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Recording Jurassic Microfossils from Jabal Al-Balaq at Marib Governorate, Yemen

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Abstract:
Fossils give a view into the historical backdrop of life by demonstrating the structures and highlights of life in ancient times. Fossils disclose to us how species have changed over long stretches of the Earth's history. The fossils record is a momentous presence in the investigation of nature. The lower part of the Shuqra Formation (Amran Group) has been investigated to document the variety of microfossils present. The Middle-Upper Jurassic (Middle Bathonian, Callovian-Kimmeridgian Stages) Shuqra Formation is exposed at Jabal Al-Balaq south and southeast of Marib city, Marib Governorate, Yemen. There are three units in the study area, (1) Basement complex, (2) Shuqra Formation, and (3) Madbi Formation. Shuqra Formation is part of the Amran Group that was deposited during Middle /Upper Jurassic Pre, Syn, and Post rifts. The Shuqra Formation in the study area is divided into three parts, the upper, middle, and lower parts. The samples used for this study were collected through the study section in a systematic manner, at every 10 m interval vertically from the base to the top. All microfossils have been described in detail in regard to taxonomy, distribution, environment, and age. In this study, 60 samples were collected and 96 thin-section slides were prepared. Ten microfossils were identified within Lower Shuqra Formation: Protopeneropli ssp, Troglotella incrustans Wernli & Fookes, Kurnubia sp., Halimeda sp., Nautiloculina oolithica Mohler, Mesoendothyra croatica Gusic, Marinella lugeoni Pfender algae,Protopeneroplis ultragranulata sp., Dasycladales algae (dasycladalean algae) and Orbitopsella praecursor (Gümbel 1872).

Keywords: *Jurassic Microfossils, Amran Group, Shuqra Formation, Sab'atayn Basin, Yemen*.

INTRODUCTION

The study area is located to the south and southeast of Marib City, Marib Governorate, northwestern central of the Republic of Yemen between longitudes 45° 27′ 50″–45° 11′ 38″ E and latitudes 15° 14′ 00″–15° 25′ 59″ N (Fig. 1). The studied section is a part of the Amran Group which was studied by numerous workers (Lamare, 1923; Lamare et al., 1930; Beydoun, 1964, 1998; Beydoun & Greenwood, 1968; EL-Anbaawy, 1984; AL-Thour, 1992; EL-Nakhal, 1990; AL-Wosabi ,2009, 2011,Howarh& Morris,1998). The study area is named Jabal Al-Balaq which has been divided into three sectors: Jabal Al-Balaq Al-Sharqi (eastern), Jabal Al-Balaq Al-Awsat (central), and Jabal Al-Balaq Al-Qibli (western). Amran Group is considered to be one of the most important rock units in Yemen and in the Arabian Peninsula due to its economic potentiality as the main hydrocarbon system in the Sab'atayn Basin, as well as its mineralization (lead, zinc, copper, and silver). Amran Group was introduced by Lamare (1923, 1930) as the ‘Amran Series’, but it was emended to Amran Group by Beydoun(1964), who subdivided it into four formations: Shuqra, Madbi, Sab'atayn, and Nayfa Formations.

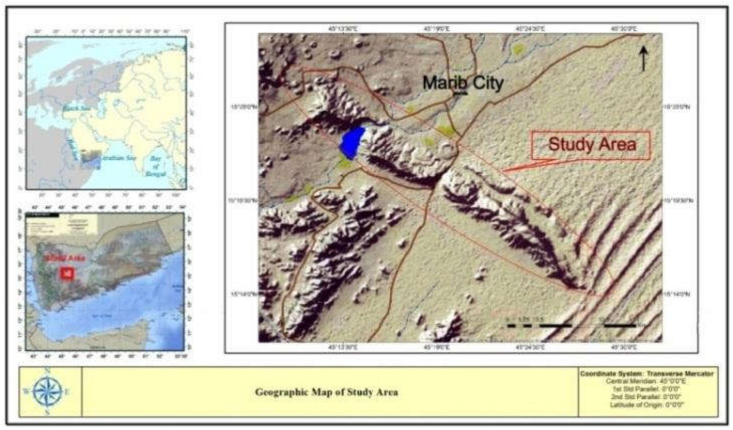

Figure 1a: Location Map of Study Area

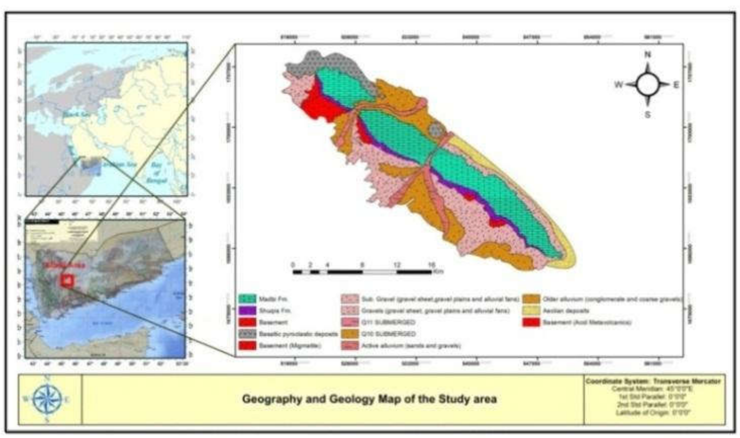

Figure 1b: Geographic and Geologic Map of Study Area.

Jabal Al-Balaq area (Fig. 3), includes Precambrian basement rocks, Jurassic rocks (Amran Group), Quaternary volcanic, and Quaternary deposits. The study section is the lower part of the Shuqra Formation, where the microfossils were recorded.

GEOGRAPHICAL AND GEOLOGICAL SETTING

Yemen is situated, geographically in the southwestern part of the Arabian Peninsula, and geologically it is transitional between the Arabian and African plates. The study section crops out in Jabal AL-Balaq, south of Marib city, Yemen (Fig. 1). The area geologically belongs to Sab'atayn Basin, Marib Sector,and geographically to Marib Governorate. The Sab'atayn Basin has three tectonic events, pre-rift, syn-rift, and post-rift. It includes a basement, Mesozoic sediments, and Quaternary volcanic and quaternary deposits. The development of the Sab'atayn Basin has been subdivided into three tectonostratigraphic mega-sequences: (1) a pre-rifting phase (Permian-Oxfordian/Kimmeridgian), (2) a syn-rifting phase (Kimmeridgian/Tithonian), and (3) a post-rifting phase (Early Cretaceous). Pre-rift deposits are represented by non-marine to shallow-marine clastic rocks Kuhlan Formationoverlain by shallow-marine carbonates (Shuqra Formation) (Beydoun et al., 1998). A latest Triassic to Middle Jurassic age is generally accepted for both Formations (AL-Wosabi & Wasel, 2011); but Stephenson& AL-Mashaikie (2011) provide evidence for a Late Carboniferous age for the lower part of the Kuhlan Formation. The syn-rift sequence is characterized by horsts and nested fault blocks that were developed during Late Jurassic to Lower Cretaceous time (Redfern & Jones, 1995). Syn-rift sections consist of the Madbi, Sab'atayn, and Nayfa Formations that were deposited during the Jurassic in marine settings in the structurally lowest areas (Smewing, 1997; Smewing et al., 1998). The syn-rift sediments of the Madbi Formation were deposited during the Late Jurassic, commencing in the Kimmeridgian age (Beydoun et al., 1998). In the last late stage of the syn-rift phase, the ocean circulation in the Sab'atayn Basin became restricted and deposited the Sab'atayn Formation which has an isolated marine environment. The Sab'atayn Formation has a sequence that consists of thick massive halite interbedded by shales, which are rich in organic matter (Brannan et al., 1999). In the Marib sector of Sab'atayn Basin, where sandstone and mudstone are presently designated as Yah, Seen, Alif, and Safir Members (Fig. 2). Yah Member is dominated by fluvial-deltaic sandstone, mudstone, and evaporates, followed by Seen Member, which is the second evaporite-clastic sequence, Alif Member is composed of sandstone with minor shale, and Safir Member consists, predominantly of halite with subordinate anhydrite divisible into several bodies separated by an interbedded organic-rich shale and sandstone with minor argillaceous, dolomite and limestone. Stratigraphically, Safir Member is found at the top of Sab'atayn Formation, but there are some thin sheets, identical in the composition of Safir Member, found as the interbedded status between other members through the Sab'atayn Formation. (Fig. 2).

Duringthe period of the transition from syn-rift to the post-rift stage, Nayfa Formation was deposited in the shallow-marine environment in Upper Jurassic-Lowermost Cretaceous (Beydoun et al., 1998). Later Seaborne (1996) proposed the deposition of the Nayfa Formation inthe late Tithonian-Late Berriasian age. After that time in the Marib sub-basin (subsurface) Sector of Sab'atayn Basin there is missing sedimentation for an unknown reason, whereas in the Shabwa sub-basin (subsurface) Sector there is Sa'ar Formation in the Berriasian age, in the Marib sub-basin Sector the absence of sequences was keeping a hold on until Hauterivian age, then the Tawilah Group (undifferentiated), mainly consists of white, yellowish sandstone, fine coarse-grained, often cross-bedded, at time gravelly and frequently cut by numerous Tertiary fissures and dykes (Beydoun et al., 1998). In the Late Upper Cretaceous, Maastrichtian age the Tawilah Group ended in deposition, then the quaternary and recent sediments have been started. These presented as a conglomerate and coarse gravels, frequently cemented and formed during late to Post Miocene, occur in the lower reaches wadis, also gravel sheets, gravel plain, and alluvial fans generally in areas of low relief with a stony surface and there are active alluviums that are sands and gravels showing tight stones occurring in water sources.

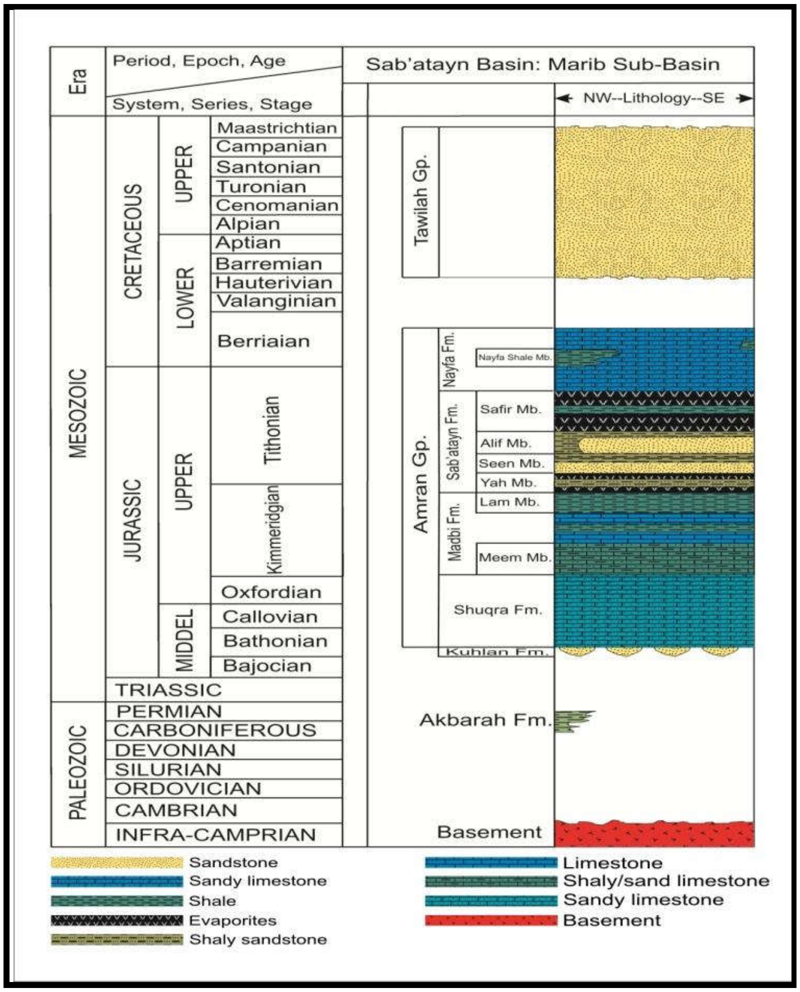

Figure 2: Lithostratigraphic chart of the Sab'atayn Basin.

