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PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY AND PALEOENVIRONMENTAL ANALYSIS OF THE KHASIB FORMATION, EAST BAGHDAD OIL FIELD, CENTRAL IRAQ

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Abstract

The current study deals with the biostratigraphy and paleoenvironmental analysis of the Khasib Formation, in Well (EB 11), within the East Baghdad Oil Field, Central Iraq. Nineteen samples were examined to recover planktonic foraminiferal microfossils from the studied section. Thirteen species belonging to five genera have been identified and classified. These include: *Heterohelix globulosa*, *Heterohelix reussi*, *Hedbergella delrioensis*, *Globotruncanita arca*, *Globotruncanita bulloides*, *Globotruncanita linneiana*, *Globotruncanita elevata*, *Globotruncanita lapparenti*, *Dicarinella concavata*, *Dicarinella primitiva*, *Dicarinella asymetrica*, *Marginotruncana renzi*, *Marginotruncana sigali*. Based on the identified species' stratigraphic distributions Khasib Formation has been subdivided into three planktonic foraminiferal biozones: *Dicarinella concavata* Interval Range Biozone, *Dicarinella asymetrica* Total Range Biozone, and *Globotruncanita elevata* Total Range Biozone. These biozones have been correlated with similar studies conducted both within and beyond Iraq. Based on stratigraphic evidence, the Khasib Formation has been concluded to be of the early Late Coniacian to Early Campanian age.

According to the lithological characteristics and the abundance of planktonic foraminiferal species in the studied well, the Khasib Formation was deposited in the outer shelf to the upper bathyal of an open marine environment, which was deposited during a significant transgression episode.

Keywords: Biostratigraphy; Foraminifera; Khasib Formation; East Baghded Field; Iraq.

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1. Introduction

The Iraqi National Oil Company discovered the East Baghdad Field in 1975, reaching a total depth of 4,842 meters. It is considered a giant field with multiple reservoirs. The Khasib Formation serves as the primary Cretaceous oil reservoir, alongside the Tanuma and Zubair reservoirs in the East Baghdad Oil Field. Oil released in the Late Cretaceous to Early Paleogene by the Chia Gara Formation that has been accumulated in Cretaceous structural traps, such as the Tanuma and Khasib reservoirs (Al-Ameri, 2011; Al-Mansoor et al., 2023). Various studies have reported different ages for the Khasib Formation, indicating ongoing uncertainty, as follows: in Southern Iraq, Bellen et al. (1959), Late Campanian;

Darmoian (1975), Late Turonian – Coniacian; Al-Qayim (2010), Late Turonian – Early Coniacian; Al-Dulaimy and Sa'ad (2013), Early Turonian- Early Campanian; (Mahammed et al., 2020), Late Turonian- Early Coniacian; Al-Ali et al. (2020), Turonian- Coniacian; and from Central Iraq:(Jan, 2013), Middle – Late Cenomanian; Tukkee et al. (2023), Turonian – Early Campanian; and Al-Juboury and Al-Tharb (2013), Late Turonian in Northeastern Tikrit

Additionally, there are several petrographical, sequence stratigraphical, and petroleum studies that were made on the Khasib Formation in other sections. The following summarizes the important studies on the Khasib Formation:(Al-Badrani & Al-Khashab, 2013; Al-Fandi et al., 2020, 2023; Al-Hamdani, 1986; Al-Khaykanee, 2015; AL-Sadooni, 1981; Al-Shaoosh, 2003; Alrazzaq, 2019; Hadeed, 2017; Jameel et al., 2020).

1.1. Location of the Studied Area

The studied East Baghdad Oil field (EB-11) is located about 20 km from Baghdad City, Central Iraq. It lies east of the River Tigres. It extended from about 40 km northeast of Baghded to Taji, about 25km southwest of Baghdad, and was distributed over the portion northeast of the Diyala River between longitude (44˚21'23".57) and latitude (33˚27'55".34) (Figure 1).

1.2. Geological Setting

Tectonically, the geological structure of this oil field is a highly complex anticline fold structure, due to the presence of numerous faults (Alrazzaq, 2019). It is a block-faulted asymmetrical anticline extending NW – SE, covering 120 km in length and 20 – 30 km in width. The field is distinguished by horst-graben-related features (Sadooni, 2004) that are strongly influenced by the deformation along the Northeastern Tethyan margin of the Arabian Plate after the opening of Southern Tethys. The Khasib Formation belongs to the Late Turonian- Early Campanian secondary cycle of Late Turonian-Danin Megasquence (AP9), in the Fore deep basin within the Mesopotamian zone of the stable shelf (Buday & Jassim, 1987; Ditmar & Team, 1971) (Figure 2). The sequence is absent in the eastern part of the Rutba Subzone due to non-deposition and erosion. Buday (1980) confirmed that the sequence rests on the mid-Turonian regional unconformity and beneath another break that delimited the overlying sequence (Late Campanian- Maastrichtian; Jassim & Goff, 2006; Sharland et al., 2001) (Figure

