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Lower Cretaceous Shallow-Marine Sedimentation and Biota on Dinaric Carbonate Platform between Logatec, Krka and Kolpa (Southeastern Slovenia)

Spodnjekredna plitvomorska sedimentacija, favna in flora na Dinarski karbonatni platformi med Logatcem, Krko in Kolpo (južnovzhodna Slovenija)

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Abstract

On the basis of detailed biofacies and microfacies analysis of several cross-sections in the southeastern Slovenia the biostratigraphic subdivision of the Lower Cretaceous stratigraphic sequence has been made. In the study area the Lower Cretaceous involves five cenozones and four subzones, namely: *Clypeina ? solkani, Salpingoporella muehlbergii, Salpingoporella dinarica, Orbitolina (Mesorbitolina)* ex gr. *texana* and *"Valdanchella" dercourti* (cenozones) as well as *Favreina salevensis + Salpingoporella annulata, Epimastopora ? cekici + Cuneolina tenuis, Orbitolinopsis capuensis* and *Palorbitolina lenticularis* (subzones). The sediments and fossils in the inner part of the Dinaric carbonate platform point at more or less continual sedimentation, chiefly in very shallow water environments from intertidal to shallow subtidal. The continuity of the sedimentation was interrupted by sporadic intensified intertidal movements and short-lasting emersions.

Kratka vsebina

Na podlagi nadrobne mikrofacialne in biofacialne analize več profilov je opravljena biostratigrafska razčlenitev spodnjekrednega zaporedja sedimentov. Na obravnavanem ozemlju obsega spodnja kreda 5 cenocon in 4 podcone, in sicer: *Clypeina ? solkani, Salpingoporella muehlbergii, Salpingoporella dinarica, Orbitolina (Mesorbitolina)* ex gr. *texana* in *"Valdanchella" dercourti* (cenocone) ter *Favreina salevensis + Salpingoporella annulata, Epimastopora ? cekici + Cuneolina tenuis, Orbitolinopsis capuensis* in *Palorbitolina lenticularis* (podcone). Sedimenti in fosili notranjega dela karbonatne platforme kažejo na bolj ali manj zvezno sedimentacijo v plitvem podplimskem, medplimskem in nadplimskem okolju. Sedimentacijo so občasno prekinjali pojačani epirogenetski premiki in kratkotrajne emerzije.

Introduction

The study area was geologically mapped and reconnoitred for the Geologic map of Slovenia 1 : 100 000 in the years between 1965 and 1985 by Pleničar et al. (1970), Buser (1974), as well as Savić and Dozet (1985). In the frame of the research programme "Mesozoic of Slovenia" biostratigraphic investigations of the Lower Cretaceous were performed in the Logatec area (Šribar, 1979a). Detailed sedimentological investigation (Strohmenger & Dozet, 1991) have been carried out in the section Kompolje-Ogorelec on the Mala gora mountain and in the section Krka-Mali Korinj in Suha Krajina about 35 km SSE from Ljubljana. The second systematic regional geological investigations of the Slovene territory with a purpose to make the Geologic map of Slovenia on the scale of 1:50 000, involving detailed field mapping and accompanying systematic examinations in the Logatec and Suha Krajina area, is being carried out by Dozet and Stojanovič.

A detailed study and correlation of several geological sections and numerous useful data obtained in the field during described geological mappings have been used as a base for the description and biostratigraphic subdivision of the Lower Cretaceous stratigraphic sequence in the Slovene Karst Dinarides between Logatec, Krka and Kolpa in the Dinaric carbonate platform area. A complete development of the Lower Cretaceous comprising the Berriasian to the Upper Albian was established.

Hydrozoans, sponges and corals have been determined by Dragica Turnšek. Mario Pleničar determined the rudist macrofauna. The carbonate rocks are classified according to Folk's (1959) practical petrographic classification of limestones and Dunham's (1962) classification of carbonate rocks according to depositional texture.

Important Previous Investigations

Uršič (1933) discovered and described coral, rudist and orbitolinid limestones in the Kočevje area.

Radoičić (1960) was the first to subdivide biostratigraphically the Lower Cretaceous beds in the Outer Dinarides. On the basis of microfossil associations, especially foraminifera and algae, she ranged the beds with tintinnids into the lowermost part of the Lower Cretaceous (Infravalanginian, Valanginian). She also registered Hauterivian with *Muneiria baconica* and Barremian-Aptian with *Salpingoporella dinarica* and *Bacinella irregularis*.

Farinacci and Radoičić (1964) correlated the Jurassic and Cretaceous beds of the Apennines and the Dinarides. The comparision showed similar paleoecological conditions of the Jurassic and Lower Cretaceous sedimentation. Nevertheless, in the Dinarides the zone of aberrant tintinnins is ascribed to Valanginian, whereas the zone *Clypeina jurassica + Bankia striata* (tintinnins) in the Central Apennines is attributed to the Upper Malm.

On the basis of micropaleontological examination of the samples from Trnovski gozd Turnšek and Buser (1966) placed the boundary between the Portlandian and the Valanginian there where *Clypeina jurassica* became extinct. The abberant tintinnins appear already in the Upper Malm but are more frequent in the Valanginian. In their opinion, the aberrant tintinnins together with Nerineae disappeared at the end of Valanginian.

In the explanatory text to the map sheet of the Postojna area P l e n i č a r et al. (1970) presented the data and results of systematic geologic mapping for the Geological map of Slovenia 1:100 000.

B u s e r (1974) described the general geology in the Ribnica map sheet area. He subdivided the Lower Cretaceous succession into the following mapping units: Valanginian, Hauterivian and Barremian, Valanginian and Hauterivian, Aptian, Albian and Cenomanian.

T u r n š e k and B u s e r (1974) examined and described the Lower Cretaceous Cnidaria found in several places between Osojnica, AvščQek and Levpa on Banjška planota, which they dated from the Barremian to the Aptian time.

O r e h e k and O g o r e l e c (1979, 1981) correlated the microfacial and geochemical characteristics of beds of the southern carbonate platform in Slovenia. According to the literature they are within the general limits of carbonate rocks.

According to algal and foraminiferal contents of the Lower Cretaceous succession from the Logatec plateau Š r i b a r (1979a) recognized five cenozones and one interzone. After she had studied all the aspects of the occurrences of the aberrant tintinnids she attributed the limestones with clypeinas and aberrant tintinnids to the Upper Malm.

Š r i b a r et al. (1979) described the Lower Cretaceous sediments in the cross-section Vrhnika-Logatec. The Lower Cretaceous sedimentary rocks begin with the Berriasian stromatolitic dolomites and limestones and end with the Albian bituminous limestone.

In the area between Kočevje and Krka P l e n i č a r and Š r i b a r (1983) proved by microfossils and rudists the continuous Lower and Upper Cretaceous sedimentary succession. In the Lower Cretaceous stratigraphic sequence they distinguished the Berriasian *(Favreina salevensis)*, Valanginian-Hauterivian *(Clypeina ? solkani)*, Barremian (Dasycladaceae), Lower Aptian *(Palorbitolina lenticularis)*, Upper Aptian *(Salpingoporella dinarica)*, and Albian *(Cuneolina pavonia parva)*.

S a v i ć and D o z e t (1985) described the general geology of the Delnice map. They subdivided the Lower Cretaceous succession into the following mapping units: limestones and dolomites, calcareous breccias, limestones and dolomites, Barremian limestones and dolomites, Aptian limestones and Albian limestones.

On the basis of detailed and extensive investigations and by correlation of the obtained results in the wider area D o z e t (1990) subdivided the Lower-Cretaceous stratigraphic sequence of the Kočevje and Gorski Kotar area in five cenozones and three subzones.

In the Kočevje and Gorski Kotar area D o z e t and Š r i b a r (1991) established and described the uninterrupted Lower Cretaceous sedimentary succession from Berriasian to the Upper Albian carbonate rocks.

S t r o h m e n g e r and D o z e t (1991) studied sedimentologically a complete succession of the Jurassic beds including the contacts between the Upper Triassic and the Lower Lias as well as the Upper Malm and Lower Cretaceous.

T u r n š e k et al. (1992) paleontologically studied the Lower Cretaceous coral, rudist and foraminiferal fauna of Slovenski vrh in the Kočevje area. The authors supposed the Lower Cretaceous coral-rudist reef development on Slovenski vrh most probably corresponds to the white coral limestone and white yellow chamid limestone of the second horizon as mentioned by U r š i č (1933).

Lower Cretaceous Stratigraphy

In southern Slovenia the Jurassic beds pass gradually into the Lower Cretaceous ones. The biostratigraphic boundary between the Upper Malm and the Lower Cretaceous is rather problematic in the Dinarides. Some authors draw the boundary either at the appearance of the aberrant tintinnids (Radoičić, 1960; Farinacci & Radoičić, 1964), after the extinction of *Clypeina jurassica* (Buser, 1968, 1989; Turnšek & Buser, 1966), or later after the extinction of the aberrant tintinnins (Velić, 1977; Velić & Sokač, 1978; Šribar, 1979a, b). However, it must be taken into consideration that these microfossils are rather facies dependent (Radoičić, 1969). Since the treated beds do not show appreciable facies changes we place the boundary between the Upper Malm and the Lower Cretaceous, after the last appearance of the aberrant tintinnins.

The Lower Cretaceous sedimentary succession of the study area is predominantly composed of shallow marine carbonates deposited in the inner part of the vast Dinaric carbonate platform. Limestones were formed in shallow-marine environments i.e. lagoon, subtidal, restricted shoals, back-reef, reef and others. Limestones were occasionally more or less late-diagenetically or early-diagenetically dolomitized. Consequently, all transitional types between limestone and dolomite can be observed in the studied area.

In the study area the complete development of the Lower Cretaceous beds has been found, representing the Berriasian, Valanginian, Hauterivian, Neocomian, Barremian, Lower Aptian, Upper Aptian, Lower Albian and the Upper Albian.

Berriasian

Generally, in the study area four developments of the Berriasian beds can be distinguished: the predominantly dolomitic develoment, the limestone development, dolomite-limestone development and finally, the dolomite development with chert.

The Berriasian stratigraphic sequence consists of alternating brownish gray, gray, medium gray, light gray and very light gray sparitic dolomite, laminated stromatolitic dolomite as well as micritic, dismicritic and intraclastic limestones. Strong dolomitization is characteristic for the Berriasian rocks. Early diagenetic dolomite is light gray to white, stratified (40-150 cm), fine-grained, cryptocrystalline to microcrystalline, laminated and stromatolitic, containing ostracods, gastropods, oncoids, shrinkage pores, fecal pellets and birdseyes. The early diagenetic dolomites are often associated with birdseyes and stromatolitic structures. Intercrystalline pores are generally filled with late diagenetic blocky calcite. The dolomite is chemically pure with some illite, montmorillonite and chlorite admixture. Late diagenetic dolomite is chiefly dark gray to brownish gray, coarse-grained, saccharoidal, without inner structures, occurring in lens-like or irregular bodies. Both dolomites are encountered relatively frequently and in great quantities. The Berriasian beds are up to 100 metres thick.

In the limestones, which according to their stratigraphic position belong to Berriasian, a low-diversity and predominance of *Favreina* pellets, peloids and micritic intraclasts is characteristic. Abundant birdseyes, stromatolitic structures and gravitational cements occur in the described carbonate sediments. Consequently, the sediments were chiefly formed in a shallow subtidal, intertidal to supratidal environments with strong meteoric influx.

