Iraqi National Journal of Earth Science

www.earth.mosuljournals.com

Benthic Foraminifera and Sedimentary Environment of Shiranish Formation, Dukan Area, Northeastern Iraq

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Article information

Received: 25- May -2023

Revised: 26- Jul -2023

Accepted: 10- Aug -2023

Available online: 01- Jan – 2024

Keywords:
Benthic Foraminifera
Sedimentary environment
Shiranish Formation
Campanian-Maastrichtian
Iraq

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ABSTRACT

Systematic study of the benthic foraminifera and the sedimentary environment of Shiranish Formation (Campanian-Maastrichtian) has been accomplished by collecting sixty-three rock samples from outcropped section in the south eastern limb of Sara anticline in Dukan area, Sulaymaniyah Governorate, northeastern Iraq. The studied section consists of successions of marly limestone, marl, and thin layered limestone. By observing the difference in the rock character and hardness, the Shiranish Formation section study is divided into two rock units. The aim of the current study is to diagnose the benthic foraminifera species and identifying and interpreting the sedimentary environment of Shiranish Formation in the current study section. Forty-five species and subspecies belonging to twenty-five genera are recorded. Based on the recorded genera, benthic foraminifera assemblages found in the sedimentary environment of Shiranish Formation in the studied section, are represented by three depositional sites: the middle-outer shelf in the lower part of the for mation; the upper-middle slope in the middle part; and the outer shelf in the upper part of the formation.

DOI: 10.33899/earth.2023.140401.1086, ©Authors, 2024, College of Science, University of Mosul.

الفورامنيفرا القاعية والبيئة الترسيبية لتكوين شيرانش، منطقة دوكان، شمال شرقي العراق

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معلومات الارشفة

تاريخ الاستلام: 25- مايو-2023

تاريخ المراجعة: 26- يوليو -2023

تاريخ القبـول: 10- أغسطس-2023

تاريخ النشر الالكتروني: 01- يناير -2024

الكلمات المفتاحية:
الفورامنيفرا القاعية
البيئة الترسيبية
تكوين شيرانش
كامبانيان - ماسترختيان
العراق

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الملخص

تمت دراسة الفورامنيفرا القاعية والبيئة الترسيبية لتكوين شيرانش (كامبانيان – ماسترختيان) من خلال جمع ثلاثة وستين إنموذجاً صخرياً من الجناح الجنوبي الغربي من طية سارة المحدبة في منطقة دوكان، محافظة السليمانية، شمال شرقي العراق. يتكون المقطع المدروس من تتابعات الحجر الجيري المارلي والمارل وطبقات رقيقة من الحجر الجيري. من خلال ملاحظة اختلاف الصفة الصخرية والصلادة، تم تقسيم تكوين شيرانش في المقطع قيد الدرس إلى وحدتين صخريتين. تهدف الدراسة الحالية إلى تشخيص مجاميع الفورامنيفرا القاعية وتحديد وتفسير البيئة الترسيبية لتكوين شيرانش في مقطع الدراسة الحالي، حيث تم تسجيل 45 نوعاً وتحت النوع من الفورامنيفرا القاعية تنتمي إلى 25 جنساً. اعتمادا على مصنفات الفورامنيفرا القاعية تم تمييز ثلاثة بيئات ترسيبية في التكوين وبالترتيب التالي بحيث أن الجزء السفلي من التكوين ترسب في بيئة الرف الأوسط – الخارجي، أما الجزء الأوسط من التكوين فهو مترسب ضمن بيئة المنحدر الأعلى- الأوسط، بينما الجزء الأعلى من التكوين فهو مترسب ضمن بيئة الرف الخارجي.

DOI: 10.33899/earth.2023.140401.1086,

Introduction

The Shiranish Formation was described for the first time by Henson (1940; in Bellen *et al.*, 1959) within the high folds range in northern Iraq. The type section of the formation is located near the village of Shiranish Islam in Zakho district, North of Dohuk City in northern Iraq. The Shiranish Formation is widespread in northern Iraq and is represented by the Late Campanian-Maastrichtian sedimentary cycle. The studied section is located in the southwestern limb of Sara anticline in Dukan area, which is at about 67 km northwest of Sulaymaniyah City (Fig. 1). Based on the field observations, the upper contact of the formation is conformable and gradually turned to Tanjero Formation (Upper Maastrichtian), while the lower contact is unconformable with Kometan Formation (Turonian) as shown in Figures (2,3). The thickness of the Shiranish Formation in the studied section reaches 217 m. It consists of successions of marly limestone, grayish-blue marl and thin layers of limestone (Fig.4). Al-Dulaimi (1988) studied the benthic Foraminifera assemblages of the Shiranish Formation in Sinjar area, and he divided the formation into two biozones. Widmark (2000) studied the biogeography of terminal Cretaceous benthic foraminifera in deep- water circulation and tropic gradients in the deep South Atlantic. Kumar and Srinivasan (2004) studied the factor analysis of recent benthic foraminifera from the Coleroon River estuary, Tamilnadu. Abdel-Kireem (1983) studied the sedimentary environment of the Shiranish Formation in northern Iraq based on the Foraminifera fossils, and he determined the environment of the middle slope of the lower part of the formation and the environment of the outer shelf of the upper part of the formation. Al-Atroshi (2007) studied the sedimentology of Shiranish Formation at Dohuk Area. The previous paleoenvironmental studies indicate that the Shiranish Formation was deposited in middle-outer shelf and upper-middle bathyal depositional environments (Malak, 2015). Tamar-Agha *et al*. (2021) studied the sedimentology of the Late Campanian-Maastrichtian sequence, southwestern Iraq. Al- Dulaimi *et al*. (2023) studied the depositional setting of the Shiranish Formation (Campanian-Maastrichtian) in selected sections from northern Iraq.

Aim of study

The present study aims to describe the benthic foraminifera assemblages that obtained from the outcropped section, and interpreting the sedimentary environment of Shiranish Formation.

Materials and Methods

Sixty-three rock samples are collected from outcropped section of Shiranish Formation in the southeastern limb of Sara anticline in Dukan aria, northeast of Iraq. The samples were prepared according to the preparation procedure of Moore and Pitrat (1961), in which 40 gm of each sample was carefully crushed then boiled with distilled water for a period of time ranging between 4-8 hours according to the lithology, then passed through ranged sieves (40, 60, 80 and 100 mesh) to separate the residuals, then dried in the oven and stored in clean bags. The foraminiferal fossils were picked and collected in proper slides.

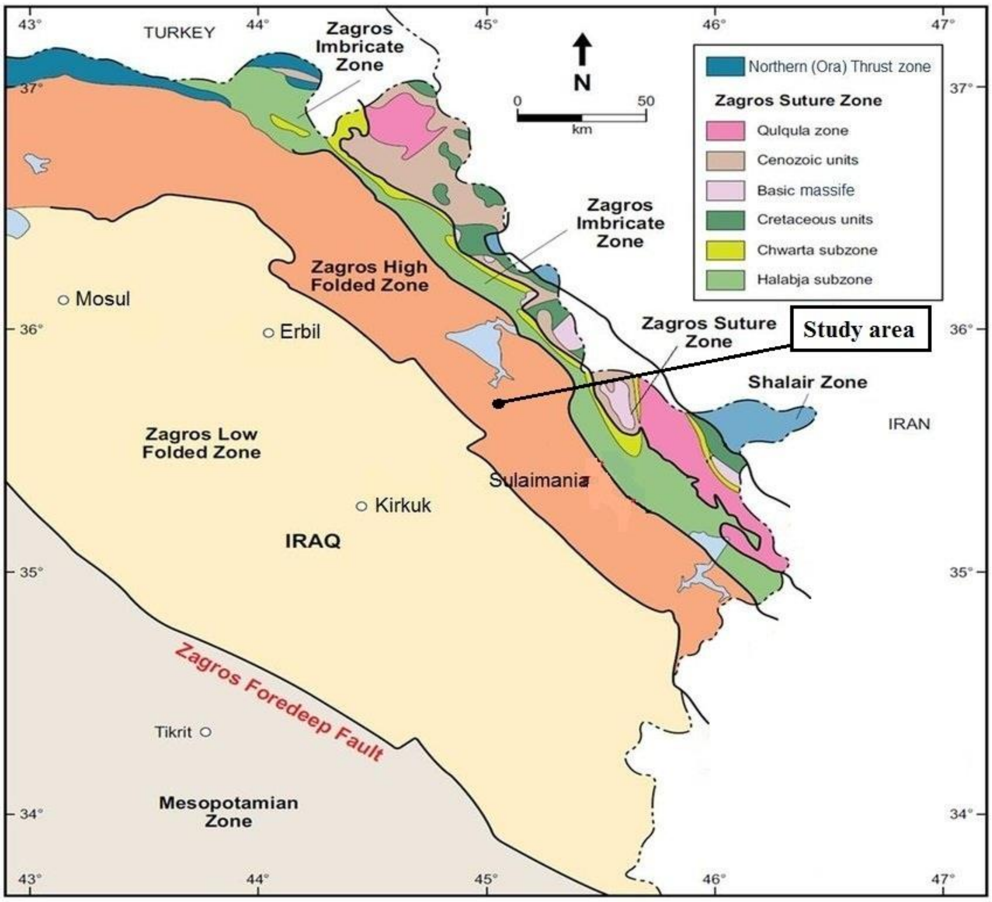


Fig.1. Tectonic Map of Northern Iraq Showing in The Location of The Studied Section (After Al-Qayim el al., 2012)