2). During the Middle Cretaceous orogeny and the opening of the Atlantic Ocean, the sequence was deposited when the Northeastern edge of the Arabian plate underwent compression, and the onset of ophiolite obduction along the southern edge of Neo-Tethys (Sharland et al., 2001). These events led to the recognition of two main facies, within the lower part of the Megasequence, first, (deep inner shelf and lagonal Khasib, Tanuma, and Sa'adi Rock units), and second, towards the North, (outer shelf of the basinal Kometan rock unit including Mushorah Formation). The upper part comprises Hartha, Tayarat, Drigma, Aqra, Bekhme, Shiranish, Tanjero, and Hadiena formations (Jassim & Buday, 2006) (Figures 2 & 3). Buday (1980) provided a detailed study of this subcycle within the broader Cenomanian- Early Campanian cycle. The Sequence is thickest near Baghdad, in the Sinjar area, and in Southern Iraq, where it exceeds 500 m thick. Generally, the main thickness is reported in the Tigris subzone of the Mesopotamian basin (Jassim & Buday, 2006).

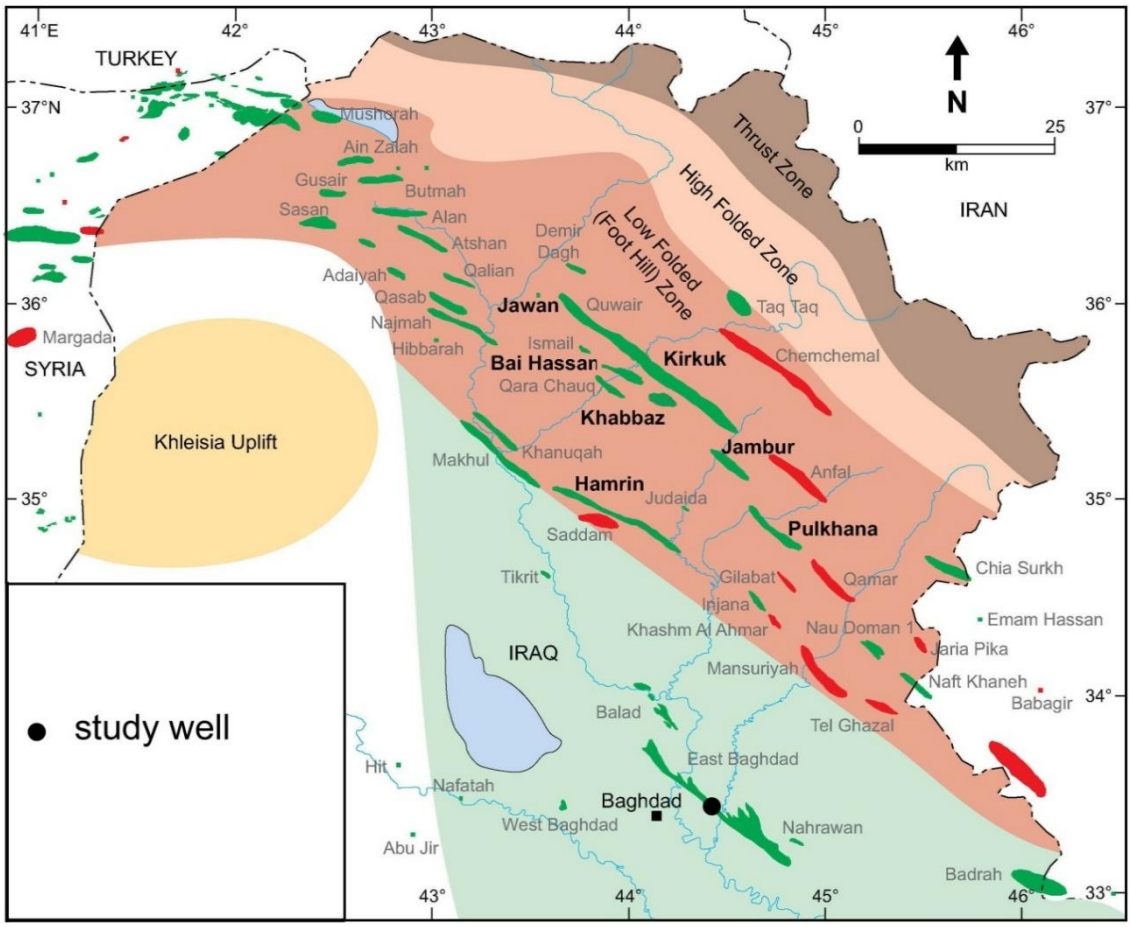


Figure 1. Iraqi oil fields map showing the location of the East Baghdad oil field (modified from Al-Ameri, 2011).

