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Sedimentological Study and Age Determination of the Shiranish Formation in Perat Anticline, Northern Iraq

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ABSTRACT

A sedimentological and nannofossil biostratigraphical study of the Shiranish Formation focuses on an exposed section of the Perat anticline's northern limb. The formation consists of limestone, marl, and marly limestone. It produces a diverse range of calcareous nannofossils, planktic foraminiferal fauna, and some bioclasts. The calcareous nannofossil's stratigraphic distribution allows for the identification of three distinct biozones. These are Uniplanarius trifidus Interval zone (cc22), Tranolithus phacelosus Interval zone (Part) (cc23), and Reinhardites levis Interval zone (cc24), which indicate that the age of the studied Shiranish Formation in Perat anticline is estimated to span from Late Campanian to Early Maastrichtian. On the other hand, the studied section is composed of Globular Planktic Foraminiferal lime wackestone microfacies (Sh1), Keeled Planktic Foraminiferal lime wackestone microfacies (Sh2), Bioclastic lime wackestone microfacies (Sh3), Argillaceous Planktic Foraminiferal lime packstone microfacies (Sh4), and Marl lithofacies (Sh5). The formation's depositional habitats extend from the middle shelf to the upper bathyal based on the distinctive characteristics of these facies.

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دراسة رسوبية وتحديد عمر تكوين شرانش في طية بيرات المحدبة، شمالي العراق

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الملخص

اجريت دراسة رسوبية وطباقية حياتية لمقطع سطحي من تكوين شرانش الذي يقع ضمن الطرف الشمالي من طية بيرات المحدبة. تتألف صخارية التكوين في منطقة الدراسة من طبقات الحجر الجيري والحجر الجيري المارلي وصخور المارل، والتي امتازت بمحتواها الجيد من متحجرات النانو الكلسية وحشود الفورامنيفرا الطاقية مع القليل من حطام الاصداف. وقد افرزت دراسة الطباقية الحياتية لمتحجرات النانو تشخيص ثلاثة انطقة حياتية وهي: *Uniplanarius trifidus* Interval zone (cc22), *Tranolithus phacelosus* Interval zone (Part) (cc23), *Reinhardites levis* Interval zone (cc24). ومن خلال مقارنة هذه الانطقة مع الانطقة العالمية والمسجلة في مناطق متفرقة، تم تحديد عمر التكوين بالكامباني المتأخر–الماسترختي المبكر. من جهة أخرى فقد قسمت صخور التكوين الى خمسة سحنات رسوبية وهي: سحنة الحجر الجيري الواكي الحاملة لمتحجرات الفورامنيفرا الطافية ذات الحجرات الكروية (Sh1) وسحنة الحجر الجيري الواكي الحاملة لمتحجرات الفورامنيفرا الطاقية ذات الجؤجؤ (Sh2) وسحنة الحجر الجيري الواكي الحاملة لحطام الاحياء (Sh3) وسحنة الحجر الجيري–الطيني الواكي الحاملة لمتحجرات الفورامنيفرا الطاقية (Sh4) والسحنة الصخارية للمارل (Sh5) . هذه السحنات قد عكست صفات ومحتويات البيئة الترسيبية للتكوين في منطقة الدراسة والتي امتدت من الرصيف الأوسط – الباثيال الأعلى.

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Introduction

Around the village of Shiranish Islam, which is located 17 kilometers northeast of Zakho City, (Henson 1940; in Bellen et al., 1959) first described the Shiranish Formation. Within the type section of the formation, there are two units: the upper unit (99 m) is composed of blue marl, while the bottom one (128 m) is thinly bedded with blue limestone. However, Al-Qayim et al. (1986) separated the type section into three parts, where the marly- and shaly-limestone make up the lower part (65 m), the sandstone and limestone make up the middle part (20 m), and the bluish marly shale makes up the upper part (100 m). It is reported that the formation environment is located far from the shore in a deep, open ocean environment. Al-Badrani (2001) examined the Ammonites of the lower Shiranish Formation in the Sinjar area and concluded that the depositional environment of the formation represents the upper continental slope. According to the examination of microfacies, Al-Atroshi (2007) deduced that the upper-middle bathyal and outer shelf environments are the depositional settings of the Shiranish Formation in the Duhok region. Furthermore, the age of the formation in the same area (Duhok) was determined to be Late Campanian-Maastrichtian (Al-Mutwali and Al-Juboury, 2005; Bamarni, 2010) through their studies of the foraminifera and biostratigraphy of the formation. Alrashedi (2013) used the study of planktic foraminifera to examine the biostratigraphy of the Shiranish Formation on the southern limb of the Perat anticline within the Bekhma area. He concluded

that the formation extends from the Late Campanian–Early Late Maastrichtian period. Finally, the depositional habitat of the Shiranish Formation, which is middle Campanian in age, ranges from the outer shelf to the upper bathyal according to research done by Al-Dulaimi et al. (2023) on the litho- and biostratigraphy of the Shiranish Formation in the Diana area.

Given the lack of research on the studied formation at the northern limb of Perat anticline, this study goals to identify the fossil species of calcareous nannofossil, to determine their biostratigraphic zones for age determination, and to conclude the paleoenvironmental context based on facies analysis.

