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Eobigenerina, a cosmopolitan deep-water agglutinated foraminifer, and remarks on late Paleozoic to Mesozoic species formerly assigned to *Pseudobolivina* and *Bigenerina*

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ABSTRACT

The genus *Eobigenerina* (type species *Bigenerina variabilis* Vašíček, 1947) is re-described from a Cretaceous section in the Eastern Carpathians (Romania) and well material from the North Atlantic and western Barents Sea. The genus is defined by its biserial to uniserial chamber arrangement and is otherwise isomorphic to *Bigenerina*, differing in its solid, noncalcareous, silicified wall structure and older stratigraphic occurrence (Pennsylvanian to Eocene). A neotype is selected for the type species, *Eobigenerina variabilis* (Vašíček, 1947), and one new species, *Eobigenerina kuhnti* n.sp. is described herein. We also transfer some cosmopolitan agglutinated taxa described previously from deep-water Cretaceous deposits as *Pseudobolivina, Bimonilina,* and "*Bigenerina*" to our new genus *Eobigenerina*, to *Parvigenerina* Vella 1957, or to the more recently described genera *Hagimashella* Neagu & Neagu, 1995, *Rashnovammina* Neagu & Neagu, 1995 and *Bicazammina* Neagu & Neagu, 1995.

INTRODUCTION

Since the description of *Bigenerina* d'Orbigny, 1826 and *Pseudobolivina* Wiesner, 1931, a number of Cretaceous deep-water agglutinated species have been incorrectly assigned to these genera. Vašíček (1947), in his classic paper "Remarks on the micro-biostratigraphy of the Magura flysch in Moravia" introduced five new species of *Bigenerina* from the "Bigenerina Zones" in the Czech Republic, stating that these zones are older than Senonian (we assume this interval was Cenomanian – Turonian). However, no mention of the shape and position of aperture or a canaliculate type of wall and was made in the original descriptions. The test wall was reported to be "rough but polished", with "cement as translucent as the arenaceous material".

One of these species, *Bigenerina variabilis* Vašíček 1947, which becomes terminally uniserial, is widely used in Polish, Czech and Romanian Carpathian biostratigraphy. The purpose of this paper is to formally separate the late Paleozoic to Mesozoic species formerly lumped into the genus *Bigenerina* by introducing a new genus to accommodate the stratigraphically older isomorphic forms that possess a solid organically-cemented silicified wall (Cetean *et al.*, 2008). Finally, we review the late Paleozoic to Paleogene occurrences of biserial to uniserial organically cemented taxa that we reassign to *Eobigenerina*.

Previous studies of Mesozoic *"Bigenerina"*

Bigenerina variabilis was mentioned by Geroch (1959) from the Lower Cretaceous Verovice shales (Barremian – Lower Aptian), which outcrop in the Silesian Unit near Żywiec, Poland. Huss (1966) recorded it from Albian – Cenomanian marly deposits of the Subsilesian Unit, and from the Węglówka Sandstone.

Geroch (1966) considered synonymous two of the *Bigenerina* species described by Vašíček (1947), *B. variabilis* and *B. paradoxa*, and remarked that these forms cannot be ascribed to *Bigenerina* because the aperture is in the shape of a slit, and transferred them to the genus *Pseudobolivina*. However, Geroch (1966, pl.

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14, figs 1-4) only figured specimens that are biserial and have a high bolivinid-type aperture, and therefore they do not correspond with Vašíček's definition and illustrations of *Bigenerina variabilis*. Because the definition of the genus *Pseudobolivina* includes forms that never become uniserial and are characterised by having an aperture in the shape of a high interiomarginal arch extending up the final chamber face, this generic assignment of *Bigenerina variabilis* to *Pseudobolivina* must now be disregarded. Our specimens from the Romanian Eastern Carpathians and Barents Sea clearly exhibit a round to oval terminal aperture situated at the end of a short neck.