More than 90% of the surface of Marib Sector of the Sab'atayn Basin is covered by sand dunes which are: linear sand dunes, branch dunes, and loess and ancient dunes. The linear sand dunes often termed Sief dunes are formed parallel to the prevailing wind direction. In addition, the branch dunes are classic crescent-shaped dune fields, and the loess and ancient dunes are present in the area of wind-blown soils and sands (generally fertile land). In Marib Sector of the Sab'atayn Basin, there are Basaltic lava and Basaltic pyroclastic deposits. Pliocene to Quaternary volcanism is also fairly widespread in the areas NW of Sana'a–Amran, Dhamar–Rada, Marib–Sirwah, Balhalf–Bir Ali, and Shuqra area (Menzies et al., 1994). The most recent volcanism in Yemen is found: (i) along the tectonically active Gulf of Aden, (ii) on the Plateau from north of Sana'a to the south of Ta'iz, and (iii) near Marib (Minissale et al., 2007). In both volcanic districts of Sana'a – Amran and Dhamar – Marib, basaltic flows, and scoria cones. They have been enclosed through fissures of roughly E-W direction, and produced basaltic flows only, with no associated silicic products (Kalidi et al., 2010) (Fig. 3).

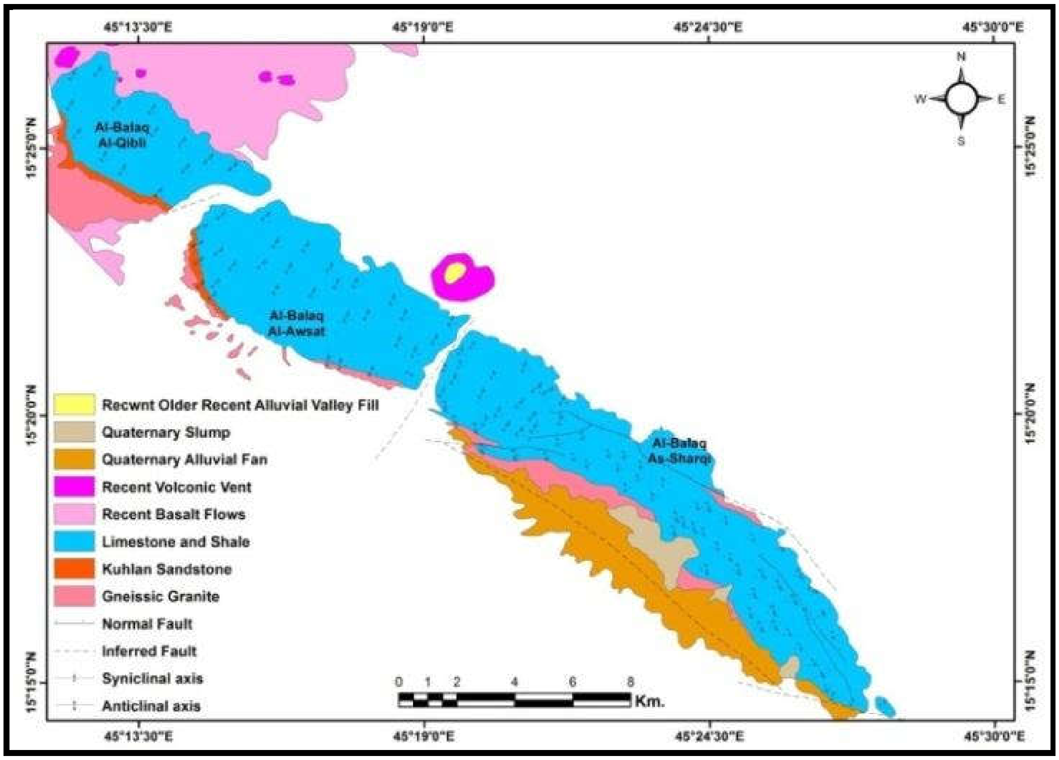

Figure 3: Geological map of the study area.

In Marib Sector, the surface stratigraphy observed in Jabal Al-Balaq is Basement, Shuqra Formation, and Madbi Formation (Fig. 4) and (Fig. 5).

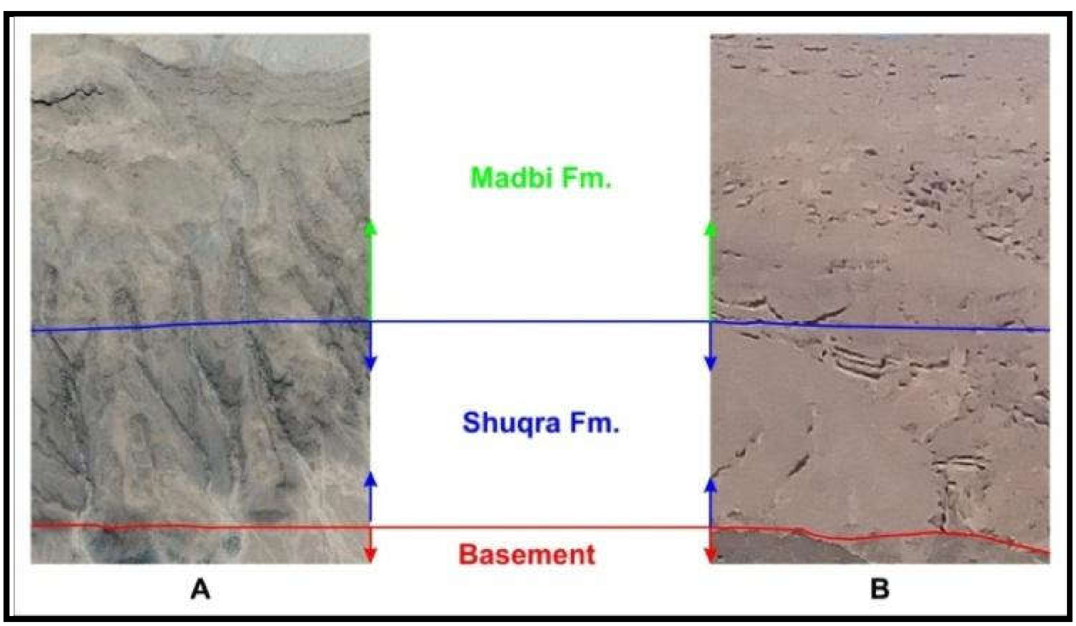

Figure 4: Google screenshot (A) and field photograph (B) showing the lithology in the study area.

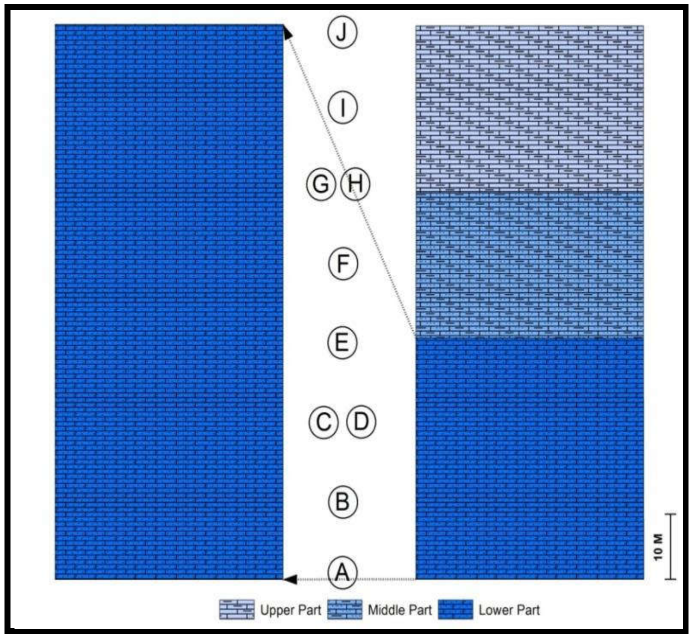

Figure 5: Representative lithological section of the study area.

MATERIAL AND METHODS

60 samples were collected from the study area carefully taken perpendicular to the strike of the bed and then poked in a hard plastic container. 96 thin section slides were made in thin section lap three sides for all sample, used only which we saw it important for this study, photomicroscope has been used to clip photo for thin section by well-defined scale. A German handheld GPS was used to determine the approximate locations of samples. As a matter of course we used toposheet, geological map, topographic map, and previous works of the study area. In addition, some programs were utilized such as ArcMap10.1, Global Mapper18, CorelDRAW Graphics Suite X3, AutoCAD 2016, and Google Earth Pro.

Lithology and fossils

The 97 m of Shuqra Formation strata overlie basement rocks, and the lithology consists of basal sandy limestone made up of dark grey to yellow sandy oolitic limestone intercalated with argillaceous and bioclastic sandstone with conglomeratic horizons (EL-Anbaawy et al., 1989).

The Shuqra Formation predominantly consists of limestone, commonly with wackestone textures and locally dolomitic. In addition, subordinates dolomites are locally observed, particularly in the lower section. The carbonates are locally silty, arenaceous, rarely cherty, and oolitic and slightly pyritic, interbedded minor mudstones are commonly moderately calcareous and locally silty rarely non-calcareous. Shuqra Formation in the study is overlainnon conformable on Basement and underlies conformable by Madbi Formation.

The study section is divided into three sections. The samples for fossils have been taken from the ≈ 37m thick lower section, which is sandy oolitic limestone and contains more of Terebratulida, Rhynchonellida, gastropods, corals, brachiopods, pelecypodsbivalve, and other marine invertebrates macrofauna, larger benthic foraminifera and algae (Fig. 6).

