

Facies Modelling of Mishrif Formation in Selected Wells of Tuba Oil Field, Southern Iraq

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Abstract— The current study includes building a 3D geological facies model of the Mishrif Formation (Cenomanian-Early Turonian) in Tuba oilfield, southern Iraq. Microfacies study and core samples examination reveals the occurrence of six facies associations within Mishrif succession represented by; Basin, deep marine, rudist biostrome, shoal, back- shoal, and lagoon. Each reservoir unit is characterized by distinct facies distribution that controls their quality. High reservoir quality is predominantly developed in rudistid facies that are productive from units MB1 and MB2. The 3D facies model shows that these units have greater continuity and thickness along Tuba anticline and control the structural and stratigraphic trapping. Units MA and Mishrif have lower reservoir quality due to the dominance of mud-dominated facies. The unit CR2 consists of non-reservoir facies, and can be captured along the oilfield structure.

Keywords—Carbonate, Mishrif, facies, Modelling, Petrophysics, reservoir

I. INTRODUCTION

The Tuba oil field consists of different reservoir zones

and the zones considered for this study includes Mishrif Formation. The Mishrif Formation is one of the most important carbonate reservoirs in central and southern Iraq. During Cenominian-early Turonian, the carbonate succession of Mishrif Formation within the Mesopotamian basin is a part of the Wasia Group and has widespread distribution throughout Arabian plate. Currently, twelve wells producing from Mishrif Formation in Tuba oil field. An understanding of rudistid facies distribution has been instrumental in the development of similar oil fields in the Mesopotamian Basin [1]. The reservoir model presented in this study shows the importance of these facies as a formation for future field development.

II. THE STUDY AREA

The Tuba oil field is located nearly 35 Km southwest Basrah city between Zubair from the East (5km distance) and South Rumaila from West (2km distance) (Figure1). The Tuba anticline trends approximately N-S and is 29 km long and the width reaches about 9 km (Figure 2)

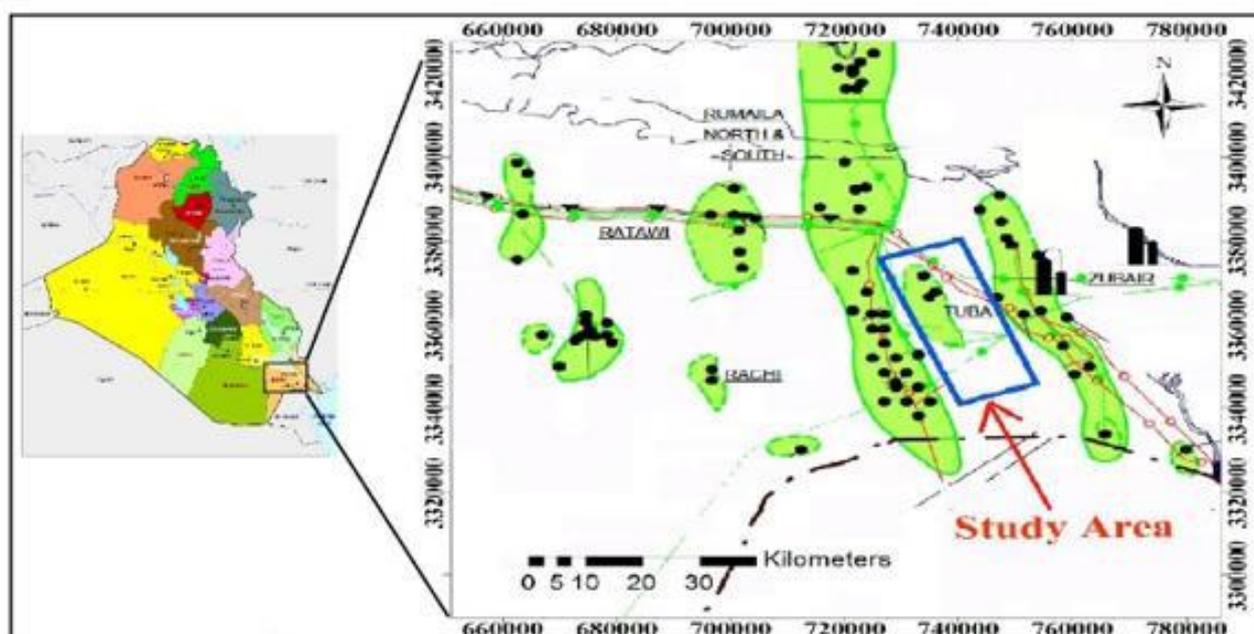


Fig.1: Location Map of Tuba oilfield (global exploration & production service-gis-2010).

III. AIMS OF STUDY

- 1-Identification of facies associations in each reservoir unit of Mishrif formation in Tuba oil field
- 2-Building the 3D Facies model by using Petrel software to assess the vertical and horizontal changes in facies associations, and their distribution within Tuba oil field.

IV. METHODOLOGY

- 1-The petrographic study and microfacies analysis were based on the study of more than 300 thin sections of cores from the selected wells (TU-3, TU-4, TU-5, TU-15, TU-19, TU-22).
- 2- Using interactive petrophysical software IP (V3.5) for the environment correction, lithology and mineralogy identification and log interpretation.
- 3-Using of Petrel software for construction 3D Facies model.

V. STRATIGRAPHY

The Mishrif Formation (Cenomanian-Early Turonian) represents a heterogeneous carbonate succession originally described as organic detrital limestones, capped by limonitic freshwater limestone [3], [5]. It is considered to be an overall progradational marine shelf sequence, with the development of rudist shoal and biostromes[1].The Mishrif Formation is composed of two major sedimentary cycles abruptly terminated by the unconformity, which separates the Mishrif from the overlying Khasib Formation [5]. The lower contact of the formation is conformable with the underlying Rumaila Formation, whereas the upper contact is unconformable with Khasib Formation [4].

