

EVOLUTION LINE OF THE ENDEMIC GENUS *NOELAEHRABDUS*
(Pannonian; Pannonian Basin)

10

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Abstract: The Noelaerhabdaceae family consists of endemic nannofossils represented by the *Praenoelaerhabdus*, *Noelaerhabdus* and *Bekelithella* species that characterise the Pannonian nannoplankton assemblages of the Pannonian Basin. It is supposed the next phyletic line of the *Noelaerhabdus* species: *Praenoelaerhabdus banatensis*, that occurs in the Early Pannonian-*Noelaerhabdus bozinovicae*, *N. bekei*, *N. jerkovici*, with the first occurrences in the Middle Pannonian-*Noelaerhabdus bonagali* and *N. mehadicus*, that appear in the Late Pannonian.

Key words: Calcareous nannoplankton, Pannonian, Pannonian Basin

The total isolation of the Central Paratethys (represented on the Romanian territory by the Pannonian and Transylvanian Basins) at the beginning of the Pannonian time span induced the gradual changes in the evolution of the calcareous nannoplankton. The strong salinity decrease (0.5-1.6 ‰; Bona, 1964) of the biotic environment caused the transformation of the *Prinsiaceae*, widespread in the Sarmatian deposits, into *Noelaerhabdaceae*, thus determining the marked endemic character of the Pannonian nannofossil assemblages.

These endemic nannofossils show many specific features in their evolution. Thus, the first forms, *Praenoelaerhabdus banatensis* Mihajlovic, of the Early Pannonian (Pannonian A-B, Papp, 1953) retain many native characters of the *Reticulofenestra pseudoumbilicus* (Gartner) species. Moreover, the placoliths of these forms do not contain atypical processes.

Later, in the Middle Pannonian (Pannonian B-D; Papp, 1953), *Noelaerhabdus bozinovicae* Jerkovic, *N. bekei* Jerkovic, *N. tegulatus* Bona & Gál, *N. jerkovici* Bona & Gál, *Bekelithella echinata* Bona & Gál, with prominent *Noelaerhabdaceae* features were individualized. Any mentioned species is represented by numerous individuals with various placolith morphostructures and with eccentric positions of atypical processes.

The morphological intraspecies variability of the *Noelaerhabdus* genus is very reduced in the Late Pannonian (Pannonian E; Papp, 1953), when such new species as *Noelaerhabdus bonagali* Mărunțeanu, *N. mehadicus* Mărunțeanu and *Bekelithella n. sp.* occur. The concentric position of atypical processes characterizes the Late Pannonian *Noelaerhabdaceae* (Mărunțeanu, 1996). The endemic character of the Pannonian nannofossils makes their assignment to the Standard Zonation impossible (Martini, 1971). The stratigraphic correlation between the Pannonian (Central Para-tethys) and the Dacian (Eastern Paratethys) Basins, during the Pannonian (or Late Bessarabian-Meotian) time span, led us to presume (Mărunțeanu, 1977) that the *Noelaerhabdus* and *Bekelithella* species belong to the intervals of zones NN9 (partly), NN10 and NN11 (partly).

Phylogeny of the *Noelaerhabdus* genus

The phylogenetic relationship between *Prinsiaceae* Hay & Mohler (1967) and *Noelaerhabdaceae* Jerkovic (1970)

was achieved by the *Praenoelaerhabdus* Mihajlovic (1995) genus, which present common morphostructural characters with these both nannoplankton families. Thus, the oval to subcircular placoliths, constituted of two unequally developed shields (the proximal shield smaller than the distal one), with a dextrogyre interference Figure between crossed polarizers in the distal view and the absence of atypical processes are related to the *Praenoelaerhabdus* genus with *Prinsiaceae* nannofossils. On the other hand, this genus has numerous structural features, similar to *Noelaerhabdus bozinovicae* Jerkovic (1970), the generotype of the *Noelaerhabdaceae* family, such as the small sizes of the placoliths (3-5 micrometers), the number of the shield elements (30-40) and the structure of the central placolith area, covered with calcitic bars.

