IRAQI BULLETIN OF GEOLOGY AND MINING (IBGM)
IRAQ GEOLOGICAL SURVEY (GEOSURV-IRAQ)

Vol.20, No.1, 2024 ***p 1 – 20***

MICROFACIES ANALYSIS OF THE MISHRIF FORMATION (MID-CRETACEOUS) AT THE TUBA AND ZUBAIR OILFIELDS, SOUTHERN IRAQ

Ayhem A. Dawood[1*], and Salam I.M. Al-Dulaimi[2]

[1] Department of Earth Science, College of Science, University of Baghdad,
[*]Correspondence e-mail: Ayhem94@yahoo.com
[2] Department of Earth Science, College of Science, University of Baghdad,
e-mail: salamgeo2018@gmail.com

Type of the Paper: Article
Received: 27/ 05/ 2023
Accepted: 17/ 07/ 2023

Keywords: Mishrif Formation; Tuba and Zubair Oilfields; Microfacies analysis; Southern Iraq.

ABSTRACT

The Cenomanian-Early Turonian Mishrif Formation, which has been studied in selected Oilfields of Tuba Well (TU-5, TU-24, TU-40) and Zubair Well (ZB-41, ZB-42, and ZB-46), which are located in the Mesopotamian basin, southern Iraq, and considered major carbonate reservoir in Iraq and the Arabian Gulf. Seven microfacies types are identified showing that Mishrif formation deposited in five sedimentary facies: **1.** Basin Facies Associations; **2.** Deep Marine Facies Associations: Bioclast pelagic foram mudstone-wackestone; **3.** Shallow Open Marine Facies Associations: Foraminiferal bioclastic wackestone-packstones; **4.** Rudisted Reef Facies Associations; **5.** Shoal Facies Associations: Peloidal packstone-grainstone; **6.** Back-shoal Facies Association: **a.** Foraminiferal-bioclastic wackestone-packstone, **b.** Rudisted-foraminiferal wackestone-packstone; **7.** Lagoon Facies Associations: **a.** Fossiliferous mudstone-wackestone, **b.** Bioclast foraminiferal wackestone, **c.** Benthic foraminiferal wackestone.

1. INTRODUCTION

The study of the Cretaceous period in Iraq holds significant academic value due to the presence of numerous formations deposited during this period, as well as the occurrence of phases and structural movements. Additionally, it is noteworthy that the formations of this period contain a substantial proportion of the essential oil reservoirs, as highlighted by Buday (1980). The Mishrif Formation, which extends from the Cenomanian to the Early Turonian period, is a significant carbonate reservoir formation that is widely distributed in central and southern Iraq, as well as in the Arabian Gulf. This has been documented by various sources, including (Al-Khersan, 1975; Alsharhan & Nairn, 1988, 1993; Aqrawi et al., 2010; Burchette, 1993; Harris & Frost, 1984; Mahdi & Aqrawi, 2014; Reulet, 1982; Videtich et al., 1988). Additionally, it has been reported by Al-Sakini (1992) that the Mishrif Formation in Iraq contains 30% of the country's entire oil reserves.

The formations known as Cenomanian Mahlban, Moatsi, and Fahad exhibit similarities to the Mishrif Formation located in the central region of Iraq (Jassim & Goff, 2006a). The aforementioned representational groups are associated with the Mishrif and Rumaila regions in southern Iraq. All geological formations in the Mesopotamian basin are classified as chronostratigraphic units that date back to the middle Cretaceous period. The Mishrif Formation is among the Wasia groupings, as stated by Alsharhan & Nairn (1988).

The Mishrif Formation is present in the Cenomanian-early Turonian, which is a secondary sedimentary cycle. From an economic standpoint, the formation is considered to be among the most valuable oil resources in Iraq and the Arabian Gulf (Jassim & Goff, 2006b). The geological extension and facies characteristics of the rocky features, which contain porous units carrying rudist, render it an ideal hydrocarbon reservoir. The formation in question has been the subject of numerous geological studies at both local and regional levels. These studies have focused on various aspects, such as lithological fossils and stratigraphic features within specific fields or areas of multiple fields, as noted by Al-Jumaily (2001).

There have been many studies of the Mishrif Formation, and the majority of these studies have concentrated on the biological content and stratigraphic nature of the deposits; (Rabanit, 1952) referred to the Mishrif Formation and, for the first time in Zb-3 well inside the upper section, described the (Khutiah Formation) within (the Wasia group). These three formations (i.e., Mishrif, Ahmady, and Rumaila) were the divisions he made. Owen & Nasr (1958) in Van Bellen, the thickness of the formation has been detected and is equal to the Mugwa Formation in Kuwait in (Zb-3) well. Then the rock content is described, whereas the thickness is renewed with 122 m to consider the 35 m belonging to the Mishrif Formation. Chatton & Hart (1961) included the organic detrital neritic limestone units of sub-cycle (Cenomanian-Early Turonian), such as the M'sad, Gir Bir, and Mergi formations in Mishrif Formation, they placed freshwater limestone through the newly introduced Kifl Formation. James & Wynd (1965) suggested the upper part of the Sarvak Formation as the Mishrif Formation. Al Naqib (1967) researched the formation and explained that the upper part of the Wasia Group is identical to the Mishrif Formation. Gaddo (1971) Studied the microfacies, paleoenvironments, and petrography of the Mishrif Formation. Belarabi (1982 and Reulet (1970, 1982) studied Sedimentology, microfacies analysis, and depositional environment models. Al-Khersan (1975) studied the Mishrif Formation and believed the formation was deposited within five marine environments: intertidal, littoral, bank margins, bank, and open sea environments. Al-Siddiki (1978) studies have covered a wide range of Mishrif Formation-related topics, including Lithostratigraphy, Biostratigraphy, thickness variations, lateral expansions, and age determination. Sherwani (1983) divided the Mishrif formation environments into supratidal, tidal, and subtidal Rudist facies, Rudist coral banks, and shelf facies. Al-Sherwani (1988) studied the Cenomanian – Early Turonian sedimentological system in S of Iraq. Van Buchem et al. (1996) based on a transect of outcrops in the Adam Foothills. Aqrawi et al. (1998) in their investigation of the sequence stratigraphy of the Mishrif formation in Iraq, exclusively used the regressive cycle. Hussain et al. (2020) studied the Mishrif Formation vertical and horizontal distribution of porosity and permeability values related to stratigraphy in the West Qurna Oilfield. Sharland, Archer, Casey, Davies, et al. (2001) found out that the AP8/AP9 megasequence boundary is formed at 92 million years by the Mishrif top truncation. Al-Jumaily (2001) The Mishrif Formation's microfacies have been investigated, and the results show that the formation has two regressive cycles. Van Buchem et al. (2002) used the same outcrops with subsurface data to construct a more detailed model. Mahdi (2004) examined the Mishrif Formation's sequence stratigraphy and reservoir characteristics in several South Iraqi wells. Al-Ubaidy (2004) studied the stratigraphic sequence of the Mishrif Formation and suggested four major subenvironments shallow restricted, shallow open marine, shoal, and deep marine environment in Zubair Field. Al-Khalidi (2004) studied the Mishrif Formation in S of Iraq and recognized fourteen microfacies in well HF-1. Sadooni (2005) believed that the Dujail Shoal, a nearby uplift, limited the maximum thickness of the Mishrif Formation in the Dujail area since it exhibits build-up areas some distance from the main platform margin. Farzadi (2006) studied the Middle Cretaceous carbonate platforms of the Gulf and Mishrif Formation using seismic stratigraphy, suggesting that the Mishrif Formation is equivalent to the upper part of the Sarvak Formation and represented by a high concentration of organic matter in an intra-shelf basin associated with shallowing upward succession. Al-Kilaby (2009) studied the porosity and reservoir characteristics of the Mishrif Formation in the Abu Ghraib and Fauqi fields. Al-Rubaiy (2009) examined the southern Iraqi sequence stratigraphy including the oilfields in North Rumaila and West Qurna, respectively. Aqrawi et al. (2010) Characterization of the Southern Mesopotamian Basin's Mid-Cretaceous Reservoir, south of Iraq. Al-Dabbas et al. (2010) investigated the deposition and porosity distribution settings in southern Iraq's regressive Mishrif Formation limestone reservoirs. Hamdan (2011) In 8 wells of the Buzurgan field, The Mishrif Formation carbonate sequence (Cenomanian – Early Turonian) suggested reservoir and modeling. Al-Baldawi (2012) Six wells in the Amara oil field's carbonate reservoirs were characterized, and a 3D geological model of the Mishrif Formation was constructed. Al-Dulaimi et al. (2012) Late Cenomanian-early Turonian Mishrif Formation, two demise stages. Rudist bearing. The first occurs during the early Late Cenomanian, as evidenced by a strong declination within the widespread prevalence of both (Caprinidae and Ichthysarcolitidae) recumbent rudists; they collectively constitute the Cenomanian species of the Mishrif Formation. Along with this, the loss of lift of Hippuritidae and Radiolitidae marked the second demise of the rudists. Al-Dulaimy & Sa'ad (2013) studied the Mishrif Formation's biostratigraphy from the oil wells Halfaya-1, Amara-1, and Majnoon-1 in southeast Iraq. Mahdi et al. (2013) investigated the characterization of the southern Mesopotamian Basin of Iraq's mid-Cretaceous Mishrif reservoir. Nasser & Nabaa (2013) checked the microfacies present in Mishrif rocks and the affected digenesis processes. Mahdi & Aqrawi (2014, 2018) studied the Mid-Cretaceous Mishrif Formation in the Southern Mesopotamian Basin of Iraq using sequence stratigraphic analysis. Saeed (2014) investigated the sequential workflow of geological applications for the Cenomanian – Early Turonain carbonate successions of the Mishrif Formation in the Noor Oilfield, South of Iraq (Petrography and microfacies study, petrophysical evaluation, and modeling; Saqer (2014) . In the Tuba Oilfield, the Mishrif Formation's four primary microfacies were identified. The well logs were then analyzed, and a reservoir geological model was created. Al-Shabender (2014) provides a sequential geoscience workflow (geophysical, petrophysical evaluation, and modeling) for the Cenomanian Early – Turonian Mishrif Formation carbonate succession at the Buzurgan oilfield, southeast of Iraq. Al-Mosawy (2014) includes petrography and microfacies investigation, petrophysical evaluation, and modeling for the Cenomanian – Early Turonian Mishrif Formation carbonate succession in the Halfaya Oilfield, southeast Iraq. Al-Ameri (2015) displays the depositional environment and Mishrif Formation reservoir properties in the Rumaila North field. Al-Marsumi (2014) reflection seismic study interpretation of Tuba Oilfield over 261 Km^2 area. Al-Khafaji (2015) interpreted the petrophysical characteristic of Mishrif to set up the 3D geological static model of the Mishrif reservoir. Alrrawi et al. (2015) four main facies have been diagnosed in the Mishrif Formation (Grainstone, packstone, wackestone, and mudstone), which are spread all over the reservoir units. Al-Rahim & Hashem (2015) enhance the precise information method about subsurface reservoir characterizations by improving the petrophysical properties estimation (porosity, water saturation, and lithology) through the combination of good logs and seismic data. Al-Yasi & Jaed (2016) to create a reservoir model for the Mishrif Formation, facies, and readily available well log data integration were done in the Gharraf Oilfield. AlBahadily & Nasser (2017) divided the Mishrif Formation into seven units. They concluded that it consists of four principal oil-bearing units: (MA, MB11, MB12, and MB13), whereas MB21, MC1, and MC2 units are moderately good reservoir properties set under oil-water contact in the study area. BAR2 and BAR3 have to include intervals of oil-bearing. Altameemi & Alzaidy (2018) Studied were done on the Mishrif Formation's sedimentological and reservoir properties at the Noor Oilfield in Southern Iraq. Al Jawad & Tariq (2019) selected wells from the North Rumaila field that showed the Mishrif Formation's reservoir characteristics. Bareh (2019) a 3D integrated geological model has been carried out of the Mishrif Formation in the Tuba field, south of Iraq, deduced that the Facies model indicates the rudist biostrome and shoal facies associations form the essential oil-bearing units in the formation. Chafeet, Hussein et al. (2019) at the Faiha and Sindibad Fields in South Iraq, researchers looked at the microfacies, depositional environments, and diagenetic processes of the Mishrif and Yamama Formation. Al-Dulaimy et al. (2022) Studied the Biozosnation (benthic foraminifera) of the Mishrif Formation at Majnoon and Zubair Oilfields, Southern Iraq.

