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Stratigraphy of the Lower Cretaceous index fossils in the Karst Dinarides (Yugoslavia)

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With 1 text figure

ABSTRACT

Stratigraphic subdivision of the Lower Cretaceous in the Karst Dinarides – developed in an uniform carbonate facies of shallow-marine environments – is possible only on the base of systematic research of microfossils.

Index fossils have a distinct significance both for the biostratigraphic zonation and the chronostratigraphic subdivision, compared to other species within taxa with wider stratigraphic distribution.

In the Karst Dinarides the Lower Cretaceous index fossils belong to two main microorganism groups: Calcareous algae (Dasycladaceae) and Foraminifera (Orbitolinidae and others). Algae predominate as index fossils in the lower part, and Foraminifera in the upper part of the Lower Cretaceous of the Karst Dinarides.

KURZFASSUNG

Eine stratigraphische Untergliederung der Unterkreide im Dinariden-Karst, wo eine eintönige Fazies aus Flachwasserkarbonaten vorliegt, ist nur durch gründliche Erforschung des gesamten Mikrofossil-Inhaltes möglich.

Die meisten Taxa haben eine lange stratigraphische Reichweite, so kommt einigen Mikrofossilien als Leitformen eine besondere Bedeutung für die Biostratigraphie zu. Es sind dies besonders Kalkalgen (Dasycladacea) im tieferen Teil und Foraminiferen (Orbitolinidae etc.) im höheren Teil der Unterkreide im Dinariden Karst.

INTRODUCTION

Specific facial development of the Mesozoic strata in the karst region of the Dinarides requires a special approach to their stratigraphic description. The Karst Dinarides (in the literature they are often called by the inadequate name – Outer Dinarides) are characterized by development of mostly shallow-marine carbonate sediments – limestones and dolomites. There predominate limestones which are represented by various types formed in shallow-marine environments: subtidal, restricted shoals, lagoons, fore-reef, reef and back-reef zones etc. These carbonate sediments are in some places mostly dolomitized in latediagenesis and rarely in earlydiagenisis. Similar, often invariable development of such sediments, almost through the whole Mesozoic, does not allow the stratigraphic analyses in the means of the chronostratigraphic classification, although it has been used for more than a hundred years in this region. The main reason is in the totally different lithofacies and especially biofacies in relation to the areas with tipically developed chronostratigraphic units.

Beside the great possibilities, the use of lithostratigraphic classification does not give enough detail stratigraphic subdivision necessary in the modern researches. Biofacial researches, with the fossil groups and taxa within, and their space and time relationships enable a detail and confident biostratigraphic subdivision of the Mesozoic strata in the Karst Dinarides.

Results of the systematic biostratigraphic researches, which started about twenty years ago, have shown that the use of only microbiostratigraphy is possible for the most of the Me-

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sozoic, and so far the Lower Cretaceous, because of the greater number of microfossils than macrofossils. According to this, the micropalaeontologic researches of the benthic Foraminifera and calcareous algae (microorganism groups) in the Mesozoic sediments of the Karst Dinarides are of particular importance.

Discussing about the Lower Cretaceous of the Karst Dinarides, it is necessary to point out the meaning of the microfossils for its stratigraphic subdivision. First of all, it is the result of lithofacial uniformities: rhythmic exchange of the uniform limestone types with dolomites of the Lower Cretaceous with rare presence of macrofossils but numerous microfossils. Within the two mentioned fossil groups benthic foraminifers predominate. This predominance reflexes in the overall microfossil content, as well as in the number of index fossils. Although the microfossil assemblages make the most confident category in biostratigraphic researches, the whole biostratigraphic scheme is based on individual characteristic forms (index fossils).

In the Lower Cretaceous of the Karst Dinarides such index fossils are found, in the first place, within the significant foraminifer group of the Orbitolinidae, rarely in the Ataxophragmiidae, and also within a group of calcareous algae in the Dasycladaceae. Frequent presence of the orbitolinids, whose chronostratigraphy has been accurately examined especially in Western Europe (for instance MOULLADE, 1960; SCHROEDER, 1963a, 1963b, 1964a, 1964b; JAFFREZO & SCHROEDER, 1972; DECROUEZ & MOULLADE, 1974; MASSE, 1976; PEYBERNES, 1976; SAINT-MARC, 1977; JAFFREZO, 1980 and others) allow to correlate between those regions and the Karst Dinarides. Such an approximate chronostratigraphic subdivision with reference to chronostratigraphy of the biostratigraphic units could be also carried out in Dinarides. In this review of the Lower Cretaceous index fossils and their stratigraphic distribution in the Karst Dinarides we shall be dealing with chronostratigraphic units.