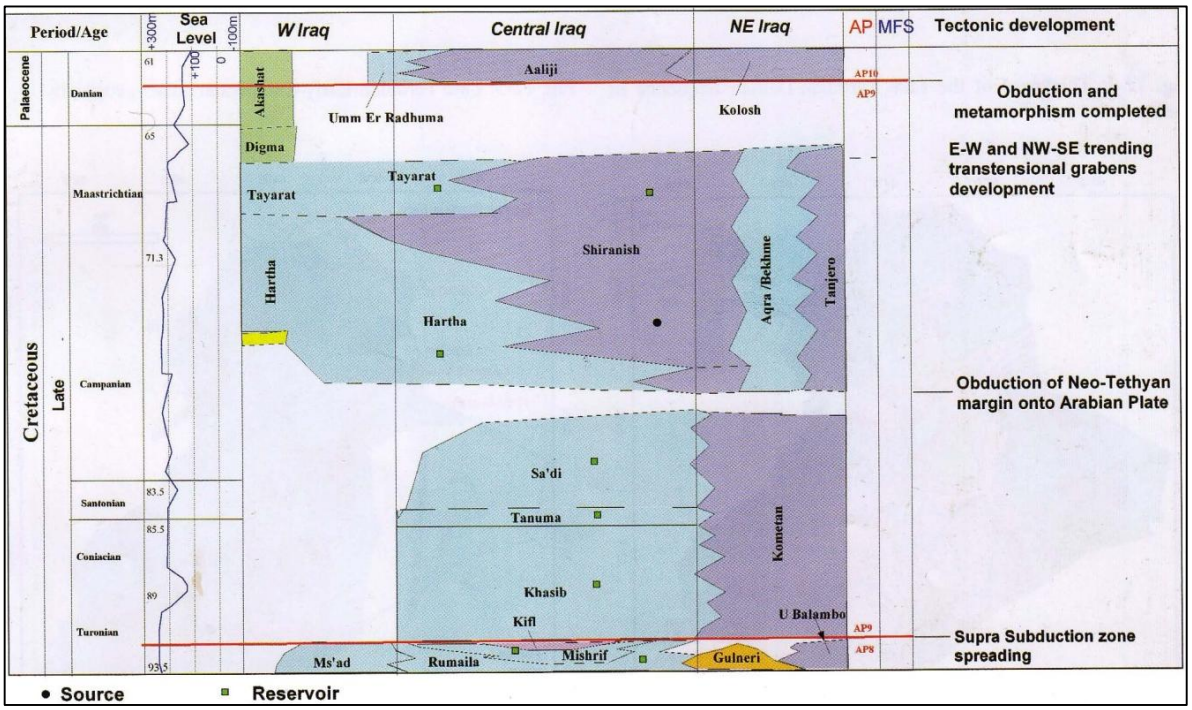


Figure 2. Stratigraphic correlation of formations of the late Early Turonian-Danian Megasequence AP9 (Jassim and Goff, 2006).

