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Urgonian Type Microfossils of the Dariyan Formation, from Southwest of Iran (Northeast of Shiraz)

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Abstract

The Lower Cretaceous Carbonate deposits of the Dariyan Formation of the High Zagros Belt are mainly composed of thick to medium bedded limestone. These deposits contain abundant and diversified benthic foraminifera which have been recovered from carbonate rocks. A rich assemblage of microfossils with characteristic: *Palorbitolina lenticularis* (Blumenbach), *Mesorbitolina subconcava* (Leymerie), *Mesorbitolina texana* (Roemer), *Mesorbitolina parva* (Douglass) *Pseudocyclammina hedbergi* (Maync), *Archalveolina reicheli* (de Castro), *Praechrysalidina infracretacea* Luperto Sinni, *Chofatella decipiens* (Schlumberger), *Debarina hahonerensis* (Fourcade, Raoul et Vila), *Rumanoculina ponticuli* (Neagu), *Rumanoloculina pseudominima* (Bartenstein et Kovatcheva), *Istriloculina* cf. *elliptica* (Iovcheva) indicate paleoenviromental conditions of shallow water carbonate sedimentation and Urgonian type facies. Based on microfossils distribution and biozones identification in study sections, the age of the Dariyan Formation is assigned late Barremian-early Albian. The microfossils assemblages are regarded to be comparable with the Urgonian-type fauna known from the peri-Mediterranean Tethys in the Barremian-Albian time interval.

Keywords: Cretaceous; Dariyan Formation; Foraminifera; Urgonian; Zagros.

Introduction

The Dariyan Formation (northeastern High Zagros Belt, Iran) is composed of light colored hard limestone contain benthic foraminifera, bivalve (rudists) and echinoids. The most common foraminifera belong to Orbitolinacea, Miliolacea and lituolacea. Previously this Formation was known *Orbitolina* Limestone, Aptian-Albian limestone and included within the Khami Group. The type section measured is located Kuh-e Gadvan, east of Shiraz, Just north of the village Dariyan. The Dariyan Formation is considered to be equivalent of Suiba Formation in Saudi Arabia, Kuwait and Iraq [7,4,10]. Typically this Formation is overlain and underlain by Kazhdumi and Gadvan formations respectively. Towards the Persian Gulf, the underlying the Gadvan Formation gradually grades into limestone and the Dariyan Formation merge with the Fahliyan Formation [7,4].

Benthic foraminifera have an exceptional importance

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for the lower Cretaceous stratigraphy of the carbonate deposits of Zagros fold-thrust belt. The assemblage foraminifera indicate exclusively a shallow water environment with a low energy [6,8,13,16]. Of course in some area there is a planktonic unite within platform carbonates of the Dariyan Formation and divided it into three members. The middle part consists of the black shale and marl associated with radiolarian and planktonic foraminifera that assigns an early to early late Aptian age [19].

Urgonian facies contain hard limestones associated with *Orbitolina* (foraminifera), bivalve, corals, small and large foraminifera and algae [3,9]. Foraminiferal assemblages of the Early Cretaceous Urgonian-type limestones cover the time interval of Hauterivian–Albian, predominantly the Barremian to early Aptian [3,9]. The Aptian to early Albian age was suggested based of different species of Orbitolind in the Rahmant Mountain, NE Shiraz. [12].

Since this area has not been investigated in detail, in this paper we present Urgonian type fossils based on benthic foraminifera of Mediterranean Tethys basin within shallow marine, and biostratigraphy of Dariyan formation and introduction of biozones especially based on Orbitolina and define a direct age in the basis of identification of biozones.

Materials and Methods

In this study, a total of 240 samples of hard rocks and 960 thin sections were prepared from two outcrops namely Kuh-e Siah and Kuh-e Gadvan (Figs. 2 and 3), for their foraminiferal content. Thin sections were studied by polarized microscope and benthic foraminiferal species from different families were identified. On the basis of micropaleontological studies of the Dariyan Formation in these two sections, a biostratigraphic zonation was established and 4 biozones recognized. Three of them were distinguished based on the zonal scheme proposed by Velic (2007) & Schroeder et al. (2010) and one biozone was locally defined.

Geological setting and studied sections

The Zagros orogenic belt is located on the eastern and northeast margin of the Arabian Plate (Fig. 1). During the Paleozoic, Iran, Turkey and the Arabian realms together with Afghanistan and India made up the

