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Calpionellid biostratigraphy and sedimentation of the Biancone limestone from the Rudnica Anticline (Sava Folds, eastern Slovenia)

Kalpionelidna biostratigrafija in sedimentacija Biancone apnenca Rudniške antiklinale (Posavske gube, vzhodna Slovenija)

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Ključne besede: Rudnica, Dinaridi, potopljena platforma, biancone – maiolica apnenec, kalpionelide, biostratigrafija, berriasij

Abstract

Mt Rudnica in eastern Slovenia structurally belongs to the Sava Folds. The mountain itself is an exposure of the Mesozoic core of the Rudnica Anticline. The major part of the core is composed of Triassic rocks deposited on the NE margin of the Dinaric (Adriatic) Carbonate Platform, overlain locally by deep-marine Berriasian Biancone limestone. The latter formation was logged in a newly discovered section on the northern slopes of Mt Rudnica near the village of Loka pri Žusmu. The Biancone limestone of Mt Rudnica is mostly monotonous, calpionellid-bearing limestone with only minor up-section differences in colour, chert presence, and clay content. It is characteristic pelagic facies for the entire Tethyan Realm of the time. Using calpionellid as well as dinocyst biostratigraphy, the formation was subdivided into Early Berriasian Calpionella Zone - Alpina and Ferasini Subzones, Middle Berriasian Calpionella Zone - Elliptica Subzone and upper Berriasian Calpionellopsis Zone - Oblonga Subzone. Within the Early Berriasian part of the formation a synsedimentary slump was documented, whereas the largest increase in clay content is observed in the topmost, i.e. Late Berriasian part of the formation.

Izvleček

Gora Rudnica v vzhodni Sloveniji strukturno pripada Posavskim gubam. V osrednjem delu gore izdanja mezozojsko jedro Rudniške antiklinale. Večji del jedra sestavljajo triasne kamnine, ki so se odlagale na severovzhodnem obrobju Dinarske (Jadranske) karbonatne platforme, nad njimi pa je mestoma odložen globokomorski, berriasijski biancone apnenec. Slednji je bil posnet v novo odkritem profilu na severnih pobočjih Rudnice pri vasi Loka pri Žusmu. Biancone apnenec iz Rudnice je povečini monoton apnenec s kalpionelami, ki vzdolž zaporedja kaže le manjše spremembe v barvi, prisotnosti rožena in vsebnosti gline. Predstavlja značilen pelagični facies celotne Tetidine province tega časa. Na podlagi kalpionelidne in tudi dinocistne biostratigrafije je bila formacija razdeljena na spodnji berriasij (Calpionella cona - Alpina in Ferasini podconi), srednji berriasij (Calpionella cona - Elliptica podcona) in zgornji berriasij (Calpionellopsis cona - Oblonga podcona). V spodnjeberriasijskem delu formacije je bil dokumentiran sinsedimentni plaz, medtem ko v vrhnjem, zgornjeberriasijskem delu formacije opazujemo povečano vsebnost glinene komponente.

Introduction

At present, the GSSP of the Jurassic-Cretaceous boundary remains undefined (Cohen et al., 2018) and as such encourages the search for precise biostratigraphic markers within different fossils groups. Calpionellids are an example of such group, owing to their uniform occurrence and diversification; as a result they are widely used in biostratigraphic analyses of the Late Jurassic and Early Cretaceous pelagic sequences throughout the Tethyan Realm (Allemann et al., 1971; Remane, 1971; Remane et al., 1986; Pop, 1974, 1994; Reháková & Michalík, 1997; Lakova, et al., 1999; Boughdiri et al., 2006; Houša et al., 2007). From the point of view of calpionellid biostratigraphic potential, we note that alongside *Calpionellites darderi*, the index marker for the Berriasian/Valanginian stage boundary (Bulot, 1996), *Calpionella alpina* is considered to be most useful marker for determination of the Jurassic/Cretaceous boundary (Andreini et al., 2007; Houša et al., 2007; Wimbledon, 2008; Michalík et al., 2009; Grabowski et al., 2010a,b; Lukeneder et al., 2010; Pruner et al., 2010; Michalík & Reháková, 2011; Petrova et al., 2012; Guzhikov et al., 2012; Lakova & Petrova, 2013; López-Martínez et al., 2013, 2015; Wimbledon et al., 2013, 2017; Hoedemaeker et al., 2016; Michalík et al., 2016; Svobodová & Košťák, 2016; Grabowski et al., 2017; Elbra et al., 2018 a,b; Kowal-Kasprzyk & Reháková, 2019).

This study presents the calpionellid biostratigraphy (supplemented by dinocyst data) of the Biancone limestone from Mt Rudnica (fig. 1). Biancone limestone is found on the northern slopes of Mt Rudnica, where it overlies, with a prominent stratigraphic gap, the Late Ladinian to Early Carnian dolomite (Aničić et al., 2004). Pioneering work on calpionellids from Mt Rudnica was provided by Babić (1979), who already recognized most of the calpionellids described in our paper. However, in this study, sample, locations were scattered along the wider area and only point-samples were taken. We revisited the area and found, logged, and sampled a near-fully exposed section of the Biancone limestone. This paper provides a description of the section as well as detailed calpionellid biostratigraphy combined with calcareous dinocyst determinations. We also provide data from a supplementary section that we logged, which is likely from the GK-1418 sampling site of Babić (1979). We describe and discuss the sedimentological particularities of the Biancone limestone from Mt Rudnica.

