The types of nummulitins localities in the Dinarides

Tipi numulitinskih nahajališč v Dinaridih

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Abstract: In Dinarides occur numerous localities of nummulins in limestones and in flysch. True paleobiocenoses in limestones are rare, while nummulitins in flysch were transported from elsewhere. The primary localities in limestone are subdivided in the article into genuine paleobiocenoses and to at least patly destroyed paleobiocenoses. In secondary localities occurs in limestones fauna either from the same biotope or from various biotopes. In flysch beds, fauna is either synchronous with beds, or the fauna is mixed from various times. A review is presented of the most abundant and most important nummulitic species in limestones and flysch beds.

Izvleček: V Dinaridih so številna nahajališča numulitin v apnencih in v flišu. V apnencih so redke prave paleobiocenoze, medtem ko so numulitine v flišu prinešene od drugod. V članku so razdeljena primarna nahajališča v apnencu na prave paleobiocenoze in na vsaj delno uničene paleobiocenoze. V sekundarnih nahajališčih je v apnencih favna iz istega biotopa in iz različnih biotopov. V flišu je favna ali sinhrona s plastmi, ali je mešana favna iz različnih obdobij. Podan je pregled najpogostejših in najpomembnejših numulitinskih vrst v apnencih in v flišu.

Key words: localities of nummulitins, Paleogene, Dinarides.
Ključne besede: nahajališča numulitin, paleogen, Dinaridi.

Introduction

In Dinarides occur rich localities of nummulitins especially in Eocene and less in Oligocene beds in limestones, flysch beds and partly in other clastites. In this connection arises a number of questions. The first concerns the problem of biocenoses or paleobiocenoses in limestones. In flysch, however, the nummulitins occur transported to secondary place. Interesting is further the question of reliability of nummulitins in flysch for biostratigraphic purposes.

With respect to the mentioned problems the nummulitins localities will be subdivided into autochthonous and allochthnonous localities. Also the use of biostratigraphic data from these localities will be discussed. In this sense are distinguished:

In limestones:

1. Primary localities of nummulitins
   a. paleobiocenosis
   b. destroyed paleobiocenosis;

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2. Secondary localities of nummulitins
   a. fauna from the same biotope
   b. mixed fauna from various biotopes;

In flysch:

3. source of fauna
   a. synchronous with beds
   b. mixed fauna.

LOCALITIES IN LIMESTONES

In the Dinarides rich localities of nummulitins occur in Ilerdian, Cuisian and Lutetian limestones that are also named alveolinal-nummulitic, nummulitic and, some horizons, assilina limestones (AUBOIN & NEUMANN, 1960). There often occurs mixed alveolinal and nummulitic fauna, in places prevail alveolinas, in others nummulitins. Most often the fauna was not transported from older beds. This is explained by the fact that at the time of deposition of calcareous mud older sediments were already lithified to the degree that foraminifer tests could not be easily shelled out of them. But also in cases when older sediments were not lithified, they could be covered by younger deposits. For the most part at those times there were no stronger orogenic or other events that would result in the removal of material into younger sediments. The situation was different in the flysch beds. In the Slovenian part of Dinarides in Cuisian olistostrome beds numerous fragments of Ilerdian limestones can be found. This indicates that during the release of Cuisian submarine slumps the Ilerdian limestone was already lithified.

1. Primary localities of nummulitins

In connection with the fossil localities in limestones arises the question of the possibility of preservation of a true paleo-biocenosis in them. This concerns especially the smaller organisms to which belong also foraminifers. On one hand the remains of nonskeletal sea plants and animals are lacking. Owing to this the paleobiocenosis is not complete. On the other hand it is mostly not clear which of the present organisms used to live together. After their decease their remains were moved by waves and currents and transported to secondary places. This transport as a rule was not distant. Nonetheless it resulted in fossil localities into assemblages of remains of animals and plants that had not lived together, and consequently do not belong to the same paleobiocenoses.

All this is valid also for nummulitins localities. The optimum living environments for individual groups or genera of foraminifers slightly differed. A good example for certain genera of foraminifers is known from the Red Sea region where their distribution with respect to depth, light intensity, water energy and other conditions was studied (HOTTINGER & DREHER, 1974; HOTTINGER, 1977; 1982). It is well known that in the shallow waters on the Paleogene carbonate platform in Dinarides numerous miliolids and conic foraminifers lived, the large miliolids especially in shallow littoral tropic and subtropic regions, and preferrably on solid bottom (DROBNE ET AL., 2002). And somewhat deeper water or a relatively greater distance from shore was most probably needed by alveolinas and also by nummulitins. Differences as to the depth of sea and the distance

from shore existed also within the nummulitins. Various foraminifers differed in the way of life and feeding habits. This is most probably valid to a certain degree also for the nummulitins. In the Dinarides in certain Lower Lutetian horizons large assilinas are frequent (Pavlovec, 1993), as the species *Assilina monacensis* (Pavlovec) and *Assilina maxima* (Pavlovec). Elsewhere in the alveolina-nummulites limestone in the same assemblage numerous alveolinas and nummulites are found. Under the assumption that these genera did not live at exactly the same places, it can be concluded they were brought together only after their death. This hypothesis is confirmed also by the frequently observed irregular distribution of nummulitins tests in the limestone.