Studied Section

Location: It is located near the Bekhma Dam tunnel on the northern limb of the Perat anticline to the southwest of the residential complex (Fig. 1). Within the Unstable Shelf's High Folded Zone, the section's midpoint is located at latitude (36° 42′ 00″) and longitude (44° 17′ 00″).

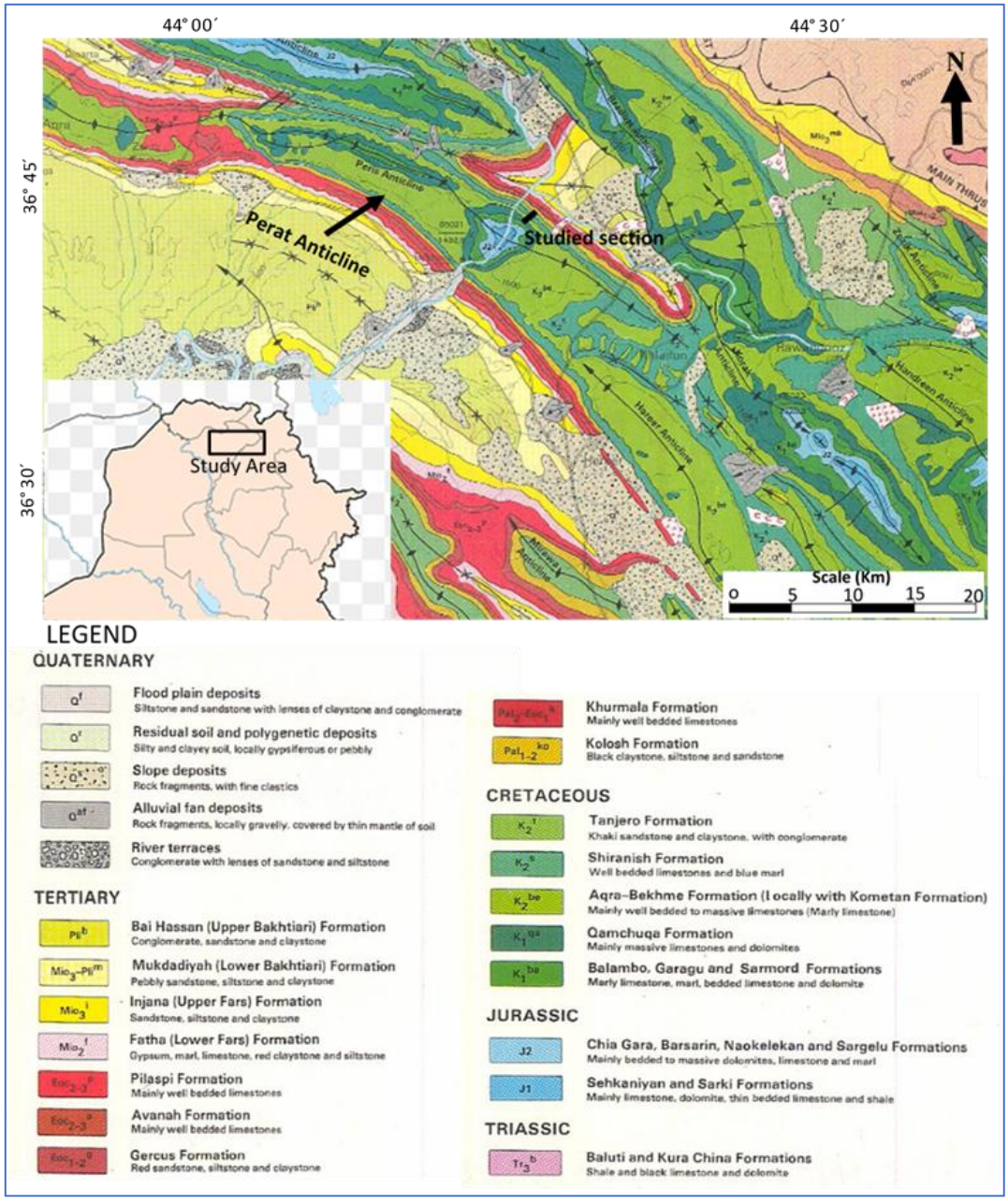

Fig. 1. Geological map of the studied area (after Sissakian et al., 1997).

Lithology: The studied section's thickness is approximately 154 m (Fig. 2). The lower contact of Shiranish Formation with Bekhma Formation is not clear due to its coverage by recent sediments. Gray marly limestone and pale gray limestone (30-150 cm thick) are intercalated by thin beds of pale green marl, which represent the bottom portion of the formation (Fig. 3), followed by sequences of pale green marl that are roughly 20 m thick. The middle portion is made up of a series of beds that are 40 cm to 2 m thick of pale grey argillaceous limestone, 30 cm to 3 m thick of greenish grey marly limestone, and 30 cm to 5 m thick of greenish marl (Fig. 4). Whereas the upper portion is distinguished by a predominance of greenish-grey marl beds mixed with a very small number of limestone beds, each is not thicker than 10 cm, and on its top, there are thick beds of light grey limestone (Fig. 5). The upper boundary is comfortable with the Tanjero Formation.