Valanginian

The Valanginian sedimentary succession chiefly consists of medium gray, gray, and light gray, stratified, micritic, pelmicritic, pelsparitic, biomicritic, oncolitic and intraclastic limestones with LLH stromatolites, pellets, pseudoooids, oncoids, gastropods, benthic foraminifera as well as numerous fenestrae, desiccation cracks and erosion surfaces. Among clasts are most common intraclasts, pellets and pseudoooids. For the lower part of the Valanginian stratigraphic sequence an alternation of microcrystalline dolomites and more or less dolomitized limestones is characteristic. At some places a rhythmic alternation of light gray early-diagenetic and dark gray to brownish gray, coarse-grained, bituminous late-diagenetic dolomite can be observed. Strata rich in oncoids occur in the upper part of the succession. Microfauna and microflora are rare. Most frequent and numerous are textularians, favreinas and clypeinas. In the described carbonate sediments the mosaic cement B and fibrous early diagenetic cement A are most common. Granular cements are coarser in birdseyes fillings and finer in packstone and grainstone carbonates. According to structural and textural properties the Valanginian carbonate rocks were formed in shallow lagoon as well as subtidal, intertidal and supratidal environments.

Hauterivian

The Hauterivian beds are composed of thick-bedded (40-100 cm), medium gray and light gray limestones. In the lower part of the Hauterivian lithological column extremely thick-bedded (75-200 cm) limestones occur. According to texture the limestones belong to micrites, pelsparites, biopelmicrites, biointrasparites, oosparites, pseudooosparites, oncolites and stromatolites. In the Hauterivian stratigraphic sequence limestones strongly prevail. Dolomites and carbonate clastic rocks are rare. In the lowermost part of the Hauterivian sedimentary succession stromatolites containing gastropods, ostracods, foraminifera, intraclasts and pellets are quite abundant.

Neocomian

On the Jurassic/Lower Cretaceous boundary some parts of the studied area were subjected to tectonic movements as consequence of the Late Kimmerian orogenetic phase, resulting in the uplifting and rupturing of particular parts of the sea bottom. The newly formed land gave the material for heterogeneous limestone, dolomite, and limestone-dolomite sedimentary breccia intercalated with dolomite and limestone.

These beds lie erosionally, and slightly discordantly upon the Upper Malm limestone and dolomite succession. At some places there are no traces of orogenetic activity; intensified epeirogenic movements can be followed resulting in more intensive sinking of the sea bottom and continuous sedimentation of the Lower Cretaceous sequence of limestones and dolomites.

The Neocomian beds are composed of heterogeneous limestone-dolomite breccia which contains fragments of various Jurassic limestones and dolomites, and in the Prezidanski Berišček area fragments of chert, too. Consequently, two types of Neocomian breccia can be found: carbonate breccia and carbonate-chert breccia.

The carbonate-chert breccia is composed of angular and subangular fragments of gray, medium gray and dark gray micrite, biomicrite, biosparite and rarely oosparite, further on, fragments of dark gray medium- and coarse-grained bituminous dolomite as well as 1 cm to 5 cm angular dark gray chert fragments. Carbonate and chert fragments from 5 cm to 30 cm are rare. Sporadically occur in the breccia mollusc fragments. Some fragments contain the Upper Malm microfossils. The described fragments are bounded together with basal and pore cement. The breccia is massive to poorly stratified. Contacts among beds are not clear. Occasionally, intercalations of medium gray, gray, dark gray and grayish black oomicritic limestone, dolomitized micritic limestone and coarse-grained dolomite occur in the carbonate-chert breccia. Since the breccia contains fragments with the Upper Malm fauna, and it is overlain by the limestones containing the Barremian-Aptian microfossil association, the breccia corresponds to Neocomian (S a v i ć, 1973; S a v i ć & D o z e t, 1985). The thickness of the Neocomian beds ranges from 100 m to 120 m.

Barremian

Two developments of the Barremian beds can be distinguished in the study area: the limestone and the limestone-dolomitic development. The limestone development includes medium- and thick-bedded as well as thin-bedded and platy medium gray, gray, dark gray, blackish gray and black, more or less bituminous micrites, pelmicrites, pelsparites, biointrasparites, biosparites, stromatolites, rarely intraformational breccias and conglomerates. Among biomicrites and biosparites foraminiferal and occasionally algal limestones predominate. Rhythmic sedimentation of enumerated limestones is very common. Numerous intertidal oscillations, shallowings and emersions can be observed in the considered stratigraphic sequence. The emersions were accompanied by interruptions of sedimentation, weak erosion and carbonate breccias of various origin. Also characteristic is a rhythmic alternation of light-coloured early diagenetic and dark late diagenetic dolomites. The late diagenetic dolomites mostly originated by dolomitization of micrites, pelsparites, pelmicrites, intrasparites, and especially oncolites and stromatolites. Complete and selective dolomitization are present. Consequently, all types from limestone to dolomite can be seen in the Barremian sedimentary succession. Late diagenetic dolomite occurs in the form of thick beds, lenses and irregular patches or bodies. They consist of more or less coarse-grained and bituminous dolomite.

Aptian

Lower Aptian-Bedoulian. Upon the Barremian sediments lie conformably bedded and platy dark gray and grayish black, rarely gray and light gray micritic, biomicritic, intramicritic, biointrasparitic more or less bituminous limestones. At some places miliolids and salpingoporellas are accumulated in such quantities that they are rock-building. Bedoulian beds build the outer parts of Kočevje and Požar synclines and are exposed also in the extremely southwest part of the Kolpa area. For the Lower Cretaceous are especially characteristic the lagoonal and back reef sediments consisting of micrites, biomicrites, biosparites, oncolites and intrasparites. These sediments predominantly originated in a shallow and calm restricted marine environment with numerous green algae (Dasycladacea, Codiaceae), foraminifera (miliolids, orbitolinids) and ostracods. In some layers moluscs (small requienids and gastropods) occur. Relatively common with gastropods, orbitolinids and *Bacinella* are incrusted oncolites. Furthermore, for the Lower Aptian succession a rhythmic alternation of micrites, biomicrites and oncolites is characteristic too.

The most characteristic for the lower part of the succession are the so-called Lower *Orbitolina* limestones, orbitolinid biomicrites and biosparites respectively, involving gastropods, miliolids and salpingoporellas. Laminated sediments are rare. Interlayers of limestone breccia and dark gray bituminous dolomite are also pretty rare. Consequently, the Lower Cretaceous sediments were prevalently formed in lagoonal, subtidal and other shallow marine environments.

Coral-rudist patch reefs. Lagoonal, subtidal and other shallow marine micrites, biomicrites and oncolites pass at some places into reef facies that consists of reef-building macroorganisms such as corals, bryozoans, primitive rudistids, gastropods, echinoids as well as algae and foraminifera. Coral-rudist reef limestones with orbitolinas in the Kočevje area were found earlier by Uršič (1933). In the coral limestone at Spodnje Ložine and at Koblerski Hrib Uršič mentioned 5 coral species, namely: *Isastraea hoernesi, Lithoraea vaughani, Phyllosmilia transiens, Montlivaltia lamx, Cyclotites nummulus* in *C. hemisphaerica*. Coral-rudist features of patch-reef type were discovered east of Željne and southeast of Škodovnik in the Kočevje area (Dozet, 1983). Turnšek et al. (1992) examined the coral-rudist reef development of Slovenski vrh probably corresponding to the white coral limestone and white yellow chamid limestone of II. horizon quoted by Uršič (1933). The coral-rudist reef on Slovenski vrh belongs to a patch reef of the inner part of the Dinaric carbonate platform. In the lower part of the reef predominate rudists of *Caprina-Praecaprina* and *Offneria* type, and corals of the type *Cyathophora-Actinaraea-Microsolena*. In the upper part of the Aptian-Albian reef the rudist species *Ichthyosarcolites* and corals *Procladocora-Strotogyra* type (Turnšek et al., 1992) occur.

Turnšek et al. (1992) determined the following corals and rudists in the rock samples collected at the top of Slovenski vrh:

Corals: *Cyathophora pygmaea* Volz, *Peplosmilia fromenteli* Angelis d'Ossat, *Procladocora kocevjensis* n. sp., *Calamophylliopsis fotisalensis* (Bendukidze), *Strotogyra augusti* n. sp., *Microsolena distefanoi* (Prever) and *Actinaraea tenuis* Morycowa.

Rudists: *Ichthyosarcolites monocarinatus* Slišković, *Monopleura* sp., and *Offneria* sp.

According to its shape, extension and fauna the coral-rudist reef at Željne belongs to a relatively small patch reef originated in the inner part of the Dinaric carbonate platform. In the patch reef area a vertical and lateral differentiation of fauna can be observed. In the lower part of the patch reef rudistids of the *Requenia* and *Toucasia* type predominate, whereas in the upper part corals occur. Rudistid biostromes, coral bioherms and coral detritus point at a patch reef as well as periodically open and wavy shallow marine environment. Rudists, corals, bryozoans as well as echinoderms and molluscs indicate open shoals and smaller isolated patch reefs populated with the enumerated organisms. To all appearance patch reefs were extended in the Aptian and Albian in the inner parts of the Dinaric carbonate platform.

In the coral patch reefs area the following microfossils have been determined: *Palorbitolina lenticularis* (Blumenbach), *Praeorbitolina wienandsi* Schroeder, *P. cormyi* Schroeder, *Orbitolina (Mesorbitolina) lotzei* Schroeder, *Orbitolina (Mesorbitolina) texana* Roemer, *Neotrocholina friburgensis* Guillaume & Reichel, *Debarina hahounerensis* Fourcade et al., *Spiroloculina cretacea* Reuss, *Bacinella irregularis* Radoičić, *Paleodictyoconus* sp., *Nezzazata* sp., *Trocholina* sp., *Sabaudia* sp., *Praechrysalidina* sp., Miliolidae, Ophthalmidiidae and Textulariidae. According to the enumerated microfauna and microflora the patch reefs of the study area belong to the Aptian-Lower Albian period.

Upper Aptian-Gargasian. The Upper Aptian corresponds to the interval between the Lower and Upper *Orbitolina* limestones. Relatively numerous erosion surfaces and layers of intraformational breccias at the end of the Lower Aptian indicate intensified shallowing of the study area. The Upper Aptian beds are found on Požarje, Kočevsko pogorje, to the east of Željne and in the extremely nordeastern part of the Delnice map sheet. However, the Upper Aptian succession does not differ essentially from the Lower Aptian one. Shallow marine subtidal and lagoonal facies of micrites, biomicrites, rhythmically alternating with foraminiferal and mollusc biointrasparites and biosparites as well as patch reefs and oncolites represent the main characteristics of the Upper Aptian sedimentation. The examined geological interval is relatively rich as in diversity of facies as in fossils. In the patch reefs rudistids and corals form the framework structure. To the structure of the patch reefs contribute their part bryozoans, codiaceans and other algae, molluscs and echinoderms. The facies surrounding the patch reefs consists of biosparites, biointrasparites and biosparrudites (packstones, grainstones and rudstones). In the lagoon rhythmic micrites, pelmicrites as well as miliolid, *Salpinogoporella*, dasycladacean and foraminiferal biopelmicrites and biomicrites (wackestone, packstone) occur indicating normal shallow marine conditions in an open lagoonal inner shelf environment.

