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THE UPPER JURASSIC — LOWER CRETACEOUS PARABIOSTRATIGRAPHIC SCALE ON THE BASIS OF *TINTINNINAE, CADOSINIDAE, STOMIOSPHAERIDAE, CALCISPHAERULIDAE* AND OTHER MICROFOSSILS FROM THE WEST CARPATHIANS

(Tab. 1)

Abstract: On the basis of succession of microfossils studied in thin sections, the author of the paper distinguished the following 16 zones for the Upper Jurassic up to the Lower Cretaceous in the West Carpathians: "*fibrata*" zone in the Upper Oxfordian, "*moluccana*" in the Early Upper Kimmeridgian, "*borzai*" in the Upper Kimmeridgian up to the lowermost part of the Lower Tithonian, "*pulla-tithonica*" for the lower part of the Lower Tithonian, "*malmica*" for the upper part of the Lower Tithonian. *Chitinoidella* zone is an important zone in the Middle Tithonian, it may be divided to "*dobeni*" subzone for smaller chitinoidel forms and "*boneti*" subzone for greater forms. There is *Praetintinnopsella* zone on transition of the Middle and Upper Tithonian. For the Upper Tithonian up to the Lower Valanginian standard calpionellid zones (cf. Allemann et al., 1971; *Crassicollaria, Calpionella, Calpionellopsis* and *Calpionellites* zones) are fully accepted. *Tintinnopsella* zone is delimited for the Upper Valanginian up to the Hauterivian. For the present, there are no important microfossils in the Barremian up to the Lower Aptian. *Praecolomiella* zone is characteristic of the Upper Aptian, *Colomiella* zone represents the Uppermost Aptian up to the Lower Albian. *Cadosina oraviensis* zone is typical of the Middle Albian. *Calcisphaerula* zone is characteristic of the Upper Albian.

Резюме: В статье автор выделил для верхней юры — нижнего мела 16 следующих зон в районе Западных Карпат на основе последовательности микроостатков изучаемых в шлифах: зону „*fibrata*" в верхнем оксфорде, „*moluccana*" в раннем верхнем киммериджи, „*borzai*" в верхнем кимериджи вплоть до самой нижней части нижнего титона, „*pulla-tithonica*" для нижней части нижнего титона, „*malmica*" для верхней части нижнего титона. Для среднего титона является важной зона *Chitinoidella*, которую можно разделить на субзону „*dobeni*" для меньших форм хитиноидел и субзону „*boneti*" для больших форм. На переходе среднего и верхнего титона находится зона *Praetintinnopsella*. Для верхнего титона вплоть до нижнего валанжина в полной мере принимаются стандартные калпионеллидные зоны (ср. Allemann et al., 1971; зоны *Crassiocollaria, Calpionella, Calpionellopsis* и *Calpionellites*). Зона *Tintinnopsella* определена для верхнего валанжина вплоть до готерива. В бареме вплоть до нижнего апта пока нет значительных микроостатков. Для верхнего апта характерна зона *Praecolomiella*, зона *Colomiella* представляет самый верхний апт вплоть до нижнего альба. Для среднего альба характерна зона *Cadosina oraviensis*. Зона *Calcisphaerula* характеризует верхний альб.

Introduction

Upper Jurassic and Lower Cretaceous sediments of the West Carpathians are represented predominantly by limestones, marly limestones, rarely by

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quartzy limestones and radiolarites, lithological character of which limits the possibility of application of common micropalaeontologic research methods. This work is based on systematic study of thin section material, whereby we have observed rock textures, their admixtures and, naturally, microfossil assemblage.

The Upper Jurassic and Lower Cretaceous sediments are relatively rich in various microfossils. A part of them has relatively great stratigraphic distribution and it is irrelevant for biostratigraphy, another part is applicable to biostratigraphic division. The paper is aimed at application of tintinnids and microproblematics *(Cadosinidae, Stomiosphaeridae, Calcisphaerulidae)* and several other microfossils for biostratigraphy.

