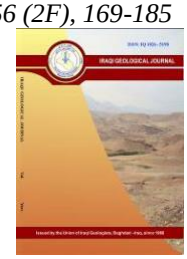
Iraqi Geological Journal

Journal homepage: https://www.igj-iraq.org



Biostratigraphy of Shiranish Formation from Selected Wells, Central of Iraq

Anwar K. Mousa[1] and Luay S. Shakir[1,*]

1 Department of Geology, College of Science, University of Baghdad. Baghdad, Iraq
* Correspondence: anwar.mousa@sc.uobaghdad.edu.iq

Received:
12 June 2023

Accepted:
12 August 2023

Published:
31 December 2023

Abstract

The Quantitative high-resolution planktonic foraminiferal analysis of the subsurface section in three selected wells in the Ajeel Oil Field (Aj-8, Aj-12, and Aj-15) in Tikrit Governorate, Central Iraq has revealed that Shiranish Formation deposited in Late Campanian- Latest Maastrichtian age. This formation consists mainly of marly and marly limestone yielding diverse planktonic foraminiferal assemblages and calcareous benthic foraminifera, with a total of 46 species that belong to 23 genera, Three zones and four subzones, which cover the Late Campanian to the Latest Maastrichtian, were identified based on the recorded planktonic foraminifera and their ranges. They are as follows:1. Globotruncana aegyptiaca Zone that dated to be Late Campanian 2. *Gansserina gansseri* Zone that refers to Early Maastrichtian 3. *Abathomphalus mayaroensis* Zone that indicates Late Maastrichtian, in this section, the *Abathomphalus mayaroensis* Zone is divided into four subzones, namely in that order from bottom to top: *Racemiguembelina fructicosa* (Early Late Maastrichtian), *Pseudoguembelina hariaensis* (Middle-Late Maastrichtian), *P. palpebra* (Late Late Maastrichtian), and *Plummerita hantkeninoides* (latest Maastrichtian).

Keywords: Shiranish Formation; Planktonic foraminifera; Campanian; Maastrichtian; Biozone; Ajeel oilfield

1. Introduction

The Late Campanian–Maastrichtian transgression cycle, which is represented by the Shiranish Formation, consists of globigerinal marl marls and limestone (Henson, 1940 in Bellen et al., 1959; Buday, 1980). Henson (1940) in Bellen et al. (1959) were the first to define the Shiranish Formation, which is located close to the village of Shiranish Islam, which is located on the southern limb of the Khamteer anticline, northeast of Zakho city, from the High Folded Zone of North Iraq. In its type section, the Shiranish Formation consists of 227.8 meters of globigerinal sediments (locally dolomitic), with an upper division of 99 meters of blue marls and lower division of 128.8 meters of thin-bedded marly limestone (Owen and Nasr, 1958; Bellen et al., 1959). In areas of northern Iraq, the formation is extensively dispersed in the subsurface and at outcrops, and it is contemporaneous with several other formations in different regions of Iraq (Bellen et al., 1959; Jassim and Goff, 2006; Al-Banna, 2010).

According to several studies (Lawa et al., 2013; Ameen and Gharib, 2014; Omar et al., 2015), the Late Cenomanian–Early Turonian subduction between the Arabian plate beneath the Iranian plate is what gave elevation to the Shiranish Formation, which is primarily composed of flysch facies in

DOI: 10.46717/igj.56.2F.11ms-2023-12-17

the Kurdistan Foreland Basin. According to Znad et al., 2020, the influence of the Forebulge Depozone's tectonic rise causes a non-existing pelagic sediment unit of the Shiranish Formation in the region bounded by northwest Amadiya Town (the south limb of Mateen Anticline) and southeast areas (Gara Anticline). Based on Buday (1980), the Shiranish Formation is composed of gray limestone and blue to gray marl, as a result of his research on microfossils from the Upper Cretaceous and Lower Tertiary formations, most of the planktonic forms belong to the genus *Globotruncana*. According to Bellen *et al*. (1959), the most significant representatives are *Globigerina cretacea* (d'Orbigny), *G. aspera* (Ehrenberg), *Rugoglobigerina* sp., *Gumbelina striata* (Ehrenberg), *G. globulosa*(Ehrenberg), *Pesudotextularia elegans* (Rzehak), *Globotruncana arca* (Cushman), *G. fornicate* (Plummer), *G. gagnebini* (Tilev), *G. gansseri* (Bolli), *G. leupoldi* (Bolli), *G. lapparenti* ssp., *G. cf. rosetta* (Carsey), *G. stuarti* (de Lapparent), *Bolivina incrassata* (Reuss), and inoceramic and macrofossil debris. Kassab (1972 and1979) was able to identify biozones based on planktonic foraminifera and define the age of the Formation in its type area as Late Campanian-Middle Maastrichtian. Kassab (1972) conducted extensive planktonic foraminifer's research at the type locality for the Shiranish Formation and gave the upper portion of the formation a lower-middle Maastrichtian age. Kassab et al. (1986) determined the age of the Shiranish Formation (Lower-Middl Maastrichtian). Al-Badrani (2012) examined the lower Shiranish Formation portion in the Sinjar anticline and concluded that it is Late Campanian in age. Many authors emphasized that the age of the formation is Late Campanian-Maastrichtian (Bellen et al., 1959; Buday, 1980; Jassim and Goff, 2006; Al-Banna, 2010; Aqrawi *et al*., 2010), but it does not reach the Late Maastrichtian (Jaff et al., 2014; Jaff, 2021), While in the Sinjar region, the age may be extending to the Late Maastrichtian by (Al-Mutwali and Al-Juboury, 2005), and at the southern limb of the Bekhair anticline the age of Formation recorded asLate Campanian- latest Maastrichtian by (Al-Mutwali and Al-Doori, 2012), also in Duhok Area, Kurdistan Region, North of Iraq the age of Formation suggested extending to the Late Maastrichtian by (Bamerni et al., 2021). According to Sahib and Al-Dulaimi (2022), the Shiranish Formation is divided into five biozones that refer to the Late Campanian- Early Maastrichtian age. Hawramy et al., 2023 in Dukan Area, Northern Iraq refers to the age of formation is Late Campanian–Early Maastrichtian by a detailed systematic study of ostracods. Establishing the biostratigraphy of the Shiranish Formation in Ajeel oil field based on benthic and planktonic foraminiferal assemblages and estimating biozonations achieved to do accurate determination for the geologic age of the formation are the aims of the current high-resolution biostratigraphic investigation.

2. Geological Settings

The type and distribution of rock units were impacted by tectonic activity in the Upper Cretaceous, and the thickness of the Shiranish Formation was altered (Al-Naqib, 1967). In northern Iraq, marls from the Shiranish Formation (Jib'ab Marl), fore- or back-reef limestones from the Bekhme, Aqra, and obsolete "Pilsener" formations, and clastic from the Tanjero Formation indicate the Late Campanian -Maastrichtian transgression cycle. These formations may intersect one another above, below or inter-tongue, additionally; the Hartha, Shiranish, Tayarat, and Digma formations from the Late Campanian-Maastrichtian era are being utilized in southern and western Iraq (Jassim and Goff, 2006) (Fig 1). Jan et al. (2012) deduced from a petrographic examination of the Hijran section (about 50 km north of Erbil) that the formation was deposited mostly in a quiet deep marine environment. According to Jassim and Goff (2006), the formation is thought to be an outer shelf to basinal deposit that conformably follows marine clastic deposits of the Tanjero Formation and unconformably overlies the Kometan Formation. The formation denotes marine outer shelf and slope deposited carbonates and mudstones (Jaff et al., 2014; 2015; Jaff and Lawa, 2019). Aba- Hussan, (1983) determined the upper contact as conformable with the Aaliji Formation, while in the type area Kassab (1972

and1979), in north-west Iraq in Safaiya oil Field (Al-Jawary, 1989), and in Northern Iraq (Aqrawi et al., 2010), the upper contact was superimposed unconformably by the Aaliji Formation, whereas the lower contact is conformable with the Bekhme Formation. The Kermav marls of the Mardin area are comparable to the Shiranish Formation in Southeast Turkey (Beer 1966 in Buday, 1980; Ismail, 2011) and equivalent to the Shiranish Formation in Syria (Ismail, 2011). The formation is comparable to the upper portion of the pelagic Grupi Formation toward the southeast of Iran (Buday, 1980; Gayara and Mousa, 2015). According to Kent et al., 1951 in Jassim and Goff (2006), the Upper Cretaceous Marl Group corresponds to the Tayrat Formation in Kuwait and the upper section of the Aruma Formation in Saudi Arabia. Shiranish Formation's upper portion corresponds toTayarat, Hartha, Aqra-Bekhme, Tanjero, and Digma formations, while the lower portion is comparable to Kuwait's Bahrah Formation and Iraq's Hadiena Formation (Sissakian, 2005) Fig 1.

