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Foraminiferal Biostratigraphy of the Uppermost Cretaceous Period, Duhok Area, Kurdistan Region, North of Iraq

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Abstract

A relatively complete Late Maastrichtian succession of the upper part of the Shiranish Formation (Upper Cretaceous) in the Duhok area is investigated for the planktic foraminiferal assemblages. This studied interval consists mainly of bluish shale, marl, and thin beds of hard marly limestone all with grey-blue color. The upper contact of the Shiranish Formation is conformable with the overlies Danian Aaliji Formation. Based on the recorded planktic foraminifera and their ranges, the studied succession is subdivided into three main biozones of the latest Maastrichtian age, these zones are *Pseudoguembelina hariaensis* (CF3) Interval Zone, *Pseudoguembelina palpebra* (CF2) Interval Zone, and *Plummerita hantkeninoides* (CF1) Total Range Zone. These zones show continuous and complete Upper Cretaceous sediments, which are preserved in the Bade section of the Duhok area.

Keywords: Foraminifera; Biostratigraphy; Maastrichtian; Shiranish; Kurdistan; Iraq

1. Introduction

Although the explosion of the calcareous nanoplankton and foraminifera in the warm seas of the Cretaceous is widely reported, for the Tethys realm no precise zonation schemes of the marine fauna are available (Gradstein et al., 2020). According to Renne et al. (2013) in Gradstein et al. (2020) the base of the uppermost Cretaceous (Maastrichtian) started 72.17 Ma ago and the top of the Maastrichtian Stage is anchored to the well calibrated K/Pg boundary, placed at 66.04 Ma ago with a duration of 6.13 million years.

The uppermost Cretaceous (Maastrichtian) deposits are represented by the upper part of the Shiranish Formation in the current study. Henson (1940) in Bellen et al. (1959) investigated the uppermost rock unit of the Cretaceous in Duhok and Zakho areas and assigned it as the Shiranish Formation of Maastrichtian age at top, and stated that although the upper part of the Shiranish Formation in the type section is of a continuous sequence of blue marls and without any apparent angular unconformity, but thought that topmost beds of the original Shiranish Formation were removed by erosion and the formation at its top is of Upper Maastrichtian but not uppermost Maastrichtian age. Al-Omari (1966, 1970) studied the foraminiferal fauna from the upper part of the Shiranish Formation in northwestern Iraq and proved to be of Maastrichtian age. A detailed planktic foraminifera study was

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done by Kassab (1972) for the Shiranish Formation at the type locality, in addition other studies from different localities of Shiranish Formation in North of Iraq (i.e., Kassab, 1974; 1978; 1979) he assigned the lower-middle Maastrichtian age for the upper part of the formation. Al-Qayim and Al-Shaibani (1989) through their study to the Cretaceous-Paleogene contact northwest Iraq, they concluded a relatively long hiatus include the uppermost Maastrichtian of the upper part of the Shiranish Formation. Many studies of the uppermost Cretaceous deposits in Iraq and Kurdistan Region suggested that the Cretaceous ends with probably abrupt, erosional, paraunconformity or hiatus among them (Al-Safawee, 1982; Al-Mutwali, 1983; Al-Shaibani and Al-Qayim, 1986; Kassab, 1986; Ghafor, 1988; Al-Qayim and Al-Shaibani, 1995; Al-Omari et al., 1994; Awadh et al., 2008; Al-Hadiedi, 2010; Hammoudi, 2011; Al-Mutwali and Al-Doori, 2012; Al-Wazan, 2013; Al-Mutwali and Ibrahim, 2019; Al-Dulaimi and Abdallah, 2019). In contrast, other foraminiferal biostratigraphic studies have supported the occurrence of complete uppermost Maastrichtian deposits (Sharbazheri et al., 2009 and 2011; Salih et al., 2013; Mousa et al., 2020; Al Nuaimy et al., 2020). The current high resolution biostratigraphic study aims to prove the occurrence of complete uppermost Maastrichtian deposits throughout the planktic foraminiferal assemblages and its biozonations for the upper part of the Shiranish Formation, Duhok area, Kurdistan Region, North of Iraq.

