Large Benthic Foraminifera Biozonation of Mauddud Formation in Selected Section from Balad Oil Field, Central Iraq

Shahad F. Asady¹,* and Salam I. Al-Dulaimi¹

¹ Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq
* Correspondence: alasadyshahad95@gmail.com

Abstract
Three subsurface sections Ba-1, Ba-4, and Ba-8, and sixty-five thin sections were examined to investigate the biostratigraphy of the Mauddud Formation (age Early Albian - Late Cenomanian) within the Balad Oil Field located in central Iraq. The formation is lithologically composed of dolomitic limestone, creamy oolitic limestone, and shale. Orbitolina qatarica, Orbitolina sefini, and Orbitolina concava range zones were distinguished as biozones, including the Late Albian (Orbitolina qatarica), Late Albian to Early Cenomanian (Orbitolina sefini), and Early-Cenomanian (Orbitolina concava) zones. The age of these biozones confirmed the extent throughout the early Cenomanian age. Fossils of twenty-seven species of Foraminifera, including Conicorbitolina conica, Miliolids, Neoiraqia convexa, Nezzazata, orbitolina sp., Spiroluculina sp., and Trocholina sp., and others like Coral, gastropods, and rudist were identified.

Keywords: Mauddud Formation; Benthic foraminifera; Biostratigraphy; Balad oilfield; Central Iraq

1. Introduction
The Cretaceous formations of Iraq are characterized by a wide geographic distribution and many of them represent significant carbonate and siliciclastic reservoirs. Many studies are conducted to investigate the paleontology, stratigraphy, and reservoir properties of the Cretaceous carbonate formations in Iraq (e.g., Al-Dulaimy, 2020; Al-Mamory and Al-Dulaimi, 2020; Faisal and Mahdi, 2020a; Kamil et al., 2021; Mousa et al., 2021; Mousa and Shakir, 2023; Shakir and Mousa, 2023; Khazaal and Shakir, 2022; Jabbar and Al-Zaidy, 2023; Noori et al., 2016; Manhi and Alsultani, 2021; Ezzulddin and Ibrahim, 2022). In the Luhais and West Qurna Oil fields in Southern Iraq, Abid et al. (2015) and Al-Zaidy and Amer (2015) investigated the facies associations and evolution of the diagenetic features during the Albian-Early Turonian period. The Mauddud Formation is widely distributed throughout the subsurface of the Arabian Plate area and consists of shallow water carbonates. The initial description of this formation occurred in Qatar; since then, it has gained recognition in the northern Gulf, Kuwait and Iraq, the southern Gulf, UAE and Oman, and eastern Arabia, Saudi Arabia, and Bahrain, as well (Sadooni and Alsharhan, 2003). In Kuwait's northern region, the formation consists of a single limestone unit whose thickness ranges from less than 2 m in the Umm Gudair field to more than 90 m in the Raudhatain field, (Adasani, 1967; Al-Shamlan, 1975). The Mauddud Formation disappears between Wara and Nahr Umr in western Kuwait, as well as pinches out on the eastern flank of the Hail-Rutbah Arch (Ibrahim, 1981). According to Ibrahim (1983) and Jassim and Goff, 2006, the

DOI: 10.46717/gj.57.1D.8ms-2024-4-18
Mauddud Formation has a disconformable upper contact with the Ahmadi Formation in southern Iraq. The conformable and gradational lower contact of the Mauddud Formation is observed in relation to the Nahr Umr Formation. The thickness of the succession varies due to lateral changing of the facies and erosion truncation. The outcrops in northeast Iraq include Qamchuqa succession which comprising of organo-detrital, detrital and locally including argillaceous limestone with variable dolomitization stages (Bellen et al., 1959). Qamchuqa Formation is represented by the upper and lower Qamchuqa Formation deposited during the Early Aptian-Late Albian within the Zagros foreland basin (Buday, 1980). *Oorbitolina rich* microfacies are observed in Mauddud Formation (Al-Dabbas et al., 2012; Amer and Al-Zaidy, 2021). The upper and middle portions of the Mauddud Formation are dominated by open marine facies, whereas the lower section is occupied by mid-ramp facies, according to the facies model (Faisal and Mahdi, 2020b).