These arguments lead to the conclusion that many nummulitins are presently not situated exactly there where they lived, and that many tests of nummulitins and other foraminifers became redistributed after their death. This

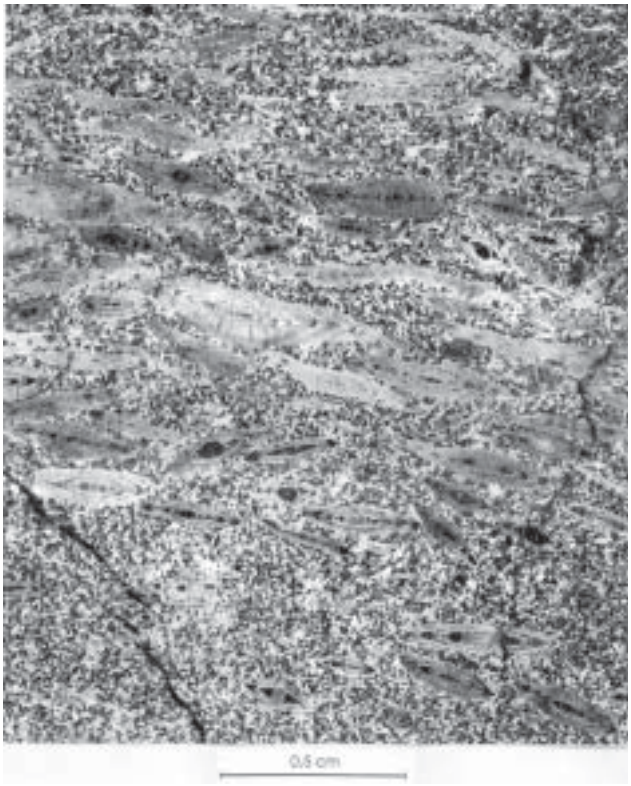

Figure 1. Example of primary locality of nummulitins in limestone, younger part of Lower Lutetian, southwest of Vrbnik on the island of Krk. Nummulitins are oriented parallelly to beds in which occur *Assilina spira abrardi* Schaub, *Nummulites hilarionis* Schaub and *N. kugleri* Schaub.
Slika 1. Primer primarnega nahajališča numulitin v apnencu, mlajši del spodnjega lutecija, južnozahodno od Vrbnika na Krku. Numulitine so položene vzporedno s plastmi, v katerih so *Assilina spira abrardi* Schaub, *Nummulites hilarionis* Schaub in *N. kugleri* Schaub.

means that a large part, or even the majority of localities of nummulitins do not represent true paleobiocenoses, but rather thanatocenoses or taphocenoses (ALADŽOVA-HRISČEVA, 1980; PAVLOVEC, 1983).

In the Dinarides occur in certain limestone beds very abundant nummulites, and in others assilinas. Since these forms are at least to a certain degree orderly distributed in various parts of limestone beds, we may assume that even certain nummulitins required for their optimal development various distances to shore, sea depths and possibly other conditions. At Črni Kal in south Slovenia a good example of different foraminifers in individual horizons can be observed. In older Eocene horizons alveolinas are very abundant, above them prevail nummulites, and higher assilinas, especially *Assilina spira abrardi* Schaub. At Dubravica in Dalmatia occurs in a limestone bed almost exclusively *Assilina maior* Heim, for which at that time obviously the living conditions were excellent. In those times lived in the sea certainly also other organisms that are not found at present among the assilinas. In other parts of the same profile occurs a rapid interbedding of layers with alveolinas, then with nummulites and again with alveolinas. This allows the assumption of the existence of synsedimentary processes (DROBNE ET AL., 1991).

In some parts of limestones the nummulitic tests are disorderly distributed, and in others they are parallel to bedding (Figure 1). For the second case the hypothesis of them having lived in a place, without disturbance of currents and waves, might be valid (PAVLOVEC, 1983). It is also possible that tests became oriented in the described way during transport (ALIDŽOVA-HRISČEVA & HRISČEV, 1976).