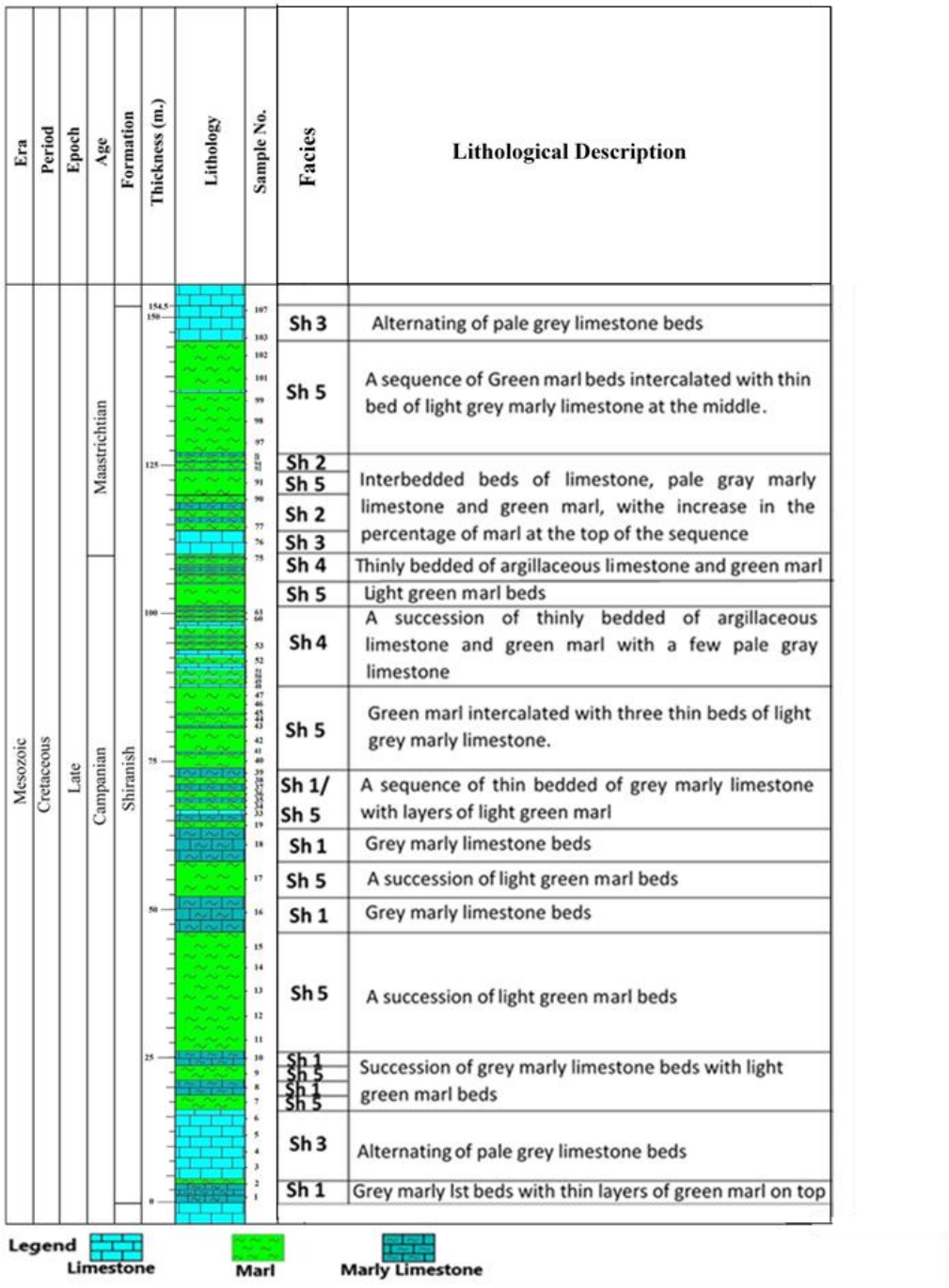

Fig. 2. Lithological column and facies types in the studied section.

Fig. 3. Lower part of Shiranish Formation in the study section.

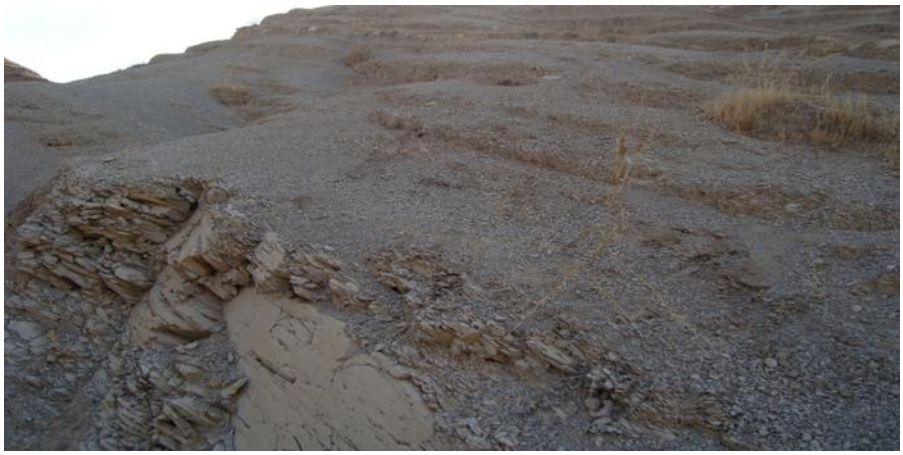

Fig. 4. Middle part of Shiranish Formation in the study section.

