

JANINA SZCZUCHURA

MICROPROBLEMATICS *BOLBOFORMA* AND *BACHMAYERELLA*  
FROM THE MIDDLE MIOCENE OF CENTRAL PARATETHYS

SZCZUCHURA, J.: Microproblematics *Bolboforma* and *Bachmayerella* from the Middle Miocene of Central Paratethys. Acta Palaeont. Polonica, 31, 3—4, 213—228, 1986 (issued 1987).

Middle Miocene (Badenian) microproblematics, known as *Bolboforma* Daniels et Spiegler, 1974 and *Bachmayerella* Rögl et Franz, 1979, from the Central Paratethys (Poland, Czechoslovakia, Austria, Bulgaria and Romania) have been examined here. It has been stated that they are important for biostratigraphy, especially for distinguishing the Upper Badenian deposits from the older ones. *Bolboforma taentifera* sp.n. is described.

Key words: Calcareous microproblematics, plankton, paleoecology, taxonomy, biostratigraphy, Miocene, Central Paratethys.

Janina Szczuchura, Zakład Paleobiologii, Polska Akademia Nauk, al. Żwirki i Wigury 93, 02-089 Warszawa, Poland, Received: September, 1985.

## INTRODUCTION

Two groups of Miocene problematic microfossils assigned to genera *Bolboforma* Daniels et Spiegler, 1974 and *Bachmayerella* Rögl et Franz, 1979 have been recently used for stratigraphic purposes and for interpretations of paleoenvironments. In the present paper I applied the forms recorded in the Miocene of Poland for similar purposes. The material here described comes from the Middle Miocene (Badenian) of Poland and has been compared with that from other samples of the same age from the Central Paratethys elsewhere (Austria, Czechoslovakia, Bulgaria and Romania). Therefore, the results obtained may appear valid for the whole Central Paratethys. However, the sampled sections were rather discontinuous and the available samples were taken rather at random and therefore, the presented stratigraphic and paleoecological conclusions require verification in the course of further, more systematic studies.

The majority of samples containing the microfossils described below were obtained by the courtesy of my fellow students mentioned in acknowledgements. Some materials have been collected by myself. The

described material is housed at the Institute of Paleobiology, Polish Academy of Sciences, Warsaw (abbreviated ZPAL).

*Acknowledgements.*—Warm thanks are due to Dr. T. Musiał (Institute of Geology, University of Warsaw) for making available samples from the Roztocze region, Dr A. Gaździcki (Institute of Paleobiology, Polish Academy of Sciences, Warsaw), Dr. M. Holzkecht (Geological Survey, Hodonin), and Dr. S. Juranov (Institute of Mining and Geology, Sofia), for comparative material from the Vienna Basin, the Moravian part of the Carpathian Foredeep and Dacian Basin respectively.

SEM photographs were taken at the Electron Microscopy Laboratory of the Nencki Institute of Experimental Biology, Warsaw. Figures were drawn by Mrs. D. Sławik (Institute of Paleobiology, Polish Academy of Sciences, Warsaw).

#### MATERIAL

To extract the material, the samples, mainly clays and marls, were washed with water, with the use of sieves of the 0.087 mm meshes.

#### Poland

The Polish samples come from the Carpathian Foredeep and the Roztocze region (fig. 1: Carpathian Foredeep — vicinity of Korytnica, Gacki, Machów; Roztocze region — Węglin, Trzęsiny, Józefów, Długi Goraj).

In the Korytnica Basin, the Korytnica Clays in the proximity of Korytnica village, and a marly layer cropping out near Chomentów have been sampled. The exposures were described by Bałuk and Radwański (1977), Szczuchura and Pisera (in press) and others. The rocks have been dated, basing on the recorded calcareous nannoplankton at the NN5-6, i.e. Middle Badenian by Martini (1977). The analysis of foraminifera and ostracodes showed that these rocks, especially clays, represent sediments of middle part of the neritic zone of a very warm sea (Szczuchura and Pisera, in press). The tropical character of the faunas in the sediments of the Korytnica Basin has also emphasized by several other authors.

A sample from a quarry at Gacki represents yellowish, sandy glauconitic marls dated as Lower Badenian (*Orbulina suturalis* zone, Krach *et al.* 1974). As indicated by Krach *et al.* (1974) and confirmed by Szczuchura (1984), the foraminiferal assemblage is characteristic of a warm and relatively deep (at least the lower neritic zone) sedimentary environment, broadly communicating with open sea.

A sample from Machów represents loamy Upper Badenian shales exposed in the sulphur mine (*Hanzawaia crassiseptata* horizon, Krach *et al.* 1974). Besides foraminiferal species reported by Łuczowska in Krach *et al.* (1974). I have also found *Bulimina aculeata*, *Cibicides pseudoungerianus*, *Gyroidina* sp., *Melonis pompilioides*, and a very rich assemblage of planctic foraminifera composed of diverse species of the genus *Globigerina*. The assemblage of planktic foraminifera appears characteristic of cold waters. Scarce ostracodes are represented by *Henryhowella asperrima* and

*Krithe* sp. The whole assemblage of microfossils indicates that the sediments are of the middle part of neritic zone in a marine basin broadly communicating with open sea.