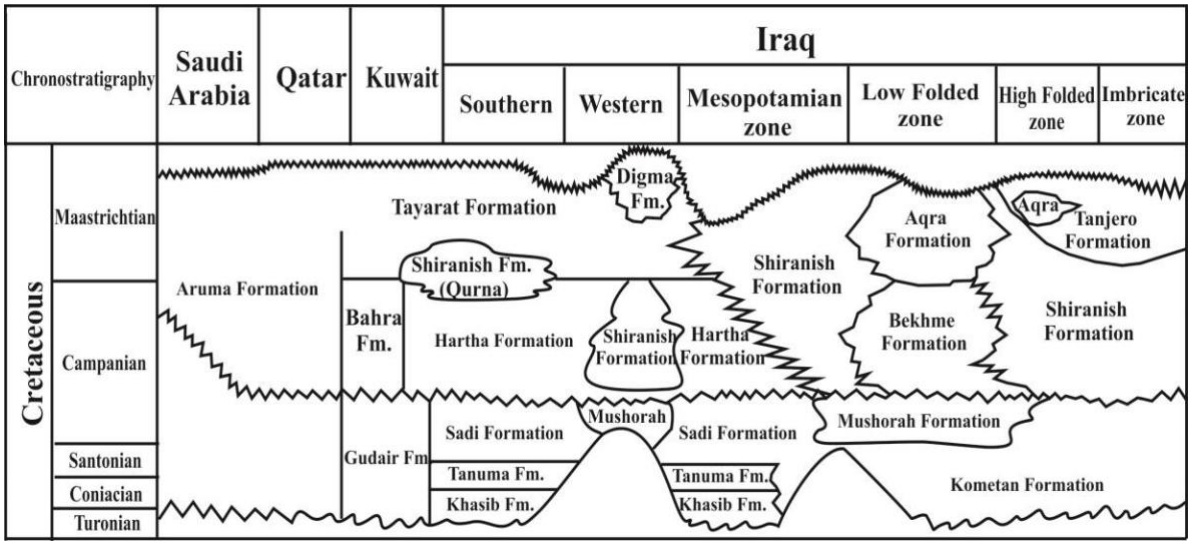


Fig.1. Lithostratigraphy and chronostratigraphy for the Upper Cretaceous succession in Iraq and neighboring Arabian countries (modified from Al-Naqib, 1967)

3. Location of the Study Area

Ajeel Oil Field is located roughly 30 kilometers northeast of Tikrit City, in northern Iraq. The field area is typically 150–170 meters above mean sea level. Geographically, Ajeel Oil Field located between the cities of Tikrit and Beiji, east of the Tigris River, in Salah Al-Deen Governorates. This field is one of numerous structurally oriented NW-SE fields that are located in the northern region, close to the Low Folded Zone of the Zagros Fold Belt (El Diasty et al., 2018). The thickness of the chosen formations in the study region and the geographic coordinates are shown in Table 1 for the three boreholes that have been investigated. They are designated as Aj-8, Aj-12, and Aj-15 in Fig 2.

Table 1. Coordinates of three selected sections of the research region and thickness with the top and bottom of the formation

Well no.	Longitude	Latitude	Thickness of Fm.	Top of Fm.	Bottom of Fm.
Aj-8	389°05’14" E	38° 60’000"N	167m	1370m	1537m
Aj-12	390°817’5" E	3858° 116’5"N	220 m	1437m	1657m
Aj-15	377°446’4" E	3851° 042’8"N	178m.	1253m	1431m

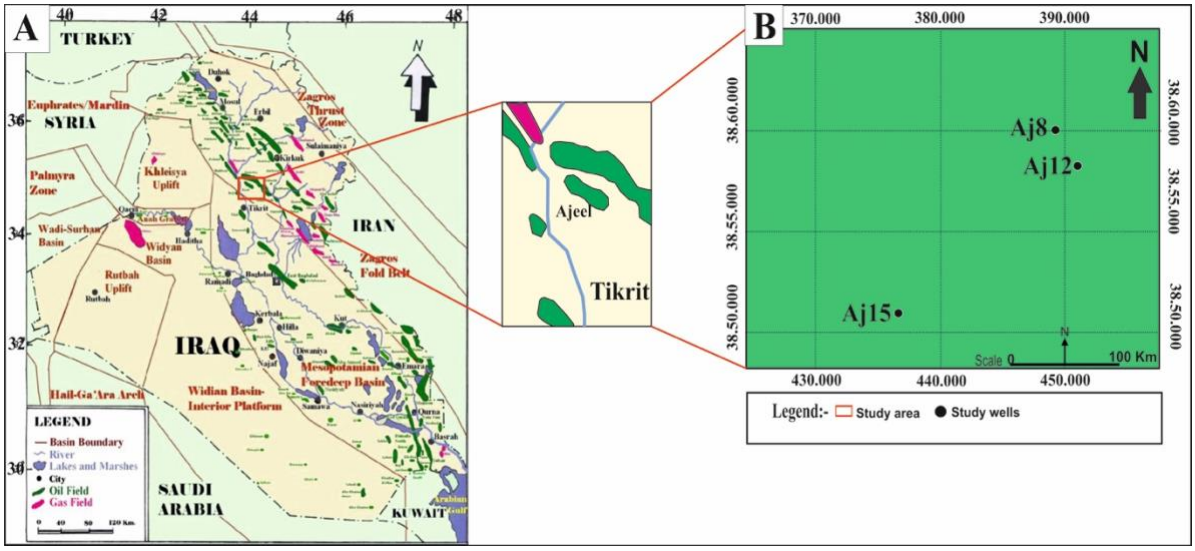


Fig.2. A. Map of Iraq showing Oil and Gas fields (After AL-Khafaji, 2014); B. Location map of studied wells

4. Materials and Methods

The estimation of the biostratigraphy and identification of the biozone create based on the following standard taxonomic concepts (Robaszynski et al., 1983; Caron, 1985; Li and Keller, 1998a and b; Nederbragt, 1991), about 233 thin sections of core and cutting from three oil field,66 thin section from Aj-8 , 95 thin section from Aj-12, and 72 thin section from Aj-15, were studied under a polarized microscope to realize the petrographic component, fauna content and evaluated for recognized planktonic and benthic foraminiferal assemblages.

5. Planktonic Foraminiferal Biostratigraphy

Planktonic foraminifera is often numerous and well preserved, although enhanced carbonate dissolution was occasionally seen in some intervals. The lowest portion of the formation documented the effect of dissolution; in some part of the Late Maastrichtian strata exhibit no signs of dissolution, yet low specimen abundance and the presence of pyrite in some areas point to low oxygen conditions (Jaff et al,. 2015). There were reported 46 species of planktonic foraminifera from 23 different taxa (Fig. 3, 4, and 5). The most common planktonic foraminifera are those belonging to the Globotruncanidae, Heterohelicidae, Rugoglobigerinidae, Globigerinelloididae, and Globigerinidae genera. These forums also provide the strongest indications of the typical Tethyan fauna type. Plates 1 and 2 include illustrations of important index species. Shiranish Formation consisted of limestone and marly limestone underlain by the Hartha Formation, and this study documented where the first appearance of planktonic foraminifera belonging to the Globotruncanidae. And the upper contact is with Aliji Formation determined where the last appearance of Globotruncanidae and last appearance of *Plummerita hantkeninoides* and the first appearance of *Parvularugoglobigerina eugubina* represented the Paleocene age. Hence, there is no evidence of planktonic foraminifera belonging to *Globotruncana* species. Through the detailed biostratigraphic study of the Shiranish Formation and depending on the presence of planktonic foraminifera, seven biozones were recorded from the Aj-8, Aj-12 and Aj-15. The biozones of the Shiranish formation in the studied wells are identified from the lower part to the upper part of the formation as follows:

5.1. *Globotruncana Aegyptiaca* Zone

Definition: The *Globotruncana aegyptiaca* Zone (Pl.1, Fig. A) was described as the partial range of the nominate taxon from the lower occurrence (LO) of the nominate taxon to the LO of *Gansserina gansseri* (Bolli, 1951).

Occurrence: This biozone is recorded in the lower part of the formation and represents the oldest foraminiferal biozone identified. The zone covers intervals around 39 m in thickness from depth 1537m to 1498m in Aj-8, 67 m in thickness from depth 1657m to 1597 m in Aj-12, 47 m in thickness from depth 1431m to 1384m in Aj-15 (Fig. 3, 4, and 5).

Age: Late Campanian.

Assemblages: This zone related to the occurrence of the *Globotruncana aegyptiaca*, additionally to the planktonic foraminifera represented by:- *Heterohelix* sp., *H. striata* (Ehrenberg, 1840) (Pl.1, Fig. B), *H globulosa* (Ehrenberg,1840) (Pl.1, Fig. C), *H. punctulats* (Cushman, 1983), *Globotruncana* sp., *Glt orientalis*(El-Naggar, 1966) (Pl.1, Fig. D), *Glt. arca* (Cushman, 1926) (Pl.1, Fig. E), *Glt. dupeublie* (Caron et al.1984) (Pl.1, Fig. F), *Glt. falsostuarti* (Sigal, 1952) (Pl.1, Fig. G), *Glt. linneiana* (d Orbigny, 1839) (Pl.1, Fig. H), *Glt. lapparenti* (Boli, 1945) (Pl.1, Fig. I), *Glt. bulloides* (Vohgler, 1941) (Pl.1, Fig. J), *Archaeoglobigerina blowi* (Passango, 1967) (Pl.1, Fig. K), *A. cretacea* (d Orbigny, 1840), *Rogoglobigerina* sp., *R. hexcamerata*(Bronnimann,1952) (Pl.1, Fig. L), *R. rugosa* (Plummer,1927), *Globotruncanita stuarti* (de Lapparent, 1918) (Pl.1, Fig. M), *G. stuartiforms* (Dalbez, 1955) (Pl.1, Fig. N), *Rugotruncana circumnodifer* (Finlay, 1940), *Contusotruncana fornicata* (Plummer, 1931), *Globotruncanella havanensis* (Voorwijk, 1937) (Pl.1, Fig. O), *G. petaloidea, Hedbergella monmothensis* (Olsson, 1960) (Pl.1, Fig. P), *Globigerinelloides* sp., In addition to these planktonic foraminiferal assemblages, a few benthonic foraminiferal species were documented, such as: *Cibicidoides* sp. (Pl.1, Fig. Q), *C. dayi* (White, 1928), *C. excavata* (Brotzen, 1984), *Bolivina* sp., *Bolivina incrassata* (Reuss, 1851) (Pl.1, Fig. R), *Neoflabellina* sp. (Pl.2, Fig. A), *Bulimina* sp., *Bulimina midwayensis*(Cushman and Parker,1936) (Pl.2, Fig. B), *Bulimina aspera* (Cushman and Parker, 1940), *Ammodiscus* sp., *Textularia* sp., *Globorotalites* sp. (Pl.2, Fig. C). *Globotruncana linneiana* (d Orbigny, 1839) only documented in this zone in Aj-8. (Figs 3, 4,and 5).

