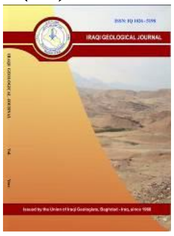
Iraqi Geological Journal *Hameed and Mousa* *2025, 58 (2B), 94-111*

Iraqi Geological Journal

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



Late Campanian- Maastrichtian Planktonic Foraminiferal Biostratigraphy in Ain Zalah Oil Field, Northwestern Iraq

Noor S. Hameed[1*] and Anwar K. Mousa[1]

[1] Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq
[*] **Correspondence:** noor.salem2308@sc.uobaghdad.edu.iq

Received:
12 March 2025
Accepted:
21 June 2025
Published:
31 August 2025

Abstract

An analysis of three selected wells in the Ain Zala oil field (AZ-16, AZ-17, and AZ-24) in the northwestern part of Mosul Governorate. In terms of biostratigraphy, it consists of planktonic and suspended foraminifera, which comprise 37 species belonging to 17 genera. Based on the recorded planktonic foraminifera, three main biozones were identified: *Globotruncana aegyptiaca* Partial Zone, which refers to the age of the Late Campanian, *Gansserina gansseri* Partial Range Zone, which indicates the age of the Early Maastrichtian, and *Abathomphalus mayaroensis* Interval Zone, which indicates the age of the Late Maastrichtian. The *Abathomphalus mayaroensis* Interval Zone is divided into four subzones: *Racemiguembelina fructicosa* Partial Range Subzone, which indicates the age of Early Late Maastrichtian, *Pseudoguembelina hariaensis* Partial Range Subzone, which refers to the age of Middle Late Maastrichtian, *Pseudoguembelina palpebra* Subzone, which covers the age of Late Late Maastrichtian, and *Plummerita hantkeninoides* Subzone, which refers to the age of Latest Maastrichtian. The Shiranish Formation in northwestern Iraq was deposited during the Cretaceous period, from the Late Campanian to Late Maastrichtian. The stratigraphy of this formation consists mainly of marl and marly limestone.

Keywords: Shiranish Formation; Campanian; Maastrichtian; Planktonic foraminifera

1. Introduction

In northern Iraq, the Shiranish Formation is thought to be one of the most prevalent and extensively distributed Late Cretaceous successions. The Shiranish Formation was first defined by Henson (1940) in Bellen et al. (1959) from the High Folded Zone of Iraqi Kurdistan, northeast of Zakho, close to the Shiranish Islam village.

The Lower Cretaceous (Campanian-Maastrichtian) regional transgression-regression depositional sequence, which flooded almost all of Iraq, is represented by this formation (Dunnington, 1958).

According to several studies, such as (Al-Banna, 2010; Al-Shareefi et al., 2014; Sahib and Al-Dulaimi, 2022; Mousa and Shakir, 2023), this formation is considered to be of Late Campanian to Late Maastrichtian age. However, (Al-Mutwali and Al-Doori (2012), Hassan and Al-Hadidi (2022) consider this formation to be of Middle Campanian to Late Maastrichtian age (Table 1).

According to Jaff et al. (2014) and Jaff (2021), the Shiranish Formation's age does not reach the Late Maastrichtian. Other authors (Bellen et al., 1959; Buday, 1980; Jassim and Goff, 2006; Al-Banna, 2010; Aqrawi et al., 2010) have emphasized that the formation is Late Campanian-Maastrichtian in age.

However, the age may reach the Late Maastrichtian in the Sinjar region (Al-Mutwali and Al-Juboury, 2005).

Between Hemrin and Mandali in eastern Iraq, the Shiranish Formation reaches 1,300 m in thickness (Abdula et al., 2018). On the western rim of the Ga'ara depression, the thickness drops to 50 meters as one moves westward across Iraq (Jassim and Goff, 2006).

Buday (1980) states that the genus Globotruncana, composed of blue to gray marl and gray limestone, contains the majority of the planktonic forms in the Shiranish Formation. This conclusion is based on Buday’s study of microfossils from the Upper Cretaceous and Lower Tertiary rocks. According to Bellen et al. (1959), the most important microfossil representatives are:

Globigerina aspera (Ehrenberg), *G. cretacea* (d'Orbigny), *Rugoglobigerina* sp., *Gumbelina striata* (Ehrenberg), *G. globulosa* (Ehrenberg), *Pseudotextularia elegans* (Rzehak), *Globotruncana arca* (Cushman), *G. gagnebini* (Tilev), *G. fornicate* (Plummer), *G. gansseri* (Bolli), *G. lapparenti* sp., *G. leupoldi* (Bolli), *G. stuarti* (de Lapparent), *G. rosetta* (Carsey), *Bolivina incrassata* (Reuss), Macrofossil debris, This study's objectives are to estimate the biozonations obtained to determine the formation’s geologic age accurately and to establish the biostratigraphy of the Shiranish Formation in the Ain Zala oil field, based on planktonic foraminiferal assemblages.

Table 1. The age of the Shiranish Formation has been determined through numerous studies

Age Of Shiranish Formation					
Studies	**Campanian**			**Maastrichtian**	
	Early	**Middle**	**Late**	**Early**	**Late**
Present Study			Late	Late	
Ahmed and Al-Hadidi 2019	Early		Late	Earliest	
Al-Wazan, 2013			Late	Early	
Al-Omari et al., 2005			Late	Early to Middle	
Al-Banna, 2010			Late	Early	
Mousa and Shakir, 2023			Late	Latest	
Sahib and Al-Dulaimi, 2022			Late	Late	
Al-Mutwali and Al-Doori, 2012			Late	Latest	
Al-Shareefi et al., 2014			Late	Ealy	Late
Hassan and Al-Hadidi 2022		Middle		Late Early	

2. Location of Study Area

The Ain Zala field is located 64 kilometers northwest of Mosul (Fig. 1). The anticline is asymmetrical and runs east to west. The field, which is approximately 19.3 km long and 4.8 km wide at its widest point, was discovered in 1939. According to Al-Juboury et al. (2016), the structure's length is about 1.3 km, and its widest point is 6 km. According to Hart and Hay (1974), the field's structure is a strongly folded hill anticline that was formed during the Late Tertiary Orogeny of Taurus and Zagros. Only six wells in this field (Nos. 7, 14, 16, 19, 23, and 24) were drilled to explore the Lower and Middle Cretaceous sections, whereas 28 wells encountered Upper Cretaceous units (Walid, 2007) (Table 2).