Geological setting

The Sava Folds of E Slovenia are characterized by post-Miocene N-S shortening inside the Sava compressive wedge that originated in the triangle between the W-E striking Periadriatic tectonic zone, the NW-SE Idrija tectonic zone, and the WSW-ENE mid-Hungarian tectonic zone (fig. 1a) (Placer, 1999, 2008). The entire region is composed of a series of anticlines and synclines with generally E-W striking fold-axes. In the synclines, Oligocene to Neogene Paratethys sediments are preserved. In the anticlines, this sedimentary cover is eroded, and anticline cores reveal Carboniferous, Permian and Mesozoic successions (Buser, 1978; Aničić & Juriša, 1985a; Aničić et al., 2004; Buser, 2009). Older structures, particularly thrust-faults, show the clear overprint of a young compression of the Sava Folds, namely, the folding of thrust planes (Placer, 1999).

The studied sections are situated in the eastern part of the Sava Folds – more precisely, in the Mesozoic core of the Rudnica Anticline that is a large scale, morphologically well-expressed anticline. It is embraced by the Laško Syncline to the north and the Planina Syncline to the south (fig. 1b), both of which are composed of Oligocene and Miocene sediments that show only minor deformation as the result of young N-S compression (Placer, 1999, 2008). Unlike the synclines, the anticline core is composed of more intensively deformed Mesozoic, mostly Triassic rock successions (Buser, 1978; Aničić & Juriša, 1985a) (fig. 1c). It begins with Anisian limestone and dolomite. Upwards it passes on to the highly diverse Ladinian succession, which is characterized either by mafic volcanic rocks (diabase) or by alternating shales, limestones with chert, and sandstone. Further upwards it passes on to coarse crystalline (saharoid) massive dolomite that locally alternates to limestone (Buser, 1978, 1979; Aničić & Juriša, 1985a, b; Aničić et al., 2004). Traditionally, this formation is considered to be Carnian in age, but more recent studies from other parts of Slovenia indicate that it is, at least in part, still Ladinian (Celarc, 2004, 2008; Čar, 2010). At Mt Rudnica, it can contain limestone with chert and shale in the upper part of the formation (Aničić et al., 2004). On the northern slopes of Mt Rudnica, near the village of Loka pri Žusmu, this formation is overlain by Biancone limestone that is considered to be a latest Jurassic to earliest Cretaceous in age (Aničić et al., 2004). The stratigraphic contact is marked by a prominent gap that covers the major part of the Upper Triassic

