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Ammonites and Foraminifera of Shiranish Formation (Late Campanian-Maastrichtian) from Sulaimaniya and Erbil Governorates, Northern Iraq

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Abstract

This study deals with the biostratigraphy of Shiranish Formation (Late Cretaceous), depending on the Ammonite and associated Foraminifera in four outcrop sections, three of which are located in Al-Sulaimaniya governorate (Dokan, Esewa and Kanny dirka sections) and one in Erbil governorate, northern Iraq (Hijran section). Fourteen species of Ammonite belonging to fourteen genera were determined, which are: Dsemoceratidae, Gaudryceras, Gunnarites, Hoplitoplacenticeras, Kitchinites, Kossmaticeratinae, Neancyloceras, Neokossmaticeras, Nostoceras, Paratexanites, Partschiceras, Phylloceras, Pseudophyllites and Yubariceras. Also, thirty- five species of Foraminifera belonging to thirteen genera were determined, which are: Cibicides, Cymopolia, Eggellina, Elphidium, Globigerinelloides, Globotruncana, Hedbergella, Heterohelix, Marginulina, Miliolid, Neobulimmina, Nodosaria and Textularia. Seven range zones were determined, three of which are of Ammonite, which are: Desmophyllites larteti (Seunes, 1892), Nostoceras (Nostoceras) hyatti and Pseudophyllites teres (Van Hoepen, 1920), whereas the others are of Foraminifera species, which are: Glt. gagnebini Tilev, Glt. tricarinata lapparenti Brotzen, Glt. tricarinata tricarinata (Querean) and Glt. Stuartiformis Dalbiez. According to these findings, the age of Shiranish Formation was determined as the Late Campanian- Maastrichtian.

Keywords: Biostratigraphy, Late Cretaceous, Shiranish Formation, Ammonite, Foraminifera, Northern Iraq.

الامونايت والفورامنيفر لتكوين الشيرانش (الكمبانيان المتأخر–الماستريختيان) في محافظة السليمانية واربيل, شمال العراق

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الخلاصة

تناولت هذه الدراسة الطباقية الحياتية لتكوين الشيرانش (الطباشيري الاعلى) أعتمادا على الامونايت والفورامنفيرا المصاحبة لها في اربع مقاطع سطحية,ثلاث منها في محافظة السليمانية وهي مقطع دوكان ومقطع كاني دركه ومقطع ايسوه ومقطع واحد في محافظة اربيل وهو مقطع هجران.

ومن خلال هذه الدراسة تم تشخيص (14) نوع من الامونايت تعود الى (14) جنس وهي:

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Dsemoceratidae, Gaudryceras, Gunnarites, Hoplitoplacenticeras, Kitchinites, Kossmaticeratinae, Neancyloceras, Neokossmaticeras, Nostoceras, Paratexanites, Partschiceras, Phylloceras, Pseudophyllites and Yubariceras.

وكذلك حدد (35) نوعا من الفورامنفيرا والتي تعود الى (13) جنس وهي:

Cibicides, Cymopolia, Eggellina, Elphidium, Globigerinelloides, Globotruncana, Hedbergella, Heterohelix, Marginulina, Miliolid, Neobulimmina, Nodosaria and Textularia.

واعتمادا على تلك المتحجرات تم تحديد سبعة انطقة مدى حياتية, ثلاثة منها للامونايت وهي:

Desmophyllites larteti (Seunes, 1892), *Nostoceras (Nostoceras) hyatti* and *Pseudophyllites teres* (Van Hoepen, 1920).

واربعة انطقة للفورامنفيرا وهي:

Glt. gagnebini Tilev, *Glt. tricarinata lapparenti* Brotzen, *Glt. tricarinata tricarinata* (Querean) and *Glt. Stuartiformis* Dalbiez.

اما عمر التكوين فقد حدد بالكمباني المتأخر – الماسترختي اعتمادا على تلك الانطقة المثبتة محليا واقليميا.

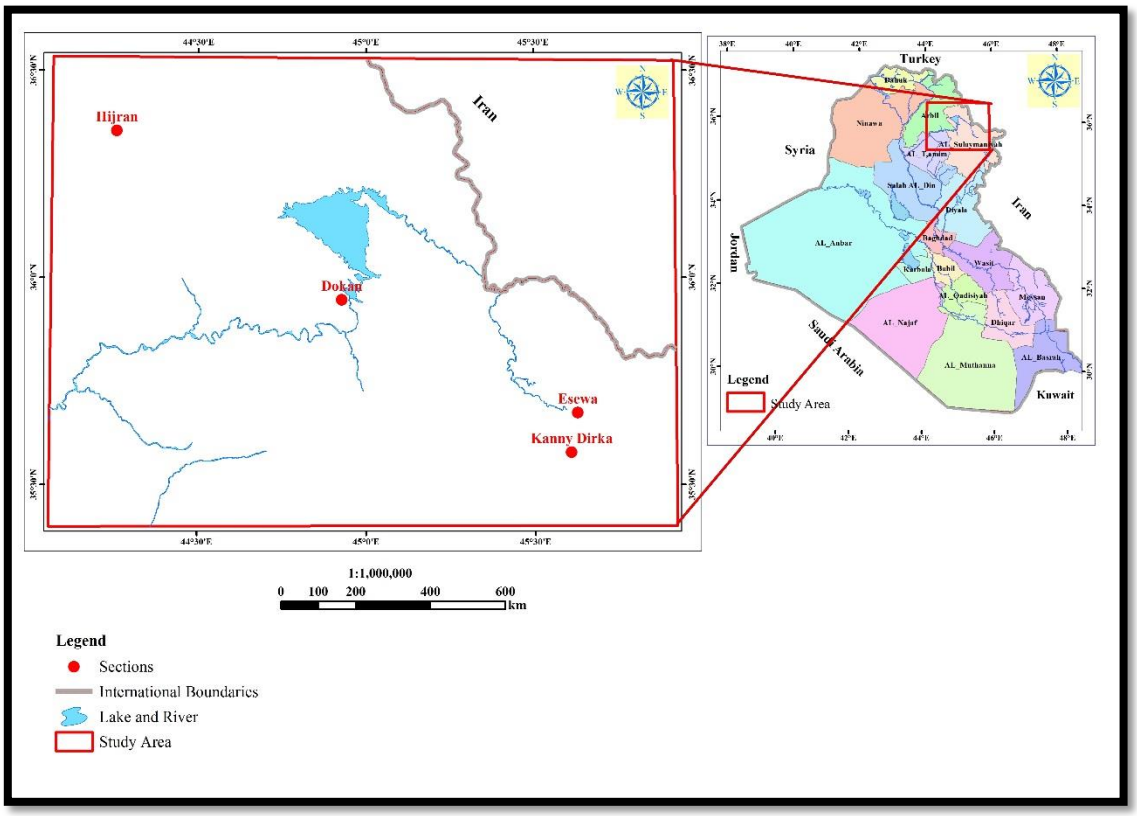


Figure 1-Location map of the study area

Introduction

Starting from earlier studies, Ammonites have been considered as prime biostratigraphic indicators in marine sediments [1-6]. The group generally possesses many of the characteristics of the ideal index fossil: wide, rapidly attained geographic distribution, high degree of facies independence, rapid evolutionary rates, and high preservation potential. Ammonites are conspicuous and commonly determinable even when fragmentary. These factors allow the recognition of fine biostratigraphic subdivisions that are correlatable over long distances [7].

As for planktonic Foraminifera, their use as guide fossils is generally accepted today. The Planktonic Foraminifera, being of practical use in biostratigraphy, first occurred during the Early Cretaceous. They have continued to distribute on a worldwide scale, and in a rapid succession of species, to the recent time [8].

Comprehensive studies dealing with the Late Cretaceous Ammonite- Foraminifera association within Shiranish Formation are limited. However, the present study of Shiranish Formation was conducted at four selected geological sections, which are Dokan, Hijran, Esewa and Kanny dirka (Figure 1). The current study aims to determine the biostratigraphy of the formation depending on the Ammonite fossils with Foraminifera associations.

Results and Discussion

According to the fossil associations of the Ammonites and Foraminifera, seven biozones were determined; three are related to the Ammonites and the other four are related to the planktonic Foraminifera. The following is a description of the recorded fossils in each section.

Biostratigraphy of Dokan Section

Various macrofauna were identified in the sediments of Shiranish Formation at the Dokan section (Figure 2). These include the following Ammonite species:

Desmophyllites larteti (Seunes, 1892) (Pl.1, Figures 3, 4), *Gaudryceras denseplicatum* (Jimbo, 1894) (Pl.1, Figures 1, 2), *Gunnarites* Kilian & Reboul, 1909 (Pl.3, Figures 5, 6), *Hoplitoplacenticeras (Hoplitoplacenticeras)* Preyi sp. (Pl.5, Figures5,6), *Kitchinites* Kennedy & Summesberger, 1999 (Pl.2, Figures1,2), *Kossmaticeratinae* gen. et sp. nov. (Pl.3, Figures 2, 3, 4), *Neancyloceras bipunctatum* (Schluter, 1872) (Pl.2, Figures 3, 4), *Nostoceras (Nostoceras)* hyatti (Pl.4, Figures 1, 2, 3), *Phylloceras* Kennedy & Summesberger, 1999 (Pl.1, Figures 5, 6) and *Pseudophyllites teres* (Van Hoepen, 1920) (Pl.4, Figures 4, 5, 6).

The identified macrofauna also included the following Foraminifera:

Bucherina sandidgei Bronnimann and Brown. (Pl.8, Figure 2), *Eggerellina gibbosa* Marie (Pl.6, Figure 4), *Glt. falsocalcarata* Kerdany and Abdelsalam (Pl.6, Figure 1), *Glt. concavata* cyrenaica Barr(Pl.7, Figure 6), *Glt. gagnebini* Tilev (Pl.7, Figure 2), *Glt. marginata* (Ruess) (Pl.7, Figure 4), *Glt. conica* White (Pl.8, Figure 5), *Glt. stuartiformis* Dalbiez (Pl.8, Figure 6), *Glt. tricarinata lapparenti* Brotzen (Pl.7, Figure 5), *Glt. tricarinata tricarinata* (Quereau) (Pl.7, Figure 3), *Globigerinelloides multispina* (Lalicker) (Pl.6, Figures 2&5), *Globigerinelloides bollii* Passagno (Pl.8, Figures 3&4 and Pl.13, Figure 6), *Hedbergella* sp. (Pl.6, Figure 6), *Heterohelix* sp. (Pl.6, Figure 3) and *Textularia* sp. (Pl.6, Figure 1). Other microfossils were also identified, such as Ostracoda shells (Pl.8, Figure 1).

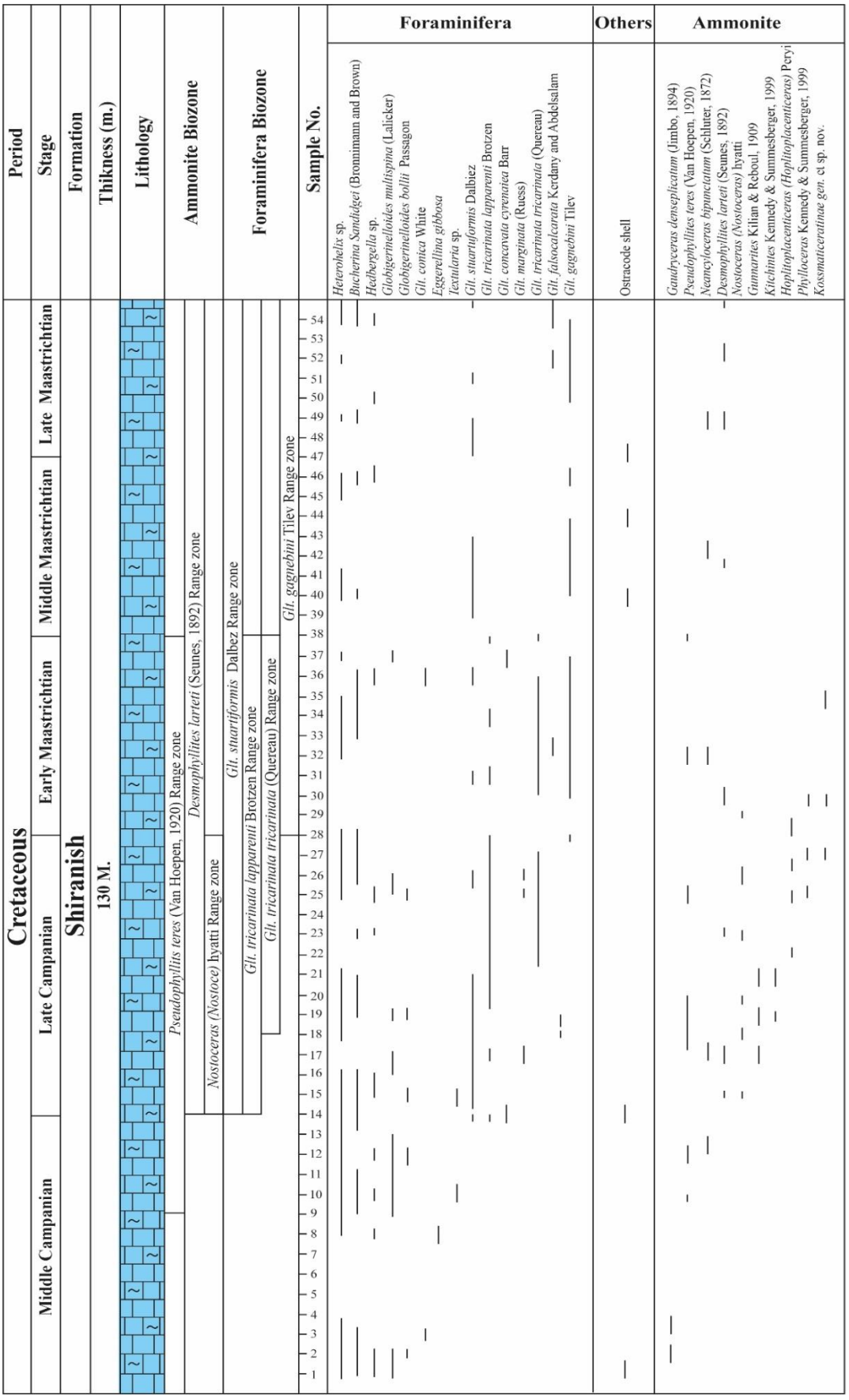


Figure 2-Distribution of Ammonite and Fossils / Dokan section

Biostratigraphy of Hijran Section

Different types of macrofauna were identified in the sediments of Shiranish Formation at the Hijran section (Figure3). These include the following Ammonites:

Desmophyllites larteti (Seunes, 1892) (Pl., Figure), *Gaudryceras denseplicatum* (Jimbo, 1894) (Pl.1, Figures1, 2), *Gunnarites* Kilian & Reboul, 1909 (Pl.3, Figures 5, 6), *Hoplitoplacenticeras (Hoplitoplacenticeras)* Preyi sp. (Pl.5, Figure5, 6), *Kitchinites* Kennedy & Summesberger, 1999 (Pl.2, Figures1, 2), *Kossmaticeratinae* gen. *et* sp. nov. (Pl.3, Figures2, 3, 4), *Neancyloceras bipunctatum* (Schluter, 1872) (Pl.2, Figures3, 4), *Neokossmaticeras redondensis* sp. nov. (Pl.3, Figure1), *Nostoceras (Nostoceras)* hyatti (Pl.4, Figures1, 2, 3), *Paratexanites serratomarginatus* (Redtenbacher, 1873) (Pl.2, Figures5, 6), *Partschiceras? Japonicum* Matsumoto, 1959 (Pl.5, Figures1, 2, 3), *Phylloceras* Kennedy & Summesberger, 1999 (Pl., Figure), *Pseudophyllites teres* (Van Hoepen, 1920) (Pl.4, Figure4,5,6) and *Yubariceras yubarense* (ex YABE ms.) sp. nov. (Pl.5, Figure4).