STRATIGRAPHIC REVIEW

The forms refered to index fossils are those which are in the Lower Cretaceous of the Karst Dinarides the guide fossils for a narrow stratigraphic interval, either biostratigraphic (zone, subzone) or chronostratigrahic unit (stage, substage). There are cases that the stratigraphic range of such significant taxa includes for instance bordering parts of two units, or even the whole two units (Fig. 1).

BERRIASIAN

There are no index fossils in the strata, which according to their stratigraphic position belong to Berriasian, because they lay between improved Tithonian underlaying beds and Valanginian overlaying ones. The Berriasian microfossil assemblage of the Karst Dinarides lacks the abundance several species of various taxa.

Calcareous algae *Salpingoporella katzeri* CONRAD & RADOIČIĆ and *Pseudoclypeina crnogorica* RADOIČIĆ, which are registered in the Berriasian, can be conditionally used as index fossils, but only locally, because they are both originally described in younger layers: *S. katzeri* from Valanginian (CONRAD & RADOIČIĆ, 1978) and *P. crnogorica* from Berriasian to Aptian (RADOIČIĆ, 1972).

Beside the mentioned species, *Salpingoporella annulata* CAROZZI and *Actinoporella podolica* (ALTH.) are more frequently present as well as foraminifers *Trocholina elongata* (LEUPOLD) and *T. alpina* (LEUPOLD). However, all these species extent from the Malm to the Upper Neocomian and they can not be used as good index fossils. There also have been locally registered algae *Coniporella piriformis* SOKAČ & VELIĆ and *Clypeina delmatarum* SOKAČ & VELIĆ in the Mt. Biokovo (SOKAČ & VELIĆ, 1981b) but they can not be surely refered as index fossils until their longer stratigraphic distribution and stratigraphic position in greater number of findings shall be improved.

VALANGINIAN

Index fossils:

Algae:

Clypeina marteli EMBERGER
Salpingoporella istriana (GUŠIĆ)
Selliporella campanensis (AZEMA & JAFFREZO)
Triploporella? neocomiensis RADOIČIĆ

Foraminifera:

Pseudotextulariella salevensis CHAROLLAIS & al.

The following algae and foraminifers can be joined to the above mentioned forms as index fossils of a wider range within the Neocomian:

Algae:

Epimastopora? cekici RADOIČIĆ
Clypeina? solkani CONRAD & RADOIČIĆ

Foraminifera:

Cuneolina tenuis VELIĆ & GUŠIĆ

E.? cekici has its maximum abundance in the Valanginian, but it can be individually found also in the Hauterivian, just opposite then *C.? solkani*, which rarely occures in the Valanginian but is numerous in the Hauterivian. *C. tenuis* is also more frequent in the Valanginian (Fig. 1).

The Valanginian microfossil assemblage of the Karst Dinarides is enriched with other numerous species, whose stratigraphic range is from the Jurassic to the Neocomian and from the Valanginian throughout the whole Lower Cretaceous. The calcareous algae will be mentioned here: *Salpingoporella annulata, Actinoporella podolica, Macroporella praturloni, Salpingoporella pygmaea, Dissocladella hauteriviana, ?Goniolina minima*, then foraminifers *Trocholina elongata, T. alpina* and the group of the Lower Cretaceous Ataxophragmiidae with species which occur in almost all Lower Cretaceous units including Vraconian, these are *Cuneolina camposaurii* SARTONI & CRESCENTI, *C. laurentii* SARTONI & CRES-