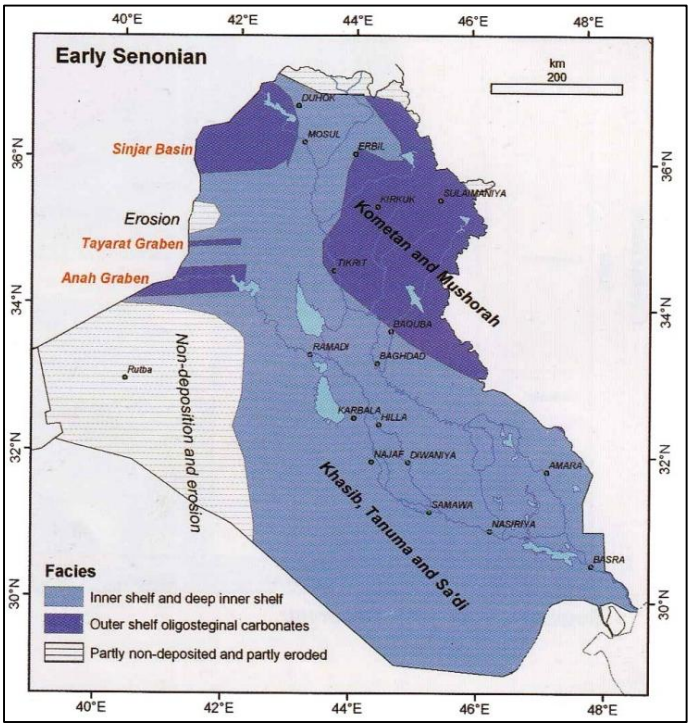
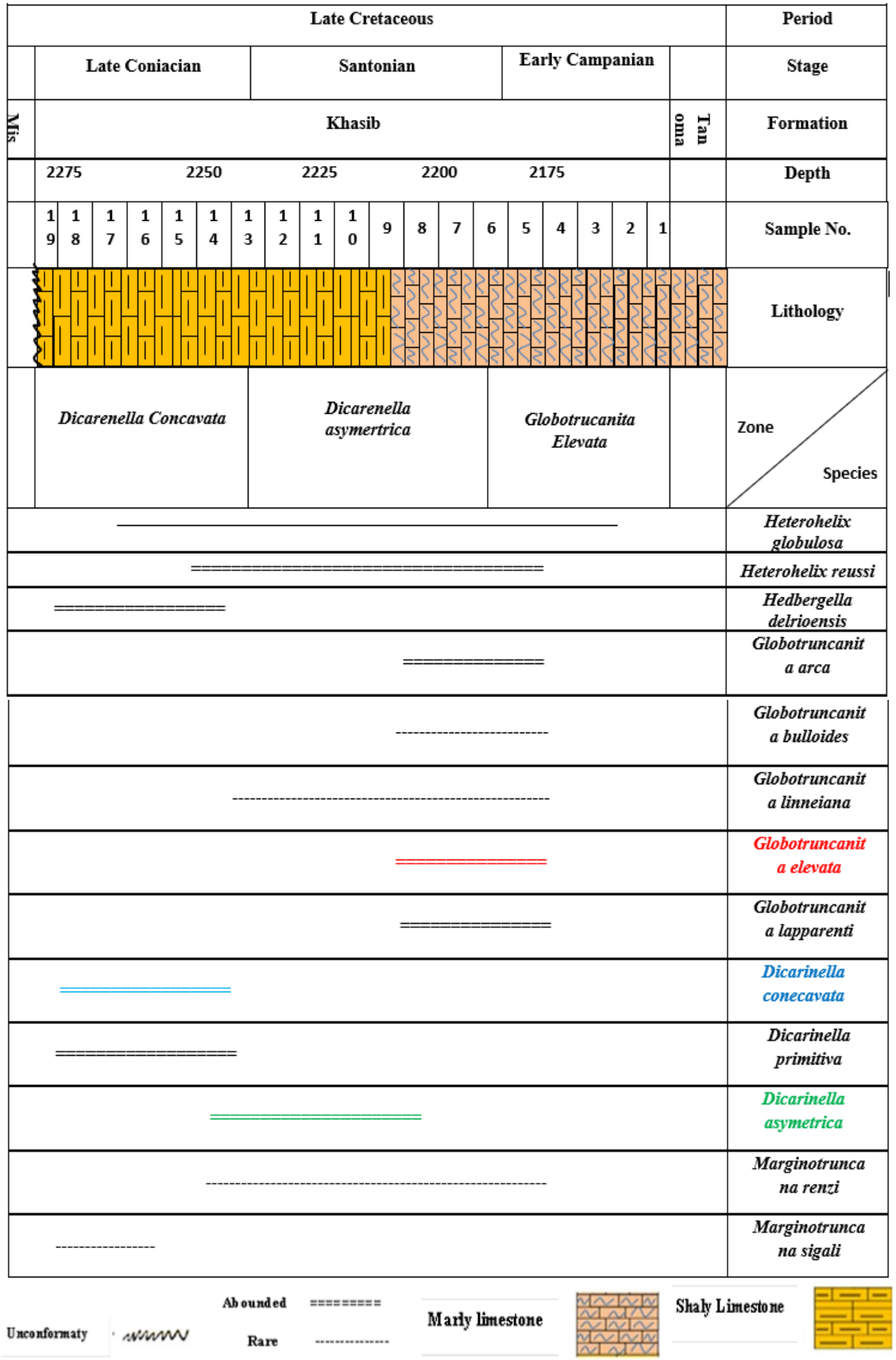


Figure 3. Late Turonian – Early Campanian main Facies and Paleogeography (Jassim and Goff, 2006).

The Khasib Rock Unit was initially defined by Bellen et al. (1959) from Zubair well in the Mesopotamian basin, Southern Iraq. It was subdivided into two lithological units: the lower part (20 meters) consists predominantly of fine-grained, grey argillaceous limestones interbedded with dark grey to greenish-grey shales. According to Bellen et al. (1959), the upper 30 meters are mainly composed of fine-grained, grey argillaceous limestones. In other wells, the formation typically comprises chalky and oligosteginal limestones. It reaches a maximum thickness of 225 meters in southern Iraq, with its greatest development observed in the Tigris subzone (Alsultan et al., 2022).In the East Baghded Oil Field, the stratigraphic column extends from the Late Jurassic to the Pliocene in age. Its thickness ranges from 60 meters to 130 meters. Although the formation exhibits a range of lithological components, it is predominantly characterized by bioturbated chalky limestones, with minor occurrences of marly limestones, dolomites, and shales (Al-Qayim, 2010; Al-Qayim et al., 1993; Al-Temimi, 2018). Al-Temimi (2018) noted that the Khasib Formation in this field mainly comprises limestone with some dolomite inclusions. The components of the lower and upper parts of the Khasib Formation are different in all areas of its distribution, and several variations within the carbonate series have appeared, including marl, shale with some alternative units of damaged and porous carbonates (Aqrawi et al., 2010). The Khasib Formation has a wide range of lithological variations throughout the whole areas of its occurrence, caused by the sedimentary processes of the basin, which began with a marine transgression resulting in the deposition of the Khasib Formation. After that, a relative drop in the sea level was followed by this episode, which is indicated by a change from the Khasib limestone marine beds into green marls and shales upwards towards the overlying Tanuma Formation (Al-Fandi et al., 2020; Aqrawi et al., 2010; Buday, 1980; Sharland et al., 2001).

