

Paleoecology of Nummulitines

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ABSTRACT — Data on the genesis of nummulitic beds («bancs à Nummulites») are still very incomplete. The majority of authors maintain that nummulites are benthonic animals of shallow and warm sea. Considering their way of life some researchers are convinced that they lived in the vertical position in the bottom mud, while others favour the idea they lived on marine plants. The observations of living nummulitins and related foraminifers tend to support the latter hypothesis.

The ideal model of P. Arni postulates nummulitic beds on the outer margin of the continental platform. This scheme worked out on the basis of observations on the African platform does not suit in all parts of the shallow Tethys area, as already remarked by several authors. In the majority of recent discussions on the genesis of the nummulitic beds the following problems have not been considered with sufficient clarity:

- When occurs in the nummulitic beds a genuine biocenose (or better a paleobiocenose), and when a thanatocenose;
- Are the observed beds really from entirely synchronous horizons, or do exist between them smaller time differences;
- The abundance of macroforaminifers depends quite often more on sea plants and slight ecological differences than on the depth of the sea; attention to this was called during investigations in the Red Sea by L. Hottinger, and it holds true possibly also for particular species of nummulites, operculinas and assilinas.

In western parts of the Outer Dinarides often indications were found by us of short range redeposition of nummulitins in nummulitic beds. In many beds occur mixed nummulites, alveolinas and other large foraminifers.

In western Yugoslavia the continental platform became intensively deformed during Paleocene and Eocene in course of orogenic movements. The uplifting progressed from northwest towards southeast. In front of the rising parts existed flysch basins. South of the flysch basins remained the platform on which the nummulitic beds were deposited. From the platform numerous nummulitins came into the flysch sea, especially into the flysch olistostromes.

The least data are available on paleoecological differences between the nummulites, assilinas and operculinas. From differences in abundance of these genera in different beds smaller differences in the way of life of these genera can be inferred.

RIASSUNTO — [Paleoecologia dei Nummulitini] — I dati sulla genesi dei banchi a Nummuliti sono ancora molto incompleti. La maggioranza degli autori ritiene che i nummuliti fossero animali bentonici di acque calde e poco profonde. Alcuni credono che essi vivessero in posizione verticale nel fango del fondo, mentre altri preferiscono l'idea che essi vivessero su piante marine. L'ultima ipotesi è suffragata dalle osservazioni su nummulitini e analoghi foraminiferi viventi.

Il modello ideale di P. Arni postula banchi nummulitici sul margine esterno della piattaforma continentale. Questo schema venne elaborato sulla base di osservazioni sulla piattaforma africana ma non si adatta a tutte le parti della Tetide come è già stato osservato da diversi autori. Nella maggior parte delle discussioni recenti sulla genesi dei banchi nummulitici non sono stati considerati con sufficiente chiarezza i seguenti problemi:

- quando nei banchi nummulitici si trova una vera biocenosi (o meglio una paleobiocenosi) e quando una tanatocenosi;
- se i banchi osservati provengono da orizzonti realmente sincroni o se esistono fra essi piccole differenze cronologiche;
- l'abbondanza di macroforaminiferi dipende molto spesso più dalle piante marine e da piccole differenze ecologiche che dalla profondità del mare; l'attenzione su questi fatti fu richiamata da L. Hottinger durante le sue ricerche nel Mar Rosso ed è possibile per varie specie di nummuliti, operculine ed assiline.

Nella parte occidentale delle Dinaridi Esterne sono state trovate spesso indicazioni di una rideposizione a breve distanza dei nummuliti nei banchi nummulitici. In molti banchi si trovano assieme nummuliti, alveoline ed altri grandi foraminiferi.

Nella Jugoslavia occidentale la piattaforma continentale fu deformata intensamente nel Paleocene e nell'Eocene, con la formazione di bacini flyschoidi di fronte alle aree in sollevamento. Dalla piattaforma molti nummulitini finivano nel mare del flysch, in particolare negli olistotromi.

La diversa abbondanza di nummuliti, assiline e operculine in vari sedimenti indica piccole differenze nel loro modo di vita.