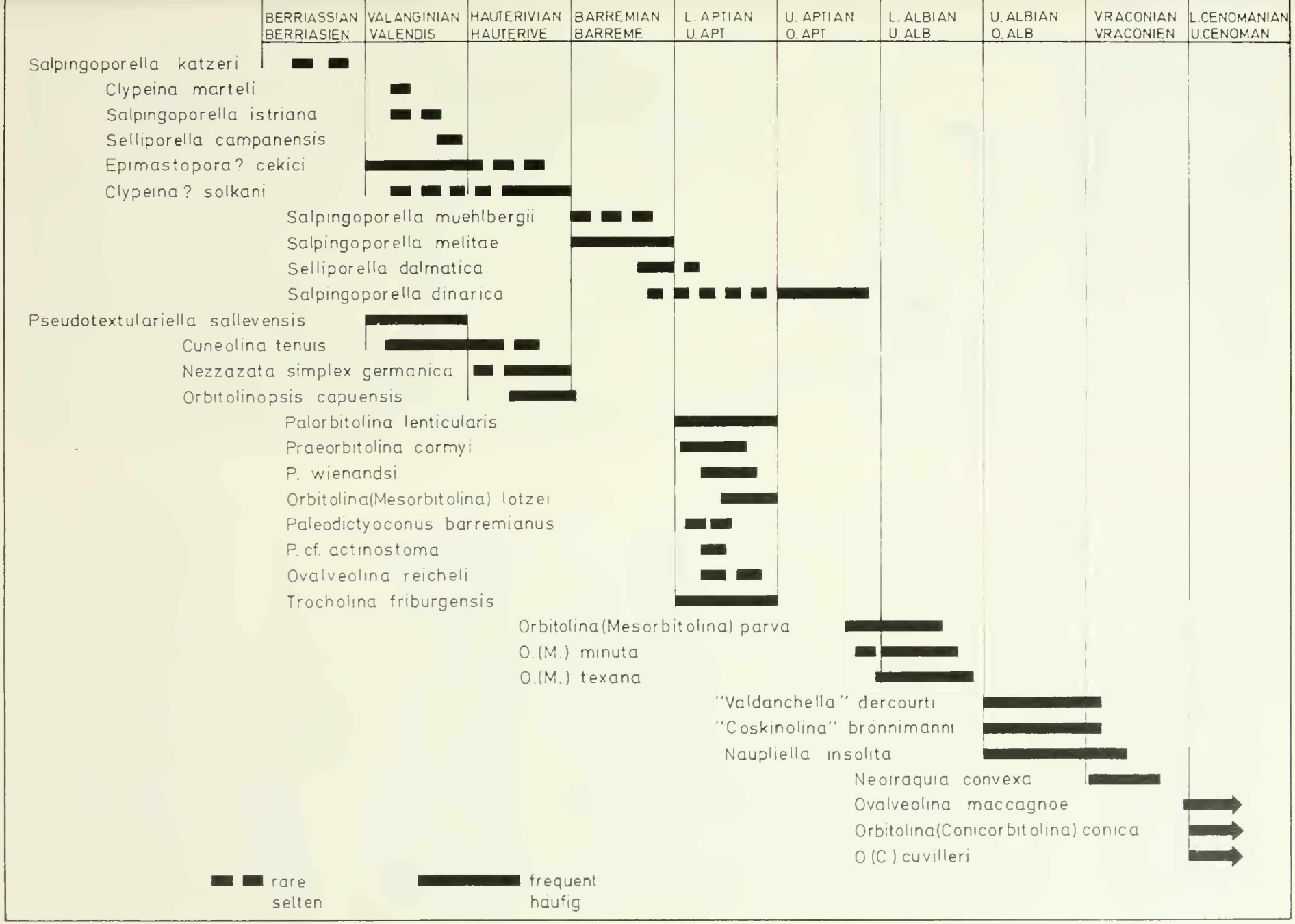

Fig. 1. The stratigraphic range of Lower Cretaceous index fossils in the Karst Dinarides.

CENTI, *Pseudotextulariella? scarsellai* (DE CASTRO) and *Sabaudia minuta* (HOFKER). The last four listed forms are Lower Cretaceous index fossils for the interval of Valanginian to the Upper Albian. In the next units these will be mentioned by the joint name-standard assemblage of the Lower Cretaceous Ataxophragmiidae. There are some indications of local presence of *Debarina hahounerensis* FOURCADE et al. already in the Valanginian, although it becomes frequent not earlier than the interval Barremian – Lower Albian.