Geroch & Nowak (1984) established the upper Barremian to Aptian *Pseudobolivina variabilis* – *Reophax minutus* Zone based on the first occurrences of the nominate taxa in the Silesian Unit of the Polish Carpathians, and this scheme was used as the starting point for a Tethyan deep-water benthic foraminiferal biozonation by Kaminski & Geroch (1992).

Under the name *Pseudobolivina variabilis*, the species was also mentioned by Neagu (1970) from the lower Turonian of the Teleajen Nappe of the Eastern Carpathians, Romania, and by Bubík (1995) from the Hluk Formation (Aptian to Albian) of the Bílé Karpaty Unit, West Carpathians, in the Czech Republic.

Krasheninnikov (1973) described the new species *Pseudobolivina munda* from Santonian to Campanian abyssal pelagic sediments of the northwestern Pacific Ocean, DSDP Holes 196 and 198A. Krasheninnikov remarked that this species closely resembles *Pseudobolivina variabilis* (Vašíček, 1947), which according to him differs in having "trapeziform chambers throughout growth, and an aperture not encircled by a neck". Other species of *Pseudobolivina* were introduced subsequently by Krasheninnikov (1974) from the Upper Cretaceous of the Indian Ocean, DSDP Sites 260 and 261: *Pseudobolivina cuneata*, *P. lagenaria* and *P. normalis*. Yet, only one of Krasheninnikov's species appears to truly fit within the genus *Pseudobolivina*. This is *Pseudobolivina normalis,* which has an aperture that "is long, loop shaped or oval, arranged perpendicular to the base of the apertural face". We currently assign the remaining species to other deep-water agglutinated genera.

Unnamed species of *Pseudobolivina* were also mentioned from Lower to Upper Cretaceous deposits from the North Atlantic Ocean at Hole 603B (DSDP Leg 93) and Holes 640A and 641A (ODP, Leg 103) by Moullade *et al.* (1988). One of them, *Pseudobolivina* sp. 2, has the "last chamber strongly compressed, showing a trend to becoming uniserial" and "seems to possess an apertural neck". However, the specimens figured in their plate 9, fig. 11 and 12 clearly becomes uniserial. We believe this form to be a synonym of *Bigenerina variabilis* Vašíček, 1947. In addition, this species seems to be an opportunistic taxon which is able to live in dysoxic conditions, playing a major part in the post recovery faunas after the Cenomanian – Turonian anoxic event (OAE 2), both in North Atlantic ODP Site 641A (Kuhnt, 1992), in the Scaglia Bianca Formation at Gubbio, Italy (Coccioni *et al*., 1995) and in the Dumbrăvioara Formation, Ceahlău Nappe, Eastern Carpathians, Romania (Cetean *et al*., 2008).

Finally, an abyssal species from the Tithonian of ODP Hole 765 on the Argo Abyssal Plain was assigned by Kaminski *et al.* (1992, pl. 7, figs 1-2) to *"Bigenerina* sp." These forms show a true uniserial part of two chambers with a terminal aperture on a short neck. It is possible that some of the Late Jurassic specimens reported by various authors as *"Bigenerina jurassica"* may also be synonymous.

Neagu & Neagu (1995) recognised the taxonomical problem with the noncalcareous nature of the Jurassic taxa recovered from acid residues that were formerly known as *"Bigenerina"*. These authors described three new genera:

- *Bicazammina* (type species *Pleurostomella jurassica* Haeusler, 1890) to accommodate forms biserial in the early stage and which have a long lax-uniserial portion that almost becomes uniserial and an areal to terminal aperture on a neck;
- *Rashnovammina* to accommodate biserial forms with a tendency to become loosely biserial in the last third part of the test, slightly globulous chambers and areal to terminal aperture, elliptical or circular in outline, supported by a short neck;
- *Haghimashella* to accommodate forms that have a short biserial early stage followed by a laxuniserial adult stage with glandular-globulose chambers and a terminal aperture, circular or elliptical, supported by a short neck.

