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Biostratigraphy of Shallow Marine Jurassic Beds in Southeastern Slovenia

Biostratigrafija plitvovodnih jurskih plasti južnovzhodne Slovenije

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Ključne besede: alge, foraminifere, biostratigrafija, jura, Zunanji Dinaridi, južnovzhodna Slovenija

Abstract

The stratigraphic range of fossils collected from different localities has been studied and used as a basis for biostratigraphic subdivision of Jurassic beds in southeastern Slovenia. On the basis of collected micropaleontological data in the area between Logatec, Žužemberk and the river Kolpa, it has been possible to define all units used for the biozonation of these beds in Outer Dinarides. The following cenozones, which can be recognized throughout the carbonate platform area, have been determined: *Palaeodasycladus mediterraneus, Mesoendothyra croatica, Selliporella donzellii, Salpingoporella (Macroporella) sellii* and *Clypeina jurassica*. Some of the above-mentioned cenozones are further divided into subzones. A brief correlation has been carried out among Kočevje shelf lagoon, the Vrhnika-Logatec back-reef and the Suha Krajina central and fore reef Jurassic sediments and fossils. In the back-reef area the cenozone *Palaeodasycladus mediterraneus* with the subzone *Orbitopsella praecursor*, the horizon *Dictyoconus cayeuxi* and the cenozone *Protopeneroplis striata* have been established.

Kratka vsebina

Na mnogih krajih južnovzhodne Slovenije smo zbirali fosilne organske ostanke in preučevali stratigrafsko razširjenost fosilov, dobljene podatke pa uporabljali za biostratigrafsko razčlenitev jurske sedimentne skladovnice. Bolj ali manj neprekinjeno jursko zaporedje sedimentov v slovenskem delu Zunanjih Dinaridov vsebuje sorazmerno bogato in pestro favno in floro. V jurski periodi so na obravnavanem ozemlju nastajale karbonatne kamnine z mikrofavno in floro, hidrozoji, spongijami, koralami, redkeje s školjkami, polži in brahiopodi.

Z zbranimi mikropaleontološkimi podatki smo dokazali in izločili vse enote, ki jih uporabljamo pri biostratigrafski razčlenitvi jurskih plasti Zunanjih Dinaridov, in sicer: *Palaeodasycladus mediterraneus, Mesoendothyra croatica, Selliporella donzellii, Salpingoporella sellii* in *Clypeina jurassica*. Nekatere biostratigrafske enote so razdeljene v podcone. Nadalje smo primerjali jurske sedimente in fosile kočevske lagune, vrhniško-logaškega zagrebenskega območja ter grebenskega in predgrebenskega območja Suhe krajine. V zagrebenskem območju smo ugotovili cenocono *Palaeodasycladus mediterraneus* s podcono *Orbitopsella praecursor*, horizont *Dictyoconus cayeuxi* in cenocono *Protopeneroplis striata*.

Introduction

The aim of the present study is to offer a detailed biostratigraphic classification of the Jurrassic shallow-marine carbonate stratigraphic sequence in southeastern Slovenia.

In the years from 1959 to 1965 S. Buser geologically mapped the territory of south Slovenia from the Italian-Slovenian border in the west, across Trnovski gozd, Hrušica, Nanos, Logatec and Bloke plateau with Javorniki, Krim-Mokrec hills and Lower Carniola, to Suha krajina in the east. During this work he collected a rich fossil material, and achieved the subdivision of Jurassic beds (B u s e r, 1965).

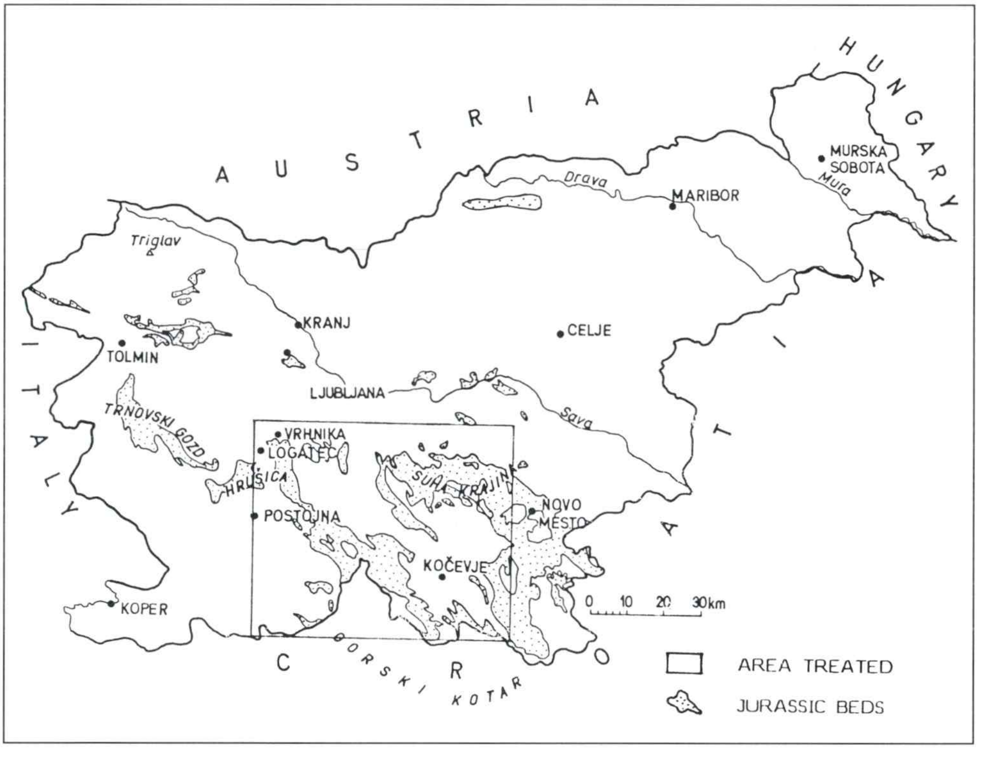

Fig. 1. Distribution of the Jurassic beds in Slovenia and the location sketch map of the study area

Sl. 1. Razširjenost jurskih plasti v Sloveniji in položajna skica ozemlja

The systematic regional mapping of the Slovene territory between Logatec, Žužemberk and the river Kolpa (fig. 1) was carried out in the years between 1960 and

1980 within the framework of regional mapping for the Geologic map of Yugoslavia on the scale of 1:100000. In the study area this enormous project was accomplished by B u s e r (1974), P l e n i č a r & P r e m r u (1977), B u k o v a c et al. (1984) and S a v i ć & D o z e t (1985) who elaborated geological maps on the scale of 1:100 000 with corresponding explanatory texts. A number of new biostratigraphic and other geological data were obtained. Further on, T u r n š e k, B u s e r and O g o r e l e c (1981) described the Upper Jurassic reef complex in the Slovene area. Detailed geological investigations have been carried out in the sections Krka-Mali Korinj and Kompolje-Ogorelec in the Suha Krajina area about 35 kilometres SSE from Ljubljana (S t r o h m e n g e r & D o z e t 1991). In these sections the complete stratigraphic sequence of the Jurassic beds including the contacts between the Upper Triassic and Lower Liassic as well as the Upper Malm and the Lower Cretaceous is exposed. Finally, in the framework of regional investigations for the Geologic Map of Slovenia on the scale of 1:50000 detailed regional mapping of the Suha Krajina region has been carried out by Stevo Dozet and Božo Stojanovič.

On the other hand, the following Serbian and Croatian geologists have made a great contribution to the Jurassic biostratigraphy in the Outer Dinarides: R a d o i č i ć (1964, 1966, 1969, 1987), G u š i ć (1969), G u š i ć et al. (1971), V e l i ć (1977), N i k l e r & S o k a č (1968).

Not at last the present work is based upon the geological investigations and biostratigraphical knowledge of the Mesozoic beds from the Apennines in Italy. The first complete biostratigraphical investigations and subdivision of the Mesozoic beds of the southern Apennines were made by S a r t o n i and C r e s c e n t i (1962). These were followed by De C a s t r o (1962, 1963), C r e s c e n t i and S a r t o n i (1964), C r e s c e n t i (1966), C a t e n a c c i, De C a s t r o and S g r o s s o (1963). A correlation of the Central Apennines and the Outer Dinarides Jurassic and Cretaceous beds was executed by F a r i n a c c i and R a d o i č i ć (1964). C r e s c e n t i (1969) recognized in the Jurassic and Cretaceous outcrops of the Central Apennines three principal facies, and defined the litostratigraphic and biostratigraphic units and their paleogeographical distribution. B u s e r and D e b e l j a k (1994/95) studied the distribution of lithiotids in the Jurassic beds of south Slovenia. The horizon with bivalves (lithiotid horizon) is attributed to Pleinsbachian (Domerian). The most interesting are three large bivalve species: *Lithiotis problematica, Cochlearites loppianus* and *Lithiopedalion scutatus*. In addition, the following genera can be found: *Gervilleioperna, Mytilus, Opisoma* and Pachyrisma (with subgenera *Pachymegalodon* and *Durga)*.

The carbonate rocks are classified according to F o l k's (1959) practical petrographic classification of limestones. The microfauna and microflora are determined by the authors of this paper and Rajka Radoičić. Hydrozoans, sponges and corals were determined by Dragica Turnšek.

Jurassic Bistratigraphy in the Shelf Lagoon Area

In the southeastern part of Slovenia, the Outer Dinarides respectively, comprising Kočevje, Bela Krajina, Kočevski Rog and the extreme northern part of the Gorski Kotar area (Croatia), the complete development of Jurassic beds has been revealed. The 1500 m to 2000 metres thick Jurassic sedimentary succession lies concordantly upon the Upper Triassic dolomite and continually passes upwards into the Lower

Cretaceous limestone and dolomite. The Jurassic beds exposed in the area mentioned consist of shallow-marine carbonate rocks: limestones, dolomites as well as calcareous-, dolomitic-, and calcareous-dolomitic breccias. These carbonate sediments were formed in various carbonate platform environments, such as intertidal, supratidal, subtidal, restricted shoals and lagoons. Generally speaking, the Jurassic sedimentary succession is predominantly built of limestones. The dolomites are subordinated. Breccias occur in larger quantities at the Lower Malm/Upper Malm and Jura/Lower Cretaceous boundaries. The bauxite bodies are arranged along the Lower Kimmeridgian/Upper Kimmeridgian contact in the form of lenses and funnel-shaped bodies. Marls, clays, coal and chert appear in extremely subordinate quantities.

On the basis of significant lithofacies and biofacies as well as their superposition the shallow water Jurassic sedimentary succession was divided into eight lithostratigraphic units. They follow from the oldest to the youngest in this way: 1)- grained bituminous dolomite (Lower Liassic), 2)- lithiotid limestones and dolomites (Middle Liassic), 3)- spotted limestones (Upper Liassic), 4)- foraminiferal, algal and micritic limestones (Dogger), 5)- *Cladocoropsis* limestones and dolomites (Oxfordian and Lower Kimmeridgian), 6)- bauxite, 7)- *Clypeina-Tintinnina* limestones and dolomites (Upper Kimmeridgian and Tithonian), 8)- limestones and dolomites with chert (Upper Kimmeridgian and Tithonian).

