

PALEOENVIRONMENTAL AND BIOSTRATIGRAPHIC DATA FOR THE EARLY MIOCENE OF THE NORTH-WESTERN TRANSYLVANIAN BASIN BASED ON PLANKTONIC FORAMINIFERA

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Abstract: Early Miocene planktonic foraminifera were investigated from the turbidites of the Hida Formation in the north-western Transylvanian Basin. At least three distinct acmes of planktonic foraminifera have been revealed. Although the particular assemblages can be hardly calibrated to the standard biozones, they are very distinct and can be attached to relative sea-level fluctuations, this way showing potential for regional correlations. The possible Indo-Pacific affiliation of the planktonic assemblages proves the wide connections of the Paratethyan area to the east during the Early Miocene. Calcareous nannoplankton assemblages identified in the Hida Formation are characteristic for the entire Early Miocene.

Keywords: Early Miocene, Transylvanian Basin, Paratethys, planktonic foraminifera

1. INTRODUCTION

The Lower Miocene sedimentary record of the Transylvanian Basin reaches up to 1000 m and has been preserved mainly in the flexural basin developed in front of the thrusting Pienides (Krezsek & Bally, 2006). Well data and regional interpretations (Krzsek & Bally, 2006, Dicea et al., 1980; Tischler et al., 2008) indicate the large-scale shallowing upward trend. Several lithostratigraphic units were described for coexisting particular sedimentary paleoenvironments (Fig. 2): marine fine siliciclastic deposits of the upper Rupelian - lower Burdigalian Vima Formation (Lăzărescu, 1957; emend. Rusu, 1969), brackish facies with coals and quartzitic - kaolinitic sandstones of the upper Rupelian - Aquitanian Valea Almaşului Formation (Răileanu & Saulea, 1956), inner shelf sandstone of the upper Rupelian - lower Burdigalian Buzaş Formation (Dumitrescu, 1957), marine marls and sandstones of the Aquitanian Rohia Formation (Popescu, 1971) and Valea Lăpuşului Formation (Bombiţă, 1966), marine sandstones of the upper Aquitanian Coruş Formation (Hauer & Stache, 1863) and Gostila Formation, outer shelf marls of the upper Aquitanian - lower

Burdigalian Chechiş Formation (Hofmann, 1879), and coarse-grained fan deltas and deep-marine deposits of the Burdigalian Hida Formation (Hofmann, 1879, Koch, 1900).

In our view, the lithostratigraphic classification should be reviewed and simplified. For this reason we decided to attach to Hida Formation all the turbiditic sequences deposited during the Early Miocene in the northern and north-western part of the Transylvanian Basin (some parts of the Vima, Gostila, Rohia, and Valea Lăpuşului formations).

Foraminifera assemblages identified in the Hida Formation are abundant and diverse, represented both by planktonic and benthic (calcareous and agglutinated) forms (Şuraru, 1952; Moisescu & Popescu, 1967; Popescu, 1970; 1971; 1972; 1975; 1999; Cioflica & Popescu, 1971; Iva et al., 1971; Filipescu & Beldean, 2008; Beldean et al. 2010; Beldean et al., 2011; Beldean & Filipescu, 2011). The formation still preserves the characters of the Eggenburgian micropaleontological assemblages in its lower part, while toward its upper part the benthic microfossils gradually disappear (Filipescu, 2001). Since Popescu (1975) published his monograph on

the Miocene fossil foraminifera from the north-western Transylvanian Basin, no studies on trochospiral planktonic foraminifera have been published on this area. Recently, biserial planktonic foraminifera have been documented for the first time (Beldean et al., 2010). New biostratigraphic and paleoenvironmental data have become available based on particular planktonic assemblages.

2. MATERIAL AND METHODS

Planktonic foraminifera were recovered from several sections displaying Lower Miocene deep-sea sediments (mainly siliciclastic turbidites). The representative sections are located at Dragu (N47.04954; E23.37083), Fântânele (N47.06852; E23.40868), Chiuiesti (N47.31983; E23.06481), Fabrică (N47.205251; E23.38715), Şimişna (N47.13301; E23.36030), Cristolţ (N47.19695; E23.43706), Strâmbu (N47.19175; E23.56594), Ciceu-Giurgeşti (N47.24549; E24.03438), Zagra (N47.26599; E24.28779) and Pâglişa (N47.00231; E23.39009) (Fig. 1).

Samples were processed by standard micropaleontological methods and planktonic foraminifera were recovered from the >63 µm fraction. After observation under stereomicroscope, the characteristic specimens were examined by SEM (JSM-JEOL 5510 LV scanning electron microscope). Calcareous nannofossils were processed by the standard smear slide technique and examined under the polarizing microscope (Axiolab Zeiss) at 1000x magnification.

3. RESULTS AND DISCUSSIONS

Three types of planktonic foraminifera assemblages have been identified: small trochospiral globigerinids (*Globigerina* spp., *Tenuitella* spp. and *Tenuitellinata* spp.), large trochospiral globigerinids (*Globigerina* spp.) and biserial *Streptochilus*. The morphometric character of the individuals has been considered because the size of the planktonic foraminifera tests reveal specific environmental conditions.

