Rivista Italiana di Paleontologia e Stratigrafia | volume 108 | numero 2 | tavole 5 | pagine 325-336 | Luglio 2002

NEOGLOBOQUADRINA ATLANTICA PRAEATLANTICA, NEW SUBSPECIES FROM LATE MIDDLE MIOCENE

LUCA MARIA FORESI [1], SILVIA M. IACCARINO [2] & GIANFRANCO SALVATORINI [1]

Received July 15, 2001; accepted January 24, 2002

Key words: planktonic foraminifera, taxonomy, Middle Miocene

Riassunto. Viene eretta a nuovo taxon e denominata *Neogloboquadrina atlantica praeatlantica* una forma identificata in precedenza con nomi diversi. Il taxon compare nel Mediterraneo nel Miocene medio (Serravalliano) a 11.78 Ma e si estingue entro la Zona a *Globigerinoides obliquus extremus* (Tortoniano). La comparsa di *N. atlantica praeatlantica* nel Mediterraneo non è un evento evolutivo ma è dovuta alla sua migrazione dalla alte latitudini in risposta ad un raffreddamento climatico globale. Da questa specie si evolve *N. altantica atlantica* di cui i primi esemplari si rinvengono nel Mediterraneo a 11.15 Ma, immediatamente dopo la scomparsa di *Paragloborotalia siakensis* (Le Roy).

Abstract. A new subspecies of *Neogloquadrina atlantica atlantica* previously reported under different names, is here distinguished and named *Neogloboquadrina atlantica praeatlantica*. Its first occurrence into the Mediterranean dated at 11.78 Ma, is not evolutionary appearance but is related to a global climatic cooling which pushed southwards from high latitude this taxon; however, the area of its evolutionary appearance is not clearly defined; its extinction occurs within the *Globigerinoides obliquus extremus* Zone. *N. atlantica atlantica* which evolves from *N. atlantica praeatlantica* occurs in the Mediterranean at 11.15 Ma, just after the Mediterranean exit of *Paragloborotalia siakensis* (Le Roy).

Introduction

Data from literature (Poore 1979; Hilgen et al. 2000) (Fig. 1) and our original data which chiefly arise from the Mediterranean successions (Tremiti Islands: Iaccarino et al. 2001, Foresi et al. in press, Foresi et al. 2002 and Sicily: Di Stefano et al. 2002) indicate that the first neogloboquadrinids are dominated by morphotypes with 4 chambers in the last whorl (Pl. 1, figs. 1-12; Pl. 2, figs. 1-4, 6, 8, 12, 13); specimens with 4 and half chambers are very rare (Pl. 1, fig. 13; Pl. 2, figs. 5, 9). The equatorial periphery is lobate; chambers are globular and their size grows moderately. The last chamber is often more finely perforated and is more compressed towards the marginal side where it is attached to the first chamber of the last whorl. In some specimens, the last chamber is smaller than the penultimate, or is abortive (Pl. 2, figs. 7, 11) and often looks like a little and thin cowl generally shifted towards the umbilical area. The umbilical and spiral sutures are radial and moderately depressed. The umbilicus is more or less open and deep. The aperture is a high umbilical-extraumbilical arch extending towards the peripheral margin; more rarely it is limited to the umbilical area (Pl. 2, figs. 6, 12) and generally is asymmetrical against the umbilicus; it is bordered by a not perforated thick rim (Pl. 2, figs. 13a, 14) and sometimes with a thin lip (Pl. 1, figs. 3, 5; Pl. 2, figs. 9, 11). On the spiral side the chambers are moderately inflated forming a flat or slightly convex surface; rarely the spiral side is elevated (Pl. 2, fig. 10). The axial periphery is well rounded.

The above described neogloboquadrinids were labelled in different way through time. For instance, *Globigerina* aff. *pachyderma* (Ehremberg) of Tijalsma (1971) certainly is referable to these forms on the base of the description, the stratigraphic distribution and the figures (text-fig. 15, I-VI; pl. 9, figs. 4-8) (see also Hilgen et al. 2000). However, most authors referred such morphotypes to (1) *Neogloboquadrina* (or *Globorotalia*, or *Globigerina*) *continuosa* (Blow) or to (2) *N. atlantica* (Berggren).

Mazzola (1971), Crescenti et al. (1973), Giannelli & Salvatorini (1975), D'Onofrio et al. (1975), Zachariasse (1975), Colalongo et al. (1979), Serrano Lozano (1979), Zachariasse and Spaak (1983), Chamley et al. (1986), Sprovieri et al. (1996b), Miculan (1997), Montanari et al. (1997), and Foresi et al. (1998) followed the Blow's taxonomy and some of them adopted the FO of the taxon as zonal marker.

Poore (1979) and more recently Hilgen et al. (2000) considered these morphotypes a primitive form

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[1] Dipartimento di Scienze della Terra, Università di Siena, Via Laterina 8, 53100 Siena, Italy. e-mail: foresi@unisi.it

[2] Dipartimento di Scienze della Terra, Università di Parma, Parco Area delle Scienze 157A, 43100 Parma, Italy; e-mail: iaccarin@ipruniv.cce.unipr.it