Due to a century and a half of studies of Nummulitines, their biostratigraphical importance is relatively well known, and recently also their phylogenetical evolution well understood, especially thanks to investigations of prof. Hans Schaub. Less clear are data on the way of life of these foraminifers, and on the formation of beds with Nummulitines. Comparison with related recent foraminifers shows that many, or the majority of Nummulitines lived attached on sea plants. In some beds occur along with Nummulitines frequent corallinaceas, so it would be possible they lived attached also to these algae. Less probable is the hypothesis that they lived in vertical position in the marine mud, or that they drifted or swam in water, as proposed by some geologists. Although the possibility of life of some species on the sea bottom cannot be excluded, the majority of them did not live there. If they really lived stuck in the sea bottom, they would be less subject to transport.

It is very difficult to exactly determine for particular fossil Nummulitines in what environment they lived and to what sea plants they were attached. Lucas Hottinger (1977, p. 35) came during his investigations of foraminifers of the Red Sea to conclusion that individual species are attached to certain types of marine vegetation. Algae and other marine plants, however, can be preserved in limestones with Nummulitines only exceptionally.

These insufficient data on the way of life of individual nummulitine genera and species are among the main reason of difficulties in understanding the paleoecology of Nummulitines. In these studies appear especially the following problems:

- when occur in limestones with Nummulitines genuine biocenoses (paleobiocenoses), and when thanatocenoses;
- are the studied beds in fact from entirely synchronous horizons, or are between them certain small time differences;
- the abundance of macroforaminifers depends in many cases more upon the sea plants and smaller ecological variations than upon the sea depth (cf. Hottinger, 1977).

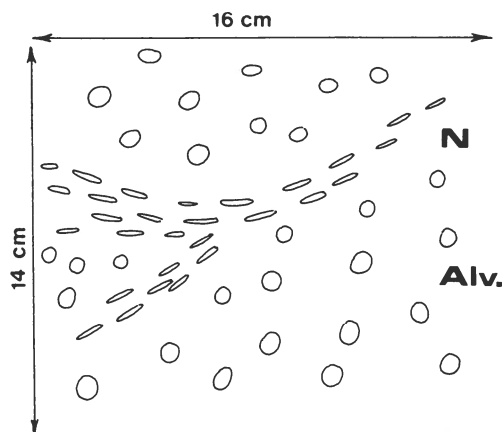
Recently was quite often used in similar variants the ideal model set by P. Arni (1965) upon his observations on the African platform for the «banc à Nummulites». This model is not entirely suitable, according to this author's opinion, for all regions of shallow parts of Tethys and its margins (cf. also Decrouez & Lanterno, 1979). Especially it does not seem convenient in view of various nummulitic species which lived in slightly varying environments. This is actually suggested already by Arni himself which mentions from the main bed with Nummulitines only

certain species of Nummulitines, while he cites in other parts of his model other species. Arni's environment of formation of «banc à Nummulites» should have been a sort of barrier between the shallow, partly even lagoonal and near-coast sea, and the more open sea. I suppose, however, that many nummulitine species were not so abundant to be able to build such a closing barrier.

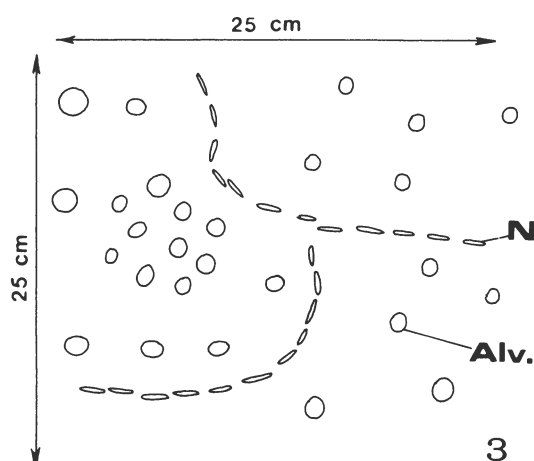
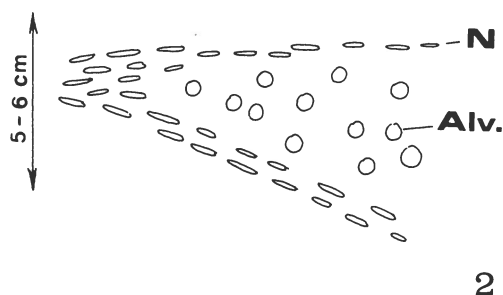
K. Aladžova-Hrisčeva (1980) is of opinion that a large part of Nummulitines is found in secondary place, and that in limestones with Nummulitines occurs a thanatocenose. Very probably the nummulitine shells were much subject to transportation by currents, or they moved from their original place due to action of tidal waves. However, in many cases it is not entirely clear, whether Nummulitines in limestones occur in primary or secondary places. It is further also almost certain that Nummulitines cannot occur in the primary position at all, if they lived attached to sea plants which perished. In this case Nummulitines are at least somewhat moved from the place where they lived, even if they are in general still at their primary place. Nevertheless, this is not a genuine biocenose any more.