2. Geological Setting

The current study is based on a high-resolution investigation of the planktic foraminifera of a stratigraphic outcrop in the Duhok area, namely Bade section that is located about 15.6 km NE Duhok city and exposed on the northern limb of the Bekhair anticline at exact coordination of latitude $36^{\circ}53'52.98''\text{N}$ and longitude $43^{\circ}5'5.50''\text{E}$. The studied area is located within the High Folded Zone of the Outer Platform of Western Zagros Fold Thrust Belt (WZFTB) according to the tectonic divisions of Iraq by Fouad (2015) (Fig. 1).

Fig. 1. Location map of the studied section, with general geology of the Bekhair anticline (Abdulla, 2013)

The studied uppermost Maastrichtian deposits belong to the Ninth Arabian Plate Megasequence (AP9) that extends in age from Middle Turonian to Middle Eocene (Al-Qayim, 2019). The Shiranish Formation is well exposed within the Bekhair anticline, which consists of double plunging fold, with two main directions of trends. The first trend is parallel to the direction of the Zagros Range (NW-SE), whereas the other coincides with the direction of the Taurus Range (E-W) occupying a large area extending from Geli Zawita (eastern plunge) at Duhok to Deraboone village (western plunge) on the Iraqi-Syrian-Turkish borders (Al-Azzawi and Al-Hubiti, 2009). Stratigraphically, Bekhair anticline represents one of the main anticlines within the High Folded Zone of the WZFTB in Duhok area (Fouad, 2015). It comprehends outcrops from Late Cretaceous to Pliocene in age and including AP9, AP10 and AP11 Late Turonian – Danian; Middle Paleocene – Eocene and Latest Eocene – Recent Arabian Plate Tectonic Megasequences (Jassim and Goff, 2006).

The Shiranish Formation of the current study named after Shiranish Islam village, which lies on the southern limb of Khamteer anticline, to the northeast of Zakho city. The type section of the Formation firstly described by Henson (1940) In Bellen et al. (1959) below and above the village at Long. 37°11'32" N; Lat. 42°50'30" E. Shiranish Formation in its type section is of 227.8 m Globigerinal sediments, consisting of upper division of 99 m of blue marls, overlying lower division of 128.8 m of thin bedded marly limestone. All having a typical pale blue color that increase in darkness with increasing of bituminous. Conformably overlies the limestone of Bekhme Formation, while its upper contact seemingly conformable, but it marks a faunal break, corresponding to the Cretaceous-Paleogene contact, with the Lower Paleocene marl of the Aaliji Formation (Bellen et al., 1959).

3. Materials and Methods

Two sets of sampling were collected in the current study: a) preliminary sampling for constraining the end of the uppermost Maastrichtian deposits of the Shiranish Formation and b) high-resolution sampling for detailed biostratigraphical investigations. On overall, (39) fresh rock samples were collected from the upper part of the Shiranish Formation in the studied Bade section. Later in the laboratory, the retrieving of the calcareous foraminifera from the lithified lime deposits depends mainly on the "Cold Acetolyses" techniques called as Lirer (2000) method. Fresh extracted samples were dried at room temperature, softly crushed into small sized fragments (not less than 3 mm), put in covered-beaker and digested in cold, highly concentrate Acetic Acid with 2 cm level higher than the residue, continuously checking for the treated samples to note the deposition of fine residue on the bottom of the beaker. The time of disaggregation varied according to the hardness and lithology. 3, 5 and 7 hours were recorded due to different lithology as shale, marl and limestone respectively. As soon as the reaction ends with turning the liquid acid into dense substance. Samples washed under strong water current, sieved through the standard ASTM sieves (250, 177, 149, 125 and, 63 μm) and dried at room temperature. After this procedure, the residue should be free of inorganic matter and the foraminifera tests supposed to be clean and ready to be examined under stereomicroscope. Otherwise, the residue dipped again in beaker containing water diluted Desogen and gone under Ultrasonic cleaner till getting the satisfying results. All materials are stored at Department of Geology, University of Dohuk (Kurdistan Region of Iraq). In this study, authors followed the biozonal schemes of Li and Keller (1998 a, b); Coccioni and Premoli Silva (2015) for the Late Maastrichtian.