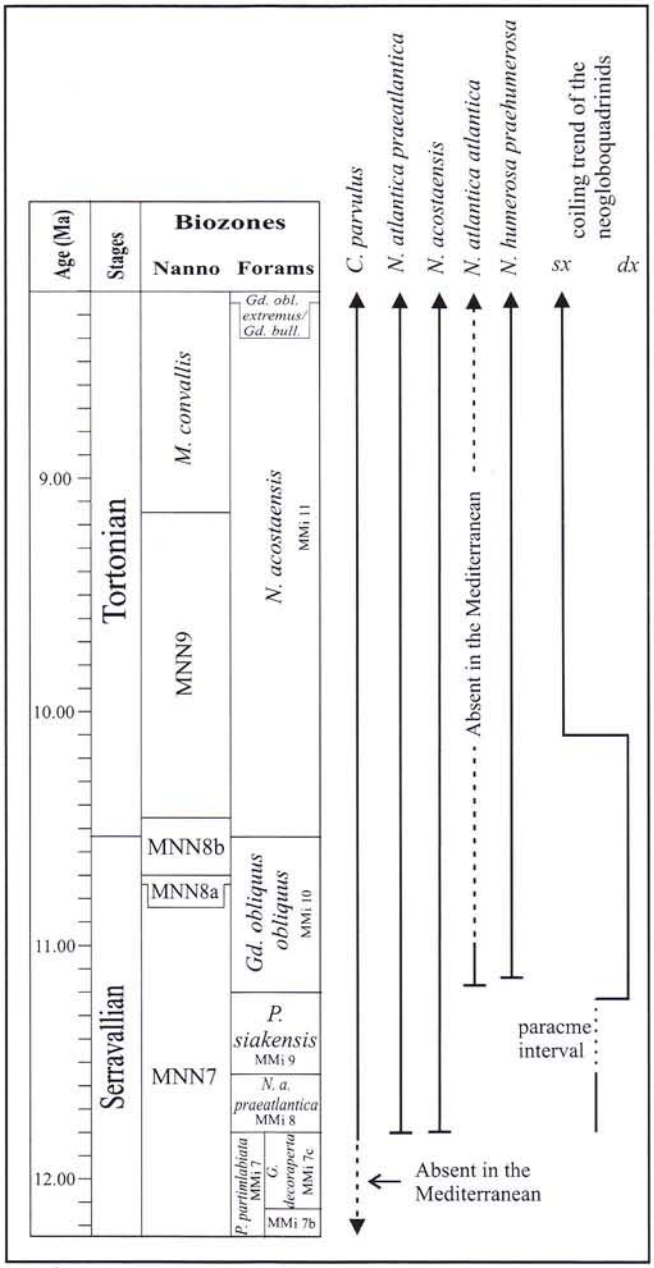

Fig. 1 - Distribution of *Neogloboquadrina atlantica praeatlantica* and related taxa in the Mediterranean plotted versus the composed zonal scheme of Sprovieri et al. (2002) and Sprovieri et al. (1996b) obtained from the data of the sections cited in Tab1; the Tortonian/Serravallian boundary has been located at the FRO of *N. acostaensis* which approximates the base of the historical Tortonian stratotype (Hilgen et al. 2000).

and a small-sized phenotype of *N. atlantica*, respectively.

Comparison with *N. continuosa* (Blow)

The relationship of the 4-chambered morphotypes with the *continuosa* holotype as re-figured by Blow (1969, pl. 3, figs. 4-6) is based on the general shape, the aperture an high arch extended towards the peripheral margin. The holotype of Blow shows strong similarities with the specimens referred to *Neogloquadrina* 4-chambered type by Hilgen et al. (2000).

Poore (1979) also does not exclude a relationship of the specimens from the N.14-N.15 interval of the Northern Atlantic Sites 407 and 408 - DSDP Leg 49 with such a species. These are well comparable both for morphology (pl. 15, figs. 10-12 in the quoted paper) and age with those of the Mediterranean (see Pl. 2, this paper).

However, Bolli & Saunders (1982, 1985) investigating the variability of *P. siakensis* (=*P. mayeri* according to them), concluded that Blow's species has to be considered as a 4-chambered-variant of *P. siakensis*. Like Bolli & Saunders, we also recognize the presence of these 4-chambered variants in the *P. siakensis* populations. Nevertheless, in our opinion, there is a clear indication that in the *continuosa* concept of Blow are included also forms not related to *P. siakensis*. In fact, distinguishing the *Globorotalia (Turborotalia) continuosa* concurrent range Zone (N.15) whose base is defined by the LO of *P. siakensis*, Blow necessarily utilized forms we suspect are neogloquadrinid morphotypes.

Therefore, is *continuosa* only a 4-chambered variant of *P. siakensis* or could include also neogloboquadrinid morphotypes? The uncertainty was solved through the direct observation of the holotype and of the paratypes because the photos of the holotype kindly provided by B. Huber (Curator of the Smithsonian Institution of Washington where the holotype is deposited) and reported in Foresi et al. (1998, text-fig. 3), show a specimen devoid of the last chamber which limits a correct identification. One of the authors (S.I.) who had the opportunity to check the holotype, observed that it does not correspond to the holotype re-figured by Blow (1969) and to the *continuosa* specimens of Foresi et al. (1998). Holotype and paratypes are smaller in size and the aperture is a low arch and the texture of the wall is very similar to that of *P. siakensis*. Only some specimens among the paratypes show a higher aperture and they could be small neogloboquadrinids. Concluding the taxonomic status of *continuosa* remains uncertain and the use of this name is unsuitable.