Calpionellids are planktonic microorganisms limited to the Tethys realm. They occur in the region reaching from the East Mexico and Venezuela in the west to New Guinea in the east. Data on geographical distribution of calpionellids can be found in the work of Colom (1965). It is very probable, that calpionellids formed in the Tethys ocean very large populations constantly mixed by marine currents without significant barriers, which appeared practically simultaneously in the whole area of their distribution.

Stratigraphic importance of calpionellids is widely known thanks to Colom's work (1948). In last decades various authors often paid an attention to the problems of detailed stratigraphic classification of the Upper Jurassic and the Lower Cretaceous on the basis of calpionellids. There are frequent discrepancies in vertical distribution of individual genera. It can be seen in synoptic table published by Magné et Sigal (1965). Lately, besides the other authors, especially the works of Remane (1963, 1964, 1965, 1969, 1974) are important from the stratigraphic and palaeontologic points of view.

Great success in calpionellid stratigraphy was reached in 1970 at the II Planktonic Conference in Rome, where three papers on stratigraphic distribution of calpionellids (Allemann, 1970; Catalano – Ligouri, 1971; Farès – Lasnier, 1971) were presented. In addition to the cited papers, results of Remane's works (1963, 1964, 1969 and 1968 in Le Hégarat – Remane, 1968) and papers delivered in discussion proved agreement of composition and succession of calpionellid associations in very distant regions. On the basis of this fact, standard zones of the western Mediterranean province (Allemann – Catalano – Farès – Remane, 1971) have been established. Further papers demonstrated (Rusu, 1970; Kreisel – Furrazzola Bermudez, 1971; Dragastan – Mutiu – Vinogradov, 1973; Borza, 1969, 1974; Mantovani – Masetti, 1976; Furrazola Bermudez – Kreisel, 1973; Pop, 1974, 1976, 1980; Trejo, 1975 and others) that mentioned zones are applicable to much larger geographical area and they serve as a basis for further more detailed classification of calpionellid zones.

More detailed division to subzones occurs in the works of Remane (1963, 1964, 1968 in Le Hégarat – Remane, 1968), Allemann – Grün – Wiedmann (1975), Trejo (1975), Pop (1974, 1976, 1980) and others. In spite of this, it seems to me useful to preserve zones in a broader sense.

Stratigraphic ammonite-calpionellid correlation has been carried out by Barthel et al. (1966); Le Hégarat – Remane (1968), Allemann

– Grün – Wiedmann (1975), Enay – Geyssant (1975) and Busnardo – Thieuloy – Moullade et al. (1979).

First attempt to divide the Upper Jurassic and Lower Cretaceous sediments in the West Carpathians on the basis of calpionellids has been carried out by Scheibner (in Houša – Scheibner – Stránik, 1963). Later on, Borza (1969, 1974, 1980) paid an attention to this problem. Lately, microfossil-ammonite correlation from the West Carpathian region is presented in the following works: Borza – Gašparíková – Michalík – Vašíček (1980, 1984), Borza – Fedor – Michalík – Vašíček (1983), Borza – Michalík – Vašíček (1981) and Vašíček – Michalík – Borza (1983).

Similarly as calpionellids, little known unilocular calcareous tests denoted as "fibrospheres", "stomiospheres" or "cadosines" have been mentioned in literature for many years. Originally they were taken for foraminifers. Lately, owing to insufficient explanation of their origin they have been placed to Incertae sedis.

These microfossils have been described in last decades from the Jurassic and Cretaceous sediments from the East Mexico in the west to the East-Indian Islands in the east, i. e. in the same way as calpionellids which accompany them (cf. Colom, 1955; Wanner, 1940; Vogler, 1941; Bonet, 1956; Durand Delga, 1957; Leischner, 1959; Borza, 1961, 1964, 1969, 1980; Nagy, 1966, 1971; Nowak, 1963 a, 1963 b, 1965, 1966, 1968, 1976 and others). Their mass occurrence in the Upper Jurassic and Lower Cretaceous sediments and ascertainment of assemblage differentiation in profiles enable to judge of their application for correlation purposes as calpionellids. However, it must be pointed out, that nowadays this group is not worked out so much as calpionellids are. Majority of species has greater stratigraphic distribution than calpionellids and, therefore, they are less apt for detailed division. Same species are, however, well applicable for detailed biostratigraphic classification (cf. Vogler, 1941; Nagy, 1966, 1971; Nowak, 1966, 1968, 1976; Borza, 1969, 1980; Lineckaja, 1974 and others).

