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## Reservoir units of Mishrif Formation in Majnoon Oil field, Southern Iraq

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### Abstract

The reservoir units of Mishrif Formation in Majnoon oil field were studied by using available wireline logs (gamma ray, porosity and resistivity) and facies that derived from core and cutting samples for three wells including Mj-1, Mj-15, and Mj-20. The reservoir properties were determined and interpreted by using IP software. The results showed that unit D have the best reservoir properties due to high effective porosity, low water saturation and very low volume of shale. Furthermore, a large part of this unit was deposited in shoal environment. The other reservoir units are then graded in reservoir properties including units B, A, F & E respectively, except unit C, which is considered as a cap unit, because it consists of restricted marine facies so that; it has high volume of shale and water saturation and very low effective porosity.

**Keywords:** Reservoir units, Mishrif Formation, Majnoon oil field

### الوحدات المكمنية لتكوين المشرف في حقل مجنون النفطي، جنوب العراق

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### الخلاصة

تمت دراسة الوحدات المكمنية لتكوين المشرف في حقل مجنون النفطي بالاعتماد على المجسات المتوفرة (اشعة كاما، مجسات المسامية ومجسات المقاومة) والسجلات الرسوبية المستنتجة من نماذج اللباب والفتات الصخري لثلاثة آبار وهي (مجنون-1، مجنون-15، مجنون-20). حيث تم تحديد وتفسير الخواص المكمنية من المجسات باستخدام برنامج تفسير الخواص البتروفيزيائية. اظهرت النتائج ان الوحدة D تمتلك أفضل الخواص المكمنية وذلك لمساميتها الفعالة العالية، التشبع المائي القليل وحجم السجيل القليل جداً. فضلاً على ذلك فإن الجزء الغالب من هذه الوحدة قد ترسب ضمن بيئة الساحل. تتدرج بعدها الوحدات المكمنية الأخرى في خواصها المكمنية وهي على التوالي B, A, F & E، ماعدا الوحدة C، فتعتبر وحدة غطائية لأنها تتكون من سحنات البيئة البحرية المحصورة وبذلك فان حجم السجيل والتشبع المائي لها عاليين ومساميتها الفعالة واطئة جداً.

### Introduction

Cenomanian–Early Turonian carbonates of the Mishrif Formation in the Mesopotamian Basin form one of the world's most prolific hydrocarbon reservoirs in many oil fields in Iraq, such as West Qurnah, Halfaya, Majnoon and Rumaila [1].

Deposits of Middle and Upper Cretaceous are more heterogeneous than underlying units. They include various types of carbonate build-ups (sponge-stromatoporoid, algae and rudist) including those in Mishrif and Aqra/Bekhme Formations [2].

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Majnoon oil field produces hydrocarbons from carbonate reservoirs that are hosted in Hartha, Sadi, Khasib, Mishrif, Ahmadi, Shuaiba, and Yamama [3]. This study deals with the evaluation of reservoir properties of Mishrif Formation based well logs data.

Identification of reservoir units based on the results of computer processed interpretation (CPI) of well logs. The evaluation is based on porosity, water saturation, and volume of shale. In addition, the effect of facies properties in each unit is discussed.

### The Study Area

Majnoon oil field is located in southern Iraq, Basrah and Missan Governorate, 70 km to the north west of Basra City, close to the Iraqi Iranian borders (Figure-1). This oil field was discovered after interpretation of the seismic survey data which was done by Petro Brass (Brazilian Company) in 1972. The first exploration well was drilled in 1976 [3].

