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Upper Jurassic-Lower Cretaceous limestones from the Hăghimaș Massif (Eastern Carpathians, Romania): Microfacies, microfossils and depositional environments

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Abstract: The Hăgimaş Massif provides important data for reconstructing the geological evolution of the Transylvanian Carbonate Platform. This unit is present nowadays in the basement of the Transylvanian Depression and as large-scale olistoliths, which crop out in various locations in the Eastern Carpathians and Apuseni Mountains. They contain a large variety of microfacies as well as microfossil assemblages partly encompassing the Jurassic/Cretaceous boundary. This study presents a detailed account of uppermost Jurassic-lowermost Cretaceous limestones from the Lapoş Valley (Hăghimaş Mountains) containing two distinct successions separated by a fault. The first succession contains platform margin and inner platform deposits (subtidal, intertidal) whereas the second one consists of inner platform deposits (shallow-subtidal to peritidal carbonates). The Upper Jurassic Stramberk-type facies is overlain by lower Berriasian regressive peritidal limestones. The upper Berriasian-? lower Valanginian consists mainly of inner platform deposits. They contain alternating, high and low-energy carbonates with rare calpionellids and calcispheres. The age assignment is based on a rich and diverse micropaleontological assemblage containing similar biota reported from other regions of the Tethysian Realm.

Key-words:

- microfacies;
- algae;
- Foraminifera;
- depositional environments;
- Hăghimaș Massif;
- Romania

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Résumé : *Les calcaires du Jurassique supérieur-Crétacé inférieur du Massif de Hăghimaș (Carpathes orientales, Roumanie) : Microfaciès, microfossiles et environnements de dépôt.-* Le Massif de Hăghimaș fournit des données cruciales pour reconstruire l'évolution géologique de la plate-forme carbonatée transylvanienne. Cette unité est présente de nos jours dans le substratum de la dépression transylvanienne sous forme d'olistolites de grandes dimensions qui affleurent en de nombreuses localités des Carpathes orientales et des monts Apuseni. Ils comportent une grande variété de microfaciès, ainsi que des associations micropaléontologiques, qui couvrent en partie la limite Jurassique/Crétacé. Cette étude présente dans le détail un affleurement de calcaires du Jurassique terminal-Crétacé basal de la vallée de Lapos (Monts Hăghimaș) comportant deux séries distinctes séparées par une faille. La première série correspond à des dépôts marginaux de plate-forme et de plate-forme interne (subtidaux, intertidaux), tandis que la seconde correspond à des dépôts de plate-forme interne (carbonates peu profonds subtidaux à péritidaux). Les faciès jurassiques supérieurs de type Stramberg sont surmontés par les calcaires péritidaux régressifs du Berriasien inférieur. Le Berriasien supérieur - ? Valanginien inférieur est principalement représenté par des calcaires de plate-forme interne. Ils com-

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portent une alternance de carbonates de haute et de basse énergies avec de rares calpionelles et des calcisphères. Leur datation se fonde sur un assemblage micropaléontologique riche et diversifié comportant des organismes semblables à ceux décrits dans d'autres régions du domaine téthysien.

Mots-clefs :

- microfaciès ;
- algues ;
- foraminifères ;
- environments de dépôt ;
- Massif de Hăghimaș ;
- Roumanie

1. Introduction

Carbonate microfacies analysis, as well as micropaleontological associations play a key role in defining depositional systems by applying sedimentological and paleontological techniques (FLÜGEL, 2010). This methodology was applied to the Upper Jurassic-Lower Cretaceous succession from the Hăghimaş Massif exposed in a section located on the Lapoş Valley (a left tributary of the Bicaz Valley, Fig. 1).

The Hăhgimaş Massif has been studied by many authors since the 19th century (*e.g.*, HERBICH, 1866; NEUMAYR, 1873). It is worth mentioning the contributions of SĂNDULESCU (1967, 1968, 1969, 1975, 1984), DRAGASTAN (1969, 1975a, 1975b, 1981, 2011), GRASU *et al.* (2010), and D.A. POPESCU and L.G. POPESCU (2005). Some studies have focused on ammonite associations (VADASZ, 1915; JEKELIUS, 1921; PREDA, 1973; TURCULEŢ, 1980; GRIGORE, 2010a, 2010b, 2011), dasycladalean algae (DRAGASTAN, 1971, 1975a; BUCUR & SĂSĂRAN, 2011; BUCUR *et al.*, 2011), foraminifers (Th. NEAGU & M. NEAGU, 1995), and brachiopods (LAZĂR *et al.*, 2011).

Recently, DRAGASTAN (2011) studied the Upper Jurassic-Lower Cretaceous sedimentary succession from the Lapoș Valley, and identified a thin basal package of upper Tithonian limestones that is overlain by thicker, Berriasian-Hauterivian carbonates. Based on microfacies and micropa-leontological studies the whole package was divided into three distinct subunits: SU1 - carbonate sandstones with limonite concretions, marly limestones and micrites with algal nodules towards its upper part; SU2 - micrites associated with a basal breccia; SU3 - nodular limestones with algal nodules and interbedded pelsparites and micrites.

Following DRAGASTAN (2011), upper Tithonian limestones are present in the lowermost part of the succession. They contain foraminifers [*Anchispirocyclina lusitanica* (EGGER), *Everticyclammina virguliana* (KOECHLIN), *Coscinoconus alpinus* LEUPOLD, *C. elongatus* LEUPOLD] and calpionellids [*Crassicolaria brevis* REMANE, *C. parvula* REMANE, *Calpionella alpina* LORENZ, and *Tintinnopsella carpathica* (MURGEANU & FILIPESCU)]. The "Jurassic/Cretaceous boundary" is placed in the basal part of the profile at the confluence with the Bicaz River. DRAGASTAN (2011) mentions a hardground surface between subunits SU1 and SU2 marking the lower-upper Berriasian boundary based on the following microfossil associations: 1) a lower Berriasian assemblage with *Calpionella alpina* (Alpina B and C zones); 2) an upper Berriasian assemblage with dasycladalean algae [*Rajkaella iailaensis* (MASLOV), *Humiella* sp. cf. *H. sardiniensis* (OTT & FLAVIANI)] and foraminifers [*Coscinoconus campanellus* (ARNAUD-VANNEAU *et al.*), *C. cherchiae* (ARNAUD-VANNEAU *et al.*), *Charentia cuvillieri* NEUMANN, *Rumanoloculina pseudominima* (BARTENSTEIN & KOVATCHEVA), and *Scythiloculina confusa* NEAGU]. Subunit SU3 is assigned by DRAGASTAN (2011) to the lower Valanginian-Hauterivian interval. The base of this subunit is represented by another hardground surface. The age of the lower part of SU 3 was attributed by DRAGASTAN (2011) to the Lower Valanginian based on the microfossil assemblage with foraminifers [*Everticyclammina greigi* (HENSON); *E. kelleri* (HENSON); *Pseudocyclammina lituus* (YOKOYAMA); *P. sphaeroidalis* HOTTINGER, *Coscinoconus cherchiae*, *Neotrocholina molesta* (GORBATCHIK)], algae [*Salpingoporella annulata* CAROZZI, *Rajkaella alpina* DRAGASTAN, *Humiella cataeneformis* (RADOIČIĆ)], cyanobacteria [(*Rivularia piae* FROLLO, *Garwoodia bardosi* DRAGASTAN], and calpionellids [*Calpionellites allemanni* REHANEK and *Tintinnopsella carpathica* (MURGEANU & FILIPESCU)]. The middle part of the subunit was assigned to the upper Valanginian starting from the presence of abundant miliolid associations (*Decussoloculina*, *Scythiloculina*, and *Rumanoloculina)* and microbial structures (*Litho-codium*, *Rivularia piae*, *Garwoodia bardosi)*. The upper part of SU3 was assigned by DRAGASTAN (2011) to the Hauterivian based on the presence of *Neotrocholina molesta*, miliolids and *Rivularia*-like cyanobacteria. Foraminifers and calcareous algae recorded by DRAGASTAN (2011) are not sufficiently diagnostic for such a detailed biostratigraphy, and calpionellids, which could be diagnostic for the age, were not illustrated.

The present study describes the microfacies and microfossils characteristics of the Mesozoic de-posits from the Lapoș Valley, Bicazului Gorges (Fig. 1). The main purpose was to examine the Jurassic-Cretaceous transition based on detailed sampling and the analysis of relatively-rich micropaleontological assemblages.

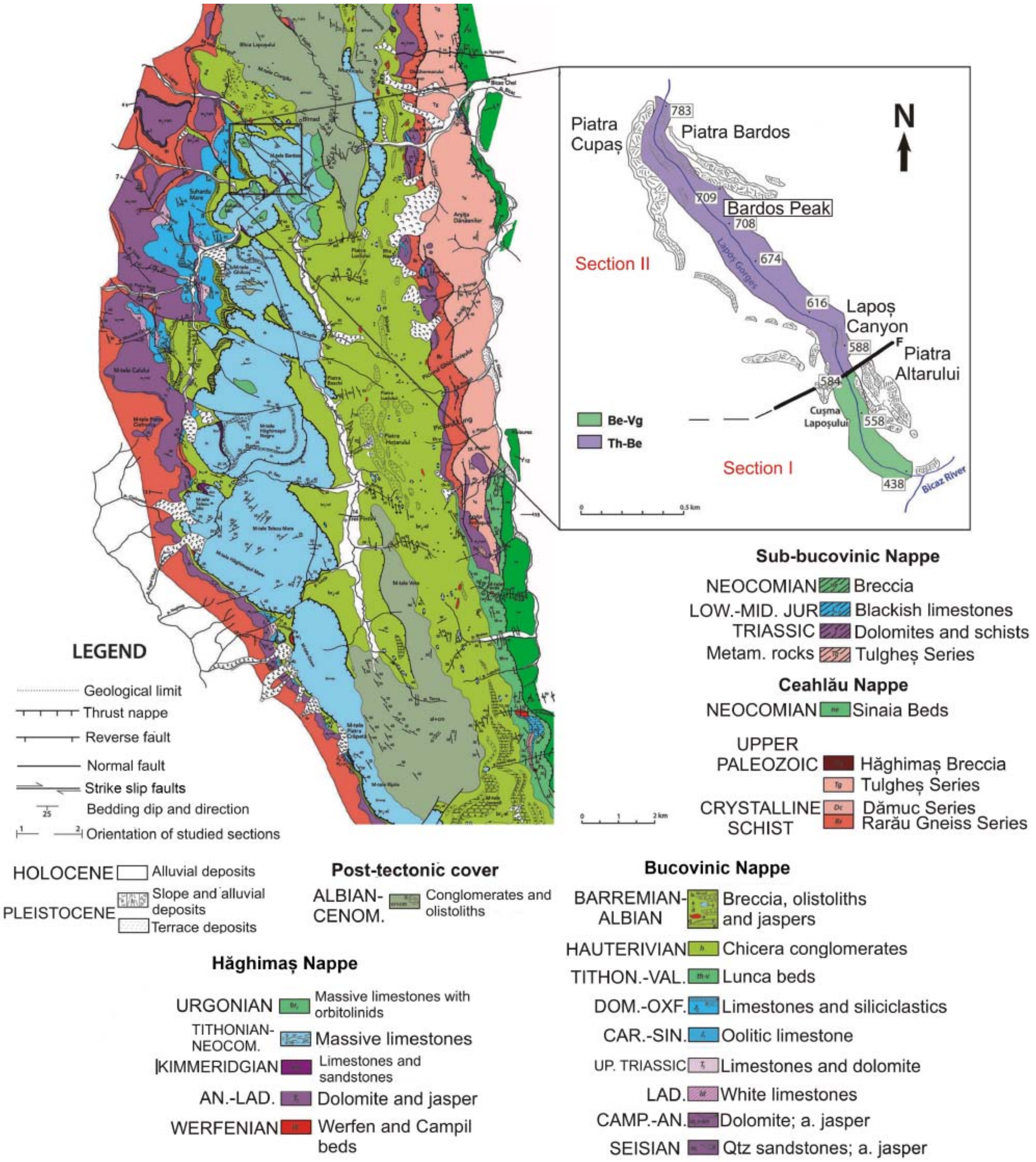


Figure 1: Geological map of the Hăghimaș Syncline (modified from Săndulescu, 1975) with location of the sampled section (right up - detail with the samples location).

