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Facies distribution and depositional environment of Fatha Formation (Middle Miocene) in Heet area, western Iraq

Saba F. Al-Karbooli[1*], Amer S. Al-Jibouri[1]

[1]Department of Geology, College of Science, University of Anbar, Anbar, Iraq

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Corresponding author
Saba F. Al-Karbooli
Sab21s4004@uoanbar.edu.iq

ABSTRACT

The Fatha Formation, the youngest recognized formation, represents a Middle Miocene age in the study area. The Heet section, which is situated in the northeast part of Al-Anbar city, about 70 kilometres from Al-Ramadi, was sampled carefully for microfacies studies of the Middle Miocene succession of the Fatha Formation. Lithologically, this formation consists of two cyclic alternations of sandstone, siltstone, and claystone interbedded with marl, marly limestone, and gypsum with a thickness ranging from 7.2 to 4.8 meters. The details obtained from the textural and faunal properties have aided in the identification of microfacies zones, which have led to the division of the environment. Seven mixed clastic-carbonate facies types were recognized in the Fatha Formation in the Heet section. These include: Sandy Lime Mudstone, Dolomitized Lime Mudstone, Gastropods Lime Packstone, Bioclastic Lime Packstone, Claystone to Siltstone lithofacies, Marly Limestone lithofacies, and Gypsum lithofacies. These microfacies types can be grouped into four depositional environments: coastal, evaporitic, restricted to shoal environments.

Keywords: *Depositional environment, Fatha Formation, Microfacies,, Middle Miocene, Western Iraq*

1 INTRODUCTION

Busk and Mayo (1918) first described the Fatha Formation in the province of Fars, Iran [1]. Then, Jassim et al. (1984) renamed this formation in the Al Fatha Gorge as the Fatha Formation, where the Makhul-Hamrin Range [2]. The formation is primarily evaporitic, characterized by numerous shallowing-upward cycles of alternating mud rocks, limestones, gypsum, anhydrite, and halite. Additionally, the formation contains economically significant deposits of sulfur, found in evaporite beds that consist mainly of gypsum and anhydrite, as well as sulfate and salts [3–5]. The Fatha Formation consists of cycles of mudstone, limestone, and gypsum in the Heet area [6]. The sedimentary environment for this formation is a closed lagoon environment [7], and the study of [8] proved that the depositional basin of the Fatha Formation comprises a subtidal shelf with lagoons. While a previous study concluded that the formation is deposited in the inner ramp in a shallow part (peritidal, lagoon, and shoal zone) [9]. Several studies and books have described the Fatha Formation; most of these studies have concentrated on geological overviews of Iraq and provided descriptions of specific lithofacies [1, 10–13].

The study area lies between the stable shelf of the western desert and the unstable shelf of the Mesopotamian zone, within the Abu-jir fault zone, situated in the northeast of the Anbar Governorate about 70 Kilometer from Al-Ramadi. The section is situated at coordinates 42° 50' 25" E, 33° 37' 1" N with a thickness of about 12 meters (Figure 1). The main aim of this study is to interpret the depositional environment based on microfacies analysis.

1.1 Geological setting

The Fatha Formation (Middle Miocene) is one of the most regionally widespread formations in Iraq [6, 14]. The section is situated in the NE part of the Arabian plate. The present study is within the main tectonic division, specifically the Stable shelf of western Iraq [6]. It's

bounded to the north by the Jazera subzone, to the east by the Salman Zone, and to the west by Syria and Jordan. The section is also bounded by two types of transverse fault zones, which are the Amij-Samarra Fault to the north and the Sirwan Fault to the south, situated within the central Iraqi block [6]. The main structural features in the northern and eastern regions of this area are the Euphrates and Abu-Jir fault zones, which demarcate the boundary between the stable shelf and unstable shelf of the Arabian platform [15].

