PALEO-DEPOSITIONAL ENVIRONMENTS OF MIRDITA ZONE DURING THE UPPER JURASSIC- LOWER CRETACEOUS

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ABSTRACT

To decipher the paleo-depositional environments and the geodynamic evolution of Mirdita zone during the Upper Jurassic- Lower Cretaceous, as well as timing of the emplacement of the underlying ophiolitic deposits, several areas with different sedimentary patterns were analyzed. These included outer sedimentary facies of Upper Jurassic-Lower Cretaceous (Upper Berriassian-Lower Valanginian) and inner sedimentary facies of the Upper Barremian-Lower Aptian. Detailed analyses were conducted from microfacies and micropaleontological/biostratigraphic perspectives. Based on sedimentological and micropaleontological data, two depositional environments were identified: i) a hemipelagic slope platform environment with calci-turbiditic characteristics that prevailed during Berriassian-Valanginian, and ii) an inner platform environment, which characterized the Upper Baremian-Lower Aptian.

***Keywords*:** Mirdita zone, Upper Jurassic-Lower Cretaceous, Upper Barremian-Lower Aptian, microfauna, ophiolites, geodynamic evolution

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1. INTRODUCTION

A detailed study of the Upper Jurassic-Lower Cretaceous sedimentary deposits of Mirdita zone along with their relationship to the underlying ophiolitic deposits, is of great importance for the regional geology of Albania and, more broadly for the entire Dinarides -Albanides-Hellenides belt. These sedimentary deposits, which extensively overlie the ophiolite deposits, key to reconstructing the geological history of the region. Over time, differing t regional geological interpretations provided by many authors, have underscored the need for in-depth studies that contribute to a more accurate understanding of the geodynamic evolution of this zone. This study addresses the need for new data, particularly of a biostratigraphic, paleoenvironmental, and geodynamic nature. Microfacies analysis and the study of microorganisms—sensitive indicators of the geological age of sedimentary formations and their depositional environments—are central to this work. Accurate identification of microorganisms at the species level, along with categorization into a larger number of taxa, provides a precise biostratigraphic framework for the Mirdita Zone. Such detailed analysis enables age determinations of these formations down to the stage and sub-stage levels. To obtain comprehensive insights into the depositional environments and geodynamic evolution, we integrated micropaleontology with microfacies analysis. This approach has yielded a deeper understanding of the nature of these carbonate deposits, their relationship to the overlying ophiolites, and, most importantly, the timing of the deposition of these ophiolitic formations.

In this study, the vertical and lateral depositional variations of these sedimentary deposits were analyzed with the aim of reconstructing the geodynamic conditions of the region. Paleoecological analyses of macro- and microfauna were also employed to refine the understanding of depositional environments.

To achieve these objectives, several stratigraphic sections were examined along a transect extending from Rahovec, Kosovo, to Shtyllë, Albania (Figure 1).

Geological background of Mirdita zone during Jurassic-Cretaceous

The Mirdita tectonic zone is widely spread in Albania. The ophiolites, which are the main components of this area, represent remnants of the

Mirdita oceanic basin that developed during the Middle Triassic to Middle Jurassic. The orogen evolved through continued convergence between Adria and Europe, beginning with the Late Jurassic emplacement of the West Vardar and Mirdita ophiolites onto the northeastern Adriatic rifted margin. This was followed by thrust-sheet emplacement throughout the Cretaceous and Cenozoic and culminated in the collision along the Sava suture during the Paleocene (van Hinsbergen *et al*., 2019; Schmid *et al*., 2020). The closure of the Mirdita oceanic basin occurred between the end of the Middle Jurassic and the beginning of the Late Jurassic (Xhomo *et al*., 2002, 2005). The Middle–Upper Jurassic and Jurassic–Cretaceous sedimentary deposits that overlie the ophiolites, as well as the continental formations surrounding them, have been extensively studied by many authors (see, for example, Prela, 1996, 2000; Shehu *et al*., 1990; Meço and Aliaj 2000; Xhomo *et al*., 2002; Marku, 1999, 2000, 2002). 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. This sedimentary cover includes the "Kaluri" radiolarian chert of Middle Jurassic age, mélange blocks in the "Simoni" matrix, 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 "Firza flysch" (Bortolotti et al., 1996). 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 has been determined as Upper Tithonian–Valanginian, based on numerous calpionellids and other microfaunal evidence (Melo *et al*., 1971; Gjata *et al*., 1989; Peza *et al*., 1981, 1983,1988 1989, 2002; Xhomo *et al*., 2002, 2005, among others). In central and eastern 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 "Kaluri" radiolarian chert of Middle Jurassic age, mélange blocks in the "Simoni" matrix, and Callovian–Lower Oxfordian ophiolitic breccia and conglobreccia. In many cases, these Jurassic–Cretaceous deposits are overlain by substantial carbonate Cretaceous deposits. At the regional level, the Jurassic–Cretaceous and Cretaceous deposits display a consistent structural framework. An essential distinction between the Jurassic–Cretaceous deposits in western Mirdita and those in central and eastern Mirdita is the variation in lithology. In western Mirdita, the deposits are predominantly composed of clayey-sandy-marly flysch (Firza). In contrast, central and eastern Mirdita also contain molasse deposits, which include shallow-water carbonate deposits and, rarely, conglomerates. These shallow-water limestones within the flysch deposits were first identified in the Bisak region by Melo et al. (1971) and Dodona *et al*. (1975). Gawlick et al. have also documented similar deposits southwest of Munella. Uta (2018) determined the Berriasian–Valanginian age of the Guri i Pellumbave limestones, confirming the same age for the base of the Mali i Shenjtë platform (Uta, 2019).