2. Geological setting

Lapoș Valley (Fig. 1) is located in the Hăghimaș Massif or Hăghimaş syncline (Grasu *et al.*, 2012). The sedimentary succession from the Hăghimaș Mountains consists of three distinct tectonic units (Săndulescu, 1967, 1984; Dragastan, 1971; Grasu *et al.*, 2010): the Bucovinian, the Subbucovinian and the Hăghimaș Nappes (the last being part of the Transilvanian Nappes).

The Bucovinian Nappes are important tectonic units of the inner part of the Eastern Carpathians. Their emplacement took place during the Early Cretaceous (Popescu-Voitești, 1929; Kräutner, 1980; Săndulescu, 1984). They represent the equivalent of the Getic Nappe from the Southern Carpathians (Săndulescu, 1984). These structures represent fragments of continental crust derived from the European Margin, along the Ceahlău-Severin oceanic rift (Schmid *et al.*, 2008). The Bucovinian Nappe from the Hăghimaş Massif contains

Figure 2: A - Berriasian peloidal bioclastic wackestone-packstone carbonates (base of Piatra Altarului); B-Massive Tithonian reefal limestones with grainstone/rudstone facies types, reefal fragments, dasycladalean algae and encrusting organisms in Cheile Lapoșului (Lapoş Gorges).

a Triassic-Lower Cretaceous sedimentary succession that overlies metamorphic basement. The final term is represented by a Barremian-Aptian "wildflysch" incorporating olistoliths derived from the Transylvanian (Hăghimaş) Nappes (PATRULIUS, 1969; SĂNDULESCU, 1975, 1984; ŞTEFĂNESCU, 1976). The Subbucovinian Nappes have a lower position in respect to the Bucovinian ones. They contain similar metamorphic and Triassic-Lower Cretaceous deposits. The Transylvanian Nappes overthrust the Bucovinian Nappes and contain a group of obduction nappes, consisting of sedimentary rocks and ophiolites (SĂNDULESCU, 1984) occurring mostly as olistoliths in the Bucovinian "wildflysch". Their emplacement occurred during the Lower Cretaceous and was triggered by a series of tectonic events preceding the Lower Cretaceous post-tectonic cover (SCHMID *et al.*, 2008).

The Hăghimaș Nappe, as part of the Transylvanian nappes, represents a decollement nappe thrust over the Bucovinian Nappe from the west. Thrust was time equivalent to deposition of "wildflysch" in the Bucovinian Nappe. These tectonic processes ended probably in the upper Albian, and were followed by subsequent erosion (SĂNDULESCU, 1975; BUCUR *et al.*, 2011). Terrigenous and carbonate Triassic, Jurassic and Lower Cretaceous carbonates (SĂNDULESCU, 1975) form the sedimentary succession in the Bicaz Valley area of the Hăghimaş Mountains. The Triassic contains calcarenites, sandstones, marls, dolomites and cherty limestones (SĂNDULESCU, 1975). Nodular limestones, sandy limestones with *Saccoccoma* sp., interbedded sandy limestones and marls define the basal Kimmeridgian. They pass upwards into interbedded marls and limestones (SĂNDULESCU, 1975).

The Tithonian-Valanginian-?Hauterivian deposits consist of limestones and marly limestones (SĂNDULESCU, 1975; DRAGASTAN, 1975a). The Kimmeridgian-lower Tithonian marly limestones were dated on various ammonite associations (*Platynota*, *Hypselocyclum*, *Divizum* and *Uhlandi* zones for the lower Kimmeridgian; *Acanthicum*, *Eudoxus*, *Beckeri* zones for the upper Kimmeridgian; *Hybonotum*, *Vimineus*, *Semiforme* and *Falauxi* zones for the lower Tithonian) (GRIGORE, 2011). The ages assigned to the upper Tithonian-? Hauterivian carbonates were based on microfossil assemblages (DRAGASTAN, 1971, 1975a, 2011; SĂNDULESCU, 1975; BUCUR *et al.*, 2011).

3. Material and methods

Fieldwork was performed during the summer of 2014. A total number of 340 samples was collected and used to prepare 350 thin sections. Sampling was performed at 3-4 m resolution, over a total distance of two kilometers. The starting point is located fifty meters above the confluence between the Lapoș and Bicaz rivers (Fig. 1). Microscope analysis was used to describe the microfacies and microfossil associations. Classification of carbonate rocks follows DUNHAM (1962), EMBRY and KLOVAN (1971), and WRIGHT (1992).

4. Microfacies

The studied succession follows the Lapoș Valley over a total distance of approximately two kilometers (Fig. 1, upper right). Carbonate beds dip to more than 45 degrees, in areas where bedding planes are conspicuous (Fig. 2.A-B). The succession is interrupted by a fault which is located 700 m from the starting point of the section. This fault separates two distinct segment that contain different facies characteristics. Eight microfacies associations were separated from base to top (MFL 1-MFL 8).

MFL 1 - Peloidal bioclastic wackestone (Fig. 3.A-C; Table 1)

Angular to well-rounded, abundant peloids characterize these submicrofacies types. They are uniformly distributed within the muddy sediment. Sometimes they form aggregated structures. They are associated with dasycladalean algae (Fig. 3.B-C), benthic foraminifers (Fig. 3.A) and poorly-preserved calpionellids. Some of the peloids have a biotic origin. They were produced by complete bioclast micritization. The grains are coated by a micritic rim (Fig. 3.B-C), and the non-homogeneous matrix is frequently bioturbated (Fig. 3.B). Rare fenestral structures are present. Sometimes they have a laminar aspect with a well-defined orientation. Fenestrae shape ranges from oval to circular, irregular or digitated with a planar/sinusoidal base; they are filled with sparite or geopetal vadose silt (Fig. 3.C).

MFL 2 - Bioclastic oncoidal floatstone (Fig. 3.D-F; Table 1)

The bioclastic floatstone facies is the most abundant subtype. It contains angular to subrounded centimeter-sized bioclasts, including rudist fragments and other bivalves, gastropods, coral fragments and echinoderm spines (Fig. 3.D). These bioclasts are encrusted by different organisms (Fig. 3.E).

Oncoidal floatstone is less frequent within this microfacies association. Micritic or porostromatic oncoids are common. They present growth discontinuities and irregular, ovoidal or spherical shapes. Bioclastic or lithoclastic cores are frequent. They are commonly associated with encrusting organisms, benthic foraminifers and dasycladalean algae. The internal sediment is a peloidal bioclastic wackestone with benthic foraminifers and/or dasycladalean algae (Fig. 3.D-F). Common grain types include peloids, intraclasts and sometimes extraclasts (terrigenous quartz). Peloids and intraclasts have variable shapes from angular to well rounded. They are scattered through the muddy sediment. Angular to subangular quartz-rich extraclasts are present. This facies association contains grains with surficial micritic envelopes. They have a clastic or bioclastic origin.

MFL 3 - Peloidal bioclastic lithoclastic packstone/wackestone (Fig. 4.A-C; Table 1)

The peloidal bioclastic lithoclastic facies contains various amounts of grains. Peloids are the most abundant whereas bioclasts and lithoclasts are subordinate. Peloid dimension ranges from 0.1 to 0.8 mm. The peloidal fraction is disseminated within the micritic/sparitic mass. Their shape ranges from subangular to subrounded (Fig. 4.A-C). Bioclasts are represented by benthic foraminifers (Fig. 4.A-C), fragments of calcareous algae, sponges (Fig. 4.A), and mollusks (Fig. 4.A-C). Skeletal grains present a surficial micritic rim. Lithoclasts are scarce, with subangular to subrounded shapes. They are mainly represented by intraclasts which have the same composition as other carbonate grains. Peloids are uniformly distributed within the peloidal bioclastic packstone-wackestone submicrofacies type. They have small dimensions (less than 0.5 mm) are associated with benthic foraminifers and calcareous algae, and have a moderate to good sorting. Rare