Parvigenerina Vella, 1957 has similar overall morphology, but lacks a terminal uniserial stage. It consists of a short biserial stage that may be slightly twisted, and later becoming loosely biserial, and finally lax uniserial with a terminal aperture on a produced neck. Among the five syntypes preserved in the Heron-Allen type collection at the Natural History Museum, London, four are terminally loosely biserial, and only one specimen becomes terminally lax-uniserial with a single lax-uniserial chamber. The suture between the final two chambers is still steeply inclined with respect to the growth axis. Although its range was reported by Loeblich & Tappan (1987) as a Holocene (the type species *Bifarina prorecta* Brady var. *arenacea* Heron Allen & Earland, 1922 is from the modern Southern Ocean), additional taxa that are loosely biserial are recorded as *Parvigenerina* from the Upper Jurassic of Nepal (Nagy *et al.,* 1995) and from the Upper Cretaceous of Gubbio, Italy (reported as *Pseudobolivina* sp. 3 by Kuhnt, 1990).

STUDIED MATERIAL

For the purpose of this study, we examined Upper Cretaceous samples from four geographical areas: The Romanian Carpathians, the Contessa Highway Section of Italy, the southern Labrador Sea, and the western Barents Sea. The Romanian samples studied within this project were collected from upper Cenomanian to lower Turonian deposits exposed in the Miriuţa Quarry near the Stoeneşti locality in the southern part of the Eastern Carpathians, Romania. The mentioned deposits are part of the Albian to Turonian Dumbrăvioara Formation (Ceahlău Nappe, Outer Dacides), which was described in greater detail in the Ph.D. project carried out by the first author (Cetean, 2009).

The western Barents Sea material consists of six exploration wells drilled by Statoil in the 1980s. These wells sampled the Kviting Formation, which contains rich assemblages of deep-water agglutinated foraminifera belonging to the *Caudammina gigantea* Zone of Geroch & Nowak (1984). The Upper Cretaceous biostratigraphy of the western Barents Sea is currently the topic of a Ph.D. project carried out by the second author (Setoyama et al, this volume).

The Labrador Sea locality is the Indian Harbour M-52 well, which recovered deep-water Upper Cretaceous to Paleocene deposits on the Labrador Margin. Faunal slides from the Indian Harbour well are housed in the BP Collections at the Natural History Museum, London. The foraminiferal biostratigraphy of the well was described in detail by Kaminski (1988) and the quantitative foraminiferal zonation of the Cenozoic part of the well was given by Gradstein *et al*. (1994).

Unfortunately, the Vašíček collection of type specimens, once housed at the Czech Geological Survey no longer exists. Miroslav Vašíček traded some specimens with Stanisław Geroch, but a search of the Geroch Collection at the Jagiellonian University in Kraków did not uncover any slides labeled *Bigenerina variabilis*. It is believed that M. Vašíček took his collection home with him upon his retirement.

In Hluk village in the Czech Republic, the samples from test pits and trenches studied by Vašíček (1947) were revised based on the Geofond archive documentation from 1943. Originally the test pits and trenches were dug in frame of oil exploration and documented by A. Matějka and Z. Roth. From the Hluk Formation exposed by these excavations, Vašíček (1947) described selected taxa of agglutinated foraminifera (including 5 species of *Bigenerina*). For the purpose of this study one of us (M. Bubík) collected new samples from the vicinity of the original location of the 9R and 10R test pits. Only the sample close to the 9R pit provided abundant agglutinated fauna, including biserial forms assigned by Vašíček to *Bigenerina*. Additional comparative material from the Hluk Formation was available in archive borehole samples housed at the Czech Geological Survey (boreholes Hluk HAG1 and V3), and original slides from the test pits and trenches of Vašíček (1947).

The new test pit near 9R is represented by green gray noncalcareous clay with dark gray shale to siltstone intercalation (Hluk Formation). Light gray marly clay intercalations and a gray fine-grained calcareous sandstone bank also occur. The agglutinated fauna is relatively abundant. Fragile taxa ("*Bigenerina*") are unfortunately often broken. Frequent *Recurvoides imperfectus* (Hanzlíková), *Pseudonodosinella troyeri* (Tappan), *Ammodiscus infimus* (Franke), *Hippocrepina depressa* Vašíček and rare *Plectorecurvoides alternans* Noth indicate a Cenomanian age.