The identified macrofauna also included the following Foraminifera:

Bucherina sandidgei Bronnimann & Brown (Pl.10, Figure1 and Pl.13, Figure2), *Cibicides* sp. (Pl.12, Figure3), *Cymopolia* sp. (Pl.12, Figure3), *Globotruncana Bulloides* vogler (Pl.11, Figure6), *Globotruncana concavata cyrenaiea* Barr (Pl.9, Figure1), *Glt falsocalcarata* Kerdany and Abdelsalam (Pl.11, Figure4), *Glt. Conica* white (Pl.11, Figure5), *Glt. gagnebini* Tilev (Pl.9, Figure2), *Glt. helvetica* Bolli (Pl.12, Figure4), *Glt. Marginata* (Ruess) (Pl.9, Figure3& 4), *Glt. Stuarti* (de Lapparent) (Pl.9, Figure5), *Glt. Stuartiformis* Dalbiez (Pl.11, Figure1), *Glt. tricarinata lapparenti* Brotzen (Pl.11, Figure2), *Glt. tricarinata tricarinata* (Quereau) (Pl.9, Figure6), *Nodosaria* sp. (Pl.12, Figure2), *Hedbergella sp.* (Pl.13, Figure3), *Globigerinelloides multispina* (Lalicker) (Pl.10, Figures3&4) *Globigerinelloides bollii* Passagno (Pl.10, Figure6 and Pl.13, Figure4), *Heterohelex* sp. (Pl.13, Figure1), *Praeglobotruncana* cf. *delrioensis* (Lplummer) (Pl.11, Figure3) and *Textularia* sp. (Pl.10, Figure2). We also identified othertypes of fossils, such as those of lithoclastic (Pl.13, Figure5), shell fragments (Pl.10, Figure5), and Rotaliid shells (Pl.12, Figure1&5).

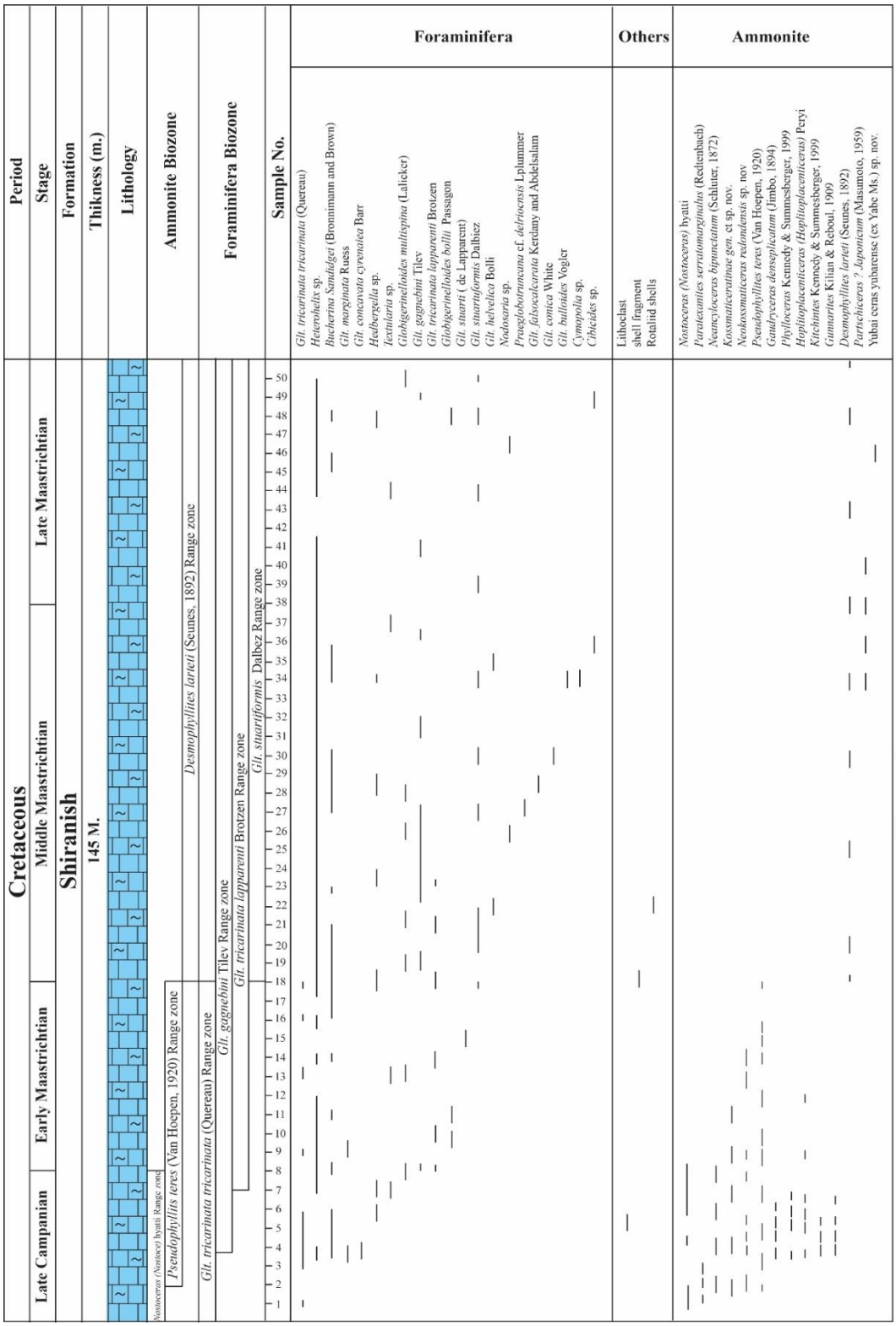


Figure 3-Distribution of Ammonite and Fossils /Hijran section.

Biostratigraphy of Esewa Section

Several macrofauna were identified in the sediments of Shiranish Formation at the Hijran section (Figure4). These include the following Ammonites:

Desmophyllites larteti (Seunes, 1892) (Pl.1, Figures3, 4), *Kitchinites* Kennedy & Summesberger, 1999 (Pl.2, Figures1, 2), *Kossmaticeratinae* gen. *et* sp. nov. (Pl.3, Figures2, 3, 4), *Neancyloceras bipunctatum* (Schluter, 1872) (Pl.2, Figures3, 4), *Nostoceras (Nostoceras)*

hyatti (Pl.4, Figures1, 2, 3) and *Phylloceras* Kennedy & Summesberger, 1999 (Pl.1, Figures5, 6). They also included the following Foraminifera:

Bucherina sandidgei Bronnimann and Brown (Pl.14, Figure1), *Cibicides* sp. (Pl.14, Figure4), *Globigerinelloides multispina* (Lalicker) (Pl.15, Figure3) , *Globigerinelloides bollii* Passagno (Pl.14, Figure2 , Pl.15, Figure1 and Pl.16, Figure2), *Globotruncana gagnebini* Tilev (Pl.15, Figure5), *Hedbergella* sp. (Pl.14, Figure3), *Heterohelix* sp. (Pl.14, Figure6), *Neobulimmina* sp. (Pl.15, Figure6), *Siphonodosaria* sp. (Pl.14, Figure5). Other fossil types were also identified, such as Ostracod shell (Pl.15, Figure4), Rotaliid shells (Pl.15, Figure2) and Echinoderm (Pl.16, Figure1).

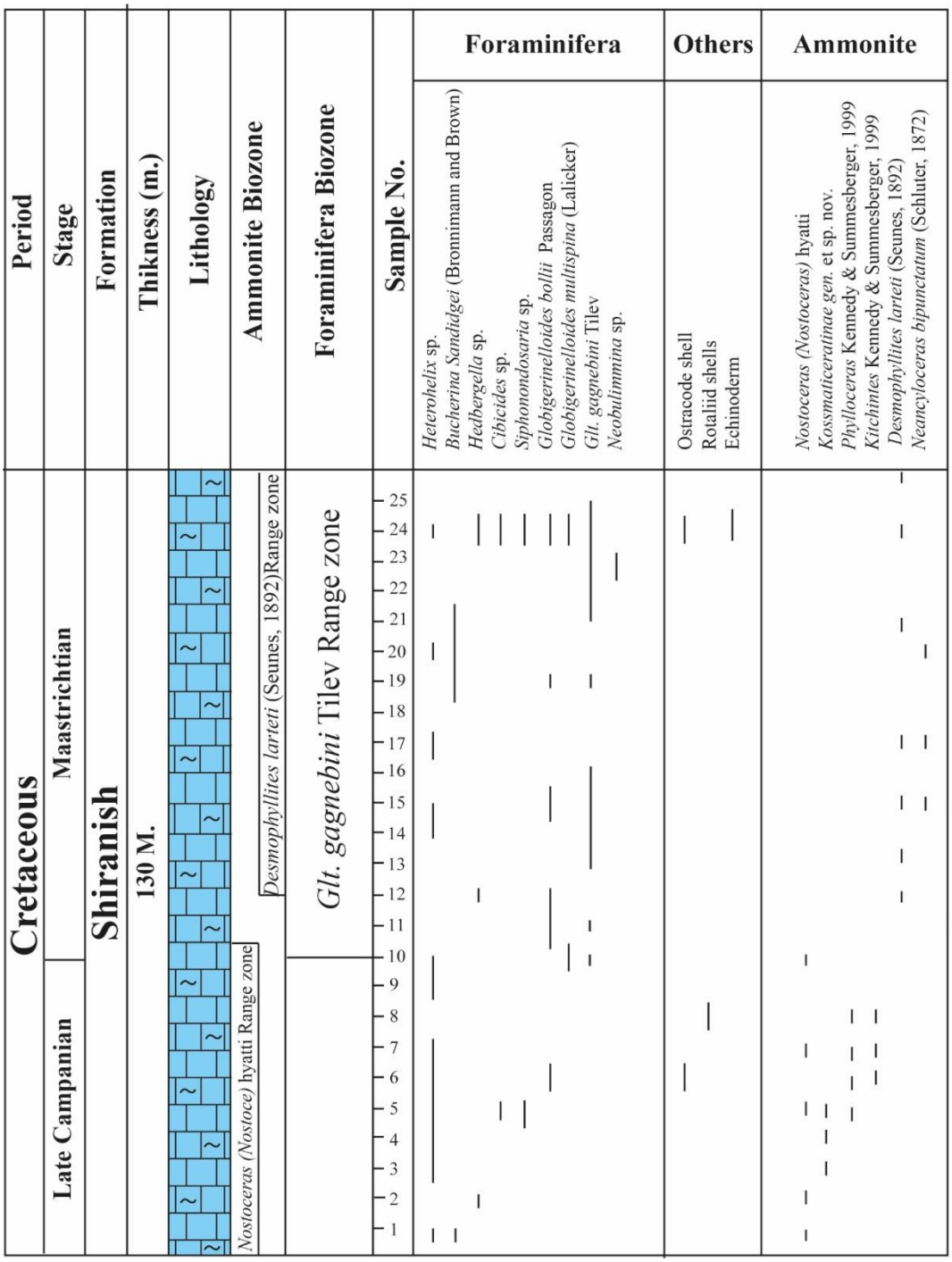


Figure 4-Distribution of Ammonite and Fossils / Esewa section.

Biostratigraphy of Kanny Dirka Section

Various microfauna were identified in the sediments of Shiranish Formation at the Kanny dirka section (Figure5). These include the following Foraminifera:

Bucherina sandidgei Bronnimann (Pl.17, Figures1&3), *Cibicides* sp. (Pl.15, Figure3), *Eggerellina gibbosa* Marie (Pl.16, Figure4 and Pl. 17, Figure4), *Elphidium* sp. (Pl.20, Figure2), *Glt. gagnebini* Tilev (Pl.16, Figure3), *Globigerinelloides multispina* (Lalicker), (Pl.19, Figure3), *Hedbergella* sp. (Pl.19, Figure4), , *Heterohelix striata* Eherenberge (Pl.19, Figure1), *Heterohelex* sp. (Pl.19, Figure2), *Lenticulina* sp (Pl.20, Figure4), *Marginulinoposis* anstinana (Cushman) (Pl.18, Figure2), *Miliolid* sp. (Pl.20, Figure1) *Nodosaria* sp. (Pl.18, Figure1), and others such as: red algae (Pl.17, Figure5), *Echinoderm* spine (Pl.17, Figure2), *Rotalia* sp. (Pl.17, Figure6) and Radiolaria (Pl.18, Figure4).

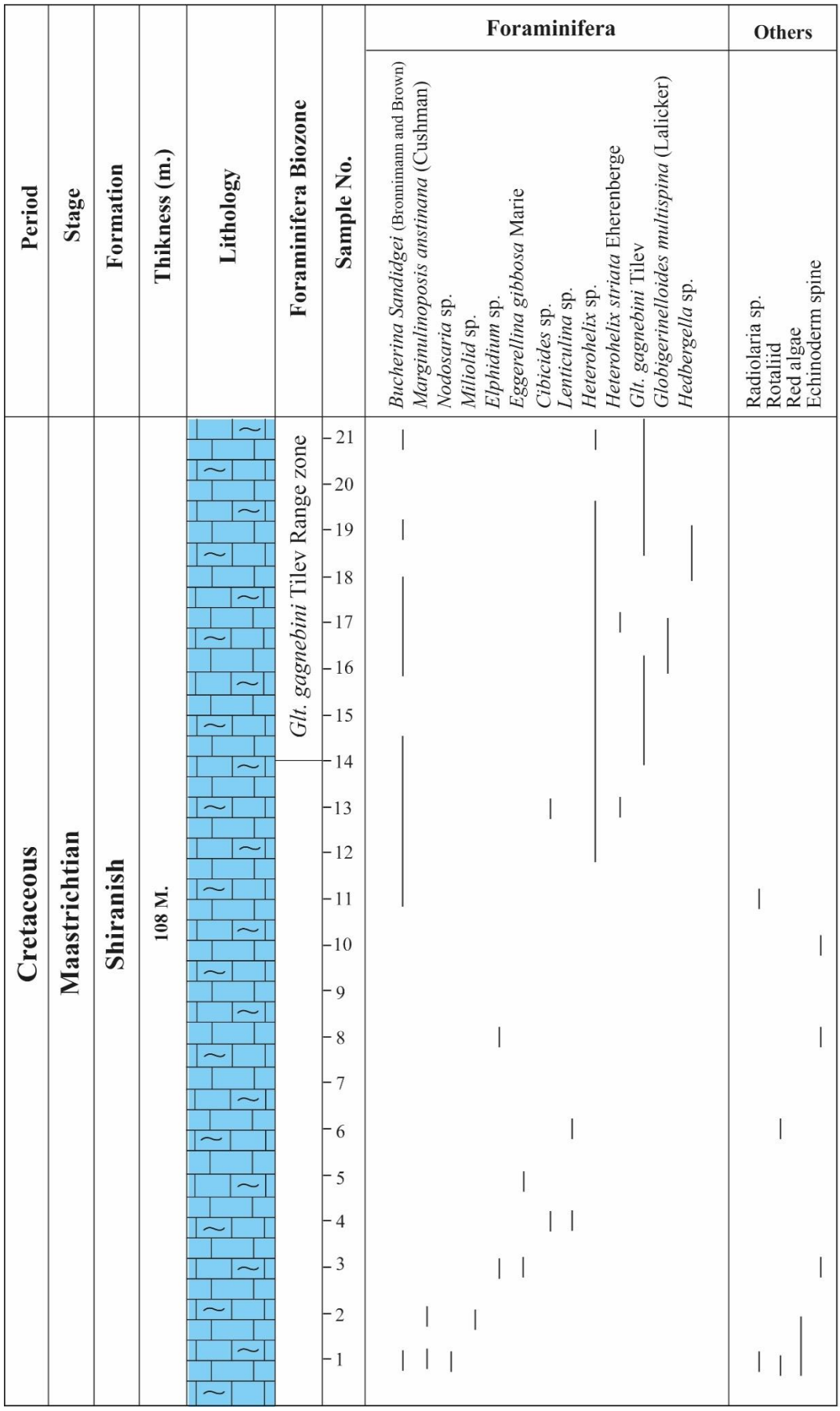


Figure 5-Distribution of Ammonite and Fossils / Kanny dirka section

Biozones of the studied area

Ammonite biozones

The ranges of Ammonites were studied through the stratigraphic sections to determine their biostratigraphic zones. Accordingly, each of the Dokan and Hijran sections were divided into three main biozones, which are *pseudophyllites teres* (Van Hoepen, 1920) biozone, *Desmophyllites larteti* (Seunes, 1892) biozone, and *Nostoceras (Nostoceras) hyatti*, Stephenson, 1941 biozone. While Esewa section was divided into two biozones, which are *Desmophyllites larteti* (Seunes, 1892) biozone and *Nostoceras (Nostoceras) hyatti* (Stephenson, 1941) biozone.

***Pseudophyllites teres* (Van Hoepen, 1920) rang zone**

The lower limit of this biozone is set in accordance with the first appearance of *Pseudophyllites teres* species, whereas its upper limit coincides with the disappearance of this species. The thickness of the zone is 60 m in Dokan section and 34 m in Hijran section. This biozone is coincident with two biozones of Foraminifera within Dokan section, which are *Glt. tricarinata lapparenti* (Brotzen) biozone and *Glt. tricarinata tricarinata* (Querean) biozone. In addition, the presence of *Nostoceras (Nostoceras) hyatti* Stephenson, 1941 Ammonite biozone was recorded, as well as the presence of the following fossils:

Gunnarites Kilian & Reboul, 1909, *Kritchinites* Kennedy & Summesberger, 1999, *Hoplitoplacenticeras (Hoplitoplacenticeras)* Preyi sp., *Phylloceras* Kennedy & Summesberger, 1999 and *Kossmaticeratinae* gen. et. sp. nov.