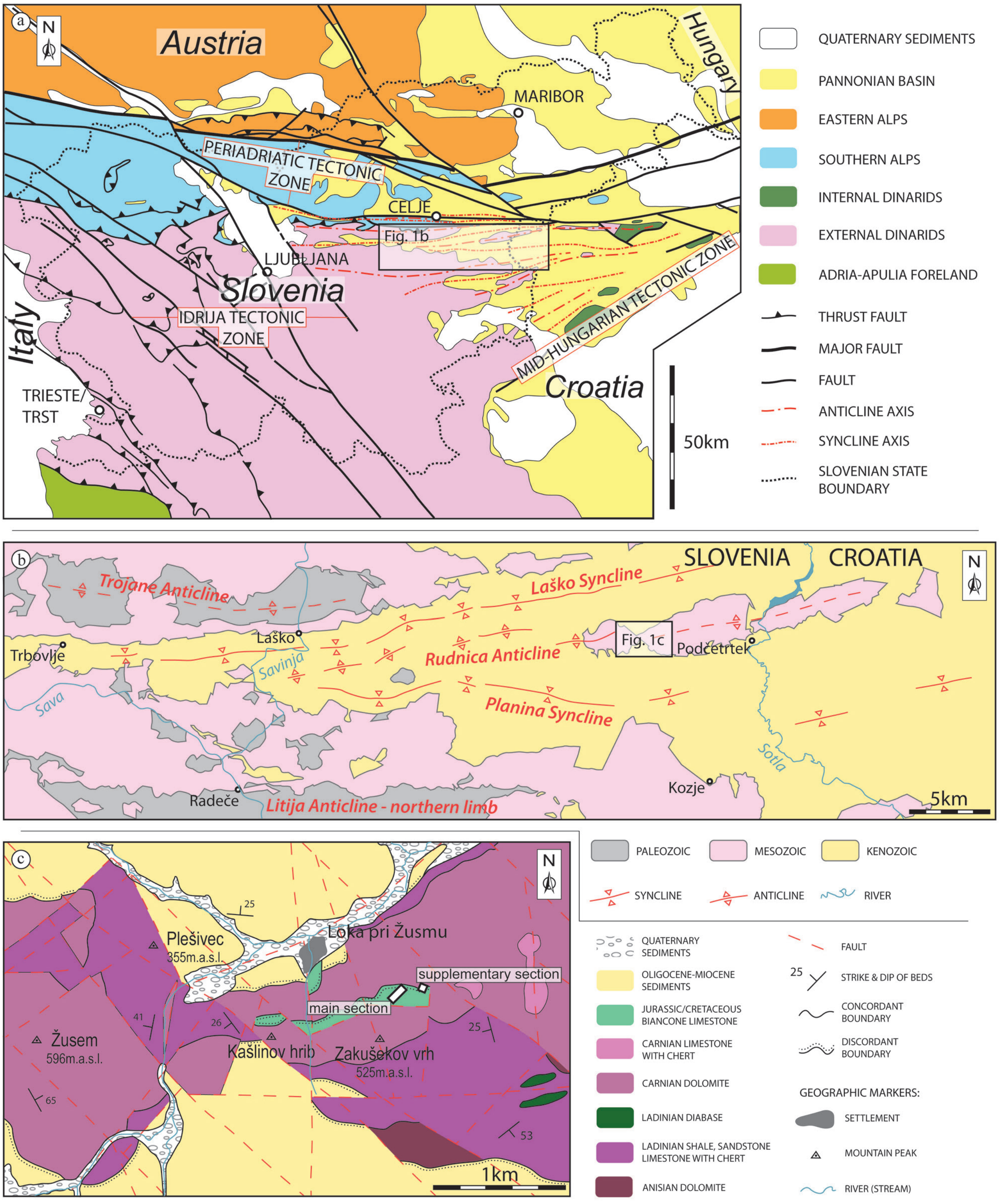

Fig. 1. a) Geostructural subdivision of the Alpine-Dinaric-Pannonian transition zone with axes of the Sava Folds (compiled from Placer, 1999, 2016); boxed area is enlarged in Figure 1 b. b) Eastern Sava Folds with positions of major structures marked (simplified from Buser, 1978; Aničić and Juriša, 1985a); boxed area is enlarged in Figure 1 c (national border follows the Sotla River). c) Geological map of the eastern part of the Rudnica Anticline (after Aničić et al., 2004) with positions of studied sections marked.

as well as most all of the Jurassic. Outcrops of the Biancone limestone are limited to the rather narrow area between the village of Loka pri Žusmu and two minor peaks (Zakušekov vrh and Kašlinov hrib) of Mt Rudnica.

Methods

Biancone limestone was logged in two sections. The main section was logged on the northern slope of the small peak (N46°09'21'', E15°31'26''), some 300 m NNE of the Zakušekov vrh peak. The supplementary section was logged along the forest road, some 200 m further NW of the main section (N46°09'25'', E15°31'31''). Samples were taken in closely-spaced intervals. Beds have been numbered with the RA prefix designating the main section and RB the supplementary section. A total of 17 samples were selected for the thin sections, which were used for microfacies analyses and to document successions of stratigraphically important calcareous microfossils, namely calpionellids and calcareous dinoflagellates. Thin sections were studied under the LEICA DM 2500 polarizing microscope, and selected bioclasts and allochems were identified. The Axiocam ERc 5s camera was used to document microfacies and bio markers. The thin-sections will be stored in the archive of the Faculty of Natural Sciences and Engineering, University of Ljubljana. The Calpionellid zonal scheme sensu Reháková and Michalík (1997) combined with cyst distribution (Reháková, 2000) were applied. Microfacies types are named according to the terminology of Dunham (1962); standard microfacies type (SMF) and facies zones (FZ) as proposed by Wilson (1975) and modified by Flügel (2004) were determined.