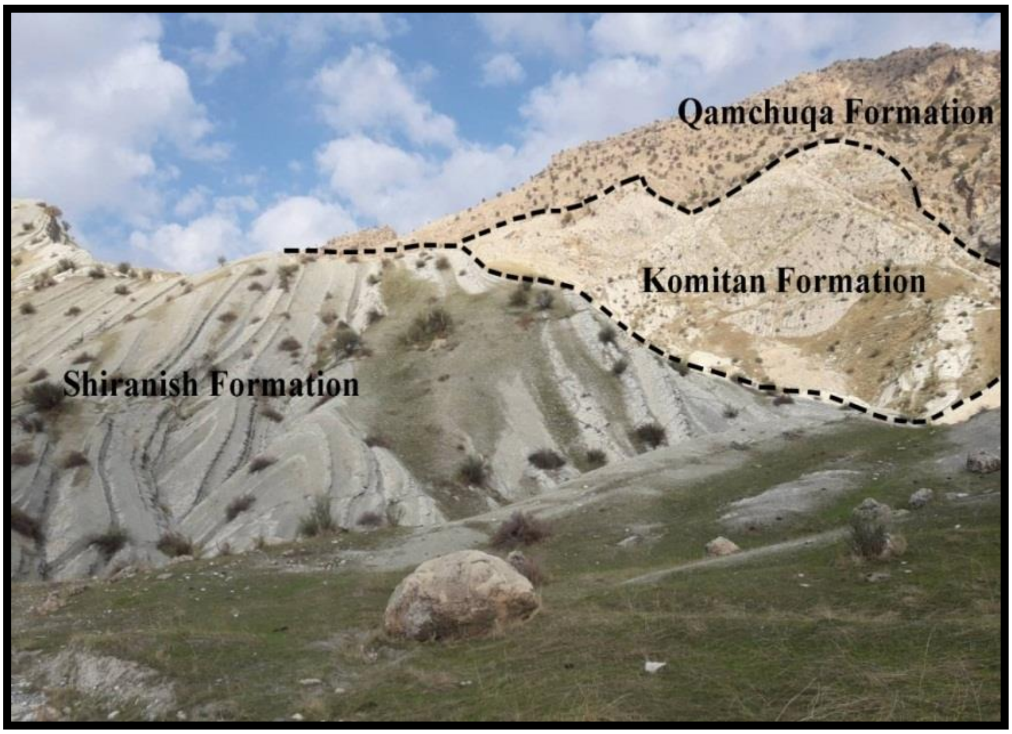


Fig.2. Shows the lower boundary of the Shiranish Formation with the Kometan Formation in the studied section

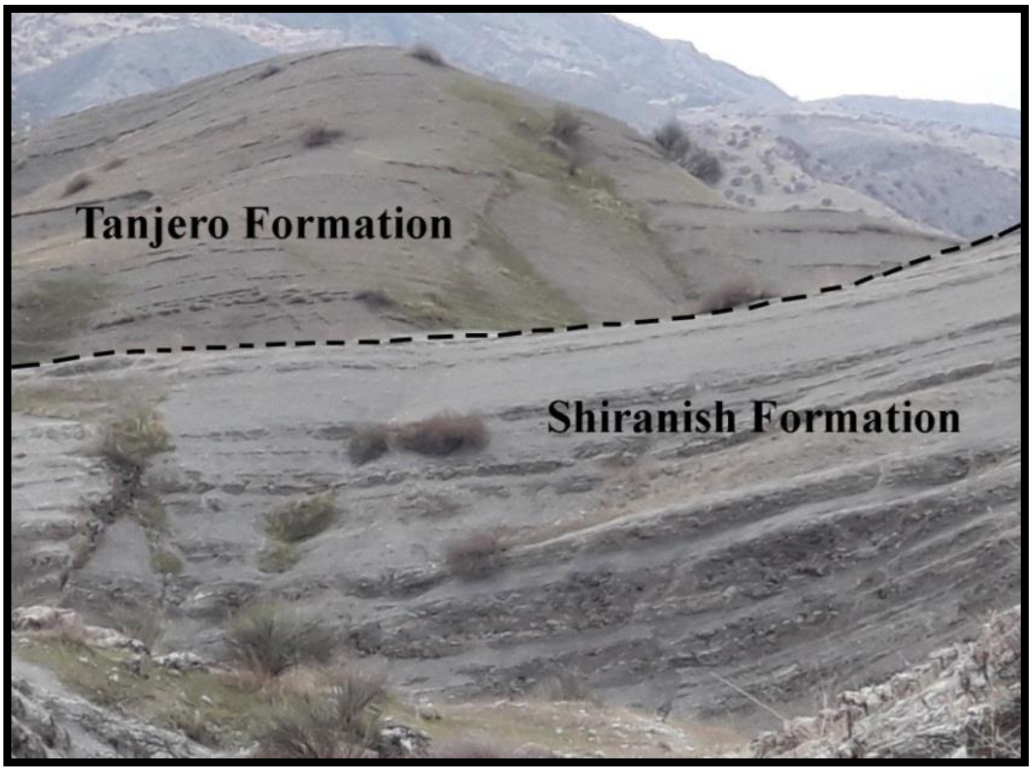


Fig.3. Shows the Upper boundary of the Shiranish Formation with the Tanjero Formation in the studied section

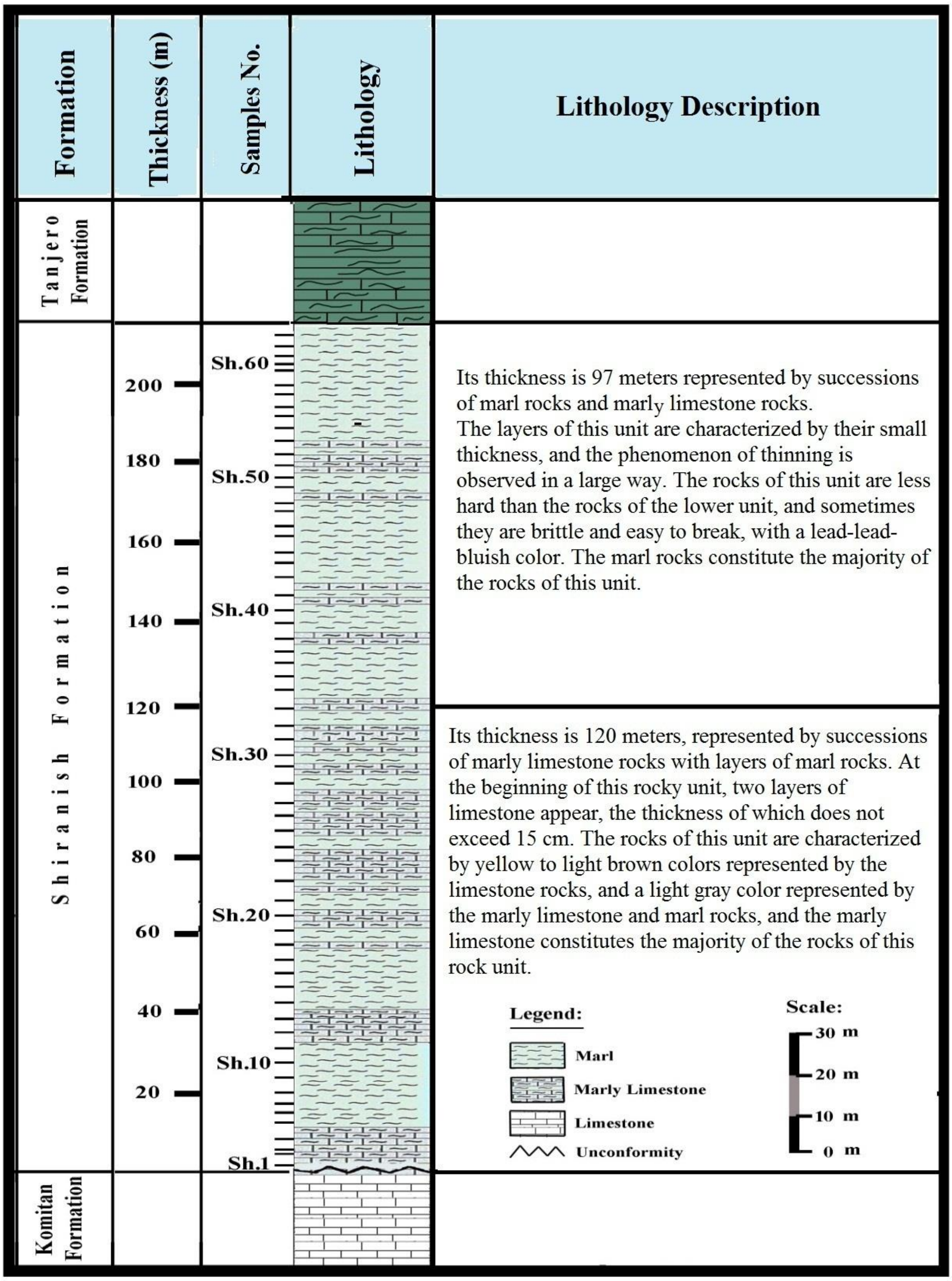


Fig. 4. Stratified column and lithology of Shiranish formation in the studied section

Results and Discussions

Systematic Description of the Benthic Foraminifera

The classification system used to classify the benthonic foraminifera in the present study is the classification system that established by Loeblich and Tappan (1992). The ranges of the obtained foraminifera are shown in Figure (5), As well as identifying and describing benthic foraminifera species based on the following sources: (Loeblich and Tappan, 1987) (Kaminski, 2004) (Pawlowski *et al*., 2013) (Holzmann and Pawlowski, 2017).

Kingdom	**Chromista**	**Cavalier-Smith, 1981**
Phylum	**Foraminifera**	**d`Orbigny, 1826**
Class	**Globothalamea**	**Pawlowski, Holzmann and Tyszka, 2013**
Subclass	**Rotaliana**	**Mikhalevich, 1980**
Order	**Rotaliida**	**Delage and Hérouard, 1896**
Superfamily	**Bolivinitoidea**	**Cushman, 1927**
Family	**Bolivinitidae**	**Cushman, 1927**
Subfamily	**Bolivinitinae**	**Cushman, 1927**
Genus	***Bolivina***	**D'Orbigny,1839**
Type species	***Bolivina plicata* SD**	**Cushman,1911**

Bolivina incrassata Reuss,1851

Pl.1 , Fig.7

1851 *Bolivina incrassata* Reuss, P. 29, Pl.4, Fig.13.
2006 *Bolivina incrassata* Reuss–El–Nady, Pl.1, Fig. 26.