From the biostratigraphic point of view, the Jurassic sedimentary successions of the Kočevje area and the whole shelf lagoon area in southeastern Slovenia are subdivided by algae and foraminifers into five cenozones and three subzones. The biostratigraphic subdivision is comparable with the chronostratigraphic one.

Lower and Middle Liassic - Cenozone *Palaeodasycladus mediterraneus*

The Upper Triassic cryptocrystalline and stromatolitic dolomite with rare oncoids, foraminifers and megalodontids grades upwards into the dark-gray, coarsely crystalline, bituminous late diagenetic dolomite containing lithiotids in its upper part, or into the dark-gray shallow-marine limestones alternating with dolomites. The main lithologic characteristics of the Middle Liassic successions is - in addition to lithiotid horizons - the alternation of oolitic, intraoosparitic, and dolomitic layers. Generally speaking, in southern Slovenia three lithologic developments of the Lower and Middle Liassic are distinguished: dolomitic, calcareous-dolomitic, calcareous.

The cenozone *Palaeodasycladus mediterraneus* was established by Sartoni and Crescenti (1959) comprising originally the whole Liassic. In the Slovenian part of the Dinarides, its appartenance has been proved only in relation to the Lower and Middle Liassic. The Lower and Middle Liassic beds are usually rather rich in fossil remains (Plate 1). Among the most important ones are lithiotids.

Lithiotids are very widespread, easily recognizable and relatively well-preserved megafossils with a limited (Middle Liassic) chronostratigraphic range; for this reason we consider them the most convenient fossils for designation of Middle Liassic in the Outer Dinarides.

Within the framework of the *Palaeodasycladus mediterraneus* cenozone the subzone *Orbitopsella praecursor* Guembel (Middle Liassic) is separated and distinguished by the following fossil association:

Foraminifers: *Orbitopsella praecursor* Guembel (Plate 1/3), *Mayncina termieri* Hottinger, *Haurania amiji* Henson, *H. deserta* Henson, *Litousepta recoarensis* Cati, *Orbitopsella* sp., *Involutina* sp., *Trocholina* sp., *Frondicularia* sp., Verneuilinidae, Miliolidae, Textulariidae, Lituolidae.

Algae: *Palaeodasycladus mediterraneus* (Pia) (Plate 1/2), *Thaumatoporella parvovesiculifera* (Raineri), Codiaceae.

Lithiotids: *Lithiotis problematica* Guembel, *Cochlearites loppianus*.

Upper Liassic - Zone of spotted limestones

The upper part of the Liassic sedimentary succession includes spotted limestones characterized by lithologic uniformity and lack of fossils. The Upper Liassic shows the same development throughout the carbonate platform area. These beds are composed of micritic limestones intercalated with oomicritic and intramicritic ones. The spotted limestones are characterized by numerous spots as a result of irregular mineral and chemical rock composition, selective late diagenetic dolomitization of limestones, bioturbation, decolourized iron, and different contents of clay and organic substances. In the considered beds, fossil remains are very rare. They belong to biostratigraphically insignificant foraminifers, Algae, ostracods, microgastropods, and other molluscs. The characteristics of the sediments indicate a deposition in a somewhat deeper restricted shelf environment.

The described succession of limestones lies everywhere in the Kočevje area conformably upon Lithiotid limestones, and it is conformably overlain by sediments with guide Dogger microfossils. Thus, its stratigraphic position is clear, although the limestones do not contain index fossils.

Lower Dogger - Cenozone *Mesoendothyra croatica*

The Lower Dogger beds are uniformly developed in the form of micritic limestones with rare interlayers of biomicrites and grained bituminous dolomite, especially in the lower part of the succession. Among the biomicritic limestones the foraminiferal ones predominate.

Mudstone and wackestone sedimentary structures and law energy index indicate a calm sedimentation in the shallow restricted shelf, or lagoon. The interlayers of intraformational breccia and biointrasparitic limestones point to a temporary agitated environment with a relatively high energy index and periodical influences from the open sea.

The *Mesoendothyra croatica* cenozone comprises calcareous beds with the following association:

Foraminifers: *Mesoendothyra croatica* Gušić, Verneuilinidae, Textulariidae, Glomospira sp.,

Algae: *Thaumatoporella parvovesiculifera* (Raineri), Codiaceae and other fossils such as *Favreina salevensis* (Paréjas), Echinodermata, ostracods and microgastropods.

Upper Dogger - Cenozone *Selliporella donzellii*

The Upper Dogger sedimentation is very similar to the one from the Lower Dogger, additionally including interlayers of intraformational breccia and algal biointrasparite. The relatively uniform sedimentation of micritic, pelmicritic and biopelmicritic sediments indicates that the Upper Dogger beds were formed in the predominantly calm and shallow water of the restricted shelf or even in a lagoon. On the other hand, rare thin intraclastic and breccia interbeds were formed in short periods when intertidal and shallow subtidal conditions predominated.

The Upper Dogger beds are generally more rich in fossils than the Lower Dogger ones, and contain the following fossil association:

Algae: *Selliporella donzellii* Sartoni & Crescenti, *Thaumatoporella parvovesiculifera* (Raineri), Cyanophyta.

Foraminifers: *Meyendorfina bathonica* Aurouze & Bizon, *Trocholina elongata* (Leupold), *Pfenderina salernitana* Sartoni & Crescenti (Plate 2/4), *P. cf. neocomiensis* (De Castro), *Protopeneroplis striata* Weynschenk, *Pfenderina* sp., *Endothyra* sp., *Nodosaria* sp., *Favreina* sp., Verneuilinidae, Textulariidae, Lituolidae as well as Ostracoda, and Echinodermata.

Lower Malm - Cenozone *Salpingoporella sellii*

Concordantly on the Dogger foraminiferal, algal and micritic limestones rest in the study area limestones and dolomites characterized by mass appereance of hydrozoan *Cladocoropsis mirabilis* Felix (Plate 4/1-2). The most significant facies of the succession are *Cladocoropsis* limestones and dolomite as well as foraminiferal, algal, brachiopod and oncolitic limestones. In the lower part of this sedimentary succession micritic, biomicritic and biosparitic limestones alternate. In the middle part of the succession biocalcarenites are predominant. At some places there are minor parastromatoporoid patch reefs and lenses of oolitic and oncolitic limestones. In the whole succession limestones are predominant.

On the basis of the determined macrofauna, microfauna and flora the Malm beds have been divided into two parts: The lower part comprises the Oxfordian and Lower Kimmeridgian, and the upper one includes the Upper Kimmeridgian and Tithonian. Limestones, dolomites and calcareous breccias of the lower part of Malm have been assigned to the *Salpingoporella sellii* cenozone. This biostratigraphic unit is well documented with Algae, foraminifers and megafossils.

Algae: *Salpingoporella (=Macroporella) sellii* (Crescenti), plate 3/1-2, *Gryphoporella minima* Nikler & Sokač, *Salpingoporella annulata* Carozzi, *Thaumatoporella parvovesiculifera* (Raineri), *Aeolisaccus dunningtoni* Elliot, Codiaceae, Cyanophyta.

Foraminifers: *Nautiloculina oolithica* Mohler, *Kurnubia palastiniensis* Henson, *Protopeneroplis striata* Weynschenk, *Labyrinthina mirabilis* Weynschenk, *Pfenderina salernitana* Sartoni & Crescenti, *Pfenderina trochoidea* Smouth & Sugden, *Trocholina elongata* (Leupold), plate 3/3-4, *Trocholina alpina* (Leupold), Verneuilinidae, Biokovinidae, Textulariidae and Lituolidae.

Hydrozoans: *Cladocoropsis mirabilis* Favre, *Shuqraia arrabidensis*.

Anthozoans: *Microphyllia bachmayeri* Geyer, *Convexastraea sexradiata* (Goldfuss), *Rhipidogyra* cf. *alata* (Quensted), *Acanthogyra micra* Eliašova, *Montlivaltia* sp., *Epistreptophyllum tenue* Milaschewitsch.

The hydrozoans and corals were determined by Dragica Turnšek.

Upper Malm - Cenozone *Clypeina jurassica*

The upper part of the Malm succession is uniformly developed in the whole study area. It consists of limestones, dolomites and calcareous-dolomitic breccias. The Upper Malm succession begins usually with intrasparruditic limestone or intraformational breccia. The most frequent sediments in the succession are *Clypeina* limestones and dolomites. In the upper part of the succession intensely dolomitized limestone and dolomite are frequent. In the uppermost part of the succession the beds with aberrant tintinnins predominate. The *Clypeina, Clypeina-Tintinnina* (Plate 6, 7/1-2) and *Tintinnina* limestones and dolomites are the most typical facies of this unit.

In spots, in the upper part of the Upper Malm succession there occur limestones and dolomites with oval, lenticular, rarely irregular chert concretions. The chert nodules in limestones and dolomites are of diagenetic origin. They were probably formed in still unconsolidated carbonate mud by the action of the silica-rich solutions on carbonate, where the carbonates were substituted by silica.

The Upper Malm beds of the Kočevje, Bela Krajina and Gorski Kotar area were formed on the vast carbonate platform in the shallow waters of subtidal, intertidal, supratidal and lagoonal environments. The presence of the organic substance in the sediments indicates a reducing environment. Intraformational conglomerate, and biolaminated limestones and dolomites with nodules and lenses of chert were formed in the intertidal and supratidal environments. The beds of limestones and dolomites with nodules and lenses of chert were formed in a lagoon or in a shallow subtidal environment.

Limestones and calcareous dolomites contain a relatively rich microfossil association with the following Algae, foraminifers and other fossils.

Algae: *Clypeina jurassica* Favre (Plate 5/1-4), *Salpingoporella (Pianella) grudii* (Radoičić), *Salpingoporella annulata* (Carozzi), *Actinoporella podolica* Alth, *Thaumatoporella parvovesiculifera* (Raineri), Cyanophyta, Charophyta and Codiaceae.

Foraminifers: *Kurnubia palastiniensis* Henson, *Trocholina elongata* (Leupold), *Trocholina alpina* (Leupold), *Pseudocyclammina lituus* (Yokoyama), plate 7/4, Verneuilinidae, Lituolidae, Biokovinidae, Textulariidae, Opthalmidiidae, Miliolidae.

Aberrant tintinnids: *Campbelliella milesi milesi* Radoičić (Plate 8).

Gastropods: *Nerinea jeanjeani* Roman, *Ptygmatis minuta* Yin as well as fossils *Favreina salevensis* (Paréjas), Echinodermata and ostracods.

Correlation between the Shelf Lagoon and Reef Complex Sedimentation, Biostratigraphy and Paleogeography in Southeastern Slovenia

Three different sedimentary areas in southern Slovenia are considered and correlated in this paper: 1 - the carbonate platform area (Kočevje, Bela Krajina, Kočevski rog, Gorski Kotar), 2 - the back-reef area (Vrhnika, Logatec plateau, southern Suha Krajina, and 3 - central and fore reef area (northern Suha Krajina, Novo mesto, Metlika).