VI. TECTONIC AND STRUCTURAL SETTING OF THE STUDY AREA

The study area is located in Zubair Subzone, which is the southern part of the Mesopotamian Foredeep. Mesopotamian Zone is the easternmost tectonic unit of the Stable Shelf and includes the largest and richest petroleum province in Iraq and is dominated by Cretaceous plays [5]. This zone was probably uplifted during the Hercynian deformation but it subsided from Late Permian time onwards. The thickness of Cretaceous stratigraphic succession increases towards east. It comprises 700-1400m of the Upper Cretaceous. The Mesopotamian Zone contains buried faulted anticlines below the Quaternary cover, separated by broad synclines. Such structures include Tuba oil field (Figure 2), which represents an asymmetrical anticline, where the western limb dips 0.9 degree. It is worthy to be mentioned that the depression, which separate the Zubair and Tuba

field is deeper approximately 40 - 60 m than the depression separate Tuba and Rumaila.

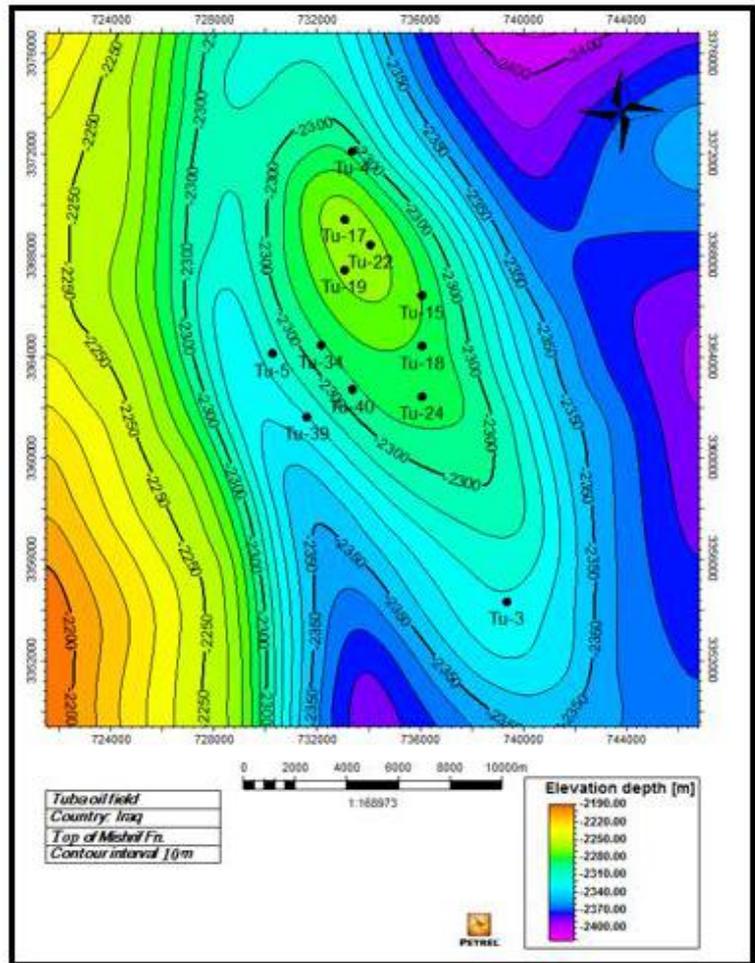


Fig.2: Structural contour map of Top of Mishrif Formation.

VII. MICROFACIES ANALYSIS AND DEPOSITIONAL ENVIRONMENT OF RESERVOIRS UNITS

The Mishrif Formation can be subdivided into several reservoir units in Tuba oilfield based on petrophysical properties. These include Top of Mishrif, MA, CR2, MB1, MB2). The depositional facies of reservoir units control their reservoir quality, and are important in reservoir characterization and geologic modeling. This is related to different texture and diagenetic overprint of carbonate facies[1]. Generally mud-dominated facies show low reservoir quality and grain-dominated facies have better quality due to high porosity and permeability. A collection of thin section has been prepared from more than 300 core samples obtained from selected wells. The results of petrographic study of thin sections show that the reservoir units consist of different facies associations, which can be interpreted in terms of depositional

environments (Figures 3-10). Major characteristics of facies associations are summarized as follow:

1-BasinFacies association

This facies association consists of shale units that are found in all studied wells except well Tu-4, where it replaced by deep marine facies (Figures 3-10).The basin facies association occurs only in CR2 unit, which represent non-reservoir unit. It is characterized by highest gamma ray log values.

2- Deep marine Facies association

The deep marine facies association forms thick succession of Planktonic mudstone-wackestone microfacies. Stratigraphic position of this association remarkably occurs above and below CR2 unit (Figures 3-10). It has poor reservoir properties and forms part of some reservoir units including MA, MB1, and Top of Mishrif unit.

3- Shallow open marine Facies association

This facies association includes mainly of bioclastic packstone or packstone or wackestone. It occurs at lower and middle parts of Mishrif Formation within Mb1 and Mb2 units, in addition to MA unit (Figures. 3-10). According to [1], shallow open marine facies association is comparable with slope facies described in equivalent formations.

4- Rudist Biostrome Facies association

Most reservoir rocks of Mishrif Formation consist of rudist-bearing facies, which were deposited in rudist biostrome and shoal environments. In Tuba oilfield, the rudistid packstone, and rudistid packstone-floatstone occur in reservoir units Mb1 and Mb2, and characterized by high sonic log values and low gamma ray log response (Figures 2-5).The high reservoir quality of this facies association is attributed to the abundance of rudist shells and fragments that are largely affected by dissolution forming potential vuggy porosity[1],[2].

5- Shoal Facies association

This facies association consists of grain-dominated microfacies such as rudistid packstone-grainstone. They were deposited in shallow, high energy and current swept environment[1].They form the most important reservoir units in Tuba oilfield including MB2(Figures 3-10).

6-Back-shoal Facies association

The back-shoal facies association has limited occurrence in the study area. It consists of Foraminiferal-bioclastic wackestone-packstone and rudistid floatstone microfacies. This facies association has lower reservoir quality than shoal and rudist biostrome facies. It occurs mainly in MB1 and MB2 units (Figures 3-10).