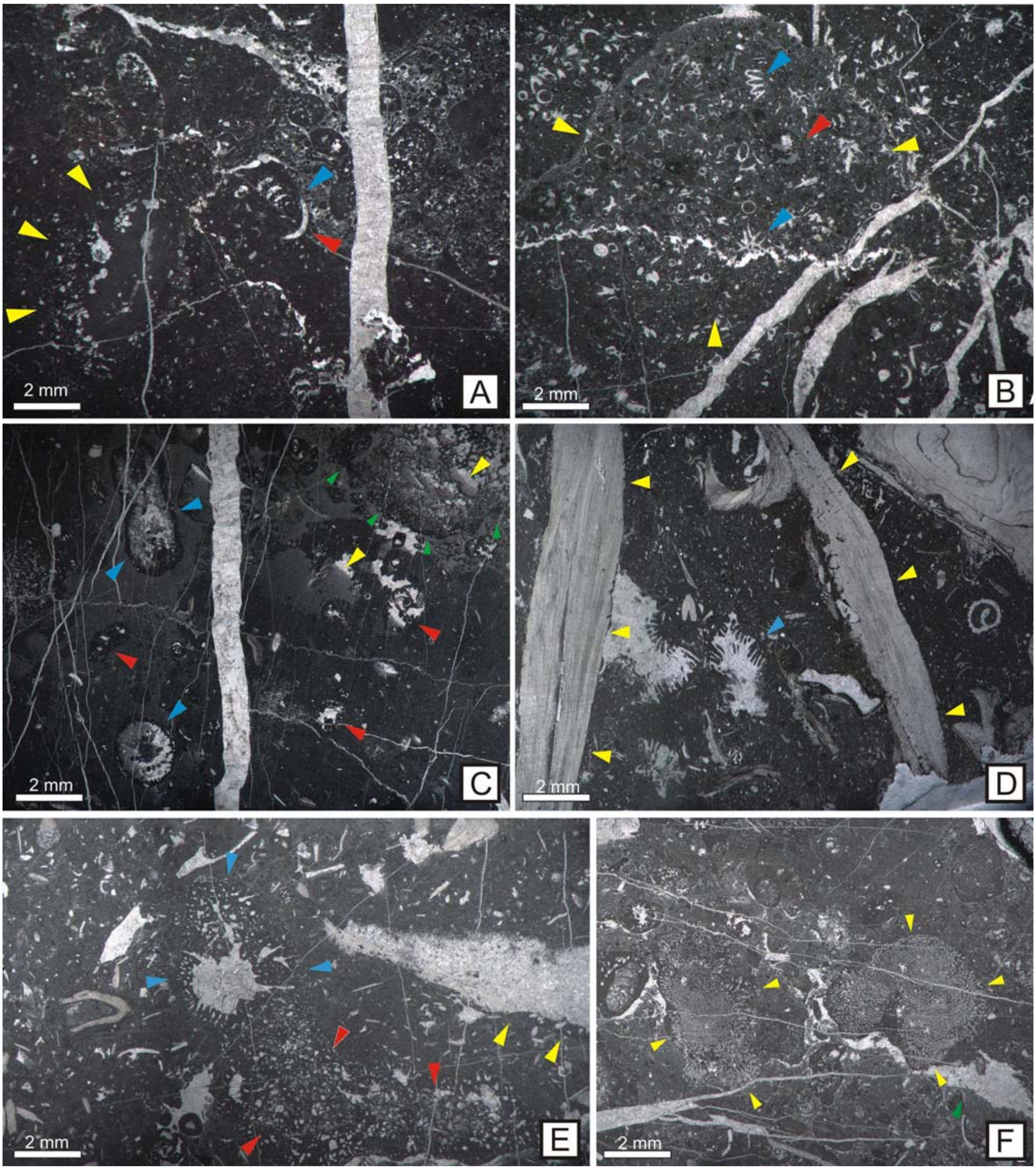


Figure 3: MFL 1-MFL 2 (Peloidal bioclastic wackestone and bioclastic oncoidal floatstone). **A:** Peloidal wackestone with agglutinated foraminifers; abundant peloids with dimensions ranging from 0.1 to 0.8 mm; associated agglutinated foraminifers (blue arrows), encrusting organisms attached to a lithoclast (yellow arrows) and bivalve fragments (red arrows); the matrix is non-homogeneous and contains micrite, microsparite and rare sparite (sample 453). **B:** Bioclastic wackestone with dasycladalean algae. Skeletal grains consist of abundant dasycladalean algae (ex: *Actinoporella podolica, Clypeina parasolkani, C. solkani, Rajkaella bartheli*) (blue arrows) and agglutinated foraminifers (red arrows); the matrix is non-homogeneous displaying bioturbation (yellow arrows); moderately fractured fabric with fractures containing sparite (sample 444). **C:** Bioclastic wackestone-floatstone with geopetal sediment; large fragments of dasycladalean algae (blue arrows) and benthic foraminifers (red arrows) are present; the matrix is non-homogeneous and contains micrite, microsparite and rare sparite; voids partially filled with geopetal structures (yellow arrows) (sample 528). **D:** Bioclastic floatstone with rudists; large bioclasts are represented by rudist fragments (yellow arrows) and coral fragments (blue arrows); all these bioclasts are encased in a bioclastic wackestone-type matrix with small peloids (sample 562). **E:** Bioclastic floatstone with microbial structures. It consists of bioclastic fragments encrusted by different organisms (yellow arrows), microbial structures (*Bacinella* sp., *Lithocodium* sp.) (red and blue arrows), foraminifers and fragments of dasycladalean algae; the grains are coated by a micritic rim; these bioclasts are hosted by a peloidal wackestone matrix (sample 493). **F:** Microbial floatstone with *Rivularia*-like cyanobacteria (yellow arrows); microbial organisms are abundant; they are hosted by a fine, peloidal wackestone matrix; the green arrow indicate geopetal structures (sample 712).

intraclasts have angular to subrounded shapes. Their size exceeds 1 mm. Silt to sand grade, angular to subangular terrigenous extraclasts (less than 0.5 mm in dimension) are common. They are disseminated within the micritic matrix (Fig. 4.B). Ovoidal porostromatic oncoids are mo-derately frequent. Their size sometimes exceeds 1 mm. Their core has a bioclastic origin.

Benthic foraminifers are common in the peloidal bioclastic packstone microfacies type. They are associated with peloids which have an average dimension of 0.3 mm. Intergranular pores con-tain micrite, microsparite and sparite.

MFL 4 - Bioclastic peloidal lithoclastic grainstone-packstone (Fig. 4.D-G ; Table 2)

Bioclastic peloidal lithoclastic subtype is the most abundant. Peloids have various shapes and dimensions, ranging from 0.1 to 1 mm. They are scattered through the rock mass, being associated with various bioclasts. Microorganisms include benthic foraminifers, dasycladalean algae, bivalves and gastropods (Fig. 4.D). Most of the grains have a biotic origin. They have micritic rims and sometimes they are completely micritised. Associated angular to subrounded lithoclasts have dimensions which do not exceed 1 mm (Fig. 4.D).

The microbreccia submicrofacies type contains angular, submillimeter to ruditic fragments of reworked intraclasts. Subrounded clasts are scarce. Their composition is relatively homogeneous. This feature points to an intrabasinal source area. The intraclasts contain coral fragments, *Bacinella*-like structures, *Rivularia*-like cyanobacteria and small peloids (Fig. 4.E). They are encased in a sparitic cement which may contain iron oxide pigmentations. Such structures may form the base of *Bacinella*-like structures.

Peloids occupy all the rock mass, within the peloidal grainstone microfacies subtype (Fig. 4.F). They are defined by good sorting and subrounded to well-rounded shapes and are commonly associated with benthic foraminifers, dasycladalean algae and bivalve fragments. These bioclasts are totally or partially micritised. A grain-supported fabric is common, the intergranular pores being filled with sparite cement. Another facies subtype is represented by coarse bioclastic grainstone. It contains coral fragments, sponges, echinoderms, dasycladalean algae, benthic foraminifers, bivalve fragments, gastropods and encrusting organisms (Fig. 4.G). Skeletal grains have angular to subrounded shapes. Intergranular pores are filled with sparitic cement.

MFL 5 - Lithoclastic bioclastic rudstone (Fig. 4.H-I ; Table 2)

The first subfacies type contains angular to rounded intraclasts. Some of these fragments have a microbial origin. They are associated with peloids. Bioclasts are represented by dasycla-dalean algae and mollusk fragments (Fig. 4.H). Intergranular pores are filled with sparite, micrite or vadose silt. Bioclastic rudstone with reefal fragments is the most common submicrofacies type. It contains abundant sponge fragments (Fig. 4.I). Other bioclasts include encrusting organisms, dasycladalean algae, echinoderm plates and various mollusk fragments (Fig. 4.I). Intraclasts and extraclasts (subangular quartz fragments) are subordinate. Some bioclasts are bordered by a surficial micritic rim. Intergranular pores are filled with sparite or a combination of vadose silt and iron oxides.

MFL 6 - Microbial bindstone (Fig. 5.A-B ; Table 2)

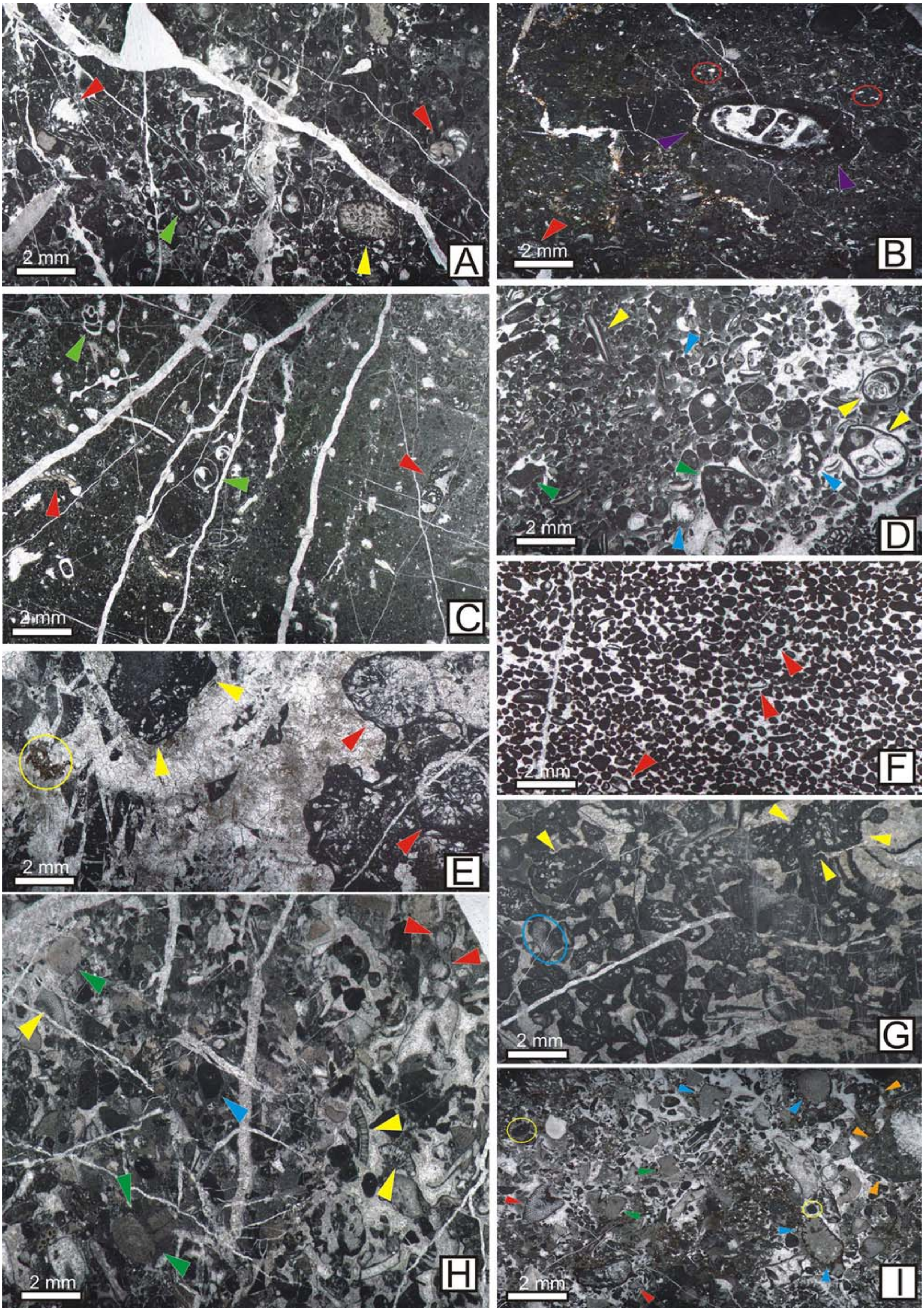
Bacinella-like structures dominate the first subfacies type (Fig. 5.A). These structures are associated with other microbial organisms and form a solid framework that binds together all the carbonate clasts. Other bioclasts include dasycladalean algae, corals, rudist and other mollusk fragments (Fig. 5.A). Intergranular pores are filled with micrite and rare sparitic cement. A rare subfacies type is represented by microbial bindstone with *Rivularia*-like cyanobacteria and other encrusting organisms (*Bacinella* type structures). This subtype contains abundant *Rivularia*-like cyanobacteria. Small other bioclasts and peloids are associated. Intergranular pores contain micrite and rare sparitic cement (Fig. 5.B).

MFL 7 - Coral boundstone (Fig. 5.C; Table 2)

Corals form a solid framework which strengthens the rock structure. They are associated with encrusting microorganisms [(*Radiomura* sp., *Crescentiella morronensis* (CRESCENTI)] (Fig. 5.C). The clastic components consist of peloids (smaller than 0.2 mm). Intergranular pores are filled with micrite and rare sparitic cement.

MFL 8 - Algal framestone with *Neoteutloporella socialis* (Fig. 5.D; Table 2)

This microfacies type is rare. It contains only one species of dasycladalean algae. This species in growth position occupies the entire rock mass forming small "patch reefs" (Fig. 5.D).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5. Facies distribution, micropaleontological assemblages, and biostratigraphy

DRAGASTAN (2011) presented new data on the stratigraphy and micropaleontology of the Lapoş Valley section. The succession is considered to be of Tithonian-Hauterivian age. The author (DRAGASTAN, 2011) identified several calpionellid zones, but did not illustrate them. He also identified two discontinuity surfaces (lower Berriasian-upper Berriasian and lower Valanginian-Hauterivian). Within the studied section a fault (near sample 584) (Fig. 1) separates the upper Berriasian-? lower Valanginian deposits from the upper Tithonian-lower Berriasian carbonates. The microfacies distribution and micropaleontological data (Figs. 6-8) will be presented in stratigraphic order.

