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A NEW SPECIES OF PRIMITIVE *Reticulophragmium* (FORAMINIFERA) FROM THE PALEOCENE VIDOÑO FORMATION OF NORTHEASTERN VENEZUELA

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Abstract: The new species *Reticulophragmium vidonioensis* Kaminski & Crespo de Cabrera is newly described from the subsurface Vidoño Formation of northeastern Venezuela. The foraminiferal assemblage is dated as Zone P3 (mid Paleocene), and represents an outer neritic-upper bathyal biofacies. *Reticulophragmium vidonioensis* n.sp. displays very primitive morphological features, and illustrates the close evolutionary relationship between the earliest Paleocene alveolar genus *Reticulophragmium* and the non-alveolar genus *Haplophragmoides*.

Abstrakt: Z osadów srodkowego paleocenu (zona P3) formacji Vidoño w północno-wschodniej Wenezueli opisano nowy gatunek *Reticulophragmium vidonioensis* Kaminski & Crespo de Cabrera, należący do grupy otwornic aglutynujących. Zespół otwornic z nowo opisanym taksonem reprezentuje biofacje z pogranicza strefy nerytycznej i górnego batiału. Gatunek *Reticulophragmium vidonioensis* n.sp. charakteryzują cechy stawiające go jako forme posrednią pomiedzy rodzajem *Reticulophragmium* o alweolarnej strukturze i rodzajem *Haplophragmoides* nie wykazującym w budowie wewnetrznej skorupki struktury alweolarnej.

Key words: agglutinated Foraminifera, taxonomy, *Reticulophragmium vidonioensis* n. sp., Paleocene

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INTRODUCTION

During the early to mid-Paleocene, primitive representatives of the genus *Reticulophragmium* evolved along several lineages. Although the genus is well represented in the Arctic Ocean and in the boreal Atlantic basins (McNeil, 1997; Charnock & Jones, 1997), the record of the genus in the tropical seas is still poorly known. It is generally believed that during the Paleocene much of the evolution of the group took place in the high latitudes. Likely candidates for the root stock of this organically-cemented alveolar genus are the non-alveolar genera *Haplophragmoides* and/or *Evolutinella*. In some lineages, sparsely alveolar transitional forms are observed, an example of which is the genus *Reticulophragmoides* Gradstein & Kaminski, 1989.

In this paper, we report the occurrence of a new species of very primitive *Reticulophragmium* from the Vidoño Formation of northeastern Venezuela. The morphology of this species clearly suggests close taxonomic affinity to the genus *Haplophragmoides* without passing through a transitional "reticulophragmoidal" stage.

MATERIAL

Specimens are derived from the Tala-1 well, drilled just south of the Anaco Thrust, near Anaco, Anzoategui State, Venezuela (Fig. 1). At this locality, the Vidoño Formation is only about 10 m thick. The foraminiferal assemblage at the type level (2280 ft.) consists of a mixed assemblage of calcareous benthic and agglutinated foraminifera, with poorly preserved planktonics that include *Morozovella angulata* and *Igorina pusilla* suggesting correlation to Zone P3. The benthic assemblage is dominated by *Lenticulina* and large spe- cimens of *Gavelinella* and *Clavulinoides*. The species *Ga- velinella beccariiformis* is absent, suggesting deposition in outer neritic to upper bathyal depths.

GEOLOGICAL SETTING

The Vidoño Formation of the Santa Anita Group of northeastern Venezuela consists of a thick sequence of dark grey noncalcareous claystones with siderite nodules inter-

bedded with finely grained, thinly-bedded glauconitic turbidite sandstones. At its type locality in the Vidoño Valley near Puerto La Cruz, the formation is over 300 m thick and is interpreted as a "channel levee complex" deposited on the passive margin of northern South America (Galea-Alvarez 1985), most likely within a strongly developed oxygen minimum zone. The frequency and thickness of turbidite sandstones increase towards top of the formation, indicating the development of a transgressive systems tract. The overlying Caratas Formation of early Eocene age is comprised largely of thick-bedded calcareous, and occassionally glauconitic sandstones interbedded with thin shale horizons.