7- Lagoon Facies association

This facies association consists of mud-dominated microfacies such as fossiliferous lime-mudstone and benthonic foraminiferal wackestone. They form thick

succession at uppermost part of Mishrif Formation within Top of Mishrif and MA units (Figures 3-10).The low reservoir quality of lagoon facies association is indicated by the low values of sonic log (Figures.2-5).

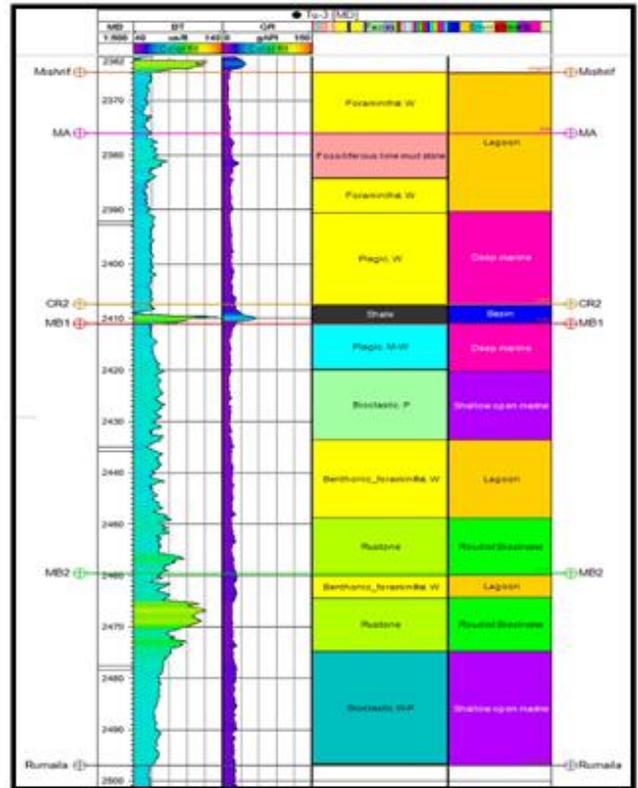


Fig.3: Facies associations and logs response of Mishrif Formation at well Tu3.

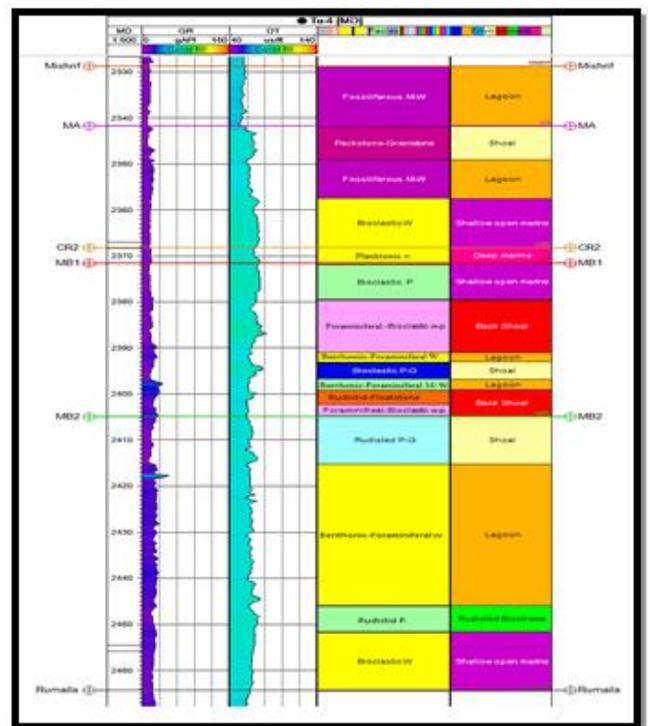


Fig.4: Facies associations and logs response of Mishrif Formation at well Tu4.

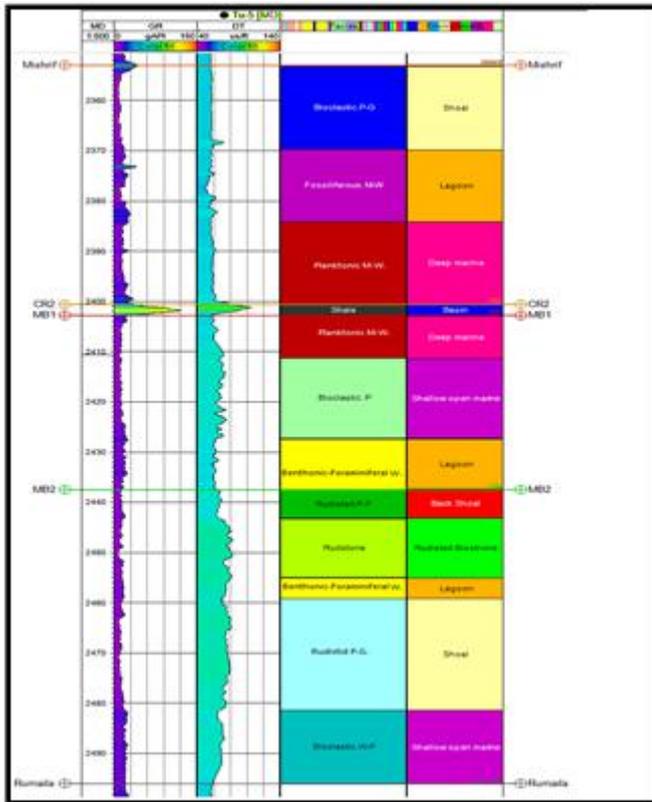


Fig.5: Facies associations and logs response of Mishrif Formation at well Tu15.

