

## UPPER JURASSIC-LOWER CRETACEOUS *INCERTAE SEDIS* ORGANISMS FROM MIRDITA ZONE, ALBANIA

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### ABSTRACT

*Incertae sedis*, also referred to as microproblematica, are organisms with an uncertain systematic position. In micropaleontological studies—particularly those focused on paleoenvironmental research or bathymetric zoning of marine environments—these organisms serve as an invaluable tool, alongside other microorganisms such as foraminifera and algae. This paper presents a series of species identified within Jurassic-Cretaceous deposits, specifically from the Berriasian-Valanginian interval, based on stratigraphic sections studied in the Mirdita geological zone.

**Key words:** incertae sedis, microproblematica, microencrusts,

### 1. INTRODUCTION

The geological study of Jurassic-Cretaceous and Lower Cretaceous carbonate deposits, which extensively overlie ophiolites and their primary sedimentary cover, is critically important for reconstructing the geological evolution of the Mirdita Zone. The significantly differing regional geological interpretations proposed by various authors underscore the need for more detailed studies to develop a more reliable understanding of this evolution.

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*Incertae sedis* microorganisms and other *microproblematica* have played a key role in the formation of Upper Jurassic–Lower Cretaceous reef environments. Alongside other characteristic macro- and microorganisms, they are essential for interpreting sedimentary environments and for zoning reefs and the inner parts of carbonate platforms. Many of the forms discussed in this paper are described for the first time in Albania, making this study the only work in the Albanian literature entirely dedicated to these types of organisms.

## 2. MATERIAL AND METHODS

This study analyzes approximately 400 thin sections from Upper Berriasian–Lower Valanginian carbonate deposits in the Mirdita geological zone, Albania. These sections revealed numerous *incertae sedis* organisms with uncertain systematic positions, identified under an optical microscope.

These microscopic analyses involved examining the morphology of the specimens, after which individuals belonging to each species were photographed and classified according to taxonomic hierarchy. Since these organisms have uncertain systematic positions, each species was compared with the affinities proposed by various authors in the international literature. This comparison helped determine the specific affinities of the specimens identified in our material, as well as the age of the deposits in which they were found. Following species identification and classification, the stratigraphic intervals documented in the international literature were compared with the stratigraphic intervals observed within the studied areas. Each species is presented with high-quality microscope photographs, organized into plates that include detailed explanations, such as sample numbers, collection locations, and magnification levels.

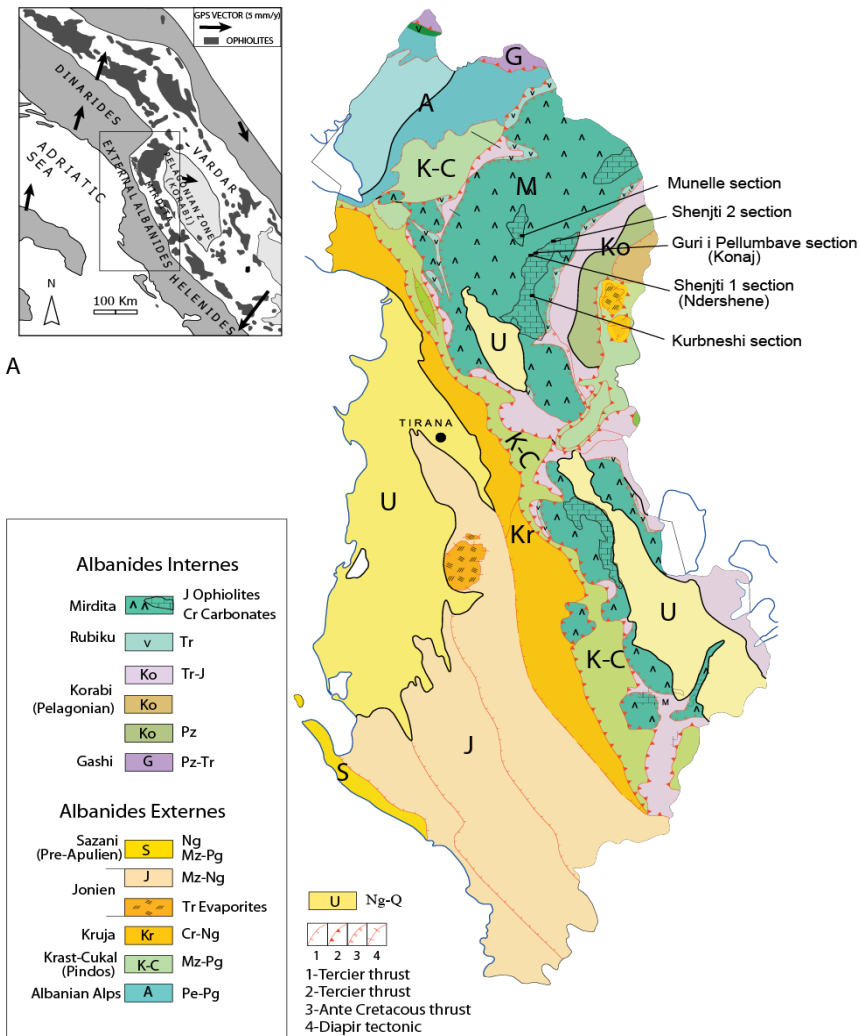
The samples analyzed in this study were collected from five stratigraphic sections within the Mirdita geological zone: Guri i Pellumbave, Mali i Shenjte, Kurbnesh, Munella, and Gur Shpati. The locations of these sections are shown in Figure 1.

### **Geological background of Mirdita zone during Jurassic-Cretaceous**

The Mirdita tectonic zone extends over a large area of Albania. The ophiolites, which are the main components of this region, represent parts of the Mirdita oceanic basin that formed during the Middle Triassic to