Unfortunately, both material from the new trench (see above) and specimens of "*Bigenerina*" from the Hluk V3 and Hluk HAG1 wells were proved to be unsuitable for our study, owing to poor and fragmentary preservation that did not allow a complete description of morphological features.

SYSTEMATIC TAXONOMY

In this study we used the higher systematics of agglutinated foraminifera published by Kaminski (2004).

Suborder SPIROPLECTAMMININA Cushman, 1927
Superfamily SPIROPLECTAMMINACEA Cushman, 1927
Family TEXTULARIOPSIDAE Loeblich & Tappan, 1982

Eobigenerina Cetean, Setoyama, Kaminski, Neagu, Bubík, Filipescu and Tyszka, 2008

Type species. *Bigenerina variabilis* Vašíček, 1947.

Description. Test with an early biserial stage comprising at least one-third the length of the adult test, followed by a loosely biserial stage, then a short lax uniserial portion, and finally by a terminal uniserial stage of low chambers that are round in cross-section. Wall solid, noncanaliculate, finely finished, of fine agglutinated particles in organic material, often well-silicified, insoluble in HCI. Aperture terminal, small and rounded, on a collar or short neck.

Distribution & Stratigraphic range. Upper Pennsylvanian to Eocene; Australia; USA: Kansas, Texas; Indian Ocean; North Atlantic; Barents Sea; Alpine-Carpathian region: Romania, Poland, Czech Republic, Austria, Germany, Italy.

Remarks. Differs from *Bigenerina* in having a solid, noncanaliculate wall that is insoluble in acid, and from *Aaptotoichus* in having a well-developed biserial part, a short apertural neck, and a finely agglutinated test wall. It differs from *Bimonilina* in having chambers that are truly uniserial, rather than lax-uniserial, and in having a round terminal aperture. Differs from *Rashnovammina* and *Bicazammina* in the addition of a truly uniserial terminal part with horizontal sutures between last chambers.

Eobigenerina variabilis (Vašíček, 1947)

Plate 1, figs 1 – 12

Text figure 1. *Bigenerina variabilis* Vašíček. Cenomanian-Turonian?, Czech Republic, magnification not given (from Vašíček, 1947).

Bigenerina variabilis Vašiček, 1947, p. 246, pl. 1, figs. 10-12.
non *Pseudobolivina variabilis* Vašíček. – Geroch, 1966, pl. 14, figs 1-4.
Bigenerina sp. Kaminski *et al.* 1992, p. 252, pl. 7, figs 1, 2
Bimonilina entis Mjatliuk, 1988, p. 62, pl. 24, fig. 7
Pseudobolivina sp. 2 Moullade *et al*., 1988, p. 366, pl. 9, figs. 11-12
Pseudobolivina sp. 1 Coccioni *et al.* 1995, p. 146, pl. 3, fig. 11
pars *Pseudobolivina parvissima* Neagu 1970, p. 41, pl. 24, figs. 19, 20 (not figs 16-18).

Description. Test free, elongated, with an initial biserial early stage consisting of 6 to 7 pairs of chambers, followed by a loosely biserial part consisting of 2 pairs of chambers, then often a short lax-uniserial stage, and finally a uniserial stage of 1 to 3 chambers. Sutures in the biserial to loosely biserial stage are oblique and depressed; in the uniserial stage sutures are horizontal. Wall noncalcareous, often well-silicified, glassy in appearance, comprised of small quartz particles. Connections between chambers are areal in the lax-uniserial part. Aperture in uniserial stage is terminal, round, on a short neck.

Remarks. This species is commonly confused with other biserial forms. Unfortunately, Vašíček made no mention of shape of the aperture, but because he originally placed the species in *Bigenerina*, we can assume that the aperture was terminal.

