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BIOSTRATIGRAPHY OF THE BARTONIAN DEPOSITS FROM GILĂU AREA (NW TRANSYLVANIA, ROMANIA)

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Abstract. The present paper focussed on the biostratigraphy of the mollusks, larger foraminifers, benthonic and planktonic foraminifers as well as on calcareous nannofossils, identified in the Bartonian (Middle Eocene) deposits (Căpuşu Formation, Inucu Formation, Văleni Limestone and Ciuleni Formation) of the NW Transylvania region. The mollusks could be grouped in three assemblages, with the following ostrein horizons: *Pycnodonte brongniarti, Sokolowia eszterhazyi, Ostrea bersonensis* and *Cubitostrea orientalis*. The larger foraminifers are characteristic for SBZ 17 (Lower Bartonian) and SBZ 19 (Lower Priabonian) Standard Zones. The *Nummulites perforatus* Level is present in the Lower Bartonian. The benthonic foraminifers were assigned to the local biozones *Pararotalia calveze, Pararotalia subinermis* and *Pararotalia lithothamnica*. The planktonic foraminifera, identified from the upper part of the Căpuşu Formation belongs to the *Morozovella lehneri* Zone (P12). The calcareous nannofossil assemblages were assigned to the *Discoaster tani nodifer* (NP16), *Discoaster saipanensis* (NP17) and *Chiasmolithus oamaruensis* (NP18) Zones. The Lutetian/Bartonian boundary is placed just above the *Pycnodonte brongniarti* Level corresponding with the bloom of the nannofossil *Reticulofenestra tokodensis* (within the NP16 Zone). The Bartonian/Priabonian boundary could be approximated by the first occurrence of the Priabonian nummulites (bioevent placed within the NP18 Nannofossil Zone) toward the terminal part of the Ciuleni Formation.

Keywords: biostratigraphy, Mollusca, Foraminifera, Calcareous Nannofossils, Bartonian, NW Transylvania.

INTRODUCTION

The Bartonian stage was created by Mayer-Eymar in 1857 (fide Feuillée 1964), taking into account the Barton Clay (Hampshire, England), but it was defined in the Paris Basin, by the formations between Beauchamp Sands and the Marls with *Pholadomia ludensis*. Latter, in 1869, the above-mentioned author limited the stage interval, by excluding from the upper part the Pholadomia ludensis Marls. Mayer-Eymar divided the Middle and Upper Eocene in Parisian (Parisian A *sensu stricto*), Bartonian (Parisian B *sensu stricto*) and Ligurian. Hofmann (1879) and Koch (1894) used this classification for the deposits of the Paleogene of the Transylvanian Basin. The later authors assigned to the Bartonian Stage ("Bartonische Stüfe") the "Intermedia Mergel" (known today as Nummulites fabianii Level) and the so-called "Bryozoan-Schichten" or "Breder Mergel" (Brebi Marl Formation).

Abrard (1933) stated that the Bartonian covered the whole Upper Eocene and represented the septentrional time-correlative interval of the Priabonian stage (*sensu* Munier-Chlamas & de Lapparent, 1893) of the mesogean areas.

Starting with Pomerol (1964), the French authors have considered that the Bartonian, as a Superstage, included the deposits of the Auversian, Marinesian and Ludian.

For the English authors, the Bartonian corresponds to the Barton Beds as well as to the Lower Headon Beds (Curry *et al*., 1978; Curry, 1981).

According to Feuillée (1964), at least 15 different stratigraphical interpretations have been given to the Upper Eocene and 8 or 9 ones to the Bartonian, since its definition.

In order to obtain an Eocene global chronostratigraphical scale, high-resolution studies have been made also on the Bartonian stage. The geological works from the seven-decade of the last century pointed out that the English stratotype of the Bartonian stage was older than the Priabonian stage. The detailed biostratigraphical investigations, mainly carried out on the planktonic organisms, led to a Paleogene Standard Scale (Cavelier & Pomerol, 1976 a, b), in which the authors placed the Bartonian stage between the Lutetian (at the base) and the Priabonian (at the top). It should be mentioned here the surprising intuition of Munier-Chalmas & de Lapparent (1893), which already considered that the Middle Eocene is divided in the Lutetian and Bartonian stages, the Priabonian only corresponding to the Upper Eocene.

The revitalization of the studies carried out on the Bartonian stage was also influenced by the definition of a new Eocene stage in the Transylvania region: the Napocian (Bombiță, 1963, 1984). This was defined as an Upper Eocene complementary stage for the historical stratotype of the Priabonian. In Transylvania, its stratotype area, the Napocian was

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defined as covering Mortănuşa "Marls", "Leghia" Limestone and the continental deposits of "Nadăşu Continental Beds". It should be noted that the Napocian corresponds now to the upper part of the Bartonian and lower part of the Priabonian.

Gheţa (1984), accomplishing a detailed zonation based on calcareous nannoplankton, established for the first time the content of the Bartonian in the succession of the Paleogene deposits from NW Transylvania. He noted that the Bartonian included the most part of the Căpuşu Beds as well as the entire succession of the Mortănuşa "Marls". Important contribution on the Bartonian biostratigraphy were published by Mészáros et al. (1987).

The present paper critically reviews the published data on the Bartonian from the NW Transylvania region and also offers palaeontological arguments for establishing the boundaries of this stage in the stratigraphical column of the Eocene deposits. To add that the investigations carried out on several groups of organisms (mollusca, larger foraminifera, benthonic and planktonic foraminifera, as well as calcareous nannofossils), allow us to obtain an integrated biostratigraphical scheme of the Bartonian deposits from the studied area.

LITHOSTRATIGRAPHY

The first marine Paleogene sedimentary cycle follows, in NW Transylvania, the deposition of continental red beds (Jibou Formation). The marine sedimentation had begun towards the end of the Lutetian, with a pelitic succession, containing also evaporitic sequences (schizohaline waters) - the Foidaş Formation. This one is follows by the Căpuşu Formation, made up of fossiliferous marls. During the deposition time of the Căpuşu Formation, the Transylvanian shelf was already covered by shallow marine waters, populated by a large diversity of organisms (mainly benthonic ones).

The same palaeoenvironmental setting characterized the beginning of the Upper Eocene. The marine cycle ended in the Lower Priabonian, with the deposition of the Viştea Limestone, and it was followed (also during the Lower Priabonian) by a short deposition of the continental deposits of red bed type (Valea Nadăşului Formation).

The study presented herein is focussed on the Bartonian sediments from the depositional Gilău Area (as defined by Popescu *et al*., 1978). Our investigation was carried out on the most representative sections from the area situated between Huedin and Cluj-Napoca towns (around the Ciuleni, Văleni, Leghia, Căpuşu Mic, Căpuşu Mare, Gilău and Luna de Sus localities – Cluj County). The studied lithostratigraphical units, belonging to the Călata Group (Rusu, 1995a), are the Căpuşu Formation and the Mortănuşa Subgroup, represented in the region by the Inucu Formation, the Văleni Limestone and the Ciuleni Formation.

