Microfacies analysis and depositional environment of Shiranish Formation in Selected Sections, Kurdistan Region, NE Iraq
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**ABSTRACT**
Shiranish Formation in both Smaquli and Rawanduz sections is composed of an alternation of marly limestones, limestone and marl beds with fissile shale beds. Depend on color, lithology and other sedimentological criteria during field observations of the studied sections, the Shiranish Formation is divided lithologically into lower, middle and upper units. Planktonic Foraminiferal Lime Mudstone Microfacies (Shf1), Lime Wackestone (Shf2) and Planktonic Foraminiferal Lime Packstone Microfacies (Shf3) have been defined as three distinct microfacies with four submicrofacies ((Keeled Planktonic Foraminiferal Lime Wackestone submicrofacies (Shf2b), Globular Chamber Planktonic Foraminiferal Lime Wackestone submicrofacies (Shf2a), Bioclastic Lime Wackestone submicrofacies (Shf2c), Planktonic Foraminiferal Lime Wackestone submicrofacies (Shf2d)). The major microfacies in both sections was lime wackestone which is dominated in middle and upper units in both sections. Sedimentological and paleontological evidences suggest that the Formation was deposited in the outer shelf setting and progressed to the upper bathyal setting, in addition to that the microfacies changed from packstone to mudstone meaning deeping upward sequence.
تحليل السحنات الدقيقة والبيئة الترسيبية لتكوين الشيرانش في مقاطع مختارة إقليم كوردستان، شمال شرق العراق.

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الملخص

يتكون تكوين الشيرانش من ثلاث وحدات (السموئي والوسطي والشامي) بناءً على اللون الصييموي والرموش ويييو ين بهب من سمات نوعية شيرانش التي تكون من سمات نوعية شيرانش من ناحية الاتجاه والانفصال. تقسم الخريطة الزماني والرياضية إلى سمات نوعية شيرانش من ناحية الاتجاه والانفصال. تقسم النواحي الزمنية والرياضية إلى سمات نوعية شيرانش من ناحية الاتجاه والانفصال.

1. Introduction

Henson 1940 identified the Shiranish Formation for the first time near the village of Shiranish Islam, northeast of Zakho in Northern Iraq [1]. This formation is the lower part of a regional transgressive-regressive depositional series in the Upper Cretaceous (Campanian and Maastrichtian) that flooded nearly all of Iraq [2].

Due to the lack of late Maastrichtian sediments in the Shiranish area, the formation's type locality provides the possibility of dating the Shiranish Formation to the Late Campanian-Maastrichtian [3]. In the Sinjar area, the upper Shiranish Formation can be dated to the Late Maastrichtian [4]. Based on foraminifera discovered in the Hujran region, the Shiranish Formation’s age can be stretched to the Paleocene [5; 6].

Overall, Shiranish Formation is a significant geological formation in northern Iraq that has been the subject of a number of investigations and researches that aimed in revealing its depositional setting, paleoenvironment, and diagenetic conditions.

1.1. Aim of the Study

The main aims for studying these two new sections are to discuss the geology, lithology, sedimentology of the Upper Cretaceous Shiranish Formation, and to determine the sedimentary properties and depositional environment of a marl, marly-limestone and limestone units that occur within this Formation.

1.2. Location of Studied Sections

The studied sections are located around the Jali Dam (1st section) in the Smaquli area, and Banazok area around Rawanduz town (2nd section) both sections are in Erbil Governorate, Iraqi Kurdistan Region (Fig.1).
1.3. Geological Setting