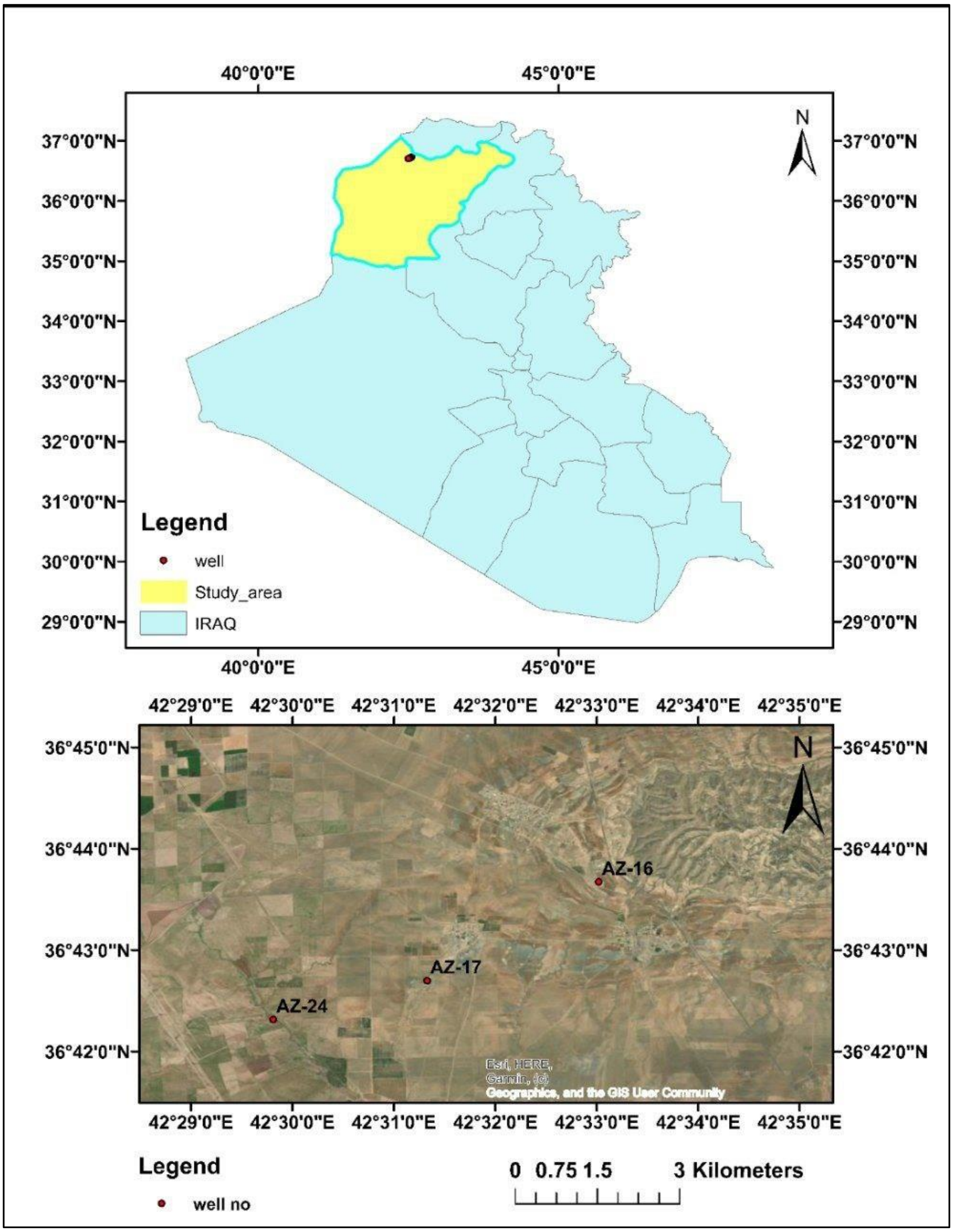


Fig. 1. Location map of the study area

Table 2. Coordinates of three specific areas within the study site and their thickness in relation to the formation's top and bottom

Well no.	Longitude	Latitude	Thickness of Fm.	Top of Fm.	Bottom of Fm.
AZ-16	36°44'0"	42°33'0"	675m	1527	2202
AZ-17	36°43'0"	42°31'0"	632m	1518	2150
AZ-24	36°42'0"	42°30'0"	876m	1684	2560

3. Geological Setting

In this study, samples from northwestern Iraq, collected from three oil wells (AZ-16, AZ-17, and AZ-24), were used. This area is located in the foothills of the mountain range and is characterized by long, narrow, asymmetrical convex folds, separated by wide concave folds (Buday and Jassim, 1987).

According to Abdel-Kireem (1983), the paleoenvironment and environmental conditions during the Late Cretaceous sedimentation of the Shiranish Formation were studied. The formation is divided into two rock units: the upper unit is made up of marly shale, and the lower unit is composed of marl. The upper contact is unconformable with the Kolosh Formation, while the lower contact is gradational both sedimentologically and paleontologically with the Bakhme Formation (Atroshi, 2007).

According to Al-Banna (2010), the Shiranish Formation region, which is composed of marl and marly limestone, was formed in a deep-marine environment.

Other researcher (Buday, 1980) proposed that deposition occurred during the Turonian, marking the final stage of marine transgression, and regarded the Mushorah Formation facies as being at the upper part of the Kometan Formation.

According to Bayrakdar (2011), the Shiranish Formation is a deep-marine basin environment, as determined using paleontological methods, sedimentary analysis, microfacies studies, and diagenetic processes. This is because the Shiranish Formation represents a deep-basin setting in most parts of the study area.

The thickness, type, and distribution of rock units in the Shiranish Formation were altered by tectonic activity during the Upper Cretaceous. In northern Iraq, marls from the Shiranish Formation (Jib'ab Marl), fore-reef or back-reef limestones from the Bekhme and Aqra formations, and clastics from the Tanjero Formation are indicative of the Late Campanian-Maastrichtian transgression cycle (Mousa and Shakir, 2023; Al-Naqib, 1967) (Fig. 2).

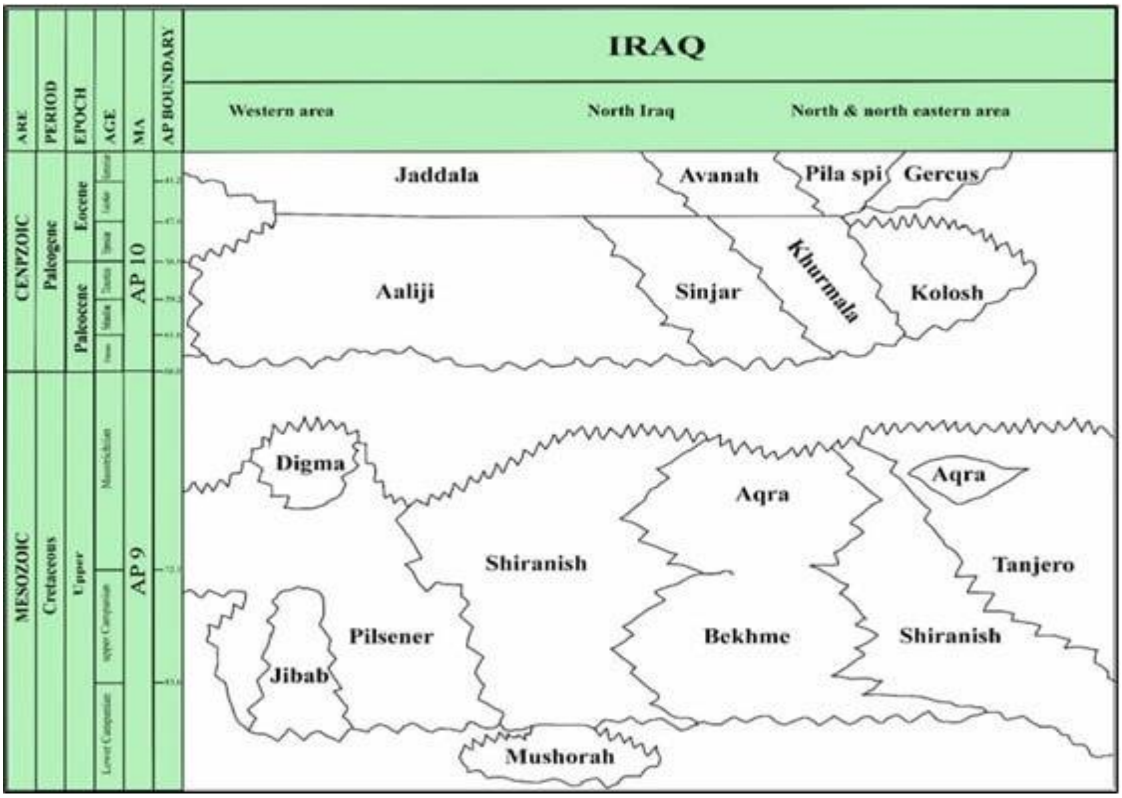


Fig. 2. Correlation of the chronostratigraphic cross-section for AP9 and AP10 (modified after Al-Omari and Sadiq, 1977)

4. Materials and Methods

Many writers such as Caron (1985), Li and Keller (1998a), Nederbragt (1991), Mohammed et al. (2022), Mousa and Shakir (2023) have developed the following basic taxonomic principles as the basis for estimating biostratigraphy and identifying biozones.

About 209 thin sections of core samples and cuttings from three oil wells were examined: 93 thin sections from AZ-16, 62 thin sections from AZ-17, and 54 thin sections from AZ-24. These were analyzed under a polarized microscope to determine the faunal content, petrographic composition, and planktonic and benthic foraminiferal assemblages.

5. Results

5.1. Biostratigraphy

The organization of successive events in the geologic record, gathering more detailed data, and dividing the strata according to the presence of fossils are the primary goals of biostratigraphic studies (Keller, 2004).

According to Sissakian et al. (2015), ecological variations and evolutionary changes resulting from shifts in climatic and depositional environments are the two main reasons for the variation in fossil richness in a stratigraphic succession.

With an emphasis on planktonic foraminifera and certain related fossils, the present study investigated the biostratigraphy of the Shiranish Formation in the Ain Zala Oil Field. Planktonic foraminifera were abundant in this formation.

In this study, 37 species of planktonic foraminifera were described, representing 17 different taxa (Figs 3, 4, and 5).

The three main biozones were determined by a comprehensive biostratigraphic analysis based on the presence of planktonic foraminiferal assemblages, exemplified by: *Globotruncana aegyptiaca, Gansserina gansseri*, *Abathomphalus mayaroensis.* The last biozone is divided into four subzones, including: *Racemiguembelina fructicosa, Pseudoguembelina hariaensis*, *Pseudoguembelina palpebra, Plummerita hantkeninoides* (Mousa and Shakir, 2023).

5.1.1. Globotruncana aegyptiaca zone

Definition: The *Globotruncana aegyptiaca* zone (Plate 1; Fig. A) represents the partial interval between the nominated species' first appearance datum (FAD) and last appearance datum (LAD) of *Gansserina gansseri* (Bolli) and was originally introduced by Caron (1985).

Boundaries: This biozone, located in the lowest part of the formation, represents the earliest known foraminiferal biozone. The lower boundary is defined by the first appearance of *Globotruncana aegyptiaca* (Nakkady), while the upper boundary is marked by the appearance of *Gansserina gansseri* (Bolli)

Age: Late Campanian.

