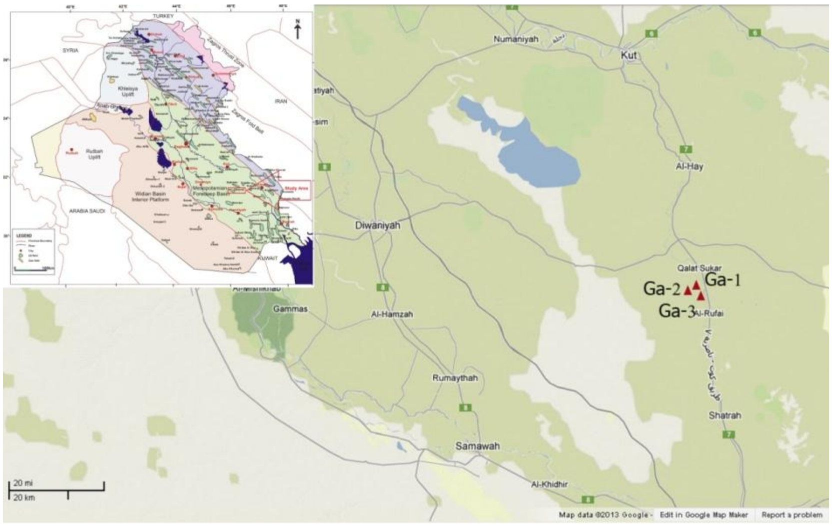

Figure 1- Location map of the study area

Sampling and methodology

This study is based on observation on 73 thin section collected from core and cutting in the three wells Ga-1,Ga-2,Ga-3. The microfacies analysis of Mishrif Formation have been classified according to Dunham classification, figure 2. This classification is easy to apply and depends on the texture of the rock. The environment of the formation is determined in addition to the diagenetic processes and their effects on reservoir properties.

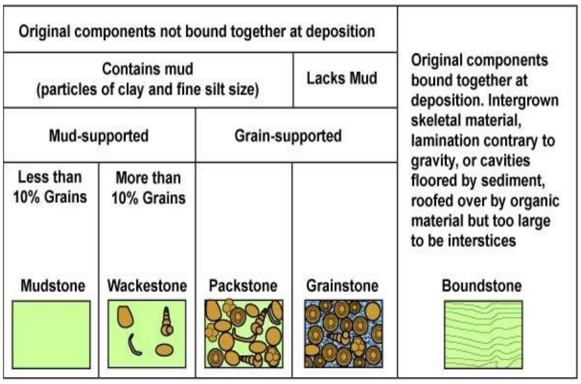

Figure 2- Dunham Classification[4]

Petrographic Description

The petrographic study of the thin sections reflects that, the Mishrif formation consist of :

Skeletal grains

a- Benthic foraminifera: Benthic foraminifera of different size are found, concentrated in the upper and middle parts of the formations, and less recorded in the lower part of the formation, such as *Nezzazata*. The diagenetic process affected the rocks making it difficult to distinguish (p-1a,b).

b- Planktonic foraminifera : Planktonic foraminifera exist in the sections, especially in the lower part of the Mishrif Formation. This occurrence continue to the transitional zone between the Mishrif and the underlying Rumila Formation. The main planktonic foraminifera that can be recognized are :*Hedbergella sp.*, *Heterohelix sp.*, *Globigerina sp.*,. (p-1c)

Mollusca : Mollusca is characterized by its wide distribution along the studied section. It is found in several forms generally as shell fragments (longitudinal bioclast or concave shape). Others in the form of large bioclast or full size shells affected by different diagenetic processes.

Rudist: Rudist represents the main component and the index fossil for the Mishrif Formation. Rudist appearance is noticed in several forms (longitudinal, concave, shell fragment). In well Ga-3, large parts of rudist are noticed representing the main form of the reservoir unit in this well. Otherwise the talus (rudist fragments) are recognized only in well Ga-2. All the rudist are affected by diagenetic process (p-1 d,e,f).