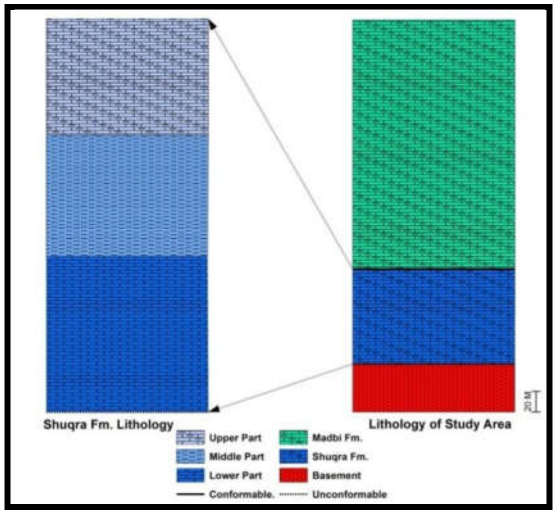

Figure 6: Letters A=J. Microfossils from each sample are illustrated in the following figures:

A = Fig. 7 (d).; = Fig. 8 (a); = Fig. 9 (a);.D = Fig. 7(a); E = Fig. 7 (b);F = Fig. 7 (c); G = Fig. 8 (b); H = Fig. 8 (d);I = Fig. 8 (c); J = Fig. 9 (b).

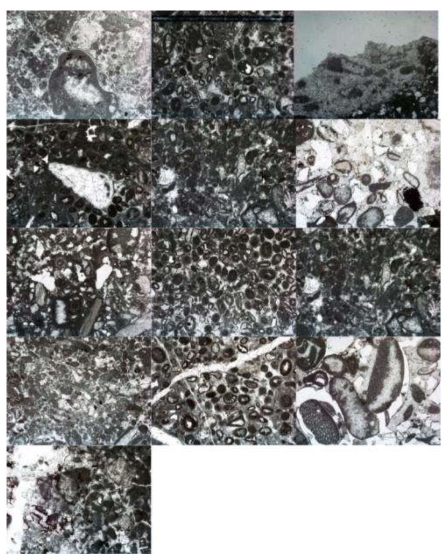

Plate 1:

Nautiloculina oolithica Mohler, 1938, *Mesoendothyra croatica* Gusic, 1969, *Marinella lugeoni* Pfender,*Protopeneroplis ultragranulata* Weynschenk 1950, *Nautiloculina oolithica* Mohler, 1938, *Mesoendothyra croatica* Gusic, 1969, *Marinella lugeoni* Pfender, *Protopeneroplis ultragranulata* Weynschenk 1950, *Dasycladales algae* (*Salpingoporella?* sp., *Clypeina?* sp.), and *Orbitopsella praecursor*.

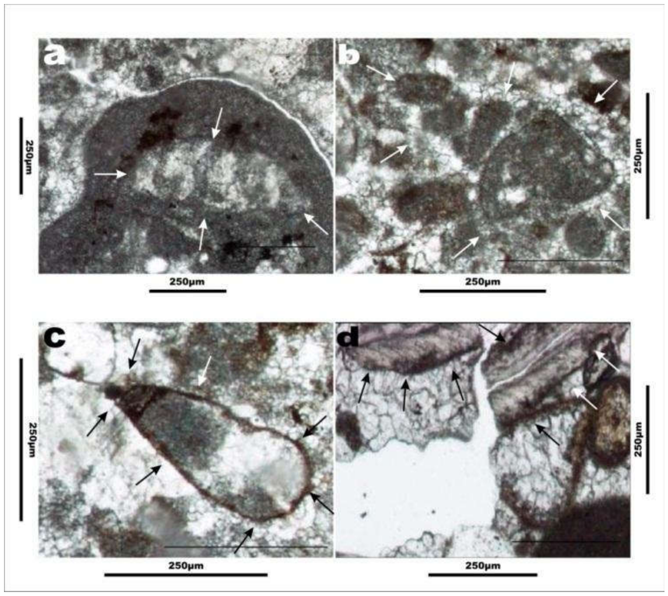

Figure 7:

a. *Protopeneroplis banatica* Bucur Kotouč.

b. *Troglotella incrustans* Wernli and Fookes, 1992.

c. *Kurnubia palastiniensis* Henson, 1948.

d. *Halimeda* sp.

Taxonomy

Protopeneroplis sp.
Order: Involutinida Elichwald 1830.
Suborder: Fusulina Wedekind 1937.
Superfamily: Endothyracea Brandy 1884.
Family: Ventrolaminidae Weynschenck, 1950.
Genus: Protopeneroplis,Weynschenck, 1950-Arnaud-Vanneau, A. (1995).
Type species: *Protopeneroplis banatica* Bucur.

Selected synonymy
1971 *Hoeglundia* (?) *ultragranulata* n. sp. - Gorbatchik, p. 135, pl. 5, figs. 2a-c.
1974 *Protopeneroplis trochangulata* n. sp. - Septfontaine, p. 608, pl. 1, figs. 1-18.
1989 *Protopeneroplis trochangulata* Septfontaine - Fourcade and Granier, pl. 1, fig. 11.
1993b *Protopeneroplis ultragranulata* (Gorbatchik) - Bucur, p. 214, pl. 2, figs. 1-2, 5, 8, 11-12.
2005 *Protopeneroplis ultragranulata* (Gorbatchik) - Schlagintweit et al., p. 37-38, figs. 21a-d (with synonymy).

Distribution:
The *Protopeneroplis banatica* Bucur was found at Upper Jurassic - Lower Cretaceous Formations in Lower 40 m of Topeşti Formation, of the southwestern part of Vâlcan Mountains, south Carpathians; it was also found in the Berriasian-Valanginian olistoliths sediments, the north-eastern flank of Gilău Mountains, the eastern border of the Gilău (Bucur et al., 2004). The *Protopeneroplis banatica* Bucur was found in limestone clasts at the Guanajuato Conglomerate, central Mexico (Omana Maña et al., 2014). It was found in the lower part of a

third depositional sequence of the upper Jurassic-Lower Cretaceous deposits of the Tascău mountains (Bucur & Săsăran, 2005).

Paleoenvironment:
The *Protopeneroplis* sp. was found in limestone clasts that contain shallow-water platform characteristics including bivalves, brachiopods, gastropods, echinoderms, and foraminifers at the Guanajuato Conglomerate, central Mexico (Omaña et al., 2014). In the lower part/section of the third depositional sequence at the upper Jurassic-Lower Cretaceous deposits of the Tascău mountains it was found in a shallow or very shallow water environment (Bucur & Săsăran, 2005).

Age:
Protopeneroplis banatica is known only from the Early Cretaceous (Bucur et al., 1993, 1999). Age is potential Barremian from Samples 143-866A-127R-1, 25-27 cm; -126R-1, 70-72 cm; -125R-3, 19-21 cm; -125R-2, 70-72 cm; and -125R-1, 143-145 cm (Arnaud-Vanneau A.,1995). *Protopeneroplis trochoagulata* Septtontain had given age from Late Tithonian- Berriassian, Zone 3.

Protopeneroplis ultragranulata (Gorbatchik) in grainstone intercalations within the upper part of unit 3 suggests a maximum age of Middle/Late Tithonian (Heinz & Isenschmid, 1988; Altiner & Özkan, 1991; Gkawlick & Schlagintweit, 2009). Most records of *P. ultragranulata* are from the Berriasian and Valanginian; the last occurrence is recorded in the Early Barremian (Bucur, 1993b; Schlagintweit & Enos, 2013). *Protopeneroplis* sp. is ranging in age from Berriasian to Valanginian generally is thought not to occur younger than the Hauterivian (BUCUR, 1993).

***Troglotella incrustans* Wernli & Fookes**
Superfamily: Hormosinaacea Haeckel 1894.
Family: Telamminidae Loeblich and Tappan, 1985
Genus: Troglotella Wernli & Fookes, 1992 *Troglotellaincrustans* Wernli & Fookes (Fig. 1a, b pars, Fig. 3-10)
Type species: *Troglotella incrustans* Wernli and Fookes, 1992 *Troglotella incrustans* Wernli and Fookes 1992 pl. 1, figs 1-7.

Selected synonymy
1991 *Boring foraminifer gen. et* sp. indet – Schlagintweit, p. 44, pl. 10, figs. 13-14.
1992 *Troglotella incrustans* nov. gen., nov. sp. – Wernli and Fookes, p. 97, pl. 1-2.
1996 *Troglotella incrustans* Wernli and Fookes – Bucur et al., p. 69, pl. 2, fig. 3, pl. 5, figs. 6, 9-10.
1996 *Troglotella incrustans* Wernli and Fookes – Schmid and Leinfelder, p. 25, pl. 1, figs. 1-4, pl. 2, figs. 1-6, text-figs. 1-8 (with synonymy).
1997 *Troglotella incrustans* Wernli and Fookes– Kolodziej, Figs. 2a-f (pars); fig. 3. 2005 *Troglotella incrustans*Wernli and Fookes– Schlagintweit et al., p. 46, fig. 29 a-c (with synonymy).
2010 *Troglotella incrustans* Wernli and Fookes– Krajewski, fig. 4.33/C (pars), fig. 4.35/A (pars), fig. 4.39/D (pars), fig. 4.41/D (pars), fig. 4.52/C (pars), fig. 4.57/D (pars), fig. 4.67/A (pars).
2011 *Troglotella incrustans* Wernli and Fookes– Bucur and Săsăran (2005), pl. 2, fig. 5, pl. 4, figs. 12, 14 (pars), pl. 5, figs. 4-6, pl. 16, fig. 3 (pars).
The *Troglotella incrustations* were found and described by Wernli & Fookes(1992) from the Kimmeridgian of France.
Schmid & Leinfelder,(1996) summarized its stratigraphic range as Middle Oxfordian to Tithonian.
Cherchi & Schroeder (1999) and Schlagintweit (2012). figured *Troglotella n.* sp. from the Lower Cenomanian of France.

Distribution:
The *Troglotella incrustations* were found in Piano Camarrone, Monte Pellegrino near Palermo (Sicily, Italy) (Cherchi & Schroeder, 2010). This microfossil was found in the Upper Jurassic-Lowermost Cretaceous limestones of southern Crimea, Romania (Bucur et al., 2014). *Troglotella incrustans* sp. was recorded in the Upper Jurassic-Lower Cretaceous deposits of the Trascău mountains (Bucur & Săsăran, 2005).

Paleoenvironment;
The paleoenvironment of a section of southern Crimea, Romania, that Troglotella incrustans recorded in it, with other fossils such as cyanobacteria, gastropods, and ostracods, was likely formed in a moderate- to the high-energy

subtidal environment (Bucur et al., 2014). The sedimentary rocks of southern Crimea, Romania, where the *Troglotella incrustans* sp. was found are shallow-marine deposits of various environments related to the evolution of the Crimean carbonate platform (Krajewski, 2010; Bucur et al., 2014).

Age:
The *Troglotella incrustations* were found in Jurassic-lowermost Cretaceous limestones of southern Crimea, Romania that were deposited during the Kimmeridgian-Tithonian age (Bucur et al., 2014).