Thickness: The thickness of this zone is approximately 193 m in well Ain Zala-16, 140 m in well Ain Zala-17, and 132 m in well Ain Zala-24.

Assemblages : This zone was associated with *Pseudoguembelina hariaensis* Nederbragi's presence. The most important of these types are : *Contusotruncana fornicata* (Plummer), *Pseudotextularia elegans* (Rzehak) (Plate 1; Fig. B), *Rogoglobigerina hexacamerata* (Bronnimann), *Heterohelix globulosa* (Plate 1; Fig. C), *Globotruncanella havanensis* (Voorwijk), *Globotruncanita stuartiformis* (Dalbiez) (Plate 1; Fig. D), *Hedbergella planispira* (Tappan) (Plate 1; Fig. E), *Globotruncana bulloides* (Vohgler) (Plate 1; Fig. F), *Globotruncana dupeublie* (Caron) (Plate 1; Fig. G), *Globotruncana falsecalcarata* (KerdanyandAbdelsalam) (Plate 1; Fig. H), *Globotruncana linneiana* (d'Orbigny), *Contusotruncana fornicata* (Plummer) (Plate 1; Fig. I), *Globotruncanita conica* (White) (Plate 1; Fig.

J), *Globotruncana rosetta* (Carsey), *Globotruncana esnehensis* (Nakkady). In addition to other types that continue to appear from the previous range *Globotruncana falsostuarti* (Sigal), *Globotruncana arca* (Cushman) (Plate 1; Fig. K), *Globotruncana insignis* (Gandolfi), *Archaeoglobigerina blowi and A. cretacea* (d'Orbigny), *Globotruncanita stuarti* (de Lapparent) (Plate 1; Fig. L), *Globotruncanita elevata* (Brotzen), *Globotruncana orientalis* (El Naggar), *Rugoglobigerina rugosa* (Plummer), *Globotruncana insignis* (Gandolfi), *Globotruncana lapparenti* (Brotzen), *Gublerina cuvilleri* (kikoine), *Globotruncana rugosa*(Marie), *Pseudogumbelina costulata* (Cushman), *Gansserina wiedenmayeri* (Gandolfi), *Globotruncanella petaloidea* (Gandolfi), *Hedbergella monmothensis* (Olsson), *Htereohelix reussi* (Cushman), *Rugoglobigerina hexacamerata* (Brönnemann), *Heterohelix striata* (Ehrenberg), *Heterohelix sp., Globigerinelloides* sp..

Correlation: The present zone is comparable to the *Globotruncana aegyptiaca* zone defined by Li and Keller (1998a) in Germany. In Europe, Caron (1985) identified this zone as dating to the Late Maastrichtian. In Northern Iran, Darvishzad and Abdolalipour (2009) documented this zone at an age of Late Campanian. Its equivalent in Iraq has been recorded by (Al-Omari et al., 2005; Al-Juboury, 2002) at an age of Late Early Maastrichtian. However, at the Late Campanian stage in Iraq, similar zones were identified by (Al-Doori, 2010; Hassan and AL-Hadidi, 2022; Bamerni, 2010; Raoof, 2011; Al-Mutiwty, 2020). In the current study, this biozone is considered to be of Late Campanian age (Fig. 6, and 7).

5.1.2. Gansserina gansseri zone

Definition: (Bronnimann) defined this zone as the partial range between the first appearance of *Gansserina gansseri* (Bolli) within its stratigraphic range and the first appearance of *Abathomphalus mayaroensis* (Bolli) (Plate 1; Fig. M).

Boundaries: The first appearance of *Gansserina gansseri* (Bolli) marks the lower boundary of this zone, while the first appearance of *Plummerita hantkeninoides* (Bronnimann) marks the upper boundary of this area.

Age: Early Maastrichtian.

Thickness: The thickness of this zone is approximately 224 m in well Ain Zala-16, 503 m in well Ain Zala-17, and 205 m in well Ain Zala-24.

Assemblages: This biozone has a large and highly diverse planktonic foraminiferal association, including: *Globotruncanita stuartiformis* (Dalbiez), *Globotruncana orientalis* (el-Naggar), *Globotruncana rosetta* (Carsey), *Globotruncanita stuarti* (deLapparent), and *Contusotruncana contusa* (Cushman) are the species that fall under this category. In addition to: *Heterohelix navarroensis* (Loeblish), *H.reussi* (Cushman), *Rogoglobigerina macrocephala* (Bronnimann), and *Globotruncana elevate* (Brotzen).

Correlation: Most biostratigraphic scheme experts have assigned the *Gansserina gansseri* zone to the Early Maastrichtian in Iraq (Al-Mutwali, 1996; Al-Mutwali and Al-Jubouri, 2005); in Germany, as represented by (Liangquan Li et al., 1999; Luning et al., 1998); in India (Changkham and Jafar, 1998); in Spain (Chacon and Martin-Chivelet, 2005); and in Italy (Premoli Silva et al., 1998).

However, some studies have placed this zone in the Middle Maastrichtian, including (Sliter, 1989; Moghaddam, 2002; Robaszynski et al., 1984) in Italy, and (Li and Keller, 1998b) in Tunisia.

According to this study, the *Gansserina gansseri* zone is considered to be of Early Maastrichtian age.

5.1.3. Abathomphalus mayaroensis interval zone

According to Keller et al. (1995), the Late Maastrichtian marker species below the Cretaceous-Tertiary boundary is thought to be *Abathomphalus mayaroensis* (Bolli) (Plate 1; Fig. N).

5.1.3.1. Racemiguembelina fructicosa partial range subzone

Definition: Li and Keller (1998b) classified the *Racemiguembelina fructicosa* (Egger) (Plate 1; Fig. O) subzone as the nominate taxon's partial range between the lower limit of *Pseudoguembelina hariaensis* (Nederbragt) and the upper limit of *Gansserina gansseri* (Bolli).

Age: Early Late Maastrichtian.

Boundaries: The initial appearance of *Racemiguembelina fructicosa* marks the base of this range, while the appearance of the *Plummerita hantkeninoides* zone (Bronnimann) marks its upper limit.

Thickness: The thickness of this zone is approximately 69 m in well Ain Zala-16, 54 m in well Ain Zala-17, and 65 m in well Ain Zala-24.

Assemblages: With the exception of *Hedbergella planispira* (Tappan) and *Archaeoglobigerina blowi* (Pessagno), this zone contains a variety of species, including those present in the *Gansserina gansseri* range.

Correlation: Most researchers have classified the *Racemiguembelina fructicosa* zone as Early Late Maastrichtian. The lower portion of *A. mayaroensis* is associated with the *Racemiguembelina fructicosa* zone, which is thought to be of Early Late Maastrichtian age. In Iraq, this zone has been documented by (Al-Doori, 2010; Sharbazheri, 2008; Abdel-Kareem, 1986; Abawi et al., 1982; Robaszynski et al., 1984). In Egypt, it was identified by Obaidalla (2005). In Italy, (Premoli and Sliter, 1995; Premoli and Sliter, 1999) described a similar biozone. In general, Caron (1985) recognized this zone as comparable. In Tunisia, studies by (Li and Keller, 1998; Samir, 2002; Abramovich et al., 2002; Rostami et al., 2009) confirm its presence.

5.1.3.2. Pseudoguembelina Hariaensis Partial Range Zone

Definition: According to Li and Keller (1998b), the partial range is defined by the last appearance of *Gansserina gansseri* (Bolli) and the first appearance of *Pseudoguembelina hariaensis* (Nederbragt) (Plate 1; Fig. P).

Age: Middle Late Maastrichtian.

Boundaries: This range extends between the lower boundary of the *Pseudoguembelina palpebra zone* range and the upper boundary of the *Racemiguembelina fructicosa* range zone (Bolli).

Thickness: The thickness of this zone is about 68 m in well Ain Zalah-16, 52 m in well Ain zalah-17, and 60 m in well Ain Zalah-24.

Assemblages: In addition to the planktonic species found in the preceding zone, this zone had numerous of species of *Pseudoguembelina hariaensis*. The following species were also noted: *Abathomphalus mayaroensis, Pseudogumbilina hariansin, Racemiguembelina fructicosa, Globotruncana aegyptiaca, Contusotrunca fronicata, Globotruncana falsostuarti, Globotruncanita stuartiformis, Hedbergella planispira, Globotruncana bulloides, Globotruncana arca, Globotruncana linneiana, Globotruncana sp., Globigerinelloides sp., Heterohelix punctulatus, Rogoglobigerina sp., Rogoglobigerina macrocephala, Rogoglobigerina hexcamerata, Hedbergella sp., Chilogumbilina sp., Echnoderma sp., Hedbergella monmouthensis, Heterohelix globulosa, Heterohelix sp., Heterohelix reussi* , *Globotruncana duplicate* .and the benthonic foraminiferal as a *Bulimina sp.*

Correlation: This study defines the age of the *Pseudoguembelina hariaensis* Zone as Middle Late Maastrichtian and considers it equivalent to Shanbazheri (2008). The zone is associated with the *Pseudoguembelina hariaensis* Zone in Iraq, placing it in the Middle Late Maastrichtian age according to Darvishzad et al. (2007). Additionally, in Tunisia, studies by Li et al. (1999); Arenillas et al. (2006); and Li and Keller (1998) support this classification. In this study, this zone is recorded as Middle Late Maastrichtian.