Middle Jurassic, between the Adriatic plate and the Korab–Pelagonian continental microblock, or between the Adriatic and Eurasian plates. The closure of the Mirdita oceanic basin occurred from the end of the Middle Jurassic to the beginning of the Late Jurassic (Xhomo *et al.*, 2002; 2005). The Middle to Upper Jurassic and Jurassic to Cretaceous sedimentary deposits, which cover the ophiolites and the surrounding continental formations, have been extensively studied by numerous authors (for main references, see Prela 1996, 2006; Shehu *et al.* 1990; Meço and Aliaj 2000; Xhomo *et al.*, 2002; Marku 1999; 2000; 2001). Jurassic–Cretaceous sedimentary formations are widespread in the Mirdita zone, where they lie with stratigraphic and structural unconformities above the Jurassic ophiolites and their sedimentary cover, which includes the Middle Jurassic *Kaluri* radiolarian chert, the *mélange* blocks in the matrix known as *Simoni*, and the Callovian–Lower Oxfordian ophiolitic breccia and conglobreccia. In the western part of the Mirdita zone, the Jurassic–Cretaceous deposits are represented by the clayey-sandy-marl flysch formation known as the "Firza Flysch" (Bortolotti *et al.*, 1996). Some of the most prominent outcrops of this flysch are found in the areas of Rubik, Rrëshen (Derven), Fang, and others. The age of the "Firza Flysch" is Upper Tithonian–Valanginian, as confirmed by numerous calpionellids and other microfauna (Melo and Dodona 1971; Peza 1981; 1983; 1989; Gjata 1989; Xhomo *et al.*, 2002; 2005). In the central and eastern regions of Mirdita, as well as in western Mirdita, the Jurassic–Cretaceous deposits lie with stratigraphic and structural unconformities above the Jurassic ophiolites and their sedimentary cover, which includes the Middle Jurassic *Kaluri* radiolarian chert, the *mélange* blocks in the matrix known as *Simoni*, and the Callovian–Lower Oxfordian ophiolitic breccia and conglobreccia. In many cases, the Jurassic–Cretaceous deposits of central and eastern Mirdita are overlain by significant Cretaceous carbonate deposits. Overall, the same structural pattern of Jurassic–Cretaceous and Cretaceous deposits is observed at the regional level. A key difference between the Jurassic–Cretaceous deposits of western Mirdita and those of central and eastern Mirdita is that, while western Mirdita is characterized solely by clayey-sandy-marly flysch (Firza), central and eastern Mirdita contain, in addition to clayey-sandy-marly flysch, molasse deposits, which include shallow-water carbonate deposits and, less frequently, conglomerates. These shallow-water limestones within the flysch deposits were first identified in the Bisak region by Melo & Dodona (1971) and Meço *et al.* (1975). Gawlick *et al.* also documented such deposits in the regions southwest of

Munella. Uta (2018) determined the Berriasian–Valanginian age of the Guri i Pellumbave limestones and confirmed the same Berriasian–Valanginian age at the base of the Mali i Shenjte platform (Uta, 2019).



**Fig. 1: A):** Albanides position in the southern branch of the Mediterranean Alps. **B):** Schematic geological map of Albanides (modified after Muceku et al 2008) and Sampling places for this study. Pz, Paleozoic; Pe, Permian; Mz, Mesozoic; Tr, Triassic; J, Jurassic; Cr, Cretaceous; Pg, Paleocene; Ng, Neocene; Q, Quaternary.

### 3. RESULTS AND DISCUSSIONS

Some of the most debated forms are *Lithocodium aggregatum* (Elliott, 1956) and *Bacinella irregularis* (Radoičić 1959), commonly referred to as the *Lithocodium-Bacinella* association, which are among the most common organisms encountered in the Upper Jurassic–Lower Cretaceous. In the past, some authors considered *Lithocodium* and *Bacinella* as a single taxon rather than two distinct ones (Schlagintweit *et al.*, 2010). For example, *Lithocodium aggregatum* in Štramberk facies limestones was classified as *Bacinella irregularis* (Eliášová 1981b), while calcimicrobial crusts with entobians (*Lithocodium aggregatum* sensu Schmid and Leinfelder, 1996) were classified as *Bacinella crispa* (Eliášová, 1981a, pl. 2, fig. 3). When the attribution to a specific species (*L. aggregatum*) or to a structure (calcified crusts with piercing entobians, bacinellid microbial structures) is problematic or impossible to determine precisely, they are collectively referred to as "*Lithocodium–Bacinella*," as used in our study. Other structures identified in the Guri i Pëlumbave, Mali i Shenjte, and Kurbnesh stratigraphic sections include "bacinellid fabrics" (Schlagintweit and Bover-Arnal, 2013), "Bacinella" type structures (Pleș *et al.*, 2013; 2016; Kaya and Altiner, 2015), and bacinellid structures (Pleș *et al.*, 2017).

#### **Bacinella-type structures (Bacinellid fabrics)**

#### **Plate 2, Fig. 20-21, Fig 38; Plate 4: Fig 58-60,**

The enigmatic organism *Bacinella irregularis* was first described by Radoičić (1959) as an incertae sedis alga. Later, some authors proposed a microbial or cyanobacterial origin (Schaefer and Senowbari-Daryan, 1983; Maurin *et al.*, 1985; Camoin & Maurin, 1988; Schmid & Leinfelder, 1996; Vachard *et al.*, 2001; Uta and Bucur, 2003). More recently, Schlagintweit *et al.*, (2010) and Schlagintweit and Boveri-Arnal (2013) considered *Bacinella* as a monotypic taxon, interpreting *Bacinella irregularis* as a euendolithic alga with a thallus composed of cylindrical filaments that pierce other bioclasts, such as corals or *Lithocodium aggregatum* type crusts. With this new, limited diagnosis, Schlagintweit and Boveri-Arnal (2013) assert that many of the species previously described as *Bacinella irregularis* do not actually belong to this taxon. They demonstrated that these species instead exhibit vesicular crusts ("bacinellid fabric") of possible microbial origin. The specimens identified in our material are more similar to these "bacinellid fabrics."

**Biostratigraphic Distribution:** "Bacinellid structures" are commonly found in the Upper Jurassic–Lower Cretaceous deposits throughout the Tethys region. Borza (1975) and Senowbari-Daryan (1984) also described similar structures in materials of Upper Triassic age. In the stratigraphic sections of our study, these structures were identified in the Berriasian–Valanginian interval at Guri i Pellumbave and Kurbnesh.

*Lithocodium aggregatum*

**Plate 1:fig.11, fig. 15-16., Plate 2:fig. 24-26, fig. 35, Plate 4: fig.61, fig.64, fig.66, fig.68. fig.71**

Another enigmatic and intensively debated organism, *Lithocodium aggregatum*, consists of two main parts: a micritic crust that appears branched, along with the cavities within this micritic crust. Elliott (1956) first described *Lithocodium aggregatum* as a codiaceus alga. Leinfelder *et al.* (1993a) considered it a burrowing organism with a central inner cavity and an outer part with radial or branched filaments. The possibility of a microbial origin has also been suggested by several authors (Camoin and Maurin 1988; Riding 1991). Schmid and Leinfelder (1995; 1996) interpreted *Lithocodium aggregatum* as a burrowing loftusiacean foraminifer, while Koch *et al.* (2002) proposed it to be a sponge. Cherchi & Schroeder (2006) suggested it as a colony of calcified cyanobacteria. More recently, *Lithocodium aggregatum* has been interpreted by Schlagintweit (2010) and Cherchi and Schroeder (2010; 2013) as a microbial crust-boring sponge. The association of *Lithocodium aggregatum* with Bacinella-type structures and other burrowing organisms, such as *Troglotella incrustans* (Plate 2: Fig. 26), is typically found in Late Jurassic reef environments but also in Early Cretaceous environments.