As for Hijran section, it was found to be coincident with *Glt. tricarinata tricarinata* (Quereau) foraminifera biozone, in addition to the presence of *Nostoceras (Nostoceras) hyatti* Stephenson, 1941 Ammonite biozone and the following fossils:

Gaudryceras denseplicatum (Jimbo, 1894), *Phylloceras* Kennedy & Summesberger, *Hoplitoplacenticeras (Hoplitoplacenticeras)* Preyi sp., 1999, *Kritchinites* Kennedy & Summesberger, 1999 and *Gunnarites* Kilian & Reboul, 1909. However, the disappearance of this section is coincident with the appearance of *Desmophyllites larteti* (Seunes, 1892) Ammonite biozone.

Age of *Pseudophyllites teres* (Van Hoepen, 1920) rang zone

The age of this zone is dependent on the recorded age of the species *Pseudophyllites teres* in other countries [9], which showed that the range of this species is from the late Santonian to the early Campanian. This range has to be extended to the late Campanian, on the basis of the Gschliefgraben specimen. The geographic range of the species involves Pondoland (South Africa), Madagascar, and possibly Brazil. In the percent study, the age of this zone was determined to be the late Campanian- early Maastrichtian in Dokan and Hijran sections.

***Desmophyllites larteti* (Seunes, 1892) rang zone**

The lower limit of this zone is determined based on the first appearance of this species. Its upper limit coincides with the disappearance of the species (until the sections end). The thickness of the zone is 82 m in Dokan section, 66 m in Hijran section, and 28 m in Esewa section.

This biozone is coincident with *Glt. stuartiformis* Dalbies biozones of foraminifera, along with the presence of foraminfera biozones within Dokan section, which are *Glt. tricarinata lapparenti* Brotzen biozone, *Glt. tricarinata tricarinata* (Querean) biozone and *Glt. gagenbini* Tilev biozones.

In addition, we recorded the presence of *Nostoceras (Nostoceras) hyatti* Stephenson, 1941 Ammonite biozone and the following fossils:

Gunnarites Kilian & Reboul, 1909, *Kritchinites* Kennedy & Summesberger, 1999, *Hoplitoplacenticeras (Hoplitoplacenticeras)* Preyi sp., *Phylloceras* Kennedy & Summesberger, 1999 and *Kossmaticeratinae* gen. et. sp. nov.

As for Hijran section, it is coincident with the appearance of *Glt. Stuartiformis* Dalbies biozone of foraminifera and with the disappearance of *Pseudophyllites teres* (Van Hoepen, 1920) ammonite biozone and *Glt. tricarinata tricarinata* (Quereau) foraminfera biozone. In addition, the presence of the fossils of *Partschiceras? Japonicum* (Motsumoto) and *Yubariceras yubarense* (ex yabe ms.) sp. nov. was observed within this biozone.

As for Esewa section, it is coincident with the appearance of *Glt. gagnebini* Tilev foraminifera biozone and with the disappearance of *Nostoceras (Nostoceras) hyatti* ammonite biozone. It also contains the fossil *Neancyloceras bipunctatum*.

Age of *Desmophyllites larteti* (Seunes, 1892) rang zone

The age of this zone was determined depending on the occurrence of this species within sediments belonging to Campanian- Maastrichtian age in Iraq and other countries. This zone was recorded to belong to the late Campanian to late Maastrichtian in Pyrenees- Atlantiques and Landes in France, the coastal sections of the Biscay region of France and NW Spain, the Gschliefgraben, Austria, and possibly Madagascar [10]; it also ranges from early Maastrichtian to late Maastrichtian of Madagascar [11]. In the present study, it was determined to the late Campanian- late Maastrichtian within Dokan section, middle Maastrichtian- late Maastrichtian within Hijran section, and Maastrichtian within Esewa section.

***Nostoceras (Nostoceras) hyatti* Stephenson, 1941 rang zone**

The lower limit of this zone was determined based on the first appearance of this species and its upper limit coincides with the disappearance of the species. The thickness of the zone is 30 m in Dokan section, 16 m in Hijran section, and 20 m in Esewa section.

This biozone is present within two ammonite biozones, which are *Desmophyllites larteti* (Seunes, 1892) biozone and *Pseudophyllites teres* (Van Hoepen, 1920) biozone, within Dokan section. It also contains the following fossils:

Gunnarites Kilian & Reboul, 1909, *Kritchinites* Kennedy & Summesberger, 1999 and *Hoplitoplacenticeras (Hoplitoplacenticeras)* Preyi sp.

As for Hijran section, it is located within the *Pseudophyllites teres* (Van Hoepen, 1920) zone and contains the fossils of *Paratexanites serratomarginatus* (Redtenbach) and *Neancyloceras bipunctatum* (Schluter, 1872).

The disappearance of this biozone is coincident with the appearance of two foraminifera biozones, which are *Glt. gagnebini* Tilev biozone and *Glt. tricarinata lapparenti* Brotzen biozone. Within Esewa section, the disappearance of this biozone is coincident with the appearance of *Desmophyllites larteti* (Seunes, 1892) Ammonite biozone and *Glt. gagnebini* Tilev Foraminfera biozone. In addition, it contains the following fossils:

Kossmaticeratinae gen. *et* sp. nov., Phylloceras Kennedy & Summesberger, 1999 and Kitchinites Kennedy & Summesberger, 1999.

Age of *Nostoceras (Nostoceras) hyatti* Stephenson, 1941 rang zone

The age of this zone is dependent on the age of the species *Nostoceras (Nostoceras) hyatti* in Iraq and other countries. This species is widespread worldwide and represents the last range of the Campanian age, where the period after its last appearance was that of the beginning of the Maastrichtean [12]. These countries include France, the United States of America, Spain, Belgium, Poland, Angola, Madagascar, Palestine, and Iraq [13, 14]. Also, it was recorded to belong to the late Campanian age in the lower part of Shiranish Formation, NW Iraq [15]. In the percent study, the age of this zone was determined to be the late Campanian within each of Dokan, Hijran, and Esewa sections, depending on the age of the species *Nostoceras (Nostoceras) hyatti*.

Foraminifera biozones

Through the detailed biostratigraphic study of Shiranish Formation, depending on the

presence of planktonic and benthonic foraminifera, four biozones were recognized in each of Dokan and Hijran sections, which are *Globotruncana Stuartiformis* Dalbiez biozone, *Glt. tricarinata lapparenti* Brotzen biozone, *Glt. tricarinata tricarinata* (Querean) biozone, and *Glt. gagnebini* Tilev biozon . Also, *Glt. gagnebini* Tilev biozone was recorded in Esewa and Kanny dirka sections. The description and discussion of the biozones are manifested below,

***Globotruncana stuartiformis* Dalbiez rang zone**

This zone is identified depending on the range of extension of *Glt. stuariformis* species. The lower limit of the zone was identified according to the occurrence of this species, whereas the upper limit was determined based on the last appearance. The thickness of the biozone is 82 m in Dokan section and 66 m in Hijran section.

Within Dokan section, this biozone includes the Foraminfera biozones of *Glt. tricarinata lapparenti* Brotzen, *Glt. tricarinata tricarinata* (Querean), and *Glt.gagnebini* Tilev. The appearance of this biozone is coincident with the appearance of *Glt. tricarinata lapparenti* Brotzen biozone. It also included the fossils of *Glt. concavata* cyrenaiea, *Glt. marginata* (Ruess), and *Globigerinelloides bollii* Passagno.

Within Hijran section, the appearance of this biozone is coincident with the disappearance of *Glt. tricarinata tricarinata* (Quereau) biozone. The section was within *Glt. gagnebini* Tilev biozone and includes the following fossils: *Globigerinelloides bollii* Passagno, *Glt. helvetica* Bolli, *Nodosaria* sp., *Praeglobotruncana* cf. *delrioensis* (Lplummer), *Glt. falsocalcarata* Kerdany and Abdelsalam, *Glt. conica* White, *Glt. bulloides* Vogler, *Cymopolia* sp., and *Cibicides* sp.

Age of the *Globotruncana stuartiformis* Dalbiez rang zone

The age of this zone was determined to be dependent on the age of the species *Glt. stuartiformis* in Iraq and other countries. In north- east Iraq, *Glt. stuartiformis* is one of the abundant species of *Globotruncana,* observed in the Shiranish Formation (Campanian-Maastrichtian) [16] and Maastrichtian within Sinjar area [17]. The species was originally described to be from the Campanian- early Maastrichtian strata of Tunisia. It is also known from the strata of similar ages in Texas and Puerto Rico [18-20], New Jersey [21], and the Maestrichtian of Egypt [22]. *Glt. stuartiformis* was also recorded from the Campanian-Maastrichtian of Europe and Russia. Dalbiez [23] described *Glt. stuartiformis* as a subspecies of *Glt.elevata* (Brotzen) from the Campanian- Lower Maastrichtian of Tunisia [24]. In the present study, it was determined to belong to the late Campanian- late Maastrichtian in Dokan section and middle Maastrichtian- late Maastrichtian within Hijran section.

***Globotruncana tricarinata lapparenti* Brotzen rang zone**

This zone is identified depending on the range of extension of *Glt. tricarinata lapparenti* subspecies. The lower limit of this zone is determined based on the first appearance of this species and its upper limit coincides with disappearance of the species. The thickness of the biozone is 50 m in Dokan section and 32 m in Hijran section.

In Dokan section, this biozone is within *Glt. stuartiformis* Dalbies biozone and includes *Glt. tricarinata tricarinata* Brotzen biozone along with the fossils of *Glt. concavata cyrenaiea, Glt. marginata* (Ruess) and *Globigerinelloides bollii* Passagno.

Within Hijran section, the appearance of this biozone is coincident with the appearance of *Glt. gagnebini* Tilev biozone and includes the fossils of *Globigerinelloides multispina* (Lalicker) and *Glt. Stuartiformis* (de' lapparent).

Age of *Glt. tricarinata lapparenti* Brotzen rang zone

This biozone is recorded depending on the occurrence of this species within sediments in Iraq and other countries, as in the following:

This species is recorded from the Campanian portion of the Shiranish Formation where it occurs rather commonly [16]. De Lapparent's original figures are of specimens from strata within the Turonian to Campanian interval in Europe. The subspecies is also recorded from

strata of early Santonian to early Maastrichtian age of Mexico and Texas [20], Santonian-Campanian of Puerto Rico [18, 19], and Santonian- Lower Maestrichtian of Trinidad [25]. It is also known in the strata of the similar age in Russia [26], Australia [16, 27, 28], and North Africa [29]. In the present study, it was determined in the late Campanian- early Maastrichtian within Dokan section and early Maastrichtian- middle Maastrichtian within Hijran section**.**

***Globotruncana tricarinata tricarinata* (Querean) rang zone:**

The lower limit of this zone is set in accordance with the first appearance of this species and its upper limit coincides with the disappearance of the species. The thickness of the biozone is 42 m in Dokan section and 36 m in Hijran section.

In Dokan section, this biozone is within *Glt. stuartiformis* Dalbies biozone and *Glt. tricarinata lapparenti* Brotzen biozone.

Within Hijran section, the disappearance of this biozone coincides with the appearance of *Glt. stuartiformis* Dalbies biozone and includes the fossils of *Globigerinelloides multispina* (Lalicker) and *Glt. Stuarti* (de' lapparent).

Age of *Glt. tricarinata tricarinata* (Querean) rang zone

The age of this zone was determined depending on the occurrence of this species within sediments recorded in Iraq and other countries, as follows:

Glt. tricarinata tricarinata occurs rather commonly in Campanian portions of the Shiranish Formation [16]. The species was originally described from Campanian to early Maestrichtian strata of Switzerland. Bolli [25] and [30] used the subspecies as a distinctive zonal marker for the Campanian- early Maastrichtian strata of Trinidad and the subsurface Campanian- early Maastrichtian. Strata uncounted in Leg 15 sites in the Caribbean Sea. It is also described from the Campanian of the Carnarvon Basin, north- west Ausralia [27], the Santonian of England [31], and the Campanian- early maestrichtian of Libya [29, 32]. According to previous reports [16, 33], the subspecies is also recorded from the type Campanian section at Aubeterre in the Aquitain Basin. It is also known in the strata of lower Maastrichtian age in New Jersey [21]. Turonian- Maastrichtian worldwide [24, 34] determined the age from the late Maastrichtian of north and west Iraq. In the present study, it is determined in the late Campanian- early Maastrichtian age within each of Dokan and Hijran sections.

***Globotruncana gagnebini* Tilev rang zone**

The lower limit of this zone is set in accordance with the first appearance of this species and its upper limit coincides with the disappearance of the species. The thickness of the biozone is 54 m in Dokan section, 84 m in Hijran section, 32 m in Esewa section, and 16 m in Kanny dirka section.

In Dokan section, this biozone is within *Glt. stuartiformis* Dalbies biozone. Within Hijran section, the appearance of this biozone coincides with the appearance of *Glt. tricarinata lapparenti* biozone and includes each of *Glt. tricarinata lapparenti* Brotzen and *Glt. Stuartiformis Dalbies* biozones. It also includes the following fossils: *Globigerinelloides multispina* (Lalicker), *Globigerinelloides bollii* Passagno, *Glt. stuarti* (de Lapparent), *Glt. helvetica* Bolli, *Nodosaria* sp., *Praeglobotruncana* cf. *delrioensis* (Lplummer), *Glt. falsocalcarata* Kerdany and Abdelsalam, *Glt. conica* White, *Glt. bulloides* Vogler, *Cymopolia* sp., and *Cibicides* sp. Within Esewa section, this biozone includes *Neobulimmina* sp. fossils, whereas within Kanny dirka section, it includes *Globigerinelloides multispina* (Lalicker), *Hedbergella* sp., and *Bucherina sandidgei* Bronnimann fossils.

Age of *Globotruncana gagnebini* Tilev rang zone

The age of this zone was determined depending on the occurrence of this species within sediments belonging to the Maastrichtian age in Iraq and other countries.

The specimens are identical to the specimen figured by an earlier study [21] from the Maastrichtian strata of New Jersey. In the present study, it is determined in the early

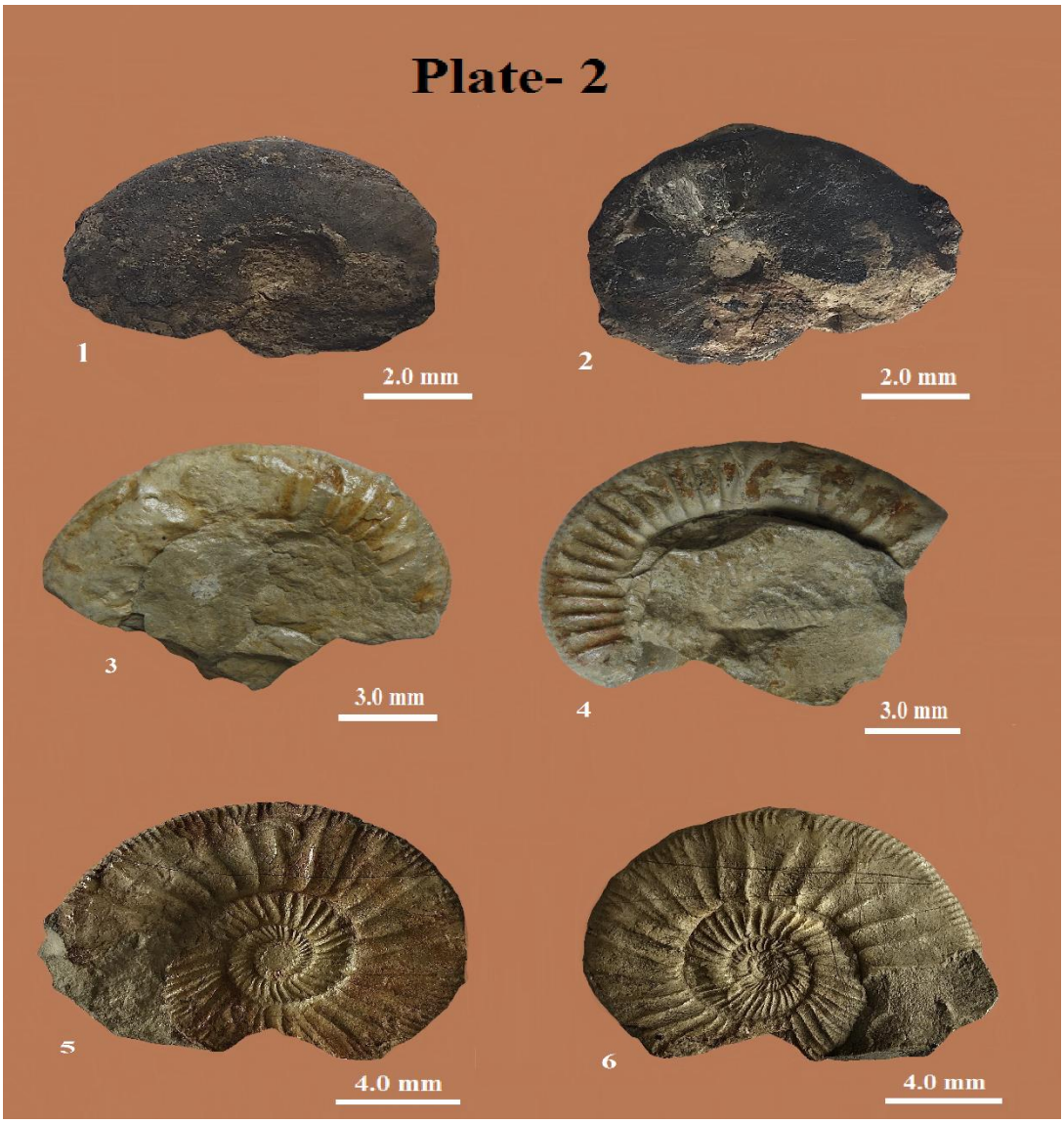
Maastrichtian- late Campanian within Dokan and Hijran sections and the Maastrichtian within Esewa and Kanny dirka sections.