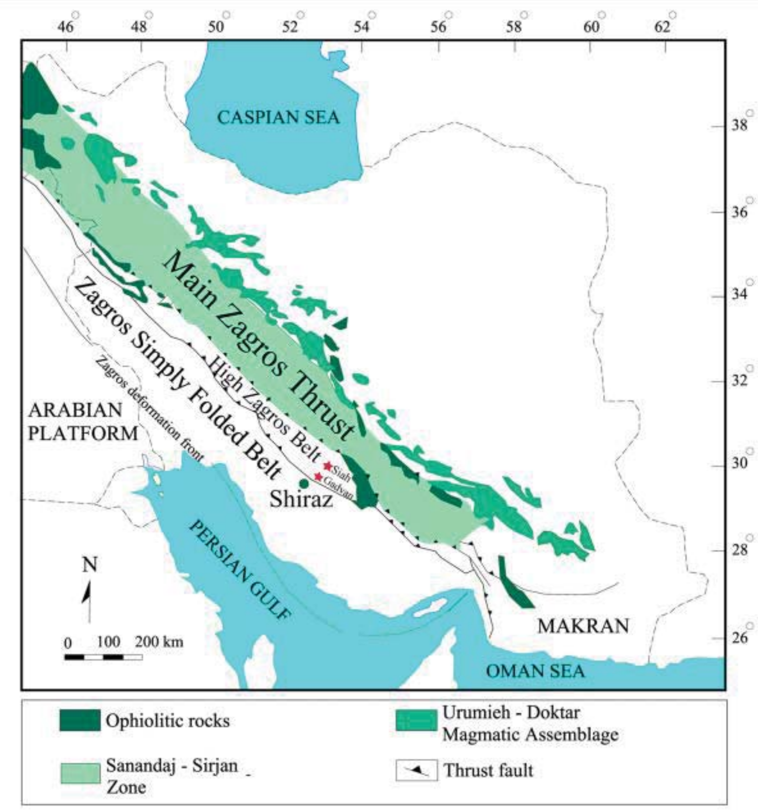

Figure 1. Location map of Zagros Basin [12] and studied sections.

long, very wide and stable passive margin of Gondwanaland bordering the Paleo-Tethys Ocean to the north [2]. In the Paleozoic era, the thick sedimentary sequences of the Zagros basin are ranging in age from Cambrian to Recent. Major thrust faults divide Zagros basin to subdivisions that are parallel to high Zagros

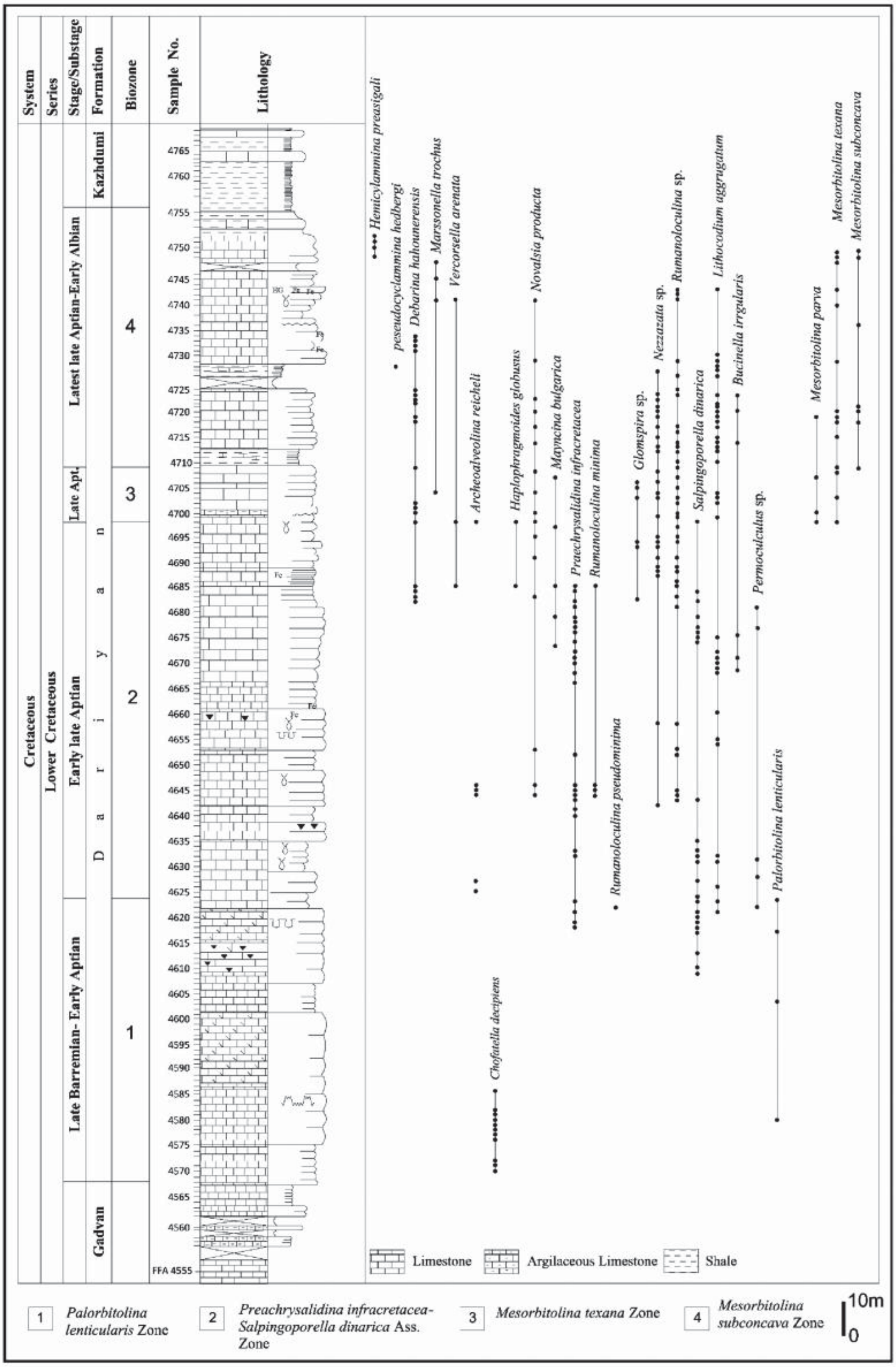

Figure 2. Distribution of benthic foraminifera and biostratigraphic zonation of the Kuh Gadvan Section.