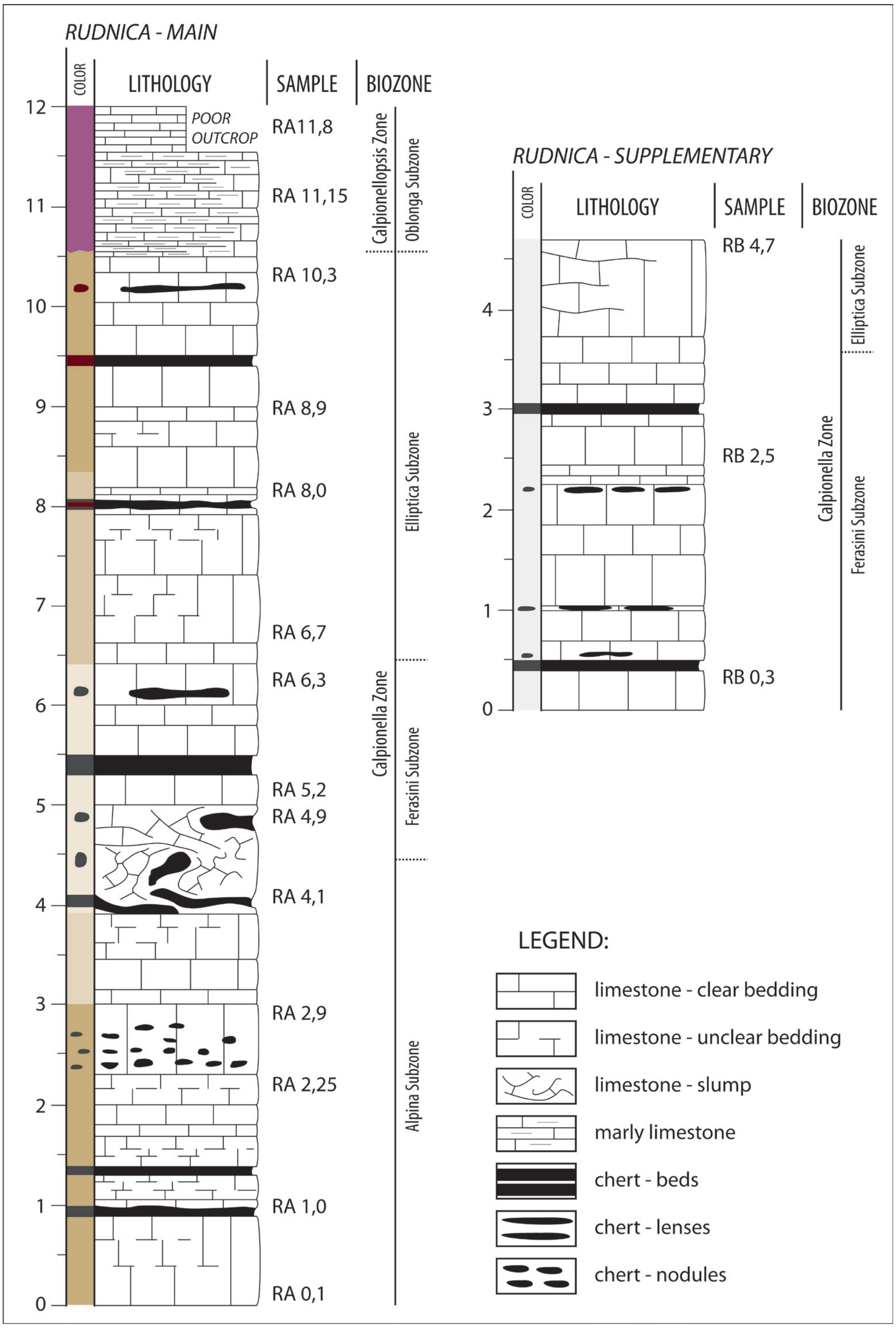

Fig. 2. Detailed sedimentological sections of the Biancone limestone from the Rudnica Anticline, with positions of samples and calpionellid biozones marked.

Description of the studied sections

In the main studied section of the Biancone limestone from Mt Rudnica, both boundaries are covered. The first outcrops of coarse-crystalline dolomite occur some 5 m below the logged section. In the covered interval, dolomite and subordinate chert particles are found in the soil. The top of the section is also covered. Fragments of dark-coloured shale are present in the soil. Our field observations indicate that the upper boundary is also stratigraphic. We propose that the overlying succession belongs to the very spatially limited Aptian-Albian Lower Flyschoid formation, which in the wider region either lies over the Biancone limestone or directly over Triassic strata (Buser, 1978; Aničić & Juriša, 1985a).

In the main section, the Biancone limestone was logged for 12 m (figs. 2, 3a). It forms a monotonous succession of well-bedded, micritic, variably-coloured limestone. It is light yellowish-brown in the lower 3 m, becomes brighter in the next meter, and is almost white in the next 2.5 m. Upwards, in the next 5 m the opposite trend is observed. In the uppermost 1.5 m the limestone is coloured violet-red (fig. 3b). This part of the formation also shows a slight increase in clay content, is laminated, and beds are thinner than in the major part of the formation.

Chert occurs in the form of beds (up to 20 cm), lenses and nodules. Generally speaking, it is black/dark grey in colour in the lower part of the formation and dark red in the upper part of the formation. From the 4th to 5th m of the section, the chert is folded. Folded bedding planes are also expressed within the limestone, albeit less clearly, and this interval probably represents a synsedimentary slumping of the pelagic sediment (fig. 3c).

According to the description by Babić (1979), the location of the supplementary section most likely corresponds to his sampling site GK-1418. In this section, contacts of the Biancone limestone with the surrounding formations are also not exposed, but the nature of the outcrops indicates that they are represented, at least partly, by fault contacts. 4.5 m of the Biancone limestone were logged. As a rule, the succession corresponds to the main section, but colours are largely light-grey to white, whereas cherts are black to dark-grey in colour. In the topmost part, bedding planes are wavy and laterally discontinues.

Fig. 3. a) General up-section field view of the Biancone limestone from Mt Rudnica main section. b) Violet-red coloured and thin-bedded limestone and chert from uppermost part of the formation. c) Synsedimentary slump between the 4th and 5th meter of the main section.

Microfacies, calpionellid zonation

The studied limestone belongs to the standard microfacies SMF 3. Biomicritic mudstone to wackestone contains rare calpionellids, dinoflagellate cysts, calcified radiolarians, ostracods, globochaetes, and crinoids. Silt-size quartz grains are locally present. Facies indicates a basin to lower slope depositional environment (facies zones 1–3 in Flügel, 2004). Despite the fact that bioclasts are quite rare and some are not particularly well preserved, it was possible to determine the main calpionellid index markers, on which basis the limestone sequence was dated as Early to Late Berriasian (standard Calpionella Zone with the Alpina, Ferasini and Elliptica subzones and the standard Calpionellopsis Zone, Oblonga Subzone). The Ferasini and Oblonga subzones were established and could improve the calpionellid zonation scheme previously identified by Babić (1979).