The purpose of this study is to describe the lithological composition of the Tuba and Zubair Oilfields, determine the age of the Mishrif Formation, and interpret depositional paleoenvironments by microfacies analysis.

2. MATERIALS AND METHODOLOGY

Sampling and describing selected boreholes from two Oilfields by taking rock samples from the cutting and core for these wells, the interval between each sample is approximately (1 m). The preparation of the thin sections for the cutting and core sample, with the petrographic description of thin sections by transmitted light microscope, by examination of 300 thin sections using a polarized microscope (Leica, pro-Las core 4.13), a thin section description is used to identify the paleontological lithology and Microfacies characters. Also, examining the thin sections is used to describe carbonate microfacies, and diagenesis processes and then delineate the age of the formation.

3. GEOLOGICAL SETTING

The Mishrif Formation was formed in the Mesopotamian Basin. During the Late Permian era, the Neo-Theys Ocean experienced an opening process (Sharland, Archer, Casey, Hall, et al., 2001). Throughout the Early Triassic, the Neo-Theys Ocean steadily enlarged, resulting in a breakup unconformity along the northern and eastern margins of the Arabian plate. The Mesopotamian Basin and the passive margin megasequence were formed as a result of thermal subsidence (Jassim & Goff, 2006).

During the Late Cenomanian – Early Turonian period, the microcontinent that had broken off from the Arabian plate during the Late Tithonian period moved closer to the trench of the intra-oceanic subduction zone (Sharland, Archer, Casey, Hall, et al., 2001). The formation of N – S trending structures in southern Iraq, Kuwait, and Saudi Arabia is thought to be the result of the diachronous collision of these micro-continents with the fore-arc region above the trench. Buday and Jassim (1987) identified five distinct tectonic-physiographic zones, with the Mesopotamian basin being one of the most notable divisions. The Mishrif Formation is situated tectonically in the Mesopotamian basin, which has been separated into the Zubair, Euphrates, and Tigris subzones from the south to the north, as documented by Buday and Jassim (1984). The basin exhibits asymmetry in its foredeep configuration and displays a regional dip towards the northeast and east. The geographical region known as the Mesopotamian Basin is predominantly situated in the southeastern and central areas of Iraq.

The western and southwestern boundaries of the region are demarcated by the Abu-Jir fault zone, while the eastern boundary is formed by the Zagros Mountains, and the northeastern boundary is marked by the Hamrin Mountains. The Mesopotamian Basin is primarily situated on the Mesopotamian block, as well as on adjacent blocks to the northwest and southeast, as depicted in (Figure 1).

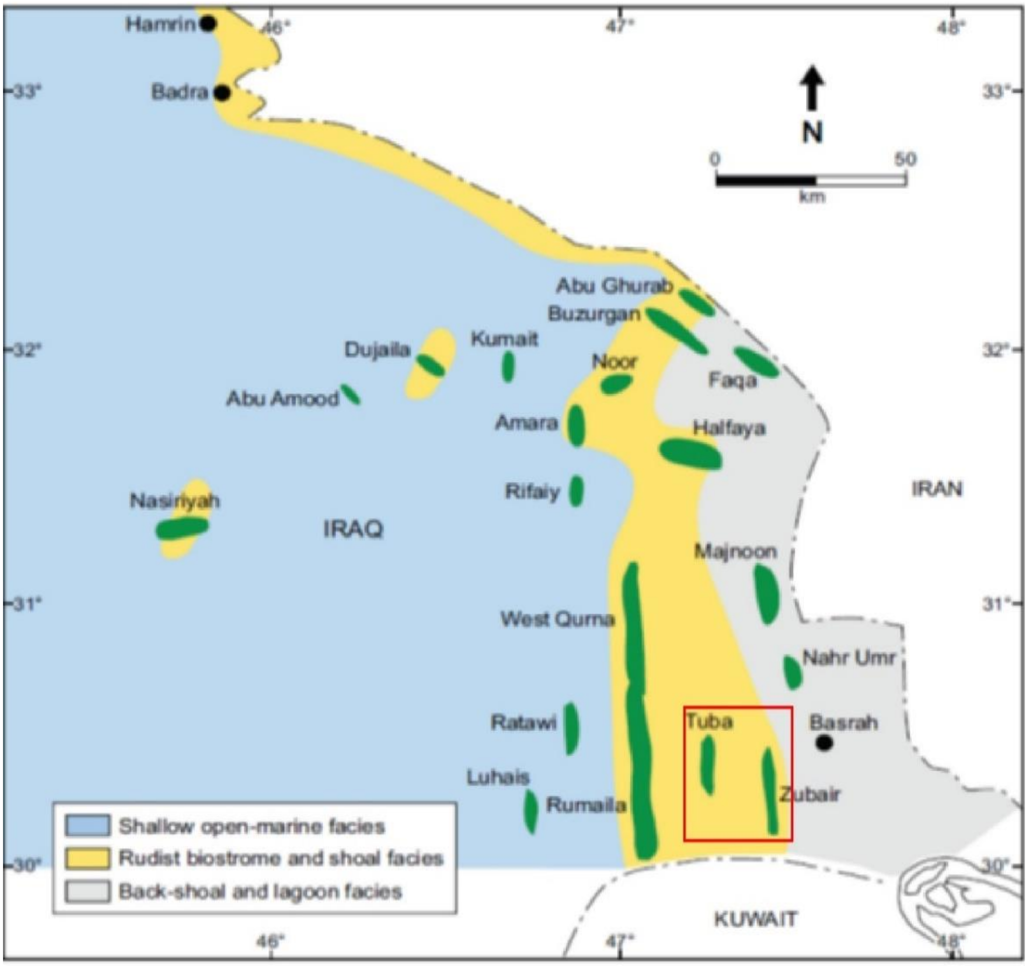

Figure 1: The Mishrif Formation's main depositional areas are depicted on this general palaeogeographic map of the Southern Mesopotamian Basin in South Iraq (which has been adapted from Mahdi et al., 2013).

4. FACIES ASSOCIATIONS IN THE MISHRIF FORMATION

Description and observation of the fossils content and microfacies led to determining the facies association in this study, which is based on (Dunham, 1962), and rudist-bearing facies were classified according to Embry & Klovan (1971). In contrast to the models of typical microfacies and depositional environment belts of carbonates proposed by Wilson (1975) and Fluegel (1982) and taking into account the interpretive model of rudist palaeoenvironment zones proposed by Kauffman (1973); Burchette & Britton (1985) were used to group facies types as "association" rather than a single type or class. Basin, deep marine, shallow open marine, rudist biostrome, shoal, back shoal, and lagoon were the seven facies relationships identified in this study. Similar facies associations were described in other oilfields within the Mesopotamian basin (Mahdi, 2004; Mahdi et al., 2013; Sherwani, 1998). As shown in (Figures 2, 3, 4, 5, 6, and 7).