The Khasib Formation is conformably overlain by the Tanuma Formation of Late Cretaceous age (Bellen et al. 1959; Jassim & Buday, 2006; Al-Badrani & Al-Khashab, 2013). The boundary is marked by a transition from grey marly limestone below to overlying black, fissile shales. It is unconformably underlain by the Mishrif Formation, identified by the first appearance of anhydrite as a cementing mineral. In central Iraq wells, however, the Khasib Formation rests unconformably on the lagoonal inner shelf deposits of the Kifl Formation (Table 1). Laterally, it grades northeastward into the Kometan Formation and transitions eastward and southeastward into the basinal Balambo Formation. Western Iraq, in contrast, was an uplifted area during deposition (Bellen et al. 1959; Jassim & Buday, 2006; Figures 2 & 3). Regionally, it correlates with the Lower Mutria Formation of Kuwait (Douban & Medhadi, 1999) and shares similarities with the middle shale-chalky limestone interval of Saudi Arabia's Aruma Formation (Powers, 1966). The type well of the Khasib Formation includes relatively scarce fossils, although other sections have an abundance of fossils (Darmoian, 1975). The formation was primarily deposited within marine carbonate platform shoals. The presence of Oligosteginal fauna and dwarfed fossils suggests a restricted depositional basin, with occasional open-marine influences, as indicated by occurrences of *Globotruncana* fossils (Jassim & Buday, 2006).

Table 1. The geological range of the planktonic foraminifera and Biozone in the Khasib Formation in Well no. 11, East Iraq.



1.3. The Aim of the Study

The current study aims to identify the planktonic foraminiferal species in the studied section and to determine their relative age, establishing biostratigraphic biozones, and correlating them with equivalent biozones both within and beyond Iraq. Additionally, the study seeks to interpret the paleoenvironment of the Khasib Formation.

2. Methodology

To accomplish the primary objectives of this research, our work is divided into two phases. The first phase includes the collection of nineteen samples (both core and cutting) from the selected well. The sconed phase is the laboratory work where samples are examined. 30 g of each sample was weighed, crushed, and boiled for 30 – 120 min, and washed with water. The sample was dried, sieved with sizes ranging from 40-60-80-100-120 mesh. Then, all the samples were picked and mounted on microslides for identification under a binocular microscope. All samples were stored at the University of Mosul, Department of Geology, Khasib 25.

3. Biostratigraphy

The samples from the Khasib Formation yielded a rich and diversified foraminiferal assemblage; thirteen planktonic species belonging to five genera were recorded from the Khasib Formation (Figures 4, 5 & 6).

The planktonic foraminiferal species, and their stratigraphy distribution are shown in Table 1. Three planktonic foraminifera biozones are recorded in the current study, these are:

- *Dicarinella concavata* Interval Biozone, *Dicarinella asymetrica* Total Range Biozone, *Globotruncanita elevata* Total Range Biozone.

The present biozones are correlated with similar ones established by Bolli (1957, 1966); Caron (1985); Hammoudi (1995); Huber & Petrizzo (2014); Premoli Silva & Sliter (1995); Premoli Silva & Verga (2004); Robaszynski et al. (1984); Robaszynski & Caron (1995); Sari (2009, 2006); Sliter (1989), as shown in Table 2.

- *Dicarinella concavata* Interval Range Biozone.

Biozone limits: the top of the zone is situated at the first appearance of *Dicarinella asymetrica*, and the base of the horizon at the first appearance of the nominate *Dicarinella concavata* species.

Age: early Late Coniacian. Tables (1, 2).

Thickness: The recorded thickness of the zone is (35) m.

Characteristics: The planktic Foraminifera associated with this biozone are:

Heterohelix globulosa, Heterohelix reussi, Hedbergella delrioensis, Dicarinella concavata, Dicarinella primitive, Marginotruncana sigali.