We observe specimens in all transitional growth patterns from biserial to loosely biserial, laxuniserial, and finally wholly uniserial (sensu Kaminski *et al*., 2009). Although the typical form of the species is terminally uniserial with one or two uniserial chambers, juvenile specimens terminate with a loosely biserial or lax-uniserial portion. In our opinion, the species designation *"variabilis"* by Vašíček (1947) was a good choice of a name.

Distribution. Widely reported from various tectonic units in the Carpathians, Germany, Italy.

Stratigraphic range. Lower Cretaceous (Tithonian) to Eocene (Scaglia Cinerea Formation, Belluno province, northeastern Italy – Giusberti, 2009, personal communication to CGC).

Type specimens. A neotype specimen is here designated from the Dumbrăvioara Formation in the southern Romanian Eastern Carpathians. The sample was collected from the Cenomanian/Turonian boundary interval in the Miruţa Quarry, near the Stoeneşti locality. The neotype (PF70262) and six paraneotypes (PF70263-68) were deposited in the Paleontology Department, Natural History Museum, London. Additional paraneotypes are housed in the Grzybowski Library (Geological Museum of the Jagellonian University, Kraków, Poland).

Eobigenerina kuhnti n.sp.

Plate 1, figs 13 – 16

Pseudobolivina sp. 4 Kuhnt, 1990, p. 324, pl. 6, figs. 6–7.
pars *Pseudobolivina parvissima* Neagu, 1970, pl. 24, fig. 18 (not figs 16, 17, 19, 20).
Bimonilina sp. Holbourn & Kaminski, 1997, pl. 17, fig. 11.

Description. Test free, elongated, with an initial biserial early stage consisting of 6 to 7 pairs of chambers, followed by a twisted loosely biserial part consisting of 2-3 pairs of chambers, then often a short laxuniserial to uniserial stage of few chambers. Chambers are initially low, becoming higher in the terminal stage. Sutures in the biserial to loosely biserial stage are oblique and depressed; in the lax-uniserial stage sutures finally become horizontal. Wall noncalcareous, well-silicified, glassy in appearance, comprised of small quartz particles. Connections between chambers are areal in the lax-uniserial part. Aperture in uniserial stage is terminal, round, on a short neck.

Remarks. This species is characterised by its twisted biserial – lax-uniserial part, and final globular chamber with horizontal suture. Kuhnt (1990) compared his specimens with *Pseudobolivina parvissima* Neagu, 1970, described from the Turonian of the Romanian Carpathians. In our opinion one of the specimens of this species illustrated by Neagu (1970, pl. 24, fig. 17) conforms to the description of our new species.

Table 1. Additional species previously assigned to *Pseudobolivina* or *Bigenerina* that are here transferred to *Eobigenerina* other recently described genera.

Original Name	**New Combination**
Bigenerina ciscoensis Cushman & Waters, 1928	*Eobigenerina ciscoensis* (Cushman & Waters, 1928)
Bigenerina perkinsi Ireland, 1960	*Eobigenerina perkinsi* (Ireland, 1960)
Bigenerina perexigua Plummer, 1945	*Eobigenerina perexigua* (Plummer, 1945)
Bigenerina virgilensis Ireland, 1956	*Eobigenerina virgilensis* (Ireland, 1956)
Pseudobolivina munda, Krasheninnikov, 1973	*Rashnovammina munda*, (Krasheninnikov, 1973)
Pseudobolivina cuneata, Krasheninnikov, 1974	*Bicazammina cuneata,* (Krasheninnikov, 1974)
Pseudobolivina lagenaria Krasheninnikov, 1974	*Bicazammina lagenaria,* (Krasheninnikov, 1974)
Pseudobolivina sp. 3 Kuhnt (1990)	*Parvigenerina* sp. 3 (Kuhnt, 1990)
Bimonilina elenae Mjatliuk, 1988, p. 63, pl. 24, figs. 16-23	*Bicazammina lagenaria,* (Krasheninnikov, 1974)
Pseudobolivina laxa Hedinger, 1993	*Parvigenerina laxa* (Hedinger, 1993)
Pseudobolivina oonadattensis Ludbrook, 1966	*Hagimashella oonadattensis* (Ludbrook, 1966)
Pseudobolivina elongata Kalantari, 1969	*Rashnovammina elongata* (Kalantari, 1969)

Eobigenerina kuhnti n.sp. differs from the holotype of *Eobigenerina parvissima* in having a twisted test.