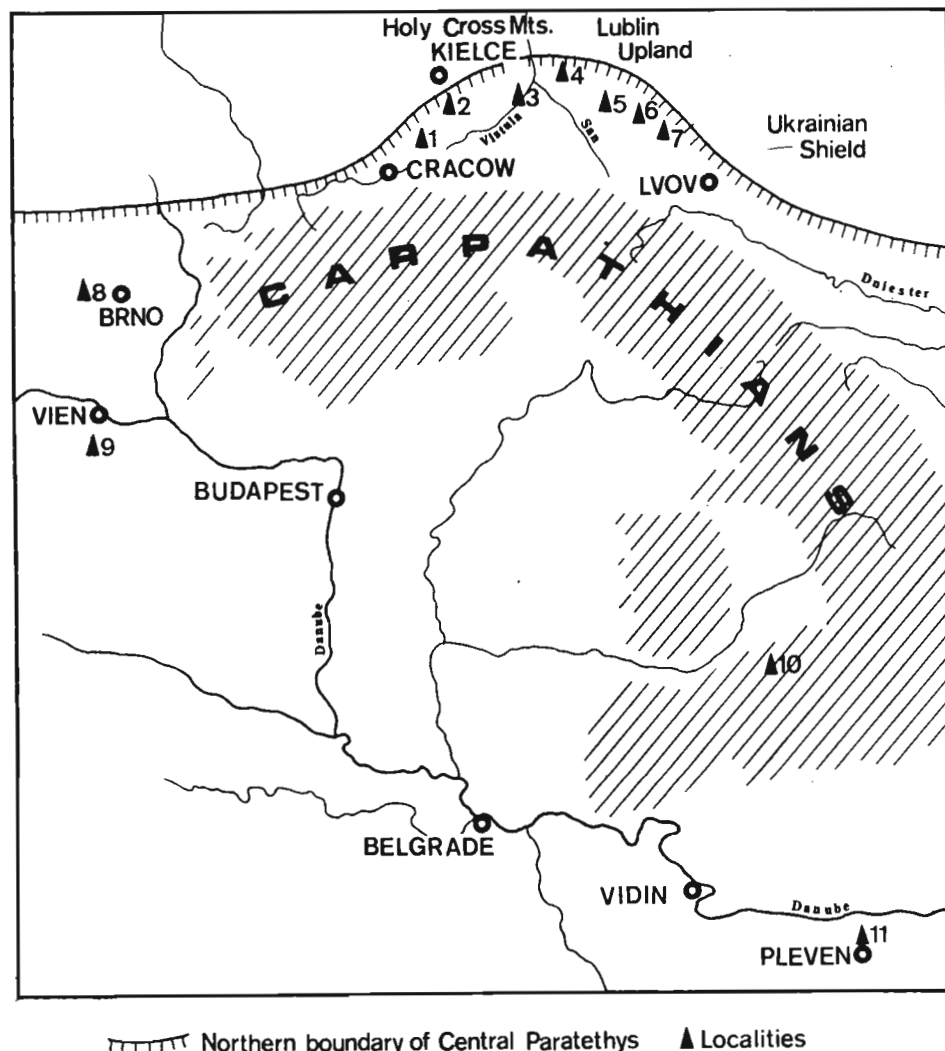


Fig. 1. Location of *Bolboforma* and *Bachmayerella* sites (marked with triangles) discussed in the paper: 1 Gacki, 2 Korytnica, 3 Machów, 4 Węglin, 5 Trzęsiny, 6 Józefów, 7 Długi Goraj, 8 Kralice, 9 Sooss, 10 Apold, 11 Opanets.

Other samples come from the Roztocze region. This region is at present uplifted in relation to the Carpathian Foredeep and plateau in character. Sediments (marls and clays) yielding the below discussed microproblematics are exposed in numerous localities; the figured specimens come from Węglin, Trzęsiny, Józefów, and Długi Goraj. The rocks are of the Upper Badenian age (cf. Szczuchura 1982, 1984) only.

The samples from Węglin represent a marly layer (overlying lithothamnian limestones) and clay and silty intercalations in a sandy packet (Szczecura and Pisera, in press). The assemblage of foraminifera and ostracodes, reported from these strata, is indicative of neritic marine environment of the basin rather broadly communicating with open sea, and reflects some climate cooling.

The clays from Trzęsiny (sample no. 7) yielded benthic and planktic foraminifera indicative of the middle part of neritic zone and of cooler climatic conditions (Szczecura 1982).

The samples from Józefów and Długi Goraj represent clay intercalations in detrital limestones (Musiał, in preparation). The foraminiferal microfauna from Józefów is characterized by predominance of diverse elphidids and *Cibicides lobatulus* but the shares of *Bolivina*, *Cassidulina*, *Reussella* and other taxa appear also significant. The presence of a rich assemblage of planktic foraminifera, almost exclusively consisting of globigerinids is worth attention; *Velapertina* appears very rare. The assemblage indicates a shallow part of neritic zone of the open sea. The samples from Długi Goraj yielded more diversified microfaunal assemblages comprising *Bulimina aculeata*, *Sphaeroidina bulloides*, *Pullenia bulloides*, *Hoeglundina scalaris*, *Cibicides ungerianus*, numerous uvigerinids and an association of planktic foraminifera (composed of globigerinids only), indicative of a deeper part of neritic zone in a rather cool, open sea.

### Austria

Comparative material from Austria comes from a brickyard at Sooss near Baden (stratotype of the Badenian) in the Vienna Basin (see Kirchner *et al.* 1978). The silty sample, dated as Lower Badenian (Upper Lagenid Zone), yielded foraminiferal assemblage similar to that of the Korytnica Clays but more diversified and comprising larger and better developed individuals. I interpret the assemblage as indicative of a lower part of neritic zone in an open and very warm sea.

### Romania

The sample represents tuffaceous clays of the Lower Badenian age (*Orbulina suturalis*—*Globorotalia bykovae* Zone) from the section at Apold in the Transylvanian Basin (for description and microfaunistic characteristics see Gheorghian in Bombiță 1979: 176, layer 2a). It is very rich in planktic foraminifera and the share of foraminifera in microfaunal spectrum approaches 100%. Benthic foraminifera, relatively scarce here, represent fairly monotonous assemblage indicative of a deep-water (bathyal), warm sedimentary environment.