5.1.3.3. Pseudoguembelina palpebra zone

Definition: define by (Li and Keller, 1998) this zone is represents the partial range of *Pseudoguembelina palpebra* (Bronnimann and Brown, 1953) (Plate 1; Fig. Q). Between the initial appearance of the Plummerita hantkeninoides (Bronnimann, 1952) and the final appearance of Gansserina gansseri (Bolli).

Age : Late Late Maastrichtian.

Boundaries: This range extends between the upper boundary of *Gansserina gansseri* range zone (Bolli) and the lower boundary of *Plummerita hantkeninoides* Totale range zone (Bronnimann).

Thickness: The thickness of this zone is approximately 60 m in Ain Zalah-16, 48 m in Ain Zalah-17, and 56 m in Ain Zalah-24.

Assemblages: In addition to the species previously identified, there are other planktonic foraminifera assemblages including: *Abathomphalus mayaroensis, Gansserina gansseri, Globotruncana aegyptiaca, Pseudogumbilina hariansin, Globotruncana lapparenti, Racemiguembelina fructicosa, Contusotrunca fronicata, Globotruncana falsostuarti, Globotruncanita stuartiformis, Globotropic bulloides, Globotruncanita stuarti, Echnoderma sp. Globotruncana arca, Heterohelix punctulatus, psuodoguebelina palpebra, Rogoglobigerina macrocephala, Globotruncana linneiana, Rogoglobigerina hexcamerata, Heterohelix reussi, Globotruncana sp., Hedbergella sp., Heterohelix sp., Rogoglobigerina sp., Chilogumbilina sp., Globigerinelloides sp., Globotruncana duplicate.* and types of benthic Formifera have been identified in this range as *Turrillinidae sp.*

Correlation: this study defines the age of this zone as Late Late Maastrichtian and considers it equivalent to: Locally in Iraq by (Al-Mutwali and Al-Jubouri, 2005; Sharbazheri, 2008; Al-Doori, 2010); from Egypt by (Obaidalla et al., 2020; Obaidalla, 2005); from Spain by (Premoli and Sliter, 1995; Premoli and Sliter, 1999); in Iran by (Rostami and Balmaki, 2018; Darvishzad et al., 2007), but from Tunis by (Keller et al., 1995) in the Late Maastrichtian sediment. In this study, the biozone was determined to be Late Maastrichtian in age.

5.1.3.4. Plummerita Hantkeninoides Zone

Definition: This zone defined by (Pardo et al., 1996) which is the total range of the nominate taxon It ends with the disappearance of the *Plummerita hantkeninoides* (Bronnimann) (Plate 1; Fig. R).

Age: Latest Maastrichtian .

Boundaries: The *Plummerita hantkeninoides* zone range emergence marks the beginning of this species, and the extinction of the same species marks the end of its bounds.

Thickness: The thickness of this zone is approximately 57 m in Ain Zalah-16, 44 m in Ain Zalah-17, and 54 m in Ain Zalah-24.

Assemblages: The planktonic foraminiferal assemblages of this biozone are highly diversified and abundant. This zone includes numerous species; *Pseudoguembelina hariaensis*. The following species observed in this range including; *Abathomphalus mayaroensis, Globotruncana aegyptiaca, Gansserina gansseri, Racemiguembelina fructicosa, Contusotrunca fronicata, Globotruncana falsostuarti, Globotruncanita stuartiformis, Globotruncana duplicate Globotruncana bulloides, Globotruncanita stuarti,Globotruncana arca, Heterohelix punctulatus, Rogoglobigerina hexcamerata, psuodoguebelina palpebra, Globotruncana linneiana, Rogoglobigerina macrocephala, Hedbergella sp., Heterohelix sp., Heterohelix reussi, Globotruncana sp., Globigerinelloides sp., Echnoderma sp., Rogoglobigerina sp.*

Correlation: This study defines the age of *Plummerita hantkeninoides* zone as Latest Maastrichtian is equivalent; in Iraq (Al-Doori, 2010; Sharbazheri, 2007; Sharbazheri, 2010; Al-Mutwali and Al-Doori, 2012; Al-Mutwali and Ibrahim, 2019; Al Nuaimy et al., 2020) from Egypt by (Samir, 2002; Obaidalla, 2005; Obaidalla et al., 2020); from Iraq by (Sahib and Al-Dulaimi, 2022); Syria by (Pecimotika et al., 2014); Tunisia by (Li and Keller, 1998); from from Mexico by (Maestas et al., 2003); from Spain by

(Premoli and Sliter, 1995; Premoli and Sliter, 1999); from Italy by (Premoli et al., 1998). In the present study, this range was determined by the age of Latist Maastrichtian.

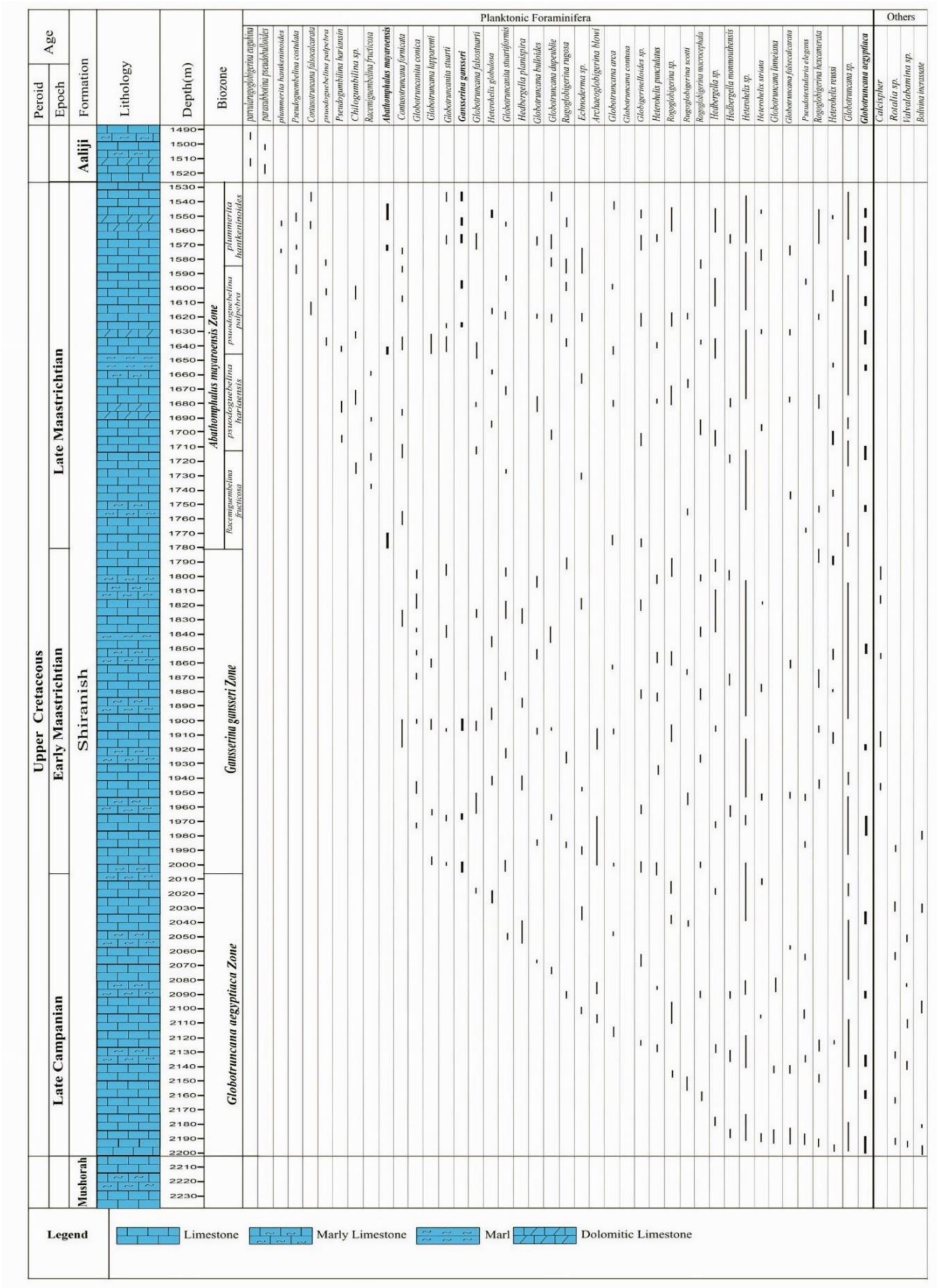


Fig. 3. Biostratigraphy of the Shiranish Formation in Ain zalah oil filed at well No.16

