MICROFACIES AND DEPOSITIONAL ENVIRONMENT OF MISHRIF FORMATION, NORTH RUMAILAOILFIELFD, SOUTHERN IRAQ

Maher Mandeel Mahdi
University of Basrah

Iraqi Geological Journal
Http://igj-iraq.org
Vol.52, No.2, 2019
ISSN 2414 - 6064

MICROFACIES AND DEPOSITIONAL ENVIRONMENT OF MISHRIF FORMATION, NORTH RUMAILAOILFIELFD, SOUTHERN IRAQ

[1]Muslim M. Al-Ali, [2]Maher M. Mahdi*, [3]Rasha A. Alali

[1]Basrah Oil Company, Ministry of Oil, Basrah, Iraq

[2]Geology Department, College of Science, University of Basrah,

[3]Geology Department, College of Science, University of Basrah

*E-mail: maher_mandeel@yahoo.com

Received: 29 April 2019; accepted: 15 June 2019

ABSTRACT

Mishrif Formation is one of the main oil reservoirs in southern Iraq. This study analyzes the microfacies and depositional environment for Mishrif Formation in North Rumaila oilfield. The study was based on the analysis of 17 wells core. The Mishrif Formation represents deposition in a carbonate platform ramp system, with scattered patch reefs and shoals developed across the ramp margin and the platform top. It is characterized by skeletal grains (bioclasts) which are dominated such as foraminifera, rudist, calcareous Algae and other skeletal grains included mollusks shell fragments with Chondrodonta sometimes, and Echinoderms while non-skeletal grains are less abundant which are represented by Peloids and Ooids. According to the petrography analysis of Mishrif Formation, the fossils are dominated in the formation, four groups of these fossils are diagnosed, and these are Oligosteginid, Alveolinids, Dicyclina and Miliolids. Can be identified and build the sedimentary model with microfacies which apply to the Mishrif Formation. The sedimentological and stratigraphic analysis of Mishrif Formation core led to identification of 16 facies association, seven of which are found in the mB unit (lower part of the Formation) whereas they are deposited in outer ramp, mid ramp, ramp margin and lagoon, while nine in the mA unit (upper part of the formation) which are deposited in intraplate basin, mid ramp, inner ramp, ramp margin and lagoonal supra tidal.

Keywords: Mishrif Formation; Rumaila oilfield; Microfacies; Sedimentary model

INTRODUCTION

Mishrif Formation is the most significant carbonate reservoir unit in the south of Iraq, it includes up to 30% of the total Iraqi oil reserves (Aqrawi et al., 2010), The formation is composed of thick carbonates of middle Cenomanian–early Turonian age (Chatton and Hart, 1961), which deposited on a basin-wide shallow-water platform, accommodation space was supplied by a major eustatic sea-level rise in the middle Cenomanian (Haq et al., 1987). The Mishrif and underlying Rumaila formations were originally described in southern Iraq in well Zb-3 in Zubair oilfield (Aqrawi et al., 2010). The contact between the Mishrif and Rumaila formations is gradational, the Mishrif Formation is unconformably overlain by the Khasib Formation (Aqrawi, 1995). Th e microfacies of Mishrif Formation were classified into mud or grain-supported textural types according to Folk's (1962) and Dunham's (1962), adjusted by Embry and Klovan (1972) and revised by Wright (1992).

STUDY AREA

North Rumaila oilfield is a giant oilfield located in southern Iraq which is approximately 32 Km far from Kuwait border and about 50 km west of Basra city. It lies between the coordinates 47°16'46"–47°26'14" E and 38°28'34"–38°42'30.8" N. The longitudinal axis of the North Rumaila oilfield is about 30 km, while the width is about 20 km. It is covered by an area of about 600 km^2. Zubair, Tuba oilfields located at the east, while West Qurna oilfield located at the north and Ratawi oil field in the west of North Rumaila oilfield, it is consisted of subsurface anticlines which are trending N-S (Karim, 1992), it is separated by saddle form south Rumaila oilfield subsurface anticlines (Jaffar, 2018) (Fig. 1). The present works aim to study of Microfacies of Mishrif Formation and to determine the sedimentary model of the formation with important fossils.

METHODOLOGY

Methodology in this study includes the following:

1. Collection data: Twenty-two core samples were cut, these core samples distribute on seventeen wells in the study area, and the wells have been selected according to the location of each well in the North Rumaila oilfield and availability of core interval covering almost all units of Mishrif Formation (Fig. 2).
2. Core description with a correction to the depth for core sample interval with wireline log depth.
3. Two hundred and eight conventional thin-sections have been for studied the petrography and microfacies of Mishrif Formation on the seventeen wells along the North Rumaila oilfield.