Remarks and Correlation: According to the *Globotruncana aegyptiaca* zone which reported from Late Campanian- Early Maastrichtian sediment of Italy by Premoli Silva and Sliter, 1995and 1999; reported from Early Maastrichtian in Northwestern Iraq by Al-Mutwali and Al-Jubouri,(2005); north Iraq by Sharbazheri, (2007, 2010), and from Late Campanian sediment of Low and Mid Latitude by l(Caron 1985 and Li and Keller, 1998b); Iraq by(Kassab, 1972 , Al-Mutwali and Al-Doori, 2012, Jaff et al., 2014 and 2015, Malak et al., 2021, Sahib and Al-Dulaimi, 2022); eastern Mediterranean by (Premoli Silva et al. ,1998); Mexico by (Maestas et al. 2003); Egypt by (Obaidalla et al., 2020) (Table 2), This study defines the age of Globotruncana aegyptiaca as Late Campanian.

5.2. *Gansserina Gansseri* Zone

Definition: *Gansserina gansseri* Zone was defined by Brönnimann(1952) as the partial range of the nominate taxon between LO of the *Gansserina gansseri* (Bolli) (Pl.2, Fig. D) and LO of *Abathomphalus mayaroensis* (Bolli).

Occurrence: This biozone is recorded in the lower part of the formation. The zone covers intervals around 48 m in thickness from depth 1498 m to 1450m in Aj-8, 78 m in thickness from depth 1597 m to 1519 m in Aj-12, 54 m in thickness from depth 1384m to 1330m in Aj-15 (Figs. 3, 4, and 5).

Age: Early Maastrichtian.

Assemblages**:** The same species documented *Globotruncana aegyptica* in addition to recording the following species: - *Heterohelix navarroensis* (Loeblish), *H reussi* (Cushman), *Globotruncana elevate* (Brotzen) (Pl.2, Fig. E), *Glt. rosetta* (Carsey) (Pl.2, Fig. F), *Rogoglobigerina macrocephala*

(Bronnimann) (Pl.2, Fig. G). In addition to these planktonic foraminiferal assemblages, the same benthonic foraminiferal species documented in the previous zone were also recorded in this biozone. (Figs 3, 4, and 5).

Remarks and Correlation: The *Gansserina gansseri* Zone of studied sections is equivalent to the comparable zone of the *Gansserina gansseri* Zone recorded by many authors, they regarded the age of this zone as Early Maastrichtian in DSDP Site 525A by Li and Keller, (1998a), and in Mahajanga Basin by (Abramovich et al., 2002); in Egypt by (Abdel-Kareem and Samir, 1995), (Elnady and Shahin, 2001), (Samir, 2002) and (Obaidalla et al., 2020); in Iraq by (Kassab 1972), (Abawi et al., 1982) (Abdel-Kareem, 1986), (Kassab et al., 1986), (Al-Mutwali, 1996), (Al-Mutwali and Al-Jubouri, 2005), (Sharbazheri 2007and 2010),(Al-Mutwali and Al-Doori, 2012), and (Sahib and Al-Dulaimi,2022) in Italy by (Premoli Silva et al., 1998) and in general by Caron (1985), this zone has been recorded from Middle Maastrichtian in Egypt by(Khalil and Mashally, 2004) this zone placed of Late Maastrichtian in Egypt by Obaidalla (2005). The Late Campanian–Early Maastrichtian period was assigned to this Zone by Maestas et al., (2003) of California, Mexico, by Jaff et al., (2014 and 2015) and Malak et al., (2021) of the Kurdistan region (Table 2), NE Iraq. This study defines the age of *Gansserina gansseri* Zone as Early Maastrichtian.

5.3. *Abathomphalus Mayaroensis* Zone

Definition: According to Brännimann (1952), the total range zone was used for the definition of this zone. It is characteristic of the Late Maastrichtian of the Tethyan palaeogeographic region and the low latitude deep-sea successions. According to *Racemiguembelina fructicosa* (first appearance), *Gansserina gansseri* (last appearance), and *Plummerita hantkeninoides* (first appearance), the stratigraphic bioevents suggest that A.mayaroensis is subdivided into four subzones that are arranged in stratigraphic order: Racemiguembelina fructicosa, *Pseudoguembelina hariaensis*, *P. palpebra*, and *Plummerita hantkeninoides* subzones that also used in this study.

5.3.1. Racemiguembelina fructicosa subzone

Definition: Li and Keller (1998b) designated the *Racemiguembelina fructicosa Zone* as the partial range of the nominate taxon between LO of *Racemiguembelina fructicosa* (Pl.2, Fig. H) to the LO of the *Pseudoguembelina hariaensis* Nederbragt.

Occurrence: This biozone is recorded in the middle part of the formation. The zone covers intervals around 15 m in thickness from depth 1450 m to 1435m in Aj-8, 16 m in thickness from depth 1519 m to 1503 m in Aj-12, 17 m in thickness from depth 1330 m to n Aj-15 (Figs. 3, 4, and 5).

Age: Early Late Maastrichtian.

Assemblages: This zone covered abundant occurrences of the nominate species, in addition to the planktonic species identified from the *Gansserina gansseri* zone, and also recorded the following species: *Abathomphalus mayaroensis* (Bolli) (Pl.2, Fig. I) and *A. intermedius* (Bolli) (Pl.2, Fig. J), a rare benthonic foraminiferal species were recognized, such as: *Cibicidoides* sp., *Bolivina incrassate Reuss, Bulimina* sp., *Globorotalites* sp.

Remarks and Correlation: The majority of the researchers assigned *Racemiguembelina fructicosa* Zone to the Early Late Maastrichtian such as: (from Tunisia by Keller et al., (1995); at DSDP Site 525A Li and Keller, (1998a and b) and Abramovich et al., (2002); from Tunisia Samir, (2002) and from Egypt by Obaidalla, (2005) and from Iraq by Sharbazheri, (2007 and 2010) and Malak et al., (2021). The Racemiguembelina fructicosa Zone, as described above, corresponds to the lowest portion of A. mayaroensis of Abawi et al. (1982) and Abdel-Kareem (186) in Iraq; Robaszynski et al., (1983) and Caron (1985) in general; and Premoli Silva and Sliter (1995 and 1999) in Italy, this zone refers to the

Early Maastrichtian in Egypt by Obaidalla *et al*., (2020) (Table 2). This study defines the age of *Racemiguembelina fructicosa* Zone as Early Late Maastrichtian.

5.3.2. Pseudoguembelina hariaensis zone

Definition: According to Li and Keller (1998b), it is the partial range of *Pseudoguembelina hariaensis* (Pl.2, Fig. K) that extends from the low occurrence (LO) of *P. hariaensis* Nederbragt to the high occurrence (HO) of *G. gansseri* (Bolli).

Occurrence: This biozone is recorded in the middle part of the formation. The zone covers intervals around 19 m in thickness from depth 1435 m to 1416m in Aj-8,21 m in thickness from depth 1503 m to 1482m in Aj-12, 20 m in thickness from depth 1316 m to 1296 m in Aj-15 (Figs. 3, 4, and 5).

Age: Middle Late Maastrichtian.

Assemblages: This zone covered abundant occurrences of the Pseudoguembelina hariaensis, in addition to the planktonic species identified from the previous zone, and also recorded the following species: *Pseudotextularia deformis*, *Pseudoguembelina costulata*, *Globotruncanita conica* (Pl.2, Figs. L and M) and *Pseudoguembelina palpebral* (Pl.2, Fig. N), the same benthonic foraminiferal species that were recognized previously were documented in this zone.

Remarks and Correlation: The *Pseudoguembelina hariaensis* zone which reported from Late Maastrichtian sediment of South Atlantic DSDP Site 525A by Li and Keller, 1998a; from Mahajanga Basin by Abramovich et al., 2002; from Tunisia by Li and Keller, 1998b; from Egypt by (Samir, 2002), (Obaidalla, 2005). The zone is synchronous with the middle portion of the *Abathomphalus mayaroensis* Zone, which was identified in northeastern Iraq by Abawi et al., 1982 and by Abdel-Kareem, 1986. Additionally, it correlated with the same zone that was observed from the Late Maastrichtian sediment of Northern Iraq by Al-Mutwali and Al-Doori (2012), Hammoudi (2011), Sharbazheri et al., (2011), Salih et al., 2013, Al-Bakkal (2013), the zone defines as the Middle Late Maastrichtian age from the western desert of Iraq by Mousa et al., (2020) and from Northern Iraq by Bamerni et al., (2021) and Malak et al., (2021); the zone is considered as middle Maastrichtian age by Obaidalla et al., (2020) in Egypt (Table 2). This study defines the age of *Pseudoguembelina hariaensis* Zone as Middle Late Maastrichtian.