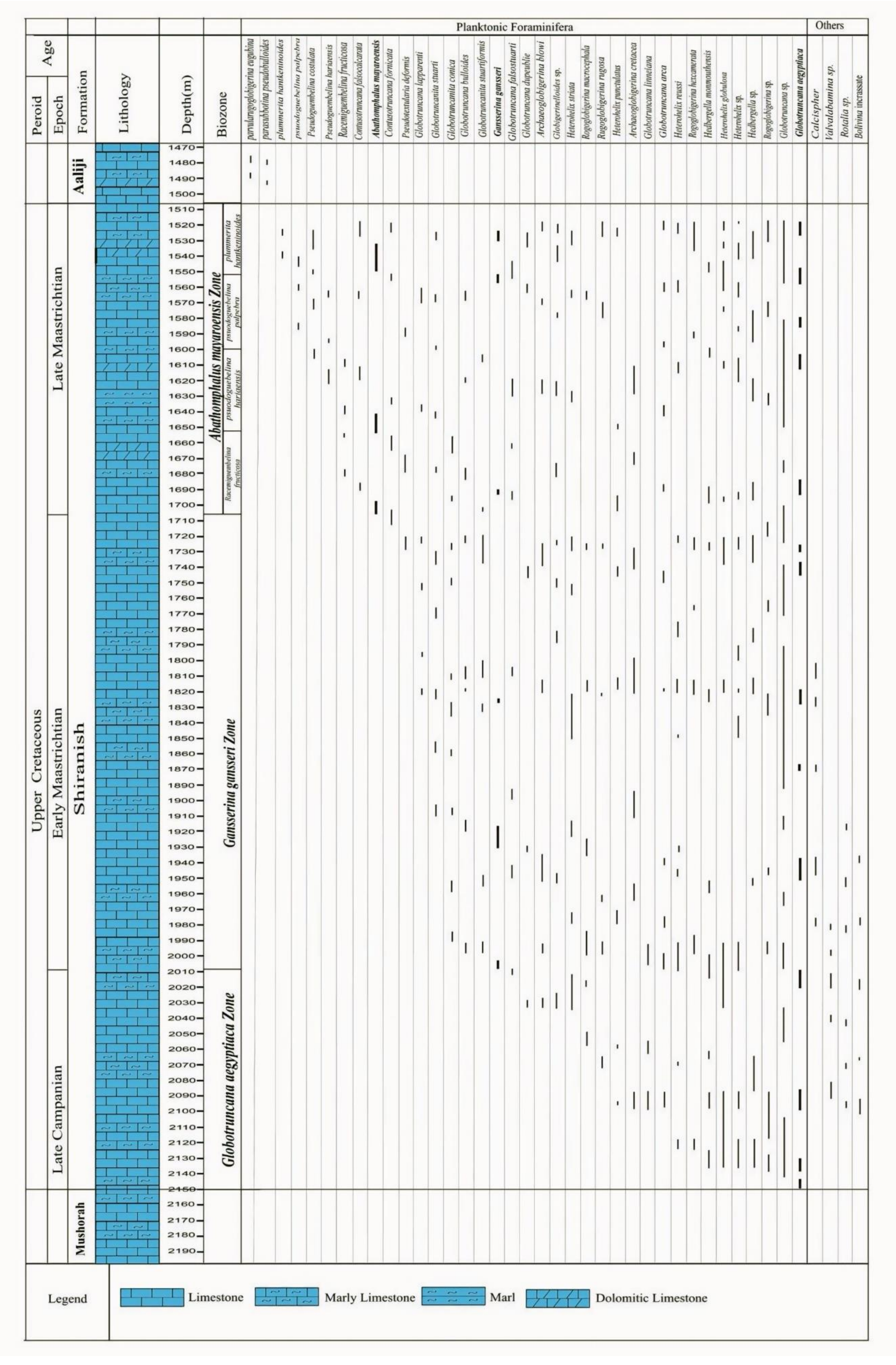


Fig. 4. Biostratigraphy of the Shiranish Formation in Ain zalah oil filed at well no.17

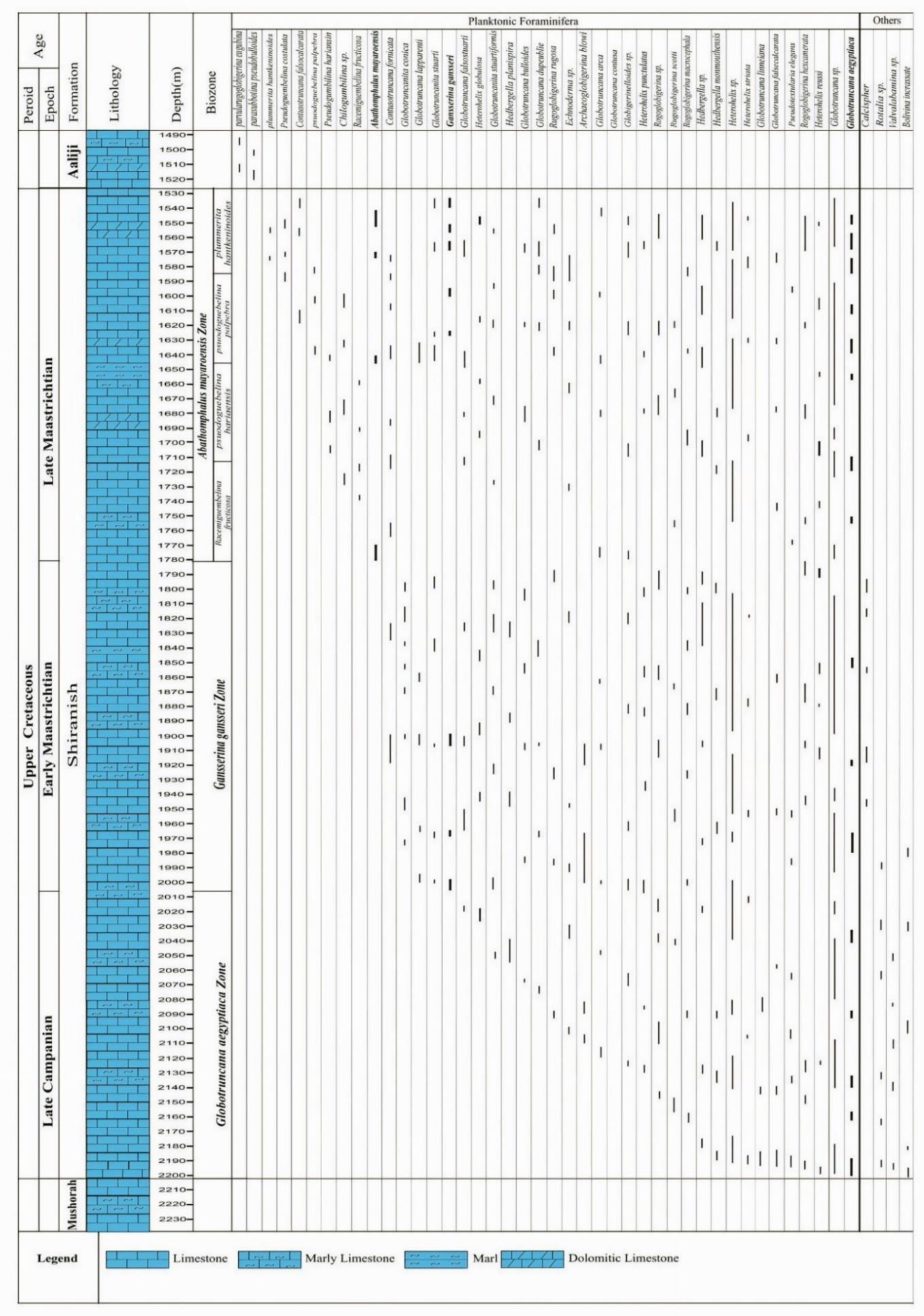


Fig. 5. Biostratigraphy of the Shiranish Formation in Ain zalah oil filed at well No.24