HAUTERIVIAN

The Hauterivian index fossils are limited only to the Foraminifera:

Nezzazata simplex germanica OMARA & STRAUCH
Orbitolinopsis capuensis DE CASTRO

Among the numerous tiny Nezzazatidae, which we can follow from the beginning of the Valanginian throughout the whole Lower Cretaceous and which can be listed as *Nezzazata* gr. *simplex* OMARA. The subspecies *N. simplex germanica* is found in the most part of Hauterivian. On the other hand, *O. capuensis* is characteristic for the uppermost layers of this stage, so it can possibly enter into the Lower Barremian, what we do not exclude nor for the former species.

As already quoted, foraminifer *Cuneolina tenuis* and algae *Clypeina solkani* and *Epimastopora? cekici* should be mentioned here as index fossils for the most part of Neocomian. *C.? solkani*, described in the Karst Dinarides (CONRAD & RADOIČIĆ, 1971) (the stratigraphic position in Lower Aptian is not well argumented and later revised to Neocomian [VELIĆ & SOKAČ, 1978]) has its maximum abundance just in the Hauterivian layers below and with *O. capuensis*. *C.? solkani* should be treated as a Neocomian species in the entire Mediterranean, also mentioned by BASSOULLET et al. (1978).

The foraminifers *Cuneolina tenuis*, a standard assemblage of the Lower Cretaceous Ataxophragmiidae and algae *Salpingoporella annulata*, *Actinoporella podolica*, *Selliporella pejovicae* (RADOIČIĆ), *S. danilovae* (RADOIČIĆ) and *Humiella teutae* SOKAČ & VELIĆ (known only from the type locality; SOKAČ & VELIĆ, 1981 a) and others can be individually found in the Hauterivian.

BARREMIAN

Barremian index fossils, so far known, refer to the few species of calcareous algae:

Salpingoporella melitae RADOIČIĆ
S. muehlbergii (LORENTZ)

The Barremian of the Karst Dinarides generally lacks foraminifer assemblages; so mostly only standard Lower Cretaceous Ataxophragmiidae, tiny Nezzazatidae and the already mentioned *Debarina hahounerensis* can be found. Algae are represented by a greater number of species, so other species of the genus *Salpingoporella* will be listed next to the mentioned index fossils: *Salpingoporella genevensis* (CONRAD), *S. dinarica* RADOIČIĆ, *Selliporella dalmatica* (SOKAČ & VELIĆ) and *Triploporella marsicana* PRATURLON. All these species range to younger stratigraphic units of the Lower Cretaceous.

APTIAN

The main biostratigraphic significance of the Aptian strata is their distinctly better fossil content in relation to the former units. Foraminifers, especially orbitolinids predominate. Because of their small vertical distribution a more detailed subdivision and zonation is possible. Biostratigraphic problem of the Aptian in the Karst Dinarides is connected mainly with orbitolinids and alga *Salpingoporella dinarica*. Relevant researches, without detail zonation, enabled the subdivision of the Aptian into Lower Aptian – Bedoulian and Upper Aptian – Gargasian.

Lower Aptian (Bedoulian)

Index fossils:
Foraminifera:

Palorbitolina lenticularis (BLUMENBACH)
Praeorbitolina cormyi SCHROEDER
P. wienandsi SCHROEDER
Orbitolina (Mesorbitolina) lotzei SCHROEDER
Paleodictyoconus barremianus (MOULLADE)
P. cf. actinostoma ARNAUD-VANNEAU & SCHROEDER
Ovalveolina reicheli DE CASTRO
Trocholina friburgensis (QUILLAUME & REICHEL)

Occurence of the quoted index fossils in the Bedoulian beds, which are also called the "Lower Orbitolinid Limestones" because of the extremely numerous orbitolinids, refers to the very frequent and common species *P. lenticularis* and rarely found representatives of the genus *Paleodictyoconus*. The "Lower Orbitolinid Limestones" or Bedoulian in general are limited within range of the species *P. lenticularis*, considering that the index *Orbitolina* in the Karst Dinarides is slightly younger than in the NW Europe and so its stratigraphic range is within the interval from Upper Barremian–Lower Aptian boundary to the Lower Aptian–Upper Aptian boundary (VELIĆ & SOKAČ, 1978). Among the Lower Cretaceous Foraminifera in general, beside *Debarina hahounerensis*, appears species *Sabaudia auruncensis* in Bedoulian within the standard assemblage of the Lower Cretaceous Ataxophragmiidae. *Nautiloculina* gr. *cretacea* PEYBERNES, *N. brönnimani* ARNAUD-VANNEAU & PEYBERNES, *Chrisalidina gradata* D'ORBIGNY, species of genus *Valvulammina* and other also appear.