5.3.3. Pseudoguembelina palpebra zone

Definition: The stratigraphic range between the HO of *G. gansseri* (Bolli) and the LO of *Plummerita hantkeninoides* (Brönnimann) is covered by the *Pseudoguembelina palpebra* Zone, which was classified here as a partial-range zone.

Occurrence: This biozone is recorded in the middle part of the formation. The zone covers intervals around 29 m in thickness from depth 1416 m to 1387m in Aj-8, 27 m in thickness from depth 1482 m to 1455 m in Aj-12, 25 m in thickness from depth 1296m to 1271m in Aj-15 (Figs. 3, 4, and 5).

Age: Late Late Maastrichtian.

Assemblages: The previously known species of planktonic and benthonic foraminiferal found in this zone. As well as rare documented of *Contusotruncana falsocalcarata* (Kerdany and Abdelsalam) (Pl.2, Fig. O and P) in upper part of this zone. *G. gansseri* (Bolli) presence in previous biozone and not documented in this biozone.

Remarks and Correlation**:** the *Pseudoguembelina palpebra* zone which reported from Late Maastrichtian sediment of South Atlantic DSDP Site 525A by Li and Keller (1998a); from Late Maastrichtian sediment of Tunisia by Keller et al., (1995) and from Madagascar by Abramovich et al., (2002); from Egypt Obaidalla (2005) and Obaidalla et al., (2020); and from Northeastern Iraq by Sharbazheri (2007 and 2010), and Al Nuaimy et al. (2020); from Northern Iraq by Al-Mutwali and Al-Doori (2012), Salih et al. (2013), Al-Mutwali and Ibrahim (2019), and Bamerni et al., (2021) and Malak

et al., (2021); from Western Iraq by Mousa *et al*., (2020); from Iran by Rostami and Balmaki (2018). The upper portion of the *Abathomphalus mayaroensis* Zone, which is described by various authors, can be correlated with the *Pseudoguembelina palpebra* Zone which recorded in several countries: from Spain by Premoli Silva and Sliter(1995and1999); from Mediterranea by Premoli Silva *et al*., (1998); from Mexico by Maestas *et al*., (2003) (Table 2); from Egypt by Elnady and Shahin (2001) and by Samir (2002) in; from Iraq by Kassab (1972), Kassab *et al*., (1986), Abawi *et al*., (1982), Abdel-Kireem (1986), Al-Mutwali (1996), and Al-Mutwali and Al-Jubouri (2005); The zone can be equal to the *Kassbiana falsocalcarata* zone recognized in North Iraq by Kassab *et al*., (1986).

5.3.4. Plummerita hantkeninoides zone

Definition: This zone was here defined as a total range zone which cover the stratigraphic interval from the LO and HO of the nominate taxon (Pl.2, Fig. Q and R).

Age: Latest Maastrichtian.

Occurrence: This biozone is recorded in the middle part of the formation. The zone covers intervals around 17 m in thickness from depth 1387 m to 1370 m in Aj-8, 18 m in thickness from depth 1455 m to 1437 m in Aj-12, 18m in thickness from depth 1271 m to 1253 m in Aj-15 (Figs. 3, 4, and 5).

The same benthonic foraminiferal species recorded in the previous zone were also found in this biozone, in addition to these planktonic foraminiferal assemblages.

Assemblages: This Zone still had the numerous planktonic foraminifera found in the prior Zone. It yields a variety of well-to-moderately preserved planktonic species, the *Globotruncana bulloides* and *Archaeoglobigerina cretacea*, which were present in a different biozone but were not found in this one.

Remarks and Correlation**:** The *Plummerita hantkeninoides* Zone represents the latest Maastrichtian foraminiferal biozone recorded from sediment of Tunisia by Li and Keller, (1998b) and from Egypt by Obaidalla (2005) and Obaidalla et al., (2020); Samir (2002); in South Atlantic in DSDP Site 525A by Li and Keller, (1998a); In Mahajanga Basin by Abramovich et al., (2002); In Northeastern Iraq Sharbazheri (2007 and 2010), Al-Mutwali and Ibrahim (2019), and Al Nuaimy et al., (2020); from Northern Iraq by Al-Mutwali and Al-Doori (2012), Salih et al., (2013), Al-Mutwali and Ibrahim (2019), Malak et al. (2021), and Bamerni et al., (2021); from Western Iraq by Mousa et al.,(2020); This Zone is equivalent to the highest part of *Abathomphalus mayaroensis* zone recognized in various regions of the countries: from Iraq by Abawi et al., (1982) and Abdel-Kireem (1986), from Spain by Premoli Silva and Sliter (1995 and1999); from Italy by Premoli Silva et al., (1998); from Mexico by Maestas et al., (2003) (Sahib and al Dulaimi, 2022) (Table 2); and from Syria by Pecimotika et al., (2014); The *Kassbiana falsocalcarata* zone described in Kassab et al. (1986) is comparable to the *Plummerita hantkeninoides* zone.

Lithology and paleoenvironment: The lithology of this biozone is limestone and marly limestone with Planktonic foraminifera and calcareous benthic foraminifera meaning to accumulation in outer ramp depositional settings that equivalent to RMF5 of Flügel,2010 and correspond to microfacies of planktonic foraminifera in Syria by Pecimotika et al.,2014; in Iraq by Mousa et al.,2020).

6. Conclusions

46 species of planktonic foraminifera from the Late Campanian to the latest Maastrichtian have been identified in this study. The Shiranish Formation of three chosen wells in the Ajeel Oil Field, Central of Iraq, are divided into three biozones and four subzones, according to the index planktonic foraminifera. The three zones are 1. *Globotruncana aegyptiaca* Zone (Late Campanian) 2. *Gansserina gansseri* Zone (Early Maastrichtian) 3. *Abathomphalus mayaroensis* Zone (Late Maastrichtian). The *Abathomphalus mayaroensis* Zone is separated into four subzones in this section

1.*Racemiguembelina fructicosa* (Early Late Maastrichtian) 2.*Pseudoguembelina hariaensis* (Middle Late Maastrichtian) 3. *P. palpebra* (late Late Maastrichtian), and 4. *Plummerita hantkeninoides* (Latest Maastrichtian).

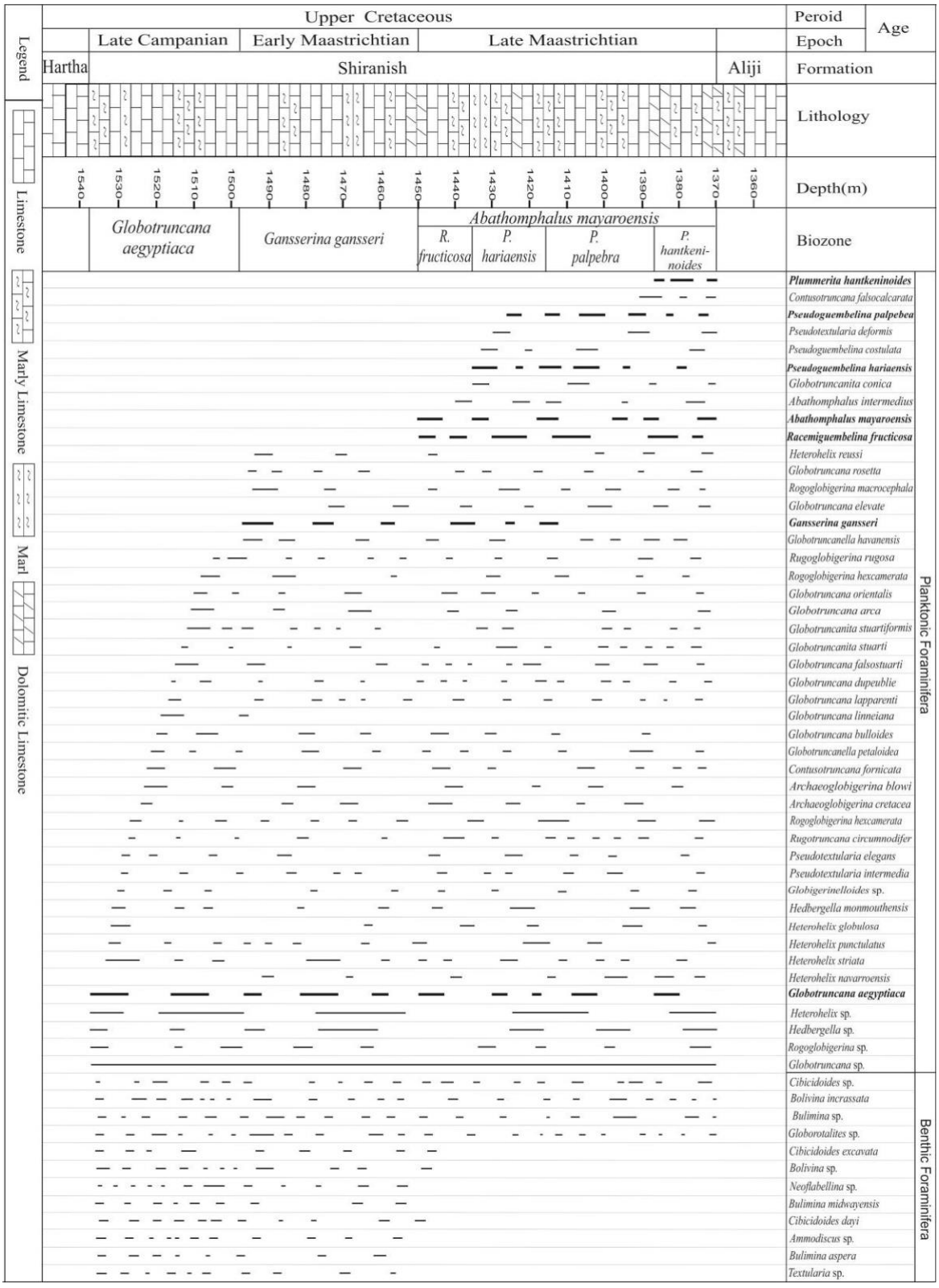


Fig.3. Biozone and Biostratigraphic distribution of planktonic and benthic Foraminifera Shiranish Formation in Aj-8