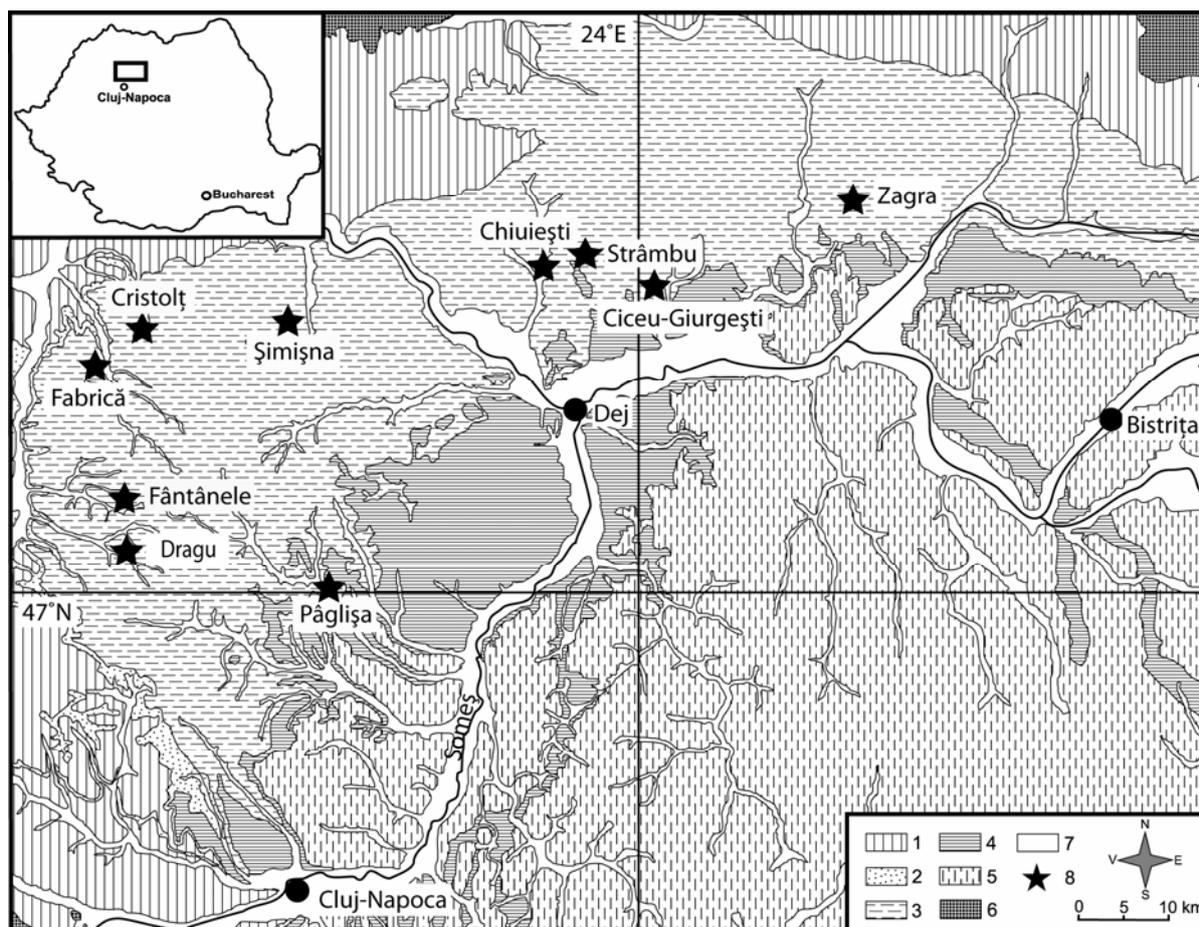


Figure 1. Location of investigated sections on the simplified geological map. 1 – Paleogene, 2 – Lower Miocene shallow marine formations, 3 – Hida Formation, 4 – Badenian, 5 – Sarmatian, 6 – metamorphics, 7 – Quaternary, 8 – investigated sections (modified after Beldean et al. 2010).

3.1. Assemblages with small globigerinids (*Globigerina* spp., *Tenuitella* spp. and *Tenuitellinata* spp.)

At Dragu, Cristolț, Fântânele and Strâmbu, together with species of *Gobigerina*, high proportions *Tenuitella* and *Tenuitellinata* are present. The specimens are small-sized (about 100 μm) and the dominant species are: *Tenuitellinata angustiumblicata*, *Tenuitellinata juvenilis*, *Tenuitellinata pseudoedita*, *Tenuitella clemenciae*, *Tenuitella munda*, *Globigerina dubia*, *Globigerina ottnangiensis*, *Globigerina tarchanensis*, *Globigerina woodi*, *Globigerinella obesa*, *Paragloborotalia* sp.

The evolution of this microporiferate tenuitellid foraminifera with Indo-Pacific affinity have been used as cold-water indexes in paleoceanographic studies (Li et al., 1992). High abundance of microporiferated trochospiral foraminifera of the genera *Tenuitellinata* and *Tenuitella* were associated with transgressive events (Filipescu & Silye, 2008). These forms have been described from various Miocene deposits from Trinidad to New Zealand (Li, 1987) but usually have been included in other genera (Cicha et al., 1998; Rögl, 1985; Bicchi et al., 2003; Oleszewska, 1999; Szczechura, 1982, 2000).

Similar assemblages along the south coast of Australia were interpreted by Li & McGowran (1998) as associated to a mixture of warm and cold waters. Al-Sabouni et al. (2007) associate similar assemblages to regions with surface-water instability. Organic input and temperatures are the main factors that influence these assemblages (Schmidt et al., 2004a). The very low abundance of the warm-water indicators belonging to *Globigerinoides* group (Bicchi et al., 2003; Amore et al., 2004) argues for the existence of cool climate at this interval.

Schmidt et al. (2004a) showed that planktonic foraminifera assemblages from upwelling (high productivity) regions are dominated by fewer species and the shell size ranges are comparatively smaller than those from the same latitudes in the open ocean. This is reflected in the negative correlation between test size and primary productivity, which indicates that foraminifera assemblages from higher productivity regions tend to be composed of species with small shell sizes. Upwelling areas may inhibit growth directly by the high environmental variability and light attenuation caused by high plankton standing stocks.

Planktonic foraminifera assemblages with small globigerinids were identified in several areas of Central Parathethys. In the Early Miocene of Austria such assemblages have been reported by

Rögl & Nagymarosy (2004) from the late Aquitanian – early Burdigalian (biozone N5 after Blow, 1969) and by Roetzel et al., 2006 in the Ottnangian from Austria. Dominant species here are *Tenuitellinata selleyi*, *Tenuitellinata* sp., *Tenuitella clemenciae*, *T. minutissima*, *Turborotalita quinqueloba*, *Globigerina lentiana*, *G. ottnangiensis*, *G. praebulloides*. The mass occurrence of small sized foraminifera may reflect upwelling or enhanced nutrient input from the continent (Roetzel et al., 2006).

Beside the absence of index taxa of the standard biozones, the assemblage with small globigerinids offers indirect means of correlation at a regional scale by considering their position in the transgressive intervals of the relative sea-level fluctuations. Calcareous nannoplankton Zones NN1 and NN2 were identified at Dragu.

Correlation of our micropaleontological and sedimentological data suggests that these assemblages could be connected to the early and late stages of transgressive intervals with high productivity, possibly related to the organic input from the continent. Similar assemblages described from the Indian and Pacific oceans (Li, 1987; Li et al., 1992) suggest a possible marine connection to the Indo-Pacific area.

3.2. Assemblages with large globigerinids (*Globigerina* spp.)

This assemblage is characterized by larger sized trochospiral globigerinids: *Globigerina bulloides*, *Globigerina ciperoensis*, *Globigerina concinna*, *Globigerina dubia*, *Globigerina gnaucki*, *Globigerina lentiana*, *Globigerina ottnangiensis*, *Globigerina praebulloides*, *Globigerina steiningeri*, *Globigerina* cf. *wagneri*, *Globigerinodes sicanus*. This type of assemblage was identified at Chiuiești, Fabrică, and Șimișna.

Larger sizes planktonic foraminifera are characteristic for the ecologically optimum niche and oligotrophic environments (Schmidt et al., 2003, 2004b). *Globigerina bulloides* develop large test in the somewhat warmer temperatures (10–18 $^{\circ}\text{C}$), more saline and lower nutrient levels found in weak and shallow thermoclines (Viliers, 2004). When the environmental parameters exceed the species' limit tolerance, the growth rate decreases (Viliers, 2004). However, the general trend is the shell size increase with rising surface waters temperature (Rutherford et al., 1999; Schmidt et al., 2004b). Similar assemblages have been identified in the Early Miocene of Austria (Molasse Basin) where foraminifera indicate warm-temperate waters (Rögl & Spezzaferri, 2003).