The mentioned arguments allow the conclusion about the extreme rareness of true biocenoses in limestones. Together may be found the organisms that lived very close, but not exactly in the same places. Besides, remains of certain animals and plants are absent. Therefore such an assemblage cannot be an example of a true paleobiocenosis, but rather of a destroyed paleobiocenosis. Nevertheless, the fossils in such localities can be usable for dating the beds.

2. Secondary localities of nummulitins

Secondary localities are defined as those with nummulitins at secondary place, possibly also away from the site where they lived, and they may be also either from the same or from different biotopes. They could have been transported by currents or waves (Figure 2). These localities are more rare than the primary ones. This is indicated by relatively few damaged tests. To the secondary localities can not be attributed the formerly mentioned mixed faunas that do not belong to true paleobiocenoses, but those can for which the transport took place over somewhat longer distances. Such cases are, by the way, not easy to distinguish or to prove. If the transport of nummulitins tests was carried out over longer distances, they could be expected to occur at least among the miliolidas that lived in larger numbers elsewhere than the ummulitins. Similar examples can be observed also with other organisms, e.g. in the Maastrichtian Vreme beds of southern Slovenia. In certain parts the pelecypod valves occur accumulated as a result of tossing the valves, most probably towards the coastal part of the sea (KNEZ, 1992, 1994). More difficult are the conclusions on whether

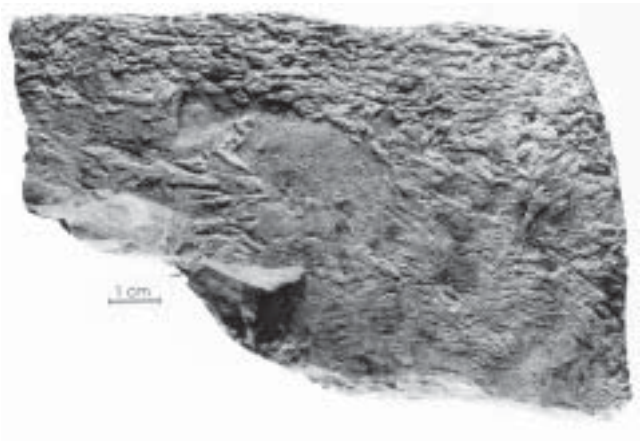

Figure 2. A secondary locality of nummulitids in limestone near the Ilerdian/Cuisian boundary, Golež in southern Slovenia. Tests are aligned in part parallelly to beds, and in part irregularly distributed. This indicates a transport and accumulation of tests in nests. In the beds are present *Nummulites increscens* Schaub, *N. ornatus* Schaub in *N. subramondi* De la Harpe.
Slika 2. Sekundarno nahajališče numulitin v apnencu, blizu meje ilerdij/cuisij, Golež v južni Sloveniji. Hišice so položene deloma vzporedno, deloma so nepravilno razmetane. To kaže na prenašanje in kopičenje hišic v gnezdih. V teh plasteh so *Nummulites increscens* Schaub, *N. ornatus* Schaub in *N. subramondi* De la Harpe.

the shorter transport was a result of tidal currents, and the longer transport of more violent waves and currents (Johnson & Baldwin, 1986), or on possible three models of transport, as hypothesized in Bulgaria (Aladžova-Hrisčeva & Hrisčev, 1976): by rolling on the sea bottom or saltation, by submarine currents, or owing to thickening of suspension. Benjamini (1980) wrote that nummulitins inhabited the low to high-energy seas.

Also at secondary localities in limestones the fauna is most often synchronous with the beds, and is therefore applicable to stratigraphic conclusions.

Localities in flysch

In an entirely different manner as in limestones occur the nummulitins in flysch beds. It is understandable that the environment in which flysch sediments accumulated was not favorable for the life of nummulitins and other organisms. The sea was too deep, not clean enough, and larger fragments among the rocky clasts could destroy, or at least damage the skeletons (Pavlovec, 1977). Nevertheless occur locally in flysch rich localities of fossils, among which also of nummulitins, even in coarse olistoliths. Already in 1962 Papp drew attention to the fact that nummulitins in sediments of the flysch type do not occur in their living environment,

but were brought in there by turbidity currents. A fine example for this is the calcareous turbidite at Fiesa in southern Slovenia (PAVLOVEC, 2001). In the lower part of this horizon occurs an abundance of tests of species *Nummulites millecaput* Boubée that are of a different orientation than the current lines in the remaining parts of the turbidite (PAVLOVEC, 1966). This should signify that the rocky material was supplied from other sources than the nummulitins that lived on the carbonate platform.