The Căpuşu Formation (Popescu, 1978) is composed by 15-25 m of sandy marls, with bioclastic limestone and marlstone intercalations. Slightly above the base of the formation, a stratiform accumulation with *Pycnodonte brongniarti* (BRONN) is present, while at the top a nummulitic lumachel with *Nummulites perforatus* (MONTFORT) could be noted (Fig.1). In the middle part of the Căpuşu Formation a ferrolitical level with limonitic oolites (5-7m in thickness) in the proximal facies and with gluconite (0.5-1m in thickness) in the distal one, could be remarked. This level is characterized by the common presence of the large-sized ostreid *Sokolowia eszterhazyi* (PÁVAY). It is followed by a nummulitic lumachelle, with a variable thickness (2 up to 10m), mainly made of *Nummulites perforatus* tests.

Notice should be taken of the transgressive character of the Căpuşu Formation. To the edge of the basin *Nummulites perforatus* Level directly overlay the basal part of the subjacent Foidaş Formation.

The palaeontological content of the Căpuşu Formation includes a rich fauna of mollusks, echinoids, foraminifers, ostracods, decapods, as well as a marine flora (calcareous nannofossils and dinoflagellates). The marine-euhaline faunas (mainly a benthonical one, of shallow water) as well as the sedimentological features of the deposits indicate as depositional palaeoenvironment the inner shelf of an open sea, with a tidal regime.

The Inucu Formation (Mészáros & Moisescu, 1991) is mainly made of fossiliferous marls, which comformably overlain the *Nummulites perforatus* bank (the top of the Căpuşu Formation). The deposits of the Inucu Formation discordantly overlay the continental red clays of the Jibou Formation, at the edge of the basin. The heterocronous character of the upper boundary of the Inucu Formation is reflected also in its variable thickness, from several cm up to 18m.

Foraminifera, mollusks and echinoids dominate the rich and diversified fauna of the Inucu Formation, entirely a marine one. The presence of *Ostrea bersonensis* (MATHERON), appearing in stratiform accumulation at the upper part of the lithostratigraphical unit it is to be noted, making a good marker level (Fig.1).

The sedimentological features as well as the palaeontological content indicate that the Inucu Formation was deposited in the shelf environment of an open sea, with normal marine waters.

The Văleni Limestone (Rusu, 1987) represents the calcareous member, predominantly arenitical, at the top of the Inucu Formation, replacing it in several areas of the former shore. The thickness of the Văleni Limestone is 1-3m, reaching 10m in the type locality. Here massive limestones, represented by

bioclastic calcarenites/calcirudites, with a reduce of micritic cement, along with fissile limestones-calcilutites/bioclastic calcarenites with a marly limestone cement, could be observed.

The bioclasts are made of benthonic foraminiferal tests, as well of fragments of bivalves, gastropods and echinoids. Foraminifers, mollusks and echinoids dominate the fauna, exclusively a marine one. Among the mollusks identified in this member the gastropod *Velates perversus* GMELIN (used in the informal name of this lithological unit: "The Velates limestone") could be mentioned, while from the echinoids the presence of *Eupatagus multituberculatus* LMK., with a larger spatial distribution, is noticeable.

Concerning the depositional palaeoenvironment, the Văleni Limestone Member was sedimented in the intertidal spaces of the inner shelf.

The Ciuleni Formation (Rusu, 1995) contains a succession of greenish-gray clays and clay marls, more and more sandy towards the top. It has a total thickness of 45m in the western part of the studied area and 75m in the eastern part. A glauconitic level (0.5m in thickness) appeared 4m above the base of the lithostratigraphical unit, but only locally, south of Luna de Sus locality.

The clays of this formation contain microforaminiferal assemblages, ostracods, calcareous nannofossils, dinoflagellates and even pollen. In the third upper part of the Ciuleni formation, a lumachellic accumulation with *Cubitostrea orientalis* (MAYER *in* PAVÁY) is present and constitutes a good marker level (Fig.1).

The fossil content of the formation indicates a shelf domain, covered by euhaline waters, with brackish episodes. The lithological and sedimentological features suggest a deepening of the basin, coeval with the intensification of the erosion from the land and the massive supply of the terigenous material.

The Ciuleni Formation is gradually passing to the Vişţea Limestone (= Leghia Limestone), also a marine formation.

BIOSTRATIGRAPHY

Our biostratigraphical studies pointed out the regional/global events of marine organisms, such as: mollusca, larger foraminifera, benthonic and planktonic foraminifera, as well as calcareous nannofossils. To note that, for the larger foraminiferal biostratigraphy, we have not made our own investigations; the data discussed herein proceeded from published papers.

Mollusks are mainly represented by bivalves and gastropods, which constitute the most numerous megafaunal group of the Shallow Paleogene from Transylvania. In the formations assigned to the Bartonian, three successive malacological assemblages, interpreted by Moisesecu et al., 1991 as local biozones, are to be noted. These are, in stratigraphical order:

The assemblage of Căpuşu Formation (Venericardia aizyensis – Sokolowia eszterhazyi Zone, Moisescu et al., 1991). As characteristical taxa are *Sokolowia eszterhazyi*[1] (PÁVAY)[1] – Figs. 1 and 2, Pl. I, *Callista heberti* (DESH.), *C. elegans* (LMK.), *C. laevigata* (LMK.), *Clava striata* (BRUG.) and *Cassidaria sulcaria* DESH. As frequency taxa *Chlamys* spp. and *Cardium* spp. could be noted, together with *Barbatia textiliosa* (DESH.), *Bicorbulla gallica* (LMK.), *Panopea oppenheimi* KOROB., *Turritella imbricataria* LMK., *Cepatia cepacea* (LMK.), *Angaria calcar* (LMK.), *Cassidaria nodosa* (SOL.), *Harpa mutica* (LMK.), *Melongena mimax* (SOL.), *M. subcarinata* (LMK.), etc.

To add that the proliferation of the ostrein taxa led to the lumachellic accumulation, which constitute good biomarkers (Rusu, 1987). Two biomarkers could be distinguished in the above-mentioned malacological assembalges: the Pycnodonte brongniarti Level (around the base of the Căpuşu Formation) and the Sokolowia eszterhazyi Level, at the middle part of the formation, several m. below the *Nummulites perforatus* bank. The accumulations of the shells of Sokolowia eszterhazyi are discontinuous and accompanied a glauconitic key-bed or its litoral equivalent, with limonitical oolites. Odin (1978) reported for this glauconite a radiometric date (K/Ar analyses) of 41.2 $^{+}_{-}$ 2.1m.a.