Al-Dulaimi, 2020, recorded the gastropod of Aptian-Cenomanian succession in Northern Iraq. In Southern Iraq, Mauddud succession comprises frequently dolomitized organo-detrital limestones (Bellen et al., 1959). Reservoir abilities are increased in grain-supported microfacies, which, depending on the size of the grains, have primary or vuggy porosity, with different pore sizes (Faisal and Mahdi, 2020a). The Balad Oil Field is situated in the Salah Al-Din Governorate and along the Tigris River, in Central Iraq. It is approximately 60–70 km north of Baghdad (Fig. 1).

Geologically, the Balad Oil Field is located in flat area with elevation ranging between 48 to 58 m a s l (Abdul-Rhaman, 1997; Sissakian, 2000; Jassim and Buday, 2006). Moreover, Iraq lies between three tectonic plates belonging to the Phanerozoic age; these are the Arabian, the Turkish and Iranian plates. The plates, which formed Iraq were a part of the Zagros and Arabian sedimentary province (Konert et al., 2001). The northern and north east margins of the Arabian Plate are bounded by the collisional Taurus-Zagros suture, in contrast, the western plate boundary is stranded in the NW by the left lateral transtensional Dead Sea fault zone, and in the south west by the Red Sea spreading axis (Beydoun, 1991). Balad Oil Field is located with the Unfolded Zone (Mesopotamian Basin), in the northwestern part of the Zagros fold–thrust belt of northeastern Iraq (Fig. 2). Multiple stages of convergence resulted in the origin and development of this belt between the Eurasian and Arabian plates. Elongated, asymmetric anticlines of Balad Field are separated by narrow synclines, which are likely controlled by thrust faults (Aqrawi et al., 2010). The northwest and southeast direction of the Balad Oilfield’s axis parallel-shifted to the Zagros Mountains’ extended axis. The Balad Oilfield is located close to the Foot Hills zone. Moreover, it was noted that secondary stress faults had developed in the strike and dip orientations (Muhsin, 2012).
**Fig 1.** Location map of the study area modified from (Sissakian and Fouad, 2012)

**Fig. 2.** Tectonic map of Iraq show the study area after (Aqrawi et al., 2010)
This research aims to study the biostratigraphy of three boreholes (Ba-1, Ba-4, and Ba-8) located in the Balad Oil Field in central Iraq, by studying the large benthic foraminifera to determine the biozonation of Mauddud Formation.

2. Materials and Methods

Three subsurface boreholes Ba-1, Ba-4, and Ba-8, and sixty-five thin sections were examined to investigate the biostratigraphy of the Mauddud Formation (age Early Albian-Late Cenomanian) within the Balad Oil Field located in central Iraq.

For this purpose, the 65 thin sections (mostly core) were described and interpreted, together with hundred thin sections previously prepared by the Iraq North Oil Company (NOC), and were studied petrographically. The polarized microscope and CD2 camera to determine the microfossils are used (Table 1).

Table 1. Information regarding the three selected wells

<table>
<thead>
<tr>
<th>well</th>
<th>Depth(m)</th>
<th>No. of thin section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ba-1</td>
<td>2877-3110</td>
<td>25</td>
</tr>
<tr>
<td>Ba-4</td>
<td>2840-2995</td>
<td>20</td>
</tr>
<tr>
<td>Ba-8</td>
<td>2870-3152</td>
<td>20</td>
</tr>
</tbody>
</table>

3. Results and Discussion

The results of the biostratigraphic biozones of Mauddud Formation of three boreholes, Ba-1, Ba-4, and Ba-8, that are located in the Balad Oil Field, central Iraq, by studying the large benthic foraminifera are shown in Figs. 3, 4, and 5. Two types of Foraminifera are recognized in the rock samples of the Mauddud Formation: Benthonic and a small number of planktonic foraminifera, as well as echinoderm bioclasts and pieces of other fossils, make up the majority of the skeleton grains (Mousa et al., 2021). Generally, the planktonic Foraminifera are used as guide fossils (Kamil et al., 2021).