In Istria occur in olistostrome sediments several localities with rich fossil fauna and flora. In them next to numerous nummulitins and several other foraminifers also remains of sea urchins, corals, snails, bivalves and lithothamnians are found. Near Pićan in central Istria apear in Lutetian olistostromes (HAGN ET AL., 1979) nummulitins from various stratigraphic horizons: *Nummulites distans* Deshayes, *N. millecaput* Boubée, *N. praelorioli* Herb & Schaub, *Assilina spira spira* De Roissy. A model of supply of rock material from one side and of living organisms or their skeletons from the other side, i.e., from the carbonate platform, was established (PAVLOVEC, 1969, 1988). Examples from Istria indicate a vigorous orogenic activity at the time of occurrence of olistostrome sediments. This activity was accompanied by earthquakes. They at times triggered the release of submarine slumps, of tsunamis and possibly other events that drove parts of the sediments and organisms that lived on them towards the open sea. In this way the fossils that are found in the flysch beds got mixed within the flysch deposits in the deeper sea.

In the described model the tests of nummulitins and skeletons of other organisms became mixed with the flysch material only near the sea bottom, or on the bottom, there where the flysch sediments accumulated. Occurrence of relatively rare fragmented or otherwise damaged tests allowed the conclusion that sediment and the remains of organisms did not arrive to the sea bottom at the same time. Among the nummulitins in Istrian localities occurs a high proportion of damaged and healed up specimens, e.g. broken off and subsequently closed up parts of a nummulitic tests (PAVLOVEC, 1976). This could happen still during the life of foraminifers on the carbonate platform, since otherwise the damage would not heal up. There is a very low probability that the nummulitins could stay alive in a somehow deeper flysch sea within the rock material and muddy water. This means that damages happened on the carbonate platform itself, presumably in general owing to stronger orogenic movements and processes associated with them. Damage and healing up is less frequent among nummulites than assilinas, the tests of which are thinner and therefore less resistant.

On ground of this interpretation of the fossil accumulation in flysch the paleobiocenoses there are out of the question. In addition, also no conclusions can be made on the environment in which lived on the carbonate platform the organisms that are found in flysch beds, since during transport the organisms from various biotopes got mixed. On the other hand, the conclusions about the age can be made, if the organisms found in flysch were synchronous with the beds. Care must only be taken to ascertain that no mixing of animals and plants from different stratigraphic horizons took place.

A good example is offered in Goriška brda in western Slovenia. There the flysch Kožbana beds of Paleocene and Lower Eocene are overlain by the Eocene Medana beds. During the time of deposition of Kožbana beds the orogenic movements were stronger, as suggested by inclusions of olistostromes. Therefore into the rock material sediments of Cretaceous flysch were introduced. With this material also Cretaceous fossils were transported into the Paleogene sea. In the Medana turbiditic beds the Cretaceous fossils are much more rare.

North of Goriška brda above Kanal were found in flysch almost exclusively Maastrichtian fossils *Orbitoides media* (D'Archiac), *O.* cf. *apiculata* Schlumberger, *Clypeorbis mamillata* (Schlumberger), *Lepidorbitoides* aff. *socialis* (Leymerie), *Simplorbites gensasicus* (Leymerie), *Siderolites* sp. Only the genus *Orbitolina* was introduced from older sediments (Pavlovec, 1962). In the Medana beds at Vipolže in Goriška brda no mixing of fauna within the nummulitins occurred, but there was appreciable mixing within the nannoplankton. These beds were deposited during the younger Cuisian, or at the pasage Cuisian–Lutetian. The following species and subspecies were determined (Cimerman et al., 1974; Pavlovec & Simčič, 1999): *Assilina maior maior* Heim, *Ass. maior punctulata* Schaub, *Ass. medanica* Pavlovec, *Ass. cuvillieri* Schaub, *Ass. suteri* Schaub, *Ass. reicheli* Schaub, *Ass.* aff. *praespira* Douvillé, *Nummulites campesinus* Schaub, *N. friulanus* Schaub, *N. manfredi* Schaub, *N.* aff. *lehneri* sensu Schaub, 1981, *N. praelorioli* Herb & Schaub, *N. quasilaevigatus* Pavlovec. The mentioned forms belong to the same stratigraphic horizon. At the time of deposition of these beds the orogenic activity was obviously weaker, or were perhaps the older sediments covered by the younger ones.

More frequent nummulitins of Slovenia, Istria, Quarner Islands, Dalmatia and Herzegovina

The data below are listed from publications cited in the references.