2. MATERIAL AND METHODS

In the field works, the selected stratigraphic sections were examined and interpreted in relation to their lithology, microfacies and faunal content with a hand lens and during 12 sections and 556 samples were collected. During the laboratory studies, detailed micropaleontological and microfacies analyzes were performed and For these analyses, 556 samples were prepared in the Petrology and Thin Sections Laboratory of FGJM. Micropaleontological analyzes were made by investigating the morphology of the specimens (mainly foraminifera, calcareous algae, microbial organisms and calpionellids) and individuals belonging to each species were photographed and classified according to the taxonomic hierarchy. Then the identification and classification of foraminifera and other organisms was done, using their stratigraphic distributions. Microfacies analyzes involve examination of sample based on their textural properties, (ie abundance and types of allochems and background material). Several types of microfacies have been defined and photographed to show their typical features. Vertical changes in microfacies type and micropaleontological content have been used in the interpretation of the evolution of the carbonate deposits of geological Mirdita zone.

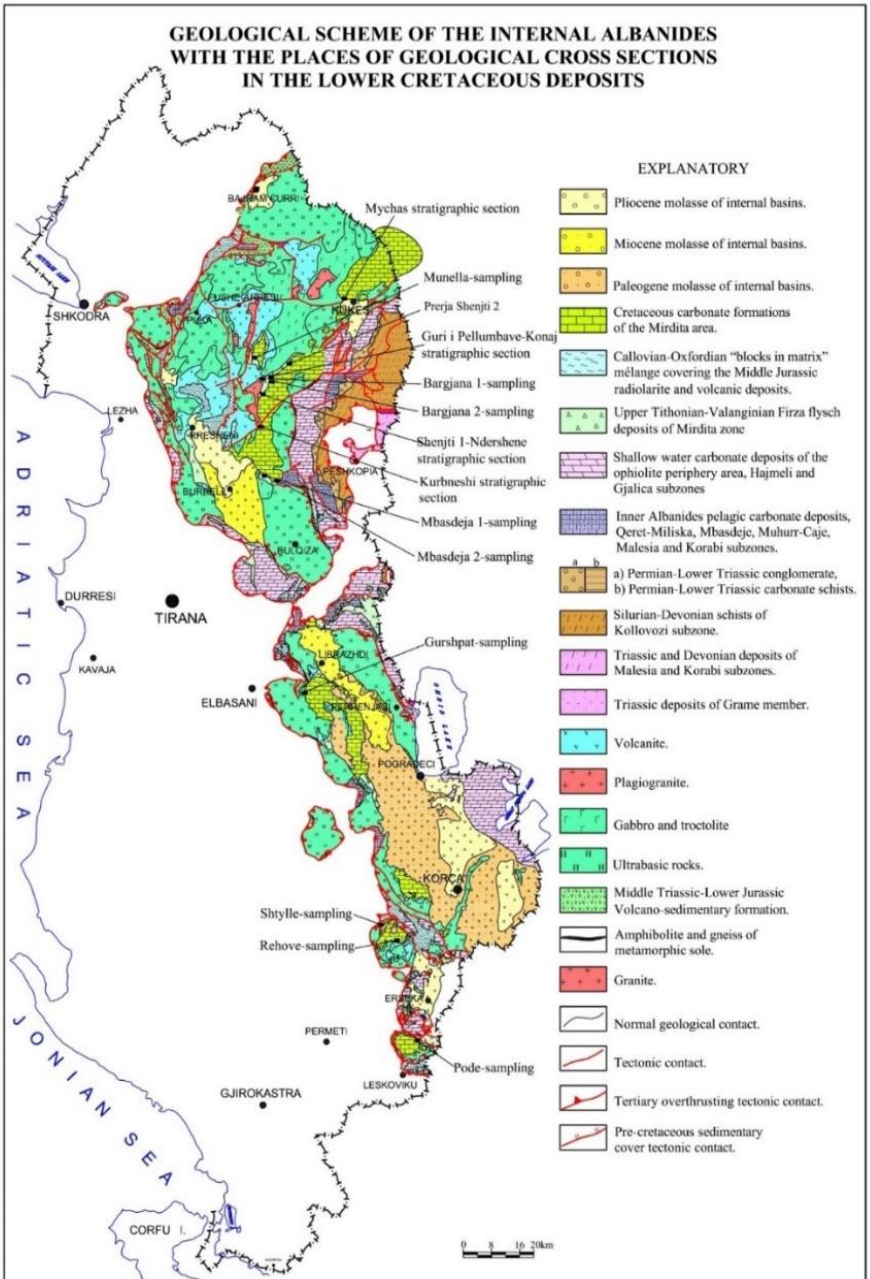

Fig. 1: Geological map of inner Albanides and the performed stratigraphic sections.

Geological Background

Guri i Pëllumbave Section

The Guri i Pëllumbave section consists of ophiolitic formations and their overlying deposits (Figure 2). The ophiolitic formations represent an oceanic crust sequence, with gabbros at the base and andesites capped by dacite-rhyolite dykes at the top. The deposits covering the ophiolites include: i) Limited strips of “blocks in matrix” mélange, overlying the volcanic rocks, with an assigned age of Upper Callovian–Lower Oxfordian (Xhomo et al., 2002; Aliaj and Kodra, 2016) and, ii) "Firza" flysch deposits above the andesites with dacite-rhyolite dykes. These deposits comprise: a) Sandy-clayey-marly horizons of Berriasian age, b) A thin horizon of Berriasian platy limestones, c) A shallow-water horizon and slope deposits of Upper Berriasian–Lower Valanginian age in the Guri i Pëllumbave section and, d) Conglomerates and clayey-sandy-marly flysch deposits of Valanginian–?Hauterivian age.

Melo (1971) and Meço (1975), using ammonites and calpionellids, assigned the Berriasian age to the horizons below the Guri i Pëllumbave limestones. Based on these studies, we propose that the andesites with dacite-rhyolite dykes, located between the two lower flysch horizons, do not represent Berriasian volcanic activity or olistoliths within the flysch. Instead, we interpret these volcanic rocks as the basement of the Berriasian flysch deposits, repeated in the section due to Berriasian synsedimentary tectonics. This study focuses exclusively on the shallow-water carbonate horizon of the Guri i Pëllumbave section and does not address the other sedimentary sequences. These deposits form a horizon several kilometers long, with an average thickness of 50–70 meters. In the northeastern part of the section, these deposits overlie the volcanic rocks and “blocks in matrix” mélange, while in the southwestern part, they stratigraphically lie above the flysch horizon and the Berriasian platy limestone.