In the relatively small region of southern Slovenia T u r n š e k (1969) recognized three types of hydrozoan fauna which were connected with the three mentioned areas: the hydrozoan *Cladocoropsis* in the southern faunistic area, the parastromatoporidian hydrozoans, corals, and chaetetids in the central faunistic area, and the actinostromaridian hydrozoans in the northern faunistic area. These different types had developed due to the different ecologic conditions prevalent in each of these areas. The areas with individual faunistic types follow each other in narrow and long belts extending from the southwest to the northeast.

Generally speaking, in the Jurassic beds of the study area in southeastern Slovenia five particular facies are recognizable: shelf lagoon facies, back-reef bioclastic and oolitic facies as well as organic reef facies (central reef) and fore reef facies.

In the Lower Liassic there was a constant shelf lagoon sedimentation all over the area of southeastern Slovenia. The significant differentiation of the Dinaric carbonate platform (fig. 2) environment began there in the Middle Liassic. The back-reef facies had its beginning after the shelf lagoon sedimentation in the Middle Liassic. The reef sedimentation began and ended there in the Malm period.

Fig. 2. Paleogeographic map of the Jurassic beds in the study are

Sl. 2. Paleogeografska karta jurskih plasti obravnavanega ozemlja

The Shelf Lagoon Area

In inner parts of the Dinaric carbonate platform in the Kočevje, Bela Krajina and Gorski Kotar area the carbonate platform shelf lagoon facies existed. It has been already described in detail (R a d o i č i ć, 1966, 1969; B u s e r, 1974, 1978; P l e n i č a r, 1970; D o z e t & Š r i b a r, 1981; B u k o v a c et al., 1984; S a v i ć & D o z e t, 1985; D o z e t, 1990, 1993, 1996; and S t r o h m e n g e r & D o z e t, 1991). However, it is necessary to emphasize the continuity and diversity of the sedimentation there. It was most extensive in Lower and Middle Liassic comprising the whole southern Slovenia. Very interesting is the Lower Liassic limestone development at Krka in the Suha Krajina area (D o z e t, 1993) composed of shallow water lagoonal limestones formed in subtidal, intertidal, and supratidal environments. The succession is characterized by predominantly dark grey carbonate sediments among which micritic, biomiciritic, oomicritic and oncomicritic limestones prevail. The main characteristics of Krka limestones is the well-developed rhythmic sedimentation. The cycles are composed of three members such as cyclothems in the type locality Loferer Steinberge (F i s h e r, 1964).

The Krka limestone succession with Lofer cyclic sedimentation lies concordantly between the Upper Triassic Hauptdolomit and the Middle Liassic beds with lithiotids. The stratigraphic position of the Krka limestones points to their Lower Liassic age. Their age is also confirmed by the fossils: *Palaeodasycladus mediterraneus* Pia, *P. elongatus* Praturlon, *Linoporella lucasi* Cros & Lemoine, *Thaumatoporella parvovesiculifera* (Raineri), *Gyroporella* sp., *Palaeodasycladus* sp., and Codiacea as well as fossils *Favreina salevensis* Paréjas, Textulariidae, and Verneuilinidae. Besides the microfauna and microflora, megalodontids and gastropods also appear in the considered beds.

The Back-Reef Area

The back-reef sedimentation in southeastern Slovenia is represented by oolitic and bioclastic calcarenites which are most typically developed at Vrhnika and in the southern Suha Krajina area. **Tidal-bar oolitic limestones** are massive to thick-bedded. They consist of well-sorted ooids, well-rounded intraclasts, and fossil detritus showing in spots clear graded bedding and cross-bedding. Stromatoporoid hydrozoans, chaetetids, corals, echinoids, bryozoans, pelecypods and benthic foraminifers occur sporadically in the oolitic limestones. In the limestones coated bioclasts are quite frequently encountered. The sedimentologic features in the limestones point to a transport of the clasts in a rather agitated environment. The fossil contents in the limestones indicate the existence of small patch reefs. Numerous echinoid fragments also indicate the proximity to reefs. Oolitic limestones have a thickness of some hundred metres. The oolitic limestones at Vrhnika are of the Middle Liassic to the Lower Kimmeridgian age.

Winnowed edge bioclastic limestones are rocks consisting of fragmental and broken remains of Malm reef-building organisms and calcitic cement. Larger limestone and megafossil fragments and minor arenitic microfossil ones are the main constituents of the limestones. The fragments mostly originate from the Jurassic hydrozoans, sponges, corals, Algae, echinoids, gastropods and other molluscs, as well as bryozoans. From the structural point of view the bioclastic limestones are represented by intrabiosparites in which a strong recrystallization of fossils and fragments of arenitic size is present. Predominantly micritic intraclasts are strongly recrystallized. Also the original matrix is recrystallized. Bioclastic sediments are usually massive to weakly stratified. In spots, the limestones pass laterally and vertically into dolomites formed by a selective late diagenetic dolomitization of the limestones.

The back-reef biostratigraphy differs from the carbonate platform one and is only partly applicable there. In the Jurassic back-reef sedimentary succession the follo-

Table 1. Biostratigraphic subdivision of the back-reef Jurassic beds in the southeastern Slovenia

Tabela 1. Biostratigrafska razčlenitev zagrebenskih plasti južnovzhodne Slovenije

<table>
<tr><th colspan="4">SOUTHEASTERN SLOVENIA
JUŽNOVZHODNA SLOVENIJA</th></tr>
<tr><th colspan="4">Back-reef area - Predgreben</th></tr>
<tr><th colspan="2">AGE - STAROST</th><th>CENOZONE - CENOCONA</th><th>SUBZONE - SUBCONA</th></tr>
<tr><td rowspan="3">M A L M</td><td rowspan="2">Upper
zgornji</td><td rowspan="2">Clypeina jurassica</td><td>Clypeina jurassica
Campbelliella milesi milesi</td></tr>
<tr><td>Clypeina jurassica</td></tr>
<tr><td>Lower
spodnji</td><td rowspan="2">Protopeneroplis striata</td><td></td></tr>
<tr><td rowspan="2">D O G G E R</td><td>Upper
zgornji</td><td rowspan="2"></td></tr>
<tr><td>Lower
spodnji</td><td>HORIZON Dictyconus cayeuxi HORIZONT</td></tr>
<tr><td rowspan="2">L I A S</td><td>Middle
srednji</td><td rowspan="2">Palaeodasycladus mediterraneus</td><td rowspan="2"></td></tr>
<tr><td>Lower
spodnji</td></tr>
</table>

wing biostratigraphic units (table 1) are defined (from bottom to top): 1 - Cenozone *Palaeodasycladus mediterraneus* Pia, 2 - *Dictyoconus cayeuxi* Lucas horizon, 3 - Cenozone *Protopeneroplis striata* Weynschenk.

Lower and Middle Liassic - Cenozone *Palaeodasycladus mediterraneus*

The cenozone *Palaeodasycladus mediterraneus* (Pia) with the *Orbitopsella praecursor* (Guembel) subzone was first described in the southern Apennines in the Venice and Trento districts by S a r t o n i and C r e s c e n t i (1959). The biozone was ascribed to the Liassic, and the subzone to the Middle Liassic.

In the Dinaric carbonate platform area this cenozone corresponds to the stratigraphic range of alga P. *mediterraneus* (Pia) comprising the Lower and Middle Liassic. In the oolitic limestones of the back-reef area, only the upper part of the P. mediterraneus cenozone is presented which is of the Middle Liassic age. In the middle part of the cenozone the *Orbitopsella praecursor* subzone is defined. The Middle Liassic sedimentary succession contains numerous microfossils among which predominate **foraminifers:** *Orbitopsella praecursor* (Guembel), *Lituosepta recoarensis* (Cati), *Agerina martana* (Farinacci), *Orbitopsella* sp., *Glomospira* sp., Textulariidae, Ophthalmidiidae, Verneuilinidae, and Lagenidae.

In addition to foraminifers there also appear **Algae:** *Paleodasycladus mediterraneus* Pia, *Thaumatoporella parvovesiculifera* (Raineri), *Palaeodasycladus* sp., Cyanophyta, Codiaceae and blue-green algae. Rarely found are the species *Favreina salevensis* (Paréjas) and fragments of alga *Aeolisaccus* sp. In addition to foraminifers and Algae, remains of hydrozoans, bryozoans, corals, ostracods, echinoids and molluscs can also be found.

Dogger - *Dictyoconus cayeuxi* horizon

The horizon *D. cayeuxi* was considered by C r e s c e n t i (1969) as coinciding with the stratigraphic range of the foraminifera *Dictyoconus cayeuxi* Lucas. In the Outer Dinarides area it is referable to the Dogger. It is characterized by the following microfossils:

Foraminifera: *Dictyoconus cayeuxi* Lucas, *Spiraloconulus perconigi* Allemann & Schroeder, *Nautiloculina oolithica* Mohler, *Mesoendothyra croatica* Gušić, *Mesoendothyra* sp., *Trocholina* sp., *Protopeneroplis* sp., *Evertycyclammina* sp., *Frondicularia* sp., Verneuilinidae, Textulariidae, Miliolidae, Trochaminidae, Lituolidae and Ophthalmidiidae.

Algae: *Selliporella donzellii* Sartoni & Crescenti, *Thaumatoporella parvovesiculifera* (Raineri), Cyanophycea, Codiacea.

Ostracods, corals, gastropods and other molluscs as well as bryozoans.

Dogger and Lower Malm - Cenozone *Protopeneroplis striata*

This cenozone is most characteristic of the oolitic facies in the back-reef area. It was established by S a r t o n i and C r e s c e n t i (1962), its lower limit being marked by the extinction of *Dictyoconus cayeuxi* as well as by the appearance of *Protopeneroplis striata*. The cenozone is relatively rich in microfossils, especially foraminifers, among which the species *P. striata* is of major extent and importance.

Foraminifera: *Protopeneroplis striata* Weynschenk (Plate 2/2-3), *Labyrinthina mirabilis* Weynschenk, *Nautiloculina oolithica* Mohler, *Trocholina elongata* (Leupold), *Trocholina alpina* (Leupold), *Kurnubia palastiniensis* Henson, *Pfenderina* sp., *Protopeneroplis* sp., *Trocholina* sp., *Lepidocyclina* sp., *Frondicularia* sp., *Cristelaria* sp., Lituolidae, Textulariidae, Verneuilinidae, Miliolidae, Lagenidae.

Algae: *Salpingoporella annulata* Carozzi, *Heteroporella anici* Nikler & Sokač, *Thaumatoporella parvovesiculifera* (Raineri), *Palaeosyphonium convolvens* (Praturlon), *Solenopora jurassica* (Nicholson).

In addition to microfossils there also appear some megafossils:

Hydrozoans: *Cladocoropsis mirabilis* Felix (Plate 4/1-2), *Dehornella omanensis* Hudson, *D. crustans* Hudson, *Milleporidium remeši, Parastromatopora japonica* Yabe & Sugiyama, *P. memoria naumanni* Yabe & Sugiyama, *Shuqraia zuffardii.*

Chaetetids: *Acanthochaetetes foroiuliensis* (Zuffardi & Comerci), *Bauneia multitabulata* (Deninger), *Chaetetopsis crinita* (Neumayr).