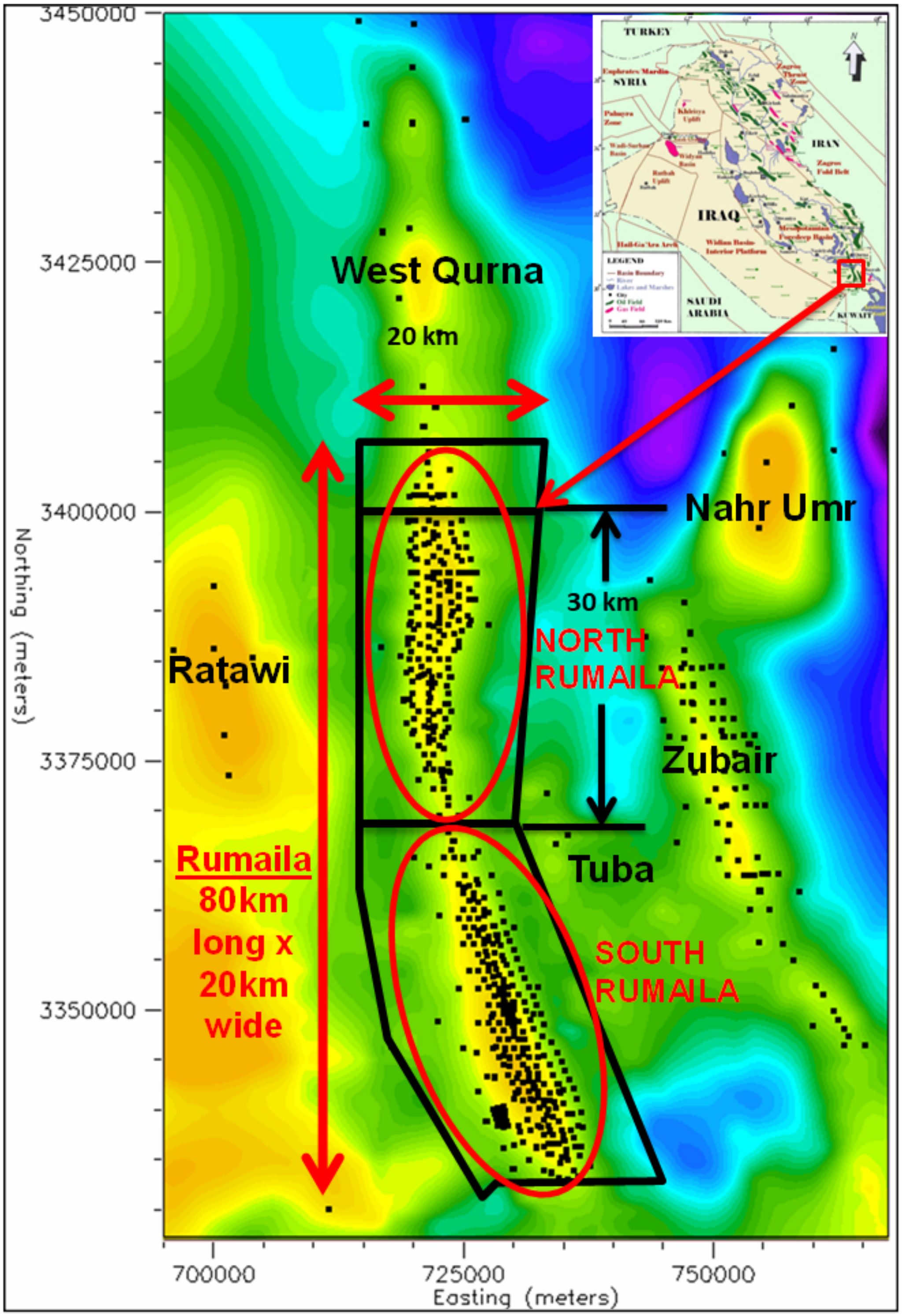

Fig. 1: Location map of the Rumaila oilfield

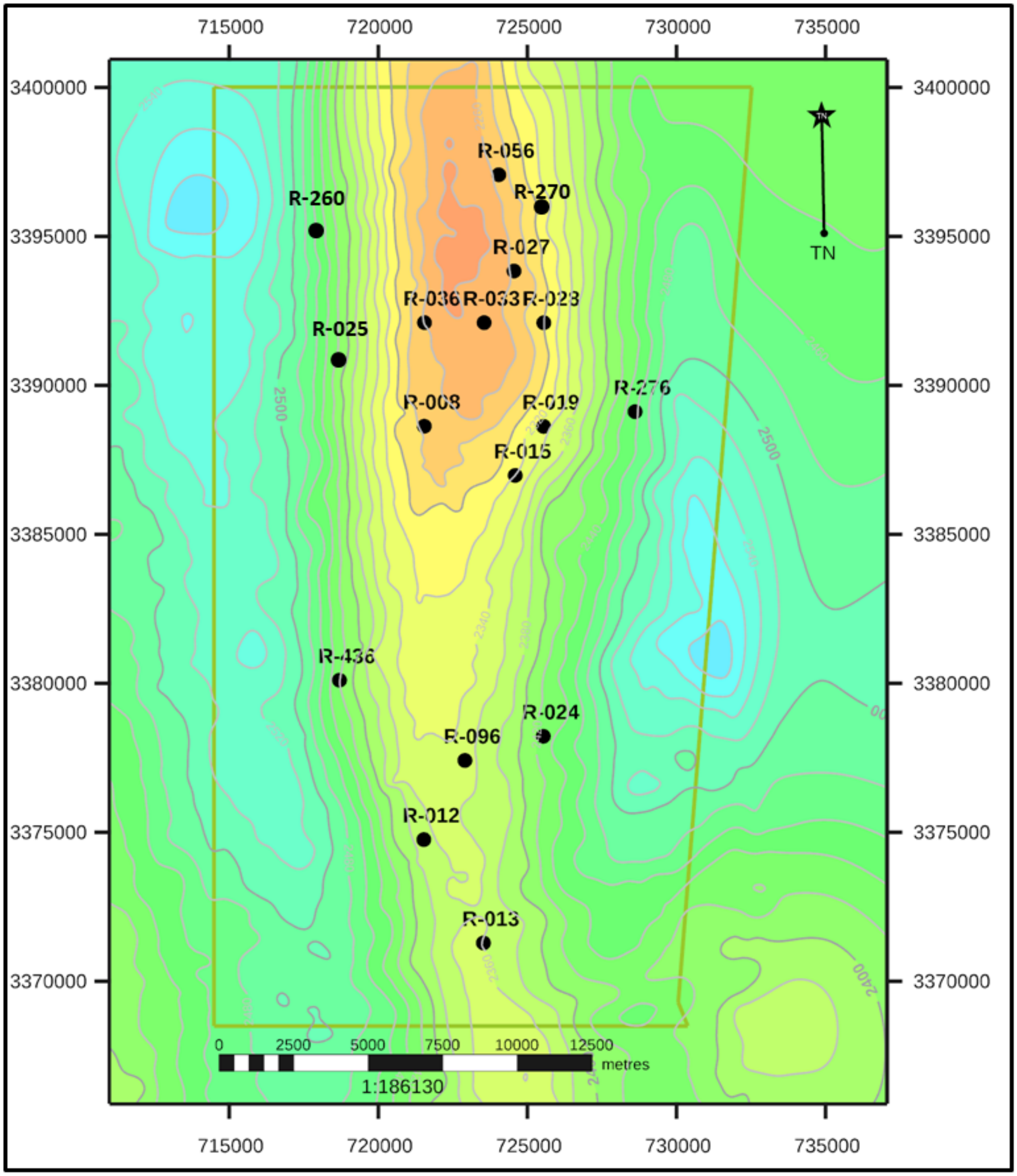

Fig. 2: Distribution of core wells in the study area (North Rumaila oilfield)

MICROFACIES

The microfacies analysis of the Mishrif Formation core led to the identification of sixteen microfacies, seven occur in the (lower part of the formation) and nine in the mA (upper part of the formation) depending on South Oil Company division.