### Czechoslovakia

The samples from Kralice upon the Oslava river, from the Moravian

part of the Carpathian Foredeep, represent marls of the Lower Badenian age (Dr. M. Holzknacht, personal communication), resting beneath limestones. The marls yield microfaunal assemblage very rich in number of taxa and individuals, especially foraminifera. The share of planktic foraminifera is very high here. Among benthic foraminifera there are: uvigerinids, gyroidinids, buliminids, *Pullenia bulloides*, *Cibicides ungerianus*, *Siphonina reticulata*, *Oridorsalis* sp. and *Fursenkoina schreibersiana*; among the planktic ones: *Globorotalia* (div. sp.), *Globigerinoides* (div. sp.), and *Globoquadrina* sp. Ostracodes are represented here by *Parakrithe crystallina*, *Buntonia subulata*, *Cytheropteron* sp., *Henryhowella asperima*, and others. All the taxa indicate at least middle neritic marine zone and very warm, open sea conditions.

### Bulgaria

The sample from Opanets (near Pleven), from the Dacian Basin, represents clays (so called "lower clays") of the Lower Badenian (Dr. S. Juranov, personal communication), resting upon sands and beneath limestones of the same age. It is rich in planktic foraminifera (including *Orbulina*, *Globigerinoides*, *Globigerina* and *Globorotalia*) and benthic foraminifera (among others, *Lenticulina* div. sp., *Nodosaria* div. sp., *Heterolepa dutemplei*, *Pullenia bulloides*, *Sphaeroidina bulloides*, *Melonis pompilioides*, *Ceratobulimina* sp., *Hanzawaia boueana*, *Siphonina reticulata*, *Hoeglundina scalaris*, *Chilostomella* cf. *ovoidea*, *Cibicidoides conspiciendus*, *Uvigerina* div. sp., *Cassidulina* div. sp., *Cibicides ungerianus* and *Gyroidina* div. sp.). Both groups of foraminifera are indicative of warm and deep-water conditions. Ostracode remnants include only few valves belonging to *Parakrithe dactylomorpha* and *Cytherella* sp. and indicate deep water sedimentary environment.

#### BOLBOFORMA IN THE CENTRAL PARATETHYS AND OTHER REGIONS: STRATIGRAPHIC AND REGIONAL DISTRIBUTION

*Bolboforma* Daniels et Spiegler, 1974 has been found in all the Polish samples mentioned above, in the strata varying in age from the Lower to Upper Badenian. The samples of the Lower Badenian (Gacki section) and Middle Badenian (localities in Korytnica Basin) yielded *Bolboforma metzmacheri*. This species has been also recorded in Lower Badenian clay in the vicinity of Kików, i.e. in another sector of southern margin of the Holy Cross (Świętokrzyskie) Mts. (Odrzywolska-Bieńkowska 1976). The Upper Badenian samples from Machów and some localities of the Roztocze region yielded *Bolboforma badenensis*, and the latter region — scarce *B. taenifera* and *B. cf. aculeata* (fig. 2).

In comparative materials of the Lower and Middle Badenian age from Austria, Czechoslovakia, Bulgaria and Romania, has been found *Bolboforma metzmacheri*. It seems, therefore, that *B. metzmacheri* is characteristic of lower parts of the Badenian in the whole of the Central Paratethys, whereas the presence of *B. badenensis*, *B. taenifera*, and *B. cf. aculeata* seems stratigraphically restricted and typical of the Upper Badenian (*sensu* Papp *et al.* 1978).

MIDDLE MIOCENE			SPECIES
LOWER	MIDDLE	UPPER	
		•	<i>metzmacheri</i>
			<i>badenensis</i>
			<i>taenifera</i>
			<i>cf. aculeata</i>
			sp.
		--	<i>tenuis</i>
		--	<i>laqueata</i>

*Bolboforma metzmacheri*  
*Bachmayerella*

Fig. 2. Stratigraphic range of *Bolboforma* and *Bachmayerella* species in the Badenian (Middle Miocene) of the Central Paratethys.

From the species recorded in the Paratethys, only *B. metzmacheri* is known beyond this region. *B. cf. rotunda* reported from the Badenian of Poland by Odrzywolska-Bieńkowska (1976) seems to be a sponge spicule (Szczeczura in preparation). *B. metzmacheri* is known from the Middle and Upper Badenian of NW Europe (Germany, Belgium, the Netherlands; see Daniels and Spiegler 1974, Willems 1976, Doppert 1980), where its range in that interval is regarded as continuous. However, the subdivision of Miocene (including Middle Miocene) in NW Europe is less precise and based on other stratigraphic premises than in the Paratethys. This makes it difficult to compare the stratigraphic range of the taxon in the former part of Europe to its undoubted ecostratigraphic range in the latter areas. Moreover, the question of species concept in the case of bolboforms remains to be solved. *Bolboforma metzmacheri* is a species of unusually high variability and, at the same time, similar to other representatives of this genus (cf. p. 221). It therefore seems that the question of utility of *B. metzmacheri* in a correlation of the Miocene strata as well as its stratigraphic value for the whole area of Europe requires further studies.

Spiny bolboforms, assigned to *B. clodiusi* and closely resembling *B. badenensis*, were reported from the Lower Miocene in the Antarctic Ocean (Rögl and Hochuli 1976) and from the Middle Miocene in the Mediterranean region (Bizon *et al.* 1977).

### Paleoecological significance

It seems that in the Central Paratethys Badenian species of *Bolboforma* preferred clayey and marly sediments reflecting quiet sedimentary conditions of deep shelf zones as they are missing in a very nearshore shallow-water sediments. *Bolboforma metzmacheri*, known in Lower and Middle Badenian, occurs together with tropical microfauna, while *B. badenensis*, *B. taenifera*, and *B. cf. aculeata*, that are known in the Upper Badenian, occur with microfauna including no warm-water elements. It follows that time ranges of these species in the Paratethys were correlated with the thermic conditions of their environment. The presence of the same species of that genus in the Lower and Middle Badenian suggests that the environmental conditions were similar. The change in species spectrum in the Upper Badenian reflects a change in environmental conditions (cf. *Globigerinoides* and *Globigerina* ecozones as suggested by Szczechura 1982).