Salpingoporella dinarica is more common than the Upper Barremian-Lower Aptian *Selliporella dalmatica* and *Triploporella marsicana*. Problematic *Bacinella irregularis* RADOIČIĆ or *Lithocodium aggregatum* ELLIOTT are somewhere of lithogenetic significance.

Lagoonal, subtidial and other shallow-marine facies in some places laterally change into facies of reef – back reef environments with dominating macrofossils – reef-building organisms (corals, hydrozoans, bryozoans, primitive rudistid lamellibranchs, gastropods) which have not been studied on yet, because of their poor preservation. All formerly quoted microfossils can be found in these facies, too.

Upper Aptian (Gargasian)

There are no real-"autochthonous" Gargasian index fossils in the Karst Dinarides. Inspite of that, alga *Salpingoporella dinarica* can be postulated as Gargasian index fossil with no

doubt, because its maximum abundance is in Upper Aptian. It must be repeated that *S. dinarica* just locally occures in the Upper Barremian, it is quite frequent in the "Lower Orbitolinid Limestones" of Bedoulian and then in the Gargasian it has maximum abundance. Throughout the Karst Dinarides, with extremely numerous individuals, it becomes lithogenetic not only in individual layers but in the whole zone. Beside *S. dinarica*, rare individual specimens of alga *Triploporella marsicana* can be found.

Refering to foraminifers, through the whole Upper Aptian, species within the standard assemblage of the Lower Cretaceous Ataxophragmiidae, *Debarina hahounerensis* and others occur. The appearence of the larger *Mesorbitolina* in the upper part of Gargasian is significant. These species appear in progression from *Orbitolina (Mesorbitolina) parva* Douglass over *O. (M.) minuta* Douglass to *O. (M.) texana* (Roemer). The first two are frequently found with *S. dinarica*. On the contrary, the first individual findings of the third mark the uppermost Aptian layers (Clansayesian) and it is not yet registered together with *S. dinarica*. All three *Mesorbitolina* species have their maximum abundance in the Lower Albian.

ALBIAN

Lower Albian

Index fossils:

Foraminifera:
Orbitolina (Mesorbitolina) texana (Roemer)
O. (M.) subconcava Leymerie

The first layers with the appearence of numerous orbitolinids, overlaying those with disappearing *S. dinarica*, are marked as the "Upper Orbitolinid Limestones" in Dinarides. Their stratigraphic range responds to the Lower Albian. Beside mentioned index fossils some other *Mesorbitolina*, found already in the Upper Aptian, have also their maximum abundance: *O. (M.) parva* and *O. (M.) minuta*. Other genera like *Paracoskinolina*, *Orbitolinopsis* and *Urgonina* also appear, but with no significance for the biostratigraphy, because of their rare occurence and wider stratigraphic range.

The next two facts about the Lower Albian are very important, too:

1. Maximum abundance of species within the assemblage of the Lower Cretaceous Ataxophragmiidae as *Cuneolina camposaurii*, *C. laurentii*, *Pseudotextulariella? scarsellai*, *Sabaudia minuta*, *S. auruncensis* as well as *Debarina hahounerensis*, which all except *P.? scarsellai* and *S. minuta* do not pass the Lower Albian.
2. The appearence and distribution of microfossils (Foraminifera) which have their maximum abundance in the Upper Cretaceous like *Cuneolina pavonia* d'Orbigny etc. These forms occur also through the Upper Albian and Vraconian.

The calcareous algae, which are found in the Lower Albian, have wider stratigraphic range. However, it is valuable to mention that the first appearence of the alga *Salpingoporella turgida* Radoičić marks the Lower to Upper Albian boundary.

Upper Albian s. str.

Index fossils:

"Valdanchella" dercourti Decrouez & Moullade
"Coskinolina" brönnimanni Decrouez & Moullade
Naupliella insolita Decrouez & Moullade

Quoted species belong to the group of so called primitive Orbitolinidae. According to Decrouez & Moullade (1979) they were found in the Upper Albian (including Vraconian) of Pelopones/Greece. In the Karst Dinarides they extent from the beginning of the Upper Albian to only the first layers of the Vraconian. Beside these species, in the Upper Albian layers occur all the other Foraminifera species like in the Lower Albian but do not disappear by the end of the Lower Albian.