Calcispheres: Shelf limestone yield small-sized (diameter commonly <500µm hollow spherical microfossils exhibiting calcite walls. Many of these fossils, often designated as (calcispheres),are interpreted as algal remains, particularly as algal cysts. These calcispheres are abundant in association with other planktonic algae and occur in pelagic, basinal carbonate [4].

Other organisms: There are several types of organism found in the Mishrif Formation, but it's occurrence is few or restricted such as ostacoda shells, Echinoderms fragment, alge in addition to spicules.

Non skeletal grains

Peloids: Peloids are spherical, ovoid, or rod-shaped, mainly silt size carbonate grains that commonly lack definite internal structure. They are generally dark gray to black owing to contained organic material and may or may not have athin, dark outer rim. Peloids are composed mainly of fine micrite 2 to 5 microns in size [2]. Peloids are distributed as little numbers along the section The identification of peloids is sometimes difficult because of daigenetic process that made some fossils look like pelloids.

Groundmass

a- Micrite : Most groundmass of Mishrif rocks is composed of micrite. Micrite is microcrystalline (1-4) microns. Micrite has a grayish to brownish, subtranslucent appearance under the microscope do to consist organic matter. The presence of substantial micrite in limestone is commonly interpreted to indicate deposition under fairly low-energy conditions, where little winnowing of fine mud take place [2].

b- Sparry calcite: Crystals of sparry calcite are large (0.02- 0.1 mm) compared to micrite crystals and appear clean or white when viewed in plane light under a polarizing microscope. They are distinguished from micrite by their larger size and clarity and from carbonate grains by their crystalline shapes and lack of internal microstructures [2]. The sparry calcite is less occurance than micrite in Mishrif rocks. It occurs as a cement that fills channels and inside the carbonate grains.

Carbonate microfacies and marine depositional environments

Flügel (2004) [4] defines a microfacies as the total of all sedimentological and paleontological data which can be desecribed and classified in thin section, peels, polished slabs or rock samples. The purpose of microfacies analysis is to provide a detailed inventory of carbonate rock characteristics (carbonate grain types, kinds and growth forms of fossils, size and shape of grains, nature of micrite, cement, particle fabrics) that can subsequently be related to depositional conditions [2]. After examined the thin sections by using polarizer microscope, the Mishrif microfacies have been determined, and the depositional environments have been concluded according to standard microfacies types, figure 3.

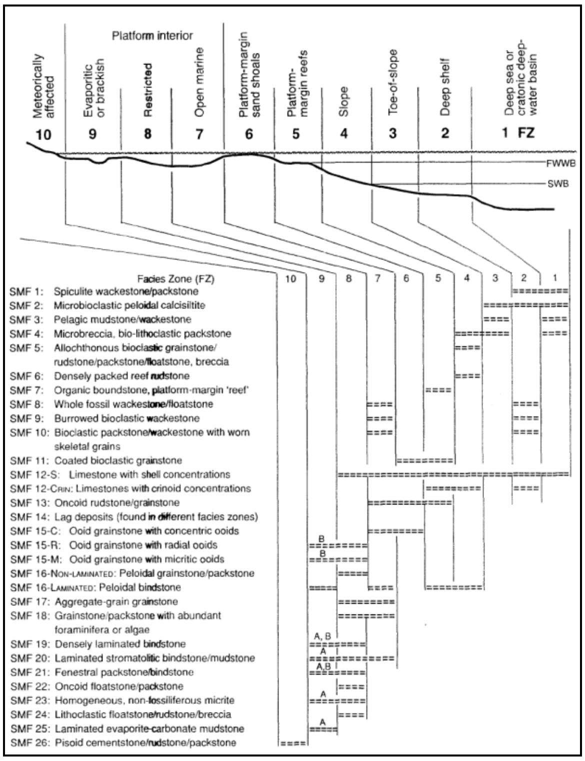

Figure 3- Distribution of *SMF* Types in the Facies Zone (*FZ*) of the rimmed carbonate platform model [2].