**Biostratigraphic Distribution:** The stratigraphic distribution of *Lithocodium aggregatum* is attributed to the Tithonian–Coniacian (Oxfordian) interval (Pleş *et al.*, 2013). In the material of our study, it has been identified in the Berriasian–Valanginian deposits from Guri i Pellumbave, Mali i Shenjte, Kurbnesh, and Munella.

*Troglotella incrustans*

**Plate 2: fig.26, fig.31.**

The association of *Troglotella incrustans* with *Lithocodium aggregatum* was discussed in detail by Schmid & Leinfelder (1996), who

interpreted this relationship as a symbiosis, with *Troglotella* residing inside the spar-filled chambers of *Lithocodium*. The stratigraphic range of *Troglotella incrustans* extends from the Middle Oxfordian to the Lower Cenomanian (Schlagintweit, 2012). In our study, it has been identified in the Berriasian–Valanginian deposits from Guri i Pellumbave and Mali i Shenjte.

### ***Radiomura cautica***

**Plate1: fig2, Plate 4:fig.62, Plate 5:fig.56.**

Despite some specialists defining *Radiomura cautica* as a sponge species, its systematic position remains unclear (Pleş *et al.*, 2013). *Radiomura cautica* is a typical organism found in reef facies, particularly in fore-reef environments, alongside the related species *Perturbatacrusta leini* (Schlagintweit & Gawlick, 2011). There are three main differences between *Radiomura cautica* and *Perturbatacrusta leini*: i) the absence of the microcrystalline divergent radial fibers typical of *Radiomura cautica* in *Perturbatacrusta leini*; ii) the internal structure of *Perturbatacrusta leini*, which exhibits a labyrinthine canal system (Schlagintweit and Gawlick, 2011); and Differences in their stratigraphic ranges. *Radiomura cautica* (Senowbari-Daryan & Schäfer, 1979) consists of several nearly spherical to spherical chambers and is morphologically similar to *Perturbatacrusta leini* (Schlagintweit & Gawlick, 2011), which was previously classified as *Radiomura cautica*. *Perturbatacrusta leini* displays a labyrinthine structure consisting of an irregular, interconnected system of tubes. Both forms may represent calcified sponges (Schlagintweit and Gawlick 2011; Pleş and Schlagintweit, 2014).

**Biostratigraphic Distribution:** *Radiomura cautica* is known from the Late Triassic to Neocomian interval (Schlagintweit & Gawlick, 2011). In our study, it has been identified in the Berriasian–Valanginian deposits from Guri i Pellumbave and Kurbneshi.

### ***Koskinobulina socialis***

**Plate1: fig.6, Plate 2: fig.23, fig.27/**

*Koskinobullina socialis* was initially described by Cherchi and Schroeder (1979) as a red alga, whereas Schmid (1996) classified it as a foraminifer. He also documented its association with another microencrusting organism, *Iberopora bodeuri*. Due to its hemispherical morphology, it has been compared to the Paleozoic genus *Wetheredella*, which Kazmierczak and Kempe (1992) suggested shares similarities with



modern cyanobacteria. *Koskinobullina socialis* Cherchi & Schroeder (1979) is considered an incertae sedis organism, possibly classified as either an alga or a foraminifer. This organism is characterized by hemispherical chambers with perforated walls (see Pleş et al., 2013; Kaya and Altiner, 2015). The Upper Jurassic–Lower Cretaceous forms of *Koskinobullina socialis* are typically associated with crusts of other microproblematica organisms, such as *Iberopora bodeuri* (Granier & Berthou, 2002), which consists of small, bubble-like, overlapping cells (Schlagintweit, 2004a).

**Biostratigraphic distribution:** Cherchi & Schroeder (1985) report the stratigraphic distribution of *Koskinobullina socialis* as spanning from the Batonian to the Cenomanian. In the present study, *Koskinobullina socialis* is found in the Berriasian-Valanginian deposits at Guri i Pellumbave.

### *Iberopora bodeuri*

#### **Plate 1: fig.12-13.**

This organism was described by Schmid (1996) as "crust problematicum" with a potential relationship to red algae. Schmid (1996) also discussed possible similarities between *Iberopora bodeuri* and the Paleozoic cyanobacterium *Sphaerocodium*. Granier and Berthou (2002) highlighted the affinities of *Iberopora bodeuri* with another problematic organism, *Solenomeris ogormani* (Douville), which has long been interpreted as a solenoporacean alga, but was later considered a burrowing foraminifer. Helm et al. (2003) proposed an alternative origin, suggesting that the structural similarities between *Iberopora bodeuri* and *Wetheredella* point to a possible cyanobacterial origin.

**Biostratigraphic distribution:** According to Schlagintweit (2004), the stratigraphic range of *Iberopora bodeuri* extends from the Oxfordian to the Berriasian. In our study, it was identified in the Berriasian-Valanginian deposits at Guri i Pellumbave.

### *Crescentiella morronensis*

**Plate 1: fig.10, fig.17; Plate 2:fig.31-34;;Plate 2:fig.39, fig.52, fig.54-55; Plate 4: fig.57, fig. 67, fig.72; Plate 5:fig.76.**

*Crescentiella morronensis* consists of a cylindrical (tube-like) micritic body with an internal cavity of variable diameter. In thin sections, the cylindrical body and outer contour appear as a dense, dark-colored material composed of dense micrite layers with a concentric structure (Senowbari-Daryan et al., 2008). The internal structure of *Crescentiella morronensis*



may be a foraminifer with amphora-shaped chambers, a cylindrical tube filled with calcite cement, or sometimes containing bioclasts or even dolomite crystals. The length of the foraminiferal chambers varies depending on the nature of the short or long necks of the amphora-shaped chambers. The exact affinity of the cylindrical tube structure remains uncertain (Senowbari-Daryan *et al.*, 2008).

Although this enigmatic organism has been mentioned in several studies, its systematic position remains debated. Flügel (1981) proposed a symbiosis between a nubeculariid foraminifer and a cyanophyte alga, while more recently, Senowbari-Daryan *et al.* (2008) interpreted *Crescentiella morronensis* as an association between cyanobacteria and a nubeculariid foraminifer. The association of *Terebella lapilloides* with *Crescentiella morronensis* was reported by Leinfelder *et al.* (1993b), characterized by a dense peloidal microbial fabric, a significant presence of *Crescentiella morronensis* and *Terebella lapilloides*, and a very rare occurrence of other microencrusting organisms. This type of association was identified in the Guri i Pellumbave section (Plate 2: Fig. 28).