4. Results and Discussion

4.1. Lithostratigraphy

The studied section named after the nearby Bade village, it is about 15.6 km to the northeast of Duhok. The investigated uppermost Maastrichtian sediments of Bade section is 23.30 m in thickness,

belong to the upper part of the Shiranish Formation (Henson, 1940 in Bellen et al., 1959). The described interval of the Shiranish Formation in the current study consists of marl and marly limestone interbedded with soft shale intervals, all with bluish grey color. The lower part of the this studied interval shows a soft grey-blue shale of about (8.5 m) thickness, overlies by (6.2 m) of soft marl interbedded with hard marly limestone (20 – 30 cm) beds. All dark grey – blue in color, following by (5.6 m) of soft bluish marl. The uppermost part of Shiranish Formation in this section is around (3 m) of hard bluish marl (Fig. 2).

Fig. 2. The lithologic column of the studied succession and a field photo of the stratigraphic succession of the studied Bade section, Duhok

On the other hand, the light brown and soft marl of the Danian Aaliji Formation (Bellen, 1950 In Bellen et al., 1959) starts directly above the pelagic blue marl of the Shiranish Formation in Duhok area in general and in the studied Bade section as well, representing the continuous transition of the Cretaceous and Paleogene sediments in the area (Bamerni et al., 2020) (Figs. 3 A, B, C).

Fig. 3. A. Hard marly limestone beds; B. Field photo of the upper contact of the Shiranish Formation with the overlies Aaliji Formation in Bade section; C. Color variation of laboratory treated sediments between Cretaceous and Paleogene marls

4.2. Biostratigraphy

Thirty-nine planktic foraminiferal species belong to fifteen genera were recorded through the high-resolution investigation of the uppermost Maastrichtian deposits of the studied interval of the Shiranish Formation in the Bade section. Genera showed good diversity with abundance of species mainly for *Heterohelix*, *Pseudoguembelina*, *Globotruncana*, *Globotruncanita*, *Plummerita*, *Planoglobulina*, *Rugoglobigerina*, *Pseudotextularia*, *Globotruncanella* and *Racemiguembelina* respectively. Also, rare occurrence of species belong to typical late Maastrichtian genera were identified, among them: *Trinitella*, *Gansserina*, *Guembeliteria* and *Abathomphalus*.

The following is an alphabetical order of the generic abbreviations discussed in this study: *Abathomphalus* = Ab., *Archaeoglobigerina* = Ar., *Gansserina* = Ga., *Globotruncana* = Gana., *Globotruncanella* = Glla., *Globotruncanita* = Gita., *Gublerina* = Gu., *Guembeliteria* = G., *Hedbergella* = Hed., *Heterohelix* = Hx., *Planoglobulina* = Plg., *Plummerita* = Pl., *Praemurica* = Pr., *Pseudoguembelina* = Psg., *Pseudotextularia* = Pst., *Racemiguembelina* = Rac., *Rugoglobigerina* = Rug., *Trinitella* = T. The most important bioevents recorded in the current biostratigraphical investigations are: the highest occurrence (HO) of *Ga. gansseri* (Bolli) (Pl.1, Fig. 3), Abundance of *Hx. navarroensis* Loeblich (Pl.1, Fig.5) in the top part of the Maastrichtian deposits, Rare occurrence and disappearance of *Ab. mayaroensis* (Bolli) (Pl.1, Figs. 1,2) few meters above the HO of *Ga. gansseri* (Bolli). The lowest occurrence (LO) of the *Pl. hantkeninoides* (Brönnimann) (Pl.1, Fig. 15), *Pl. cf. hantkeninoides* (Brönnimann) (Pl.1, Fig. 14) and *G. cretacea* Cushman (Pl.1, Fig. 14) were synchronous.

