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Early Cretaceous Foraminifera, Algal Nodules and Calpionellids from the Lapoş Valley, Bicaz Gorges (Eastern Carpathians, Romania)

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Abstract

The Early Cretaceous (Neocomian) carbonate deposits of the Transylvanian carbonate Platform (Patrulius et al., 1976) are well-developed, with a nearly complete geological section along the Lapoş Valley, Bicaz Gorges (Eastern Carpathians), forming the *Lapoş Formation*. From this section, several foraminifera (*Anchispirocyclina lusitanica*, species of the genus *Andersenolina*, *Everticyclammina virguliana*, *E. kelleri, E. greigi*), along with new taxa – *Streptocyclammina orientalis* n. sp. (Fam. Spirocyclinidae), *Buccicrenata maynci* n. sp., *Pseudocyclammina transylvanica* n. sp. (Fam. Cyclamminidae) and *Mohlerina* n. sp. – are described. The Berriasian *Everticyclammina irregularis* (Dragastan, 1989 non 1975) is here transferred to the genus *Buccicrenata* and, thus, becomes *B. irregularis* (Dragastan, 1989) Dragastan nov. comb. Algae and algal nodules are also described from these foraminifera-bearing assemblages; their age is calibrated through correlation with the calpionellid zonation.

Keywords: foraminifera, new taxa, algae, algal nodules, calpionellids, Early Cretaceous.

Introduction

The Romanian Late Jurassic – Cretaceous deposits are well-developed in the Carpathian Realm, towards the southern part of the Moesian Platform and around the East-European Platform. The Tithonian – Neocomian deposits appear under different facies, two of which are more important, namely:

– the massive limestone with minor intercalations of limy sandstones, sponges, scleractinian corals and algal nodule-bearing biolithites, accumulated in a shelf carbonate platform, developed both in the orogenic Carpathian and in the platform realms;

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– the micrites rich in ammonites, aptychus and calpionellids, characteristic to the deeper Carpathian Trough, as well as to the central-western part of the Moesian Platform and the Ciureşti-Lom Embayment (Fig. 1).

In the Carpathian Realm, north of the Moesian Platform, two main palaeogeographic units can be separated: the Mehedinţi carbonate Platform, in the southern part of the Danubian Autochton, bordered towards the west and north-west by the Sviniţa Trough, with ammonites and calpionellid-bearing limestones, and the Getic carbonate Platform (Dragastan, 2010).

Within the central part of the Carpathian Realm, another paleogeographic unit was represented by the Transylvanian carbonate Platform (Patrulius et al., 1976). Several large blocks (olistoliths) were tectonically detached from this platform and are presently found either to the east, within the Bucovinian Basin (the Hăghimaş and Mereşti olistoliths), or to the west, within the Drocea-Trascău Basin (the Bedeleu-Cheile Turzii Nappe). The same is valid for the isolated olistoliths of Pietrele Cetii, Vulcan and Poiana Ampoiului from the Southern Apuseni Mts. Other olistoliths from the Southern Apuseni Mountains are of different origin, namely the Bihor carbonate Platform (Northern Apuseni Mts.), located north of the Mureş carbonate Platform, and west-southwest of the Transylvanian carbonate Platform.

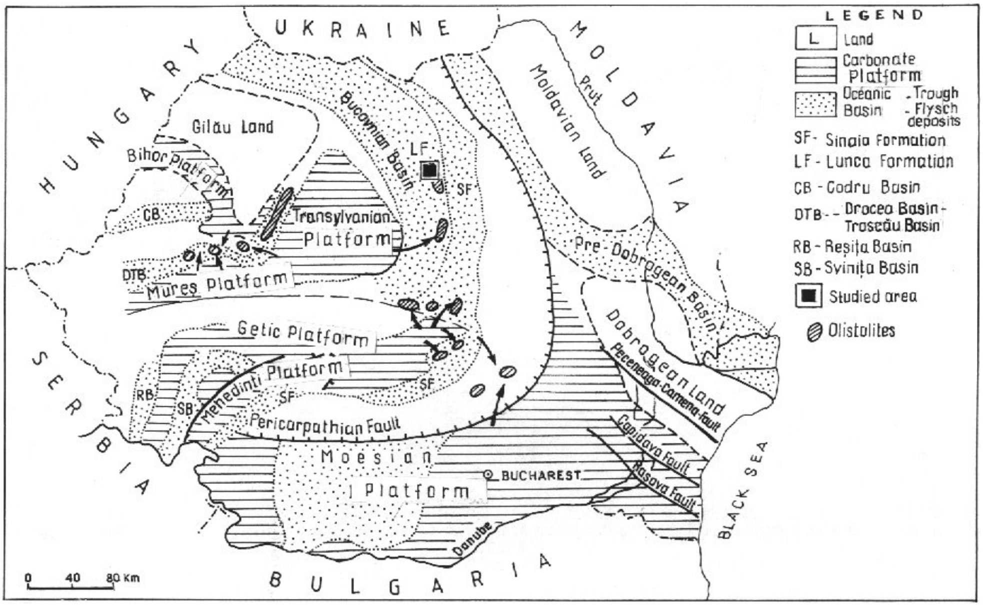

Fig. 1 Jurassic-Cretaceous shelf carbonate platforms and deep-sea basins of the Carpathians and Pericarpathias areas (after Patrulius, 1976; modified with new data).

Stratigraphy of the deposits; associated foraminifera and other microfossils

The total thickness of the Late Jurassic – Early Cretaceous deposits in the area of the Bicaz Gorges varies between 500 and 800m. Along the Lapoş Valley, the deposits belong to two different lithostratigraphic units: the *Ghilcoş Formation* (Dragastan, 1999) (Kimmeridgian – Tithonian) and the *Lapoş Formation* (Dragastan, 1999) (Neocomian). In the central part of the Bicaz Gorges

(Bardoş Mountain), where a complete section of Neocomian deposits exists, the *Lapoş Formation* can be subdivided into three informal members or subunits: SU I, SU II and SU III.

The **SU I Member** (samples 1–20) is represented by limy sandstones with limonitic concretions, marly limestones and micrites, with algal nodules in the upper part of the sequences.

The **SU II Member** (samples 21–35) contains micrites showing basal breccias and hard-grounds with cyanophyceean borings.

The **SU III Member** (samples 36–70) is made up of nodular limestones with frequent algal nodules and micrites with minor intercalations of pelsparites.

In the Lapoş Valley, the Jurassic – Cretaceous boundary was established at the base of the section, at the confluence with the Bicaz Valley, where the gray micrites contain *Crassicollaria intermedia* (Durand Delga, 1957), corresponding to the *Crassicollaria* A Zone, as well as several *Calpionella alpina* (Lorenz, 1902) and *C. elliptica* (Cadisch, 1932), which form part of the B Zone.

The Uppermost Tithonian is marked by the presence of *Anchispirocyclina lusitanica* (Egger, 1902), *Everticyclammina virguliana* (Koechlin, 1942), *Andersenolina alpina* (Leupold, 1935), *A. elongata* (Leupold, 1935) and the following calpionellids: *Crassicolaria brevis* (Remane, 1962), *C. parvula* (Remane, 1962), *Calpionella alpina* (Lorenz, 1902) and the "small lorica" of *Tintinnopsella carpathica* (Murgeanu and Filipescu, 1933), the latter being characteristic for the A3 Subzone with *Calpionella*, sensu Remane (in Cariou and Hantzpergue, 1997).

The frequent occurrence of *Crassicollaria brevis* allows the tracing of the Jurassic – Cretaceous boundary between the *Crassicollaria brevis* Subzone (Uppermost Tithonian) and the *Calpionella* Subzone (Early Berriasian), dominated by species such as *Calpionella alpina*, *Tintinnopsella carpathica* with medium-sized lorica, and *Crassicollaria parvula*.

Lithostratigraphically, in the central area of the Bicaz Gorges, the Lapoş Formation is a Neocomian unit with three distinct subunits.

Thus, **the SU I Member** has a conformable lower boundary, continuing over the deposits of the Ghilcoş Formation (here, in the Lapoş Valley, including only the Uppermost Tithonian). From base to top, this member is made up of the following lithological succession: limy sandstones with limonitic nodules, marly limestones and micrites, with a thickness of 25–30m. The basal limy sandstones contain *Neithea valanginiensis* (Pictet and Campiche) yielding inter-to-subtidal foraminiferal assemblages with *Anchispirocyclina lusitanica* (Egger, 1902) (Pl. 1, Figs. 1-7, Pl. 2, Figs. 1-6), *Everticyclammina virguliana* (Koechlin, 1942) (Pl. 3, Fig. 4), *E. kelleri* (Henson, 1948) (Pl. 1, Fig. 7) and *Earlandia inconstans* (Radoicić, 1967) (Text – Fig. 2).