Microfacies in the mB Interval

Benthonic Foraminiferal Lime-Wackestone Microfacies

This microfacies including miliolids and alveolinids, common gastropod fragments, with peloids, this biofacies are readily identifiable due to the abundant preferential dolomitization of burrows/cavity fills, abundant burrowed hardgrounds, karstic features affecting the tight and muddy sediments, it is present in the most of the study area, locally creating thick continuous successions in wells R-033, R-056, R-036, R-025 and R-436. The standard of microfacies (SMF) of these facies is 16 & 17 which lie within facies zone (FZ) 8 (Flugel, 2010) (Fig. 3).

Prealveolinids and Dicyclinid Lime-Wackestone to Packstone Microfacies

This microfacies is defined by the presence of large prealveolinids and dicyclinids, also it has large rudist fragments. Bioturbation was noticed in this microfacies. Textures are more heterogeneous and porous than Wackestone benthic foraminiferal biofacies. This association is variably present in the study area wells, while in R-027, R-033 and R-436 it is poorly developed. The SMF of these facies is 9&11 which lie within FZ (6&7) (Flugel, 2010) (Fig.3).

Benthonic Foraminiferal Lime-Packstones to Grainstone Microfacies

This microfacies is characterized by fine to relatively coarse-grained packstones to grainstones dominated by fine echinoderm debris and benthonic foraminifera (miliolids and textulariids). The observed facies are very similar to those occurring in mixed rudist/bivalve/echinoderm lime-packstone to lime grainstone biofacies and can be differentiated mainly based on slight compositional differences (mainly through microscopic analysis). In core, this biofacies appears to be relatively less sorted and with slightly more heterogeneous textures than mixed rudist/bivalve/echinoderm lime-packstone to lime-grainstone biofacies. This group is present in R-027, R-036, R-056 and R-025. The SMF of these facies is 11&12, which lie within FZ (6) (Flugel, 2010) (Fig.4).

Fossiliferous Lime-Packstones to Grainstone Microfacies

Comparatively fine to medium-grained packstones to grainstones comprising abundant bivalve (rudist) and echinoderm debris, with following to benthic foraminifera. In thin-section increased bivalve content of these biofacies relative to Echinoderm and benthic foraminifer's lime-packstones to grainstone microfacies visible. Slightly more argillaceous layers and rudist fragments present in these biofacies. Small echinoderm fragments are recorded. It is present in R-033, R-036, R-027, R-019 and R-056. The SMF of these facies is 12&13 which lie within FZ (5&6) (Flugel, 2010) (Fig.4).

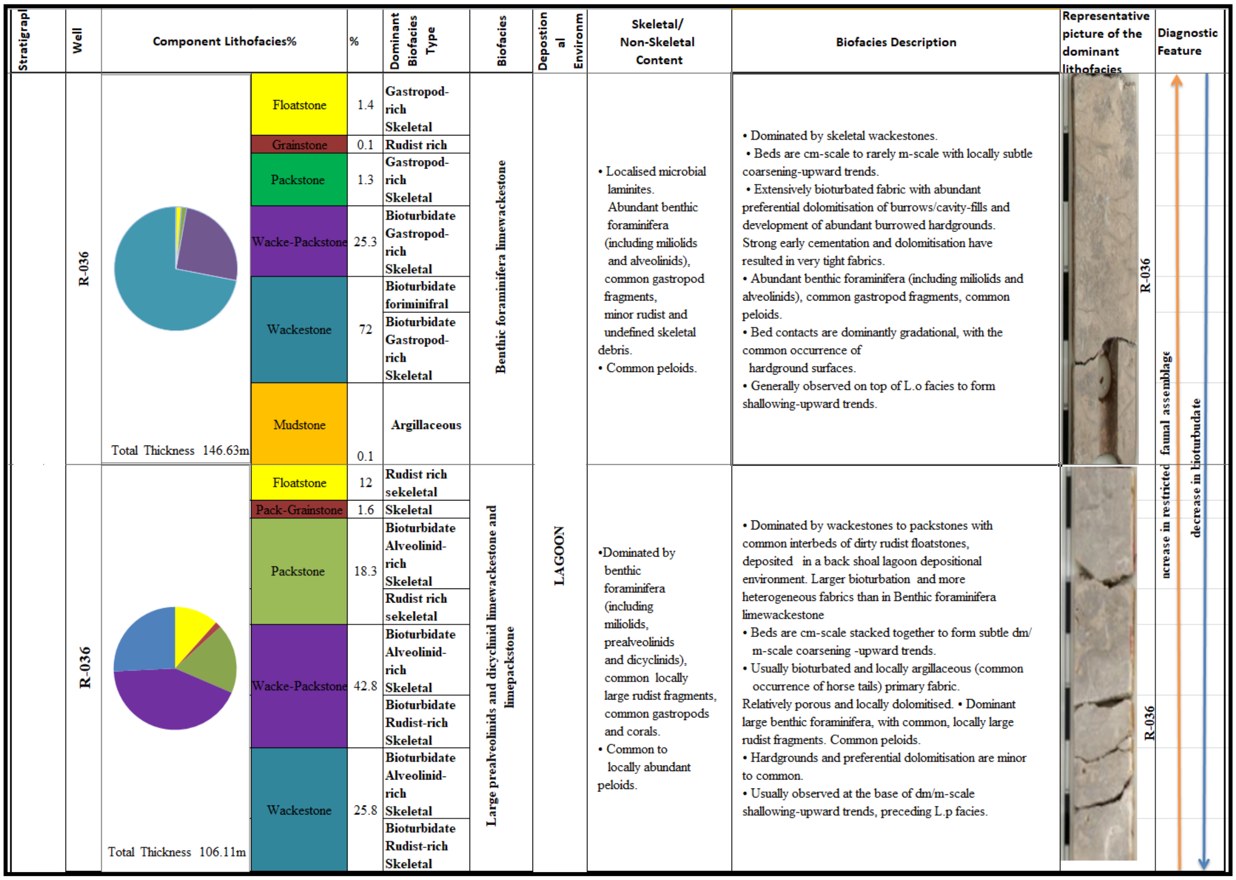

Fig.3: Distribution of microfacies on mB unit of Mishrif Formation with core description of the same interval

Rudist Lime-Packstone to Rudstone Microfacies

This biofacies is defined by the abundance of large rudist content within strongly filtered packstone to rudstone textures, with subordinate muddier wackestone to floatstone textures. Fabrics are usually massive and merged with no visible bed-scale trends and rare possible lamination. This biofacies association is commonly observed throughout the study area. The SMF of these facies is 7&12 which lie within FZ (5) (Flugel, 2010) (Fig.5).