It is evident, that within this group chronological succession of species, at least in essential features, is well determinable. But it is a mistake, that the same species are often cited by different authors under different species names and, that is why, parallelization of fauna succession is sometimes obscure.

As far as succession of stomiospherides in different regions is the same, Nowak (1968 p. 282) distinguished the following six zones in Těšín beds: 1. *Stomiosphaera moluccana* zone (Upper Kimmeridgian), 2. *Colomisphaera pulla* zone (Lower – ? Middle Tithonian), 3. *Parastomiosphaera malmica* zone (Lower – Middle Tithonian), 4. *Colomisphaera cieszynica* and *C. carpathica* zone (? Middle – ? Upper Tithonian), 5. *Colomisphaera minutissima* and *C. carpathica* with tintinnids and *Cadosina semiradiata* zone (Upper Tithonian – Berriasian), 6. *Stomiosphaera echinata* zone (Hauterivian). As Nowak (l. c.) points out the significance of distinguished zones for correlation is not identical. Especially zones Nos. 1–4 are applicable and, maybe, that in the course of time zone No. 6 will get a greater importance. Zone No. 5 is of lesser importance. Later on, Nowak (1976, p. 99) arranged the zones in a following way: 1. "*moluccana*" zone (Upper Kimmeridgian), 2. "*borzai*" zone (Upper Kimmeridgian – Lower-

most Tithonian), 3. "*malmica*" zone (Lower Tithonian), 4. "*cieszynica*" zone (Middle Tithonian), 5. *Calpionellidae* BONET zone (Upper Tithonian – Berriasian).

Succession of microfossils and distinguishing of the Upper Jurassic and Lower Cretaceous zones

Since the Upper Jurassic and Lower Cretaceous sediments are very rich in various microfossils, we can not pay an attention to all of them in this paper. We are aimed just at those, which help to a greater or smaller extent to solve biostratigraphic problems. We give them chronologically in the way as individual species occur (cf. Tab. 1).

1. Zoning of the Callovian up to the Lower Tithonian

Protoglobigerinae sporadically as rock-forming microorganisms are known from the Bathonian up to the Kimmeridgian. According to Colom (1955) they are pelagic foraminifers with two development maxima, the first during the Middle Dogger and the second during the Middle Malm. Dragastan – Mutiu – Vinogradov (1975) place *Protoglobigerinae* to Kimmeridgian base.

Cadosina parvula NAGY appears during the Oxfordian, it is more abundant in the Kimmeridgian and the Lower Tithonian when it gradually decreases. It is mentioned by Nagy (1966) in the similar stratigrahic position.

