

## Microfacies analysis and depositional environment of Shiranish Formation in Selected Sections, NE of Kurdistan, Iraq.

Shapol Shwan Abdulhameed\* and Waleed S. Shingaly\*\*

\*MSc., Earth Sciences and Petroleum Dept., Salahaddin University-Erbil

\*\* PhD., Earth Sciences and Petroleum Dept., Salahaddin University-Erbil

### Abstract

Shiranish Formation (136m and 157m thick) in both Smaquli and Rawanduz sections is composed of an alternation of marly limestones, limestone and a marl beds with fissile shale beds. Depend on color, lithology and other sedimentological criteria during field observations of the studied sections, lithology of Shiranish Formation divided 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 (Keelbed Planktonic Foraminiferal Lime Wackestone Microfacies-Shf2b, Globular Chamber Planktonic Foraminiferal Lime Wackestone Microfacies-Shf2a, Bioclastic Lime Wackestone-Shf2c, Planktonic/Benthic Foraminiferal Lime Wackestone-Shf2d). The major microfacies in both sections was Lime wackestone which is dominated in middle and upper unit in both sections. Sedimentological and biological data 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.

**Key Words:** *Microfacies, Depositional Environment, Shiranish Formation, Smaquli, Rawanduz.*

## Introduction

Henson identified the Shiranish Formation for the first time near the village of Shiranish Islam, northeast of Zakho in Iraqi Kurdistan's High Folded Zone (1940, in Bellen et al., 1959). 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 (Dunnington, 1958).

Due to the absence of late Maastrichtian sediments in the Shiranish region, where the formation's type locality is found, the Shiranish Formation may be dated as Late Campanian-Maastrichtian (Kassab, 1973). In the Sinjar region, the age of the upper part of the Shiranish Formation can be extended to the Late Maastrichtian (Al-Mutwali & Al- Juboury, 2005). The Shiranish Formation's age can be extended to the Paleocene based on foraminifera found in the Hijran region (Hammoudi, 2011).

Overall, the Shiranish Formation is an important geological formation in northern Iraq that has been the subject of several studies aimed at understanding its depositional setting, paleoenvironment, and diagenetic conditions.

## Location and aim of the Study

The studied sections are located around the Jali Dam (1st section) in the Smaqli area, and Banazok area around Rawanduz town (2nd section) both sections are in Erbil Governorate, Iraqi Kurdistan Region (Fig.1). These two new sections have been studied to discuss the geology, lithology and sedimentology of the upper Cretaceous Shiranish Formation in new sections, and to determine the sedimentary properties with microfacies analysis and depositional environment of a Marl, Marly-limestone and Limestone units that occur within this formation.