Epoch (Ma)	Regional Age (Central Paratethys)	Biozones			Litostratigraphic Units (Bombiță, 1966; Rusu, 1969; Popescu, 1971; Filipescu, 2001; Krzsek & Bally, 2006)
		Planktonic foraminifera		Nanno- plankton (Martini, 1971)	
		Berggren et al., 1995	Popescu, 1975; Beldean et al., 2010		
15.97	BADENIAN	M6	<i>Orbulina suturalis</i>	NN5	Dej Formation
		M5	<i>Praeorbulina glomerosa</i>		
	KARPATIAN	M4	<i>Streptochilus-Bolivina</i>	NN4	Hida Formation
	OTTNANGIAN	M3	<i>Globigerinoides trilobus</i>	NN3	Cechiș Fm. / Gostila Fm.
	EGGENBURGIAN	M2		NN2	Coruș Fm. / Valea Almașului Fm. / Buzaș Fm. / Vima Fm. / Rohia Fm. / Valea Lăpușului Fm.
23.03	EGERIAN	M1	<i>Globigerinoides primordius</i>	NN1	
				a	
		P22	<i>Globigerina ciproensis</i>	NP25	

Figure 2. The correlation between the Lower and Middle Miocene Biozones based on the foraminifera and calcareous nannoplankton with the lithostratigraphic units in the Transylvanian Basin.

We consider this kind of assemblage as belonging to a more stable and oligotrophic environment, probably related to the maximum flooding. No typical foraminifera index species for the standard zonations were identified in the studied sections. Calcareous nannoplankton from Șimișna indicates the NN3 Zone (Martini, 1971).

3.3. Assemblages with *Streptochilus pristinum*

The samples collected from Ciceu-Giurgești and Zagra contain almost exclusively small biserial planktonic foraminifera belonging to *Streptochilus pristinum*, a species described from the Indo-Pacific region by Brönnimann & Resig (1971).

In the Transylvanian Basin, the Early Miocene *Streptochilus* may have bloomed opportunistically in response to highly fluctuating nutrient conditions caused by rapid transgression or could have been a part of the planktonic invasions from the Indian Ocean stimulated by the pattern of the surface circulation (Beldean et al., 2010).

Miocene *Streptochilus* spp. have been described as tropical to warm-subtropical forms (Brönnimann & Resig, 1971; Kennett & Srinivasan, 1983; Resig, 1989), but they have been reported from the northernmost Atlantic Ocean (Flower, 1999) through the Bahama Bank (Kroon et al., 2000), the equatorial western Pacific (Premoli-Silva & Violanti, 1981; Resig, 1989) and the eastern Indian Ocean (Resig, 1989). High abundances of biserial planktonic foraminifera are indicative of eutrophic waters in the Paleogene (Hallock et al., 1991), while high abundances of Miocene - Pliocene *Streptochilus* species were correlated with high accumulation rates of plankton (Resig, 1989).

In the Transylvanian Basin, the hypothesis of

eutrophic waters seems to fit better, because an important planktonic bloom was recorded only subsequently, related to the advancing Middle Miocene transgression. The early stage of the sea-level rise, associated to the high organic input (LST) should be biostratigraphically assigned to the regional *Streptochilus - Bolivina* Abundance Zone (Beldean et al., 2010).

Calcareous nannoplankton from Ciceu-Giurgești and Zagra (Beldean et al., 2010) suggest the late Burdigalian NN4 Zone.

Based on biostratigraphic data, we consider that the lower part of the Hida Formation (or Valea Lăpușului and Rohia formations) is equivalent to the Coruș (Hauer & Stache, 1863), Cechiș (Hofmann, 1879), Vima (Rusu, 1969), Buzaș (Dumitrescu, 1957), Valea Almașului (Răileanu & Saulea, 1955) formations (Fig. 2). The superposition of the characteristic lithofacies of these formations produced due the initial transgression (basin formation) and subsequent regression (uplift of the Pienides).

4. TAXONOMIC NOTES

The taxonomic identification and classification of species is based largely on the Kennett & Srinivasan (1983), Cicha et al. (1998), Popescu (1975), and Spezzaferri (1994).

Order GLOBIGERINIDA Lankester, 1885

Superfamily HETEROHELICACEA Cushman, 1927

Family CHILOGUEMBELINIDAE Reiss, 1963

Genus *Streptochilus* Brönnimann & Resig, 1971

Streptochilus pristinum Brönnimann & Resig, 1971
pl. 1, fig. 1, 1a, 2

Streptochilus pristinum Brönnimann & Resig, 1971,

p. 1289, pl. 51, fig. 4
Streptochilus pristinum Brönnimann & Resig, 1971
– Spezzaferri, 1994, p. 65, pl. 29, fig. 6, 7a-b.
Occurrence: Zagra, Ciceu-Giurgești, Pâglișa.

Superfamily GLOBOTRUNCANACEA Brotzen, 1942

Family GLOBOROTALIIDAE Cushman, 1927

Genus *Globorotalia* Cushman, 1927

Globorotalia peripheroronda Blow & Banner, 1966
pl. 1, fig. 11

Globorotalia (Turborotalia) peripheroronda Blow & Banner, 1966, p. 294, pl. 1, fig. 1 (fide Ellis & Messina, 1942-2010).

Globorotalia (Fohsella) peripheroronda Blow & Banner – Kennett & Srinivasan, 1983, p. 96, pl. 22, fig. 1-3.

Globorotalia fohsi peripheroronda (Blow & Banner, 1966) - Bolli & Saunders, 1985, p. 203, 205, fig. 27.

Globorotalia peripheroronda Blow & Banner, 1966 – Spezzaferri, 1994, p. 58, pl. 25, fig. 6.

Occurrence: Chiuiеști, Șimișna.

Globorotalia praescitula Blow, 1959

pl. 1, fig. 7, 8

Globorotalia scitula (Brady) subsp. *praescitula* Blow, 1959, p. 221, pl. 19, fig. 128a-c (fide Ellis & Messina, 1942-2010).

Globorotalia (Globoconella) praescitula Blow, 1959 – Kennett & Srinivasan, 1983, p. 108, pl. 24, fig. 1, pl. 25, fig. 4-6.

Globorotalia praescitula Blow, 1959 – Spezzaferri, 1994, p. 59, pl. 26, fig. 7a-c.

Occurrence: Dragu.

Globorotalia sp.

pl. 1, fig. 5

Occurrence: Dragu

Genus *Globoturborotalia* Hofker, 1976

Globoturborotalia decoraperta (Takayanagi &

Saito, 1962)

pl. 1, fig. 13

Globigerina druryi Akers subsp. *decoraperta* Takayanagi & Saito, 1962, p. 85, pl. 28, fig. 10a-c (fide Ellis & Messina, 1942-2010).