Fault and Mountain Front Faults. In the north of high Zagros fault and south of main Zagros thrust fault known as imbricated belt [11,14] and high Zagros belt [15] (Fig. 1). high Zagros fault has divided Zagros orogenic belt into two major belts parallel structural zones known as Zagros Imbricated Zone to the northeast

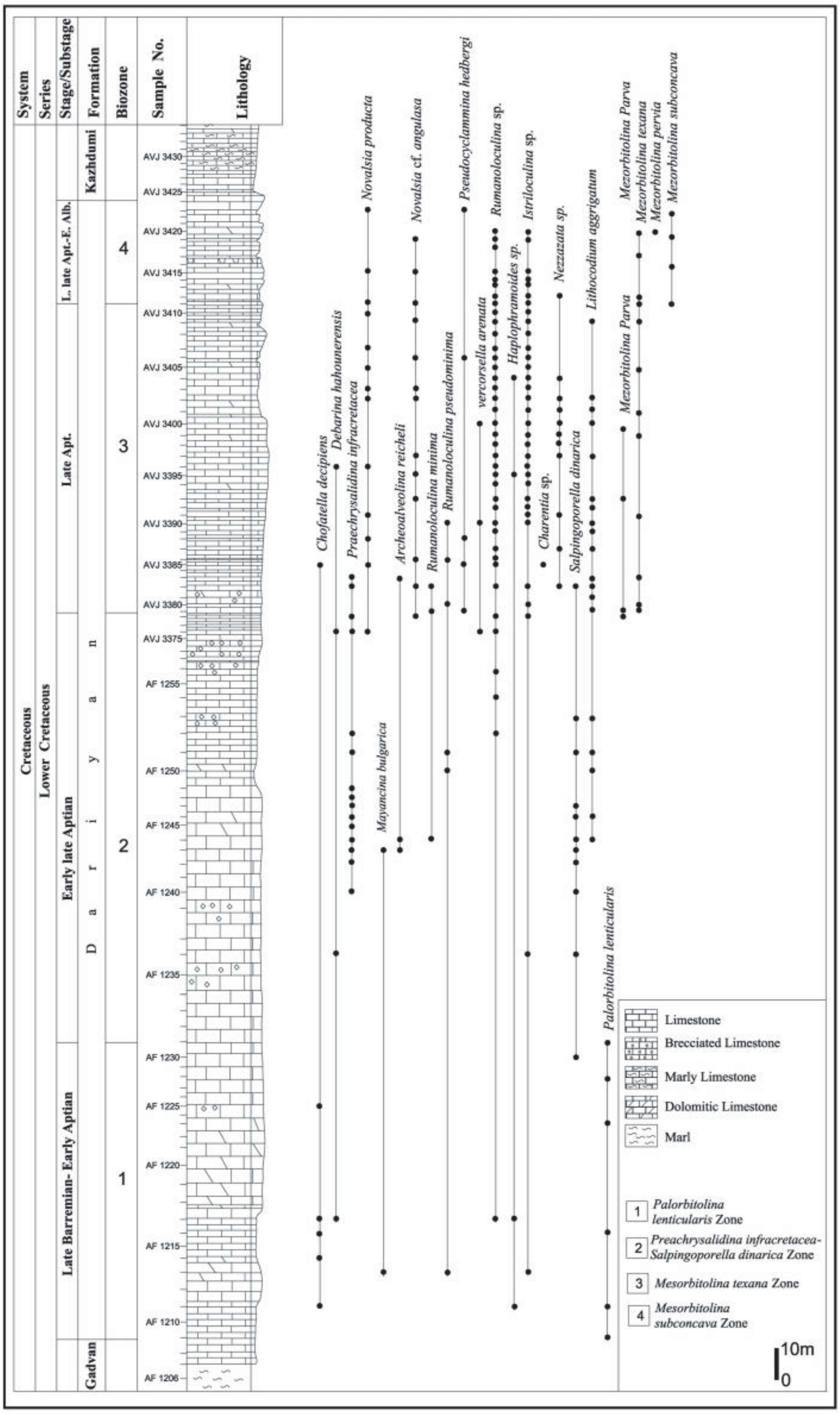

Figure 3. Distribution of benthic foraminifera and biostratigraphic zonation of the Kuh Siah section.

and Zagros fold – thrust belt to the southwest [1]. The Zagros fold thrust-belt of Iran is the central part of the Alpine-Himalayan system [11,1].

Kuh Gadvan section: This outcrop section is located in the Gadvan anticline, approximately 50 km east of the town of Shiraz (Fig. 1). The thickness of the Dariyan Formation is up to 287 m. The Dariyan Formation consists of mainly of grey to light colored hard limestones containing rudists, echinoids, algae as well as small and large foraminifers. The lower boundary of the Dariyan Formation at the contact with the Gadvan Formation is conformable and its upper contact with Kazdumi Formation is disconformable.

Kuh Siah section: The outcrop section exposed in Kuh-e Siah anticline, approximately 90 km northern part of the town of Shiraz, northeastern High Zagros Belt (Fig. 1). The thickness of the Dariyan Formation at Kuh-e Siah section is 320 m. This Formation is composed mainly buff to grey hard thick bedded limestones comprised foraminifera and bivalves. The lower boundary of the Dariyan Formation with the Gadvan Formation is conformable and its upper contact with Kazdumi Formation is disconformable.

Biostrtigraphy

Four biozones were introduced in the two sections (Figs. 2, 3) based on the biostratigraphical investigations. The stratigraphical zones are briefly described below.

