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Lithostratigraphy and Biostratigraphy of the Shiranish Formation (Late Campanian- Maastrichtian) in Diana area, Northern Iraq

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Abstract

The lithostratigraphic and biostratigraphic studies of the Shiranish Formation in the Diana area, Erbil, Northern Iraq, were conducted to distinguish the main lithostratigraphic units, depositional environment and the formation age. The Shiranish Formation in the study area can be divided into three rock units. The lower and upper units consist of marly limestone, marl and limestone deposited in the outer shelf environment, while the middle unit is dominated by laminated calcareous shale and marl deposited in the upper bathyal environment. Calcareous nannofossils showed the presence of about 20 species/genera in the studied Shiranish Formation. Three biozones are identified; *Misceomarginatus pleniporus* biozone; *Ceratolithoides aculeus* biozone, and *Uniplanarius sissinghii* biozone. From a regional perspective, these biozones were compared with other nannobiozones, leading to the conclusion that the studied section is of Middle Campanian age.

Keywords: Calcareous nannofossils; Shiranish Formation; Lithostratigraphy, Nannobiostratigraphy; Diana area.

الطباقية الصخرية والحياتية لتكوين شرانش (الكامبانين المتأخر–الماسترختي) في منطقة ديانا شمال العراق

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الخلاصه

تم دراسة الطباقية الصخرية والطباقية الحياتية لتكوين شيرانش في منطقة ديانا التابعة لمحافظة اربيل شمالي العراق وذلك بهدف تمميز الوحدات الصخرية وبيئتها الترسيبية وتحديد عمر التكوين. تم تقسيم التكوين في منطقة الدراسة الى ثلاث وحدات صخرية. الوحدتين السفلى والعليا مؤلفة من حجر جيري مارلي مع الحجر الجيري او المارل والمترسبة في بيئة الرصيف الخارجي، اما الوحدة الوسطى والمؤلفة من السجيل الجيري المترقق والمارل والمترسبة في بيئة الباثيل العلوي. درست متحجرات النانو

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الكلسية من تكوين شرانش، وشخص عشرين نوع\جنس. تم تحديد ثلاثة انطقة حياتية بالاعتماد على المجاميع المدروسة، وهذه الانطقة هي
Misceomarginatus pleniporus biozone; *Ceratolithoides aculeus* biozone; *Uniplanarius sissinghii* biozone.
قورنت هذه الانطقة الحياتية لمتحجرات النانو الكلسية بمثيلاتها المحلية والعالمية قادت الى استنتاج عمر الكامبانيان الاوسط لهذا المقطع .

Introduction

The Shiranish Formation is regarded as one of the common and widely spread late Cretaceous successions in northern Iraq. The formation has economic importance and is considered one of the most important oil reservoirs in several Iraq oilfields due to the presence of secondary fracture porosity and could be regarded as potential hydrocarbon source rocks [1].

The Shiranish Formation has been described in numerous research papers and academic thesis such as [2-9]. Most of these have discussed the depositional paleoenvironment of formation in terms of foraminiferal biostratigraphy, geochemistry and microfacies.

In the current study, a superficial section was chosen near the city of Soran in northeastern Iraq, and a detailed field description was conducted, including a description of the stratigraphic units of the Shiranish Formation and the lithological characteristics. Additionally, biostratigraphy of the Shiranish Formation based on calcareous nannofossils was achieved.

The study aims to describe the lithostratigraphy and biostratigraphy of the Shiranish Formation based on the field, lithological characteristics, and nannofossils with their ages. Then matching them globally and locally to determine the exact age of this formation.

Geologic setting

The study area is situated in northeastern Iraq, north of the Soran City (Diana section), to the northwest of Zozik anticline, at latitude (36° 40 88.35) and longitude (44° 33 55.40) (Figure 1). Tectonically, Iraq was divided into three tectonic zones, the Low Folded Zone; High Folded Zone; and the Zagros Fold and Thrust Suture Zone [10, 11]. The study area is located in High Folded Zone (Figure 1).

The depositional environment of the Shiranish Formation was deposited in an open deep marine environment [12, 13]. Al-Atrushi [14] mentioned that the depositional environment of the formation extends from the outer shelf to the upper bathyal, and the age of the formation is recorded as early-late Maastrichtian in Dohuk Governorate, northern Iraq. Whereas, Al-Jubouri, [15] determined two microfacies and two sub microfacies for the formation in Khabaz Oilfield, Kirkuk that was deposited in outer shelf to upper bathyal environments. Based on planktonic foraminifera, Hassan [8] determined the sedimentary environment of the Shiranish Formation in Sarah anticline, Dokan, to extend from the outer shelf to the middle bathyal.

The Shiranish Formation belongs to the Late Campanian and Maastrichtian cycle, which also includes, Aqra, Bekhme, Degma, Hadiena, Hartha, Tanjero, and Tayarat formations (Figure 2). The thickness of the Shiranish Formation from one region to another according to its location in the sedimentary basin. Generally, it increases towards the center of the basin on the northwestern side of Iraq and decreases at the edges of the sedimentary basin (Figure 3). According to Henson 1940, in Bellen et al. [16], the thickness of the Shiranish Formation in the type section is about 225 m, and the thickness outside this region is variable and ranges between 100 to 400 m. However, the thickness of the Shiranish Formation in the esent section is about 73 m.

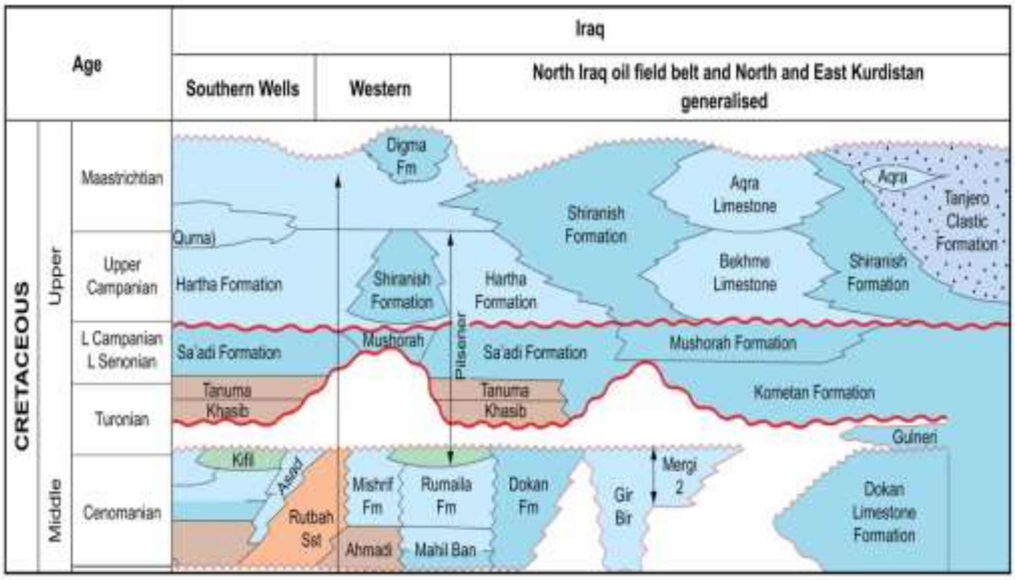

Figure 1: Tectonic map of Iraq shows the location of the study section [11]