In the grayish marly limestones and micrites, together with the above-mentioned taxa, *Andersenolina elongata* (Leupold, 1935), *A. delphinensis* (Arnaud-Vanneau et al., 1988) (Pl. 1, Fig. 1), as well as the rare *Pseudocyclammina lituus* (Yokoyama, 1890), *Nautiloculina broennimanni* (Arnaud-Vanneau and Peybernes 1986), *Mohlerina basiliensis* (Mohler, 1938), *Mohlerina* nov. sp., *Dobrogellina ovidi* (Neagu, 1981) and *Rumanoloculina pseudominima* (Bartenstein and Kovatcheva, 1982) can also be found.

Due to their biostratigraphic range, two foraminiferal associations can be distinguished as being characteristic for the Early Berriasian:

– *Anchispirocyclina lusitanica*, *Everticyclammina virguliana* and *E. kelleri* (Pl. 1, Fig. 7e, Pl. 4, Figs. 11-13), to which *E. greigi* (Pl. 4, Figs. 15-16) can also be added for the uppermost part of the SU I, and

– *Andersenolina elongata* and *A. delphinensis.*

From the first association, *Anchispirocyclina lusitanica* is remarkable for its morpho-structural features and stratigraphic range. The study of the topotype and of several other Mesogean populations of *A. lusitanica* carried out by Maync (1959) indicated the presence, within these populations, of the phenomenon of holotrimorphism (sensu Hofker), expressed both in the morphology of the test and in the vital processes. This trimorphism, represented by alternating generations of schizonts A – B and gamonts, was considered by Maync (1959) as a polymorphic process (the presence of different kinds of individuals within the same species).

Following Maync (1959), the two categories can be easily separated due to the more inflate-ovoidal aspect of the test in the I_2 individuals, as compared to the more flattened test of the I_1 individuals.

Paleoenvironmentally, *A. lusitanica* is a taxon characteristic for the inter-to-subtidal shelf carbonate platform.

In the Bicaz Gorges, the stratigraphical range of *A. lusitanica* starts above the *Clypeina jurassica* Zone, followed by the first Abundance Zone in the Uppermost Tithonian of the *Crassicolaria brevis* Subzone (= *Durangites – Transitorius – Microacanthum* pro-parte). Around the Jurassic-Cretaceous boundary, there is a marked drop in the number of individuals, but in the Early Berriasian the taxon displays a second Abundance Zone within the *Calpionella* Zone. The taxon became extinct in the Late Berriasian.

In conclusion, according to the data from the Lapoş section, the stratigraphic range of *A. Lusitanica* recorded two abundance zones, one in the Uppermost Tithonian, and the second in the Early Berriasian.

A similar distribution was noticed by Benest et al. (1977) in the Lamorcière area of Algeria, where, within the "*Argilles de Lamorcière*" (Late Berriasian, *Berriasiella boissieri* Zone pars), they note the following: "From the base of the formation, an opening towards the open sea is evidenced by the appearance of calpionellids, [...] while the massive influx of land-derived material from its upper part is linked to the disappearance of anchispirocyclinids and dasycladalean algae."

In the Lapoş section, this disappearance is obvious between samples 10 and 11; it does not seem to be linked to an increased terrestrial sediment influx, although the limy sandstones (samples 1 to 4) usually display a smaller number of specimens (10-18 counted on a $2cm^2$ slide), compared to the micrite and marly limestones, which contain up to 50 specimens in samples 5 to 10. No *Anchispirocyclina* specimens were recorded within the rest of the interval of the SU I (Early Berriasian), namely between samples 11 and 20.

According to Jaffrezo (1980), *A. lusitanica* represents a biozone that "has a global geographical extension, a stratigraphic range that is easily evidenced through the traditional marker fossils and, thus, represents a good index fossil, although the upper limit of the biozone is slightly fluid." The same author considers that the range of the biozone may belong to the Late Kimmeridgian, certainly comprising, in his view, the interval between the base of the "Portlandian" and the Berriasian.

A close stratigraphic range for *A. lusitanica* (Late Tithonian to Early Berriasian) was pointed out in the type locality of the Barmstein limestone, northwest of Hallein, in the Salzburg Calcareous Alps (Gawlick et al., 2005).

In the Plassen Formation from Salzkammergut, Austria, within Zone II with *Pseudocyclammina sphaeroidalis-lituus*, a Subzone IIa with *Anchispirocyclina lusitanica*, corresponding to the Middle Tithonian, was separated (Schlaginweit et al., 2005).

The second association of foraminifera, represented by *Andersenolina elongata – A. delphinensis*, has an exclusively Early Berriasian stratigraphic range. Arnaud-Vanneau et al. (1988) state that the "neotype of *A. elongata*, established in the thin sections, occurs in a locality close to one of the two localities mentioned by Leupold, and is definitively Berriasian in age."

A. delphinensis is an easily-recognizable taxon; its evolution within the Lapoş section supports the claim of Arnaud-Vanneau et al. (1988) according to which this species has an essentially Berriasian stratigraphic range, diminishing in frequency during the Late Berriasian and disappearing progressively during the Valanginian. In the Lapoş section, *A. delphinensis* disappears during the Late Berriasian.

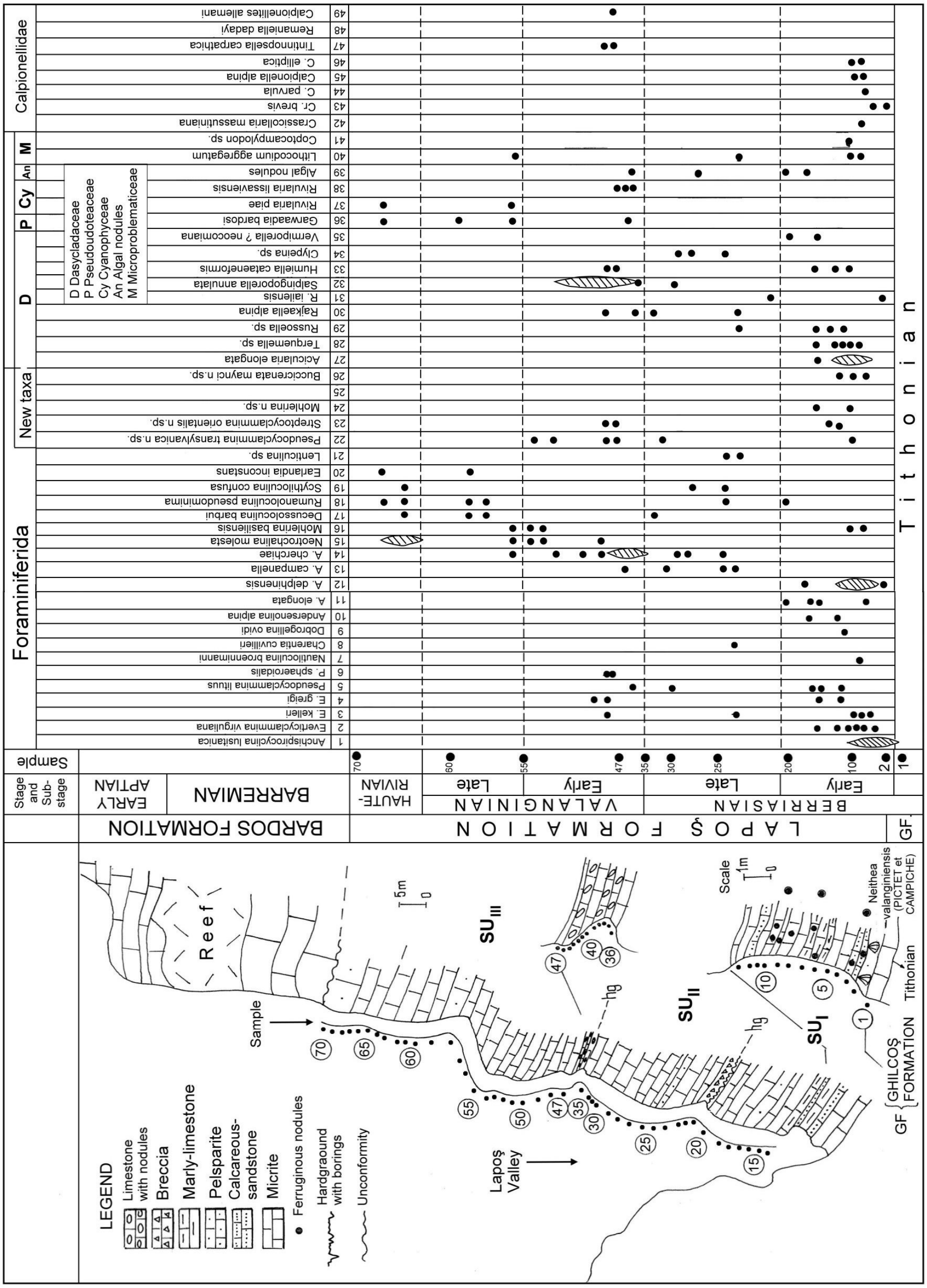

Fig. 2 Lithostratigraphy and stratigraphic range of the foraminifera, algae and calpionellids (Berriasian – Hauterivian) of Lapoş Valley, Bicaz Gorges, East Carpathians.