***Kurnubia* sp.**
Suborder: Ataxophragmiacea Schwager, 1877
Family: Pfenderinidae Smout and Sugden 1962
Subfamily: Kurnubiianae Redmond 1964.
Genus: Kurnubia Henson, 1948
Type species: *Kurnubia palastiniensis* Henson, 1948

Selected synonymy
1948, *Kurnubia palastiniensis* Henson, fig. 7(b)
1948. *Kurnubia palastiniensis* Henson, p. 609, pl. 16, figs. 8, 11, pl. 18, figs. 10, 11.
1966. *Kurnubia palastiniensis* Henson – Maync, p. 12, pl. 5, figs. 1–7.
1967. *Kurnubia palastiniensis* Henson – Hottinger, p. 167, figs. 30–34, 38–48, text-fig. 45, 46.
1984. *Kurnubia palastiniensis* Henson – Pélissié et al., p. 486, pl. 2, fig. 14.
1988. *Kurnubia palastiniensis* Henson – Loeblich and Tappan, p. 154, pl. 165, figs. 1–6.
2004. *Kurnubia palastiniensis* Henson – Ivanova and Koleva-Rekalova, p. 226, pl. 3, figs. 3, 4.

Distribution:
The *Kurnubia palastiniensis* was found at the top of Carbonate Member of Shuqra Formation, a Jurassic succession of Ras Sharwayn, South-eastern of Yemen (Fazzuoli et al., 2009). It was also found in the n lower part of the Al-Khothally Formation, Amran Group, Sana'a region, Republic of Yemen (AL-Al Thour, K. A. A. (1992): Stratigraphy, sedimentary, and diagnosis of the Amran Group (Jurassic) of the region to the west and north-west of Sanaa, Yemen Republic.- Doctoral dissertation, Ph.D. Thesis. Birmingham University, UK., 1997). Found also in Coatepec Arroyo,Santiago Coatepec, SE Puebla, Mexico (Omaña, 2008). This microfossils assemblage was found in the limestones the of Topeşti Formation, Vãlcan mountains, and South Carpathians (Pop Grigore et al., 2001).

The stratigraphic frame and the association of *Kurnubia palastiniensis*, *Salpingoporella annulata, Salpingoporella grudii, and Cladocoropsis mirabilis* indicate the top of the member a Late Oxfordian age, although the earliest Kimmeridgian cannot be excluded.

Paleoenvironment:
As we have denes and huge micrites in the slides used in this study and according to Kemal Tasli (2001) the predominantly dense micrites and abundant on coids this indicate low energy in a sheltered environment and shallow-water conditions.

Age:
In Ras Sharwayn, South-eastern Yemen the *Kurnubia palastiniensis* Hensonwas found in Shuqra Formation, Bathonian-Kimmeridgian age (Fazzuoli et al., 2009).

In Al-Khothally Formation, Amran Group, Sana'a Region, Republic of Yemen, it was found in Oxfordian-? Late Callovian (AL-Thour, 1997).

Kurnubia palastiniensis described from the Jurassic of Israel (Henson,1948) was subsequently reported from the Late Jurassic by Abbate et al. (1974), Callovian-Portlandian by Jaffrezo (1980), Lower Oxfordian by Pelissie & Peyberns (1982), Oxfordian-Lower Kimmeridgian by Peyberns (1976), Kimmeridgian by Hottinger (1967); Fourcade (1970); Altiner (1991) and Dya (1992) or Kimmeridgian-Early Tithonian by Pop & Bucur (2001); Schlagintweit et al., (2005). In Bassoullet's research (1997) the range of this species is given as Middle Oxfordian.

The stratigraphic frame and the association of *Kurnubia palastiniensis, Salpingoporella annulata, Salpingoporella grudii,*and *Cladocoropsis mirabilis* indicate the top of the member at the Late Oxfordian age, although the earliest Kimmeridgian cannot be excluded.

***Halimeda* sp.**

Order: Dasycladales Pascher 1931
Superfamily: Halimedaceae
Family: Halimedaceaedasycladale Kützing, 1843; Schlagintweit, F. and Wilmsen, M. 2014.
Genus: Halimedal Amouroux, 1812.
Type species: *Halimeda* sp.

Selected synonymy

2008 *Halimeda cuneata* Hering, fig.1-10. fig. 31-34 Schlagintweit F. (2012).
H. discoidea Decaisne, fig. 17-23, fig. 35-37 Atasoy, S. G., Altiner, D. and Okay, A. I. (2017)
H. gracilis Harvey ex J. Agardh, fig. 24-25 OmañaMiranda-Avilés and Puy-Alquiza, (2015). fig. 35-37(Omaña and Arreola 2008).
H. incrassata (Ellis) Lamouroux, fig. 24-25 Luka, G. A. L. E. (2014).
H. opuntia (Linnaeus) Lamouroux,
H. simulans Howe, fig. 26-27.
H. tuna (Ellis and Solander) Lamouroux,fig. 41.
Corallina incrassata Ellis, Philosophical Transactions 57: pl.17, figs. 20-27. 1767.

Distribution:

Halimeda sp. was found in the Early Miocene Sadat Formation, Sadat area northwest Gulf of Suez at Egypt (Hamad, 2009).
Also, it was found in Santiago Coatepec Stream, located in the southeast of the state of Puebla, Mexico (Omaña & Arreola, 2008).
It was found in the Altamira Formation of northern Cantabria at Spain (Schlagintweit & Wilmsen, 2014).
The *Halimeda* sp. also has been mentioned as one of investigated in Jamaica locality at Brazil (Bandeira-Pedrosa et al., 2004).

Paleoenvironment:

The *Halimedaceae* family is recorded and represented by fragments of *Halimeda* sp. in the Sadat Formation with a shallow-marine shelf environment, at the Sadat area northwest Gulf of Sinz at Egypt (Hamad, 2009). In Santiago Coatepec Stream, located in the southeast of the state of Puebla, Mexico it was found in the shallow-water platform environment in the high-energy zone (Omaña & Arreola, 2008).

Age:

Halimeda sp. was inventoried of the Lower-Middle Cenomanian in the Altamira Formation of northern Cantabria in Spain (Schlagintweit &Wilmsen, 2014).

Halimeda sp. was found in the Early Miocene Sadat Formation in Wadi Tweirig, Sadat area, northwest of Gulf of Suez region Egypt (Hamad, 2009).

It was also found in the Cenomanian age from where the rock specimens were sampled (Cenomanian Altamira Formation), in the northern part of the Spanish province of Cantabria, Spain (Schlagintweit et al., 2014).

***Nautiloculina oolithica* Mohler**

Family: Nautiloculinidae Loeblich and Tappan, 1985
Genus: Nautiloculina Mohler, 1938
Type-species: *Nautiloculina oolithica* Mohler 1938

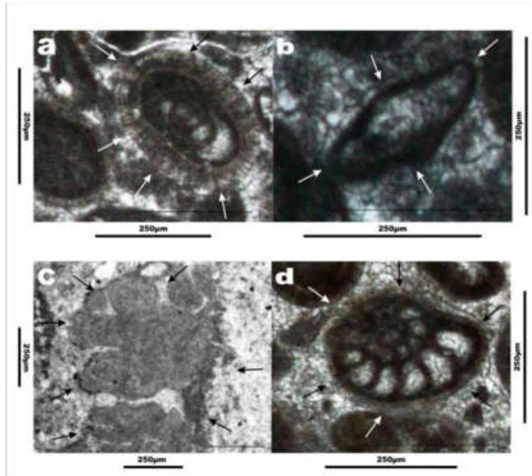

Figure 8:

a. *Nautiloculina oolithica* Mohler, 1938.

b. *Mesoendothyra croatica* Gusic, 1969.

c. *Marinella lugeoni* Pfender,

d. *Protopeneroplis ultragranulata* Weynschenk 1950.

Selected synonymy

1966 *Nautiloculina circularis* (Said and Barakat).- Derin and Reiss, Photo Nos. 70, 71, 83, 254, 263, 264, 271, 280, 283, 286-289, 309.

1968 *Nautiloculina circularis* (Said and Barakat).- Br.Nnimann, p. 64, fig. 3, pl. 1, figs. 1-8, pl. 2, figs. 1-6.

1977 *Nautiloculina oolithica* Mohler - Velle, pl. VIII, figs. 7, 8.

1978 *Nautiloculina bronnimanni* Arnaud-Vanneau and Peybernesés, p. 70, Pl. 1, figs. 6-8; pl. 2, figs. 4-11.

1983 *Nautiloculina bronnimanni* Arnaud-Vanneau and Peybernesés, Darsac p. 208, pl. 6, figs. 26-27.

1985 *Nautiloculina circularis* (Said and Barakat).- Fourcade, Arafa and Sigal, pl. 3, fig. 4.

1989 *Nautiloculina bronnimanni* Arnaud-Vanneau and Peybernés, Arnaud-Vanneau and Masse p. 264, pl. 1, fig. 9.

1997 *Nautiloculina oolithica* Mohler (Dozet and Šribar) p. 192,197 in all three zones.

2001*Nautiloculina oolithica* Mohler (Tasli Kemal), p.9, pl.1, fig.2

2003 *Nautiloculina bronnimanni* Arnaud-Vanneau and Peybernés, Dragastan and Richter p. 93, pl. 1, fig. 2; pl. 9, figs. 10, 11, 16.

2004 *Nautiloculina broennimanni* Arnaud-Vanneau and Peybernés, Bucur et al., pl. 3, fig. 22.

2004 *Nautiloculina bronnimanni* Arnaud-Vanneau and Peybernés, Ivanova and Koleva-Rekalova, pl. 1, fig. 5.

2004 *Nautiloculina bronnimanni* Arnaud-Vanneau and Peybernés, Ivanova and Kolodziej, fig. 1D.

2005 *Nautiloculina cretacea* Peybernés and Olszewska, p. 35, pl. 4, fig. 3.

2007 *Nautiloculina bronnimanni* Arnaud-Vanneau and Peybernés, Krajewski and Olszewska p. 297, fig. 4 H (11,12,13).

Distribution:
It was found in:
Berriasian-Upper Albian of the French and Spanish Pyrenees (Arnaud-Vanneau & Peybernés, 1978).
Berriasian-Lower Valanginian of Ain, Savoie, France (Darsac, 1983).
Berriasian-Aptian of the Neuchatel area, Switzerland (Arnaud-Vanneau& MASSE,1989); Upper Berriasian-Lower Valanginian of the Mathana Peninsula, Asprovouni Mts. (Dragastan, O. & Richter, 2003).
Valanginian-Hauterivian of the Berdiga Limestone, Kale- Gümüshane region, NE Turkey (Bucur et al., 2004).
Berriasian-Valanginian of Southwestern Bulgaria, upper Berriasian-Valanginian of Stramberk-type limestones, Polish Carpathians (Ivanova and Koleva-Rekalova, 2004).
Berriasian-Hauterivian of the Southern part of the Crimea Mts., Southern Ukraine; Berriasian-Hauterivian of the Southern part of the Crimea Mts., Southern Ukraine (Krajewski & Olszewska, 2007).

Paleoenvironment:
The presentation of dense micrites and abundant oncoids usually indicates the low energy in a sheltered environment and shallow-water conditions as what was found at Upper Jurassic Platform Carbonate Sequence in Aydincik (Içel) Area, Central Taurids, S Turkey (Tasli, 2001).