Benthonic, Planktonic Foraminiferal Lime-Wackestone to Packstone Microfacies

The muddy texture of this biofacies is characterized by strong bioturbation and fine seams resulting in common pseudo-nodular texture. Grey to black chert nodules are common and the skeletal content is represented by minor undifferentiated skeletal fragments, benthic and planktonic foraminifera only visible in thin section. Moderate cementation and poor to moderate micropore-dominated pore systems. This biofacies are observed in wells R-012, R-013, R-024 and R-028. The SMF of these facies is 5&6 which lie within FZ (4) (Flugel, 2010) (Fig.5).

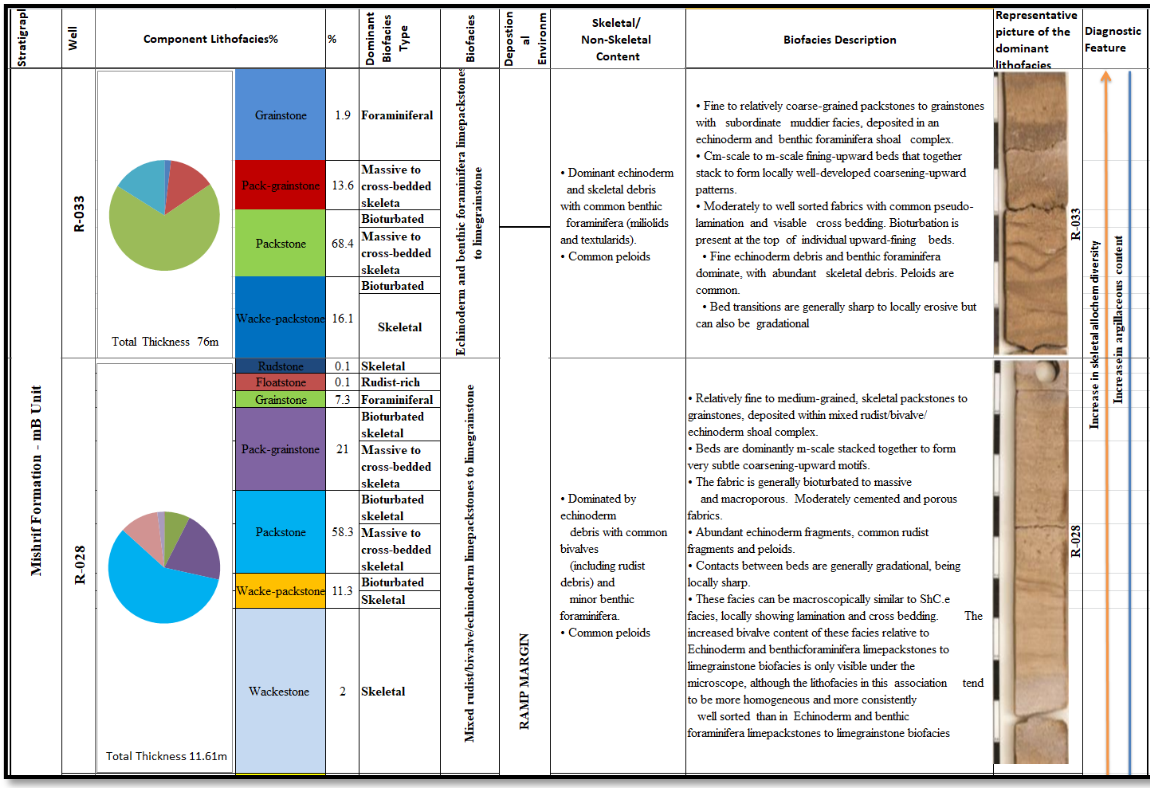

Fig.4: Distribution of benthonic foraminiferal lime-packstones of grainstone microfacies with fossiliferous lime-packstones to grainstone microfacies in mB unit

Oligosteginids Lime-Mudstone to Wackestone Microfacies

Argillaceous, laminated and bioturbated mudstones to wackestones with black chert nodules. Very fine-grained skeletal allochems from planktonic foraminifera and Oligosteginids were diagnosed. This biofacies observed at the base of mB unit in well R-036, R-096 and R-024. The SMF of these facies is 2&3 which lie within FZ (2&3) (Flugel, 2010) (Fig.5).

Microfacies in the mA Interval

Benthonic Foraminifera Lime-Wackestone to Packstone Microfacies

This biofacies is defined by the abundant benthic foraminifera, algal crusts and gastropods. The beds are arranged in subtle coarsening-upward trends. Mainly represented by intraclasts-rich wackestones to packstones, showing highly variable fabrics, from microbial laminates to pisolitic and brecciated fabrics. Abundant cracks and green clay in fills. Common stylolitised contacts, erosive surfaces and hardgrounds characterize these biofacies. These biofacies present in the lower part of the study area (R-012, R-013, R-436). The SMF of these facies is 20 & 23 which lie within FZ (9) (Flugel, 2010) (Fig. 6). Dicyclinids lime-Wackestone to Packstone microfacies. This microfacies is dominated by bioturbated wackestones to packstones with abundant benthonic foraminifera and gastropods. It is characterised by the presence of abundant large benthonic foraminifera especially dicyclinids with gastropod fragments and by the absence of large rudist fragments. This biofacies is observed in the northern part of the study area (R-019, R-027, R-033, and R-036). The SMF of these facies is 18 & 19 which lie within FZ (8) (Flugel, 2010) (Fig. 6).