The assemblage of Inucu Formation, including the Văleni Limestone (Clavagella coronata – Crassostrea bersonensis Zone, Moisescu et al., 1991) is characterized by the presence of the strictly located taxa: *Ostrea bersonensis* MATHERON (Figs. 1,2, Pl.II), *Venus subaglaurae* d'ARCH., *Miltha prominensis* (OPP.), *Globularia picteti* (HÉB & RÉNEV.) and *Campanile defrenatum* GREG. As frequency taxa *Bicorbulla gallica* (LMK.), *Pelecyora incrassata* (SOW.), *Cubitostrea plicata* (SOL.), *Pycnodonte rarilamella* (MELLEV.), *Crassatella plumbea* DESH., *Turitella oppenheimi* NEWT., *Globularia patula* (LMK.), *Rimella fissurella* (LINNÉE), *Melongena subcarinata* (LMK.), *Velates perversus* GMELIN, *Terebellum sopitum* (SOL.), *Tibia goniophora* (BELL.), *T. ampla* (SOL), *Akera striatella* (LMK) could be listed among other species.

Another biomarker, the Ostrea bersonensis Level, is associated with the above-mentioned assemblage, occurring at the upper part of the Inucu Formation, just below the Văleni Limestone (Fig.1).

The assemblage of Ciuleni Formation, (Crassostrea orientalis Zone, Moisescu et al., 1991) is poorer than those identified in the two older mollusk assemblages. It is characterized by the

[1] *In our opinion, the presence of this taxon in the Inucu Formation, reported only around the Iara locality by Koch, 1894, could represent a reworking. To underline that, near Iara, the Inucu Formation transgressively overlain older formations.*

presence of strictly limited taxa *Cubitostrea orientalis* (Figs. 3,4 – Plate II) and *Trapezium alpinum* (MATHERON), while frequency taxa are, among others, *Chlamys* spp., *Cubitostrea plicata* (SOL.), *Vulsella legumen* d'ARCH., *Anomia casanovei* DESH., *Glossus isocardioides* (DESH.), *Pseudomiltha mutabilis* (LMK.), *Crasatella curata* DESH., *Fimbria lamellosa* (LMK.), *Chama subgigas* d'ORB, *Turitella imbricataria* LMK., *Globularia patula* (LMK.) and *Angaria lima* (DESH.).

The Cubitostrea orientalis Level is associated with this malacofaunal assemblage, being situated in the third part of the Ciuleni Formation, in a clay-sandy sequence.

The molluscan assemblages with Bartonian deposits with termophile taxa pointed out a water temperature nearly 25^0, corresponding to the Warm Subtropical Zone (Rusu, 1995b).

Larger Foraminifera

The oldest association identified in the NW Transylvania occurred within the lower part of the Căpuşu Formation and extends up to the top of the Văleni Limestone. This association contains the nummulites: *N. striatus* (BRUG.), *N. lunae* BOMBITA, *N. beaumonti* d'ARCH. & HAIME and *N. perforatus* (MONTF.). To note that from the sequence with large-sized nummulites (upper part of the Căpuşu Formation) Bombiță (1984) listed also other taxa, which specifical identification could need a review. In the Văleni Limestone Nummulites gizehensis (FORSKAL) and Alveolina elongata (d'ORB.) also occurred.

The above mentioned assemblage was assigned by Papazzoni & Sirotti (1995) to their Nummulites lyelli Zone, corresponding to the SBZ 17 from the Standard Zonation of Shallow Benthic (Serra-Kiell et al., 1998) - Lower Bartonian (= Biarritzian) in age.

Concerning the assembalges of the Ciuleni Formation, these contain *Nummulites striatus*, *N. perforatus* (mainly Form A) and *Alveolina elongata*. *Nummulites cf. hormoensis* NUTTALL & BRIGHTON is present only in the upper third part of the formation (Papazzoni & Sirotti, 1995). Because the index taxa defining the SBZ18 of Upper Bartonian (=Napocian) are lacking, the existence of this biozone could be only presumed.

An important change in larger foraminiferal assemblages took place towards the top of the Ciuleni Formation, where along with Bartonian nummulites, the first Priabonian ones, represented by *Nummulites garnieri* DE LA HARPE and *N. aff. chavannesi* DE LA HARPE occurred (Bombiță, 1984). Their FAD marks the base of the SBZ19 (Lower Priabonian). This biozone is better characterized by the assembalge with *Nummulites fabianii* (PREVER) and *Linderina brugesi* SCHLUMB., identified in the Vişţea Limestone.

Benthic Foraminifera

The study of the benthic foraminifers was carried out on three sections: the Şoiomu Hill (with the Căpuşu Formation) and the Malătau Hill (wih the Inucu Formation) from Văleni locality as well as the Cetătii Hill (wih the Ciuleni Formation) from Ciuleni locality.

The taxa were assigned to the local biozones, based on the *Pararotalia* species, as defined by Iva (*in* Popescu *et al*., 1978). It should be noted that the Pararotalia inermis Zone (erroneously defined) was replaced by the Pararotalia calveze Zone (defined herein).

The Pararotalia calveze Zone (Interval Zone). Definition: interval between the FO of the index species and the FO of Pararotalia subinermis. This biozone extends in the pelitical sequence of the Căpuşu Formation.

Two distinct benthic foraminifera assemblages characterized this biozone. The older one, (located in the first 2m of the section, - sample 1, below the Pycnodonte brongniarti Level) is characterized by several species restricted to this interval (from 1 – *Nonion olssoni* to 6 – *Triloculina trigonula* in Fig.2). The age of this assemblage is latest Lutetian. Other taxa with wider range are present, more frequent being *Pararotalia calveze* and *Nonion planulatum*. The younger assemblage of the biozone (encountered in the upper 7m of the section, samples 2 to 5, between the Pycnodonte brongniarti and the Nummulites perforatus Level) is characterized by *Gaudrina jacksonensis* and *Lobatula lobatula*. Other taxa with wider range are present (from 15 to 26 in Fig.2). Among them, more common are *Pararotalia audouini* and *P. inermis* (Fig.1, Pl.III). To note also the presence of Pararotalia byramensis (Fig.6, Pl.III). The assemblage was assigned to the Lower Bartonian, taking into account the nannofloral zones (see below).

The Pararotalia subinermis Zone (Interval Zone) contains the interval between the FO of the index species (sample 6, just bellow the Nummulites perforatus Level) and the FO of Pararotalia lithothamnica (sample 25, below the Cubitostrea orientalis Level). This biozone extends from the upper part of the Căpuşu Formation up to the upper third of the Ciuleni Formation. Two distinct assemblages were also observed within this biozone, related at two lithofacies. The older, extremely rich (see also Bombiță et al., 1975) is present in the Inucu Marls, being characterized by *Nonion incrassatum*, *Quinqueloculina anquina* and *Q. ludwigi*, as well as the first acme of the genus *Pararotalia* (*P. audouini* and *P. subinermis* –, Figs. 2a,b, Pl. III). The presence of *Pararotalia armata* (Fig.4, Pl. III) and *P. inermis* (with a lower frequency) should be noted. The youngest assemblage of this biozone, identified in the siltical-sandy clays of the Ciuleni Formationis dominated by agglutinated forms, is characterized by several taxa (33-45 in Fig.