**Biostratigraphic Distribution:** *Crescentiella morronensis* is found in Oxfordian to Barremian deposits, with an acme in the Kimmeridgian–Tithonian (Pleş *et al.*, 2013). It has been identified throughout all the studied sections in the Berriasian-Valanginian deposits.

### *Terebella lapilloides*

#### **Plate 2: fig.28; Plate 4: Fig.73-74**

Annelids that construct agglutinated tubes are generally grouped under the name "Terebella." *Terebella lapilloides* Münster, a species of the genus *Terebella*, is commonly found in Late Jurassic reef environments. In thin sections, the tube exhibits an agglutinated wall, filled with blocky calcite, fine micritic sediment, and peloids. The wall of *Terebella lapilloides* primarily consists of fine carbonate grains. In larger specimens, coarser grains, such as foraminifera and peloids, are also observed as agglutinated material on the tube's wall. Previous descriptions of *Terebella lapilloides* vary: Schorr & Koch (1985) classified it as a microproblematica, while Flügel and Steiger (1981) interpreted it as an agglutinated boring organism. Jansa *et al.* (1972) described it as an allogromid foraminifer, and later, Klieber (1985) identified it as an agglutinated worm. Hammes (1995) reported a preferential association of *Terebella lapilloides* with peloidal crusts and sponge skeletons from Upper Jurassic sponge mud-mounds.

Similarly, Helm and Schülke (2006) described several large arenacean tubes that agglutinated ooids, peloids, foraminifera, and sponge spicules.

**Biostratigraphic distribution:** The age range of *Terebella lapilloides* extends from the Late Triassic to the Early Cretaceous (Berriasian). In our stratigraphic sections, it has been identified in the Berriasian-Valanginian deposits from Guri i Pellumbave and Munella.

***Thaumatoporella parvovesiculifera* Raineri, 1922**

**Plate 1:fig.14; Plate 3:Fig.40-41**

According to Rainer's (1922) original description, *Thaumatoporella parvovesiculifera* is characterized by an irregular cylindrical morphology and perforated walls. Its origin has generally been interpreted as algal, with assignments to green, red, or cyanophycean algae. In some instances, isolated layers of *Thaumatoporella* cells are incorporated into irregular calcimicrobial crusts, indicating a "bacinellid fabric" (Schlagintweit, 2013). In the literature, mixed monostromatic cell layers embedded in bacinellid crusts have been described as *Thaumatoporella*, but true *Thaumatoporella* are ladder- or bridge-shaped structures (Schlagintweit, 2013). Flügel (1983) interpreted *Thaumatoporella parvovesiculifera* as an organism with animal affinities. In our sections, the specimens of *Thaumatoporella parvovesiculifera* resemble bacinellid fabrics, with a single layer formed by a row of cells.

**Biostratigraphic distribution:** In the literature, *Thaumatoporella parvovesiculifera* has been described from the Middle Triassic to the Early Cenozoic (Schlagintweit, 2013). In our study area, it was identified in the Berriasian-Valanginian deposits at Guri i Pellumbave and Kurbneshi.

***Pseudorothpletzella schmidi* n. gen., n. sp. Schlagintweit & Gawlick (2007)**

**Plate 1: fig.8-9.**

*Pseudorothpletzella schmidi* is an encrusting microorganism that exhibits flat or dome-shaped, overlapping layers, with superimposed layers of small tubes that are laterally discontinuous, forming a thin, micritic wall. Schlagintweit & Gawlick (2007) proposed a possible microbial origin for *Pseudorothpletzella schmidi* and noted its similarity to the Paleozoic genus *Rothpletzella*.

**Biostratigraphic Distribution:** The age of *Pseudorothpletzella schmidi*, as reported by Schlagintweit & Gawlick (2007), spans the Middle to Late Jurassic, from the Oxfordian to Late Tithonian–Early Berriasian.

In our stratigraphic sections, it has been identified in the Berriasian-Valanginian deposits at Guri i Pellumbave.

### ***Gemeridella minuta***

#### **Plate 4: fig.63**

This enigmatic organism was first described by Borza and Mišík (1975; 1978) from the Triassic deposits of the Western Carpathians. It was compared with similar organisms, such as *Globochaete alpina* Lombard and *Microcodium*, though it is morphologically distinct from these taxa. Borza and Mišík (1975) described *Gemeridella minuta* as comprising approximately spherical to distinctly polyhedral corpuscles, consisting of wedge-like segments, likely pyramidal in shape. In thin sections, 6–9 mostly triangular segments were observed per corpuscle. These segments were noted to grow around a foreign body and attach themselves to it. Each segment is an optical single crystal, potentially "giant grains" with partially undulating extinction. The segments are composed of clear calcite with rare inclusions of an indefinable pigment. No central cavity was observed within the corpuscles. The diameter of the corpuscles ranges from 47  $\mu\text{m}$  to 1 mm.

**Biostratigraphic Distribution:** The age of *Gemeridella minuta* was initially assigned to the Norian by Borza and Mišík (1975), based on its presence in limestones of the Hallstatt and Dachstein facies. However, it has also been reported from Jurassic–Cretaceous deposits. In our stratigraphic sections, it was identified in the Berriasian-Valanginian deposits of Kurbneshi.

### **Rivulariacean-type cyanobacteria, cyanobacterial structures and cyanobacterial crusts.**

**Plate 1: fig.3-4, fig.7, fig.18-19; Plate 2:fig.30; Plate 3: fig.42-43, fig.45, fig.48-51; Plate 4:fig. 65**

### **Some paleoenvironmental considerations of microbial structures**

The *incertae sedis* organisms play a significant role in paleobathymetric reconstructions. A wide variety of microbial, microencrusting, and microboring structures—such as *Bacinella irregularis*, *Crescentiella morronensis*, *Koskinobulina socialis*, *Radiomura cautica*, *Iberopora bodeuri*, and cyanobacterial structures—have been identified in the Upper Jurassic–Lower Cretaceous deposits of the Mirdita Zone. In some of our sections, particularly at Guri i Pellumbave, coral bioconstructions are

extensively encrusted by microbial, algal, and foraminiferal structures. Most of these encrustations are characteristic of shallow marine environments, primarily reefal settings, with hydrodynamic regimes ranging from intertidal, high-energy environments to protected subtidal, low-energy environments.

*Lithocodium aggregatum*, *Bacinella* (bacinellid structures) and *Koskinobulina socialis* are common in the back-reef facies, but are rare in the shallower reef-marginal facies. *Crescentiella morronensis* occurs both in shallow environments (lagoon, reef) and in deeper environments (sponge reef, slope facies). *Perturbatacrusta leini* and *Radiomura cautica* are found in reef and fore-reef facies. This distribution pattern is consistent with other known carbonate platform patterns of the Tethyan range (Pleš *et al.*, 2013; Kaya and Altıner, 2015).