The Early Berriasian calcareous algae of the **SU I Member** are rather diversified; they include *Acicularia elongata* (Carozzi, 1955) – Pl. 2, Fig. 6, Pl. 4, Figs. 1-6; *Terquemella* sp. (Pl. 2, Fig. 2, 6, Pl. 4, Figs. 1-6); *Russoella* sp. (Pl. 2, Fig. 3, Pl. 4, Figs. 1-3); *Rajkaella alpina* (Dragastan, 2000) – Pl. 5, Fig. 10; *Humiella cataeneformis* (Radoicić, 1978; Masse, 1981) – Pl. 5, Fig. 6; *Vermiporella* ? *neocomiana* (Dragastan, 1978) and *Carpathoporella* sp. The *Lithocodium* algal nodules in this sequence have diameters of up to 1cm.

The basinal oceanic influences are supported by the presence of interlayers of allodapic mudstone pelagites containing the following calpionellids: *Crassicollaria massutiniana* (Colom, 1948), *C. parvula*, *Calpionella alpina*, *Tintinnopsella carpathica* and *Remaniella dadayi* (Knauer, 1964).

This assemblage corresponds to the *Calpionella* B Subzone (Remane, 1997) and to the *Calpionella* C Subzone, containing *C. elliptica*, as well (the upper section of the Early Berriasian).

The base of the **SU II Member** displays hardground crossed by borings, overlain by ferruginous crusts, followed by grayish micrites and subordinate pelsparites, suggesting a regressive trend for the sequence. The basal breccias originating from desiccation are made up of micritic intraclasts cemented with sparite-ferrouginous "melt." The basal hardground (sample 21) is interpreted as a marker for the Early Berriasian – Late Berriasian boundary.

The specific foraminiferal assemblage of this subunit includes the following: *Andersenolina campanella* (Arnaud-Vanneau et al., 1988), *Charentia cuvillieri* (Neumann, 1971), *Rumanoloculina pseudominima* (Bartenstein and Kovatcheva, 1982), *Scythiloculina confusa* (Neagu, 1985) and, rarely, *A. cherchiae* (Arnaud-Vanneau et al., 1988).

The trocholinids, represented by *Andersenolina campanella*, a species frequently found in the Late Berriasian and Valanginian, as well as by *A. cherchiae* (a rare Berriasian species), together with the miliolids *Rumanoloculina pseudominima* and *Scythiloculina confusa*, are definitely of Late Berriasian – Early Valanginian age.

Calcareous algae are less abundant, being represented by *Rajkaella iailensis* (Maslov) and *Humiella* sp. cf. *H. sardiniensis* (Ott and Flaviani, 1976), as well as rare *Lithocodium* nodules. In spite of the varied stratigraphic range of the taxa, the age of the SU II Member is Late Berriasian.

During the Berriasian and Early Valanginian, algal nodules varying in size are a remarkable presence between two levels of hardground.

The SU III Member has a transgressive lower boundary, marked by a hardground surface, while its upper boundary has a transgressive contact, which is overlain by the *Bardoş Formation* (Barremian – Early Aptian).

This sequence starts with two meters of gray nodular limestones, Early Valanginian in age (samples 36–55), followed by micrites with pelsparitic interbeds of Late Valanginian and Hauterivian age (samples 56–70). The thickness of this subunit varies between 75 and 100 meters (Fig. 2).

The foraminiferal assemblage of the Early Valanginian is dominated by the cyclamminids *Everticyclammina greigi* (Henson, 1948) – Pl. 4. Figs. 15-16, Pl. 5, Fig. 5, Pl. 6, Fig. 8; *E. kelleri* (Henson, 1948) – Pl. 4, Figs. 11-13; *Pseudocyclammina lituus* (Yokoyama, 1890); *P. sphaeroidalis* (Hottinger, 1970), and the trocholinids *Andersenolina cherchiae* and, rarely, *Neotrocholina molesta* (Gorbatchik, 1959).

The algae are represented by *Salpingoporella annulata* (Carozzi, 1953), *Rajkaella alpina* (Dragastan, 2000), *Humiella cataeneformis* (Radoicić, 1978), *Garwoodia bardosi* (Dragastan, 1985), and *Rivularia piae* (Frollo, 1938).

The species *Calpionellites allemanni* (Rehanek, 1985), with very small lorica, and *Tintinnopsella carpathica*, with large lorica, support the hypothesis of an Early Valanginian age.

The reappearance of calpionellids is suggestive for influences from the deep-sea basin. The calcareous algae are allochtonous in this assemblage.

The age of the deposits is delineated by the presence of *Calpionellites allemanni*, a small-lorica index species of the Early Valanginian, the terminal section of the *Calpionellite* Zone. The Early Valanginian alga *Salpingoporella annulata* has an Abundance Zone in association with *Calpionellites oblonga* (Le Hegarat and Remane, 1968; Dragastan, 1971, 1975, 1975a; Bassoullet and Fourcade, 1979).

The Late Valanginian (samples 56–64) is marked by a progressive reduction in the participation of trocholinid and cyclamminid species, on one hand, and by the abundance of miliolids (various species of *Decussoloculina*, *Scythiloculina* and *Rumanoloculina*), on the other.

Along with algal mats, crusts of *Lithocodium*, *Rivularia piae*, *Garwoodia bardosi* and, rarely, sphaeromicrobialites or microbial algal nodules, the increased presence of miliolids is characteristic for subtidal lagoon and patch-reef areas (Dragastan and Richter, 2003).

The dominance of miliolids, together with that of cyanophyceeans, and the exclusion of dasycladaceans, with only the rare presence of pseudoudoteacean algae, suggest frequent fluctuations in water salinity and a drop in the sea level during the Late Berriasian and the Valanginian.

The Hauterivian (samples 65–70) is dominantly micritic, with subordinate pelsparitic beds, characterized by the abundance of *Neotrocholina molesta*, a species frequently recorded in this stage. Miliolids are abundant as well, while pseudoudoteacean and rivulariacean algae are only sparsely present.

Systematic description

Order Foraminifera Eichwald 1830
Family Cyclamminidae Marie 1941
Subfamily Buccicrenatinae Loeblich and Tappan 1985
Genus *Buccicrenata* Loeblich and Tappan 1949

Buccicrenata irregularis (Dragastan, 1989 non 1975) Dragastan nov. comb.
Pl. 6, Figs. 3-5.

1975 *Everticyclammina irregularis* n. sp. Dragastan, p. 52, Pl. 53, Figs. 1-4.

A *lectotype* was designated in 1989 in the *Révue Roumaine de Géologie et Géophysique, Géologie*, t. 33, Bucharest, Pl. 53, Fig. 1, after having been initially figured and described in 1975 in the PhD thesis *Mémoires*, vol. XXI, Institut de Géologie et Géophysique, deposited in the L. P. B. IV Collection, No. 9878, sample 1067.

Type locality: sample 1067, Berriasian biosparite from the Făgetul Ciucului Massif, Bicaz Gorges, Eastern Carpathians.

Syntypes: Pl. 6, Figs. 4, 5, Coll. L. P. B. IV, No. 9879, Făgetul Ciucului Massif, Bicaz Gorges, Eastern Carpathians.