◀ **Figure 4:** MFL 3-MFL 5 (Peloidal bioclastic lithoclastic packstone-grainstone, grainstone, lithoclastic bioclastic rudstone). **A:** Peloidal bioclastic lithoclastic packstone-grainstone; this microfacies contains diverse bioclasts, such as foraminifers (red arrows), sponge fragments (yellow arrow), gastropod fragments (green arrows) and other bioclasts; intergranular pores are filled with micrite, microsparite and sparite; moderately fractured fabric (sample 487). **B:** Peloidal bioclastic packstone-wackestone; abundant peloids incorporate benthic foraminifers (red arrow), algae fragments, porostromatic oncoids (purple arrows) and quartz extraclasts (red circles); intergranular pores are filed with micrite and microsparite; iron oxide pigmentations may occur (sample 578). **C:** Bioclastic peloidal packstone with foraminifers; the fabric is dominated by bioclasts and small peloids; red arrows indicate benthic foraminifers. Dasycladalean algae and gastropod fragments (green arrows) are present; intergranular pores contain micrite and microsparite (Sample 783). **D:** Bioclastic peloidal lithoclastic grainstone-packstone; bioclasts are represented by fragments of dasycladalean algae, benthic foraminifers (blue arrows), and mollusks (yellow arrows); peloids and subangular to subrounded intraclasts are present (green arrows); the intergranular pores contain equally proportioned sparite and micrite (sample 489). **E:** Microbrecciated lithoclastic grainstone. Intraclasts are abundant. They consist of broken, angular fragments yellow arrows encased in a sparitic mass; some of them exceed 2 mm in dimension; other bioclasts include coral fragments and microbial organisms (red arrows); the fabric is pigmented with iron oxides (yellow circle) (sample 641). **F:** Peloidal grainstone. Well-sorted peloids are frequent. Coated grains are common (red arrows). The intergranular pores is filled with sparry cement (sample 670). **H:** Coarse bioclastic grainstone with encrusting organisms (*Crescentiella morronensis*) (blue arrow), benthic foraminifers (red arrows), calcareous algae (yellow arrows), echinoderm plates (green arrows); some of these coated grains are bordered by a surficial micritic rim; small peloids are common and the intergranular pores contain micrite, microsparite and sparitic cement (sample 603). **G:** Lithoclastic bioclastic rudstone with calcareous algae (blue circle), mollusk fragments, microbial-bacinellid structures (yellow arrows) and small peloids; intergranular pores are filled with sparry cement (sample 700). **I:** Bioclastic rudstone; bioclasts are represented by encrusting organisms (*Crescentiella morronensis*) (yellow circles), sponges (blue arrows), calcareous algae (red arrow), echinoderm plates (green arrows). peloids and mm-sized intraclasts (orange arrows); grains are coated by a micritic rim and the intergranular pores contain sparite, silt and micrite (sample 594).

Upper Tithonian-lower Berriasian

This interval (samples 585-783) (Fig. 1) contains inner and platform margin deposits with variable facies types. The first part contains rare boundstone / framestone microfacies types, rudstone and grainstone with reefal fragments (MFL4, MFL5,, MFL7, MFL8). The upper part of the interval passes towards restricted facies types with abundant muddy subcategories (floatstone, packstone, wackestone or bindstone) (MFL1, MFL2, MFL3, MFL 6). Coarse reefal detritus is present in the lower part of the interval. It contains sponges, corals, red algae, dasycladalean algae, benthic foraminifers and abundant, angular lithoclasts. By contrast, the upper interval contains abundant peloids and microbial structures together with dasycladalean algae, benthic foraminifers and coated grains (Fig. 6). The micropaleontological association consists of dasycladalean algae (Fig. 9.A-Q; Table 1), benthic foraminifers (Fig. 10.A-Q; Table 1) microproblematic organisms (Fig. 11.A-G, arrows; Table 1), sclerosponges (Fig. 11.H-J, Table 1), annelid worm tubes (Fig. 11.K), coral fragments, echinoderm plates, rudists and other mollusks.

In terms of biostratigraphy, some of the most representative species are dasycladalean algae [*Campbelliella striata* (Tithonian cf. GRANIER & DELOFFRE, 1993; upper Tithonian-lower Berriasian cf. BUCUR *et al.*, 2014), *Neoteutloporella socialis* (Kimmeridgian-Tithonian cf. GRANIER & DELOFFRE, 1993; BASSOULLET, 1997; BUCUR, 1999), *Petrascula bursiformis* (Kimmeridgian-Tithonian cf. GRANIER & DELOFFRE, 1993), *Aloisalthella sulcata* (Kim-meridgian-Berriasian cf. BASSOULLET, 1997; BUCUR, 1999; Kimmeridgian-middle Berriasian cf. GRANIER, 2019; GRANIER & LETHIERS, 2019), *Clypeina parasolkani* (Berriasian cf. FARINACCI & RADOIČIĆ, 1991; Berriasian-Valanginian cf. BUCUR & SĂSĂRAN, 2005; BRUNI *et al.*, 2007; Tithonian-Berriasian cf. SCHLAGINTWEIT, 2011), *Otternstella lemmensis* (upper Kimmeridgian-lower Berriasian cf. GRANIER & DELOFFRE, 1993), *Rajkaella bartheli* (Kimmeridgian-Berriasian cf. GRANIER & DELOFFRE, 1993; BUCUR, 1999; BUCUR *et. al.*, 2013)], sponges [*Neuropora lusitanica, Thalamopora lusitanica,* and *Calcistella jachenhausenensis* (Tithonian cf. REITNER, 1992; PLEȘ *et al.*, 2013; KAYA *et al.*, 2015)], foraminifers *[Charentia cuvillieri* (Berriasian-Cenomanian cf. NEUMANN, 1965; BUCUR *et al.*, 1995; SCHLAGINTWEIT & WAGREICH, 2005), different representatives of the genus *Coscinoconus* (upper Tithonian-lower Valanginian cf. ARNAUD-VANNEAU *et al.*, 1988; NEAGU, 1994, 1995; BUCUR *et al.*, 1995; BUCUR & SĂSĂRAN, 2005), *Haplophragmoides*

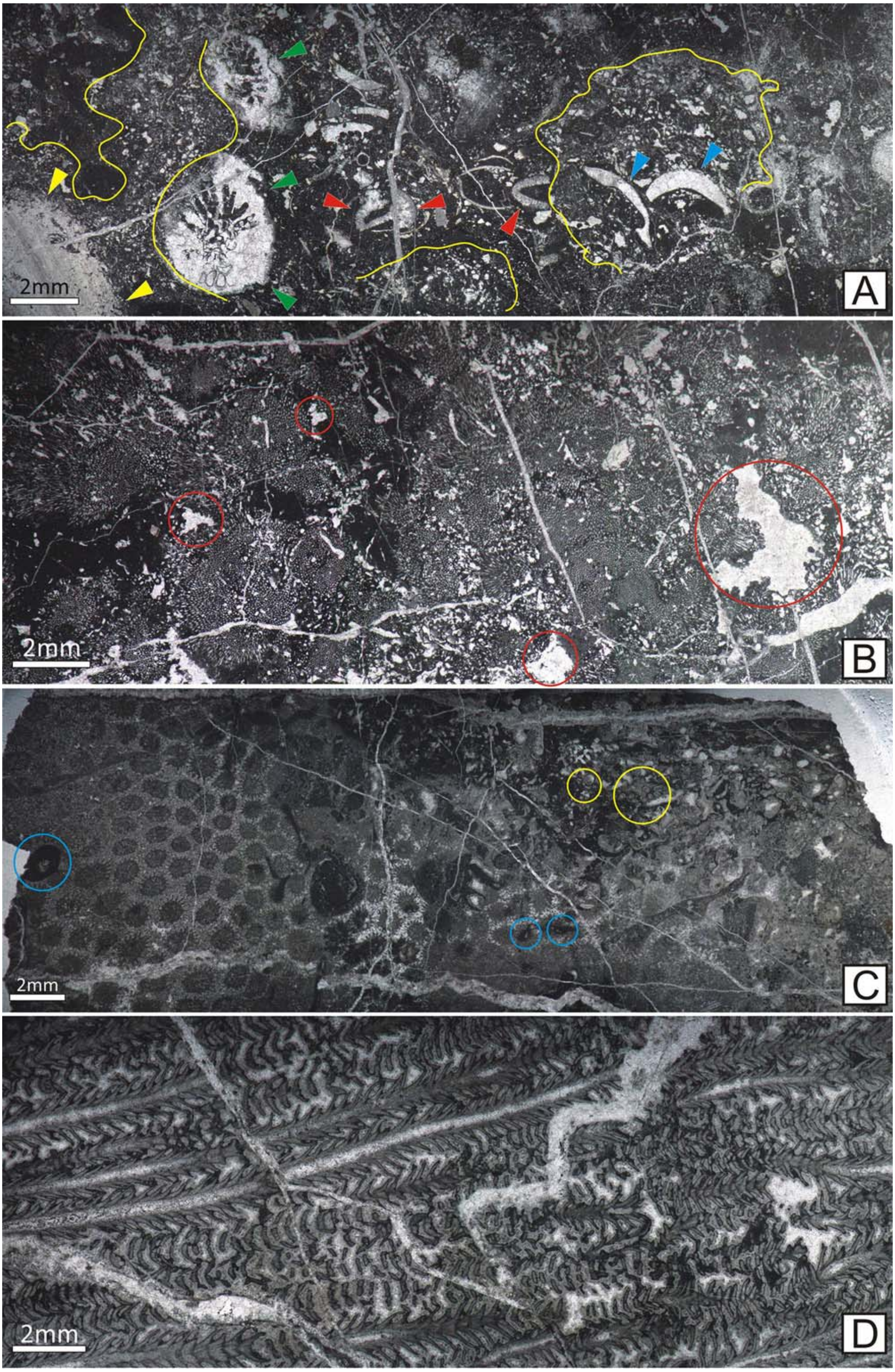
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Table 1

Depositional environment	Inner platform restricted and high-energy settings
Lithofacies association	MFL1-MFL3
Lithofacies	Peloidal bioclastic wackestone, bioclastic wackestone, bioclastic wackestone-floatstone, oncoidal floatstone, peloidal bioclastic packstone-wackestone, bioclastic peloidal packstone
Sedimentary structures	Micritic rims, bioturbation, surficial micritic envelopes, fenestral structures
Grain types	Angular to well rounded peloids, peloids of biotic origin, oncoids, porostromatic oncoids, intraclasts, extraclasts
Biota	Benthic foraminifers [*Ammobaculites* sp., *Anchispirocyclina lusitanica* (EGGER), *Kastamonina abanica* SIREL, cf. *Bramkampella arabica* (REDMOND), *Charentia cuvillieri* (NEUMANN), *C. evoluta*, *Coscinoconus alpinus, C. campanellus* (ARNAUD-VANNEAU *et al.*), *C. cherchiae, C. delphinensis, C. elongatus, C. molestus*, *C.* cf. *perconigi, C. sagittarius* (ARNAUD-VANNEAU *et al.*), *Everticyclammina* gr. *hedbergi* (MAYNC), *E. virguliana, Freixialina planispiralis, Lenticulina* sp., *Mayncina* sp., *Mohlerina basiliensis, Nautiloculina broennimanni, Ichnusella infragranulata, Protopeneroplis ultragranulata, Pseudocyclammina lituus, Spiraloconulus suprajurassicus*, *Tro-glotella incrustans*], algae [*Actinoporella podolica, Arabicodium* sp., *Clypeina cf. loferensis*, *C. maslovi* (PRATURLON), *C. parasolkani*, *C. solkani* CONRAD & RADOIČIĆ, *Aloisalthella sulcata*, *Cylindroporella* sp., *Deloffrella quercifoliipora* GRANIER & MICHAUD, *Felixporidium* sp., *Holosporella* sp., *Otternstella lemmensis* (BERNIER), *Permocalculus* sp., *Petrascula bursiformis*, *Rajkaella bartheli*, *R. iailaensis* (MASLOV), *R. subtilis*, *Russoella* sp., *Salpingoporella annulata* CAROZZI, *S. pygmaea*, *Suppiluliumella* sp., "*Solenopora*" *jurassica, Thaumatoporella parvovesiculifera*], encrusting organisms (*Bacinella irregularis*, *Lithocodium aggregatum*, *Rivularia* sp.), sponges (*Cladocoropsis* sp.), calpionellids [*Calpionellopsis simplex* (COLOM), *Calpionella minuta* (HOUŠA), ?*Precalpionellites filipescui* (POP), *Sturiella oblonga* (BORZA), ?*Tintinnopsella carpathica* (MURGEANU & FILIPESCU)], rare calcispheres [*Cadosina minuta* (BORZA)], and mollusk fragments.