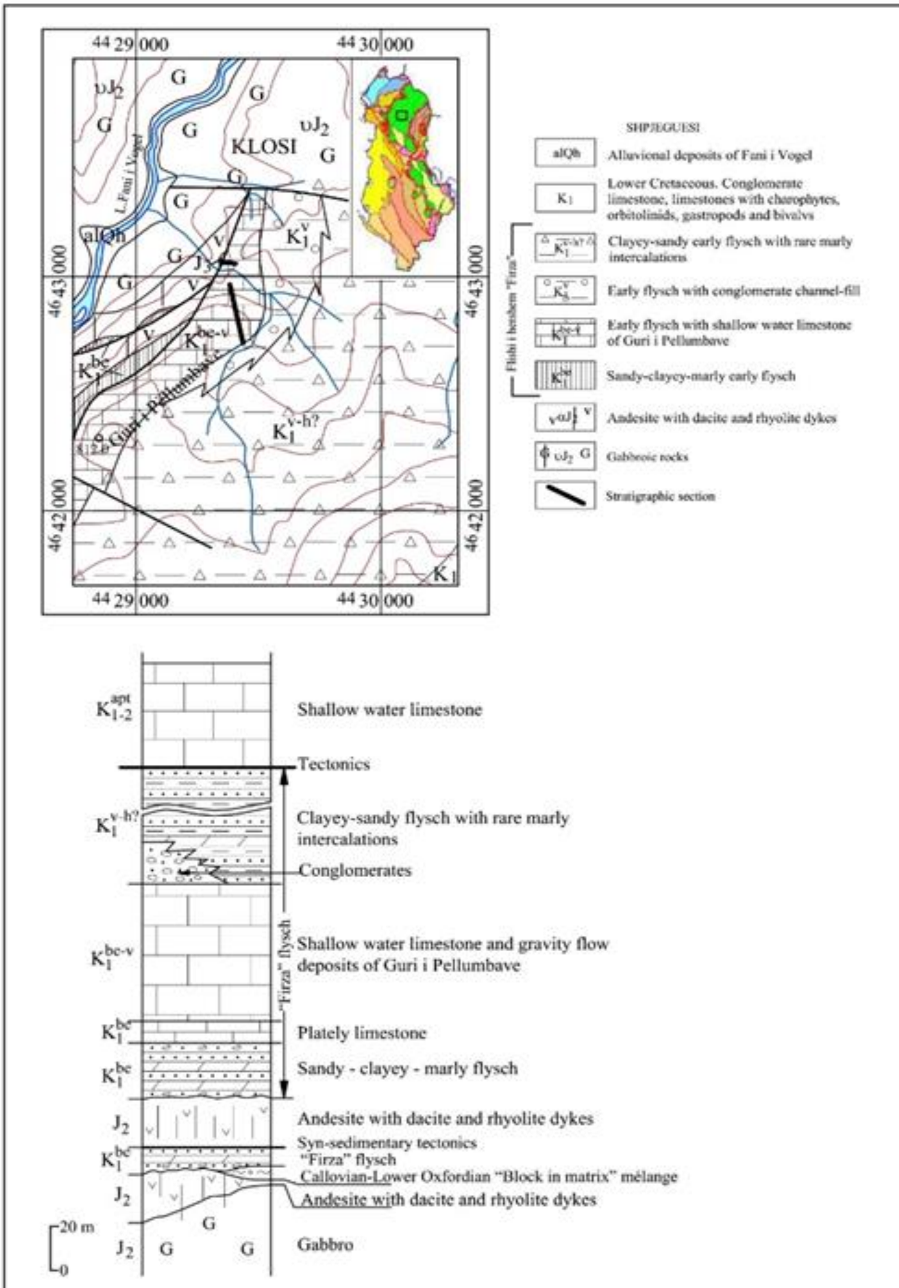

Fig.2: Geological map and stratigraphic column of Guri i Pëllumbave section (1: 25 000).

In the Guri i Pëllumbave stratigraphic section, the following microfacies were identified: peloidal bioclastic packstone-grainstone, packstone-rudstone, bioclastic grainstone, bioclastic peloidal packstone-grainstone, rudstone, packstone-rudstone, bioclastic rudstone-boundstone, bindstone, and microbialites. Together with their associated microfaunal assemblages, these microfacies allow for the interpretation of the entire succession as slope deposits.

Based on the identified micropaleontological assemblages, the studied deposits were assigned to the Upper Berriasian–Lower Valanginian (?Hauterivian). This interpretation considers the following biostratigraphically significant associations:*Pseudocyclammina lituus, Protopeneroplis ultragranulata, Mohlerina basiliensis, Coscinoconus alpinus*, and *Coscinoconus elongatus*—forms that are typical of the Upper Jurassic but are also frequently observed in the lower part of the Lower Cretaceous. *Gaudryina ectypa*, which is widely distributed within the Lower Cretaceous (Berriasian–Albian). The most definitive species supporting the age assignment are: *Haplophragmoides joukowskyi, Montsalevia salevensis, Coscinoconus cherchiae, Coscinoconus delphinensis, Neotrocholina valdensis*, and *Protopeneroplis banatica*, which are exclusively Berriasian–Valanginian species.

Regional paleogeographic considerations.

Numerous studies over the years have demonstrated the regional context during the Jurassic–Cretaceous period, highlighting the existence of a deep basin where the “Firza” flysch was deposited (Xhomo, 2002). In the central part of the Mirdita zone, and more rarely in its eastern part, sectors existed that were occupied by shallow-water carbonate deposits during the Berriasian and Valanginian (Meço, 1975; Peza, 1983; Schlagintweit, 2006, among others). In the Guri i Pëllumbave section, as well as in the Krejë Lura region, calpionellids have been identified within these shallow-water carbonate deposits. Specifically, the *Calpionellopsis* biozone of Berriasian age and the *Calpionellites darderi* biozone of Lower Valanginian age have been documented (Peza *et al*., 1983).