Description: The test is longitudinally shaped, chambers are biserial, suture lines are curved and clear, edge is twisted, this species can be distinguished from type *Bolivina incrassata gigantea* by large size and thickness of the chambers.

Bolivina incrassata gigantea Wicher,1949

Pl.1 , Fig.8

1949 *Bolivina incrassata gigantea* Wicher, P.57,Pl. 5, Fig. 2–3.
2010 *Bolivina incrassata gigantea* Wicher–Bamerni,P.64, Pl.13, Fig.9.

Description: The test is longitudinal and compressed, the chambers are biserial, suture lines are curved and compressed, edge is rounded.

Class	**Tubothalamea**	**Pawlowski, Holzmann and Tyszka, 2013**
Order	**Spirillinida**	**Hohenegger and Piller, 1975**
Suborder	**Ammodiscina**	**Mikhalevich, 1980**
Superfamily	**Ammodiscoidea**	**Reuss, 1862**
Family	**Ammodiscidea**	**Reuss, 1862**
Subfamily	**Ammodiscinae**	**Reuss, 1862**
Genus	***Ammodiscus***	**Reuss, 1862**
Type Species	***Ammodiscus infimus***	**Bornemann, 1874**

Ammodiscus glabratus Cushman and Jarvis,1928

Pl.1, Fig.1

1928 *Ammodiscus glabratus* Cushman & Jarvis, P.86, Pl.12, Fig.6.
1968 *Ammodiscus glabratus* Cushman & Jarvis – Sliter, P.42, Pl.1, Fig.9.

Description: The test is oval shape and compressed from the sides a secondary chamber is tubular in shape, planispirally coiled and gradually increases size, aperture is located at end of tubular chamber.

Ammodiscus cretaceus (Reuss,1845)

Pl.1, Fig.2

1845 *Operculina cretacea* Reuss, P. 35, Pl. 13, Figs. 64– 65.
2010 *Ammodiscus cretaceous* (Reuss) –AL–Duori, P.70, Pl.12, Fig.2.

Description: The test is planispiral coiling disc shaped, primary chamber is disc shaped, secondary chamber is tubular, coiled one plane and compact with each other, circular aperture is located at end of tubular chamber.

Class	**Monothalamea**	**Haeckel, 1862**
Order	**Astrorhizida**	**Lankester, 1885**
Suborder	**Astrorhizina**	**Lankester, 1885**
Superfamily	**Astrorhizoidea**	**Brady, 1881**
Family	**Rhabdamminidae**	**Brady, 1884**
Genus	***Bathysiphon***	**Sars ,1872**
Type Species	***Bathysiphon Filiformis***	**Sars,1872**

Bathysiphon varans Sliter,1968

Pl.1, Fig.3

1968 *Bathysiphon varans* Sliter, P. 40, Pl.1, Fig. 4.
2020 *Bathysiphon varans* Sliter–AL–Mutiwty, P.79, Pl.14, Fig. 2.

Description: The test is tubular and sinuous, aperture is located at top of test, this type is distinguished from *Bathysiphon vitta,* that it is smaller in diameter and surface of test is rough.

Bathysiphon vitta Nauss,1947

Pl.1, Fig.16

1947 *Bathysiphon vitta* Nauss, P. 334, Pl. 48, Fig. 4
2011 *Bathysiphon vitta* Nauss–Raoof, P. 94, Pl. 15, Fig. 6.

Description: The test is large longitudinal tubular shape, aperture is located at end of test, and wall is smooth.

Class	**Globothalamea**	**Pawlowski, Holzmann and Tyszka, 2013**
Subclass	**Rotaliana**	**Mikhalevich, 1980**
Order	**Rotaliida**	**Delage and Hérouard, 1896**
Superfamily	**Bolivinoidea**	**Glaessner, 1937**
Family	**Bolivinoididae**	**Loeblich and Tappan, 1984**
Genus	***Bolivinoides***	**Cushman,1927**
Type species	***Bolivina draco***	**Marsson,1878**

Bolivinoides draco draco (Marsson,1878)

Pl.1 , Fig.9

1878 *Bolivina draco* Marsson, P. 157, Pl. 3, Figs. 25 a–d.
2009 *Bolivinoides draco draco* (Marsson)–ALHaidary, P.84, Pl.16, Fig .5.

Description: The test is rhombic shape, in cross section it appears lenticular in shape, arrangement of the chambers is biserial and increases in width rapidly, it is characterized by the presence of two parallel shadows in center of test separated by a central groove, and lenticular aperture is located at base of the last chamber.

Bolivinoides angulatus Reiss,1954

Pl.1, Fig.10

1954 *Bolivinoides angulata* Reiss, P.155, Pl. 28, Figs. 1–4.
2006 *Bolivinoides angulatus* Reiss–EL–Nady, Pl. 674, Pl.1, Fig.1–2.

Description: The test is rhombic shape, chambers are angular shape, it is characteristic that distinguishes it from rest of *Bolivinoides* genus.

Phylum	**Foraminifera**	**d`Orbigny, 1826**
Class	**Nodosariata**	**Mikhalevich, 1992 emend. Rigaud *et al.*, 2015**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Vaginulinida**	**Mikhalevich, 1993**
Family	**Vaginulinidae**	**Reuss, 1860**
Subfamily	**Vaginulininae**	**Reuss, 1860**
Genus	***Citharina***	**d'Orbigny,1839**

Type species ***Vaginulina(Citharina)strigillata*** **Reuss,1846**

Citharina suturalis (Cushman,1937)

Pl.1, Fig.14

1937 *Vaginulina suturalis*	Cushman,P.102, Pl.15, Fig.5–7.
1968 *Citharina suturalis*	(Cushman)–Sliter, P.56,Pl.5, Fig.7.

Description: The test has a cylindrical shape, aperture is circular shape, and ornamentation is form of jagged ribs.

Class	**Nodosariata**	**Mikhalevich, 1992 emend. Rigaud *et al.*, 2015**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Vaginulinida**	**Mikhalevich, 1993**
Family	**Vaginulinidae**	**Reuss, 1860**
Subfamily	**Vaginulininae**	**Reuss, 1860**
Genus	***Vaginulina***	**D'Orbigny, 1826**
Type species	***Dentalina confluens***	**Reuss, 1826**

*Vaginulina Plummerae (*Cushman,1937)

Pl.1, Fig.15

1937 *Marginulina plummerae*	Cushman,P.97, Pl.13, Fig.21–23.

Description: The test is longitudinally round and multilocular, arrangement chambers uniserial chambers are rectangular in shape and are closely packed at first then gradually increase in size, suture lines are arched and low.

Class	**Nodosariata**	**Mikhalevich,1992 emend. Rigaud *et al.*, 2015**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Nodosariida**	**Calkins, 1926**
Suborder	**Nodosariina**	**Catkins, 1926**
Superfamily	**Nodosarioidea**	**Ehrenberg, 1838**
Family	**Nodosariidae**	**Ehrenberg, 1838**
Subfamily	**Nodosariinae**	**Ehrenberg, 1838**
Genus	***Dentalina***	**Risso,1826**
Type species	***Nodosaria (Dentaline) cuvieri***	**d'Orbigny,1826**

Dentalina catenula Reuss,1860

Pl.1, Fig.17

1860 *Dentalina catenula*	Reuss, P.185, Pl.3, Fig. 6.
2011 *Dentalina catenula*	Reuss–Raoof,P.92, Pl.15, Fig. 1.

Description: The test is longitudinal, uniserial, chambers are oval to pear shaped, aperture terminal is radial, suture line is low and clear, and ornamentation smooth.

Phylum	**Foraminifera**	**d'Orbigny, 1826**
Class	**Nodosariata**	**Mikhalevich,1992 emend. Rigaud *et al.*, 2015**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Nodosariida**	**Calkins, 1926**
Suborder	**Nodosariina**	**Calkins, 1926**
Superfamily	**Nodosarioidea**	**Ehrenberg, 1838**
Family	**Nodosariidae**	**Ehrenberg, 1838**
Subfamily	**Frondiculariinae**	**Reuss, 1860**
Genus	***Frondicularia***	**Defrance in d'Orbigny,1826**
Type species	***Renulina complanata***	**Defrance, in de Blainville,1824**

Frondicularia verneuiliana d'Orbigny,1840

Pl.1, Fig.21

1840 *Frondicularia verneuiliana* d'Orbigny, P.20, Pl.1, Fig. 32,33.

Description: The test is longitudinally compressed; suture lines are oblique and clear.

Phylum	**Foraminifera**	**d'Orbigny, 1826**
Class	**Globothalamea**	**Pawlowski, Holzmann and Tyszka, 2013**
Subclass	**Rotaliana**	**Mikhalevich, 1980**
Order	**Rotaliida**	**Delage and Hérouard, 1896**
Superfamily	**Planorbulinoidea**	**Schwager, 1877**
Family	**Cibicididae**	**Cushman, 1927**
Subfamily	**Cibicidinae**	**Cushman, 1927**
Genus	***Cibicidoides***	**Thalmann, 1939**
Type species	***Truncatulina mundula***	**Brady, Parker and Jones, 1890**

Cibicidoides hyphalus (Fisher,1969)

Pl.1, Fig.22

1969 *Anomalinoides hyphalus* Fisher, P.197, Pl.3.

1991 *Cibicidoides hyphalus* (Fisher) –Nomura, P.22, Pl.3, Fig.9.

Description: The test has a trochospiral coiling, convex on both sides, multilocular, aperture is arched in shape extending from the umbilical side to circumferential side, the suture lines are arched and deep, edge is lobed.