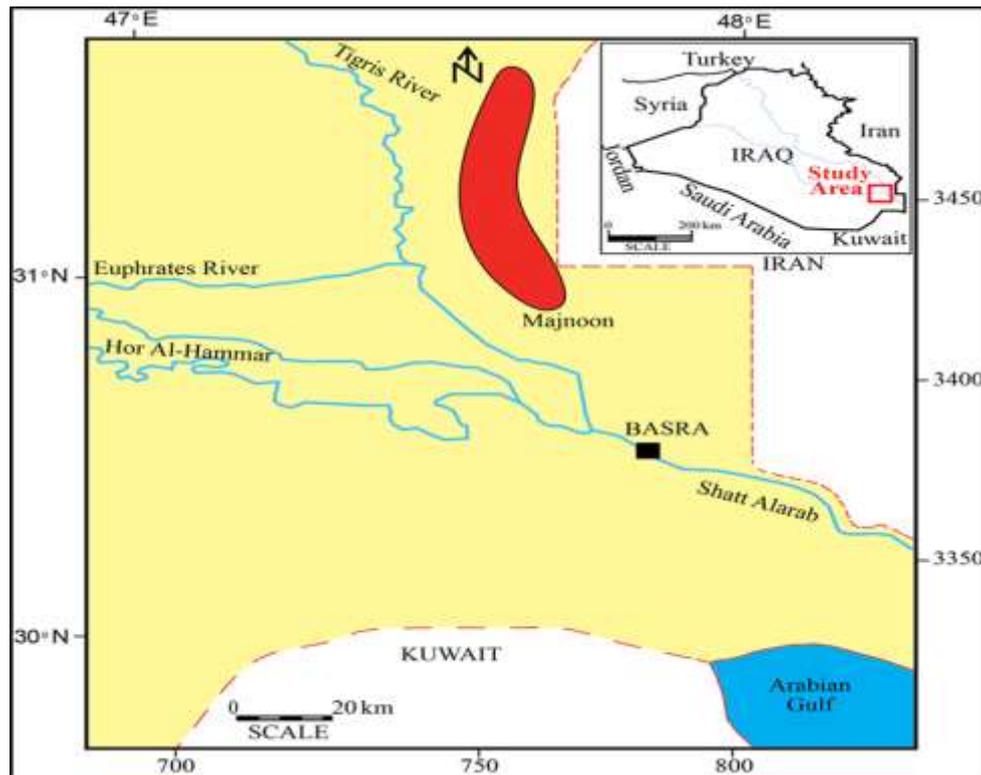
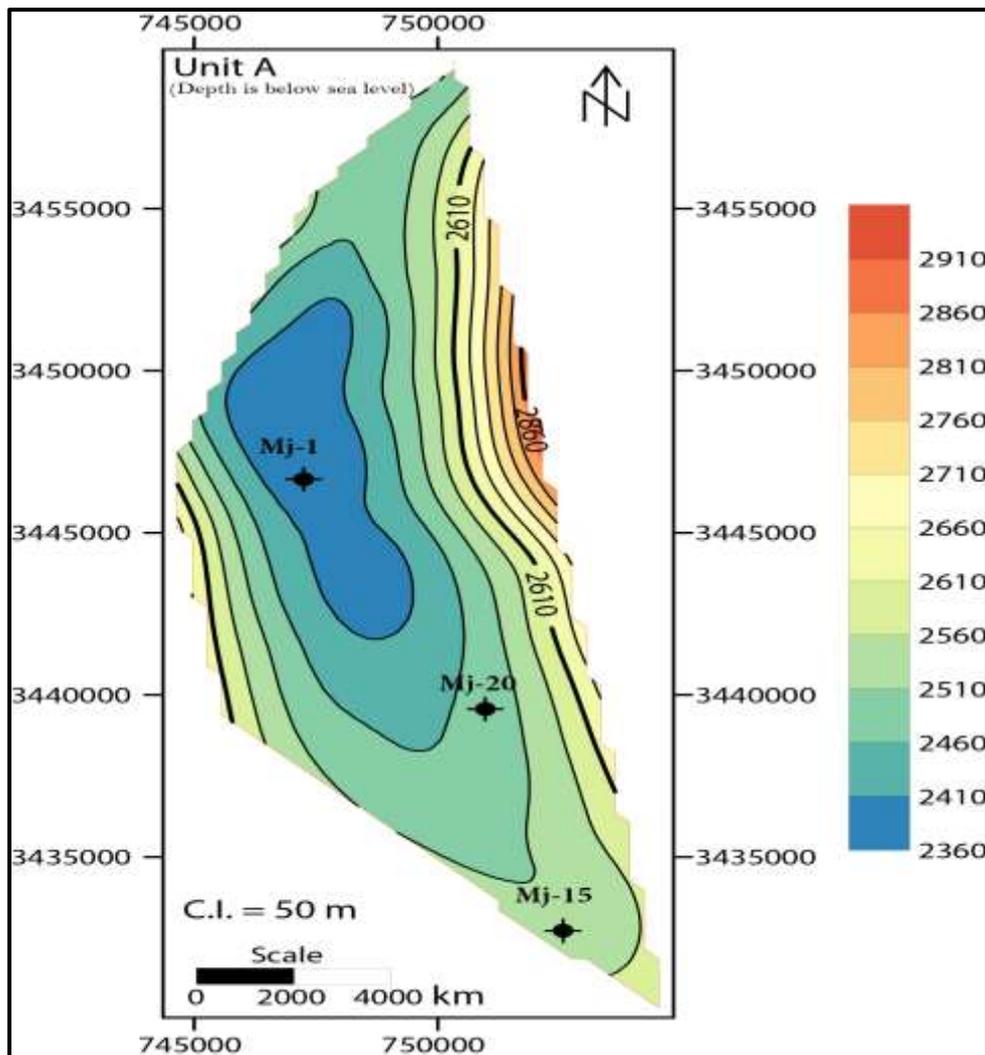