A probable scheme of evolutionary succession of the various *Noelaerhabdaceae* species is suggested in the Fig. 1.

It was supposed (Mihajlovic, 1993; Perch-Nielsen, 1985) that *Praenoelaerhabdus* and *Noelaerhabdus* genera may have evolved from *Dictyococcites* Black (1967) because their central area is thus covered with two layers of calcitic bars, the prolongations of the shield elements. But, looking attentively at the illustrations of these two *Noelaerhabdaceae* genera (Mihajlovic, 1993 - Pl. I, Pl. II; Jerkovic, 1970 - Figs. 1-8) the following significant structural characters of the placoliths can be observed:

- the shields are bordered towards the central area by a secondary cycle of elements or element wall;
- the central placolith area is filled with a single layer of calcitic bars, prolongations of the wall proximal elements, that distal plunge steeply and converge to the long coccolith axis; this more or less ridge-like convex plunge appears in the distal shield central area.

The presence of the calcitic elements wall and a single elements layer, which covers the placolith central area, are the principal features of the *Reticulofenestra* Hay, Mohler & Wade (1966) species. Therefore, it can be supposed that *Reticulofenestra pseudoumbilicus* (Gartner, 1967) candidates as ancestral nannofossil for the *Praenoelaerhabdus* species. This conclusion appears really because the Sarmatian nannoplankton assemblages of the Pannonian Basin contain numerous morphotypes of *Reticulofenestra pseudoumbilicus*, but none *Dictyococcites* forms (Mărunțeanu et al., 1995).