Thick layers of rudstones with coral-microbial boundstones have been identified in the Guri i Pëlumbave, Mali i Shenjtë, and Kurbnesh sections. Microencruster organisms have played a crucial role in the development and stabilization of Jurassic and Cretaceous coral reefs and are key elements in deciphering and interpreting their depositional environments. The main microencruster organisms identified in our sections include *Crescentiella morronensis*, *Koskinobullina socialis*, *Lithocodium aggregatum*, *Bacinella*-type structures, *Radiomura cautica*, *Coscinophragma* sp., and *Troglotella incrustans*.

The *Lithocodium-Bacinella* association, characteristic of shelf environments, has been documented throughout the northern Tethys and North Atlantic regions, occurring in both lagoonal facies and coral reefs (Leinfelder *et al.*, 1993). Among the microborers that cement the boundstones, *Perturbatacrusta leini* and *Radiomura cautica* are relatively common; however, they are notably absent from coral reefs developed in the northern Tethys (Schlagintweit and Gawlick 2008; 2011).

Typical microencrusters for coral-microbial boundstones, such as *Lithocodium-Bacinella*, *Iberopora bodeuri*, and *Koskinobulina socialis*, are commonly described in Upper Jurassic–Early Cretaceous coral reefs dominated by phototrophic biota. These reefs developed in reef and platform interior (back-reef) environments (e.g., Leinfelder *et al.*, 1993; Dupraz and Strasser 2002). On intra-Tethysian carbonate platforms, *Lithocodium aggregatum* and bacinellid microbial structures were extensively developed in lagoonal settings (e.g., Kaya and Altıner, 2015). A similar distribution pattern is observed in the Štramberg facies (Elias and Eliasová 1984) and, more prominently, in Štramberg-type facies from

Poland, where these microencrusters are characteristic of algal-foraminiferal facies (Bucur *et al.*, 2005).

The species associated with *Koskinobulina socialis* and *Iberopora bodeuri* are characteristic of oligotrophic to mesotrophic conditions in Upper Jurassic coral reefs (Leinfelder *et al.*, 1994; Dupraz and Strasser 2002).

Conversely, the extensive proliferation of *Lithocodium aggregatum* during the Aptian has been attributed, among other factors, to an increased nutrient supply (Immenhauser *et al.*, 2005).

The environmental factors typical of Aptian coral reefs dominated by *Lithocodium aggregatum* and bacinellid microbial structures differ from those of Upper Jurassic coral reefs where *Lithocodium aggregatum* typically occurs as a moderate component (Schlagintweit *et al.*, 2010). Upper Jurassic–Lower Cretaceous coral reefs dominated by microencruster structures were first identified by Schlagintweit and Gawlick (2008) in the Kimmeridgian and Berriasian sedimentary deposits of the Northern Austrian Alps (Plassen Carbonate Platform) and are described for the first time in our sections.

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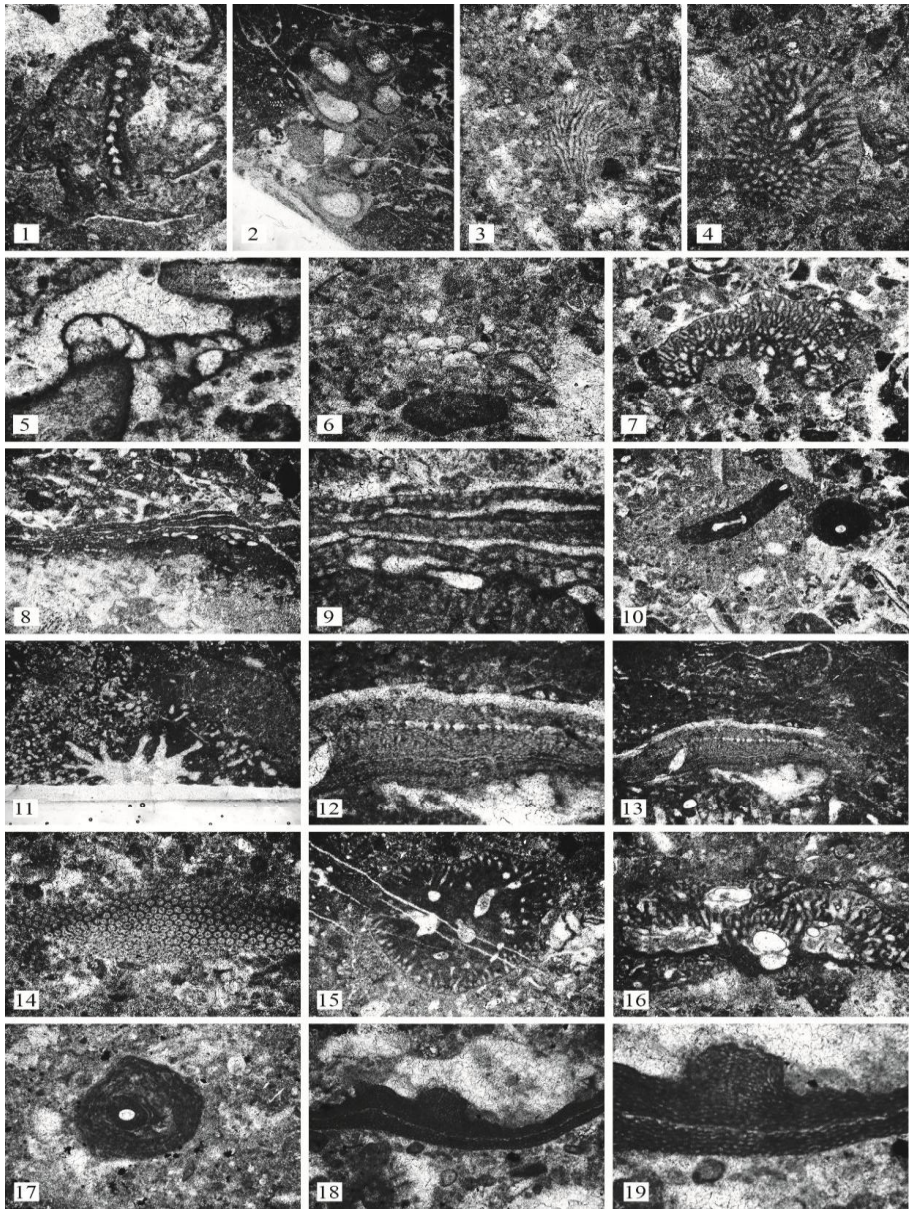
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Plate 1