Limestones

In Dinarides of southwestern Slovenia, Istria, Quarner islands, Dalmatia and Herzegovina certain nummulitins forms are more frequent. It is not clear, in the sense of discussion above, which species or subspecies belong to the same paleobiocenoses. We shall review the more important species and subspecies in the alphabetic order.

Nummulitins are rare in limestones of the youngest Paleocene of southwestern Slovenia. Recorded were *Assilina azilensis* (Tambareau), *Ass. ornata* (Hottinger) and *Ass. yvettae* Schaub. In the remaining parts of Dinarides these horizons have not been studied sufficiently with respect to nummulitins yet.

In older parts of Lower Ilerdian limestones of southwestern Slovenia *Assilina azilensis* (Tambareau), *Ass. ammonea tectosaga* (Hottinger), *Nummulites deserti* De la Harpe, *N. gamardensis* Kapellos & Schaub, *N. subplanulatus* Hantken & Madarasz are known. In somewhat younger horizons occur *Assilina ammonea ammonea* (Leymerie), *Nummulites carcasonensis* Schaub,

N. deserti De la Harpe and *N. praecursor* De la Harpe, although not very abundantly. In even higher horizons of Lower Ilerdian appear *Assilina adrianensis* Schaub and *Nummulits minervensis* Schaub.

In Middle Ilerdian are known *Assilina ammonea ammonea* (Leymerie), *Ass. douvillei douvillei* (Schlumberger), *Ass. exiliformis* (Pavlovec), *Nummulites globulus globulus* Leymerie, *N. praecursor* De la Harpe and *N. soerenbergensis* Schaub.

In Upper Ilerdian are present *Assilina ammonea ammonea* (Leymerie), *Nummulites alpinus* Schaub, *N. increscens* Schaub, *N. soerenbergensis* Schaub and *N. subramondi subramondi* Schaub.

In Lower Cuisian limestones occur *Nummulites aquitanicus* Benoist, *N. burdigalensis burdigalensis* De la Harpe, *N. partschi partschi* De la Harpe, *N. rotularius* Deshayes, *N. soerenbergensis* Schaub and *N. subdistans* De la Harpe.

In Middle Cuisian beds were determined *Assilina laxispira* De la Harpe, *Ass. reicheli* Schaub, *Nummulites distans* Deshayes, *N. increscens* Schaub and *N. praelaevigatus* Schaub.

From Upper Cuisian are known *Nummulites campesinus* Schaub, *N. manfredi* Schaub, *N. polygyratus* Deshayes and *N. praediscorbinus* Schaub. In transition horizons between Cuisian and Lutetian occur *Nummulites polygyratus* Deshayes and *N. praediscorbinus* Schaub.

Much more abundant are nummulitins in Lutetian beds that obviously provided for them a more favorable environment. In Lower Lutetian limestones occur *Assilina maxima* (Pavlovec), *Ass. monacensis* (Pavlovec), *Ass. praespira* Douvillé in the way that *Assilina praespira* appeared first, somewhat later *Ass. monacensis,* and even later *Ass. maxima* (PAVLOVEC & MAJCEN, 1986; PAVLOVEC, 1993). From the Lower Lutetian are known further *Assilina spira abrardi* Schaub (= *Ass. istrana*, Pavlovec), very abundant in Istria and on Quarner islands, *Ass. tenuimarginata* Heim, *Nummulites alponensis* Schaub, *N. gallensis* Heim, *N. laevigatus* (Bruguière), *N. lehneri* Schaub, *N. obesus* D'Archiac & Haime, *N. praebullatus* Schaub, *N. praediscorbinus* Schaub, *N. praelorioli* Herb & Schaub, *N. syrticus* Schaub, *N. tobleri* Schaub and *N. uranensis* De la Harpe.

In the older part of Middle Lutetian appear *Assilina exponens* (Sowerby), *Ass. spira spira* (De Roissy), *Nummulites lorioli* De la Harpe, *N. millecaput* Boubée and *N. praeaturicus* Schaub. From the younger part of Middle Lutetian are known *Assilina spira planospira* Boubée, *Nummulites bullatus* Azzaroli, the very abundant *N. discorbinus* (Schlotheim), and abundantly in certain beds *N. lorioli* De la Harpe, *N. millecaput* Boubée and *N. tavertetensis* Reguant & Clavell.

Flysch beds

Nummulitins are abundant in Cuisian flysch beds of southern Slovenia. A number of species are the same as in the limestones. Certain species, however, are much more frequent in flysch than in the limestones of the same age. They were most probably removed from those parts of the carbonate platform where the living conditions were especially

favorable. This suggests the idea on how little we still know about some platform areas. Many nummulitins in Lutetian flysch are found especially in Istria, on Quarner islands and in Dalmatia.