Palorbitolina lenticularis taxon rang Zone:

Age: Late Barremian-early Aptian

Definition: Interval of stratigraphic range of *Palorbitolina lenticularis*. This biozone represents 84 m of Kuh Gadvan (from 31 to 115 m) and 94 m of kuh-e Siah (from 30 to 124 m).

Remarks: the microfossil assemblage of this biozone includes: *Praechrysalidina infracretacea*, *Debrina hahounerensis*, *Novalesia producta*, *Rummanoloculina pseudominima*, *Vercorsella arenata*, *Maynana bulgarica*, *Pseudocylammina hedbergi*, *Salpingoporella dinarica*, Rummanoloculina sp., *Istriloculina* sp.

***Praechrysalidina infracretacea-salpingoporella dinarica* assemblage Zone:**

Age: Late Barremian-early Aptian

Definition: Interval of assemblage range of *Praechrysalidina infracretacea-salpingoporella dinarica*. This biozone was locally defined and includes 111 m of Kuh-e Gadvan (from 115 to 226 m) and 97 m of kuh-e Siah (from 255 to 358 m).

Remarks: the microfossil assemblage of this biozone includes: *Praechrysalidina infracretacea, Debrina hahounerensis, Novalesia producta, Rummanoloculina pseudominima*, *Vercorsella arenata*, *Maynana bulgarica*, *Pseudocylammina hedbergi*, *lithocodium aggregatam*, *Salpingoporella dinarica*, *Rummanoloculina* sp., *Istriloculina* sp.

***Mesorbitolina texana* Interval Zone**

Age: late late Aptian

Definition: Interval Zone from first occurrence of *Mesorbitolina texana* to the first occurrence of *Mesorbitolina subconcava.* This biozone represents 17 m of Kuh-e Gadvan (from 226 to 243 m) and 97 of kuh-e Siah (from 258 to 355 m).

Remarks: the microfossil assemblage of this biozone includes: *Mesorbilotina Parva*, *Pseudocyclammina hedbergi*, *Vercorsella* cf. *Laurenti*, *Novalsia producta*, *Debarina hahounerensis*, *Meorbitolona pervia*, *Hemicylammina Preasigali*, *Rummanoloculina* sp, *Nezzazata* sp., *Glomspira* sp.

***Mesorbitolina subconcava* taxon rang Zone:**

Age: latest late Aptian to early Albian

Definition: Interval of stratigraphic range of *Mesorbitolina subconcava*. This biozone represents 67 m of Kuh Gadvan (from 243 to 310 m) and 33 m of kuh Siah (from 355 to 388 m).

Remarks: the microfossil assemblage of this biozone includes: *Hemicyclammina Preasigali*, *Pseudocylammina hedbergi*, *Debrina hahounerensis*, *Novalesia producta*, *Mesorbitolina texana*, *Mesorbitolina sbconcava*, *Pseudocyclammina hedbergi*, *Rummanoloculina minima*, *Vercorsella arenata*, Pseudocyclammina sp., *Glomospira* sp., *Rummanoloculina* sp., *Nezzata* sp.

Results and Discussion

Deposition of Urgonian type limestones in the Barremian-Albian interval has been documented in many parts of the world [3, 9]. The paleoenvironmental interpretations are based on fossil assemblages is composed of abundant *Palorbitolina*, *Mesorbitolina*, *Choffatella*, *Pseudocyclammina* and miliolids. The outer morphology of orbitolinids recorded in discoidal and mainly conical forms in theses study sections. The conical orbtolinids characterize shallow water environment settings but the discoidal forms are related to deeper water environments [5,8,13,18].

In the study area, in addition to orbitolinids, other benthic foraminfera were recognized such as *Choffatella decipiens* (Figs. 4A, B), *Istriloculina* cf. *elliptica* (Fig. 4C), *Rumanoloculina ponticuli* (Fig. 6E), *Rumanoloculina pseudominima* (Fig. 6D), *Novalsia producta* (Fig. 6F), *pseudocyclammina hedbergi* (Fig. 5F), *Glomospira urgoniana* (Fig. 6A) *Praechrysalidina infracretacea* (Figs. 5C, D), *Debarina hahonerensis* (Fig. 5A), *Archalveolina reicheli* (Fig. 3E), *Derventina*