**Fig. 1:** *Crescentiella morronensis* and *Nodophtalmidium* sp in nucleum, 5x, sample D6, Guri i Pëllumbave.

**Fig. 2:** *Radiomura cautica*, 2.5x, sample D14, Guri i Pëllumbave

**Fig. 3:** *Rivulariacean*-type cyanobacteria, 10x, sample D45, Guri i Pëllumbave

**Fig. 4:** *Rivulariacean*-type cyanobacteria, 10x, kampioni D61, Guri i Pëllumbave

**Fig. 5:** Encrusting foraminifer, 10x, sample D14, Guri i Pëllumbave

**Fig. 6:** *Koskinobulina socialis*, 10x, sample D16, Guri i Pëllumbave

**Fig. 7:** Cyanobacterial structure, 5x, sample D16, Guri i Pëllumbave

**Fig. 8:** *Rothpletzella* core-type, 2.5x, sample D17, Guri i Pëllumbave

**Fig. 9:** *Rothpletzella* core-type, 5x, sample D17, Guri i Pëllumbave

**Fig. 10:** *Crescentiella morronensis*, 5x, sample D17, Guri i Pëllumbave

**Fig. 11:** *Lithocodium-Entobia* type-structure, 2.5x, sample D33, Guri i Pëllumbave

**Fig. 12:** *Iberopora bodeuri*, 10x, sample D34, Guri i Pëllumbave

**Fig. 13:** *Iberopora bodeuri*, 5x, sample D34, Guri i Pëllumbave

**Fig. 14:** *Thaumatoporella parvovesiculifera*, 10x, sample D36, Guri i Pëllumbave

**Fig. 15:** *Lithocodium aggregatum*, 5x, sample D38, Guri i Pëllumbave

**Fig. 16:** *Lithocodium aggregatum*, 5x, sample D37, Guri i Pëllumbave

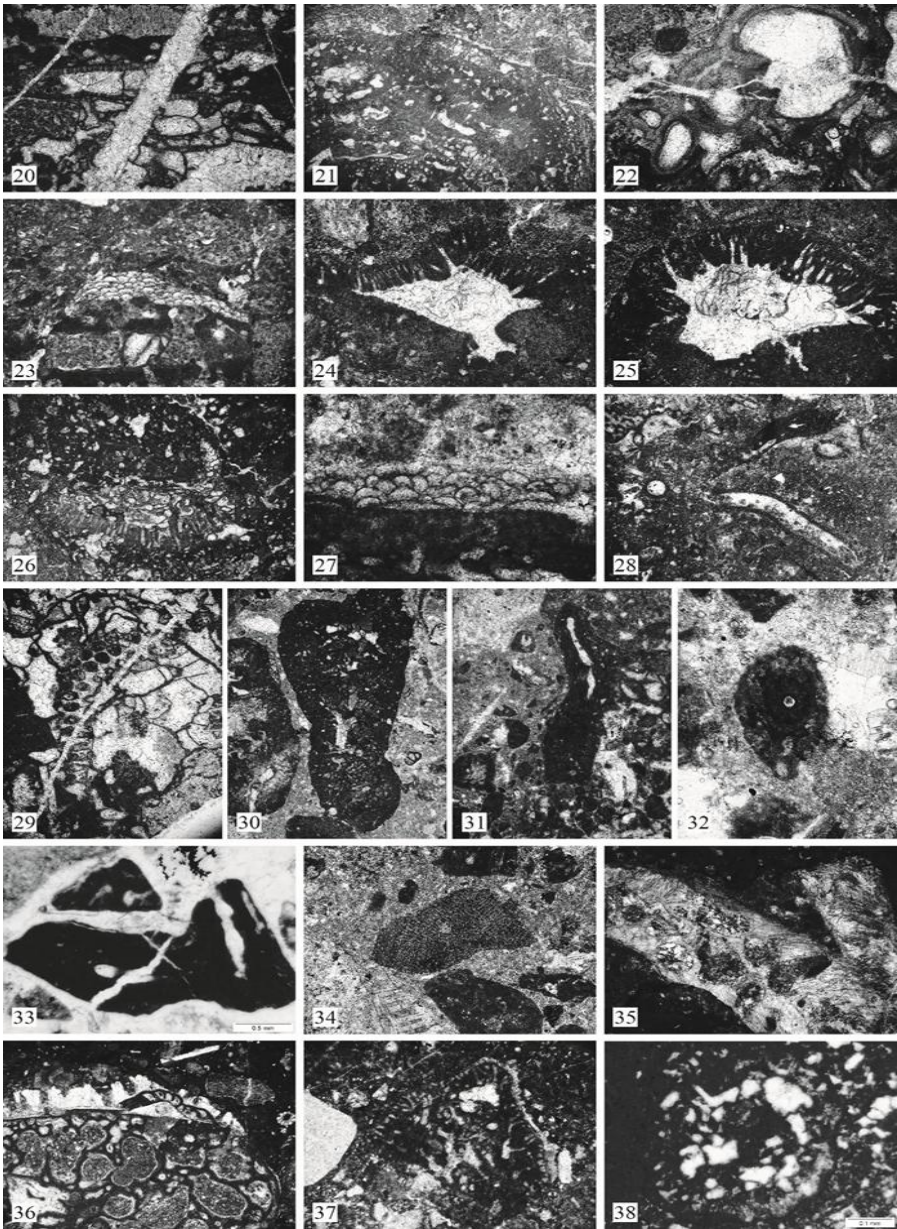
**Fig. 17:** *Crescentiella morronensis*, 10x, sample D38, Guri i Pëllumbave