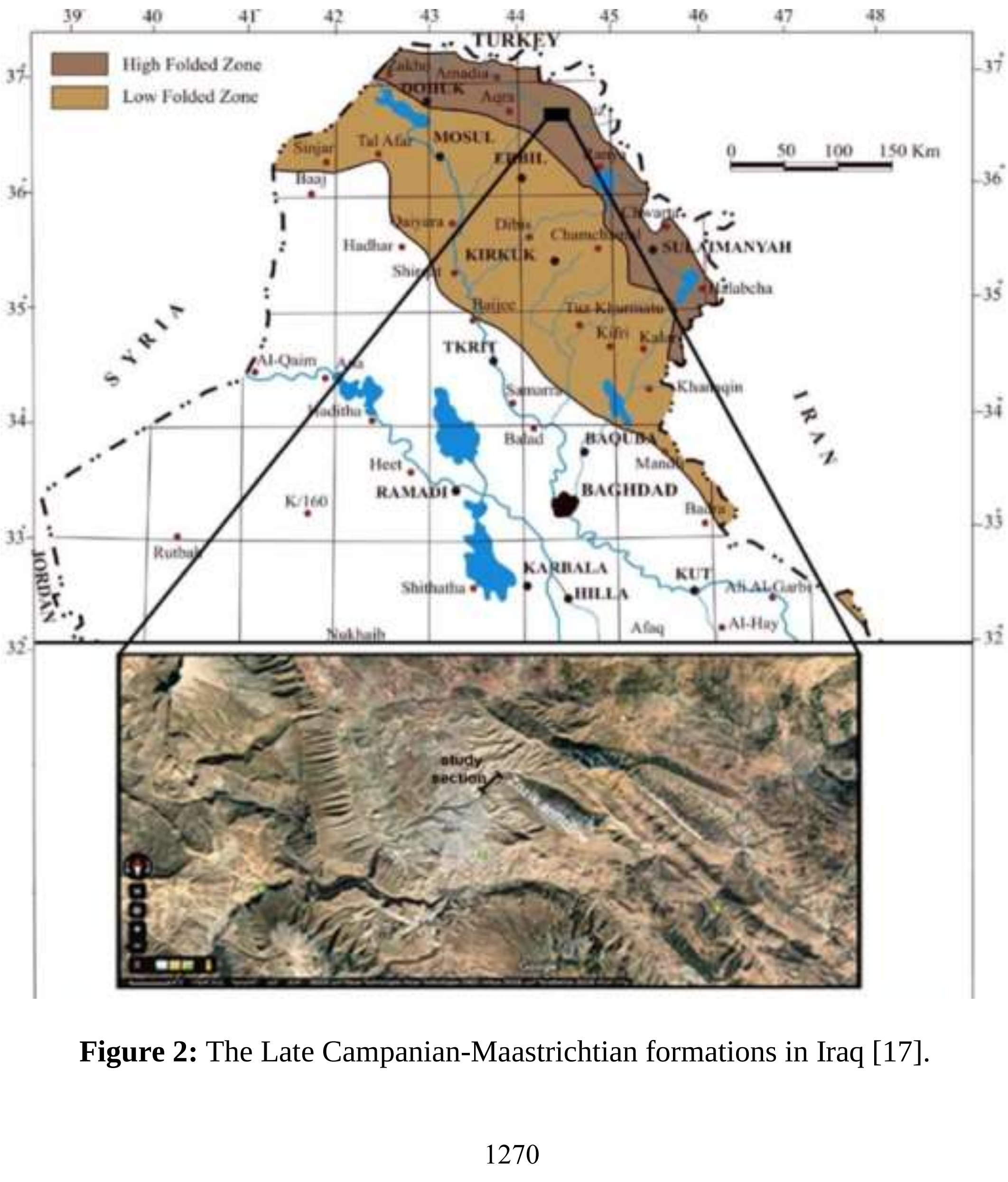

Figure 2: The Late Campanian-Maastrichtian formations in Iraq [17].

The thickness of the Shiranish Formation increases towards the basin center in northwestern Iraq and decreases toward the sedimentary basin edge. This supports the opinion of Sissakian [18], who indicated a great thickness of Cretaceous formations at different areas of Iraq during variation of the Cretaceous period. According to Henson 1940 in Bellen et al. [16], the thickness of the Shiranish Formation succession type section is about 225m The average exposed succession outside this region is variable, and it ranges between 400 and 100m. However, the thickness of the Shiranish Formation in the present section is about 73m.

Materials and methods

The stratigraphic successions were described based on a comprehensive field study of the rock unit, including their lithologic characteristics, sedimentary structures, bed color and geometry, and vertical and lateral variations and determining the upper and lower boundaries of the formation. Forty-eight samples are chosen to study the calcareous nannofossils to determine the age of the formation. This was done using the methods by Armstrong and Brasier (2005) [19] and by using the transmission light microscope type (Italy, POL353-B Optika). The result was compared with the atlas chart of Young and Bown (1997) [20]. Rock slides were made for solid lime samples in the Geology Department of Mosul University to study their calcareous nannofossils components.

Results and Discussion

1 - Nature of the contacts

The nature of the lower and upper contacts of the formation differs. Below is a detailed explanation of each contact's nature from top to bottom.

Shiranish-Bekhme boundary (lower contact)

The nature of the formation's lower boundary seems uncomfortable and sharp with the underlying Bekhme Formation (Campanian -Maastrichtian), which usually consists of dark yellow massive dolomitic limestone. The overlaying contact has been set by the first appearance of well-bedded gray limestone layers with sharp contact (Figure 3a). The petrographic study of samples at this contact revealed the presence of glauconite near the boundary between the two formations, which is one of the important evidence for the unconformity (Figure 3c)

Shiranish-Tanjero boundary (upper contact)

The Shiranish Formation is conformably overlaid by the Tanjero Formation (Campanian-late Maastrichtian) by gradual change in color and lithology from bluish-yellow marly limestone of the Shiranish Formation to olive-green shale of the Tanjero Formation (Figure 3b). The petrographic study showed that the lower part of the Tanjero Formation contains clay facies (Figure 3d), whereas the upper part of the Shiranish Formation consists of marl and marly limestone with no evidence of unconformity between the two formations.