2). Common are: *Ammonia propinqua* (Figs.8 a, b, Pl. III), *Nonion laeve* (Figs. 7a,b, Pl. III), *Alveolophragmium planum* (Fig.11, Pl. III) and *Haplophragmoides deformis* (Fig.10, Pl.III). This zone was assigned to the Bartonian.

The Pararotalia lithothamnica Zone (Total Range Zone). It extends in the upper third part of the Ciuleni Formation (Upper Bartonian) up to Mera Formation (Early Rupelian). Only the lower part of this biozone is present in the Ciuleni Formation, characterized by a new acme of the genus *Pararotalia* (with the taxa *P. audouini*, *P. inermis*, *P. subinermis* and *P. lithothamnica* – Figs. 3, 5 – Pl.III).

Planktonic Foraminifera

The taxa of this group have isolated occurrences and low frequency in the studied area, taking into account the depositional paleoenvironment of the investigated Bartonian deposits.

Iva (*in* Popescu *et al*., 1978) noted the presence of *Truncorotaloides rohri* (BROENNIMANN & BERMUDEZ), *Subbotina inaequispira* (SUBBOTINA), *Turborotalia convexa* (SUBBOTINA), *T. centralis* (CUSHMANN & BERMUDEZ), *Acarinina rotundimarginata* (SUBBOTINA), *A. rugosoaculeata* (SUBBOTINA) and *Igorina broedermani* (CUSHMANN & BERMUDEZ). This assemblage was erroneously assigned by her to the *Trucarotaloides rohri* Zone (P14), due to the presence of the index taxon, but which has a wider range. We found also "*Globigerina*" *medizzai* TOUMARKINE & BOLLI and *Dipsidripella hodisensis* BROTEA (1995), arguing for the Morozovella lehneri Planktonic Foraminiferal Zone (P12). The two species appeared also in several samples collected from the lower part of the Ciuleni Formation (Fig.2).

Calcareous nannofossils were investigated in the Luna de Sus and Leghia sections (analyzed also by Gheța, 1984) as well in Gilău, Văleni and Ciuleni ones. The nannofloral assemblages were assigned to the NP16-NP18 Zones of Martini, 1971.

The Discoaster tani nodifer Zone (NP16) was identified in the Căpuşu, Inucu (including the Văleni Limestone) and the lower part of the Ciuleni formations (Fig.1). The index species, *Discoaster tanii nodifer* Bramlette & Riedel, 1954) Bukry, is not present. Important biostratigraphical taxa, arguing for this zone are: *Reticulofenestra hillae* Bukry & Percival –, Figs. 7, 8, Pl. IV - and *R. umbilica* Levin – Figs. 5, 6, Pl. IV - (both species with known FO in NP16), *R. reticulata* (Gartner & Smith) Roth & Thierstein, *R. dictyoda* (Deflandre *in* Deflandre & Fert) Stradner *in* Stradner & Edwards – Fig. 16, Pl. IV -, *R. primitiva* Gheta (total range within the Lower Bartonian), *R. nanna* Gheta (FO in the Lower Bartonian), *R. bisecta* – Fig. 4, Pl. IV - (Hay, Mohler & Wade) Roth, with the known FO in NP16 (Fig. 4, Pl. IV), *R. tokodensis* Báldi-Beke – Fig.13, Pl. IV- (having a bloom in this zone) and *H. compacta* Bramlette & Wilcoxon - Fig.1, Pl. IV - (with the FO in the Lower Bartonian) as well as *Sphenolithus furcatolithoides* Locker and *Blackites gladius* (Locker) Varol –Figs. 9, 10, Pl. IV -, (both taxa having the LO within NP16). The assemblage of NP16 is moderate as diversity and it is dominated by the taxa of the *Reticulofenestra* genus (Fig.1).

The Discoaster saipanensis Zone (NP17) is present from the lower part of the Ciuleni Formation. The base of NP17 is pointed out by the FO of the index species, *Discoaster saipanensis* Bramlette & Riedel –Fig.7, Pl. IV-. To note that the nannofloral assemblage contains also: *Sphenolithus obtusus* Bukry – Figs. 14, 15, Pl. IV - *Discoaster barbadiensis* (Tan) Bramlette & Riedel – Fig. 12, Pl.IV - *Ellipsolithus calceolus* Gheta – Figs. 2, 3, Pl. IV -, *Sphenolithus predistensus* Bramlette & Wilcoxon and *S. pseudodistensus* Gheta (all three taxa with known FO in Bartonian), as well as *Neoccoccolithes dubius* Deflandre in Deflandre & Fert) Black (kown LO in the Upper Bartonian), and common *Reticulofenestra* spp.

The Chiasmolithus oamaruensis Zone (NP18) was identified in the upper part of the Ciuleni Formation. The base of NP18 is marked by the FO of *Chiasmolithus oamaruensis* (Deflandre) Hay, Mohler & Wade.

DISCUSSION

The Subcommission on Paleogene Stratigraphy of ICS (International Commission of Stratigraphy) selected the nannofossils in order to define the boundaries of the Bartonian. The lower boundary (the Lutetian/Bartonian) is defined based on the last occurrence (LO) of the nannofossil *Reticulofenestra reticulata*, while the upper one (the Bartonian/Priabonian boundary) is defined by the first occurrence (FO) of *Chiasmolithus oamaruensis* (base of the NP18 Zone of Martini, 1971). No stratotype boundary was selected for the Lutetian/Bartonian boundary so far, while for the Bartonian/Priabonian the stratotype was proposed in Italy (Umbria - Marche Region).

This Lutetian/Bartonian boundary concept is in agreement with the data of Aubry (1986), which found the LAD of *R. reticulata* within the NP16 Nannofossil Zone, in some areas of NW Europe, including the historical stratotype. The Lutetian/Bartonian boundary falls, after Berggren *et al*. (1995) in the short interval of the C19n Magnetic Chron (41.25Ma).

Perch-Nielsen (1985) noted that the FO of *R. reticulata* has regionally its limitation. In Hungary (Báldi-Beke, 1984) and in NW Transylvania (Gheta, 1984 and Melinte, herein) the LO of *R. reticulata* is younger than the NP16, surviving at least up to NP18-NP19. According to Varol (1998) the base the Lutetian/Bartonian boundary could be approximated by the FO of the nannofossil *Helicosphaera compacta* Bramlette & Wilcoxon (top of his NNTe10A

Zone), placed within the NP16 Zone of Martini (1971). Báldi-Beke (1984) noted that, in the Transdanubian deposits (Hungary), the Lutetian/Bartonian boundary is marked by the bloom of *Reticulofenstra tokodensis*.

In the investigated sections we used, in pointing out the Lutetian/Bartonin Boundary the criterion used by Báldi-Beke (1984), the bloom of the nannofossil *Reticulofenestra tokodensis* (situated within the Pycnodonte brongniarti Mollusk Horizon), in the nannofloral assemblage being present also *Helicosphaera compacta*. To add that the Lutetian/Bartonian boundary is placed, in the investigated area, at the base of the SBZ17 Larger Foraminifera Zone and in the Pararotalia calveze Benthic Foraminifera Zone, correlated with the P12 Planktonic Foraminiferal Zone. The Sokolowia eszterhazyi Mollusk Level and the Nummulites perforatus Horizon are therefore situated in the Lower Bartonian.