Peloidal Lime-Packstone to Grainstones Microfacies

Coated grain, aggregate grain and peloids-dominated packstone to grainstones with rare wacke-packstones forming thin beds only occurring in wells R-028 and R-036. Benthic foraminifera are generally observed at the nuclei of coated grains. The SMF of these facies is 11 & 16 which lie within FZ (6 &7) (Flugel, 2010) (Fig.6).

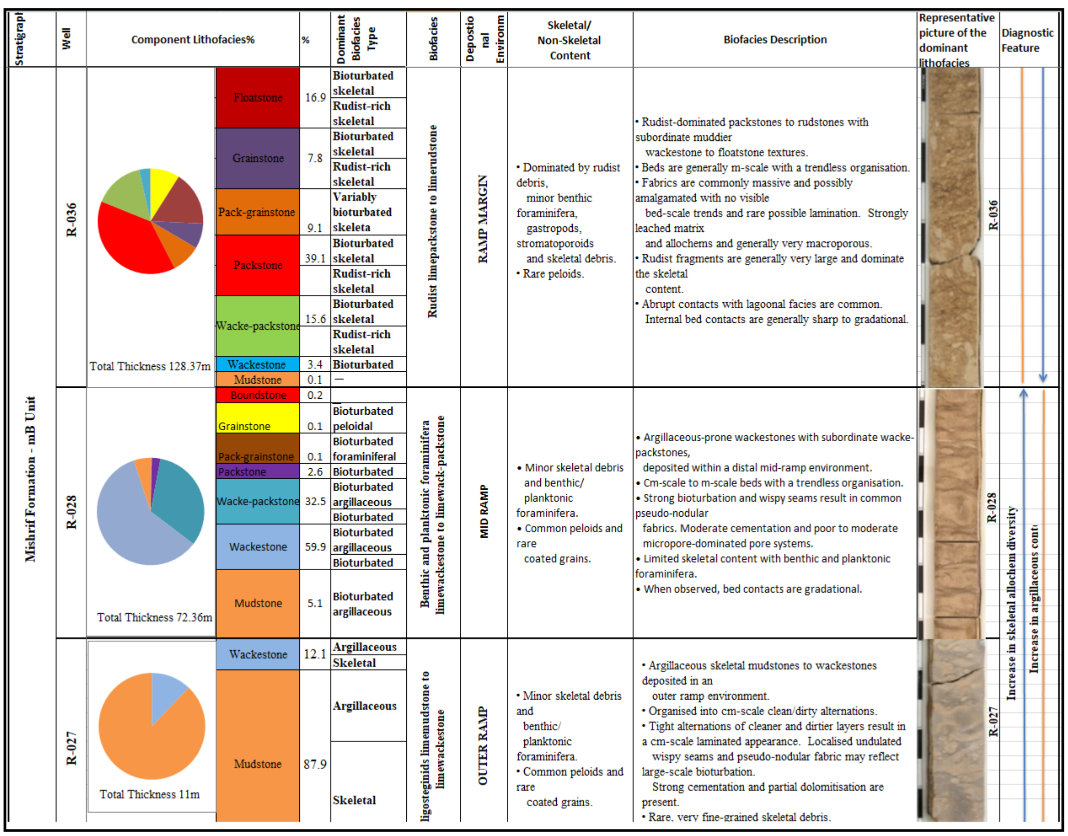

Fig.5: Distribution of rudist lime-packstone to rudstone microfacies, benthonic and planktonic foraminiferal lime-wackestone to packstone microfacies with Oligosteginids lime-mudstone to lime-wackestone microfacies in mB unit