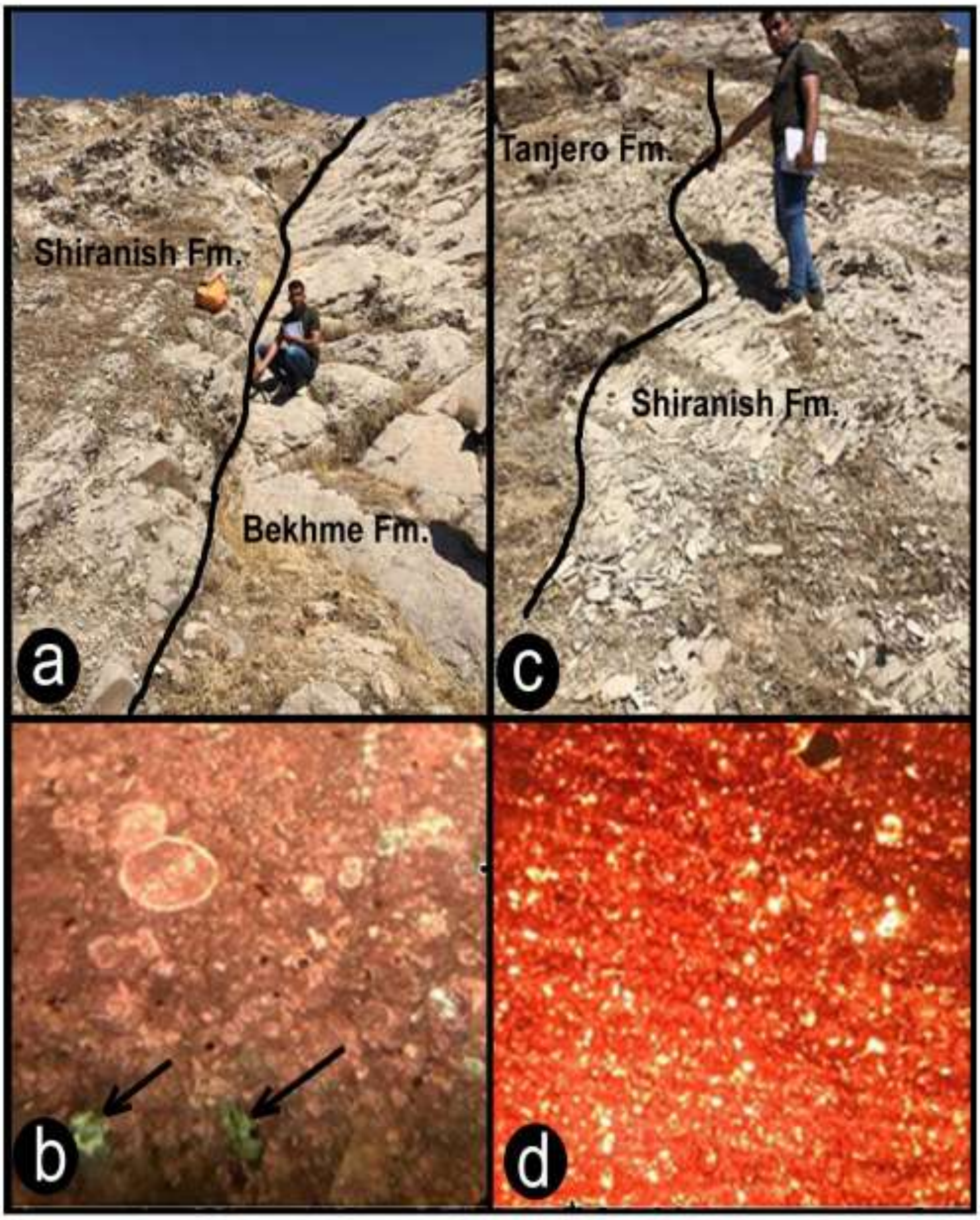

Figure 3: (a) Sharp unconformable contact between the Shiranish and the Bekhme formations. (b) Glauconite mineral near the boundary between the Shiranish and the Bekhme formations. (c) The upper conformable boundary between the Shiranish and the Tanjero formations. (d) Clastic materials (shale) of the Tanjero Formation.

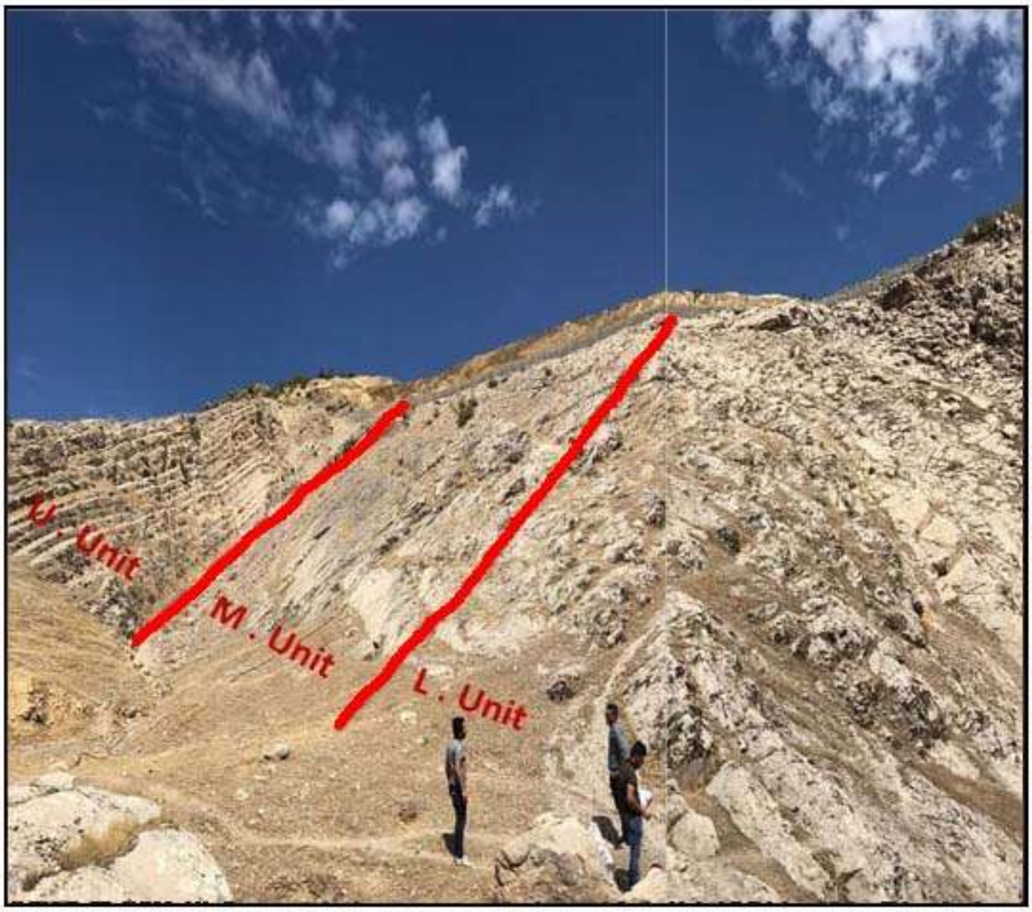

Figure 4: General view of the main rock units of the Shiranish Formation in the study area, showing the lower, middle and upper units.

2- Lithostratigraphic units

The stratigraphy of the Shiranish Formation generally consists of successive beds and layers of marly limestone, marl and limestone.

The formation could be divided into three rock units based on a detailed sedimentologic study of the rock successions (Figure 7). These units, from bottom to the top, are as follows:

Lower unit

This unit represents the oldest one of the successions as it was deposited directly over the Bekhme Formation. It is about 24-meter thick and characterized by many joints and fractures (Figure 5a). It consists of successive layers of dark marly limestone and limestone, starting with a relatively hard and well-layered limestone less than 50 cm thick (Figure 5b).

This is followed by well-bedded dark grey marly limestone with a thickness of about 8 meters, containing joints and veins. These beds are in turn followed by thin marl layers alternating with fissile shales of about 1m thick that are affected by the erosion process (Figure 5c) than layers of hard marl with a thickness of 1 meter followed by a layer of erosional marl of about 5.1-meter thick. It is followed then by a succession of massive limestone with a thickness of about 7-meters with dark color and hard and containing joints (Figure 5d). This unit is ended by a succession of marly limestone with a thickness of 5.5-meters containing iron oxides, fractures and calcite veins (Figure 5e-f).