Considering all the microfacies and microfaunal associations described above, along with the geological context, the Guri i Pëllumbave section can be interpreted as an isolated "haut fond" type platform. On this platform, bioclasts of shallow-water origin were transported and redeposited by turbidic currents, mixing with typical deep-water biota represented by calpionellids. Based on the foraminifera and calpionellids, the age of this section is assigned to the Upper Berriasian–Lower Valanginian.

The Mali i Shejnte stratigraphic section

This stratigraphic section was studied on Mali i Shenjte mountain, north of Shelbum, along the edge of the motorway, near the village of Nenshejt. In contrast to the typical geological conditions observed in the region, where Cretaceous deposits transgressively overlie the Upper Titonian–Valanginian *Firza* flysch deposits, the Shenjti1 section belongs to the lower part of the Mali i Shenjte carbonate platform. This section is characterized by the absence of significant tectonic faults that could have affected the normal sedimentary succession (Figures 3 and 3-1).

The entire section was divided into three parts: a basal part, a middle part, and an upper part. During field trips conducted between 2015 and 2016, approximately 130 samples were collected for microfacies and micropaleontological analysis.

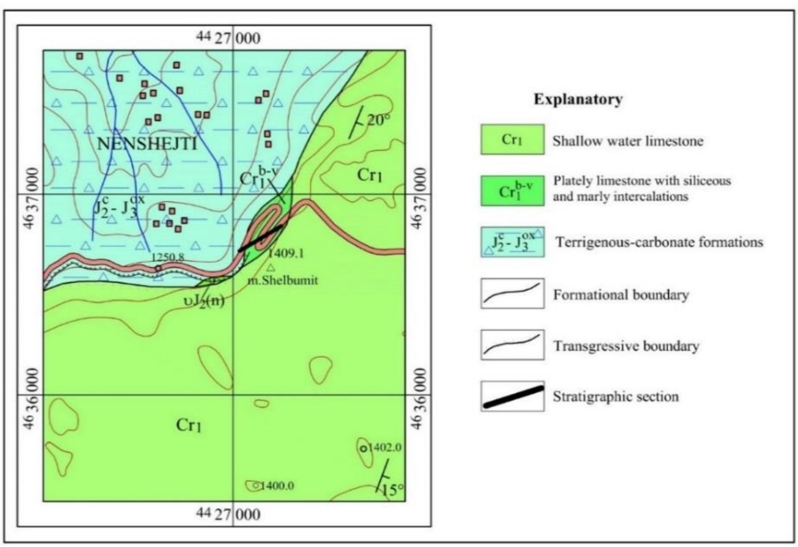

Fig. 3: Gjeological map o Mali i Shenjte (modified after Xhomo *et al* 2005).

After analyzing the thin sections of these samples, we identified the typical microfacies and their associated micropaleontological assemblages, including groups such as benthic foraminifera, calcareous algae, incertae sedis, calpionellids, and calciphers.

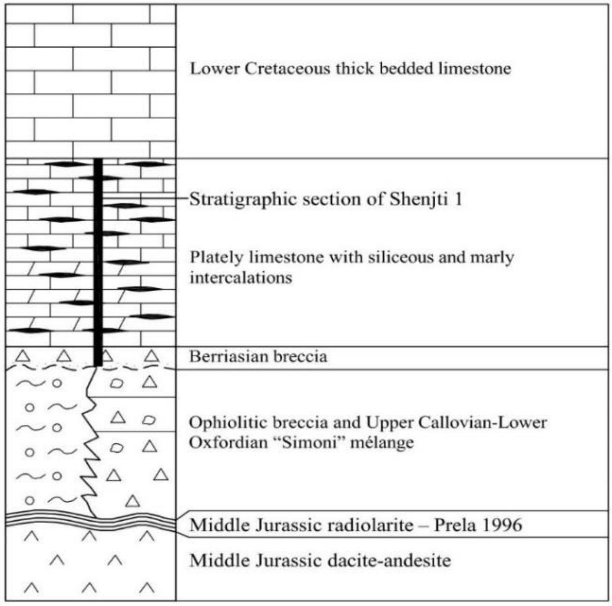

Fig. 3-1: Stratigraphic column of Nenshenjtit.

The basal part of the section consists of a limited sequence of conglomerates, primarily containing ophiolitic material (fragments of basalts, gabbros, microgabbros, etc.). The middle part is characterized by relatively deep carbonate facies with siliceous lenses and marly intercalations. The upper part of the section exhibits a normal, gradual transition to shallow-water limestone.

The Mali i Shenjte section begins with conglomerate layers containing ophiolitic material (fragments of basalts, gabbros, microgabbros, etc.) and carbonate material within a fine matrix (silt and sand-sized), giving the appearance of a polymictic conglomerate. The poorly sorted clasts range in shape from angular to nearly rounded, with sizes ranging from pebbles to cobbles. Within the matrix and in the carbonate fragments, the following biota were identified: *Crescentiella morronensis*, *Bacinella irregularis*, *Lithocodium* sp., *Lenticulina* sp., and fragments of calcareous algae, corals, echinoderms, and bryozoans. The succession continues with several layers of conglomerates containing microbialite crusts and coral bioconstructions, accompanied by sponges and stromatoporoids. The identified biota includes microproblematica such as *Crescentiella morronensis*, *Bacinella irregularis*, *Lithocodium aggregatum*, and

Radiomura cautica, as well as foraminifera including *Lenticulina* sp., *Protopeneroplis ultragranulata*, *Coscinoconus* sp., *Pseudocyclammina* sp., alongside fragments of algae, corals, bryozoans, echinoderms, and also extraclasts.

These conglomerates can be interpreted as slope breccias due to their significant content of eroded reef material and fragments of organisms that lived in reef and foreslope environments. Based on the identified intraclasts and bioclasts, it can be inferred that they were formed on the slope of the carbonate shelf or at the base of the slope.

The middle part of the section is characterized by medium-bedded gray limestones, representing a relatively deep facies. These limestones contain siliceous lenses, marly intercalations, and small ammonites. The upper part of the section is represented by shallow-water limestones of white color.