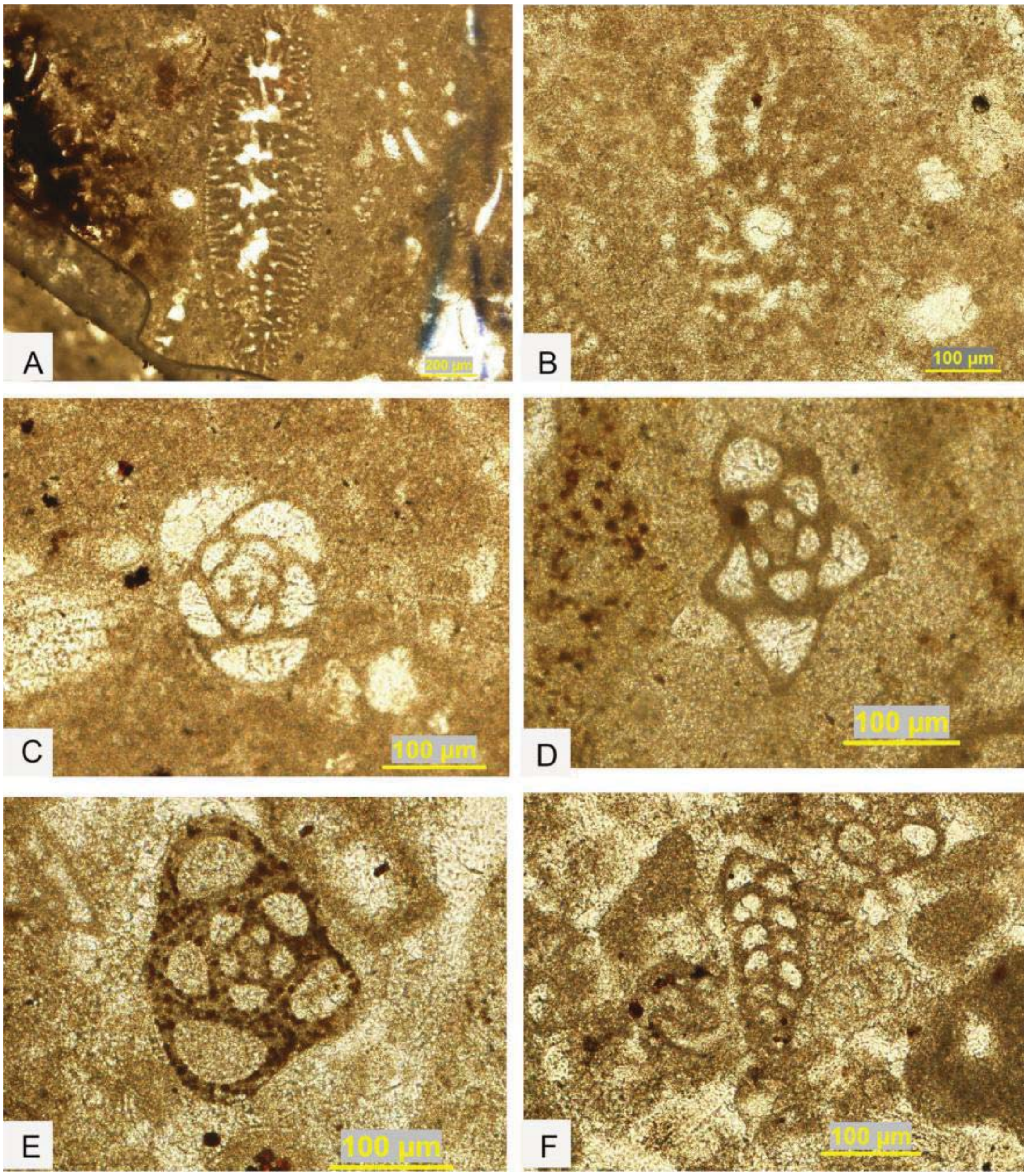

Figure 4. A, *Choffatella decipiens* Schlumberger, 1905 (Longitudinal section); B, *Choffatella decipiens* Schlumberger, 1905 (Tranvesal section); C, *Istriloculina* cf. *elliptica* (Iovcheva, 1962) (transversal section); D, *Rumanoloculina pseudominima* Bartenstein et Kovatcheva, 1984 (transversal section); E, *Rumanoloculina ponticuli* Neagu, 1986 (transversal section); F, *Novalesia producta* (Magniez) (sub-axial section).

cf. *filipescui* (Fig. 4B). These fauna assemblages suggested suggest deposition on a shallow-water carbonate platform. The fossil assemblages and depositional environment indicate the Dariyan Formation can be comparable with deposits of the Barremian-Aptian Interval in the south Carpatians of Romania and northeastern Serbia [3].

The orbitolinids are one of the most important larger foraminifera mainly for Barremian to Albian biostratigraphic. Studies of carbonate platform sediments with an embryonic apparatus and its structures enable phylogenetic lineages to be regarded for lower to mid Cretaceous. Therefore orbitolinid micropaleontology is an ideal biostratigraphic tool for age determination. The changes of outer morphology and the inner structure including embryonic apparatus have revealed the numerous species to be established as biostratigraphical markers [13].

According to Schroeder et al. (2010) the evolutionary trends of the outer morphology consist of a) increasing the size of the test b) extention of the apical angel and making the test flatter c) the gradual decrease of the initial spire in the melospheric forms. The main evolution of the internal structures include a) a gradual increase of the size of the megalospheric embryo and moving from eccentric to centric position b) a gradual formation of the subepidermal chamberlets in the upper part of the embryonic chamber c) a gradual complexity subdivision of the marginal zone by vertical and horizontal plates.