The studied sections of Shiranish Formation are located in the High Folded Zone (HFZ). The HFZ is a component of the Western Zagros Fold-Thrust Belt [8] (Fig. 2). Thus, in addition to the form of exposed rocks and climatic environments, tectonic and structural influences have formed the major geomorphologic units and geodynamic processes. The High Folded Zone has a width of 25 to 50 kilometers. The area is composed of sedimentary rocks dating from the Triassic to the Pliocene, as well as different forms of Quaternary sediments [9; 10]. Structurally, the first studied section is located at High Folded Zone near the boundary between High Folded and Low Folded zones, but the second studied section is located at the boundary between High Folded and Imbricate zones [11; 12; 13]. The first Zagros Foreland Basin was created initially when the basin of the Shiranish Formation, which was located below, merged with the basin of the Tanjero Formation, which was located above [14]. The majority of the region is made up of anticlines and synclines that have a high amplitude and trend in the same direction (northwest to southeast). Many of the anticlines are asymmetrical, with the limbs that are located to the southwest being steeper than the ones that are located to the northeast. The cores of certain anticlines are
composed mostly of carbonates and include outcrops of Cretaceous rocks, while the synclines in the surrounding area are filled with Tertiary rocks that are composed of clastic sediments and carbonates.

2. Method and Materials

For this investigation of the Shiranish Formation, fieldwork was conducted at the end of summer 2021 in order to select the suitable outcrops. Lower and upper contacts were detected. More than seventy limestone, marly limestone, and marl hand specimens were obtained. Based on vertical facies variations, 52 samples (24 in Smaquli and 28 in Rawanduz) were collected for thin section petrographic examination. Carbonates were petrographically analyzed using thin sections preparation at Salahaddin University's College of Science and the Faculty of Science at Urmia University in Iran. To identify and distinguish calcite and dolomite, thin sections were coated with Alizarin Red 'S' Solution using Friedman's (1959) technique. Facies were classified using Dunham [15] categorization method.
Fig. 2 Tectonic map of Iraq showing studied sections [8]
3. Result and Discussion

3.1. Lithology

Depend on color, lithology and other sedimentological criteria during field observations of the studied sections we can divided Shiranish Formation’s lithology to three units in each section as follows:

- **Smaquli Section:** The thickness of Shiranish Formation in this section is about 136 m and consist of Limestone, Marly limestone and Marl (Fig.3A,4A,4B and 6) as follow:
  - **Lower unit:** Alternation between limestone and marly limestone light yellow in color, soft and medium to thick beds, the thickness of limestone beds are from 25 cm to 40 cm while the thickness of marly limestone beds are thinner from 5 cm to 20 cm the overall thickness of this unit is about 36m.
  - **Middle unit:** This unit consist of limestone, marly limestone light yellow in color, hard and medium to thick beds with soft beds of bluish grey marl and beds of fissile shale dark grey in color, the thickness of limestone and marly limestone beds ranging from 15 cm to 50 cm while the thickness of marl beds in this unit 50 cm and thickness of shale is about 2 m, the overall thickness of this unit is about 60m.
  - **Upper unit:** This unit consist of yellow to light brown hard marly limestone with soft bluish grey marl and thick beds of limestone the overall thickness of this unit is about 40m.
  - **Lower boundary:** The lower contact of Shiranish Formation is conformable contact with Bekhma Formation.
  - **Upper boundary:** The upper contact of Shiranish Formation is gradational contact with Tanjero Formation.

- **Rawanduz Section:** The thickness of Shiranish Formation in this section is about 157m and consist of Limestone, Marly limestone and Marl (Fig.3B,5A,5B and 7) as follow:
  - **Lower unit:** Alternation between limestone and marly limestone light yellow in color, soft and medium to thick beds, the thickness of limestone beds are from 25 cm to 40 cm while the thickness of marly limestone beds are thinner from 5 cm to 20 cm the overall thickness of this unit is about 37m.
  - **Middle unit:** This unit consist of limestone, marly limestone light yellow in color, hard and medium to thick beds with soft beds of bluish grey marl and beds of fissile shale dark grey in color, the thickness of limestone and marly limestone beds ranging from 15 cm to 50 cm while the thickness of marl beds in this unit 50 cm the overall thickness of this unit is about 70m.
  - **Upper unit:** This unit consist of yellow to light brown hard marly limestone with soft bluish grey marl and thick beds of limestone, the overall thickness of this unit is about 50m.
  - **Lower boundary:** The lower contact of Shiranish Formation is conformable contact with Bekhma Formation.
  - **Upper boundary:** The upper contact of Shiranish Formation is gradational contact with Tanjero Formation.