Globigerina (Zeaglobigerina) decoraperta (Takayanagi & Saito, 1962) – Kennett & Srinivasan, 1983, p. 48, pl. 9, fig. 7-9.

Occurrence: Dragu

Genus *Paragloborotalia* Cifelli, 1982

Paragloborotalia continuosa (Blow, 1959)

pl. 1, fig. 6

Globorotalia opima subsp. *continuosa* Blow, 1959, p.

218, pl. 19, fig. 125a-c (fide Ellis & Messina, 1942-2010).

Globorotalia (Turborotalia) continuosa (Blow, 1959) – Popescu, 1975, p. 83, pl. 66, fig. 3, pl. 71, fig. 6.

Neogloboquadrina continuosa (Blow, 1959) – Kennett & Srinivasan, 1983, p. 192, pl. 47, fig. 3-5.

Paragloborotalia continuosa (Blow, 1959) – Spezzaferri, 1994, p. 54, pl. 20, fig. 7a-c.

Occurrence: Dragu, Fântânele, Cristolț, Fabrică

Paragloborotalia semivera (Hornibrook, 1961)

pl. 1, fig. 9

Globigerina semivera Hornibrook, 1961, p. 149, pl. 23, fig. 455-457 (fide Ellis & Messina, 1942-2010).

Globorotalia (Jenkinsella) semivera (Hornibrook, 1961) – Kennett & Srinivasan, 1983, p. 172, pl. 42, fig. 3-5.

Paragloborotalia semivera (Hornibrook, 1961) – Spezzaferri, 1994, p. 55, pl. 20, fig. 6a-c.

Occurrence: Dragu, Fântânele, Cristolț, Șimișna, Fabrică.

Family CATAPSYDRACIDAE Bolli, Loeblich & Tappan, 1957

Genus *Catapsydrax* Bolli, Loeblich & Tappan, 1957

Catapsydrax martini (Blow & Banner, 1962)

pl. 2, fig. 13

Globigerinita martini Blow & Banner, 1962, p. 110, pl. 14, fig. O (fide Ellis & Messina, 1942-2010).

Catapsydrax martini (Blow & Banner, 1962) – Spezzaferri, 1994, p. 49, pl. 33, fig. 7a-c.

Occurrence: Fântânele, Cristolț, Dragu.

Genus *Globoquadrina* Finaly, 1947

Globoquadrina altispira (Cushman & Jarvis, 1936)

pl. 2, fig. 12

Globigerina altispira Cushman & Jarvis, 1936, p. 5, pl. 1, fig. 13a-c, 14 (fide Ellis & Messina, 1942-2010).

Globoquadrina altispira altispira (Cushman & Jarvis, 1936) – Kennett & Srinivasan, 1983, p. 188, pl. 46, fig. 4-6.

Dentoglobigerina altispira altispira (Cushman & Jarvis, 1936) – Spezzaferri, 1994, p. 41, pl. 40, fig. 4a-c.

Globoquadrina altispira (Cushman & Jarvis, 1936) – Cicha et al., 1998, p. 103, pl. 41, fig. 1-2.

Occurrence: Dragu.

Globoquadrina langhiana Cita & Gelati 1960

pl. 4, fig. 3

Globoquadrina langhiana Cita & Gelati 1960, p. 242, pl. 29, fig. 1-20 (fide Ellis & Messina, 1942-2010).

Globoquadrina langhiana Cita & Gelati 1960 – Cicha et al., 1998, p. 232, pl. 40, fig. 27-32.

Occurrence: Chiuiеști, Fabrică, Fântănele, Dragu.

Superfamily GLOBOROTALIACEA Cushman, 1927

Family GLOBIGERINITIDAE Bermúdez, 1961

Subfamily Tenuitellinae Banner, 1982

Genus Tenuitella Fleisher, 1974

Tenuitella munda (Jenkins, 1966)

pl. 2, fig. 2

Turborotalia munda Jenkins, 1966, p. 1121, pl. 14, fig. 126-133, pl. 13, fig. 152-156 (fide Ellis & Messina, 1942-2010).

Globorotalia (Tenuitella) munda – Kennett & Srinivasan, 1983, p. 162, pl. 39, fig. 5-7.

Tenuitella munda Jenkins, 1966 – Li, 1987, p. 310, pl. 2, fig. 13;

Occurrence: Dragu, Strâmbu, Cristolț, Fântănele.

Tenuitella selleyi Li et al., 1992

pl. 2, fig. 14a, 14b

Tenuitella selleyi Li et al., 1992, p. 581, pl. 4, fig. 1-4.

Occurrence: Fântănele, Dragu.

Tenuitella sp.

pl. 2, fig. 6

Occurrence: Fântănele, Dragu, Strâmbu.

Genus Tenuitellinata Li, 1987

Tenuitellinata angustiumbilitata (Bolli, 1957)

pl. 2, fig. 10

Globigerina ciperoensis angustiumbilitata Bolli 1957, p. 109, pl. 22, fig. 12-13.

Globigerina (Globigerina) angustiumbilitata (Bolli, 1957) – Kennett & Srinivasan, 1983, p. 31, pl. 4, fig. 3-5.

Tenuitellinata angustiumbilitata (Bolli, 1957) – Li, 1987, p. 311, pl. 2, fig. 15, 17-19.

Occurrence: Dragu, Cristolț, Fântănele, Strâmbu.

Tenuitellinata juvenilis (Bolli, 1957)

pl. 2, fig. 3a, 3b, 7, 11

Globigerina juvenilis Bolli, 1957, p. 110, pl. 24, fig. 5-6.

Tenuitellinata juvenilis (Bolli, 1957) – Li et al., 1992, p. 579, pl. 2, fig. 3-6;

Occurrence: Cristolț, Dragu, Fântănele.

Tenuitellinata pseudoedita (Subbotina 1960)

pl. 2, fig. 4, 5, 8, 9

Globigerina pseudoedita Subbotina, 1960, p. 55, pl. 11, fig. 1-3 (fide Ellis & Messina, 1942-2010).

Tenuitellinata pseudoedita (Subbotina, 1960) – Li, 1987, p. 312, pl. 3, fig. 1-5, pl. 4, fig. 11-13, pl. 5, fig. 1, 4, 7, 11;

Occurrence: Cristolț, Dragu, Fântănele.

Tenuitellinata uvula (Ehrenberg, 1861)

pl. 2, fig. 1

Pyloedexia uvula Ehrenberg, 1861, p. 276, 277, 308 (fide Ellis & Messina, 1942-2010).

Globigerinita uvula (Ehrenberg, 1861) – Rögl, 1985, p. 323, fig. 5/25a-b, 5/26.

Tenuitellinata uvula (Ehrenberg, 1861) – Li et al., 1992, p. 579, pl. 3, figs. 10-11.

Occurrence: Șimișna.