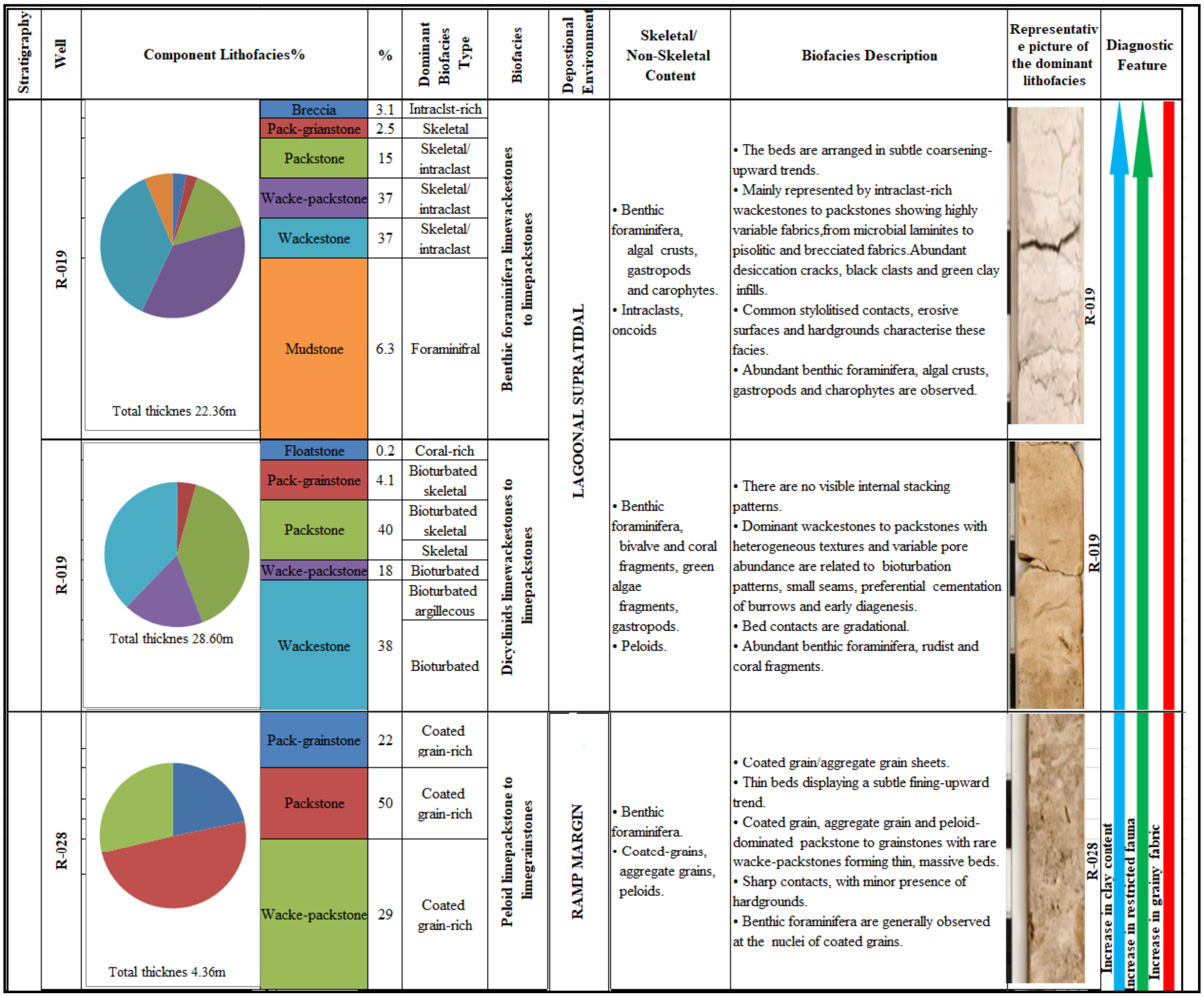

Fig. 6: Distribution of benthonic foraminifera lime-wackestones to packstones microfacies, dicyclinids lime-wackestones to packstones microfacies with peloidal lime-packstone to grainstones microfacies in mA unit

Rudist-Coral Lime-Wackestone to Packstone Microfacies

Variably rudist and/or coral are dominated in this microfacies, wacke-packstones and sometimes floatstone with subordinate gastropods, benthic foraminifera and another reef-building ecology are classified to this microfacies. This biofacies in the mA zone Mishrif Formation, generally show more disorganized and preferentially cemented and fractured textures, with massive beds stacked in no clear stratigraphic trends. This biofacies occurs in wells R-027, R-028 and R-036, with possible very thin intervals in R-019. The (SMF of these facies is 7 which lie within FZ (5) (Flugel, 2010) (Fig.7).

Large Benthonic Foraminiferal Lime-Wacke to Packstone Microfacies

Strongly bioturbated wacke to packstones with subordinate wackestones usually characterized by a clay/organic-rich bioturbated mudstone at the base, which contains a hardground. This biofacies present a more intense large-scale bioturbation and dominant large benthic foraminifera (dicyclinids) that are not observed in the mB unit. This biofacies present throughout the study area except for R-019. The SMF of these facies is 4&7 which lie within FZ (4&5) (Flugel, 2010) (Fig.7).

Benthonic Lime-Packstone to Grainstones Microfacies

Packstones to grainstones typically dominated by peloids, aggregate and coated grains, with rare planktonic foraminifera. These facies occur in R-012, R-436. Locally rudist-rich wacke-packstone to floatstone with common benthic foraminifera (miliolids) and no planktonic foraminifera. This particular biofacies is only observed in R-027. The SMF of these facies is 4&6 which lie within FZ (4) (Flugel, 2010) (Fig.8.)

Planktonic Lime-Wackestone Microfacies

Strongly bioturbated wackestones with a pseudo-nodular texture are associated with the large, relatively clean burrows, and the common thin seams surrounding them. Black chert nodules are locally present and a hardground surface is observed in the lowermost part of the succession. These facies are similar to large benthonic foraminiferal lime-wacke to lime-packstones biofacies, but can be distinguished due to the largely limited skeletal content (mainly planktonic foraminifera). This biofacies observed in R-025 and R-033 where texture is slightly grainier. The SMF of these facies is 4&3 which lie within FZ (3) (Flugel, 2010) (Fig.8).

Ostracod Lime Wackestone with Mudstones Microfacies

This microfacies characterized by thin-layered and small laminated, mm to cm-scale bioturbated wackestones with subordinate mudstone textures and common argillaceous content. Beds are cm-scale and are arranged in lighter/darker colour alternations, reflecting variable clay content and microporosity distribution. Ostracod has been observed. This biofacies is occurred in well R-033 and R-025. The SMF of these facies is 3 which lie within FZ (3) (Flugel, 2010) (Fig.8).

Planktonic Lime-Mudstones Microfacies

This microfacies recognize by thin-layered to locally small laminated, bioturbated mudstones with variable abundance of organic matter. Organic-rich intervals comprise black, Shaly mud rocks with no visible skeletal content, resulting in a very distinct appearance. More carbonate-rich layers are thicker and lighter in color, with common planktonic foraminifera, rare to minor ostracod fragments and local bioturbation. The SMF of these facies is 1 which lie within FZ (2&1) (Flugel, 2010) (Fig.8).