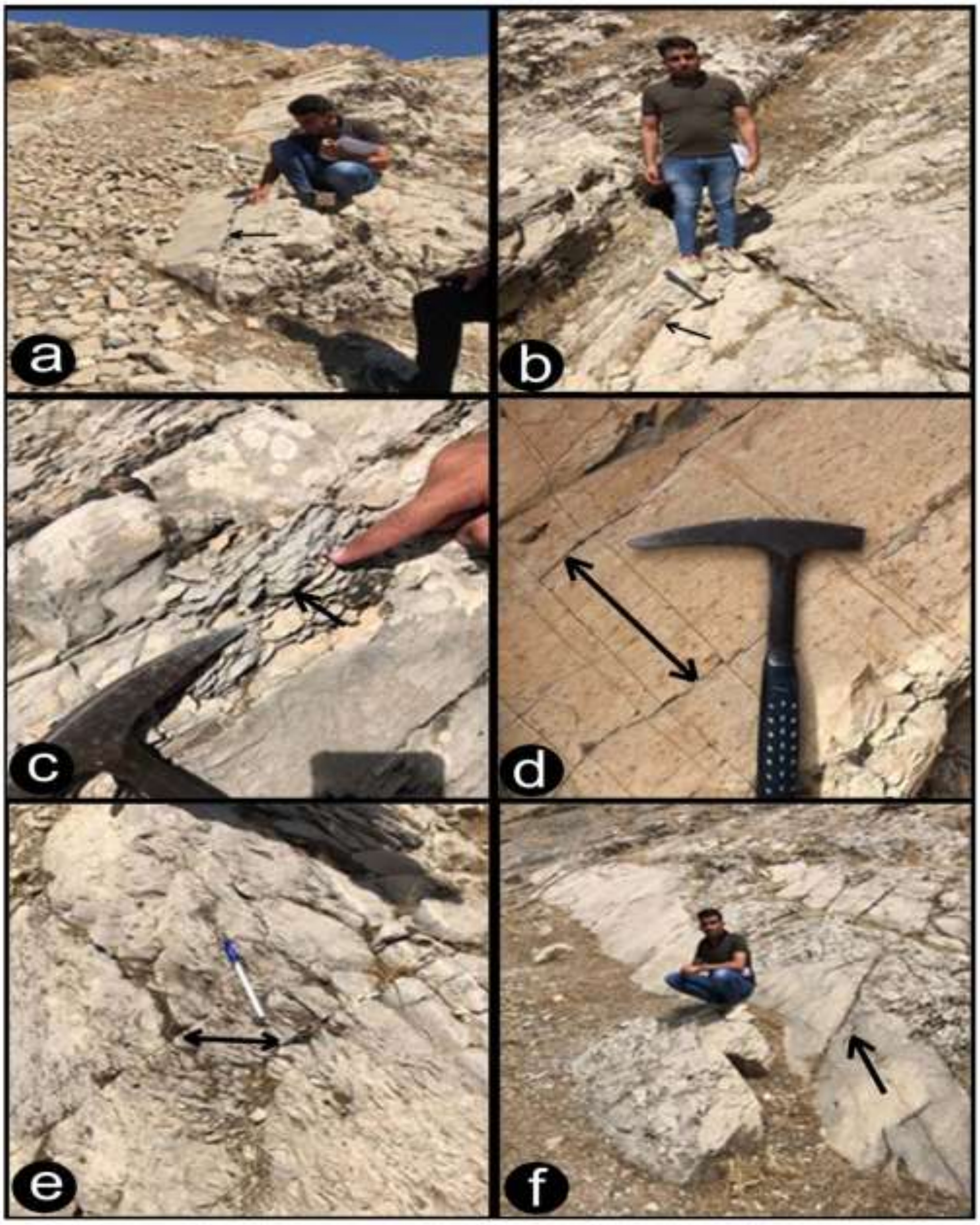

Figure 5: Field photos of the lower unit. (a) Bed of limestone containing joints. (b) The lower limestone unit bed represents the Shiranish Formation's first bed. (c) Fissile shale between marl beds. (d) Massive limestone-containing joints. (e) Calcite veins. (f) Bedding dark gray marly limestone surface contains a set of fractures and joints.

Middle unit

The total thickness of this units is about 19 m. It begins with layers of a lighter gray color than the previous unit, which consists of alternating marl and well-bedded marly limestone. The marl layer is about 7 m thick. The marl is greatly affected by erosion processes and alternated with fissile shale (Figure 6a). This unit was affected by mass collapses of the marl (Figure 6b) as well as containing limonite (Figure 6c). This layer, in turn, is followed by a 5 m thick massive marly limestone bed alternated with shale (Figure 6d). The middle unit is ended by a marl sequence reaching about 7-meters thick and characterized by needle-blade structures (Figure 6e). Some bedding surfaces in this sequence are also distinguished by their polygon structures, which are one of the diagnostic features of marl (Figure 6f).