The Vidoño Formation thins to a thickness of *ca* 10 m towards the central part of Anzoategui State. In this region sandstones become increasingly glauconitic. A distinctive condensed glauconitic horizon is present in the mid-Paleocene in the lower part of the formation, indicating maximum transgression (Crespo de Cabrera & Pizon, 1989). Benthic foraminiferal assemblages suggest a shallower (outer neritic) depositional environment in this part of the Venezuelan continental margin. The foraminifera from the Vidoño Formation in northern Anzoategui State were initially described by Cushman (1947). The agglutinated foraminifera from sections in the Vidoño Valley near the coast were studied by Galea-Alvarez (1985), but no mention was made of the species described herein in either of the previous studies.

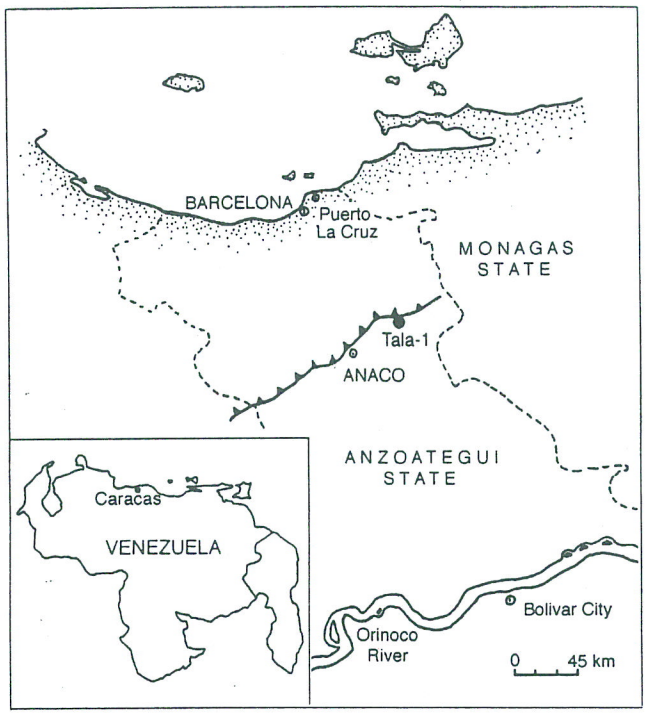

Fig. 1. Location of the Tala-1 well, in Anzoategui State, Venezuela

SYSTEMATIC PALEONTOLOGY

Class FORAMINIFEREA Lee, 1990
Order HAPLOPHRAGMIINA Wedekind, 1937
Family CYCLAMMINIDAE Marie, 1941

Genus *Reticulophragmium* Maync, 1955

Reticulophragmium vidonioensis
Kaminski & Crespo de Cabrera, n. sp.
Fig. 2 (1a–4d)

Etymology: Named after the Vidoño Formation of northeastern Venezuela.

Holotype: The microsphaeric specimen illustrated in Fig. 2(1a–d) is deposited in the collections of the Department of Palaeontology, Natural History Museum, London. Additional paratype specimens are deposited in the Bermudez Collection in Caracas and in the second author's collection.

Type-locality: The Tala-1 well, drilled near Anaco, Anzoategui State, Venezuela. Sample collected at 2280 ft.

Type-level: Mid-Paleocene, based on a poorly preserved planktonic assemblage suggesting correlation with planktonic foraminiferal Zone P3.

Differential diagnosis: Differs from other known Paleocene species by its comparatively small size, few quadrate chambers, and sparse alveoles.