Superfamily GLOBIGERINACEA Parker & Jones, 1862

Family GLOBIGERINIDAE Carpenter, Parker & Jones, 1862

Genus Globigerina d'Orbigny, 1826

Globigerina bollii Cita & Silva, 1960

pl. 4, fig. 7

Globigerina bollii Cita & Silva, 1960, p. 120, pl. 13, fig. 1-18 (fide Ellis & Messina, 1942-2010).

Globigerina bollii Cita & Silva, 1960 – Popescu, 1975, p. 85, pl. 73, fig. 1-3;

Occurrence: Chiuiеști, Cristolț, Dragu, Fântănele.

Globigerina ciperoensis Bolli, 1954

pl. 4, fig. 9, 12

Globigerina ciperoensis Bolli, 1954, p. 109, pl. 22, fig. 10a-b (fide Ellis & Messina, 1942-2010).

Globigerina ciperoensis ciperoensis Bolli, 1954 – Bolli & Saunders, 1985, p. 183, fig. 13 (1a-b, 2, 3).

„*Globigerina*” *ciperoensis* Bolli, 1954 – Spezzaferri, 1994, p. 28, p. 3, fig. 2a-c.

Occurrence: Chiuiеști, Fabrică, Dragu, Cristolț, Fântănele.

Globigerina concinna Reuss, 1850

pl. 3, fig. 13, 14

Globigerina concinna Reuss, 1850, p. 373, pl. 47, fig. 8a-b (fide Ellis & Messina, 1942-2010).

Globigerina concinna Reuss, 1850 – Rögl, 1994, p. 139, pl. 1, fig. 23-26, pl. 2, fig. 1-6.

Occurrence: Dragu, Fântănele, Fabrică, Cristolț.

Globigerina dubia Egger, 1857

pl. 4, fig. 1, 2

Globigerina dubia Egger, 1857, p. 281, pl. 9, fig. 7-9 (fide Ellis & Messina, 1942-2010).

Globigerina dubia Egger, 1857 – Cicha et al., 1998, p. 216, pl. 32, fig. 5-8.

Occurrence: Cristolț, Dragu, Fabrică, Fântănele, Strâmbu.

Globigerina falconensis Blow, 1959

pl. 3, fig. 2, 3

Globigerina falconensis Blow, 1959, p. 177, pl. 9,

fig. 40-41 (fide Ellis & Messina, 1942-2010).

Globigerina falconensis Blow, 1959 – Cicha et al., 1998, p. 222, pl. 35, fig. 4-8.

Occurrence: Chiuiești, Șimișna.

Globigerina foliata Bolli, 1957

pl. 4, fig. 4

Globigerina foliata Bolli, 1957, p. 111, pl. 4, fig. 1a-c.

Globigerina foliata Bolli, 1957 – Rögl, 1969a, p. 30, pl. 6, fig. 3a-c.

Occurrence: Dragu, Strâmbu.

Globigerina gnaucki Blow & Banner, 1962

pl. 4, fig. 7, 8

Globigerina ouchitaensis gnaucki Blow & Banner, 1962, p. 91, pl. 9, fig. L-N.

Globigerina gnaucki Blow & Banner, 1962 – Rögl & Nagymarosy, 2004, p. 140, pl. 3, fig. 10.

Occurrence: Dragu, Fabrică, Fântânele.

Globigerina lentiana Rögl, 1969

pl. 1, fig. 3

Globigerina bollii lentiana Rögl, 1969b, p. 220, pl. 2, fig. 1-2; pl. 3, fig. 1-2.

Globigerina lentiana Rögl, 1969 – Cicha et al., 1998, p. 100, pl. 34, fig. 21-23.

Occurrence: Chiuiești, Dragu.

Globigerina officinalis Subbotina, 1953

pl. 4, fig. 4, 5

Globigerina officinalis Subbotina, 1953, p. 78, pl. 11, fig. 1-7 (fide Ellis & Messina, 1942-2010).

Globigerina officinalis Subbotina, 1953 – Cicha et al., 1998, p. 214, pl. 31, fig. 14-17

Occurrence: Chiuiești, Cristolț, Dragu, Fântânele, Strâmbu, Șimișna.

Globigerina ottangiensis Rögl, 1969

pl. 4, fig. 6, 11

Globigerina ottangiensis Rögl, 1969b, p. 221, pl. 2, fig. 7-10, pl. 4, fig. 1-7

Globigerina ottangiensis Rögl, 1969b – Spezzaferri, 1994, p. 9, pl. 7, fig. 7-10, pl. 8, fig. 2a-d.

Occurrence: Chiuiești, Cristolț, Dragu, Fabrică, Fântânele, Strâmbu, Șimișna.

Globigerina ouachitaensis Howe & Wallace, 1932

pl. 4, fig. 8

Globigerina ouachitaensis Howe & Wallace, 1932, p. 74, pl. 10, fig. 7a-b (fide Ellis & Messina, 1942-2010).

Globigerina ouachitaensis ouachitaensis Howe & Wallace, 1932 - Bolli & Saunders, 1985, p. 182, fig. 13 (15a-b).

Globigerina ouachitaensis Howe & Wallace, 1932 – Spezzaferri, 1994, p. 27, pl. 2, fig. 1a-c.

Occurrence: Cristolț, Dragu.

Globigerina praebulloides Blow, 1959

pl. 3, fig. 5, 6

Globigerina praebulloides Blow, 1959, p. 180, pl. 8, fig. 47, pl. 9, fig. 48 (fide Ellis & Messina, 1942-2010).

Globigerina praebulloides Blow, 1959 – Cicha et al., 1998, p. 220, pl. 34, fig. 13-16.

Occurrence: Chiuiești, Cristolț, Dragu, Fabrică, Fântânele, Strâmbu, Șimișna.

Globigerina scalena Rögl, 1969

pl. 3, fig. 11, 12

Globigerina scalena Rögl, 1969b, p. 223, pl. 1, fig. 16a-c, pl. 3, fig. 6.

Occurrence: Cristolț, Dragu, Fântânele, Strâmbu.

Globigerina steiningeri Rögl, 2004

pl. 4, fig. 10

Globigerina steiningeri Rögl, 2004, p. 141, pl. 2, fig. 31-33, pl. 3, fig. 13-20, text-fig. 3, în Rögl & Nagymarosy, 2004.

Globigerina globularis Roemer, 1838 – Rögl, 1985, p. 321, fig. 4.9-4.10.

Occurrence: Dragu, Fântânele, Strâmbu.

Globigerina tarchanensis Subbotina & Chutzieva,

1950

pl. 3, fig. 9, 10

Globigerina tarchanensis Subbotina & Chutzieva, 1950, p. 173, pl. 10, fig. 5a-c (fide Ellis & Messina, 1942-2010).

Globigerina tarchanensis Subbotina & Chutzieva, 1950 – Cicha et al., 1998, p. 216, pl. 32, fig. 18-22.

Occurrence: Fântânele.

Globigerina woodi Jenkins, 1960

pl. 3, fig. 1

Globigerina woodi Jenkins, 1960, p. 352, pl. 2, fig. 15-26 (fide Ellis & Messina, 1942-2010).