Type Level & Locality. Dumbrăvioara Formation, Dâmboviţa Valley, Eastern Carpathians, Lower Turonian (Helvetotruncana helvetica Zone).

Distribution. Holbourn & Kaminski (1997, pl. 17, fig. 11) illustrated a specimen as *Bimonilina* sp. from the Tithonian of Hole 765C on the Argo Abyssal Plain. Neagu (1970) reported the species from the Turonian of the Romanian Carpathians. Kuhnt (1990) reported it from the lower Campanian of the Hacho de Montejaque section of the Penibetic Unit in southern Spain.

Stratigraphic range. Tithonian – Campanian.

Type specimens. The holotype (PF70258) and three paratypes (PF70259-61) were deposited in the Paleontology Department, Natural History Museum, London.

DISCUSSION

The new genus *Eobigenerina* has the same evolutionary relationship to the Cenozoic genus *Bigenerina* as *Eomarssonella* has to *Marsonella*. Many of the Late Cretaceous to Cenozoic calcareous-cemented genera with canaliculate walls appear to have older late Paleozoic to Mesozoic isomorphs that display solid, organically-cemented walls. As noted by F.T. Banner and co-workers in a series of studies (Banner & Pereira, 1981; Desai & Banner, 1987), a clear evolutionary trend from solid noncalcareous agglutinated walls to solid calcareous-cemented walls, and finally to canaliculate calcareous-cemented walls is observed within several lineages during the Cretaceous. The *Bigenerina* group appears to be no exception. The abyssal and "flysch-type" species reported by us from the Cretaceous of the Tethys and the North Atlantic clearly have solid, noncalcareous walls, and it would be no surprise to us if all the Cretaceous deep sea species formerly placed in *"Bigenerina"* by various authors displayed a similar feature. We therefore proposed the name *Eobigenerina* Cetean *et al.,* 2008 to accommodate these older noncalcareous isomorphs of *Bigeneria*.

A large number of Mesozoic biserial taxa display a tendency to become uniserial, and several genera have been recently described to accommodate taxa that display this growth pattern, but none of these genera are completely uniserial (Neagu & Neagu, 1995). Such forms are commonly found in Upper Cretaceous and Paleocene deep-water sediments (e.g., Kuhnt, 1990; Galeotti *et al.,* 2004) and have been commonly referred to the genus *Pseudobolivina*. These taxa are attributed here to the genera *Rashnovammina* and *Bicazammina* (Table 1), and we extend the known stratigraphic range of these genera into the Paleocene.

CONCLUSIONS

The Cenozoic genus *Bigenerina* characterised by calcareous-agglutinated canaliculate wall is not found in Paleozoic–Mesozoic sediments. Consequently, the isomorphic late Paleozoic–Mesozoic taxa with solid, organically cemented walls that were traditionally placed in the genus *Bigenerina* must be assigned to another genus. We proposed the genus *Eobigenerina* (type species *Bigenerina variabilis*) to accommodate these biserial to uniserial forms with an organically-cemented (silicified) noncanaliculate wall (Cetean *et al.*, 2008).

Table 2. Character matrix of the genera mentioned in this study.