Figure 1-Location map of the study area [4].

### Tectonic and Structural Setting

The area of study is located in the Mesopotamian Zone precisely in Zubair subzone, which is considered as a part of the Mesopotamian Foredeep Basin. The most prolific petroleum region in Iraq is the Zubair subzone. This subzone forms the Mesopotamian Zone southernmost unit and has a uniform structural style by the underlying basement. It incorporates prominent N-S trending structures, which continue hundreds of kilometers southwards into Kuwait and east Saudi Arabia (Figure-2). During the late Nabitah orogeny and where reactivated during Permian, Mesozoic and Tertiary time these structures originated. The N-S trending structures amplitude of the subzone increase with depth and reach 300 m at Lower Cretaceous level. The structures are long and relatively narrow anticlines separated by broad synclines especially in the east. The Zubair and Rumaila structures are the most prominent narrow elongated antiforms. Nahr Umr, Majnoon, Rachi, Ratawi, Subba and Luhais Shorter, often broad structures [5].

The structure contour map shows limited change in the structural attitude of the Majnoon oil field during the deposition of the Mishrif Formation as indicated by shifting of structural closure towards north and south directions (Figure-2).



**Figure 2-** Structure contour map at the top of Mishrif Formation in Majnoon oil field.

### Stratigraphy

The type section of Mishrif Formation was described as heterogeneous succession of organic detrital limestone, with beds of algal, rudist, and coral-reef limestone, capped by limonitic fresh water limestone [6]. This description was given by Rabanit [7], who first described the formation in the Zubair area of southern Iraq [8]. The Mishrif Formation occurs in most oil fields in Central Iraq as far north as the Hamrin Mountains and throughout SE Iraq. The formation thickness varies according to the location within the Mesopotamian Basin. The thickness reaches of about 350 or 400m in SE Iraq [9] (the Amara, Halfaya, Majnoon and Buzurgan oil fields near the Iranian border) and thins or wedges out in the west and SW [10].

The formation lower contact is usually conformable with the Rumaila Formation in the south. South parts of Iraq, where the Kifl Formation is present the upper contact is conformable. Where the Kifl is absent the top of the Mishrif Formation is marked by an unconformity as in the present study. The Kifl Formation progressively wedges out to the south (Towards the Burgan Structure in Kuwait) due to Intra Turonian erosion or because of non-deposition [5].