Globigerina (Zeaglobigerina) woodi (Jenkins, 1960) – Kennett & Srinivasan, 1983, p. 43, pl. 7, fig. 4-6.

Zeaglobigerina woodi (Jenkins, 1960) – Spezzaferri, 1994, p. 31, pl. 4, fig. 3a-c, pl. 5, fig. 3a-c.

Globoturborotalia woodi (Jenkins, 1960) – Cicha et al., 1998, p. 104, pl. 35, fig. 14-16.

Occurrence: Cristolț, Dragu, Fântânele, Strâmbu.

Genus *Globigerinoides* Cushman, 1927

Globigerinoides primordius Blow & Banner,

1962 pl. 1, fig. 4, 14

Globigerinoides primordius Blow & Banner, 1962,

p. 15, pl. 9, fig. Dd-Ff.

Globigerinoides primordius Blow & Banner, 1962 – Spezzaferri, 1994, p. 35, pl. 11, fig. 1a-d, pl. 12, fig. 2a-b.

Occurrence: Dragu, Fabrică.

Globigerinoides trilobus (Reuss, 1850)

pl. 1, fig. 12

Globigerina triloba Reuss, 1850, p. 374, pl. 47, fig. 11 (fide Ellis & Messina, 1942-2010).

Globigerinoides triloba (Reuss, 1850) – Kennett & Srinivasan, p. 62, pl. 10, fig. 4, pl. 13, fig. 1-3.

Globigerinoides trilobus (Reuss, 1850) – Popescu, 1975, p. 90, pl. 69, fig. 1, 70, fig. 3.

Occurrence: Fabrică, Fântânele.

Genus *Globigerinella* Cushman, 1927

Globigerinella obesa (Bolli, 1957)

pl. 1, fig. 10

Globorotalia obesa Bolli, 1957, p. 119, pl. 29, fig. 2-3 (fide Ellis & Messina, 1942-2010).

Globorotalia obesa Bolli, 1957 – Bolli & Saunders, p. 206, fig. 26.

Globigerinella obesa (Bolli, 1957) – Kennett & Srinivasan, p. 234, pl. 59, fig. 2-5.

Occurrence: Dragu, Strâmbu.

5. CONCLUSIONS

A total of thirty-four taxa belonging to eleven genera and five families of planktonic foraminifera have been identified from the Lower Miocene Hida Formation. Three particular assemblages of planktonic foraminifera have been identified. These assemblages correspond to distinct transgressive intervals on the relative sea-level curve and indicate different nutrient levels (small globigerinids and *Streptochilus* assemblages indicate eutrophic environment while large globigerinids assemblage indicate oligotrophic environment).

High abundance of *Streptochilus* and Tenuitellinids suggest open-sea connections to the east of the Paratethys during the Early Miocene.

The identified planktonic foraminifera assemblages have a good potential for regional biozonations. The calcareous nannoplankton indicates a broad age interval, respectively the entire Early Miocene (NN1-NN4).

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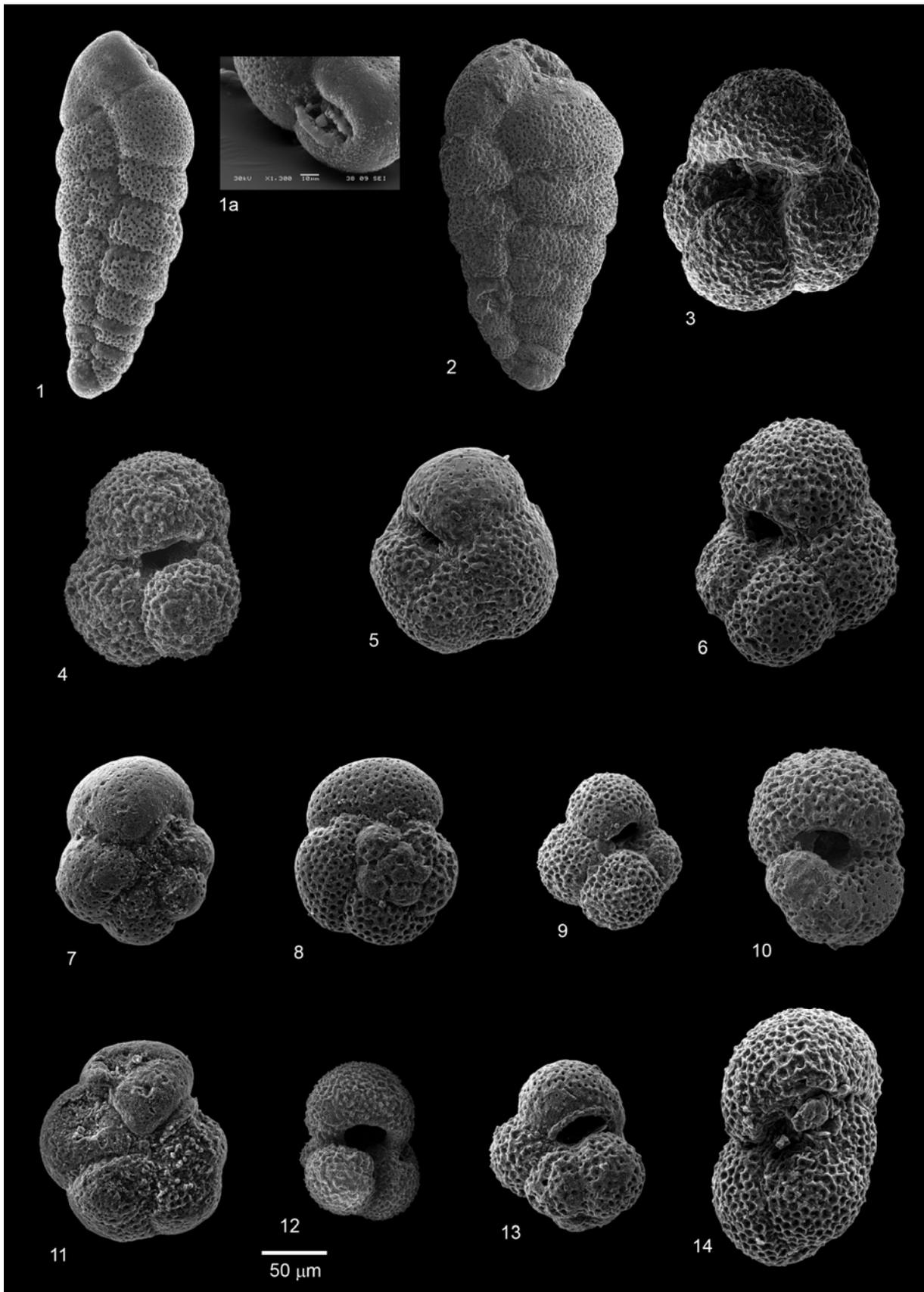


Plate 1. 1, 2 - *Streptochilus pristinum* Brönnimann & Resig; 3 - *Globigerina lentiana* Rögl; 4, 14 - *Globigerinoides primordius* Banner & Blow; 5 - *Globorotalia* sp.; 6 - *Paragloborotalia continuosa* Blow; 7, 8 - *Globorotalia praescitula* Blow; 9 - *Paragloborotalia semivera* (Hornibrook); 10 - *Globigerinella obesa* (Bolli); 11 - *Globorotalia peripheroronda* Blow & Banner; 12 - *Globigerinoides trilobus* (Reuss); 13 - *Globoturborotalia decoraperta* Takayanagi & Saito.