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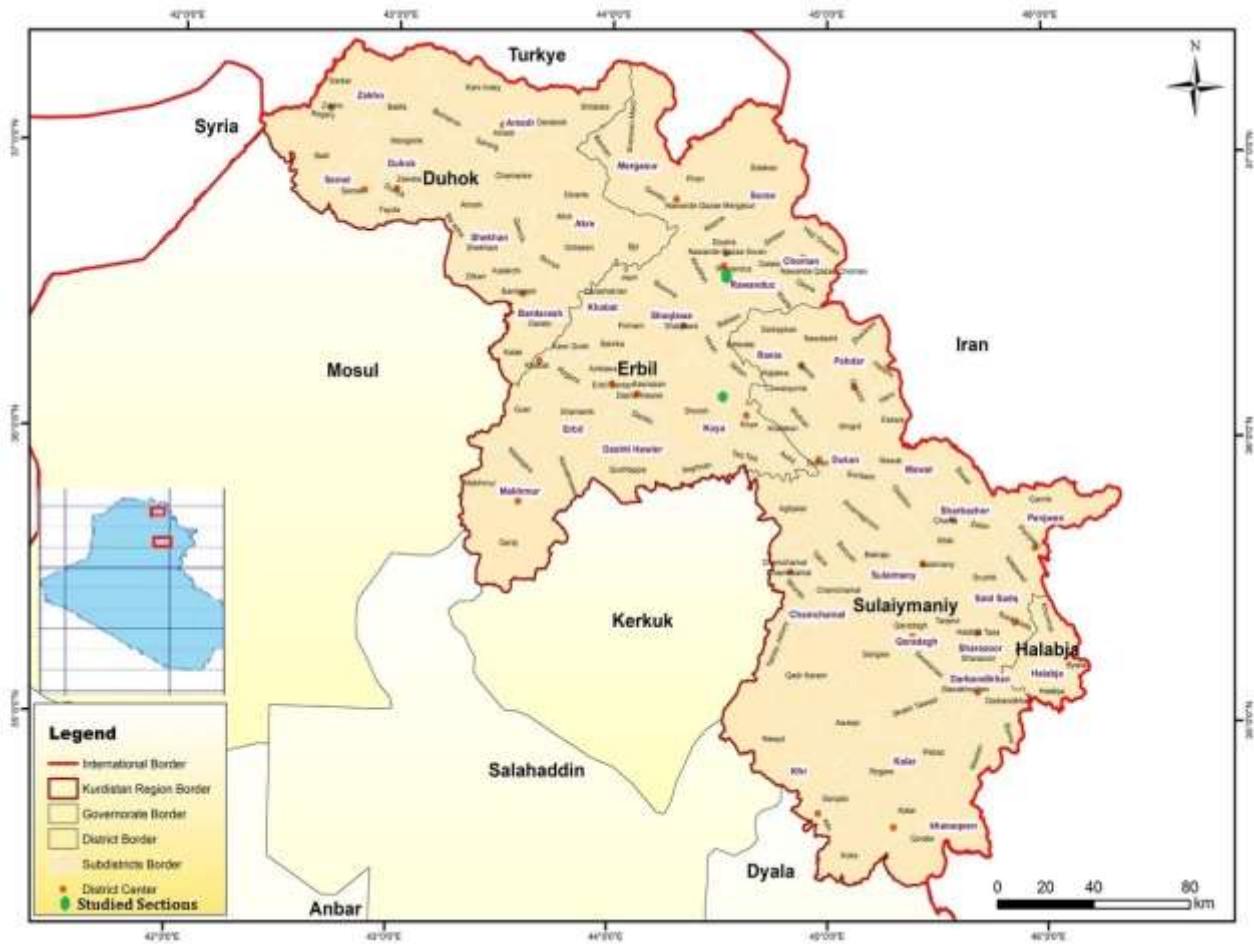


Fig.1 Location map of Northern Iraq showing studied sections (Website of Ministry of Planning-KRG)

## Method and Materials

For this investigation of the Shiranish Formation, fieldwork was conducted at the end of summer 2021 in order to select the new suitable outcrops. Lower and upper contacts were detected. More than seventy hand specimens of Limestone, Marly Limestone and Marl were collected. Fifty-Two samples were obtained for thin section petrographic analysis based on vertical facies alterations. The petrographic analysis of carbonates was conducted using thin sections prepared at Salahaddin University's College of Science and Faculty of Science in Urmia University, Iran. In order to detect and differentiate calcite and dolomite, thin sections were stained with

Alizarin Red 'S' Solution according to the method of Friedman (1959). The classification scheme of Dunham (1962) was used to classify facies.

### 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 (Fouad, 2012a and b, Fouad, 2014) (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 (Sissakian and Fouad, 2012; Sissakian and Al-Jibouri, 2014). Tectonically, the studied area is located in the Zagros Fold – Thrust Belt, directly to the southwest of the main Zagros Suture Zone. 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 (Buday, 1980, Buday and Jassim, 1987 and Jassim and Goff, 2006). The basin of Shiranish Formation merged tectonically with that of the overlying Tanjero Formation to form the original Zagros Foreland Basin (Karim & Surdasy, 2005; Karim et al., 2008). Despite its enormous science significance for reconstructing upper Cretaceous events in Iraqi Kurdistan, this unit has received little attention outside of the area (Ahmed et al., 2016). Buday (1980) merged the Bekhme and Aqra formations to create the Aqra-Bekhme Limestone Formation, stating that it wedges out very quickly and develops thin tongues within the Shiranish Formation. According to Jassim and Goff (2006), the area was uplifted during the Oligocene, and as a result, there are no Oligocene formations in the region. The area consists mainly of high amplitude anticlines and synclines, which have the same trend (northwest – southeast). Many of the anticlines are asymmetrical with the southwestern limbs being steeper than the northeastern ones. Cretaceous rocks outcropped in some anticlines core, which are mostly carbonates, whereas nearby synclines are filled with Tertiary rocks, which are clastic and carbonate in composition.