### Materials and Methods

1. Digitizing well logs by using Didger software.
2. Well logs analysis and interpretation by using Interactive Petrophysics (IP) software.

### Results and discussion

#### Reservoir Units

Conventional wireline logs are the most common method of determining subsurface rock and fluid properties. It is more prefer than core samples because core are expensive and time-consuming [11]. Petrophysical evaluation requires the calculation of different well logs parameters such as, porosity,

resistivity and water saturation. These parameters are determined directly or inferred indirectly by one of three general types of logs: 1) Electrical (Resistivity) 2) Nuclear (Gamma Ray, Density and Neutron logs) 3) Acoustic or sonic logs [12].

The present study represents identifying reservoir units of Mishrif Formation by interpretation available wireline logs in interactive petrophysics software (IP). Each reservoir unit is characterized by facies association that control rock texture and pore types.

The Mishrif Formation is divided into five reservoir units based on petrophysical properties that are derived from logs analysis. In addition, the stacking of facies associations in each unit is included in reservoir subdivision. The reservoir units are A, B, D, E and F according to CPI results and depositional facies associations. The petrophysical parameters derived from well logs and facies association taken into consideration in identification of each unit as follow:

**Unit A** represents the uppermost unit of Mishrif Formation. The effective porosity of this unit varies, where the upper part is characterized by low porosity due to the increase in density log ( $\rho_b$ ) and coincided decrease in neutron porosity (NPHI). While it gradually increases downward the unit as observed in wells Mj-1, Mj-15, and Mj-20 Figures-(3, 4, 5). Higher reservoir quality of unit A occurs at lower part, which shows lower shale volume, high effective porosity and high hydrocarbon volume. These good reservoir properties are related to shoal facies association that is characterized by secondary porosity and grain-supported microfacies.

**Unit B** is the thickest reservoir unit in the Mishrif Formation succession in Majnoon oil field. It consists of shoal, back-shoal, and restricted marine facies associations. The high reservoir properties are associated with shoal facies at different depths Figures-(3, 4, 5). Other facies have lower reservoir quality due to lower effective porosity, hydrocarbon volume, and high shale volume.

**Unit C** is located in the middle part of the formation. It is considered as a cap unit due to very low of porosity and permeability comparing with other units. This unit is recognizable easily from logs due to very low effective porosity that deduced from the high values of (DRHO) and low readings of (NPHI), very high volume of shale that identified from maximum GR log readings and high water saturation. These properties are attributed to mud-supported microfacies of restricted marine facies association Figures-(3, 4, 5). Mud-dominated packstones, wackestones and mudstones are deposited in environments of low-energy and typically have higher activity of gamma-ray [13].

**Unit D** is a potential reservoir unit in Mishrif Formation. It consists of shoal and shallow open marine facies with secondary occurrence of back-shoal facies association. These facies are characterized by high effective porosity that detected from porosity log patterns, low volume of shale that measured from GR log and low water saturation that deduced from deep resistivity log (LLD, IND) Figures-(3, 4, 5).

**Unit E** have similar cap rock characteristics to unit C. However, it is composed of shallow open marine facies association Figures-(3, 4, 5)

**Unit F** is located at the lowermost part of Mishrif Formation and consists of shallow open marine facies, which is capped by shoal facies in most wells. Therefore, these wells show an upward increase of effective porosity and decrease of shale volume Figures-(4, 5).