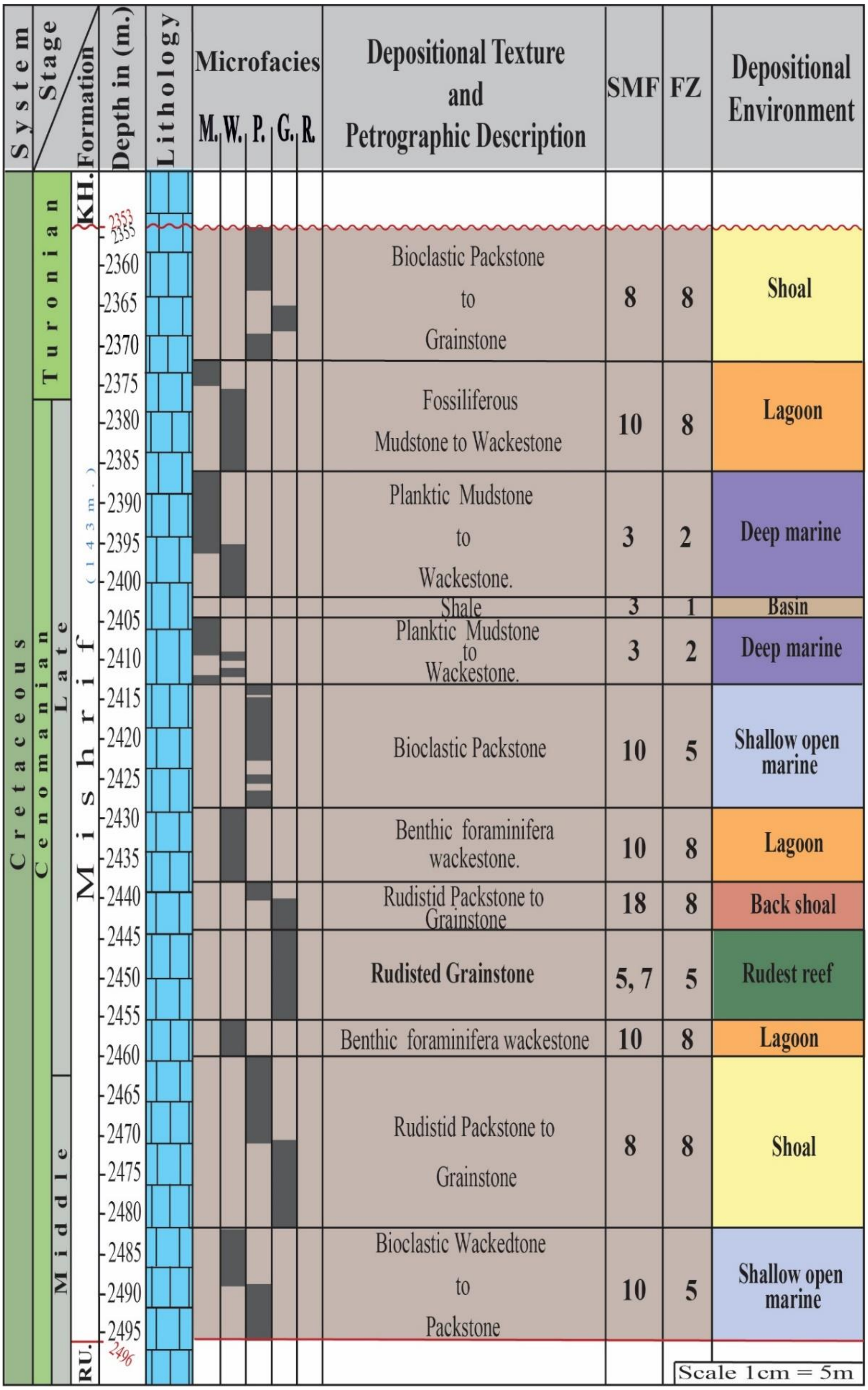

Figure 2: Stratigraphic section showing the microfacies description and depositional environments of Mishrif Formation at Tuba Oilfield in well TU-5.

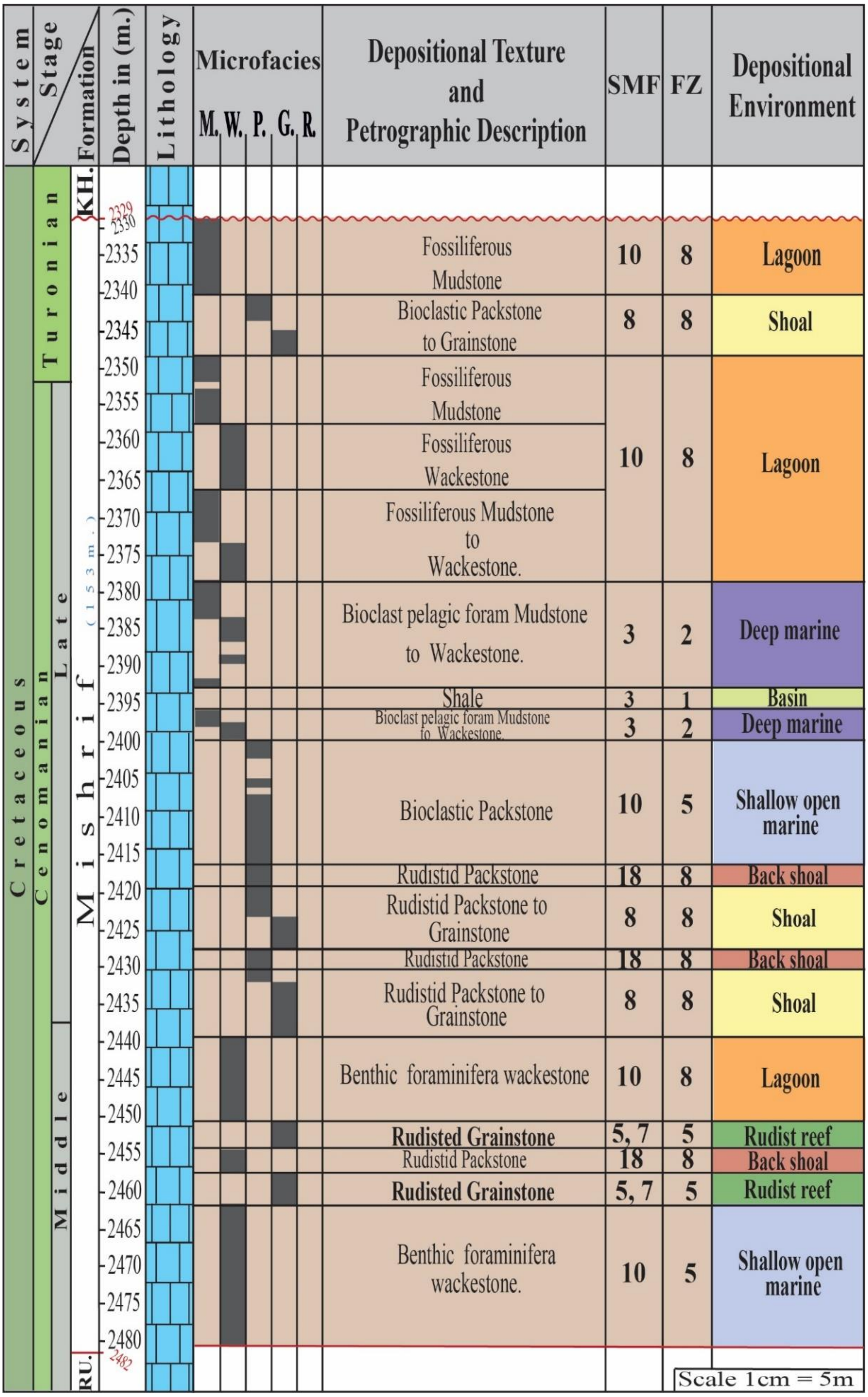

Figure 3: Stratigraphic section showing the microfacies description and depositional environments of Mishrif Formation at Tuba Oilfield in well TU-24.

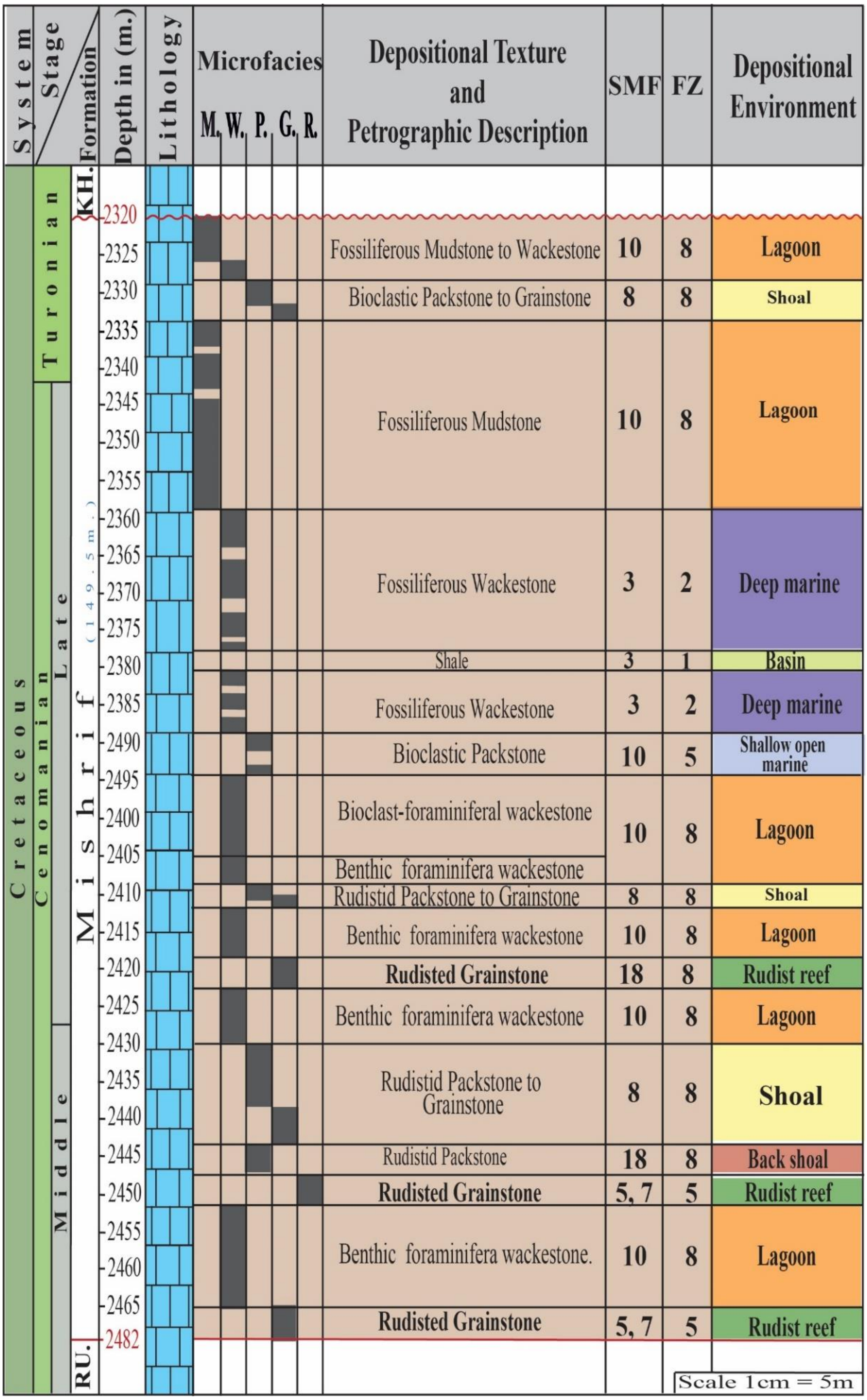

Figure 4: Stratigraphic section showing the microfacies description and depositional environments of Mishrif Formation at Tuba Oilfield in well TU-40.