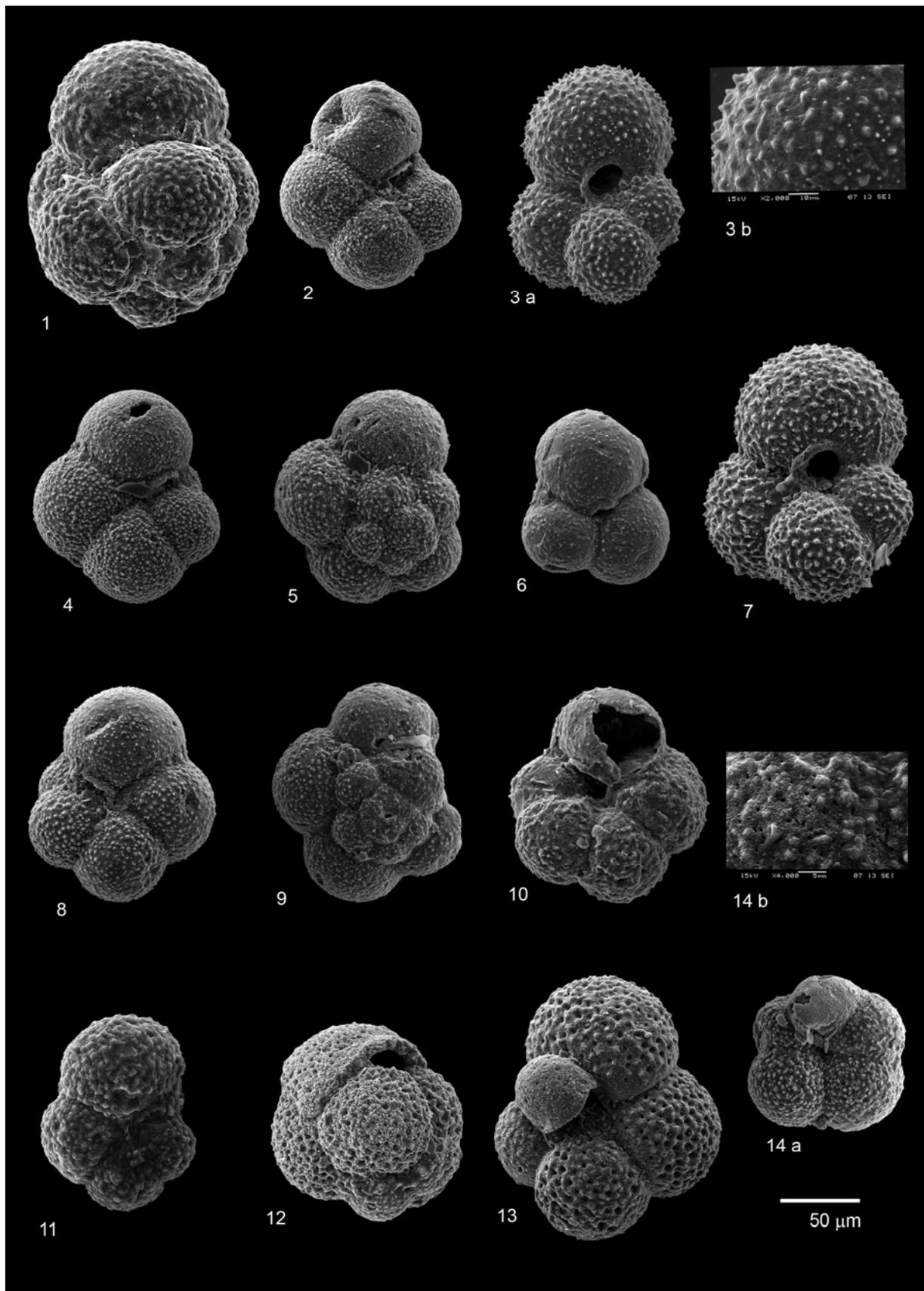


Plate 2. 1 - *Tenuitellinata uvula* (Ehrenberg); 2 - *Tenuitellinata munda* (Jenkins); 3, 7, 11 - *Tenuitellinata juvenilis* (Bolli); 4, 5, 8, 9 - *Tenuitellinata pseudoedita* (Subbotina); 6 - *Tenuitella* sp.; 10 - *Tenuitellinata angustiumbilitata* (Bolli); 12 - *Globoquadrina* cf. *altispira* (Cushman & Jarvis); 13 - *Catapsydrax martini* (Blow & Banner); 14 - *Tenuitellia selleyi* Li et al.