Discussion and conclusions

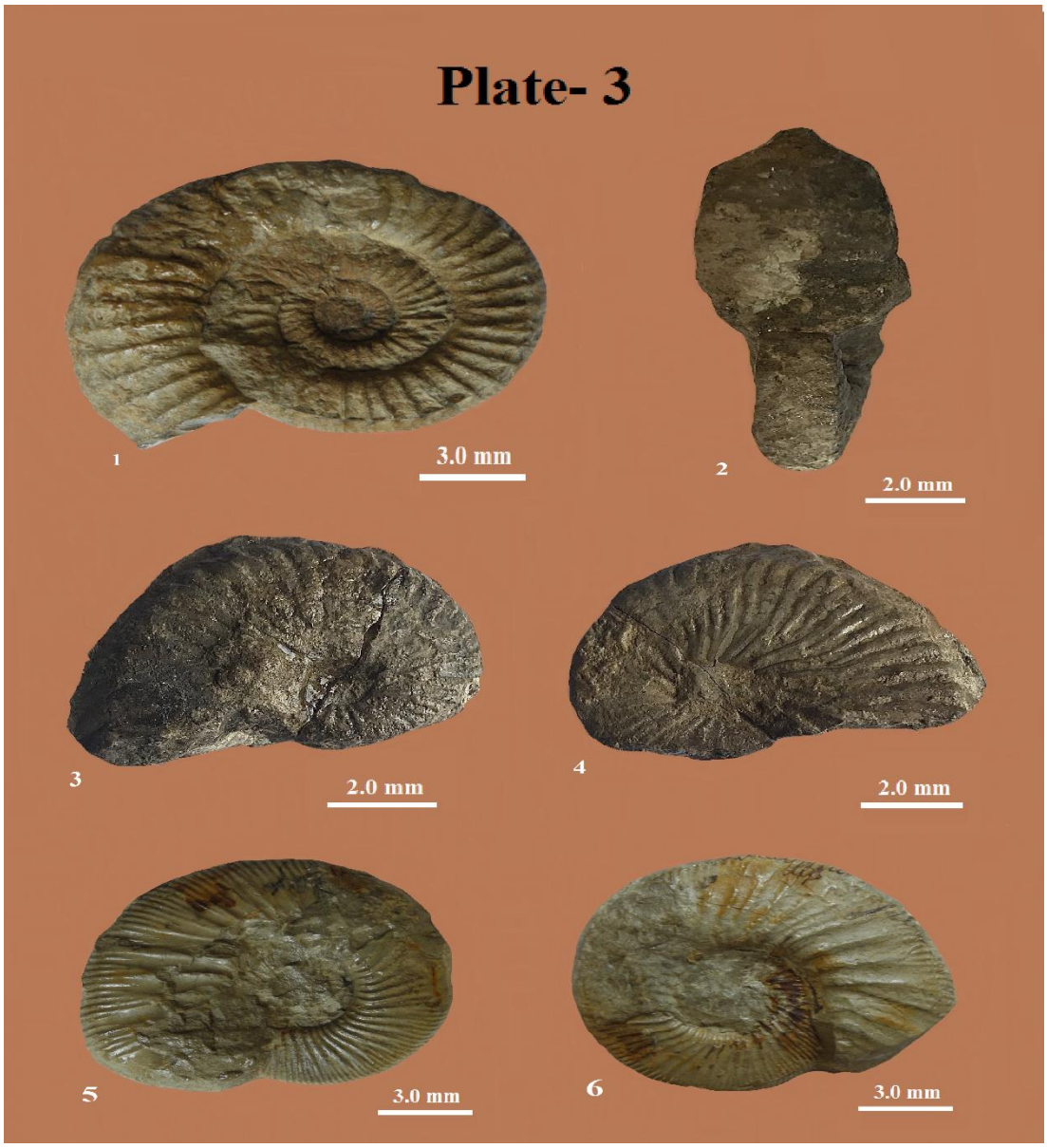
Fourteen species of Ammonites belonging to fourteen genera were identified from the three study sections (Dokan, Hijran, and Esewa). In addition, thirty- five species of Foraminfera (planktonic and benthonic) belonging to thirteen genera were recognized in the four sections (Dokan, Hijran, Esewa, and Kanny dirka) in Shiranish Formation .

Seven range zones were determined at the studied work, three of them are Ammonites, which are *Desmophyllites larteti* (Seunes, 1892), *Nostoceras (Nostoceras) hyatti* and *Pseudophyllites teres* (Van Hoepen, 1920), and the others are Foraminifers, which are *Glt. gagnebini* Tilev, *Glt. tricarinata lapparenti* Brotzen, *Glt. tricarinata tricarinata* (Querean) and *Glt. Stuartiformis* Dalbiez. And according with these biozones, the age of Shiranish Formation was determined as the Late Campanian- Maastrichtian.

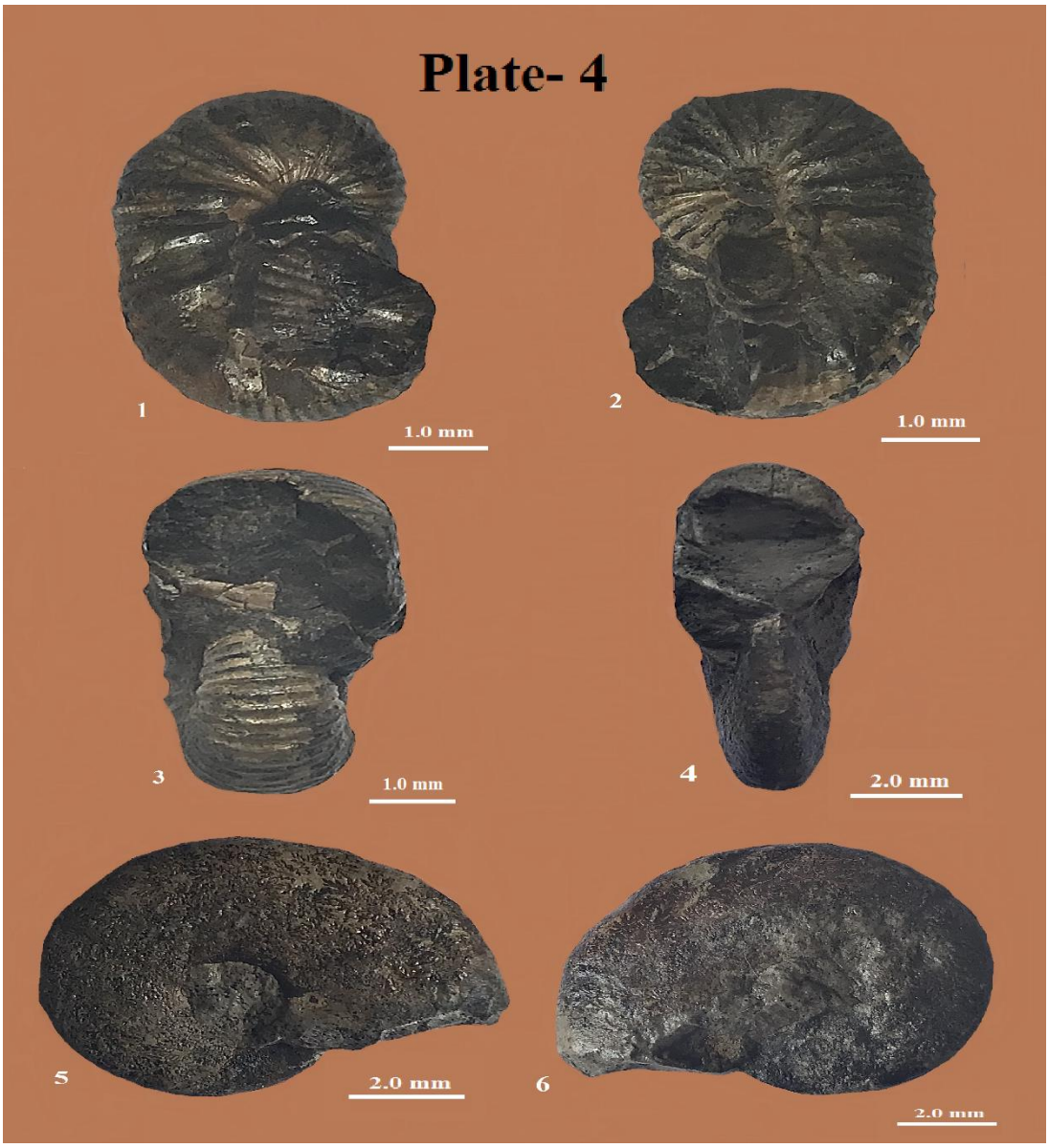
Plate 1-Shiranish Formation**.** ***Gaudryceras denseplicatum*** **(Jimbo, 1894);** Figure 1: B.U.A. 1, side view, Dokan section, sample no. 2; Figure 2: B.U.A. 2, side view, Dokan section, sample no. 2. ***Desmophyllites larteti*** **(Seunes, 1892)**; Figure 3: B.U.A. 3, side view, Dokan section, sample no. 13; Figure 4: B.U.A. 4, side view, Dokan section, sample no. 13. ***Phylloceras*** **Kennedy & Summesberger, 1999**; Figure 5: B.U.A. 5, side view, Dokan section, sample no. 25; Figure 6: B.U.A. 6, side view, Dokan section, sample no. 25.



***Kitchinites* Kennedy & Summesberger, 1999**
Figure 1 B.U.A. 7, side view, Esewa section, sample no. 6, Shiranish Formation.
Figure 2 B.U.A. 8, side view, Esewa section, sample no. 6, Shiranish Formation.
***Neancyloceras bipunctatum* (Schluter, 1872)**
Figure 3 B.U.A. 9, side view, Dokan section, sample no. 30, Shiranish Formation.
Figure 4 B.U.A. 10, side view, Dokan section, sample no. 30, Shiranish Formation.
***Paratexanites serratomarginatus* (Redtenbacher, 1873)**
Figure 5 B.U.A. 11, side view, Hijran section, sample no. 3, Shiranish Formation.
Figure 6 B.U.A. 12, side view, Hijran section, sample no. 3, Shiranish Formation.



***Neokossmaticeras redondensis* sp. nov.**
Figure 1 B.U.A. 13, side view, Hijran section, sample no. 4, Shiranish Formation.
***Kossmaticeratinae* gen. *et.* sp. nov.**
Figure 2 B.U.A. 14, apertural view, Esewa section, sample no. 5, Shiranish Formation.
Figure 3 B.U.A. 15, side view, Esewa section, sample no. 5, Shiranish Formation.
Figure 4 B.U.A. 16, side view, Esewa section, sample no. 5, Shiranish Formation.
***Gunnarites* Kilian & Reboul, 1909**
Figure5 B.U.A. 17, side view, Dokan section, sample no. 15, Shiranish Formation. Figure 6 B.U.A. 18, side view, Dokan section, sample no. 15, Shiranish Formation.



***Pseudophylliites teres* (Van Hoepen, 1920)**

Figure 1 B.U.A. 19, side view, Hijran section, sample no. 10, Shiranish Formation.

Figure 2 B.U.A. 20, side view, Hijran section, sample no. 10, Shiranish Formation.

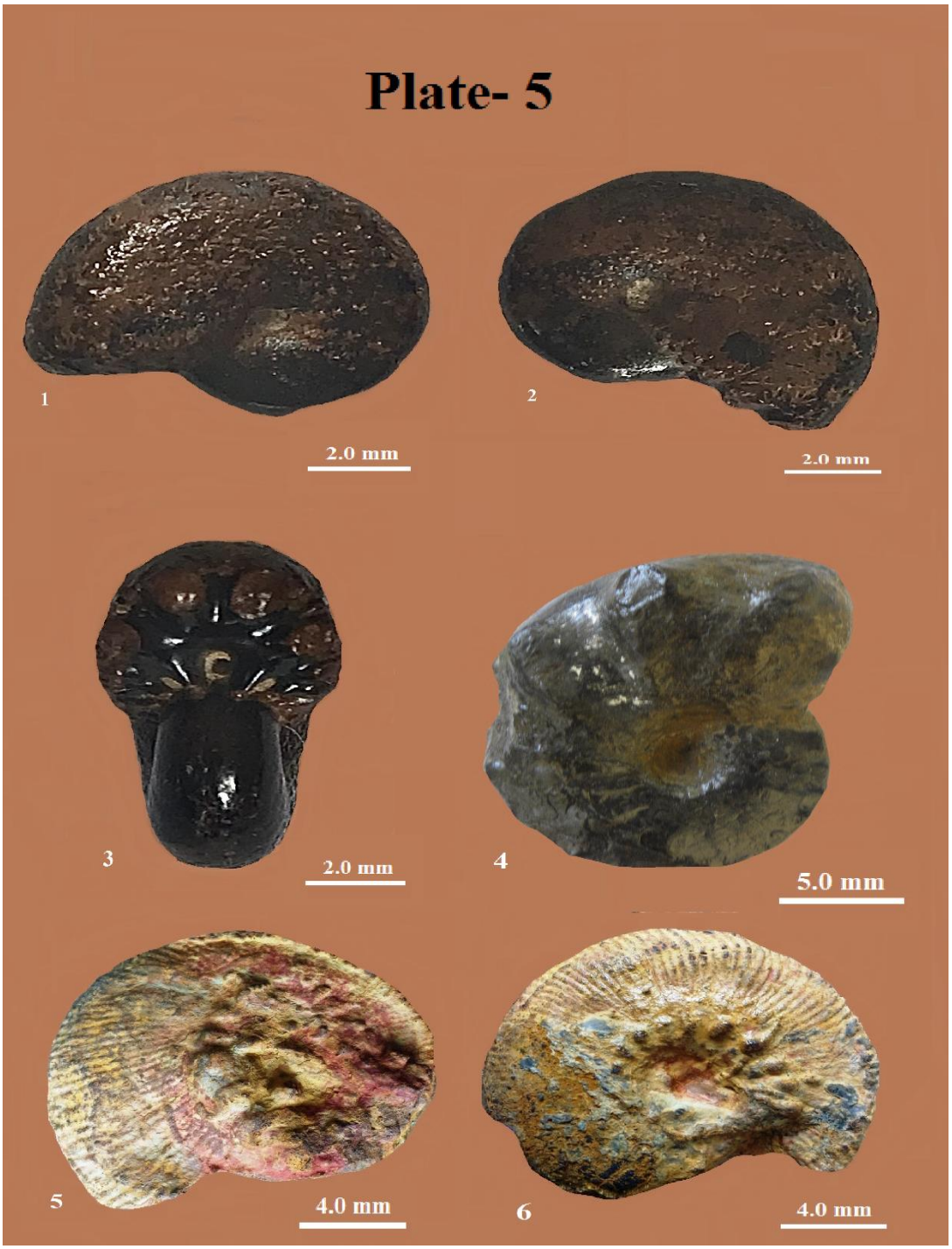
Figure 3 B.U.A. 21, apertural view, Hijran section, sample no. 10, Shiranish Formation.

***Nostoceras (Nostoceras)* hyatti**

Figure 4 B.U.A. 22, apertural view, Dokan section, sample no. 18, Shiranish Formation.

Figure 5 B.U.A. 23, side view, Dokan section, sample no. 18, Shiranish Formation.