Albian

Lower Albian. The limestones with *Salpingoporella dinarica* are overlain by limestones containing numerous orbitolinids. Orbitolinas in the limestone are so numerous that they are rock-building. These sediments are known under the name of the upper *Orbitolina* limestones (V e l i ć, 1977; V e l i ć & S o k a č, 1978a, b) corresponding biostratigraphically to the Lower Albian. The sedimentary succession consists of bedded and platy, dark gray, gray and dark brownish gray, bituminous micrites, pelmicrites, biomicrites and biosparites. Among biomicritic and biosparitic limestones predominate the orbitolinid and miliolid ones. Oncolites and requienid lumachelles are present but are relatively rare. Lumachelles with gastropods also occur in this interval of the Lower Cretaceous sequence. The limestones usually contain some organic admixture being therefore brownish.

Upper Albian. At the end of the Lower Albian a shallowing tendency (lagoon-shallow subtidal-intertidal-supratidal) occurred. At the beginning of that period a rhythmic sedimentation of stromatolites and intraformational breccia predominated. In fact, the Upper Albian succession chiefly consists of stratified or platy dark gray micritic, pelmicritic, biomicritic and biosparitic limestones. Lagoonal and subtidal sedimentation (micrite, biomicrite) also prevails in the upper part of the Upper Albian stratigraphic sequence. Pretty common are the miliolid biomicrites. Lumachelles with small requienids are still present. In the uppermost part of the succession coarse-grained dark gray and brownish gray bituminous dolomites and intrasparrudites predominate. The dolomites were formed by the late dolomitization of micrites, oncolites, intrasparrudites and stromatolites.

In the study area the transition from the Lower to the Upper Cretaceous beds is not clear either from paleontological or lithological point of view. This is a consequence and influence of the orogenetic movements of the Austrian tectonic phase (D o z e t, 1989). On the boundary between the Lower and the Upper Cretaceous occurs a some hundred metres thick transitional succession of alternating breccia, dolomite and limestone. The boundary between the Lower and the Upper Cretaceous passes within this sequence.

Biostratigraphy

On the basis of characteristic lithofacies and biofacies as well as their superposition the shallow marine Lower Cretaceous stratigraphic sequence in the area between Logatec and Krka and Kolpa Rivers (Fig. 1) consists of the following characteristic

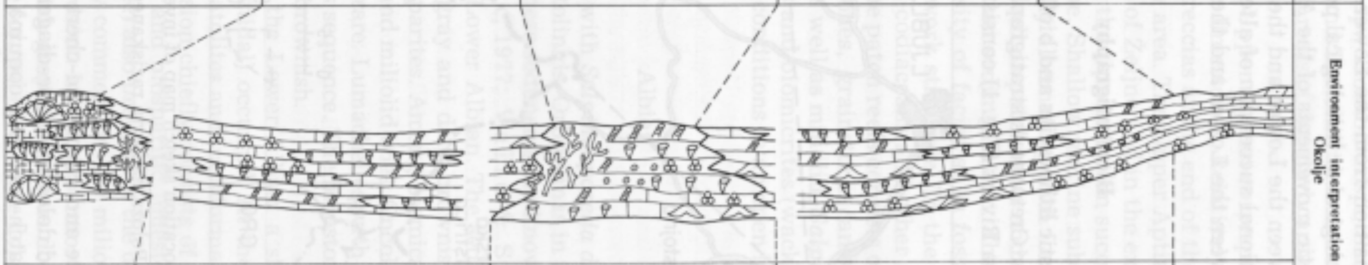
Fig. 1. Location sketch map of investigated area

Sl. 1. Položajna karta raziskanega ozemlja

lithofacies (Fig. 2): carbonate and carbonate-chert breccias, fenestral, stromatolitic and laminated limestones and dolomites, late-diagenetic dolomites, oncolitic, bioclastic, micritic, intraclastic, patch-reef and coquina limestones. The enumerated sedimentary carbonate rocks contain rich microfossil associations which are very im-

Microfacies / Mikrofacies	Massive and thick-bedded very light gray to white beds Biolithites Biosparrudites Biospararenites	Thin to medium grayish black to black beds Micrites Pelmicrites Fine-laminited limestones Bioturbated wackestones Biomicrites Cycles of biosparites	Very light gray to gray massive and thick-bedded beds Biolithites Biosparrudites Biospararenites Bioooosparites	Thin to medium grayish black to black micrites, pelmicrites Fine-laminated limestones Bioturbated wackestones Biomicrites Cycles of biosparites	Medium to thick light gray brownish gray beds Fenestral and pseudooolitic limestones and dolomites
Biota / Favna in flora	Radiolitids Chondrodontids Caprinids Colonial corals Encrusting algae Benthonic foraminifers	Miliolids Dasycladaceans Orbitolinids Biostromes of small requienids	Corals Biostromes of *Requienia* and *Toucasia* Orbitolinids Miliolids Trocholinids Dasycladaceans	Miliolids Dasycladaceans Orbitolinids Biostromes of small requienids	Coprolites Rare foraminifers and algae
Facies	Reefal	Lagoonal	Barrier	Lagoonal	Intertidal

Environment interpretation / Okolje



Environment interpretation / Okolje	Reef	Exterior lagoon	Barrier Patch reef	Interior lagoon	Intertidal
AGE / STAROST	CENOMANIAN CENOMANIJ	UPPER ALBIAN ZGORNJI ALBIJ	LOWER ALBIAN-APTIAN SPODNJI ALBIJ-APTIJ	BARREMIAN-BERRIASIAN BARREMIJ-BERRIASIJ	

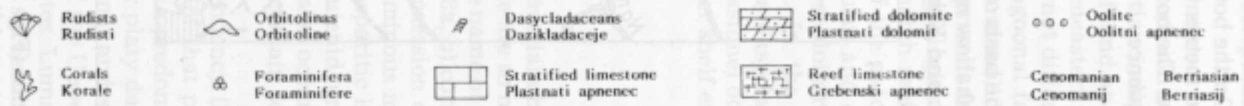


Fig. 2. Schematic cross-section of the Cretaceous (Berriasian to Cenomanian) shelf with characteristic biota in southeastern Slovenia

Sl. 2. Shematski presek skoz kredni (berriasij do cenomanij) šelf z značilno favno in floro v južnovzhodni Sloveniji portant, useful and characteristic for biozonation of the Lower Cretaceous beds. From the biostratigraphic point of view the Lower Cretaceous sedimentary succession has been divided by microfossils into five cenozones and four subzones (Fig. 3). In the study area the Lower Cretaceous microfossils belong to two main groups, namely:

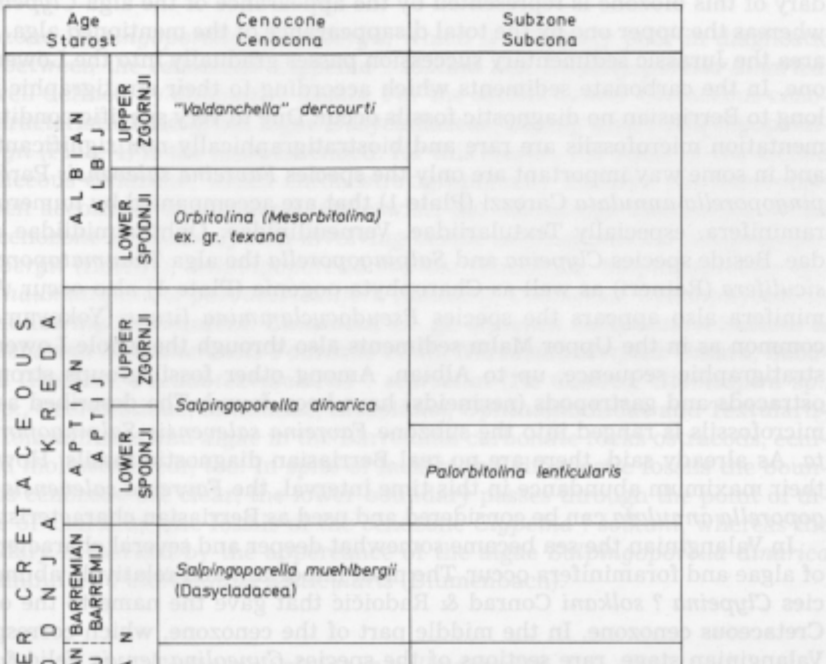


Fig. 3. Biostratigraphic subdivision of the Lower Cretaceous beds in southeastern Slovenia

Sl. 3. Biostratigrafska razčlenitev spodnjekrednih plasti jugovzhodne Slovenije

calcareous algae Dasycladacea and benthic foraminifera *Orbitolina*. Algae are numerous and important in Berriasian, Valanginian, Hauterivian, Barremian, and Aptian; on the other hand, foraminifera predominate in the Lower Aptian and Albian.

Cenozone *Clypeina ? solkani*

This cenozone is denominated according to the alga *Clypeina ? solkani* Conrad & Radoičić (Plate 3) which appears at the beginning of Berriasian (S t r o h m e n g e r & D o z e t, 1991) and expanding in Valanginian and Hauterivian. The lower boundary of this biozone is represented by the appearance of the alga *Clypeina ? solkani*, whereas the upper one by the total disappearance of the mentioned alga. In the study area the Jurassic sedimentary succession passes gradually into the Lower Cretaceous one. In the carbonate sediments which according to their stratigraphic position belong to Berriasian no diagnostic fossils occur. Due to very specific conditions of sedimentation microfossils are rare and biostratigraphically non significant. Numerous and in some way important are only the species *Favreina salevensis* Paréjas and *Salpingoporella annulata* Carozzi (Plate 1) that are accompanied by numerous small foraminifera, especially Textulariidae, Verneuilinidae, Ophthalmidiidae and Miliolidae. Beside species *Clypeina* and *Salpingoporella* the alga *Thaumatoporella parvovesiculifera* (Raineri) as well as Charophyta oogonia (Plate 1) also occur. Among foraminifera also appears the species *Pseudocyclammina lituus* (Yokoyama), which is common as in the Upper Malm sediments also through the whole Lower Cretaceous stratigraphic sequence, up to Albian. Among other fossil groups stromatoporoids, ostracods and gastropods (nerineids) have been found. The described association of microfossils is ranged into the subzone *Favreina salevensis-Salpingoporella annulata*. As already said, there are no real Berriasian diagnostic fossils. However, due to their maximum abundance in this time interval, the *Favreina salevensis* and *Salpingoporella annulata* can be considered and used as Berriasian characteristic fossils.

In Valanginian the sea became somewhat deeper and several characteristic species of algae and foraminifera occur. The most important and relatively abundat was species *Clypeina ? solkani* Conrad & Radoičić that gave the name to the oldest Lower Cretaceous cenozone. In the middle part of the cenozone, which corresponds to the Valanginian stage, rare sections of the species *Cuneolina tenuis* Velić & Gušić have been found. Beside the guide alga *Clypeina ? solkani* the Valanginian sediments also contain associations of fossils composed of salpingoporellas, cuneolinas, thaumatoporellas, ostracods and the algae *Epimastopora ? cekici*. Microfossils *Cuneolina tenuis* and *Epimastopora ? cekici* Radoičić have their maximum abundance in Valanginian but can also be present in the Hauterivian. Some Valanginian characteristic fossils are accompanied by species with the stratigraphic range from Jurassic to Barremian (*Salpingoporella annulata* Carozzi). The alga *Clypeina ? solkani* Conrad & Radoičić has its maximum abundance in Hauterivian.