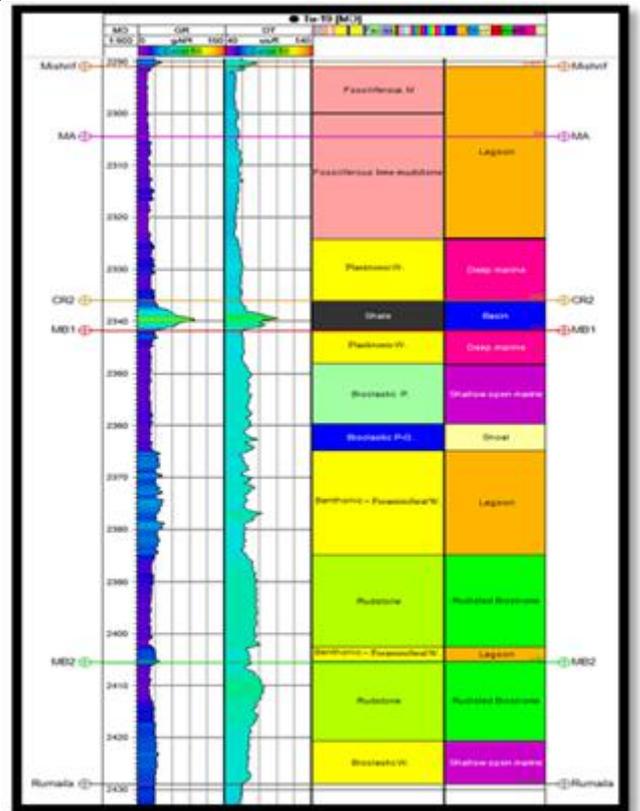


Fig.7: Facies associations and logs response of Mishrif Formation at well Tu19

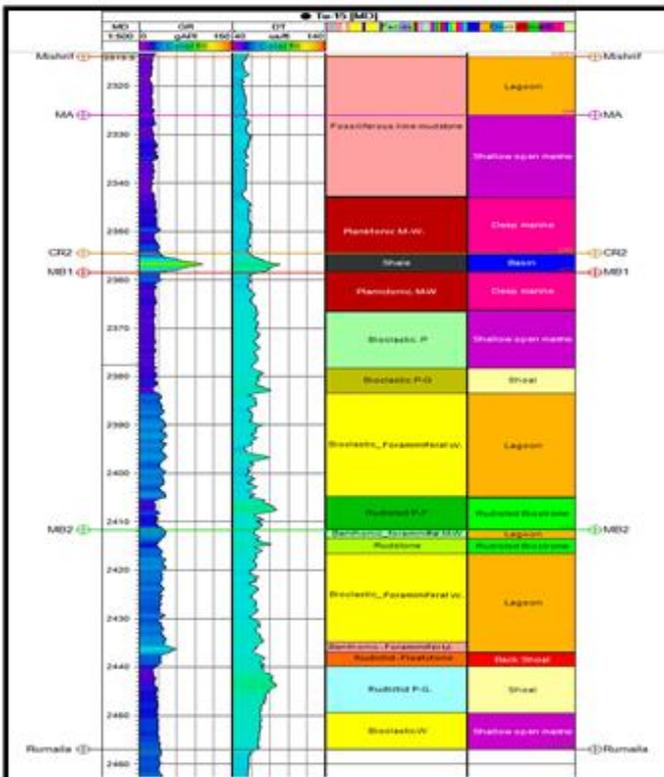


Fig.6: Facies associations and logs response of Mishrif Formation at well Tu5.

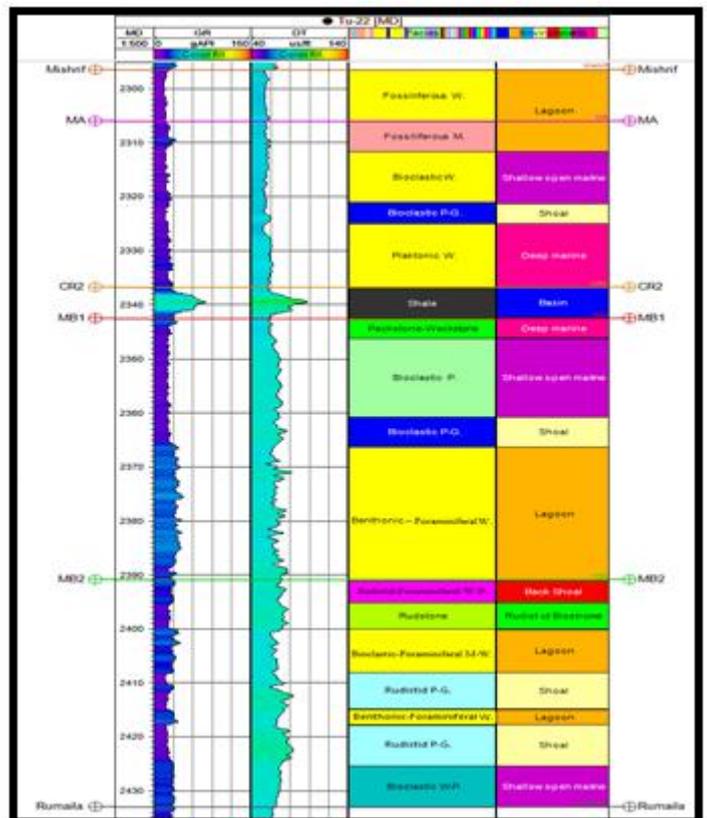


Fig.8: Facies associations and logs response of Mishrif Formation at well Tu22.