Figure 6 B.U.A. 24, side view, Dokan section, sample no. 18, Shiranish Formation.



***Partschiceras? Japonicum* (Matsumoto, 1959)**
Figure 1 B.U.A. 25, side view, Hijran section, sample no. 40, Shiranish Formation.
Figure 2 B.U.A. 26, side view, Hijran section, sample no. 40, Shiranish Formation.
Figure 3 B.U.A. 27, apertural view, Hijran section, sample no. 40, Shiranish Formation.
***Yubartceras yubarense* (ex yabe ms.) sp. nov.**
Figure 4 B.U.A. 28, side view, Hijran section, sample no. 46, Shiranish Formation.
***Hoplitoplacenticeras* (*Hoplitoplacenticeras*) preyi sp.**
Figure 5 B.U.A. 29, side view, Dokan section, sample no. 20, Shiranish Formation.
Figure 6 B.U.A. 30, side view, Dokan section, sample no. 20, Shiranish Formation.

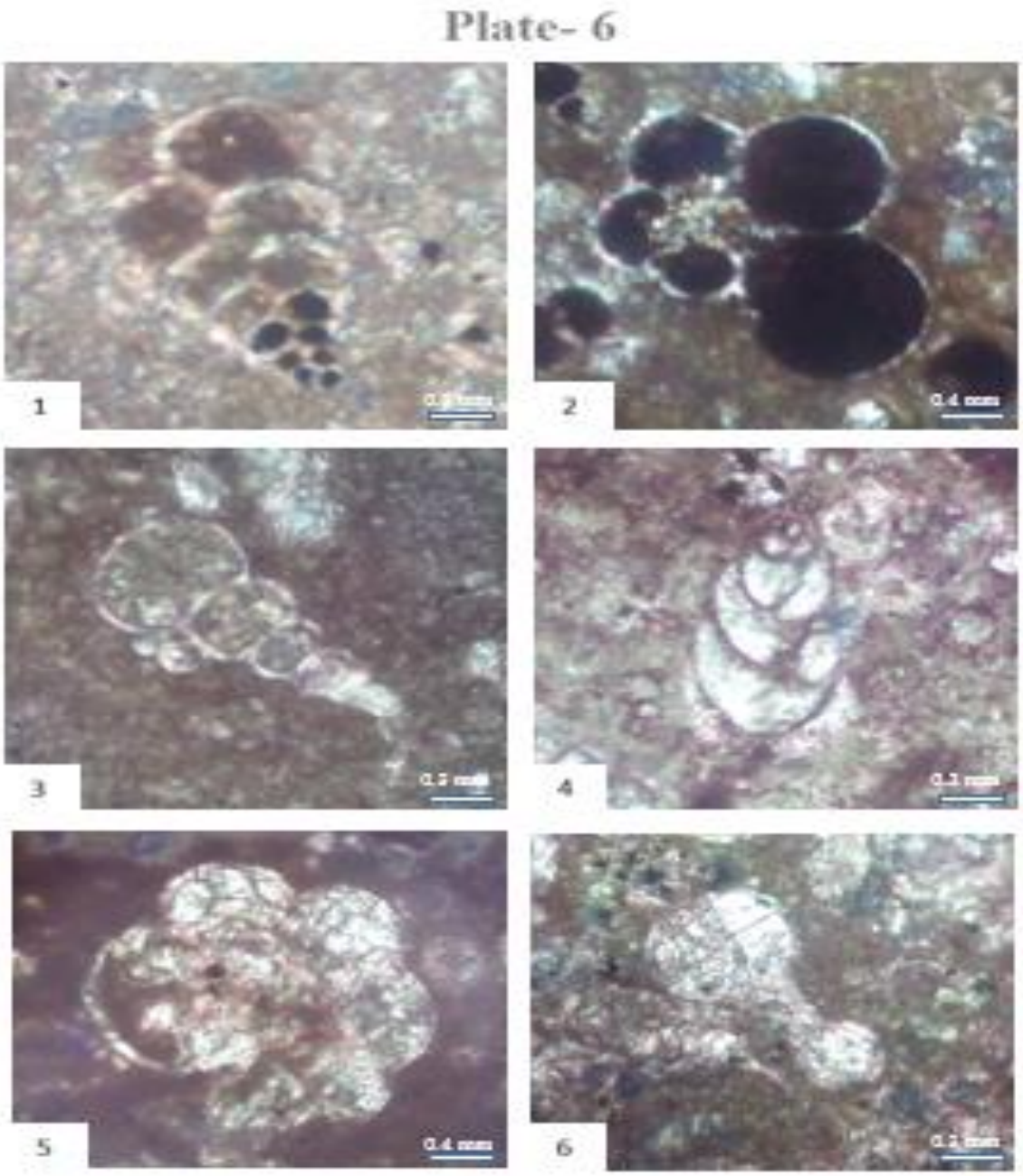


Figure 1 *Textularia* sp., Dokan section, sample no. 15, Shiranish Formation.
Figure 2 *Globigerinelloides multispina* (Laliker), Dokan section, sample no. 46, Shiranish Formation.
Figure 3 *Heterohelix* sp., Dokan section, sample no. 27, Shiranish Formation.
Figure 4 *Eggerellina gibbosa* Marie, Dokan section, sample no. 8, Shiranish Formation.
Figure 5 *Globigerinelloides multispina* (Laliker), Dokan section, sample no. 11, Shiranish Formation.
Figure 6 *Hedbergella* sp., Dokan section, sample no. 10, Shiranish Formation.

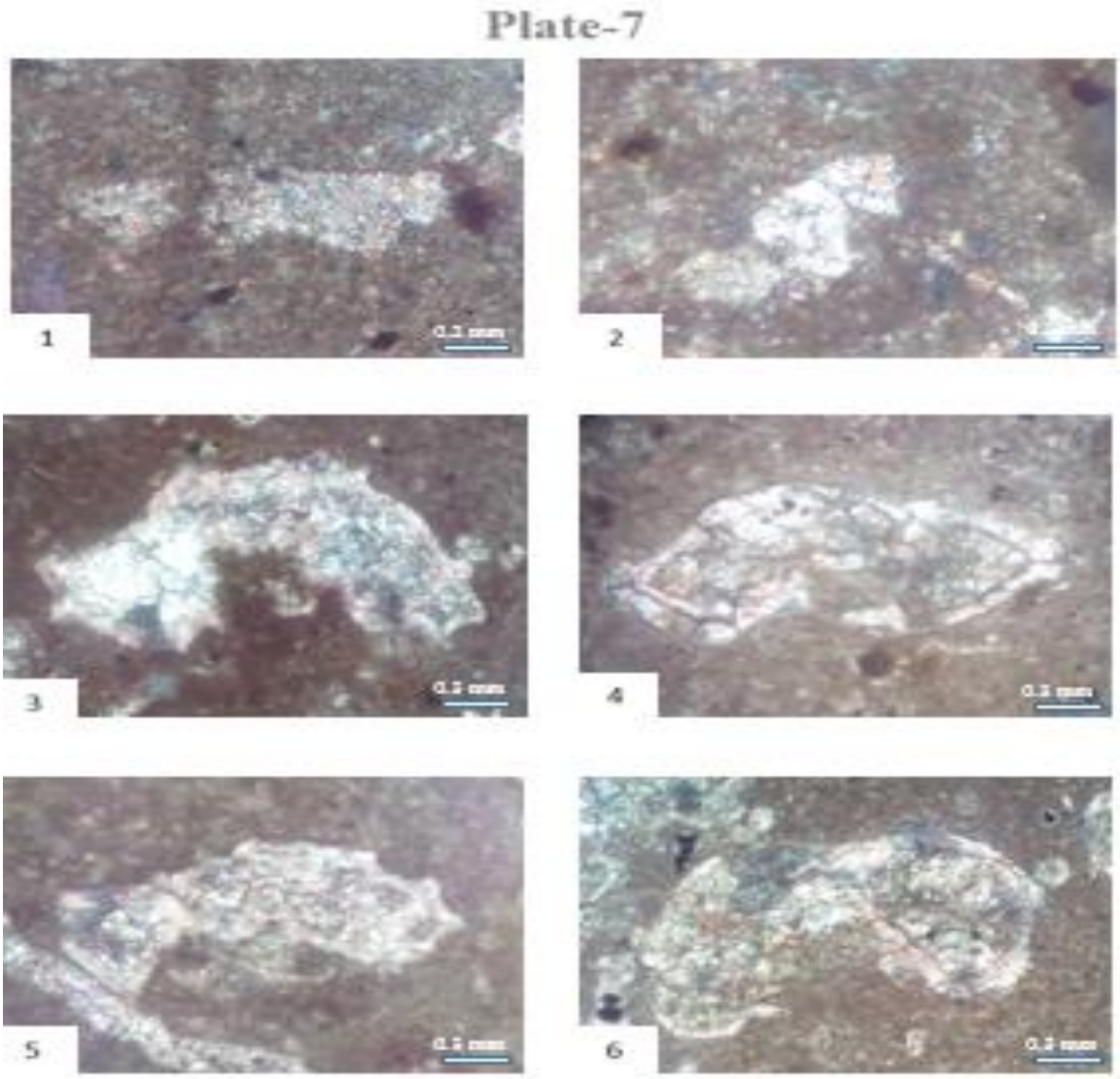


Figure 1 *Glt. falsocalcarata* Kerdany and Abdelsalam, Dokan section, sample no. 32, Shiranish Formation.
Figure 2 *Glt. gagnebini* Tilev, Dokan section, sample no. 46, Shiranish Formation.
Figure 3 *Glt. tricarinata tricarinata* (Quereau), Dokan section, sample no. 19, Shiranish Formation.
Figure 4 *Glt. marginata* (Ruess), Dokan section, sample no. 17, Shiranish Formation.
Figure 5 *Glt. tricarinata lapparenti* Brotzen, Dokan section, sample no. 34, Shiranish Formation.
Figure 6 *concavata* cyrenaiea Barr, Dokan section, sample no. 14, Shiranish Formation.

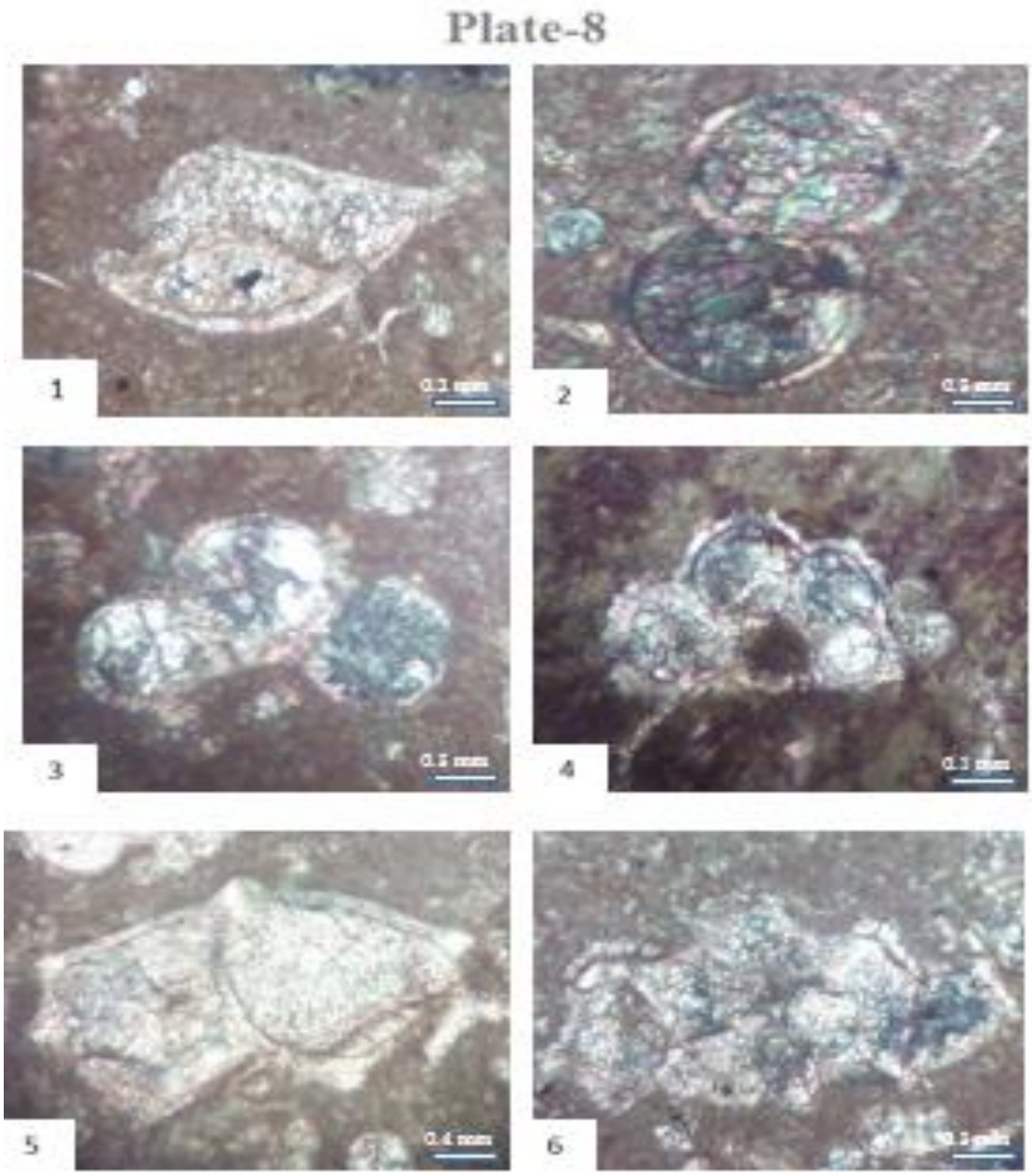


Figure 1 *Ostracoda* shell, Dokan section, sample no. 14, Shiranish Formation.
Figure 2 *Bucherina sandidgei* Bonnimann and Brown, Dokan section, sample no. 1, Shiranish Formation.
Figure 3 *Globigerinelloides bollii* Passagno, Dokan section, sample no. 19, Shiranish Formation.
Figure 4 *Globigerinelloides bollii* Passagno, Dokan section, sample no. 55, Shiranish Formation.
Figure 5 *Glt. conica* white, Dokan section, sample no. 03, Shiranish Formation.
Figure 6 *Glt. Stuartiformis* Dalbies, Dokan section, sample no. 14, Shiranish Formation.

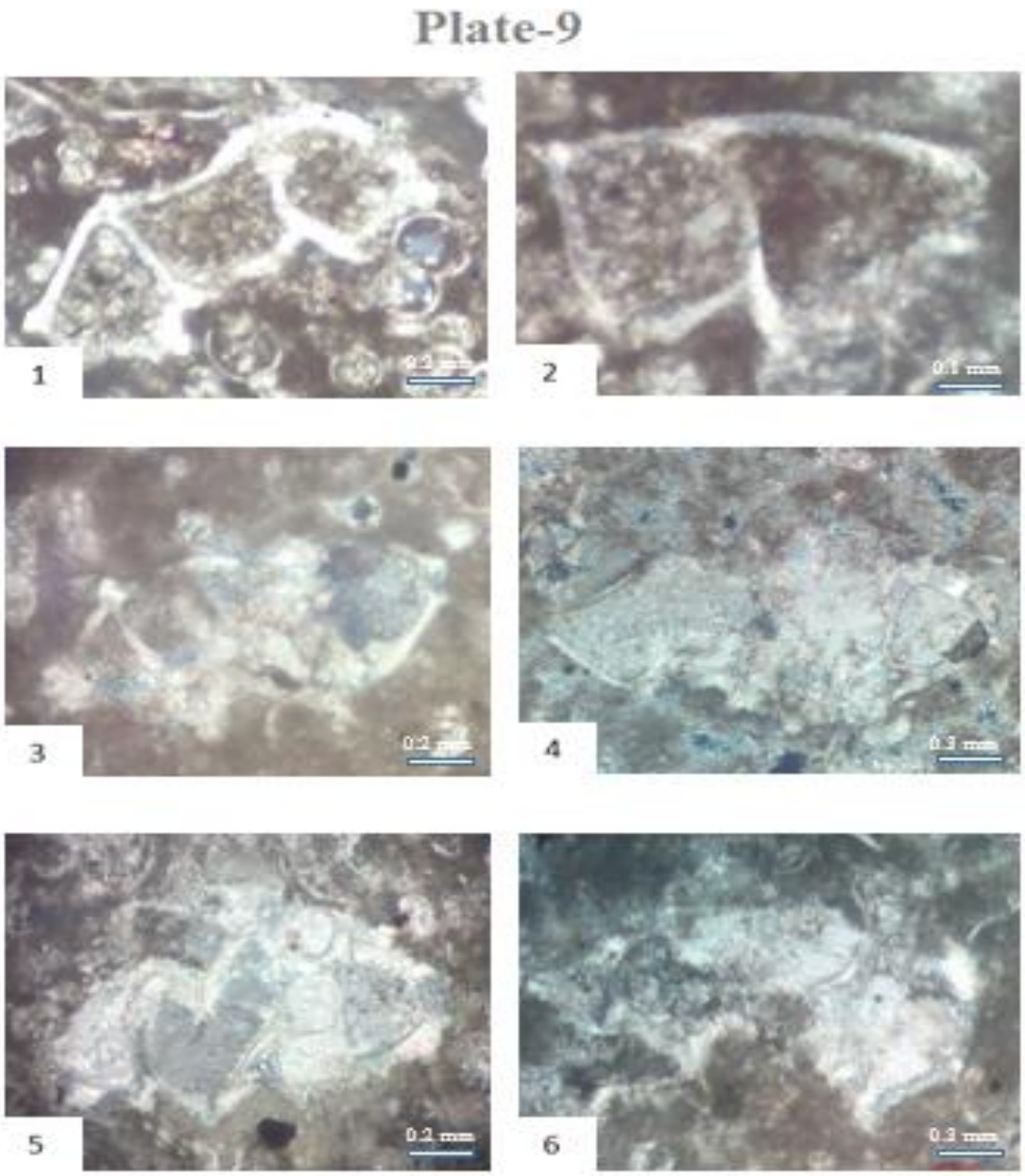


Figure 1 *Glt. concavata* cyrenaiea Barr, Hijran section, sample no. 4, Shiranish Formation.
Figure 2 *Glt. gagnebini* Tilev, Hijran section, sample no. 4, Shiranish Formation.
Figure 3 *Glt. marginata* (Ruess), Hijran section, sample no. 9, Shiranish Formation.
Figure 4 *Glt. marginata* (Ruess), Hijran section, sample no. 12, Shiranish Formation.
Figure 5 *Glt. Stuarti* (de Lapparent), Hijran section, sample no. 15, Shiranish Formation.
Figure 6 *Glt. tricarinata tricarinata* (Quereau), Hijran section, sample no. 18, Shiranish Formation.