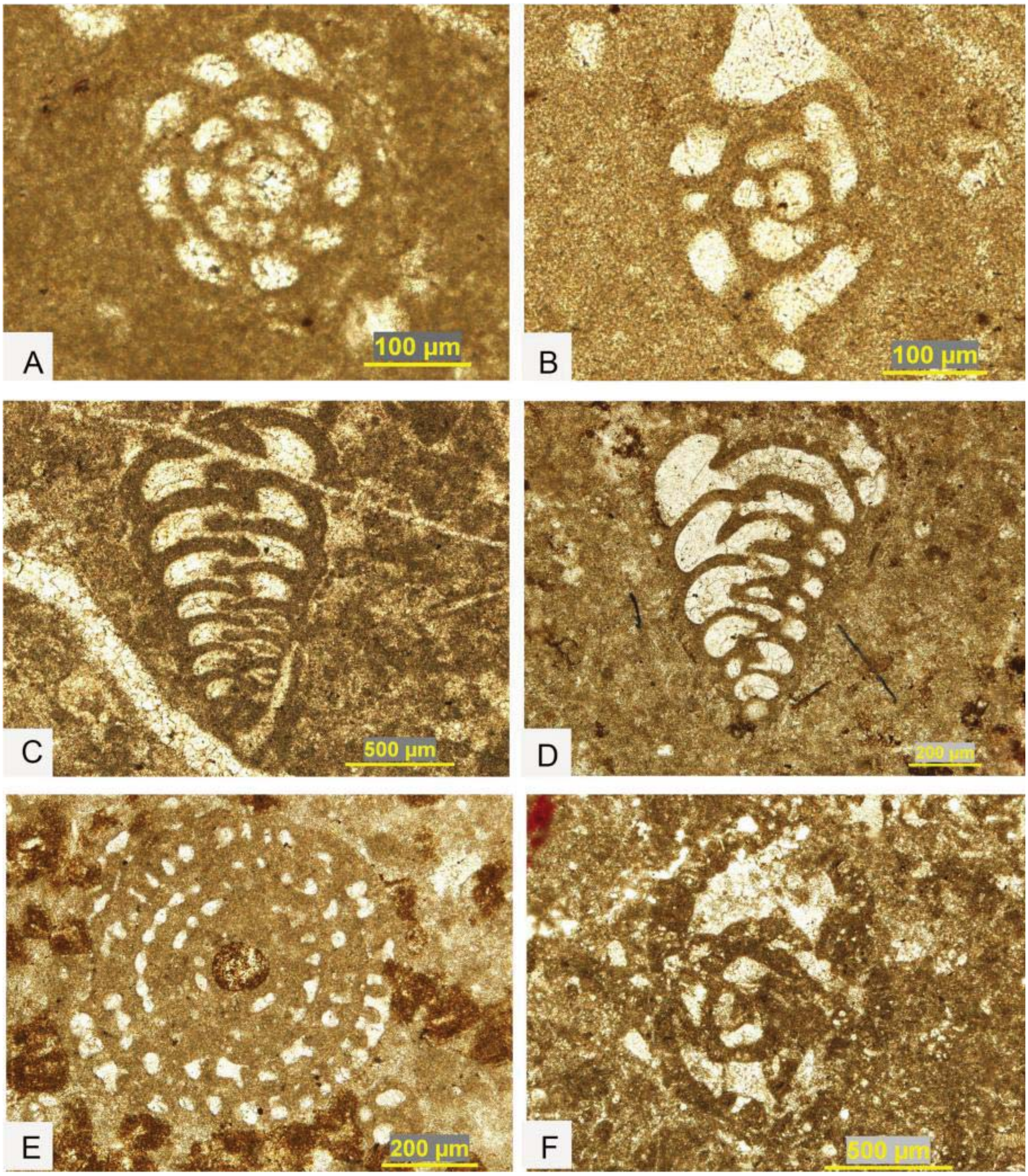

Figure 5. A, *Debarina hahounerensis* Fourcade, Raoult et Vila, 1979 (transversal section); B, *Debarina hahounerensis* Fourcade, Raoult et Vila, 1979 (vertical section); C, D, *Praechrysalidina infracretacea* Luperto Sinni, 1979 (vertical section); E, *Archaealveolina reicheli* (de Castro, 1976) (transversal section); F, *Pseudocyclammina hedbergi* Yokoyama, 1980 (subaxial section).

In the upper Barremian and early Aptian carbonates *Palorbitolina Lenticularis* (Figs. 4C, 4D) appear in chronological [13,17]. This taxa occur in the lower part of Dariyan Formation accompanied by rudists and some benthic foraminifera.in the test of Orbitolina lenticularis, the embryonic apparatus is central and the first post-embryonic chamber is very large, enclosing the proloculus as a periembryonic ring.

Based on stratigraphic range of Palorbitolina *lenticularis* [13,17] the age of the Lower part of Dariyan Formation is from upper Barremian to early Aptian.

The evolutionary trends of the embryo in megalospheric forms of the *Mesorbitolina* have enabled numerous species to be regarded as biostrtigraphical