**Fig. 18:** Cyanobacterial crust, 10x, sample D39, Guri i Pëllumbave

**Fig. 19:** Cyanobacterial crust, 20x, sample D39, Guri i Pëllumbave



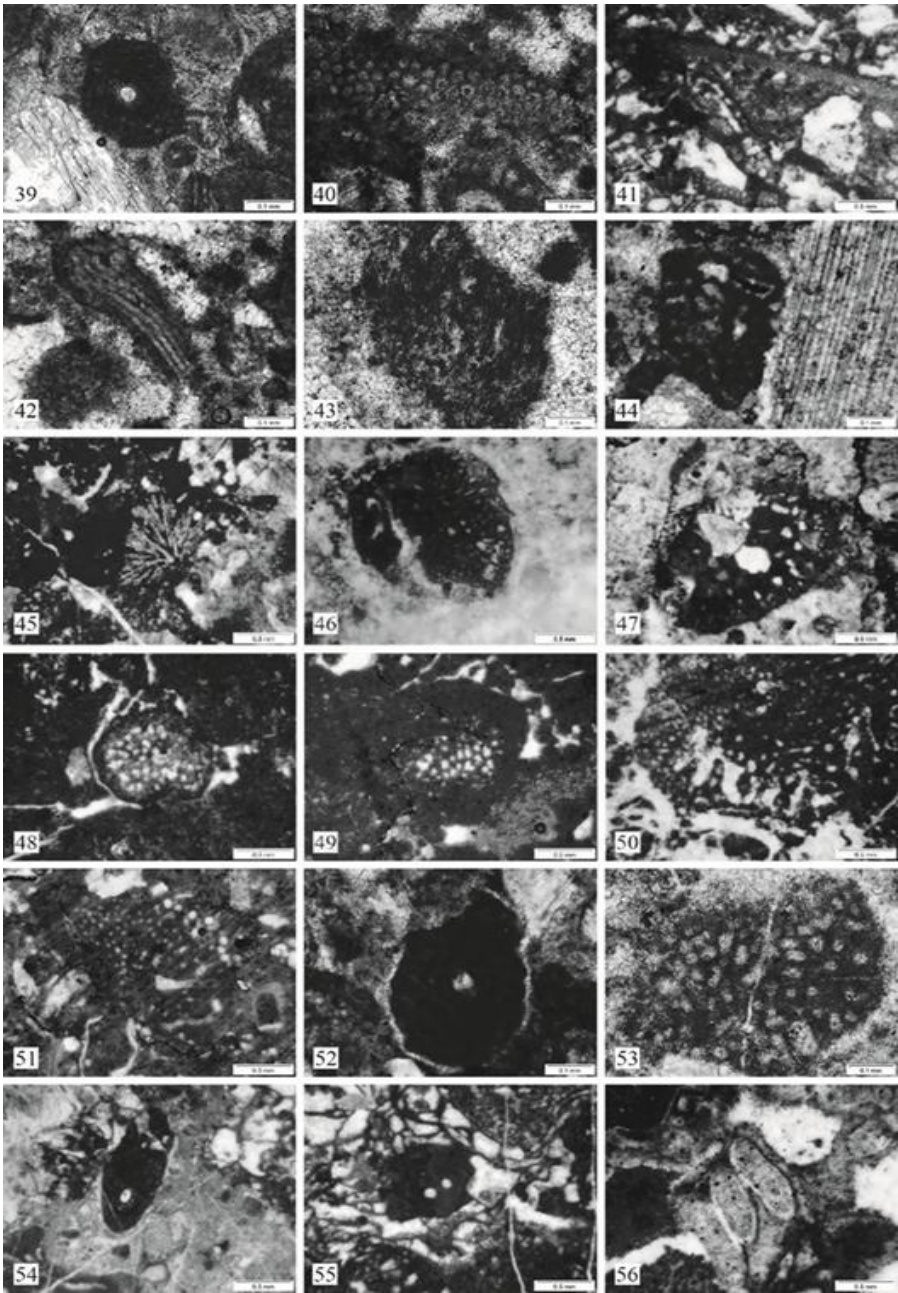
Plate 2





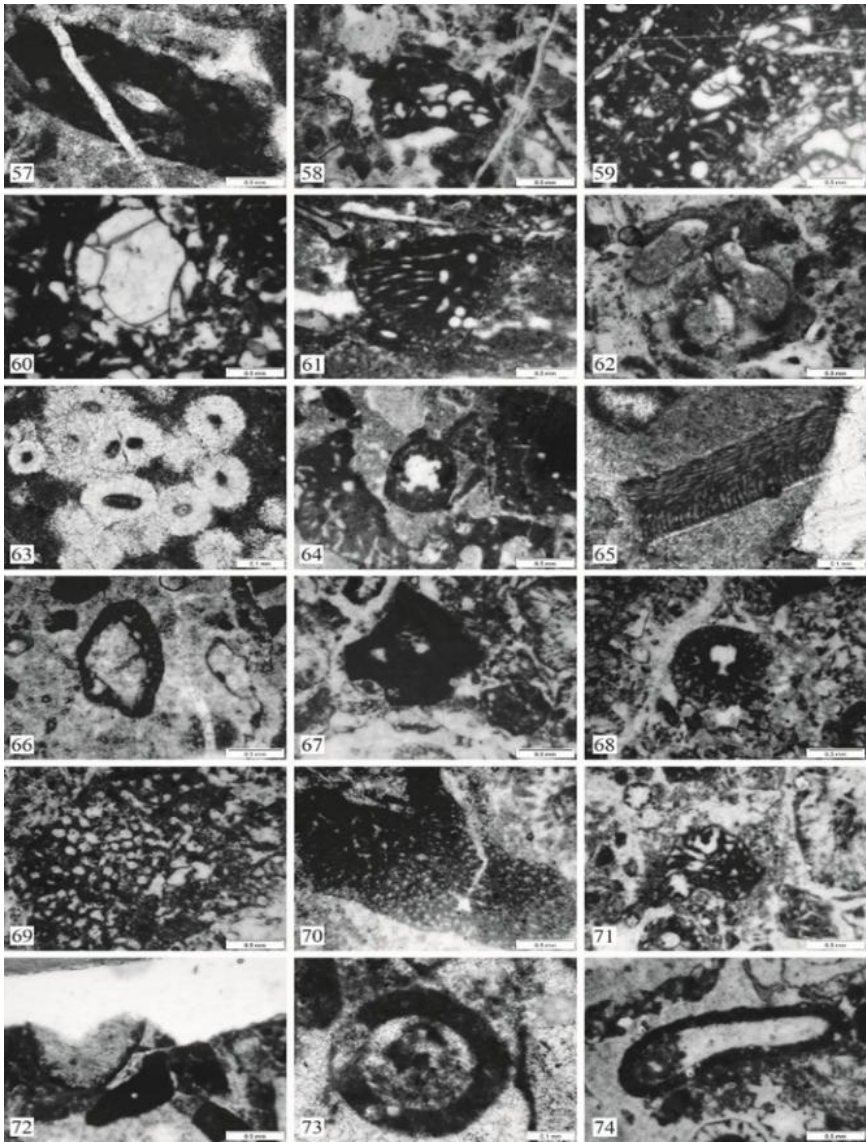
- Fig. 20:** *Bacinella irregularis* and *Thaumaporella parvovesiculifera*, 5x, sample D44, Guri i Pëllumbave.
- Fig. 21:** Bacinellid-type nodule, 2.5x-1zoom, sample D46, Guri i Pëllumbave.
- Fig. 22:** *Radiomura cautica*, 2.5x, sample D60, Guri i Pëllumbave.
- Fig. 23:** *Koskinobulina socialis*, 5x, sample D94, Guri i Pëllumbave.
- Fig. 24:** *Lithocodium aggregatum* and *Entobia* sp, 5x, sample D89, Guri i Pëllumbave.
- Fig. 25:** *Lithocodium aggregatum* and *Entobia* sp, 5x, sample D89, Guri i Pëllumbave.
- Fig. 26:** *Lithocodium aggregatum* and *Troglotella incrustans*, 2.5x, sample D94.
- Fig. 27:** *Koskinobulina socialis*, 10x, sample D101, Guri i Pëllumbave.
- Fig. 28:** *Terebella lapilloides* and *Crescentiella morronensis*, 2.5x, sample D101, Guri i Pëllumbave.
- Fig. 29:** *Bacinella irregularis* and *Steinmanniporella* sp, 5X-1zum, sample Dx, Guri i Pëllumbave.
- Fig. 30:** Cyanobacterial structure, 2.5x, sample M48, Mali i Shenjte.
- Fig. 31:** *Crescentiella morronensis* and *Troglotella incrustans*, 5x, sample S14-1, Mali i Shenjte .
- Fig. 32:** *Crescentiella morronensis*, 5x, sample S14, Mali i Shenjte.
- Fig. 33:** *Crescentiella morronensis*, sample S15, Mali i Shenjte.
- Fig. 34:** *Crescentiella morronensis*, 5x, sample M46, Mali i Shenjte.
- Fig. 35:** *Lithocodium aggregatum*, 5x, sample S13, Mali i Shenjte.
- Fig. 36:** Foraminifera encrusting a sponge, 2.5x, sample S13, Mali i Shenjte.
- Fig. 37:** *Lithocodium aggregatum*, 5x, sample S13, Mali i Shenjte.
- Fig.38:** Bacinellid-type nodule, sample X3, Kurbneshti.