The most frequent are *Chrysalidina gradata*, *Valvulammina picardi*, *Cuneolina pavonia*, *C. pavonia parva*. The calcareous algae are very poorely represented. *Salpingoporella turgida* is frequent in the first layers together with the Upper Albian s. str. index fossils. Other findings of algae are very rare, except individual forms and taxa with a wider stratigraphic range.

Vraconian

The Vraconian index fossils have not been determinated yet with accuracy in the Karst Dinarides. The strata, separated as Vraconian, lay between the described Upper Albian s. str. and accurately defined Cenomanian. That marks an interval from the first appearence of *Neoiraquia convexa* Danilova till the first finds of *Ovalveolina maccagnoe* de Castro. Such subdivision is possible only in the region of middle and southern Dalmatia and Hercegovina, where continuous development of layers from the Albian to the Cenomanian can be seen, mainly in calcareous facies. In other regions of the Karst Dinarides this level is developed as dolomite and dolomite-breccia zones (Velić et al., 1979).

N. convexa, originally described of inaccurate Cenomanian-Turonian beds (Danilova, 1962) and later found in the Lower Cenomanian (Berthou & Schroeder, 1978), is certainly older in this strata because it appears much earlier than in the strata which are positively Lower Cenomanian. If we include here another species *Naupliella insolita* (sensu Barthou & Schroeder, 1978) then its stratigraphic range would go rather down to the Albian. *O. maccagnoe* is also described from the Middle Cenomanian (de Castro, 1966), but in the Karst Dinarides it appears much earlier.

In this uppermost level of the Lower Cretaceous next to the stated Foraminifera also occur all the others, which appear in Lower Albian and extent to the Upper Cretaceous, so the species within the Lower Cretaceous Ataxophragmiidae – *Sabaudia minuta* and *Pseudotextulariella? scarsellai*.

Alga *Marinella lugeoni* Pfender is in some places very frequent. The described level, which has been included in the Vraconian, underlays the Lower Cenomanian biodetritic limestones in which beside to many other index micro- and macrofossils appear *Orbitolina (Conicorbitolina) cuvillieri* (Moullade) and *O. (C.) conica* (d'Archiac).

CONCLUSION

Because of the uniform lithofacial development (shallow-marine carbonate sediments – limestones and dolomites) and a very rare appearence of macrofossils, biostratigraphic subdivision is based on the microfossil content. The microfossil assemblages are here of outstanding significance and are used as index fossils for stratigraphic subdivision. In the Karst Dinarides index fossils are found among the Foraminifera and Calcareous algae. Within Foraminifera the significant orbitolinid family should be pointed out. Algae are represented mainly with species of the genus *Salpingoporella*. In the Lower Cretaceous of the Karst Dinarides the main index fossils are:

BERRIASIAN

Algae:
Salpingoporella katzeri (only locally)

VALANGINIAN

Algae:
Clypeina martelli
Salpingoporella istriana
Selliporella campanensis
Epimastopora? cekici (maximum abundance)

Foraminifera:
Pseudotextulariella salevensis

HAUTERIVIAN

Algae:
Clypeina? solkani (maximum abundance)

Foraminifera:
Orbitolinopsis capuensis
Nezzazata simplex germanica

BARREMIAN

Algae:
Salpingoporella melitae
S. muehlbergii

LOWER APTIAN

Foraminifera:
Palorbitolina lenticularis
Praeorbitolina cormyi
P. wienandsi
Orbitolina (Mesorbitolina) lotzei
Paleodictyoconus barremianus
Ovalveolina reicheli
Trocholina friburgensis

UPPER APTIAN

Algae:
Salpingoporella dinarica (maximum abundance)

LOWER ALBIAN

Foraminifera:
Orbitolina (Mesorbitolina) texana
O. (M.) subconcava

UPPER ALBIAN (Vraconian included)

Foraminifera:
"Valdanchella" dercourti
"Coskinolina" brönnimanni
Naupliella insolita = Neoiraquia convexa (?)

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