Description: Test free, coiled planispirally in one to two whorls, circular in outline, with a rounded periphery. Chambers are quadrangular, with straight, thick septa, and simple alveoles mostly concentrated along the sutures. Sutures are straight, radial, and depressed very slightly. Megalosphaeric individuals have a comparatively large proloculus, are coiled in only one (or only slightly more than one) whorl, with 7–8 chambers in the last volution, and are thickest at the umbilicus. In the megalosphaeric form, alveoles begin with the second chamber, but are small, simple, sparse, and concentrated along the septa, not at the peripheral margin of the test. Microsphaeric individuals have more numerous chambers in about 1.5–2 whorls, a depressed umbilicus with a raised umbilical shoulder, and up to 9 chambers in the final whorl. In the microsphaeric generation, the chambers of the final whorl also have alveoles developed along the peripheral margin of the test, and in some individuals only, on the outer chamber wall of the last chambers. Wall finely agglutinated, well silicified, translucent, and finely finished. Apertural face flat or slightly convex (depending up the degree of secondary compression). Aperture a long and thin interiomarginal slit, with no trace of a lip.

Measurements (mm): Maximum diameter of holotype – 0,59.

Remarks: This species is distinguished by its quadrate chambers (with flat chamber floors), and thick, straight septa, with small, sparse, simple alveoles. The alveoles do not appear to branch distally. Its overall morphology is reminiscent of the species *Haplophragmoides* sp. aff. *H. deformis* (Andreae), described by Frizzell (1943) from the Paleocene of Peru, but it differs in the presence of its alveolar structure. *Reticulophragmoides jarvisi* (Thalmann) found in the upper Paleocene of Trinidad by Cushman and Renz (1946) and by Kaminski *et al.* (1988) differs in possessing triangular chambers that end in a blind tube in the umbilical region, and in its sigmoidal sutures. Other species of Paleocene *Reticulophragmium* known from the Atlantic region show much more "advanced" morphological features. *Reticulophragmium garcilassoi* (Frizzel) known from the upper Paleocene of Peru and the Vidoño Formation (Frizzel, 1943; Cushman, 1947) is a large, lenticular form with 12–15 chambers in the final whorl and evenly distributed alveoles. *Reticulophragmium elegans* (Cushman & Jarvis), a species from Trinidad that was previously reported by Cushman (1947) from the Vidoño Formation, differs in its larger size, more broadly rounded periphery, and evenly distributed alveoles. *Reticulophragmium paupera* (Chapman), known from the upper Pa-