Beyond the Paratethys, *Bolboforma metzmacheri* is known to occur along with other species of this genus only in NW Europe, where the relevant environments still remain insufficiently known. Attention should be paid to the fact that this species is known neither in the Lower Miocene of the Antarctic region (Rögl and Hochuli 1976), where other species of this genus have been recorded, nor in the Middle Miocene strata drilled in the Mediterranean Sea (and interpreted as deposited under conditions of deteriorating climate), from which also other bolboforms are also known (Bizon *et al.* 1977). In the Antarctic region, Miocene bolboforms are known from silty claystones regarded as formed under lower bathyal conditions, and in the Mediterranean Sea — from sediments interpreted as formed at depths from 1000—1800 m. In the two regions mentioned above this genus is represented by smooth and spiny forms. The latter are very similar to those from the Upper Badenian of Poland, assigned to *B. badenensis*.

Taking into account the geographic distribution Bizon *et al.* (1977) interpreted *Bolboforma* as cold-water forms. However, the subsequent records from sediments formed in a warm or even very warm Paratethys sea showed that they were much more tolerant to the temperature of their environment. It cannot be excluded that individual species (or morphological types) of *Bolboforma* were confined to definite environmental conditions, especially to temperature.

**BACHMAYERELLA IN THE CENTRAL PARATETHYS  
STRATIGRAPHIC AND REGIONAL DISTRIBUTION**

In the studied Badenian material from Poland, representatives of *Bachmayerella*, i.e. *B. laqueata* and *B. tenuis*, have been found in samples of Middle Badenian strata from the Korytnica Basin only. Of the two species specimens of *B. laqueata* dominate in the samples. It can not be excluded, however that sieves had too large meshes and some fine tests of *B. tenuis* were simply washed out.

In material examined coming from other countries, *Bachmayerella tenuis* was found in a sample from the Lower Badenian from the Dacian Basin (Bulgaria), whereas *Bachmayerella* sp. was found in the Lower Badenian samples from Moravia (Czechoslovakia). The same species as recorded in Poland have been reported earlier from Middle/Upper Badenian passage beds (i.e. the *Spiroplectamina carinata* — *Bulimina* — *Bolivina* zones) by Rögl and Franz (1979), and *Bachmayerella* cf. *laqueata* — from similar passage beds in Croatian part (Jugoslavia) of the Paratethys and used as the basis for the discrimination of the *Bachmayerella* subzone by Bajraktarević (1984). In the light of the above data, especially the record of this genus in the Lower Badenian strata of Moravia and Dacian Basin, it is difficult to agree with the stratigraphic value ascribed to these microfossils by Bajraktarević. These fossils occur throughout the Lower and Middle Badenian, becoming very rare in lower parts of the Upper Badenian to disappear thereafter (see Rögl and Franz, 1979). It can not be excluded, however, that individual species may be useful for biostratigraphic subdivision of the sections in the Paratethys. The genus is unknown beyond the Paratethys.

### **Paleoecological significance**

In the Middle Badenian of Poland, *Bachmayerella* (*B. laqueata* and *B. tenuis*) occur in clays and marly rocks yielding warm-water microfauna and characteristic of relatively shallow part of neritic zone of open sea. In the Badenian of Moravia and Dacian Basin *Bachmayerella* presumably lived in neritic (but relatively deep-water) conditions.

In the Vienna Basin, *Bachmayerella* was reported from biofacies characterized by the wealth of benthic and planktic foraminifera, typical of outer shelf of open sea, as well as biofacies poor in foraminifera; the latter fact having been explained as due to a salinity crisis, leading to the origin of evaporitic rocks. It may be therefore assumed that preferable conditions for *Bachmayerella* were those of open, warm, rather shallow sea and quiet sedimentation.



## SYSTEMATIC POSITION AND TAXONOMY OF THE STUDIED FORMS

*Bolboforma*

The systematic position of *Bolboforma* Daniels et Spiegler, formerly assigned to the foraminiferal genus *Lagena*, has been recently analysed in detail by Daniels and Spiegler (1974), Odrzywolska-Bieńkowa (1976), Rögl and Hochuli (1976), and Bizon *et al.* (1977). Daniels and Spiegler as well as Odrzywolska-Bieńkowa assigned these microfossils to Protozoa, whereas Rögl and Hochuli — to cyst-forming algae (more precisely — to an unknown group of planktic Chrysomonadales), and Bizon *et al.* considered them *incertae sedis*.

In the analysis of the systematic position of these microfossils it seems worth while to consider the assumption put forward by Bizon *et al.* (1977) on the possibility of replacement of test material and comparison of the forms with chrysomonads (Bizon *et al.* 1977, as well as Rögl and Hochuli 1976). Chrysomonads, i.e. cysts of yellow-brown algae, actually resemble *Bolboforma* in general appearance, except for markedly smaller size and test built of silica. Because of these differences bolboforms were not identified with chrysomonads. However, Dr. A. Gaździcki (Institute of Paleobiology, Polish Academy of Sciences, Warsaw) has recently found microfossils almost identical in size and external morphology to the Badenian *Bolboforma metzmacheri* from the Central Paratethys in the Oligocene (?) of the Antarctic region. As above, the only difference is siliceous test of Dr. Gaździcki's forms. It can be concluded that either a post-mortem replacement of original test-forming mineral or a change in a mineral composition of the secreted test material has taken place.

It appears that further studies are necessary for unequivocal interpretation of systematic position of *Bolboforma*, all the more so as some of the tests examined display an element which resembles the aperture covering operculum (pl. 23: 11) and some show a fissure-like aperture (pl. 26: 1). Moreover, some bolboform tests fail to dissolve completely in HCl, and there is growing evidence for bi-layered structure of the test wall (p. 223, see also Bizon *et al.* 1977). The presence of calcite membrane closing the apertural neck was also found in *Bolboforma* described from the Miocene of the Antarctic region by Rögl and Hochuli (1977).