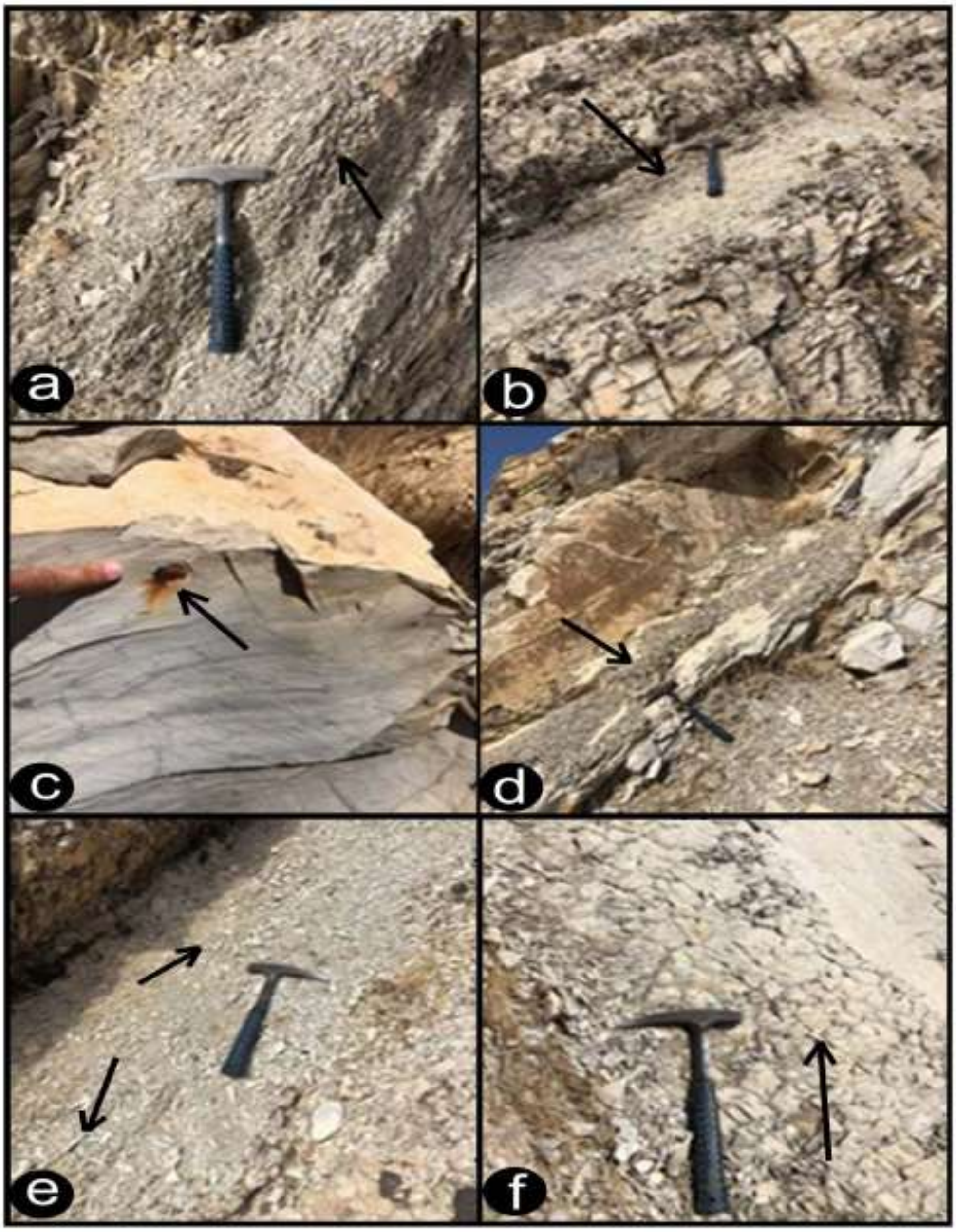

Figure 6: (a) Brittle marl beds contain clay and shale materials. (b) Marl bed are affected by erosion processes, which cause the collapse of marl blocks. (c) Marly limestone bed contains limonite. (d) Thick sequences of marly limestone, including fissile shale. (e) Marl blade structures as a result of erosion. (f) Marly limestone, including polygonal structures.

Upper Unit

This unit consists of well-developed sequences of marly limestone about 30 m thick, which is more resistant to erosion than the middle unit and is characterized by well-bedded dark gray-blue color (Figure 7a). It begins with a sequence of marly limestone with a thickness of 9-meters that contains a lot of limonite (Figure 7b). A conglomerate bed 1m thick was observed at this unit. The conglomerate was interpreted by Karim et al. [21] as transported sediments to the Shiranish basin. This conglomerate bed is of dark color and contains pebble size carbonate embedded in the lime matrix (Figure 7 c-d).

This conglomerate bed is followed by dark marly limestone with a thickness of about 15 meters. It is characterized by the presence of calcite veins in addition to bitumen and iron oxides (Figure 7 e-f). This unit is terminated by a succession of marly limestone and hard limestone with a thickness of 5 meters, which gradually changes to the clastic deposits of the Tanjero Formation.

In general, the division of the Shiranish Formation into three rock units revealed that the depositional environment is deep since most lithofacies are represented by the marly limestone and marl and calcareous shale. Most lithofacies in the lower and upper unit consist of the marly limestone, marl and some bed of limestone that may indicate their deposition in the outer shelf environment [22, 23]. Whereas common lamination in the middle unit and lithological components of marl, marly limestone and calcareous shale may indicate that the deposition occurred within the upper bathyal environment. The same conclusion was mentioned by [24, 25].

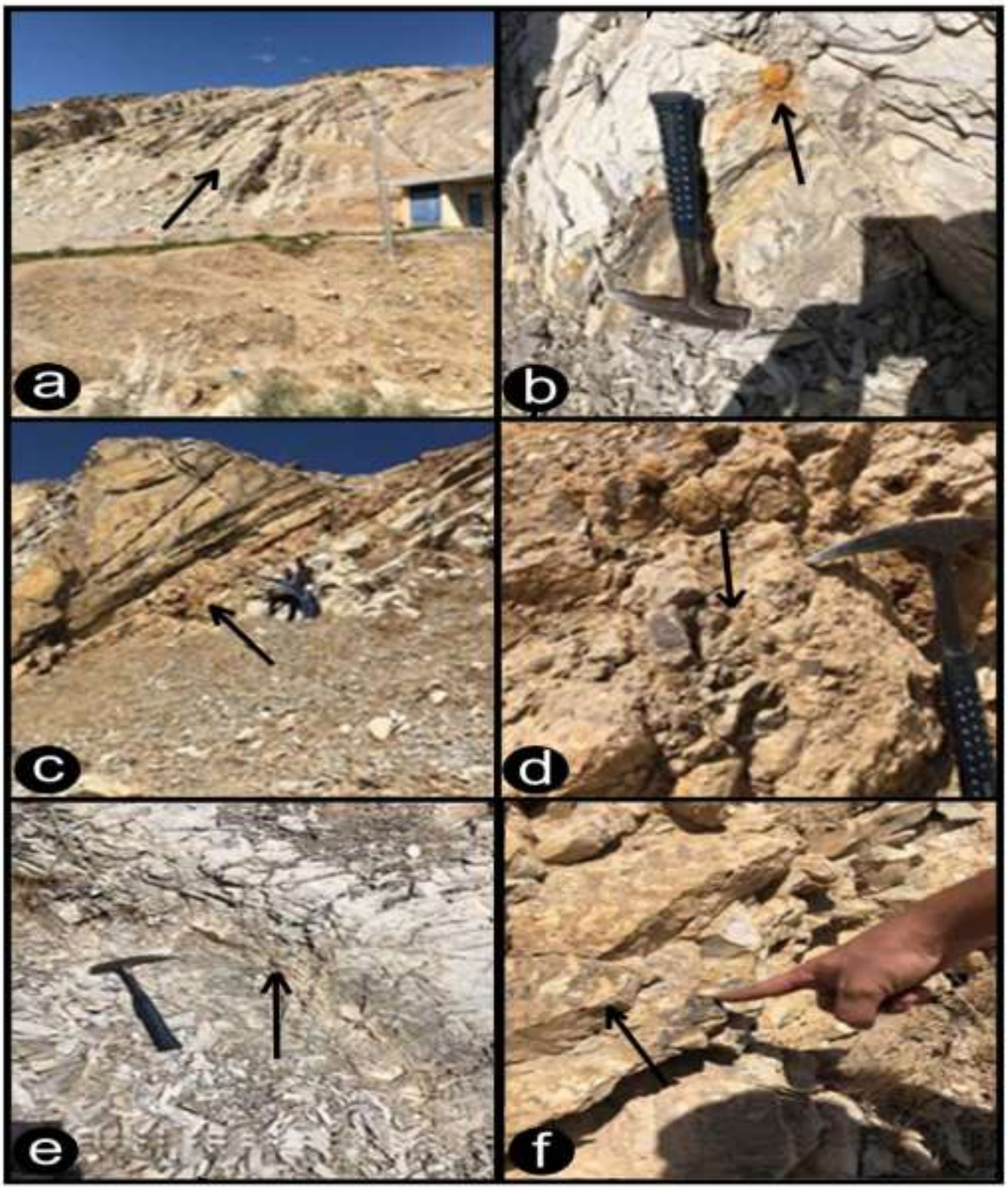

Figure 7: Field photos of the upper unit. (a) Well-bedded marly limestone sequences. (b) Marly limestone bed contain limonite. (c) Lime conglomerate bed of the upper unit sequences of the formation. (d) conglomerate in the Shiranish Formation. (e) Pyrite in veins. (f) Bituminous materials within the upper unit of the Shiranish Formation.