◀ **Figure 5:** MFL 6-8 (Bindstone, coral boundstone, algal framestone with *Neoteutloporella socialis*). **A:** Bindstone with *Bacinella*-like structures and bioclasts; *Bacinella* type structures are abundant (outlined by yellow lines) together with large corals (green arrows), rudists (yellow arrows) and mollusks (blue arrows); calcareous algae are present (red arrows); intergranular pores contain micrite and rare sparry cement (sample 782). **B:** Microbial bindstone with *Rivularia*- type cyanobacteria. It also contains *Bacinella*-like structures and rare peloids; pores are filled with micrite; fenestral fabric with sparite infillings (red circles) (sample 518). **C:** Coral boundstone. Corals are dominant; rare encrusting organisms are present (*Radiomura* sp.-yellow circles, *Crescentiella morronensis*-blue circles); rare small peloids are present; the intergranular pores are filled with micrite and sparry calcite (sample 667). **D:** *Neoteutloporella* boundstone. occupy the entire rock mass. The original growth position can be clearly observed. Intergranular pores are filled with sparite (sample 681).

joukowskyi (Berriasian-Hauterivian cf. CHAROLLAIS *et al.*, 1966; ALTINER, 1991; BUCUR *et al.*, 1995; IVANOVA, 2000), microproblematic organisms [*Iberopora bodeuri* (Berriasian cf. GRANIER & BERTHOU, 2002; UȚĂ & BUCUR, 2003; Oxfordian-Berriasian cf. SCHLAGINTWEIT, 2004)] or the annelid worm *Terebella lapilloides* (Kimmeridgian-lower Berriasian cf. KAYA & ALTINER, 2014). This association indicates an upper Tithonian-Berriasian age for this part of the succession. However, the exact boundary between these stages cannot be identified.

Upper Berriasian-? lower Valanginian

The succession corresponding to this interval shares similar characteristics with the upper part of the previously described succession. It contains inner platform facies types with slight tendencies towards peritidal transitions (MFL1-MFL 3) (Fig. 7). Bioclastic fragments (*e.g.*, mollusks, dasycladalean algae, microbial organisms, benthic foraminifers) dominate the clast spectrum. They are followed by peloids and lithoclasts (intraclasts and extraclasts) (Fig. 7). The micropaleontological association consists of calcareous

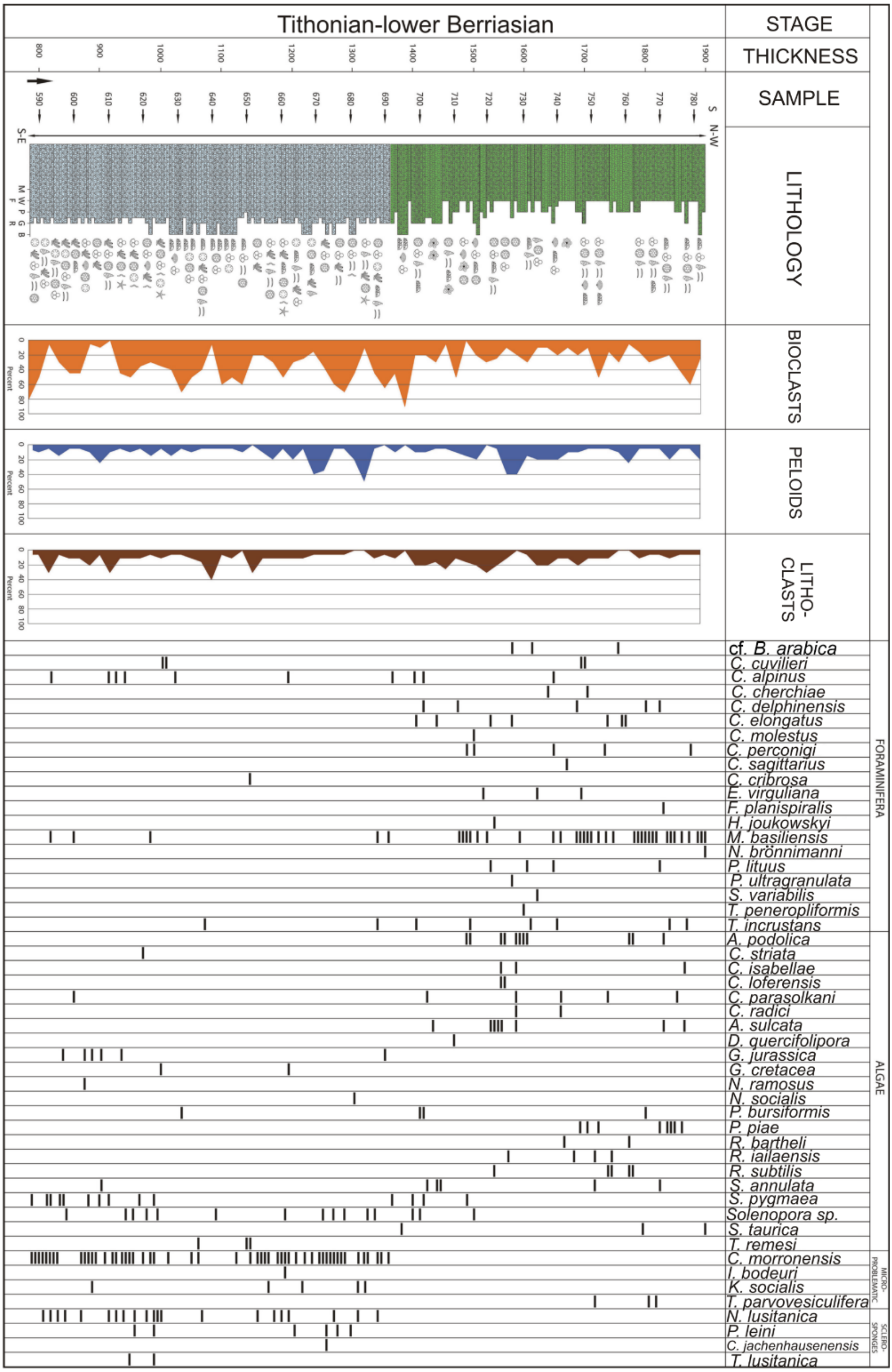


Figure 6: Lithological column of section II (upper Tithonian - lower Berriasian). The quantitative abundance of the most important carbonate components and the occurrence of the most important microfossils is indicated.