Description: The test is plan-spiral, involute, with a slight lateral compression. There is a tendency towards uncoiling in the adult stage, the test becoming straight. A sub-equatorial oblique transverse-section (Pl. 6, Fig. 3) displays a small number of chambers with irregular lumen in the plan-spiral stage, followed by a short, uncoiled and straight adult stage, made up of maximum two chambers. The passage from the plan-spiral to the uncoiled adult stage is marked by a straight suture line. The oblique transverse sections show a small number of sequential chambers and an irregular lumen. The test wall is thick, agglutinated, built up of rather large limestone clasts. The structure is alveolar. The aperture is elongated in the adult stage and placed in the terminal position within the central area (Pl. 6, Fig. 3).

Dimensions in mm: Diameter of the plan-spiral stage – between 1.60 and 1.80, maximum length – 3.20, height of the adult stage – between 1.20 and 1.40, diameter of the adult stage – 1.20, thickness of the wall – between 0.15 and 0.20.

Observations: The species *Buccicrenata irregularis* is comparable to the Albian species *B. subgoodlandensis* (Vanderpol, 1933) due to the small number of chambers in the plan-spiral stage. It differs, however, in the number of chambers during the uniseriate adult stage, having only two.

Buccicrenata maynci n. sp. has a plan-spiral stage with a smaller diameter of the chambers, as well as a different number of chambers in the adult stage. The thickness of the wall in the genus *Buccicrenata*, compared to the same parameter in the genus *Everticyclammina* (Redmond, 1964), is noteworthy. The axial section is also more inflated and globose in the former taxon.

Buccicrenata maynci n. sp.
Pl. 3, Figs. 1-3, 5.

Derivation nominis: Species dedicated to Professor Wolf Maync from the Bern University, well-known researcher in the field of benthic foraminifera.

Holotype: Pl. 3, Fig. 1, Coll. L. P. B. IV, No. 10979.

Type locality: Sample 10, Early Berriasian, in association with *Dobrogellina ovidi*, *Acicularia elongata*, *Terquemella* sp., *Russoella* sp., *Andersenolina delphinensis*, algal nodules and serpulids, Lapoş Valley, Bicaz Gorges, Eastern Carpathians.

Paratypes: Pl. 3, Figs. 2-3, 5, Coll. L. P. B. IV, No. 10980-10982, samples 4, 7, 11, Early Berriasian, Lapoş Valley, Bicaz Gorges, Eastern Carpathians.

Description: Plan-spiral, slightly laterally compressed. Test made up of 10 to 12 chambers with well-marked, irregular lumen; the lumen area is enlarged in the direction of the coiling. The chamber septae are robust and thick at the base. Usually, the uncoiled, adult stage consists of a single large convex chamber. The axial sections are globular, slightly elongated, with a reduced height of the test, a different aspect noticed in relation to the genus *Everticyclammina*. The test wall is thick, heavily agglutinated, made up of small limestone clasts. Clear alveolar structure (Pl. 3, Figs. 2-3). The elongated aperture is terminal and has a central position (Pl. 3, Fig. 3).

Dimensions in mm: Diameter of the plan-spiral stage – between 2.10–2.20, maximum length – 4.20, diameter of the proloculum – 0.140, width of the lumen in the last chamber – 1.80, height of the lumen in the last chamber – 1.00, thickness of the wall – between 0.30–0.36.

Observations: It differs from the species *B. subgoodlandensis* (Vanderpol, 1933) through the plan-spiral stage, made up of 10–12 chambers, and the adult stage, which comprises only one large, inflated chamber, and from *B. irregularis* (Dragastan, 1989) Dragastan nov. comb. through its larger size and the presence of a single chamber in the adult stage.

Genus *Anchispirocyclina* Jordan and Applin 1952
Anchispirocyclina lusitanica (Egger, 1902) Jordan and Applin 1952
Pl. 1, Figs. 1-7, Pl. 2, Figs. 1-6.

Material: Twenty-seven thin sections, samples 2 (K I), 4-5 (K III – K IV), 7 (K VI), 9-10 (K VIII – K IX), Coll. L. P. B. IV, No. 11009–11017, Early Berriasian, Lapoş Valley, Bicaz Gorges, Eastern Carpathians.

Description: Test flat, discoidal or inflate-ovoidal in shape, represented by alternating generations of schizonts A-B and gamonts (sensu Maync, 1959).

The microspherical B schizonts generally have reniform, rarely cyclic, circular and flattened tests with diameters usually varying from 4.0–6.0–10 to 18mm. The test diameter varies between 5.0–9.0 and 19mm, while the thickness ranges from 0.9 to 1.10mm. The proloculum usually has a diameter of 30µm, rarely, in the case of the largest tests, reaching 60µm. The megalospherical A schizonts have a circular, involute and cyclic test. Maync (1959) has distinguished two different kinds of individuals within the megalospheric test: I_1, with a great diameter of the test, between 0.77 and 2.20mm, and a small-diameter proloculum, of 60 to 260µm, and I_2, with a small diameter of the test, between 0.37 and 2.0mm, and a larger-diameter proloculum, of 140 to 450µm (see also Text – p. 2).

In the Lapoş Valley, the population of megalospheric *Anchispirocyclina* is characterized by a test diameter between 0.50 and 3.60mm and a proloculum diameter of 100–480µm. We consider that the proper limit between the two population categories should be traced mainly based on the diameter of the proloculum, those individuals with the proloculum diameter over 300µm being of the inflated I_2 type and the test thickness varying between 1.0 and 1.4mm.

Observations: Although Maync (1959) does not accept the existence of intermediate morphotypes within the megalospheric population (I_1 and I_2), claiming that their internal structures "seems identical", we consider that the *Anchyspirocyclina* populations display marked homeomorphism, and that a separation between the two types could be done only based on the dimension criterion.

Genus *Everticyclammina* Redmond 1964
Everticyclammina sp.
Pl. 3, Fig. 6.

Material: A specimen in the Collection L. P. B. IV, No. 11007, sample 1631, Bicăjel Massif, Bicaz Gorges, Eastern Carpathians.

Description: Test strongly involute, plan-spiral, formed of 8–10 chambers. The diameter of the plan-spiral stage is smaller than that of the chambers from the uncoiled adult stage. The septae are short. The serrated plan-spiral stage is continued by a straight, uncoiled biseriate adult stage, which contains two chambers. The wall is agglutinated, with an alveolar structure, thinner that in the case of the genus *Buccicrenata*. The aperture looks like an areal slot in the center of the last chamber.

Dimensions in mm: Diameter of the plan-spiral stage – 1.20, maximum length – 4.00, width of the chambers in the adult stage – between 1.50 and 1.65, width of the chambers in the adult stage – between 0.90 and 1.20, thickness of the wall – between 0.18 and 0.23.

Observations: *Everticyclammina* sp. resembles the Late Kimmeridgian-Tithonian *E. virguliana* (Koechlin, 1942) in the general morphology of the test, but differs from it through the serrated plan-spiral stage, the smaller diameter of the uniserial adult stage and the high chambers. The total length of the test (4.0mm) is similar to that of the *Everticyclammina virguliana* from the Early Cretaceous of Presa, Portugal (Brun and Rey, 1975). It is closer to the Early Cretaceous *Everticyclammina* species, which have smaller diameters in the plan-spiral stage and a shorter test (1.30–150mm).

Subfamily Choffatellinae Maync 1958
Genul *Pseudocyclammina* Yabe and Hanzawa 1926
Pseudocyclammina transylvanica n. sp.
Pl. 4, Figs. 7-10, 14, Pl. 6, Figs. 6-7.

Derivatio nominis: from the name of the historical region of Transylvania, Romania.

Holotype: Pl. 4, Fig. 7, Coll. L. P. B. IV, No. 10988.

Type locality: sample 10, Early Berriasian, Lapoş Valley, Bicaz Gorges, Eastern Carpathians; biomicrite with *Anchispirocyclina lusitanica*, *Acicularia elongata*, *Mohlerina basiliensis*, *Pseudocyclammina lituus* and *Everticyclammina kelleri*.

Paratypes: Pl. 4, Figs. 8-10, 14, Coll. L. P. B. IV. Nos. 10980, 10990, 11005, samples 25, 27 and 52, Lapoş Valley, Early-Late Berriasian (Abundance Zone), Early Valanginian.

Description: The test is globular, the plan-spiral is small, strongly involute. The test has a reduced number of chambers, namely 5 or 6. The septae are short and massive. The uncoiled stage is absent. The agglutinated wall contains very small foraminifera and a layer beneath the epidermis, and has a network-like structure. The hypodermis is continuous and alveolar.