Fig. 5. Uppermost part of Shiranish Formation in the study section

Materials and Methods

Based on changes in lithology between 50 cm and 4 m intervals, 107 samples were collected from the study area. An analysis is conducted on approximately fifty thin sections accomplished in the Department of Geology workshop, Mosul University, for petrographical description and facies analysis, which forms the basis of the current investigation. In addition, numerous samples are selected in order to examine the calcareous nannofossils and ascertain the age of formation. Armstrong and Brasire's (2005) techniques, as well as the transmitted light microscope (Italy, POL353-B Optika), are used for this purpose. The atlas map of Young and Bown (1997) is utilized for comparison with the results.

Facies Analysis

Sedimentological hints are utilized to ascertain the depositional environment for each of the five facies that make up the Shiranish Formation, which are identified as Sh1 through Sh5. This facies are as follows:

1- Globular Planktic Foraminiferal lime wackestone microfacies (Sh1)

The allochems make up roughly 40% of the facies' overall contents, and they are extensively distributed throughout the lower and middle portions. With a minor number of bivalvia and bioclasts, the majority is composed of globular foraminifera (Fig. 6A) such as *Heterohelix* and *Pseudotextularia*, with minimal keeled planktic foraminifera genera. The distribution of these materials is in a fine micrite ground. This facies are impacted at some levels by the dissolution process, which dissolved some fossils, and some are to be filled with calcite crystals in the form of sparse cement inside fossil skeletons. As a result, the overall evidence for this microfacies points to its deposition within middle-outer shelf settings (Leicke, 1987).

2- Keeled Planktic Foraminiferal lime wackestone microfacies (Sh2)

It is well documented in the formation's upper parts, with fossils making up roughly 30–40% of the facies' overall composition. Large and well-preserved keeled foraminifera make up the majority of this facies (*Globotruncana* and *Globotruncanita*), with a small number of globular forms (Fig. 6B). Moreover, a very few benthic foraminifera and bioclastics with some irregular quartz crystals (chalcedony) are seen. Occasionally, certain diagenetic processes affect this facies, such as recrystallization into microspar and cementation in the form of spary calcite crystals inside the fossil shells. The sedimentological and biological evidences of this microfacies indicate that it was deposited in the upper bathyal zones (Leicke, 1987; Koutsoukos and Hart, 1990).

3- Bioclastic lime wackestone microfacies (Sh3)

Hard limestone beds with a pale grey color make up this facies, which are found in all the formation's parts (lower, middle, and upper). Although a few bivalve shells and planktic foraminifera are present, the shell debris makes up the majority of this facies' composition (up to 20–30% of the total) (Fig. 6C). This facies are affected by some diagenetic processes, especially neomorphism resulting from recrystallization of micrite, and the presence of spary cement in a scattered manner within the micrite, in addition to documenting the effect of the dissolution process on some shells. According to Flügel (2004), this microfacies was deposited in the uppermost regions of the outer shelf.

4- Argillaceous Planktic Foraminiferal lime packstone microfacies (Sh4)

This facies consists of limestone beds with a tiny quantity of clay in the micritic matrix, and it is located in the middle and upper parts of the formation, primarily composed of globular planktic foraminifera, which make up roughly 50% of the total components (Fig. 6D). There are also some rock fragments and a tiny amount of shell debris in addition to iron oxides in a fair percentage. The existence of fractures and vugs porosity in this facies indicates that it is impacted by the dissolution process to some extent (Al-Fandi et al., 2023). The sedimentary and skeletal criteria of this microfacies suggest the middle shelf environment (Gibson, 1989; Flügel, 2004).

5- Marl lithofacies (Sh5)

The thickness of this facies ranges from 1-20 m, and is evidently the dominant property among the formation sequences as reported throughout the studied section. This facies are composed of light green friable marl sequences that are occasionally intercalated with thin beds of pale grey marly limestone. These beds are distinguished by a high percentage of planktic foraminifera up to 40%. At certain levels, the dominance of keeled-shaped planktic foraminifera

is observed, while the prevalence of globular planktic foraminifera is predominant at other levels. This facies were deposited within a sedimentary range that extends from upper bathyal to outer shelf (Gibson, 1989; Flügel, 2004).