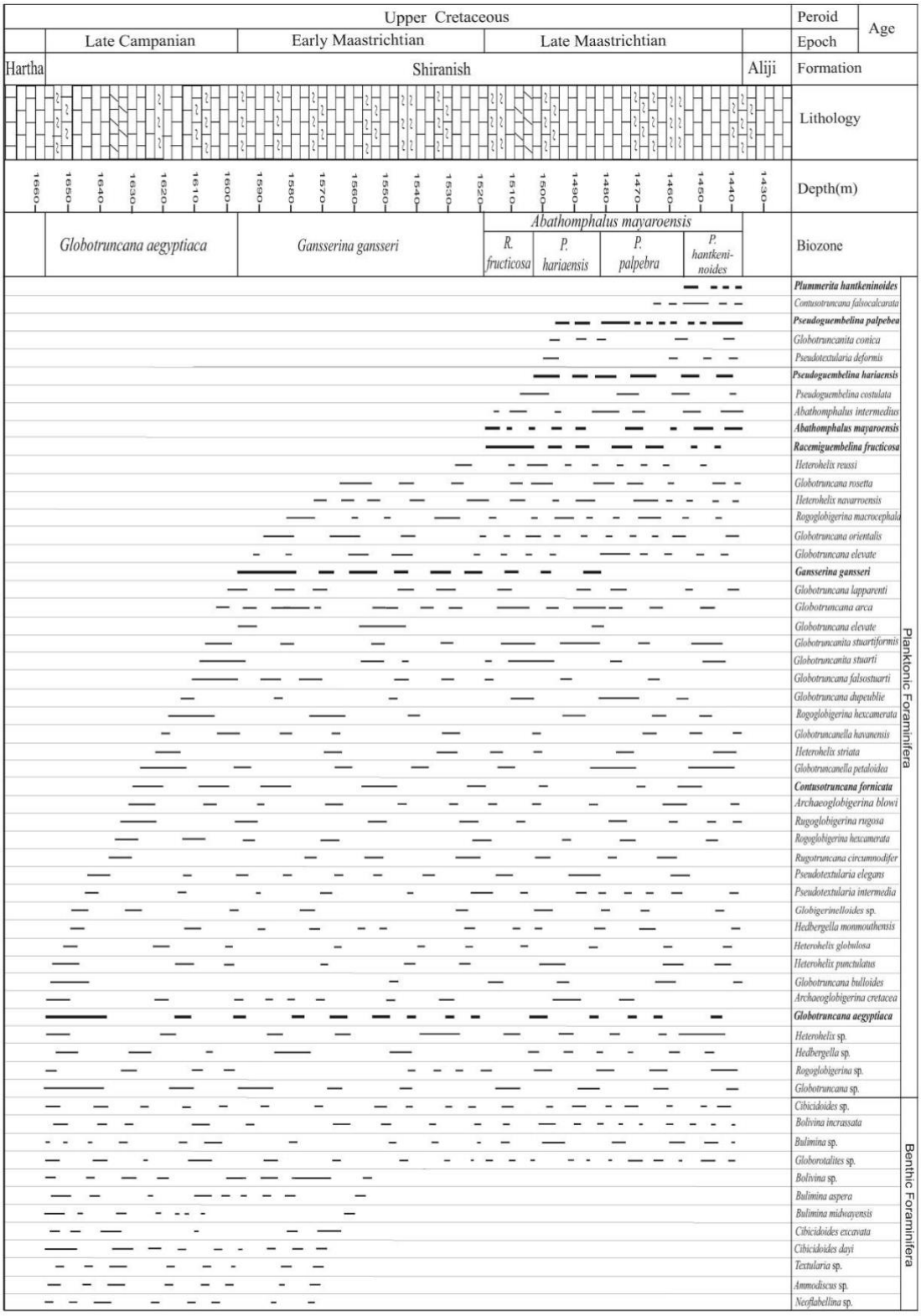


Fig.4. Biozone and Biostratigraphic distribution of planktonic and benthic Foraminifera Shiranish Formation in Aj-12

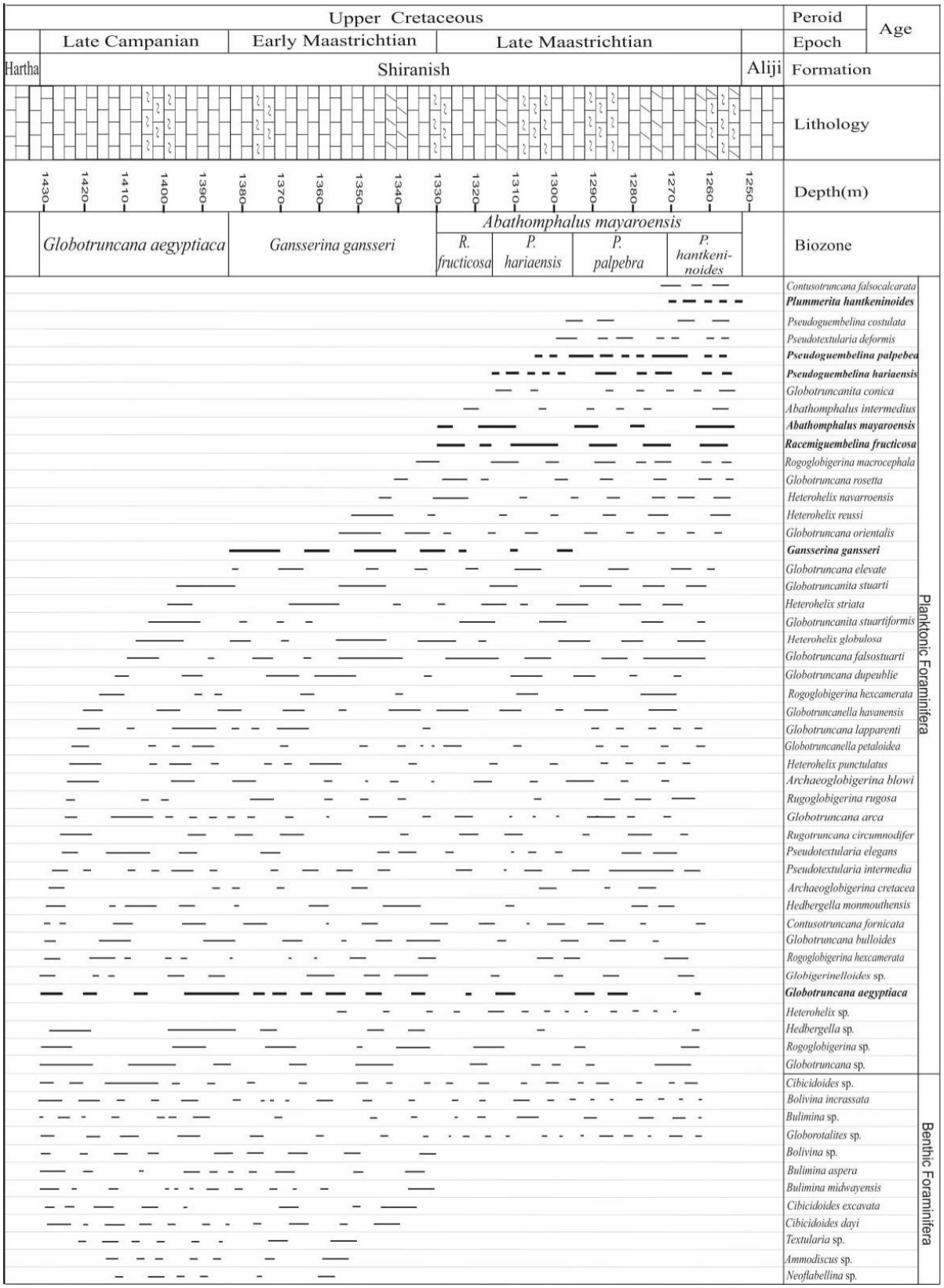


Fig.5. Biozone and Biostratigraphic distribution of planktonic and benthic Foraminifera Shiranish Formation in Aj-15

Table 2. Correlation chart showing the Foraminiferal biostratigraphic zones of Late Campanian - Maastrichtian in the studied section with the foraminiferal zonation commonly used in Iraq and different country