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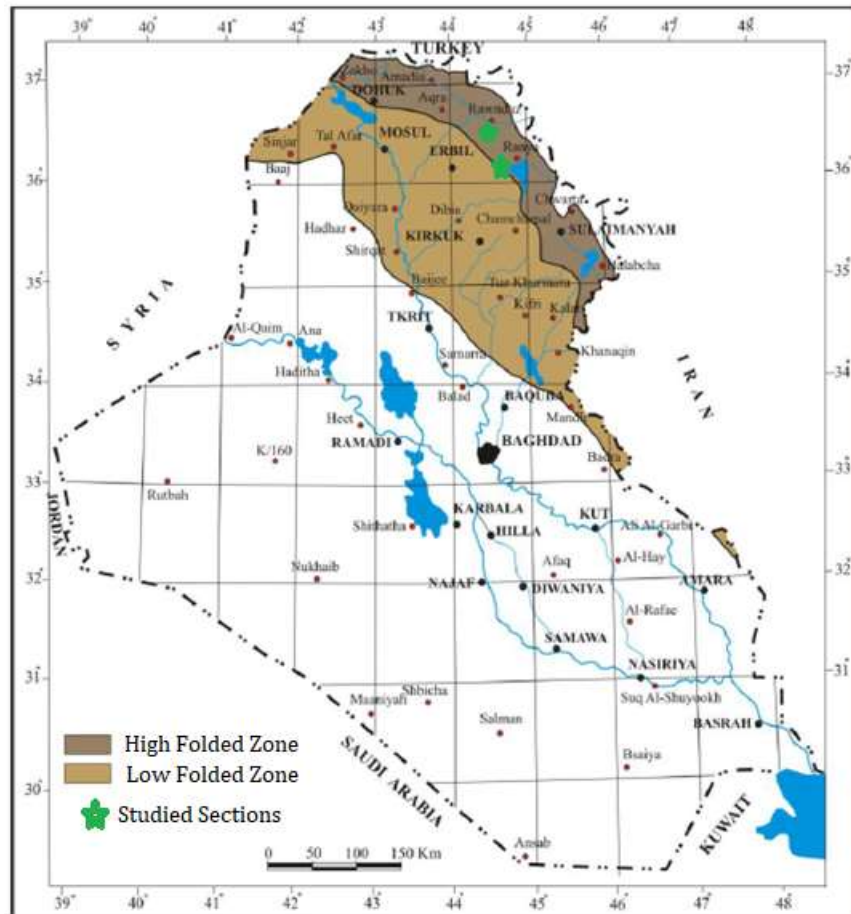


Fig.2 Tectonic map of Iraq showing studied sections (Fouad, 2015)

## 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.3,4,5,6) 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 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 the overall thickness of this unit is about 40m.

**Lower boundary:** The lower contact of Shiranish formation is unconformable 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.3,4,5,7) 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 the overall thickness of this unit is about 50m.
  - **Lower boundary:** The lower contact of Shiranish formation is unconformable contact with Bekhma formation.
  - **Upper boundary:** The upper contact of Shiranish formation is gradational contact with Tanjero formation.