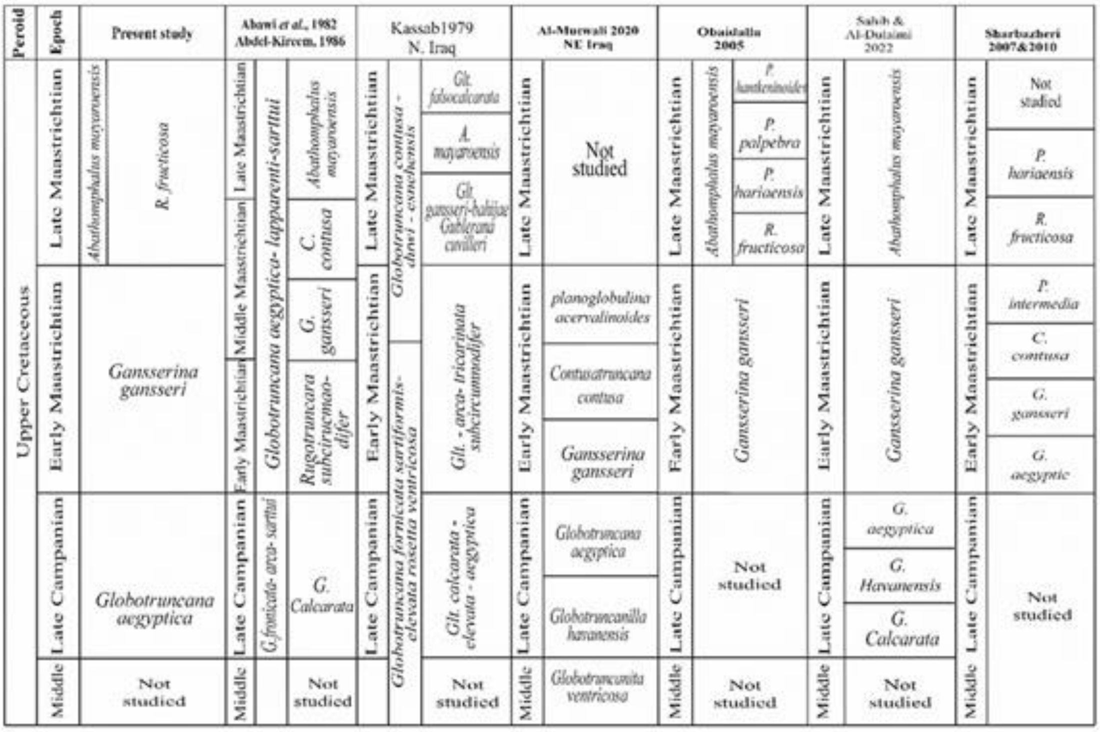


Fig. 6. Correlation of planktonic foraminiferal biozones of the Shiranish Formation in Iraq

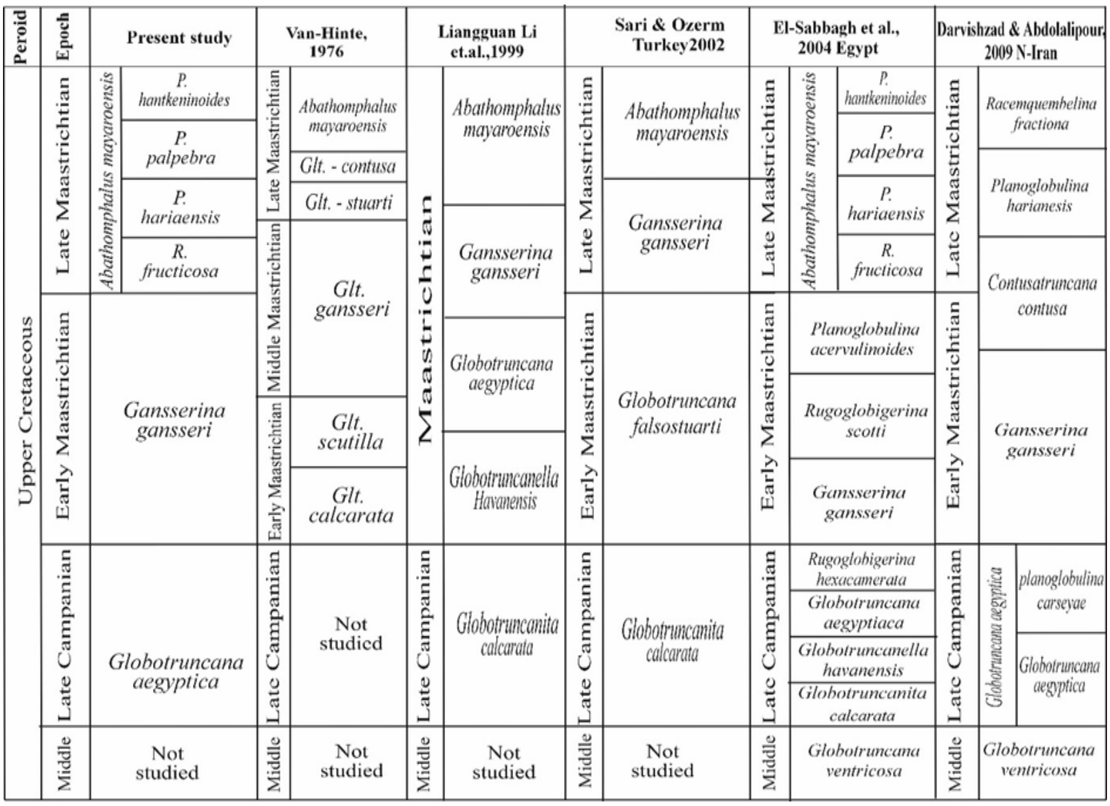


Fig. 7. Correlation of planktonic foraminiferal biozones of the Shiranish Formation out of Iraq

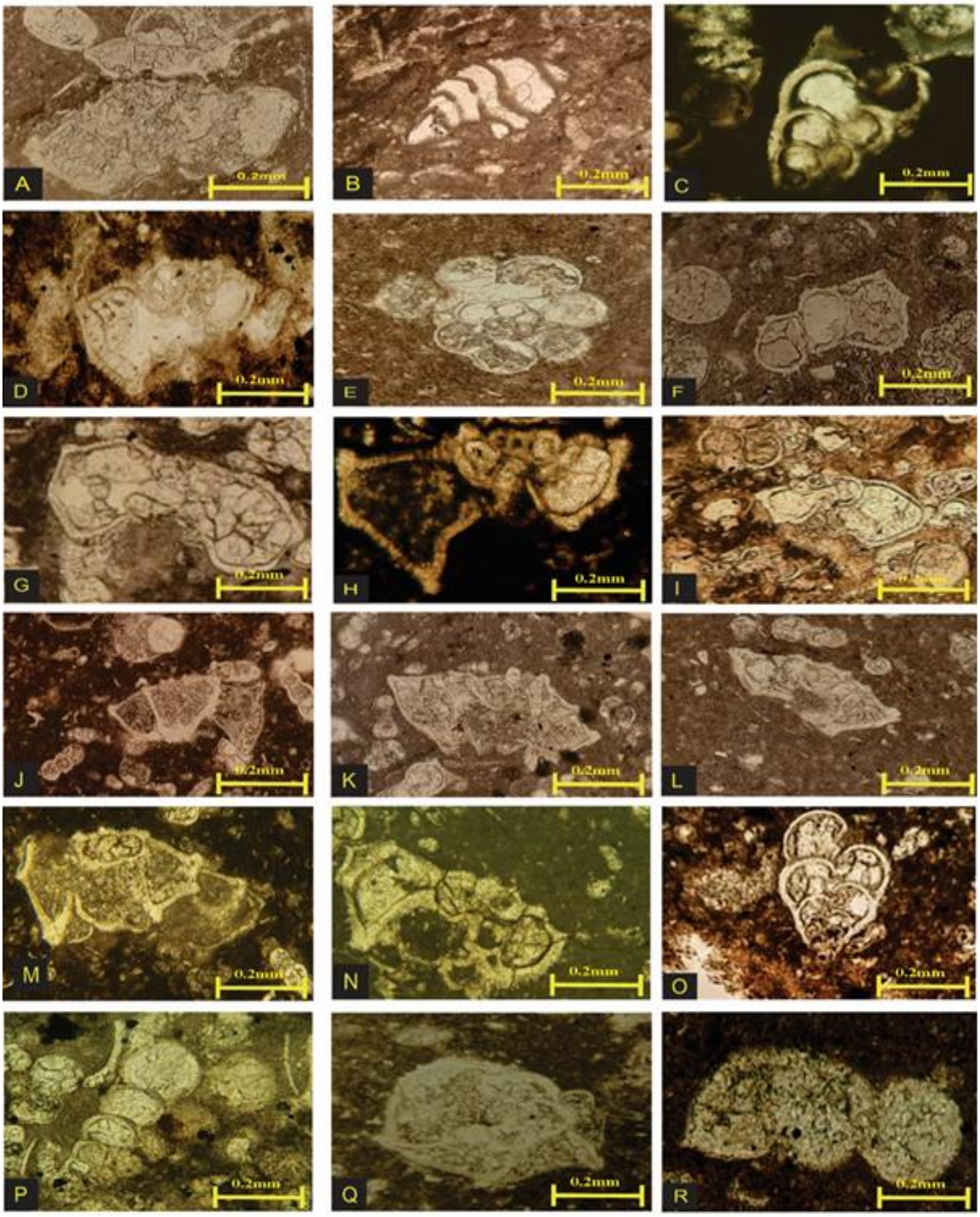


Plate 1. A- *Globotruncana aegyptiaca* (Nakkady),B- *Pseudotextularia elegans* (Rzehak),C -Heterohelix globulosa (Ehrenberg), D- *Globotruncanita stuartiformis* (Dalbiiez), E- *Hedbergella planispira* (Tappan), F- *Globotruncana bulloides* (Vogler), G- *Globotruncana dupeublei* (Caron), H- *Globotruncana falsecalcarata* (KerdanyandAbdelsalam), I- *Contusotruncana fornicate* (Plummer), J-*Globotruncanita conica* (White), K- *Globotruncana arca* (Cushman), L- *Globotruncanita stuarti* (De Lapparent), M- *Gansserina gansseri* (Bolli), N- *Abathomphalus mayaroensis* (Bolli), O- *Racemiguembelina fructicosa*(Egger), P-*Pseudogumbilina hariansin* (Nederbragt), Q- *Pseudoguembelina palpebra* (Bronnimann and Brown), R-*plummerita hantkeninoides* (Brannimann).