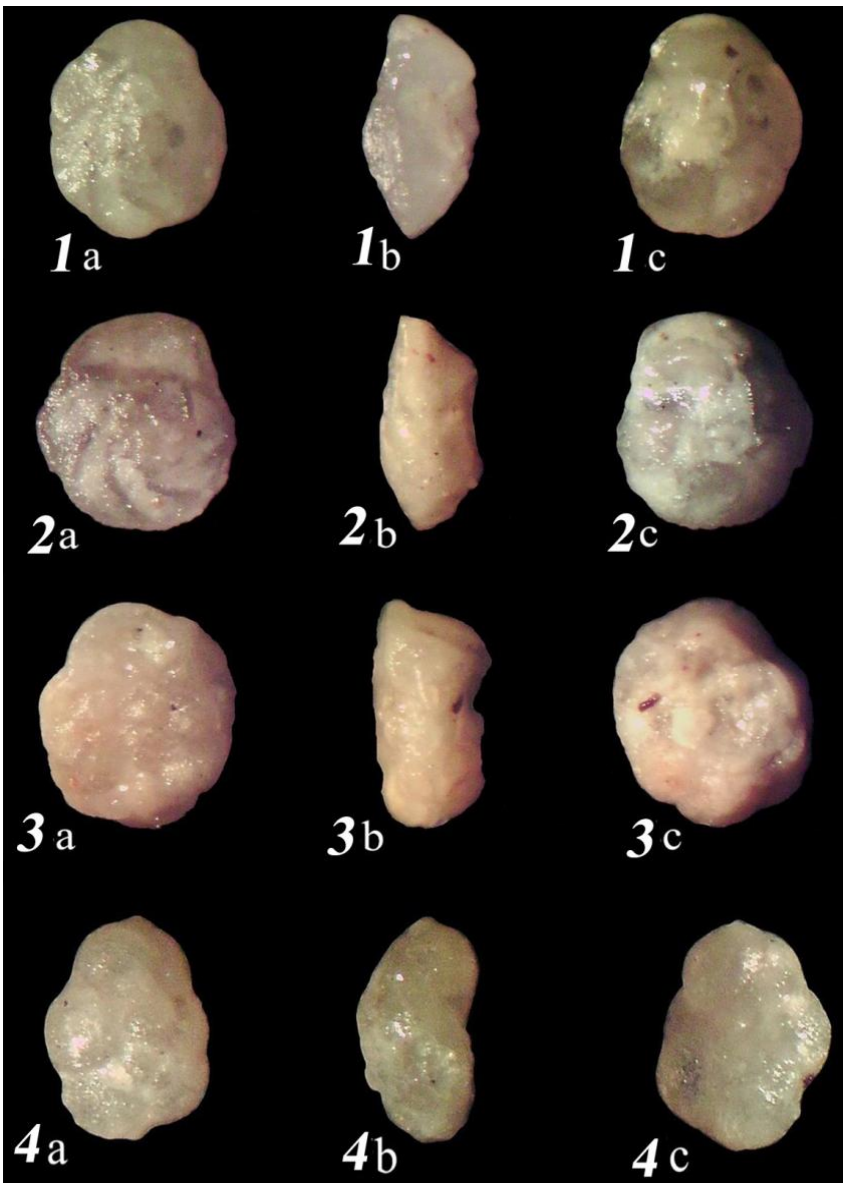


Figure 4. Planktonic foraminifera species identified from the Khasib Formation in Well No. 11, East Iraq.

1: *Globotruncanita elevata* (Brotzen). X90. 1a: Spiral side. 1b: Side view. 1c: Umbilical side. Sample No.2.

2: *Dicarinella concavata* (Brotzen). X90. 2a: Spiral side. 2b: Side view. 2c: Umbilical side. Sample No.13.

3: *Dicarinella asymetrica* (Sigal). X90. 3a: Spiral side. 3b: Side view. 3c. Umbilical side. Sample No.8.

4: *Hedbergella delrioensis* (Carsey). X90. 4a: Spiral side. 4b: Side view. 4c: Umbilical side. Sample No.15.

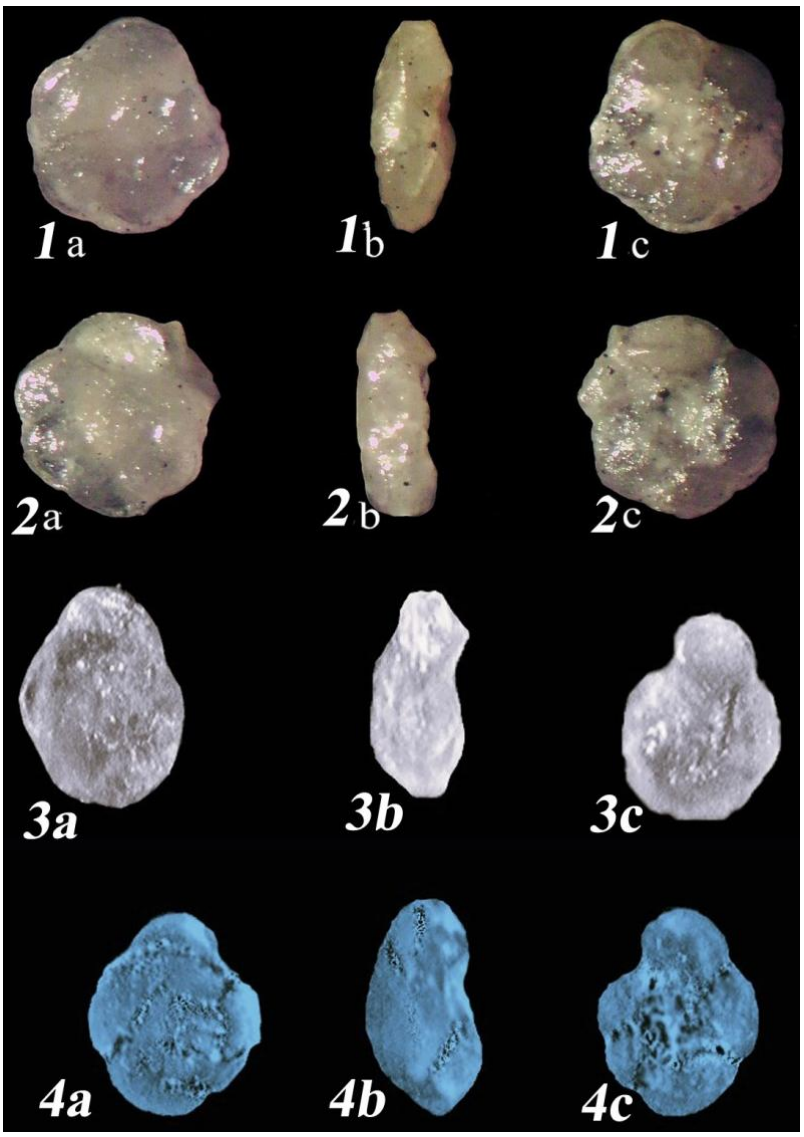


Figure 5. Planktonic foraminifera species identified from the Khasib Formation in Well No. 11, East Iraq.