The Bartonian/Priabonian boundary falls, after Berggren *et al*. (1995) in the lower part of the Chron C17n (36.9Ma). The bio-event selected by ICS to indicate this boundary is the FO of *Chiasmolithus oamaruensis*.

Varol (1998) approximates the top of the Bartonian by the LO of *Chiasmolithus grandis* (Bramlette & Riedel) Radomski and/or *Neococcolithes* spp. (top of his NNTe11 Nannofssil Zone), situated within the NP18 of Martini (1971).

In the studied area, the FO of *Chiasmolithus oamaruensis* was identified around the middle part of the Ciuleni Formation. This nannofossil event is situated below the Cubitostrea orientalis Level. To note that the FO of Priabonian nummulites (including *Nummulites garnieri* and *N. aff. chavannesi* (base of the SBZ19) is situated around 15m in the stratigraphical succession of the Ciuleni Formation higher than the FO of *Chiasmolithus oamaruensis*.

To add that the Bartonian/Priabonian boundary falls, in the studied area, within the Pararotalia lithotamnica Benthonic Foraminiferal Zone.

CONCLUSION

The succession of the bio-events observed in the studied sequence of NW Transylvanian deposits is the follows:

Pycnodonte brongniarti Mollusk Horizon;

Reticulofenstra tokodensis Nannofossil Bloom – the Lutetian/Bartonian boundary;

Sokolowia eszterhazyi Mollusk Horizon;

FO of benthic foraminifera *Pararotalia subinermis*;

Nummulites perforatus Horizon;

Ostrea bersonensis Mollusk Horizon;

FO of the nannofossil *Discoaster saipanensis*;

FO of the nannofossil *Chiasmolithus oamaruensis*;

FO of the benthic foraminiferal taxon *Pararotalia lithothamnica*;

Cubitostrea orientalis Mollusk Horizon;

LO of the nannofossil *Neococcolithes dubius*;

FO of Priabonian nummulites (*Nummulites garnieri* and *N. aff. chavannesi*) – the Bartonian/Priabonian boundary.

FO of *Nummulites fabianii*.

Taking into account the biostratigraphical data, the Căpuşu Formation (without its lower part), the Inucu Formation (including the Văleni Limestone) and the Ciuleni Formation (without its upper part) are Bartonian in age.

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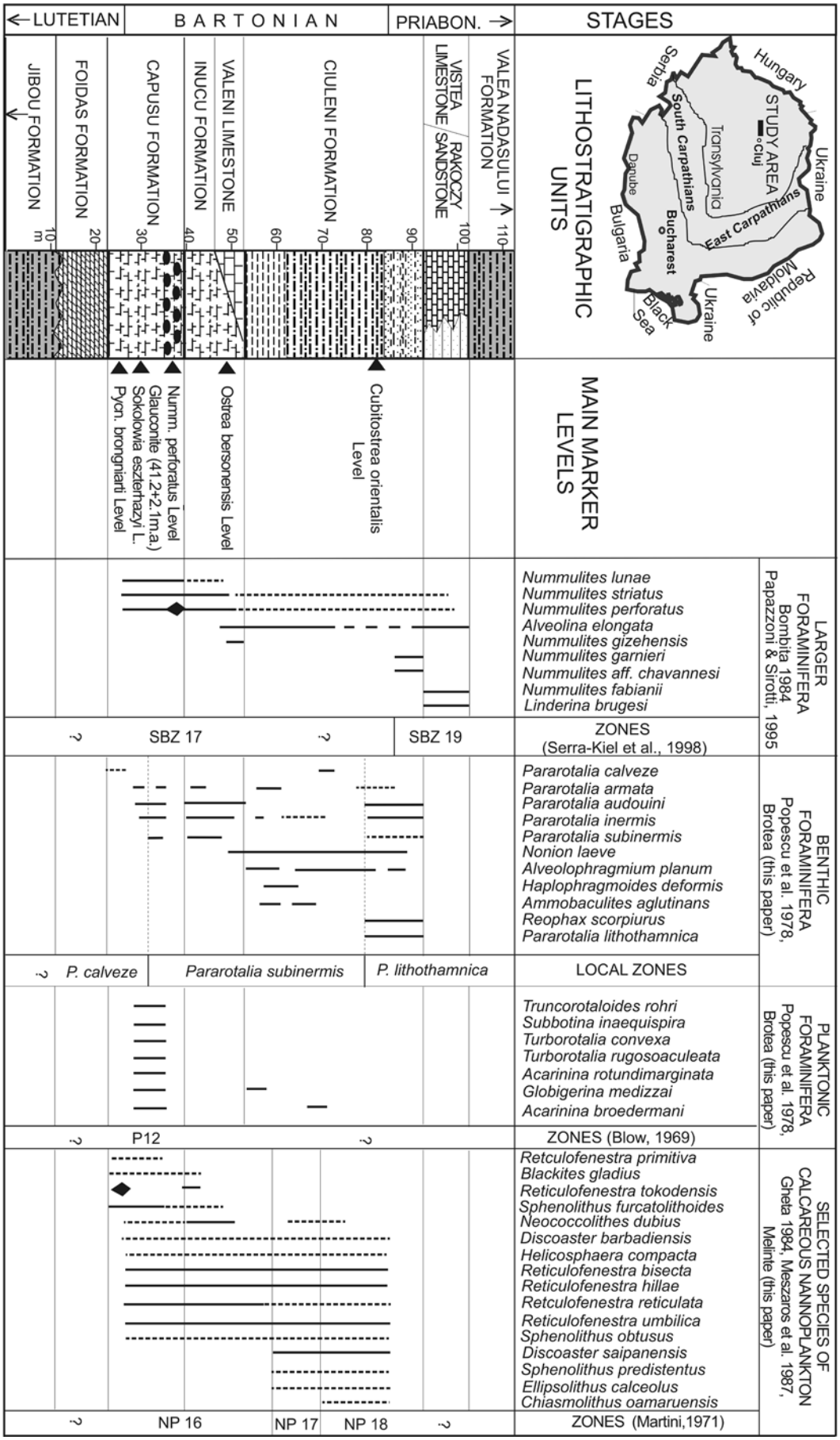

Fig.1 Biostratigraphyof the Bartonian deposits from NW Transylvania (Romania)