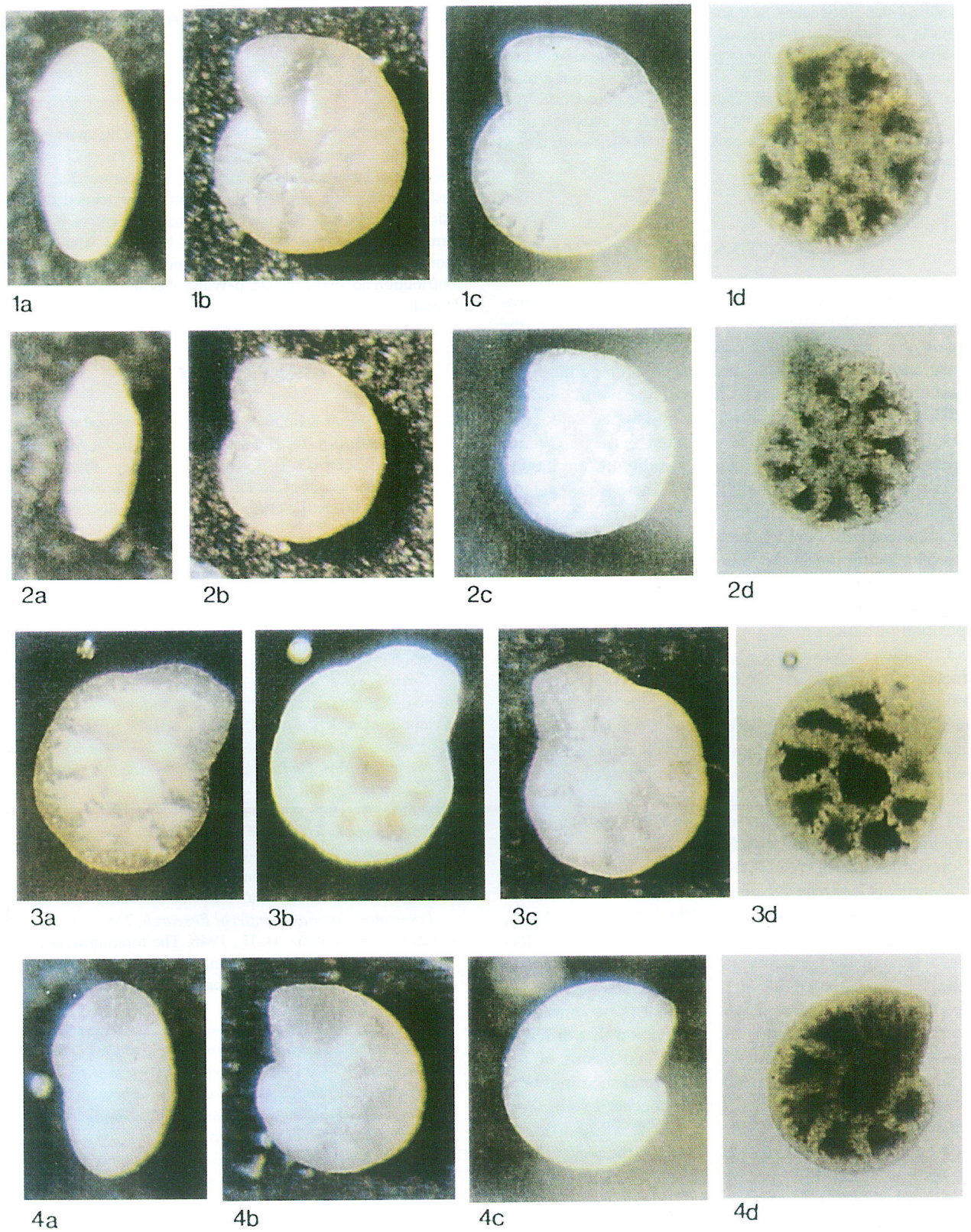

Fig. 2. *Reticulophragmium vidonioensis* Kaminski & Crespo de Cabrera. **1a-d.** Holotype (NHM PF66965); microsphaeric form: 1a, b – reflected light; 1c – immersion oil, reflected light; 1d – immersion oil, transmitted light. **2a-d.** Paratype; microsphaeric form: 2a, b – reflected light; 2c – immersion oil, reflected light; 2d – immersion oil, transmitted light. **3a-d.** Paratype (NHM PF66966); megalosphaeric form: 3a – immersion oil, reflected light; 3b – immersion oil, dark field illumination in transmitted light; 3c – reflected light; 3d – immersion oil, transmitted light. **4a-d.** Paratype; megalosphaeric form. 4a, b – reflected light; 4c – immersion oil, reflected light; 4d – immersion oil, transmitted light. All specimens photographed on a Zeiss SV-11 photomicroscope, 65x magnification

leocene of the Norwegian Sea and Central North Sea region, differs in possessing a compressed test, much higher chambers, and alveoles that are noticeably larger along the sutures. *Cyclammina schencki*, first described by Cushman (1928) from a black shale "below the Tejon Eocene sandstone at Topatopa Bluff, Ventura Co, California" differs in its much larger dimensions, more numerous chambers in the last whorl, and in its backwards arched sutures.

DISCUSSION

The finding of a new species of primitive *Reticulophragmium* in the Vidoño Formation of Venezuela illustrates the long-suspected point that the evolution of alveolar structure among the organically-cemented deep-water agglutinated foraminifera took place concurrently along several lineages, in different oceanic basins during the mid to late Paleocene. Oceanic organic productivity as indicated by the $\delta^{13}C$ ratios of pelagic carbonate was increasing steadily during the Paleocene (Corfield & Cartlidge, 1992). Increased levels of sea-floor organic flux would have resulted in enhanced oxygen minimum zones below the thermocline and low values of oxygen saturation in the deep ocean. During the middle part of the Paleocene, the Atlantic Ocean became poorly oxygenated (Mountain & Miller, 1992), resulting in the deposition of dark colored sediments in the deep basins. In the Carpathians, the upper Paleocene flysch deposits are sometimes referred to as "the black Paleocene" (Ślączka & Kaminski, 1997). If the evolution of complex avleolar structure was a morphological adaptation to life in a poorly oxygenated environment, it is reasonable to assume that this evolutionary trait would evolve independently in different species. The concurrent evolution of morphological traits in other groups of foraminifera (e.g. the Neogene planktonic foraminiferal genus *Globorotalia)* is a well-established fact.