According to Coccioni and Premoli Silva (2015) the HO of *Ga. gansseri* (Bolli) is dated (66.53 Ma), and defined the base of the planktic foraminiferal *Pseudotextularia elegans* Zone of their study, that is equivalent to the base of CF2 of Li and Keller (1998 a, b). On the other hand, they concluded that the LO of *Pl. hantkeninoides* (Brönnimann) dated as (66.15 Ma) and pointed the base of the nominated zone. Based on the ranges of the planktic foraminiferal fauna recorded in the current study, three main Late Maastrichtian zones were identified throughout the upper part of Shiranish Formation in the studied Bade section, Duhok area (Fig. 4).

4.2.1. Planktic foraminiferal biozones

- *Pseudoguembelina hariaensis* (CF3) interval zone part (Late Maastrichtian)

The CF3 Zone is defined as interval span from the LO of the nominated zonal marker *Psg. hariaensis* Nederbragt to the HO of *Ga. gansseri* (Bolli). In the investigated Bade section of Duhok area, only the upper part of this zone was recognized in the current high-resolution study. The studied part of this zone is represented by interval of 5 m thickness.

The planktic foraminiferal assemblages recorded in this zone showed a good level of preservation. It showed main abundance of *Pst. elegans* (Rzehak) (Pl.1, Fig. 6), *Gita. stuarti* (de Lapparent), *Hx. globulosa* (Ehrenberg), *Gana. aegyptiaca* Nakkady, *Gita. stuartiformis* (Dalbiez), *T. scotti* (Brönnimann) (Pl.1, Fig. 12), *Rug. rugosa* (Plummer) (Pl.1, Fig. 11) with common occurrences of *Plg. carseyae* (Plummer), *Hx. labellosa* (Nederbraget), *Hx. reussi* (Cushman), *Psg. costulata* (Cushman), *Psg. hariaensis* Nederbraget (Pl.1, Fig. 7), *Gana. arca* (Cushman), *Hx. striata* (Ehrenberg), *Rug. hexacamerata* Brönnimann, *Pst. intermedia* Rzehak, *Plg. brazoensis* Martin. Associated with rare occurrences of *Ga. gansseri* (Bolli), *Rac. powelli* Smith and Pessagno, *Rug. macrocephala* Brönnimann, *Pl. reicheli* (Brönnimann) (Pl.1, Fig. 13), *Hed. monmouthensis* (Olsson) and *Ar. blowi* Pessagno (Fig. 4).

Fig. 4. Planktic foraminiferal species and their ranges of the Bade section, datum plains of the zones follow Li and Keller (1998 a, b) and Coccioni and Premoli Silva (2015)

The zonal marker is easily to recognize and commonly abundant in this zone. This zone is equivalent to the middle part of *Abathomphalus mayaroensis* Zone, recorded by Abawi et al. (1982), Al-Qayim and Al-Shaibani (1989), Al-Mutwali (1992), northern of Iraq. Hammoudi (2011) considered the CF3 Zone as subzone within the *Abathomphalus mayaroensis* Zone. The current *Pseudoguembelina hariaensis* (CF3) Zone is equivalent to the same CF3 Zone recorded by many authors as: Sharbazheri (2008), Sharbazheri et al. (2011), Al-Mutwali and Al-Doori (2012), Salih et al. (2013), Al-Mutwali and Ibrahim (2019), Al Nuaimy et al. (2020) from different localities north of Iraq. Also, the CF3 Zone is correlated to the same zone of Mousa et al. (2020) from the Western Desert of Iraq. (Fig. 5).