![Fig.3](image1.png) Field photograph showing A: outcrop of Shiranish Formation in Smaquli Section and B: Outcrop of Shiranish Formation in Smaquli and Rawanduz Sections
**Fig. 4** Field photograph showing A: Lower contact of Shiranish Formation in Smaquli Section and B: Upper contact of Shiranish Formation in Smaquli Section

**Fig. 5** Field photograph showing A: Lower contact of Shiranish Formation in Smaquli Section and B: Upper contact of Shiranish Formation in Rawanduz Section
Fig. 6 Stratigraphic column of Shiranish Formation of Smaquli Section.
Fig. 7 Stratigraphic column of Shiranish Formation of Rawanduz Section.
3.2. Microfacies Analysis

The Shiranish Formation is divided into three primary microfacies, which are designated as Shf1–Shf3, together with various submicrofacies represent the paleoecology and bathymetry of the Formation.

Planktonic Foraminiferal Lime Mudstone Microfacies Shf1: This facies allochems represent fewer than 10% of the total facies content and are dominated by globular planktonic foraminifera such as *Heterohelix*, *Globigerinelloides*, *Rugoglobigerina*, and *Hedbergella*, as well as benthonic foraminifera and echinoderm spines (Fig. 8A). Based on an increase in the ratio of *Heterohelix* to *Globigerinelloides* species, the matrix is composed of micrite with foraminiferal chambers filled with microsparite cement or iron oxide as an oxidation product of the facies' mid-outer shelf depositional environment [16; 17]. This submicrofacies matches the (SMF3) of [18; 19] and (FZ2) of [20].

Lime Wackestone Microfacies Shf2: The major microfacies type in Shiranish Formation samples from the lower and middle units. The Shiranish Wackestone is made up of a diversity of planktonic foraminifers within a neomorphosed micritic matrix and is usually yellow to light brown, occasionally light grey. It is classified into three sub-microfacies:

Keelied Planktonic Foraminiferal Lime Wackestone submicrofacies Shf2a: *Globotruncanana*, *Globotruncanella*, and *Globotruncanita*, keeled types of planktonic foraminifera, make up the majority of the allochems. They make over 75% of the entire population of planktonic foraminifers. These genera are healthy and of average size. Benthonic foraminifera and rare globular planktonic foraminifera were also detected. With water depths ranging from 150 to 300 m, this facies is likely to have evolved in an outer-shelf to upper-bathyal environment. The range of planktonic foraminifera and the keeled/globular ratio, which rose or decreased according to the facies' transgressive or regressive development, serve as the bounds for these ranges [16; 21] (Fig. 8 B). This submicrofacies matches the (SMF3) of [18; 19] and (FZ2) of [20].

Globular Chamber Planktonic Foraminiferal Lime Wackestone submicrofacies Shf2b: Allochems account for about 20% to 50% of the total microfacies content (Fig. 5b), and include planktonic foraminifer a (*Globotruncanella sp.*, *Heterohelix sp.*, and *Globigerinelloides*). Micrite constitutes the majority of the matrix in the wackestone. Any forams' chambers are fully filled with microsparite. The paleontological mark for this microfacies pointed to the facies's outer shelf conditions [17] (Fig. 8 C). This submicrofacies matches the (SMF3) of [18; 19] and (FZ2) of [20].

Bioclastic Lime Wackestone submicrofacies Shf2c: Allochems comprise approximately 20% to 30% of the overall microfacies content, and composed of planktonic foraminifera, few benthic foraminifera, ostracods, echinoderm and bivalve. The SMF3 (Mixed Bioclastic Mudstone Microfacies) of facies zone 1 may be associated with the microfacies, which in general imply a deep basinal reducing environment [18; 19] (Fig. 8 D). This submicrofacies matches the (SMF3) of [18; 19] and (FZ2) of [20].