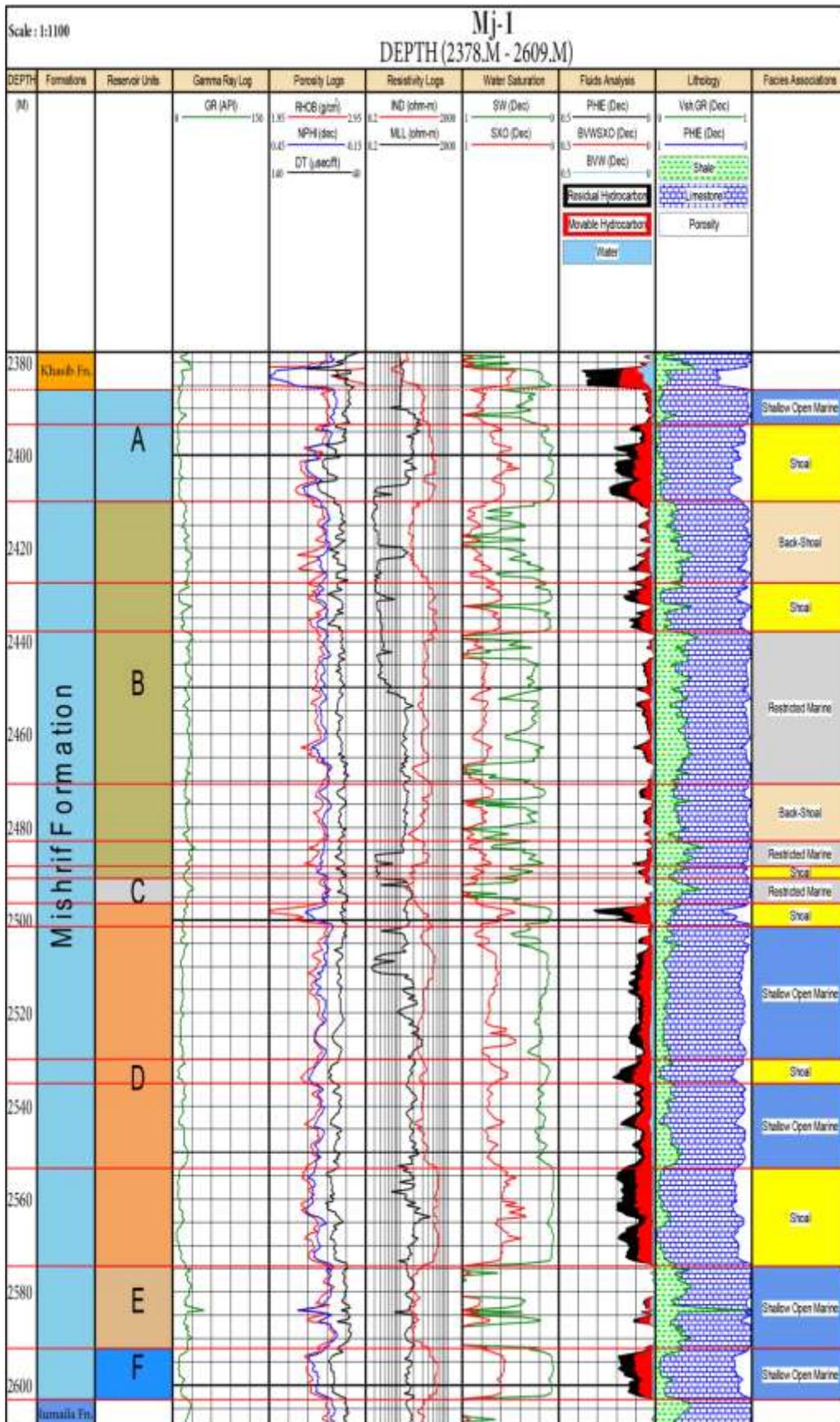