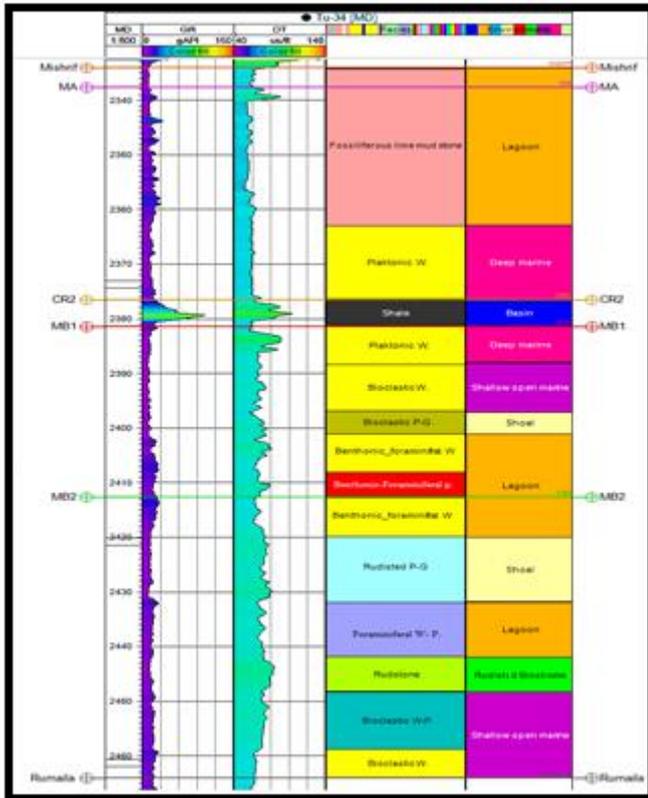


Fig.9: Facies associations and logs response of Mishrif Formation at well Tu34.

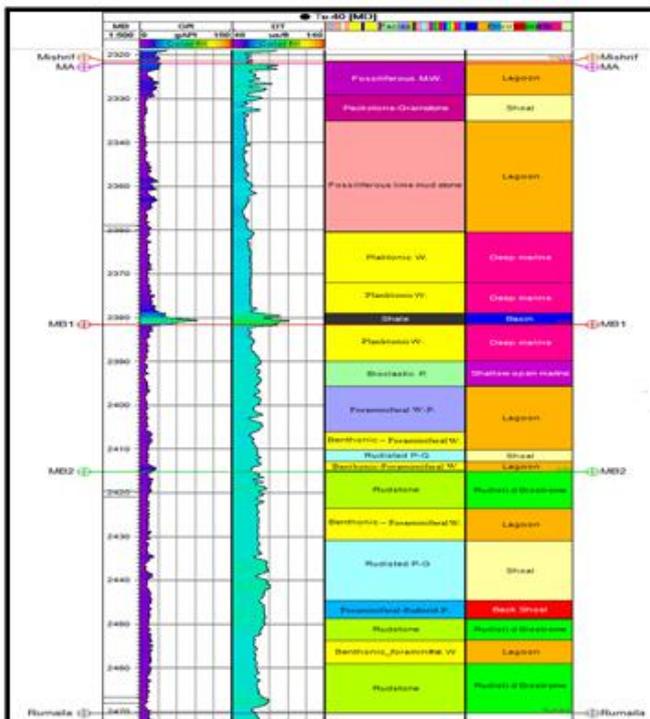


Fig.10: Facies associations and logs response of Mishrif Formation at well Tu40.

VIII. FACIES MODEL OF RESERVOIR UNITS

The 3D facies Model of Mishrif Formation in Tuba oilfield is shown in Figure (11). It was constructed by petrel software through importing facies association data. The model shows a nearly uniform distribution facies association along Tuba oilfield anticline. Most reservoir Facies (Shoal and Rudist biostrome) are stacked in the lower part of Mishrif Formation. They are capped by a thick succession of shallow open marine and deep marine facies (Figure 11). Each reservoir unit exhibits distinct lateral facies variations. Such variation among lagoon, shoal and rudist biostrome facies along the limbs of Tuba anticline forming stratigraphic traps (Figures 12 and 13). The units Top of Mishrif and MA is dominated by non-reservoir facies including lagoon, shallow open marine, and deep marine (Figures 14-16). In addition, isolated occurrence of shoal facies is clear at the flank and crest of Tuba anticline (Figures 16 and 17).

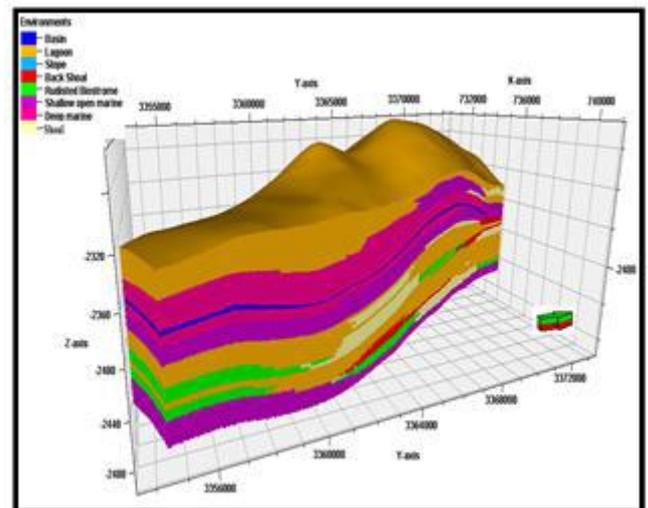


Fig.11: Facies and Environmental model for Mishrif Formation of Tuba oilfield.

Most homogeneous distributions of facies accrue in unit CR2, which consists mostly of basin facies with limited distribution of deep marine facies (Figure 18). Both facies associations form a cap unit with remarkable thickness at the top of unit MB1. This unit is characterized by intercalation of reservoir (Shoal, rudist biostrome) and non-reservoir facies (lagoon, back-shoal) at the lower part (Figures 15, 18, 21), forming stratigraphic trap as in unit MA. The vertical facies change in MB2 unit shows a shallowing upward trend, which is observed at the lower part of Mishrif Formation in several oil fields [1]. As with unit MB1, the unit MB2 includes potential reservoir facies that interbeds with lagoon and back shoal facies. However, the cap unit consists mainly of lagoon facies (Figures 22, 23, 24)