Lithologically, the Valanginian-Hauterivian passage is designated by intensified intertidal oscillations and rhythmic sedimentation of pelmicrites, micrites, biomicrites, oncolites, stromatolites, fenestral carbonates as well as intrasparites and biointrasparites.

In the Hauterivian part of the cenozone *Clypeina ? solkani* the foraminifera *Orbitolinopsis capuensis* (De Castro) appear. Beside the above quoted characteristic microfossils the Hauterivian involves some other microfossils with wider stratigraphic range, such as salpingoporellas, sabaudias, miliolids, ophthalmidiids and thaumatoporellas. The described Hauterivian association belongs to the subzone *Epimastopora ? cekici + Orbitolinopsis capuensis*. In the upper part of the *Clypeina ? solkani* cenozone still appear numerous foraminifera *Cuneolina* ex. gr. *laurentii-camposaurii* Sartoni & Crescenti, *Debarina hahounerensis* Fourcade et al., *Pseudo-*

textulariella ? scarsellai (De Castro), *Glomospira* sp., Miliolidae, Ophthalmidiidae and Textulariidae.

Cenozone *Salpingoporella muehlbergii*

The cenozone *Salpingoporella muehlbergii*, which is relatively poor in diagnostic fossils, lies between the cenozones *Clypeina ? solkani* and *Salpingoporella dinarica*, which are well defined by diagnostic fossils. For the second Lower Cretaceous cenozone are characteristic blue-green algae Dasycladaceae, among which *Salpingoporella muehlbergii* (Plate 4) is the most extended: for this reason, the name of the second Lower Cretaceous cenozone, which chronostratigraphically includes the Barremian stage, is given according to this algae. Otherwise, the microfossil association of the considered cenozone is relatively rich involving beside salpingoporellas /*Salpingoporella muehlbergii* (Lorenz), *Salpingoporella melitae* (Radoičić), *Salpingoporella* sp./ also algae *Thaumatoporella parvovesiculifera* (Raineri), Codiaceae, Cyanophyceae as well as the following foraminfera: *Cuneolina* ex. gr. *laurentii camposaurii* Sartoni & Crescenti, *Debarina hahounerensis* Fourcade et al., *Nezzazata simplex* Omara, *Sabaudia minuta* (Hofker), *Pseudotextulariella ? scarsellai* (De Castro), *Glomospira* sp., *Nezzazata* sp., Orbitolinidae, Miliolidae, Lituolidae, Ophthalmidiidae and Textulariidae. Beside foraminifera and algae in the Barremian carbonate rocks ostracods, echinoderms and molluscs occur, too. In spite of lack of real diagnostic fossils the boundaries of this cenozone are clear; the lower boundary passes through the point of disappearance of characteristic fossils of the cenozone *Clypeina ? solkani*, whereas the upper boundary is marked by the appereance of the algae *Salpingoporella dinarica* and the foraminifera *Palorbitolina lenticularis* (Blumenbach).

Cenozone *Salpingoporella dinarica*

This cenozone comprises the whole Aptian sedimentary succession together with the fossil contents. It is named by the characteristic alga *Salpingoporella dinarica* Radoičić (Plate 5) which is very common especially in the upper part of the Aptian stratigraphic sequence. In the lower part of the Aptian succession numerous orbitolinids can be seen. Owing to their small vertical stratigraphic range the orbitolinids are very usefull for detailed subdivision and biozonation. On the basis of orbitolinids it is possible to subdivide the Aptian stratigraphic sequence of the study area into the Lower Aptian (Bedoulian) and the Upper Aptian (Gargasian). The lower part of the cenozone is designated as the subzone *Palorbitolina lenticularis* (Blumenbach). From the lithostratigraphical point of view the lower part of the cenozone corresponds to the lower *Orbitolina* limestones. Beside the characteristic *Palorbitolina lenticularis* (Plate 6/1-2) and algae *Salpingoporella dinarica* (rather rare in the lower part of the Aptian succession), numerous other foraminifera and algae occur:

Foraminirefa: *Praeorbitolina cormyi* Schroeder, *P. wienandsi* Schroeder, *Trocholina friburgensis* Guillaume & Raichell, *Debarina hahounerensis* Fourcade et al., *Sabaudia minuta* (Hofker), *S. auruncensis* (Chiocchini & Di Napoli Alliata), *Pseudotextulariella ? scarsellai* (De Castro), *Nezzazata simplex* Omara, *Ovalvelina* cf. *reichelli* De Castro, *Cuneolina* sp., *Nummoloculina* sp., *Glomospira* sp., Biokovinidae, Miliolidae, Textulariidae and Ophtalmidiidae.

Algae: *Bacinella irregularis* Radoičić (Plate 7/1-2), *Thaumatoporella parvovesiculifera* (Raineri), *Lithocodium aggregatum* Elliot and *Salpingoporella* sp. Moreover, numerous rudists and corals settled the small Aptian patch reefs. Orbitolinids, miliolids, salpingoporellas and requienids, being often rock-building, reach in Aptian their maximum abundance. In fact, the Upper Aptian corresponds to the interval between the lower and upper *Orbitolina* limestones characterized by maximum abundance of the species *Salpingoporella dinarica*. There are no proper Gargasian diagnostic fossils. However, due to maximum abundance the algae *Salpingoporella dinarica* can be considered as the Upper Aptian characteristic fossil. On the boundary between the Lower and Upper Albian the species *Sabaudia minuta* (Plate 7/4) and *Pseudotextulariella ? scarsellai* (Plate 7/3) disappeared.

Cenozone *Orbitolina (Mesorbitolina)* ex gr. *texana*

Upon the beds with the alga *Salpingoporella dinarica* lie conformly the 80 metres thick upper *Orbitolina* limestones which are built of numerous orbitolinas. Their stratigraphic range corresponds to the Lower Albian. Accordingly, the cenozone *Orbitolina (M.)* ex gr. *texana* begins with the extinction of *Salpingoporella dinarica* and with the first appearance of the species *O. (M) texana* (Plate 6/3-4) and ends with the disappearance of the latter mentioned foraminifer. Thus, the cenozone is characterized by mesorbitolinas and by numerous microorganisms with a wider stratigraphic range, such as: *Sabaudia minuta* (Hofker), *S. auruncensis* (Chiocchini & Di Napoli Alliata), *Vulvulammina picardi* Henson, *Pseudotextullariella ? scarsellai* (De Castro), *Debarina hahounerensis* Fourcade et al., *Bacinella* sp. and Miliolidae. Orbitolinids were rock-building. They lived in a calm lagoonal and shallow marine environment.

Cenozone *"Valdanchella" dercourti*

In the uppermost part of the Lower Cretaceous stratigraphic sequence primitive orbitolinids occur. Among them the diagnostic species *"Valdanchella" dercourti* (Plate 8/1) is relatively well extended. Beside the diagnostic primitive orbitolinas numerous other foraminifera can be seen, namely: *Cuneolina* ex gr. *pavonia* parva Henson *C.* ex gr. *laurentii-camposaurii* Sartoni & Crescenti, *Nummoloculina heimi* Bonet (Plate 8/2), *Nezzazata simplex* Omara, *Debarina hahounerensis* Fourcade et al., *Valvulammina picardi* Henson (Plate 8/3), *Nummoloculina*. sp., as well as numerous Miliolidae, Ophthalmidiidae and orbitolinids. Algae are rare in the Upper Albian beds. Only remains of *Thaumatoporella parvovesiculifera* (Raineri), *Salpingoporella turgida* (Radoičić) (Plate 8/4) and *Salpingoporella* cf. *hasi* Conrad et al. can be found.

Discussion and Interpretation

Several sections of the Lower Cretaceous beds in the area between Logatec and the rivers Krka and Kolpa have been studied. Our data are based on field observations as well as thin-section analysis. Detailed section study and regional correlation of the Lower Cretaceous stratigraphic sequences indicate a high similarity of mineralogical, textural, structural and environmental characteristics as well as high similarity of associations of fossils throughout the whole study area. Generally speaking, sedimentological and paleontological properties suggest that the Lower Cretaceous carbonates were formed in the inner part of the Dinaric carbonate platform in various shallow-marine depositional environments, namely: littoral, lagoons, restricted shoals, as well as reef. Eustatic, intertidal and tectonic movements caused a differentiation of the carbonate platform (various depositional environments), lateral and vertical changes, different thickness of sediments and rhythmic sedimentation. Several developments of the Lower Cretaceous beds can be recognized in the study area. A poor faunal diversity i.e. a low number of species, stromatolites, birdseyes, numerous local erosion surfaces, common occurrences of marine and meteoric cements, dolomitization, occurrences of karstification indicate a short lasting supratidal environment during Berriasian, Valanginian and Hauterivian. Locally, the dry land stayed through the whole Valanginian and Hauterivian. The shallow marine conditions became predominant at the beginning of the Lower Barremian. In the Upper Barremian two main types of sediments can be distinguished: (1) - subtidal to lagoonal micrites, biomicrites and oncolites, and (2) - intertidal to supratidal intramicrites, intrasparites, stromatolites and intraformational breccias, dolomites. Normal marine conditions, subtidal and lagoonal environment respectively, characterized by high faunal and floral diversity were established at the beginning of Aptian. In the middle and at the end of Aptian there were tendencies of eustatic and intertidal oscillations as well as slight tectonic movements, which were manifested by rhythmic alternation of biomicrites, biosparites, intramicrites, intrasparites, biointrasparites, stromatolites and intraformational breccias. Subtidal to lagoonal regime with several small patch reefs settled by corals, requienids and algae, back reefs and shoals was dominant in the Lower Albian and Aptian. The Upper Albian is characterized by frequent changes of sedimentation and depositional environments, from subtidal and lagoonal environment rich in microfossils to intertidal ones poor in fauna and flora. In that time late diagenetic dolomites were pretty extended. The described carbonate rocks are often diagenetically changed.

In the Aptian and Lower Albian the coral-rudistid reefs in the Željne, Škodovnik, Spodnje Ložine, Koblerski hrib and Slovenski Vrh area belong to patch reefs originating in a central part of the lagoon. Vertical differentiation can be observed on the mentioned patch reefs. In the lower part of the reef rudists *Monopleura-Praecaprina-Offneria* type and corals of massive bulbous and lamellar *Cyathophora-Actinaraea-Microsolena* type predominate (T u r n š e k et al., 1992). Colonies are small and rare indicating a low rate water energy. In the upper part of the reef the rudist *Ichthyosarcolites* and corals *Procladocora-Strotogyra* are widespread indicating a higher water energy environment. In the uppermost part usually the codiaceans *Lithocodium* occur. Coral-rudist reefs appear to be present but not extremely common in the Aptian and the Lower Albian beds.