Plate 3



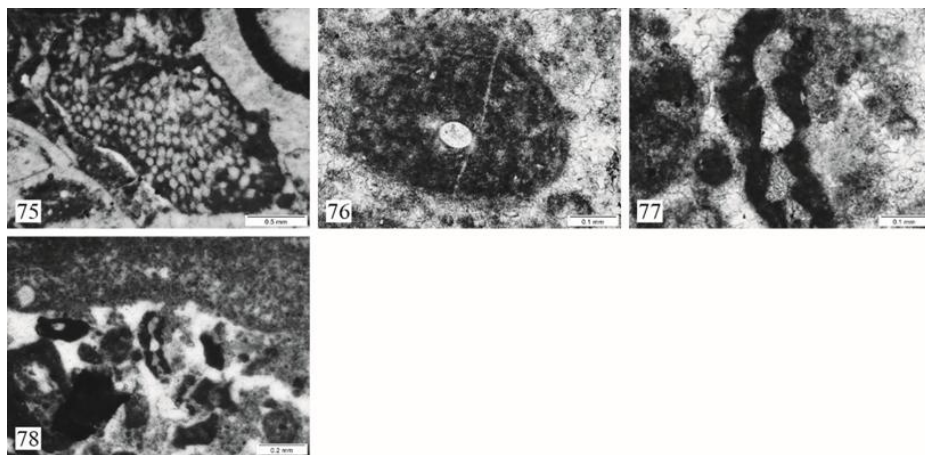
- Fig. 39:** *Creccentiella morronensis*, sample X8, Kurbneshi .
- Fig. 40:** *Thaumatoporella parvovesiculifera*, sample X10, Kurbneshi.
- Fig. 41:** *Thaumatoporella parvovesiculifera*, sample X10, Kurbneshi
- Fig. 50:** *Rivulariacean*-type cyanobacteria, sample Z0, Kurbneshi *Thaumatoporella parvovesiculifera*, sample X10, Kurbneshi.
- Fig. 42:** *Rivulariacean* type cyanobacteria, sample X14, Kurbneshi.
- Fig. 43:** *Rivulariacean*-type cyanobacteria, sample X16, Kurbneshi.
- Fig. 44:** *Lithocodium*-type nodule, sample X17, Kurbneshi.
- Fig. 45:** Cyanobacteria, X35, Kurbneshi.
- Fig. 46:** *Lithocodium*-type nodule, sample Z0, Kurbneshi.
- Fig. 47:** *Lithocodium*-type nodule, sample Z0, Kurbneshi.
- Fig. 48:** *Rivulariacean*-type cyanobacteria, sample Z0, Kurbneshi
- Fig. 49:** *Rivulariacean*
- Fig. 51:** *Rivulariacean*-type cyanobacteria, sample Z4, Kurbneshi
- Fig. 52:** *Creccentiella morronensis*, sample Z4, Kurbneshi.
- Fig. 53:** *Rivulariacean*-type cyanobacteria, sample Z5, Kurbneshi.
- Fig. 54:** *Creccentiella morronensis*, sample Z5, Kurbneshi.
- Fig. 55:** *Creccentiella morronensis* and *Bacinella irregularis*, sample Z5, Kurbneshi.
- Fig. 56:** *Radiomura cautica*, sample Z10, Kurbneshi.

Plate 4



- Fig. 57:** Fig. 57 *Crescentiella morronensis*, sample Z0, Kurbneshi.  
**Fig. 58:** Bacinellid-type nodule, sample Z11, Kurbneshi.  
**Fig. 59:** *Bacinella irregularis* and encrusting foraminifera, sample Z12, Kurbneshi.  
**Fig. 60:** *Bacinella irregularis*, sample Z12, Kurbneshi.  
**Fig. 61:** Nodul te tipit *Lithocodium*, sample Z12, Kurbneshi.  
**Fig. 62:** *Radiomura cautica*, sample Z17, Kurbneshi.  
**Fig. 63:** *Gemeridella minuta*, sample Z37, Kurbneshi.  
**Fig. 64:** *Lithocodium*-type nodule, sample Z56, Kurbneshi.  
**Fig. 65:** *Rivulariacean*-type cyanobacteria, sample Z69, Kurbneshi.  
**Fig. 66:** *Lithocodium*-type nodule, sample MN1, Munella.  
**Fig. 67:** *Crescentiella morronensis*, sample MN11, Munella.  
**Fig. 68:** *Lithocodium*-type nodule, sample MP1, Munella.  
**Fig. 69:** *Tubuliella fluegeli*, sample MP3, Munella.  
**Fig. 70 :** *Tubuliella fluegeli*, sample MP16, Munella.  
**Fig. 71:** *Lithocodium aggregatum*, sample MP16, Munella.  
**Fig. 72:** *Crescentiella morronensis*, sample MP18, Munella.  
**Fig. 73 :** *Terebella lapilloides*, sample MP18, Munella.  
**Fig. 74 :** *Terebella lapilloides*, sample MP19, Munella.

### Plate 5



- Fig. 75:** *Tubuliella fluegeli* sample MP19, Munella  
**Fig. 76:** *Crescentiella morronensis* sample G1, Gur Shpati.  
**Fig. 77:** *Nodophthalmidium* sample G3, Gur Shpati  
**Fig. 78:** *Nodophthalmidium* , sample G3, Gur Shpati