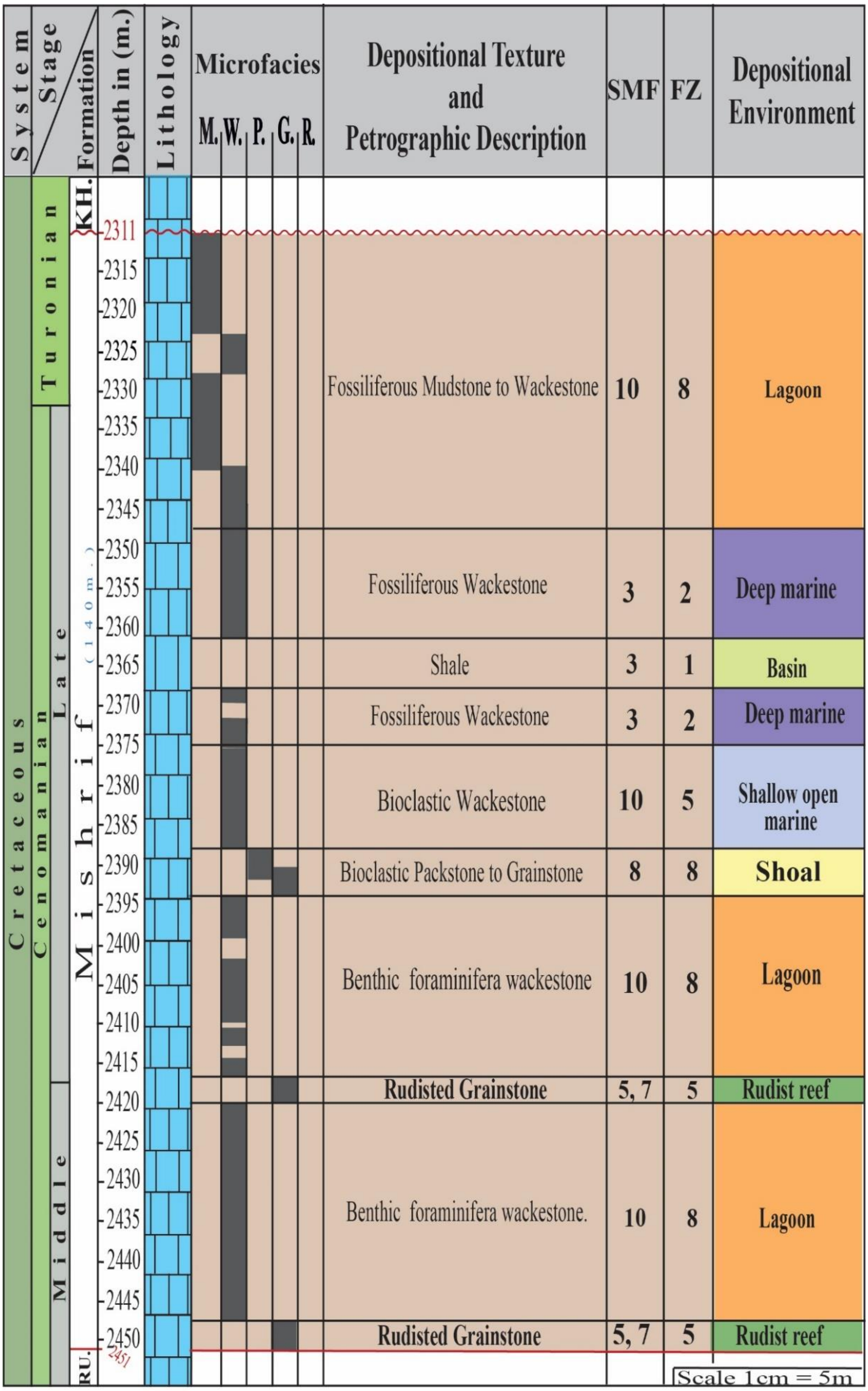

Figure 5: Stratigraphic section showing the microfacies description and depositional environments of Mishrif Formation at Zubair Oilfield in well Zb-41.

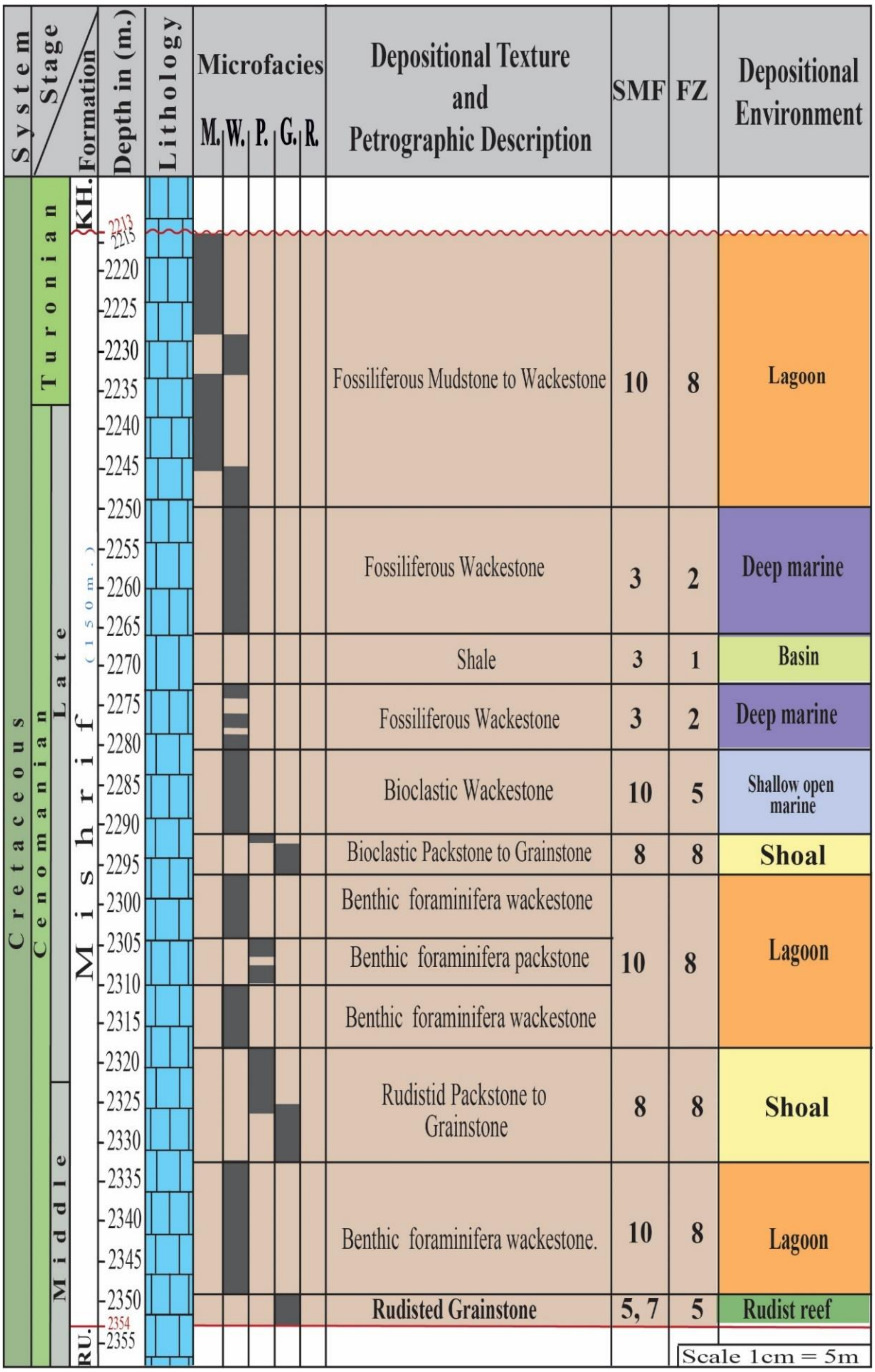

Figure 6: Stratigraphic section showing the microfacies description and depositional environments of Mishrif Formation at Zubair Oilfield in well ZB-42.