Comparison with *N. atlantica* (Berggren)

In the Mediterranean, first typical specimens of *N. atlantica* (Pl. 3, figs. 1-8) occur later than the 4-chambered morphotypes above described and precisely at 11.15 Ma (Di Stefano et al. 2002; Foresi et al. 2002) or at 11.12 Ma (Hilgen et al. 2000) after the LO of *P. siakensis*. It remains in the Mediterranean for a short time (about 200 ky according to Di Stefano et al. 2002 and 270 ky according to Hilgen et al. 2000); it re-appears within the late Tortonian - Messinian (Colalongo et al. 1979; Sprovieri et al. 1996a) and later in the Middle

Reference succession	Geographical location	Reference
Leg 47(1) - Site 397	North Atlantic Ocean Lat. 26° N	Foresi et al. (1998)
Leg 49 - Site 407 and Site 408	North Atlantic Ocean Lat. 63° N	Poore (1979)
Leg 154 – Site 926	Equatorial Atlantic Ocean Lat. 3° N	Turco et al. (in press)
Leg 162 - Site 982	North Atlantic Ocean Lat. 52° N	Lirer (unpublished data)
Leg 42A – Site 372	Balearic Basin - Mediterranean	Foresi et al. (1998)
Sicily	Southern Italy - Mediterranean	Foresi et al. (1998), Hilgen et al. (2000), Di Stefano et al. (2002)
Tremiti Islands (Apulia)	Southern Italy - Mediterranean	Foresi et al. (1998, 2002 and in press), Iaccarino et al. (2001)

Tab.1 - Reference areas of *Neogloboquadrina atlantica praeatlantica* distribution.

Pliocene (Zachariasse & Spaak 1983, Sprovieri 1993). The specimens of *N. atlantica* recorded in early Tortonian sediments by Coccioni et al. (1992, 1994) and Coccioni & Galeotti (1995) are well correlatable with those of our findings. Such specimens correspond very well to the species concept reported and figured by Berggren (1972; see also in Poore & Berggren 1975).

Hilgen et al. (2000) include in *N. atlantica*, large and small-sized forms considering the small ones as small-sized phenotypes of *N. atlantica*.

In our opinion the two taxa have distinct morphology and texture; additionally they show a different stratigraphic distribution and we suggest that *N. atlantica* (small) is the ancestor of *N. atlantica* (large). In fact, the adult forms of the latter have larger size and higher number of chambers in the last whorl (5 instead of 4), the aperture is commonly umbilical (not usually umbilical-extraumbilical), without thick rim or lip. The most remarkable difference between the two taxa is the wall texture, which is coarse in *N. atlantica* (large) because of the presence of overgrowth consisting of closely spaced blunt "spines" (Poore & Berggren 1975). As it concerns the stratigraphic range, *N. atlantica* (large) first occurs just after the *P. siakensis* LO in the Mediterranean (in the Northern Atlantic is reported from N.16 by Berggren 1972 and by Poore 1979), whereas *N. atlantica* (small) is present since N.14 (and may be also in older levels in Site 407; Poore 1979). The questionable occurrences of "*atlantica*" from Middle Miocene (Serravallian) Zones N.14-N.15 reported by Berggren (1972) possibly are referable to this form. Finally, gradational forms of *N. atlantica* (small) to *N. atlantica* (large) occur in the Mediterranean sequences (see also Hilgen et al. 2000, pl. 3, figs. 17-21), supporting the hypothesis of Poore (1979) that "a possible ancestor of *Neogloboquadrina atlantica* occurs in the Middle Miocene of Holes 407 and 408, and is recorded on Tables 2 and 3 as *N. atlantica* (primitive form). This primitive form has 4 globular to sub-globular chambers in the final worl. The umbilical to extraumbilical-umbilical aperture is lipped and has a tendency to be "comma-shaped", which suggests a relationship with *Globorotalia continuosa*. The test-surface of *Neogloboquadrina atlantica* (primitive form) is the same as that observed on other *Neogloboquadrina*, but the heavy secondary encrustation observed on many individuals in populations of typical *N. atlantica* was not found on the primitive form" (p. 472 of the quoted paper).

In conclusion, we agree that the 4-chambered neogloboquadrinids belong to the *N. atlantica* plexus and we consider it a subspecies of *N. atlantica atlantica* for which we propose the name *Neogloboquadrina atlantica praeatlantica*.

Description of the holotype

Neogloboquadrina atlantica praeatlantica n. subsp.

(Pl. 1, figs. 1a-c holotype; Pl. 1, figs. 2-13; Pl. 2, figs. 1-14)

1971 *Globigerina* aff. *pachyderma* Tjalsma, p. 69, pl. 9, figs. 4-8; text-fig. 15.
1975 *Globigerina continuosa* Zachariasse, p. 121, pl. 15, figs. 1-2; pl. 17, fig. 9; text-fig. 16.
1979 *Globorotalia continuosa* - Colalongo et al., pl. 6, fig. 2.
1979 *Globorotalia continuosa* - Salvatorini & Cita, pl. 10, figs. 3-4.
1979 *Neogloboquadrina atlantica* primitive form Poore, p. 472, pl. 16, figs. 10-12.
1998 *Neogloboquadrina continuosa* - Foresi et al., p. 105, pl. 2, figs. 5-6.
2000 *Neogloboquadrina atlantica* (small-sized) Hilgen et al., pl. 2, figs. 1-4.

Holotype: (Pl.1, figs. 1a-c). Specimen deposited at the Micropaleontology Laboratory of the Department of Earth Sciences, University of Siena (Via Laterina 8, 53100 Siena, Italiy).

Type locality: S. Nicola Island (Tremiti Islands, Adriatic Sea, Souhern Italy), SE coast, Castle section (Foresi et al. 2002).

Type level: Cretaccio Formation: sample TT-AA 170 (level 18,43 m) in the carbonate layer of cycle 61 of the Castle section (Foresi et al. 2002).

Biostratigraphy: late Serravallian; *N. atlantica praeatlantica* (MMi 8) Zone of Sprovieri et al (2002); *N. continuosa* - *P. siakensis* Zone (*N. continuosa* Subzone) of Foresi et al. (1998).