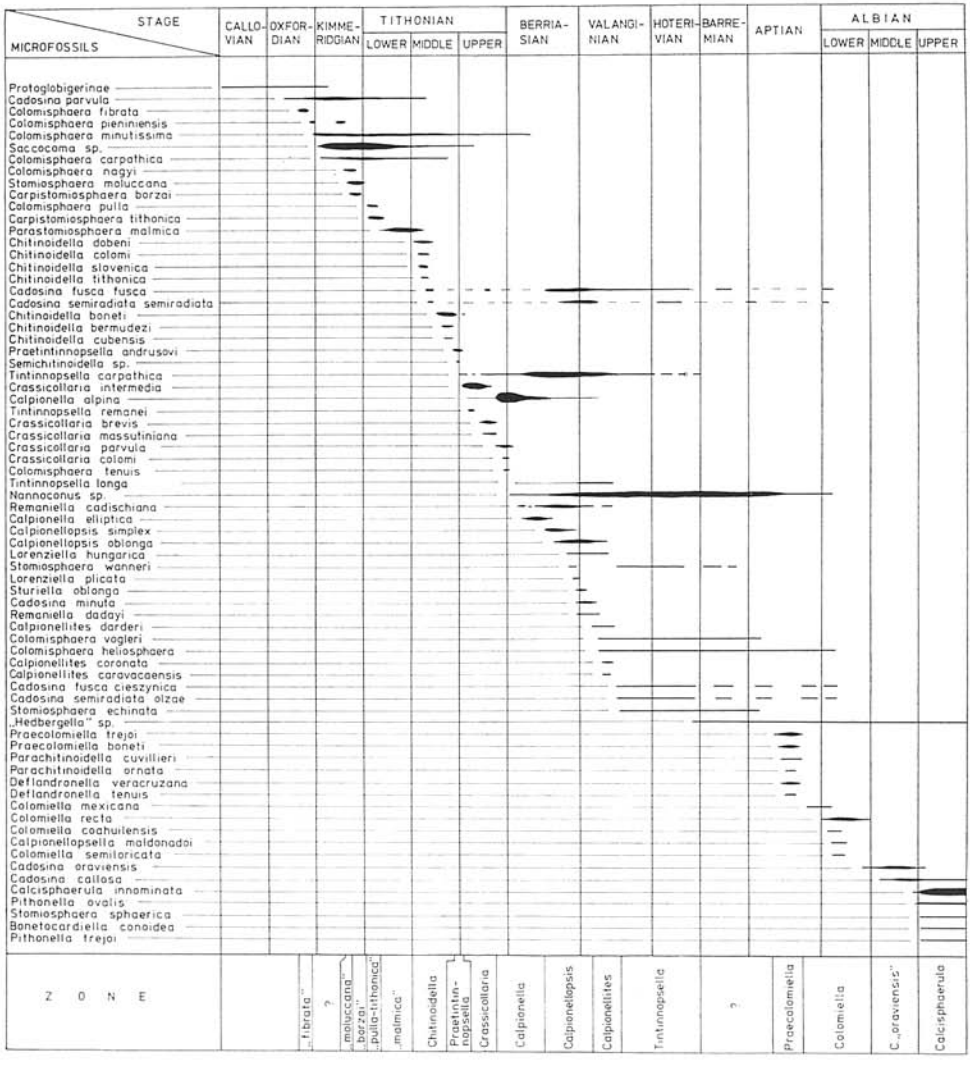
Colomisphaera fibrata (Nagy) is characteristic of the Oxfordian. According to Nagy (1971) it reaches two maxima during the Oxfordian: the first one is Early – Lower Oxfordian, the second one is Upper Oxfordian. In the West Carpathian region we have established hitherto occurrence only in the Upper Oxfordian sediments. It is so expressive and characteristic form, that it cannot be confused with another species. It is a suitable form for "*fibrata*" zone.

Colomisphaera pieniniensis (BORZA) is a rare form in the Upper Oxfordian up to the Kimmeridgian.

Colomisphaera minutissima (COLOM) appears during the Upper Oxfordian, it is more abundant in the Kimmeridgian when it gradually decreases and passes to the Berriasian. In accordance with Nowak (1968) by means of this species the Upper Tithonian up to Berriasian zone may be characterized.

A typical fossil of the Kimmeridgian is *Saccocoma* sp., which occurs as far as the Upper Tithonian (*Crassicollaria* zone). Dragastan – Mutiu – Vinogradov (1975) delimited *Saccocoma* zone for the Kimmeridgian up to the lower part of the Lower Tithonian. In the upper part of the Kimmeridgian *Colomisphaera nagyi* (BORZA) occurs rarely and in the Upper Kimmeridgian *Stomiosphaera moluccana* WANNER appears, it passes as far as the Lowermost Tithonian. Somewhat later, in the Upper Kimmeridgian *Carpiostomiosphaera borzai* (NAGY) apperas. By means of the both forms Nowak (1976) differentiated the Upper Kimmeridgian "*moluccana*" zone and "*borzai*" zone for the Upper Kimmeridgian up to the Lowermost Tithonian. According to Nowak (1976, p. 107) the Kimmeridgian – Tithonian boundary runs in the uppermost part of "*borzai*" zone.