The microfaunal associations identified in the Mali i Shenjte stratigraphic section have enabled clear biozonations using benthic taxa, such as foraminifera, calcareous algae, and microbial organisms, as well as pelagic organisms like calpionellids and calciphers. These biozonations, combined with microfacies data, provide a valuable tool for correlating deep-marine deposits with shallow-marine deposits and for reconstructing the carbonate platform architecture. It is well known that taxa found in slope environments, which are also present in shallow-platform environments, such as *Protopeneroplis ultragranulata*, *Coscinophragma* sp., *Coscinoconus* sp., *Neotrocholina* sp., and *Crescentiella morronensis*, are crucial for reconstructing Upper Jurassic–Lower Cretaceous carbonate platforms

Based on the micropaleontological associations identified in the Mali i Shenjte stratigraphic section, the age of the studied deposits is assigned to Upper Berriasian–Lower Valanginian, with the possibility that the upper part of the section may correspond to Upper Valanginian–? Hauterivian. The most important biostratigraphic taxa include *Pseudocyclammina lituus*, *Protopeneroplis ultragranulata*, *Mohlerina basiliensis*, *Coscinoconus cherchiae*, and *Coscinoconus elongatus*, which are typical Upper Jurassic taxa, though they are also found in the Lower Cretaceous. According to BouDhager-Fadel (2008), the large benthic foraminifera that survived the Jurassic–Cretaceous boundary were mainly forms with strong, large tests, such as *Pseudocyclammina* and *Everticyclamina*. The forms described in our stratigraphic section demonstrate that these taxa can still be found in the Berriasian–Valanginian shallow-water environments (Banner and Whittaker, 1991).

Kurbneshi stratigraphic section

In the Kurbnesh section (Figure 4), the sedimentary deposits consist of a mixture of pelagic limestones and allodapic limestones, containing a small amount of ophiolitic detritus. The allodapic limestones are primarily composed of lithoclasts and bioclasts derived from a fully eroded carbonate platform, where the Upper Jurassic-aged reef components are mainly represented by stromatoporoids, sponges, corals, the Bacinella/Lithocodium consortium, and various microproblematica within a hemipelagic matrix. Among these components, reefal boundstones with abundant microbial structures, stromatoporoids, sponges, corals, and bindstones with *Bacinella*/*Lithocodium* are characteristic. The most frequently encountered microbial structures include *Radiomura cautica* Senowbari-Daryan & Schäfer, *Koskinobulina socialis* Cherchi & Schroeder, and *Crescentiella morronensis* Crescenti, along with benthic foraminifera, calcareous algae, and calpionellids. These taxa indicate an Upper Berriasian–Lower Valanginian age for this section, consistent with the biostratigraphically important foraminifera, algae, and calpionellids identified in the previously described stratigraphic sections of Guri i Pëllumbave and Mali i Shenjte.

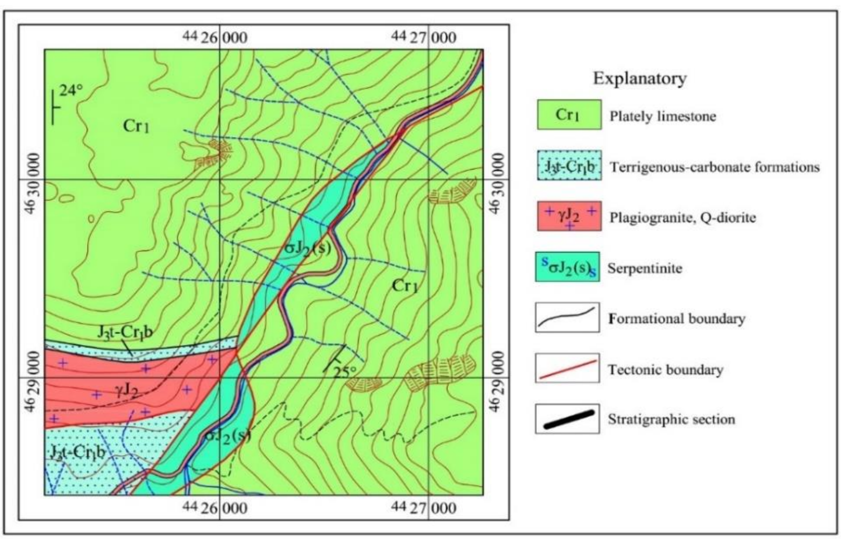

Fig. 4: Geology of the Kurbnesh region (according to Xhomo *et al*., 2005 with modifications and changes).

In the Kurbnesh section (Figure 4), the sedimentary deposits consist of a mixture of pelagic limestones and allodapic limestones, containing a small amount of ophiolitic detritus. The allodapic limestones are primarily composed of lithoclasts and bioclasts derived from a fully eroded carbonate platform, where the Upper Jurassic-aged reef components are mainly represented by stromatoporoids, sponges, corals, the Bacinella/Lithocodium consortium, and various microproblematica within a hemipelagic matrix. Among these components, reefal boundstones with abundant microbial structures, stromatoporoids, sponges, corals, and bindstones with *Bacinella*/*Lithocodium* are characteristic. The most frequently encountered microbial structures include *Radiomura cautica* Senowbari-Daryan & Schäfer, *Koskinobulina socialis* Cherchi & Schroeder, and *Crescentiella morronensis* Crescenti, along with benthic foraminifera, calcareous algae, and calpionellids. These taxa indicate an Upper Berriasian–Lower Valanginian age for this section, consistent with the biostratigraphically important foraminifera, algae, and calpionellids identified in the previously described stratigraphic sections of Guri i Pëllumbave and Mali i Shenjte.