Early Berriasian Calpionella Zone, Alpina Subzone (sensu Pop, 1974, Remane et al., 1986); samples RA 0,1; RA 1,0; RA 2,25; RA 2,9; RA 4,1

The lowest part of the studied section is built of variable bedded light Biancone limestone bearing chert nodules and chert layers. Slump structures appear at the top of the interval containing the samples RA 4,1 and RA 4,9 (note that the last one already belongs to the succeeding Ferasini Subzone). Biomicritic limestone is mudstone with rare to infrequent calpionellids (figs. 4a-e) and cysts of calcareous dinoflagellates (figs. 5m, n). Very rare *Calpionella alpina, Crassicollaria parvula* dinoflagellate cysts of *Colomisphaera minutissima, Colomisphaera lapidosa, Colomisphaera carpathica* were observed in the micrite matrix. The matrix contains frequent planar euhedral dolomite (figs. 4a-c, e). These burial-stage dolomite crystals are impregnated by Fe-hydroxide. Planar fabrics are favoured at lower precipitation temperatures. There are also thin dissolution seams filled with Fe-hydroxides and nests of pyrite (fig. 5t) visible in a slightly recrystallized matrix.

Early Berriasian Calpionella Zone, Ferasini Subzone (Pop, 1994); samples RA 4,9; RA 5,2; RA 6,3; RB 0,3; RB 2,5

The first occurrence (FO) of *Remaniella ferasini*, the index marker of the Ferasini Subzone, was identified in sample RA 4,9 (fig. 4i). Mudstone also contains rare *Calpionella alpina* (fig. 4h), *Calpionella elliptalpina, Calpionella* sp., *Remaniella duranddelgai, Remaniella catalanoi* (fig. 5k) *Crassicollaria parvula, Tintinnopsella carpathica* (figs. 4j,k), dinoflagellate cysts *Colomisphaera cieszynica* (fig. 5o), *Colomisphaera lapidosa, Colomisphaera carpathica* (fig. 5p), *Stomiosphaera mulluccana* (fig. 5s), *Globochaete alpina* spores, fragments of ostracods, crinoids, calcified radiolarians, and foraminifera with calcite tests – *Spirillina* sp. A few deformed loricae, dissolution seams, scattered pyrite and rare dolomite rhomboeders were all documented in the matrix.

Middle Berriasian Calpionella Zone, Elliptica Subzone (Pop, 1974); samples RA 6,7; RA 8,0; RA 8,9; RA 10,3; RB 4,7

The FO of *Calpionella elliptica*, the index marker of the Elliptica Subzone, was observed in sample RA 6,7 (fig. 4l, m, s). The mudstone and local wackestone of this interval also contain rare *Calpionella alpina* (fig. 4r), *Calpionella minuta* (fig. 4n), *Remaniella catalanoi* (fig. 5b), *Crassicollaria parvula* (fig. 4t), *Tintinnopsella carpathica* (fig. 5c), *Lozenziella hungarica* (figs. 4p,q), *Lorenziella plicata* (figs. 4o, 5a), locally common cysts of *Colomisphaera carpathica* (fig. 5q), *Colomisphaera cieszynica* (fig. 5r), *Colomisphaera lapidosa*, rare fragments of aptychi, ostracods, calcified radiolarians, crinoids, foraminifera *Spirillina* sp., and *Globochaete alpina* cysts. Some loricae are deformed (fig. 5l), some bioclasts and the local matrix are slightly silicified. Pyrite is commonly scattered in the matrix.

Late Berriasian Calpionellopsis Zone, Oblonga Subzone (Allemann et al., 1971); samples RA 11,15; RA 11,8

Few loricae of the genus Calpionellopsis were identified in the uppermost interval, starting in sample RA 11,15 (figs. 5d, e, g). The beds are more regular and thinner in this part of the sequence. *Calpionellopsis* cf. *simplex* (fig. 5g), *Calpionellopsis oblonga* (fig. 5d, h-j), *Calpionella elliptica, Calpionella minuta*, *Tintinnopsella carpathica* (fig. 5f), cysts of *Colomisphaera lapidosa*, calcified radiolarians, and ostracods were observed among the bioclasts. The matrix contains silt-size quartz grains and muscovite. Pyrite occurs in the walls of calcite veins (fig. 5u), which indicates that at least part of the pyrite formed after lithification.

Discussion

The Biancone limestone of Mt Rudnica corresponds to the pelagic, calpionellid-bearing limestones (known also as Maiolica limestone) that are common Late Tithonian to Lower Cretaceous facies of Western and Central Europe