Dimensions in mm: Maximum diameter between 1.30 and 2.00, maximum width between 1.20 and 1.40, thickness of the wall between 0.10 and 0.15, width of the lumen – 0.80, height of the lumen between 0.17 and 0.20.

Observations: The new species is comparable to *Pseudocyclammina sphaeroidalis* Hottinger 1970 and *P. lituus* (Yokoyama, 1890) from the Kimmeridgian-Valanginian interval, both species having globular-sphaeroidal tests. The new species differs through the ovoidal subglobose shape, the smaller dimensions of the test, the reduced number of the chambers and the thin wall.

Family Spirocyclinidae Munier-Chalmas 1887
Genus *Streptocyclammina* Hottinger 1967
Streptocyclammina orientalis n. sp.
Pl. 3, Figs. 7-11.

Derivatio nominis: after the location of the type locality in the Eastern Carpathians.

Holotype: Pl. 3, Fig. 8, Coll. L. P. B. IV, No. 10983.

Type locality: sample 11, No. 10983, Early Berriasian, micrite with *Anchispirocyclina lusitanica*, *Acicularia elongata*, *Mohlerina basiliensis* and *Everticyclammina virguliana*, and the following calpionellids: *Crassicollaria parvula*, *Calpionella alpina*, *C. elliptica* and *Remaniella dadayi*, Lapoş Valley, Bicaz Gorges, Eastern Carpathians.

Paratypes: Pl. 3, Figs. 7, 9-11, Coll. L. P. B. IV, Nos. 10984, 10985, 10986, 10987, Early Berriasian, Bicăjel Valley and Lapoş Valley, Bicaz Gorges, Eastern Carpathians.

Description: The test is strepto-spiral in the early stage, having two or three chambers. The proloculum is very small and spherical. The adult stage is plan-spiral, built up of 4–5 arched chambers. The spires show a tendency towards widening. The last chamber has an eccentric position (Pl. 3, Fig. 10) and is very large, covering the previous chambers (Pl. 3, Fig. 8). The wall is thin, finely agglutinated and there is a network-structured layer below the epidermis. The end of the skeleton is made up of massive perforated septae. The last chambers display local, short pillars. The axial section is ellipsoidal, slightly flattened, with the last chamber in eccentric position. The aperture is cribrated.

Dimensions in mm: Diameter of proloculum – between 0.025 and 0.037, maximum diameter of the equatorial section – between 2.10 and 2.40, width of the test – between 1.30 and 1.50, thickness of the wall – between 0.070 and 0.090.

Observations: The morphology of *Streptocyclammina orientalis* n. sp. is close to that of *S. parvula* (Hottinger, 1967) and *S. muluchensis* (Hottinger, 1967) from the Kimmeridgian-Tithonian deposits. The new species differs from the other species through a very small proloculum and the small strepto-spiral coiling, followed by a large peneropliform involute coiling. It is comparable to *S. hottingeri* (Schlagintweit et al., 2005) through the small plan-spiral to strepto-spiral coiling, but it differs from it through the absence of the uncoiling uniserial straight stage. Another difference is the stratigraphic range of *S. hottingeri* – Late Tithonian. Moreover, the new species differs from all the species of *Streptocyclammina* due to the accentuated eccentricity of the last chamber, evident in the axial longitudinal section.

Family Spirillinidae Reuss and Fritsch 1861
Genus *Mohlerina* Bucur et al. 1996
Mohlerina n. sp.
Pl. 4, Figs. 17-18.

Material: Specimens from two thin sections, sample 10, Coll. L. P. B. IV, No. 10994, Early Berriasian, Lapoş Valley, Bicaz Gorges, Eastern Carpathians.

Description: The test is ovoidal, slightly compressed laterally. The proloculum is very small. The test is in the early biserial stage, containing four to five chambers (Pl. 4, Fig. 17). The biserial stage is followed by a uniserial stage, composed of three chambers disposed on the vertical axis. Finally, the test presents a better-developed flabelliform stage (Pl. 4, Figs. 17-18), disposed relatively eccentrically in relation to the vertical axis.

Dimensions in mm: Height of the test – between 1.90 and 2.00, width of the test – between 1.70 and 1.80, width of the biserial stage – between 1.0 and 1.10, diameter of the proloculum – between 0.50 and 0.60, maximum width of the flabelliform stage – between 1.50 and 1.65.

Observations: This taxon is only provisionally assigned to the genus *Mohlerina* (Bucur et al., 1966), as its inner structure differs from that of the species of this genus. The inner structure of the test and of the wall is also different from that of the species of the genus *Conicospirillina* (Cushman, 1927).

It is also possible that this taxon belongs to the family *Lagenidae*, subfamily *Polymorphininae*.

Incertae sedis
Foraminifera „X“
Pl. 6, Figs. 1-2.

Material: Pl. 6, Figs. 1-2, Coll. L: P. B. IV, samples 1744 and 1794, Nos. 11008, 11009, Berriasian, micrite with *Crassicollaria parvula* and *Calpionella elliptica*, Bicăjel Massif, Bicaz Gorges, Eastern Carpathians.

Description: The test is cylindro-conical, having a megalospheric proloculum. The proloculum is followed by a short plan-spiral stage, followed, in turn, by an ortho-cylindrical, slightly conical adult stage. The latter contains three to four chambers, having a tendency towards trocho-spiral coiling. The wall is finely agglutinated, with a non-perforated epidermis. The exoskeleton, with its septulae, shows a widely alveolar structure.

Dimensions in mm: Length of the test – between 3.00 and 4.60, maximum diameter between – 1.20 and 1.54, diameter of the proloculum – between 0.53 and 0.56.

Observations: The structure of the test has a reminiscent habitus, which reminds of the genera *Haurania* (Henson, 1948) (Spirocyclinidae) and *Amijella* (Loeblich and Tappan, 1915) (Cyclaminidae). The absence of the endoskeletal pillars differentiates it from the former, while it shares this characteristic with the latter.

Genus *Torinosuella* Maync 1959
Torinosuella peneropliformis (Yabe and Hanzawa, 1926) Maync 1959
Pl. 5, Fig. 7.

Material: Pl. 5, Fig. 7, sample 1732, Coll. L. P. B. IV, No. 11001, Early Berriasian, Bicăjel Valley, Bicaz Gorges, Eastern Carpathians.

Description: The available oblique-axial and tangential sections show an initial plan-spiral coiled stage, followed by a small part of an uncoiled, peneropliform adult stage.

Observations: The stratigraphic range of the species was defined by Neumann (1967) as Kimmeridgian-Hauterivian. In the Bicăjel Valley of the Bicaz Gorges, it was found in the calpionellid-bearing Early Berriasian (*Calpionella* B Sub-Zone). This is the first record of the taxon in the Romanian Carpathians.

Class Chlorophyceae Decaisne 1842
Order Dasycladales Pascher 1931
Family Dasycladaceae Kützing 1843
Genus *Rajkaella* Dragastan and Bucur 1988
Rajkaella alpina Dragastan 2000
Pl. 5, Fig. 10.

Topotype: Pl. 5, Fig. 10, samples 1732, Coll. L. P. B. V, No. 1183, Late Berriasian, Bicăjel Valley, Bicaz Gorges, Eastern Carpathians.

Description: An oblique-transverse section in isolated primary and secondary ramifications. The primary ramifications are long, cylindrical, continued at the distal end by a small, short ellipsoidal secondary ramification.

Dimensions in mm: Length of the primary ramifications – between 0.30 and 0.35, diameter of the primary ramifications – between 0.070 and 0.090, length of the secondary ramifications – between 0.045 and 0.050.

Observations: *Rajkaella alpina* has a stratigraphic range encompassing the Berriasian and the Valanginian and was discovered in the Ghilcoş Massif, Bicaz Gorges. It was also found in the Bicăjel Valley, but in the Late Berriasian, in association with calpionellids.

Genus *Humiella* Sokac and Velic 1981
Humiella cataeneformis (Radoicić, 1978) Masse 1981
Pl. 5, Fig. 6.

Material: Pl. 5, Fig. 6, sample 48, Coll. L. P. B. V, No. 1184, Early Valanginian, Lapoş Valley, Bicaz Gorges, Eastern Carpathians.

Description: Isolated calcitic spherical ramifications. The walls of the ramification present small, sometimes confluent, pores.

Observations: In the Carpathians, the species of the genus *Humiella* are rarely recorded (Dragastan, 1989).

Algal nodules
Pl. 5, Figs. 1-6, 8.

Material: A hundred algal nodules detached from the rocks, rarely found in the Early Berriasian and frequently with maximum peak in the Early Valanginian, Lapoş Valley, Bicaz Gorges, Eastern Carpathians.