While investigating limestones with Alveolines and Nummulitines in the western Dinarides we came across several interesting phenomena. In Ilerdian limestone with Alveolines from the surroundings of Divača, south Slovenia, Nummulitines, among which occur frequent Operculines and partly *Nummulites*, are confined to particular thinner horizons. These horizons are not always parallel with the beds. In Text-fig. 1 is the case of a nummulitine «lens» which is slightly bent in the limestone with Alveolines. In this «lens» Alveolines are very scarce. However, where Alveolines are abundant, Nummulitines are not. If in such a case the nummulitine fauna were retransported, it would be surprising why Nummulitines occur only in parts where Alveolines are almost absent, and vice versa. It is easier to imagine Nummulitines to accumulate in places where plants favorable to them grew. The wavy course of horizons is probably the trace of the uneven bottom. In other words, these could be ecological niches with Nummulitines, and ecological niches with Alveolines.

In other instances from the Ilerdian limestone with Alveolines and Nummulitines from the surroundings of Divača (Text-figs. 2 and 3) horizons with Nummulitines even fork in several branches, or they bend sharply and branch. This possibly cannot be understood as remains of ecological niches, it can easier be explained with transportation of Nummulitines, or with gentle slipping of the sediment on the sea bottom. In these cases Nummulitines do not occur in primary place.



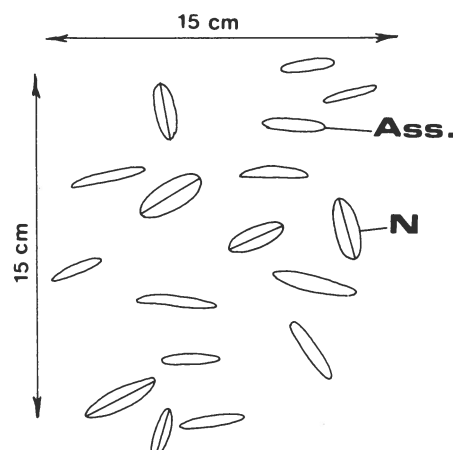
Text-fig. 1 - In the Ilirian limestone with Alveolines (=Alv.) and Nummulitines (=N) from the surroundings of Divača, south Slovenia. The Nummulitines are in the horizons, sometimes in the « lens ».



Text-figs. 2-3 - In the Ilirian limestone with Alveolines (=Alv.) from the surrounding of Divača horizons with Nummulitines (=N) even fork in several branches (2), or they bend sharply and branch (3). This phenomenon can be explained with transportation of Nummulitines.

Interesting are also observations in limestone with Assilinas at Dol near Hrastovlje, south Slovenia (Text-fig. 4). On a surface of about 15 x 15 cm occur some 40 B-forms of Assilinas. The shells are mostly aligned in the same direction. Along with them appear several thicker Nummulites which are less regularly distributed in the sediment. A similar distribution of nummulitic shells has been observed at this locality also elsewhere, on a surface of about 50 cm.

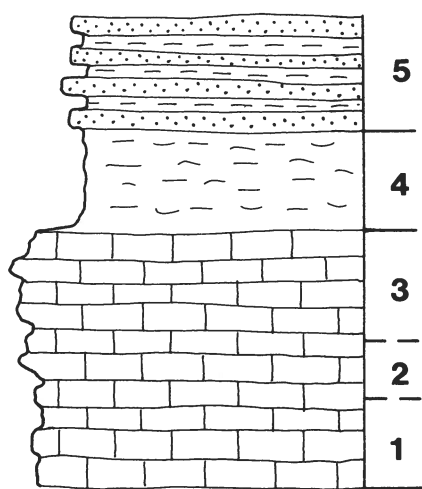
In these cases the nummulitic shells were probably slightly transported at least, or they were reworked after being attached on the sea plants. In this way the fairly regular arrangement of thin and large assilinic shells can be explained, and also the much less regular distribution of thicker nummulitic shells. But also in this way of transport longer times were not involved, and Nummulitines are synchronous with beds. This is, however, not a case of biocenose or paleobiocenose.