These depositional environments and their microfacies association are :

Restricted platform interior environment (FZ8)

The microfacies association with this environment is

-Lime mudstone microfacies

This microfacies mainly composed of homogeneous unfossiliferous(pure micrite). Some parts of these facies have been dolomitized. The dolomite crystal contributed in different percentage. The standard microfacies (SMF) which is similar to it is SMF (23). This microfacies founded in well Ga-1 Ga-2.

Open marine platform environment (FZ7)

Consist of the following facies :

-Bioclastic Wackstone Microfacies

This facies concluded shell fragments, echinoderm fragments, and some benethic foraminifera. It’s similar to SMF(9). This microfacies has been recognized in the three wells Ga-1, Ga-2, Ga-3.

-Bioclastic Packston– Wackstone Microfacies

Grains of this microfacies are dominated by shell fragments, some of these shells related to Pelecypods. And some foraminifera cored with micrite envelops also found. This microfacies is similar SMF (10) and recognized in well Ga-3.

Deep shelf environment (FZ 2)

The microfacies that represents this environment is:

- Bioclastic Wackstone –Mudstone Microfacies

Allochems of this microfacies characterized by small shell fragments and some types of planktonic foraminifera. This microfacies is similar to SMF (9), and distinguished in the well Ga-2 only because there are no available samples in the others well.

Toe-of slope environment (FZ3)

The only facies represents this environment is:

-Pelagic Mudstone- Wackstone Microfacies

Planktonic foraminifera and Calcispheres are dominating in this microfacies. It's similar to SMF (3). It is recognized in the three wells Ga-1, Ga-2, Ga-3.

Platform margin reefs environment (FZ5)

The microfacies representing this environment are:

-Bioclastic Packstone –Grainstone microfaci-es

The major components of this microfacies is rudist. Rudist fragments are ranging from small to large sizes, rare to common mollusca fragments. This microfacies is similar to SMF (7). This facies represents the main reservoir unit and is only recognized in well Ga-1,3.

Diagenesis process

Diagenesis refers to physical, chemical and biological processes. Carbonate minerals are more susceptible in general to diagenetic changes such as dissolution, recrystallization, and replacement than most silicate minerals [2].

Therefore the diagenetic processes and their effect on the petrophysical properties of the Mishrif rocks are cleared.

Cementation: Comprises processes leading to the precipitation of minerals in primary or secondary pores and require the supersaturation of pore fluids with respect to the mineral [4]**.**

This process has a negative effect on porosity and permeability of the formation in the study area. Several types of calcite cement have been recognized in the Mishrif rocks these types are :Bladed, Drusy, Dog tooth, Blocky (p-2 a).

Micritization: Organic participate in a variety of ways in generation carbonate deposits. After carbonate sediment are deposited, however, organisms may breakdown skeletal grains and other carbonate materials. This organic degradation is actually a kind of sediment-forming process because it results in the production of finer-grained sediment. Nonetheless, it is included here as a type of very early diagenesis because it brings about modification of previously formed sediment. The most important kind of biogenetic modification of sediment is caused by the boring activities of organisms. Boring by algae, fungi, and bacteria is a particularly important process for modifying skeletal material and carbonate grains [2]. If boring activities are prolonged and intense, the entire surface of a grain may become infested by these aragonite-or Mg-calcite-filled boring, resulting in the formation of a thin coat of micrite around the grain. This coating is called a micritic envelope [2]. Even more intensive boring may result in complete micritization of the grain, with the result that all internal textures are destroyed and a kind of peloid is created. This process has been affected widely on the Mishrif rocks in the study ares which led to destroy the skeletal grains of most fossils..

Recrystallization: Refers to changes in crystal size, crystal shape and crystal lattice orientation without changes in mineralogy [4]**.** This process affected on some parts of the formations characterized by the transformation of micrite to microsparite.