Plate 1. Some index planktic foraminifera from the Upper Maastrichtian Shiranish Formation of Bade section, Duhok. 1-2: *Abathomphalus mayaroensis* (Bolli, 1951) (sample 7); 3: *Gansserina gansseri* (Bolli, 1951) (sample 5); 4: *Planoglobulina acervulinoides* (Egger, 1900) (sample 37); 5: *Heterohelix navarroensis* Loeblich 1951 (sample 38); 6: *Pseudotextularia elegans* (Rzehak, 1891) (sample 1); 7: *Pseudoguembelina hariaensis* Nederbragt 1991 (sample 11); 8: *Pseudoguembelina palpebra* Brönnimann and Brown 1953 (sample 7); 9: *Gublerina acuta* De Klsz 1953 (sample 9); 10: *Guembelitra cretacea* Cushman 1933 (sample 36); 11: *Rugoglobigerina rugosa* (Plummer, 1927) (sample 15); 12: *Trinitella scotti* Brönnimann 1952 (sample 5); 13: *Plummerita reicheli* (Brönnimann, 1952) (sample 7); 14: *Plummerita cf. hantkeninoides* (Brönnimann, 1952) (sample 38); 15: *Plummerita hantkeninoides* (Brönnimann, 1952) (sample 15).

- *Pseudoguembelina palpebra* (CF2) interval zone (late Late Maastrichtian)

The CF2 Zone is defined as the interval from the HO of *Ga. gansseri* (Bolli) and the LO of *Pl. hantkeninoides* (Brönnimann). The *Pseudoguembelina palpebra* Interval Zone is identified in the studied Bade section with a thickness of (7 m). This Zone showed continuity of the abundant planktic foraminifera recognized in the previous CF3 Zone. In addition to the abundance of the zonal marker *Psg. palpebra* Brönnimann and Brow, and *Gita. conica* (White). As well as rare occurrences of *Hx. navarroensis* Loeblich, *Plg. acervulinoides* (Egger) and *Rac. fruticosa* (Egger). The *Pseudoguembelina palpebra* Zone of this study is recognized with the disappearance of *Ab. mayaroensis* (Bolli) at the base of this zone. The *Pseudoguembelina palpebra* Zone can be correlate with the upper part of the *Abathomphalus mayaroensis* Zone, which is recorded by different authors in Kurdistan and Northern Iraq (e.g., Abawi et al., 1982; Al-Qayim and Al-Shaibani, 1989; Al-Mutwali, 1992). This zone is also comparable to the *Pseudoguembelina palpebra* CF2 Zone of Hammoudi (2011) from Shaqlawa area, Al-Mutwali and Al-Doori (2012), Salih et al. (2013), Al-Mutwali and Ibrahim (2019) from north of Iraq. The CF2 Zone of the current study is match to the same zone recorded by Mousa et al. (2020) from the Western Desert of Iraq and Al Nuaimy et al. (2020) from Sulaimani area NE Iraq (Fig. 5).

Absolute Age Ma				
Epoch				
Age				
Planktonic Foraminifera Datum Events				
66.04	HO <i>Pl. hantkeninoides</i>			
66.15	LO <i>Pl. hantkeninoides</i>			
66.53	HO <i>Ga. gamsseri</i>			
<i>Abathomphalus mayaroensis</i>			Abawi <i>et al.</i> , (1982) Northern Iraq	
<i>Abathomphalus mayaroensis</i>		Hiatus	Al-Qayim and Al-Shaibani (1989) Northwest Iraq	
<i>Abathomphalus mayaroensis</i>		Hiatus	Al-Mutwali (1992) KH. 17/7Northwest Iraq	
<i>Ab. mayaroensis</i>	<i>Pseudoguembelina palpebra</i>	Hiatus	Hammoudi (2011) Shaqlawa, Northern Iraq	
CF3	CF2	CF1	Sharbazheri (2008); Sharbazheri <i>et al.</i> , (2011) Sulaimaniyah-Kurdistan Region, Iraq	
CF3	CF2	CF1	Hiatus	Al-Mutawli and Al-Doori (2012) Duhok, Northern Iraq
CF3	CF2	CF1	Salih <i>et al.</i> , (2013) Duhok Dam, Northern Iraq	
CF3	CF2	CF1	Al-Mutwali and Ibrahim (2019) Bekhme, Northeastern Iraq	
CF3	CF2	CF1	Mousa <i>et al.</i> , (2020) Western Desert, Iraq	
CF3	CF2	CF1	Al Nuaimy <i>et al.</i> , (2020) Sulamani NE-Iraq	
CF3 <i>Pseudoguembelina hantkenensis</i>	CF2 <i>Pseudoguembelina palpebra</i>	CF1 <i>Plummerita hantkeninoides</i>	This Study 2021 Bade Section, Duhok, Kurdistan Region, North of Iraq	