Text-fig. 4 - In the Lower Lutetian limestone with Assilinas (=Ass.) at Dol near Hrastovlje, south Slovenia the shells are mostly aligned in the same direction, the thicker Nummulites (=N) are less regularly distributed in the sediment.

A further question concerns the way of formation of beds with Nummulitines in western Dinarides. Bignot (1972) used also for these regions Arni's ideal model, and he believed into the following distribution: closest to the coast, lagoonal-lacustral limestone with charophyta, discorbides, farther away limestones with porcelain foraminifers (*Orbitolites*, *Alveolina*). Follow biotrititic limestone with molluscs and various foraminifers, then limestone with nummulitic bioherms and farther sediments which were deposited in a more open sea (marly limestone with *Nummulites*, *Assilina*, *Operculina*, *Discocyclina*). Follows the marly glauconitic facies with *Operculina*, and finally the marly facies with planktonic foraminifers. This

scheme by Bignot is based on observations from Cuisian and Lutetian. During these times the carbonate platform in the region of western Dinarides became intensively deformed due to orogenic movements. Deepening of the flysch basin progressed from the northwest towards southeast, and at the same time very differing facies appeared on the platform. In fact in west Yugoslavia occur facies (Text-fig. 5) as postulated by Bignot in his scheme, but these facies are partly of different ages. The characteristic miliolidal limestone is older (Middle Paleocene) than the beginning of formation of the limestone with Alveolines and Nummulitines. This indicates that the nummulitic barrier in the sense of Arni could have not been the reason for the origin of the facies with numerous Miliolides.



Text-fig. 5 - Section of the Lutetian limestone near Stena at Dragonja, north Istria. 1 = limestone with many Operculines; 2 = limestone with many Assilines; 3 = limestone with Discocyclines and echinoids; 4 = marl on the basis of flysch; 5 = flysch.

To my opinion there was no proper closing nummulitic barrier. Such a barrier is also difficult to imagine when the majority of Nummulitines lived on plants. Also the casually accumulated shells of dead animals could not resist wave action and transport by currents, since they were not connected among them like say the colonial reef organisms. Therefore I suggest in facies with predominating various nummulitic genera or even species to consider more their attachment to sea vegetation, and less the areas in front of a certain nummulitic closing barrier, or the lagoonal areas behind it. If such closing horizons in the sense of Arni existed in reality, there should be more limestones with remains of biocenose, or at least limestones with Nummulitines in primary place. This is, however,

very rare, as ascertained by many investigators of Nummulitines.

P. Arni's « banc à Nummulitines » should then be viewed as a facies in which Nummulites are largely preserved, even if to a certain degree retransported - but not as a closing barrier behind which lagoonal and other facies formed.

A question apart are numerous Nummulitines in flysch olisthostromes and in other beds. Nummulitines in flysch beds are doubtlessly in secondary place; they came from shallow marine areas and were mixed among the flysch sediments in deeper sea regions only (Pavlovec, 1969). According to my opinion Nummulitines lived in other parts of the sea and not there where the rock material for flysch sediments came from. In the flysch material originated somewhere in front of the areas with Nummulitines, or if the material for flysch sediments were derived from the disintegrating shelf threshold, then the Nummulitines would be carried towards deeper parts of the sea together with the rock material. In this case the nummulitic shells would be more damaged, and not so well preserved as they can be found mostly in the flysch beds. The same reasons which moved the rock fragments influenced also the shallow parts of the sea where Nummulitines lived, and they moved also them deeper into the sea.

Data are most sparse on differences in the way of life of Nummulites, Assilinas and Operculinas and other nummulitic genera. From differences in abundance of these genera in various beds smaller differences in the way of life of these genera may be inferred (cf. Pavlovec, 1981). However, not only various genera, but also various species were most probably attached to specific plants or dependent on specific environments, so it would be necessary to get for each of them specific data, as established by Hottinger for certain foraminiferal species from the Red Sea. Such data obviously cannot be established since most of plant remains are not preserved in fossil state, and since Nummulitines are retransported, and with this the picture of their living environment is destroyed.

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