Description: The nodules have spheroidal or elongated shapes. The surface of the nodules varies from smooth to tuberculate and is crossed by grooves and holes (Pl. 5, Figs. 1-3). In the axial-longitudinal sections (Pl. 5, Fig. 1), the shape is irregular-elongated, including some pelloids and holes. In the sub-axial longitudinal sections, the shape is also elongated and irregular, but very narrow (Pl. 5, Figs. 2-3). The transverse sections display a shape that is either rounded-ovoidal or circular (Pl. 5, Figs. 4-5). The inner microfabrics of the nodules are not built up of regular laminae; instead, they are made up of agglutinated material such as pelloids, small microbial cells or biofilms crossed by non-laminar irregular fenestrae. Sometimes, the algal nodules display a very narrow perforated wall as an aspect of the alga *Thaumatoporella* (Pl. 5, Fig. 1).

The microbial film could be produced by cyanobacteria as a dominant component of gelatinous colloform mats (Golubic, 1992), and by marine bacteria, such as the recent *Alteromonas*, which produces aggregated or diffused cells (Decho, 2000), as in the case of the nodules from the Bicaz Gorges.

Recently, Reid et al. (2003) showed that unlaminated micrite, as in case of algal nodules (sphaeromicrobolites) from the Lapoş Valley, "is characterized by dense micrite and irregular fenestral fabrics; the initially banded structure is altered to an unlaminated fabrics by partial infilling of pore spaces between the original laminae." The bioclasts and ooids in the unlaminated micrite are incorporated, being micritized and losing their initial origin.

Moreover, regarding the building of the nodules, Golubic et al. (2000) stated that "the cyanobacterians, the oldest oxygenic phototrophs (...) made the most significant impact on the sediment and on the fossil organo-sedimentary structures." Due to their shape, dimensions and inner structures (microfabrics), this type of algal nodules are considered subtidal, growing in the deep inter-channel subtidal environments.

Dimension in mm: Maximum length of the nodules – between 1.90 and 6.30, diameter of the nodules – between 2.00 and 3.35, and thickness of the wall – between 0.025 and 0.030.

Observations: The nodules occur rarely in the Early Berriasian, but frequently in the Early Valanginian, in association with *Rajkaella iailensis* (Maslov) (Dragastan and Bucur, 1998), also cited within the stratigraphic range from the Late Berriasian – Hauterivian in the Berdiga Limestone of Kircaova, Turkey (Bucur et al., 2000) or, rarely, together with *Salpingoporella annulata* (Carozzi 1955), in the Valanginian of the Ghilcoş Massif, Bicaz Gorges.

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PLATE CAPTIONS

Plate 1

Fig. 1 *Anchispirocyclina lusitanica* (Egger, 1902) Maync 1959 (A) equatorial section through the proloculum. Megalospheric morph (M) and *Andersenolina delphinensis* (Arnaud-Vanneau et al., 1988) (T), sample 2 (k I).
Figs. 2-6 *Anchispirocyclina lusitanica* (Egger, 1902) Maync 1959, 2, 4-6: axial sections through the proloculum. Megalospheric morphs (M), samples 4, 5 (k III, k IV). 3: axial section in megalospheric (M) and microspheric (m) morphs, sample 5 (k IV).
Fig. 7 *Anchispirocyclina lusitanica* (Egger, 1902) Maync 1959 and *Everticyclammina kelleri* (Henson, 1948) Banner and Simmons (e). Transverse and oblique transverse-sections through the proloculum. Microspheric morph (m), sample 7 (k IV).
Figs. 1-7 Early Berriasian, Lapoş Valley, Bicaz Gorges, Eastern Carpathians. All figures x25.

Plate 2

Figs. 1-6 *Anchispirocyclina lusitanica* (Egger, 1902) Maync 1959. 1: equatorial section through the proloculum of microspheric morph (m), sample 7 (k VI); 2: oblique transverse section through the proloculum of microspheric (m) morph and *Terquemella* sp. (t); 3: oblique transverse section through the proloculum of microspheric (m) morph and *Russoella* sp. (r); 4-5: transverse and oblique sections through the proloculum of microspheric (m) morphs, showing the alveolar calcareous test wall; 6 – transverse section through the proloculum of microspheric (m) morph, *Acicularia elongata* Carozzi 1955 (a) and *Terquemella* sp. (t); the microspheric test shows the alveolar calcareous test wall, samples 2, 7, 9, 10 (k I, k VI, k VIII, k IX).
Figs. 1-6, Early Berriasian, Lapoş Valley, Bicaz Gorges, Eastern Carpathians. All figures x25.

Plate 3

Figs. 1-3, 5 *Buccicrenata maynci* n. sp. and *Anchispirocyclina lusitanica* (Egger, 1902) Maync 1959, megalospheric morph (A); 1: Holotype, equatorial section; 2-3, 5: Paratypes. 2: oblique transverse section; 3, 5: axial and oblique axial sections.
Fig. 4 *Everticyclammina virguliana* (Koechlin, 1943) equatorial section, sample 11.
Fig. 6 *Evertcyclammina* sp., equatorial section, sample 1631.
Figs. 7-11 *Streptocyclammina orientalis* n. sp. 8: Holotype, equatorial section, sample 11; Paratypes, 7, 9-11, equatorial sections, sample 2; 9-11; axial and oblique axial sections, sample 2 and sample 3.
Figs. 1-5, 7-11Early Berriasian, Lapoş Valley; Fig. 6 Tithonian, Bicăjel Valley, Bicaz Gorges, Eastern Carpathians. All figures x25.

Plate 4

Figs. 1-6 *Acicularia elongata* Carozzi 1955 (a) and *Terquemella* sp. (t), sample 9, Early Berriasian.
Figs. 1-3 *Russoella* sp. (Koechlin, 1943) (r), sample 9, Early and Late Berriasian.
Figs. 7-10, 14 *Pseudocyclammina transylvanica* n. sp.; 7: Holotype, equatorial section, sample 10; 8-10, 14: Paratypes. 8: axial oblique section, sample 32, Late Berriasian; 9: equatorial oblique section, sample 3, Early Berriasian; 10, 14: oblique axial sections, sample 24, Late Berriasian and sample 52, Early Valanginian.
Figs. 11-12 *Everticyclammina kelleri* (Henson, 1948) Banner and Simmons, equatorial and oblique equatorial sections, sample 48, Early Valanginian and sample 10, Early Berriasian.
Fig. 13 *Everticyclammina kelleri* (Henson, 1948) Banner and Simmons and *Neotrocholina molesta* (Gorbatchik, 1959) Neagu 1994 (N), sample 48, Early Valanginian.

Figs. 15-16 *Everticyclammina greigi* (Henson, 1948) Banner and Simmons; 15: equatorial section, sample 48, Early Valanginian; 16: axial section, sample 10, Early Berriasian.

Figs. 17-18 ? *Mohlerina* n. sp.; 17 holotype: axial section, sample 10, Early Berriasian; 18: paratype axial section, sample 15, Early Berriasian.

Figs. 19-21 *Mohlerina basiliensis* (Mohler) Bucur et al., 1996.

Figs. 1-18, 21 Lapoş Valley; Figs. 19, 20 Bicăjel Massif, Bicaz Gorges, Eastern Carpathians. All figures x25.

Plate 5

Figs. 1-6, 8 Algal nodules with spheroidal or elongated shapes and smooth or tuberculate surface crossed by holes and grooves; 1-3: axial sections in different planes of the nodules; 5, 8: transverse sections, Early Berriasian; 4, 6: oblique transverse sections, Early Valanginian.

Fig. 5 *Everticyclammina greigi* (Henson, 1948) (E) and algal nodule (A), Early Valanginian.

Fig. 6 *Humiella cataeneformis* (Radoicić) Masse (H) transverse section in detached ampoule ramification, Early Valanginian.

Fig. 7 *Torinosuella peneropliformis* (Yabe and Hanzawa, 1926) Maync 1959. Differently oriented section, sample 1732, Early Berriasian.

Fig. 9 *Pseudocyclammina sphaeroidalis* Hottinger 1967, equatorial section, sample 1723, Early Valanginian.

Fig. 10 *Rajkaella alpina* Dragastan 2000, oblique transverse section in the cylindrical primary ramifications and small secondary ramifications, sample 1732, Late Berriasian.

Fig. 11 *Rivularia kurdistanensis* (Elliot, 1957) Dragastan 1985, sample 1753, Valanginian.