Peroid	Upper Cretaceous		
Epoch	Late Campanian	Early Maastrichtian	Late Maastrichtian
Present study	*Globotruncana aegyptica*	*Gansserina gansseri*	*Abathomphalus mayaroensis*: *R. fructicosa*; *P.hariaensis*; *P.palpebra*; *P. hankeninoides*
Abawi *et al.*, 1982 Abdel-Kireem, 1986	*G.fronicata- arca- sarttui*	Early Maastrichtian	Middle Maastrichtian; Late Maastrichtian
	G. Calcarata	*Globotruncana aegyptica- lapparenti-sarttui*	
		Rugotruncara subcirucmao-difer	*G. gansseri*; *C. contusa*; *Abathomphalus mayaroensis*
Caron 1985 Li & Keller 1998 a& b	*Globotruncana aegyptica*	*Gansserina gansseri*	*Abathomphalus mayaroensis*
Premoli Silva ,Sliter & 1995& 1999	*Globotruncana aegyptica*	*G. gansseri*	*C. contusa- R. fructicosa*; *Abathomphalus mayaroensis*
Maestas *et al.*, 2003	*Globotruncana aegyptica*	*Gansserina gansseri*	*Abathomphalus mayaroensis*
Obaidalla 2005	Not studied	*Gansserina gansseri*	*Abathomphalus mayaroensis*: *R. fructicosa*; *P. hariaensis*; *P. palpebra*; *P. hankeninoides*
Sharbazheri 2007& 2010	Not studied	*G. aegyptica*; *G. gansseri*; *C. contusa*; *P. intermedia*	*R. fructicosa*; *P. hariaensis*; Not studied
Al-Mutwali & AL-Doori 2012	*Globotruncana aegyptica*	*Gansserina gansseri*	*R. fructicosa*; *P. hariaensis*; *P. palpebra*; *P. hankeninoides*
Obaidalla *et al.*, 2020	*Globotruncana aegyptica*	*G. gansseri*; *R. fructicosa*; *G. gansseri*	*P. hariaensis* - *P. palpebra*; *P. hankeninoides*
Malak 2021	*Globotruncana aegyptica*	*G. gansseri*; *C. contusa*; *C. contusa*	*R. fructicosa*; *P. hariaensis*; *P. palpebra*; *P. hankeninoides*
Sahib & Al-Dulaimi 2022	*G. aegyptica*; *G. Havanensis*; *G. Calcarata*	*Gansserina gansseri*	*Abathomphalus mayaroensis*

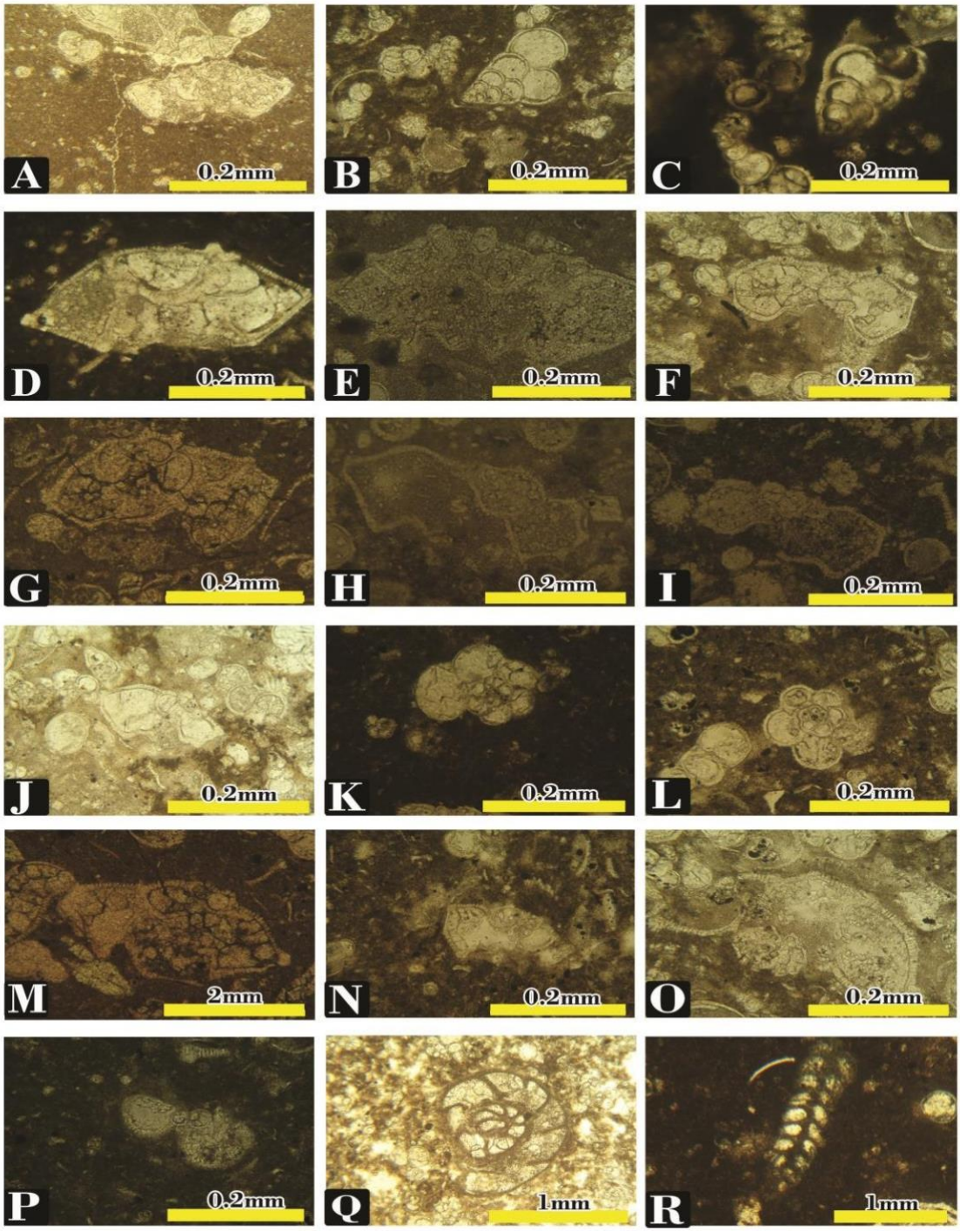


Plate1. A-*Globotruncana aegyptiaca* (Aj8, 1480m); B- *Heterohelix striata*(Aj12, 1567m); *Heterohelix globulosa*(Aj8, 139m); D- *Globotruncana orientalis* (Aj15, 1335m); E- *Globotruncana arca* (Aj12, 1483m); F- *Globotruncana dupeublie* (Aj12, 1479m); G- *Globotruncana falsostuarti* (Aj15, 1300m); H- *Globotruncana linneiana* (Aj8, 1515m); I- *Globotruncana lapparenti* (Aj12, 1512m); J- *Globotruncana bulloides* (Aj8, 1443m);K- *Archaeoglobigerina blowi* (Aj8, 1485m); L- *Rogoglobigerina hexcamerata* (Aj15, 1416m); M- *Globotruncanita stuarti* (Aj8, 1400m); N- *Globotruncanita stuartiforms* (Aj12, 1593m); O- *Globotruncanella havanensis* (Aj12, 1466m); P- *Hedbergella monmothensis* (Aj8, 1420m);Q- *Cibicidoides* sp. (Aj15, 1265m);R- *Bolivina incrassata* (Aj12, 1535m).