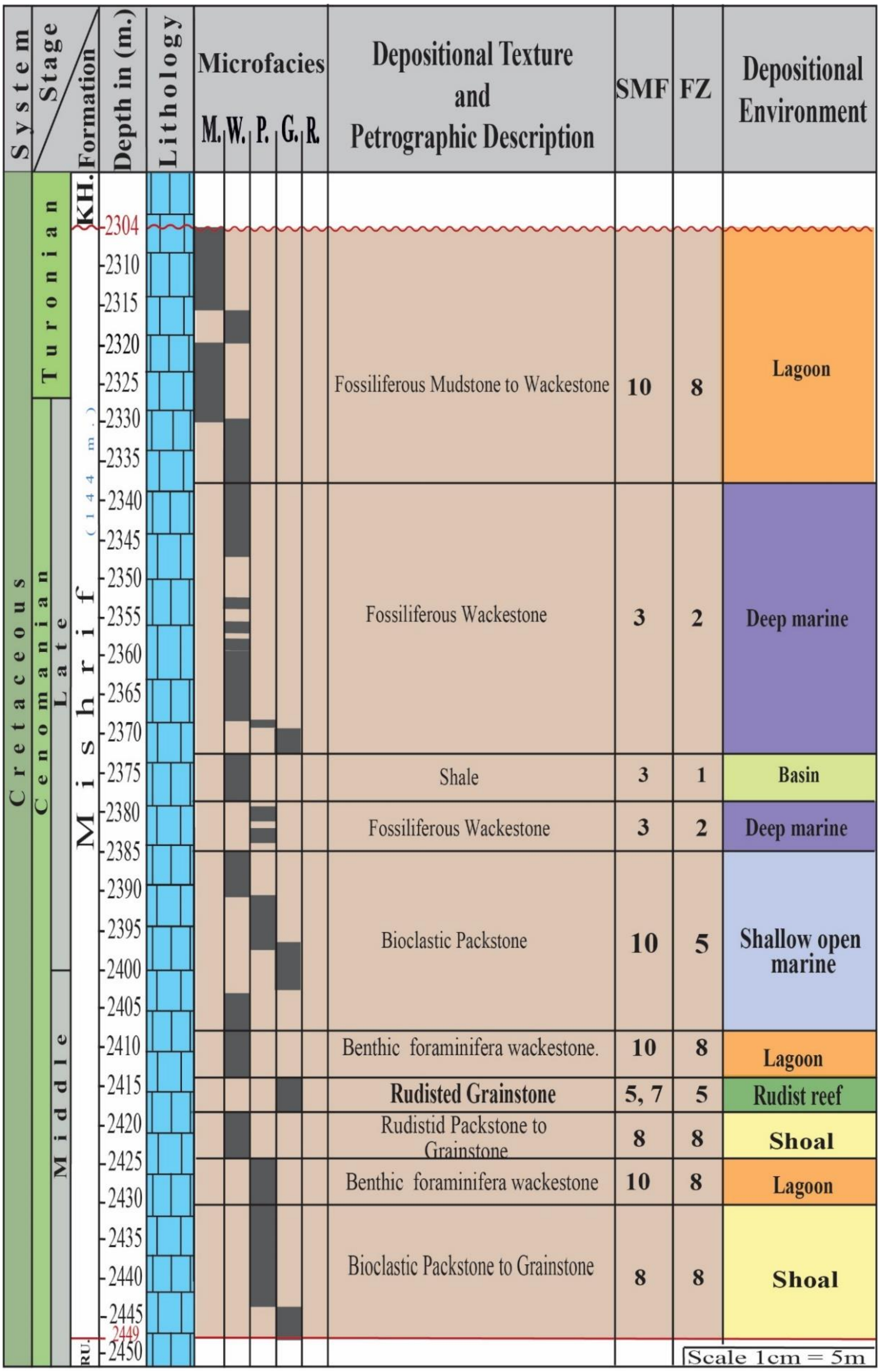

Figure 7: Stratigraphic section showing the microfacies description and depositional environments of Mishrif Formation at Zubair Oilfield in well ZB-46.

4.1. Basin Facies Association

According to Mahdi (2004) and Mahdi & Aqrawi (2014), this association mainly comprises shale units deposited during maximum flooding intervals. Similar units can correlate with other oilfields in the Mesopotamian Basin. Pelagic mudstone and wackestone microfacies represent the environment, comprising a micrite matrix with planktic foraminifera as the main skeletal component with rare calcisphere and sponge spicules. The pelagic mudstone and wackestone microfacies thickness decreases towards the Zubair and the lower (5 m.) Tuba Oil Fields, equivalent to Wilson's (SMF-3) facies zone (FZ-1) of Flügel (2004).

4.2. Deep Marine Facies Associations

Deep marine facies association consists mainly of fine-grain skeletal lime mudstones to wackestones, skeletal grain mainly consists of bioclasts that are mostly fine and unidentifiable and the coarser bioclast which is rudist and few benthic foraminiferas such as *Rotalia, Nezzazata* (Fig.8a), and *Psedudotexteulariella,* with some planktic foraminifera, rudist bioclasts have been originated from the destruction of rudist belts by waves and currents, which is equivalent to Wilson's (SMF-3) facies zone (FZ-2) of Flügel (2004).

4.2.A. Bioclast pelagic foram mudstone-wackestone

Pelagic forms including *Hedbergella*, Oligosteginid, Echinoid fragments, and sponge spicules are present in this facies zone and suggest a deep open sea environment (Simo & Lehmann, 2000). In the presence of the sparse lime mud in the matrix, which represents a low energy environment in this facies zone, the high frequency of Oligosteginid and *Hedbergella* suggests a very good nutrient condition (Adachi, 2004; Birkeland, 1987; Brasier, 1995; Luciani & Cobianchi, 1999; Silva, 1995). According to Heckel (1972), Sanders & Höfling (2000), and Flügel (2004), the faunal assemblage in this facies zone may endure typical saline open marine conditions. In conclusion, a large volume of lime mud points to a tranquil environment free of agitation.

4.3. Shallow Open Marine Facies Associations

The Mishrif Formation's most common facies are shallow open marine ones; it consists mainly of bioclastic or foraminiferal bioclastic as wackestone and packstones (Figure 8b), with rudist bioclastic (Figure 8c) occur in this facies association, the size of these bioclasts ranges in size from fine to coarse grain characterize the Mishrif carbonates. Benthic foraminifera is the most abundant in this environment and is represented by well-preserved fossils with some bioclasts. The area near the biostrome is represented by an association of benthic foraminifera and Rudist debris, corals, and rarely algae. Benthic foraminifera in this facies is *Nezzazata* (Figure 8d), *Dicyclina, Textularia, Praealveolina*, calcareous algae, coral, and sponge spicules (Figure 8e), planktic foraminifera is less common. These facies are found seaward the Formation, equivalent to Wilson's (SMF 10) facies zone (FZ-5) of Fügel (2010). The microfacies in detail:

4.3.A. Foraminiferal bioclastic wackestone-packstones

These microfacies are the most dominant in the Mishrif succession and constitute thick horizons at different levels. It is represented mainly by large benthic foraminifera like *Prealviolina* and *Cisalviolina*, and smaller faunas like Miliolide *and Nazzazata sp.* are also common. Rudist debris is also common and abundant at certain intervals; this may indicate nearness to the biostrome body. Echinoderms and gastropods are two more common components.

4.4. Rudist Reef Facies Associations

A very coarse-grained bioclastic rudstone fragment makes up these facies as a main component; the rudist occurs as whole shells or coarse bioclasts with relative preservation of their internal structure; Textures consist of grainestone (Figure 8f), These microfacies suggest that rudist reefs were present on the shelf (Mahdi et al., 2013) considered the rudist reef facies association as equivalent to Wilson's (SMF-5, and 7) facies zone (FZ-5) of Flügel (2004).

The depositional environment of rudists in the Mesopotamian basin was characterized by moderate-high energy conditions (Mahdi et al., 2013). During the Cretaceous period, paleobathymetry of this environment was estimated to be approximately 2 – 10 m (Scott, 1995).

4.5. Shoal Facies Associations

These sediments are sited on the marginal shelf, a coarse-grained peloidal packstone to grainstone, the benthic foraminifera or concentrations of their skeletal grains with rudist debris (Figure 8g), and the culmination of upward coarsening sequence. Also, pelodial packstone to grainstone consists mainly of peloids, intraclasts of various sizes with echinoderm plates, micritized grains, and various sizes of echinoderm plates. In the top regions of the Formation, these microfacies are extremely prevalent. They are equivalent to Wilson's (SMF-8) facies zone (FZ-8) of Flügel (2004). The microfacies in detail:

4.5.A. Peloidal packstone-grainstone

Rudist is widely distributed in this facies zone. This facies zone has Echinoid, Peloid, and Intraclast occurrences. According to Fluegel (1982); Ross & Skelton (1993); and Wilson (1975), this assemblage's abundance of rudist points to a very high energy state in a barrier situation.

4.6. Back-shoal facies Association

According to Mahdi et al. (2013), the association of rudist fragments and benthic foraminifera indicates that the back-shoal facies association implies a zone of sediment mixing between the shoal and lagoon (Burchette, 1993). It is composed of floatstone, rudisted-foraminiferal wackestone-packstone, and foraminiferal-bioclastic wackestone-packstone. According to Mahdi et al. (2013) and Mahdi & Aqrawi (2014), the characteristics of the back-shoal facies association point to a low-moderate energy depositional environment on the lee side of rudist biostromes or shoals. The Sarvak Formation in Iran (Razin et al., 2010) and the Mishrif Formation in the United Arab Emirates (Burchette & Britton, 1985) are two formations that exhibit the same facies relationship. They are equivalent to Wilson's (SMF-18) facies zone (FZ-8) of Flügel (2004). The microfacies in detail:

4.6.A. Foraminiferal-bioclastic wackestone-packstone

The various benthic foraminifera distinguish these microfacies; the miliolids and *Nezzazata* are examples of benthic foraminifera. There are also rare to widespread green algae. Echinoids, rudists, sponge spicules, peloids, gastropods, and less important components. These facies' fine grain size implies deposition in a Back-shoal, low-moderate energy depositional environment. The diversity of the fauna indicates that the water column and sediment surface had normal salinity, adequate water circulation, and an oxygen concentration.

4.6.B. Rudisted-foraminiferal wackestone-packstone (or Grainstone)

These microfacies are the primary constituents of the non-skeletal peloid components, which are distinguished by rudist fragments and echinoid debris. Alveolinids, orbitolinids, miliolids, *Nezzazata*, small *Rotalia*, and gastropods are some of the benthic foraminifera. Grainstone (or floatstone) with a bioclastic wackestone-packstone matrix makes up the textures.