Fig. 5. Regional correlation of the planktic foraminiferal zones of this study with other studies across Kurdistan region and Iraq. Late Maastrichtian ages are after Coccioni and Premoli Silva (2015)

- *Plummerita hantkeninoides* (CF1) total range zone (Latest Maastrichtian)

The *Plummerita hantkeninoides* Zone is defined as the interval from the LO of the zonal marker to the extinction of most of the Cretaceous planktic foraminifera including *Pl. hantkeninoides* (Brönnimann). The CF1 Zone in the current study is span an interval of 11.30 m in thickness. The *Plummerita hantkeninoides* Total Range Zone in the current high-resolution biostratigraphic analysis of the Bade section in the Dohuk area shows a great diversity of the planktic foraminiferal assemblages comparing to the CF2 and CF3 zones. It yields abundant, diverse and good to moderately preserved specimens of *Pst. elegans* (Rzehak), *Gita. stuarti* (De Lapparent), *Hx. globulosa* (Ehrenberg), *Rug. rugosa* (Plummer), *Plg. carseyae* (Plummer), *Hx. labelosa* Nederbragt, *Hx. reussi* (Cushman), *Psg. costulata* (Cushman), *Hx. striata* (Ehrenberg), *Hx. navaroensis* Loeblich and *G. cretacea* Cushman. In addition, common occurrence of: *Pl. reicheli* (Brönnimann), *Psg. hariaensis* Nederbragt, *Psg. palpebra* Brönnimann and Brown (Pl.1, Fig. 8), *Psg. kempensis* Esker, *Gana. arca* (Cushman), *Gana.*

rosetta (Carsey), *Plg. brazoensis* Martin, *Plg. acervulinoides* (Egger), and rare occurrence of *Pl. hantkeninoides* (Brönnimann).

The *Plummerita hantkeninoides* Zone represents the latest Maastrichtian foraminiferal biozone and has been introduced by Masters (1984) through his comparison of the planktic foraminifera at the K/Pg boundary in Tunisia and Egypt. Coccioni and Premoli Silva (2015) stated that the zonal marker is very rare and, sporadically, presented through their revision and identification of the CF1 Zone at the classical Tethyan Gubbio section (Italy). Sharbazheri (2008) and Sharbazheri et al. (2011) recorded the CF1 Zone in their study of the Cretaceous/Paleogene boundary in Sulaimani area of Kurdistan Region. Salih et al. (2013) and Al-Mutwali and Ibrahim (2019) recorded the same zone from Northern and Northeastern Iraq. The *Plummerita hantkeninoides* Zone is correlated to the same zones of Mousa et al. (2020) from the Western Desert of Iraq and Al Nuaimy et al. (2020) from Sulaimani North East of Iraq (Fig. 5).

5. Conclusions

The high resolution planktic foraminiferal biostratigraphy in the Bade section of the Duhok area, shows that the upper part of the pelagic bluish deposits of the Shiranish Formation are of uppermost Cretaceous (Latest Maastrichtian) age. The recorded ranges of the identified planktic foraminifera reveal a continuous and complete sedimentation throughout the upper Cretaceous sediments in the studied section. Depending on the recognized planktic foraminiferal species, the studied interval is subdivided into three main zones of the Upper Cretaceous. These zones are *Pseudoguembelina hariaensis* p.p. (CF3) Interval Zone, *Pseudoguembelina palpebra* (CF2) Interval Zone and *Plummerita hantkeninoides* (CF1) Total Range Zone. Based on these zones, this study concluded the latest Maastrichtian age for the studied sequence.

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