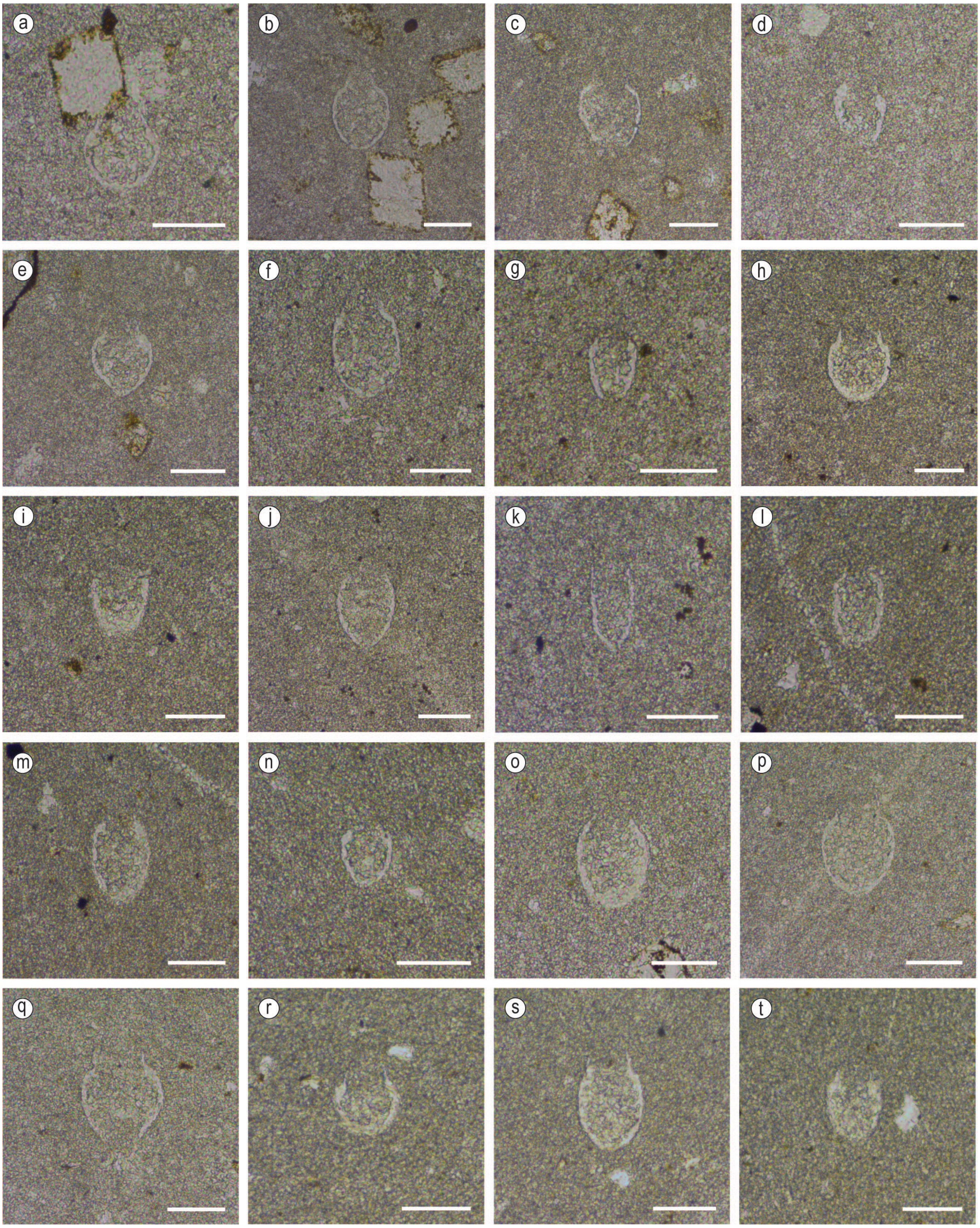

Fig. 4. Calpionellids from Rudnica main section (scale bar is 50 µm); a) *Calpionella alpina* (sample *RA 0,1*), b) *Calpionella grandalpina* (sample *RA 0,1*), c) *Calpionella alpina* (sample *RA 1,0*), d) *Crassicollaria parvula* (sample *RA 0,1*), e) *Calpionella alpina* (sample *RA 2,25*), f) *Calpionella elliptalpina* (sample *RA 4,1*), g) *Crassicollaria parvula* (sample *RA 4,1*), h) *Calpionella alpina* (sample *RA 4,9*), i) *Remaniella ferasini* (sample *RA 4,9*), j) *Tintinnopsella carpathica* (sample *RA 4,9*), k) *Tintinnopsella carpathica* (sample *RA 6,3*), l–m) *Calpionella elliptica* (sample *RA 6,7*), n) *Calpionella minuta* (sample *RA 8,0*), o) *Lorenziella plicata* (sample *RA 8,9*), p–q) *Lorenziella hungarica* (sample *RA 8,9*), r) *Calpionella alpina* (sample *RA 10,3*), s) *Calpionella elliptica* (sample *RA 10,3*), t) *Crassicollaria parvula* (sample *RA 10,3*).