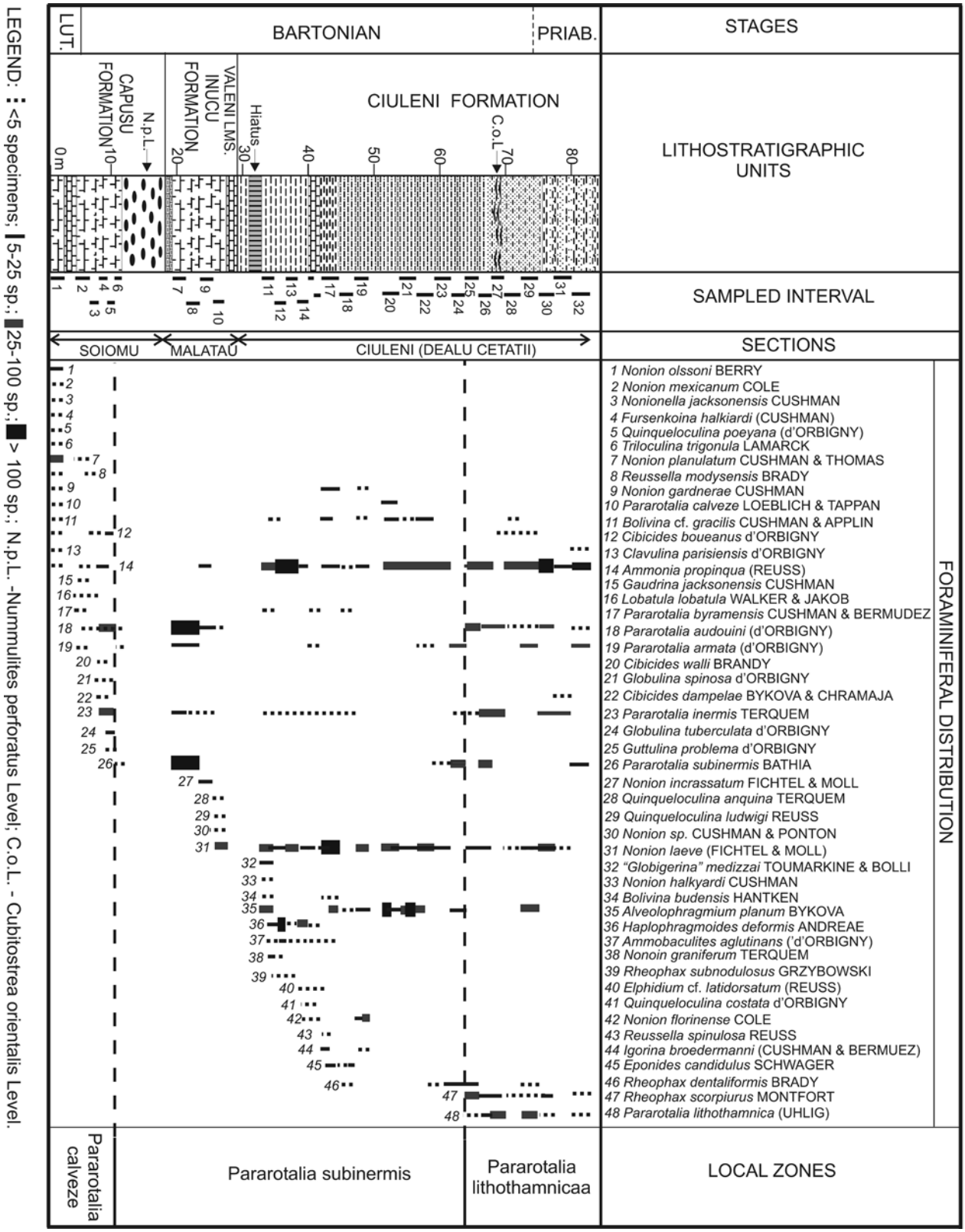

Fig. 2 Foraminiferal distribution in the Bartonian Deposits from Văleni - Ciuleni region

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PLATES

PLATE I

Figs. 1, 1a, 2. *Sokolowia esterhazyi* (PÁVAY, 1871).
Bar 1 cm

PLATE II

Figs. 1a, 1b, 2. *Ostrea bersonensis* MATHERON, 1879.
Figs. 3, 4a, 4b. *Cubitostrea orientalis* (MAYER in PÁVAY, 1871).
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PLATE III

Fig.1. *Pararotalia inermis* TERQUEM.
Figs. 2a, b. *Pararotalia subinermis* BATHIA.
Figs. 3, 5. *Pararotalia lithothamnica* UHLIG.
Fig. 4. *Pararotalia armata* d'ORBIGNY.
Fig. 6. *Pararotalia byramensis* CUSHMAN & BERMUDEZ.
Figs. 7a, b. *Nonion laeve* (FICHTEL & MOLL).
Figs. 8a, b. *Ammonia propinqua* (REUSS).
Fig. 9. *Ammobaculites agglutinans* (d'ORBIGNY).
Fig. 10. *Haplophragmoides deformis* ANDREAE.
Fig. 11. *Alveolophragmium planum* BYKOVA.

PLATE IV

LM, Scale bar for all figures 5µ.
Cross-polarized light - Figs. 1-4, 6, 8, 10, 13-16; Phase contrast light - Figs. 5, 7, 9, 11,12.

Fig. 1. *Helicosphaera compacta* Bramlette & Wilcoxon, NP16 Zone, Căpuşu Formation.
Figs.2, 3. *Ellipsolithus calceolus* Gheta 1984, NP17 Zone, Căpuşu Formation.
Fig.4. *Reticulofenestra bisecta* (Hay, Mohler & Wade, 1966) Roth, 1970, NP16 Zone, Inucu Formation.
Figs. 5-6. *Reticulofenestra umbilica* (Levin, 1965) Martini & Ritzkowski, 1968, NP16 Zone Căpuşu Formation.
Figs.7-8. *Reticulofenestra hillae* Bukry & Percival, 1971, NP16 Zone, Căpuşu Formation.
Figs. 9-10. *Blackites gladius* (Locker, 1972) Varol, 1989, NP16 Zone, Inucu Formation.
Fig.11. *Discoaster saipanensis* Bramlette & Riedel, 1954, NP17 Zone, Ciuleni Formation.
Fig.12. *Discoaster barbadiensis* (Tan, 1927) Bramlette & Riedel, 1954, NP17 Zone, Ciuleni Formation.
Fig.13. *Reticulofenestra cf. tokodensis* Báldi-Beke 1984, NP16 Zone, Căpuşu Formation.
Figs.14-15. *Sphenolithus obtusus* Bukry, 1971, NP18 Zone, Ciuleni Formation.
Figs. 16. *Reticulofenestra dictyoda* (Deflandre in Deflandre & Fert, 1954) Stradner in Stradner & Edwards, 1968, NP16 Zone, Căpuşu Formation.