Class	**Globothalamea**	**Pawlowski, Holzmann and Tyszka, 2013**
Subclass	**Textulariana**	**Mikhalevich, 1980**
Order	**Lituolida**	**Kaminski and Mikhalevich in Kaminski, 2004**
Suborder	**Verneuilinina**	**Kaminski and Mikhalevich in Kaminski, 2004**
Superfamily	**Verneuilinoidea**	**Cushman, 1911**
Family	**Verneuilinidae**	**Cushman, 1911**
Subfamily	**Verneuilininae**	**Cushman, 1911**
Genus	***Gandryina***	**d'Orbigny, 1839**
Type species	***Gandryina rugosa***	**Cushman, 1911**

Gaudryina laevigata Franke, 1914

Pl.1, Fig.23

1914 *Gandryina laevigata* Franke, P.431, Pl.27, Fig. 1–2.

1964 *Gandryina laevigata* Franke –Martin, P.52, Pl.3, Fig. 2.

Description: The test is conical shape, arrangement of the chambers is biserial and triangular in shape, aperture is concave at base of last chamber, and suture lines wavy.

Gandryina pyramidata Cushman,1926

Pl.1, Fig.4

1926 *Gandryina laevigata* Franke Var. *pyramidata* Cushman, P.578, Pl.16, Fig.8.

2007 *Gandryina pyramidata* Cushman –Sharbazeri, Pl.14, Figs.4–6.

Description: The shape of test is pyramidal, arrangement chambers biserial, aperture semicircular inner edge of last chamber, suture lines are zigzag, ornamentation smooth type.

Class	**Globothalamea**	**Pawlowski, Holzmann and Tyszka, 2013**
Subclass	**Rotaliana**	**Mikhalevich, 1980**
Order	**Rotaliida**	**Delage and Hérouard, 1896**
Superfamily	**Chilostomelloidea**	**Brady, 1881**
Family	**Gavelinellidae**	**Hofker, 1956**

Subfamily Gavelinellinae Hofker, 1956
Genus *Gavelinella* Brotzen,1942
Type species *Discorbina pertusa* Marsson, 1878

Gavelinella henbesti (Plummer,1936)

Pl.1, Fig.5

1936 *Anomalina henbesti* Plummer, P.290, Pl.5, Figs.7–10.
2010 *Gavelinella henbesti* (Plummer) – Bamerni, P.74, Pl.16, Figs.4, a,b.

Description: The test has a trochospiral coiling, convex, chambers increase in size gradually, suture lines are radial, and aperture low arc shaped extending from the edge to umbilical side.

Gavelinella sandidgei (Brotzen,1936)

Pl.1, Fig.6

1936 *Cibicides sandidgei* Brotzen, P.191, Pl.14, Fig. 2–4.
2010 *Gavelinella sandidgei* (Brotzen)–AL–Duori, P.92, Pl.11, Fig .1.

Description: The test has a trochospiral coiling, side partly convex, primary chambers are covered by calcareous rugose, aperture is arched, and suture lines are convex.

Gavelinella whitei (Martin,1964)

Pl.1, Fig.11

1964 *Anomalina Whitei* Martin, P.106, Pl.16, Fig.4.
2020 *Gavelinella Whitei* (Martin)–AL–Mutiwty, P.91, Pl.16, Figs.3, a,b.

Description: The test is trochospiral coiling, convex sides, aperture is slit extending from edge to umbilical, and suture lines are curved.

*Gavelinella stephensoni (*Cushman,1938)

Pl.1, Fig.12

1938 *Cibicides stephensoni* Cushman, P.70, Pl.12, Fig.5.
2011*Gavelinella stephensoni* (Cushman)–Raoof, P.87, Pl.14, Fig.3.

Description: The shape of test wide trochospiral, aperture is bare extending to umbilical, suture lines are curved thickened and raised.

Class Nodosariata Mikhalevich, 1992
Subclass Nodosariana Mikhalevich, 1992
Order Vaginulinida Mikhalevich, 1993
Family Vaginulinidae Reuss, 1860
Subfamily Lenticulininae Chapman, Parr and Collins, 1934
Genus *Lenticulina* Lamarck,1804
Type species *Lenticulites rotulata* Lamarck,1804

Lenticulina modesta (Bandy,1951)

Pl.1, Fig.13

1951 *Robulus modestus* Bandy, P.493, Pl. 72, Fig.9.
2020 *Lenticulina modesta* (Bandy)–AL-Mutiwty, P.97, Pl.15, Fig.6a, b.

Description: The test is planispiral coiling, lenticular shape, number chambers 7-9, aperture radial shaped is located at end last chamber, suture lines are curved, and outer edge is sharp.

Lenticulina pondi Cushman,1931c

Pl.1, Fig.24

1931c *Rolmlus pondi* Cushman, P.25, Pl. 2, Fig.9.
1946 *Rolmlus pondi* Cushman – P.52, Pl.16, Fig.1– 5.

Description: The test is trochospiral coiling, disc shaped, suture lines are curved and clear, and outer edge is semicircular.

Lenticulina muensteri (Roemer,1839)

Pl.1 , Fig.25

1839 *Robulina munsteri* Roemer, P.48, Pl. 22, Fig. 29.
2010 *Lenticulina muensteri* (Roemer)–Bamerni, P.61, Pl.12, Fig.8.

Description: The test is planispiral coiling, lenticular shape contains central protrusion number of chambers is 8-12 in last lap, aperture radial, suture lines are thick and clear, has a single keel.

Lenticulina californiensis Trujillo,1960

Pl.2, Fig.1

1960 *Lenticulina californiensis*	Trujillo, P.311, Pl. 45, Fig.7.
1963 *Lenticulina californiensis*	Trujillo–Cushman and Church, P.43, Pl.3, Fig.14.

Description: The test trochospiral coiling, suture lines highly curved, ornamentation smooth, the edge of shell sharp and it has a single keel.

Lenticulina spissocostata (Cushman,1938b)

Pl.2, Fig.2

1938b *Robulus spissocostatus*	Cushman, P.32, Pl.5, Figs.2.
1946*Lenticulina spissocostatus*	Cushman, P.52, Pl.16, Fig.11-14.

Description: The test trochospiral coiling, number of chambers 12-9, radial aperture is located at end last chamber, suture lines are curved and prominent, and shell smooth.

Lenticulina cultrata (Montfort,1808)

Pl.2, Fig.3

1808 *Robulus cultratus*	Montfort, P.215.
2011 *Lenticulina cultrata*	(Montfort)–Raoof, P.70, Pl.11, Figs.7a – b.

Description: The test is biconvex, multilocular, aperture is radial, suture lines are curved, and outer edge is provided with a keel.

Lenticulina tyalorensis (Plummer,1931)

Pl.2, Fig.8

1931 *Astacolus tyalorensis*	Plummer, P.143, Pl.11, Fig.16; Pl.15, Fig.8–11.
2010 *Lenticulina tyalorensis*	(Plummer)–Bamerni, P.61, Pl.12, Fig. 9.

Description: The test trochospiral coiling and biconvex, chambers gradually increase in size, aperture is semi rounded at end of last chamber, suture lines are curved and low, and ornamentation smooth.

Class	**Nodosariata**	**Mikhalevich, 1992**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Nodosariida**	**Calkins, 1926**
Suborder	**Nodosariina**	**Catkins, 1926**
Superfamily	**Nodosarioidea**	**Ehrenberg, 1838**
Family	**Lagenidae**	**Reuss, 1862**
Genus	***Lagena***	**Walker and Jacob,1798**
Type species	***Serpula(Lagena) sulcate***	**Walker and Jacob, 1798**

Lagena hispida Reuss,1863

Pl.1 , Fig.18

1863 *Lagena hispida*	Reuss, P. 335, Pl.6, Figs. 77–79.
2010 *Lagena hispida*	Reuss–AL-Duori, P. 80, Pl.15, Fig. 2.

Description: The test is semi spherical small size, unilocular, aperture is located at the tubular end shell, ornamentation form of soft spines.

Lagena acuticosta Reuss,1862

Pl.1 , Fig.20

1862 *Lagena acuticosta*	Reuss,P. 305, Pl.1, Fig.4.

Description: The test is semi spherical to pear shaped, unilocular, aperture circular located at the tubular end, ornamentation form of longitudinal ribs.

Class	**Tubothalamea**	**Pawlowski, Holzmann and Tyszka, 2013**
Order	**Spirillinida**	**Hohenegger and Piller, 1975**

Suborder	**Ammodiscina**	**Mikhalevich, 1980**
Superfamily	**Ammodiscoidea**	**Reuss, 1862**
Family	**Ammodiscidae**	**Reuss, 1862**
Subfamily	**Usbekistaniinae**	**Vyalov, 1968**
Genus	***Glomospira***	**Rzehak,1885**
Type Species	***Trochammina squamata***	**Jones and Parker,1860**

Glomospira gordialis (Jones and Parker,1860)

Pl.1, Fig.19

1860 *Trochammina squamata* Jones and Parker, P.304, Pl.11, Fig.4.
1946 *Glomospira gordialis* (Jones and Parker)–Cushman, P.18, Pl.1, Figs.38–40.

Description: The test is planispiral coiling first stages, and later stages it becomes with coiling and levels, consisting of semi spherical primary chamber, coiled-tubular secondary chamber.

Class	**Globothalamea**	**Pawlowski, Holzmann and Tyszka, 2013**
Subclass	**Textulariana**	**Mikhalevich, 1980**
Suborder	**Textulariina**	**Delage and Hérouard, 1896**
Superfamily	**Eggerelloidea**	**Cushman, 1937**
Family	**Eggerellidae**	**Cushman, 1937**
Subfamily	**Dorothiinae**	**Balakhmatova, 1972**
Genus	***Marsonella***	**Cushman,1933**
Type species	***Gaudryina oxycona***	**Reuss ,1860**

Marssonella oxycona (Reuss,1860)

Pl.2, Fig.9

1860 *Gaudryino oxycona* Reuss, P.229, Pl. 12, Fig. 3.
2020 *Marssonella oxycona* (Reuss)–AL–Mutiwty,P.99,Pl.14,Fig. 9.