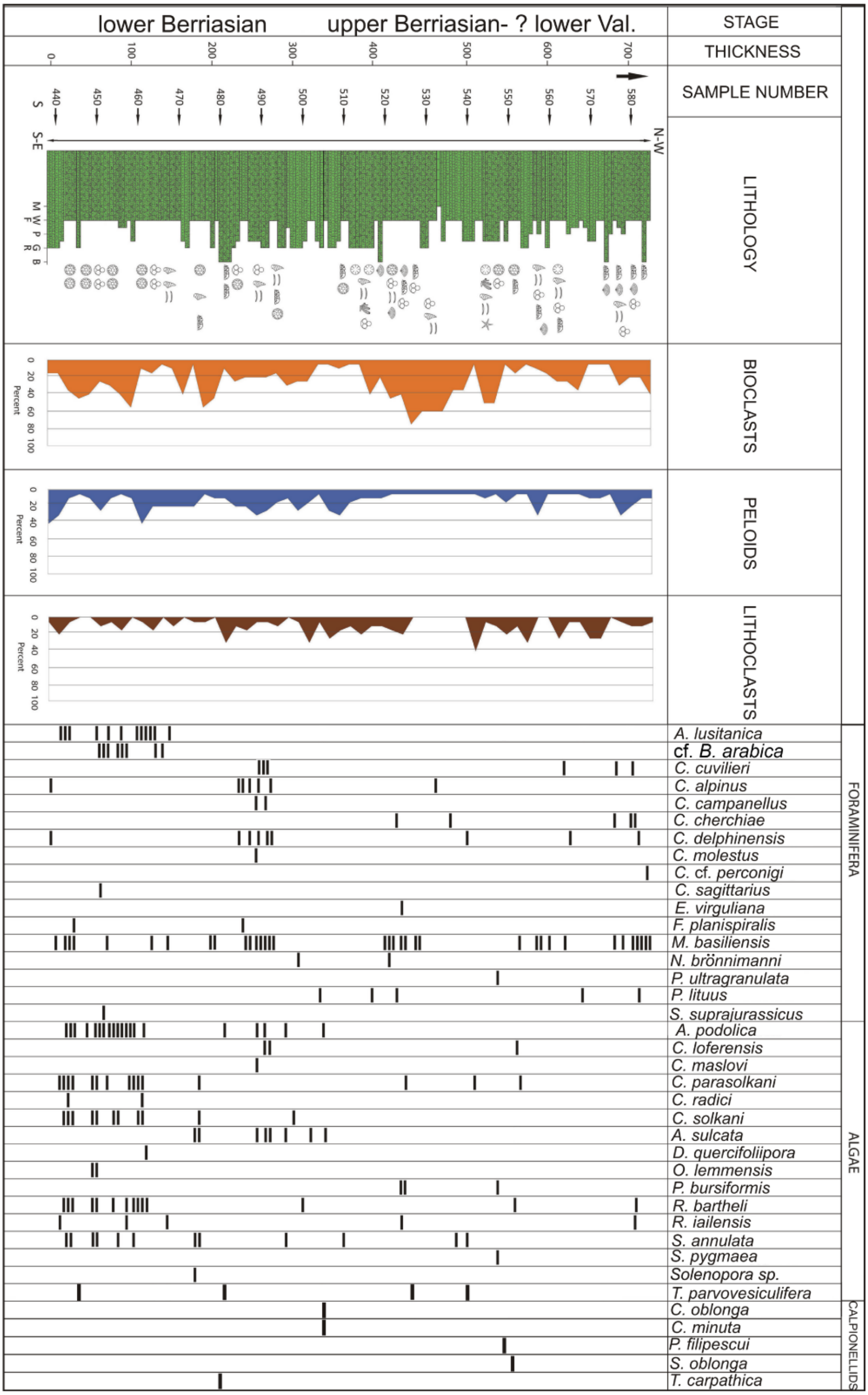
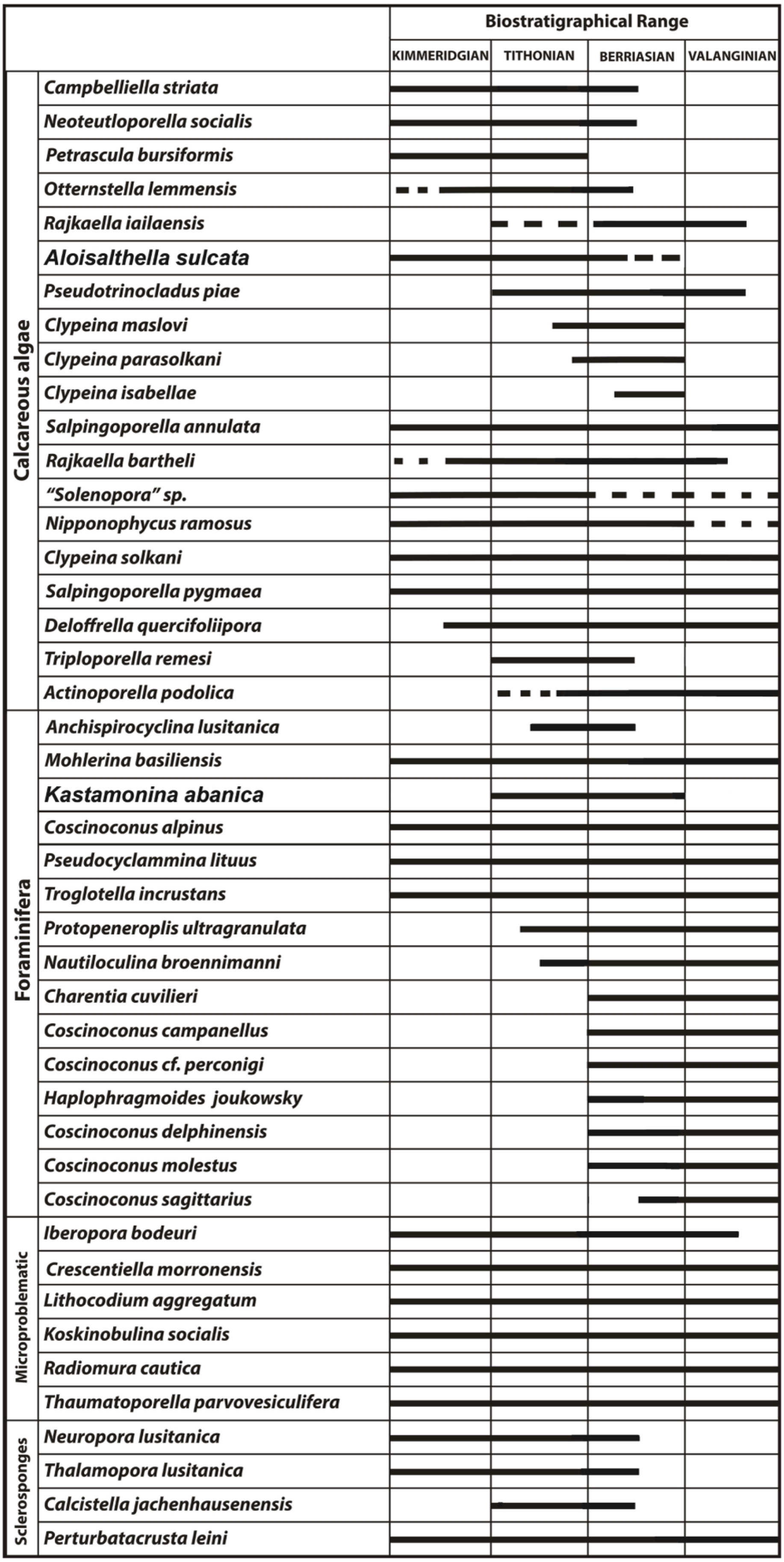


Figure 7: Lithological column of section I (upper Berriasian - ? lower Valanginian). The quantitative abundance of the most important carbonate components and the occurrence of the most important microfossils is also indicated.



◀ **Figure 8:** General stratigraphic occurence of the most important microfossil identified in the Lapoș Valley section.

▶ **Figure 9:** Upper Tithonian-Berriasian calcareous algae from the Lapoș Valley. A: *Campbelliella striata* (CAROZZI) (s. [= sample] 618); B: *Griphoporella cretacea* (DRAGASTAN) (s. 662); C: *Neoteutloporella socialis* (PRATURLON) (s. 681); D: *Nipponophycus ramosus* (YABE & TOYAMA) (s. 603); E: "*Solenopora*" *jurassica* (NICHOLSON & BROWN) (s. 598); F: *Triploporella remesi* STEINMANN (s. 650); G: *Actinoporella podolica* (ALTH) (s. 737); H: *Clypeina isabellae* MASSE *et al.* (s. 728); I: *Clypeina loferensis* SCHLAGINTWEIT *et al.* (s. 724); J: *Clypeina parasolkani* FARINACCI & RADOIČIĆ (s. 459); K: *Aloisalthella sulcata* (ALTH) (s. 777); L: *Deloffrella quercifoliipora* GRANIER & MICHAUD (s. 710); M: *Petrascula bursiformis* (ETALLON) (s. 701); N: *Rajkaella bartheli* (BERNIER) (s. 449); O: *Rajkaella subtilis* (DRAGASTAN) (s. 726); P: *Salpingoporella pygmaea* (GÜMBEL) (s. 701); Q: *Thaumatoporella parvovesiculifera* (RAINERI) (s. 767).

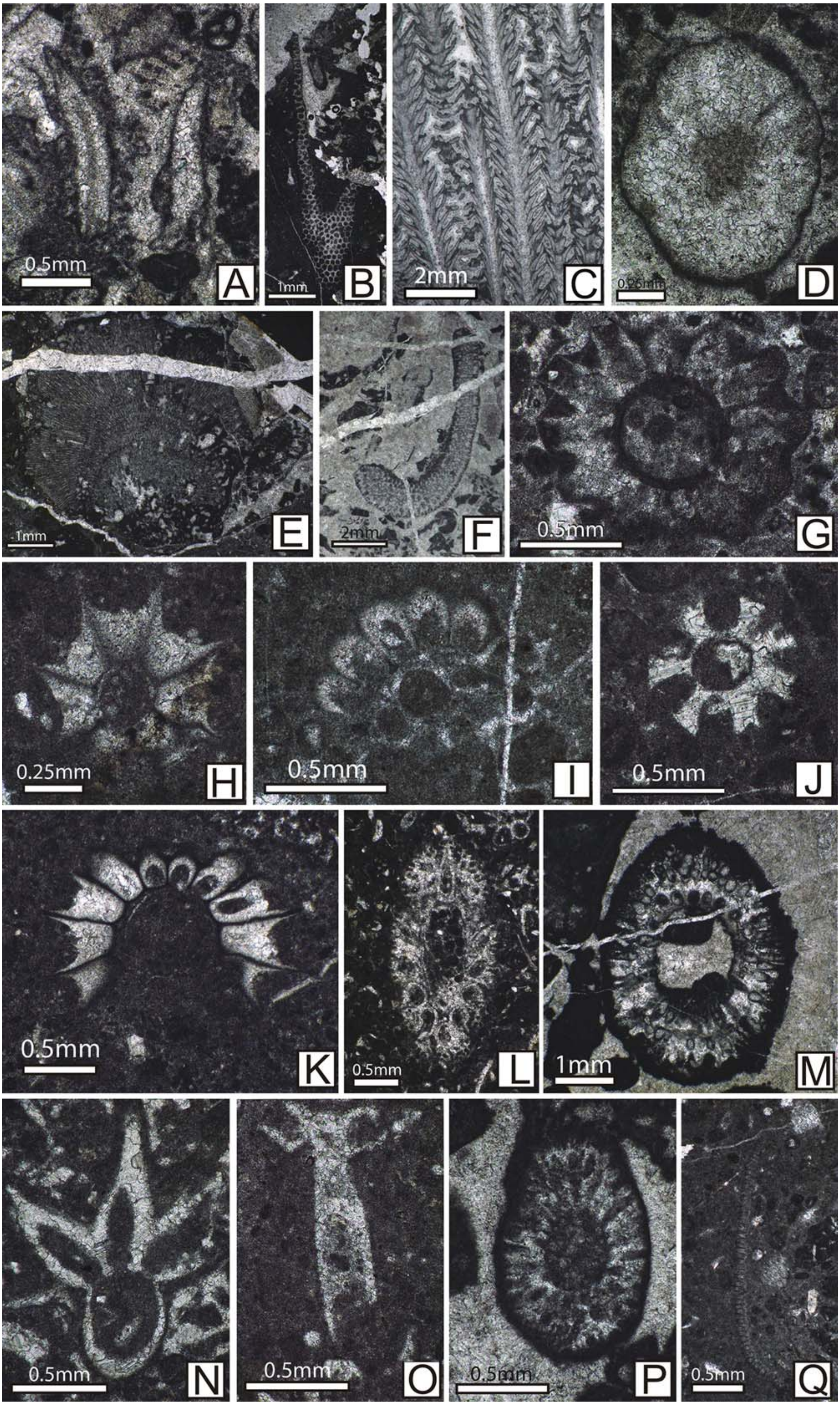

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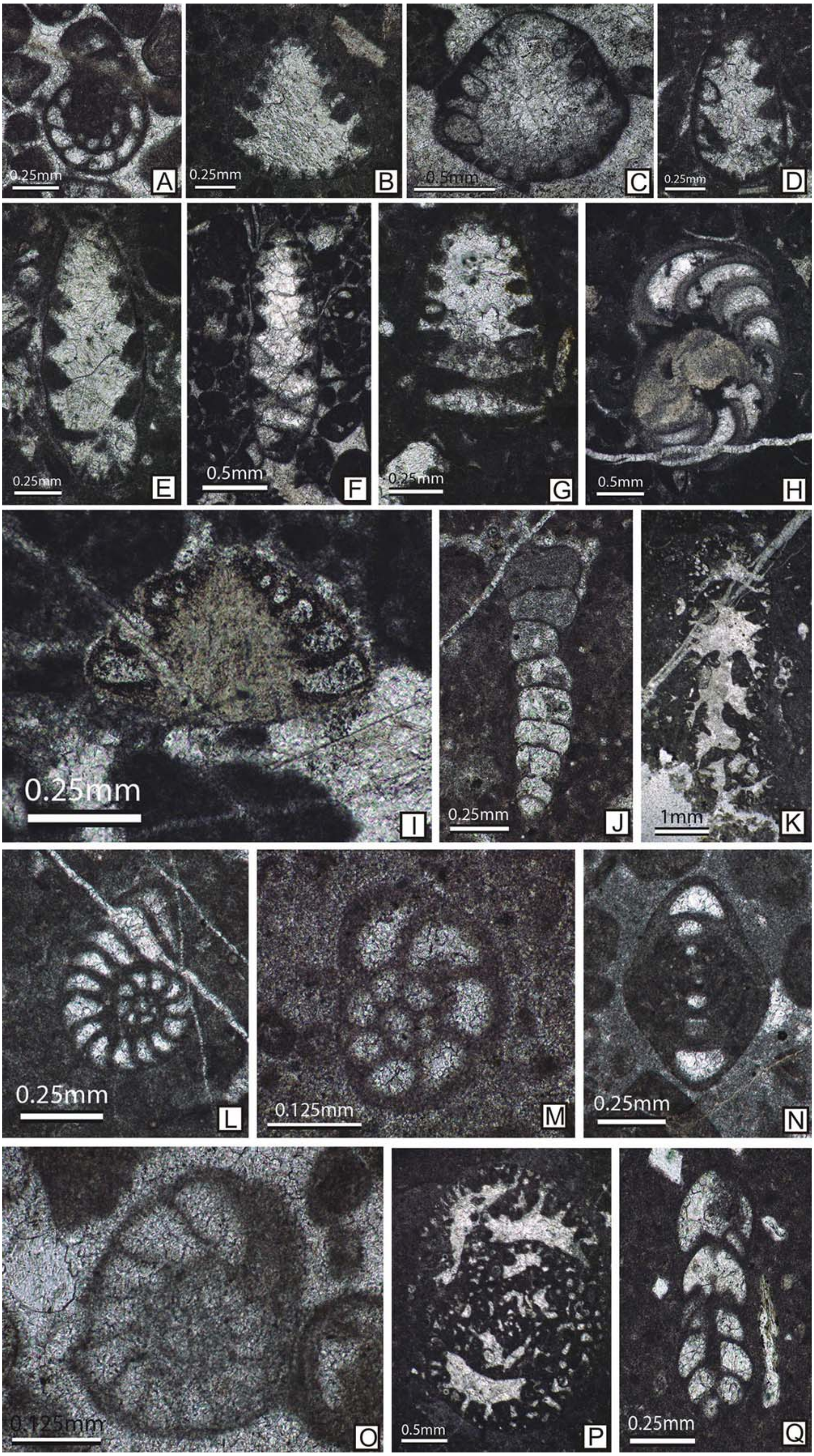
Table 2