It was also found in the southeastern part of Slovenia in shallow water Jurassic sedimentary rocks, especially in Lower Malm - Cenozone *Salpingoporella sellii*, Dogger - *Dictyoconus cayeuxi* horizon and Dogger and Lower Malm - Cenozone *Protopeneroplis striata with* shallow-marine carbonate environments (Dozet and Šribar, 1997).

The *Nautiloculina oolithica* Mohler was found in Santiago Coatepec at SE Puebla, Mexico within the shallow-water marine depositional environment (Dozet and Šribar, 1997).

Age:
Mohler (1938) recorded *Nautiloculina oolithica* from the Kimmeridgian of Switzerland. After that, it was identified from different Jurassic levels in different countries such as Iran by Kalantari (1982) and Shakib (1994). In Yemen by AL-Wosabi (2009), in Jordan it was found by Basha (1983); in Saudi Arabia by Moshrif (1984); in Yemen by AL-Ganad (1991) and AL-Wosabi (2001, 2005); and Abu Dhabi by Matos (1994) and AL-Wosabi (2009).

In the Jabal Al-Balaqstudy area, this microfossil was found in the Oxfordian and Kimmeridgian ages.

***Mesoendothyra croatica* Gusic**
Order: Loftusiida
Suborder: Loftusiina Hayward, B. (2013).
Superfamily: Loftusiacea Brady, 1884
Family: Mesoendothyridae Voloshinova in Bykova et al., 1958 Audienusina Bernier, 1985.
Type species: *Mesoendothyra croatica* Gusic,

Selected synonymy
Mesoendothyra croatica Gusic, 1969 Fig. 2(b).
1969. *Mesoendothyra croatica* Gusic, p. 65, pl. 11, figs. 1–8, pl. 12, figs. 1–2.
1975. *Mesoendothyra croatica* Gusic – Bassoullet and Poisson, pl. 2, figs. 1–5.
1981. *Mesoendothyra croatica* Gusic – Septfontaine, pl. 3, figs. 4–7.
1982. *Mesoendothyra croatica* Gusic – Pélissié and Peybernès, p. 131, pl. 3, figs. 5, 6.
1984. *Mesoendothyra croatica* Gusic – Pélissié et al., p. 487, pl. 2, fig. 12.
1993. *Mesoendothyra croatica* Gusic – Tasli, p. 50, fig. 3; p. 52, pl. 1, figs. 12–14.(4).

Distribution:
The *Mesoendothyra croatica* Gusic was found in the shallow-marine Jurassic beds in southeastern Slovenia**.** Also, it was identified in the Jurassic sediments of the Arsanjan Stratigraphic Section Northeast of Shiraz-Iran (Special Issue unpb.) PP: 286-294

Paleoenvironment:
The *Mesoendothyra croatica* Gusic has been recorded in Lower Dogger beds with shallow

restricted shelves and shallow marine in southeastern Slovenia (Dozet and Šribar, 1997).

Age:
In the study area, *Mesoendothyra croatica* Gusic was found in Shuqra Formation indicating Callovian? to Kimmeridgian (SPT Study, unpublished).

***Marinella lugeoni* Pfender algae**
Order: Rhodogorgonales Fredericq & Norris, 1995.
Family: Elianellaceaegranier in Granier & Dias-Brito, 2016 (in replacement of the Family Solenopora-ceae Pia, 1927).
Genus: **M**arinella pfender, 1939, Ivanova & Kolodziej 2010.
Type species: *Marinella lugeoni* Pfender, Ivanova & Kolodziej 2010.

Selected synonymy
Marinella lugeoni Pfender, 1939, was mentioned in nomen conservandum (figs. 3.A-C, 4, 5.A-C, 6-9; pl. 2, figs. A-K)
1939, *Marinella lugeoni* nov. gen. nov. sp.- c p. 215-216, pl. I, fig. 1 pars; pl. II, figs. 1-2.
1961, *Marinella lugeoni* - Johnson, p. 147-148, Pl. 31, figs. 1 [here fig. 6, USNM D992 a843] - 2 [here fig. 7, USNM D992 a844].
1964 *Marinella lugeoni*.- Johnson, p. 25, pl. 2, fig. 10; pl. 23, figs. 1 (excerpt from Pfender, 1939, pl. 2, fig. 2) & 3 (excerpt from Pfender, 1939, pl. 2, fig. 1).
1964, *Marinella lugeoni*.- Johnson, pl. 23, fig. 2 pars (excerpt from Johnson, 1939, pl. 1, fig. 1.
1965, *Marinella lugeoni*.- Imaizumi, p. 57-60, pl. 11, figs. 7-17; pl. 12, figs. 1-9; pl. 13, figs. 1 (excerpt from Johnson, 1964, pl. 2, fig. 10) & 2-4; pl. 14, figs. 1-2.
In 1965, *Marinella lugeoni*.- Johnson and Kaska, p. 74, pl. 6, fig. 2 [here fig. 3.B, USNM 42547].
1968, *Marinella lugeoni*.- Bouroullec and Deloffre, p. 218-219, pl. 1, figs. 7-9.
2016, *Marinella lugeoni*– Granier and Dias-Brito. p 805, fig. 3 (a).

Distribution:
Before Pfender (1939) reported its occurrence in Jurassic strata from Spain. The first time *Marinella lugeoni* was discovered in Albian-Cenomanian at strata of South Atlantic marginal basins in Angola by Romanes (1917), and second,it was found in Brazil byMaury (1937) *Marinella lugeoni* Pfender, 1939 discovered as a (calcareous alga) fossil related to those people who worked on upper Jurassic and (Lower-Middle) Cretaceous beds.

Paleoenvironment:
Marinella lugeoni is frequently present in marine-shallow water beds of Santiago Coatepec at SE Puebla, Mexico (Ivanova & Kolodziej, 2010). *Marinella* occurs in a wide variety of marine shallow-water environments, it also occurs in settings of fluctuating salinities, where it indicates the more marine phases.

Age:
Marinella lugeoni is Late Jurassic and Early Cretaceous age in Santiago Coatepec at SE Puebla, Mexico (Ivanova & Kolodziej, 2010). *Marinella Pfender, 1939* is present in the age of Late Jurassic- Lowermost Cretaceous (Watt & Blazer, 1982 and Blazer, 1982).

***Protopeneroplis ultragranulata* sp.**
Order: Foraminiferida Eivhwald 1830
Suborder: Fusulina Wedekind 1937
Superfamily: Endothyracea Brady, 1884
Family: Ventrolaminidae Weynschenck, 1950.
Subfamily: Loeblichiinae Loeblichiinae Cummings. 1955
Genus: Protopeneroplis Weynschenck, 1950, *Protopeneroplis ultragranulata* Gorbatchik, 1971.
emend. Farinacci, 1964; emend. Septfontaine 1974
Type species: *Protopeneroplis ultragranulata* Weynschenk 1950, *Protopeneroplis trochangulata*

Selected synonymy
? 1969 *Protopeneroplis striata* Luperto Sinni, pl 1, fig. 1.
1972 *Protopeneroplis striata* Bronnimann Durand-Delga and Grand- Jaquet, pI. 1. figs. '1-5.
1974 *Protopeneroplis trochangulata* Septfontaine, pp. 608-614, pI. 1. figs. 1-18.
1977 *Protopeneroplis trochangulata* Azema, Chabrier Fourcadeand Jaffrezo. pp. 126, 130, 132. pI. 3, figs. 4-5.
1978 *Protopeneroplis trochangulata* Chiocchini and Mancinelli, pI. 10. figs. 1-2, pL 11, fig. 1.

1979 *Protopeneroplis trochangulata* Chiocchini and Mancinelli. pp. 22- -24, pl 1, figs. 1-12.
1980 *Protopeneroplis trochangulata* Septfontain, pp. 190-191. pl 3. fig. 24.
1984 *Protopeneroplis trochangulata* Salvini-Bonnard, Zaninetti and Chrollais. pp. 179-180, pI. 2, fig. 12.
non Fig. 1985 *Protopeneroplis trochangulata* Bucur. pp. 206, 208.
non Fig. 1986 *Protopeneroplis trochangulata* Bucur, p. 30.
1993 *Protopeneroplis ultragranulata*, Bucur, p. 214, pl. 2, figs. 1, 2, 5, 8, 11, 12 (Synonymy). 1997 *Protopeneroplis ultragranulata* (Gorbatchik) Bucur, p. 67, pl. 1, figs. 13-16; pl. 2, figs. 1-14; pl. 3, figs. 1-3 (Synonymy).
2005 *Protopeneroplis ultragranulata* (Gorbatchik), Schlagintweit et al., p. 37, pl. 21 a-d (Synonymy).
2005 *Protopeneroplis ultragranulata*(Gorbatchik), Olszewska p. 37, pl. 5, figs. 15, 16. 2005 *Protopeneroplis ultragranulata* (Gorbatchik), Bucur and Săsăran, pl. 4, figs. 10, 11.
2006 *Protopeneroplis ultragranulata* (Gorbatchik), Arkad'ev et al., pl. 4, figs. 18, 19 a, b, c.
2007 *Protopeneroplis ultragranulata* (Gorbatchik), Bruni et al., pl. 3, figs. 5, 6.
2007 *Protopeneroplis ultragranulata* (Gorbatchik), Velić, pl. 11, figs. 1-5.
2007 *Protopeneroplis ultragranulata* (Gorbatchik), Krajewski and Olszewska, p. 303, fig. 7 C.
2008 *Protopeneroplis trochangulata* Septfontaine, fig. 7 E, F. (Ivanova et al. 2008)

Distribution and age:
Protopeneroplis ultragranulata was found in deposits of the Middle Tithonian to Barremian age (Heinz & Isensmidt, 1988; Bucur, 1993, 1997).

This fossils were found in many places with a little bit difference in age such as: Tithonian-Berriasian of the Crimea Russia by Gorbachik (1971); Lower-Middle Berriasian of the Stramberk platform, Outer Western Carpathians Slovakiaby Sotak (1987); Upper Tithonian-Barremian by Bucur(1993, 1997); Upper Berriasian-Valanginian of the Stramberk-type limestones by Ivanova and Kolodziej (2004); Upper Tithonian of the Plassen carbonate platform, Northern Calcareous Alps by Schlagintweit et al., (2005); Middle part of Upper Tithonian-Valanginian of the Cieszyn Beds, Polish Outer Carpathians by Olszewska (2005); Upper Tithonian-Valanginian of the Apuseni Mts., Romania by Bucur & Săsăran, 2005; Upper Tithonian of the eastern Crimea byArkad'ev et al. (2006); undivided Berriasian- Valanginian of Fara San Martino, Maiella, Italy byBruni et al. (2007); Upper Tithonian-Berriasian of the Karst Dinarides, SE Europe by Velic (2007); Upper Tithonian-Valanginian of the southern part of the Crimea Mts., Southern Ukraine by Krajewski & Olszewska (2007) and Berriasian-Valanginian of Southwestern Bulgaria byIvanova and Ivanova & Kolodziej, 2010.