Figs. 1-6, 8 Lapoş Valley; Figs. 7, 9-10 Bicăjel Valley; Fig. 11 Bicăjel Massif, Bicaz Gorges, Eastern Carpathians. All figures x 25.

Plate 6

Figs. 1-2 *Foraminifera* "*X*" 1: axial-longitudinal section through the proloculum; megalospheric morph, sample 1744, Berriasian, Bicăjel Massif, Bicaz Gorges, Eastern Carpathians; 2: subaxial section, showing a largely labyrinthical structure, sample 1794, Berriasian, Bicăjel Massif, Bicaz Gorges, Eastern Carpathians.

Figs. 3-5 *Buccicrenata irregularis* (Dragastan, 1989 non 1975) Dragastan nov. comb.; 3: Lectotype, oblique section, sample 1067, Berriasian, Făgetul Ciucului Massif, Bicaz Gorges, Eastern Carpathians; 4-5: Paratypes, oblique transverse sections, sample 1067, Berriasian, Făgetul Ciucului Massif, Bicaz Gorges, Eastern Carpathians.

Figs. 6-7 *Pseudocyclammina transylvanica* n. sp.; Paratypes, samples 37, 52, Early Valanginian, Lapoş Valley, Bicaz Gorges, Eastern Carpathians.

Fig. 8 *Everticyclammina greigi* (Henson, 1948), sample 48, Early Valanginian, Lapoş Valley, Bicaz Gorges, Eastern Carpathians. All figures x25.