Several studies have pointed out the polyphyletic nature of the earliest Cenozoic cyclamminids (Gradstein & Kaminski, 1989; Berggren & Kaminski, 1990; Charnock & Jones, 1997), yet the study of the group as a whole still suffers from a lack of detailed morphometric (and taxonomical) studies that would serve to document and understand the nature of its evolution. The single fact that is becoming increasingly well-established is the observation that different species have evolved in different marginal basins of the North Atlantic during the Paleocene. Several seemingly endemic species are observed in the Paleocene deltaic sediments of the Beaufort Sea (McNeil, 1997), while different species are found in the Norwegian Sea, on the west Greenland margin, and in the Caribbean region. Equally intriguing is the observation that primitive *Reticulophragmium* are apparently absent from the Scaglia Rossa of Central Italy and from the Paleocene of the Carpathian flysch basins. It is safe to assume that the evolution of alveolar structure was a localised, yet widespread response to life in the poorly oxygenated ocean of the mid Paleocene, and that this feature evolved independently among various species of *Haplophragmoides* (and *Evolutinella*, and even *Discammina*). Doubtless, if the Paleogene agglutinated foraminifera received as much scrutiny as the Paleogene planktonic foraminferal lineages, the nomenclature of these forms would be more secure.

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Streszczenie

NOWY GATUNEK O PRYMITYWNYCH CECHACH RODZAJU *Reticulophragmium* (FORAMINIFERA) Z PALEOCEŃSKIEJ FORMACJI VIDOÑO (PÓŁNOCNO-WSCHODNIA WENEZUELA)

Michael A. Kaminski & Sandra Crespo de Cabrera

We wczesnym i środkowym paleocenie miała miejsce ewolucja rodzaju *Reticulophragmium*. Prawdopodobnie rodzaj ten, o charakterystycznej alweoralnej strukturze ściany, spojonej cementem organicznym, wywodzi sie od rodzaju *Haplophragmoides* lub *Evolutinella*. Przykładem takiej formy przejściowej jednej z linii ewolucyjnych może być rodzaj *Reticulophragmoides* (Gradstein & Kaminski, 1989).

Większość dotychczas opisanych początków linii ewolucyjnych z paleocenu wśród otwornic wywodzi sie z obszarów tropikalnych. Tymczasem, w przypadku rodzaju *Reticulophragmium*, najliczniejsze obserwacje pochodzą z osadów ze środowisk Oceanu Arktycznego lub borealnej części Oceanu Atlantyckiego (McNeil, 1997; Charnock & Jones, 1997). Dane z rejonu mórz tropikalnych są rzadkie. Niniejsza praca jest ich uzupełnieniem, prezentując formę o prymitywnych cechach z tego właśnie rejonu.

Z osadów formacji Vidoño w północno-wschodniej Wenezueli opisano nowy gatunek *Reticulophragmium vidonionsis*. Gatunek *Reticulophragmium vidonioensis* n.sp. charakteryzują cechy stawiające go jako forme pośrednią pomiedzy rodzajem *Reticulophragmium* o alweolarnej strukturze i rodzajem *Haplophragmoides* nie wykazującym w budowie wewnętrznej skorupki struktury alweolarnej.