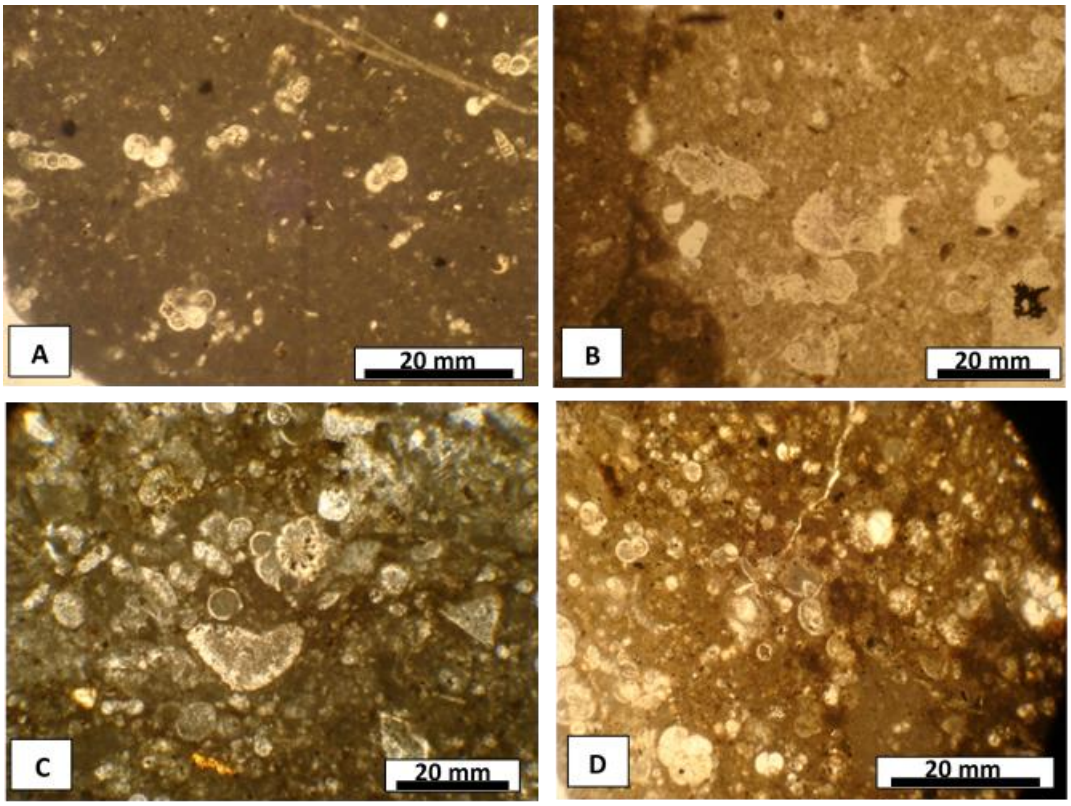

Fig. 6. Studied facies, A-Sh1, B-Sh2, C-Sh3, and D-Sh4.

Nannobiostratigraphy

In this investigation, twenty-four species from sixteen genera and ten families are identified. They are: *Ahmuellerella alboradiata, Reinhardtitus levis, Tranolithus phacelosus, Zeugrhabdotus embergeri, Eiffellithus collis, Eiffellithus eximius, Cribrosphaerella ehrenbergii, Prediscosphaera columnata, Retecapsa crenulata, Retecapsa schizbrachiata, Retecapsa ficula, Watznaueria barnesae, Watznauria coronate, Watznauria biporta, Broinsonia parca, Calculites obscurus, Lithraphidites quadratus, Microrhadulus decuratus, Micula decussate, Micula staurophora, Uniplanarius trifidus, Ceratolithoides aculeus, Ceratolithoides prominens and Ceratolithoides sagittatus*. (Figs. 7 and 8).

The detected calcareous nannofossil taxa in the examined section (Fig. 9) can be classified into three biozones based on their correlation with other places of the world (Sissingh, 1977) (Fig. 10); these zones are;

1- *Uniplanarius trifidus* Interval Biozone (cc22) (part)

Definition: The time interval is between the first occurrence of *Uniplanarius trifidus* (Vekshina, 1959) and the last recorded *Eiffelithius eximius* Stover, 1966.

Thickness: 46 m.

Discussion and Boundaries: The bottom boundary of this biozone, which is not exposed in the area under study, is marked by the first appearance of *Quadrun trifidum* Vekshina (1959), while the last occurrence of *Eiffelithius eximius* Stover, 1966, marks the upper boundary. The last occurrence of *Eiffelithius eximius* Stover, 1966, coincided with the first occurrence of *Reinhardites anthophorus* (Deflandre, 1959). This zone is similar to

the *Quadrun trifidum* biozone described by Bukry and Bramlette (1970), which was broadened by Sissingh (1977) to include the Late Campanian period (Ogg et al. 2016).

2- *Tranolithus phacelosus* Interval Biozone (cc23) (Part)

Definition: The time interval is between the last recorded instance of *Eiffelithius eximius* Stover, 1966, and the last recorded instance of *Tranolithus phacelosus* Stover (1966).

Thickness: 64 m.

Discussion and Boundaries: The lower contact is marked by the last recorded *Eiffelithius eximius* Stover, 1966; the upper contact was indicated by the last documented data of *Tranolithus phacelosus* Stover (1966). This zone exhibited a correlation with Sissingh's (1977) *Tranolithus phacelosus* zone, which was dated as the Latest Campanian to Early Maastrichtian period (Ogg et al. 2016).

3- *Reinhardites levis* Interval Biozone (cc24) (part)

Definition: an interval is between the last recorded instance of *Tranolithus phacelosus* Stover (1966) and the last recorded instance of *Renhardites levis* (Sissingh, 1977).

Thickness: 44.5 m.

Discussion and Boundaries: the lower boundary is indicated by the last recorded instance of *Tranolithus phacelosus* Stover (1966); the upper limit is not included in the section under study. This zone is similar to *Renhardites levis* (cc24) by Perch-Nielsen (1979) and Sissingh (1977), *Arkhangeskilla cymbiformis* by Doeven (1983), and *Lithraphidites praequardatus* by Roth (1978), aged Early Maastrichtian. Therefore, the age of this zone is Early Maastrichtian (Ogg et al. 2016).