Holotype description: test with low trochospire, composed of 12 chambers arranged in 3 whorls, 4 in the last whorl; the chambers are globular, subspherical, globigeriniform; the equatorial periphery is distinctly lobate. Umbilical side: the last chamber shows a slight depression in the anterior part; the sutures are radial, weakly curved, depressed; the umbilicus is open, deep; the aperture is well evident, umbilical-extraumbilical, arched, bordered by a thick and imperforated lip. Axial side: elliptical profile, widely rounded periphery; the aperture is a high arch. Spiral side: the chamber surface is slightly convexed; the spiral and intercameral sutures are depressed; the latter ones radial or slightly curved. The wall texture is non spinose, cancellate. **Max. diameter:** 340 μm.

Remarks: The variability of the subspecies has been described in detail previously by Tjalsma (1971), Zachariasse (1975), and in the foreword of this paper. We report here the most variable features: the equatorial profile may be more or less elongated (Pl. 1, fig. 4-5 and 9, 13); the aperture is sometimes limited to the umbilical area (Pl. 2, fig. 6, 12) and may vary in size; the chambers of the last whorl are rarely 4 and half and 5 only when the last chamber is abortive and smaller than the previous one (Pl. 2, fig. 11). The anterior compression of the last chamber and the high of the apertural arch become less appreciable in the upper part of its range.

N. atlantica praeatlantica differs from *N. atlantica atlantica* (Pl. 3, figs. 1-8) for the considerably smaller size (compare Pl. 3 with Pls. 1,2), less number of chambers in the last whorl (generally 4 rather than 5), commonly umbilical-extraumbilical aperture (and not generally umbilical), with a thick rim or lip (commonly absent in "*atlantica*"), cancellate wall texture without secondary encrustations.

N. acostaensis (Blow) (Pl. 4, figs. 1-8) differs for a less inflated test, the generally 4 and half -5 chambers in the last whorl, the more circular equatorial profile, the last chamber smaller than the previous one, and the aperture a low slit with well developed lip. *Neogloboquadrina* 4-chambered type, distinguished by Hilgen et al. (2000) in the neogloboquadrinid assemblages from Miocene succession of Monte Gibliscemi is considered by the authors a variant of *N. acostaensis* (pl. 2, figs. 8-9).

N. atlantica preatlantica is also related to *Catapsydrax parvulus* Bolli, Loeblich & Tappan (Pl. 4, figs. 9-19) which differs for its smaller size, more compressed chambers and test, smaller and lower aperture umbilical, the presence of a little bulla or an abortive last chamber covering the umbilicus. The relationship is based on the

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PLATE 1

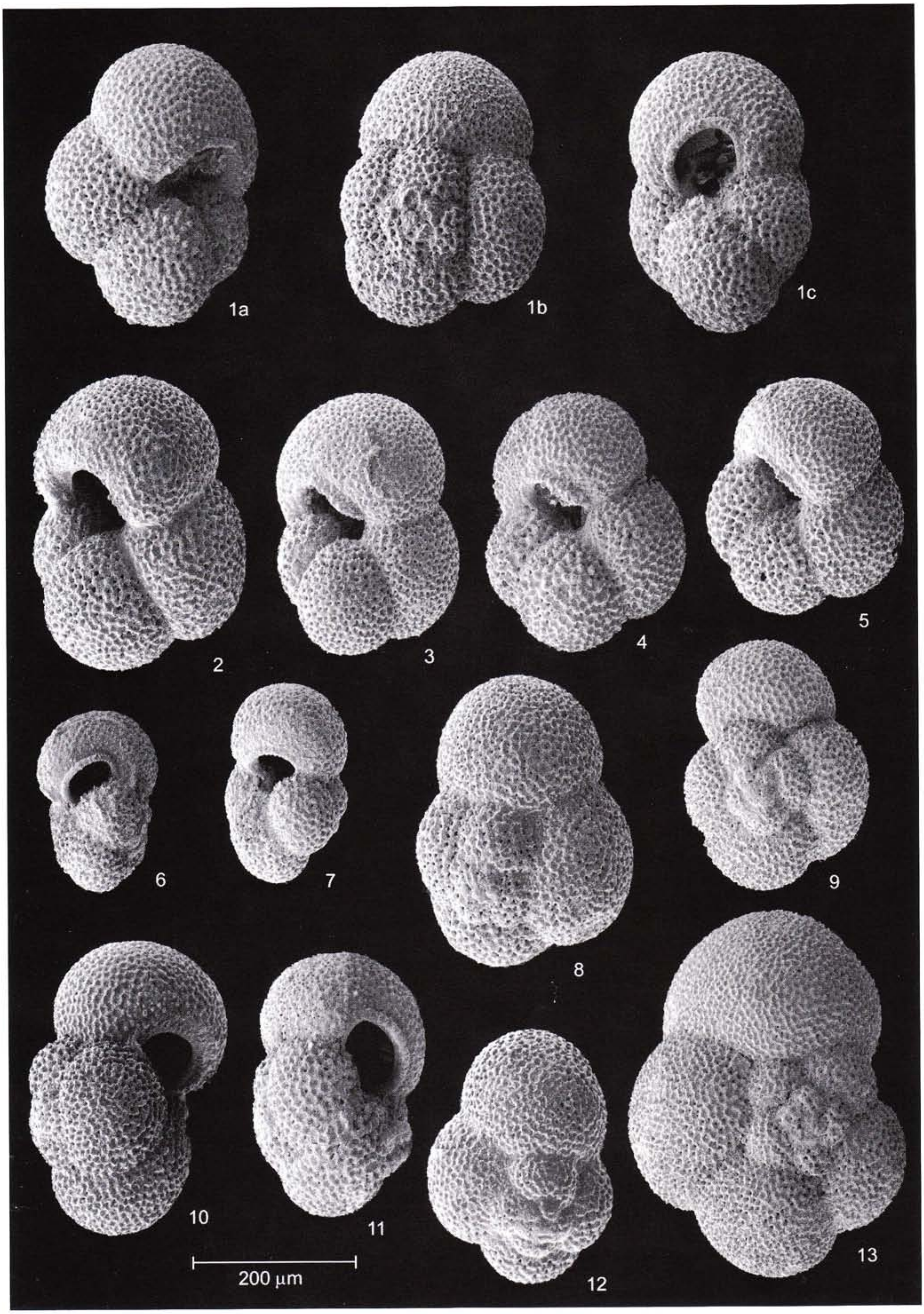
Fig. 1a-c - *Neogloboquadrina atlantica praeatlantica* n. subsp.; holotype: a- umbilical view b- spiral view, c- axial view. TTAA-170 (*N. atlantica praeatlantica* Zone)
Fig. 2 - *Neogloboquadrina atlantica praeatlantica* n. subsp. B-24 (*G. obliquus obliquus* Zone)
Figs. 3, 10 - *Neogloboquadrina atlantica praeatlantica* n. subsp. CP99-55 (*G. obliquus obliquus* Zone).
Fig. 4 - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTAA-237 (*P. siakensis* Zone)
Fig. 5 - *Neogloboquadrina atlantica praeatlantica* n. subsp. CP99-85 (*N. acostaensis* Zone)
Fig. 6 - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTAA-210 (*P. siakensis* Zone)
Fig. 7 - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTbis-30,5 (*N. atlantica praeatlantica* Zone)
Fig. 8 - *Neogloboquadrina atlantica praeatlantica* n. subsp. Pel-280 (*N. atlantica praeatlantica* Zone)
Fig. 9 - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTbis-30,5 (*N. atlantica praeatlantica* Zone)
Fig. 11 - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTAA-170 (*N. atlantica praeatlantica* Zone)
Fig. 12 - *Neogloboquadrina atlantica praeatlantica* n. subsp. Pel-240 (*N. atlantica praeatlantica* Zone)
Fig. 13: - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTAA-337 (*N. acostaensis* Zone)