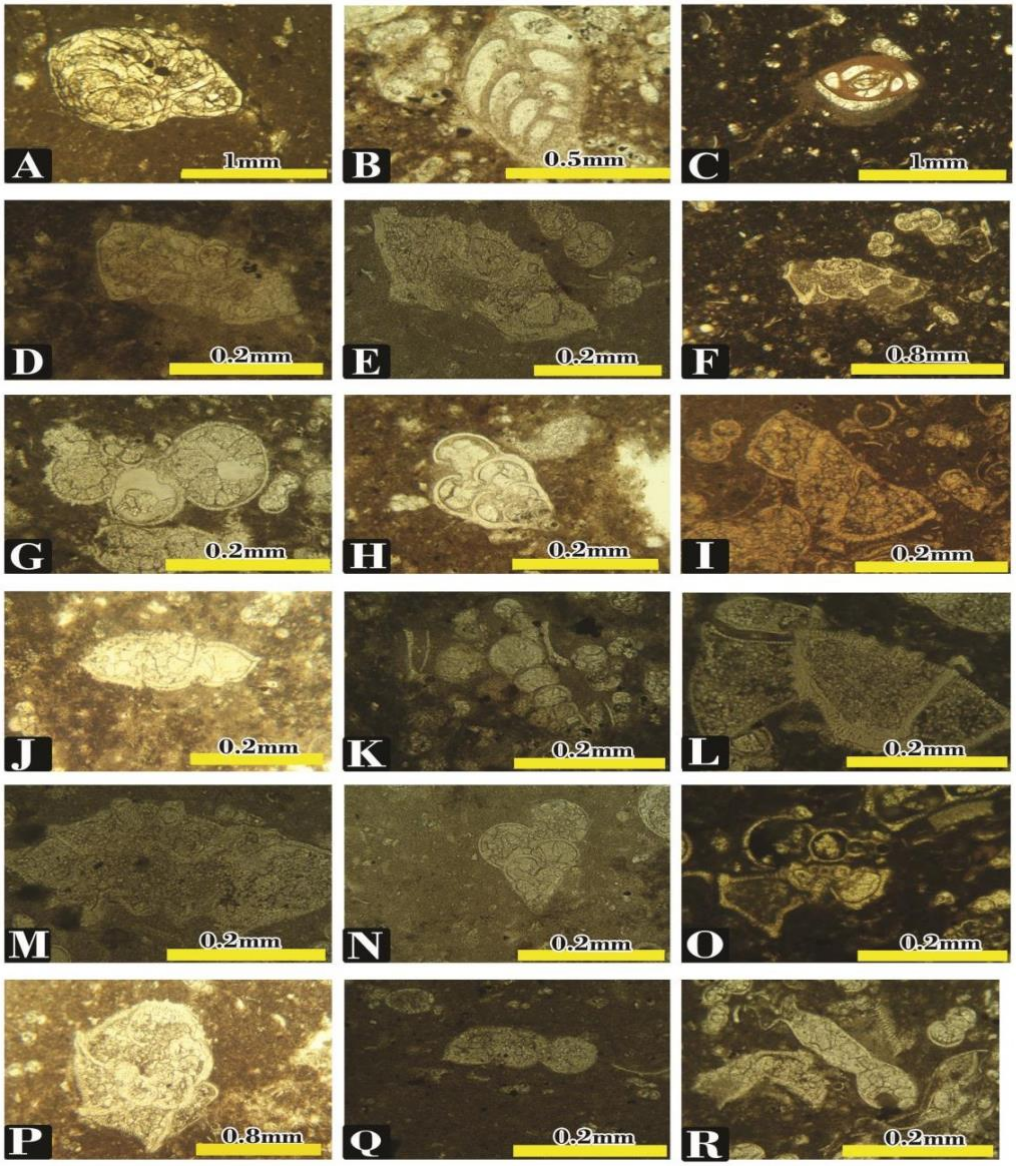


Plate 2. A- *Neoflabellina* sp. (Aj8, 1505m); B- *Bulimina midwayensis*(Aj15, 1380m); C- *Globorotalites* sp. (Aj15, 1376m); D- *Gansserina gansseri* (Aj12, 1583m); E- *Globotruncana elevate* (Aj8, 1401m); F- *Globotruncana rosetta* (Aj15, 1272m); G-*Rogoglobigerina macrocephala* (Aj8, 1398m); H- *Racemiguembelina fructicosa* (Aj8, 1447m); I- *Abathomphalus mayaroensis* (Aj12, 1495m); J- *Abathomphalus intermedius* (Aj12, 1478m); K- *Pseudoguembelina hariaensis* (Aj12, 1298m); L- *Globotruncanita conica* (Aj8, 1406m); M- *Globotruncanita conica* (Aj12, 1488m); N- *Pseudoguembelina palpebral* (Aj15, 1282m); O- *Globotruncana falsocalcarata* (Aj8, 1378m); P- *Globotruncana falsocalcarata* (Aj12, 1450m); Q- *Plummerita hantkeninoides* (Aj8, 1380m); R- *Plummerita hantkeninoides* (Aj12, 1452m).

References

Aba-Hussan, A.A., 1983. Petrography and Geochemistry of Shiranish Formation in Selected Area-Northern of Iraq, Unpubl. M. Sc. Thesis (in Arabic), University of Baghdad, Iraq.163

Abawi, T. S., Abdel-Kireem, M. R., Yousef, J. M., 1982. Planktonic Foraminiferal Stratigraphy Of Shiranish Formation, Sulaimaniah Dokan Region, Northeastern Iraq. Revista Española de Micropaleontologia, 14(1–3), 153–164.

Abdallah, F.T., Al-Dulaimi, S.I., 2019. Biostratigraphy of the Upper Cretaceous for selected sections in northern Iraq. Iraqi Journal of Science, 60, 3, 545-553.

Abdel-Kareem, M., 1986. Contribution to the stratigraphy of the Upper Cretaceous and the lower Tertiary of the Sulaimaniah-Dokan region, northeastern Iraq. Neues Jahrbuch Für Geologie Und Paläontologie, Abhandlungen, 172(1), 121–139.

Abdel-Kireem, M. R, Samir, A. M., 1995. Biostratigraphic implications of the Maastrichtian–Lower Eocene sequence at the North Guna Section, Farafra Oasis, Western Desert, Egypt. Marine Micropaleontology 26:329–340.

Abramovich,S, Keller, G., Adatte,T., Stinnesbeck,W.,Hottinger,L., Stueben, D., Randriamanantenasoa, A., 2002. Age and paleoenvironment of the Maastrichtian to Paleocene of the Mahajanga Basin, Madagascar: a multidisciplinary approach. Marine Micropaleontology, 47(1–2), 17–70.

Al- Jawary, H.A.H., 1989. Upper Cretaceous Study in selected section in Safaiya oil Field (N-W Iraq), Unpublished M.Sc. thesis, University of Baghdad, 151 (In Arabic).

Al Nuaimy, Q. A. M., Sharbazheri, K. M. I., Karim, K. H., Ghafor, I. M., 2020. Cretaceous-Paleogene boundary analysis by Planktic Foraminiferal Biozonation in the Western Zagros Fold-Thrust Belt (Smaquli valley), Sulaimani Governorate, NE-Iraq. Kirkuk University Journal, Scientific studies (KUJSS), 15 (3), 45-81.

Al-Badrani, O. A., 2012. Nannobiostratigraphy of the lower part of Shiranish Formation, Sinjar Anticline, NW Iraq. Iraqi National Journal of Earth Sciences, 12(1), 1-16.

Al-Banna, N. Y., 2010. Sequence stratigraphy of the Late Campanian–Early Maastrichtian Shiranish Formation, Jabal Sinjar, Northwestern Iraq. GeoArabia, 15(1),31-44.

AL-Khafaji, A., J., 2014. The Mishrif, Yamama, and Nahr Umr reservoir characterization and quality analysis of Carbonate rock types, case study, Southern Iraq, Petrol Explor. Prod Technol, (10), 2137-3177.

AL-Mutwali, M. M., Ibrahim, M. K., 2019. Planktonic foraminiferal biostratigraphy of Tanjero Formation (Late Maastrichtian) in Bekhme Area, Northeastern Iraq. Iraqi National Journal of Earth Sciences, 19 (1), 1 – 21.

Al-Mutwali, M. M., 1996. Planktonic foraminiferal biostratigraphy of the Shiranish Formation. Khashab well no. 1, Hemren area. Northeastern Iraq. Journal Geological Science, Iraq, 7(1), 129-136.

Al-Mutwali, M. M., Al-Juboury, F. N., 2005. Litho and Biostratigraphy of the Shiranish Formation (Late Campanian-Late Maastrichtian) In Sinjar Area, Northwestern Iraq. Rafidain Journal of science, 2005, 16, 1A special addition, 152-176.

Al-Mutwali, M.M., Al-Doori, M.A., 2012. Planktonic foraminiferal biostratigraphy of Shiranish formation in Dohuk area/northern Iraq. Iraqi National Journal of Earth Sciences, 12: 17–40.

Al-Naqib, K.M., 1967. Geology of the Arabian Peninsula, southwestern Iraq. United States Geological Survey, Professional Paper, 560g: 1–54.

Ameen, F.A., Gharib, H. 2014. Biostratigraphy of the Tethyan Cretaceous successions from northwestern Zagros fold-thrust belt, Kurdistan region, NE Iraq. Arabian Journal of Geosciences, 7: 2689– 2710.

Aqrawi, A.; Goff, J. Horbury, A., Sadooni, F., 2010. The Petroleum Geology of Iraq. Scientific Press Ltd. , Bucks, UK. 425.

Bamerni, A., Al-Qayim, B., Hammoudi, R.A., 2021. Foraminiferal biostratigraphy of the Uppermost Cretaceous period, Duhok Area, Kurdistan Region, North of Iraq. Iraqi Geological Journal, 54(2C), 48-58. DOI: 10.46717/igj.54.2C.5Ms-2021-09-24.

Bellen, R. C. Van., Dunnington, H. V., Wetzel, R., Morton, D .M., 1959. Lexique Stratigraphique International, Asia, Iraq. Int. Geol.Congr. Comm. Stratig. 3(10a), 1-333.

Buday, T., 1980. The Regional Geology of Iraq, Part I, Stratigraphy and Paleogeography. Eds., GEOSURV, Baghdad, 445.

Caron, M., 1985. Cretaceous planktonic foraminifera. In Bolli, H.M., Saunders, J.B. and Perch-Nielsen, K. (Eds), Plankton Stratigraphy. Cambridge University Press, England, 17–86.

El Diasty, W.S., El Beialy, S.Y., Peters, K.E., Batten, D.J., Al-Beyati, F.M., Mahdi, A.Q., Hasseb, M.T., 2018. Organic geochemistry of the Middle-Late Jurassic Naokelekan Formation in the Ajil and Balad oil fields, northern Iraq, Journal of Petroleum Science and Engineering, doi:10.1016/j.petrol.2018.03.031.

Elnady, H., Shahin, A., 2001.Planktonic foraminiferal biostratigraphy and paleobathymetry of the Late Cretaceous-Early Paleocene succession at northeast Sinai, Egypt. Journal Paleontology, 1, 193-227.

Gayara, A. D., Mousa, A. K., 2015. Sequence Stratigraphy and Reservoir Characterization of the Upper Campanian-Maastrichtian Succession, Buzurgan Field, Southeastern Iraqi., Iraqi Journal of Science, 56 (2), 1457–1464.

Hammoudi, R. A., 2011. High resolution biostratigraphy of the K/T boundary in the Higran Section, Shaqlawa Area, Northern Iraq. Iraqi National Journal of Earth Sciences, 11 (1), 23-48.

Hawramy, O.A., Al-Obidee, W.Y., Aziz, N.M, 2023. Campanian-Maastrichtian Ostracods (Crustacea) From the Shiranish Formation, Dukan Area, Kurdistan Province, Northern Iraq. Iraqi Geological Journal, 56(1C), 74-93.

Ismail, Sh., 2011.Sedimentology and petroleum potential of the Late Cretaceous Shiranish Formation in the Euphrates Graben, Syria, Unpublished Ph.D. thesis, Germany and TU- Berlin University- Germany, P.267.