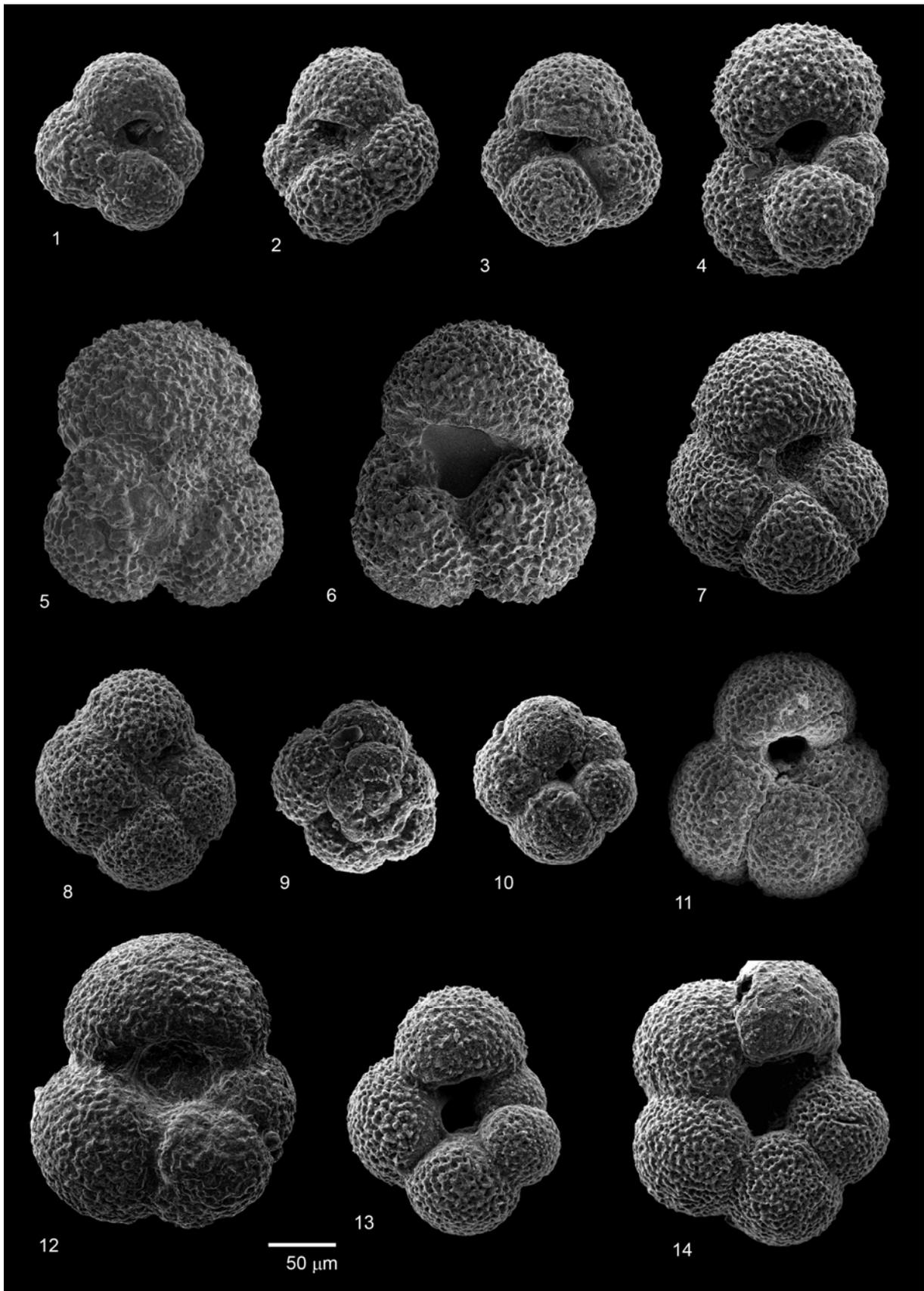


Plate 3. 1 - *Globigerina woodi* Jenkins; 2, 3 - *Globigerina falconensis*, Blow; 4 - *Globigerina foliata* Bolli; 5, 6 - *Globigerina praebulloides* Blow; 7, 8 - *Globigerina gnaucki* Blow & Banner; 9, 10 - *Globigerina tarchanensis* Subbotina & Chutzieva; 11, 12 - *Globigerina scalena* Rögl; 13, 14 - *Globigerina concinna* Reuss.

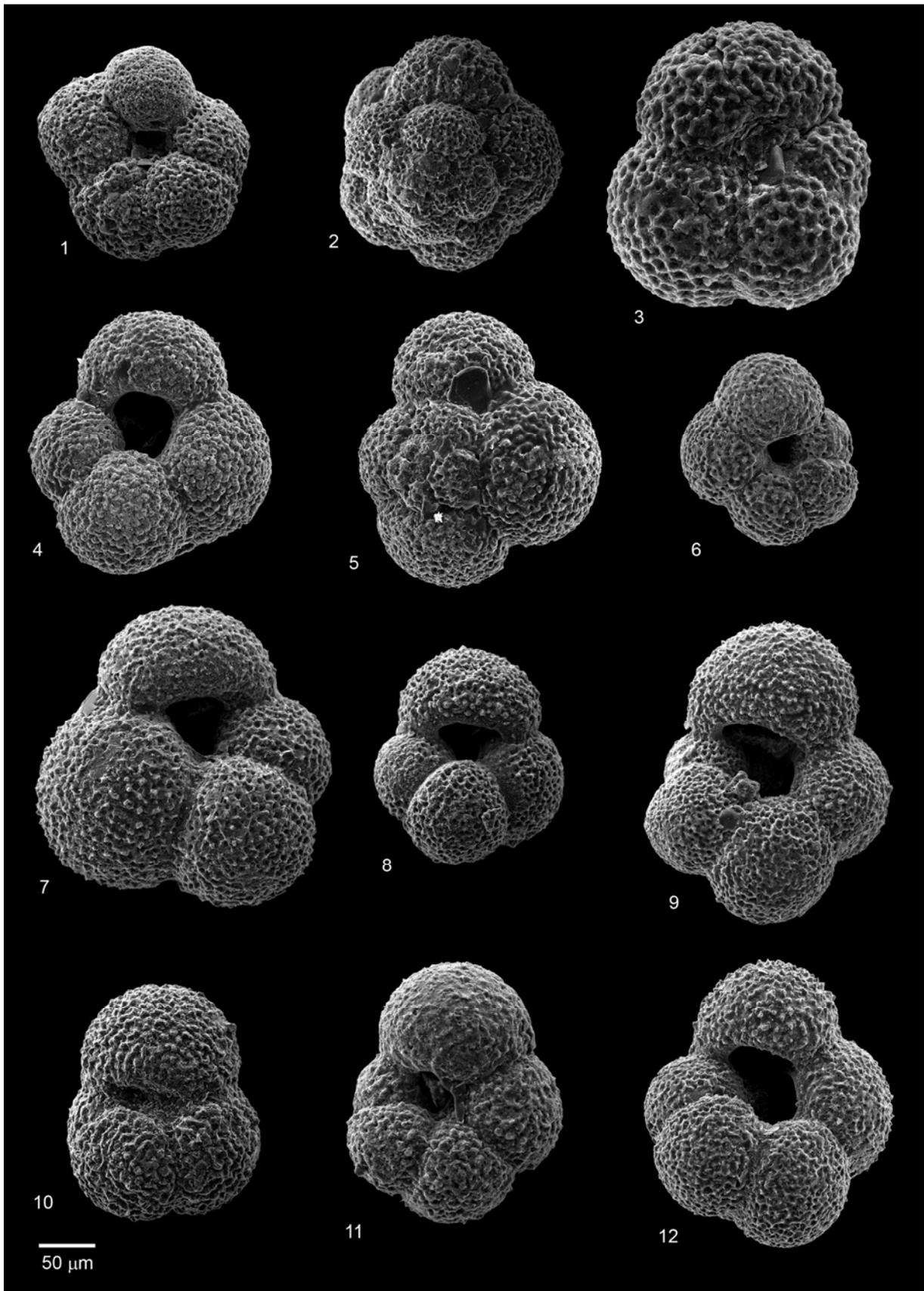


Plate 4. 1, 2 - *Globigerina dubia* Egger; 3 - *Globoquadrina langhiana* Cita & Silva; 4, 5 - *Globigerina officinalis* Subbotina; 6, 11 - *Globigerina ottmangiensis* Rögl; 7 - *Globigerina bollii* Cita & Silva; 8 - *Globigerina ouachiaensis* Howe & Wallace; 9, 12 - *Globigerina ciperoensis* Bolli; 10 - *Globigerina steingeri* Rögl.