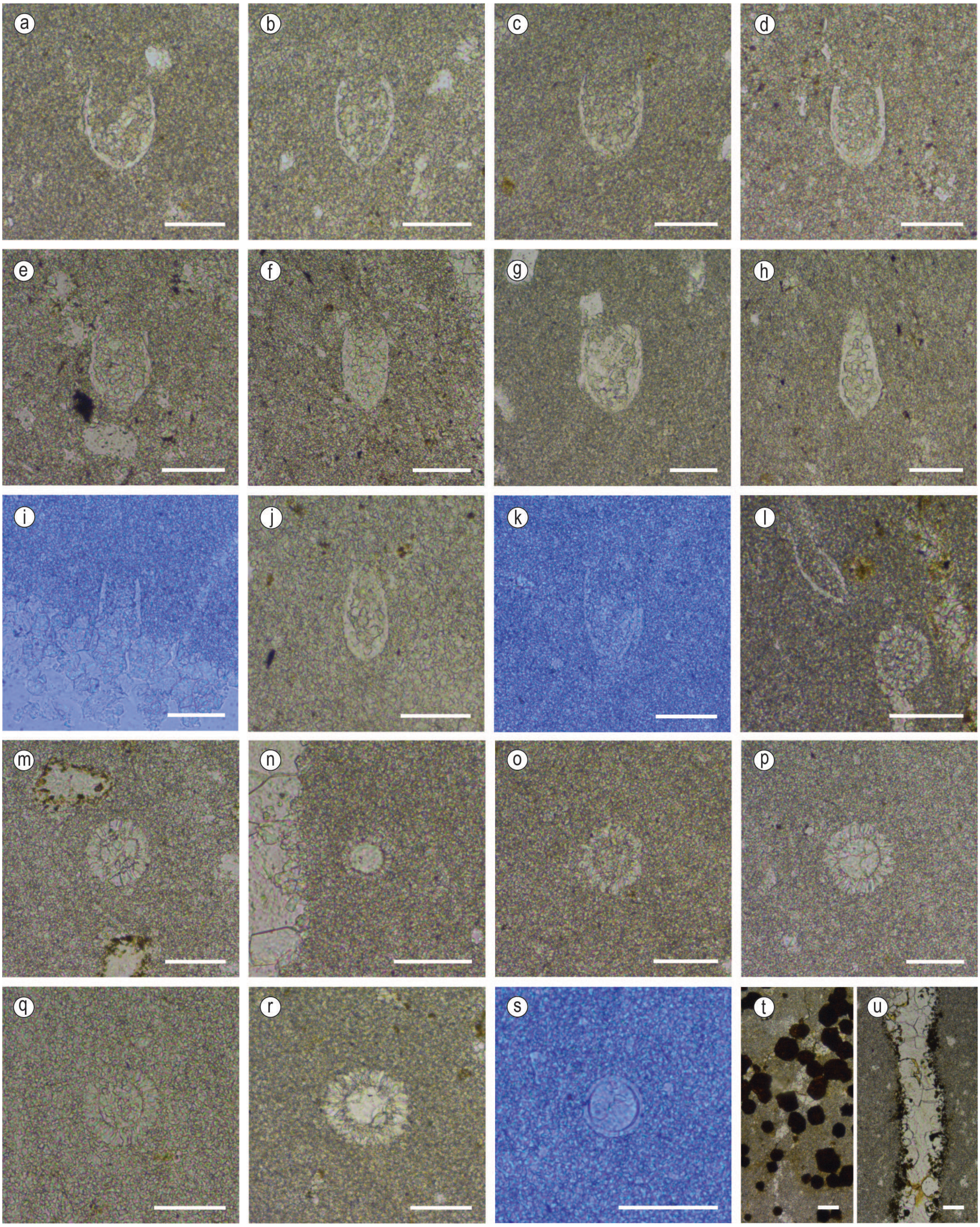

Fig. 5. Calpionellids from topmost part of Rudnica main section and supplementary section, and calcareous dinocysts from both sections (scale bar is 50 µm); a) *Lorenziella plicata* (sample *RA 10,3*), b) *Remaniella catalanoi* (sample *RA 10,3*), c) *Tintinnopsella carpathica* (sample *RA 10,3*), d) *Calpionellopsis oblonga* (sample *RA 11,15*), e) *Calpionellopsis* sp. (sample *RA 11,15*), f) *Tintinnopsella carpathica* (sample *RA 11,15*), g) *Calpionellopsis simplex* (sample *RA 11,15*), h-i-j) *Calpionellopsis oblonga* (sample *RA 11,8*), k) *Remaniella catalanoi* (sample *RB 2,5*), l) deformed lorica of *Tintinnopsella carpathica* and *Colomisphaera lapidosa* (sample *RA 6,7*), m) *Colomisphaera lapidosa* (sample *RA 0,1*), n) *Colomisphaera minutissima* (sample *RA 1,0*), o) *Colomisphaera cieszynica* (sample *RA 4,9*), p) *Colomisphaera carpathica* (sample *RA 6,3*), q) *Colomisphaera carpathica* (sample *RA 8,9*), r) *Colomisphaera cieszynica* (sample *RA 10,3*), s) *Stomiosphaera moluccana* (sample *RB 2,5*), t) subhedral pyrite within micrite matrix (sample *RA 2,9*), u) framboidal pyrite along the vein-wall (sample *RA 11,15*).

(*Wieczorek, 1988;* Weissert, 2010), and characterize all deep-water paleogeographic domains of the Southalpine-Dinaric Realm (Weissert, 1981; Goričan, 1994; Šmuc, 2005; Rožič, 2009; Goričan et al., 2012, 2018). Biancone limestone also occurs on the north-eastern margin of the Dinaric Carbonate Platform, where it overlies (with a prominent stratigraphic gap) the Lower Jurassic or Upper Triassic platform carbonates, and locally Middle to Upper Jurassic cherty limestone (Babić, 1973; Aničić & Dozet, 2000), which is known as the Izvir Formation (Rižnar, 2006; Poljak et al., 2017). The Biancone limestone on Mt Rudnica probably represents the distal, drowned part of the Dinaric Carbonate Platform.