These facies have floatstone (Embry & Klovan, 1971) classification-based textures, and wackestone-packstone (Dunham, 1962) classification-based textures. This microfacies developed in an environment with low to moderate energy on an upper slope.

4.7. Lagoon Facies Associations

An area of relatively shallow, quiet water separated from the open marine conditions by a barrier. The lagoon environment is characterized by abundant benthic foraminiferal wackestone (Figure 8h) and Miliolid mudstone to wackestone (Figure 8i). In the bottom and top regions of the Mishrif Formation, the lagoon facies association creates a thick succession of mud-dominated facies. The benthic foraminifera are abundant and diverse such as Miliolids, *Textularia*, *Pseudolituonella*, *Nezzazata* (Figure 8j), and many others. Also, sponge spicules, algae, and rudist fragments. It comprises fossiliferous mudstone-wackestone, bioclastic-foraminiferal wackestone, and benthic foraminiferal wackestone; these deposits spread in most studied wells. They are equivalent to Wilson's (SMF-10), the facies zone (FZ-8) of Flügel (2004). The microfacies in detail:

4.7.A. Fossiliferous mudstone-wackestone

According to Lakhdar et al. (2006), this facies zone is primarily made up of different frequent benthic forams that imply a lagoon environment next to a tidal flat. According to Bachmann & Hirsch (2006), a shallow bathy with sufficient saline conditions and water circulation results in a nutrient-rich environment. This is indicated by the high diversity and abundance of the skeleton allochems. A lagoon with few available energy sources is indicated by low species diversity and elevated lime mud in some facies (Masse et al., 2003; Sandulli, 2004). In the bottom and top regions of the Mishrif Formation, the lagoon facies association creates a thick succession of mud-dominated facies.

4.7.B. Bioclast foraminiferal wackestone

The varied benthic foraminifera in mud-supported textures is the main characteristic of this microfacies. Benthic foraminifera include the miliolids, alveolinids, orbitolinids, and *Nezzazata*. There are also rare to widespread green algae. Echinoids, rudists, sponge spicules, peloids, gastropods, and less important components. These facies' fine grain size (textures) imply deposition in an open lagoon, low-energy environment. The diversity of the fauna indicates that the water column and sediment surface had normal salinity, adequate water circulation, and an oxygen concentration. According to Zhicheng et al. (1997), green algae show that airflow and light penetration are both favorable.

4.7.C. Benthic foraminiferal wackestone

The predominant components of these facies are gastropods, shell fragments, green algae, small benthic foraminifera (miliolids and *Nezzazata*), and rare peloids. Fine-grained micrite forms comprise the matrix. The stratigraphic position and the minimal variety of the skeleton fauna show the restricted low-energy lagoonal environments where these facies were deposited. The deposits may have originated in a lagoonal setting with inadequate links to the marine environment given the paucity of diversity in the bioclasts and the dominance of micrites. A severely stressed environment in shallow, confined locales, with possibly large salinity and temperature changes, is indicated by the foraminifera's low biotic diversity.

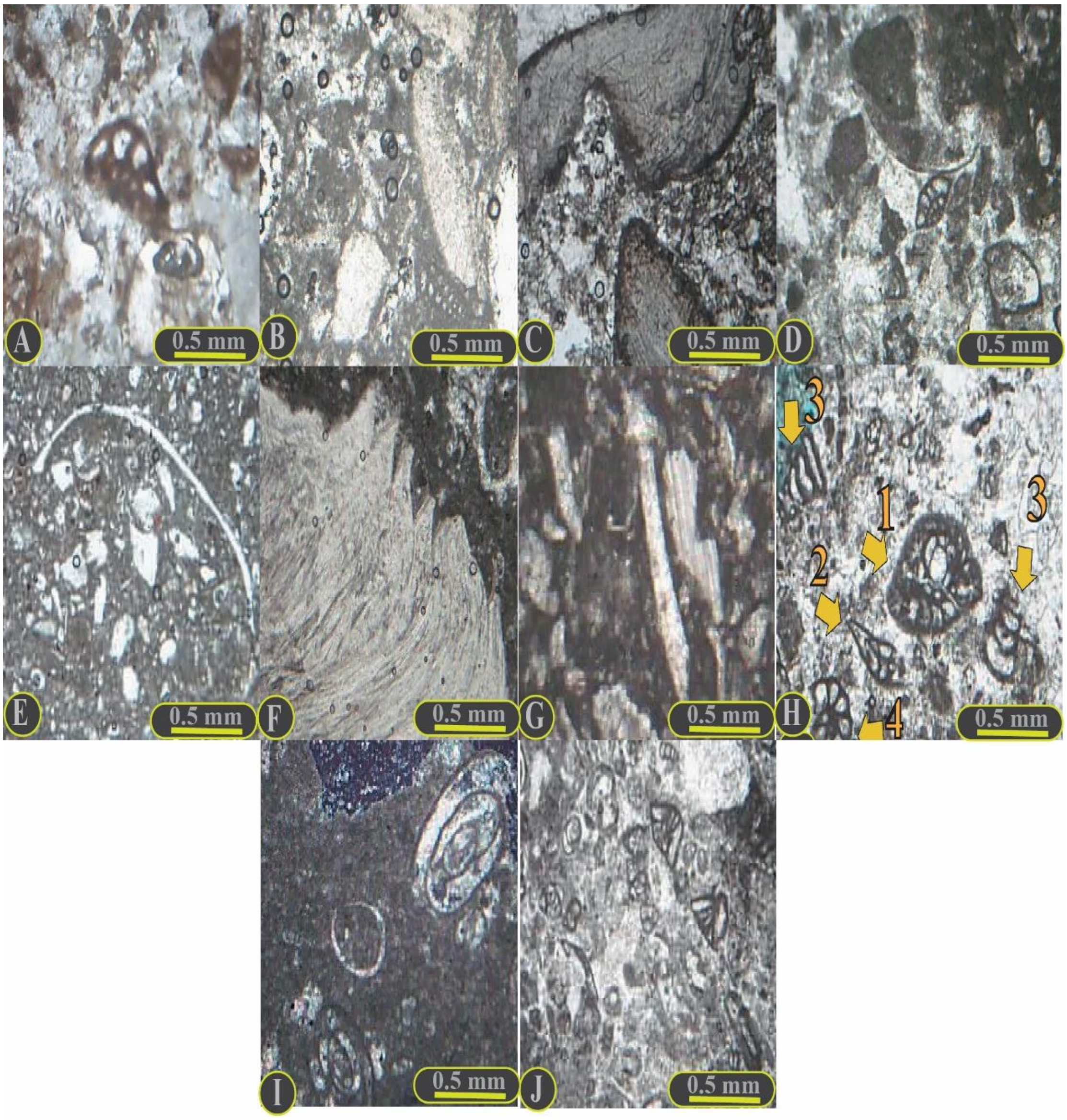

Figure 8: **a)** *Nezzazatinella picardi* (Henson, 1948), foraminiferal Wackestone to Packstone, Shallow Open marine facies, Mishrif Formation, Tuba Oilfield, well TU-40 (2420m); **b)** Foraminiferal-bioclastic wackestone to packstone, Shallow open marine association facies, Mishrif Formation, Zubair Oilfield, well ZB-42 (2380m); **c)** Rudist bioclasts, Foraminiferal-bioclastic packstones, Shallow open marine association facies, Mishrif Formation, Tuba Oilfield, well TU-5 (2425m); **d)** *Nezzazata* sp., Foraminiferal-bioclastic packstones, Lagoon facies, Mishrif Formation, Zubair Oilfield, well ZB-46 (2300m); **e)** Poorly sorted bioclasts, foraminiferal bioclastic wackestones to packstones, Lagoon facies, Mishrif Formation, Tuba Oilfield, well TU-24 (2440m); **f)** Rudist bioclasts, Rudistid Packstone, Shoal Facies, Mishrif Formation, Zubair Oilfield, well ZB-41 (1410m); **g)** Rudstone fragments, rudist biostorme facies, Mishrif Formation, Tuba Oilfield, well TU-40 (2420m); **h)** Benthic foraminiferal grainstone, Lagoon facies, Mishrif Formation, Zubair Oilfield, well Zb-42 (2438m). contains: **1)** *Orbitolina (Conicorbitolina) conica* (d'Archiac, 1837); **2)** *Nezzazata conica* (Smout, 1956), **3)** *Pseudolituonella reicheli* Marie; **4)** *Rotalia*, i.Miliolid mudstone to wackestone microfacies with bioclast, Lagoon facies, Mishrif Formation, Tuba Oilfield, well TU-5 (2435m); and **j)** *Nezzazata conica* (Smout, 1956), Benthic foraminiferal grainstone, Lagoon facies, Mishrif Formation, Zubair Oilfield, well ZB-46 (2300m).

5. CONCLUSION

- Skeletal grains are more abundant than non-skeletal grains in the Mishrif Formation in selected wells.
- The facies analysis for the wells TU-5, TU-24, TU-40, ZB-41, Zb-42, and ZB-46 of Tuba and Zubair Oilfields of Mishrif Formation led to the recognition of seven facies associations: basin, deep marine, shallow open marine, rudist reef, shoal, back shoal, and lagoon. However, the thickness differences of these facies succession indicate a change in depositional conditions controlled by the relative sea-level changes.
- The main microfacies found are:
  1. (Basin Facies Associations).
  2. (Deep Marine Facies Associations): Bioclast pelagic foram mudstone-wackestone.
  3. (Shallow Open Marine Facies Associations): Foraminiferal bioclastic wackestone-packstones.
  4. (Rudisted Reef Facies Associations).
  5. (Shoal Facies Associations): Peloidal packstone-grainstone.
  6. (Back-shoal Facies Association): **a)** Foraminiferal-bioclastic wackestone-packstone, **b)** Rudisted-foraminiferal wackestone-packstone.
  7. (Lagoon Facies Associations): **a)** Fossiliferous mudstone-wackestone, **b)** Bioclast foraminiferal wackestone, **c)** Benthic foraminiferal wackestone.

REFERENCES

Adachi, S. (2004). *Handbook on physical properties of semiconductors*. Kluwer Academic Publishers Group, Dordrecht.