Mikrofauna otwornicowa wśród której występuje *R. vidonioensis* n.sp. pochodzi z osadów wiercenia Tala-1, niedaleko Anaco w stanie Anzoategui w Wenezueli (Fig. 1). Osady badanej formacji to ciemnoszare bezwapniste mułowce z konkrecjami syderytowymi, przeławicone drobnoziarnistymi, cienkoławicowymi glaukonitowymi piaskowcami turbidytowymi. W obszarze typowym formacji Vidoño, jej miąższość przekracza 300 m, będąc wynikiem depozycji w obrębie facji kanałowej na północnej pasywnej krawędzi północnej części płyty Ameryki Południowej (Galea-Alvarez, 1985). Sedymentacja tych osadów zachodziła w warunkach niskotlenowych. Miąższość formacji cienieje do 10 m w kierunku centralnej części stanu Anzoategui, gdzie znaczący w niej udział mają glaukonitowe piaskowce. Zaobserwowano również twarde dno z poziomem wzbogaconym w glaukonit, interpretowane jako świadectwo maximum trasgresji (Crespo de Cabrera & Pizon, 1989).

Zespół otwornic z tych osadów obejmuje przede wszystkim bentos wapienny i aglutynujący oraz słabo zachowane otwornice planktoniczne z *Morozovella angulata* i *Igorina pusilla*. Datują one te osady na poziom P3 (środkowy paleoecen). Wśród otwornic wapiennych dominują formy z rodzaju *Lenticulina*, *Gavelinella* i *Clavulinoides*. Przy takim składzie mikrofauny otwornicowej i jednoczesnym braku otwornicy wapiennej z gatunku *Gavelinella beccariiformis*, autorzy interpretują środowisko sedymentacji badanych osadów na granice strefy nerytycznej i batialnej.

Opisany nowy gatunek o prymitywnych cechach rodzaju *Reticulophragmium* ze środowiska morza tropikalnego jest według autorów jednym z dowodów, że początek ewolucji otwornic aglutynujących o ścianie spojonej cementem organicznym i alweolarnej strukturze ściany miał miejsce w środkowym i późnym paleocenie jednocześnie w różnych środowiskach morskich, rozpoczynając kilka niezależnych linii ewolucyjnych.

Proporcje $\delta^{13}C$ zmierzone w pelagicznych utworach węglanowych, wskazują na wzrost produkcji organicznej w oceanie światowym w czasie paleocenu (Corfield & Cartlidge, 1992). Wzrost materii organicznej na dnach basenów oceanicznych wiązał się z podwyższeniem granicy minimum tlenowego poniżej termokliny, związanym ze słabą cyrkulacją głębokowodną (Mountain & Miller, 1992), czego efektem była sedymentacja osadów o ciemnych barwach (porównaj facje "czarnego paleocenu" w polskich Karpatach fliszowych; Ślączka & Kaminski, 1997). Jeśli ewolucja struktury alweolarnej była morfologiczną adaptacją szkieletu otwornic do życia w warunkach o ograniczonej ilości tlenu, to uzasadniona wydaje się być możliwość jednoczesnej i niezależnej ewolucji rodzaju *Reticulophragmium* na różne gatunki. Podobny trend ewolucyjny zaobserwowano wśród innych grup otwornic, np. wśród neogeńskiego rodzaju *Globorotalia*.

Dotychczasowe badania podkreślały już polifiletyczną naturę najstarszych trzeciorzędowych cyclaminidów (Gradstein & Kaminski, 1989; Berggren & Kaminski, 1990; Charnock & Jones, 1997), jakkolwiek brak jest jeszcze odpowiedniej ilości danych morfometrycznych i taksonomicznych. Interesującym w tych rozważaniach jest fakt, że prymitywne formy z rodzaju *Reticulophragmium* nie występują w paleoceńskich facjach Scaglia Rossa, ani też nie zostały znalezione w osadach Karpat fliszowych. Autorzy wyjaśniają tą sytuację przypuszczeniem, ze struktura alweolarna rozwijała się w różny sposób w różnych środowiskach jako efekt przystosowania się do warunków ograniczonego dostępu tlenu na dnie basenów morskich, czego wynikiem było powstanie wielu nowych gatunków w obrębie rodzaju *Haplophragmoides*, *Evolutinella* i *Discammina*.