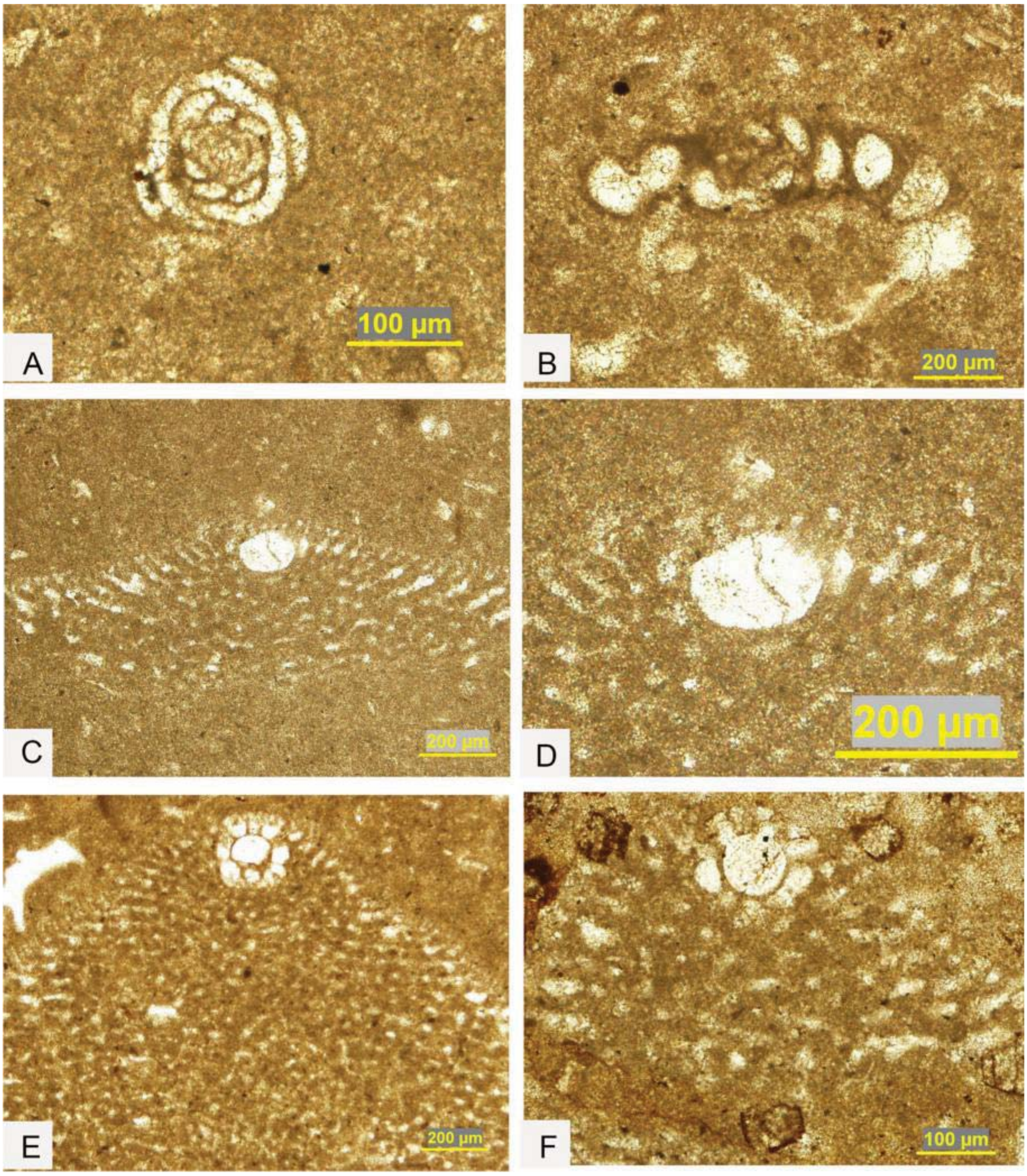

Figure 6. A, *Glomospira urgoniana* Arnaud-Vanneau, 1980 (subtransversal sections); B, *Derventina* cf. *filipescui* Neagu, 1968 (axial section); C, D, *Palorbitolina lenticularis* Blumenbach, 1805 (axial section); E, *Mesorbitolina parva* Douglass, 1960 (axial section of embryonic apparatus); F, *Mesorbitolina parva* Douglass, 1960 (subtranversal section of embryonic apparatus).

markers [13]. In the upper Draiyan Formation the different species of *Mesorbitolina* including *Mesorbitolina texana, Mesorbitolina texana* and *mesorbitolina subconcava* have cosiderable after reduction of green algae especially, *lithocodium aggregatum* and *salpingoporella dinarica*. Regarding to abundance of orbitolinids and green algae in the Dariyan Formation indicate shallow water depositional environment. The assemblages of fauna, diagnostic age and sedimentation environment represent similarity to Urgonian type facies.

Mesorbitolina parva is characterized by complete system of Alveoli. The deutroconch of this species is divided by plates in its uppermost part. The subembryonic zone presents a large and well-developed alveolar layer. Transversal section of the upper part of subembryonic zone indicates specific character of this species. The distance between two chambers is greater than the distance between protoconch and the first embryonic chamber [13].

Mesorbitolina texana (Figs. 7A, 5B) shows complexity subdivisions in deutroconch and plates in the upper part. The subembryonic zone is further developed alveolar layer and larger than *Mesorbitolina texana*. During the evolution of species, there is a marked trend to the whole embryonic apparatus, the protoconch becomes irregularly lenticular. The deutroconch of *Mesorbitolina subconcava* (Fig. 7D) subdivided by a set of plates and the size of embryonic apparatus completely increased.

In studied sections, the dominant benthic foraminifera accompanied with calarous algae, rudists and echinoderms. The association of orbitolinids with rudists and echinoderms in thick bedded limestone are represented to deposit in shallow marine and trophic conditions [12]. orbitolinid associated with green algae facies indicate inner to mid platform.