Depositional Environment

The evidence of the five sedimentary facies previously described in the facies analysis section will be the main emphasis of the discussion of the depositional environment of the studied formation, as follows:

In general, the high and diverse proportions of planktic foraminifera in the current study samples indicate an outer shelf environment (Berggren and Miller, 1989; Gibson, 1989). Additionally, the greater frequency of globular planktic foraminifera compared to keeled planktic foraminifera (Sh1) implies the existence of this facies on the continental shelf and in warm waters (Leicke, 1987). An environment near the coast is also suggested by the rise in *Heterohelix* individuals in some parts of this facies (Leicke, 1987). As a result, the overall evidences for facies (Sh1) point to its deposition within middle-outer shelf settings. Conversely, in the other parts of the studied section, high and varied proportions of keeled planktic foraminifera (Sh2) are exhibited, indicating deep marine settings distant from the shore, particularly in the upper bathyal zones (Leicke, 1987; Koutsoukos and Hart, 1990; Omana, 2006). On the other hand, the dominance of shell debris in microfacies (Sh3) suggests that this facies were deposited on the uppermost regions of the outer shelf (Wilson, 1975; Scholle et al., 1983; Flügel, 2004). However, the existence of argillaceous limestone facies with planktic foraminifera (Sh4) suggests the deposition in the middle shelf environment (Gibson, 1989; Flügel, 1982 and 2004). The distribution of the marl facies (Sh5) with its two types of planktic foraminifera, which are globular in some areas and keeled in others, suggests that this facies was deposited within a sedimentary range that reaches the upper bathyal from the outer shelf. (Berggren and Miller, 1989; Gibson, 1989; Samir, 2002).

As previously aforementioned, the Shiranish Formation's depositional environment on the northern limb of the Perat Anticline stretches from the middle shelf to the upper bathyal.