1: *Globotruncana bulloides* Vogler.X90. 1a: Spiral side. 1b: Side view. 1c: Umbilical side. Sample No.4.

2: *Globotruncana linneiana* (d'Orbigny) .X90.2a: Spiral side.2b: Side view. 2c: Umbilical side. Sample No.3.

3: *Globotruncana arca* (Cushman) .X90. 3a: Spiral side. 3b: Side view. 3c. Umbilical side. Sample No.7.

4: *Globotruncana lapparenti* Brotzen. X90. 4a: Spiral side.4b: Side view. 4c: Umbilical side. Sample No. 5.

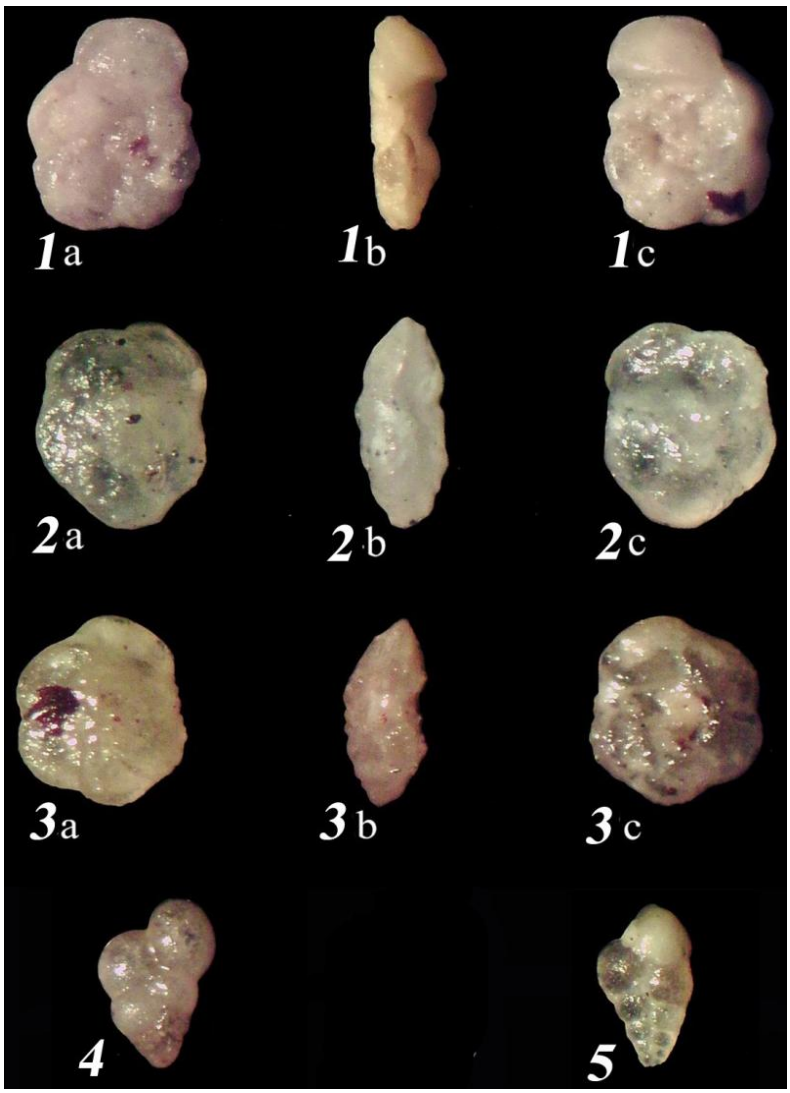


Figure 6. Planktonic foraminifera species identified from the Khasib Formation in Well No. 11, East Iraq.

1: *Dicarinella primitiva* (Dalbiez).X90. 1a: Spiral side. 1b: Side view. 1c: Umbilical side. Sample No.16.

2: *Marginotruncana renzi* (Gandolfi).X90.2a: Spiral side.2b: Side view. 2c: Umbilical side. Sample No.10.

3: *Marginotruncana sigali* (Reichel).X90. 3a: Spiral side. 3b: Side view. 3c. Umbilical side. Sample No.18.

4: *Heterohelix globulosa* (Ehrenberg). X90. Sample No.3.

5: *Heterohelix reussi* (Cushman). X90. Sample No.8.

Table 2. Correlation of the Biozones of the Planktonic formation for the Khasib Formation in the studied section with several studies inside and outside Iraq.