Table 1
Stratigraphic distribution of microfossils in the Upper Jurassic – Lower Cretaceous of the West Carpathians



During the Lower Tithonian *Colomisphaera pulla* (BORZA) and almost simultaneously *Carpistomiosphaera tithonica* NOWAK appear. Both species are found in the lower part of the Lower Tithonian. N o w a k (1968) originally established "*pulla*" zone for the Lower – ? Middle Tithonian, but later N o w a k (1976) did not mention it. It is necessary to point out, that both forms are conspicuous in the West Carpathians, sometimes they may replace each

other, however, it is irrelevant for biostratigraphy. The both forms are suitable for creation of "*pulla-tithonica*" zone (for the lower part of the Lower Tithonian). Later on, during the Lower Tithonian *Parastomiosphaera malmica* (BORZA) appears, it intervenes as far as the Middle Tithonian. It is marked, abundant form, suitable for creation of a zone. N o w a k (1976) places "*malmica*" zone above "*borzai*" zone in the Lower Tithonian.

2. Zoning of the Middle Tithonian up to the Lower Valanginian

Chitinoidels (*Chitinoidella* zone) are typical of the Middle Tithonian. Small forms *Chitinoidella dobeni* BORZA, *Chitinoidella colomi* BORZA, *Chitinoidella slovenica* BORZA and *Chitinoidella tithonica* BORZA are characteristic of the lower part. The most abundant form is *Chitinoidella dobeni* BORZA after which a lower subzone – "*dobeni*" can be named. *Cadosina fusca fusca* WANNER and *Cadosina semiradiata semiradiata* WANNER appear in this association, they transfer as far as the Lower Albian. They occur more frequently in the upper part of *Calpionella* zone and in *Calpionellopsis* zone. Above the small chitinoidel forms there are bigger forms, such as *Chitinoidella boneti* DOBEN, *Chitinoidella bermudezi* (FURRAZOLA BERMUDEZ), *Chitinoidella cubensis* (FURRAZOLA BERMUDEZ) and they form "*boneti*" subzone. Sporadic forms of *Chitinoidella boneti* DOBEN occur together with first calpionellid associations with hyaline test.

Praetintinnopsella andrusovi BORZA appears on the Middle – Upper Tithonian boundary. Gradual transition from *Chitinoidella boneti* DOBEN with microgranular texture of test wall through *Praetintinnopsella andrusovi* BORZA with internal hyaline and external microgranular layer to small variety *Tintinnopsella carpathica* (MURGEANU et FILIPESCU) is observed. *Semichitinoidella* sp. occurs sporadically with *Praetintinnopsella andrusovi* BORZA. This transient zone is denoted as *Praetintinnopsella*.

Calpionellids play an important role in the stratigraphic classification during the Upper Tithonian up to the Lower Valanginian. In 1971 A l l e m a n n–C a t a l a n o–F a r è s–R e m a n e established standard zones of the western Mediterranean province. The published results may be well correlated with stratigraphic distribution of calpionellids in the West Carpathians (cf. B o r z a, 1969, 1974, 1980). We distinguish the following zones for the Upper Tithonian up to the Lower Valanginian:

a) *Crassicollaria* zone. The lower boundary of the zone is defined by appearance of first *Calpionellidae* with total hyaline test. Small variety *Tintinnopsella carpathica* (MURGEANU et FILIPESCU) with very fine collar observable only in well preserved material appears as first one. Soon the genus *Crassicollaria* appears, the first forms are somewhat obscure, but in a short time the genus becomes multiform and dominant. *Crassicollaria intermedia* (DURAND DELGA) is represented especially in the lower part of the zone, *Crassicollaria brevis* REMANE and *Crassicollaria massutiniana* (COLOM) occur in the upper part. Rare species in this zone are small variety *Tintinnopsella carpathica* (MURGEANU et FILIPESCU) on the base, *Tintinnopsella remanei* BORZA in the lower part of the zone, *Calpionella alpina* LORENZ in the central and upper parts, *Crassi-*

collaria parvula REMANE and *Crassicollaria colomi* DOBEN in the upper part of the zone.