From the Lower/Middle Cuisian transition of southern Slovenia are known *Assilina marinellii similis* (Khan & Pavlovec), *Nummulites jacquoti* De la Harpe, *N. ornatus* Schaub, *N. partschi partschi* De la Harpe, *N. praelucasi* Douvillé, *N. rotularius* Deshayes, *N. ustjensis* De Zanche & Pavlovec and *N. vipavensis* De Zanche & Pavlovec.

In Middle Cuisian beds occur *Assilina laxispira* De la Harpe, *Ass. marinellii similis* (Khan & Pavlovec), *Nummulites archiaci* Schaub, *N. aquitanicus* Benoist, *N. brkiniensis* Khan & Pavlovec, *N. postbearnensis* Khan & Pavlovec, *N. rotularius* Deshayes and *N. subdistans* De la Harpe.

From the Upper Cuisian, or from the Cuisian/Lutetian transition are known *Assilina cuvillieri* Schaub, *Ass. medanica* Pavlovec, *Ass. maior* Heim, very abundant in certain beds, *Ass. reicheli* Schaub, *Nummulites boussaci* Rozlozsnik, *N. campesinus* Schaub, *N. distans* Deshayes, *N. friulanus* Schaub, *N. manfredi* Schaub, *N. quasilaevigatus* Pavlovec, *N. praelorioli* Herb & Schaub and *N. verneuili* D'Archiac & Haime.

In Lower Lutetian beds of Istria and Quarner islands are present *Assilina maxima* (Pavlovec), *Ass. praespira* Douvillé, *Ass. spira abrardi* Schaub, *Ass. tenuimarginata* Heim, *Nummulites gallensis* Heim, *N. laevigatus* (Bruguière), *N. lehneri* Schaub, *N. perplexus* Schaub, *N. polygyratus* Deshayes, *N. praelorioli* Herb & Schaub and *N. verneuili* D'Archiac & Haime. In Middle Lutetian are *Assilina spira spira* (De Roissy), *Ass. exponens* (Sowerby), *Nummulites millecaput* Boubée and *N. lorioli* De la Harpe.

In Herzegovina the flysch-like beds occur in the youngest part of the Middle Eocene. In them were determined *Assilina bericensis* (Oppenheim), *Ass. roselli* (Hottinger), *Nummulites cyrenaicus* Schaub, *N. dufrenoyi* D'Archiac & Haime, *N. perforatus* (De Montfort) and *N. puigsecensis* Reguant & Clavell.

Conclusions

Nummulitins localities in limestones are either primary or secondary. In the primary localities either a true paleobiocenosis may occur, or a mixed fauna and flora that came by currents and waves from a shorter distance. In limestones the nummulitins are most frequently synchronous with the beds, and forms of different ages are only rarely admixed.

In Dinarides the nummulitins were brough into the flysch sediments from the carbonate platform. In the flysch localities the organisms lived at the time of deposition of flysch, and are therefore applicable for dating the beds. In addition, with them into the flysch sea also fossils from older horizons could have been brought in.

It was found during studies of nummulitins from limestone and flysch that the most frequent species occur in both sediments, although at times in different abundancies. Particular species are very abundant in limestones and much less in flysch, and vice versa. In such a case forms from a definite part of the carbonate platform could have been supplied to the flysch. But it may also be that the entire fauna is too little known for reaching more reliable conclusions about the phenomenon.

REFERENCES

ALADŽOVA-HRISČEVA, K. (1980): Numulitidi ot centralna, severna i severozapadna Blgarija i tjahnoto stratigrafsko značenie. *Sofijski Univ., Geol.-Geograf. Fak., Kat. Dinam. Istor. Geol., Sofija.*, pp. 1-30.

ALADŽOVA-HRISČEVA, K. & HRISČEV, H. (1976): Uslovija zahoronenija i konservacii nummulitidnoj fauni, na primere paleogenovih otloženii Severnoj Blgarii (Conditions for burying and preservation of nummulitid faunas, on the example of the Palaeogene deposits of Northern Bulgaria). *Geol. Balcanica, Sofija 6*, pp. 21-30.

AUBOUIN, J. & NEUMANN, M. (1960): Sur la géologie de l'Istrie méridionale. *Bull. Soc. géol. France, Paris. 2(7)*, pp. 388-395.

BENJAMINI, CH. (1980): Facies Relationship in the Avedat Group (Eocene) in the Northern Negev, Israel. *Israel J. Earth. Sci 28, Jerusalem*, pp. 47-69.