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Spodnjekredna plitvomorska sedimentacija, favna in flora na Dinarski karbonatni platformi med Logatcem, Krko in Kolpo

Sklep

V južnovzhodni Sloveniji med Logatcem, Krko in Kolpo so se v plitvem spodnjekrednem morju odlagale debele plasti apnencev in dolomitov. Na podlagi favne in flore ter stratigrafske lege so na obravnavanem ozemlju ugotovljene vse spodnjekredne stopnje, in sicer: berriasij, valanginij, hauterivij, barremij, aptij in albij. Meja med krednim in jurskim sistemom je v tem delu Dinarske karbonatne platforme litološko jasna samo tam, kjer sta razvita bazalni konglomerat in breča. Tu gre za erozijsko, deloma tektonsko-erozijsko diskordantno mejo, ki označuje prekinitev v sedimentaciji in tektonske premike na meji med juro in kredo. Drugod je kontakt med jurskimi in krednimi plastmi normalen, brez pomembnejših sprememb v sedimentaciji. Konkordantno na zgornjemalmskih apnencih leže berriasijski, pretežno laminirani in stromatolitni apnenci in dolomiti s pogostnimi izsušitvenimi razpokami in porami, zapolnjenimi z mikritom, peleti, intraklasti ali z organskim detritusom. Berriasijske plasti so revne s fosili in praviloma bolj ali manj dolomitizirane. Litološka sestava ter struktura in tekstura obravnavanih sedimentov kažejo, da so berriasijske plasti nastale pretežno v nadplimskem in medplimskem okolju. To dokazujejo pogostni laminirani karbonatni sedimenti z izsušitvenimi razpokami, stromatoliti, zgodnjediagenetski dolomiti, gravitacijski cement in nadplimski konglomerat. Valanginijsko sedimentno zaporedje sestoji iz plastnatih mikritnih, pelmikritnih, pelsparitnih, biomikritnih, onkolitnih in intraklastičnih apnencev. Pogoji za življenje so bili v berriasiju, valanginiju in hauteriviju dokaj neugodni, kar dokazujeta pičla favna in flora v teh sedimentih. Med mikrofosili se v teh plasteh pojavljajo miliolide, tekstularije, favreine in klipeine. Valanginijski sedimenti imajo v glavnem enolično strukturo brez notranjih ali zunanjih tekstur. Ponekod v njih opazujemo vodoravno laminiranost ali redke stromatolite. Pretežni del sedimentov valanginijskega zaporedja je nastajal v plitvi in mirni vodi zaprtega šelfa in lagun. Hauterivijske plasti so zgrajene v glavnem iz debeloplastnatih mikritnih pelsparitnih, biopelmikritnih, onkolitnih, biointrasparitnih, oosparitnih, pseudoosparitnih in stromatolitnih apnencev. Pretežni del hauterivijskih sedimentov se je odlagal v podplimskem in lagunskem okolju. V barremijskem sedimentnem zaporedju ločimo v splošnem dva razvoja, in sicer apnenčevo-dolomitni in apnenčev razvoj. V strukturnem pogledu prevladujejo med apnenci mikriti, pelmikriti, pelmikrospariti in biopelspariti. Pogosto je ritmično menjavanje kamenin. Menjavajo se zlasti mikriti, pelmikriti in biopelmikriti, ponekod intramikriti, intraspariti biointraspariti, drugod mikriti, pelmikriti, stromatoliti, medplimske breče ali zgodnje- in poznodiagenetski dolomit. Pretežni del barremijskih sedimentov se je gradil v podplimskem in lagunskem okolju. Drugi barremijski sedimenti so nastajali znotraj plitvega karbonatnega šelfa, večkrat v razgibani vodi.

Močni epirogenetski premiki ob pomoči šibkih orogenetskih sil konec barremija so povzročili dviganje morskega dna. Morje je postalo plitkejše, ponekod je nastalo kopno. Na njem je nastopala erozija. Sledila je kratkotrajna transgresija, rezultat le-te pa so bile tanjše plasti apnenčeve breče, s katerimi se je ponekod na raziskanem ozemlju pričenjalo aptijsko zaporedje sedimentov. Toplo, čisto, mirno, primerno slano in od časa do časa bolj ali manj razburkano morje je bilo ugodno za naselitev dasikladacej in številnih bentonskih organizmov, med katerimi so po številu prednjačile miliolide. V obdobjih razburkanega morja so živele orbitoline. Na robu karbonatne platforme so se ponekod oblikovali koralni grebeni in biostrome z moluski. Korale so naseljevale obrobja plošč. Koralno-rudistni grebeni so pripadali “patch” grebenom. Nastajali so znotraj karbonatne platforme. Po mikrofavni sodeč, so se koralno-rudistni grebeni ohranili še v albiju. Sicer pa se je aptijsko albijska sedimentacija dogajala večidel v lagunskem in podplimskem okolju. V mirni in dokaj plitvi vodi so se odlagali mikritni, pelmikritni, biopelmikritni in tanko laminirani bolj ali manj bituminozni apnenci. Na občasno zelo plivo okolje kažejo tudi lumakele z drobnimi rekvienidami, katerih lupine so se po izumrtju teh organizmov kopičile in odlagale v plasteh.

Spodnjealbijski apnenci so nastajali deloma v mirni vodi podplimskega pasu ali lagun, večidel pa na obsežni karbonatni platformi, ki je imela pogosto stik z odptim morjem. Odpto morje in voda s povečano energijo sta bolj ali manj stalno spirala in prezračevala dno nekoliko poglobljenega šelfa, kar je bilo ugodno za rast številnih organizmov in za nastanek biosparitov, biointrasparitov in intraklastičnih sedimentov. Take razmere so bile ugodne zlasti za življenje in bogat razvoj rekvienid in drugih moluskov, ki so ustvarjali obsežne trate na bolj ali manj ravnem dnu. Proti koncu zgornjega albija so se fizikalno-kemični pogoji v albijskem morju pričeli močno spreminjati. K temu je največ pripomogla vedno bolj prisotna in naraščajoča tektonska dejavnost, ki je povzročila spremembe v globini vode. Močno so se spremenile tudi okoliščine za življenje organizmov. Poglobljeni šelf, v katerem so nastajali zgornjealbijski sedimenti, je postajal vse bolj plitev. Mnogi organizmi niso prenesli pogostnih naglih sprememb in so začeli izumirati. To velja zlasti za številne rodove foraminifer. Pojavile so se nove vrste, ki so bile sposobne kljubovati vsem spremembam globine in energije vode. Tako so se na začetku zgornje krede v plitvi in zelo plitvi razgibani vodi močno razmnožili rudisti, ki so ustvarjali obsežne morske trate in pogosto celo manjše grebene.

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Plate 1 - Tabla 1

1, 2 Pelmicritic limestone with *Chara* oogonia (55 ×)
Črnomelj, Berriasian-Valanginian

Pelmikritni apnenec z oogoniji haracej *Chara* sp. (55 ×)
Črnomelj, berriasij-valanginij

3 Dismicritic limestone with *Chara* oogonia (85.5 ×)
Kočarji (Kočevska), Berriasian-Valanginian

Dismikritni apnenec z oogoniji haracej *Chara* sp. (85,5 ×)
Kočarji (Kočevska), berriasij-valanginij

4 Biomicritic limestone with *Chara* oogonia (34 ×)
Kočarji (Kočevska), Berriasian-Valanginian

Biomikritni apnenec z oogoniji haracej *Chara* sp. (34 ×)
Kočarji (Kočevska), berriasij-valanginij

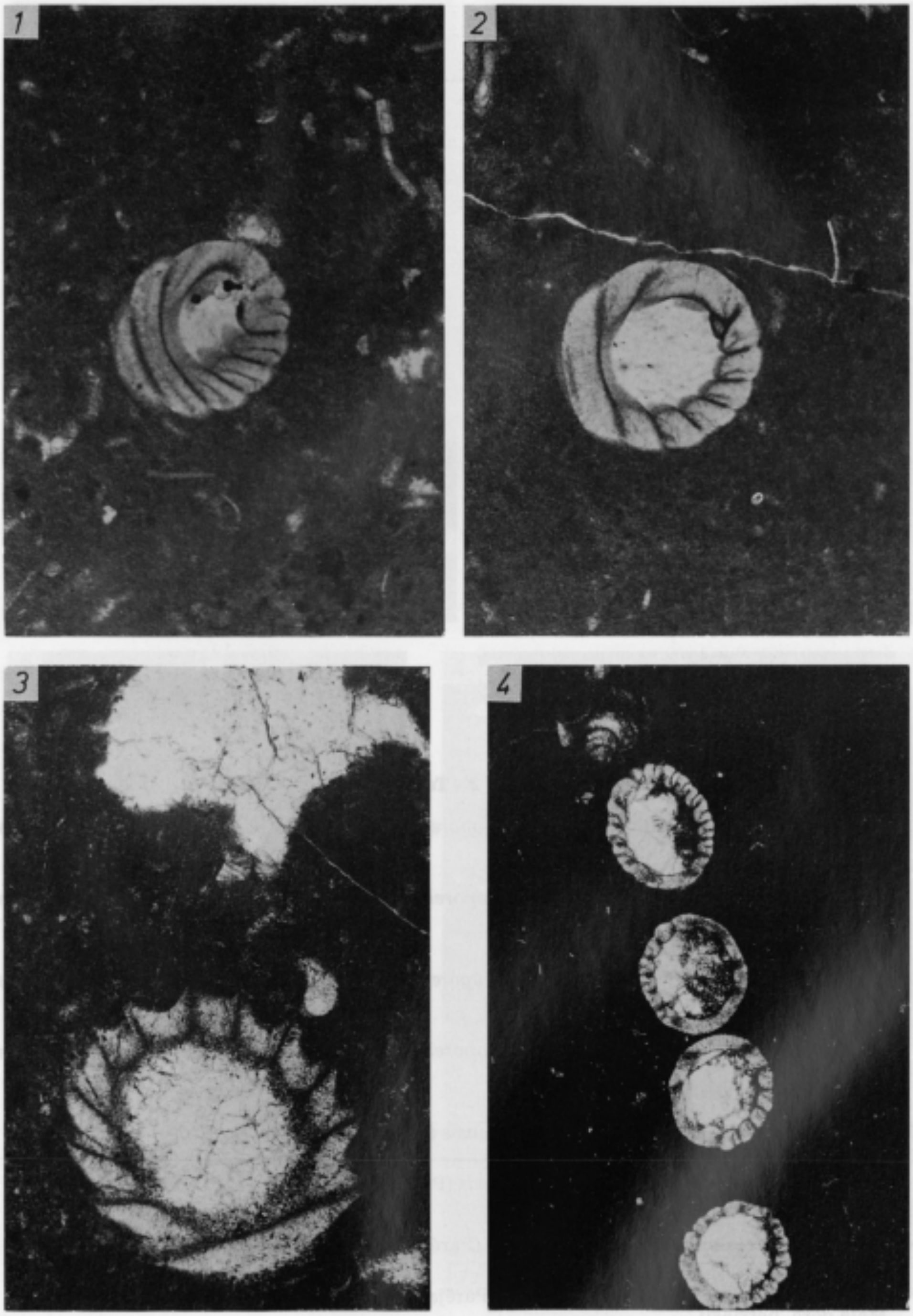
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Plate 2 - Tabla 2

1 Biomicritic limestone with fossils *Salpingoporella annulata* Carozzi and *Favreina salevensis* (Paréjas), 34 ×
W of Grčarice (Kočevska), Berriasian

Biomikritni apnenec s fosiloma *Salpingoporella annulata* Carozzi in *Favreina salevensis* (Paréjas), 34 ×
W od Grčaric (Kočevska), berriasij

2 Biomicritic limestone with fossils *Salpingoporella annulata* Carozzi and *Favreina salevensis* (Paréjas), 13.5 ×
Grčarice (Kočevska), Berriasian

Biomikritni apnenec s fosiloma *Salpingoporella annulata* Carozzi in *Favreina salevensis* (Paréjas), 13,5 ×
Grčarice (Kočevska), berriasij

3 Pelintrasparitic limestone, *Favreina salevensis* (Paréjas), 30 ×
Mala gora, Valanginian

Pelintrasparitni apnenec *Favreina salevensis* (Paréjas), 30 ×
Mala gora, valanginij