Depositional environment	High energy, inner and platform margin settings
Lithofacies association	MFL4-MFL8
Lithofacies subtypes	Bioclastic lithoclastic grainstone/packstone, bioclastic grainstone, lithoclastic rudstone, bioclastic rudstone, boundstone, algal framestone
Sedimentary structures	Micritic rims, micritised bioclasts, subrounded clasts, grain supported fabric
Grain types	Peloids, reworked intraclasts, lithoclasts, extraclasts, skeletal grains
Biota	Benthic foraminifers [*Ammodiscus* sp., cf. *Bramkampella arabica* (REDMOND), *Charentia cuvillieri* (GORBACHIK), *Coscinoconus alpinus* (LEUPOLD), *C. chiocchinii* (MANCINELLI & COCCIA), *C. delphinensis* (ARNAUD-VANNEAU *et al.*), *C. cherchiae* (ARNAUD-VANNEAU *et al.*), *C. elongatus* (LEUPOLD), *C. molestus* (GORBATCHIK), *C. perconigi* (NEAGU), *Coscinophragma cribrosa* (REUSS), *Lenticulina* sp., *Mohlerina basiliensis* (MOHLER), *Ichnusella infragranulata* (NOTH), *Reophax* sp., *Troglotella incrustan*s (WERNLI & FOOKES), *Ammobaculites* sp., *Everticyclammina virguliana* (KOECHLIN), *Freixialina planispiralis* RAMALHO, *Haplophragmoides joukowsky* CHAROLLAIS *et al., Lenticulina* sp., *Mayncina* sp., *Nautiloculina broennimanni* ARNAUD-VANNEAU & PEYBERNÈS, *Protopeneroplis ultragranulata* (GORBACHIK), *Pseudocyclammina lituus* (YOKOYAMA), *Siphovalvulina variabilis* SEPTFONTAINE], algae [*Campbelliella striata* (CAROZZI), *Griphoporella cretacea* (DRAGASTAN), *G. jurassica* (ENDO), *Neoteutloporella socialis* (PRATURLON), *Nipponophycus ramosus* YABE & TOYAMA, "*Solenopora*" *jurassica* NICHOLSON & BROWN, *Triploporella remesi* (STEINMANN), *Actinoporella podolica* (ALTH), *Arabicodium* sp., *Clypeina isabellae* MASSE *et al.*, *C. loferensis* SCHLAGINTWEIT *et al.*, *C. parasolkani* FARINACCI & RADOIČIĆ, *Aloisalthella sulcata* (ALTH), *Deloffrella quercifoliipora* GRANIER & MICHAUD, *Linoporella* sp., *Neomeris* sp., *Permocalculus* sp., *Petrascula bursiformis* (ETALLON), *Pseudotrinocladus piae* (DRAGASTAN), *Rajkaella bartheli* (BERNIER), *R. subtilis* DRAGASTAN, *Salpingoporella pygmaea* (GÜMBEL), *Thaumatoporella parvovesiculifera* (RAINERI)], encrusting organisms [*Bacinella irregularis* RADOIČIĆ, *Crescentiella morronensis* (CRESTENTI), *Iberopora bodeuri* GRANIER & BERTHOU, *Koskinobulina socialis* CHERCHI & SCHROEDER, *Labes atramentosa* ELIÁŠOVA, *Lithocodium aggregatum* ELLIOTT, *Perturbatacrusta leini* SCHLAGINTWEIT & GAWLICK, *Pseudorothpletzella* sp., *Radiomura cautica* SENOWBARI-DARYAN & SCHÄFER] *Rivularia*-like cyanobacteria, sclerosponges (*Calcistella jachenhausenensis* REITNER, *Neuropora lusitanica* G. TERMIER *et al.*, *Thalamopora lusitanica* G. TERMIER *et al.*, *Cladocoropsis mirabillis* FELIX), annelid worm tubes (*Terebella lapilloides* MÜNSTER), gastropods, and corals

green algae [Fig. 12.A-D; Table 2], benthic foraminifers [Fig. 12.E-L; Table 2], encrusting organisms and sponges (Table 2), calpionellids (Fig. 12.M-Q; Table 2), rare calcispheres and mollusk fragments (Table 2).

Some of these species indicate the presence of Berriasian [algae: *Clypeina maslovi* (Valanginian cf. GRANIER & DELOFFRE, 1993; SCHINDLER & CONRAD, 1994; Berriasian-Hauterivian cf. BUCUR *et al.*, 2000)*, C. solkani* (upper Berriasian cf. MASSE, 1993; Malm-Albian, cf. GRANIER & DELOFFRE, 1993; Berriasian-Barremian cf. BUCUR *et al.*, 2000)], Tithonian-Berriasian [benthic foraminifers: *Anchispirocyclina lusitanica* (Tithonian-Berriasian cf. DRAGASTAN, 1975a; SOTAK, 1989; SCHLAGINTWEIT *et al.*, 2005; Tithonian-lower Berriasian cf. GRANIER, 2019), *Kastamonina abanica* (Tithonian-Berriasian, cf. SCHLAGINTWEIT, 2005]. The calpionellid association characterizes the upper Berriasian (Calpionellopsis Zone, Simplex Subzone, POP, 1997). The entire association characterizes the upper Berriasian-? lower Valanginian (Fig. 8).

▶ **Figure 10:** Upper Tithonian-Berriasian foraminifers from the Lapoș Valley. A: *Charentia cuvillieri* NEUMANN (s. 491); B: *Coscinoconus alpinus* LEUPOLD (s. 486); C: *C. chiocchinii* MANCINELLI. & COCCIA (s. 610); D: *C. delphinensis* (ARNAUD-VANNEAU *et al.*) (s. 711); E: *C. cherchiae* (ARNAUD-VANNEAU *et al.*) (s. 716); F: *C. elongatus* LEUPOLD (s. 699); G: *C. perconigi* NEAGU (s. 746); H: *Mohlerina basiliensis* (MOHLER) (s. 487); I: *Ichnusella infragranulata* (NOTH) (s. 661); J: *Troglotella incrustan*s WERNLI & FOOKES (s. 778); K: *Everticyclammina virguliana* KOECHLIN (s. 524); L: *Freixialina planispiralis* RAMALHO (s. 486); M: *Haplophragmoides joukowsky* (CHAROLLAIS *et al.*) (s. 722); N: *Nautiloculina broennimanni* ARNAUD-VANNEAU & PEYBERNÈS (s. 489); O: *Protopeneroplis ultragranulata* (GORBACHIK) (s. 547); P: *Pseudocyclammina lituus* (YOKOYAMA) (s. 582); Q: *Siphovalvulina variabilis* SEPTFONTAINE (s. 734).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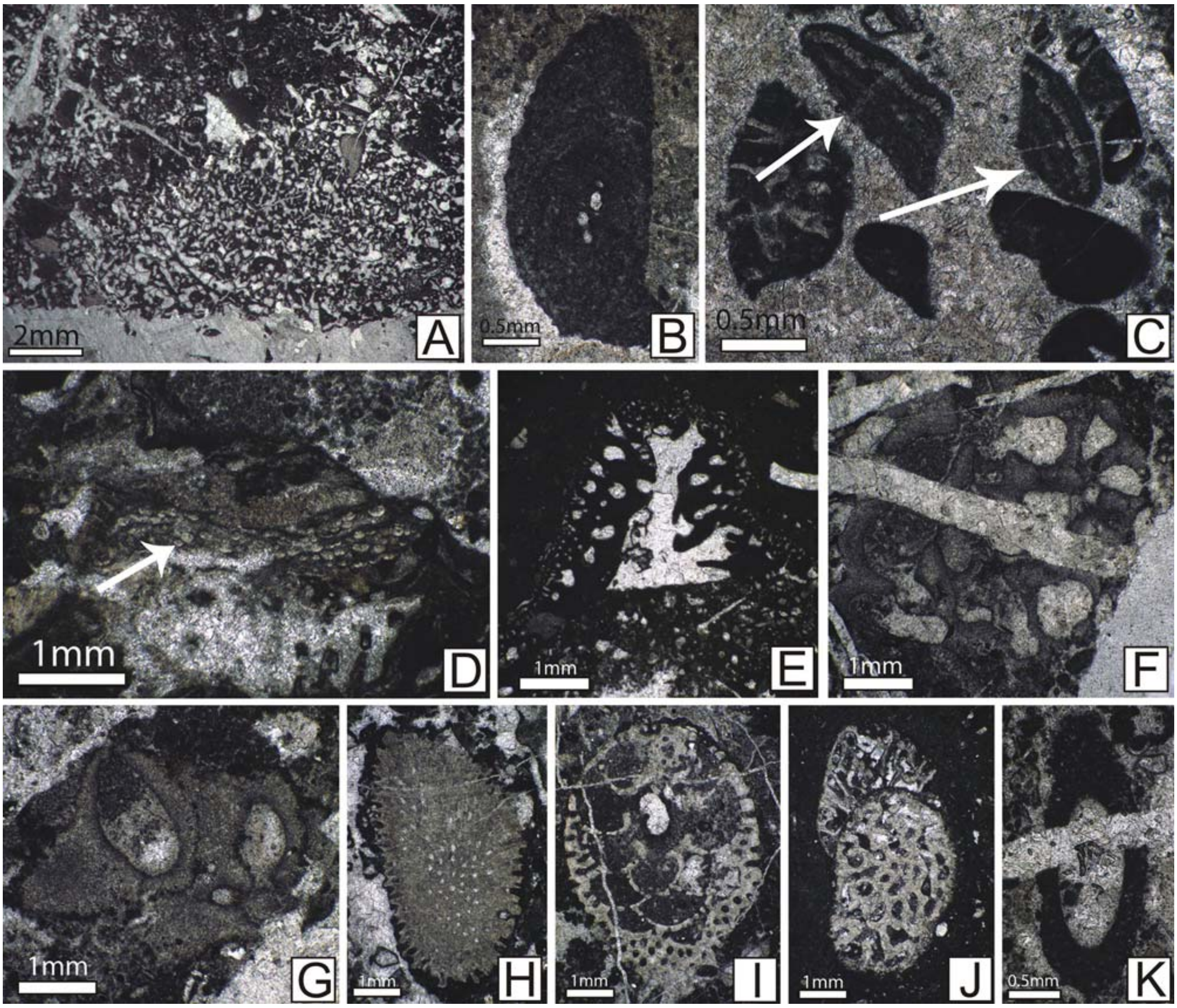

Figure 11: Upper Tithonian-lower Berriasian encrusting microorganisms and sponges from the Lapoș Valley. A: *Bacinella irregularis* RADOIČIĆ (s. 643); B: *Crescentiella morronensis* (CRESTENTI) (s. 685); C: *Iberopora bodeuri* GRANIER & BERTHOU (s. 671, arrows); D: *Koskinobulina socialis* CHERCHI & SCHROEDER (s. 682, arrow); E: *Lithocodium aggregatum* ELLIOTT (p. 522); F: *Perturbatacrusta leini* SCHLAGINTWEIT & GAWLICK (p. 617); G: *Radiomura cautica* SENOWBARI-DARYAN & SCHÄFER (s. 589); H: *Neuropora lusitanica* G. TERMIER *et al.* (s. 591); I: *Thalamopora lusitanica* G. TERMIER *et al.* (s. 616); J: *Cladocoropsis mirabillis* FELIX (s. 777); K: *Terebella lapilloides* MÜNSTER (s. 655).