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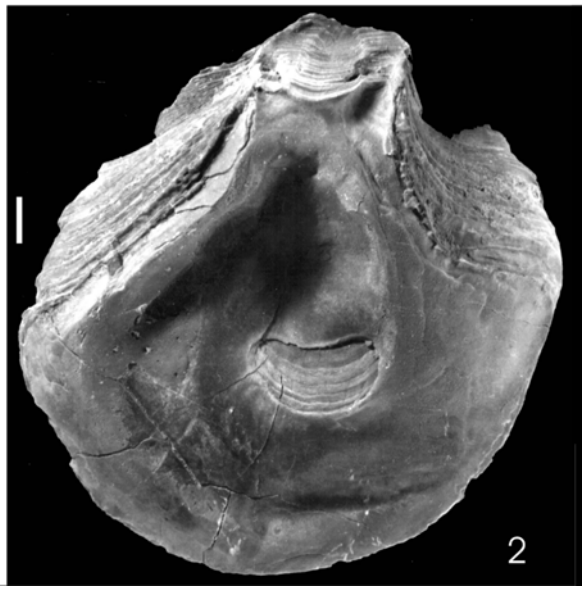
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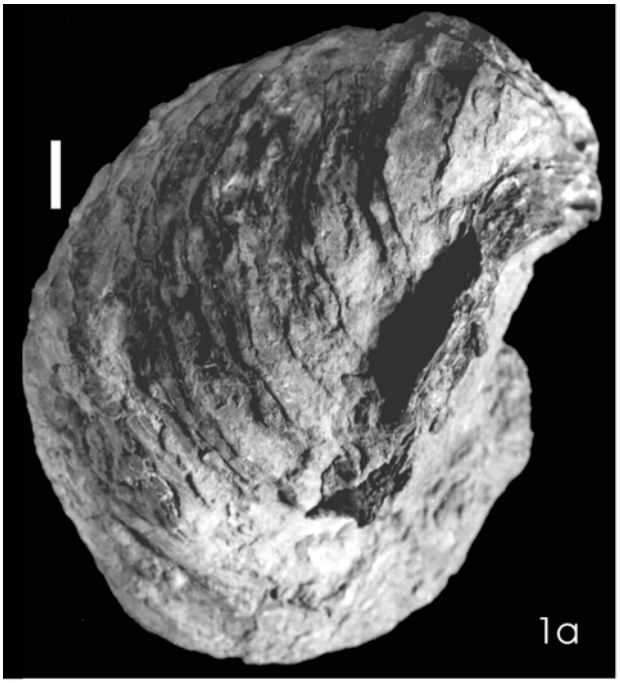
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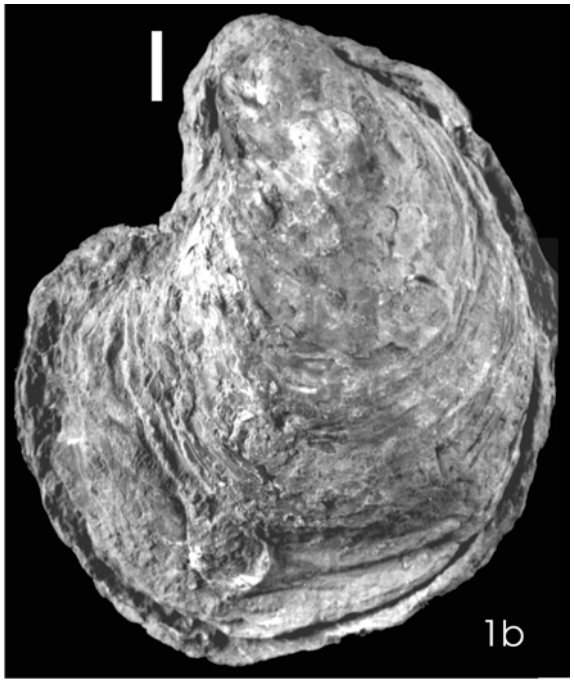
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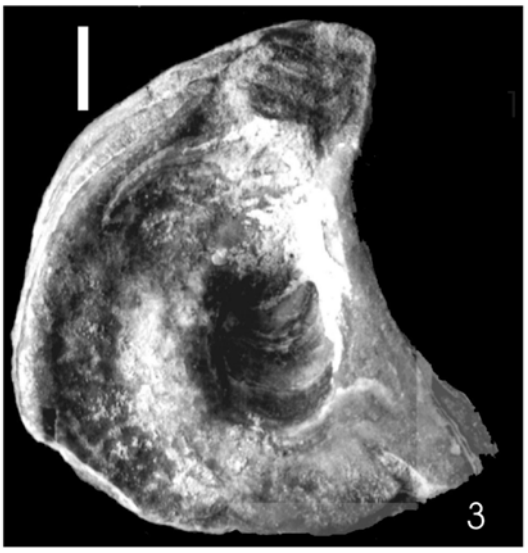