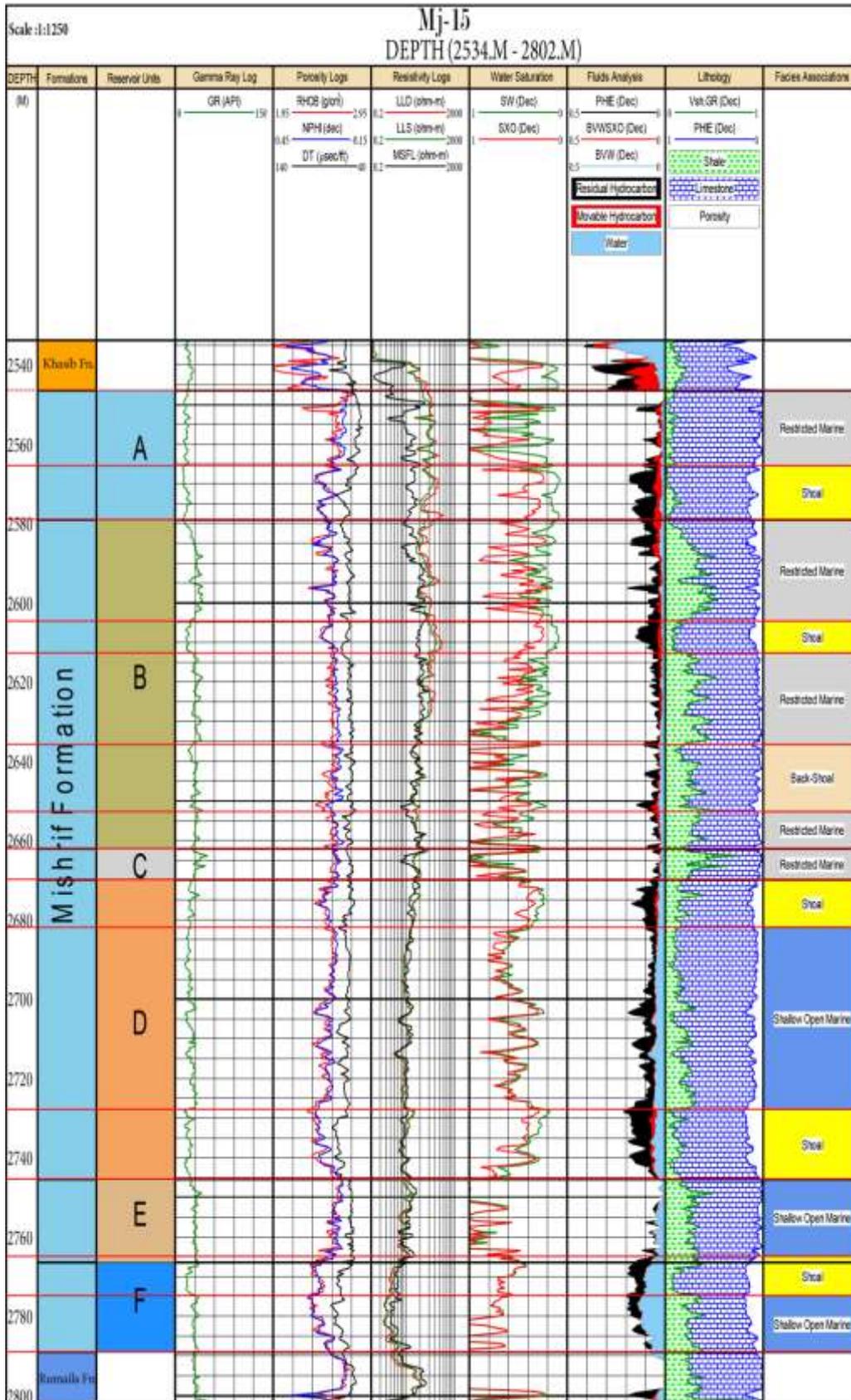