Corals: *Allocoenia trochiformis* Etallon, *Calamophylliopsis moreauana* Michelin, *Comoseris baltovensis* Roniewicz, *Meandrophyllia amedei* Etallon, *Meandrophillia edwardsi* (Michelin), *Microsolena thurmanni* Koby, *M. agariciformis* (Etallon), *Heliocoenia orbigny* Roniewicz, *Heliocoenia variabilis* Etallon, *Pseudocoenia variabilis, P. limbata* (Goldfuss), *P. longiseptata* Roniewicz, *Plesiosmilia compressa* (Koby), *Puhastraea kamiennae* Roniewicz, *Stylosmilia corallina* Koby, *Stylosmilia pumila, Thamnasteria concanna* Goldfuss, *Pleurophyllia* sp., *Enhalhellia* sp., *Thamnasteria* sp., *Halisitastraea* sp. as well as bryozoans, echinoids and molusc.

Central and Fore Reef Area

In the Jurassic period on the Dinaric carbonate platform a shallow water shelf sedimentation was established. The sedimentation was continuous, if we exclude the local short-lasting interruption on the Lower Malm-Upper Malm transition, when in periods of the short land phase thin bauxite deposits were formed. On the other hand, in the transition area between the shelf and the Slovenian trench, orogenetic activity was present, causing the lifting of the marginal parts of the Dinaric carbonate platform, thus forming dry land at the end of the Middle Liassic. With the formation of the dry land the sedimentation was completely interrupted there and such conditions were preserved until the Lower Malm. The Middle Liassic-Lower Malm stratigraphic gap is proved by the absence of the Lower Liassic and Dogger sediments. On the other hand, an erosional-tectonic discordance between the Triassic-Liassic succession and the reef sediments points to orogenic movements in that interval, which we connect with the movements of the Mesokimmerian orogenic phase (T o l l m a n n, 1966). The considered stratigraphic gap is an evident proof of an emersion after the deposition of the Middle Liassic beds which lasted until the Lower Malm transgression. The mentioned Middle Liassic-Lower Malm emersion was not a local phenomenon, for it has been observed and proved in several parts of the Slovenian, Croatian and Bosnian Dinarides. (T u r n š e k, 1969; B u s e r, 1974; B u k o v a c et al., 1974; Š p a r i c a, 1981; D o z e t, 1989, 1994). The above-mentioned authors and others emphasized that the paleogeographical and structural changes which appeared in the Dinarides after the deposition of the Middle Liassic beds, were expressed by the Middle Liassic-Lower Malm stratigraphic gap. In that time interval some areas in the Outer Dinarides were completely without sedimentation, and are understood paleogeographically as a bar with greater and minor elevations. They could be interpreted as a part of a uniform island chain extending from Bosnia Krajina, over Kordun, Banija, Žužemberk, Bela krajina, Suha krajina, Trnovski gozd, onward to the northwest. This morphologically well-exposed narrow bar was in the closest connection with the differentiation of the sedimentary areas on the - by that time uniform - Dinaric carbonate platform. Malm hydrozoan-coral reefs were also formed. The reef complex is thought to be a barrier-reef that developed along the shelf margin of an ancient carbonate platform (T u r n š e k, B u s e r & O g o r e l e c, 1981). It should be recalled that in the inner carbonate platform area no tectonic movements occurred in the Mesozoic period (D o z e t, 1989), because no folding, thrusting or nappe-tectonic traces, traces of volcanism or metasomatic changes on sedimentary rocks in that time can be found there. Nowhere any tectonic-discordant contacts can be seen; on the contrary, in all cases concordance or at most only light discordance is dealt with. In the carbonate platform area also no coarse-grained basal transgressive formations can be found so that we are right in affirming that the continuity of sedimentation was disturbed only by the periodical interruptions as a reflection of weak or stronger epeirogenic movements of the carbonate platform. These movements gave rise to periodical land in the Mesozic; they also affected the differentiation of the environment and in this way had a considerable influence on the sedimentation.

Relatively continuous sedimentation - though of another type - also occurred all over the Jurassic period in the areas of the Dinaric carbonate platform near to the bar, i.e. in the back-reef areas.

The central and fore reef area is built by sediments the main constituents of which are fossils or their fragments. Consequently, the considered sedimentation is represented by organic biolithitic limestones and fore reef breccias.

The organic reef is composed of light gray, medium gray, gray, rarely dark gray biolithitic limestones. **Biolithitic limestones** are unstratified rocks of the calcareous remains of reef-building organisms cemented by calcium carbonate. The central reef was built by Jurassic reef-building organisms such as hydrozoans, sponges, corals, bryozoans, chaetetids, Algae, gastropods and other molluscs and echinoids. The relatively numerous bioherms and the extension of the reef carbonate rocks in southeastern Slovenia indicate reefs of barrier type. In the basal part of the reef limestones there are gray, dark gray, thick-bedded limestones with nodules, lenses and thin layers of chert. The reef limestones have a thickness of 400 m to 550 m. Hydrozoans were the main reef-building organisms there. Among the hydrozoans the predominant family is Sphaeractinidae with genres *Sphaeractinia* and *Ellipsactinia,* but there are also numerous other hydrozoans of Actinostromariicea. Therefore T u r n š e k (1966, 1969) named the hydrozoans of the northern area as the actinostromarid type. Chaetetids, corals and pelecypods are rare there. The form of the colonies, the great amount of the reef-building fauna, and the structure of the sediments indicate that this northern faunistic area was a true reef formation. Because of the great prevalence of the hydrozoan fauna, T u r n š e k (1966, 1969) even called it the hydrozoan reef. This actinostromarid reef formed a reef barrier that represented the border between the shelf and the deeper sea.

Fore reef breccias are sedimentary rocks formed by the consolidation of fragments of Jurassic limestone and reef-building organisms broken off from reefs by the action of waves. In the rocks the most frequent fragments are those of hydrozoans, corals and pelecypods. They are cemented by calcitic cement.

Conclusions

Three different paleogeographic and sedimentary areas are considered and in some way correlated in this paper; these are: the shelf lagoon area, the back-reef area, as well as central reef and fore reef areas. Likewise, in the Jurassic outcrops of southeastern Slovenia, generally five different facies are recognizable: shelf lagoon facies, oolitic facies, bioclastic facies as well as organic reef and fore reef facies.

Biostratigraphically, the area studied in greatest detail is the carbonate platform in the Kočevje area. Five cenozones and three subzones are present there; these are: *Palaeodasycladus mediterraneus, Mesoendothyra croatica, Selliporella donzellii, Macroporella sellii* and *Clypeina jurassica* (cenozones); *Orbitopsella praecursor, Clypeina jurassica,* and *Clypeina jurassica* + aberrant tintinnids (subzones). The cenozone *Palaeodasycladus mediterraneus* covers the Lower and Middle Liassic. Due to the lack of significant fossils, the zone of the platy dolomites (Lower Liassic) and the zone of spotted limestones (Upper Liassic) were separated. The cenozone *Mesoendothyra croatica* covers the lower part of the Middle Jurassic succession while the cenozone *Selliporella donzellii* covers the upper one. For the carbonate platform in the Slovenian part of the Outer Dinarides the bipartite subdivision of the Malm succession is proposed: the cenozone *Salpingoporella sellii,* covering the lower part of the Malm, and *Clypeina jurassica* representing the upper part of Malm.

In the Jurassic sedimentary succession of the back-reef area three following biostratigraphic units have been defined. The cenozone *Palaeodasycladus mediterraneus,* the *Dictyoconus cayeuxi* horizon, and the cenozone *Protopeneroplis striata.* As in the inner carbonate platform, in the back reef area the cenozone *Palaeodasycladus mediterraneus* comprising Lower and Middle Liassic was established. The horizon *Dictyoconus cayeuxi* appears in Dogger. Finally, the third biostratigraphic unit, the *Protopeneroplis striata* cenozone includes the uppermost part of Dogger and Lower Malm.

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Biostratigrafija plitvovodnih jurskih plasti južnovzhodne Slovenije

Sklep

Jurske plasti so poleg triasnih najbolj razširjene kamnine obravnavanega ozemlja. Skladovnica jurskega apnenca in dolomita leži konkordantno na zgornjetriasnem dolomitu; prehod iz zgornjetriasnega stromatolitnega dolomita v zrnati bituminozni jurski (liasni) dolomit je postopen. Med Krko in Zagradcem predstavlja spodnjeliasne plasti apnenčev razvoj, kontakt z glavnim dolomitom pa je oster. Spodnjeliasni Krkini apnenci so plastnati, temno sivi do črni. V strukturnem pogledu prevladujejo mikriti in biomikriti z algami. V spodnjeliasnih apnencih je med drugim najdena in določena tudi alga *Palaeodasycladus mediterraneus* Pia. Poleg omenjenih se v spodnjeliasnem zaporedju pojavljajo še oomikritni, intrasparitni in biointrasparitni apnenci z vložki intraformacijskih breč in konglomeratov, fenestralnih apnencev, stromatolitnih apnencev, tu in tam dolomitov. Našteti sedimenti kažejo izrazite plitvomorske karakteristike in so nastajali v podplimskem, medplimskem in nadplimskem okolju. Srednjeliasna sedimentacija je bila precej bolj pestra kot spodnjeliasna. Srednjeliasno sedimentno zaporedje sestoji iz zrnatih dolomitov, intraformacijskih dolomitnih breč, biopelmikritnih, oosparitnih, oointrasparitnih ter litiotidnih in megalodontidnih apnencev. Gre za eno najbolj tipičnih jurskih formacij, ki obsega pestro zaporedje karbonatnih sedimentov, katerim skupna značilnost je vsebnost litiotid. Litiotide so ponavadi nakopičene v obliki lumakel: V spodnjem delu so lumakele redkejše in tanjše ali pa najdemo le posamične preseke in litiotidne odlomke. Litiotidni apnenci so temno sivi do sivkasto črni biomikriti, redkeje biospariti. So debeloplastnati, slabo plastnati ali celo masivni. V spodnjem delu litiotidne enote se pogosto pojavljajo biointrasparitni, oosparitni in biomikritni apnenci z orbitopsellami in drugimi mikrofosili, niso pa tudi redki vložki dolomita. V litiotidni formaciji prevladuje biostromni tip sedimentacije, zrnati apnenci in dolomiti pa so nastajali predvsem v plitvem podplimskem, medplimskem in tudi nadplimskem okolju. V srednjeliasnih plasteh južnovzhodne Slovenije so bogata nahajališča značilnih školjk, ki so v pliensbachiju in toarciju množično poselile obsežne med seboj povezane plitvomorske predele Dinarske karbonatne platforme. Najzanimivejše so tri vrste velikih školjk (B u s e r & D e b e l j a k, 1994/95): *Lithiotis problematica, Cochlearites loppianus* in *Lithiopedalion scutatus*. Poleg teh najdemo v srednjeliasnih apnencih še druge rodove, kakor npr. *Gervilleioperna, Mytilus, Opisoma* in *Pachyrisma* (s podrodovoma *Pachymegalodon* in *Durga)*.