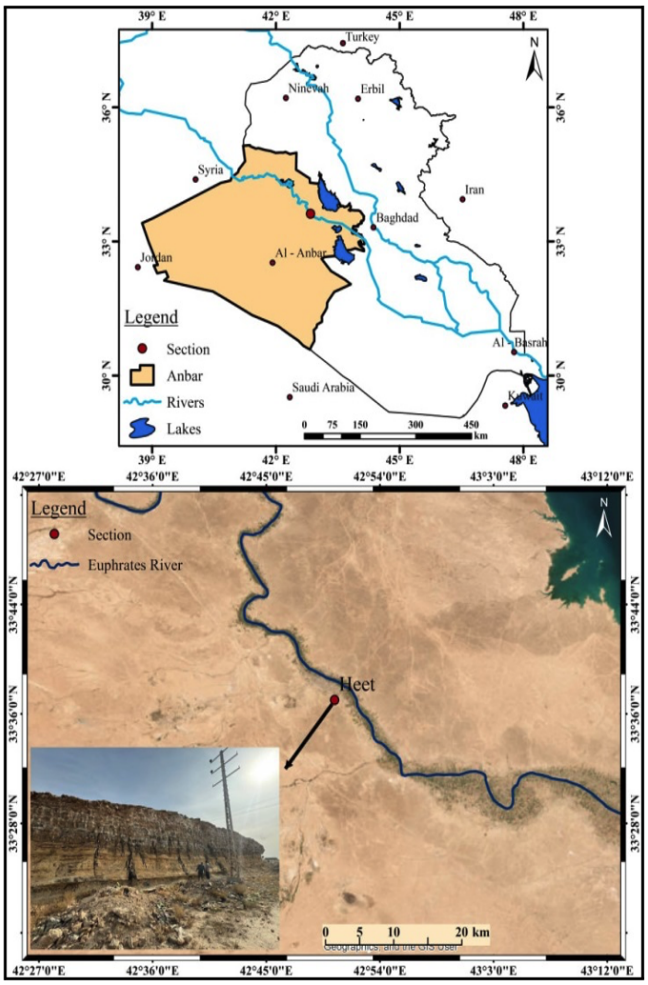

Fig. 1 Situated map of the study area

2 SAMPLING AND METHODOLOGY

Fieldwork was conducted on the Heet section (Figure 2), where thirteen samples were gathered based on their physical characteristics. Lab work, involving the preparation of twelve thin sections at the University of Anbar's geology department workshop, was conducted and studied using a polarizing microscope to identify the microfacies. The microfacies types were categorized according to the classification indicated in [16].

Fig. 2 The Fatha Formation outcrop (Heet section)

3 RESULT AND DISCUSSION

Fieldwork studies have shown that the formation succession consists of a diverse range of mudstone, limestone, and gypsum. The section was divided into two cycles: the first cycle, characterized by a yellowish silty claystone with intercalations of siltstone, yellowish limestone, marly limestone, and claystone. At the top of the cycle, massive gypsum contains oil seeps. The second cycle consists of marly limestone and siltstone, fossiliferous limestone, marly limestone, and the end of the sequence, which consists of massive gypsum (Figure 3).

3.1 Microfacies type

Four microfacies types were recognized in this section: **Sandy Lime Mudstone microfacies (HM1)**. This microfacies was recorded in the lower and middle parts of Cycle 2, characterized by the presence of pure sand grains, with sand sizes ranging from very fine to coarse-grained (Figure 4A). The facies with high mud ratios are predominantly found in environments characterized by very low energy, indicating that it is similar to (SMF-23) and (FZ.8). These microfacies are presented in the restricted Platform.

Dolomitized Lime Mudstone microfacies (HM2). This microfacies was characterized in the middle part of Cycle One. It consists mainly of dolomite (90%). The dolomite

grains were found in very small sizes (Figure 4B). It indicates that it is similar to SMF-23 and FZ.8; these facies are presented in the low-energy and Peritidal region in the restricted Platform.

Gastropods Lime Packstone microfacies (HP1). In this study, Gastropods Lime Packstone occurred in the middle parts of Cycle two. It was characterized by the presence of Gastropods (63%), ostracods (2%), and skeletal grains (10%). The dominant component is Gastropods with scattered skeletal grains and ostracods (Figure 4C). It indicates the shallow marine, low-energy, and lagoonal environments. This microfacies is compatible with the SMF-12 within FZ.6. It appears to have been deposited in a sand shoal environment.

Bioclastic Lime Packstone microfacies (HP2). These facies were recorded in the middle parts of Cycle two. This type of microfacies was characterized by the presence of bioclastic material, mainly consisting of 43% peloids, 27% Miliolids, and 12% pelecypoda, which exhibit a broken residue (Figure 4D). These facies reflect the shallow water environment. It indicates that it is similar to SMF-11 and FZ.6, which suggests the environment of the Platform-margin sand shoals.