Munella stratigraphic section

We are only dealing with a short interval from the lower part of the magnificent carbonate massif of Munella (Figure 5 and 5-1). The sampling aimed to determine whether these shallow-water limestones belong to the Barremian-Aptian. However, after analyzing the microfaunistic content, it was determined that this lower level of the Munella carbonate platform corresponds to the Upper Berriasian-Valanginian, similar to the basal level described in the Mali i Shenjte. The clasts are typical of platform slope deposits and contain reefal facies with corals and stromatoporoids, along with encrusting foraminifera such as *Subbdelloidina? Luterbacheri* (Riegraf, Schlagintweit et al., 2006), boundstones with *Bacinella irregularis*, and fragments of *Coptocampylodon* (Schlagintweit et al., 2008).

The microfacies are typically represented by dolomitized rudstones, rudstone-packstones, or boundstones that are significantly dolomitized. These contain fragments of corals, brachiopods, and a microfauna predominantly made up of calcareous algae, including *Supilliulumaella sp.*, *Salpingoporella pygmaea*, *Salpingoporella praturloni*, *Comptocamphylodon fontis*, *Nipponophicus ramosus*, *Bakalovaella elitzae* (Bakalova), *Macroporella praturloni*, *Zujovicella gocanini*, *Neomeris sp.*, *Steinmanniporella sp.*, and benthic foraminifera such as *Nautiloculina broennimani*, *Charentia cuvillieri*, *Gaudryina ectypa*, *Protopeneroplis ultragranulata*, *Pfenderina neocomienis*, *Pseudocyclammina lituus*, *Coscinoconus alpinus*. Additionally, microencrusters like *Crescentiella morronensis*, *Lithocodium aggregatum*, and *Tubuliella fluegeli* are also present.

The age of this section is Upper Berriasian–Lower Valanginian, as indicated by the presence of numerous calcareous algae, which suggest more internal environments. Additionally, most of the taxa, including those of biostratigraphic significance, were also identified in the stratigraphic sections of Guri i Pëllumbave, Mali i Shenjte, Kurbnesh, and Gur Shpati. Our data highlight the need for more detailed geological mapping, along with the densification of stratigraphic sections, to better resolve the intriguing question of the Jurassic and Cretaceous age of the Munella massif.

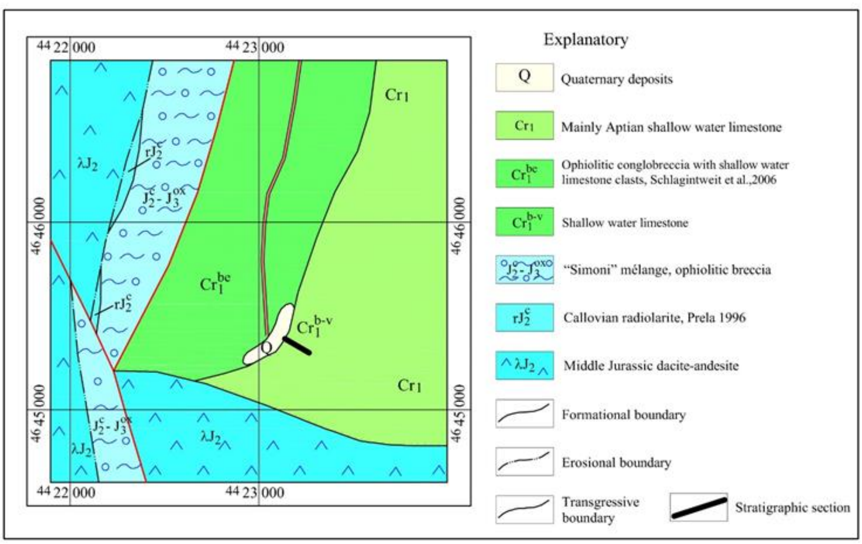

Fig.5: Geological map of Munella (modified after Xhomo *et al*. 2005).

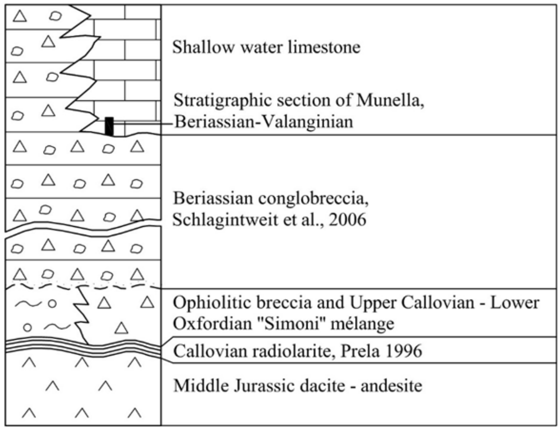

Fig. 5-1: Stratigraphic column of western Munella.

Guri i Shpatit stratigraphic section

In Guri i Shpatit stratigraphic section, the ultrabasic formations are in contact with limited outcrops of basalts accompanied by red siliceous cherts and covered by a large thick sequence of conglomerates covered by shallow water limestones of Lower Cretaceous. From this outcrop of highly deformed limestones with numerous calcite veins, 23 samples were taken at the base of the conglomerates (Figure 6 and 6-1).

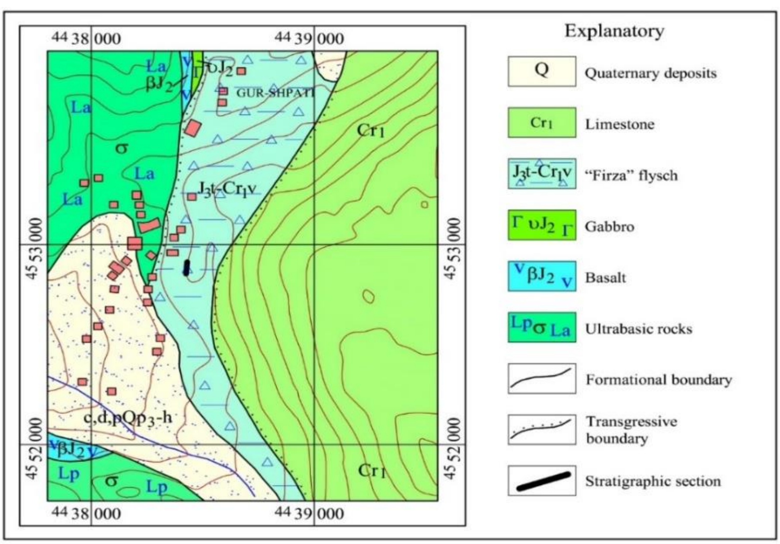

Fig.6: Guri i Shpatit geological map (modified after Xhomo et al. 2005).