Genus	Type species	Chamber arrangement	Aperture	Wall type	Family	Stratigraphical distribution
Bicazammina	*Pleurostomella jurassica* Haeusler, 1890	biserial to lax-uniserial	areal with an elliptical or circular outline, sometimes supported by a short neck	compact, noncanaliculate	Textulariopsidae	Upper Jurassic - Paleocene
Bigenerina	*Bigenerina nodosaria* d'Orbigny, 1826; SD Cushman, 1911	biserial to uniserial	areal, terminal, rounded	canaliculate	Textulariinae	Eocene to Holocene
Eobigenerina	*Bigenerina variabilis* Vašíček, 1947	biserial to loosely biserial to lax-uniserial to uniserial	terminal, round, on a short neck (but not always visible)	compact, noncanaliculate	Textulariopsidae	Upper Pennsylvanian to Eocene
Haghimashella	*Bigenerina arcuata* Haeusler, 1890	biserial to lax-uniserial but with 1-7 glandular-globulose chambers	terminal, circular or elliptical, supported by a short neck	compact, noncanaliculate	Textulariopsidae	Upper Jurassic – Lower Cretaceous
Parvigenerina	*Bifarina porrecta* (Brady) var. *arenacea* Heron-Allen & Earland, 1922	biserial to loosely biserial to lax uniserial	terminal, round, produced on a distinct neck	compact, noncanaliculate	Textulariopsidae	Upper Jurassic to Holocene
Pseudobolivina	*Pseudobolivina antarctica* Wiesner, 1931	biserial	high interiomarginal arch extending up the final chamber face	compact, noncanaliculate	Textulariopsidae	Lower Cretaceous (?Albian) to Holocene
Rashnovammina	*Rashnovammina carpathica* Neagu & Neagu, 1995	biserial with a tendency to become lax-uniserial in the last third part of the test	areal to terminal, elliptical or circular in outline, supported by a short neck	compact, noncanaliculate	Textulariopsidae	Middle Jurassic - Paleocene

Eobigenerina variabilis (Vašíček) is used as an index taxon in the Carpathian biostratigraphic zonations, but the species itself is poorly defined, owing to the broad taxonomical concept used by Vašíček (1947) and the lack of designated type specimens. We here restrict the definition of *Bigenerina variabilis* to forms that are terminally uniserial, and we designate a neotype specimen from the Cenomanian-Turonian boundary interval of the Eastern Carpathians.

Late Paleozoic to Mesozoic species that have been traditionally described as *Bigenerina, Bimonilina* (or *Pseudobolivina*) are transferred to *Eobigenerina, Parvigenerina* or to more recently-described genera such as *Rashnovammina*, *Bicazammina*, and *Haghimashella*. Species of *Rashnovammina* and *Bicazammina* are reported here for the first time from the Upper Cretaceous.

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Explanation to plate

Plate 1. All scale bars 100µm. Figs. 1-8, 13-16. Dumbrăvioara Formation, Dâmboviţa Valley, Eastern Carpathians, Cenomanian/Turonian boundary interval (1-8. Whiteinella archaeocretacea Zone; 13-16. or Helvetotruncana helvetica Zone); Fig. 11. Kirchrode boreholes, Lower Saxony Basin, Germany, Albian; Figs. 9, 17-22 Scaglia Rossa Formation, Contessa Highway, Gubbio, Italy, Coniacian - Campanian; Figs. 10a-c Kveite Formation, Barents Sea, Campanian; Fig. 12 Indian Harbour M-52 Well, Labrador Margin, Paleocene;

1-12. *Eobigenerina variabilis* (Vašiček, 1947); 1. Neotype (BMNH PF70262); 2-3. Paraneotypes. 2. PF70263; 4-6. Specimens with a uniserial stage; 7. Juvenile stage, 8-10. Juvenile with a lax uniserial stage, arrows point to aperture; 11. Small specimen from the Albian. 12. Juvenile from Labrador;

13. *Eobigenerina kuhnti* n.sp., holotype, BMNH PF70258;

14, 15. *Eobigenerina kuhnti* n.sp., paratypes 14. PF70259 15. PF70260;