Fig.3 Outcrop of Shiranish Formation in Smaquli and Rawanduz Sections



Fig.4 Upper and Lower Contact of Shiranish Formation in Smaqli Section

Fig.5 Upper and Lower Contact of Shiranish Formation in Rawanduz Section





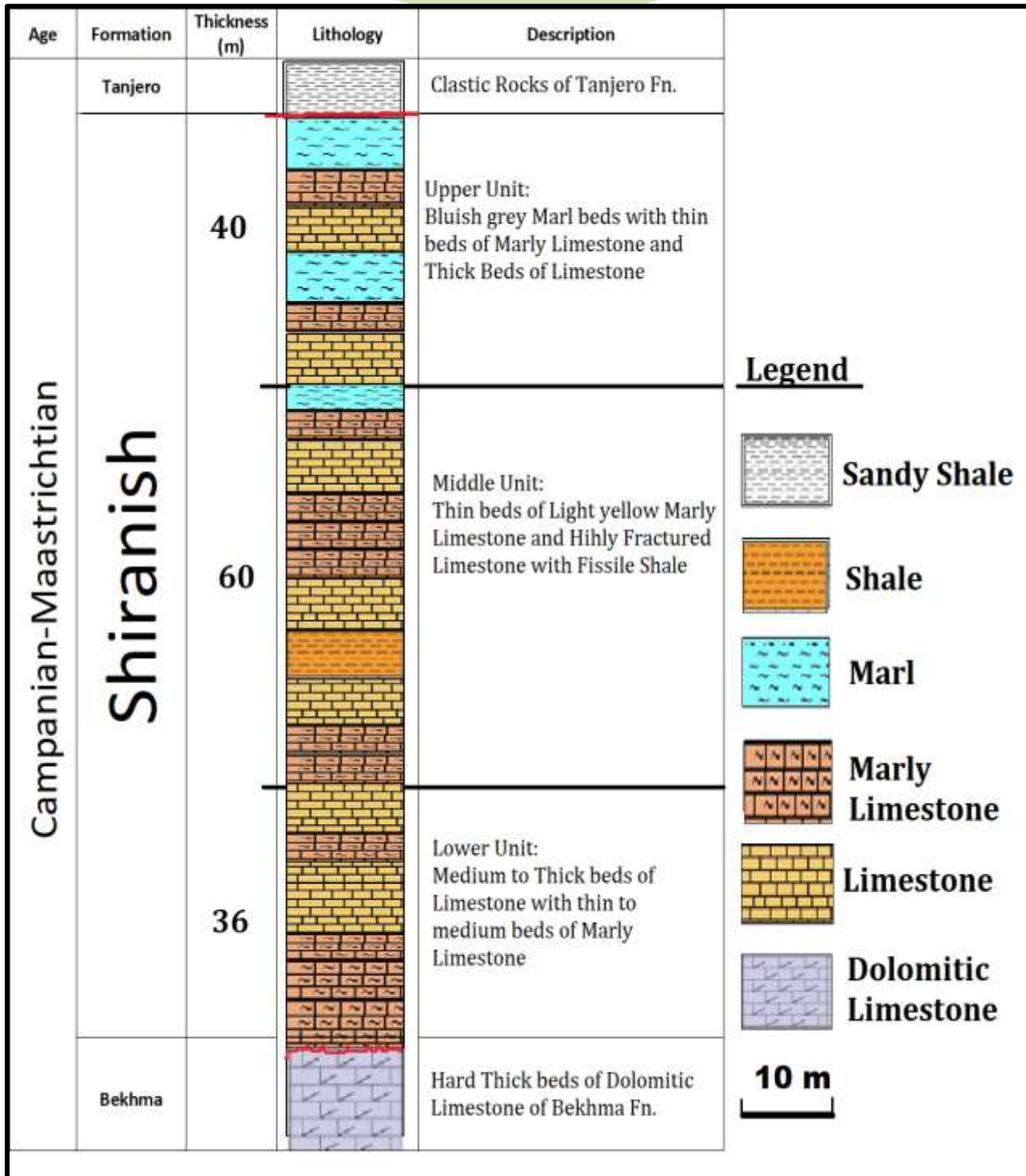


Fig.6 Stratigraphic column of Shiranish Formation for Smaquli Section.