Al-Ameri, T. K. (2015). Oil biomarkers, isotopes, and palynofacies are used for petroleum system type and migration pathway assessments of Iraqi oil fields. *Arabian Journal of Geosciences*, *8*, 5809–5831.

Al-Baldawi, B. A. U. A. (2012). *Formation Evaluation of Al-Mishrif Reservoir, Amara Oil Field, South Eastern Iraq*. University of Baghdad.

Al-Dabbas, M., Al-Jassim, J., & Al-Jumaily, S. (2010). Depositional environments and porosity distribution in regressive limestone reservoirs of the Mishrif Formation, Southern Iraq. *Arabian Journal of Geosciences*, *3*(1), 67–78. https://doi.org/10.1007/s12517-009-0057-x

Al-Dulaimi, S. I., Al-Zaidy, A. A., & Sa'ad, S. (2012). The demise stage of rudist bearing Mishrif Formation (late Cenomanian–early Turonian), Southern Iraq. *Iraqi Bulletin of Geology and Mining*, *9*(3), 1–20.

Al-Dulaimy, R. T., & Sa'ad, S. (2013). Biostratigraphy of the Mishrif Formation from well Amarah-1 southeastern Iraq. *Iraqi Bulletin of Geology and Mining*, *9*(2), 1–14.

Al-Dulaimy, S. I. M., Ibrahim, Y. K., & Abdallah, F. T. (2022). Biozonation (benthic foraminifera) of Mishrif Formation at Majnoon and Zubair oil fields, southern Iraq. *Bulletin of the Geological Society of Malaysia*, *73*, 79–89.

Al-Jumaily, S. (2001). *Facies and Depositional Environment of the Mishrif Formation in Selective Wells Southern Iraq. Unpub*. Ph. D. Thesis., University of Baghdad, College of Science.

Al-Khafaji, A. J. (2015). The Mishrif, Yamama, and Nahr Umr reservoirs petroleum system analysis, Nasiriya oilfield, Southern Iraq. *Arabian Journal of Geosciences*, *8*(2), 781–798.

Al-Khalidi, Z. A. . (2004). *Reservoir Specification and Effective Porosity of the Mishrif Formation in Halfaya Field Southeast Iraq. Unpub*. University of Baghdad.

Al-Khersan, H. (1975). Depositional environments and geological history of the Mishrif Formation in southern Iraq. *Proceeding at 4th Arab Petroleum Congress, Dubai, Paper*, *121*, 1–18.

Al-Kilaby, A. (2009). *Reservoir Characters and Porosity of the Mishrif Formation in Abu Ghirab and Fuqua Fields, Southern Iraq. Unpub*. University of Baghdad.

Al-Marsumi, S. W. (2014). *Petroleum system and hydrocarbon potential of Halfaya oil field, Mesan Governorate, South Iraq*. University of Baghdad.

Al-Mosawy, A. D. J. (2014). *3D Integrated geological modeling of Mishrif Formation in Halfaya oil field*. University of Baghdad.

Al-Rahim, A. M., & Hashem, H. A. (2015). Enhancing the indication of ancient geologic features by using Seismic Attributes technique extracted along picked horizons of seismic and flattened data. *Iraqi Journal of Science*, *56*(3C), 2640–2647.

Al-Rubaiy, H. H. F. (2009). *Sequence Stratigraphy of the Mishrif Formation at West Qurnah, North Rumaila and Zubair Fields, Southern Iraq, Unpub*. University of Baghdad.

Al-Sakini, J. A. (1992). Summary of petroleum geology of Iraq and the Middle East. *Northern Oil Company Press, Kirkuk*, *179*.

Al-Shabender, L. Y. (2014). *Geophysical Techniques and 3D Petrophysical the Modeling Used to Study the Characterization of Mishrif Formation in Buzurgan Oil Field, southeast Iraq*. University of Baghdad.

Al-Sherwani, G. H. (1988). Lithostratigraphy and Environmental Considerations of Cenomanian-Early Turonian Shelf Carbonates (Rumaila and Mishrif Formation) of Mesopotamian Basin. *AAPG Bulletin*, *71*, 614.

Al-Siddiki, A. A. (1978). Subsurface geology of southeastern Iraq: 10th Arabian Petroleum Cong. *Tripoli, Paper*, *141*.

Al-Ubaidy, U. (2004). *Stratigraphic Control on Facies and Diagenetic Development of the Mishrif Formation in Zubair Field. Unpub*. M. Sc. Thesis, University of Baghdad, 86pp (in Arabic).

Al-Yasi, A. I., & Jaed, M. A. (2016). Using Geophysical Well Logs in Studying Reservoir Properties of Mishrif Formation in Garraf Oil Field, Southern Iraq. *Iraqi Journal of Science*, *57*(1B), 446–455.

Al Jawad, M. S., & Tariq, B. Z. (2019). Estimation of cutoff values by using regression lines method in Mishrif reservoir/Missan oil fields. *Journal of Engineering*, *25*(2), 82–95.

Al Naqib, K. M. (1967). *Geology of the Arabian Peninsula; southwestern Iraq*.

AlBahadily, J. K. R., & Nasser, M. E. (2017). Petrophysical properties and reservoir modeling of Mishrif formation at Amara oil field, Southeast Iraq. *Iraqi Journal of Science*, *58*(3), 1262–1272.

Alrrawi, D. Y. A., Al-Yaseri, A. A., & Seqer, M. H. (2015). Facies and reservoir evaluation of Mishrif formation in Tuba oil field. *Iraqi J Sci*, *56*(1B), 444–465.

Alsharhan, A. S., & Nairn, A. E. M. (1988). A Review of the Cretaceous Formations in the Arabian Peninsula and Gulf: Partii. Mid-Cretaceous (Wasia Group) Stratigraphy and Paleogeography. *Journal of Petroleum Geology*, *11*(1), 89–112.

Alsharhan, A. S., & Nairn, A. E. M. (1993). *Carbonate platform models of Arabian Cretaceous reservoirs*. 173–184.

Altameemi, A. M. H., & Alzaidy, A. (2018). Geological modeling using petrel software for Mishrif Formation in Noor oil field, southeastern Iraq. *Iraqi Journal of Science*, 1600–1613.

Aqrawi, A. A. M., Goff, J. C., Horbury, A. D., & Sadooni, F. N. (2010). *The petroleum geology of Iraq*. Scientific press.

Aqrawi, A. A. M., Thehni, G. A., Sherwani, G. H., & Kareem, B. M. A. (1998). Mid-Cretaceous rudist-bearing carbonates of the Mishrif Formation: An important reservoir sequence in the Mesopotamian Basin, Iraq. *Journal of Petroleum Geology*, *21*(1), 57–82.

Bachmann, M., & Hirsch, F. (2006). Lower Cretaceous carbonate platform of the eastern Levant (Galilee and the Golan Heights): stratigraphy and second-order sea-level change. *Cretaceous Research*, *27*(4), 487–512.

Bareh, M. J. M. (2019). *Reservoir Characterization of Mishrif Formation in Selected Wells of Tuba Oil Field, Southern Iraq*. University of Baghdad.

Belarabi, I. (1982). Sedimentary environment and distribution of facies in Mishrif Formation, southern Iraq. In *Unpublished M. Sc. thesis, University of Baghdad, Iraq*. University of Baghdad.

Birkeland, C. (1987). Nutrient availability as a major determinant of differences among coastal hard-substratum communities in different regions of the tropics. *Comparison between Atlantic and Pacific Tropical Marine Coastal Ecosystems: Community Structure, Ecological Processes, and Productivity. UNESCO Reports in Marine Science*, *46*, 45–97.

Brasier, M. D. (1995). Fossil indicators of nutrient levels. 1: Eutrophication and climate change. *Geological Society, London, Special Publications*, *83*(1), 113–132.

Buday, T., and Jassim, S. Z. (1987). *The Regional Geology of Iraq. Vol. 2. Geological survey and mineral investigation*.

Buday, T. and Jassim, S. Z. (1984). *Tectonic Map of Iraq, Scale 1:1,000,000*. GEOSURV, Baghdad.

Buday, T. (1980). *The regional geology of Iraq: tectonism, magmatism and metamorphism* (Vol. 2). State Organization for Minerals, Directorate General for Geological Survey ….

Burchette, T. P. (1993). *Mishrif Formation (Cenomanian-Turonian), Southern Arabian Gulf: Carbonate Platform Growth Along a Cratonic Basin Margin: Chapter 16*. *56*, 185–199.

Burchette, T. P., & Britton, S. R. (1985). Carbonate facies analysis in the exploration for hydrocarbons: a case-study from the Cretaceous of the Middle East. *Geological Society, London, Special Publications*, *18*(1), 311–338.

Chafeet, Hussein, A. ., Dahham, Nawfal, A. ., & Basher, R. (2019). Study of Petrophysical Properties of Mishrif and Yamama Formations at Selected Fields, South Iraq. *Journal of Basrah Researches (Sciences)*, *45*(2), 131–161.

Chatton, M., & Hart, E. (1961). Review of the Cenomanian to Maastrichtian stratigraphy in Iraq. In *Manuscript report* (Issue 2/141).

Dunham, R. J. (1962). Classification of carbonate rocks according to depositional textures. *AAPG Memoir*, *1*, 108–121.

Embry, A. F., & Klovan, J. E. (1971). A late Devonian reef tract on northeastern Banks Island, NWT. *Bulletin of Canadian Petroleum Geology*, *19*(4), 730–781.

Farzadi, P. (2006). The development of Middle Cretaceous carbonate platforms, Persian Gulf, Iran: constraints from seismic stratigraphy, well and biostratigraphy. *Petroleum Geoscience*, *12*(1), 59–68.

Fluegel, E. (1982). *Microfacies Analysis of Limestone*. Springer-Verlag, New York.

Flügel, E. (2004). *Microfacies of Carbonate Rocks: Analysis, Interpretation and Applications*. Springer-Verlag.