The Dariyan Formation has been subdivided into

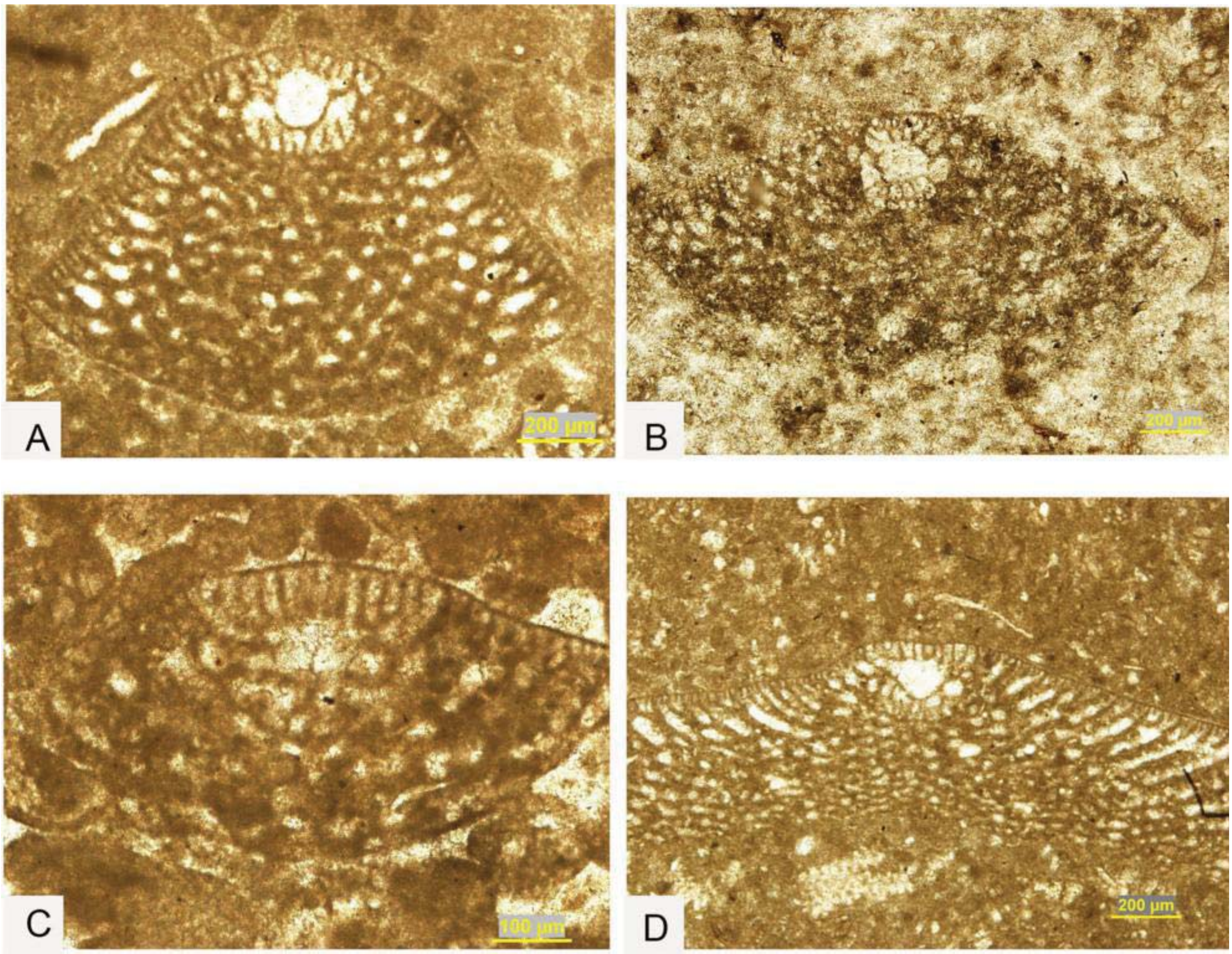

Figure 7. A, *Mesorbitolina texana* Roemer, 1849 (axial section of embryonic apparatus); B, *Mesorbitolina texana* Roemer, 1849 (subaxial section of embryonic apparatus); C, *Mesorbitolina pervia* Douglass, 1960 (axial section); D, *Mesorbitolina subconcava* Douglass, 1960 (axial section)

three units based on lithofacies variation and micropaleontological investigations. In the lower part of Dariyan Formation, the main benthic foraminifera represent *Palorbitolina lenticularis* and c*hoffatella* associated with slightly green algae. In the middle part of this Formation, the orbitolinids disappeared and green algae including Lithocodium and Salpingoporella, increased considerably. In the upper part, green algae gradually reduced and species of *Mesorbitolina* genus appeared and the successions composed of medium to thick bedded Orbitolina-rich limestone. A few planktonic organisms, such as *Hedbergella*, *Globigerinelloides* have also been observed. The presence of Planktonic elements likely doesn't indicate the deep marine and may have been transported by storms to shallower parts of the carbonate. The biotic assemblages were controlled mainly by changing of depositional factors such as water energy, light, temperature and fluctuating of sea level. Macro and microfossil assemblages of the Dariyan Formation document the existence of an Urgonian platform in the Zagros basin in the late Barremian to early Albian time interval.

Conclusion

The Lower Cretaceous benthic foraminifera from the Dariyan Formation are known from southern of the Tethys. Micropaleontological and biostrtigraphical studies led to recognition of microfossils and to establishment of 4 biozones. The assemblages of benthic foraminifera, the well diagnostic taxa including *Palorbitolina lenticularis*, *Mesorbitolina parva*, *Mesorbitolina taxa* and *Mesorbitolina subconcava* suggest late Barremian-early Albian time for the Dariyan Formation.

A systematic research of the different benthic foraminifera morphotypes in the samples allow to have an idea of the Urgonian type facies. In the study area, the most common diversified foraminifera assemblages belong to Orbitolinacea and Miliolacea. The microfossils of carbonate rocks including benthic foraminifera and green algae indicate a low energy and shallow water depositional environment. The identified benthic foraminifera consist of well-known species from the Tethyan Realm with a world-wide distribution in lower Cretaceous. Based on these data, the Dariyan Formation in northeastern Arabian plate are comparable with Barremian-Albian shallow water carbonate facies of peri-Mediterranean Tethys.

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