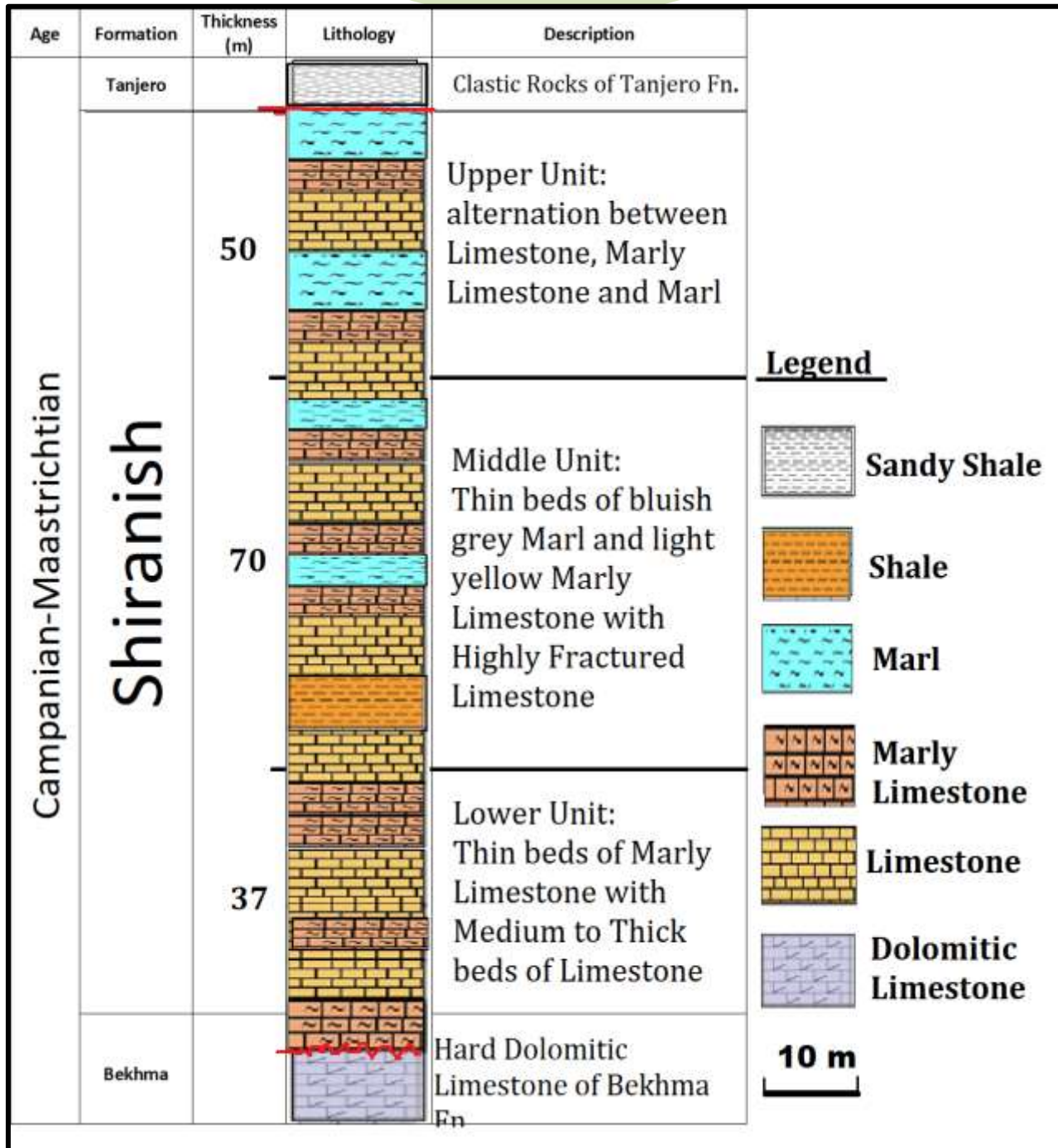


Fig.7 Stratigraphic column of Shiranish Formation for Rawanduz Section.

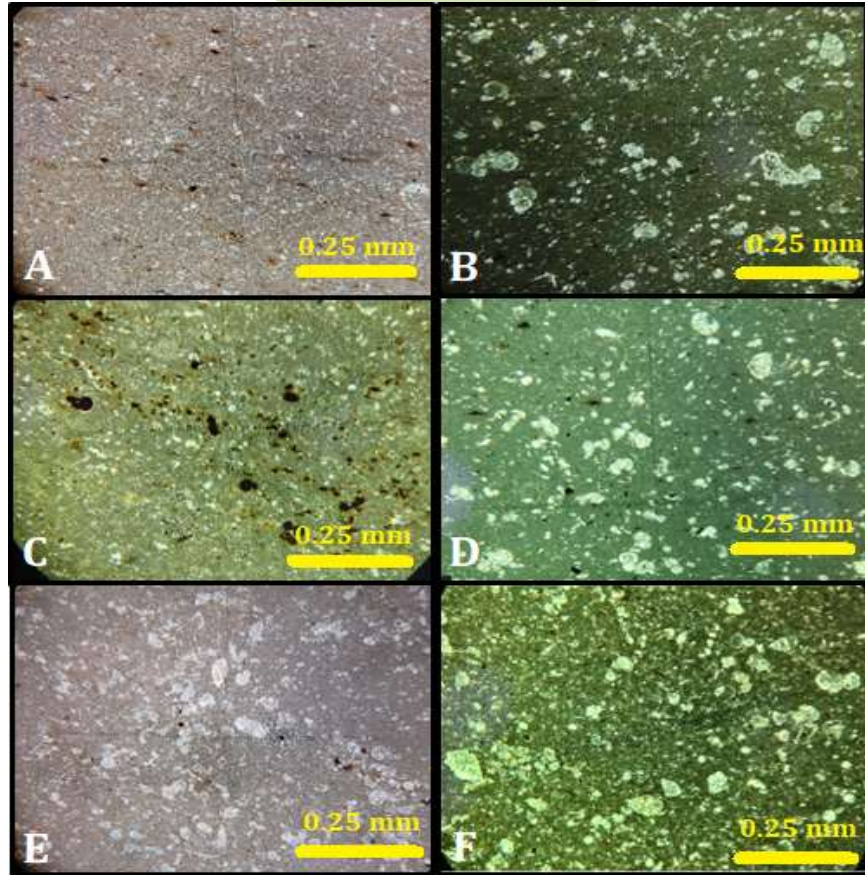
### Microfacies Analysis of Shiranish Formation