All the features mentioned above indicate that bolboforms represent cysts. If this is the case, the hitherto used generic and specific taxa should be treated with reservation. In analysis of chrysomonad cysts, Cornell (1969: 960) came to the conclusion that "... cyst-genera and cyst-species erected solely on the basis of morphology are not equivalent to taxa based on other criteria. Modern workers recognize that cyst morphology is not species-specific and in many cases is not distinctive at the generic level".

Reservations in relation to the accepted taxonomy of bolboforms should be also made because of marked variability of these microfossils, precluding unequivocal identification of species (cf. Rögl and Hochuli 1976, Willems 1976; and here). The species reported from the Badenian of Poland seem to represent ecophenotypes.

### *Bachmayerella*

In erecting *Bachmayerella*, Rögl and Franz (1970) considered it *incertae sedis*, assuming that these microfossils may represent Tintinnidae or reproductory stages of some metazoa. In my opinion, the structure of tests assigned to *Bachmayerella* is insufficient as a basis for drawing firm conclusions concerning systematic position of these microfossils. Similar platy-like structure of test wall (Rögl and Franz 1970, pl. 2: 20, pl. 3: 23—26, pl. 4: 31, 32; herein — pl. 25: 6) is displayed by some calcareous microfossils from the Upper Cretaceous of Europe, assigned to "Calcisphaerulidae" (*incertae sedis*) (see Villain 1975). The latter, however, are characterized by test-building plates (polygons) not laminar in structure (which differentiates them from *Bachmayerella*), and not porous tests. *Bachmayerella* tests are clearly porous and individual pore channels, usually situated between plates and presumably serving as free space for projections of soft parts (bristles, cirri?), seem to be mineralized independently and in different way than the plates. The complexity of general structure and the process of test mineralization distinguishes *Bachmayerella* from calcisphaeres and, thus, it seems that the former represent more complex organisms than the latter ones, which are treated by some authors as algal cysts.

## SYSTEMATIC DESCRIPTIONS

### Genus *Bolboforma* Daniels et Spiegler, 1974

#### *Bolboforma metzmacheri* (Clodius, 1922)

(pl. 23: 5—12; pl. 24: 1—9; pl. 27: 3, 9—11)

1969. *Lagena metzmacheri* Clodius; Langer: 45, pl. 2: 1, 2, 4.  
 1974. *Bolboforma metzmacheri* (Clodius); Daniels and Spiegler: 62, pl. 7: 1—3.  
 1976. *Bolboforma metzmacheri* (Clodius); Odrzywolska-Biełkowska: 554, pl. 1: 1, 2; pl. 2: 1.  
 1977. *Bolboforma metzmacheri* (Clodius); Willems: 33, pl. 1: a—d.  
 1980. *Bolboforma metzmacheri* (Clodius); Doppert, pl. 8: 3.

*Material.* — Several hundred well-preserved specimens.

*Remarks.* — The specimens from the Badenian of Poland, assigned to *Bolboforma metzmacheri*, are markedly varying, both in size (90—170  $\mu$  in larger diameter) and general shape, changing from more or less regularly spherical to, which is more common, flattened. Aperture not always circular, varying in size and sometimes not delineated by ridge-like swelling. Test surface with reticulate ornamentation,

the eyes varying in number and shape (but usually pentagonal), delineated by more or less sharp-crested riblets; short spines sometimes present at contact of riblets. Individual populations appear to vary in degree of variability so it may be assumed that the variability depended on environmental conditions. High variability, especially in size and shape, was also reported by Willems (1977), who studied material from the Upper Miocene of Belgium.

Spiny specimens of *B. metzmacheri* resemble *B. badenensis* (cf. pl. 23: 1 and pl. 24: 1, 6, pl. 26: 8).

*Occurrence.*—Poland: Lower and Middle Badenian of the northern periphery of the Carpathian Foredeep (Gacki, Kików, Korytnica region). Czechoslovakia: Lower Badenian of the Moravian part of the Carpathian Foredeep (Kralice). Austria: Lower Badenian of the Vienna Basin (Sooss). Romania: Lower Badenian of the Transylvanian Basin (Apold). Bulgaria: Lower Badenian of the Dacian Basin (Opanets). North Sea Basin (Federal Republic of Germany, Belgium and Netherlands): Middle and Upper Miocene.

### *Bolboforma badenensis* Szczechura, 1982

(pl. 24: 1—4; pl. 26: 1—9)

1982. *Bolboforma badenensis* Szczechura: 33, pl. 6: 1—4.

*Material.*—Several hundred well-preserved specimens.

*Remarks.*—Specimens assigned to *Bolboforma badenensis* are varying in size (100—170  $\mu$  in larger diameter), ornamentation, and development of aperture. Aperture varying in size, sometimes fissure-like with clearly marked operculum (pl. 26: 1), and sometimes with neck. A damaged specimen (pl. 26: 7) seems to display bilayered structure of test wall. Reticulation of test surface varying in distinctness; ornamentation sometimes limited to spines varying in size, shape and number. Specimens without visible reticulation resemble *B. clodiusi* from the German Miocene (Daniels and Spiegler 1974) and Miocene sections of the Mediterranean and Antarctic regions (Bizon *et al.* 1977, Rögl and Hochuli 1976). Specimens with irregularly spaced, knobby-like spines resemble tests assigned here to *B. cf. aculeata* (pl. 25: 4, 5). The nature and range of variability, especially in ornamentation, seems to depend on environmental conditions as it appears different in individual populations of *B. badenensis*.

*Occurrence.*—Poland: Upper Badenian of the Carpathian Foredeep (Machów) and Roztocze region (Trzęsiny, Józefów, Długi Goraj, Węglin).

### *Bolboforma taenifera* sp.n.

(pl. 25: 1—3)

*Holotype:* ZPAL V. XV/50, pl. 25: 3.

*Type horizon:* Upper Badenian (Middle Miocene).