Zgornjeliasne plasti se pojavljajo v obliki nekaj deset metrov debelega pasu. Odgovarjajo formaciji marogastih apnencev. Gre za sive do sivkasto črne mikritne in dismikritne apnence z redkimi ostanki alg in foraminifer. V mikritno osnovo so bili z valovi in tokovi naneseni bolj ali manj številni ooidi, pseudoooidi, onkoidi ali intraklasti. Med teksturnimi oblikami opazujemo v teh apnencih le rahlo, zelo drobno laminacijo. Po strukturnih in teksturnih posebnostih obravnavanih sedimentov sklepamo, da so se le-ti oblikovali v zatišnem delu šelfa, okolje pa je moralo biti za žive organizme precej neugodno. Po stratigrafski legi sodeč, je opisano zaporedje sedimentov zgornjeliasne starosti. Leži namreč med litiotidnimi apnenci in doggerskimi oolitnimi apnenci.

Konkordantno na marogastih apnencih leže foraminiferni, algni in mikritni apnenci, med katerimi prevladujejo temno sivi mikritni apnenci z vložki foraminifernih in algnih biomikritnih apnencev. V spodnjem delu skladovnice prevladujejo med apnenci biomikriti z mezoendotirami, v zgornjem delu pa biomikriti s selliporelami. Zgornjedoggersko skladovnico sestavljajo apnenec, apnenčeva breča in dolomit. Opisano zaporedje je običajno revno s fosili. Sedimentne oblike in posebnosti spodnjedoggerskih kamenin kažejo na pretežno mirno sedimentacijo v plitvem zaprtem šelfu, ponekod tudi v plitvih lagunah.

Sem in tja so se na prehodu iz liasne v doggersko dobo sedimentacijske razmere močno spremenile, kljub temu pa se je karbonatna sedimentacija še naprej nadaljevala. Nad marogastimi apnenci leži več kot sto metrov debela skladovnica temno sivih, sivkasto črnih in črnih, redkeje sivih oolitnih apnencev, v katerih so našli spodnjedoggersko in srednjedoggersko mikrofavno in floro. V strukturnem pogledu gre za srednjezrnate oosparitne in intraoosparitne apnence, ki se ločijo od spodnjemalmskih oolitnih apnencev po temnejši barvi in po tem, da ne vsebujejo grebenske favne.

Povečini gre za dobro sortirane in izprane sedimente, ki vsebujejo v glavnem le redke odlomke fosilov. V glavnem gre za foraminifere. Največ mikrofavne in flore sledimo v tankih vložkih sivih in temno sivih biomikritov.

Lagunske plasti spodnjega dela malma so litološko zelo pestre. Njihovo zaporedje se ponavadi prične s srednje sivim in sivim plastnatim sparitnim, mikritnim in biomikritnim apnencem, ki so bolj ali manj dolomitizirani. Navzgor sledi temno sivi in črni plastnati apnenec, ki pripada različnim strukturnim tipom. Za ta del zaporedja so ponekod značilne lumakele z brahiopodi in vložki dolomita s cladocoropsisi. V vrhnjem delu zaporedja prevladujejo biokalkareniti, ponekod pa so ugotovljeni tudi manjši grebeni in leče oolitnega in onkoidnega apnenca. V spodnjem in srednjem delu obravnavanega sedimentnega zaporedja so tanjše in debelejše partije drobno-, srednje- in debelozrnatega, nekoliko bituminoznega dolomita. Spodnjemalmsko zaporedje sedimentov zaključujejo plasti intraformacijskega konglomerata in breče. Našteti sedimenti so ponavadi jasno plastnati in ponekod laminirani ali celo stromatolitni. Struktura je zelo drobnozrnata, arenitna in ruditna. V strukturnem pogledu ločimo mikritne, biomikritne, pelmikritne, intrasparitne, biointrasparitne in druge prehodne oblike. Opisane spodnjemalmske plasti so se oblikovale na obsežni karbonatni platformi v mirni vodi plitvih lagun ter v med- in podplimskem pasu. Tu se je usedalo apnenčevo blato, iz katerega je nastal mikrit. Okolje je bilo ugodno predvsem za razvoj alg in foraminifer, manj za druge organizme. Od časa do časa so nastopile ugodne razmere za rast spongij, brahiopodov, školjk in polžev. S kopičenjem njihovih skeletov so ponekod nastale lumakele, ki so se ohranile v obliki tanjših vložkov znotraj spodnjemalmske skladovnice.

Oolitne apnence srečujemo v juri že v srednjeliasnih plasteh, vendar se tu pojavljajo le v obliki tanjših ali debelejših vložkov. Nekaj sto metrov debelo skladovnico oolitnih apnencev pa imamo v spodnjem delu malmskih plasti. Gre za masivne, ponekod tudi slabo plastnate, praviloma dobro sortirane oosparitne, ooonkosparitne in intraoosparitne apnence, ki vsebujejo bolj ali manj številne foraminifere, alge, odlomke moluskov ter posamične korale in hidrozoje. Večinoma gre za dobro izprane apnence tipa "grainstone". Slabo izprani oolitni apnenci so redki, pripadajo pa oomikritu in biomikritu tipa "packstone". V oolitnih apnencih dobimo vložke mikritov, biomikritov, včasih tudi nepravilne leče ali vložke poznodiagenetskega dolomita. V oolitnih apnencih se pojavljajo vodoravna in navzkrižna laminiranost ter postopna zrnavost. Ponekod so organizmi nakopičeni v toliki množini, da sestavljajo manjše ozke grebene, ki se bočno izklinjajo. Med grebenotvornimi organizmi so prevladovali hidrozoji, spongije in korale, na območju grebenov pa so živeli tudi polži (nerineide), školjke, briozoji, alge in foraminifere. Redki so bili grebeni, ki so jih sestavljali stromatoporoidi, korale in hetetide. Opisane grebene uvrščamo med zatišne grebene.

Proti koncu spodnjega malma je morje postajalo vse plitvejše. Med spodnjim in zgornjim kimmeridgijem je ponekod prišlo celo do lokalnih emerzij. Na nastalem kopnem sta nastajala breča in boksit. Talnino malmskega boksita sestavljajo oolitni apnenci, ki so na površini precej zakraseli. Malmski boksiti so sivkasto, opekasto, rjavo in oranžno rdeči, redkeje sivkasto rumeni. Struktura boksitov je pelitna, oolitna in pizolitna. Boksiti se pojavljajo v lečah in tankih plasteh. Debelina boksitnih teles je nekaj metrov. Ponekod imajo povečano vsebnost kaolinita in jih prištevamo h glinastim boksitom. V sestavi boksitov se najpogosteje pojavljajo boehmit, kaolinit, hematit in kremen.

Zgornjemalmsko zaporedje sedimentov sestavljajo algni in foraminiferni apnenci, dolomiti in njihove breče. Sedimenti, ki smo jih uvrstili v zgornji malm, se odlikujejo z bogato mikrofosilno združbo modro zelenih alg in bentonskih foraminifer, zaradi česar jih upravičeno imenujemo algni in foraminiferni. Zgornjemalmski sedimenti južnovzhodne Slovenije so nastajali na obsežni karbonatni platformi v plitvi vodi podplimskih, medplimskih, nadplimskih in tudi lagunarnih okolij. Prisotnost organske snovi, s katero so ti sedimenti ponekod impregnirani in jim v večini primerov daje temno rjavkasto barvo, kaže na občasno redukcijsko okolje. Nadplimski konglomerat in laminiti z izsušitvenimi razpokami so se oblikovali v medplimskem in nadplimskem okolju.

Konkordantno in kontinuirano na opisanem jurskem sedimentnem zaporedju leže spodnjekredne plasti. Ponekod se med vrhnjimi jurskimi in bazalnimi krednimi plastmi opaža rahla kotna diskordanca, na jurskih kamninah pa počivajo tektonsko in erozijsko odložene, nekaj sto metrov debele plasti berriasijsko-valanginijsko-hauterivijskega konglomerata. V biostratigrafskem pogledu je bila razmejitev obeh sistemov postopna. Plasti, ki vsebujejo združbo klipein in tintinin, ter plasti z aberantnimi tintininami so še malmske. Navzgor sledijo sedimenti z neznačilno in mešano mikrofavno in floro, ki kaže na berriasijsko stopnjo.

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Plate 1 - Tabla 1

1 Biooosparitic limestone with fragments of gastropods and pelecypods (8 ×)
Cross-section Krka-Hočevje, Lower Liassic

Biooosparitni apnenec z ostanki polžev in školjk (8 ×)
Profil Krka-Hočevje, spodnji lias

2 Biopelmicrosparitic limestone with remains of alga *Palaeodasycladus mediterraneus* (Pia), 30 ×, Mala gora - Middle Liassic

Biopelmikrosparitni apnenec z ostanki alg *Palaeodasycladus mediterraneus* (Pia), 30 ×
Mala gora - srednji lias

3 Pelintrasparitic limestone with *Orbitopsella praecursor* (Guembel), 35 ×
Trnovski gozd, Middle Liassic

Pelintrasparitni apnenec z algo *Orbitopsella praecursor* (Guembel), 35 ×
Trnovski gozd, srednji lias


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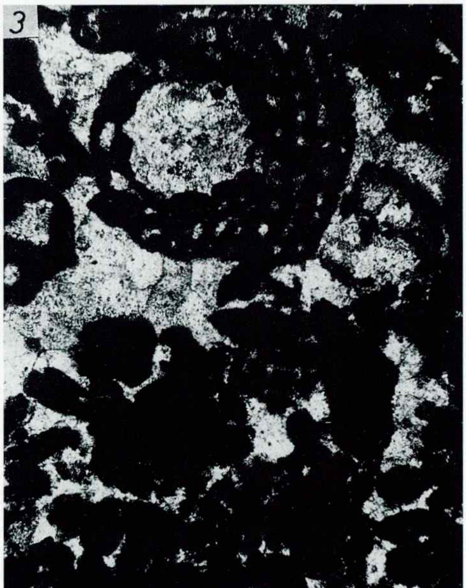
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Plate 2 - Tabla 2

1 Pelmicrosparitic limestone with *Orbitopsella praecursor* (Guembel), 34 ×
Dolenja Ponikva, Middle Liassic

Pelmikrosparitni apnenec z *Orbitopsella praecursor* (Guembel), 34 ×
Dolenja Ponikva, srednji lias

2 Oosparitic limestone with foraminifer *Protopeneroplis striata* Weynschenk (84 ×)
Cross section Krka-Hočevje, Dogger-Malm

Oosparitni apnenec s foraminifero *Protopeneroplis striata* Weynschenk (84 ×)
Profil Krka-Hočevje, dogger-malm

3 Dismicrosparitic limestone with foraminifer *Protopeneroplis striata* Weynschenk (70 ×)
W of Komarna vas
Upper Dogger-Lower Malm