Three main microfacies of Shiranish Formation donated as Shf1–Shf3 with several subfacies which reflects the paleoecology and bathymetry of the formation.

- **Planktonic Foraminiferal Lime Mudstone Microfacies Shf1:** The allochems of this facies represent less than 10% of the facies content and is dominated by globular planktonic foraminifera represented by *Heterohelix*, *Globigerinelloides*, *Rugoglobigerina* and *Hedbergella*, in addition to benthonic foraminifera and echinoderm spines (Figure 8A). The matrix consists of micrite with foraminiferal chambers filled by microspare cement or iron oxide as an oxidation product of mid-outer shelf depositional environment of the facies, based on an increase in the ratio of *Heterohelix* to *Globigerinelloides* species (Leckie ,1987; Gibson, 1989).
- **Lime Wackestone Microfacies Shf2:** The dominant microfacies type in the samples from the Shiranish Formation's lower and middle units. The Shiranish Wackestone is composed of a variety of planktonic foraminifers inside the neomorphosed micritic matrix and is normally yellow to light brown, sometimes light grey, this microfacies is divided into three sub-microfacies:
  - **Keeled Planktonic Foraminiferal Lime Wackestone Microfacies Shf2a:** The allochems consist primarily of keeled forms of planktonic foraminifera represented by *Globotruncana*, *Globotruncanella*, *Globotruncanita*. They constitute 75% of the total planktonic foraminifer's population. These genera have normal size and good preservation. Rare globular planktonic foraminifera and benthonic foraminifera were also present. This facies is thought to have developed in an outer-shelf to upper-bathyal setting with water depths varying from 150–300 m. These limits are determined by the variety of planktonic foraminifera and the keeled/globular ratio, which increased or decreased in proportion to the facies' transgressive or regressive growth (Leckie, 1987; Koutsoukos and Hart, 1990) (Fig. 8 B).
  - **Globular Chamber Planktonic Foraminiferal Lime Wackestone Microfacies Shf2b:** Allochems account for about 15% and 45% 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 evidence for

this microfacies pointed to the facies's outer shelf conditions (Gibson 1989; Berggren and Miller 1989) (Fig. 8 C).

- **Bioclastic Lime Wackestone 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 (Flugel, 2004, 2010) (Fig. 8 D).
- **Planktonik/Benthic Foraminiferal Lime Wackestone Shf2d:** This microfacies type predominate in the middle and upper units of the formation, and composed of a variety of planktonic with benthic foraminifera with a few ostracods and bivalves which embedded in a micritic matrix. The Shiranish wackestone is light grey in color, although it may also range in color from yellow to brown. In general, the microfacies are indicative of a deep basinal reducing environment (Flugel, 2004, 2010) (Fig. 8 E).
- **Planktonik Foraminiferal Lime Packstone Microfacies Shf3:** This microfacies is dominated in the lower unit of Shiranish Formation. This facies consists of brown to pale brown marly limestone, in which allochems make up 80% of the total content. They are primarily planktonic foraminifera expressed as Globotruncanell, Globotruncanita, Globotruncana, Rosita, Gansserina, Heterohelix, Globigerinelloides, Rugoglobigerina and Hedbergella. Shell fragments and small amounts of benthonic foraminifera are also present (Fig. 8 F). The occurrence of planktonic foraminifera with a high percentage of bioclasts represents an outer shelf environment with depth ranging between 150–200 m (Flugel, 2004, 2010).