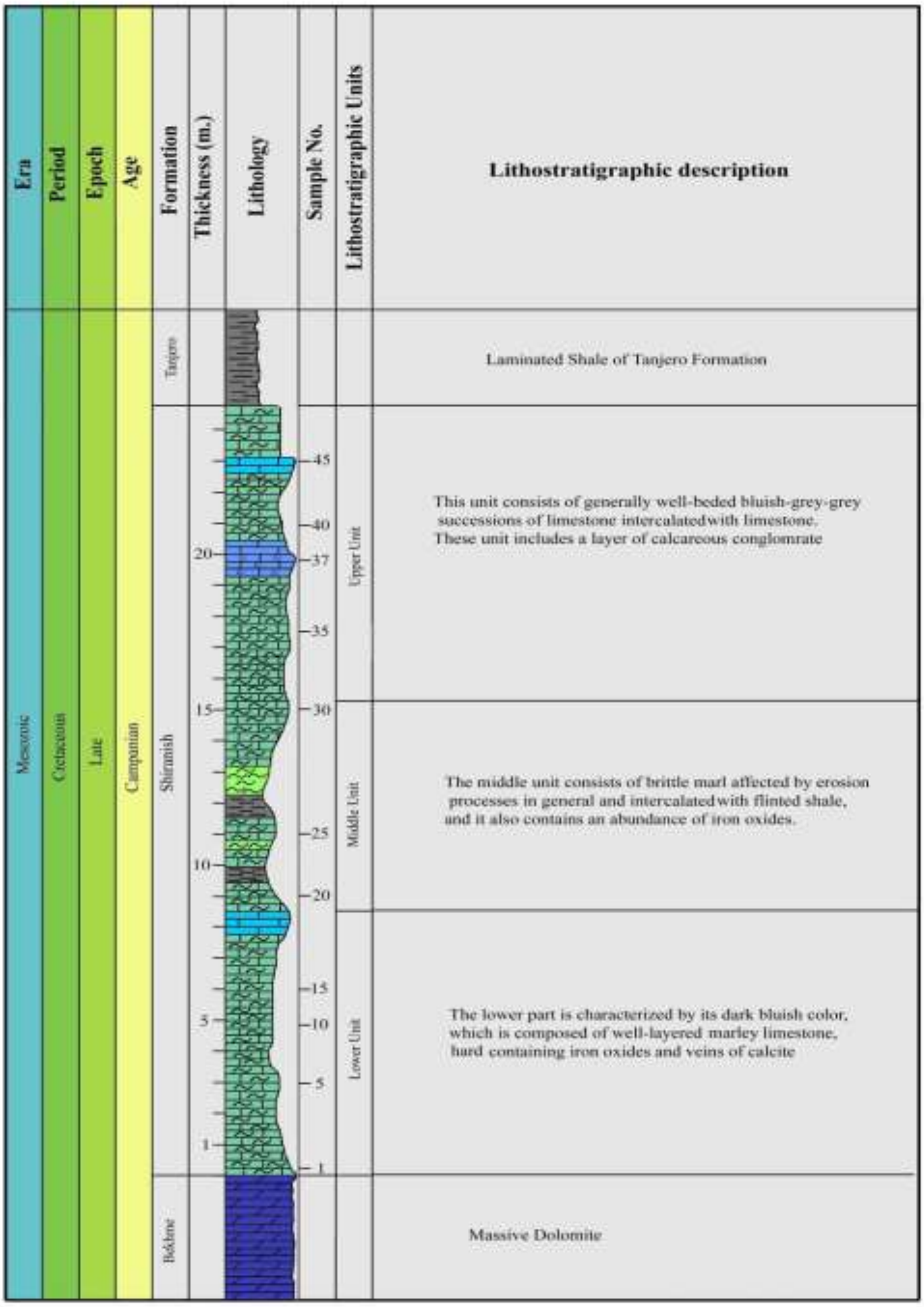

Figure 8: Lithological section of the Shiranish Formation in the study area.

3 – Nannopaleontology

A Detailed systematic study of calcareous nannofossils has been carried out for the Shiranish Formation. Twenty genera/species has determined as follows:

Heterococcoliths:

Family Chiastozygaceae Rood, Hay and Barnard, 1971 [26]

Genus *Misceomarginatus* Wind and Wise in Wise and Wind, 1977 [27]

Misceomarginatus pleniporus Wind and Wise in Wise and Wind, 1977[27]

Family Chiastozygaceae Rood, Hay and Barnard, 1973 [26]

Genus *Reinhardtites* Perch- Nielsen, 1968 [28]

Reinhardtites anthophorus Deflandre, 1959 [29]; Perch-Nielsen, 1968 [28]
Reinhardtitus levis Prins and Sissingh, in Sissingh 1977 [30]
Genus *Tranolithus* Stover, 1966 [31]
Tranolithus phacelosus Stover, 1966 [31]
Family Eiffellithaceae Reinhardt, 1965 [32]
Genus *Eiffellithus* Reinhardt, 1965 [32]
Eiffellithus eximius Stover, 1966 [31]; Perch-Nielsen, 1968 [28]
Eiffilithus parvus Watkins and Bergen, 2003 [33]
Eiffellithus turriseiffelli Deflander and Fert, (1954) in Reinhardt, 1965 [32]
Family Cretarhabdaceae Thierstein, 1973 [34]
Genus *Retecapsa* Black, 1971 [35]
Retecapsa crenulata Bramlette and Martini, 1964 [36]; Grün in Grün and Allemann, 1975 [37]
Retecapsa ficula Stover, 1966 [30]; Burnett, 1997 [38]
Family Watznaueriaceae Rood, Hay and Barnard, 1971 [26]
Genus *Watznauria* Reinhardt, 1964 [39]
Watznaueria barnesae Black and Barnes, 1959 in Perch –Nielsen, 1968 [28]
Watznauria biporta Bukry, 1969 [40]
Family Arkhangelskiellaceae Bukry, 1969 [40]
Genus *Broinsonia* Bukry, 1969 [40]
Broinsonia parca Stradner, 1962 [41]; Bukry, 1969 [40]
Holococcoliths:
Family Calyptrosphaeraceae Boudreaux and Hay, 1969 [42]
Genus *Calculites* Sissingh, 1977 [30]
Calculites obscurus Deflandre, 1959 [29]; Prins and Sissingh in Sissingh, 1977 [30]
Calculites ovalis Stradner, 1962 [41]; Prins and Sissingh in Sissingh, 1977 [30]
Calculites sp.
Nannoliths:
Family Microrhabdulaceae Deflandre, 1963 [43]
Genus *Lithraphidites* Deflandre, 1963 [43]
Lithraphidites quadratus Bramlette and Martini, 1964 [36]
Family Polycyclolithaceae Varol, 1992 [44]
Genus *Eprolithus* Stover, 1966 [31]
Eprolithus floralis Stradner, 1962 [41]; Stover, 1966 [31]
Genus *Uniplanarius* Manivit et al., 1977 [45]
Uniplanarius gartneri Manivit et al., 1977 [45]
Uniplanarius sissinghii Perch-Nielsen, 1968 [28]
Genus *Ceratolithoides* Bramlette and Martini, 1964 [36]
Ceratolithoides aculeus Stradner, 1961 [46]; Prins and Sissingh in Sissingh, 1977 [30]