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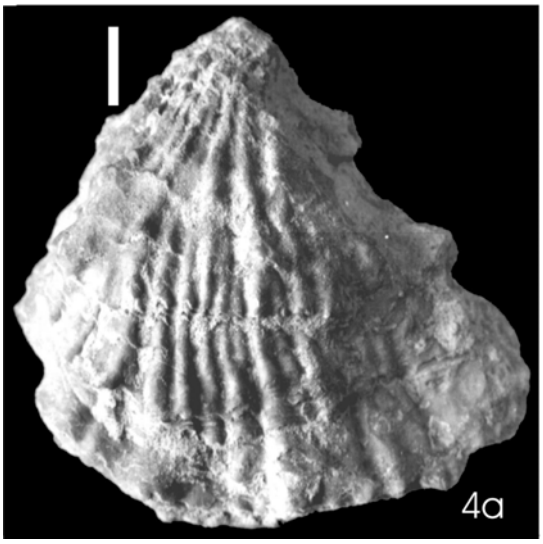
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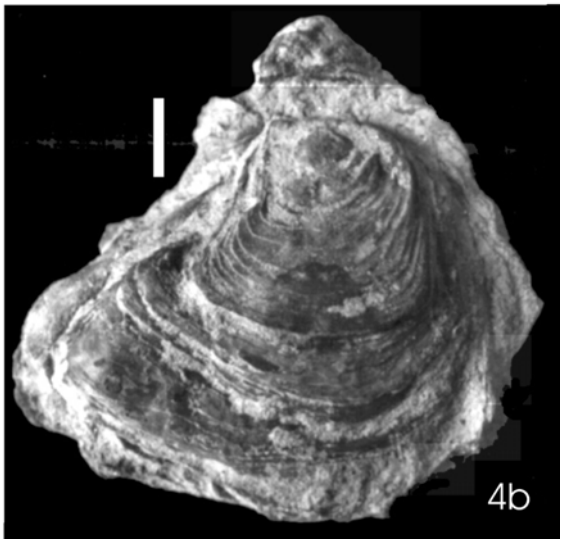
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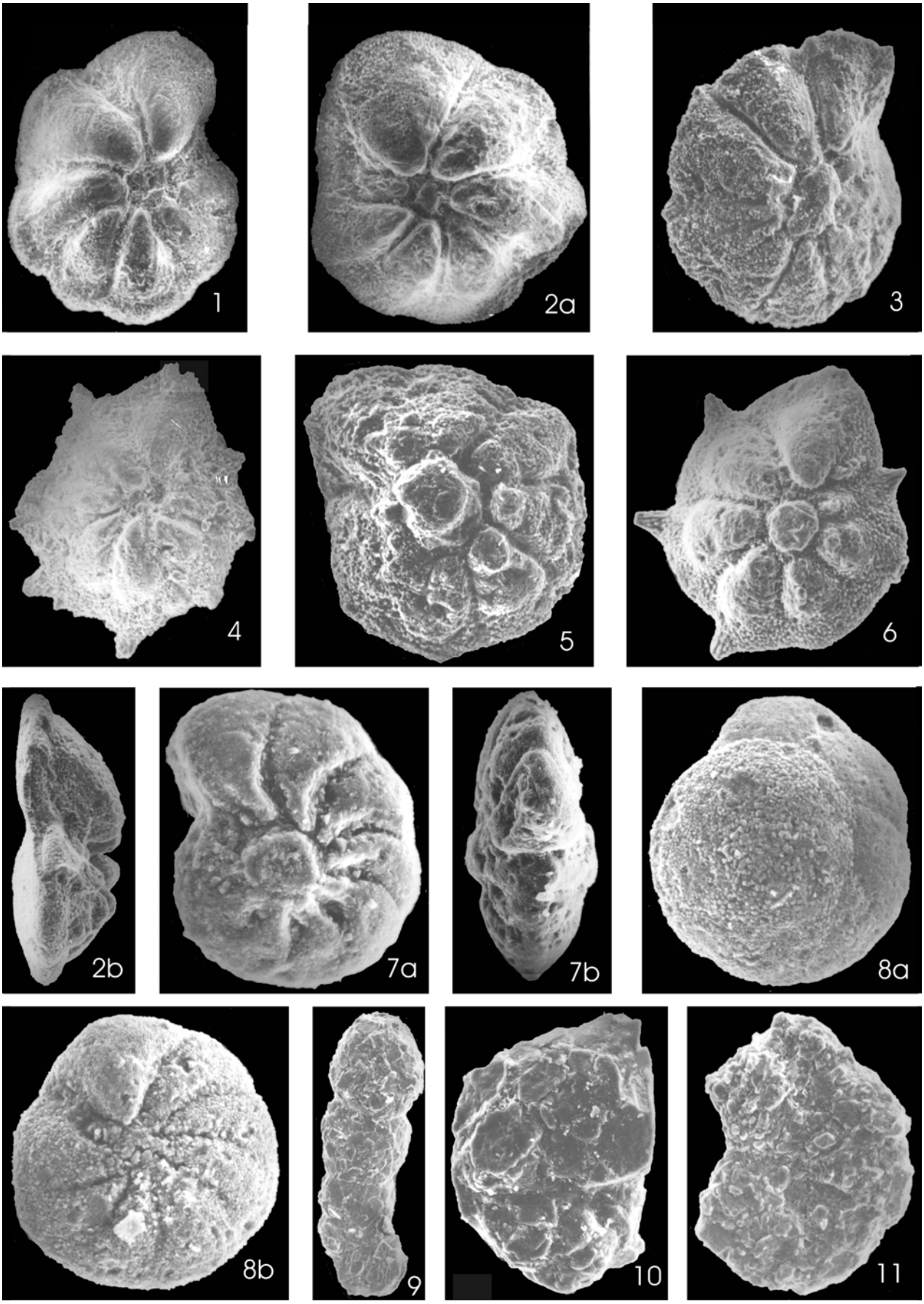
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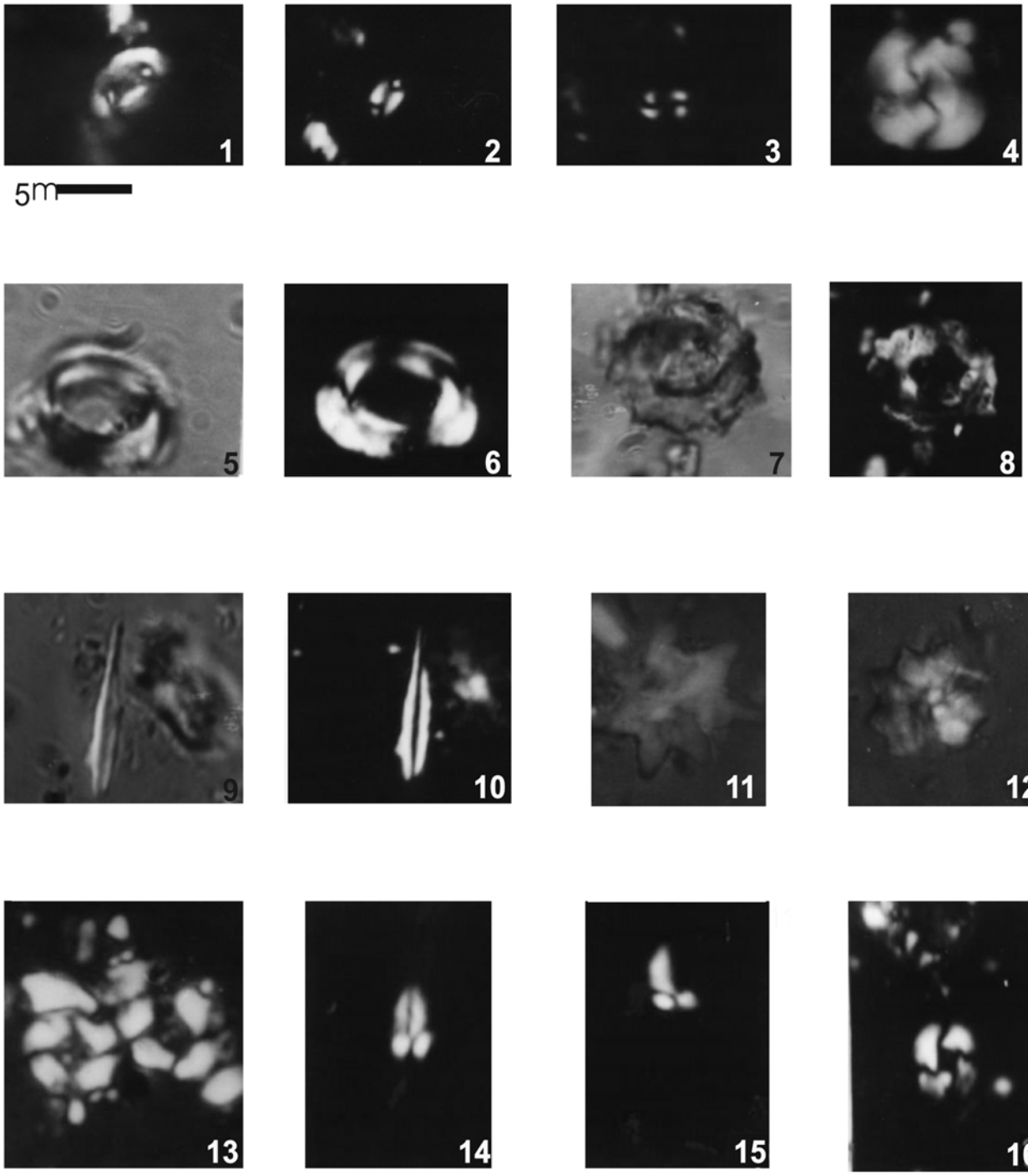
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