**Fig. 8** A. Planktonic foraminiferal lime mudstone microfacies, B. Keeled planktonic foraminiferal lime wackestone microfacies, C. Globular chamber planktonic foraminiferal lime wackestone submicrofacies, D. Bioclastic lime wackestone submicrofacies, E. Planktonic/Benthic foraminiferal Lime wackestone submicrofacies, F. Planktonic foraminiferal lime Packstone microfacies

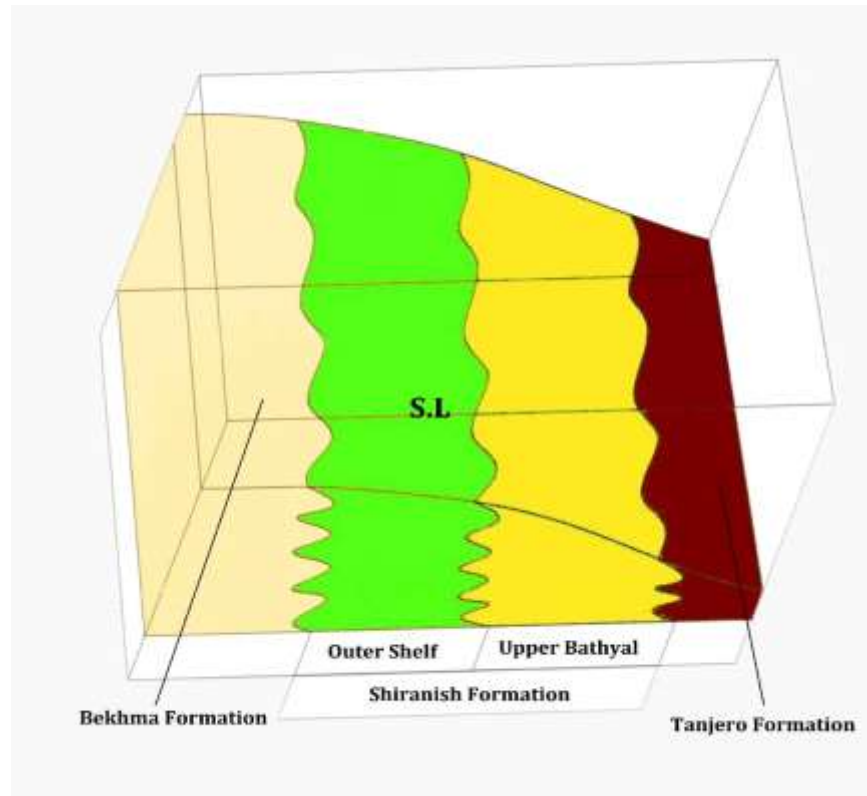
### Depositional Environment of Shiranish Formation

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 deposited in a deep and quite environment, 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.

**2- Biological 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.

Finally, after microfacies analysis with connecting to sedimentological and biological evidences all results indicate that Shiranish formation deposited in deep marine environments from (outer shelf to upper bathyal) in both sections (Fig.9).



**Fig.9** 3D block diagram of depositional environment of Shiranish Formation in both sections.

## Conclusion

1. Shiranish Formation is one of the widespread formations and an important geological formation in N and NE of Iraq, thus has been the subject of several

studies aimed at understanding its depositional setting, paleoenvironment, and diagenetic conditions.

2. Shiranish Formation well exposed in Smaquli with thickness 136m and in Rawanduz with thickness 157m.
3. The Formation is composed of an alternation of marly limestones, limestone and a marl beds with fissile shale bed, distributed lithologically, into three units (lower, middle and upper).
4. In both sections the lower contact of Shiranish formation is unconformable contact with Bekhma formation, while the upper contact is gradational contact with Tanjero formation.
5. 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 (Keeled Planktonic Foraminiferal Lime Wackestone Microfacies Shf2b, Globular Chamber Planktonic Foraminiferal Lime Wackestone Microfacies Shf2a, Bioclastic Lime Wackestone Shf2c, Planktonic/Benthic Foraminiferal Lime Wackestone Shf2d).
6. The major microfacies in both sections is Lime wackestone which is dominated in middle and upper unit in both sections.
7. Sedimentological and biological data concluded that the formation was deposited in outer shelf to upper bathyal settings, with Deeping upward sequence.

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