Fügel, E. (2010). *Microfacies of Carbonate Rocks: Analysis, Interpretation and Application*. Springer.

Gaddo, J. Z. H. (1971). The Mishrif Formation paleoenvironment in the Rumaila/Tuba/Zubair region of South Iraq. *Journal of the Geological Society of Iraq*, *4*, 1–12.

Hamdan, W. L. (2011). *Petrel software modeling of the Mishrif Formation in Buzurgan Field*. University of Baghdad.

Harris, P. M., & Frost, S. H. (1984). Middle Cretaceous carbonate reservoirs, Fahud field and northwestern Oman. *AAPG Bulletin*, *68*(5), 649–658.

Heckel, P. H. (1972). Recognition of ancient shallow marine environments. *SEPM Special Publication*, *16*, 226–286.

Hussain, S. A., Al-Obaidi, M., Khwedim, K., & Ahmad, K. (2020). Facies Architecture, Diagenesis and Paleoceanography of Mishrif (Late Cretaceous) in Selected Wells of West Qurna Oil Field, Southern Iraq. *Journal of Physics: Conference Series*, *1664*(1). https://doi.org/10.1088/1742-6596/1664/1/012137

James, G. A., & Wynd, J. G. (1965). Stratigraphic nomenclature of Iranian oil consortium agreement area. *AAPG Bulletin*, *49*(12), 2182–2245.

Jassim, S. Z., & Goff, C. J. (2006a). Geology of Iraq, Published by Dolin, Prague and Moravian. *Museum, Brno*, *341*.

Jassim, S. Z., & Goff, J. C. (2006b). *Geology of Iraq*. DOLIN, sro, distributed by Geological Society of London.

Kauffman, E.G., and S. N. F. (1973). Structure and evolution of Antillean Cretaceous rudist frameworks. *Verhandl. Naturf. Ges. Basel.*, *84*(1), 399–467.

Lakhdar, R., Soussi, M., Ismail, M. H. Ben, & M'Rabet, A. (2006). A Mediterranean Holocene restricted coastal lagoon under arid climate: case of the sedimentary record of Sabkha Boujmel (SE Tunisia). *Palaeogeography, Palaeoclimatology, Palaeoecology*, *241*(2), 177–191.

Luciani, V., & Cobianchi, M. (1999). The Bonarelli Level and other black shales in the Cenomanian-Turonian of the northeastern Dolomites (Italy): calcareous nannofossil and foraminiferal data. *Cretaceous Research*, *20*(2), 135–167.

Mahdi, T. A. (2004). *Sequence stratigraphy and reservoir characterization of Mishrif Formation in Dujaila, Kut, Amarah and Rifaiy fields, Unpub*. M. Sc. Thesis., University of Baghdad, College of Science, 160pp.

Mahdi, T. A., & Aqrawi, A. A. M. (2014). Sequence stratigraphic analysis of the mid-cretaceous Mishrif Formation, southern Mesopotamian basin, Iraq. *Journal of Petroleum Geology*, *37*(3), 287–312.

Mahdi, T. A., & Aqrawi, A. A. M. (2018). Role of facies diversity and cyclicity on the reservoir quality of the mid-Cretaceous Mishrif Formation in the southern Mesopotamian Basin, Iraq. *Geological Society, London, Special Publications*, 435.

Mahdi, T. A., Aqrawi, A. A. M., Horbury, A. D., & Sherwani, G. H. (2013). Sedimentological characterization of the mid-Cretaceous Mishrif reservoir in southern Mesopotamian Basin, Iraq. *GeoArabia*, *18*(1), 139–174.

Masse, J. P., Fenerci, M., & Pernarcic, E. (2003). Palaeobathymetric reconstruction of peritidal carbonates: Late Barremian, Urgonian, sequences of Provence (SE France). *Palaeogeography, Palaeoclimatology, Palaeoecology*, *200*(1–4), 65–81.

Nasser, M., & Nabaa, A.-I. (2013). The Microfacies Analysis of Mishrif Formation in Gharraf Oil Field. *Iraqi Journal of Science*, *54*(4Appendix), 1129–1135.

Owen, R. M. S., & Nasr, S. N. (1958). The stratigraphy of the Kuwait/Basrah area in: Weeks GL (editor) Habital of oil a symposium. In *Am. Assoc. Petr. Geol. Tulsa* (pp. 1252–1278).

Rabanit, P. M. V. (1952). *Rock units of Basrah area. Unpublished, Basra Petroleum Company (BPC), Iraq National Oil Company Archives*. Baghdad, No. BGR.

Razin, P., Taati, F., & Van Buchem, F. S. P. (2010). Sequence stratigraphy of Cenomanian–Turonian carbonate platform margins (Sarvak Formation) in the High Zagros, SW Iran: an outcrop reference model for the Arabian Plate. *Geological Society, London, Special Publications*, *329*(1), 187–218.

Reulet, J. (1970). Sedimentological study of the Mishrif Reservoir. In *Department of Exploration, ELF–Iraq*.

Reulet, J. (1982). Carbonate reservoir in a marine shelf sequence, Mishrif Formation, Cretaceous of the Middle East. *Exploration for Carbonate Petroleum Reservoirs. Elf Aquitaine. John Wiley and Sons, New York*, 165–173.

Ross, D. J., & Skelton, P. W. (1993). Rudist formations of the Cretaceous: a palaeoecological, sedimentological and stratigraphical review. In *Sedimentology review/1*. Wiley Online Library.

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*(2), 213–224.

Saeed, Z. M. M. (2014). *3D integrated geological modeling of Mishrif Formation in Noor oil field, Missan governorate*. University of Baghdad.

Sanders, D., & Höfling, R. (2000). Carbonate deposition in mixed siliciclastic–carbonate environments on top of an orogenic wedge (Late Cretaceous, Northern Calcareous Alps, Austria). *Sedimentary Geology*, *137*(3–4), 127–146.

Sandulli, R. (2004). The Barremian carbonate platform strata of the Montenegro Dinarids near Podgorica: a cyclostratigraphic study. *Cretaceous Research*, *25*(6), 951–967.

Saqer, M. H. (2014). *Geological Reservoir Evaluation of Mishrif Formation in Tuba oil field, southern Iraq*. University of Baghdad.

Scott, R. W. (1995). Global environmental controls on Cretaceous reefal ecosystems. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *119*(1–2), 187–199.

Sharland, P. R., Archer, R., Casey, D. M., Davies, R. B., Hall, S. H., Heward, A. P., Horbury, A. D., & Simmons, M. D. (2001). Arabian plate sequence stratigraphy, GeoArabia Spec. *Publ., Bahrain Gulf Pet*, *2*, 374.

Sharland, P. R., Archer, R., Casey, D. M., Hall, S. H., Heward, A. P., Horbury, A. D., Simmons, M. D., & Sissakian, V. (2001). Arabian Plate sequence stratigraphy, GeoArabia, special publication 2, Gulf Petrolink, Bahrain. *GeoArabia Special Publication 2*, 371.

Sherwani, G. H. (1983). Depositional environment and stratigraphic relationships of Mishrif Formation and equivalents in selected boreholes, southern and middle Iraq. In *Unpublished M. Sc. Thesis, University of Baghdad*. University of Baghdad.

Sherwani, G. H. (1998). *Sequence stratigraphy and depositional systems of Cenomanian-early Turonian formations in southern Iraq*. University of Baghdad.

Silva, P. (1995). Cretaceous planktonic foraminiferal biostratigraphy and evolutionary trends from the Bottaccione section, Gubbio, Italy. *Palaeontographia Ital.*, *81*, 2.

Simo, J. A., & Lehmann, P. J. (2000). Diagenetic History of Pipe Creek Jr. Reef, Silurian, North-Central Indiana, USA. *Journal of Sedimentary Research*, *70*(4), 937–951.

Van Buchem, F. S. P., Razin, P., Homewood, P. W., Oterdoom, W. H., & Philip, J. (2002). Stratigraphic organization of carbonate ramps and organic-rich intrashelf basins: Natih Formation (middle Cretaceous) of northern Oman. *AAPG Bulletin*, *86*(1), 21–53.

Van Buchem, F. S. P., Razin, P., Homewood, P. W., Philip, J. M., Eberli, G. P., Platel, J.-P., Roger, J., Eschard, R., Desaubliaux, G. M. J., & Boisseau, T. (1996). High resolution sequence stratigraphy of the Natih Formation (Cenomanian/Turonian) in northern Oman: distribution of source rocks and reservoir facies. *GeoArabia*, *1*(1), 65–88.

Videtich, P. E., McLimans, R. K., Watson, H. K. S., & Nagy, R. M. (1988). Depositional, diagenetic, thermal, and maturation histories of Cretaceous Mishrif Formation, Fateh field, Dubai. *AAPG Bulletin*, *72*(10), 1143–1159.

Wilson, J. L. (1975). Carbonate facies in geologic history Springer-Verlag. *New York*, *471*.

Zhicheng, Z., Willems, H., & Binggao, Z. (1997). Marine Cretaceous-Paleogene biofacies and ichnofacies in southern Tibet, China, and their sedimentary significance. *Marine Micropaleontology*, *32*(1–2), 3–29.

About the authors

Mr. Ayham Ali Dawood is a geologist and currently an M.Sc. student at the Department of Earth Science, University of Baghdad, Iraq. He holds a B.Sc. degree in Geology in 2019 from the University of Baghdad, Iraq.
e-mail: Ayhem94@yahoo.com

Dr. Salam I.M. Al-Dulaimi is a paleontologist and stratigrapher. He was awarded the B.Sc. degree in Geology in 1986, the M.Sc. degree in Paleontology in 1992, and the Ph.D. degree in Paleontology and Stratigraphy in 2011 from the University of Baghdad., He served as the Head of the Department of Earth Science, College of Science, University of Baghdad from 2015 – 2018. Also, he is currently the head of the Department of Earth Science, College of Science, University of Baghdad in 2022 for the second time. His main areas of interest include Biostratigraphy, Paleontology, and Microfacies Analysis.

e-mail: salamgeo2018@gmail.com