Dismikrosparitni apnenec s foraminifero *Protopeneroplis striata* Weynschenk (70 ×)
W od Komarne vasi
Zgornji dogger-spodnji malm

4 *Pfenderina salernitana* Sartoni & Crescenti (34 ×)
W of Komarna vas
Upper Dogger-Lower Malm

Pfenderina salernitana Sartoni & Crescenti (34 ×)
W od Komarne vasi
Zgornji dogger-spodnji malm

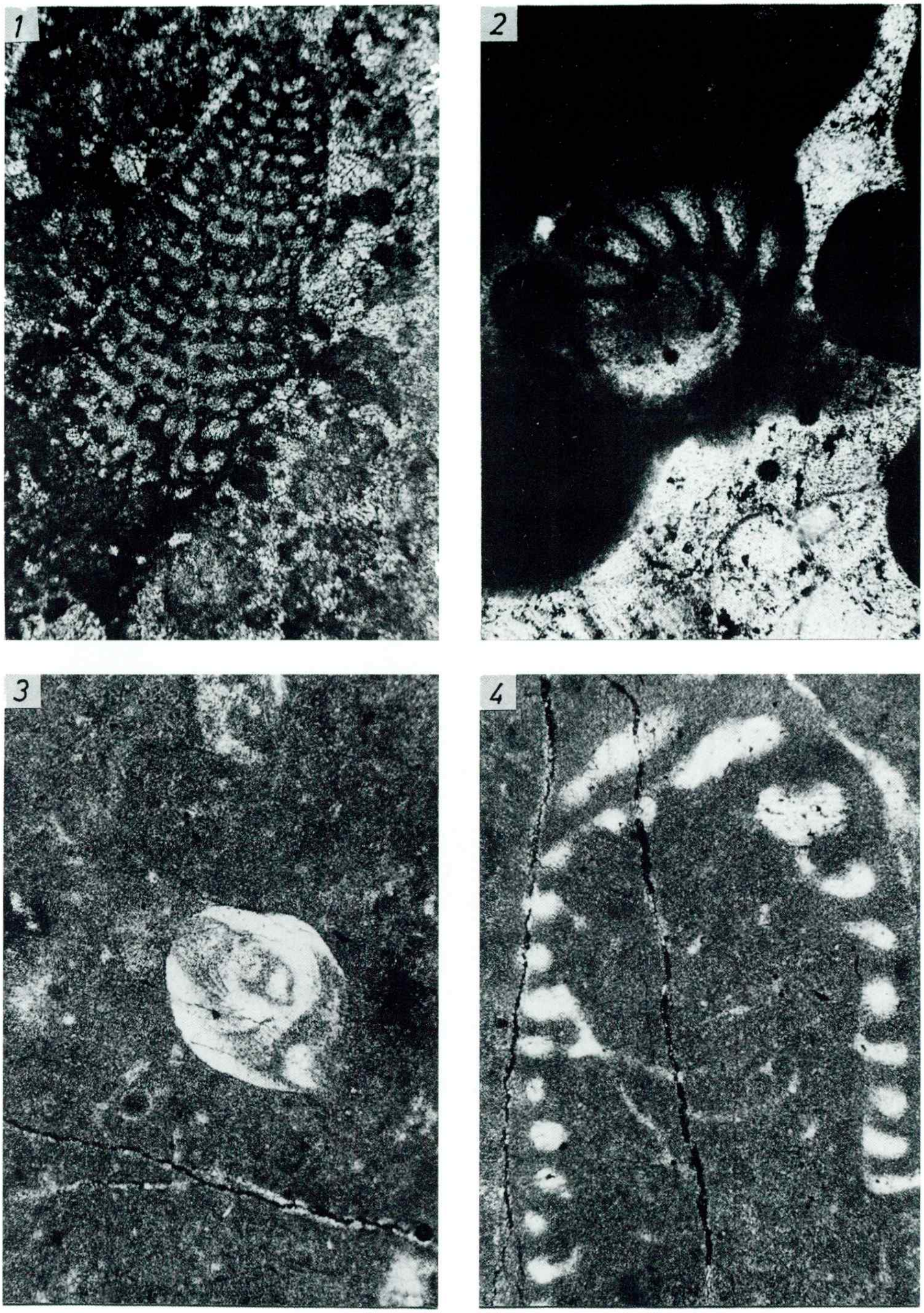
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Plate 3 - Tabla 3

1, 2 Microsparitic limestone with alga *Salpingoporella sellii* (Crescenti), 42 ×
NE of Milanov vrh, Lower Malm

Mikrosparitni apnenec z algo *Salpingoporella sellii* (Crescenti), 42 ×
NE od Milanovega vrha, spodnji malm

3, 4 Biointrasparitic limestone with trocholinids, pfenderinas and verneuilinidas (42 ×)
N of Ajbik, Lower Malm

Biointrasparitni apnenec s trocholinami, pfenderinami in verneuilinidami (42 ×)
N od Ajbika, spodnji malm

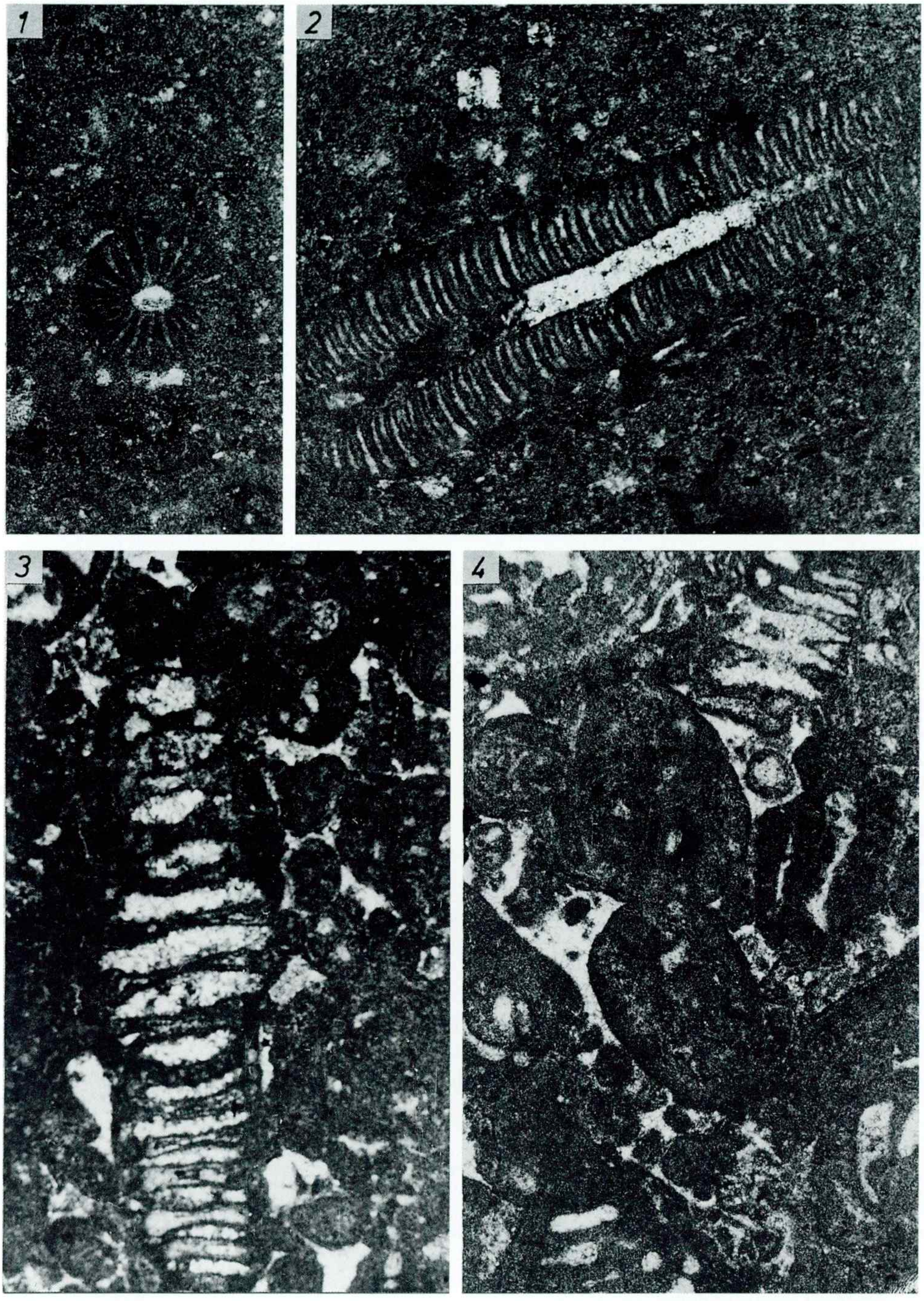
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Plate 4 - Tabla 4

1 *Cladocoropsis mirabilis* Felix (8 ×)
Transverse section of coenosteum, section Krka-Hočevje, Lower Malm

Cladocoropsis mirabilis Felix (8 ×)
Prečni presek cenosteja, profil Krka-Hočevje, spodnji malm

2 *Cladocoropsis mirabilis* Felix (8 ×)
Longitudinal section, section Krka-Hočevje, Lower Malm

Cladocoropsis mirabilis Felix (8 ×)
Vzdolžni presek, profil Krka-Hočevje, spodnji malm

3 Biooosparitic limestone, *Trocholina alpina* (Leupold), 16 ×
Črnomelj, Lower Malm

Biooosparitni apnenec, *Trocholina alpina* (Leupold), 16 ×
Črnomelj, spodnji malm

4 Biooosparitic limestone, *Trocholina alpina* (Leupold), 50 ×
Črnomelj, Lower Malm

Biooosparitni apnenec, *Trocholina alpina* (Leupold), 50 ×
Črnomelj, spodnji malm