CIMERMAN, F., PAVLOVEC, R., PAVŠIČ, J. & TODESCO, L. (1974): Biostratigrafija paleogenskih plasti v Goriških brdih (Biostratigraphy of the Paleogene Beds in Goriška Brda). *Geologija 17, Ljubljana*, pp. 7-130.

DE ZANCHE, V., PAVLOVEC, R. & PROTO DECIMA, F. (1967): Mikrofavna in mikrofacies iz eocenskih flišnih plasti pri Ustju v Vipavski dolini, JZ Slovenija (Microfauna and microfacies of the Eocene flysch series near Ustje in the Vipava valley, Vipavska dolina, SW Slovenia). *Razprave 4. razreda SAZU 10, Ljubljana*, pp. 205-263.

DROBNE, K., ĆOSOVIĆ, V. & ROBINSON, E. (2002): Velike miliolide zgornje krede in paleogena skozi prostor in čas (Larger miliolids of the Late Cretaceous and Paleogene seen through space and time). *Geologija 45/2, Ljubljana*, pp. 359-366.

DROBNE, K., VLAHOVIĆ, I., TRUTIN, M., PAVLOVEC, R., ĆOSOVIĆ, V., BABAC, D., CIMERMAN, F., LUCIĆ, D. & PAVŠIČ, J. (1991): Excursion B – Ravni Kotari, Paleogene. *Excursion Guide-Book, The second Internat. Symp. on the Adriatic Carbonate Platform, Zagreb,* pp. 53-105.

HAGN, H., PAVLOVEC, R. & PAVŠIČ, J. (1979): Excursion G, Gračišće near Pićan, Istria – Eocene. *16th Europ. Micropal. Colloquium, Ljubljana*, pp. 185-190.

HOTTINGER, L. (1977): Foraminiferes operculiniformes. *Mém. Mus. Nat. Hist., n.s. C 40, Paris*, pp. 1-160.

HOTTINGER, L. (1982): Larger Foraminifera, Giant Cells with a Historical Background. *Naturwissenschaften 69, Berlin*, pp. 361-371.

HOTTINGER, L. & DREHER, D. (1974): Differentiation of Protoplasm in Nummulitidae (Foraminifera) from Elat, Read Sea. *Marine biology 25, Berlin*, pp. 41-61.

JOHNSON, H. D. & BALDWIN, C. T. (1986): Shalow siliciclastic seas. *Sedimentary Environments and Facies, Blackwell Sci. Publ., London-Oxford,* pp. 229-282.

KHAN, M. R., PAVLOVEC, R. & PAVŠIČ, J. (1975): Eocenski mikrofosili iz okolice Podgrada (Eocene microfossils from Podgrad). *Geologija 18, Ljubljana*, pp. 9-60.

KNEZ, M. (1992): Paleoekološke značilnosti vremskih in kozinskih plasti v okolici Škocjanskih jam. *Fakulteta za naravoslovje in tehnologijo, Ljubljana* (magistrsko delo), 175 p.

KNEZ, M. (1994): Paleoekološke značilnosti vremskih plasti v okolici Škocjanskih jam (Paleo-ecological properties of the Vreme beds in the vicinity of Škocjanske jame, Škocjanske jame caves, Slovenia). *Acta carsologica 23/22, Ljubljana*, pp. 303-347.

Papp, A. (1962): Die Nummulitenfaunen von Michelberg (Waschbergzone) und aus dem Greifensteiner Sandstein (Flyschzone). *Verh. geol. Bundesanst 5., Wien*, pp. 281-290.

Pavlovec, R. (1962): O presedimentaciji makroforaminifer v flišu (On the derived large foraminifers in flysch). *Geologija 7, Ljubljana*, pp. 247-255.

Pavlovec, R. (1966): Paleogene strata in Goriška brda (Western Yugoslavia). *Bulletin scientifique 11/ 10-12, Zagreb*, pp. 243-244.

Pavlovec, R. (1969): Istrske numulitine s posebnim ozirom na filogenezo in paleoekologijo (Istrian nummulits with special regard to phylogenesis and palaeoecology). *Razprave SAZU, 4. razred 12/4, Ljubljana*, pp. 153-206, tab. 1-13.

Pavlovec, R. (1976): Patologija numulitin (The Pathology of Nummulitins). *Geologija 19, Ljubljana*, pp. 83-105.

Pavlovec, R. (1977): Numulitine in flišni sedimenti (Nummulitins and flysch sediments). *Rudarsko-metalurški zbornik 4, Ljubljana*, pp. 451-457.