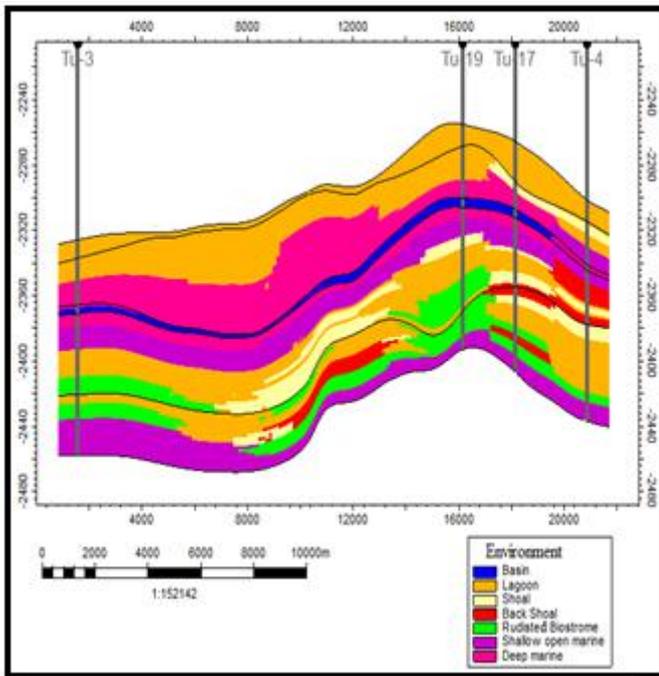


Fig.12: Cross section in direction NW-SE shows distribution of main depositional environments for Mishrif Formation in Tuba oil

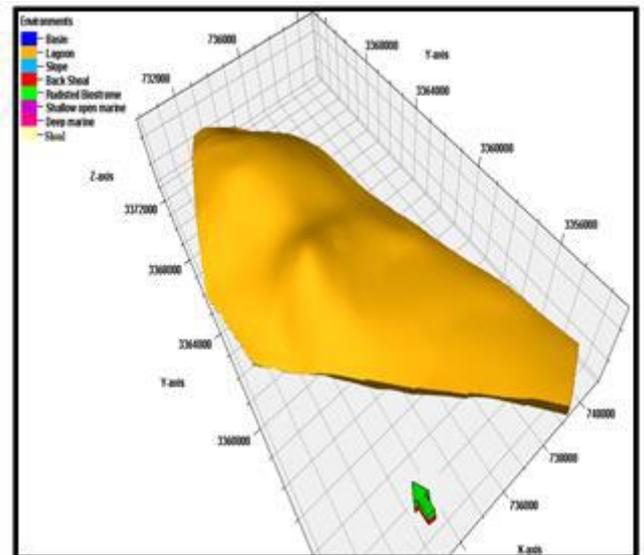


Fig.14: The facies model of Top of Mishrif unit for Mishrif Formation in Tuba oil field.

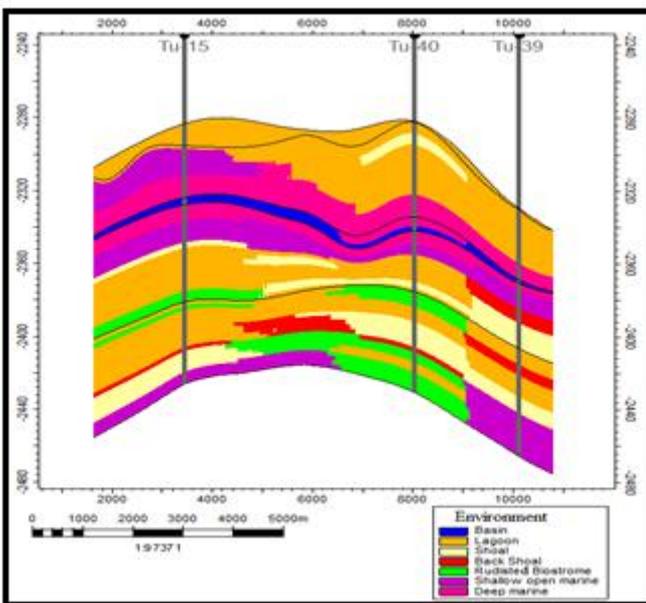


Fig.13: Cross section in direction WNW-ESE shows distribution of main depositional environments for Mishrif Formation in Tuba oil field

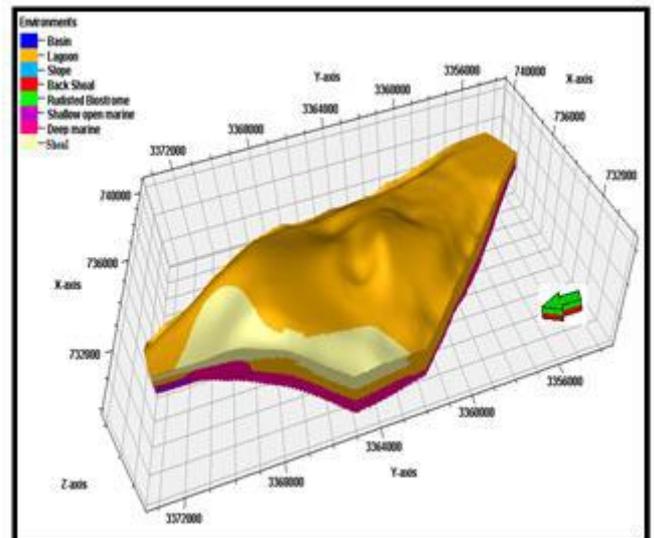


Fig.15: The facies model of MA unit for Mishrif Formation in Tuba oil field.

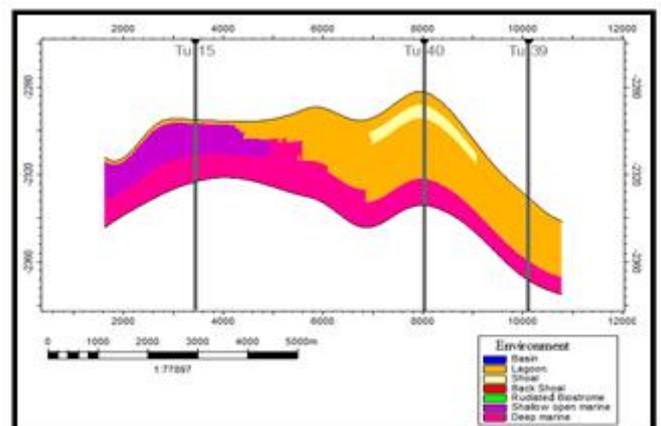


Fig.16: Cross section in direction WNW-ESE with facies of MA reservoir unit in Tuba oil field.