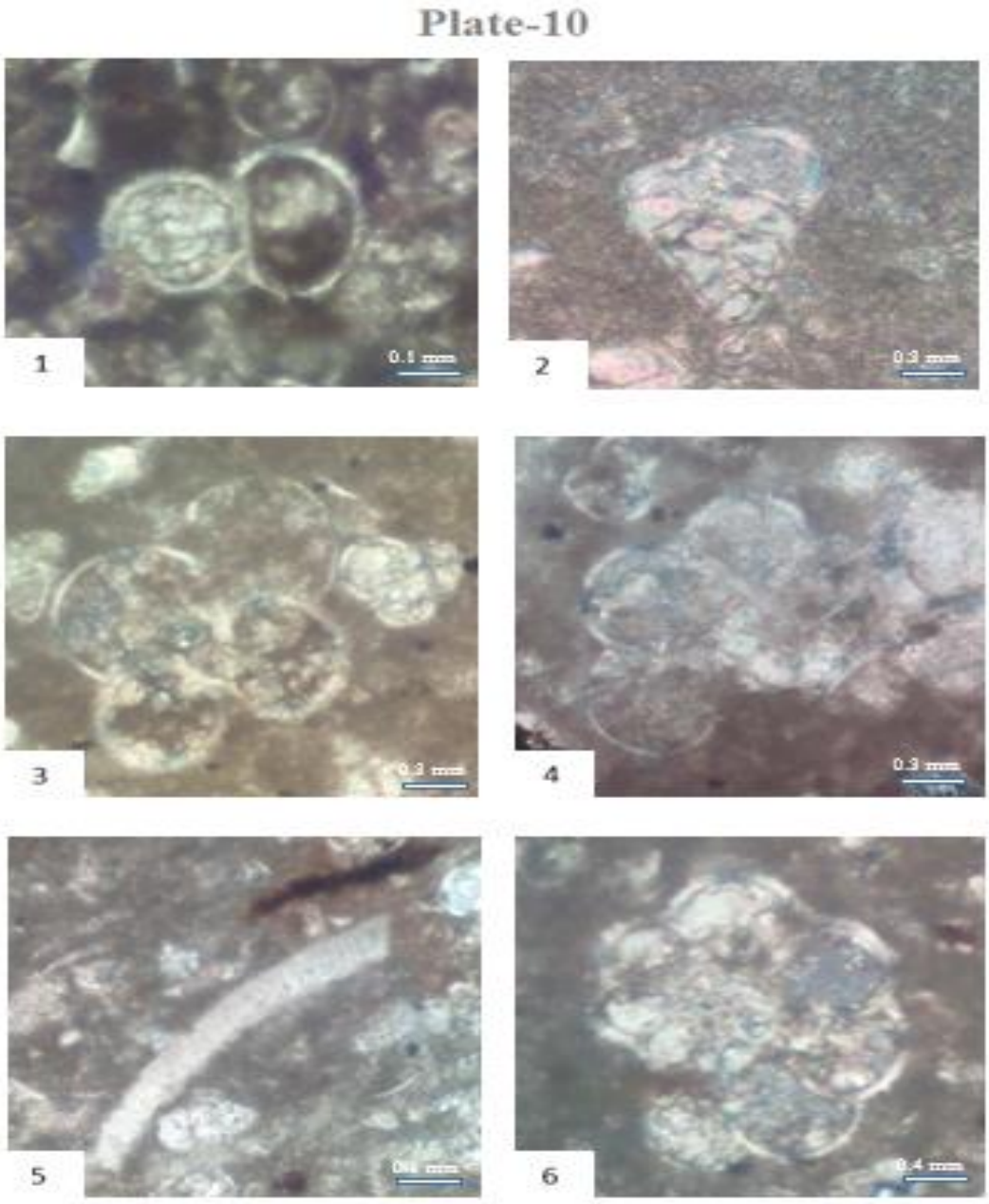


Figure 1 *Bucherina sandidgei* Bronnimann & Brow., Hijran section, sample no. 4, Shiranish Formation.
Figure 2 *Textularia* sp., Hijran section, sample no. 7, Shiranish Formation.
Figure 3 *Globigerinelloides multispina* (Lalicker), Hijran section, sample no. 9, Shiranish Formation.
Figure 4 *Globigerinelloides multispina* (Lalicker), Hijran section, sample no. 9, Shiranish Formation.
Figure 5 Shell fragments, Hijran section, sample no. 18, Shiranish Formation.
Figure 6 *Globigerinelloides bollii* Passagno, Hijran section, sample no. 18, Shiranish Formation.

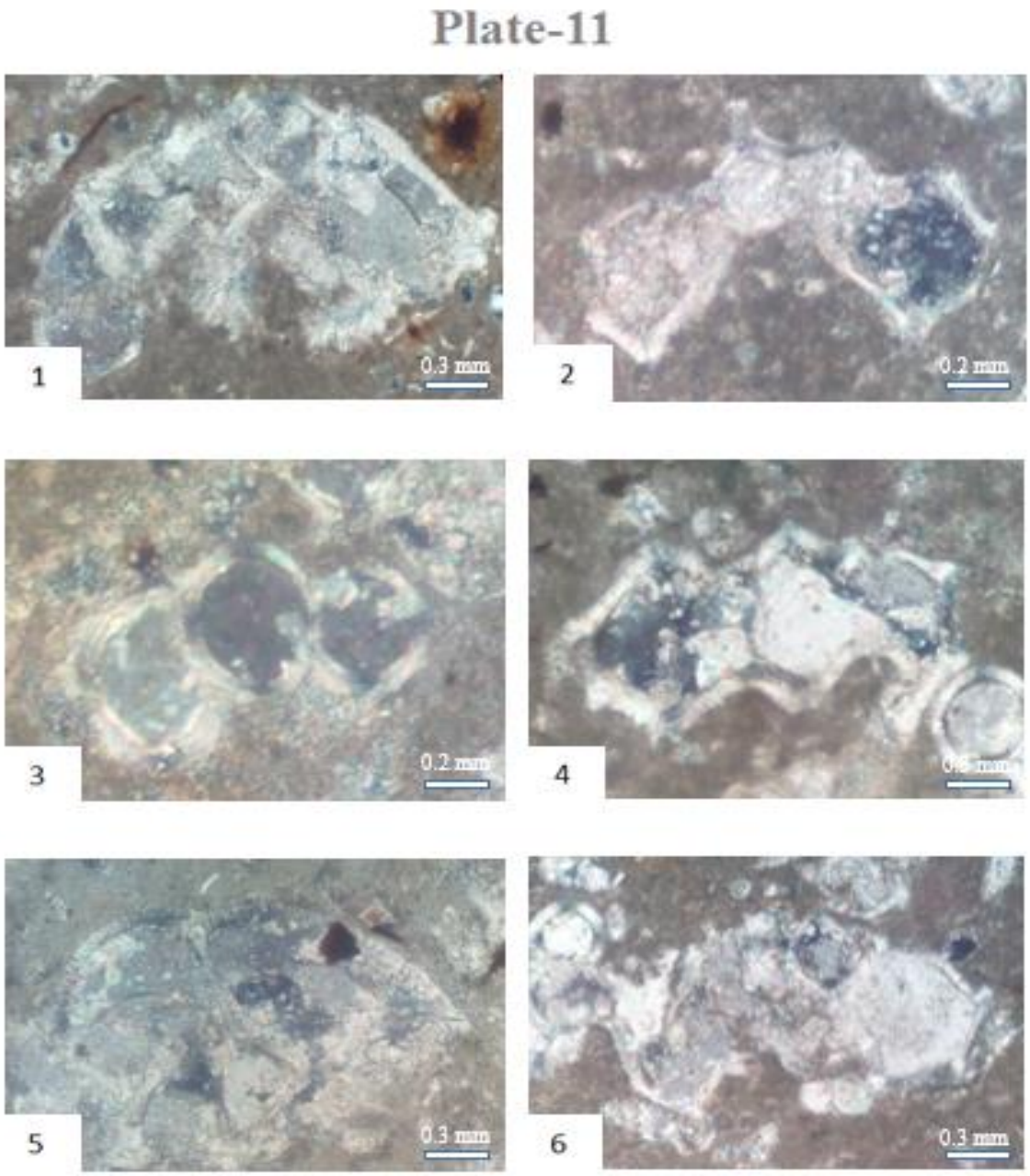


Figure 1 *Glt. Stuartiformis* Dalbiez, Hijran section, sample no. 34, Shiranish Formation.
Figure 2 *Glt. tricarinata lapparenti* Brotzen, Hijran section, sample no. 23, Shiranish Formation.
Figure 3 *Praeglobotruncana* cf. *delrioensis* (Lplummer), Hijran section, sample no. 27, Shiranish Formation.
Figure 4 *Glt. falsocalcarata* kerdany and Abdelsalam, Hijran section, sample no. 28, Shiranish Formation.
Figure 5 *Conica* white, Hijran section, sample no. 30, Shiranish Formation.
Figure 6 *Glt. bulloides* volger, Hijran section, sample no. 34, Shiranish Formation.

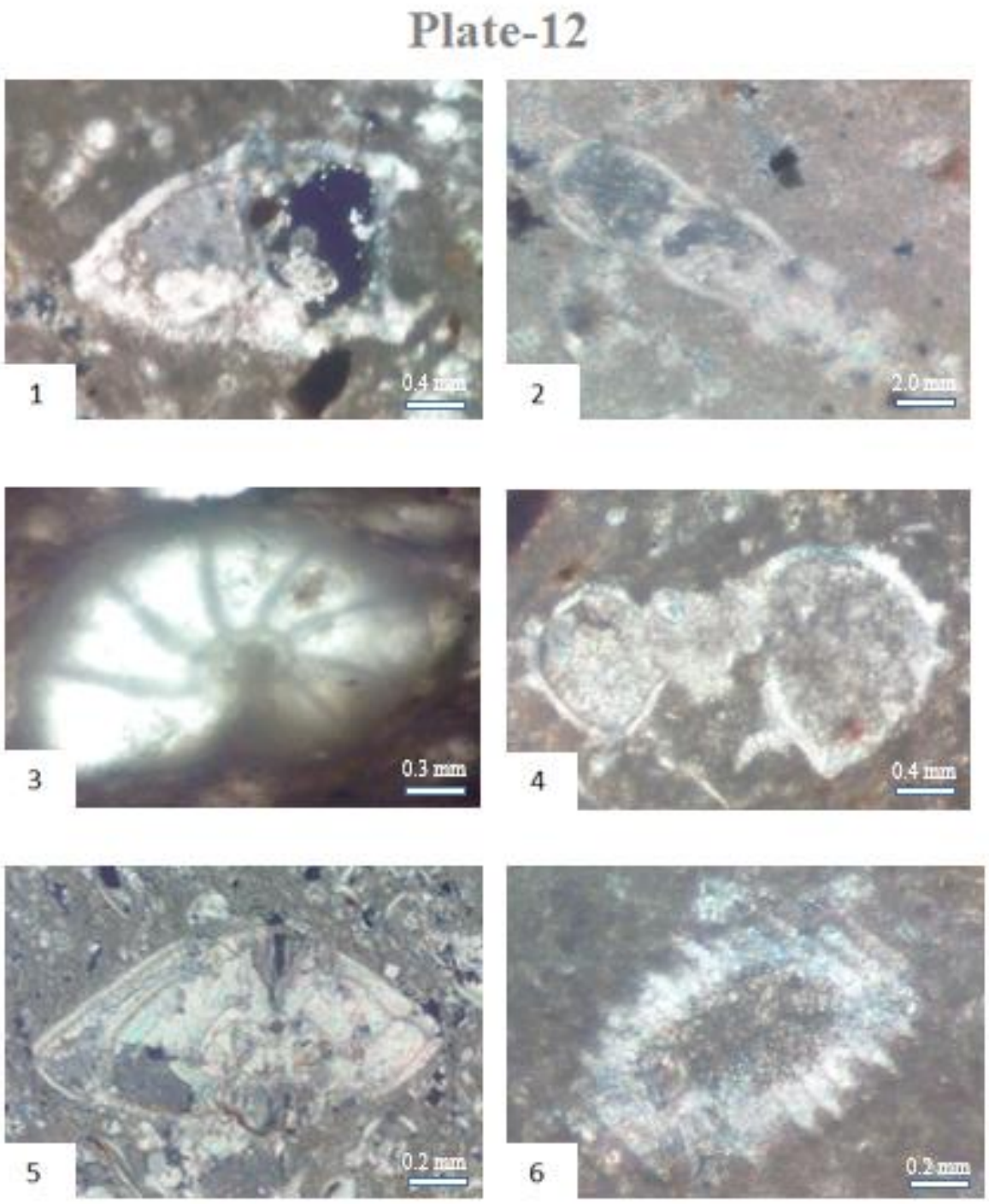


Figure 1 *Rotalid* sp., Hijran section, sample no. 22, Shiranish Formation.
Figure 2 *Nodosaria* sp., Hijran section, sample no. 26, Shiranish Formation.
Figure 3 *Cibicides* sp., Hijran section, sample no. 49, Shiranish Formation.
Figure 4 *Helvetica* Bolli, Hijran section, sample no. 35, Shiranish Formation.
Figure 5 Rotaliid shell, Hijran section, sample no. 41, Shiranish Formation.
Figure 6 *Cymopolia* sp., Hijran section, sample no. 34, Shiranish Formation.