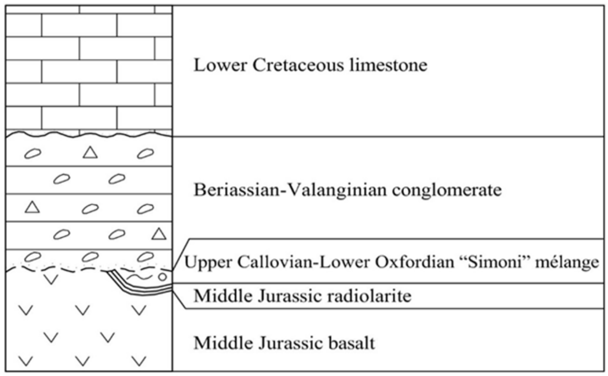

Fig. 6-1: Stratigraphic column of Guri i Shpatit.

Due to the poor condition of the limestones, only a limited number of microfacies have been identified, such as packstone-rudstone and peloidal bioclastic packstone-grainstone. Additionally, within the conglomerates, bioclasts of various biological and depositional origins have been observed, including calpionellids, which are commonly found in platform and basin slope facies. The carbonate clasts originating from platform deposits contain a micropaleontological assemblage that includes calcareous algae, benthic foraminifera, rare coral fragments, and microencrusters such as *Crescentiella morronensis*, serpulids like *Terebella lapilloides*, *Nodophthalmidium sp.*, calcareous algae such as *Terquemella sp.*, *Salpingoporella pygmaea*, *Gaudryna ectypa*, *Pseudocyclammina lituus*, *Coscinoconus delphinensis*, *Coscinoconus sp.*, *Everticyclamina sp.*, and calpionellids like *Calpionella elliptica*, *Calpionellites darderi*, *Crassicollaria sp.*, as well as calcispheres such as *Colomosphaera sp.*. Fragments of ophiolites are also present.

The age of these conglomeratic limestones was assigned as Upper Beriasian-Lower Valanginian, based on the microfaunistic associations that include taxa of biostratigraphic importance such as *Pseudocyclammina lituus*, *Coscinoconus delphinensis*, *Gaudryna ectypa*, *where Calpionella eliptica* is a typical Beriasian form, while *Calpionellites darderi* is a typical form for Valanginian.

3. DISCUSSIONS

The analysis of the carbonate deposits covering the ophiolites, particularly from biostratigraphic, microfacies, and paleoenvironmental perspectives, provides essential data for understanding their depositional history and the reconstruction of their geological evolution following the emplacement of these deposits

The identification of key genera and species of benthic foraminifera, calcareous algae, microbial organisms, and calpionellids typical of the Upper Berriasian-Lower Valanginian age in the Mirdita zone provides a basis for reasonable correlations with other Mediterranean localities, where benthic biozones are calibrated using ammonites and planktonic foraminifera schemes. The distribution of benthic fauna, particularly benthic foraminifera, calcareous algae, and microbial organisms, is strongly influenced by local ecological conditions. Foraminifera are particularly valuable biostratigraphic tools because of their rapid evolution, abundance, wide distribution, and the often-sudden disappearance of species or groups (Hallock, 1982). As a result, many species are useful for local or even regional correlations, which is the case for the platform carbonate deposits of the Mirdita zone.The microfaunal associations described in the stratigraphic sections of Guri i Pëllumbave, Mali i Shenjte, Kurbneshi, Munella, and Gur Shpati have facilitated the development of a biozonal schema composed of benthic taxa (such as foraminifera, calcareous algae, and microbial organisms), along with pelagic microorganisms like calpionellids and calcispheres. This zoning, combined with microfacies data, enables the correlation of deep marine deposits with shallow marine ones and aids in reconstructing the architecture of the carbonate platform. Microfossils found in both slope and shallow platform environments, such as *Protopeneroplis ultragranulata*, *Coscinophragma* sp., *Coscinoconus* sp., *Neotrocholina* sp., and *Crescentiella morronensis*, are important faunal markers for reconstructing Upper Jurassic-Lower Cretaceous carbonate platforms. Based on the micropaleontological associations identified in the aforementioned stratigraphic sections, the studied deposits are assigned to the Upper Berriasian-Lower Valanginian age, with a possible Upper Valanginian-Hauterivian age for the upper part of the Mali i Shenjte section. This is supported by the presence of *Stomiosphaera echinata* in sample S3, which is more representative of an Upper Valanginian-Lower Hauterivian age (Reháková, 2000a), with a biostratigraphic range extending into the Aptian. The presence of taxa such as *Montsalevia salevensis*, *Neotrocholina valdensis*, *Protopeneroplis ultragranulata*, and *Haplophragmoides joukowskyi* in the lower part of the section reinforces the Upper Berriasian-Lower Valanginian age.

In Kurbneshi zone, the the sedimentary deposits are interpreted as carbonate rocks deposited at the base of the platform slope, as they consist of resedimented lithoclasts and typical shallow-water organisms mixed with finer pelagic sediments showing platform progradation. The largest lithoclasts consist of peloidal packstone-grainstone as well as boundstones with *Bacinella irregularis*. The abundant occurrence of *Crescentiella morronenis* and its association with microbial carbonates and serpullids such as *Terebella lapilloides* are interpreted as allochthonous carbonate clasts exported from sheltered, deep, outer-slope and/or upper continental slope where rare small fragments of calcareous alga *Clypeina sulcata* are talking about the existence of a previous Upper Jurassic carbonate platform completely eroded. Bioclasts typical of shallow platform environments are represented by benthic foraminifera, bryozoans, mollusk and brachipod shell fragments, echinoderm fragments, serpulids, corals and calcareous algae. The background autochthonous pelagic sediment or matrix is represented by a lithoclastic wackestone-packestone bioclastic containing abundant calpionellids, calcispheres, ostracods and peloids. Irregularly rounded lithoclasts and poorly sorted benthic bioclasts (eroded and reworked bioclasts) are interpreted to have been derived from shallow platform environments and redeposited within typical deep-water pelagic sediments as debris flow sediments.