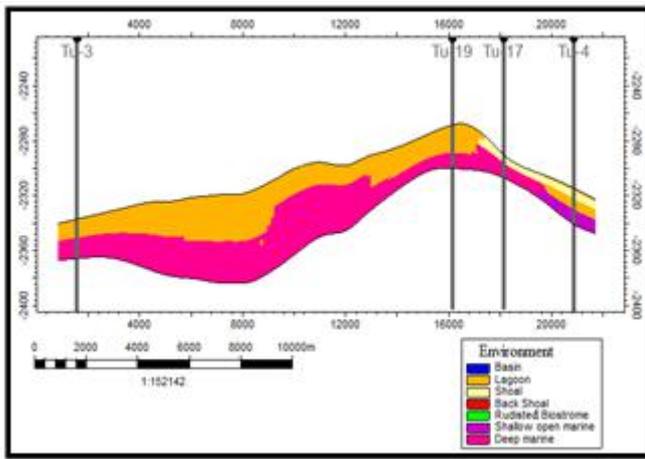


Fig.17: Cross section in direction NW-SE with facies of MA reservoir unit in Tuba oil field.

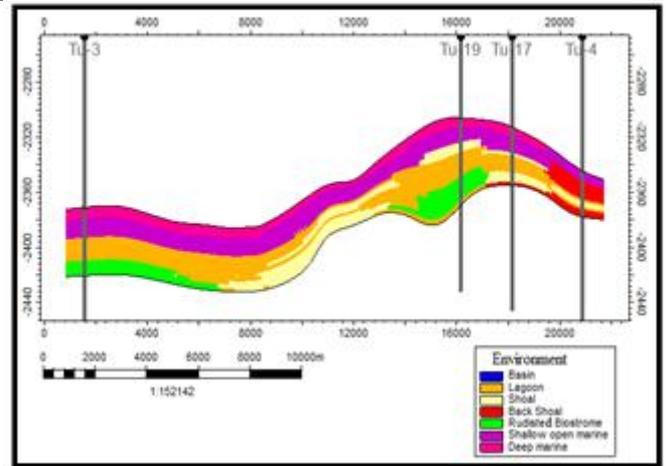


Fig.20: Cross section in direction NW-SE with facies of MB1 reservoir unit in Tuba oil field.

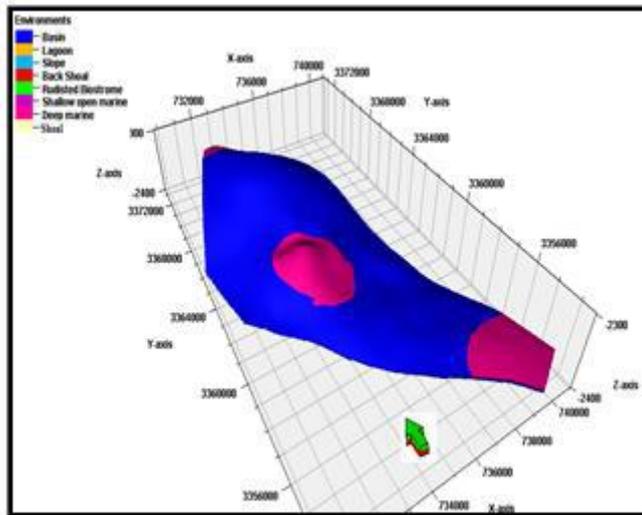


Fig.18: The facies model of CR2 unit for Mishrif Formation in Tuba oil field.

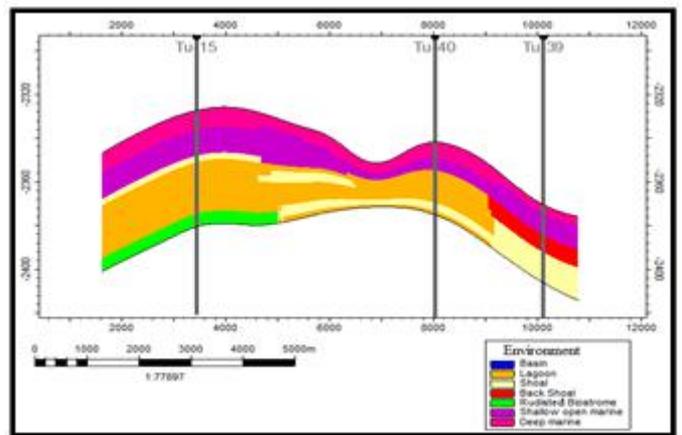


Fig.21: Cross section in direction WNW-ESE with facies of MB1 reservoir unit in Tuba oil field.

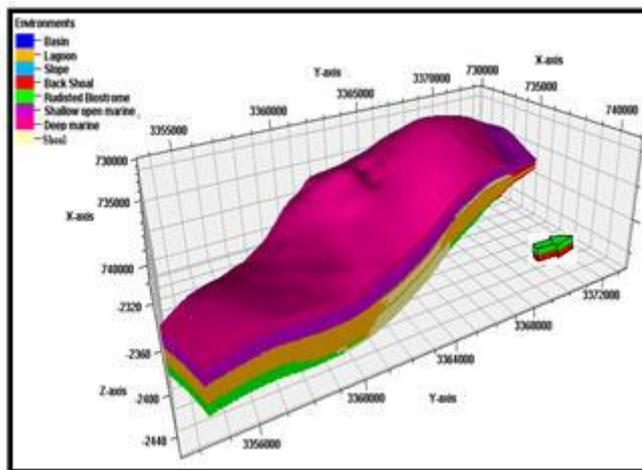


Fig.19: The facies model of MB1 unit for Mishrif Formation in Tuba oil field.