b) *Calpionella* zone. Base of the lower boundary of the zone is defined by morphological alteration in *Calpionella alpina* LORENZ passing from big, somewhat elongated varieties to smaller spherical forms and by "explosion" of these small forms, which outlast during the whole Berriasian. *Calpionella alpina* LORENZ markedly dominant in the lower part of the zone is accompanied by *Crassicollaria parvula* REMANE, sporadic individuals of *Crassicollaria colomi* DOBEN on the base and small accessory varieties of *Tintinnopsella carpathica* (MURGEANU et FILIPESCU). *Colomisphaera tenuis* (NAGY) occurs rarely in this part of the zone. Association with *Calpionella alpina* LORENZ was replaced during the Berriasian by association with *Tintinnopsella carpathica* (MURGEANU et FILIPESCU), which achieved great morphological variation and became predominant. It is accompanied by *Calpionella alpina* LORENZ and, in addition, *Crassicollaria parvula* REMANE, *Cadosina fusca fusca WANNER* and *Cadosina semiradiata* WANNER seldom occur. *Calpionella elliptica* CADISCH appears with slight retardation, it has rather limited stratigraphic distribution, owing to this fact it has been considered by some authors a zone form (Allemann, 1970; Catalano – Ligouri, 1971; Allemann – Grün – Wiedmann, 1975 and others). In this zone (lower part of the Berriasian) *Remaniella cadischiana* (COLOM) and *Tintinnopsella longa* (COLOM) occur rarely. Calpionellid association in the Berriasian is accompanied by nanocones which transfer as far as the Lower Albian.

c) *Calpionellopsis* zone. The lower boundary of *Calpionellopsis* zone is defined by first appearance of *Calpionellopsis simplex* (COLOM). This form is rare in the lowermost part of the zone. *Calpionellopsis oblonga* (CADISCH) appears soon after *Calpionellopsis simplex* (COLOM) from which it is derived. *Calpionellopsis oblonga* (CADISCH) later becomes a dominant form and it passes to further zone. *Tintinnopsella carpathica* (MURGEANU et FILIPESCU) is still frequent in this zone, sporadically *Cadosina fusca fusca* WANNER and *Cadosina semiradiata semiradiata* WANNER occur more frequently. *Calpionella alpina* LORENZ is rare in the lower and central parts, *Lorenziella hungarica* KNAUER et NAGY in the central and upper parts. *Lorenziella plicata* REMANE and *Sturiella oblonga* BORZA as well are rare, they have stratigraphically limited distribution. *Remaniella cadischiana* (COLOM), *Remaniella dadayi* (KNAUER) and *Tintinnopsella longa* (COLOM) become important in the upper part of the zone. Here *Stomiosphaera wanneri* BORZA appears, it is rare and it passes as far as the Upper Barremian. In the upper part of *Calpionellopsis* zone and on the following *Calpionellites* zone as well *Cadosina minuta* BORZA occurs, it has relatively limited stratigraphic distribution.