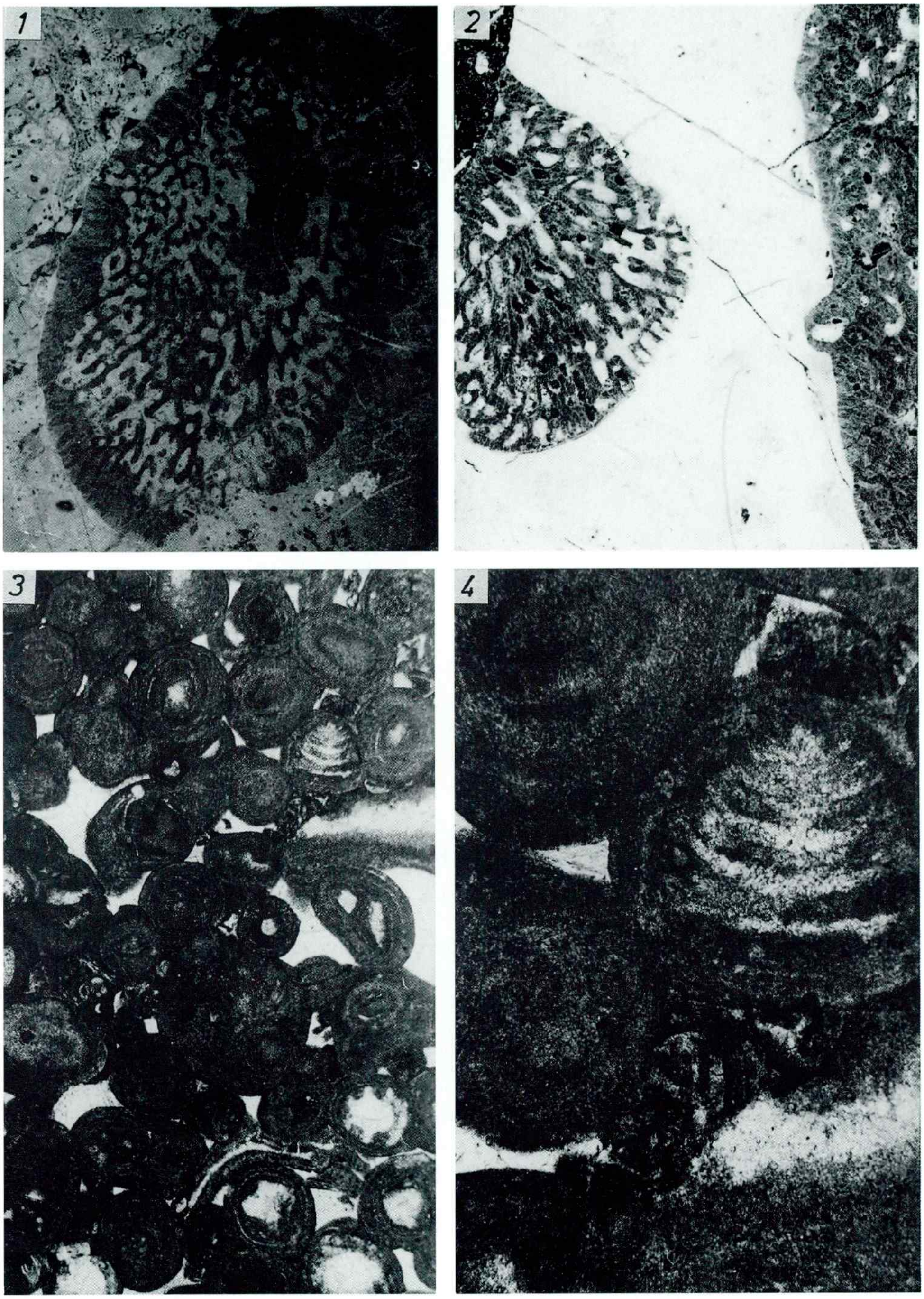
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Plate 5 - Tabla 5

1 Biopelmicrosparitic limestone with alga *Clypeina jurassica* Favre (18 ×)
N of Ajbik, Upper Malm

Biopelmikrosparitni apnenec z algo *Clypeina jurassica* Favre (18 ×)
N od Ajbika, zgornji malm

2 Algal biolithite, *Clypeina jurassica* Favre (8 ×)
N of Ajbik, Upper Malm

Algni biolitit, *Clypeina jurassica* Favre (8 ×)
N od Ajbika, zgornji malm

3 Biopelmicrosparitic limestone with alga *Clypeina jurassica* Favre (18 ×)
N of Ajbik, Upper Malm

Biopelmikrosparitni apnenec z algo *Clypeina jurassica* Favre (18 ×)
N od Ajbika, zgornji malm

4 Biopelmicrosparitic limestone with alga *Clypeina jurassica* Favre (18 ×)
Čabranska polica, Upper Malm

Biopelmikrosparitni apnenec z algo *Clypeina jurassica* Favre (18 ×)
Čabranska polica, zgornji malm

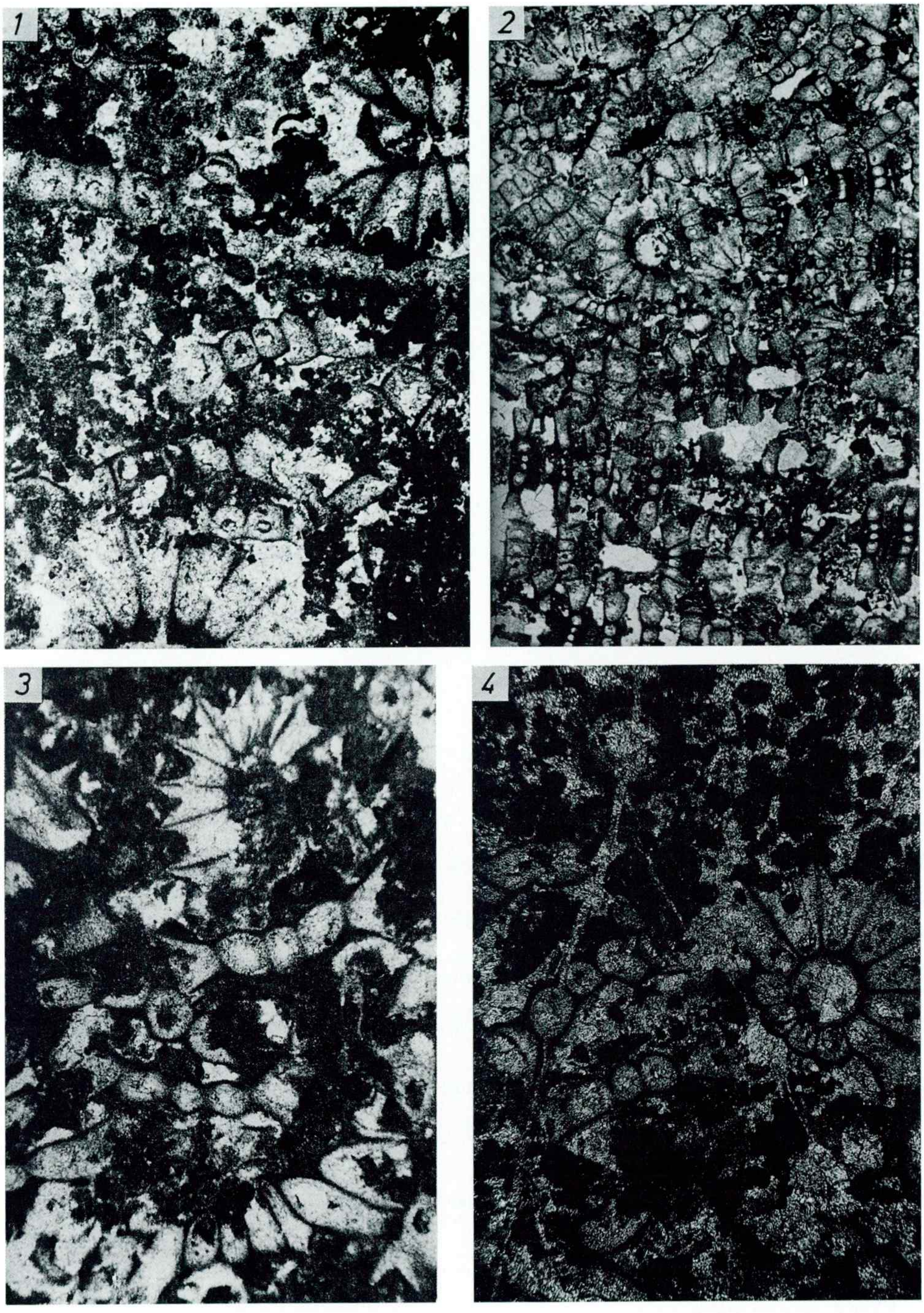
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Plate 6 - Tabla 6

1 Biopelsparitic limestone with alga *Clypeina jurassica* Favre and aberrant tintinnids (34 ×), NW of Vid, Upper Malm

Biopelsparitni apnenec z algo *Clypeina jurassica* Favre in aberantnimi tintininami (34 ×), NW od Vida, zgornji malm

2 Biointrasparitic limestone with alga *Clypeina jurassica* Favre and aberrant tintinnids (34 ×), Škrempljevec, Upper Malm

Biointrasparitni apnenec z algo *Clypeina jurassica* Favre in aberantnimi tintininami (34 ×), Škrempljevec, zgornji malm

3 Biointrasparitic limestone with alga *Clypeina jurassica* Favre and aberrant tintinnids (34 ×), NW of Vid, Upper Malm

Biointrasparitni apnenec z algo *Clypeina jurassica* Favre in aberantnimi tintininami (34 ×), NW od Vida, zgornji malm

4 Detritic biolithitic limestone, *Clypeina jurassica* Favre, *Solenopora* sp., *Tintinnopsella* sp., (30 ×)
Krnica, Upper Malm

Detritični biolititni apnenec, *Clypeina jurassica* Favre, *Solenopora* sp., *Tintinnopsella* sp., (30 ×),
Krnica, zgornji malm

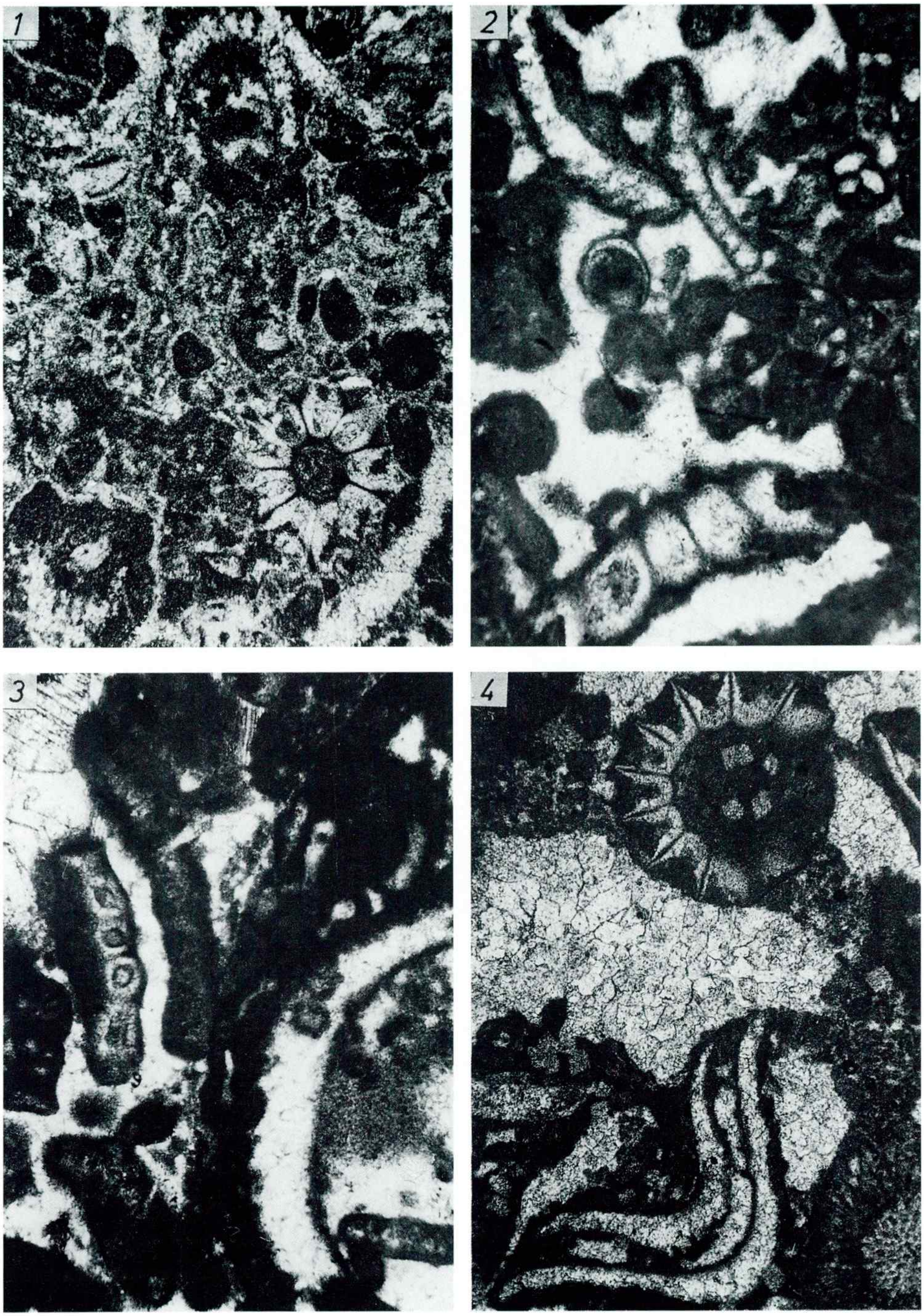
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Plate 7 - Tabla 7