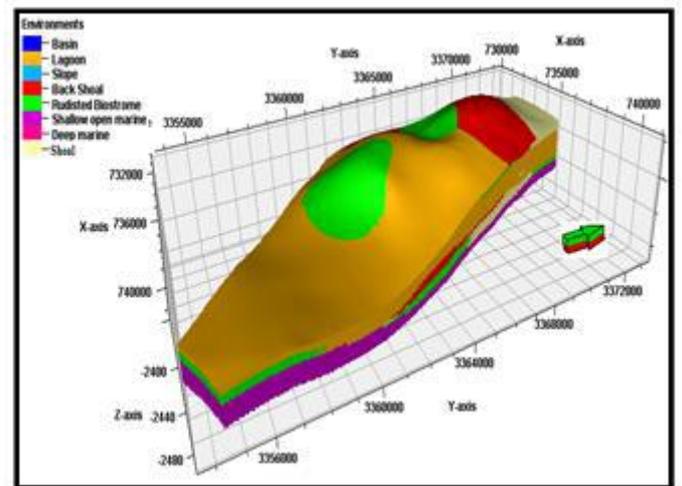


Fig.22: The facies model of MB2 unit for Mishrif Formation in Tuba oil field.

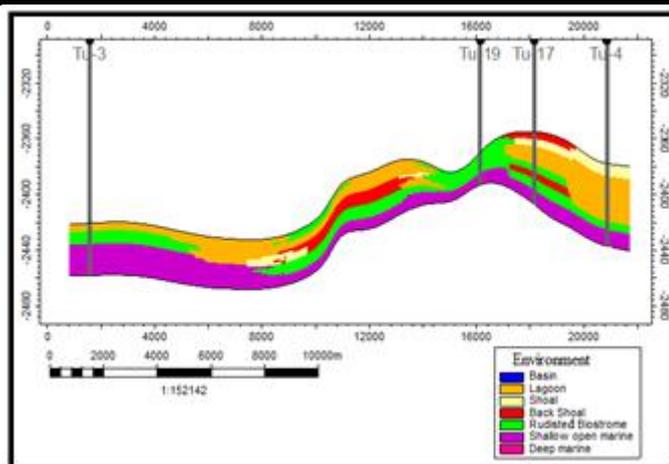


Fig.23: Cross section in direction NW-SE with facies of MB2reservoir unit in Tuba oil field.

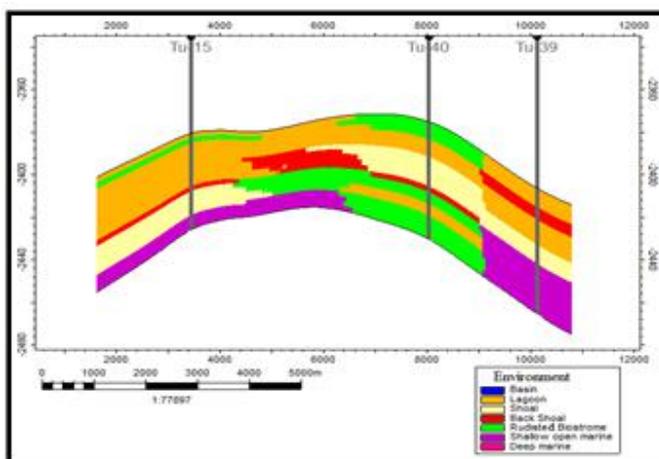


Fig.24: Cross section in direction WNW-ESE with facies of MB2reservoir unit in Tuba oil field.

IX. CONCLUSION

The Mishrif Formation in Tuba oilfield is subdivided into several reservoir unit that composed of different facies associations including basin, deep marine, shallow open marine, rudist biostrome, shoal, back shoal and lagoon. Their vertical and lateral distributions control the quality of reservoir units. The 3D facies model shows that reservoir units MB1 and Mb2 are most important due to the dominance of thick rudistid facies characterized by lateral distribution along Tuba anticline. Non reservoir units consists of basin ,deep marine, lagoon and shallow open marine facies association that mainly occur in units CR2 and MA. Unit CR2 represents the cap rocks in Tuba oilfield.

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REFERENCES

- [1] Mahdi, T.A., Aqrabi, A.A.M., Horbury, A., and Sherwani, G.H., 2013. Sedimentological characterization of the mid-Cretaceous Mishrif reservoir in southern Mesopotamian Basin, Iraq. *GeoArabia*, 18, 1, 139-174.
- [2] Aqrabi, A.A.M., Thehni, G.A., Sherwani, G.H. and Kareem, B.M.A., 1998. Mid-Cretaceous rudist-bearing carbonates of the Mishrif Formation: An important reservoir sequence in the Mesopotamian Basin, Iraq. *Journ. Petrol. Geol.*, v.21, p.57-82.
- [3] Bellen, R.C. Van, Dunnington., H.V., Wetzel, R. and Morton, D., 1959. *Lexique Stratigraphique Internal Asia*. Iraq. Intern. Geol. Congr. Comm. Stratigr, 3, Fasc. 10a, 333P.
- [4] Buday, T., 1980. *The Regional Geology of Iraq: Stratigraphy and Paleogeography*. Dar Al-Kutib house, University of Mosul, Mosul, Iraq, 445p.
- [5] Aqrabi, A.A.M., J.C. Goff, A.D.Horbury, and F.N. Sadooni, 2010. *The Petroleum Geology of Iraq: Scientific Press*, 424P.
- [6] Sadooni F.N., 2005. *The Nature and Origin of Upper Cretaceous Basin-Margin Rudist Buildups of the Mesopotamian Basin, Southern Iraq, with Consideration of Possible Hydrocarbon Stratigraphic Entrapment*, *Cretaceous Research* 26, Elsevier, 213-224 p.