4 Pelmicritic limestone, *Favreina salevensis* (Paréjas), 30 ×
Mala gora, Berriasian

Pelmikritni apnenec *Favreina salevensis* (Paréjas), 30 ×
Mala gora, berriasij

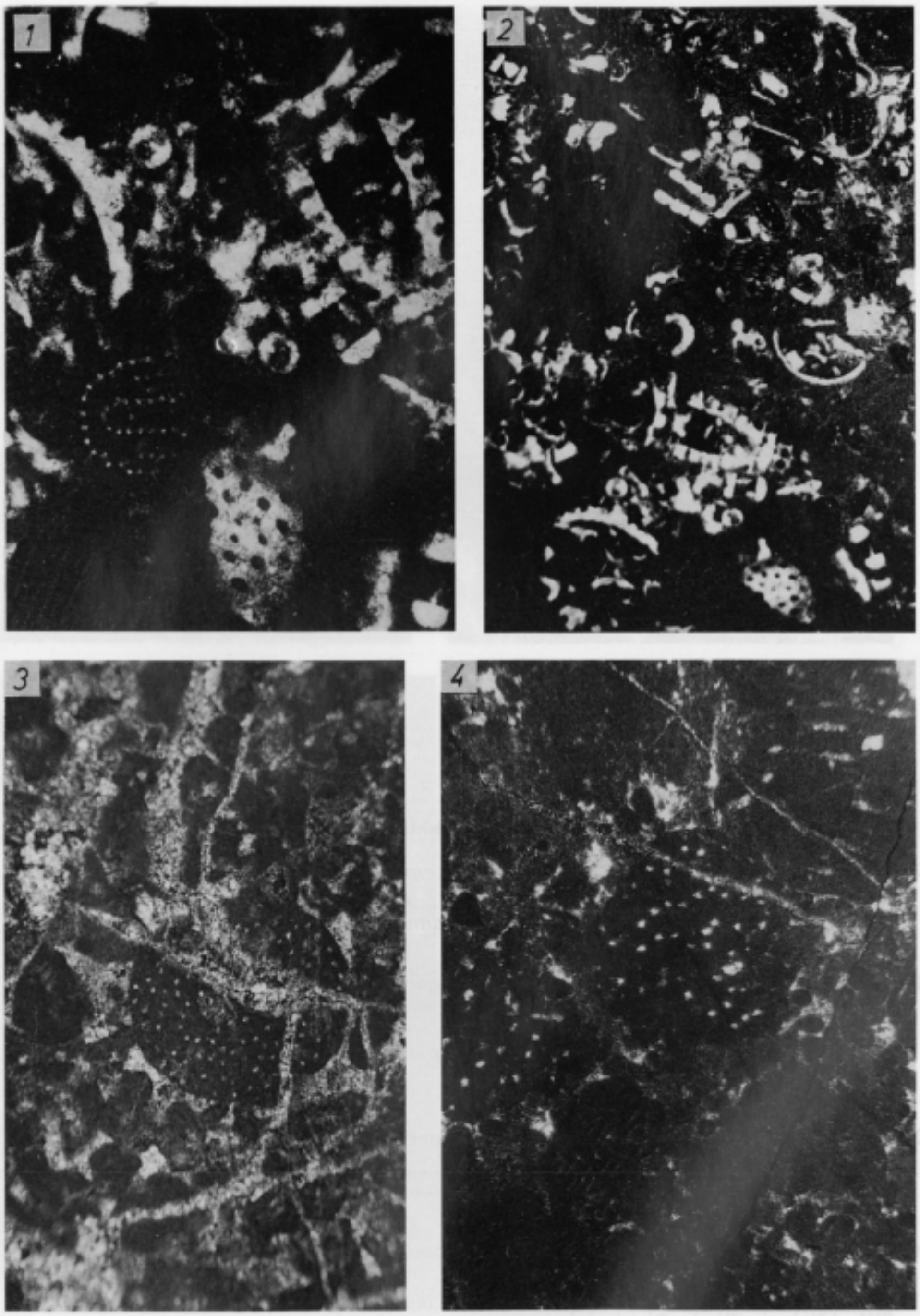
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Plate 3 - Tabla 3

1 Biopelmicrosparitic limestone, *Salpingoporella annulata* Carozzi (34 ×)
W of Grčarice (Kočevska), Barremian

Biopelmikrosparitni apnenec, *Salpingoporella annulata* Carozzi (34 ×)
W od Grčaric (Kočevska), barremij

2 Bioosparitic limestone with microfossils *Salpingoporella annulata* Carozzi (34 ×)
Miliolidae, Ophthalmidiidae, Textulariidae
N of Petekova (Ilirska Bistrica), Valanginian

Biooosparitni apnenec z mikrofosili *Salpingoporella annulata* Carozzi (34 ×)
Miliolidae, Ophthalmidiidae, Textulariidae
N od Petekove (Ilirska Bistrica), valanginij

3 Biomicritic limestone with alga *Clypeina* ? *solkani* Conrad & Radoičić (18 ×)
South of Korinj, Hauterivian

Biomikritni apnenec z algo *Clypeina* ? *solkani* Conrad & Radoičić (18 ×)
Južno od Korinja, hauterivij

4 Dasycladacea limestone, *Clypeina* ? *solkani* Conrad & Radoičić (34 ×)
SW of Dolenje (Ilirska Bistrica), Hauterivian

Biomikritni apnenec z algo *Clypeina* ? *solkani* Conrad & Radoičić (34 ×)
SW od Dolenja (Ilirska Bistrica), hauterivij

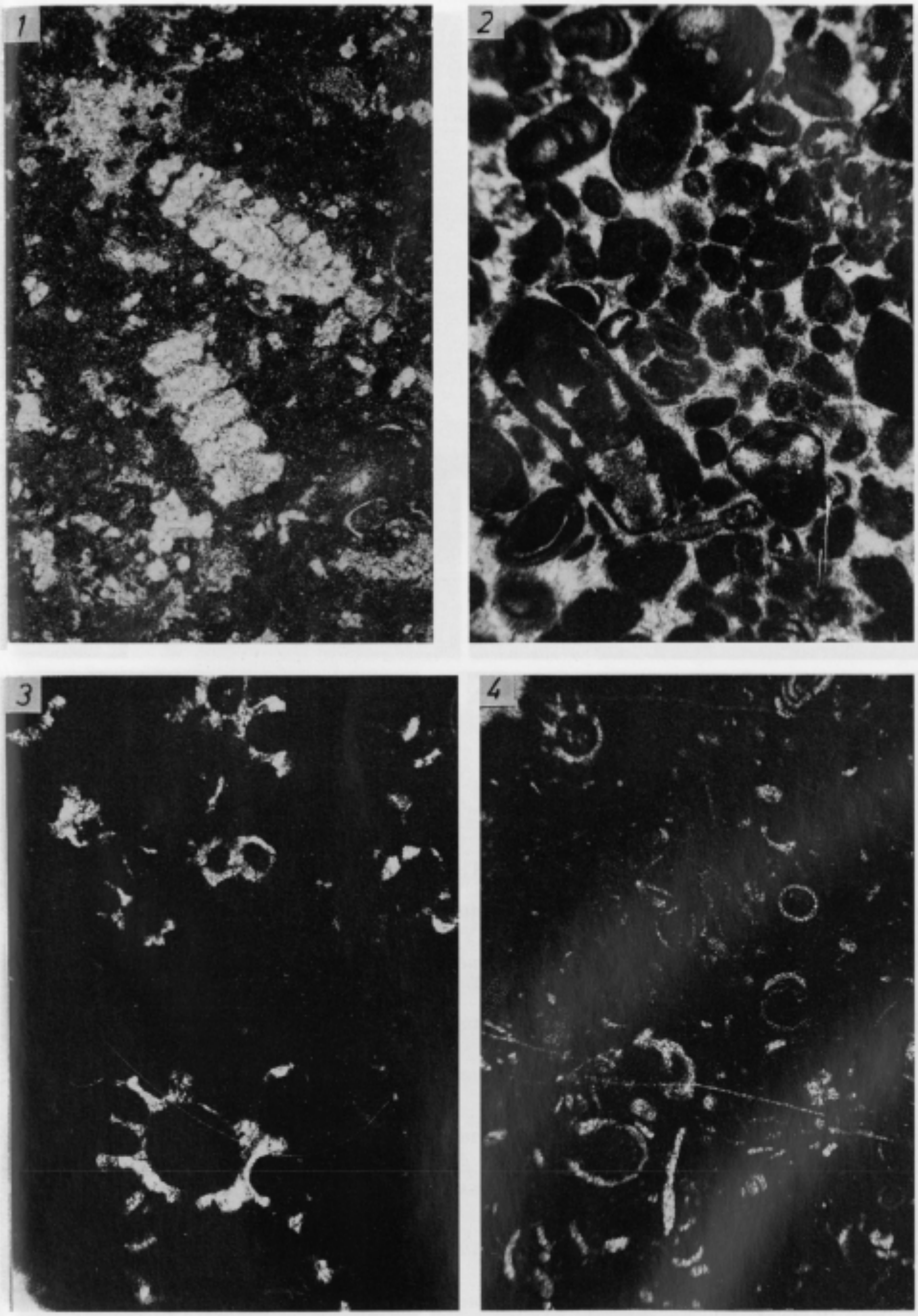
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Plate 4 - Tabla 4

1 Biopelmicritic limestone, *Salpingoporella muehlbergii* (Lorenz), 34 ×
Črnomelj, Barremian

Biopelmikritni apnenec, *Salpingoporella muehlbergii* (Lorenz), 34 ×
Črnomelj, barremij

2 Biopelsparitic limestone, *Salpingoporella muehlbergii* (Lorenz), 55 ×
Črnomelj, Barremian

Biopelsparitni apnenec, *Salpingoporella muehlbergii* (Lorenz), 55 ×
Črnomelj, barremij

3 Biopelmicritic limestone, *Salpingoporella muehlbergii* (Lorenz), 43 ×
Grelc (Kočevska), Barremian

Biopelmikritni apnenec, *Salpingoporella muehlbergii* (Lorenz), 43 ×
Grelc (Kočevska), barremij

4 Biopelmicritic limestone, *Salpingoporella muehlbergii* (Lorenz), 55 ×
Grelc (Kočevska), Barremian

Biopelmikritni apnenec, *Salpingoporella muehlbergii* (Lorenz), 55 ×
Grelc (Kočevska), barremij