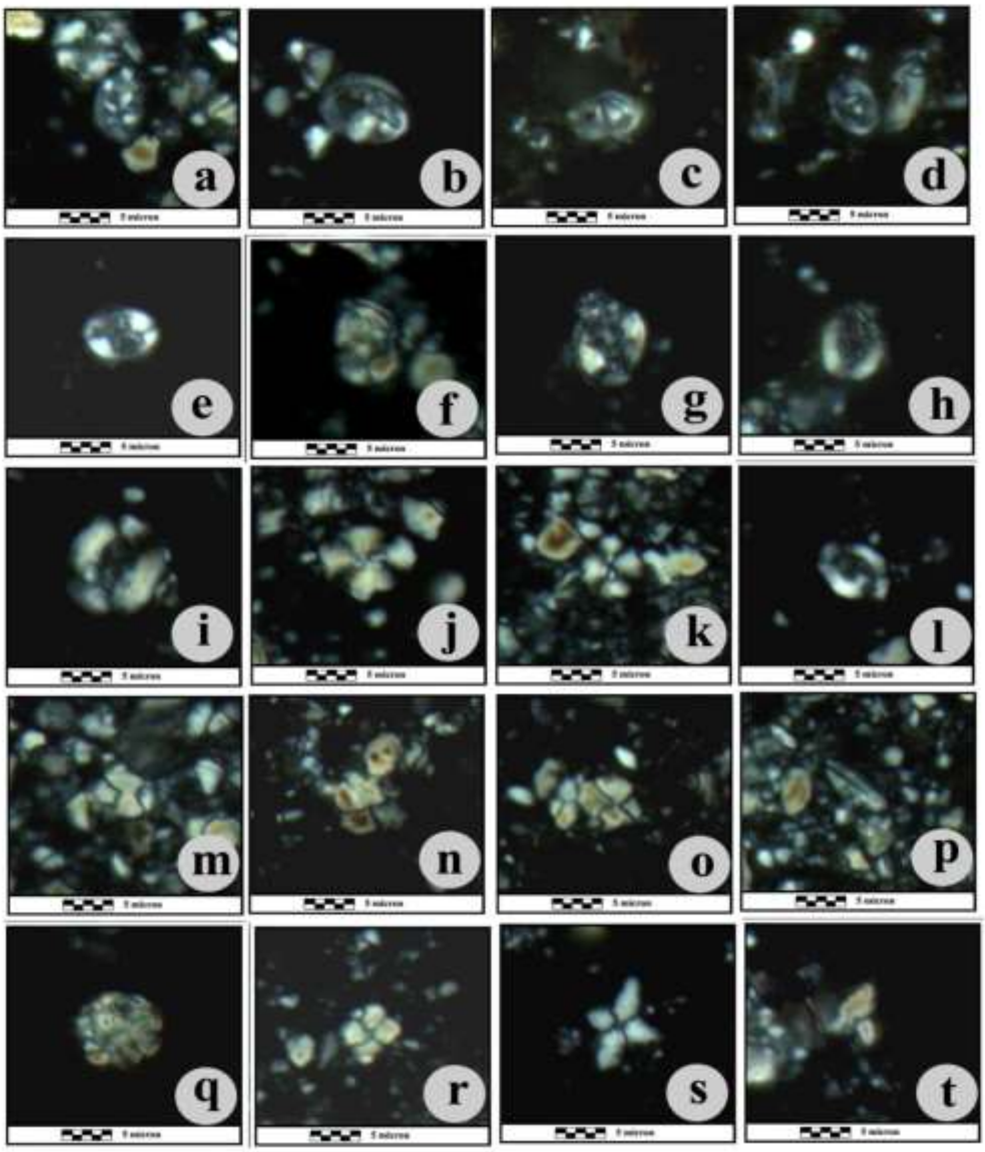

Figure 9: Cross-polarized photos of significant calcareous nannofossil taxa from the Shiranish Formation.(a) *Misceomarginatus pleniporus*; (b) *Reinhardtites anthophorus*; (c) *Reinhardtitus levis*; (d) *Tranolithus phacelosus*; (e) *Eiffellithus eximius*; (f) *Eiffellithus turriseiffelli*; (g) *Eiffilithus parvus*; (h) *Retecapsa crenulata*; (i) *Retecapsa ficula*; (j) *Watznaueria barnesae*; (k) *Watznauria biporta*; (l) *Broinsonia parca*; (m) *Calculites obscurus*; (n) *Calculites ovalis*; (o) *Calculites* sp.; (p) *Lithraphidites quadratus*; (q) *Eprolithus floralis*; (r) *Uniplanarius gartneri*; (s) *Uniplanarius sissinghii*; (t) *Ceratolithoides aculeus*.

3- Nannobiostratigraphy and age

Calcareous nannofossil biostratigraphic studies were carried out on outcropped samples from the Shiranish Formation, an offshore deep-water environment. The focus of this study was to establish a nannobiozonation, age, and correlation across the study intervals. Lithologically, the study sequence is composed of carbonate with intercalation of thin-bedded clastic. Reasonably, diverse nannofossil assemblages were recovered, and calcareous nannofossils zones were established based on the first and last occurrences of readily identifiable marker species and their relative abundances. These zones aided the age assignment of middle Campanian to the studied section. Index species and assemblage of diagnostic species such as *Misceomarginatus pleniporus*, *Ceratolithoides aculeus* and

Uniplanarius sissinghii have been used to determine the zonal ages ranging from CC19 to CC21 depending on the classic zonation scheme of Sissingh (1977), [30]. The recognition of such a disparate array of species in the study suggests that good preservation of nannofossils which could be agreed to the middle Campanian carbonate, may affect the zoning of intervals.