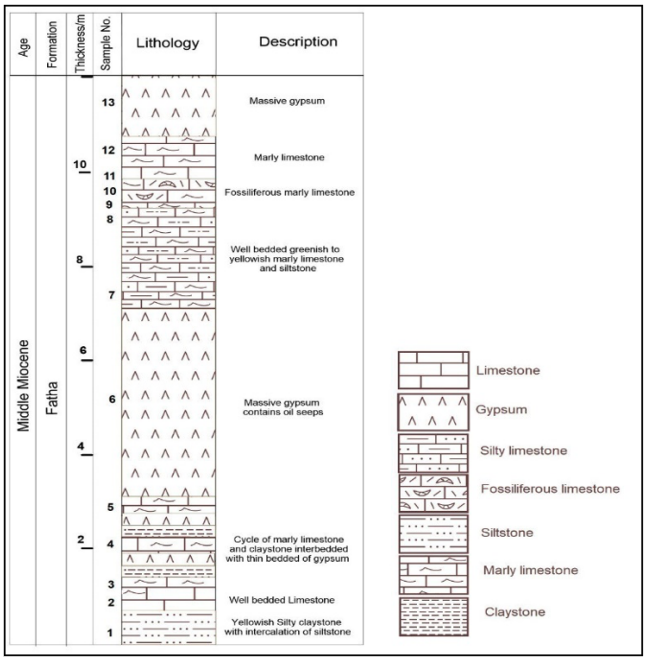

Fig. 3 Lithostratigraphy column of Fatha Formation in the study area

3.2 Lithofacies type

Three lithofacies are named as HL1, HL2, and HL3. These facies reflect the paleoecology and depositional environments that prevailed during the formation's deposition. Three lithofacies types were recognized in the Heet section:

Claystone to Siltstone Lithofacies (HL 1). This lithofacies consisted of yellowish claystone and siltstone (Figure 5A). This combination indicates a low-energy depositional environment in which fine-grained sediments accumulate. It appeared in the lower parts of the first cycle with a thickness of 70 cm. The fossils are rare, these lithofacies indicate a coastal shallow water environment with balanced currents.

Marly Limestone Lithofacies (HL 2). These facies are recorded in the middle parts of the first cycle with a thickness of 2 m, as a cycle of yellowish to greenish marly limestone and claystone interbedded with a thin layer of gypsum (Figure 5B). The presence of the clays indicates turbid water. Turbidity is not a convenient condition for fauna to survive and thus hampers the carbonate factory and limestone deposition [17, 18]. This lithofacies indicates a coastal environment with balanced currents, with variations from shallow to deeper marine conditions.

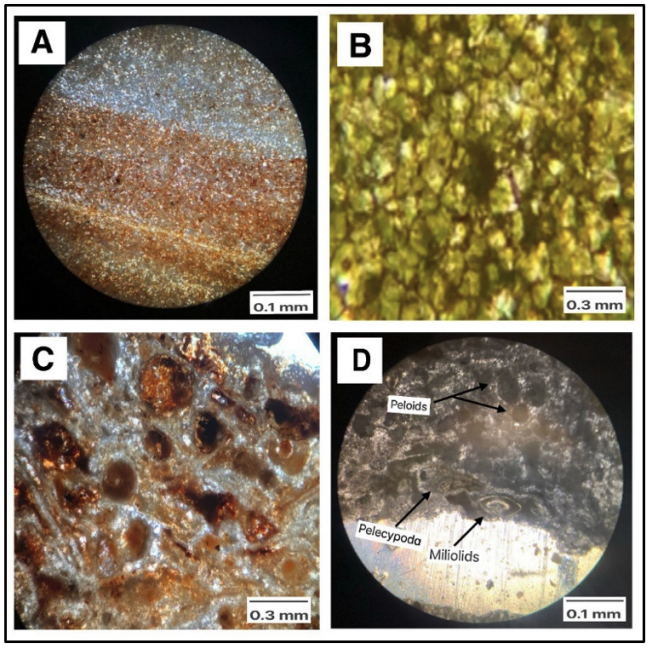

Fig. 4 Microfacies types of Heet section:A) Sandy Lime Mudstone.B) Dolomitized Lime Mudstone. C) Gastropods Lime Packstone.D) Bioclastic Lime Packstone

Gypsum Lithofacies (HL 3). Evaporites made up approximately 50% of the total thickness of the Middle Miocene Fatha Formation in Iraq [19]. It appears as white to gray massive gypsum (Figure 5C). This lithofacies is recorded in the upper parts of the first cycle with a thickness of 4 m, and in the upper parts of the second cycle with a thickness of 1.5 m. The gypsum also appears in the formation as a secondary gypsum. Gypsum may be deposited in a sabkha or supratidal flat environment, such as a coastal or inland sabkha with a semi-barred, shallow lagoon [20]. These facies indicate an evaporative environment where water evaporated extensively, leaving behind gypsum deposits.