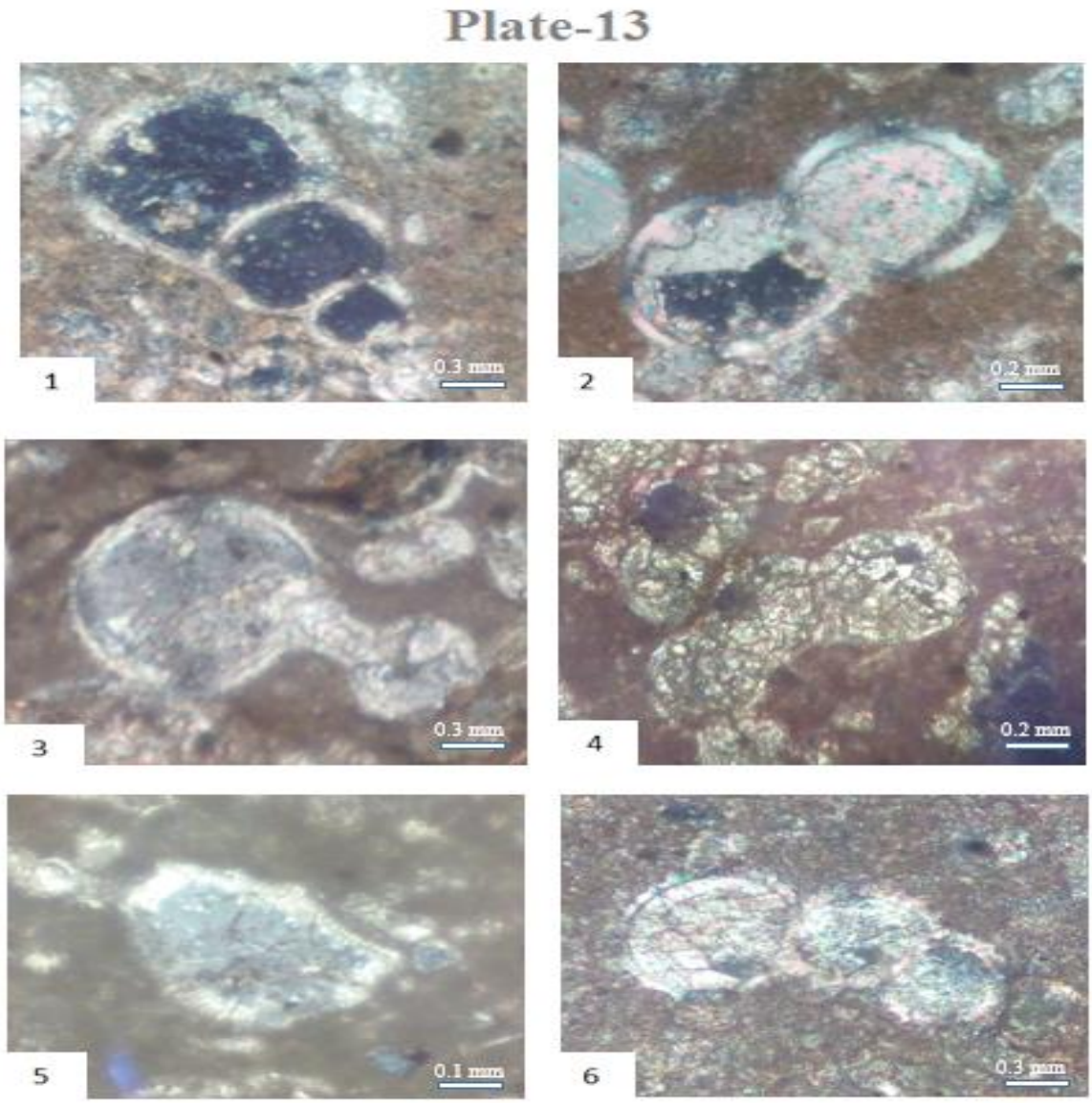


Figure 1 *Heterohelix* sp., Hijran section, sample no. 50, Shiranish Formation.
Figure 2 *Bucherina sandidgei* Bronnimann and Brown, Hijran section, sample no. 11, Shiranish Formation.
Figure 3 *Hedbergella* sp., Hijran section, sample no. 48, Shiranish Formation.
Figure 4 *Globigerinelloides bollii* Passagno, Hijran section, sample no. 48, Shiranish Formation.
Figure 5 Lithoclast, Hijran section, sample no. 05, Shiranish Formation.
Figure 6 *Globigerinelloides bollii* Passagno, Dokan section, sample no. 15, Shiranish Formation.

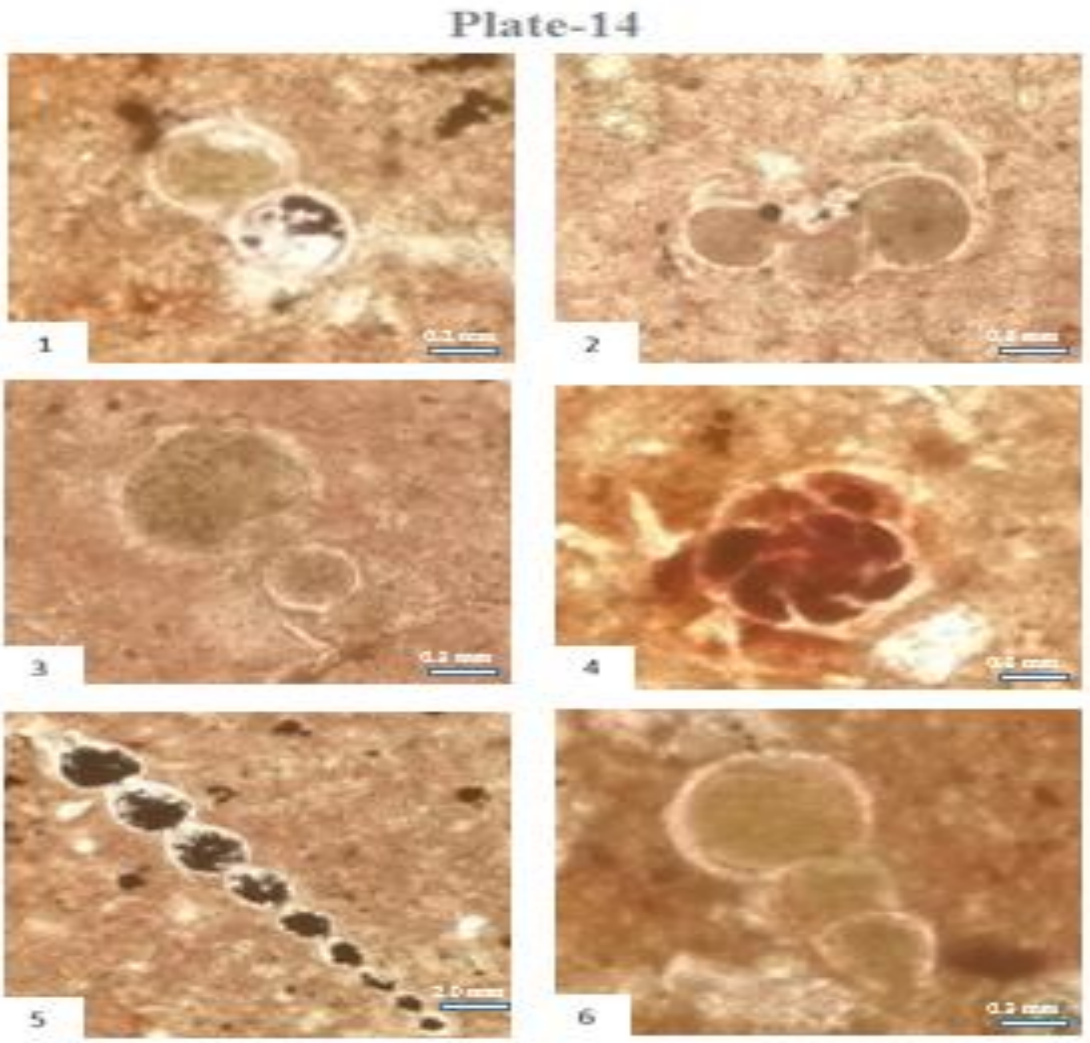


Figure 1 *Bucherina sandidgei* Bronnimann and Brown, Esewa section, sample no. 1, Shiranish Formation.
Figure 2 *Globigerinelloides bollii* Passagno, Esewa section, sample no. 7, Shiranish Formation.
Figure 3 *Hedbergella* sp., Esewa section, sample no. 2, Shiranish Formation.
Figure 4 *Cibicides* sp., Esewa section, sample no. 5, Shiranish Formation.
Figure 5 *Siphonodosaria* sp., Esewa section, sample no. 5, Shiranish Formation.
Figure 6 *Heterohelix* sp., Esewa section, sample no. 24, Shiranish Formation.

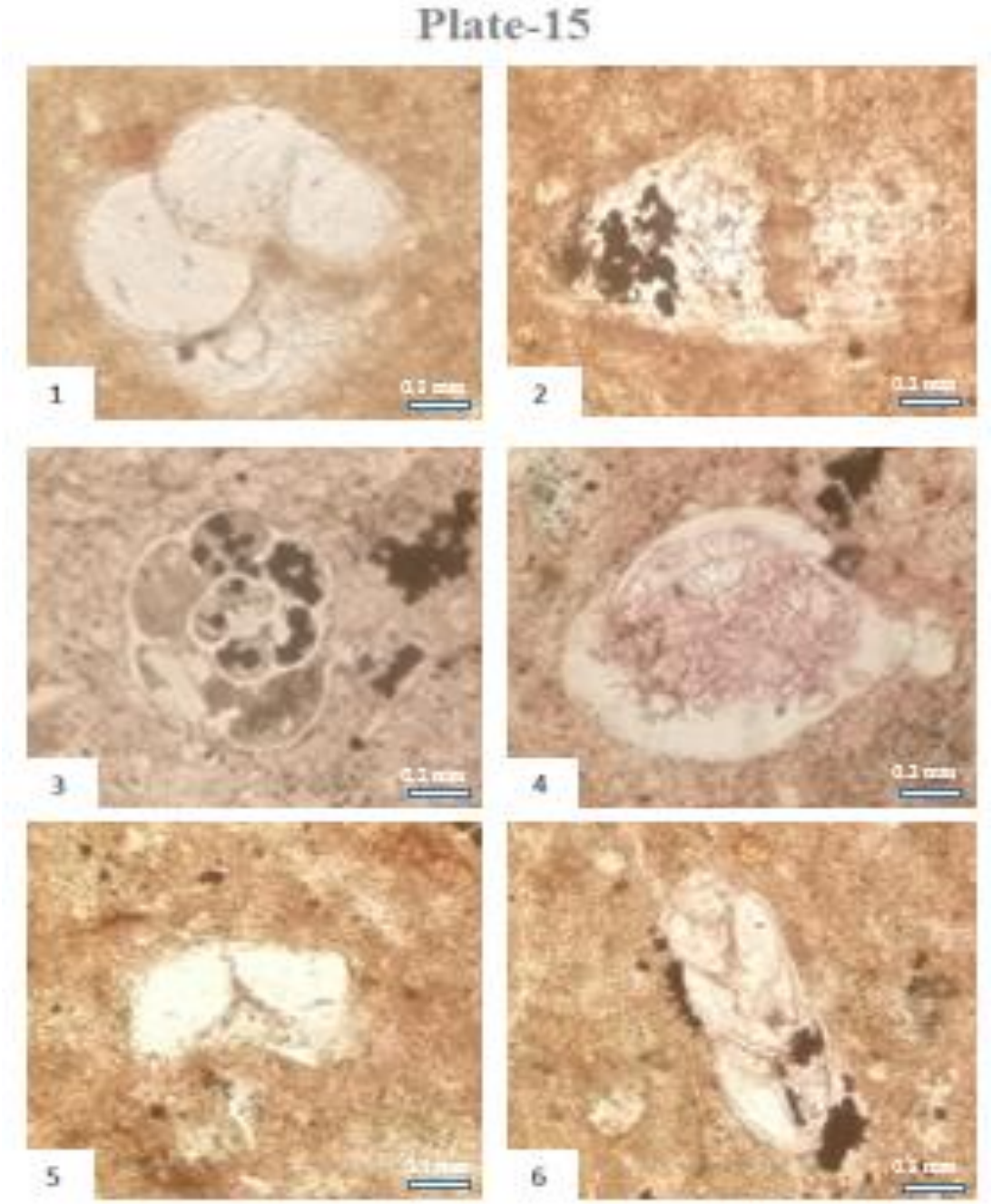


Figure 1 *Globigerinelloides bollii* Passagno, Esewa section, sample no. 8, Shiranish Formation.
Figure 2 *Rotalid* shell, Esewa section, sample no. 8, Shiranish Formation.
Figure 3 *Globigerinelloides multispina* (Lalicker), Esewa section, sample no. 10, Shiranish Formation.
Figure 4 *Ostracoda* shell, Esewa section, sample no. 6, Shiranish Formation.
Figure 5 *Glt. gagnebini* Tilev, Esewa section, sample no. 11, Shiranish Formation.
Figure 6 *Neobulimmina* sp., Esewa section, sample no. 11, Shiranish Formation.

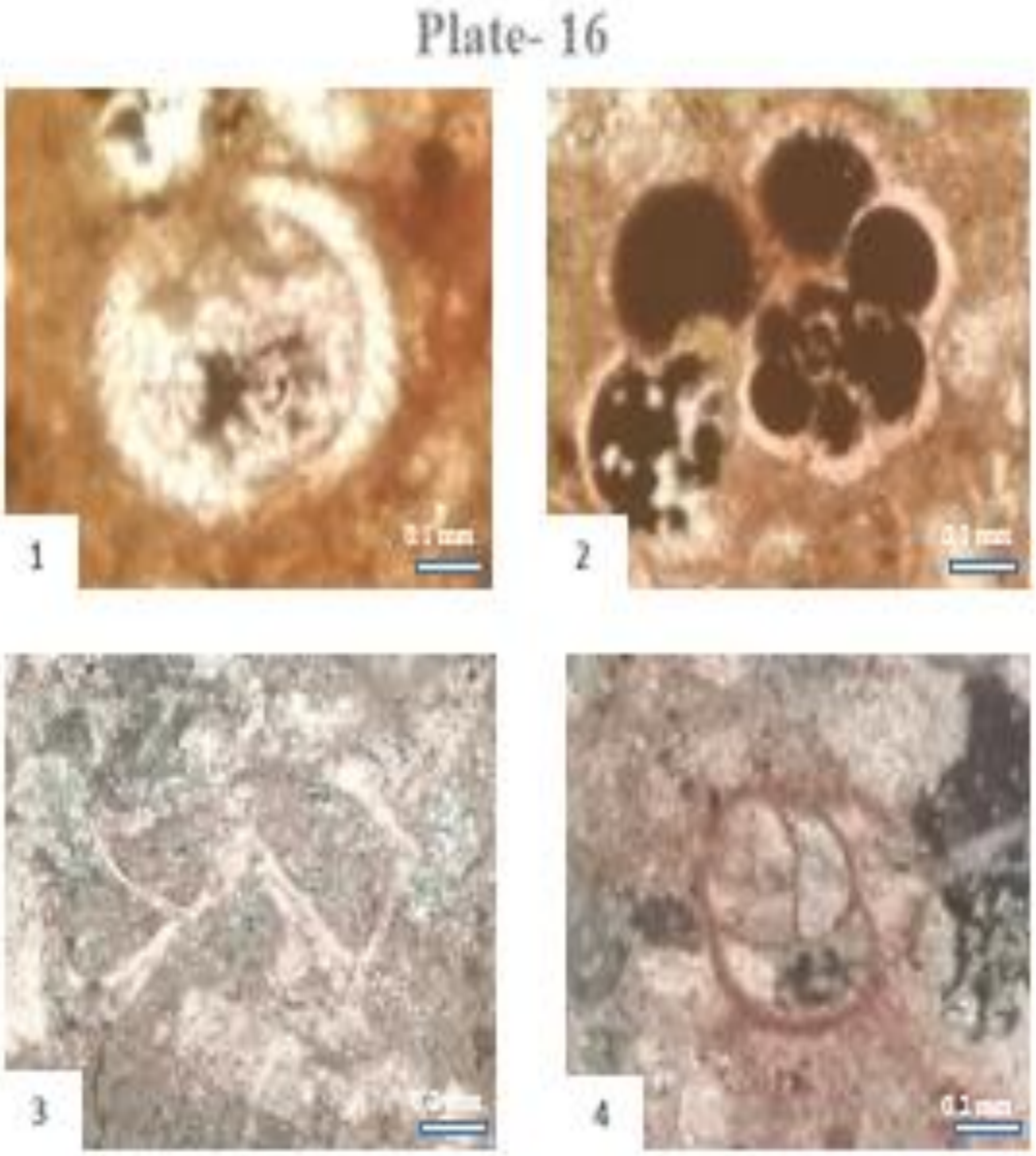


Figure 1 *Echinoderm* spine, Esewa section, sample no. 24, Shiranish Formation.
Figure 2 *Globigerinelloides bollii* Passagno, Esewa section, sample no. 24, Shiranish Formation.
Figure 3 *Glt. gagnebini* Tilev, Kanny dirka section, sample no. 16, Shiranish Formation.
Figure 4 *Eggerellina gibbosa* Marie, Kanny dirka section, sample no. 6, Shiranish Formation.