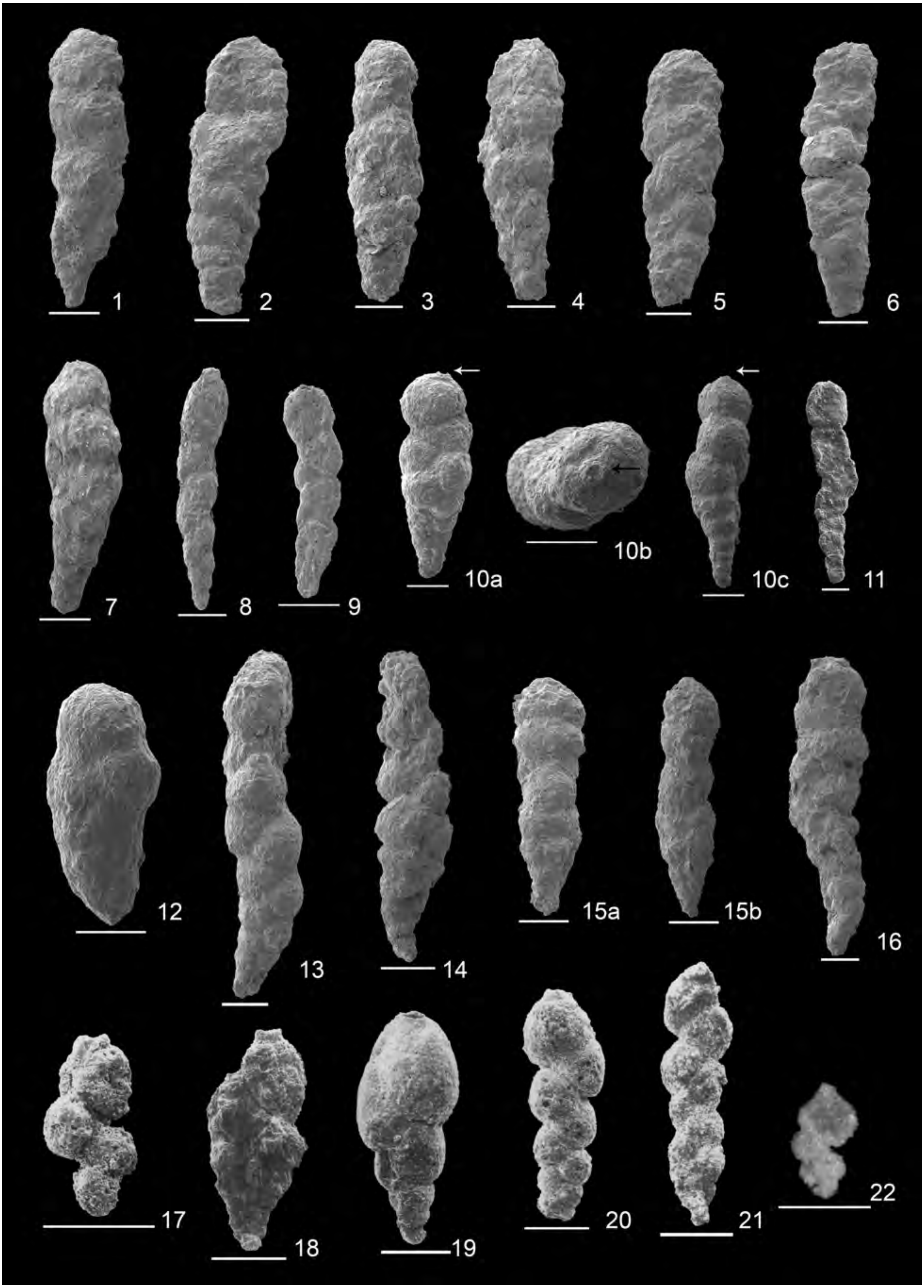
16. *Eobigenerina kuhnti* n.sp., paratype with lax-uniserial terminal part, PF70261;

17. *Bicazammina lagenaria* (Krasheninnikov 1974) n.comb., upper Coniacian;

18, 19. *Rashnovammina munda* (Krasheninnikov, 1973) n.comb., 18. upper Coniacian; 19. upper Campanian;

20, 21. *Parvigenerina* sp. 3 (Kuhnt, 1990), lower Campanian;

22. *Bicazammina cuneata* (Krasheninnikov 1974) n.comb., lower Campanian.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