Figure 3- Computer Processes Interpretation of Mishrif Formation in Mj-1 well.



**Figure 4-** Computer Processes Interpretation of Mishrif Formation in Mj-15 well.

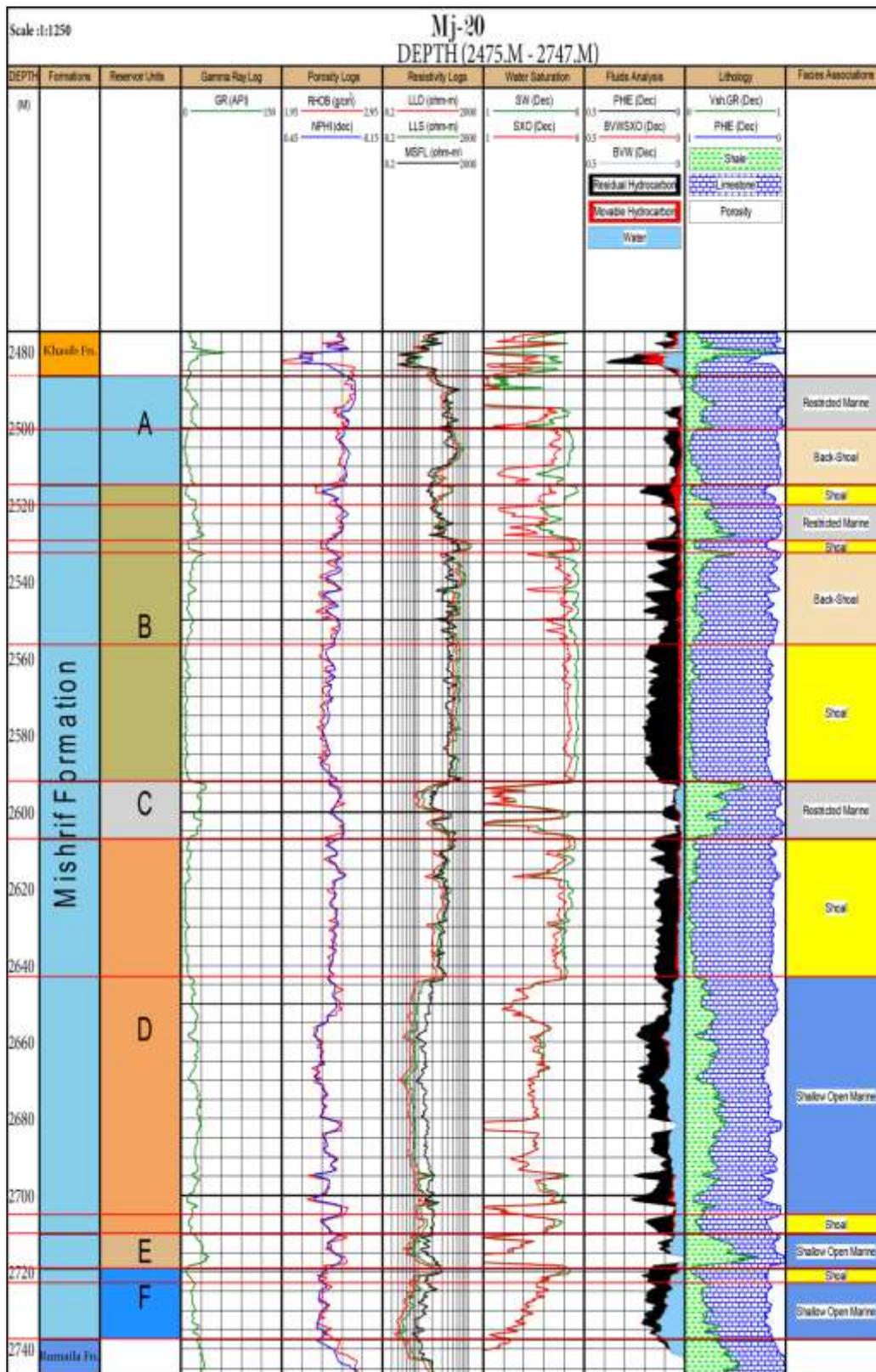


Figure 5- Computer Processes Interpretation of Mishrif Formation in Mj-20 well.

**Conclusions**

1. The Mishrif Formation was divided into five reservoir units they are A, B, D, E, and F.
2. Reservoir unit D is the best reservoir unit of Mishrif Formation in Majnoon oil field due to high reservoir quality while unit C represents a seal rock due to low reservoir quality.

3. High reservoir quality associated with shoal associations that have low volume of shale, and high effective porosity.

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