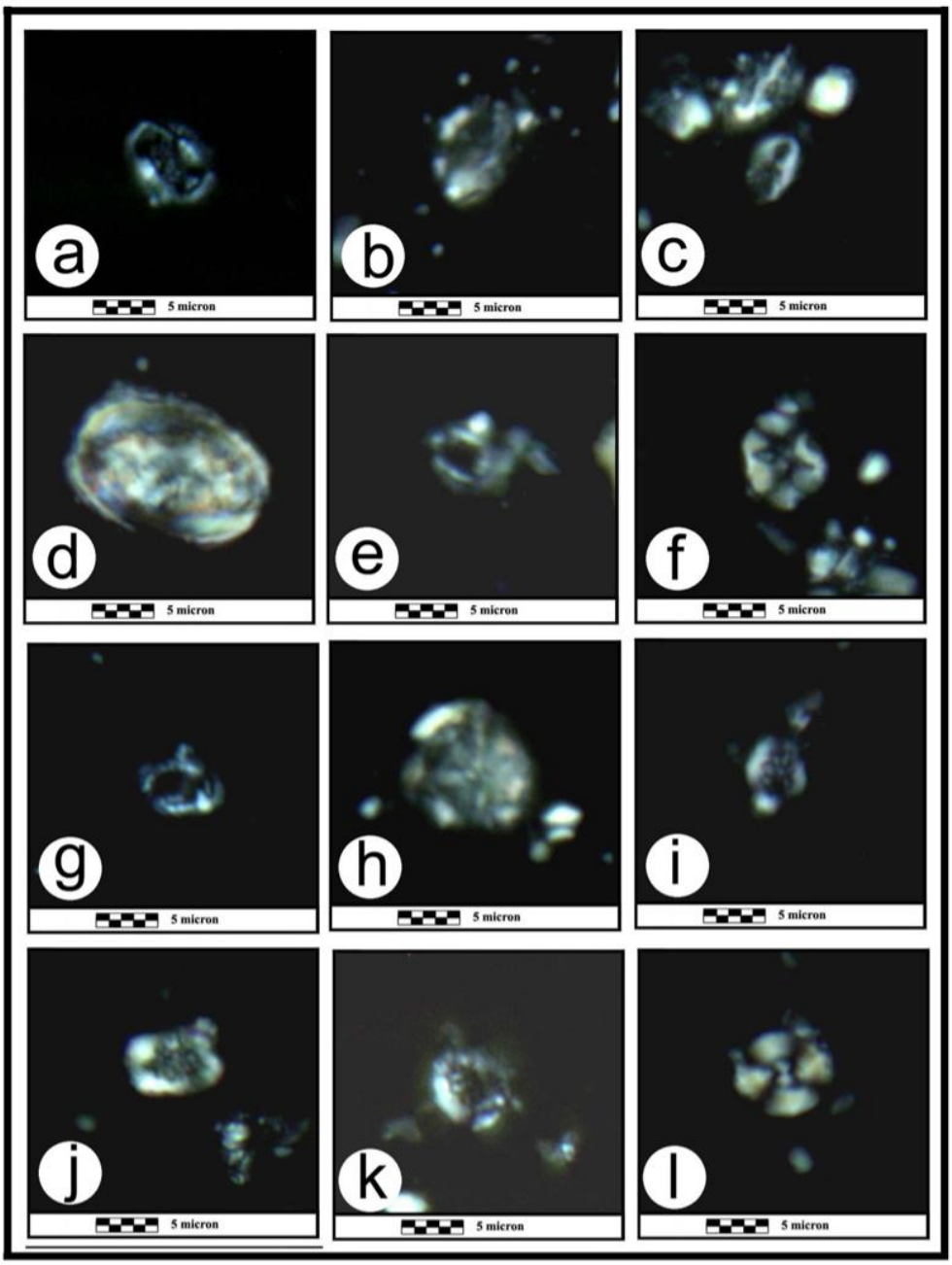

Fig. 7. Distinguished calcareous nannofossils from the studied Formation. (a) Ahmuellerella alboradiata; (b) Reinhardtitus levis; (c) Tranolithus phacelosus; (d) Zeugrhabdotus embergeri; (e) Eiffellithus collis; (f) Eiffellithus eximius; (g) Cribrosphaerella ehrenbergii; (h) Prediscosphaera columnata; (i) Retecapsa crenulata; (j) Retecapsa ficula; (k) Retecapsa schizbrachiata; (l) Watznaueria barnesae.

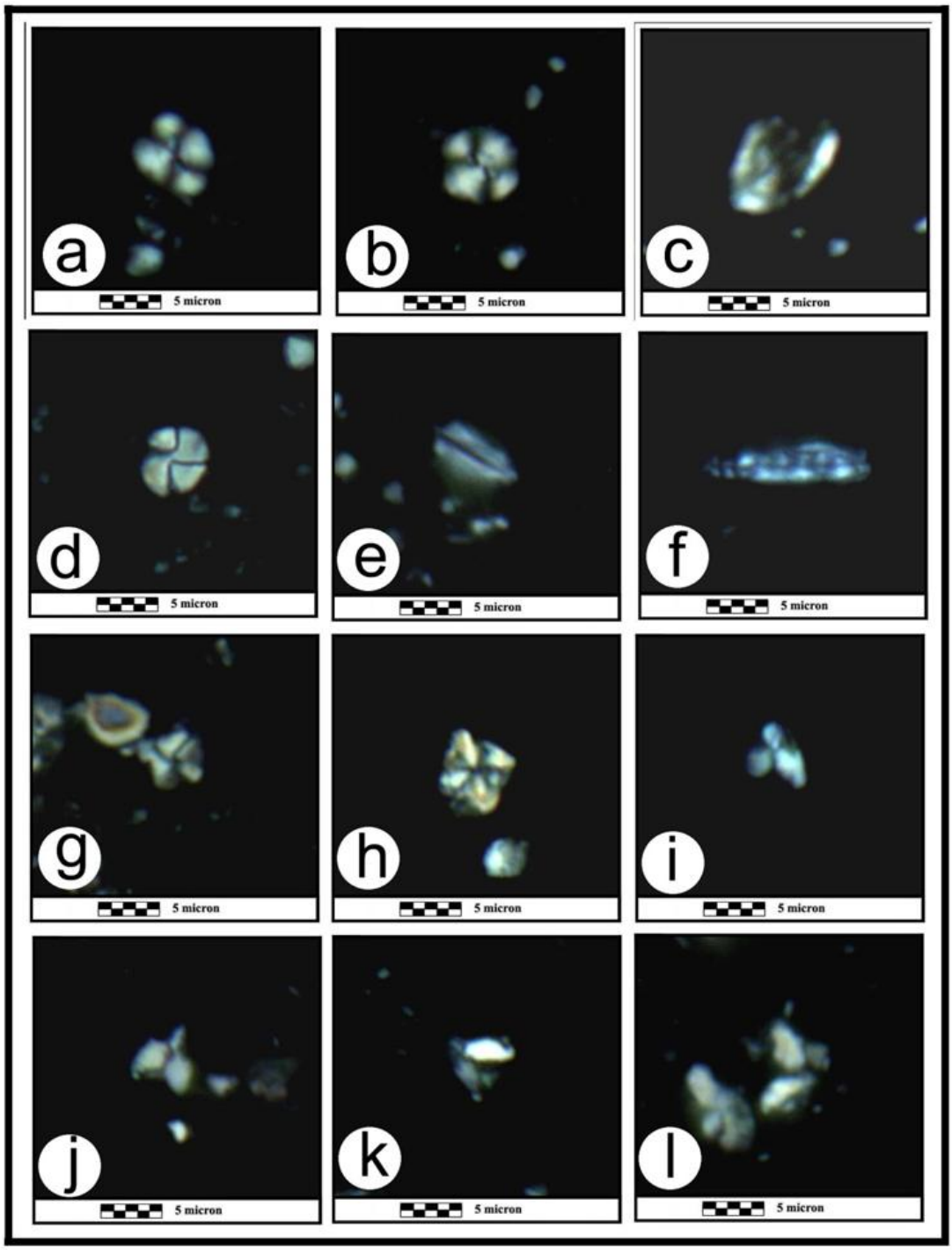

Fig. 8. Significant calcareous nannofossil taxa from the studied Formation. (a) Watznauria biporta; (b) Watznauria coronate; (c) Broinsonia parca; (d) Calculites obscurus; (e) Lithraphidites praequadratus; (f) Microrhadulus decoratus; (g) Micula decussate; (h) Micula staurophora; (i) Uniplanarius trifidus; (j) Ceratolithoides aculeus; (k) Ceratolithoides prominens; (l) Ceratolithoides sagittatus.