Plate 1

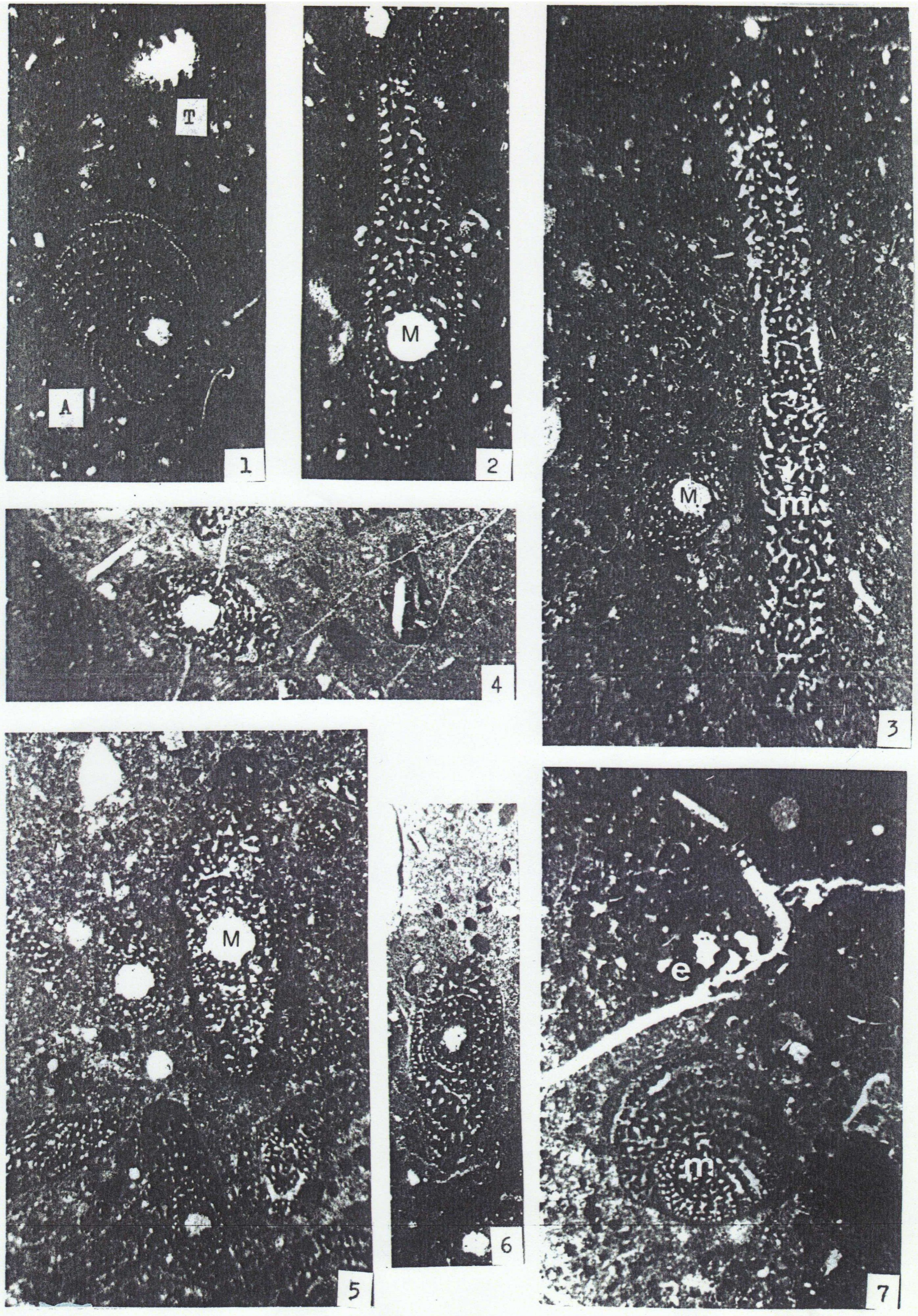

Plate 2

Plate 3

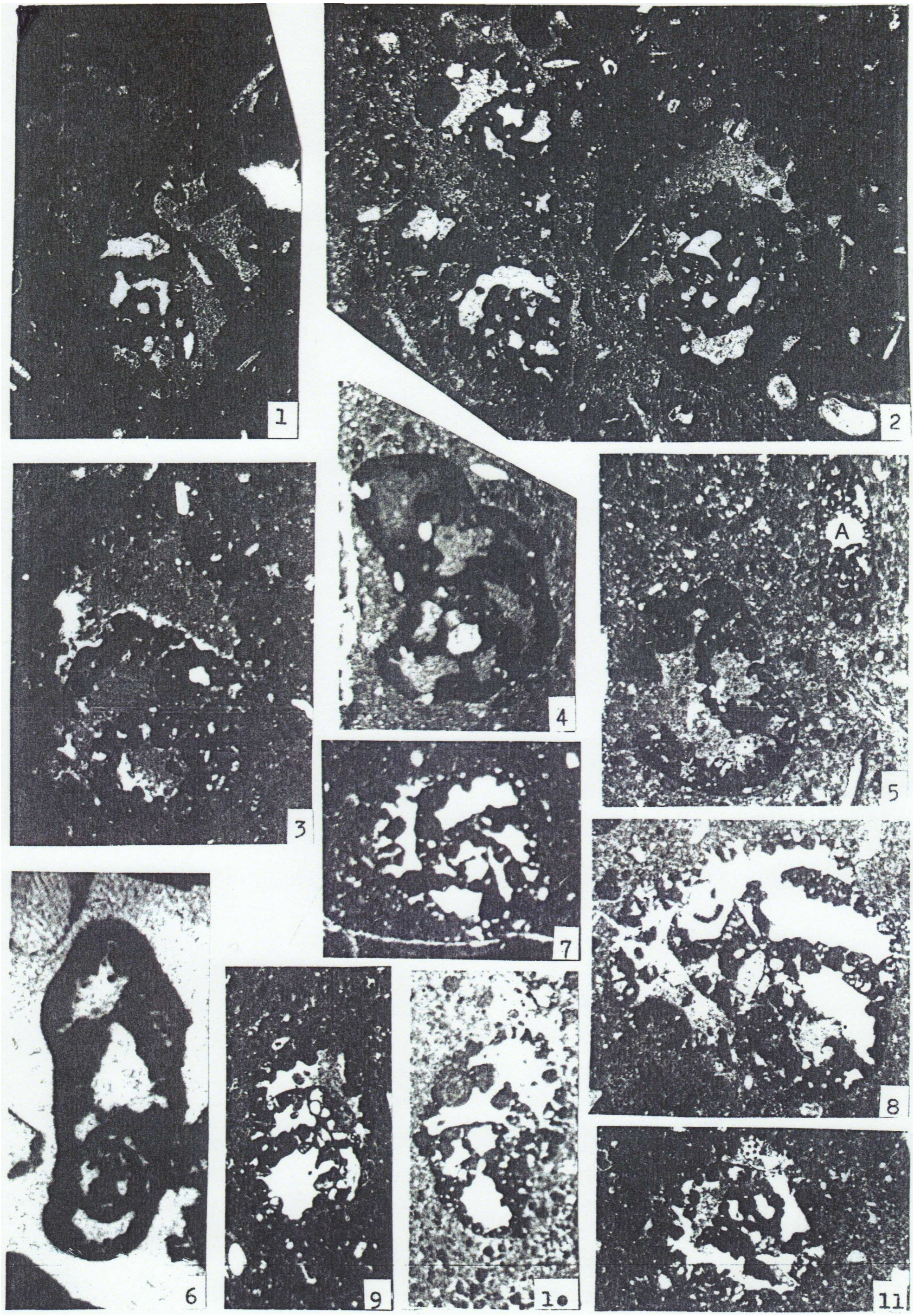

Plate 4

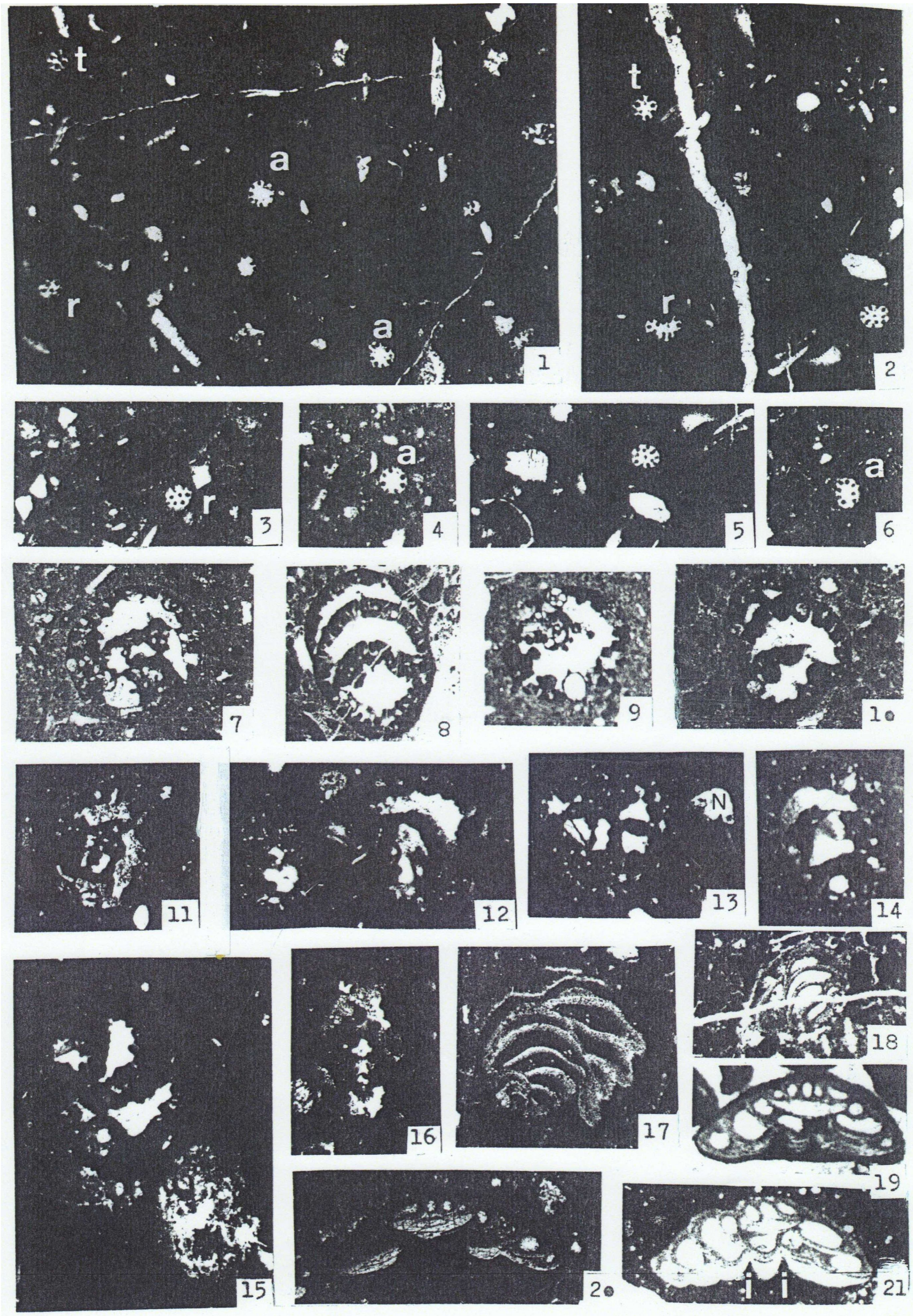

Plate 5

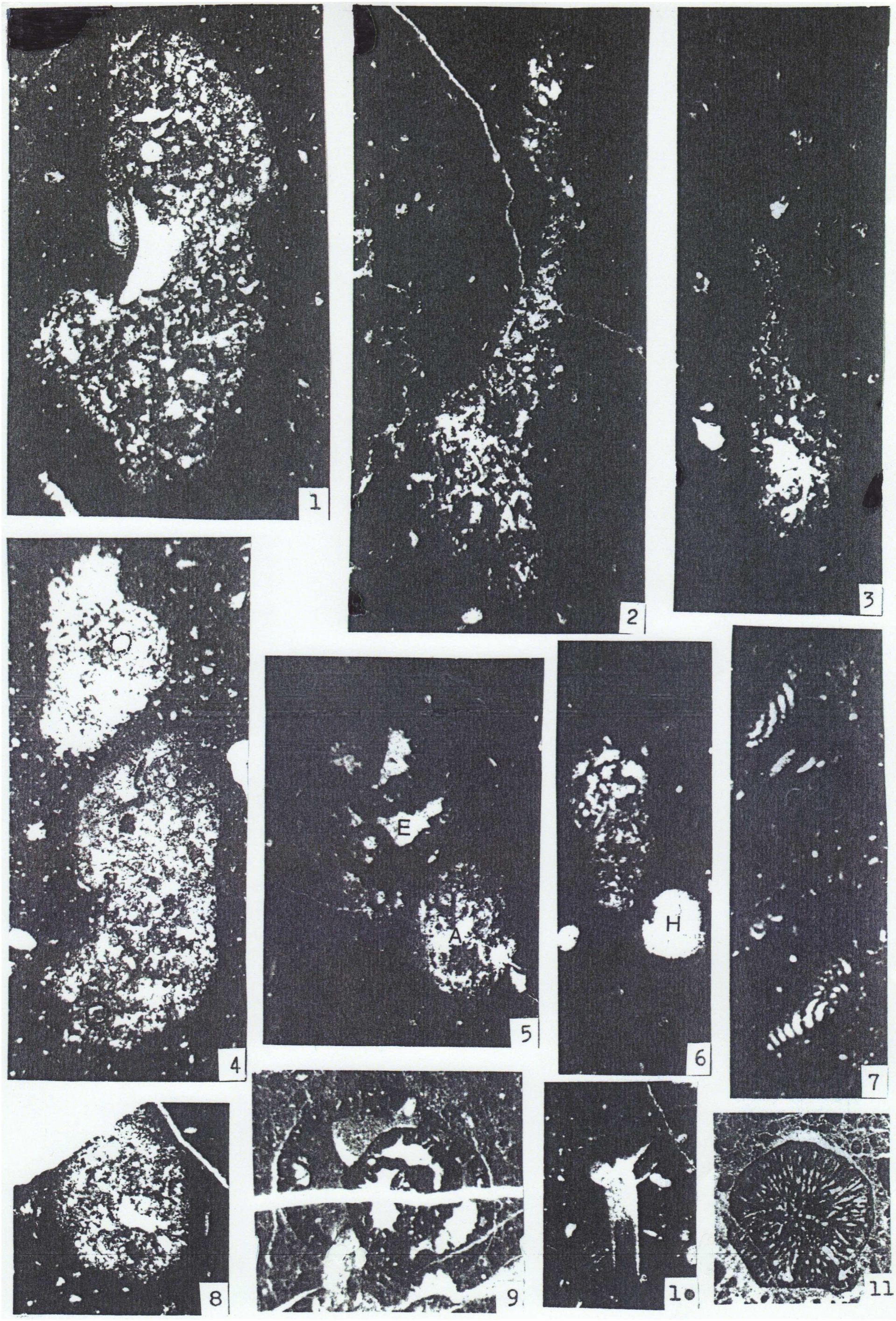

Plate 6