6. Discussions and conclusions

The studied section follows an alignment which corresponds to the Lapoș Valley. It consists of two distinct successions separated by a fault. The micropaleontological and microfacies association points to an upper Tithonian-lower Berriasian age of the succession situated above the fault. Upper Berriasian-? lower Valanginian deposits form the lower part of the succession, below this fault. A preliminary analysis of the most important facies types indicates that carbonate sediment was accumulating in two major depositional settings: inner platform areas defined by interbedded high- and low-energy deposits (upper Berriasian-? lower Valanginian) together with platform margin areas (dominated by high-energy deposits) (upper Tithonian-lower Berriasian) (Tables 1-2). The upper Tithonian-Berriasian clastic components are characterized by poor sorting, variable roundness (ranging from angular to well rounded). This part of the succession con-tains mainly platform margin high-energy de-posits, with rare interbedded low-energy car-bonates. There is a direct relationship between the existing biota and the environmental conditions. The vast majority of the identified dasycladalean algae prefer such high energy, platform margin depositional settings with reefs or bioclastic banks (*e.g.*, *Campbelliella striata*, *Neoteutloporella socialis*, *Petrascula bursiformis*) (DRAGASTAN, 1975a; SCHLAGINTWEIT & EBLI, 1999; BUCUR *et al.*, 2005). In addition, the entire association of encrusting organism and calcareous sponges characterizes such platform margin complexes that were strongly developed at the Jurassic-Cretaceous transition (PLEȘ *et al.*, 2013; MIRCESCU *et al.*, 2019). Terrigenous quartz fragments are rare. All the sedimentological features point to a shallow-water, high-energy depositional environment with

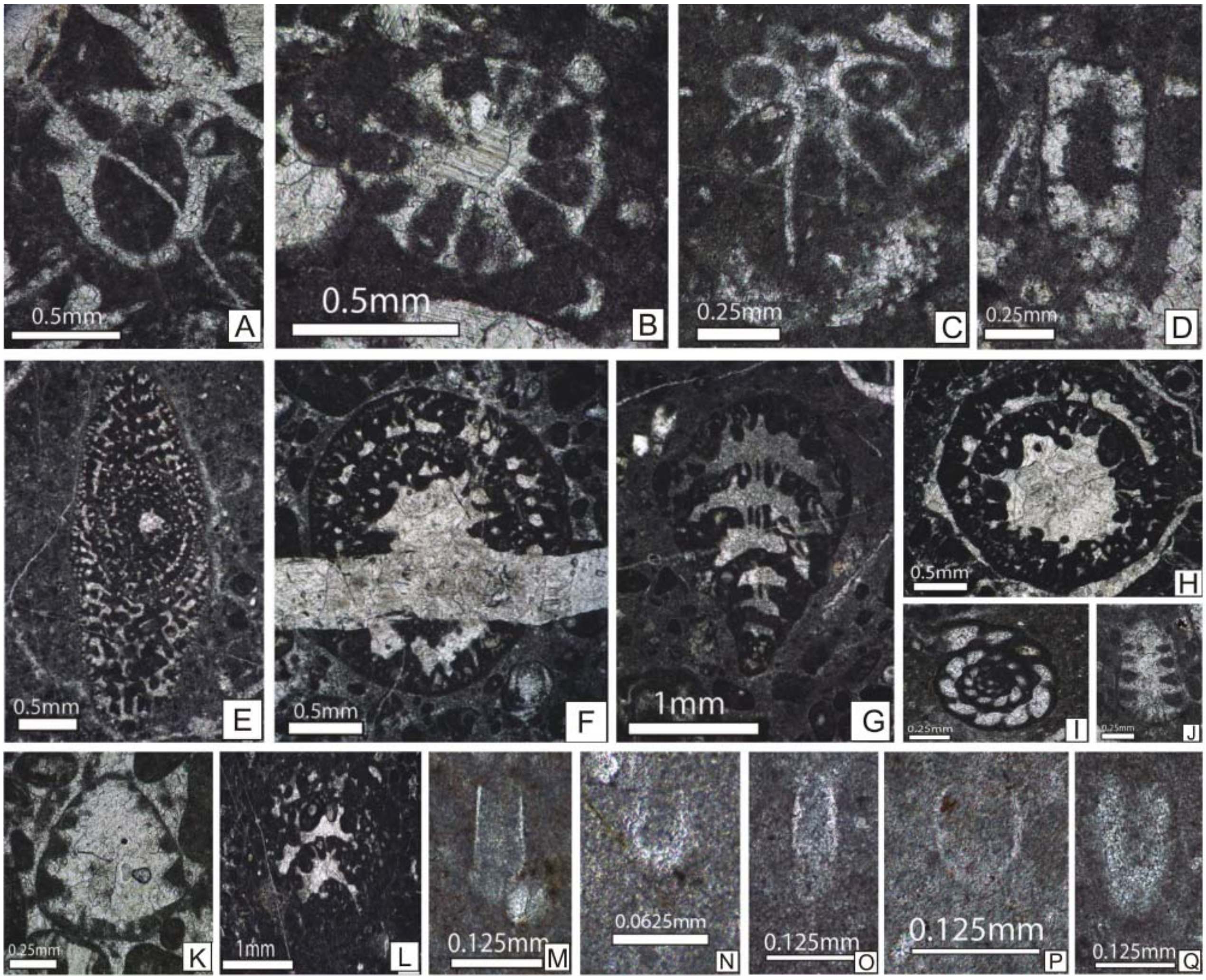

Figure 12: Upper Berriasian-? lower Valanginian microfossils from the Lapoș Valley. A: *Clypeina solkani* CONRAD & RADOIČIĆ (s. 443); B: *Otternstella lemmensis* (BERNIER) (s. 449); C: *Rajkaella iailaensis* (MASLOV) (s. 524); D: *Salpingoporella annulata* CAROZZI (s. 449); E-F: *Anchispirocyclina lusitanica* (EGGER) (s. 462, 456); G: cf. *Bramkampella arabica* REDMOND (s. 456); H: *Kastamonina abanica* SIREL (s. 446); I: *Charentia cuvilieri* NEUMANN (s. 563); J: *C. sagittarius* (ARNAUD-VANNEAU *et al.*) (s. 743); K: *Coscinoconus campanellus* (ARNAUD-VANNEAU *et al.*) (s. 491); L: *Spiraloconulus suprajurassicus* SCHLAGINTWEIT (s. 452); M: *Calpionellopsis oblonga* (CADISCH) (s. 505); N: *Calpionella minuta* HOUŠA (s. 505); O: *Sturiella oblonga* BORZA (s. 551); P: ?*Precalpionellites filipescui* POP (s. 549); Q: ?*Tintinnopsella carpathica* (MURGEANU & FILIPESCU) (s. 481).

abundant, diverse biota. Inner and margin platform shallow-water carbonates characterize the Tithonian sedimentation and are partly represented by bioclastic reefal facies types (Fig. 6). The overlying Berriasian deposits probably accumulated in a regressive depositional context. Peloids, lithoclasts and micrite make up and increasing proportion of the sediment components. Grain dimensions are smaller, their abundance decreases and sorting varies from poor to moderate. Some of the inner platform deposits accumulated in restricted environments. They are defined by a transition towards peritidal settings. These tendencies are indicated by a decrease in the proportion of bioclasts associated with a slight increase in the proportion of peloids. The upper Berriasian- ? lower Valanginian succession contains interbedded, high- and low-energy, subtidal and intertidal deposits.

The low-energy deposits from the inner platform areas are defined by the presence of abundant carbonate mud and a characteristic biota (Table 2). Such carbonate sediments accumulated under low-energy conditions in restricted, subtidal lagoons. The abundance of cyanobacteria nodules is typical for such restricted environments (SĂSĂRAN *et al.*, 2013). In these conditions, micritisation processes were very active, under the action of endolithic bacteria (BATHURST, 1966). Some of the identified dasycladalean algae prefer such isolated, lagoonal environments. *Clypeina loferensis* was originally described by SCHLAGINTWEIT *et al.* (2009) from such shallow-water subtidal lagoons. *Salpingoporella annulata* is frequently reported from similar depositional environments (BUCUR & SĂSĂRAN, 2005; MIRCESCU *et al.*, 2014). Another algae that prefers such lagoonal areas is *Clypeina parasolkani* (HUSINEC & SOKAČ, 2006; SCHLAGINTWEIT *et al.*, 2009). *Pseudocyclam-*

mina lituus and *Anchispirocyclina lusitanica* are two species of foraminifers which are well known from similar deposits (DARGA & SCHLAGINTWEIT, 1991; DYA, 1992). Oncoids are frequent within low-energy subtidal areas. In this case, *Bacinella* type structures play a key role in forming such structures. The inner platform high-energy deposits were deposited probably in intertidal littoral areas. They contain abundant representatives of the genus *Coscinoconus* (*e.g.*, *C. alpinus*, *C. sagittarius*, *C. campanellus*). Such foraminifers were described by various authors (ARNAUD-VANNEAU, 1980; SIMMONS, 1990) from this type of depositional environments.

The studied succession presents some peculiar characteristics. The low-energy deposits contain occasionally small percentages of calpionellids and calcispheres. Two explanations can be considered, either we have allodapic limestones (resedimented shallow-water carbonates in the basin with calpionellids), or that rare calpionellids were occasionally transported into the platform by storms. Taking into account the general aspect of the carbonate sediments from the succession studied the second hypothesis seems to be more appropriate. Isolated bioconstructions were developed as buildups (BURCHETTE & WRIGHT, 1992). The microfacies and micropaleontological associations are similar with previous data presented by various authors from other outcrop areas in Romania (Median Dacides) (BUCUR, 1997; PLEȘ *et al.*, 2013; MIRCESCU *et al.*, 2014; UNGUREANU *et al.*, 2015; GRĂDINARU *et al.*, 2016) and other parts of the Tethysian Realm (GAWLICK *et al.*, 2004; RUSCIADELLI & RICI, 2008; GAWLICK & SCHLAGINTWEIT, 2010; PETROVA *et al.*, 2011, 2012; CHATALOV *et al.*, 2015; IVANOVA *et al.*, 2015). They represent valuable correlation tools for future studies at the Jurassic-Cretaceous transition.

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