Description: The test is conical in longitudinal section, circular in cross section, end of test is tapering, the chambers in the initial stages trochospiral coiling and then turn into biserial, chambers are narrow and not swollen, and aperture is wide and concave located at base of last chamber.

Class	**Nodosariata**	**Mikhalevich, 1992 emend. Rigaud *et al*., 2015**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Vaginulinida**	**Mikhalevich, 1993**
Family	**Vaginulinidae**	**Reuss ,1860**
Subfamily	**Palmulinae**	**Saidova, 1981**
Genus	***Neoflabellina***	**Bartenstein,1948**
Type species	***Flabellina rugosa***	**d'Orbigny,1840**

Neoflabellina rugosa (d'Orbigny,1840)

Pl.2, Fig.10

1840 *Flabelina rugosa* d'Orbigny, P.23 , Pl.2 , Figs. 4–5,7.
2007 *Neoflabellina rugosa* (d'Orbigny)–Sharbazheri, Pl.15, Fig. 9.
2010 *Neoflabellina rugosa* (d'Orbigny)–AL–Duori, P.79, Pl.13,Fig.6.

Description: Wall material hyaline, Overall appearance leaf-like, Coiling spiral to serial Chamber form V-shaped, Aperture Position terminal, Aperture Form round oval reniform, neck, Sutures raised, straight, thickened, Ornamentation hispid - pustulose, costate.

Neoflabellina pilulifera (Cushman and Campbell,1935)

Pl.2 , Fig.4

1935 *Flabellina pilulifera* Cushman and Campbell, P.67 , Pl.10 , Fig. 6.
1968 *Neoflabellina pilulifera* (Cushman and Campbell)–Sliter, P.71,Pl.8, Fig. 19–20.

Description: The test is triangular shape and compressed, primary chambers are planispiral coiling, later chambers are longitudinal and arched, and suture lines are high and clear.

Neoflabellina jarvisi (Cushman,1935)

Pl.2, Fig.20

1935 *Flabellina jarvisi*	Cushman, P.85, Pl.13, Figs.7–8
2006 *Neoflabellina jarvisi*	(Cushman)–El–Nady, Pl.1, Fig. 27.

Description: This species is distinguished from *Neoflabellina rugosa* by having fewer primary coiled chambers, suture lines more raised, and one or more circular rings at end of each chamber.

Class	**Nodosariata**	**Mikhalevich, 1992 emend. Rigaud *et al*., 2015**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Nodosariida**	**Calkins, 1926**
Suborder	**Nodosariina**	**Catkins, 1926**
Superfamily	**Nodosarioidea**	**Ehrenberg, 1838**
Family	**Nodosariidae**	**Ehrenberg, 1838**
Subfamily	**Nodosariinae**	**Ehrenberg, 1838**
Genus	***Nodosaria***	**Lamarck, 1758**
Type species	***Nautilus radicula***	**Linne, 1758**

Nodosaria limbata d'Orbigny,1840

Pl.2 , Fig.5

1840 *Nodosaria limbata*	d'Orbigny, P. 12, Pl.1, Fig.1
2001 *Nodosaria limbata*	d'Orbigny–Valchev,P.112,Pl.1, Fig.4

Description: The test is longitudinally multilocular, chambers are uniserial spherical to elliptical, aperture is radial and terminal, suture line is straight low and clear, and ornamentation smooth.

Nodosaria sp.

Pl.2, Fig.11

Description: The test is pear shaped, initial chamber is small and the chambers increase in size rapidly, last chamber large size and spherical shape, and suture lines are straight and horizontal.

Nodosaria aspera Reuss,1845

Pl.2, Fig.12

1845 *Nodosaria aspera*	Reuss, P. 26, Pl.13, Fig.14–15.
1946 *Nodosaria aspera*	Reuss – Cushman, P.72, Pl.26, Fig.6.

Description: The test is longitudinally multilocular, arrangement of chambers is uniserial spherical, suture line is low, ornamentation is form of straight ribs along test.

Phylum	**Foraminifera**	**d'Orbigny, 1826**
Class	**Nodosariata**	**Mikhalevich, 1992 emend. Rigaud *et al*., 2015**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Nodosariida**	**Calkins, 1926**
Suborder	**Nodosariina**	**Calkins, 1926**
Superfamily	**Nodosarioidea**	**Ehrenberg, 1838**
Family	**Nodosariidae**	**Ehrenberg, 1838**
Subfamily	**Lingulininae**	**Loeblich and Tappan, 1961**
Genus	**Lingulina**	**D'Orbigny,1826**
Type species	***Lingulina californiensis***	**Martin,1964**

Lingulina sp.

Pl.2 , Fig.6

Description: The test is longitudinally shaped, multilocular, uniserial, chambers gradually increase in size, slit aperture is located at end of last chamber, and suture lines are wavy and low.

Class	**Nodosariata**	**Mikhalevich, 1992 emend. Rigaud *et al*., 2015**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Nodosariida**	**Calkins, 1926**
Suborder	**Nodosariina**	**Calkins, 1926**
Superfamily	**Stilostomelloidea**	**Finlay, 1947**
Family	**Stilostomellidae**	**Finlay, 1947**
Genus	***Siphonodosaria***	**Silvestri,1924**
Type species	***Nodosaria abyssorum***	**Brady,1881**

Siphonodosaria annulifera (Cushman and Bermudez,1936)

Pl.2, Fig.7

1936 Ellipso*nodosaria annulifera*	Cushman and Bermudez, P.28, Pl.5, Figs.8–9.
2006 *Siphonodosaria annulifera*	(Cushman and Bermudez) Ortiz and Thomas, P.132, Pl.11, Fig.6.

Description: The test is longitudinally shaped, multilocular, uniserial, oval aperture is located at end of neck of test, and suture lines are wide and low.

Class	**Globothalamea**	**Pawlowski, Holzmann and Tyszka, 2013**
Subclass	**Rotaliana**	**Mikhalevich, 1980**
Order	**Rotaliida**	**Delage and Hérouard, 1896**
Superfamily	**Chilostomelloidea**	**Brady, 1881**
Family	**Alabaminidae**	**Hofker, 1951**
Genus	***Osangularia***	**Brotzen,1940**
Type species	***Osangularia lens***	**Brotzen,1940**

Osangularia cordieriana (d'Orbigny,1840)

Pl.2, Fig.13

1840 *Rotalina cordieriana*	d'Orbigny, P.33, Pl. 3, Figs. 9–11.
2010 *Osangularia cordieriana*	(d'Orbigny)–AL–Duori,P.89,Pl.13, Fig. 2.

Description: The test trochospiral coiling, coiling side is more convex than umbilical side, the test is characterized by presence of a central protrusion on both sides, aperture is shape of a letter (V), and outer edge is sharp and provided with a keel.

Class	**Nodosariata**	**Mikhalevich, 1992 emend. Rigaud *et al*., 2015**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Polymorphinida**	**Mikhalevich, 1980**
Suborder	**Polymorphinina**	**Mikhalevich, 1980**
Superfamily	**Polymorphinoidea**	**d'Orbigny, 1839**
Family	**Ellipsolagenidae**	**Silvestri, 1923**
Subfamily	**Oolininae**	**Loeblich and Tappan, 1961**
Genus	***Oolina***	**d'Orbigny, 1839**
Type species	***Oolina laevigata***	**SD Galloway and Wissler,1927**

Oolina apiculata (Reuss,1851)

Pl.2, Fig.14

1851 *Oolina apiculata*	Reuss, P. 22, Pl. 2, Fig. 1.
2011 *Oolina apiculata*	Reuss–Raoof, P.96, Pl. 15, Fig. 8.

Description: The test is pear shaped, uniserial, aperture is rounded at end of test, and test smooth.

Oolina delicata Sliter,1968

Pl.2, Fig.15

1968 *Oolina delicate*	Sliter, P. 80, Pl. 10, Fig. 21–22.
1993b *Oolina delicata*	Sliter – Quilty, P. 433, Pl. 3, Fig. 27.

Description: The test is ovoid, uniserial, aperture is radial at end of chamber, and ornamentation smooth.

Class	**Globothalamea**	**Pawlowski, Holzmann and Tyszka, 2013**
Subclass	**Textulariana**	**Mikhalevich, 1980**
Order	**Lituolida**	**Lankester, 1885**
Suborder	**Spiroplectamminina**	**Mikhalevich, 1992**
Superfamily	**Spiroplectamminoidea**	**Cushman, 1927**
Family	**Spiroplectamminidae**	**Cushman, 1927**
Subfamily	**Spiroplectammininae**	**Cushman, 1927**
Genus	***Spiroplectammina***	**Cushman,1927**
Type species	***Textularia agglutinans***	**d'Orbigny,1865**

Spiroplectammina laevis (Roemer,1841)

Pl.2, Fig.16

1841 *Textularia laevis*	Roemer, P.97, Pl.15, Fig.17.
2010 *Spiroplectammina laevis*	(Roemer)–AL–Duori, P.72, Pl.14, Fig. 2.

Description: The test is almost triangular shape. It is planispiral coiling in initial stages and then becomes multilocular. aperture is arched and deep, and suture lines are horizontal to curvilinear shape.