*Type locality:* Józefów, Roztocze Region, Poland.

*Derivation of the name:* Lat. *taenifera* — ribbon bearing.

*Material.*—Six specimens, well preserved.

*Diagnosis.*—*Bolboforma* with sinusoidally arranged, weakly tuberculated ribbon-like rib in bottom part of the test. Three ribbon-like ribs generally join the highest parts of the bottom rib with necked aperture.

*Description.* — The test (of average size 110  $\mu$ ) slightly flattened horizontally or round, displaying sinusoidally arranged ribbon-like, weakly tuberculated rib in its bottom part. Three similar ribs connect the highest parts of the bottom rib with the aperture; the latter with ribbon-like neck. Area between the ornamental element (i.e. ribs) rather smooth, with singular, irregularly distributed tubercles, mostly at lateral test surface. In some specimens there are no ribs except that one at the bottom part.

*Remarks.* — *Bolboforma taenifera* sp. n. seems to be very close to *B. danielsi* Murray, 1984, from the Middle Miocene of NE Atlantic, as figured by Poag and Karowe (1986). Differences concern mostly the shape of the aperture and ornamentation of test. *B. danielsi* has elongate, narrow apertural neck and continuous sinuate, blade-like rib encircling the test. In holotype of *B. taenifera* apertural neck is short and large, and tops of the rib encircling the test are connected with neck by a singular, tuberculate rib. Specimens from Poland vary, however, in their morphological and ornamental details. More representatives of both compared species should be considered to determine the taxonomic value of the above mentioned features.

*Occurrence.* — Poland: Upper Badenian of the Roztocze Region (Józefów).

### *Bolboforma* cf. *aculeata* Daniels et Spiegler, 1974

(pl. 25: 4, 5)

*Material.* — A few well-preserved specimens.

*Remarks.* — Specimens assigned to *Bolboforma* cf. *aculeata* are ornamented with irregularly spaced various spines, generally more numerous and better developed in lower part of test. Aperture sometimes with distinct neck. Tests assigned to *B.* cf. *aculeata* resemble those of *B. aculeata* and *B. armata*, described from the Miocene of the Federal Republic of Germany by Daniels and Spiegler (1974), differing from the latter in weaker ornamentation. The Polish specimens resemble the co-occurring *B. badenensis* irregularly ornamented with knobby-like spines, and specimens from the Miocene of the Antarctic region, described as *B. rotunda* by Rögl and Hochuli (1976).

*Occurrence.* — Poland: Upper Badenian of the Roztocze region (Józefów).

### Genus *Bachmayerella* Rögl et Franz, 1979

#### *Bachmayerella laqueata* Rögl et Franz, 1979

(pl. 22: 1, 2, 5—10; pl. 25: 6)

1979. *Bachmayerella laqueta* Rögl et Franz: 87, pl. 1: 1—8; pl. 2: 15—22; pl. 3: 23—30; pl. 4: 31—34.

*Material.* — About fifty? well-preserved specimens.

*Remarks.* — Specimens assigned to *Bachmayerella laqueata* vary in size (150 to 200  $\mu$  in larger diameter), general shape (from regularly spherical to slightly flattened at oral side), and size of aperture. Only in one specimen the aperture appears to be equipped with operculum (pl. 22: 9). The number of plates forming the test wall is also varied. Additional mineralization (pl. 22: 1, 2, 5, 8—10) obscures the structure (or ornamentation only) of test completely or partly, making the specimens similar to those of *Pithonella*.

*Occurrence.* — Poland: Middle Badenian of the Carpathian Foredeep (Korytnica region). Austria: Upper part of the Middle Badenian and Lower part of the Upper Badenian of the Vienna Basin. Bajraktarević (1984) recorded *Bachmayerella* cf. *laqueata* from the same part of the Upper Badenian in the Croatian part of Paratethys (near Zagreb).

*Bachmayerella tenuis* Rögl et Franz, 1979

(pl. 22: 3, 4; pl. 27: 1, 2, 4—8)

1979. *Bachmayerella tenuis* Rögl and Franz: 90, pl. 1: 9—14; pl. 4: 35—39; pl. 5: 39—46.

*Material.* — A dozen of specimens well preserved.

*Remarks.* — The Polish and Bulgarian specimens assigned to *Bachmayerella tenuis* generally do not differ from representatives of this species (attaining, however, only 80—100  $\mu\text{m}$  in larger diameter) from the Badenian of the Vienna Basin (Rögl and Franz 1979). The one figured on pl. 27: 8a, b is, however, distinctly elongated in its bottom part. A very low frequency of these fossils in the material available may be due to the use of sieves with two large meshes and, consequently to loosing tests of this species in the course of the washing.

*Occurrence.* — Poland: Middle Badenian of the Carpathian Foredeep (Korytnica region). Bulgaria: Lower Badenian of the Dacian Basin (Opanets).

*Bachmayerella* sp.

(pl. 24: 10—12)

*Remarks.* — In comparison with *Bachmayerella laqueata*, the specimens assigned to *Bachmayerella* sp. are generally larger (reaching 250  $\mu\text{m}$  in larger diameter) and with test wall built of smaller and more numerous plates (polygons). However, the size of test is not constant in this species.

*Occurrence.* — Czechoslovakia: Lower Badenian of the Moravian part of the Carpathian Foredeep (Kralice).