3.1. Biozonation of Mauddud Formation

The detailed biostratigraphic study of Mauddud Formation is depending on the presence of benthonic foraminifera, three biozones are distinguished as follows:

3.1.1. Orbitolina qatarica range zone

Definition: This zone was identified based on species initial occurrence as a lower limit, followed by its absence as an upper limit.

Remax: Nezzazata conica (Smout), N.simplex (Omara) (Fig. 6a), Quinqueloculina sp., Iraqia sp. Acicularia sp., Mesorbitolina oculata (Douglass), Mesorbitolina sp., Spiroplectammina sp., Conicorbitolina conica(D'Archiac) (Fig. 6f), Lithophyllum shebae (Elliott), Praealveolina sp., Valvulina sp.(Fig. 6c), Spiroloculina sp., Nummoloculina sp., Coral fragment, Rudist fragment, Pelecypoda, Gastropoda, and Bryozoa.

Thickness: 97m at Ba-1, 50m at Ba-4, and 92m at Ba-8.

Discussion: Late Albian in age, according to Schöder (1975) and Mohammed (1996). The age of this zone was ascertained to be Albian. Several researchers documented a subset of these events; for instance, consider the following: The existence of Orbitolina qatarica in Qatar was limited to the Early Cenomanian period, according to Henson (1948). Schroeder (1962) first documented O. qatarica Early Cenomanian age in Germany. Sampo (1969) restricted its description to the Albian of Iran. Loutfi and Jaber (1970) first documented it in the littoral Albian region between Saudi Arabia and Kuwait.
addition, Sugden and Standring (1975) offered an account of O. qatarica derived from the Albian strata of Qatar. Berthou (1984) restricted its scope to the late Albian to early Cenomanian periods in Portugal, and late Albian in Iraq (Fig. 6e).

3.1.2. Orbitolina sefini range zone

Definition: The lower boundary of this zone is distinguished according to the initial occurrence of this species, and its upper limit is concordant with its disappearance incident.

Remax: Nezzazata gyra (Smout) (in Ba-4), N. simplex (Omara) (in Ba-1, Ba-4 and Ba-8), Quinqueloculina sp., Iraqia sp., Iraqia simplex, Paracoskinolina sp., Spiroloculina sp. (Fig. 7c), Spiroplectammina sp., Praevalveolina sp., Valvulina sp., Nummoloculina sp., Eclusia sp., Pseudotextulariella sp., Rabanitina basransis (Smout), Mesorbitolina oculata (Douglass), Nezzazata conica (Smout), Neoiraqia convexa (Danilova), others Coral fragment, Rudist fragment, Pelecypoda, Gastropoda, and Bryozoa.

Thickness: 65m at wells Ba-1, 32m at Ba-4, and 65m at Ba-8.

Discussion: the age of this zone was identified to be Late Albian to Early Cenomanian based on Schroeder (1975) who chose the boundary between the Late Albian and Early Cenomanian periods is where this zone is situated. Additionally, the species Orbitolina sefini has been documented in strata dating from the Albian to the Cenomanian period in each country listed below: It was discovered in Sefin Dagh from the Upper Qamchuqa Formation in northern Iraq (Henson, 1948), in the Albian (Mauddud Formation) in southern Iraq (Fig. 6d) (Chatton and Hart, 1960), and in Spain during the Late Albian period (Peybernes, 1976), in the Early Cenomanian period in Portugal (Berthou and Schroeder, 1978).

3.1.3. Orbitolina concava range zone

Definition: The determination of this zone is based on the initial occurrence of these species as a lower boundary and the absence of them at the upper boundary.

Remax: Nezzazata conica (Smout), N. simplex (Omara), N. gyra (Smout), N. picardi, Quinqueloculina sp., Mesorbitolina aperta, Triloculina sp. (Fig. 6b), Valvulina sp. (Fig. 7d), Conicorbitolina conica (D'Archiac), Corinoconus castarasi, Spiroplectammina sp., Textularia sp., Dicyconella sp., Mesorbitolina oculata (Douglass), Spiroloculina sp., Nummoloculina sp., Eclusia sp., Rabanitina basransis (Smout), Cuneolina hensoni Dalzie, Neoiraqia convexa (Danilova) (Fig. 7-e), Pseudolitunella sayyabi Mohammed (Fig. 7a and f), Acicularia sp., Neomeris cretacea (Steinmann), Pseudotextulariella sp., Coral fragment, Rudist fragment, Pelecypoda, Gastropoda, and Bryozoa.