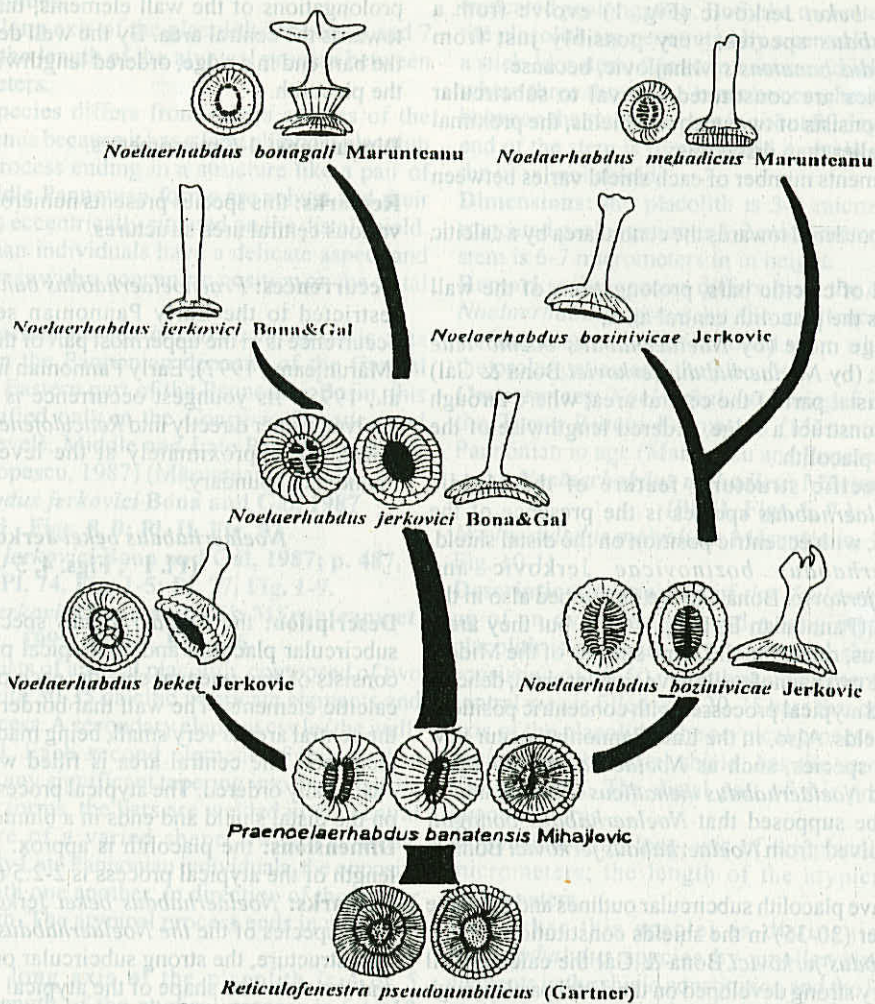


Fig. 1 - Phylogenetic lineage of *Noelaerhabdus* genus: only the end forms, which constitute distinct species are shown; for some branches, intermediate forms are recognizable

Noelaerhabdus bekei Jerkovic, 1971; p. 206, Fig. 1-2.

Description: the *Noelaerhabdus* species, is made up of a subcircu' r placolith and an atypical process. The placolith consists of two unequal shields, each of these having 40-44 calcitic elements. The wall that borders the shields towards the central area is very small, being made up of 40-44 calcitic elements. The central area is filled with calcitic granules, chaotically ordered. The atypical process is eccentric situated on the distal shield and ends in a blunted top.

Dimensions: the placolith is approx. 3-4 micrometers: the length of the atypical process is 2-2.5 micrometers.

Remarks: *Noelaerhabdus bekei* Jerkovic differs from the other species of the *Noelaerhabdus* genus by the central

area structure, the strong subcircular outline of the placolith and the club-like shape of the atypical process.

Occurrences: on the Romanian territory, this species was identified only in the Valea Timișului Formation, Middle Pannonian in age (Marinescu and Popescu, 1987). Its last occurrence is slightly higher than the first occurrence of *Noelaerhabdus bonagali* Mărunțeanu.

Beginning with the Middle Pannonian (Pannonian C-D; Papp, 1953), the endemic nannofossil assemblages are dominated by the *Noelaerhabdus* species. They retain the essential structural features of *Praenoelaerhabdus banatensis* Mihajlovic (the *Praenoelaerhabdus* generotype species) but differ from this in having the atypical processes.

It can be supposed that *Noelaerhabdus bozinovicae*

Jerkovic, *Noelaerhabdus jerkovici* Bona & Gál and *Noelaerhabdus bekei* Jerkovic (Fig. 1) evolve from a *Praenoelaerhabdus* species, very possibly just from *Praenoelaerhabdus banatensis* Mihajlovic, because:

- all these species are constituted of oval to subcircular placoliths, that consists of two unequal shields, the proximal shield being smaller than distal one;
- the calcitic elements number of each shield varies between 30 and 44;
- the shields are bordered towards the central area by a calcitic elements wall;
- only one level of calcitic bars, prolongations of the wall elements, covers the placolith central area;
- the bars plunge more (by *Noelaerhabdus bozinovicae* Jerkovic) or less (by *Noelaerhabdus jerkovici* Bona & Gál) steeply to the distal part of the central area, where through sweating they construct a ridge, ordered lengthwise of the long axis of the placolith.

The specific structural feature of the Middle Pannonian *Noelaerhabdus* species is the presence of the atypical process, with eccentric position on the distal shield.

Noelaerhabdus bozinovicae Jerkovic and *Noelaerhabdus jerkovici* Bona & Gál are developed also in the Late Pannonian (Pannonian E; Papp, 1953), but they are a little altered. Thus, related to the same species of the Middle Pannonian, these two nannofossils have smaller sizes, delicate constitutions and atypical processes with concentric positions on the distal shields. Also, in the Late Pannonian occur new *Noelaerhabdus* species, such as *Noelaerhabdus bonagáli* Mărunțeanu and *Noelaerhabdus mehadicus* Mărunțeanu.

It can be supposed that *Noelaerhabdus bonagali* Mărunțeanu evolved from *Noelaerhabdus jerkovici* Bona & Gál because:

- both species have placolith subcircular outlines and the same elements number (30-35) in the shields constitution;
- by *Noelaerhabdus jerkovici* Bona & Gál the calcitic wall elements are very strong developed on the distal part; through their excessive increase, the truncated prolongation seated on the distal shield of *Noelaerhabdus bonagáli* Mărunțeanu was built.