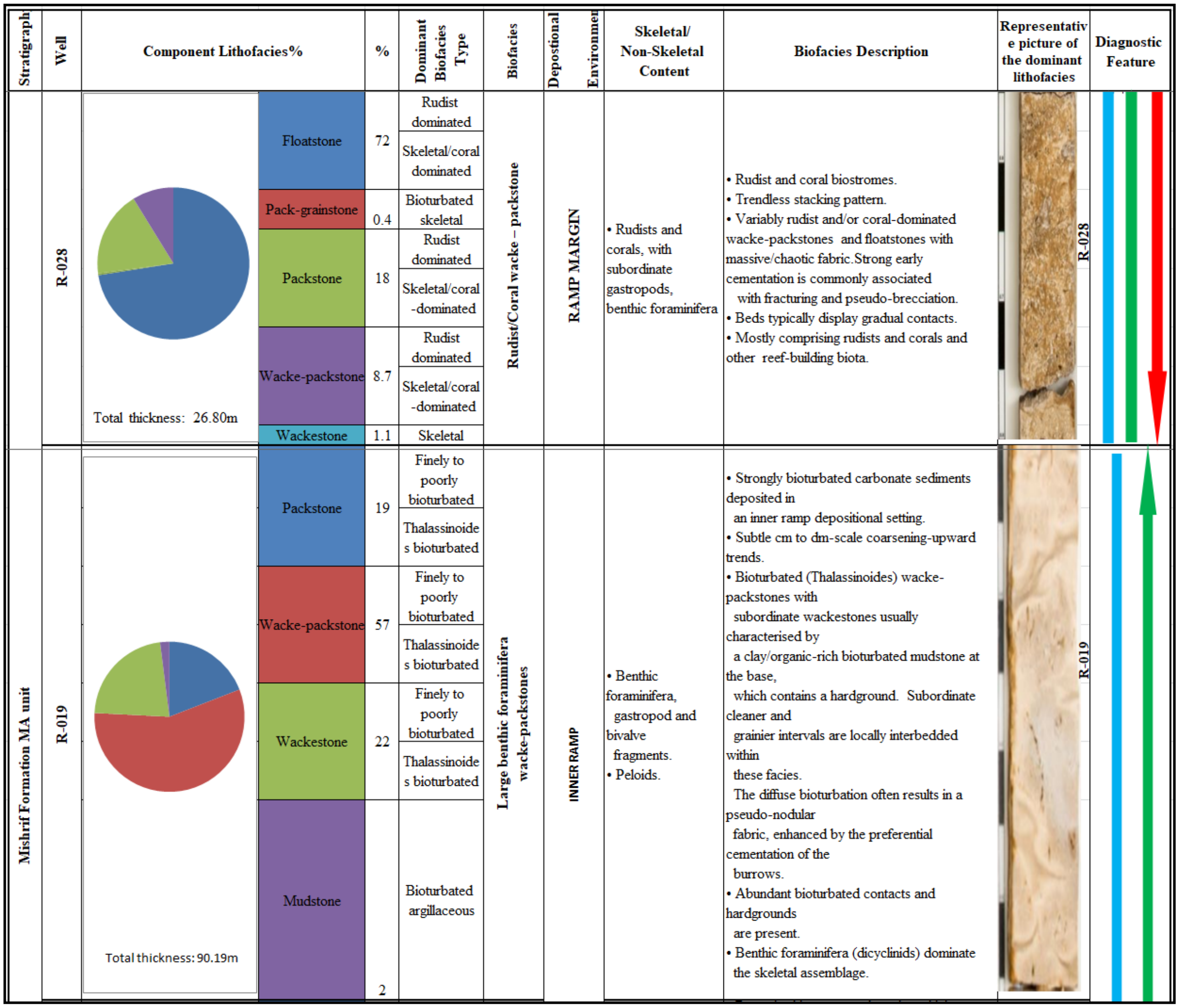

Fig. 7: Distribution of rudist-coral lime-wackestone to lime-packstone microfacies with large benthonic foraminiferal lime-wacke to lime-packstones microfacies in mA unit

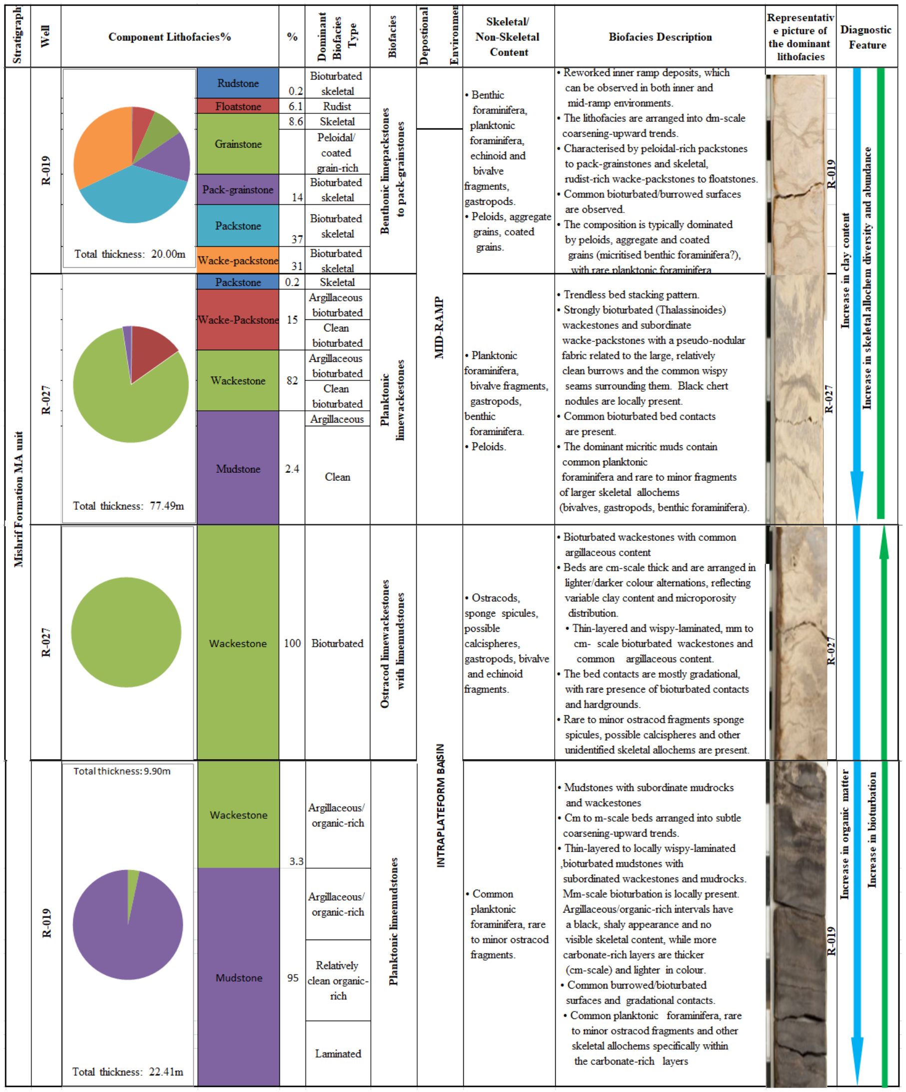

Fig.8: distribution of benthonic lime-packstones to lime-grainstones microfacies, benthonic lime-packstones to lime-grainstones microfacies, ostracod lime wackestones with lime-mudstones microfacies and planktonic lime-mudstones microfacies in mA unit

Sedimentary Environment

The depositional model of Mishrif Formation was built from the results of the microfacies analysis applying Flagel's chart for the biofacies, the formation is characterized by four types of biofacies as follows:

a. Oligosteginid/planktonic foraminiferal association: forming fine-grained (micritic) wackestones/packstones identified in open marine environment.

b. Alveolinid association: forming coarse, foraminiferal/bioclastic packstones - wackestones, sometimes associated with reefal debris identified in peri-reefal, unrestricted marine environment.

c. Dicyclina/high diversity foraminiferal association: forming coarse, foraminiferal/bioclastic packstones/grainstones, sometimes associated with dasycladacean/algal debris identified in unrestricted lagoon, back reef/shoal.

d. Miliolid/low diversity foraminiferal association: forming medium-fine, foraminiferal/bioclastic packstones - wackestones, sometimes associated with dasycladacean debris identified in restricted lagoon environment.