Class	**Nodosariata**	**Mikhalevich, 1992 emend. Rigaud *et al*., 2015**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Polymorphinida**	**Mikhalevich, 1980**
Suborder	**Pleurostomellina**	**Reuss, 1860**
Superfamily	**Pleurostomelloidea**	**Reuss, 1860**
Family	**Pleurostomellidae**	**Reuss, 1860**
Subfamily	**Pleurostomellinae**	**Reuss, 1860**
Genus	***Pleurostomella***	**Reuss,1860**
Type species	***Pleurostomella subnodosa***	**Reuss,1860**

Pleurostomella subnodosa (Reuss,1860)

Pl.2, Fig.17

1860 *Pleurostomella subnodosa*	Reuss, P.204, Pl.8, Fig.2.
1946 *Pleurostomella subnodosa*	Reuss – Cushman, P.132, Pl.55, Fig.1–9.

Description: The test is longitudinally shaped, arrangement of chambers uniserial, chambers are semi rectangular shape, initial chambers are small and later chambers are slightly enlarged, aperture is semi triangular shape covered with a calcareous structure, suture lines are straight and low are inconspicuous at first and then become clear later.

Class	**Globothalamea**	**Pawlowski, Holzmann and Tyszka, 2013**
Subclass	**Rotaliana**	**Mikhalevich, 1980**
Order	**Rotaliida**	**Delage and Hérouard, 1896**
Superfamily	**Nonionoidea**	**Schultze, 1854**
Family	**Pulleniidae**	**Schwager, 1877**
Subfamily	**Pulleniinae**	**Schwager, 1877**
Genus	***Pullenia***	**Parker & Jones, 1862**
Type species	***Nonionina bulloides***	**d'Orbigny ,1846**

Pullenia cretacea Cushman,1936

Pl.2, Fig.18

1936 *Pullenia cretacea*	Cushman, P.75, Pl.13, Fig.8.
2010 *Pullenia cretacea*	Cushman –Bamerni,P.70,Pl.14, Figs .9,a,b.

Description: The test is planispiral coiling, spherical shape, uniserial, aperture is a crescent shaped slit extending from edge to umbilical, and test smooth.

Class	**Nodosariata**	**Mikhalevich, 1992 emend. Rigaud *et al*., 2015**
Subclass	**Nodosariana**	**Mikhalevich, 1992**
Order	**Vaginulinida**	**Mikhalevich, 1993**
Family	**Vaginulinidae**	**Reuss, 1860**
Subfamily	**Marginulininae**	**Wedekind, 1937**
Genus	***Astacolus***	**de Montfort, 1808**
Type species	***Astacolus crepidulatus***	**de Montfort, 1808**

Astacolus sp.

Pl.2, Fig.19

Description: The test is rhombic shape, the primary chambers are folded in one plane, later chambers are uniserial increase in size rapidly, suture lines are arched and low.

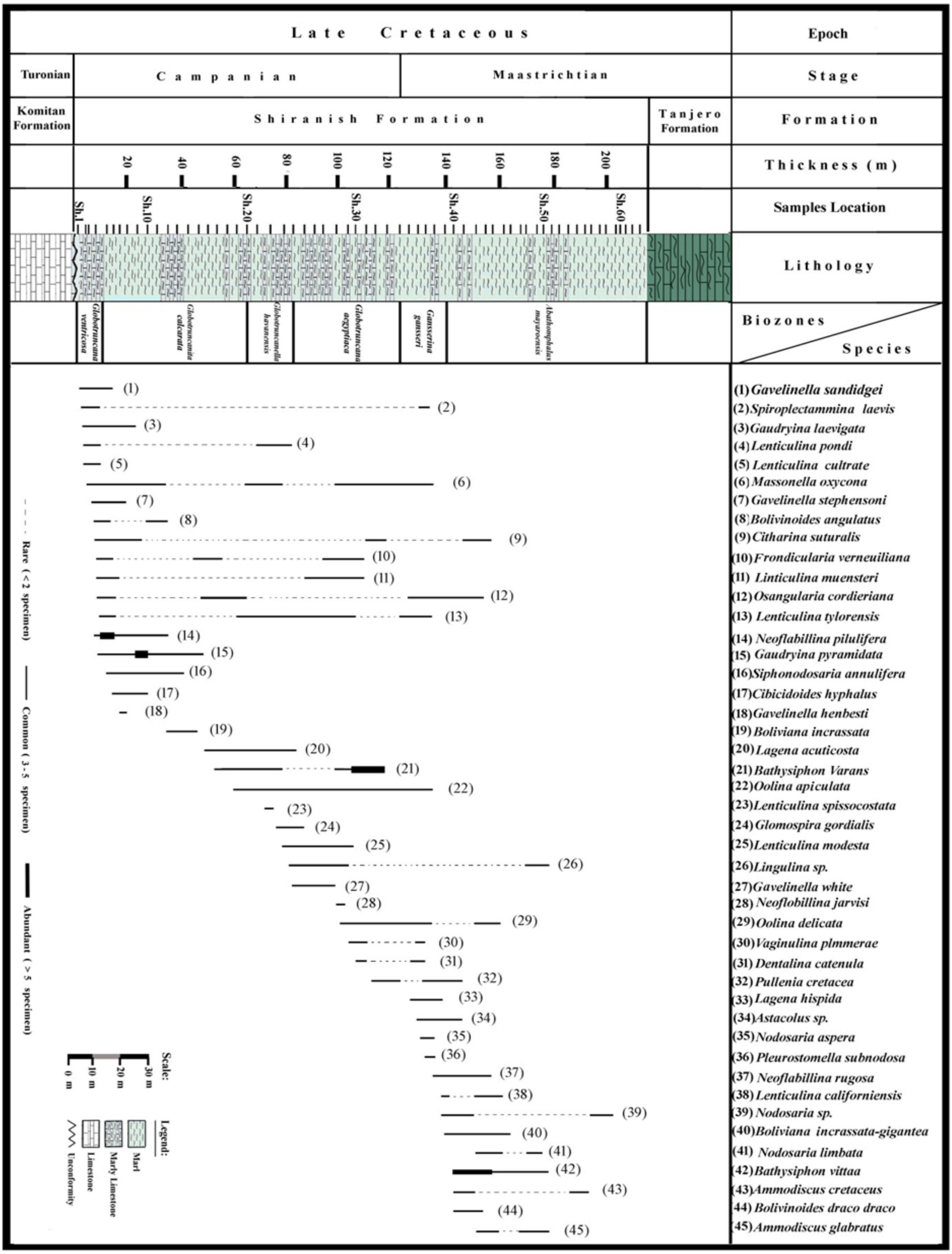
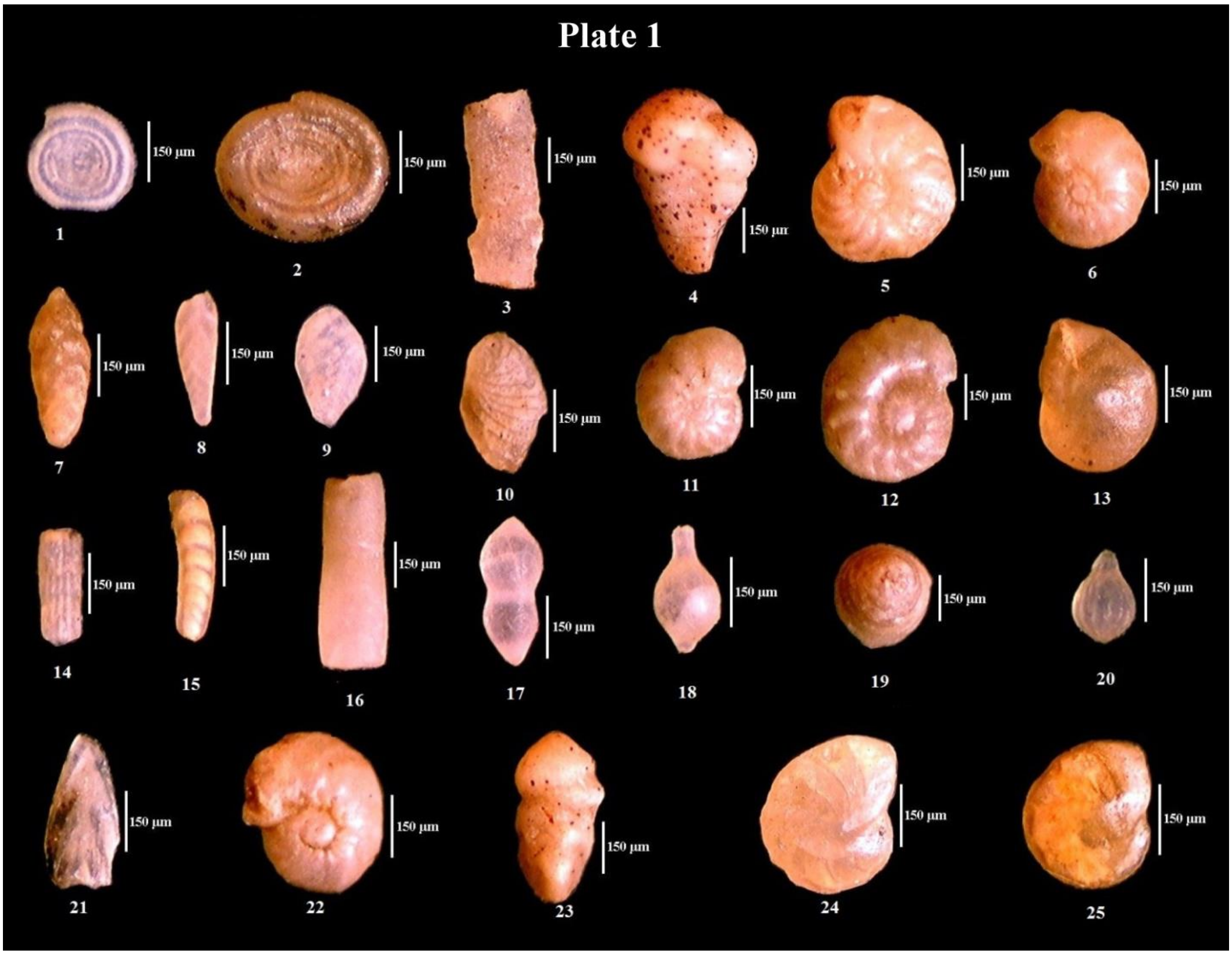
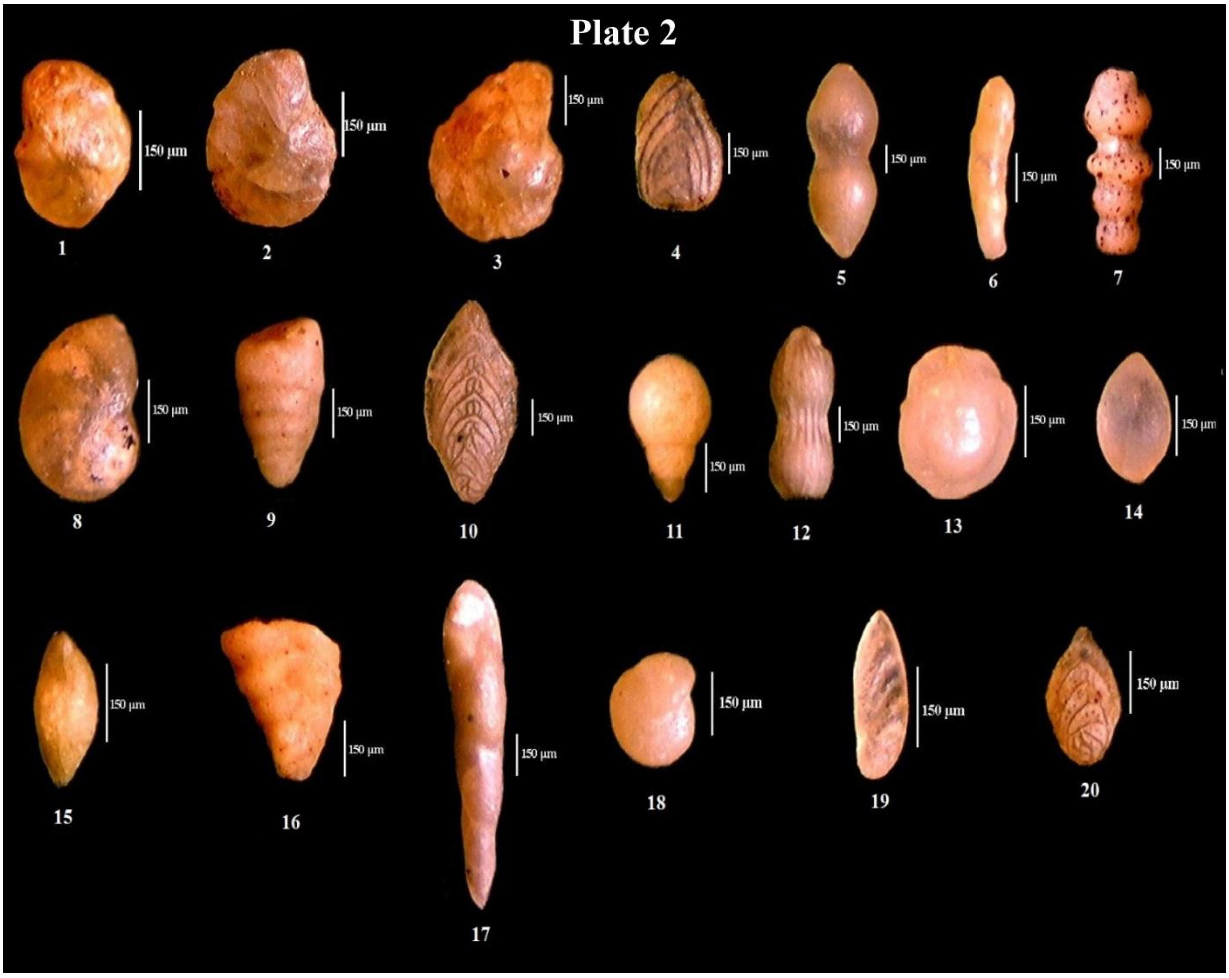