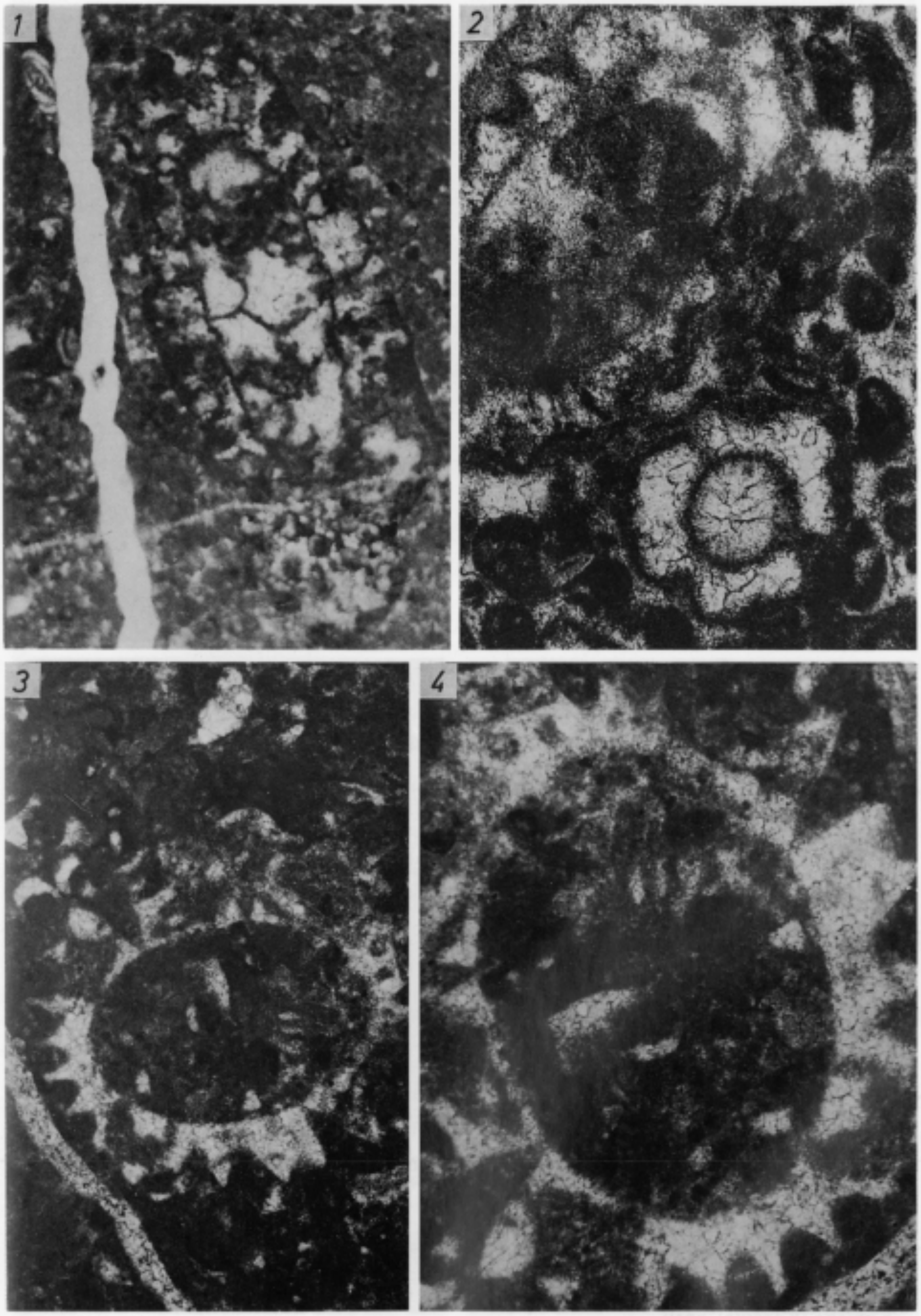
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Plate 5 - Tabla 5

1 Biomicritic limestone, *Salpingoporella dinarica* Radoičić (24.5 ×)
Miliolids, textulariids
Podgozd (Gorica), Aptian

Biomikritni apnenec, *Salpingoporella dinarica* Radoičić (24,5 ×)
miliolide, textularide
Podgozd (Gorica), aptij

2 Biomicritic limestone, *Salpingoporella dinarica* Radoičić (24.5 ×)
Miliolids, textulariids
Stara Cerkev-Vrbovec (Ribnica), Aptian

Biomikritni apnenec, *Salpingoporella dinarica* Radoičić (24,5 ×)
miliolide, textularide
Stara Cerkev-Vrbovec (Ribnica), aptij

3 Brecciated limestone, *Salpingoporella dinarica* Radoičić (24.5 ×)
Miliolids, textulariids
NE of Gomance (Ilirska Bistrica), Aptian

Brečasti apnenec, *Salpingoporella dinarica* Radoičić (24,5 ×)
miliolide, textularide
NE od Gomanc (Ilirska Bistrica), aptij

4 Biopelmicritic limestone, *Salpingoporella dinarica* Radoičić (18 ×)
Konjsko (Kočevje), Aptian

Biopelmikritni apnenec, *Salpingoporella dinarica* Radoičić (18 ×)
Konjsko (Kočevje), aptij

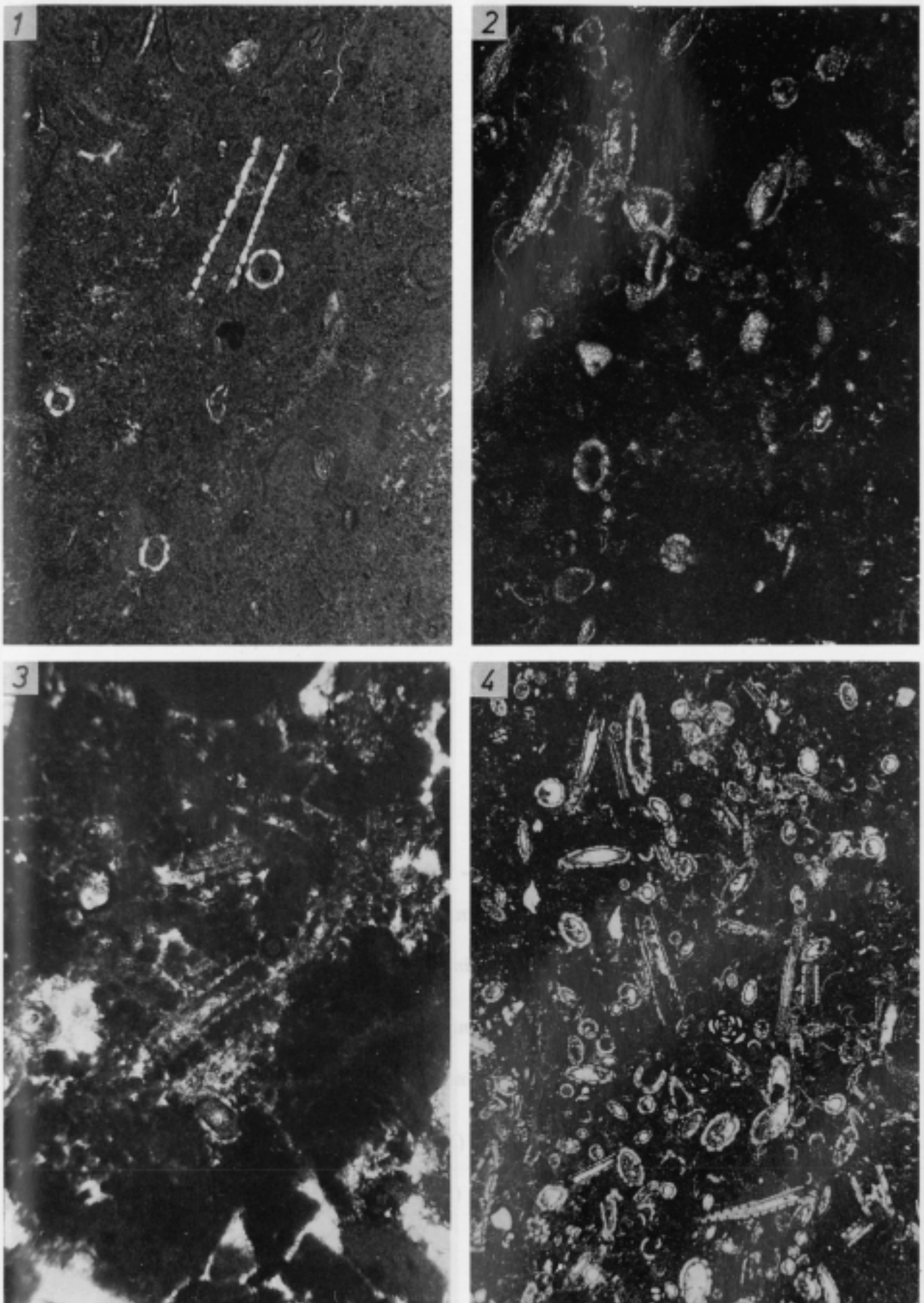
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Plate 6 - Tabla 6

1 Biomicritic *Orbitolina* limestone, ***Palorbitolina lenticularis*** (Blumenbach), 13.5 ×
Konjsko (Kočevje), Lower Aptian

Biomikritni orbitolinski apnenec, ***Palorbitolina lenticularis*** (Blumenbach), 13,5 ×
Konjsko (Kočevje), spodnji aptij

2 Pelmicritic *Orbitolina* limestone, ***Palorbitolina lenticularis*** (Blumenbach), 13.5 ×
Suha krajina, Lower Aptian

Pelmikritni orbitolinski apnenec, ***Palorbitolina lenticularis*** (Blumenbach), 13,5 ×
Suha krajina, spodnji aptij

3 Biomicritic *Orbitolina* limestone, ***Orbitolina (Mesorbitolina)*** ex gr. ***texana*** (Roemer), (55 ×)
Konjsko (Kočevje), Lower Albian

Biomikritni orbitolinski apnenec, ***Orbitolina (Mesorbitolina)*** ex gr. ***texana*** (Roemer), (55 ×)
Konjsko (Kočevje), spodnji albij

4 Biosparitic *Orbitolina* limestone (18 ×)
Logaška planota, Lower Albian

Biosparitni orbitolinski apnenec (18 ×)
Logaška planota, spodnji albij

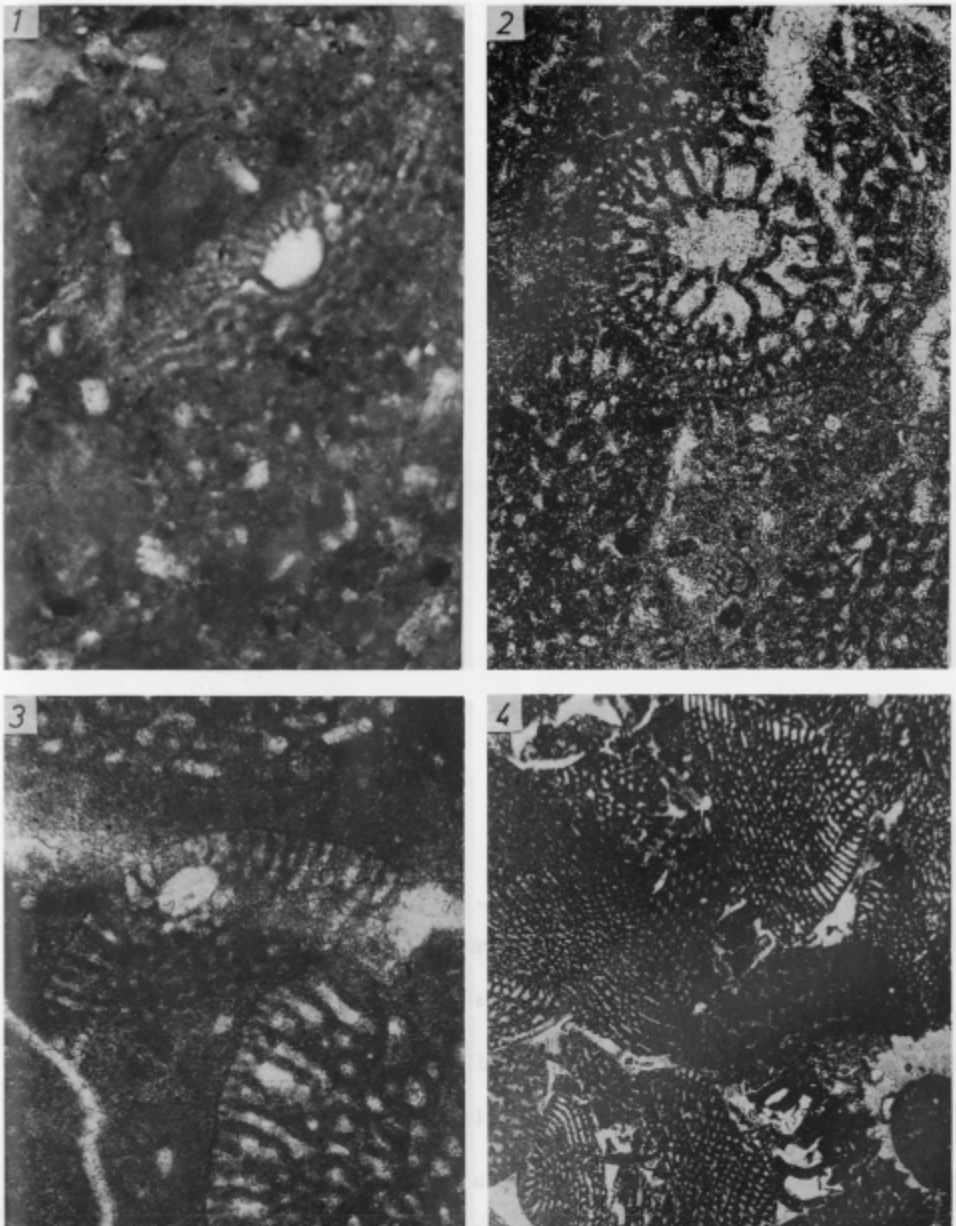
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Plate 7 - Tabla 7