6. Discussion

The present study examines the biostratigraphy of the Late Campanian–Early Maastrichtian sediments in the northeastern sector of the Outer Arabian Platform, within the Low-Folded Zone. The analysis of planktonic foraminifera reveals that the boundaries of the Shiranish Formation are biostratigraphically defined: the lower boundary is marked by the first appearance of *Globotruncana aegyptiaca*, while the last occurrence of *Abathomphalus mayaroensis* indicates the upper boundary.

Based on the distribution of index planktonic foraminifera, the Shiranish Formation in this study has been subdivided into three principal biozones and four sub-biozones. The main biozones are as follows: 1- *Globotruncana aegyptiaca* Zone, 2- *Gansserina gansseri* Zone, 3- *Abathomphalus mayaroensis* Zone. The Abathomphalus mayaroensis Zone is subdivided into four subzones:1- *Racemiguembelina fructicosa* Partial Range Subzone. 2- *Pseudoguembelina hariaensis* Partial Range Subzone. 3- *Pseudoguembelina palpebra* Subzone. 4- *Plummerita hantkeninoides* Subzone.

These biostratigraphic divisions are consistent with previous studies. For example, Mousa and Shakir (2023) examined the Shiranish Formation in three selected wells in the Ajeel Oil Field, Central Iraq. They identified an identical zonal framework based on the occurrence of planktonic foraminifera. Their subdivision included the same three main zones and four subzones outlined above.

However, some variations in zonal classification have been noted in other studies (Bamerni et al., 2021). proposed an alternative biostratigraphic framework for the Shiranish Formation. According to their findings, the formation comprises the following zones:1- *Pseudoguembelina hariaensis* (CF3) Interval Zone. 2- *Pseudoguembelina palpebra* (CF2) Interval Zone. 3- *Plummerita hantkeninoides* (CF1) Total Range Zone

These differences may reflect regional stratigraphic variation, sampling resolution, or interpretive approaches.

According to Al-Wazan in 2013, four biostratigraphy zones were identified in the formation, some of which are the oldest: 1- *Gansserina gansseri* Interval Zone, 2- *Globotruncana aegyptiaca* Interval Zone, 3- *Globotruncanella havanensis* Partial Range Zone ,4- *Globotruncana calcarata* Total Range Zone (Al-Wazan, 2013).

7. Conclusions

In this study, 36 species of planktonic foraminifera were identified from the Late Campanian to the Early Maastrichtian. Three wells in the Ain Zala Oil Field were selected for study. The formation was divided into three main biozones and four sub-biozones. These zones are 1- *Globotruncana aegyptiaca*, which indicates the age of (late Campanian). 2- *Gansserina gansseri*, which is the age of (Early Maastrichtian). 3- *Abathomphalus mayaroensis*, which refers to the age of (late Maastrichtian). This zone is divided into four sub-zones, which are 1- *Racemiguembelina fructicosa partial range subzone*, which indicates the age of (Early Late Maastrichtian). 2- *Pseudoguembelina hariaensis partial range zone*, which refers to the age of (Middle Late Maastrichtian). 3- *Pseudoguembelina palpebra subzone*, which refers to the age of (Late Late Maastrichtian). 4- *Plummerita hantkeninoides subzone*, which refers to the age of (Latest Maastrichtian).

References

Abawi, T.S., Abdel-Kireem, M.R., Yousef, G.M., 1982. Planktonic foraminiferal stratigraphy of the Shiranish Formation, Sulaimaniah-Dokan region northeastern Iraq. Revista Espanola de Micro aleontologia, 14 (1), 153 -164.

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 Fur Geologie Und Palaontologie, Abhandlungen, 172(1), 121–139. https//doi 10.1127/njgpa/172/1997/121.

Abdel-Kireem, M.R., 1983. A study of the palaeoecology and bathymetry of the foraminiferal assemblages of the Shiranish formation (Upper Cretaceous), northeastern Iraq. Palaeogeography, Palaeoclimatology, Palaeoecology, 43 (1 2), 169−180.

Abdula, R.A., Balaky, S., Khailany, R., Miran, A., Muhammad, M., Muhamad, C., 2018. Sedimentology of the Shiranish Formation in the Mergasur area, Iraqi Kurdistan.

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. https://doi.org/10.1016/S0377-8398(02)00094-4 .

Ahmed, M.R., Al-Hadidi, A.S., 2019. Biostratigraphy Study of Planktonic Foraminifera in Shiranish Formation and its Contact with Aaliji Formation in Pulkana Well No. 7 North Iraq.

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-Banna, N.Y., 2010. Sequence stratigraphy of the Late Campanian–Early Maastrichtian Shiranish Formation, Jabal Sinjar, Northwestern Iraq. GeoArabia, 15(1),31-44. https://doi.org/10.2113/geoarabia150131 .

Al-Doori, M.A., 2010. Foraminifera and the Stratigraphy of Shiranish Formation in the Dohak Region, Northern Iraq. MSc thesis, College of Science, University of Mosul, Iraq.

Al-Juboury, F.N., 2002. Planktonic Foraminiferal Biostratigraphy and Depositional Environment of Shiranish Formation, in Sinjar area, NorthwestIraq. MSc thesis, University of Mosul, Iraq.

Al-Juboury, F.N., Al-Juboury, A.A., Alhazaa, S.H., 2016. Microfacies and depositional environment of Shiranish Formation in Kirkuk Oil fields north Iraq. Tikrit Journal of Pure Science, 21(7), 119–128. https://doi.org/10.25130/tjps.v21i7.1119.

Al-Mutiwty, A.T., 2020. Classified and Stratigraphic Study of the Planktonic Foraminifera of the Shiranish Formation in the Birah Magroon Fold in the Sulaymaniyah Region/ Northeastern Iraq. MSc thesis, College of Science, University of Mosul, Iraq.

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. https://doi.org/10.46717/igj.56.2F.11ms-2023-12-17 .

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(3), 17-40.

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 16 (1A) 152-176.

Al-Naqib, K.M., 1967. Geology of the Arabian Peninsula South Western Iraq, Geo. Survey-special issue Washington.

Al-Omari, F.S., Sabah, N., Omar, A., 2005. Biostratigraphy of Planktonic Foraminifera within Shiranish formation (Late Campanian-MiddleaMaastrichtian) in Butmah well No.15 northwest Iraq. Iraqi, National Journal of Earth Science, 5, 1, 32 -43.

AL-Omari, F.S., Sadiq, A., 1977. Geology of Northern Iraq: Mosul, Iraq, Mosul University Press, 198. (in Arabic).

Al-Shareefi, I.Y., Khalaf, S.K., Al-Eisa, M.A., 2014. Ostracode Biostratigraphy of Shiranish, Hartha and Mushorah Formations from Selected Boreholes Northwest and Central Iraq. Iraqi National Journal of Earth Sciences, 14(1), 19-38.

Al-Wazan A.M., 2013. Biostratigraphy of Shiranish Formation in (K-306) Well, Kirkuk Area, Northern Iraq. Iraqi National Journal of Earth Science, 13(1).

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

Arenillas, I., Molina, E., Arz, J.A., 2006. Planktonic foraminiferal biostratigraphy and correlation across the Cretaceous–Paleogene transition at the Tethyan and the Atlantic realms. Marine Micropaleontology, 59(3–4), 185–217. https://doi.org/10.1016/j.marmicro.2006.06.001.

Asgharian Rostami, M., Darvishzad, B., Ghaseminezhad, E., 2009. Planktonic foraminifera response to sudden global warming in Late Maastrichtian, a case study from Ziyarat-Kola, Central Alborz, Iran. Journal of Sciences, Islamic Republic of Iran, 20(3), 233–242.

Atroshi, R.K., 2007. Sedimentary of Shiransh Formation in Dohuk Area. Msc thesis, College of Science, University of Mosul, Iraq.