Fig. 5. The geological range of benthic foraminiferal of Shiranish formation in the studied section



Explanation of Plate.1

1)*Ammodiscus glabratus* Cushman and Jarvis Spiral side. Sample No. 44.**2)** *Ammodiscus cretaceous* (Reuss). Spiral side. Sample No. 42. **3)***Bathysiphon varans* Sliter. Side view. Sample No. 33.**4)** *Gandryina pyramidata* Cushman. Side view. Sample No. 4.**5)** *Gavelinella henbesti* (Plummer). Umbilical side. Sample No.7. **6)***Gavelinella sandidage* (Brotzen). Spiral side. Sample No. 2. **7)***Bolivina incrassata* Reuss. Side view. Sample No. 41.**8)** *Bolivina incrassate gigantea* Wicher. Side view. Sample No.12. **9)***Bolivinoides draco draco* (Marsson). Side view. Sample. No. 43.**10)** *Bolivinoides angulatus* Reiss Side view. Sample. No. 10. **11)***Gavelinella whitei* (Martin). Spiral side. Sample No. 25. **12)***Gavelinella stephensoni* (Cushman). Umbilical side. Sample No.6.**13)** *Lenticulina modesta* (Bandy). Spiral side. Sample No. 28. **14)***Citharina suturalis* (Cushman). Side view. Sample No.31. **15)***Vaginulina plummerae* (Cushman). Side view. Sample No.37.**16)** *Bathysiphon vitta* Nauss. Side view. Sample No. 40. **17)***Dentalina catenula* Reuss. Side view. Sample No. 38. **18)***Lagena hispida* Reuss. Side view. Sample No. 36. **19)***Glomospira gordialis* (Jones and Parker). Spiral side. Sample No.23.**20)** *Lagena acuticosta* Reuss. Side view. Sample No. 24.**21)** *Frondicularia verneuiliana* d'Orbigny. Side view. Sample No. 31.**22)** *Cibicidoides hyphalus* (Fisher). Spiral side. Sample No.6.**23)** *Gandryina laevigata* Franke. Side view. Sample No. 3. **24)***Lenticulina pondi* Cushman Spiral side. Sample No. 3. **25)***Lenticulina muensteri* (Roemer). Spiral side. Sample No. 31.



Explanation of Plate.2

1)*Lenticulina californiensis* Trujillo. Spiral side. Sample No. 39.**2)** *Lenticulina spissocostata* (Cushman). Spiral side. Sample No. 21.**3)** *Lenticulina cultrata* (Montfort). Spiral side. Sample No.3. **4)***Neoflabellina pilulifera* (Cushman and Campbell). Side view. Sample No. 4.**5)** *Nodosaria limbata* d'Orbigny. Side view. Sample No. 40. **6)***Lingulina sp*. Side view. Sample No. 37. **7)***Siphonodosaria annulifera*(Cushman and Bermudez). Side view.Sample No.4.**8)***Lenticulina tyalorensis* (Plummer). Spiral side. Sample No. 37. **9)***Marssonella oxycona* (Reuss). Side view. Sample No. 4.**10)** *Neoflabellina rugosa* (d'Orbigny). Side view. Sample No. 38.**11)** *Nodosaria sp.* Side view. Sample No.39. **12)***Nodosaria aspera* Reuss. Side view. Sample No. 37. **13)***Osangularia cordieriana* (d'Orbigny). Spiral side. Sample No. 35.**14)** *Oolina apiculata* Reuss. Side view. Sample No. 37. **15)***Oolina delicata* Sliter. Side view. Sample No. 34.**16)** *Spiroplectammina laevis* (Roemer). Side view. Sample No. 3.**17)** *Pleurostomella subnodosa* Reuss. Umbilical side. Sample No. 37.**18)** *Pullenia cretacea* Cushman. Spiral side. Sample No. 41. **19)***Astacolus sp.* Side view. Sample No. 36.**20)** *Neoflabellina jarvisi* (Cushman). Side view. Sample No. 29.

The sedimentological setting

Determining the sedimentary paleoenvironment is an important factor that used to estimate the nature of sediments' source and the nature of sediments transporting conditions, and paleo depth along the sedimentary basin. In order to determine that, the obtained foraminiferal assemblage has been used as indicator tools. In the current study division of the marine depths was relied by Haq and Boersma (1978) (Fig.6). Olsson and Nyong (1984) used the ratio between the benthic and planktonic (planktonic/benthic + planktonic) (Fig.7) as follow: Less than 8%: Inner Shelf, 8-30 %: Middle Shelf, 30-70%: Outer Shelf, 70-90%: Upper Slope, and M=More than 90%: Middle Slope.