The onset of the Biancone limestone sedimentation in the continuous basinal successions of the Southalpine-Dinaric Realm is dated as Late Tithonian (Goričan et al., 2012). The calpionellid biostratigraphy of the Mt Rudnica section (presented in this paper) indicates a slightly postponed, i.e. Early Berriasian onset of sedimentation. Three possible solutions are here proposed for the delay: A) Biancone limestone is not fully exposed in the studied sections, and the Late Tithonian part of the limestone is covered (in light of our field observations, this option is less likely); B) the drowning unconformity of Mt Rudnica area was prolonged until the Berriasian as the result of certain paleogeographic conditions; and C) the Late Tithonian part of the Biancone limestone is dolomitized and consequently does not outcrop, because dolomites are more prone to weathering. This last option is supported by field observations, where weathered chert (and also dolomite) particles were observed in the soil just below the main section. Additionally, partial, upwardly-decreasing dolomitisation was also observed in the thin sections. Similar conditions are reported from the northern part of the Trento Plateau, from the area where the Biancone limestone directly overlies the Hauptdolomit/Dolomia Principale Formation (Lukeneder, 2011, 2015).

In the Early Berriasian part of the Mt Rudnica main section (Calpionella Zone, the transition from the Alpina to Ferasini subzones) a synsedimentary slump was observed, which indicates an inclined bottom in this part of the drowned platform margin. Slumps, though they are more poorly dated or more widely time-distributed, are also known from other sections of the Southern Alps and Dinarides, (Weissert, 1981; Goričan, 1994; Šmuc, 2005), where most locations are situated on the drowned platforms. A generally coeval Bohinj Formation, which is a prominent mass-movement breccia and calcarenite bed, is reported from the Bled Basin (Kukoč et al., 2012). Today, the outcrops of this basin are found in the Julian Alps in NW Slovenia but were once located paleogeographically closer to the Neotethys Ocean (Goričan et al., 2018), and probably quite close to the Mt Rudnica area.

The Late Berriasian, i.e. uppermost part of the Mt Rudnica main section (Calpionellopsis Zone, Oblonga Subzone) sees a slightly higher clay content. This may indicate changing global climate conditions, namely a gradual change from the arid Early Berriasian to the humid Valanginian climate (Föllmi, 2012). A similar trend is observed in the western part of the Slovenian Basin (Rožič and Reháková, in prep.). A Lower Cretaceous upwardly-increasing siliciclastic input is well documented in the Bled Basin, where the so-called Transitional unit lies above the Bohinj Formation. This is generally attributed to the Berriasian, which still contains beds of Biancone-type limestone, but shows a gradual upward increase in clay interlayers. Finally, it passes into flysch-type deposits of the Valanginian-Hauterivian Studor Formation, characterized by ophiolite debris (Kukoč et al., 2012; Goričan et al., 2018). A similar, albeit delayed (proposed as starting in the Barremian) turn is reported from Mt Ivanščica in Croatia, which is another inselberg that represents a direct, eastern continuation of the Mt Rudnica anticline, with corresponding outcrops located approximately 40 km to the east (Babić and Zupanič, 1973; Lužar-Oberiter et al., 2009; 2012).

Conclusions

The Biancone limestone of Mt Rudnica is a typical latest Jurassic-early Lower Cretaceous calpionellid-bearing pelagic limestone of the Tethyan Realm. It sedimented on the submarine swell, i.e. on the drowned NE margin of the Dinaric (Adriatic) Carbonate Platform. With a prominent drowning unconformity, it overlies the Upper Triassic platform dolomite. Using calpionellid biostratigraphy, the studied sections were determined as Berriasian in age. The formation was further subdivided into Early Berriasian Calpionella Zone - Alpina and Ferasini Subzones, Middle Berriasian Calpionella Zone - Elliptica Subzone, and Late Berriasian Calpionellopsis Zone - Oblonga Subzone. The monotonous pelagic succession is interrupted by a synsedimentary slump in the Early Berriasian. The Late Berriasian part of the formation shows an increase in the clay content, which may suggest a gradual shift to a humid Valanginian climate.

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Calpionella elliptalpina Nagy, 1986
Calpionella elliptica Cadisch, 1932
Calpionella minuta Houša, 1990
Calpionellopsis oblonga (Cadisch, 1932)
Calpionellopsis cf. *simplex* (Colom, 1939)
Crassicollaria parvula Remane, 1962
Lorenziella hungarica Knauer and Nagy, 1964
Lorenziella plicata Remane, 1968
Remaniella catalanoi Pop, 1996
Remaniella ferasini (Catalano, 1965)
Remaniella duranddelgai Pop, 1996
Tintinnopsella carpathica (Murgeanu and Filipescu,1933)
Calcareous dinoflagellates
Colomisphaera carpathica (Borza, 1964)
Colomisphaera cieszynica Nowak, 1968
Colomisphaera lapidosa (Vogler, 1941)
Colomisphaera minutissima Nowak,1968
Stomiosphaera molluccana Wanner, 1940