Planktonic Foraminiferal Lime Wackestone submicrofacies Shf2d: This microfacies type predominate in the middle and upper units of the Formation, and composed of a variety of planktonic with few benthic foraminifera, a few ostracods and bivalves which embedded in a micritic matrix. planktonic foraminifera represented by the genera (*Hedbergella*, *Heterohelix Globotuncana*, and *Globigerinelloides*). The Shiranish wackestone is light grey in color, although it may also range in color from yellow to brown. This submicrofacies matches the (SMF3) of [18; 19] and (FZ2) of [20] and deposited in an open deep shelf setting (Fig. 8 E).

Planktonic Foraminiferal Lime Packstone Microfacies Shf3: The bottom unit of the Shiranish Formation is where this microfacies is most prevalent. Allochems account for 80% of the overall composition of the brown to light brown marly limestone that makes up this facies. They are mostly planktonic foraminifera, including *Globigerinelloides*, *Globigerinella*, *Globigerinita*, *Globotruncanana*, *Rosita*, *Gansserina*, *Heterohelix*, and *Hedbergella*. There are also bits of shell and a few benthonic foraminifera (Fig.8F). This submicrofacies matches the (SMF3) of [18; 19] and (FZ3) of [20].
Fig. 8 A. Planktonic foraminiferal lime mudstone microfacies, B. Keeled planktonic foraminiferal lime wackestones microfacies, C. Globular chamber planktonic foraminiferal lime wackestone submicrofacies, D. Bioclastic lime wackestone submicrofacies, E. Planktonic foraminiferal lime wackestone submicrofacies, F. Planktonic foraminiferal lime Packstone microfacies
3.3. Depositional Environment

An accurate detection depositional environment for any sedimentary rocks and Formations should be done by two main evidences which are:

1- **Sedimentological Evidence**: The presence of semi-regular to regular beds of limestone, marly limestone and marl is evidence that the Shiranish Formation’s depositional environment was deep and quiet, the presence of micrite matrix in all thin sections also is other evidence for quite environment under the base wave and far from the beach [22].

2- **Paleontological Evidence**: The widespread and large number of planktonic compared with few numbers of benthic foraminifera is evidence of deep marine environment, other evidence is benthic foraminifera with thin wall and small in size.

As a result, after microfacies analysis with linking to sedimentological and biological evidences, all of the findings point to the Shiranish Formation having been formed in deep marine settings ranging from the outer shelf to the upper bathyal in both sections. (Fig.9). This conclusion is confirmed by an earlier study that the upper unit is comprised of blue pelagic marls sometimes dolomitic with occasional thin marly limestone beds rich in microfauna and the lower unit is comprised of thin bedded marly limestone [23] (Fig.9).

![Fig.9 Three-dimensional diagram of depositional setting of Shiranish Formation in both sections.](image-url)
4. Conclusion

1. The succession of the Shiranish Formation in both sections consists of marly limestone, limestone, marl and shale.
2. The formation was divided into three lithostratigraphic units in both studied sections (lower, middle and upper) units.
3. Three distinct microfacies were defined as Planktonic Foraminiferal Lime Mudstone Microfacies (Shf1), Lime Wackestone (Shf2) and Planktonic Foraminiferal Lime Packstone Microfacies (Shf3) with four submicrofacies ((Globular Chamber Planktonic Foraminiferal Lime Wackestone Microfacies (Shf2a), Keeled Planktonic Foraminiferal Lime Wackestone Microfacies (Shf2b), Bioclastic Lime Wackestone (Shf2c), Planktonic Foraminiferal Lime Wackestone (Shf2d)).
4. The major microfacies in both sections is lime wackestone which is dominated in middle and upper unit in both sections.
5. Sedimentological and biological data concluded that the formation was deposited in outer shelf to upper bathyal settings, with deepening upward sequence.

References