PLATE 2

Fig. 1 - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTAA-210 (*P. siakensis* Zone)
Figs. 2, 3, 14 - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTAA-170 (*N. atlantica praeatlantica* Zone)
Fig. 4 - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTbis-30,5 (*N. atlantica praeatlantica* Zone)
Fig. 5 - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTAA-337 (*N. acostaensis* Zone)
Fig. 6 - *Neogloboquadrina atlantica praeatlantica* n. subsp. Pel-280 (*N. atlantica praeatlantica* Zone)
Figs. 7, 10, 13, 13a - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTbis-50,5 (*N. atlantica praeatlantica* Zone)
Fig. 8 - *Neogloboquadrina atlantica praeatlantica* n. subsp. CP99-85 (*N. acostaensis* Zone)
Fig. 9 - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTAA-327 (*N. acostaensis* Zone)
Fig. 11 - *Neogloboquadrina atlantica praeatlantica* n. subsp. TTAA-287 (*G. obliquus obliquus* Zone)
Fig. 12 - *Neogloboquadrina atlantica praeatlantica* n. subsp. Pel. 280 (*N. atlantica praeatlantica* Zone)

PLATE 3

Fig. 1 - *Neogloboquadrina atlantica atlantica* (Berggren). TTAA-307 (*G. obliquus obliquus* Zone)
Figs. 2, 6, 7- *Neogloboquadrina atlantica atlantica* (Berggren). B-23 (*G. obliquus obliquus* Zone)
Fig. 3 - *Neogloboquadrina atlantica atlantica* (Berggren). TTAA-317 (*G. obliquus obliquus* Zone)
Figs. 4, 5, 8- *Neogloboquadrina atlantica atlantica* (Berggren). TD-185 (*G. obliquus obliquus* Zone)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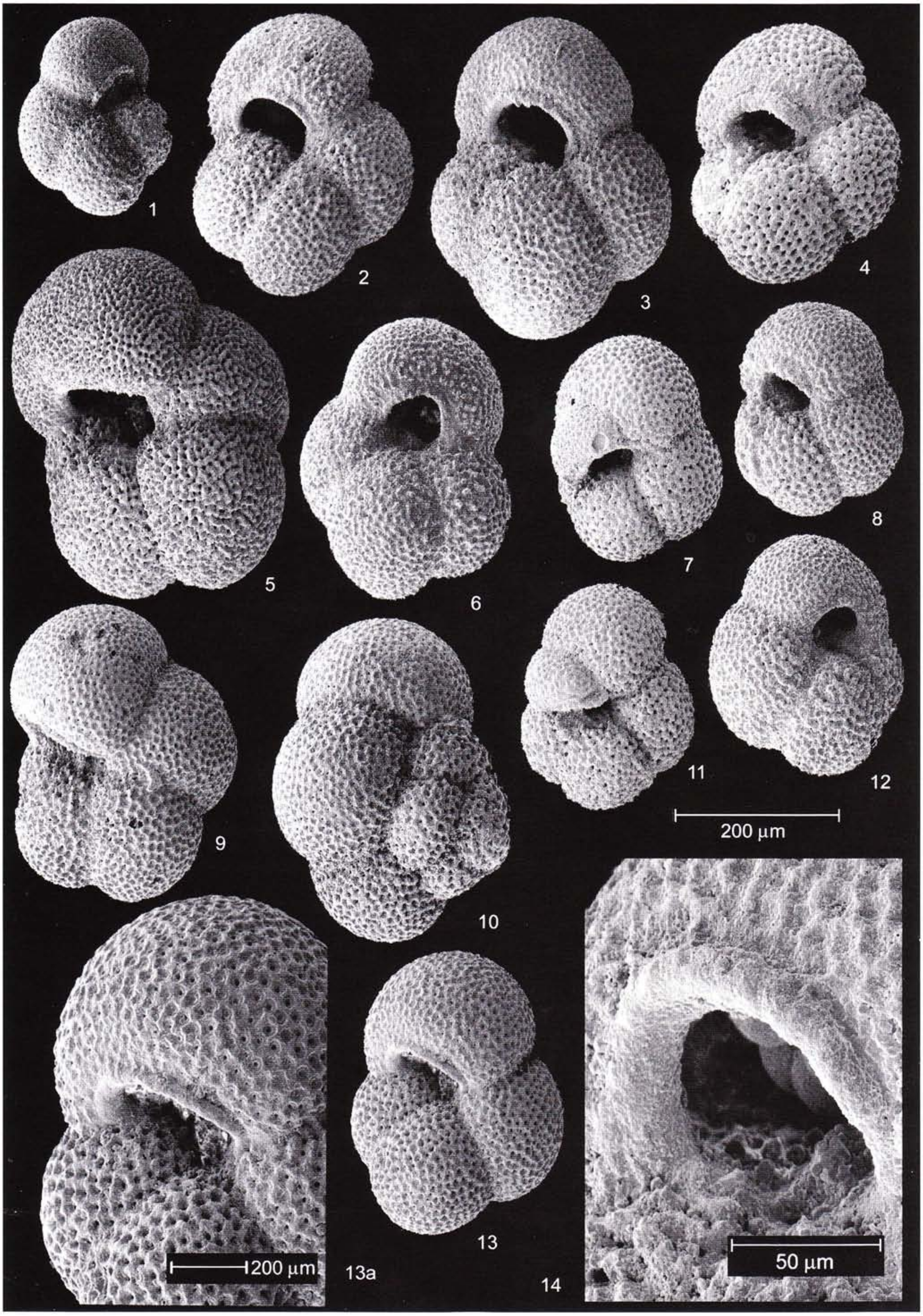
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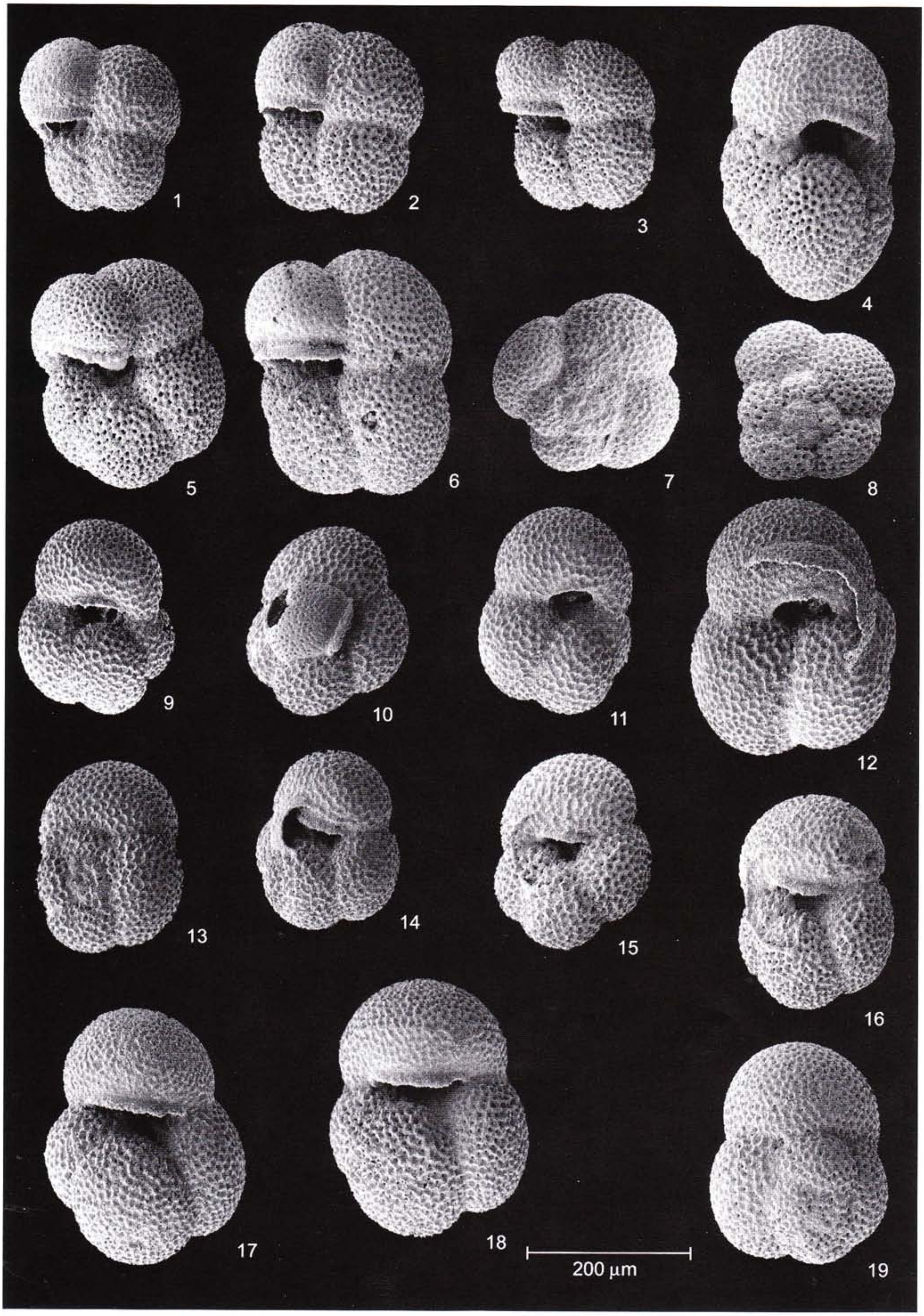
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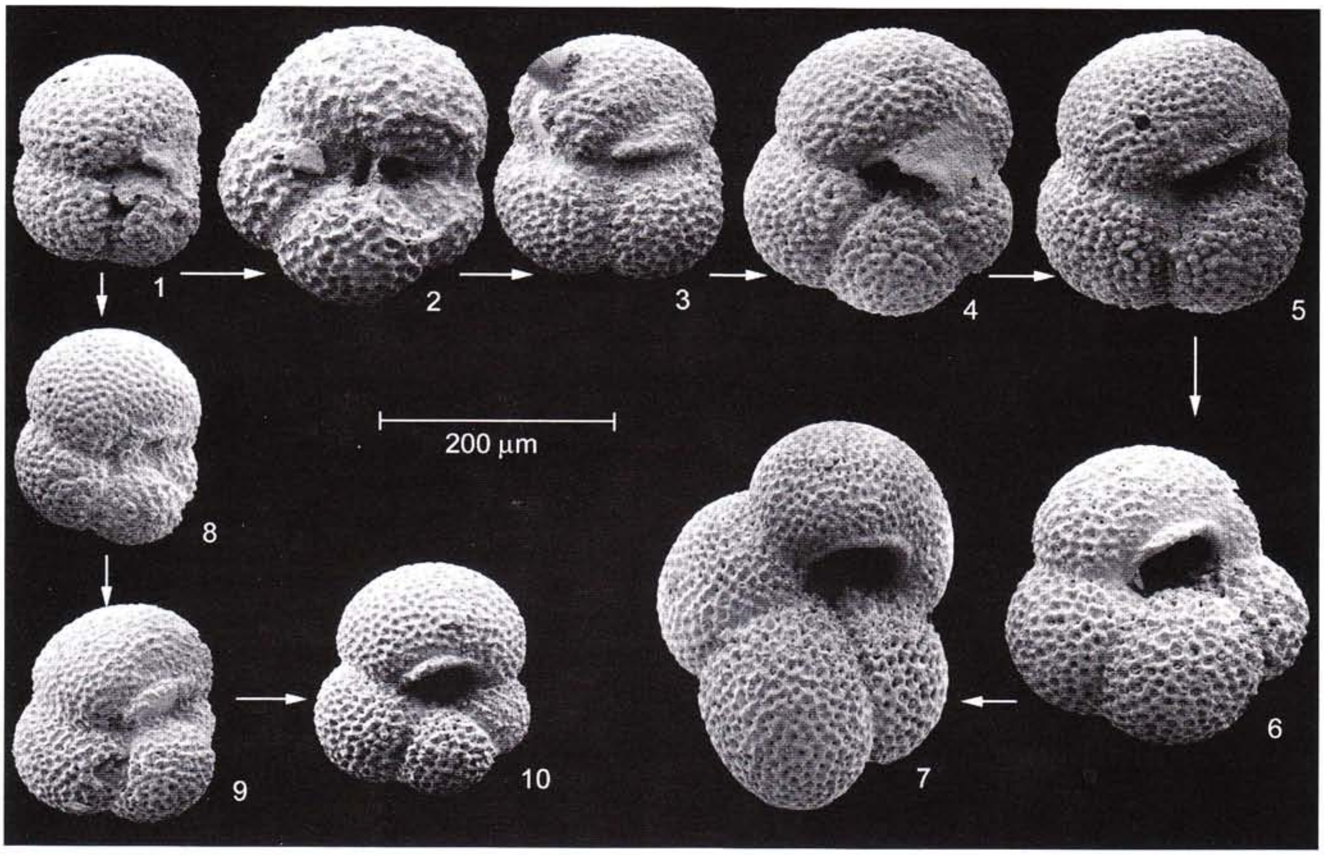