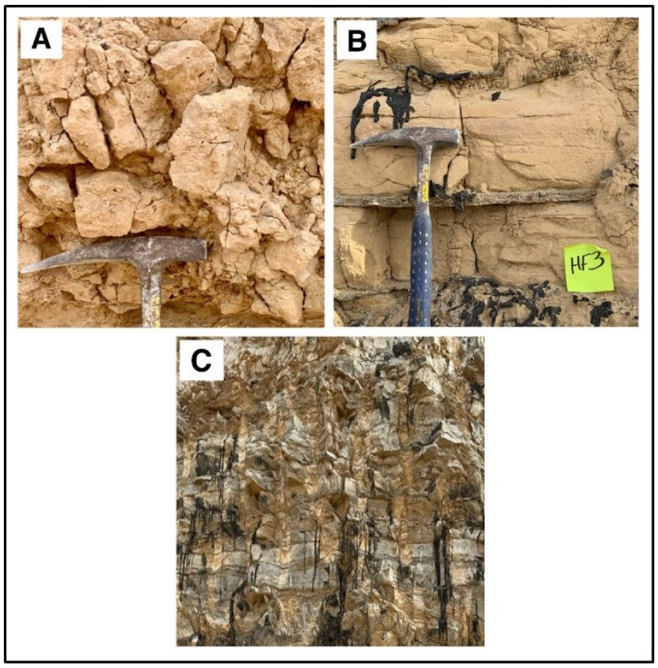

Fig. 5 Lithofacies types of Heet section: A) Claystone to Siltstone. B) Marly Limestone. C) Gypsum

3.3 Depositional environment

The current study employed the microfacies classification, as outlined in [18, 21], to elucidate the depositional environment and conditions that prevailed during the deposition of the Fatha Formation. Four depositional environments were identified in the study area (Figure 6).
Shoal: Shoal environment in this study represented by Gastropods Lime Packstone Microfacies (HP1) contains Gastropods, ostracods, and skeletal grains. The Bioclastic Lime Packstone Microfacies (HP2) containing Bivalve shell, Miliolids, Peloidal, with a smaller percentage of oolite, in the middle part of the second cycle of the Heet section (Figure 4 C and D). These facies are compatible with the (SMF-11 and 12) in facies zone (FZ.6), which indicates a sand shoal.
Restricted marine. This environment is represented mainly by the Sandy Lime Mudstone Microfacies (HM1), which contains mainly sand grains, and the Dolomitized Lime Mudstone Microfacies (HM2), which contains mainly dolomite grains. This environment was recognized in the middle of the first cycle, lower and middle of the second cycle in the Heet section (Figure 4 A and B). This microfacies is compatible with the (SMF-23) of (FZ.8) in the restricted bays and ponds in the restricted Platform.
Evaporitic environment. This environment is represented mainly by Gypsum Lithofacies (HL3). This environment is recognized in the upper part of the first and second cycles, in the Heet section. This lithofacies is compatible with the (FZ.9) in the Arid Platform Interior – Evaporitic.
Coastal Environment. It is represented by Claystone to Siltstone Lithofacies (HL1), and the Marly Limestone (HL2).

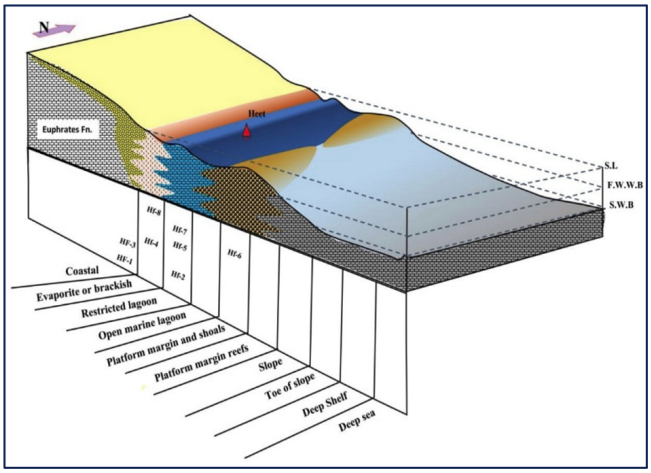

Fig. 6 Three-dimensional model showing the depositional environments of (Middle Miocene) Fatha Formation in the study area

4 CONCLUSION

According to the study, the facies of the Fatha Formation in the Heet sections. Four carbonate microfacies types were recognized in this section (Sandy Lime Mudstone, Dolomitized Lime Mudstone, Gastropods Lime Packstone, and Bioclastic Lime Packstone). These microfacies are rich in gastropods, ostracods, bivalve

shells, miliolids, and peloidal material, with a smaller percentage of oolite and skeletal debris particles. And three lithofacies types (Claystone to Siltstone, Marly Limestone, and Gypsum). Based on facies identification and interpretation, the depositional environments were identified as ranging from shoal, restricted, evaporitic, and coastal settings.

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Conflict of interest

Authors have no known competing of interests.

Consent to publish

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N/A

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