It can be also considered that *Noelaerhabdus mehadicus* Mărunțeanu evolved from *Noelaerhabdus bozinovicae*, on the basis of the following morphostructural similarities: oval placolith outline, the same central area structure, the same number of the elements of the shields (40-44).

Systematic Paleontology

Praenoelaerhabdus banatensis Mihajlovic, 1993

(Pl. I, Figs. 1-3)

Praenoelaerhabdus banatensis Mihajlovic, 1993; p. 60; Pl. I, Fig. 1-6; Pl. II, Fig. 1-6.

Reticulofenestra pseudumbilica (Gartner); Bona & Gál, 1985; p. 501; Pl. 71, Fig. 1-2; Pl. 72, Fig. 1.

Description: oval to subcircular placolith, composed of two unequal shields, the proximal shield smaller than the distal one. Each shield consists of 30 to 40 calcitic elements. The oval to the subcircular central area is filled with calcitic bars,

that converge to the coccolith long axis. These bars are prolongations of the wall elements, that border the shields towards the central area. By the well developed individuals, the bars end in a ridge, ordered lengthwise of the long axis of the placolith.

Dimensions: 4-6 micrometers.

Remarks: this species presents numerous morphotypes with various central area structures.

Occurrences: *Praenoelaerhabdus banatensis* Mihajlovic is restricted to the Early Pannonian sediments. Its oldest occurrence is in the uppermost part of the Cănicea Formation (Mărunțeanu, 1997), Early Pannonian in age (Mărunțeanu et al., 1995). Its youngest occurrence is not clear because it evolved rather directly into *Reticulofenestra pseudumbilica* (Gartner), approximately at the level of the Sarmatian-Pannonian boundary.

Noelaerhabdus bekei Jerkovic, 1971

(Pl. I, Figs. 4, 5)

Description: the *Noelaerhabdus* species, is made up of a subcircular placolith and an atypical process. The placolith consists of two unequal shields, each of these having 40-44 calcitic elements. The wall that borders the shields towards the central area is very small, being made up of 40-44 calcitic elements. The central area is filled with calcitic granules, chaotically ordered. The atypical process is eccentric situated on the distal shield and ends in a blunted top.

Dimensions: the placolith is approx. 3-4 micrometers: the length of the atypical process is 2-2.5 micrometers.

Remarks: *Noelaerhabdus bekei* Jerkovic differs from the other species of the *Noelaerhabdus* genus by the central area structure, the strong subcircular outline of the placolith and the club-like shape of the atypical process.

Occurrences: on the Romanian territory, this species was identified only in the Valea Timișului Formation, Middle Pannonian in age (Marinescu and Popescu, 1987). Its last occurrence is slightly higher than the first occurrence of *Noelaerhabdus bonagáli* Mărunțeanu.

Noelaerhabdus bozinovicae Jerkovic, 1970

(Pl. I, Figs. 6, 7; Pl. II, Figs. 1, 2, 3)

Noelaerhabdus bozinovicae Jerkovic, 1970; p. 468-470; Fig. 1-8.

Noelaerhabdus bozinovicae Jerkovic; Bona and Gál, 1987; Pl. 66, Fig. 1-4; Pl. 68, Fig. 1-4.

Noelaerhabdus bozinovicae Jerkovic; Mărunțeanu et al., 1995; Pl. III, Fig. 1-4.

Description: this species consists of a long elliptical placolith, composed of two unequal shields and an atypical process with eccentric (in the Middle Pannonian) or concentric (in the Late Pannonian) positions on its distal shield. Each shield is constituted of 34-44 nonimbricate elements. The central area is traversed by the calcitic bars, that join distally into a ridge, orientated in direction of the long axis of the coccolith. The atypical process, of variable length, ends in a structure

similar to a pair of "tongs", composed of two principal and many secondary spines.

Dimensions: the long axis of the placolith between 4 and 7 micrometers and the length of the atypical process between 6 and 12 micrometers.