PLATE 5

Figs. 1-10 - Morphological gradation from Catapsydrax parvulus to *Neogloboquadrina atlantica praeatlantica*. TTAA-160

occurrence in the basal part of the neogloboquadrinid range of *C parvulus* morphotypes grading into *N. atlantica praeatlentica.*

Stratigraphy distribution (Fig. 1): in the Mediterranean *N. atlantica praeatlantica* first occurs at the astronomical age of 11.78 Ma (Hilgen et al. 2000, Foresi et al. 2002) and vanishes within the *Globigerinoides extremus* Zone of Foresi et al. (1998). The FO of the subspecies marks the MMi7/MMi8 zonal boundary of Sprovieri et al. (2002) and the *N. continuosa/P. siakensis* zonal boundary of Foresi et al. (1998). However in the upper part of its range it becomes very rare. According to Hilgen et al. (2000) its LRO occurs around 10.48 Ma. In Site 982 located at 57°N in the Atlantic Ocean, *N. atlantica praeatlantica* occurs (Lirer, unpublished data) within the *B. badenensis* Zone (Spiegler 1999) between 11.9 and 12.6 Ma. At low latitude (Ceara Rise, 3°N) *N. atlantica praeatlantica* is absent, and the FO of neogloboquadrinids is characterized by sinistral forms of *N acostaensis* which first occurs at 9.89 Ma (Turco et al. in press). At Site 397 (Cap Bojador, 26°N) (Foresi et al. 1998) *N. a. praeatlantica* first occurs in levels postdating the LCO of *G. subquadratus* (synchronous event between Mediterranean and low latitude; Foresi et al. 2002, Turco et al. in press) at 11.54 Ma. It follows that the *N. atlantica praeatlantica* migrated from higher to lower latitude through time. This strengthens the hypothesis of Zachariasse, (1992), Zachariasse & Aubry (1994), Hilgen et al. (2000), and Turco et al. (2001) that the areal distribution of *N. atlantica* (sensu latu). is primarily controlled by cold surface water.