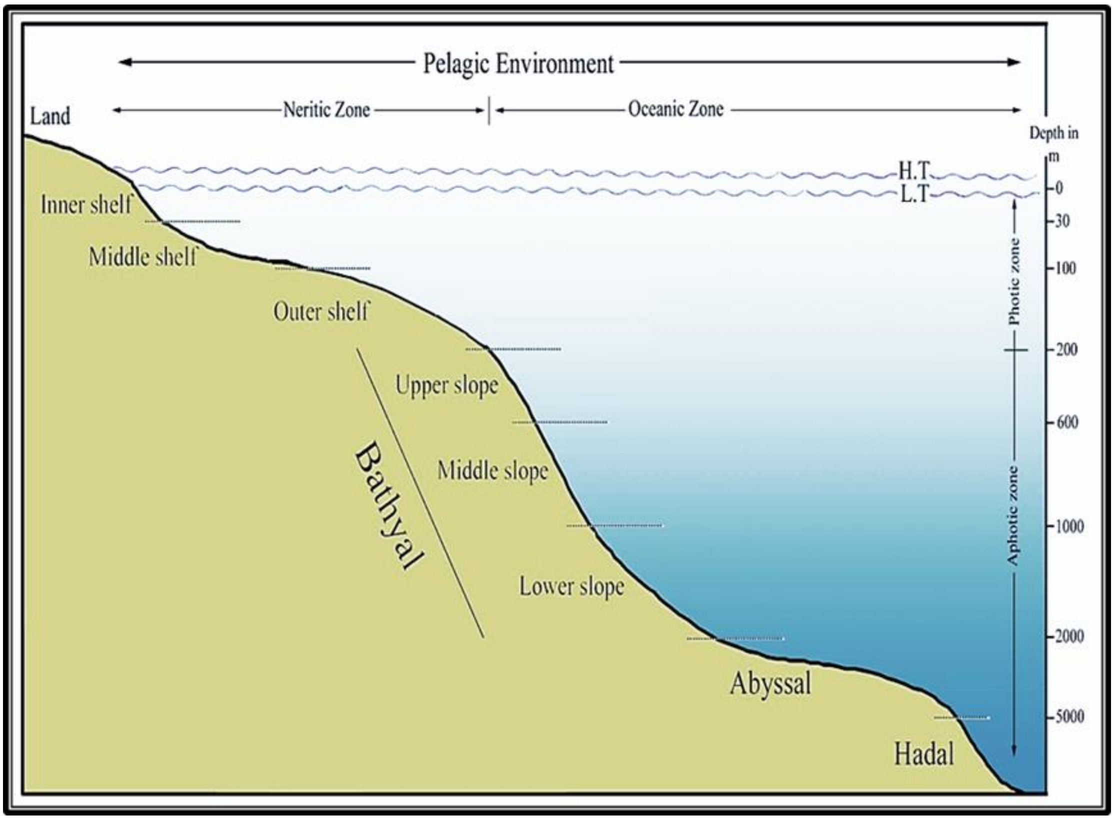


Fig. 6. Subdivisions of marine environments by (Haq and Boersma 1978)

Based on these ratios, seven distinctive environments had been recorded as described below:

1. From sample no.1 to sample no.6 (17 m thick), the planktonic foraminifera ratio is about (50-68%), which represents the outer shelf. This zone is dominated by *Gavelinella Lenticulina Bolivina*, *Bolivinoides.* Sliter and Baker (1972) pointed to that the presence of *Bolivina* indicates the outer shelf environment; Koutsoukos and Hart (1990) indicated that the presence of *Gavelinella* represents middle-outer shelf environment, while Olsson and Usmani (1992) mentioned that the presence of *Bolivinoides* is good indicator of outer shelf environment.
2. From sample no.7 to sample no.12 (20 m thick) with planktonic foraminifera ratio (13-30%) represent the middle shelf dominated by the presence of *Gavelinella*, *Lenticulina*.

(Koutsoukos and Hart, 1990) mentioned that the presence of the *Gavelinella* indicating the middle shelf environment.

3. From sample no.13 to sample no.18 (21 m thick) with planktonic foraminifera ratio (31-66%) represent the middle shelf dominated by the presence of *Lenticulina Bolivina*, *Bolivinoides.* Sliter and Baker (1972) mentioned that the presence of *Bolivina*, is an evidence of outer shelf area. Olsson and Usmani (1992) indicated that the presence of genus *Bolivinoides* represents the outer shelf environment.
4. From sample no.19 to sample no.31 (52 m thick) with planktonic foraminifera ratio (73-90%) represent the upper slope; this zone is dominated by *Lenticulina*, *Frondicularia*, *Lagena*, *Osangularia*, *Oolina*, *Bathysiphon*, *Cibicidoides*, *Marssonella*. Sliter and Baker (1972) mentioned that *Osangularia* is present in the upper slope. The study of Li *et al*. (1999) revealed that the presence of *Lagena hispida* indicates the outer shelf - upper slope. Also, Van Morkhoven *et al*. (1986) showed that genus *Marssonella* is found in the upper slope environment.
5. From sample no.32 to sample no.37 (19 m thick) with planktonic foraminifera ratio (91-97%) represent the middle slope; this zone is dominated by *Osangularia cordieriana*, *Lenticulina taylorensis*, *Lingulina.* Sliter and Baker (1972) and Abdel-Kireem (1983) identified *Osangularia cordieriana* as indicator of slope environments in general and middle slope environment in particular.
6. From sample no.38 to sample no.40 (13 m thick) with planktonic foraminifera ratio (71-90%) represent the upper slope; this zone is dominated by *Lenticulina*, *Bathysiphon*, *Dentalina*, *Nodosaria*. Koutsoukos and Hart (1990) showed that the presence of genus *Bathysiphon* is a distinct evidence of upper slope area.
7. From sample no.41 to sample no.63 (75 m thick) with planktonic foraminifera ratio (30-70%) represent the outer shelf; this zone is dominated by *Lenticulina*, *Neoflabillina*, *Lagena*, *Osangularia*, *Oolina*. Sliter and Baker (1972) indicated that the presence of *Oolina* represents the outer shelf environment. As well as, Li *et al*. (1999) mentioned that the presence of genus *Lenticulina* is an indicator of outer shelf environment.

From all mentioned above, the paleo-depth of sedimentary environment during the deposition of Shiranish Formation in the studied section was as bellows:

1. The lower part from 0-58 m (58 m thick): deposited with depths extending from middle - outer shelf.
2. Middle part from 58-132 m (74 m thick) is deposited with depths extending from upper-middle slope.
3. The upper part from 132-217 (75 m thick) is deposited in outer shelf.

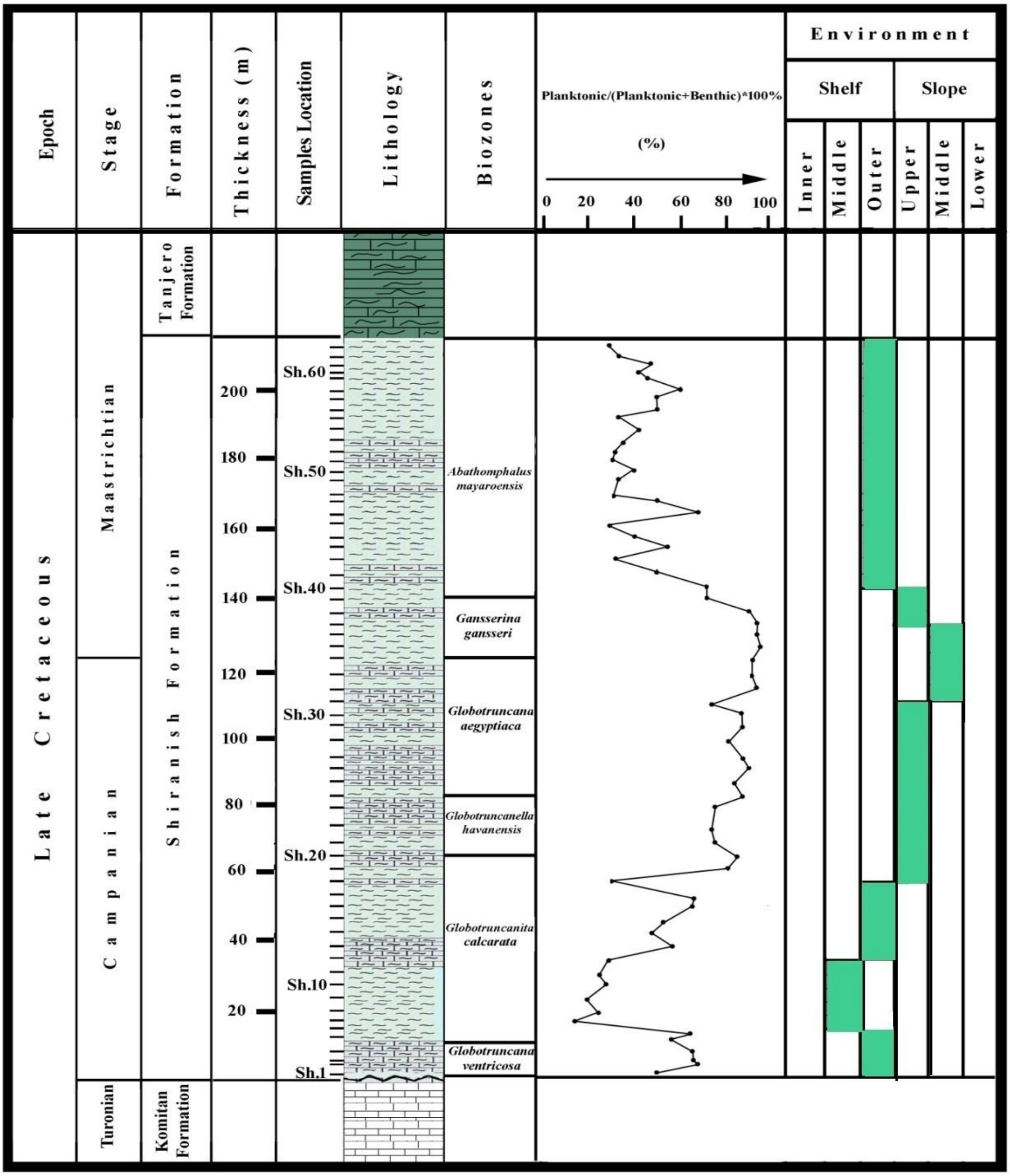


Fig. 7. The Depositional Environment of The Shiranish Formation in The Studied Section

Conclusions

Forty-five species and subspecies of benthic Foraminifera belonging to twenty-five genera are recorded. The sedimentary environment of Shiranish Formation is detected as three parts in the studied section of the Shiranish Formation: the lower part (58 m thick) was deposited in the depths of middle-outer shelf; the middle part (74 m thick) was deposited in the depths of upper-middle slope; and the upper part (75 m thick) was deposited in the outer shelf environment. Such variation in the benthic foraminiferal assemblages is controlled essentially by the interactions between the palae-obasin configuration and sea level changes from the Late Campanian to Early Maastrichtia.

Acknowledgements

The authors express their great gratitude to the College of Science at the University of Mosul for the facilities they provided during the research preparation period, which contributed to improving the quality of this work.

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