Remarks: this species differs from others species of the *Noelaerhabdus* genus because it has a long elliptical placolith and an atypical process ending in a structure like a pair of "tongs". The Middle Pannonian forms are robust and their atypical process is eccentrically situated on the distal shield. The Late Pannonian individuals have a delicate aspect and their atypical process with a concentric position on the distal shield.

Occurrences: *Noelaerhabdus bozinovicae* Jerkovic was mentioned only in the Pannonian deposits of the Central Paratethys. In the Eastern part of the Pannonian Basin, this species was identified only in the *Congeria banatica* and *Congeria czjeki* levels, Middle and Late Pannonian in age (Marinescu and Popescu, 1987) (Măruntănu, 1997).

Noelaerhabdus jerkovici Bona and Gál, 1987

(Pl. I, Figs. 8, 9; Pl. II, Fig. 8)

Noelaerhabdus jerkovici Bona and Gál, 1987; p. 487,

Fig. 1-4; Pl. 74, Fig. 1-5; Pl. 77, Fig. 1-9.

Noelaerhabdus jerkovici Bona and Gál; Măruntănu et al., 1995; Pl. III, Fig. 5-6.

Description: consists of an oval placolith, composed of two unequal shields, with 30-35 calcitic imbricate elements and a long atypical process. A secondary element cycle (the wall) is very developed. Each second element of this wall is prolonged without any significant tapering into a bar. By the Middle Pannonian forms, the bars are welded in the central area in a structure of a varied shape: swastika, cross, concentric levels. By Late Pannonian individuals, the opposite bars are welded with one another, in direction of the longer axis of the coccolith. The atypical process ends in a toothed edge.

Dimensions: the long axis of the placolith is 4 or 5 micrometers; the length of the atypical process is 6 to 12 micrometers.

Remarks: the individuals developed in the Middle Pannonian present numerous morphotypes with various morphostructures of the central area of the placolith. Also, their atypical processes are eccentrically situated on the distal shields. The forms that occur in the Late Pannonian have delicate constitutions and atypical processes with concentric positions on their distal shields.

Occurrences: this species was described only as in the Pannonian deposits of the Pannonian Basin. On the Romanian territory, *Noelaerhabdus jerkovici* Bona & Gál in Valea Timișului and Turnu Ruieni Formations, Middle and Late Pannonian in age (Marinescu and Popescu, 1987) was identified.

Noelaerhabdus bonagali Măruntănu, 1995

(Pl. II, Figs. 4, 5)

Noelaerhabdus bonagali n. sp. Măruntănu, 1995; p.

99; Pl. I, Fig. 1-2. *Noelaerhabdus* sp. *indet.* Bona and

Gál, 1985; p. 515; Pl. 78, Fig. 3.

Description: species of the *Noelaerhabdus* genus, consisting of two subcircular, slightly unequal shields, the distal one larger than the proximal one. Each shield is composed of 35-

40 elements, arranged radially. The distal shield ends in a truncated prolongation. Both the truncated prolongation and the placolith are penetrated by a central canal, introduced by a stick-like stem; this stem becomes thicker towards the top, where three thorn-like branches can be observed. The angle between the two branches is about 90 degrees. The proximal end of the stem is rounded and it reaches the central area of the proximal shield.

Dimensions: the placolith is 3-4 micrometers in size, the truncated prolongation is 1-2 micrometers in height and the stem is 6-7 micrometers in height.

Remarks: this species differs from the other species of the *Noelaerhabdus* genus by the existence of the truncated prolongation and of three-lobed stem, which penetrates both the prolongation and the placolith.

Occurrences: *Noelaerhabdus bonagali* is restricted only to the Turnu Ruieni Formation (Măruntănu, 1995), Late Pannonian in age (Marinescu and Popescu, 1987).

Noelaerhabdus mehadicus Măruntănu, 1996

(Pl. II, Figs. 6, 7)

Noelaerhabdus mehadicus Măruntănu, 1996; p. 125; Pl. 2, Fig. 10-11.