1 Biopelmicritic limestone, *Bacinella irregularis* Radoičić (30 ×)
Mala gora, Aptian

Biopelmikritni apnenec, *Bacinella irregularis* Radoičić (30 ×)
Mala gora, aptij

2 Algal biolitite, *Bacinella irregularis* Radoičić (30 ×)
Fuksov laz (Ribnica), Barremian-Aptian

Algni biolitit, *Bacinella irregularis* Radoičić (30 ×)
Fuksov laz (Ribnica), barremij-aptij

3 Biointramicrosparitic limestone, *Pseudotextulariella ? scarsellai* (De Castro), 50 ×
Črnomelj, Barremian

Biointramikrosparitni apnenec, *Pseudotextulariella ? scarsellai* (De Castro), 50 ×
Črnomelj, barremij

4 Biopelmicrosparitic limestone, *Sabaudia minuta* (Hofker), 43 ×
Konjsko (Kočevje), Aptian

Biopelmikrosparitni apnenec, *Sabaudia minuta* (Hofker), 43 ×
Konjsko (Kočevje), aptij

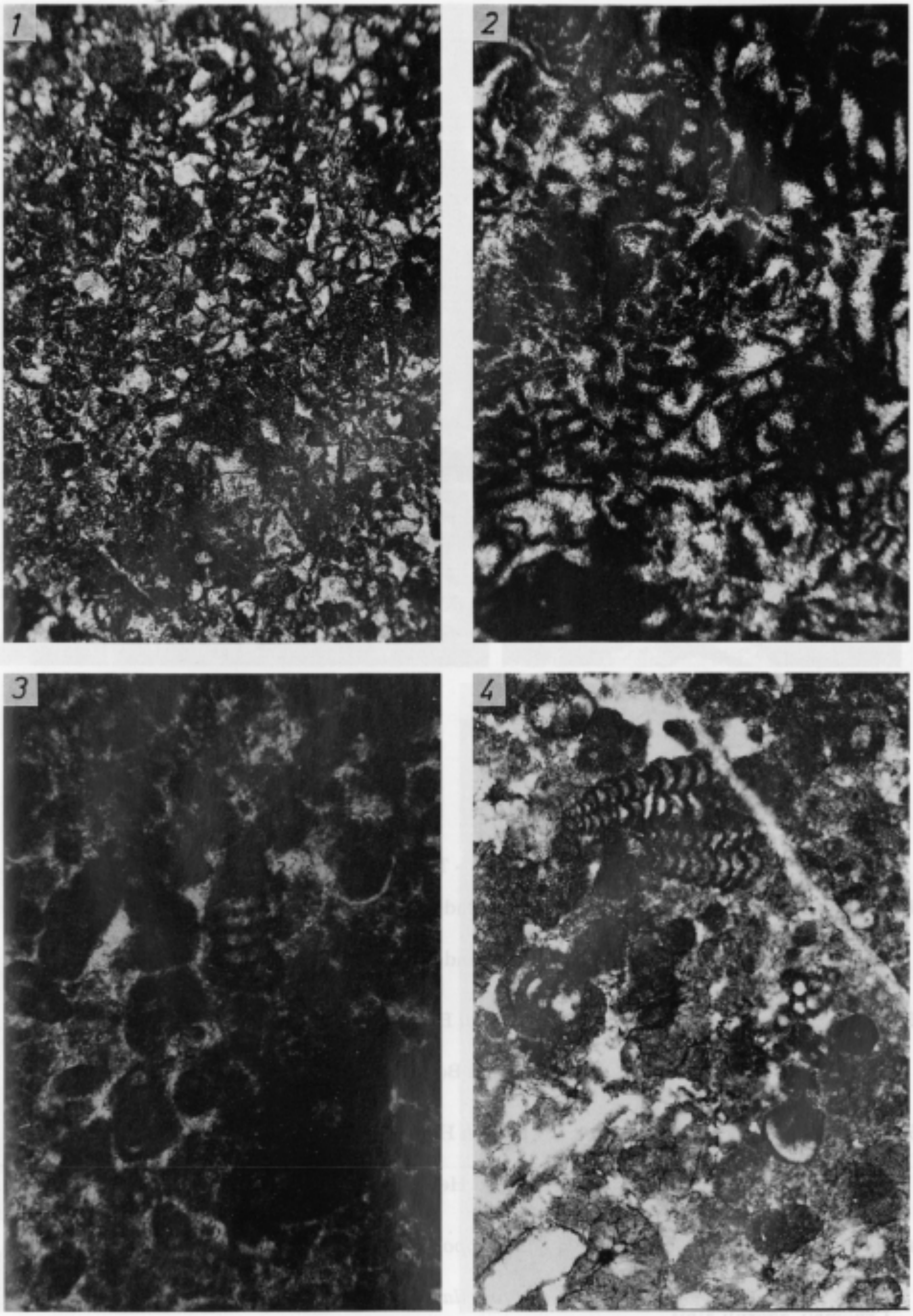
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Plate 8 - Tabla 8

1 *"Valdanchella" dercourti* Decrouez & Moullade (65 ×)
Logaška planota, Upper Albian

"Valdanchella" dercourti Decrouez & Moullade (65 ×)
Logaška planota, zgornji albij

2 Biomicritic limestone, *Nummoloculina heimi* Bonet (34 ×)
Konjsko (Kočevje), Lower Albian

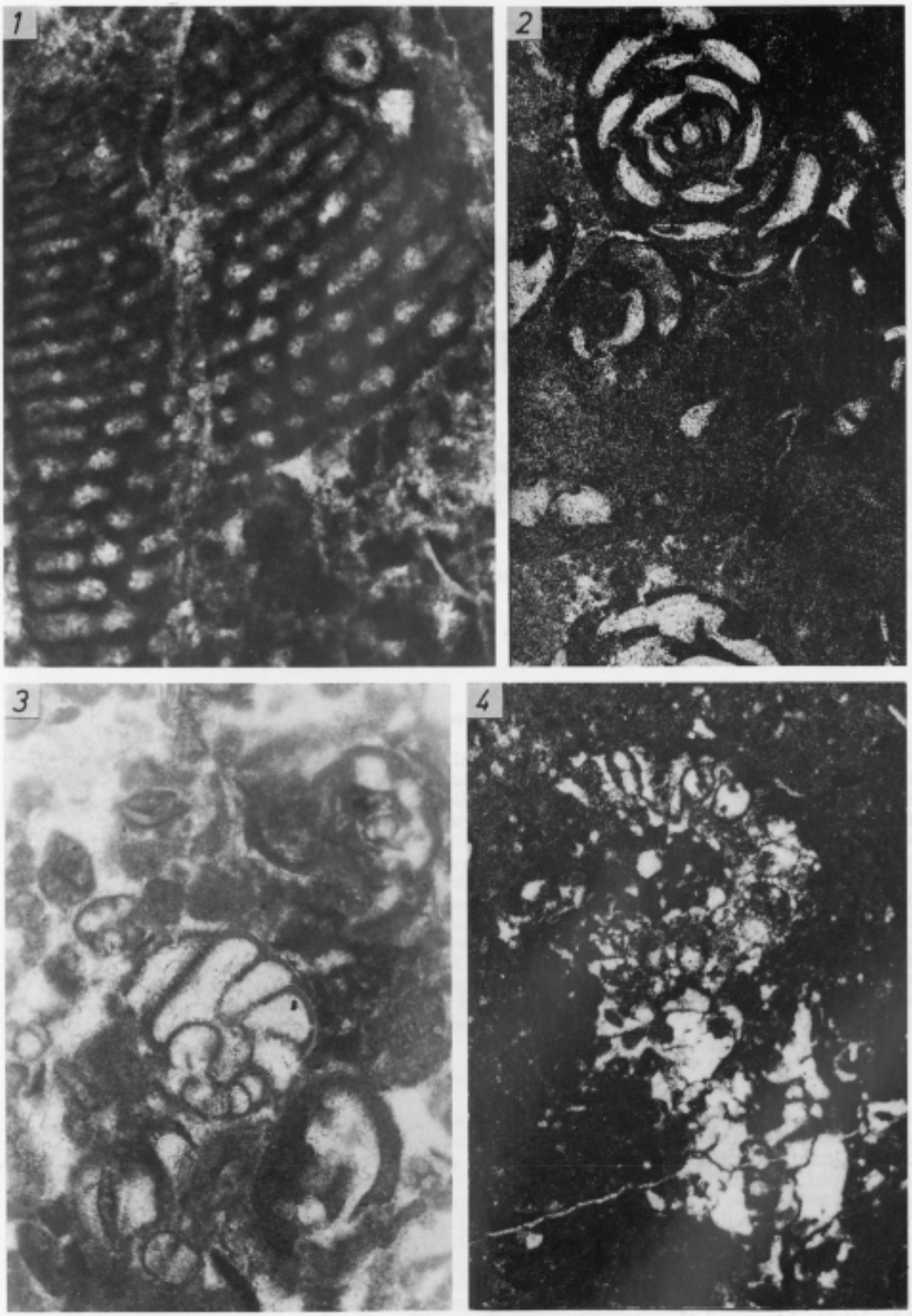
Biomikritni apnenec, *Nummoloculina heimi* Bonet (34 ×)
Konjsko (Kočevje), spodnji albij

3 Biosparitic limestone, *Valvulammina picardi* Henson (65 ×)
Logaška planota, Lower Albian

Biosparitni apnenec, *Valvulammina picardi* Henson (65 ×)
Logaška planota, spodnji albij

4 Biopelmicritic limestone with alga *Salpingoporella turgida* (Radoičić), 16 ×
Črnomelj, Upper Albian

Biopelmikritni apnenec z algo *Salpingoporella turgida* (Radoičić), 16 ×
Črnomelj, zgornji albij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