Also, it was found in the lower part of the third unit assemblage with *Andersenolina alpina*, *A. elongata*, *Anchispirocyclina lusitanica*, *Bramkampella arabica*, *Pseudocyclammina lituus*, *Neokilianina* sp., *Mohlerina basiliensis*, *Protopeneroplis cf. banatica* and *Protopeneroplis ultragranulata* (Bucur & Săsăran,2005). Other occurrences of *Protopeneroplis* in the Western trochangulata Carpathians (Sotak, 2015).

Paleoenvironment:
The *Protopeneroplis ultragranulata*was found in limestones of the southern part of the Crimea that had shallow-marine environments (Ivanova & Kolodziej, 2010.

It was found in Günören Formation, western Sakarya Zone Carbonate Platform which is characterized by shallow marine carbonate (Bucur & Săsăran, 2005).

Dasycladales algae (dasycladalean algae)
Order: Dasycladales Pascher, 1931
Family: Dasycladaceae Kützing, 1843
Genus: Actinoporella Gümbel in Alth, 1881
Actinoporella podolica (Alth, 1878). Conrad, Praturlon & Radoičić (1974), figs. 3a, 6a-n. Abad (2017).
Type species: *Dasycladales algae* (*Salpingoporella?* sp., *Clypeina?* sp.) Schlagintweit and Wilmsen (2014).

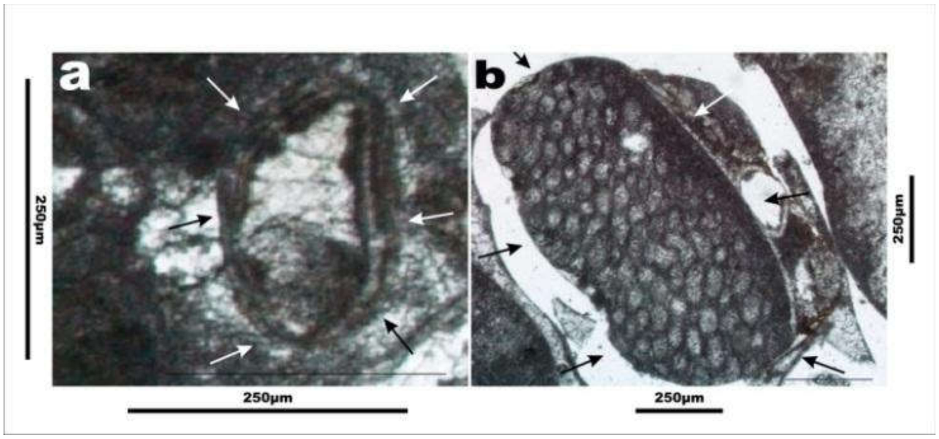

Figure 9:

a. *Dasycladales algae* (*Salpingoporella?* sp., *Clypeina?* sp.)

b. *Orbitopsella praecursor*.

Selected synonymy

1974 *Actinoporella podolica* (Alth) emend. - Conrad et al., p. 1-15, figs. 1-12.
1989 *Actinoporella podolica* (Alth)- Fourcade and Granier, pl. 1, figs. 4-5.
1991 *Actinoporella podolica* (Alth)- Farinacci and Radoičić, p.137, pl. 1, figs. 7-11.
1992 *Actinoporella lucasi* (Emberger) nov. comb. - Granier, p. 242, pl. 1, figs. 5-6.
1994 *Actinoporella podolica* (Alth)- Granier, pl. 1, figs. 1, 4, 8-10, pl. 3, figs. 5-8.
1996 *Actinoporella podolica* (Alth)- Sokač, p. 27-28, pl. 20, figs. 1-3, 5-13.
2011 *Actinoporella podolica* (Alth) - Bucur, p. 621-623, pl. 1, figs. 1-5, pl. 3, figs. 1-3, pl. 4, figs. 1-6, pl. 6, figs. 6-7, 11, pl. 7, figs. 1-6.

Distribution:

These microfossils found in Transylvanian Depression–Romania by Bucuret al (2005, 2014). Also it was found in the Zagros Foldand Thrust Beltof Iran (Schlagintweit et al., 2014).

It was found in Carbonates of the Blake Nose, USA (Schlagintweit & Enos, 2013).

Paleoenvironment:

The paleoenvironment of Shuqra Formation study area where these microfossils were found, is shallow-marine deposits.

Age:

Based on *dasycladalean* green algae and benthic foraminifera, Fourcade & Granier (1989) gave a more precise age for the carbonates from leg 392A as Berriasian-early Valanginian. Comparable to the Adriatic Carbonate Platform e.g., Di Lucia et al. (2012), *V. murgensis* may also be associated with the *dasycladale Salpingoporella dinarica* Radoičić in the Zagros fold and thrust belt (Gollestaneh, 1965; Schlagintweit, 2014).

Dasycladales is described from the upper Lower to Middle Cenomanian Altamira Formation of the North Cantabrian Basin, northern Spain (Schlagintweit & Wilmsen, 2014). The *dasycladalean* alga is restricted mainly to Middle-Upper Berriasian rocks (Jaffrezo, 1980; MASSE, 1993; Granier and Dias-Brito, 1993 ;Bucur, 1999; Bucur & Săsăran, 2003).

Orbitopsella Praecursor (Gümbel, 1872)

Order: Loftusiida.
Suborder: Loftusiina
Superfamily: Loftusioidea
Family: Mesoendothyridae**.**
Subfamily: Orbitopsellinae.
Genus: Orbitopsella.
Type species: *Orbitopsella praecursor.*

Selected synonymy
?*Orbitopsella praecursor* (Gümbel, 1872) (pl. 3, figs. 6-8)
1962 *Orbitopsella praecursor* (Gümbel) – Sartoni& Crescenti, p. 274, pl. 47, fig. 1.
1966 *Orbitopsella praecursor* (Gümbel) – Radoi^i], Pl. 20, figs. 1-2; pl. 72, figs. 1-2.
1967 *Orbitopsella praecursor* (Gumbel) 1872 – Hottinger, p. 40, pl. 5, figs. 1-12; fig. 20.
1977 *Orbitopsella praecursor* (Guembel) – Velic, pl. 1, figs. 1-5
1987 *Orbitopsella praecursor* (Gümbel) - Ulcigrai et al., figs. 5-7.
1994 *Orbitopsella praecursor* Gümbel – Chiocchini et al., pl. 2, figs. 12-13; pl. 27, fig. 10.
1998 *Orbitopsella praecursor* (Gümbel), 1872 – Fugagnoli & Loriga Broglio, p. 52, figs. 6.6-9.
1998 *Orbitopsella praecursor* (Gümbel, 1872) – Fugagnoli, p. 148, pl. 3, figs. 1-9.
1999 *Orbitopsella praecursor* (Gümbel), 1872 – Bassoullet et al., p. 224, pl. 1, figs. 1-8.
2003 *Orbitopsella praecursor* (Gümbel) – Kabal & Tasli, pl. 3, figs. 4-11
2005 *Orbitopsella praecursor* (Gümbel) – Cai et al., pl. 3, figs. 17-25.
2007 *Orbitopsella praecursor* (Gümbel 1872) – BouDagher-Fadel and Bosence, p. 7, pl. 3, fig. 3.
2007 *Orbitopsella praecursor* (Gümbel) – Velic, pl. 3, figs. 5-6; pl. 4, figs. 1-4.
Orbitopsella praecursor found in Dinarides, Slovenia, Podpe~ Limestone (Luka2014).

Distribution:
It has been carried out among Kočevje shelf lagoon, the Vrhnika-Logatec back-reef, and the Suha Krajina central. It was found in Suha Krajina central in Southeastern (Slovenia, Dozet & Šribar, 1997). *Orbitopsella praecursor* is used as an indicator for the Carixian/Domerian boundary in the Perachora-Peninsula the northwest of Corinth (Dragastan et al., 1994). This fossil was also found on Podpe limestone (External Dinarides, Slovenia), or from equivalent units are also given by Strohmenger et al. (1991); Dozet (1997); Dozet (2009) and Luka (2014).

Age:
*Orbitopsella praecursor*is Early Jurassic in age (Dozet, 1997); *Orbitopsella praecursor* biozones mentioned of early Late Sinemurian and Early Pliensbachian age, respectively (Luka, 2014). *Orbitopsella praecursor*– Late Kimmeridgian – Early Tithonian time. Bucur et al. (2010).

Orbitopsella praecursor Septfontaine found at Pre-Alps, Switzerland in Oxfordian/Kimmeridgian sediments.

The presence of *Orbitopsella praecursor* and *Bosniella oenensis* indicate Early Pliensbachian *Orbitopsella praecursor* in Taxon range Zone (Fürsich & Thomsen, 2005).

The *Orbitopsella praecursor* Septfontaine had used as an indicator ofthe Carixian/Domerian boundary in the Perachora-Peninsula northwest of Corinth (Dragastan et al., 1994).

Paleoenvironment of study section
The study section is the lower part of the Shuqra Formation in Jabal-AL-Balaq at Marib Governorate, Yemen. The pre-rift mega sequence sedimentation of the Sab'atayn Basin began in the Middle Jurassic when transgression from the southeast resulted in the deposition of paralic clastic rocks and shallow-marine carbonates of the Kohlan and Shuqra Formations (Brannan et al., 1999). The various fossils associated with the Shuqra Formation suggested a variety of depositional environments. Near of base, there are some the fossils such as oysters, bivalves, gastropods, forams, and dasyclade algae which suggested a shallow-marine environment (Brannan et al., 1999). According to Fazzuoli et al (2009), the sedimentary environment was a marine ramp with mixed carbonates and shales. The continental rocks are overlain by shallow-marine fossiliferous carbonates such as Shuqra Formation. It is Lithologically composed of carbonate marl/shale, and the depositional

environment is shallow marine of the platform and of pre-rift areas in Jurassic time (Albaroot et al., 2016). A basal transgressive sandstone (Kuhlan Formation) was laid down followed by marine carbonates (Shuqra Formation) as transgression continued. While as the Shuqra Formation was deposited in the Pre-rift stage and near Shore of Tethys Sea as shallow-marine deposits. The Shuqra Formation referred to as Thoma Member comprises a shallow-marine carbonate clastic deposit; the association of large benthic foraminifera (*Kurnubia* sp., *Pseudocyclammina* sp.) together with miliolids, echinoid, and algal debris is indicative of deposition in the shallow-marine environment. Energy conditions as interpreted from the microfacies analysis appear to have been low. In summary, a relatively nearshore, shallow-marine subtidal, low energy, inner shelf setting for the Shuqra Formation is consistent with the paleontological data (SPT Study, unpublished).

CONCLUSIONS

The conclusions that can be drawn are:

1. The microfossils are well preserved in well-represented Lower Shuqra Formation**.**
2. Ten microfossils were recorded at the study area in Shuqrah Formation, they are: Protopeneroplis banatica Bucur Kotouč, Troglotella incrustans Wernli and Fookes, 1992, Kurnubia palastiniensis Henson, 1948, Halimeda sp., Nautiloculina oolithica Mohler, 1938, Mesoendothyra croatica Gusic, 1969, Marinella lugeoni Pfender, Protopeneroplis ultragranulata Weynschenk 1950, Dasycladales algae (Salpingoporella? sp., Clypeina? sp.), and Orbitopsella praecursor.
3. The paleoenvironmental summary of Shuqrah Fm. were recorded microfossils confined to reef, buildup or bioherm, perireef or subreef, shallow subtidal, basinal (siliciclastic), lagoonal/restricted shallow subtidal, platform/shelf-margin reef, slope/ramp reef environments.
4. The ecological system of recorded fossils is stationary semi-infaunal.
5. A single variety of Dasyclad algae has been recorded in the studied section.
6. Shuqrah Formation is related to Amran Group, jurassic age.