Description: the species of the *Noelaerhabdus* genus, built up of an oval placolith and a long atypical process. The placolith is made up of two unequal shields, each of them consisting of 40-50 nonimbricate elements. The subcircular central area is filled with 20-25 bars that converge to the long axis of the placolith. The atypical process, with a concentric position on the distal shield, has the same thickness on its whole length. The distal part of this process ends in two unequal thorns.

Dimensions: the long axis of the placolith is approx. 4-5 micrometers; the length of the atypical process is 5-6 micrometers.

Remarks: this species is distinguished from other *Noelaerhabdus* species by smaller sizes, more calcitic elements in the shield constitution and the long and two-lobed atypical process.

Occurrences: *Noelaerhabdus mehadicus* Măruntănu was identified in the *Congeria czjeki* levels of the Turnu Ruieni Formation (Măruntănu, 1996), Late Pannonian in age (Marinescu and Popescu, 1987). Its first occurrence is slightly higher than the first occurrence of *Noelaerhabdus bonagali* Măruntănu.

Conclusion

The calcareous nannofossils are considered remains of the yellowish-brown unicellular planktonic algae that can live and evolve only in the marine environment. But the presence and the evolution of the *Noelaerhabdus* species in the light brackish

Pannonian waters partially contradict this affirmation.

It can be assume that the gradual and long desalinization of the biota environment makes it possible for calcareous algae to adjust to these living conditions and for endemic species to occur.

On the other hand, the stratigraphic discontinuous appearances of nannoplankton assemblages in the brackish to fresh water deposits (as well as in the Late Miocene-Pliocene formations of the Eastern Paratethys) can be explained only by short marine ingressions.

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Captions of Plates

PLATE 10. I - Early-Middle Pannonian nannofossils

1. *Reticulofenestra pseudumbilicus* (Gartner); proximal view; Sarmatian Petnic Formation; Mehadica valley - north of Mehadica.
- 2, 3. *Praenoelaerhabdus banatensis* Mihajlovic; 2 - distal view; 3 - proximal view: Early Pannonian; Cănicea Formation; Bela Rea valley - north of Mehadia.
- 4, 5. *Noelaerhabdus bekei* Jerkovic; 4 - lateral view; 5 - proximal view; Middle Pannonian; Valea Timişului Formation; Ilova valley - south of Caransebeş.
- 6, 7. *Noelaerhabdus bozinovicae* Jerkovic; 6 - lateral view; 7 - proximal view; Middle Pannonian; Valea Timişului Formation; Ilova valley - south of Caransebeş.
- 8, 9. *Noelaerhabdus jerkovici* Bona & Gál; 8 - lateral view; 9 - distal view; Middle Pannonian; Vale Timişului Formation; Golet brook - north of Slatina Timiş.

PLATE 10. II - Middle and Late Pannonian nannofossils

1. *Noelaerhabdus bozinovicae* Jerkovic; lateral view; Middle Pannonian; Valea Timişului Formation; Ilova valley - south of Caransebeş.
- 2, 3. *Noelaerhabdus bozinovicae* Jerkovic; lateral view; Late Pannonian; Turnu Ruieni Formation; 2 - Bălan hill - north east of Sadova Veche; 3 - Valea Rea brook - west of Vârciorova
- 4, 5. *Noelaerhabdus bonagali* Măruntănu; 4 - lateral view; 5 - proximal view; Late Pannonian; Turnu Ruieni Formation; Groapa Copacului brook - south of Caransebeş.
- 6, 7. *Noelaerhabdus mehadicus* Măruntănu; 6 - lateral view; 7 - distal view; Late Pannonian; Turnu Ruieni Formation; Vălişoara brook - south of Caransebeş.
8. *Noelaerhabdus jerkovici* Bona & Gál; lateral view; Late Pannonian; Turnu Ruieni Formation; Valea Rea brook - west of Vârciorova.
9. *Noelaerhabdus* sp.; lateral view; Late Pannonian; Turnu Ruieni Formation; Bălan hill - north of Sadova Veche.