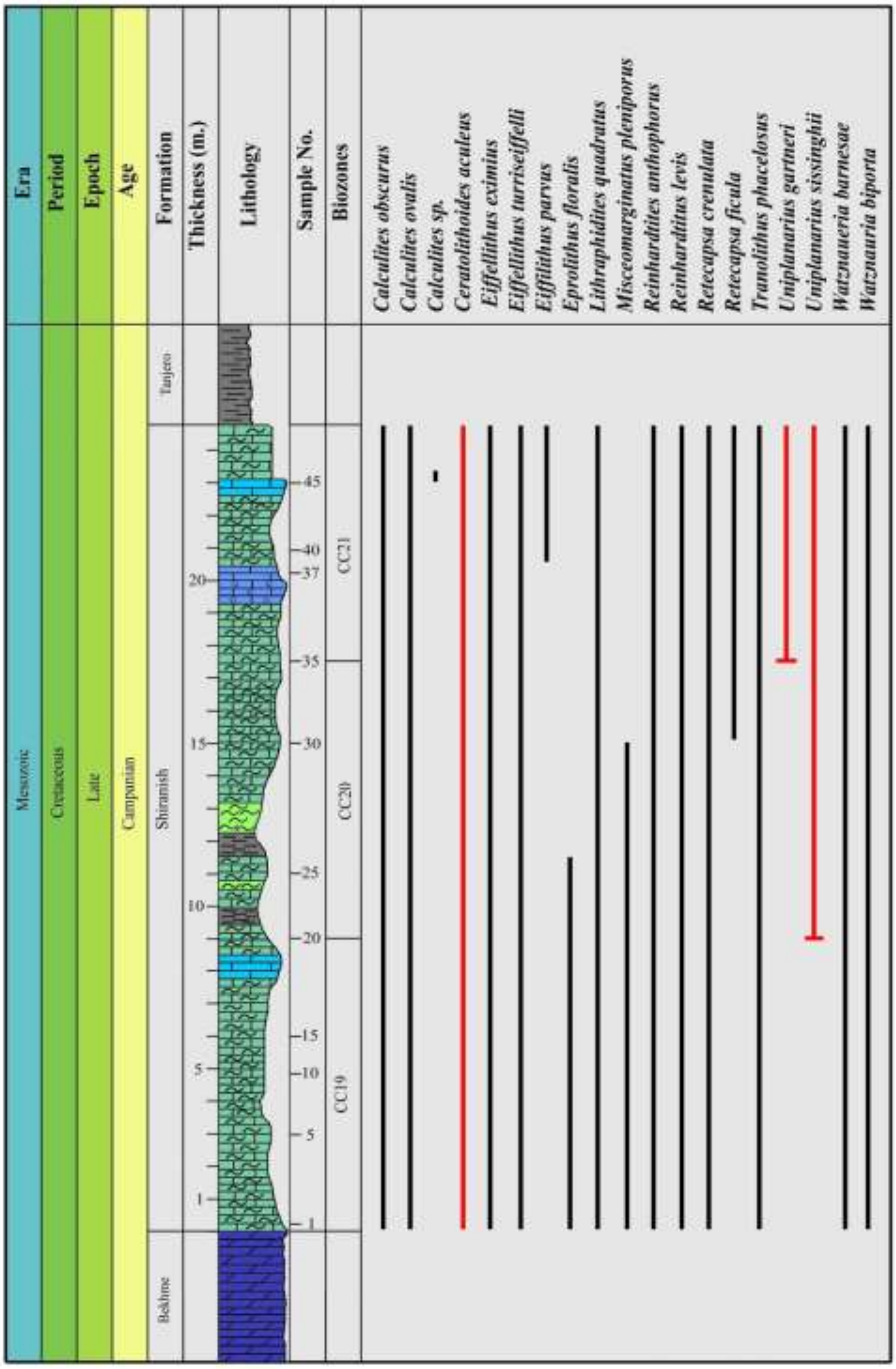

Figure 10: Distribution chart of calcareous nannofossils for the studied section

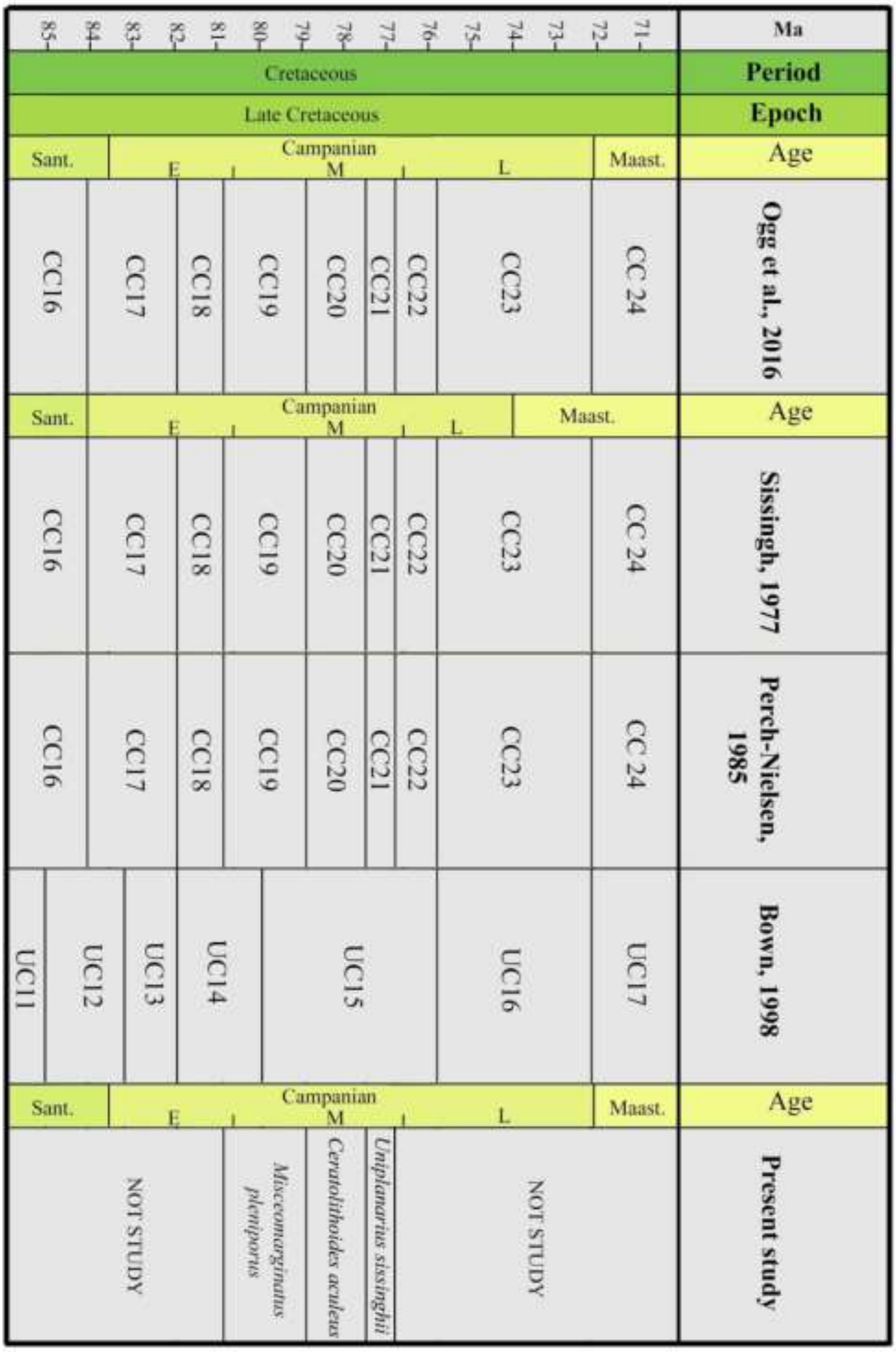

Figure 11: Age correlation chart of calcareous nannofossils

Conclusions

The study dealt with the Shiranish Formation in the surface section of the Diana area in Erbil Governorate. The rock succession of the Shiranish can be divided into three rock units. The lower and upper units were characterized by their roughly similar components and rock characteristics. It consists of marly limestone with a bit of marl and limestone containing iron oxides represented by pyrite. The Shiranish Formation is underlain by the Bekhme

Formation and overlaid by the Tanjero Formation. The depositional environment of the Shiranish Formation in the study section shows that the lower and upper units were deposited in the outer shelf, while the middle unit was deposited in the upper bathyal

The study of the Shiranish Formation, Diana area, Northern Iraq, suggested the presence of three calcareous nannofossils. These are from oldest to youngest;

1- *Misceomarginatus pleniporus* biozone

2- *Ceratolithoides aculeus* biozone

3- *Uniplanarius sissinghii* biozone

These biozones were compared with other nannobiozones, concluding that the section is middle Campanian in its age.

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