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REFERENCES

1. Abbate, E., Ficcarelli, G., Pirini Radrizzani, C., Salvietti, A., Torre, D. &Turi, A. (1974). Jurassicsequences from the Somali coast of the Gulf of Aden.- Riv. Ital. Paleont, 80(3), 409-47.

2. Al Thour, K. A. A. (1992). Stratigraphy, sedimentary, and diagnosis of the Amran Group (Jurassic) of the region to the west and north-west of Sanaa, Yemen Republic.- Doctoral dissertation, Ph.D. Thesis. Birmingham University, UK.

3. Albaroot, M., A. H. M. Ahmad, Nabil Al-Areeq &. Sultan, M. (2016). Tectonostratigraphy of Yemen and Geological Evolution: A New Perspective.

4. Altiner, D. (1991): Microfossil biostratigraphy (mainly foraminifers) of the Jurassic-Lower Cretaceous carbonate successions in north-western Anatolia (Turkey). Geologica Romana, 27, 167-213.

5. Altiner, D. & Özkan, S. (1991). Calpionellid zonation in north-western Anatolia (Turkey) and calibration of the stratigraphic ranges of some benthic foraminifera at the Jurassic-Cretaceous boundary. Geologica Romana, 27, 215-235.

6. Al-Wosabi, M. A. (2009). Jurassic foraminifera from Jabal Al-Balaq, Marib, Republic of Yemen.- Egypt J Paleontol, 9, 75-104.

7. Al-Wosabi, M. & Wasel, S. (2011). Lithostratigraphic subdivision of the Kuhlan Formation in Yemen. Arabian Journal of Geosciences, 4(7-8), 1323-1335.
8. Arkad'ev, V. V., Fedorova, A. A., Savel'eva, Y. N. & Tesakova, E. M. (2006). Biostratigraphy of Jurassic-Cretaceous boundary sediments in Eastern Crimea.- Stratigraphy and geological correlation, 14(3), 302-330.
9. Arnaud-Vanneau, A. & Masse, J. P. (1989). Les Foraminifèresbenthiques des formations carbonatées de l'Hauterivien-Barrémien pro parte du Jura Vaudois et Neuchâtelois (Suisse). Soc. neuchat. Sci. nat.
10. Arnaud-Vanneau, A. & Peybernes, B. (1978). Les représentantséocrétacés du genre NautiloculinaMohler, 1938 (Foraminifera, Fam. Lituolidae?) dans les chainessubalpinesseptentrionales (Vercors) et les pyrénées Franco-Espagnoles: Revision de Nautiloculinacretacea Peybernes, 1976 et description de Nautiloculinabronnimanni n. sp. Geobios, 11(1), 67-81.
11. Azerêdo, A. C., Wright, V. P. & Ramalho, M. M. (2002). The Middle-Late Jurassic forced regression and disconformity in central Portugal: eustatic, tectonic and climatic effects on a carbonate ramp system.- Sedimentology, 49(6), 1339-1370.
12. Bandeira-Pedrosa, M. E., Pereira, S. & Oliveira, E. C. (2004). Taxonomy and distribution of the green algal genus Halimeda (Bryopsidales, Chlorophyta) in Brazil. Brazilian Journal of Botany, 27(2), 363-377.
13. Basha, S. H. (1983). Jurassic foraminifera and microfacies of Jordan. Rev EspMicropaleontol, 15, 185-203.
14. Bassoullet, J. P. (1997). The large foraminifera. Biostratigraphie du Jurassique Ouest-Européen et Mediterranëen.- Bull. CentresRech. Explor.-Prod. Elf-Aquitaine, Mem, 17, 293-304.
15. Beydoun, Z. R. &Beydoun, Z. R. (1964). The stratigraphy and structure of the Eastern Aden Protectorate.
16. Beydoun, Z. R. & Greenwood, J. E. G. W. (1968). Aden protectorate and Dhufar.- Centre national de la recherché scientifique.
17. Beydoun, Z.R., As-Saruri, M.A.L., El-Nakhal, H., Al-Ganad, I.N., Baraba, R.S., Nani, A.S.O. & Al- Aawah, M.H. (1998). International Lexicon of Stratigraphy. Vol. III, Republic of Yemen. IUGS Publication, 34, 245p.
18. Brannan, J., Sahota, G., Gerdes, K. D. & Berry, J. A. (1999). Geological evolution of the central Marib-Shabwa basin, Yemen. GeoArabia, 4(1), 9-34.
19. Bruni, R., Bucur, I. I. & Preat, A. (2007). Uppermost Jurassic-lower cretaceous carbonate deposits from Fara San Martino (Maiella, Italy): biostratigraphic remarks. Studia UBB Geologia, 52(2), 45-54.
20. Bucur, I. I. (1993). Les représentants du genre Protopeneroplis Weynschenkdans les dépôts du Crétacéinférieur de la zone de Reşița-Moldova Nouă (CarpathesMéridionales, Roumanie). Revue de Micropaléontologie, 36(3), 213-223.
21. Bucur, I. I. (1999). Stratigraphic significance of some skeletal algae (Dasycladales, Caulerpales) of the Phanerozoic. Università" La Sapienza".
22. Bucur, I. I. &Săsăran, E. (2005). Relationship between algae and environment: an Early Cretaceous case study, Trascău Mountains, Romania.- Facies, 51(1-4), 275-287.
23. Bucur, I. I., Păcurariu, A., Săsăran, E., Filipescu, S. & Filipescu, R. (2014). First record of lowermost Cretaceous shallow-water limestones in the basement of the Transylvanian Depression (Romania).
24. Bucur, I. I., Săsăran, L., Săsăran, E. & Schuller, V. (2004). Micropaleontological study of the limestone olistoliths within the Upper Cretaceous wildflysh from Hăşdate (eastern border of the Gilău Mountains). Acta Palaeontol Romaniae, 4, 55-67.
25. Burchette, T. P. & Wright, V. P. (1992). Carbonate ramp depositional systems. Sedimentary Geology, 79(1-4), 3-57.
26. Cherchi, A. & Schroeder, R. (2010). Boring sponges (ichnogenus Entobia) in Mesozoic Lithocodiumcalcimicrobial crusts. Rivista Italiana di Paleontologia e Stratigrafia (Research in Paleontology and Stratigraphy), 116(3).
27. Cherchi, A. & Schroeder, R. (1999). Late Barremianorbitolinid foraminifera from

northern Somalia.- Bollettino-SocietaPaleontologicaItaliana, 38, 3-14.
28. Chiocchini, M. & Mancinelli, A. (1979). Protopeneroplistrochangulata Sept-fontaine, 1974 (Foraminiferida) nel Cretaceoinferioredell' Area del Gran Sassod'ltalia (Abruzzo). Studi Geologici Camerti, 5, 17-37.
29. Darsac, C. (1983). La plate-formeberriaso-valanginienne du Jura méridional aux massifs subalpins (Ain, Savoie).- Doctoral dissertation, Université Scientifique et Médicale de Grenoble.
30. De Matos, J. E. (1994). Upper Jurassic-Lower Cretaceous stratigraphy: the Arab Hith and Rayda Formations in Abu Dhabi.- Micropalaeontology and Hydrocarbon Exploration in the Middle East. Chapman and Hall, London, 81, 111.
31. Di Lucia, M., Trecalli, A., Mutti, M. & Parente, M. (2012). Bio-chemostratigraphy of the Barremian-Aptian shallow-water carbonates of the southern Apennines (Italy): pinpointing the OAE1a in a Tethyan carbonate platform. Solid Earth, 3(1), 1.
32. Dozet, S. (2009). Lower Jurassic carbonate succession between Predole and Mlačevo, Central Slovenia Spodnjejurskokarbonatnozaporedje med Predolami in Mlačevim, osrednjaSlovenija. RMZ–Materials and geoenvironment, 56(2), 164-193.
33. Dozet, S. & Šribar, L. (1997). Biostratigraphy of shallow marine Jurassic beds in southeastern Slovenia. Geologija, 40, 187-221.
34. Dragastan, O. & Richter, D. K. (2003): Calcareous algae and foraminifers from Neocomianlimestones of Methana Peninsula, Asprovouni Mts. (Greece) and from south Dobrogea (Romania).- Ann UnivBucaresti Geology Spec Publ, 1, 57-128.
35. Dragastan, O., Gielisch, H., Richter, D. K., Grewer, T., Kaziur, T., Kube, B. & Radusch, C. (1994). Jurassic algae of the Perachora-Peninsula: biostratigraphical and paleoecological implications. BeitrPaläont, 19, 49-81.
36. Dya, M. (1992). Mikropaläontologische und fazielle Untersuchungenim Oberjurazwischen Salzburg und Lofer. na.
37. El-Anbaawy, M. (1984). Contribution to the lithostratigraphic subdivisions of the Amran sequence in the Yemen Arab Republic. Bulletin of Faculty of Science, Sana'a University, 4, 65-84.
38. El-Nakhal, H. A. (1990). Surdud Group, a new lithostratigraphic unit of Jurassic age in the Yemen Arab Republic. J. King Saud Univ, 2(2), 125-143.
39. Fazzuoli, M., Morelli, M., Pavia, G., AL-Thour, K. A., Chiocchini, M., Reale., V. & Taddi, E. (2009). The Jurassic succession of RasSharwayn, South-eastern Yemen. VoluminaJurassica, 7(7), 135-145.
40. Fourcade, E. (1970): Le Jurassique et le Crétacé aux confins des chaînesbétiques et ibériques (Sud-Est de l'Espagne).- Doctoral dissertation
41. Fourcade, E. & Granier, B. (1989). Age des carbonates de plate-forme du Site 392A DSDP (Leg 44), marge atlantique du continent nord-américain. Marine Geology, 90(3), 197-204.
42. Fourcade, E. & Neumann, M. (1966). A propos des genres Labyrinthina Weynschenk, 1951 et LituoseptaCati, 1959. Revue de micropaléontologie, 8(4), 238-239.
43. Fürsich, F. & Thomsen, E. (2005). Jurassic biota and biofacies in erratics from the Sortland area, Vesterålen, northern Norway. Geological Survey of Norway Bulletin, 443, 37-53.
44. Gawlick, H., Missoni, S., Schlagintweit, F., Suzuki, H., Frisch, W., Krystyn, L., ... & Lein, R. (2009). Jurassic Tectonostratigraphy of the Austroalpinedomain. Journal of Alpine Geology, 50, 1-152.
45. Gorbachik, T. N. (1971). On early Cretaceous foraminifera of the Crimea. Voprosy Mikropaleontologii, 14, 125-139.
46. Granier, B. & Deloffre, R. (1993). Inventaire critique des alguesdasycladalesfossiles. II partie-Les AlguesDasycladales du Jurassique et du Crétacé. Rev Paléobiol, 12(1), 19-65.
47. Gümbel, W. T. (1862). Die Streitberger Schwammlager und ihre Foraminiferen-Einschlüsse.
48. Hamad, M. M. (2009). Coralline red algae and foraminiferal biostratigraphy of the Early Miocene Sadat Formation, Sadat area,

northwest Gulf of Suez, Egypt. Egyptian Journal of Paleontology, 9, 183-212.