PLATE 4

Figs. 1, 7 - *Neogloboquadrina acostaensis* (Blow). TTAA-150 (base of *N. atlantica praeatlantica* Zone)
Figs. 2, 3, 8 - *Neogloboquadrina acostaensis* (Blow). TTAA-180 (*N. atlantica praeatlantica* Zone)
Figs. 4, 6 - *Neogloboquadrina acostaensis* (Blow). TTAA-337 (*N. acostaensis* Zone)
Fig. 5 - *Neogloboquadrina acostaensis* (Blow). TTAA-327 (*N. acostaensis* Zone)
Figs. 9-13 - *Globorotaloides falconarae* Giannelli & Salvatorini; paratypes. FA5 (*N. acostaensis* Zone)
Figs. 14-19 - *Globorotaloides falconarae* Giannelli & Salvatorini. TTAA-260 (*P. siakensis* Zone); figs. 17 and 18 - specimens comparable with "*Globoquadrina* sp.1" of Hilgen et al. (2000)

Origin of *N. atlantica praeatlantica*

All the authors agree that the entry of the neogloboquadrinids in the biological record is a Middle Miocene event, but the origin and phylogeny of the genus *Neogloboquadrina* is still an open problem. As previously stated the neogloboquadrinids firstly entered into the Mediterranean sedimentary record in the late Middle Miocene (Serravallian) at the astronomical age of 11.78-11.8 Ma (Hilgen et al. 2000; Di Stefano et al. 2002; Foresi et al. 2002). According to several authors (Zachariasse 1992; Zachariasse & Aubry 1994; Hilgen et al. 2000), this invasion is connected with a climatic cooling and more precisely (Turco et al. 2001) is related to Mi 5 event of Miller et al. (1991). This entry represents an excellent and synchronous event easily recognizable in the Mediterranean successions (Foresi et al. 1998, 2002, in press; Hilgen et al. 2000) and virtually coincides with last occurrence (LO) of *Paragloborotalia partimlabiata* (Ruggieri & Sprovieri) (sensu Foresi et al. 2002, not sensu Hilgen et al. 2000). On the contrary this event is strongly diachronous (almost about 2 my) with the low latitude FO as evidenced by Hilgen et al. (2000) and Turco et al. (in press), that renders the correlation with the low latitude zonal scheme of Blow (1969) no more possible.

Foresi et al. (1998) suggested its evolution from *Globorotaloides falconarae*. This hypothesis was in agreement with that suggested by Zachariasse & Aubry (1994) who derived *N. atlantica* from *C. parvulus* of which *G. falconarae* was considered a junior synonym (Zachariasse 1992). This synonimy was rejected by Hilgen et al. (2000) who regarded *G. falconarae* as evolved from *Globoquadrina* sp.1 while *C. parvulus* was considered a low latitude homeomorphic species. The resemblance of *N. atlantica* with some morphotype of *Globoquadrina* sp.1 induced the authors to suggest that *N. atlantica* might be originated from *Globoquadrina* sp.1.

We agree with Zachariasse's (1992) opinion about the synonymy between *C. parvulus* and "*G. falconarae*" and we think that "*Globoquadrina* sp.1" represents large sized specimens of "*G. falconarae*" (Pl. 4, figs. 17, 18).

In the present intepretation *N. atlantica praeatlantica* is suggested to be evolved from *Catapsydrax parvulus* (Pl. 5, figs. 1-10) through the gradational morphotypes (described in the remarks) occurring at the beginning of the neogloboquadrinid distribution in the Mediterranean and *Globoquadrina* sp. 1 could be one of these morphotypes.

Samples from Leg 162, Site 982 located at 58° N in the North Atlantic, (Lirer, unpublished data) contain "*Globoquadrina* sp.1" morphotypes together with the first *Neogloboquadrina atlantica praeatlantica*. Therefore, the origin and philogeny of *N. atlantica praeatlantica* still remains poorly understood and documented. The previously inferred hypothesis about the origin of *N. atlantica praeatlantica* at present cannot be proved. However, according to the writers its migration into the Mediterranean should closely postdate its evolutionary appearance because its morphology is very similar to that of the suggested ancestor.

The occurrence of transitional forms between *praeatlantica* and *acostaensis* in the earliest levels of the neogloquadrinid distribution of the Mediteranean (Foresi et al. 1998, pl. 2, fig. 7 and Hilgen et al. 2000, pl. 3, figs. 1-16 and 22-27) suggests that *N. acostaensis* could be evolved from *N. atlantica praeatlantica*. In fact, rare morphotypes referable to *N. acostaensis* are already present in the earliest neogloboquadrinid assemblages entering the Mediterranean in Zone N.14. If it is not biologically certain that these very rare forms are *N. acostaensis*, it is certain that the evolutionary appearance of this taxon (which reaches the tropical regions later; Zachariasse 1992, Hilgen et al. 2000, Turco et al. 2001 and in press) predates that established by Blow (1969).

Acknowledgements. We thank E. Turco for the useful and continuous discussions during the work and we are grateful to S. Spezzaferri and W. J. Zachariasse for the critical review of the manuscript. This work was supported financially by Ministero della Università e della Ricerca Scientifica e Tecnologica (MURST, 1998).

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