## REFERENCES

- BAJRAKTAREVIĆ, Z. 1984. *Bachmayerella* i potvrda njene stratigrafske provodnosti srednjega miocena (badena). — *Geol. Vjesnik*, **37**, 7—10.
- BALUK, W. and RADWAŃSKI, A. 1977. Organic communities and facies development of the Korytnica basin (Middle Miocene; Holy Cross Mountains, Central Poland). — *Acta Geol. Polonica*, **27**, 2, 85—123.
- BIZON, G., TAUGOURDEAU-LANTZ, J. and WRIGHT, R. 1977. Présence d'algues enkystées: *Pachysphaera* et de microfossiles d'affinités incertaines: *Bolboforma* dans Miocène de Méditerranée. — *Rev. Micropal.*, **20**, 3, 140—146.
- CORNELL, W. C. 1969. The chryomonad Cyst-Families Chrysomostomataceae and Archeomonadaceae: their status in paleontology. In: Ultra micro-plankton. Symposium North American Paleontological Convention, Part G, Proc. North American Paleontological Convention, p. 959—965. Allen Press, Inc. Lawrence, Kansas, Chicago.
- DANIELS, C. H. v. and SPIEGLER, D. 1974. *Bolboforma* n. gen. (Protozoa?) — eine neue stratigraphischwichtige Gattung aus dem Oligozän (Miozän Nordwestdeutschlands. — *Paläont. Z.*, **48**, 1/2, 57—76.
- DOPPERS, J. W. CHR. 1980. Litostratigraphy and biostratigraphy of Neogene deposits in the Netherlands. — *Meded. Rijks Geol. Dienst*, **32**, 16, 255—311.
- GHEORGHIAN, M. D. 1975. Coupe d'Apold: Eocène, Badénien-Sarmatien (Excursion Q). In: G. Bombiță (ed.), Micropaleontological guide to the Mesozoic and Tertiary of the Romanian Carpathians, 14th European Micropaleontological Colloquium, Romania 1975, Bucharest, 175—178.

- KIRCHNER, E., SCHRAMM, I. M., TICHY, G. and VETTERS, W. 1978. Geological excursion to Austria 8—21 September 1978, 225—317. Institute of Geology and Paleontology, University of Salzburg.
- KRACH, W., ŁUCZKOWSKA, E. and NEY, R. 1974. VII Symposium der Arbeitsgruppe "Paratethys" in Polen. Führer zur Paratethys-Excursionen 1974 in die Neogen-Gebiete Polens vom 3—7 September 1974, 3—48, AGH, Kraków.
- LANGER, W. 1969. Beiträge zur Kenntnis einiger Foraminiferen aus dem mittleren und oberen Miozän des Nordsee-Beckens. — *N. Jb. Geol. Paläont. Abh.* 133, 23—78.
- MARTINI, E. 1977. Calcareous nannoplankton from the Korytnica basin (Middle Miocene; Holy Cross Mountains, Poland). — *Acta Geol. Polonica*, 27, 2, 125—133.
- ODRZYWOLSKA-BIENKOWA, E. 1976. O niektórych gatunkach z rodzaju *Bolboforma* (?Protozoa) w miocenie Polski. — *Kwart. Geol.*, 20, 3, 551—558.
- PAPP, A., CICHA, I. and ČTYROKÁ, J. 1978. Foraminifera: Allgemeine Charakteristic der Foraminiferenfauna in Badenian. In: E. Brestenská (ed.). Chronostratigraphie und Neostatotypen, Miozän M<sub>4</sub>, Badenian, 263—268. VEDA, Bratislava.
- POAG, C. and KAROWE, A. L. 1986. Stratigraphic potential of *Bolboforma* significantly increased by new finds in the North Atlantic and South Pacific. — *Palaios*, 5, 1, 162—171.
- RÖGL, F. and FRANZ, H. E. 1979. *Bachmayerella* — ein neues problematisches Mikrofossil aus dem marinen Mittelmiozän von Valbersdorf, Burgenland. — *Ann. Naturhist. Mus. Wien.*, 83—96.
- and HOCHULI, P. 1976. The occurrence of *Bolboforma*, a probable algal cyst, in the Antarctic Miocene of DSDP Leg 35. — Initial Rept. Deep Sea Drilling Proj., 36, 713—715. U.S. Government Printing Office, Washington.
- SZCZUCHURA, J. 1982. Middle Miocene foraminiferal biochronology and ecology of SE Poland. — *Acta Palaeont. Polonica*, 27, 1—4, 3—44.
- 1984. Morphologic variability in the Globigerinoides-Orbulina group from the Middle Miocene of the Central Paratethys. — *Ibidem*, 29, 1—2, 3—27.
- and PISERA, A. (in press). Microfauna and microfacies of the lithothamnian limestones from the Holy Cross Mts. and Roztocze (Poland). — *Zeszyty Naukowe A.G.H., Geologia*.
- VILLAIN, J.-M. 1975. "Calcisphaerulidae" (*incertae sedis*) du Crétacé Supérieur du Limbourg (Pays-Bas), et d'autres régions. — *Palaeontographica*, A, 149, 4—6, 193—242.
- WILLEMS, W. 1976. The genus *Bolboforma* Von Daniels and Spiegler in the Upper Miocene of northern Belgium. — *Bull. Soc. belge, Géologie*, 85, 1—2, 31—38.

---

JANINA SZCZUCHURA

MIKROPROBLEMATYKI BOLBOFORMA I BACHMAYERELLA  
ZE ŚRODKOWEGO MIOCENU CENTRALNEJ PARATETYDY

Streszczenie

W osadach badenu (środkowy miocen) Centralnej Paratetydy z obszaru Polski, Czechosłowacji, Austrii, Rumunii i Bułgarii znaleziono mikroproblematyki wapienne

zaliczane do rodzaju *Bolboforma* Daniels et Spiegler, 1974, i *Bachmayerella* Rögl et Franz, 1979. Rodzaj *Bolboforma* jest reprezentowany przez *B. metzmacheri*, *B. badenensis*, *B. cf. aculeata* i *B. taenifera* sp.n., a rodzaj *Bachmayerella* reprezentują *B. laqueata*, *B. tenuis* i *B. sp.* Mikrokamieniałości te są przydatne dla korelacji i biostratygrafii osadów środkowomiocęńskich Paratetydy, a w szczególności — dla różnicowania osadów górnobadeńskich od osadów starszych, tj. dolno- i środkowobadeńskich.