The nature of pelagic sedimentation in the slope deposits from Guri i Pëlumbave, Mali i Shenjte, Kurbneshi, Munella, and Gur Shpati is highlighted by the presence of calpionellids and hyaline foraminifera such as *Lenticulina* sp., *Nodosaria* sp., and *Spirillina* sp., which are typical of benthic foraminifera found in open marine environments. These taxa, present in the slope due to transport from lagoonal and back-reef areas, are critical for defining pelagic and shallow marine biozonations and reconstructing the platform slope environments. In our stratigraphic sections, we have identified key taxa such as *Protopeneroplis ultragranulata*, *Coscinophragma* sp., *Coscinoconus* sp., *Neotrocholina* sp., and *Crescentiella morronensis*, which are also found in slope calciturbidite facies. Additionally, some agglutinated, large benthic foraminifera like *Everticyclamina* sp., *Pseudocyclammina* sp., and other foraminifera such as *Charentia cuvillieri*, *Charentia* sp., and *Nautiloculina* sp., are typically restricted to back-reef environments, though they can occasionally be transported into pre-reef facies. Microbial organisms like *Lithocodium*, *Bacinella* (bacinellid structures), and *Koskinobulina* are common in back-reef facies but are rare in shallower reef-marginal facies. *Crescentiella morronensis* appears in both shallow environments (lagoons, reefs) and deeper environments (sponge reefs, slope facies), while *Radiomura cautica* is primarily found in reef and fore-reef facies. Although microencrusters such as *Koskinobulina socialis*, *Lithocodium aggregatum*, *Bacinella irregularis*, and serpulids like *Terebella lapilloides* and *Mercierella dacica* do not have significant chronostratigraphic value, they remain important facies indicators. The abundance of *Koskinobulina socialis*, *Lithocodium aggregatum*, and *Bacinella* sp., along with their in-situ positions, indicates the presence of back-reef environments (Leinfelder et al., 1993; Gawlick and Schlagintweit, 2006; Kaya & Altiner, 2015). *Terebella lapilloides* is common in Upper Jurassic fore-reef and slope environments, but also occurs in common reef environments (Leinfelder et al., 1993; Schlagintweit & Gawlick, 2008; Kaya & Altiner, 2015). *Mercierella dacica* has been reported from platform slope environments (fore-reef, slope, outer shelf), and in our stratigraphic sections, it is frequently found alongside *Crescentiella morronensis*, *Mohlerina basiliensis*, and various calpionellids. Specifically, in the Guri i Pëllumbave section, *Mercierella dacica* and *Terebella lapilloides* were identified in Upper Berriasian–Lower Valanginian slope deposits. Based on the occurrence of these forms, it is possible to interpret the studied deposits as slope turbiditic facies. This distribution pattern is consistent with the well-known facies patterns of other carbonate platforms in the Tethysian region (Pleş et al., 2013; Kaya and Altiner, 2015).

These deposits are actually massive deposits of debris-flow type according to the description of Drzewiecki & Simó (2002) and their age is Upper Berriasian – Upper Valanginian. Slope carbonates with similar microfacies and fossil content have been described further west from Serbia (Petrova et al., 2012, Rosomać Limestone), Poland (Matyszkiewicz and Slomka, 1994, Cieszyn Forest, Outer Carpathians), the Northern Alps (Schlagintweit and Gawlick, 2007, the Barmstein Limestone; Schlagintweit and Ebli, 1998, the Tressenstein Limestone and Auer et al., 2006, the Rettenstein Debris Flow), Romania (Bucur et al. 2010, Mateiaş Limestone, Southern Carpathians) and Slovenia (Kukoc et al. 2012, Inner Dinarides).

The presence of intraclastic packstones, grainstone-rudstones, and bioclastic wackestone-packstones, which contain intraclasts and fossils typical of shallow environments within a pelagic sediment matrix and scattered ophiolitic grains, can be associated with possible extensional tectonics. These tectonic processes likely led to the disintegration of the carbonate platform. As a result, massive gravitational movements (Bucković, 2006) were triggered, leading to the accumulation of bioclasts and intraclasts originating from the shallow platform into deeper hemipelagic environments. The steep palaeorelief, evidenced by the ridges of the steep blocks of the platform that were exposed and eroded during this period, can be inferred from the presence of intraclasts derived from the platform's covering layers. Additionally, the mixing of bioclasts typical of shallow environments with a calpionellid matrix and sponge spicules further supports the interpretation of a hemipelagic depositional environment.

4. CONCLUSIONS

This paper presents comprehensive studies of several Upper Berriasian-Lower Valanginian stratigraphic sections from the Mirdita zone, offering detailed micropaleontological and microfacies analyses for each section, alongside important biostratigraphic, paleoenvironmental, and geodynamic insights. In addition to field studies, the analysis of microfauna—many of which are described for the first time in Albania—is of particular significance. In the Mali i Shejnte and Munella sections, a clear, gradual transition from Berriasian-Valanginian deposits to younger Lower Cretaceous deposits is observed. These findings provide scientific evidence for the regional structural compatibility of Jurassic-Cretaceous and Cretaceous deposits. Notably, the presence of Valanginian levels overlying Berriasian deposits is identified for the first time in the Guri i Pëllumbave stratigraphic section. The Barremian-Aptian platform carbonate deposits represent the oldest deposits in the northeastern part of the Mirdita zone. In Myç Has, they overlie Fe-Ni lateritic deposits and ultrabasic mantle formations. To the east, progressively younger Cretaceous deposits are found, and in the territory of Kosovo, within the Has province, the Cretaceous limestones are dated to the Senonian. Thus, the age of the Cretaceous deposits that cover the ophiolites and their primary cover becomes increasingly younger from the central to the eastern-northeastern parts of the Mirdita zone.

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