Stage		Present study, Iraq	Stage	Bolli, 1957,1966, Trinidant	Caron(1985), Robaszynski, et al. (1984), Sliter 1989, Premoli Silva & Sliter (1995), Italy	Robaszynski & Caron, 1995, France.	Hammoudi, 1995	AL-Ali, et al., 2020, Iraq.	Al-Juboury and Al-Tharb, 2013 Iraq
Companian	Early	*Globotruncana Elevata*		*Globotruncana Stuarti*	*Globotruncana elevata*	*Globotruncana elevata*	*Globotruncana elevata*		*Globotruncana elevata*
Santonian	Early-Late	*Dicarinella Asymetrica*	Late	*Globotruncana fronicata*	*Dicarinella asymetrica*	*Dicarinella asymetrica*	*Dicarinella asymetrica*	*Marginotruncana scheegansi*	*Dicarinella asymetrica*
			Early	*Globotruncana concavata*					
Coniacian	Late	*Dicarinella Concavata*		*Globotruncana Renzi*	*Dicarinella concavata*	*Dicarinella concavata*	*Dicarinella Concavata*		*Dicarinella concavata*

- *Dicarinella asymetrica* Total Range Biozone:

Biozone limits: *Dicarinella asymetrica*, the nominate species, first and last appear at the lower and upper boundaries of this biozone.

Age: Early- Late Santonian. Tables (1, 2).

Thickness: The recorded thickness of the zone is (55) m

Characteristics: The planktic Foraminifera associated with this biozone are:

Heterohelix globulosa, Heterohelix reussi, Globotruncananita linneiana, Dicarinella asymetrica, Marginotruncana renzi.

- *Globotruncanita elevata* Total Range Biozone

Biozone limits: The base of the zone is situated at the first appearance of *Globotruncanita elevata,* which is the nominate species. The zone's highest point is situated at the horizon of *Globotruncanita elevata's* final appearance.

Age: Early Campanian. Tables (1, 2).

Thickness: The recorded thickness of the zone is (13) m

Characteristics: The planktic Foraminifera associated with this biozone are:

Heterohelix globulosa, Heterohelix reussi, Globotruncanita arca, Globotruncanita bulloides, Globotruncanita linneiana, Globotruncanita lapparenti, Globotruncanita elevata, Marginotruncana renzi.

4. The Palaeoenvironment

The Khasib Formation has variable lithological properties in central Iraq compared to its Southern part, which caused many troubles in identifying its depositional environment. Several sedimentological and palaeontological studies have been accomplished from the Khasib Formation, indicating that the deposition was in the platform interior between restricted, evaporitic, or brackish to open sea environments (Al-Ali et al., 2020; Al-Dulaimy & Sa'ad, 2013; Al-Fandi et al., 2020; Al-Juboury & Al-Tharb, 2013; Al-Qayim, 2010; Alsultan et al., 2022; Tukkee et al., 2023)

The studied section comprises shaley limestones which are upwardly changed to marly limestones, including the abundance of common existence of planktonic foraminiferal of Keeled forms as *Globotruncananita, Globular chambered* forms as *Heterohelix* with *Hedbergella* and *Dicarinella* taxa, that are scattered throughout the section. The common to abundant occurrence of these species within basically shaly and marly limestones may refer to the Outer shelf -Upper Bathyal of the marine environment (Al-Juboury & Al-Tharb, 2013; Alsultan et al., 2022; Buday, 1980; Jassim & Goff, 2006)

The depositional environment of the studied section in terms of lithological and planktonic foraminiferal fossils shows that the Khasib Formation in EB-11 well was deposited in an Upper Bathyal to outer Shelf marine environment. This supported the evidence that the Khasib Formation was deposited at its base during a significant transgression episode, when sea level succession involved episodes of rise and standstills reflecting the high subsidence environment as the main controlling factor, while the interbedded shale increases upward towards the overlying Tanuma Formation reflecting the shallowing sequence (Al-Qayim, 2010; Al-Ali *et al*., 2020; Al-Fandi e*t al.*, 2023).

5. Conclusions

The Khasib Formation in Well EB-11, East Baghdad Oilfield, consists of shaly limestone that gradually transitions upward into marly limestone. Thirteen species belonging to five genera of planktonic foraminifera were identified, including *Heterohelix globulosa*, *Heterohelix reussi*, *Hedbergella delrioensis*, *Globotruncanita arca*, *Globotruncanita bulloides*, *Globotruncanita linneiana*, *Globotruncanita elevata*, *Globotruncanita lapparenti*, *Dicarinella concavata*, *Dicarinella primitiva*, *Dicarinella asymetrica*, *Marginotruncana renzi*, and *Marginotruncana sigali*. Based on their stratigraphic distribution, three distinct biozones were recognized: the *Dicarinella concavata* Interval Biozone (early Late Coniacian), the *Dicarinella asymetrica* Range Biozone (Early–Late Santonian), and the *Globotruncanita elevata* Range Biozone (Early Campanian). These findings indicate that the Khasib Formation was deposited during the early Late Coniacian to Early Campanian. The depositional environment is interpreted as outer shelf to upper bathyal marine, inferred from the common to abundant occurrence of keeled and globular-chambered planktonic foraminifera dominating the shaly and marly limestone beds during a transgressive phase.

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