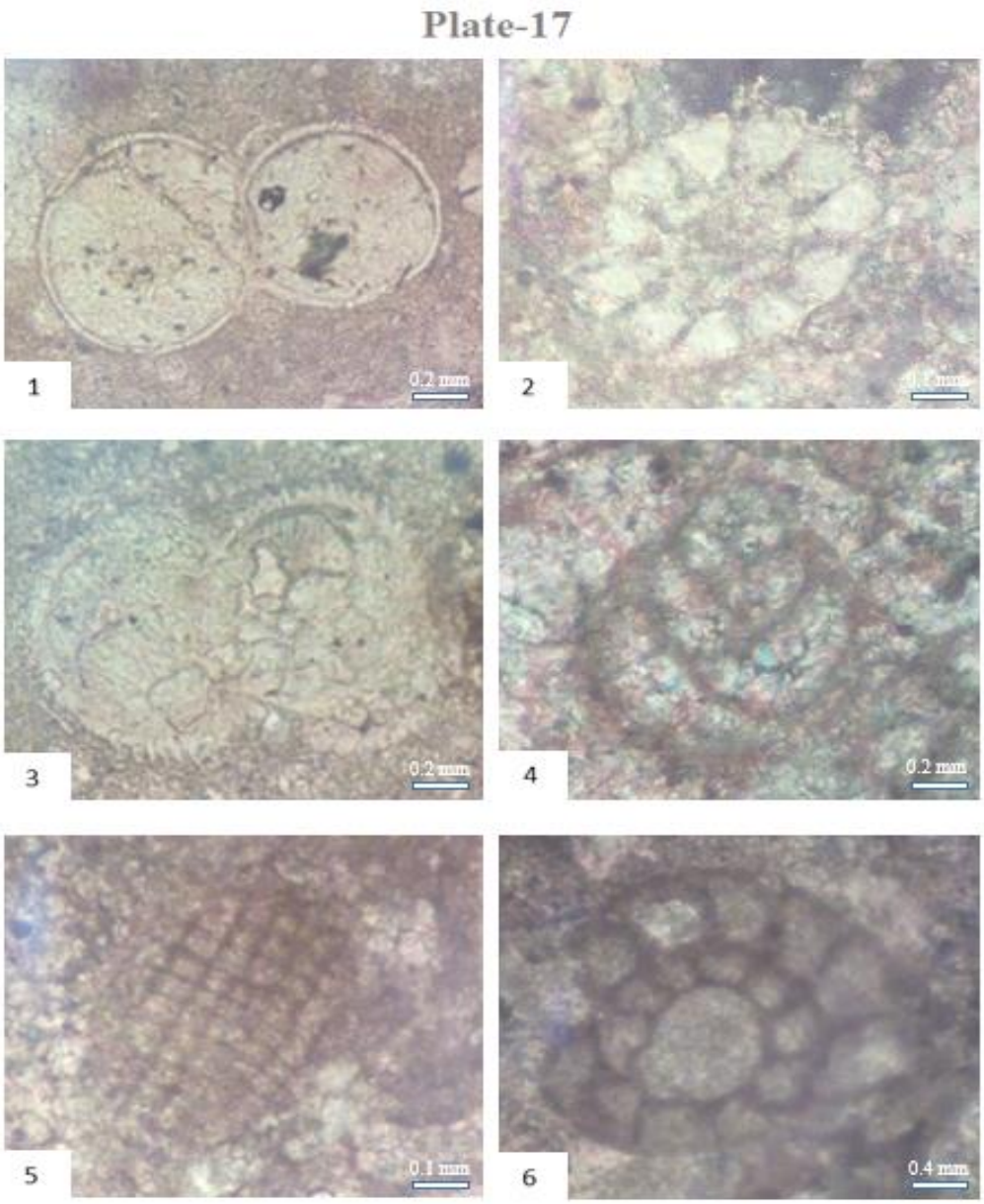


Figure 1 *Bucherina sandidgei* Bronnimann & Brown, Kanny dirka section, sample no. 17, Shiranish Formation.
Figure 2 *Echinoderm* spine, Kanny dirka section, sample no. 9, Shiranish Formation.
Figure 3 *Bucherina sandidgei* Bronnimann & Brown, Kanny dirka section, sample no. 20, Shiranish Formation.
Figure 4 *Eggerellina gibbosa* Marie, Kanny dirka section, sample no. 5, Shiranish Formation.
Figure 5 Red algae, Kanny dirka section, sample no. 1, Shiranish Formation.
Figure 6 *Rotalia* sp., Kanny dirka section, sample no. 1, Shiranish Formation.

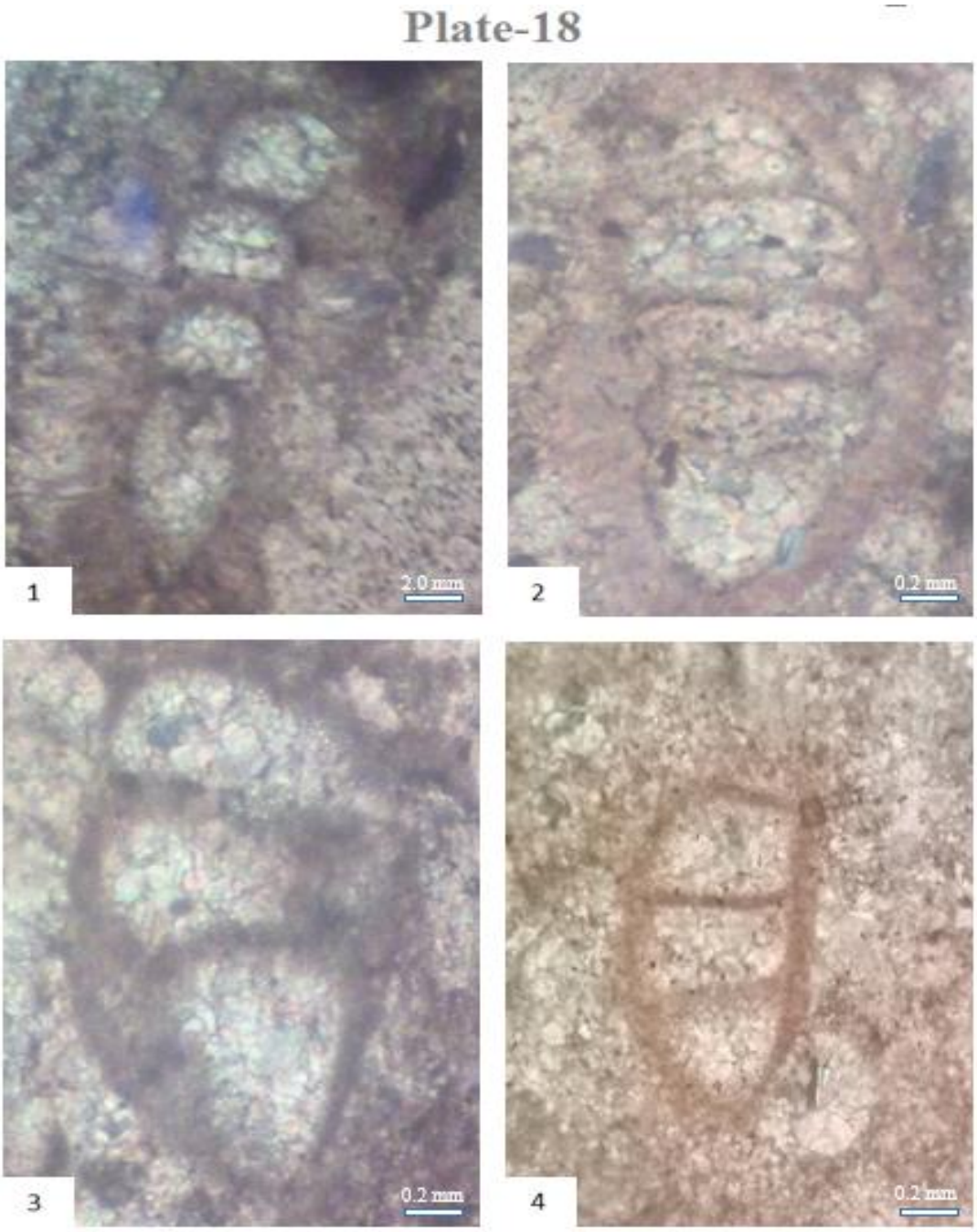


Figure 1 *Nodosaria* sp., Kanny dirka section, sample no. 1, Shiranish Formation.
Figure 2 *Marginlinopsis anstinana* (Cushman), Kanny dirka section, sample no. 1, Shiranish Formation.
Figure 3 Part of *Rotalia*, Kanny dirka section, sample no. 1, Shiranish Formation.
Figure 4 Radiolaria sp., Kanny dirka section, sample no. 7, Shiranish Formation.

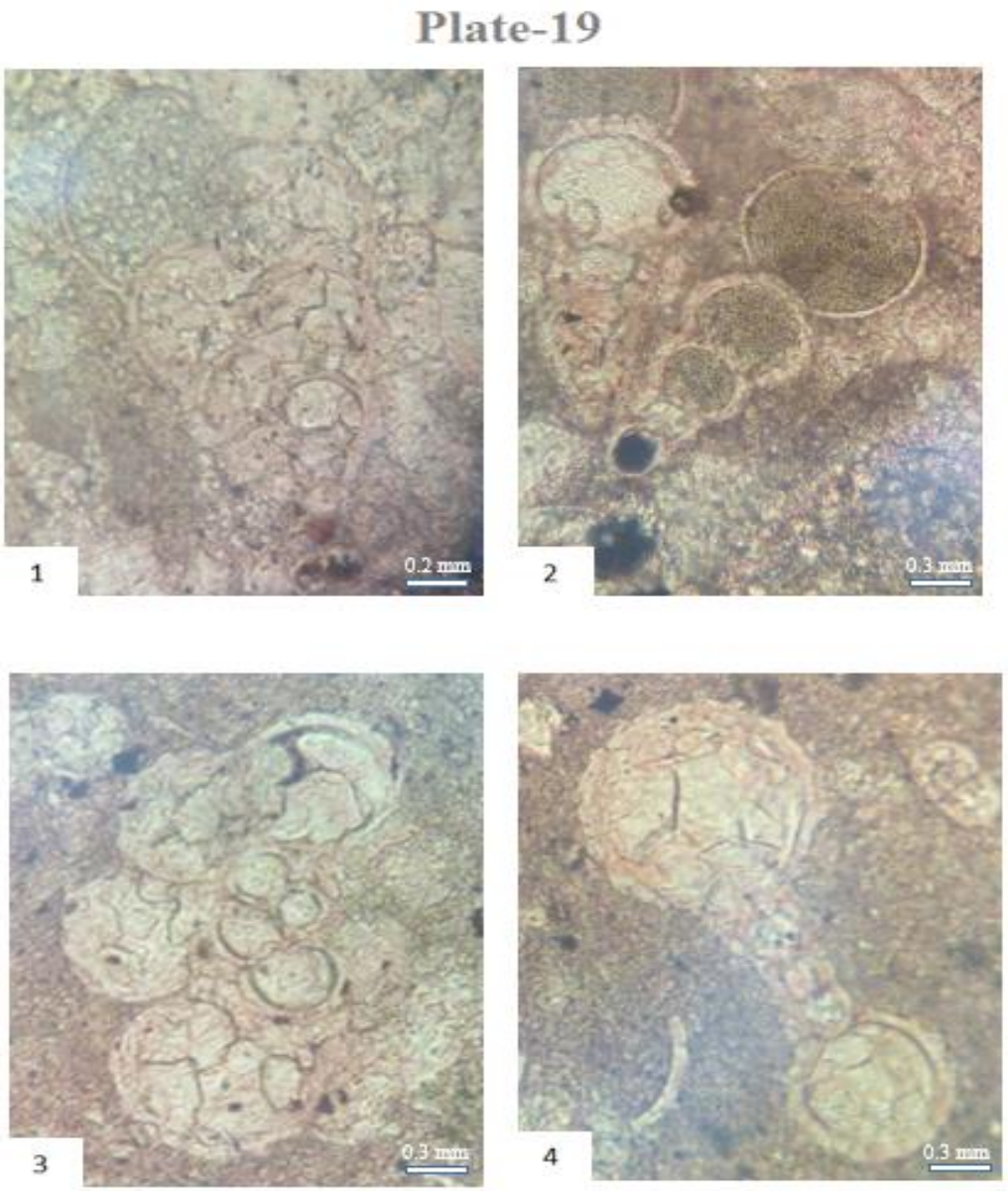


Figure 1 *Heterohelix striata* Eherenberg, Kanny dirka section, sample no. 13, Shiranish Formation.
Figure 2 *Heterohelix* sp., Kanny dirka section, sample no. 12, Shiranish Formation.
Figure 3 *Globigerinelloides multispina* (Lalicker), Kanny dirka section, sample no. 17, Shiranish Formation.
Figure 4 *Hedbergella* sp., Kanny dirka section, sample no. 18, Shiranish Formation.

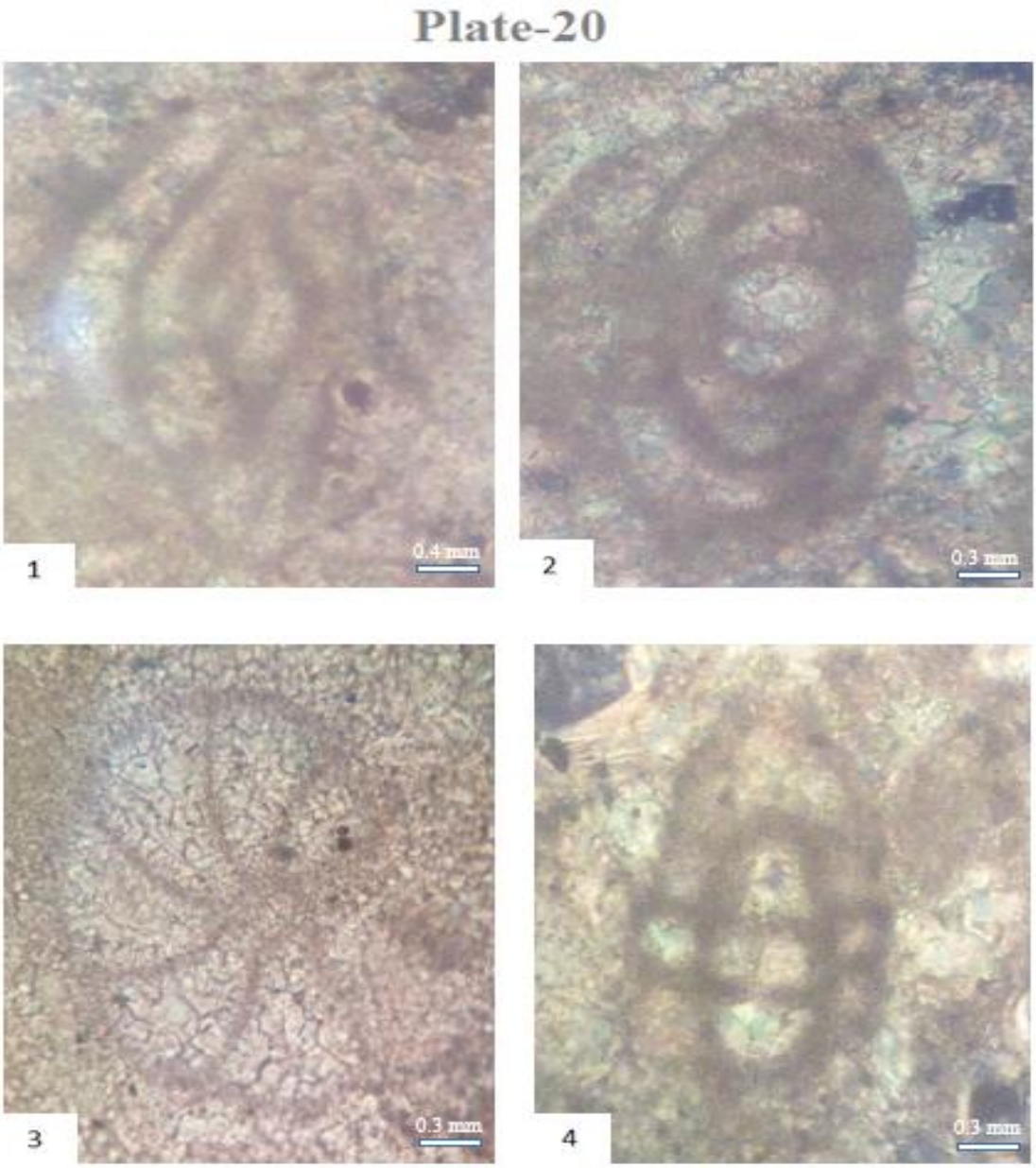


Figure 1 *Miliolid* sp., Kanny dirka section, sample no. 2, Shiranish Formation.
Figure 2 *Elphidium* sp., Kanny dirka section, sample no. 8, Shiranish Formation.
Figure 3 *Cibicides* sp., Kanny dirka section, sample no. 4, Shiranish Formation.
Figure 4 *Lenticulina* sp., Kanny dirka section, sample no. 6, Shiranish Formation.

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