Bolboformy, być może wtórnie wapienne, przyrównano do cyst alg, natomiast bachmajerelle, ze względu na znaczną złożoność struktury skorupki, potraktowano jako szczątki wyższych organizmów, których stanowiska systematycznego nie można określić.

Praca została wykonana w ramach problemu MR II 6.

#### EXPLANATION OF PLATES 22—27

##### Plate 22

- 1, 2. ?*Bachmayerella laqueata* Rögl et Franz; 1a  $\times$  800, 1b detail of outer surface.  $\times$  750, ZPAL V.XV/7; 2  $\times$  350, ZPAL V.XV/8.  
 3, 4. *Bachmayerella tenuis* Rögl et Franz; 3  $\times$  270, ZPAL V.XV/5; 4  $\times$  270, ZPAL V.XV/6.  
 5—10. *Bachmayerella laqueata* Rögl et Franz; 5  $\times$  270, ZPAL V.XV/9; 6  $\times$  350, ZPAL V.XV/10; 7a detail of outer surface,  $\times$  1000, 7b  $\times$  300, ZPAL V.XV/11; 8  $\times$  320, ZPAL V.XV/12; 9a  $\times$  300, 9b detail of aperture,  $\times$  1000, ZPAL V.XV/13; 10  $\times$  350, ZPAL V.XV/14.

1, 2, 5—10 — Chomentów, 3, 4 — Korytnica, Poland, Middle Badanian

##### Plate 23

- 1—4. *Bolboforma badenensis* Szczechura; 1  $\times$  220, ZPAL V.XV/27; 2  $\times$  220, ZPAL V.XV/28; 3  $\times$  220, ZPAL V.XV/29; 4  $\times$  200, ZPAL V.XV/30.  
 5—12. *Bolboforma metzmacheri* (Clodius); 5  $\times$  250, ZPAL V.XV/31; 6  $\times$  70, ZPAL V.XV/32; 7  $\times$  220, ZPAL V.XV/33; 8  $\times$  300, ZPAL V.XV/34; 9  $\times$  250, ZPAL V.XV/35; 10  $\times$  250, ZPAL V.XV/36; 11  $\times$  300, ZPAL V.XV/37; 12  $\times$  250, ZPAL V.XV/38.

1—3 — Machów, 4 — Józefów, Poland, Upper Badanian; 5—12 — Chomentów, Poland, Middle Badanian

##### Plate 24

- 1—9. *Bolboforma metzmacheri* (Clodius); 1  $\times$  220, ZPAL V.XV/15; 2  $\times$  220, ZPAL V.XV/16; 3  $\times$  220, ZPAL V.XV/17; 4  $\times$  220, ZPAL V.XV/18; 5  $\times$  300, ZPAL V.XV/19; 6  $\times$  220, ZPAL V.XV/20; 7  $\times$  150, ZPAL V.XV/21; 8  $\times$  300, ZPAL V.XV/22; 9  $\times$  250, ZPAL V.XV/23.

- 10—12. *Bachmayerella* sp.; 10 × 180, ZPAL V.XV/24; 11 × 300, ZPAL V.XV/25;  
12 × 180, ZPAL V.XV/26.  
1—3, 6 — Sooss, Austria, Lower Badenian; 4, 5 — Apold, Romania, Lower Badenian;  
7—12 — Kralice — Czechoslovakia, Lower Badenian

## Plate 25

- 1—3. *Bolboforma taenifera* sp.n.; 1 × 250, ZPAL V.XV/48; 2a × 250, 2b × 250, ZPAL V.XV/49; 3a × 220, 3b × 220, 3c × 220, holotype, ZPAL V.XV/50.  
4, 5. *Bolboforma* cf. *aculeata* Daniels et Spiegler; 4a × 220, 4b × 220, ZPAL V.XV/51; 5 × 220, ZPAL V.XV/52.  
6. *Bachmayerella laqueata* Rögl et Franz; damaged specimen; 6a structure of test wall, × 1500, 6b detail of inner surface, × 800, 6c detail of inner surface, ZPAL V.XV/53.  
1—5 — Józefów, Poland, Upper Badenian; 6 — Chomentów, Poland, Middle Badenian

## Plate 26

- 1—9. *Bolboforma badenensis* Szczechura; 1a × 220, 1b detail of aperture, × 1500, ZPAL V.XV/39; 2 × 250, ZPAL V.XV/40; 3 damaged specimen showing inner surface, × 270, ZPAL V.XV/41; 4a damaged specimen showing detail of structure of test wall, × 1500, 4b damaged specimen showing inner surface, × 220, ZPAL V.XV/42; 5 × 210, ZPAL V.XV/43; 6 × 210, ZPAL V.XV/44; 7a damaged specimen showing inner and outer layers of test wall, × 200, 7b detail of test wall, × 500, ZPAL V.XV/45; 8 × 250, ZPAL V.XV/46; 9 × 300, ZPAL XV/47.  
1, 2 — Weglin, 3—7 — Długi Goraj, 8, 9 — Trzęsiny, Poland, Upper Badenian

## Plate 27

- 1, 2, 4—8. *Bachmayerella tenuis* Rögl et Franz; 1 × 360, ZPAL V.XV/54; 2 × 370, ZPAL V.XV/55; 3 × 370, ZPAL V.XV/56; 4 × 370, ZPAL V.XV/57; 5 × 370, ZPAL V.XV/58; 6 × 370, ZPAL V.XV/59; 7 × 370, ZPAL V.XV/60; 8a × 320, 8b detail of outer surface near bottom part, × 1250, ZPAL V.XV/61.  
3, 9—11. *Bolboforma metzmacheri* (Clodius); 3 × 370, ZPAL V.XV/62; 9 × 220, ZPAL V.XV/63; 10 × 220, ZPAL V.XV/64; 11 × 220, ZPAL V.XV/65.  
1—4 — Korytnica, Poland, Middle Badenian; 5—11 — Opanets, Bulgaria, Lower Badenian
-