Dissolution : Undersaturation of pore fluids with respect to carbonate leads to dissolution of metastable carbonate grains and cements. Dissolution is particularly effective in shallow near-surface meteoric environments, in deep burial and cold waters as well in the deep sea [4]. This process has obvious and positive effects on the Mishrif rocks which leads to increase porosity and enhance permeability (p-2f).

Compaction and pressure solution (stylolization): Refer to mechanical and chemical processes, triggered by increasing overburden of sediments during burial and increasing temperature and pressure conditions[4]**.** A stylolite is a kind of sutured seam that is characterized by a jagged surface, is generally coated by insolubles such as clay minerals or organic matter. Stylolite are typically oriented parallel to depositional bedding; however, they can occure also at various angles to bedding and thus create reticulate or nodule-bounding patterns [2] (p-2 b).

Dolomitization: Is a process whereby limestone or its precursor sediment is completely or partly converted to dolomite by the replacement of the original $CaCO_3$ by magnesium carbonate, through the action of Mg bearing water. Porosity tend to increase slightly in the initial stages of dolomitization of limestones, but increase abruptly with higher amounts of dolomite. At this stage, the dolomite is characterized a sucrosic texture composed of equally- sized rhombohedra with intercrystalline porosity originating by dissolution of associate calcite [4]**.** This process has less effect on the formation in the study area. There are several types of dolomite texture in carbonate rocks.three types of dolomite texture are recognized in the Mishrif formation which are (planar-euhedral, planar void- filling, planar- porphyrotopic) (p-2 c, d).

Authigenic minerals

-Sulfides: Pyrite: Authigenic pyrites in limestones are usually developed in the form of cubic euhedral crystals. Pyrite attracts sedimentologists, for the mineral is a valuable indicator of chemical process and diagenetic stages [4].. Pyrite is formed in normal marine, euxinic, and freshwater environments [4]. Pyrite has been recognized in different depth in the formation. The cubic form of pyrite and pyrite inside foraminifera chambers has been noticed (p-2 e).