49. Heinz, R. A. & IIsenschmid, C. (1988). Mikrofazielle und stratigraphische Untersuchungenim Massivkalk (Malm) der Préalpesmédianes. Eclogae Geologicae Helvetiae, 81(1), 1-62.

50. Hottinger, L. (1967). Foraminifèresimperforés du Mésozoïquemarocain.- Notes et mémoires du service géologique du Maroc 209, 1–168.

51. Henson, F. R. S. (1948). Foraminifera of the Genus Trocholina in the Middle East. Annals and Magazine of Natural History 14(12), 445–59.

52. Henson, F.R.S. (1948). Larger imperforate foraminifera of south-Western Asia. British Museum of Natural History, series 12(2), 172–177.

53. Ivanova, D. & Koleva-Rekalova, E. (2004). Agglutinated foraminifers in the framework of Southwestern Bulgarian palaeoenvironmental evolution during the Late Jurassic and Early Cretaceous. In Proceedings of the Sixth International Workshop on Agglutinated Foraminifera. Grzybowski Foundation Special Publication (Vol. 8, pp. 217-227).

54. Ivanova, D., Kołodziej, B., Koleva-Rekalova, E. & Roniewicz, E. (2008). Oxfordian to Valanginian palaeoenvironmental evolution on the western Moesian carbonate platform: a case study from SW Bulgaria. Annales Societatis Geologorum Poloniae, 78, 2, 65-90.

55. Ivanova, D. & Kolodziej, B. (2010). Late Jurassic–Early Cretaceous foraminifera from Štramberk-type limestones, Polish Outer Carpathians. Studia UBB Geologia, 55(2), 3-31.

56. Jaffrezo, M. (1980). Les formations carbonatées des Corbières (France) du Dogger à l'Aptien: micropaléontologiestratigraphique, biozonation, paléoécologie, extension des résultats à la Mésogée.

57. Johnson, J. H. (1964). Miocene coralline algae from northern Iraq.- Micropaleontology, 10 (4): 477-485

58. Krajewski, M. (2010). Facies, Microfacies and Development of the Upper Jurassic-Lower Cretaceous of the Crimean Carbonate Platform from the Yalta and Aj-Petri Massifs (Crimea Mountains, Southern Ukraine).- AGH University of Science and Technology Press.

59. Krajewski, M. & Olszewska, B. (2007).: Foraminifera from the Late Jurassic and Early Cretaceous carbonate platform facies of the southern part of the Crimea Mountains, Southern Ukraine. Annales Societatis Geologorum Poloniae, 77, 3,291-311.

60. Lamare, P. (1923). Observation geologiquessur le Yemen. C.R. Academie Sciences, 176, 956.

61. Lamare, P., Basse, E., Dreyfus, M. Lacroix, A. & Tilhard De Chardin, P. (1930). Etudes geologiques en Ethipoie, Somalie et Arabie Meriodionale Soc. Geol. France, Mem. 6,1-83.

62. Loeblich JR. A.R. & Tappan, H. (1985). Some new and redefined genera and families of agglutinated Foraminifera 1. Journal of Foraminiferal Research, 15, 91–104.

63. Luka, G. A. L. E. (2014). Lower Jurassic foraminiferal biostratigraphy of Podpe~ Limestone (External Dinarides, Slovenia).

64. Luperto Sinni, E. & Masse, J. P. (1994). Precisazionimicropaleontologichesulleformazioni di piattaformacarbonatica del Giurasicosuperiore e del Cretacicobasale del massicio del Gargano (Italia Meridionale) e implicazionistratigrafiche. Palaeopelagos, 4, 243-266.

65. Maury, C. J. (1937). O Cretaceo de Sergipe. Servico Geologico e Mineralogico do Brasil. Monographia 11, 1–283.

66. Menzies, M., Baker, J., Chazot, G. &AL'Kadasi, M. (1997). Evolution of the Red Sea volcanic margin, western Yemen. Geophysical Monograph-American Geophysical, 100, 29-44.

67. Minissale, A., Mattash, M. A., Vaselli, O., Tassi, F., AL-Ganad, I. N., Sselmo, E., ... &Hazzae, M. K. (2007). Thermal springs, fumaroles and gas vents of continental Yemen: their relation with active tectonics, regional hydrology and the country’s geothermal potential. Applied Geochemistry, 22(4), 799-820.

68. Moshrif, M. A. (1984). Sequential Development of Hanifa Formation (Upper Jurassic) Paleoenvironment and

Paleogeography, Central Saudi Arabia. Journal of Petroleum Geology, 7(4), 451-460.
69. Olszewska, B. (2005). Microfossils of the Cieszyn Beds (Silesian Unit, Polish Outer Carpathians)-a thin sections study. Polish Geological Institute Special Papers, 19, 1-58.
70. Omaña, L. & Arreola, C. G. (2008). Late Jurassic (Kimmeridgian) larger benthic Foraminifera from Santiago Coatepec, SE Puebla, Mexico. Geobios, 41(6), 799-817.
71. Omaña, L., Alencaster, G. & Buttron, B. E. (2016). Mid-early late Albianforaminiferal assemblage from the El Abra Formation in the El Madroño locality, eastern Valles-San Luis Potosí Platform, Mexico: Paleoenvironmental and paleobiogeographical significance. Boletín de la SociedadGeológica Mexicana, 68(3), 477-496.
72. Omaña, L., Torres, J. R., LopezDoncel, R., Alencaster, G. & Lopez Caballero, I. (2014). A pithonellid bloom in the Cenomanian-Turonian boundary interval from Cerritos in the western Valles–San Luis Potosí platform, Mexico: Paleoenvironmental significance. Revista Mexicana de CienciasGeológicas, 31(1).
73. Pélissié, T. & Peybernès, B. (1982). Étudemicropaléontologique du Jurassiquemoyen/supérieur du Causse de Limogne (Quercy). Revue de micropaléontologie, 25(2), 111-132.
74. Peybernès, (1976). et description de Nautiloculinabron - nimanni n. sp. Geobios, 11/1, 67-81.
75. Pfender, J. &Pfender, J. (1939). Sur un calcairephytogène du Liasinférieurd' Espagne et l'extension de cefaciès en quelquesautresrégions. Imprimerie Commerciale.
76. Pop, G. &Bucur, I. I. (2001). Upper Jurassic and Lower Cretaceous sedimentary formations from the Vâlcan mountains (south Carpathians). Studia UBB Geologia, 46(2), 77-94.
77. Redfern, P. & Jones, J. A. (1995).The interior rifts of the Yemen-analysis of basin structure and stratigraphy in a regional plate tectonic context. Basin Research, 7(4), 337-356.
78. Romanes, M. F. (1917). XVI. Note on an Algal Limestone from Angola.- Earth and Environmental Science Transactions of The Royal Society of Edinburgh, 51(3), 581-584.
79. Schlagintweit, F. (2015). Taxonomic Review of Some Late Jurassic-Early Cretaceous Benthic Foraminifera Established by Geollestaneh (1965) From the Zagros Fold and Thrust Belt of Iran. Acta Palaenologica Romaniae, 9(2), 27-31.
80. Schlagintweit, F., Gawlick, H. J. & Lein, R. I. C. H. A. R. D. (2005). Mikropaläontologie und Biostratigraphie der Plassen-Karbonatplattform der Typlokalität (Ober-Jura bisUnter-Kreide, Salzkammergut, Österreich). J Alpine Geol (Mitt Ges Geol Bergbaustud Österr), 47, 11-102.
81. Schlagintweit, F. & Enos, P. (2013). Uppermost Jurassic?-Neocomian shallow-water carbonates of the Blake Nose, USA: DsDp site 392a revisite D. Acta Palaeontologica Romaniae, 9, 39-56.
82. Schlagintweit, F. & Wilmsen, M. (2014). Calcareous algae (dasycladales, udoteaceae) from the Cenomanian Altamira Formation of northern Cantabria, Spain. Acta Palaeontologica Romaniae, 10(1-2), 15-24.
83. Seaborne, T. R. (1996). The influence of the Sabatayn E vaporites on the hydrocarbon prospectivity of the Eastern Shabwa Basin, Onshore Yemen. Marine and Petroleum Geology, 13(8), 963-972.
84. Septfontainehad, M. (1974). Presence de Protopeneroplistrochangulata sp. nov.(Foraminifere) dans le Cretaceinferieur du Jura meridional et revision de Protopeneroplis Weynschenk, 1950. Eclogae Geologicae Helvetiae, 67(3), 605-28.
85. Smewing, J. D. (1997). A high-resolution sequence stratigraphic study of the Shuqra Formation in the Aden–Ahwar area of coastal south Yemen. Earth Resources Institute, Swansea, Wales, unpublished proprietary consultant study to Nexen.
86. Smewing, J. D., Saeed, A. R. & Ahmed, A. M. (1998). A high-resolution sequence stratigraphic study of the Callovian to Early Kimmeridgian Shuqra formation in the Aden–Ahwar area of coastal South Yemen (abs.): Geo’98 Conference Program with Abstracts. Manama, Bahrain, April, 20, 154.
87. Sotak, J. (1987). Protopeneroplidae foraminifers from the lowermost Cretaceous of the Stramberk carbonate platform (Outer

Western Carpathians). Geologica Carpathica, 38(6), 651-669.

88. Stephenson, M. H. & AL-Mashaikie, S. A. Z. A. (2011). Stratigraphic note: Update on the palynology of the Akbarah and Kuhlan formations, northwest Yemen. Geo Arabia-Middle East Petroleum Geosciences, 16(4), 17-24.

89. Strohmenger, C., Deville, Q. & Fookes, E. (1991). Kimmeridgian/Tithonianeustacy and its imprints on carbonate rocks from the Dinaric and the Jura carbonate platforms. Bulletin de la Societégéologique de France, 8, 661-671.

90. Tasli, K. (2001). Benthic Foraminifera of the Upper Jurassic Platform Carbonate Sequence in the Aydincik (Içel) Area, Central Taurides, S Turkey. Geologia Croatica, 54(1), 1-13.

91. Watt, A. D. & Blazer, A. M. (1982). Index of generic names of fossil plants, 1974-1978.

92. Wernli, R. & Fookes, E. (1992). Troglotellaincrustans n. gen., n. sp., un étrange et nouveau foraminifèrecalcicavicole du complexerécifal Kimméridgien de Saint-Germain-de-Joux (Ain, France). Bollettinodella Società paleontologicaitaliana, 31(1), 95-103.

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