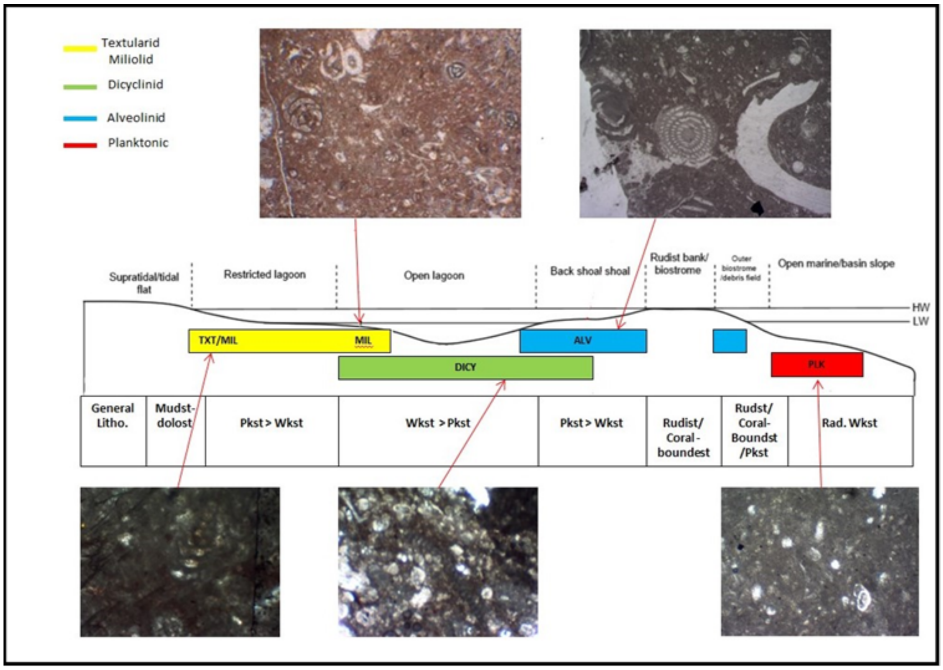

Fig.9: Suggested sedimentary model of microfacies to the Mishrif Formation at North Rumaila oilfield

CONCLUSION

The Mishrif Formation in the North Rumaila oilfield as represents as a carbonate platform ramp system, with scattered patch reefs and shoals developed across the ramp margin and the platform top.

- Echinoderm and benthic foraminifera-dominated shoal facies appear to have prefer to develop on platform top settings, whilst the rudist and echinoderm-dominated shoal facies present across a more spread area, both in front and behind the rudist patch reefs, mainly within the platform margin.
- Thick sedimentation of grainy shoal facies was consist deposited around the R-027/R-033 area on the platform top, while surrounding areas were characterized by lagoonal sedimentation.

- In mB, reservoir quality appears to be best developed in the grainy shoal and patch reef facies mainly found in the platform margin in the lower part of mB, but also happening as limited bodies in the wide lagoonal setting in the upper part of mB. Diagenetic control on reservoir quality is controlled by depositional fabrics and composition. Open lagoon facies commonly moderate reservoir quality within a mixed micropore/macropore-dominated pore system and can supply a degree of connectivity between the mixed grain-rich bodies. Mid-ramp facies also moderate reservoir quality within micrite-dominated pore system, while peritidal lagoon and outer ramp facies characterized by poor quality reservoir with high cemented and non- microporous which is represent good barrier between upper part and lower part of mB, which can prevent vertical fluid flow between the better quality, grain-rich facies of lower and upper part of mB unit
- In mA unit, the best reservoir quality is occurred in the grainier facies associated with biostromes and grain sheets. However, these facies can be locally affected by strong cementation, causing a decrease in reservoir quality (low porosity and low permeability). In the micritic facies of the inner ramp and open lagoon facies associations the quality reservoir for mA unit is moderate. Intertidal to supratidal facies which are found in the upper part of mA unit in well R-012, R-013 and R-436 are associated with poor reservoir quality due to the strong diagenesis especially cementation process modification affecting most beds.

REFERENCES

Aqrawi, A.A.M., 1995. Brackish-water and evaporitic Ca–Mg carbonates in the Holocene Lacustrine/deltaic deposits of southern Mesopotamia. J Geol Soc Lund, 152:259-268.

Aqrawi, A.A., Goff, J.C., Horbury, A.D., and Sadooni, F.N., 2010. The petroleum geology of Iraq. Scientific Press.

Chatton, M., and Hart, E., 1961. Review of the Cenomanian to Maastrichtian stratigraphy in Iraq. INOC Library, Baghdad, 2:141.

Dunham, R.J., 1962. Classification of carbonate rocks according to depositional texture. In: Ham WE (ed) Classification of carbonate rocks: American Association of Petroleum Geologists Memoir, 108–121.

Embry, A.F., and Klovan, J.E., 1972. Absolute water depth limits of Late Devonian paleoecological zones. Geologische Rundschau, 61(2): 672-686.

Flugel, E., 2010. Microfacies of carbonate rocks: analysis, interpretation and application. Springer Science & Business Media, Perlin, 984 pp.

Folk, R.L., 1962. Spectral subdivision of limestone types. In: Ham WE (ed) Classification of Carbonate Rocks-A Symposium: American Association of Petroleum Geologists Memoir, pp 62–84.

Haq, B.U., Hardenbol, J., and Vail, P.R., 1987. Chronology of fluctuating sea levels since the Triassic. Science, 235:1156-1167.

Jaffar, H.M., 2018. Structural Geology of Rumaila Oilfield in Southern Iraq from Well Logs and Seismic Data, Unpub. M.Sc. theses, University of Basrah.

Karim, H. H., 1992. Structural nature of lower Mesopotamian region from geophysical observations. In Proceeding of 3rd symposium on Oceanography of Khour Al-Zubair, Marine Science Center Basrah, 15-25 pp.

Wright, V.P., 1992. A revised classification of limestones. Sedimentary Geology,76 (3-4):177-185.