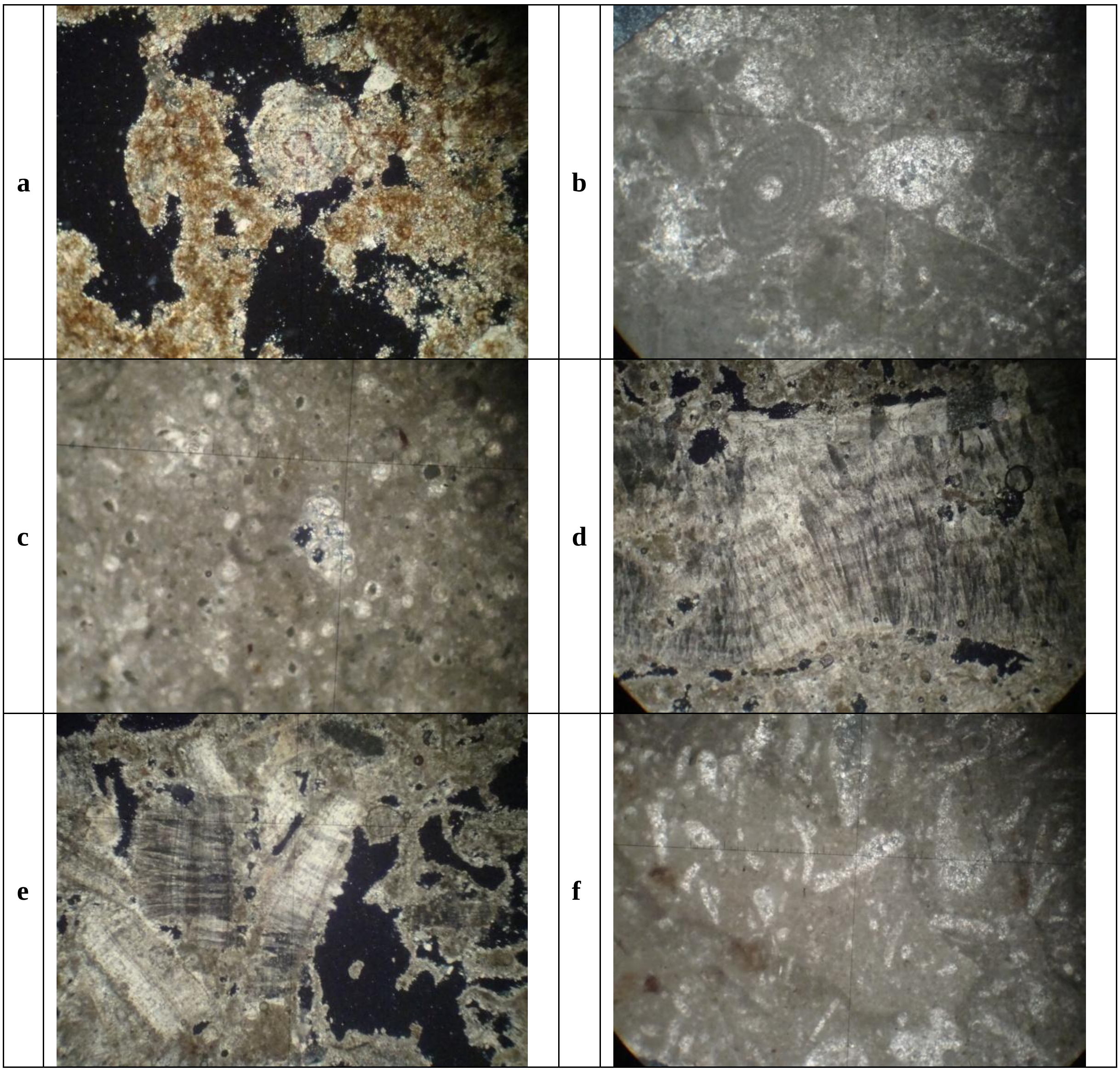

Plate 1

(a) Benthic foraminifea in Bioclastic Packstone Grainstone Microfacies, Ga-3, C.2, 2337 m,(100x)
(b) Benthic foraminifera in Bioclastic Wackestone Microfacies, Ga-2, 2508m,(4x).
(c) Foraminifera fossil in Pelagic Mudstone Wackestone Microfacies, Ga-1, C.5, 2393m,(100x).
(d) Rudist in Bioclastic Packstone Grainstone Microfacies, Ga-3 C.3, 2339.50 m(40x)**.**
(e) Rudist in Bioclastic Packstone Grainstone Microfacies, Ga-3 C.3, 2339.50m (40x).
(f) Talus in Bioclastic Wackestone Microfacies, Ga-2, 2514 m (40x). Ga-2, 2504 m(100x).