1 *Clypeina jurassica* Favre (34 ×)
E of Vid, Upper Malm

Clypeina jurassica Favre (34 ×)
E od Vida, zgornji malm

2 Aberrant tintinnids (34 ×)
Jurna vas, Upper Malm

Aberantne tintinine (34 ×)
Jurna vas, zgornji malm

3 *Piannella* cf. *gigantea* Carozzi (34 ×)
W of V. Slatnek, Upper Malm

Piannella cf. *gigantea* Carozzi (34 ×)
W od V. Slatneka, zgornji malm

4 Biopelsparitic limestone with *Pseudocyclammina lituus* (Yokoyama), 34 ×
Uševec-Birčna vas, Upper Malm

Biopelsparitni apnenec s *Pseudocyclammina lituus* (Yokoyama), 34 ×
Uševec-Birčna vas, zgornji malm

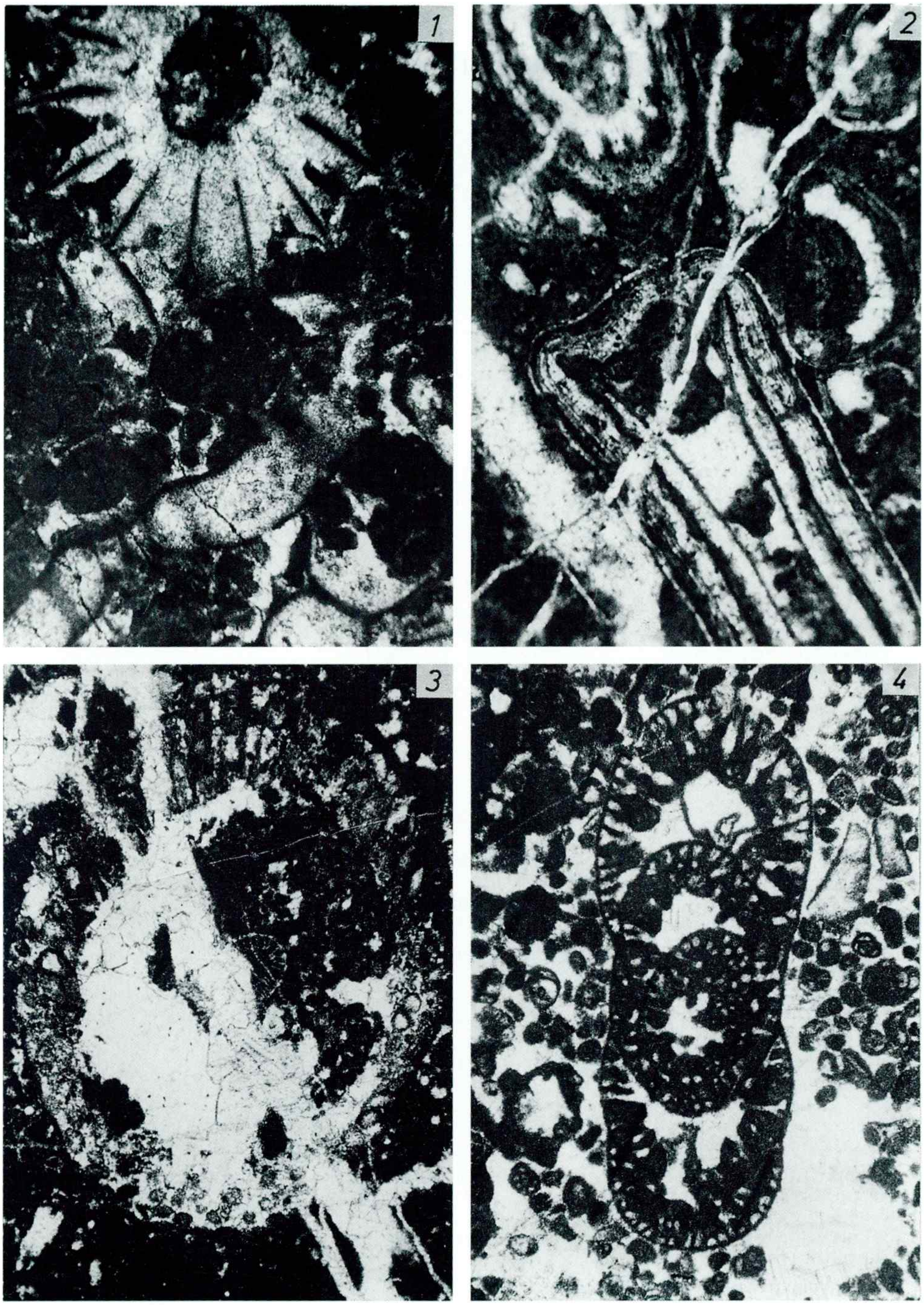
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Plate 8 - Tabla 8

1 Biomicritic limestone, *Tintinnopsella* sp., aberrant tintinnids (34 ×)
W od Jablanica, Upper Malm

Biomikritni apnenec, *Tintinnopsella* sp., aberantne tintinine (34 ×)
W od Jablanice, zgornji malm

2 Biomicritic limestone, *Cambelliella milesi* Radoičić (34 ×)
Petekovec, Upper Malm

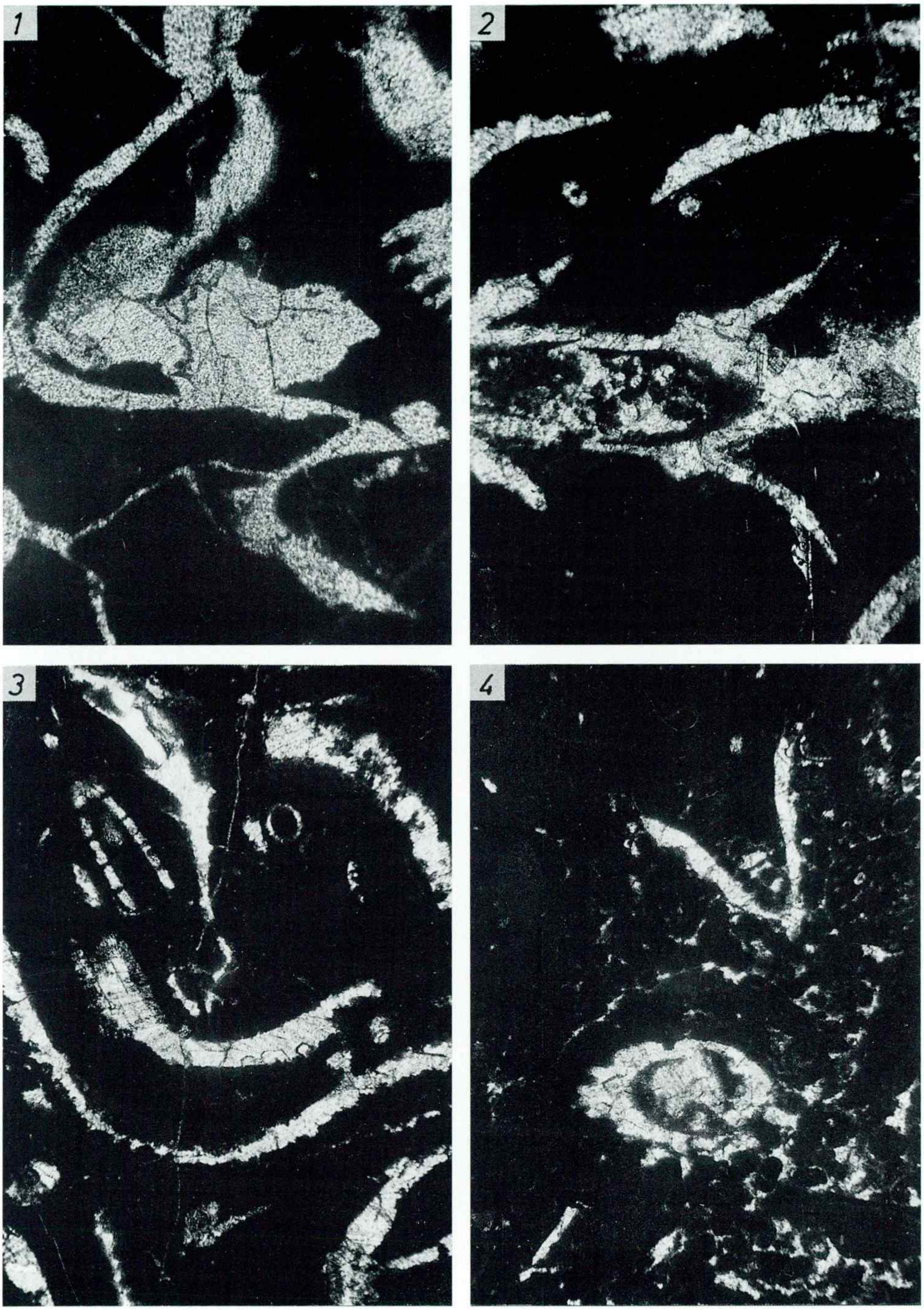
Biomikritni apnenec, *Cambelliella milesi* Radoičić (34 ×)
Petekovec, zgornji malm

3 Biomicritic limestone, aberrant tintinnids and *Salpingoporella annulata* Carozzi (34 ×)
NE of Zabiče, Upper Malm

Biomikritni apnenec, aberantne tintinine in *Salpingoporella annulata* Carozzi (34 ×)
NE od Zabič, zgornji malm

4 Pelmicrosparitic limestone, *Tintinnopsella* sp. (34 ×)
Čabranska polica, Upper Malm

Pelmikrosparitni apnenec, *Tintinnopsella* sp. (34 ×)
Čabranska polica, zgornji malm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