d) *Calpionellites* zone. The lower boundary of the zone is characterized by occurrence of *Calpionellites darderi* (COLOM). Calpionellids are rare in the Valanginian, genus *Calpionellites* does not become predominant. In this zone *C. oblonga* (CADISCH), *Remaniella dadayi* (KNAUER), *Tintinnopsella carpathica* (MURGEANU et FILIPESCU), *Lorenziella hungarica* KNAUER et NAGY *Calpionellites caravacaensis* ALLEMANN, *Calpionellites coronata* TREJO and *Tintinnopsella longa* (COLOM) occur in this zone. Calpionellids become gradually rare. In this zone *Colomisphaera vogleri* (BORZA) appears, it outlasts the Aptian and *Colomisphaera heliosphaera* (VOGLER) – the Lower Albian. The upper

boundary of the zone is not clear, it is defined by extinction of family *Calpionellidae* (the Lower Valanginian). However, it seems, that the longest life has *Tintinnopsella carpathica* (MURGEANU et FILIPESCU), its rare occurrences outlast as far as the Hauterivian, it has not been found in the Barremian. We place the period where only *Tintinnopsella carpathica* (MURG. et FILIP.) occur to *Tintinnopsella zone*. Its upper boundary runs in the Upper Hauterivian.

It should be noted, that the Tithonian – Berriasian, Berriasian – Valanginian boundaries determined on the basis of ammonite zones do not coincide with calpionellid zones.

3. Zoning of the Upper Valanginian up to the Albian

For the time being, we have not determined important microfossils in the upper part of the Valanginian up to the Barremian, on the basis of which a more detailed classification may be done.

During the Upper Valanginian appear: *Stomiosphaera echinata* NOWAK passing to the Lower Aptian and *Cadosina fusca cieszynica* NOWAK and *Cadosina semiradiata olzae* NOWAK having even greater stratigraphic range and passing to the Lower Albian.

Nanocones occur from the Berriasian up to the Lower Albian. They are rock-forming, however, on their basis a boundary between the stages cannot be determined (Brönnimann, 1955; Trejo, 1960; Baldi Beke, 1965; Geel, 1966; Manivit et al., 1969 and others),

During the Early Upper Aptian *Praecolomiella trejoi* BORZA, *Praecolomiella boneti* BORZA, *Parachitinoidella cuvillieri* TREJO, *Parachitinoidella ornata* BORZA, *Deflandronella veracruzana* (TREJO), and *Deflandronella tenuis* (TREJO) appear (Borza, 1979). Genus *Praecolomiella*, after which the zone has been named, is the most abundant in this association.

During the Upper Aptian *Colomiella recta* BONET appears, it passes to the Lower Albian. During the Lower Albian *Colomiella mexicana* BONET is the most frequent species, *Colomiella coahuilensis* TREJO, *Colomiella semiloricata* TREJO and *Calpionellopsella maldonadoi* TREJO occur rarely (Borza, 1978). We have distinguished *Colomiella* zone for the Uppermost Aptian up to the Lower Albian.

In the uppermost part of *Colomiella* zone section belonging to the species *Cadosina oraviensis* BORZA appear. It has abundant occurrence in the Middle Albian and it passes to the Upper Albian. In addition, *Cadosina callosa* KNAUER appears during the Middle Albian. We have delimited C. "*oraviensis*" zone for the Middle Albian.

During the Upper Albian *Calcisphaerula innominata* BONET occurs very frequently, it is accompanied by *Pithonella ovalis* (KAUFMANN), *Pithonella trejoi* BONET, *Bonetocardiella conoidea* (BONET) and *Stomiosphaera sphaerica* (KAUFMANN). Genus *Calcisphaerula*, after which we have named the zone, is dominant in this association.

Conclusions

In conclusion we may state, that:

a) the Upper Jurassic and the Lower Cretaceous sediments may be classified on the basis of microfossils rather in detail. Their advantage is that they occur often very frequently, therefore, in majority of cases, they can be easily determined even from the small rock pieces;

b) on the basis of microfossil succession we have distinguished 16 zones in the Upper Jurassic and the Cretaceous;

c) more detailed division can be carried out on the basis of tintinnids from the Middle Tithonian up to the Lower Valanginian and then in the Upper Aptian up to the Lower Albian;

d) unilocular microorganisms classed to Incertae sedis have in majority of cases greater stratigraphic range. They may be well applied to detailed classification of sediments from the Oxfordian up to the Middle Tithonian;

e) boundaries of the stages determined on the ammonite basis do not coincide with the zones determined on the basis of studied microfossils.

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