Thickness: 120m at Ba-1, 78m at Ba-4, and 119m at Ba-8.

Discussion: This zone is of Early Cenomanian age (Schroede, 1975); Mohammed (1996) also distinguished this zone as of Early Cenomanian age. The age of this zone was ascertained as Cenomanian in this study. A number of those appearances are as follows: several researchers created the recording in the following manner: Lamarck, 1918 and Douglass, 1960, first described the species Orbitolina cf. concava (Lamark) in the type locality, attributing it to the Cenomanian period. The following countries have documented the presence of the Orbitolina concava species in strata dating back to the Cenomanian period such as in Iraq and Qatar (Fig. 7b), (Dufaure, 1959; Schroeder, 1962; Ellis and Messina, 1966), and in Iran, Switzerland, Spain, and Italy as stated by Sampo,1969; Satorio and Venturini, 1988; and Mohammed,1996. Bozarganica (1964) named Orbitolina cf. concava (Lamark) from Albian–Early Cenomanian rocks. Orbitolina cf. concava (Lamark), was observed within the Albian–Cenomanian rock in France, Spain, and Qatar (Loeblich and Tappan, 1988). It was restricted by Al-Siddiki (1978) to southern Iraq during the Late Albian to Early Cenomanian period.
Fig. 3. Biostratigraphic biozones of Mauddud Formation in well Ba-1

Fig. 4. Biostratigraphic biozones of Mauddud Formation in well Ba-4
Fig. 5. Biostratigraphic biozones of Mauddud Formation in the well Ba-8

4. Conclusions

Twenty-seven species of foraminifera were identified, Bioconcava bentori Hamaoui, Conicorbitolina conica (D’Archiac), Iraqia simplex (Henson), Mesorbitolina sp., Neoiraria convexa (Danilova), Nezzazata simplex sp. Omara, Nezzazata gyra, Nezzazata conica, Orbitolina (Mesorbitolina) subconcava, Mesorbitolina sp, Orbitolina concava LAMARK, Orbitolina qatarica (Henson), Orbitolina sefini Henson, Orbitolina sp., Pseudolitunella sayyabi Mohammed, Pseudolitunella reicheli Marie, Pseudotextulariella sp., Quinqueloculina sp., Spiruloculina sp., Trocholina Arabica Henson, Trocholina alpina Henson, Valvulina sp., Neorbitolina sp., Spirolactammina sp., Milliolids sp., Mesorbitolina oculata, Nummoloculina, Dictyoconus pyrenaicus.

Three biozones are distinguished in the Mauddud Formation depending on benthic foraminifera. These zones are:

a- Orbitolina qatarica range zone (Late Albian age).
b- Orbitolina sefini range zone (Late Albian-Early Cenomanian age).
c- Orbitolina concava range zone (Early Cenomanian age).

The Mauddud Formation's age has been determined to be between the Late Albian and Early Cenomanian based on the biozone of foraminifera.
Fig. 6. a) Nezzazata simplex OMARA, Ba-1, b) Triloculina arabica, Transversal section, Ba – 1, c) Valvulina sp., Axial section, Ba-1, d) Orbitolina seifini, Ba-1, e) Orbitolina qatarica, Ba-4, f) Conicorbitolina Conica, Ba-4
Acknowledgements

This study was conducted with the assistance of the College of Science, Geology Department, University of Baghdad. We extend our gratitude to our counterparts from an oil exploration firm (O.E.C).

References

Bellen, R.C. van, H. V. Dunnington, R. Wetzel, D. M. Morton, 1959. Lexique Stratigraphique international. 3, Asia, fasc. 10a, Iraq, 333.
Bozargani, F., 1964, Microfacies and micro-organism of Paleozoic through Tertiary sediments of some parts of Iran, National Iran oil company, 6-22,75.
Dufaure, P., 1959. Proplémas stratigraphiques Dans Le Crétace