Bamerni, A.A., 2010. The Biostratigraphy of the Shiranish Formation in the Subsurface Section of the Khanki 1Well in the Dohuk Area-Northern Iraq. MSc thesis, College of Science, University of Mosul, Iraq.

Bayrakdar, M.M., 2011. Sedimentological and paleontological study of the Shiranish Formation in northern Iraq: Evidence of deep-marine basin environment, (Unpublished manuscript).

Bellen, R.C. Van., Dunnington, H.V., Wetzel, R., Morton, D.M., 1959. Lexique Stratigraphique International, Asia, Iraq. International Geological Congress Commission Stratigraphy, 3(10a), 1-333.

Bronnimann, P., 1952. Globigerinidae from the Upper Cretaceous (Cenomanian-Maastrichtian) of Trinidad. Bulletins of American Paleontology, 34, 5–71.

Bronnimann, P., Brown, N.K., 1953. Observations on some planktonic Heterohelicidae from the Upper Cretaceous of Cuba. Contributions from the Cushman Foundation for Foraminiferal Research, 4(4), 150–156.

Buday, T., 1980. The Regional Geology of Iraq. Stratigraphy and Paleogeography, Kassab, I.I., Jassim, S.Z., (eds), Dar Al-Kutib Publ. House, Mosul, Iraq.

Buday, T., Jassim, S.Z., 1987. The Regional Geology of Iraq, 2, Tectonism,Magmatism and Metamorphism, Geology Survey and Mining Investigation, Baghdad.

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

Chacon, B., Martin-Chivelet, J., 2005. Major palaeoenvironmental changes in the Campanian to Palaeocene sequence of Caravaca (Subbetic zone, Spain). Journal of Iberian Geology, 31(2), 299-310. https://doi.org/10.5575/geosoc.102.1039 .

Changkham, P., Jafar, S.A., 1998. Late Cretaceous (Santonian–Maastrichtian) integrated coccolith-globotruncanid biostratigraphy of pelagic limestones from the accretionary prism of Manipur, northeastern India. Micropaleontology, 44(1), 69–83.

Darvishzad, B., Ghasemi-Nejad, E., Ghourchaei, S., Keller, G., 2007. Planktonic foraminiferal biostratigraphy and faunal turnover across the Cretaceous–Tertiary boundary in southwestern Iran. Journal of Sciences, Islamic Republic of Iran, 18(2), 139–149.

Darvishzadeh, B., Abdolalipour, S., 2009. Campanian and Maastrichtian Biostratigraphy and Paleoenvironment in Jorband Section, north of Iran. Journal of Sciences, 20, 23-39.

Dunnington, H.V., 1958. Generation, migration, accumulation and dissipation of oil in northern Iraq. Weeks, L.G., Ed., Habitite of Oil, Symposium, American Association of Petroleum Geologists, 1194-1251. https://doi.org/10.1306/SV18350C49.

Hadad, S.N., Nassery, O.A., 2005. Biostratigraphy of Planktonic Foraminifera within Shiranish formation (Late Campanian-Middle Maastrichtian) in Butmah well No. 15 northwest Iraq. Iraqi National Journal of Earth Science, 5(1), 32-0.

Hart, E., Hay, J.T.C., 1974. Structure of Ain Zalah field, northern Iraq. American Association of Petroleum Geologists Bulletin, 58(6), 973-981.

Hassan, Y., AL-Hadidi, S.A.H., 2022. Planktonic Foraminiferal Biostratigraphy of Shiranish formation in Sara anticline in Dokan area, Northeastern Iraq. Iraqi National Journal of Earth Science, 22(1), 1-0.

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., 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. GeoArabia, 19(1), 161–180. https://doi.org/10.2113/geoarabia1901161.

Jassim, S.Z., Goff, J., 2006. Geology of Iraq, Dolin, Prague and Moravian Museum, Brno.

Keller, G., 2004. Low-diversity, Late Maastrichtian and Early Danian planktic foraminiferal assemblages of the Eastern Tethys. Journal of Foraminiferal Research, 34(1), 49–73. https://doi.org/10.2113/0340049.

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. https://doi.org/10.1016/0031-0182(95)00009-7 .

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. https://doi.org/10.1016/S0377-8398(97)00027-3.

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

Liangquan, L., Keller, G., Stinnesbeck, W., 1999. The Late Campanian and Maastrichtian in northwestern Tunisia: Palaeoenvironment inferences from lithology, macrofauna and benthic foraminifera. Cretaceous Research, 20: 231-252.

Luning, S., Kuss, J., Bachmann, M., Marzouk, A.M., Morsi, A.M., 1998. Sedimentary response to basin inversion: Mid Cretaceous-Early Tertiary pre-to syn-deformational deposition at the Arief El Naqa anticline (Sinai, Egypt). Institut fur palaontologieder Universitat Erlangen-Nurnberg. Facies 38, 103-136.

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. The Journal of Foraminiferal Research, 33(3), 179–191. https://doi.org/10.2113/33.3.179.

Moghaddam, H.V., 2002. Biostratigraphic study of the Ilam and Gurpi Formation based on planktonic foraminifera in SE of Shiraz, Iran. Journal of Sciences, Islamic Republic of Iran, 13(4), 339 –356.

Mohammed, I.Q., Farouk, S., Mousa, A.K., Lawa, F.A., 2022. Lithofacies types, mineralogical assemblages and depositional model of the Maastrichtian–Danian successions in the Western Desert of Iraq and eastern Jordan. Journal of African Earth Sciences, 186 ,104397, https://doi.org/10.1016/j.jafrearsci.2021.104397.

Mousa, A.K., Shakir, L.S., 2023. Biostratigraphy of Hartha formation from selected wells in Nasiriyah oil field, southern Iraq. Iraqi Journal of Science, 64(10), 5134-5150. DOI:10.24996/ijs.2023.64.10.21.

Mousa, A.K., Shakir, L.S., 2023. Biostratigraphy of Shiranish formation from selected wells, central of Iraq. Iraqi Geological Journal, 56(2F), 169-185. https://doi.org/10.46717/igj.56.2F.11ms-2023-12-17 .

Nederbragt, A.J., 1991. Late Cretaceous biostratigraphy and development of Heterohelicidae (planktic foraminifera). Micro- paleontology, 37, 329–372. https://doi.org/10.2307/1485910.

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. https://doi.org/10.1007/s12517-020-05812-x.

Pardo, A, Ortiz, N., Keller, G., 1996. Latest Maastrichtian and Cretaceous-Tertiary boundary foraminiferal turnover and environmental changes at Agost, Spain. In Cretaceous-Tertiary Mass Extinctions: Biotic and Environmental Changes.

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. https://doi.org/10.4154/GC.2014.08 .

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. https://doi.org/10.1016/j.gloplacha.2021.103595.

Premoli, S., Sliter, W.V., 1999. Cretaceous paleoceanography: evidence from planktonic foraminiferal evolution. Special Papers-Geological Society of America, 301–328. https://doi.org/10.1130/0-8137-2332-9.301 .

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.

Raoof, M.M., 2011. The stratigraphy of the Shiranish formation and the nature of its contact with the Aliji formation of the Qayyarah/54 and Balkanah/7 wells, selected from northern Iraq. MSc thesis, College of Science, Tikrit University, Iraq.

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.

Sahib, G.M., Al-Dulaimi, S.I., 2022. Biostratigraphy of the Late Cretaceous-Early Paleocene succession in selected wells, Jambur Oil field, Kirkuk, Northern Iraq. Iraqi Geological Journal, 55(2C), 223-240. https://doi.org/10.46717/igj.55.2C.17ms-2022-08-30 .

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

Sharbazheri, K., 2008. Biostratigraphy and Paleoecology of the Cretaceous/Tertiary Boundary in the Sulaimani Region, Kurdistan, NE-Iraq. PhD thesis, University of Sulaimani, Iraq.

Sharbazheri, K.M., 2007. Aging of unconformity within Tanjero Formation in Chwarta Area, northeast of Iraq (Kurdistan Region). Iraqi Journal of Earth Science, 7(1), 37–54. https://doi.org/10.33899/earth.2007.39402.

Sharbazheri, K.M.I., 2010. Planktonic Foraminiferal biostratigraphy of the reddish to pale Brown transitional succession (Upper Cretaceous) in Smaquli area, Northeast Iraq (Kurdistan region). Iraqi Bulletin of Geology and Mining, 6(1), 1–20.

Sissakian, V.K., 2015. Geological Map of Iraq, Scale 1 : 1000 000, 4th Edition, 2012, 8–17.

Sliter, W.V., 1989. Biostratigraphic zonation for Cretaceous planktonic foraminifers examined in thin section. Journal of Foraminiferal Research, 19(1), 1-19.

Walid, A., 2007. Stratigraphic and structural study of the Cretaceous section in Ain Zalah oil field, Northern Iraq. MSc thesis, University of Mosul, Iraq.