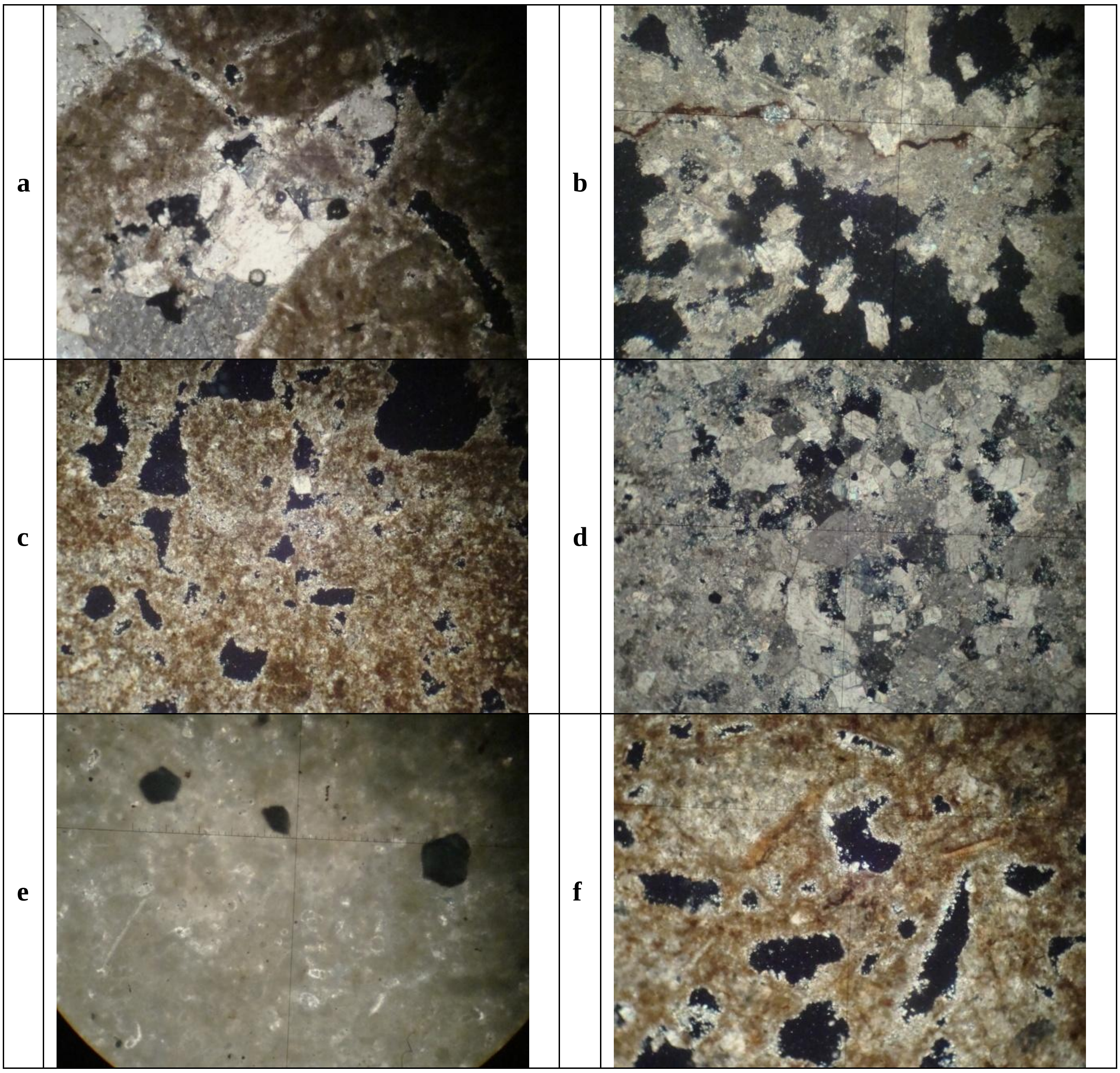

Plate 2

(a) Drusy & blocky calcite cement in Bioclastic Wackestone Microfacies,Ga-3, C.1, 2320.50 m (100x).
(b) Stylolite in Bioclastic Packstone Wackestone Microfacies, Ga-3,C.3,2344m,(40x),Ga-3.
(c) Dolomitization process, planar void-filling texture, Ga-3,C2, 2337m (40x).
(d) Dolomitization process, planar-euhedral texture, Ga-3, C2, 2334m (100x).
(e) Cubic pyrite. Ga-2, 2339m (100x).
(f) Dissolution process in Bioclastic Packstone Grainstone Microfacies,Ga-3, C2, 2337 m (100x).

Conclusion

The microfacies analysis of Mishrif Formation shows that, there are lateral facies change between Ga-1,3 and Ga-2.The main reservoir facies (Bioclastic Packstone – Wackestone) which contain large rudist are found only in well Ga-1,3, and replaced by Bioclastic Wackestone Microfacies which contain talus in well Ga-2. The diagenesis process have affected the Mishrif rocks and played a role in deteriorating reservoir porosity in well Ga-2 and enhancing it in well Ga1,3.

Acknowledgments

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