Jaff, R. B. N., Lawa, F. A., 2019. Palaeoenvironmental signature of the Late Campanian-Early Maastrichtian benthonic foraminiferal assemblages of Kurdistan, Northeast Iraq. Journal of African Earth Sciences, 151, 255–273.

Jaff, R.B.N, 2021. Biostratigraphy of Bolivinoides and Neoflabellina Benthic Foraminifera in the Upper Cretaceous Shiranish Formation, Kurdistan Region, NE Iraq. Iraqi Bulletin of Geology and Mining, 17(1),1-13.

Jaff, R.B.N., Wilkinson, I.P., Lee, S., Zalasiewicz, J., Lawa, F., Williams, M., 2015. Biostratigraphy and palaeoceanography of the early Turonian–Early Maastrichtian planktic foraminifera of northeast Iraq. Journal of Micropalaeontology, l.34, 105–138.

Jaff, R.B.N., William, M., Wilkinson, I.P., Lawa, F.A., Lee, S., Jan, A., 2014. A refined foraminiferal biostratigraphy for the Late Campanian–Early Maastrichtian succession of northeast Iraq. Geo. Arabia, 19(1), 161–180.

Jan, S. K., Al-Zubaidi A. A., Al-Dulaimi, S.I., 2012. Microfacies analysis of Shiranish Formation at Hijran section - NE Iraq. Bulletin Iraq National History Museum, 12(2), 15-24.

Jassim, S.Z., Goff, J., 2006. Geology of Iraq. Dollin and Moravian Museum, Prague,. Printing of Mosul ,Iraq, 341 Kassab, I. I. M., 1972. Micropaleontology of the Upper Cretaceous to Lower Tertiary of Northern Iraq. Unpublished Ph.D. thesis, University of London, 310.

Kassab, I. I. M., 1979. The Genus Globotruncana Cushman from the Upper Cretaceous of Northern Iraq. Journal Geological Society Iraq, 12, 27 - 127.

Kassab, I.I.M., Al-Omari, F.S., Al-Safawee, N.M., 1986. The Cretaceous–Tertiary boundary in Iraq (represented by the subsurface section of Sasan well No.1, NW Iraq). Journal Geolgical Society Iraq, 19(2), 73 – 86.

Keller, G., Li, L., MacLeod, N., 1995. The Cretaceous/Tertiary boundary stereotype section at El Kef, Tunisia, how catastrophic was the mass extinction. Paleogeographic. Paleoclimatology.Paleoecology, 119, 221-254.

Khalil H., Mashaly, S., 2004. Stratigraphy and stage boundaries of the Upper Cretaceous and Lower Paleogene succession in Gabal Musaba Salama area, Southwestern Sinai, Egypt. Egypt Journal Paleontology, 4, 1–38.

Lawa, F.A., Koyi, H., Ibrahim, A., 2013. Tectonic-stratigraphic evolution of the NW segment of the Zagros fold-thrust belt, Kurdistan, NEIraq, Journal of Petroleum Geology. Wiley online Library, 36(1), 75-96.

Li, L., Keller, G., 1998a. Maastrichtian climate, productivity, and faunal turnover in planktonic foraminifera in South Atlantic, DSDP sites 525A and 21. Marine Micropaleontology, 33, 55-86.

Li, L., Keller, G., 1998b. Maastrichtian diversification of planktic foraminifera at El-Kef and Elles, Tunisia. Eclogae Geologicae Helvetiae, 91, 75-102.

Maestas, Y., Macleod, K. G., Douglas, R., Self-Trail, J., Ward, P. D., 2003. Late Cretaceous Foraminifera, Paleoenvironments, and Paleoceanography of the Rosario Formation, San Antonio Del Mar, Baja California, Mexico. Journal of Foraminiferal Research, 33(3), 179-191.

Malak , Omar A. Al-Badrani, Ezzat I. Al-Fandi,2021. Stratigraphic and microfacies study of Upper Campanian - Lower Maastrichtian succession (Shiranish Formation) in Bade village, Bekhere anticline, Kurdistan region, northern Iraq. Bulletin of the Geological Society of Malaysia, 71, 47-55.

Mousa, A. K., Al-Dulaimi, S. I., Mohammed, I. Q., 2020. Biostratigraphy of the Late Cretaceous/Early Paleocene Successions at K.H5\6 and K.H 5\8 Core Interval, Western Desert of Iraq, Iraqi Geological Journal, 53(1E),104-125.

Mousa, A. K., Al-Dulaimi, S. I., Mohammed, I. Q., 2021. Microfacies analysis of the Late Maastrichtian- Danian Phosphatic Succession in the H3-Trebeel district, Western Desert of Iraq. Iraqi Journal of Science, 62(4), 1188-1203.

Nederbragt, A. J., 1991. Late Cretaceous biostratigraphy and development of Heterohelicidae (planktic foraminifera). Micro- paleontology 37, 329–372.

Obaidalla, N. A., 2005. Complete Cretaceous/Paleogene (K/P) boundary section at Wadi Nukhul, southwestern Sinai, Egypt: inference from planktonic foraminiferal biostratigraphy. Revue de Paleobiologic, Geneve, 24 (1), 201-224.

Obaidalla, N. A., El-Sheikh, I., Mahfouz, K. H., Salman, A. M., Soliman, M. F., Abdel-Aleem, F. M, 2020. Upper Cretaceous–lower Paleocene subsurface sequence, Farafra Oasis, Western Desert Egypt: stratigraphical and paleoenvironmental inferences. Arabian Journal of Geosciences, 13(18), 1-17.

Owen, R.MS., Nasr, S. N.,1958. The stratigraphy of the Kuwiat-Basrah area. In: Weeks, G.L. (Es). Habitat of Oil a Symposium. American Association Petroleum Geology,Tulsa.

Pecimotika, G., Cvetko Tešović, B., Premec Fućek, V., 2014. Planktonic foraminiferal biostratigraphy and paleoecology of upper Cretaceous deposits from the Palmyride region, Syria', Geologia Croatica, 67(2), 87–110.

Premoli, S., Sliter, W. V., 1999. Cretaceous paleoceanography: evidence from planktonic foraminiferal evolution. Special Papers-Geological Society of America, 301–328.

Premoli, S., I. P., Spezzaferri, S., d'Angelantonio, A.,1998. Cretaceous foraminiferal bio-isotope stratigraphy of Hole 967E and Paleogene planktonic foraminiferal biostratigraphy of Hole 966F, eastern Mediterranean. Proceedings of the Ocean Drilling Program. Scientific Results, 160, 377–394. Ocean Drilling Program.

Premoli, S., Isabella, Sliter, W. V., 1995. Cretaceous planktonic foraminiferal biostratigraphy and evolutionary trends from the Bottaccione section, Gubbio, Italy. Palaeontographia Italica, 82, 1–89.

Robaszynski, F., Caron, M., González Donoso, J. M., Wonders, A. A. H, 1984. Atlas of Late Cretaceous globotruncanids. Révue de Micropaléontologie, 26, 145-305.

Rostami, M. A., Balmaki, B., 2018. Biostratigraphy and Paleoecology of Maastrichtian and Paleocene Sediments in the Northern Alborz, Iran, Using Foraminifera. International Journal of Geography and Geology, 7(3), 56–72. https://doi.org/10.18488/journal.10.2018.73.56.72.

Sahib, G.M., Al-Dulaimi, S. I. M., 2022. Biostratigraphy of the Late Cretaceous-Early Paleocene Succession in Selected Wells, Jambur Oil field, Kirkuk, Northern Iraq, Iraqi Geological Journal, 55 (2C), 221-238.

Salih, M. S., AL-Mutwali, M. M., Aldabbagh, S. M., 2013. Geochemical study of the Cretaceous–Tertiary boundary succession exposed at Dohuk Dam area (eastern Tethys): Northern Iraq. Arabian Journal of Geosciences, 8 (1), 18.

Samir, A. M., 2002. Biostratigraphy and paleoenvironmental changes in the Upper Cretaceous-Early Paleogene deposits of Gabal Samara section, Southwestern Sinai, Egypt. Egypt. Journal Paleontology, 2, 1-40.

Sharbazheri, K. M., 2007. Aging of Unconformity within Tanjero Formation in Chwarta Area (Kurdistan Region) Northeast of Iraq. Rafidain Journal Science., 7(1), 37-54.

Sharbazheri, K. M., 2010. Planktonic Foraminiferal Biostratigraphy of the Upper Cretaceous Reddish Pale Brown Succession from Smaquli Area Northeastern Iraq (Kurdistan Region), Iraqi Bulletin of Geology and Mining, 6 (1), 1 - 20.

Sharbazheri, K. M., Ghafor, I. M., Muhammed, Q. A., 2011. Biostratigraphy of The Cretaceous-Paleogene Boundary in Dokan Area, Sulaimaniyah, Kurdistan Region, NE Iraq. Iraqi Bulletin of Geology and Mining, 7 (3), 1-24.

Sissakian, V. K., 2005. The stratigraphy of the exposed Cretaceous rocks in Iraq, as deduced from the results of the regional and detailed geological surveys (GEOSURV 1971-1996), Iraqi Bulletin of Geology and Mining. Ministry of Industry and Minerals, 1(1), 1–20.

Znad, R. Kh., Al-Khatony, S. E., Al-Sumaidaie, M.A.H., 2020. Effect Of Tectonic Setting On Distribution Of Pelagic Sediment Unit (Shiranish Formation) In Zagros Foreland Basin , Iraqi Segment, Iraqi Geological Journal, 53(2A),105-119.