Fig. 9. Distribution chart of calcareous nannofossils for the study section.

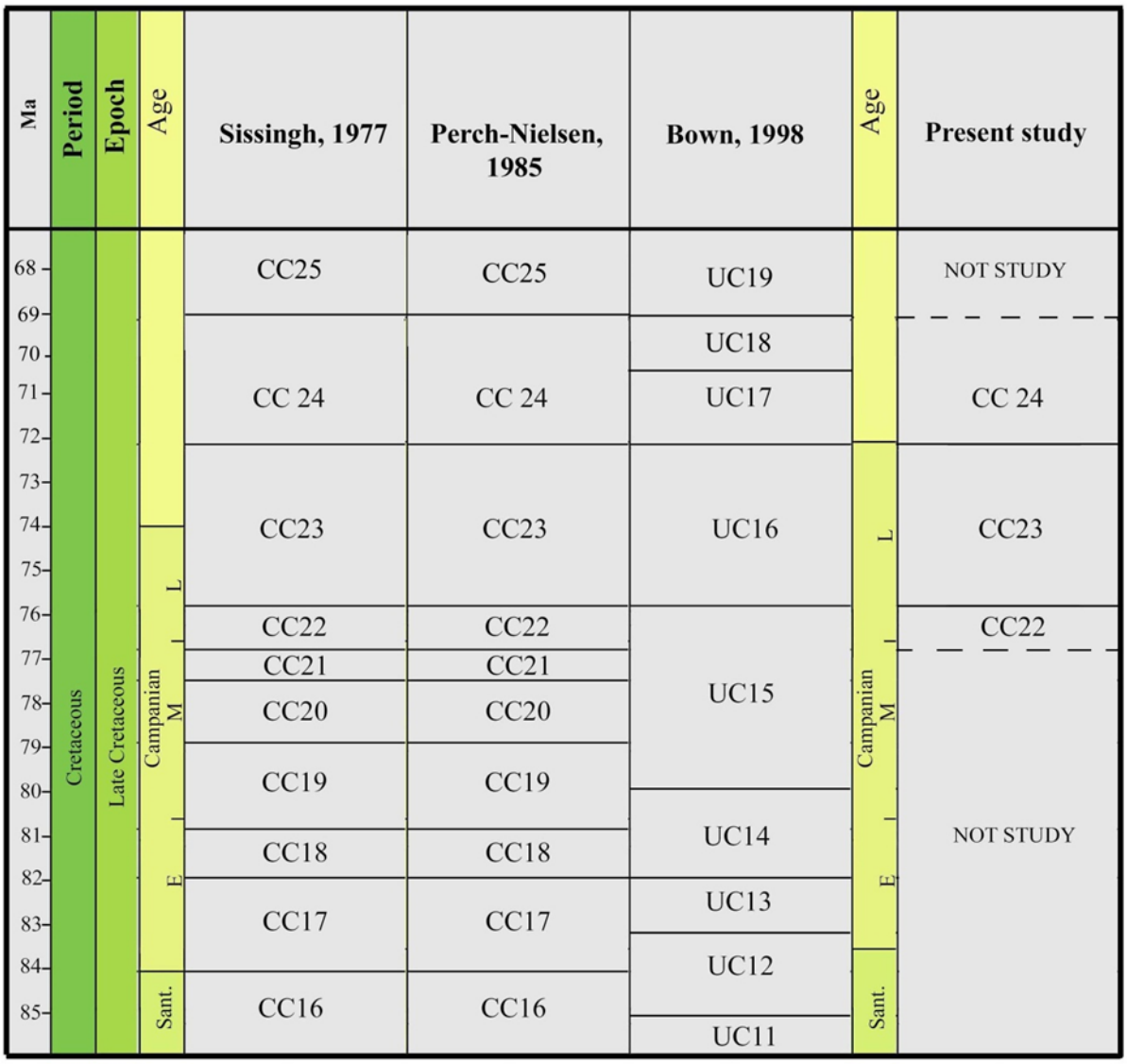

Fig. 10. Biozones of calcareous nannofossils and their age correlation chart (Ogg et al., 2016).

Conclusions

The Shiranish Formation is classified into three biozones according to the distribution of the calcareous nannofossil assemblage. These biozones are: the *Uniplanarius trifidus* Interval Biozone (cc22), *Tranolithus phacelosus* Interval Biozone (Part) (cc23), and *Reinhardites levis* Interval Biozone (cc24). They are dated from Late Campanian to Early Maastrichtian. On the other hand, the study of sedimentary facies has revealed the diagnosis of five microfacies, which are: Globular Planktic Foraminiferal lime wackestone microfacies (Sh1), Keeled Planktic Foraminiferal lime wackestone microfacies (Sh2), Bioclastic lime wackestone microfacies (Sh3), Argillaceous Planktic Foraminiferal lime packstone microfacies (Sh4), and Marl lithofacies (Sh5). The distinctive feature of the microfacies under study indicates that the Shiranish Formation, which is located in the northern limb of the Perat anticline, was deposited on the middle shelf to the upper bathyal.

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