Pavlovec, R. (1981): Middle Eocene assilinas and operculinas in the Dinarids. – *Zbornik radova, Znan. savjet za naftu JAZU A/8, Zagreb*, pp. 67-76.

Pavlovec, R. (1981): Fliš v Postojni (Flysch from Postojna). *Geologija 24/2, Ljubljana*, pp. 285-301.

Pavlovec, R. (1982): Nekaj značilnih numulitin iz fliša Jugoslavije (Some characteristical Nummulitines from Flysch of Yugoslavia). *Zbornik radova, X jubilarni kongres geology Jugoslavije 1, Budva*, pp. 193-200.

Pavlovec, R. (1983): Paleoecology of Nummulitines. *Boll. Soc.Pal. Ital 22/1-2, Modena*, pp. 15-19.

Pavlovec, R. (1987): Lutecijske numulitine z otoka Paga in Miletićev pri Zadru. *Zbornik radova Crnogorske akademije nauka i umjet., Titograd*, pp. 61-74.

Pavlovec, R. (1988): Savremeni pogledi na istraživanja numulitina (Contemporary aspects of study of nummulitinae). *Radovi Akad. nauka umjet. Bosne i Herceg., odj. teh. nauka 12, Sarajevo*, pp. 141-170.

Pavlovec, R. (1993): Unterlutetische Operculinen der Äusseren Dinariden. *Zitteliana 20, München*, pp. 295-300.

Pavlovec, R. (1993): Numulitine v apnencih na Kvarnerskih otokih in sosednjem področju. *Rudarsko-metalurški zbornik 40/1-2, Ljubljana*, pp. 93-102.

Pavlovec, R. (2001): Numuliti iz apnenčevega turbidita pri Fiesi, Slovenija (Nummulitids from calcareous turbidite at Fiesa, Slovenia). *Annales, ser. hist. nat 11/2., Koper*, pp. 295-306.

Pavlovec, R. & Jungwirth, E. (1996): Problems of Micropaleontological Studies in Herzegovina on the Example of the Nummulitids. *Natura Croatica 5/4, Zagreb*, pp. 329-337.

Pavlovec, R. & Majcen, T. (1986): Numulitine iz eocenskih apnencev Jugoslavije (Nummulitines from Eocene limestones in Yugoslavia). *XI Kongres geologa Jugoslavije 2, Tara*, pp. 263-274.

Pavlovec, R. & Simčič, I. (1999): Numulitine iz okolice Vipolž v Goriških brdih (The nummulitins from the surrounding of Vipolže in Goriška Brda, Western Slovenia). *Annales, ser. hist. nat. 9/2, Koper*, pp. 269-280.

Tipi numulitinskih nahajališč v Dinaridih

Povzetek: V Dinaridih so bogata nahajališča numulitin v paleogenskih apnencih in flišnih plasteh. V apnencih ločimo primarna nahajališča. Med njimi so takšna z ostanki prave paleobiocenoze in druga z uničeno paleobiocenozo, pri kateri manjkajo nekateri organizmi, ali so pomešani ostanki različnih paleobiocenoz. V obeh primerih prenašanje organizmov ni potekalo na večje razdalje.

Med sekundarna nahajališča v apnencih štejemo tista, pri katerih je bil transport nekoliko daljši. Pri tem se je lahko bolj ali manj ohranila prvotna združba, lahko pa so se pomešali organizmi iz različnih združb oziroma biotopov.

V primarnih in sekundarnih apnenčevih nahajališčih so numulitine največkrat sinhrone s plastmi. Mnogo redkeje so pomešane vrste iz različnih stratigrafskih horizontov.

V fliš so numulitine vedno pretransportirane iz karbonatne platforme. Ločimo nahajališča, v katerih so numulitine sinhrone s flišnimi plastmi in so zato uporabne za določanje starosti. Pogosto so v flišnih nahajališčih različno stare numulitine in drugi organizmi, ker so se v flišno morje rušili tudi deli starejših sedimentov s fosili vred. V tem primeru je treba biti pri ugotavljanju starosti flišnih plasti previden.

V članku je tudi pregled najpomembnejših in najpogostejših numulitin iz apnencev iz fliša v Dinaridih. V precejšnji meri so v obeh skladovnicah sedimentov iste vrste, le da niso povsod enako pogoste. Nekaterih oblik je več v flišu, drugih v apnencu. Morda je to mogoče razložiti s prenašanjem numulitin v fliš iz tistih delov karbonatne platforme, kjer so vladali posebno ugodni pogoji za nekatere vrste. Lahko pa še premalo poznamo vse fosile iz apnenca in fliša, da bi lahko naredili trdnejše sklepe.