THE JURASSIC/CRETACEOUS BOUNDARY IN TERMS OF RADIOLARIANS FROM THE SÜMEG AREA (TRANSDANUBIAN RANGE, HUNGARY)

"Every morning I am newly amazed at the inexhaustible richness of these tiny and delicate structures."

Ernst Haeckel (1834–1919)

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1. Introduction

The latest Jurassic to earliest Cretaceous represents a relatively poorly understood, but clearly important period in the history of the biosphere. The marine plankton diversification and radiation from the Middle Jurassic to Early Cretaceous significantly contributed the most volumetrically biogenic constituent for marine sedimentary environments (e.g. Tremolada et al. 2006, Tennant et al. 2017), although the precise mechanism and magnitude of this is currently unknown. The purpose of this study is to synthesize our current knowledge of Late Jurassic to Early Cretaceous radiolarians of the Sümeg area, Transdanubian Range, Hungary, we aim to provide insight into the potential mechanisms that supported evolutionary changes of radiolarians through the Latest Jurassic to Earliest Cretaceous period.

The Late Jurassic to Early Cretaceous boundary sections of the Sümeg area has been known since the late 1950s and early 1960s and this outcropping work led to the later discovery of the prehistoric flint mines around Sümeg. The biostratigraphic importance of this area has increased the finding of abundant Berriasian microfauna that had made it necessary to outcrop a long artificial trench to expose the deeper parts of the Jurassic-Cretaceous section. One consequence of this was the discovery of several Neolithic flint quarries and the exploration of Middle and Upper Jurassic formations in the extension of the artificial trench. The first studies of latest Jurassic to earliest Cretaceous radiolarians of the Mogyorós-domb (section Mogyorós-domb I. in Fülöp 1964) artificial trench, south of Sümeg were conducted in the early 1980s by the late Heinz W. Kozur, although he has published neither taxonomic nor biostratigraphic data from the investigated sections. Although his legacy includes extremely well-preserved radiolarians compiled on some plates and a brief report about the radiolarians from the latest Jurassic and earliest Cretaceous (Kozur, unpublished report).

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Subsequently, the late Lajos Dosztály began radiolarian studies from a new artificial trench which can be seen as a continuation of Mogyorós-domb section I., about 100 meters to the east just off-road 84. That new artificial trench exposed mainly Middle and Upper Jurassic radiolarite, although a part of the Lower Cretaceous cherty limestone sequence is also exposed in the upper part of the section (Dosztály 1998). Dosztály focused on Middle and Upper Jurassic radiolarians from the radiolarite of this section (1998), although he published a few Jurassic species, only. In addition, Dosztály began to investigate the material from the Süt-17 borehole, but all his results remained unpublished due to his tragic and untimely death. This third investigated section is a continuous epicontinental Jurassic/Cretaceous boundary core section (Süt-17) from the central area of Sümeg (Haas 1984) and it penetrated more than 400 meters of Lower Cretaceous (Hauterivian to Berriasian) and Upper Jurassic (Tithonian) sediments. In total, this work includes the documentation of moderate to poorly-preserved but previously unpublished radiolarian fauna of two continuous Jurassic/Cretaceous sections from the Sümeg area, Transdanubian Range, Hungary.

2. The geological setting of the Upper Jurassic–Lower Cretaceous sequences around Sümeg

The little town Sümeg is located in the western part of the Bakony Mountains, northwest of Lake Balaton. It belongs to the Transdanubian Range Unit of ALCAPA Megaunit (e. g. Csontos et al. 1992, Haas et al. 2014, Schmid et al. 2020) which was located between the Northern Calcareous Alps and the Southern Alps during the Mesozoic time (Haas et al. 1995). The term ALCAPA terrane was introduced by Csontos and Vörös (2004) that includes the Eastern Alps, the West Carpathians and the Transdanubian Range. During the Late Jurassic and Early Cretaceous the Transdanubian Range Unit presumably located on the northern edge of the Apulia microcontinent within the Neotethyan passive shelf (e. g. Haas et al. 1995, Gawlick et al. 1999, Fodor 2022, this volume). In the Upper Jurassic, the Apulia microcontinent was separated from the Eurasian continent by Alpine Tethys and drifted towards the north – northeast with rotation. In the Lower Cretaceous, Apulia drifted apart completely from Africa and the northern part of it collided with the southern margin of the Eurasian continent. This implied the closure of the different oceanic branches in the Neotetyan realm from the late Mesozoic time, and strongly facilitated the orogenic movements in the Alpine realm (e. g. Csontos & Vörös 2004, Schmid et al. 2008). In this geodynamic and paleogeographic framework, the Neotethyan ecosystems were fueled by a high nutrient flux, leading to formed of massive radiolarites during the Middle and Late Jurassic, while they were substituted by deep-sea phytoplankton carbonates from the Tithonian to Berriasian period. This is mainly due to the fact that calcareous nannoplankton underwent a significant global radiation from the Latest Jurassic to the Earliest Cretaceous (Weissert et al. 1998, Bornemann et al. 2003, Falkowski et al. 2004, Weissert & Erba 2004). This global revolution in calcareous phytoplankton could have had a significant impact on marine carbonate sedimentation from the Early Cretaceous (Bornemann et al. 2003, Tremolada et al. 2006), and these significant changes in the sedimentary processes can also be clearly observed in the Transdanubian Range. From the Middle Jurassic onwards, the sedimentation was characterized by radiolarites and cherty limestones. The same conditions were preserved for the Late Jurassic, but close to its end the Ammonitico Rosso facies was substituted by the Maiolica or Biancone facies typical in the basins (Császár et al. 2012)

3. The studied section

3. 1. Mogyorós-domb composite section

The rich radiolarian fauna has been obtained from two Jurassic-Cretaceous sections of the Sümeg area: Mogyorós-domb I section and Dosztály's section. The classical Mogyorós-domb I key section (Haas 1984) is located south of the town (Fig. 1), stretched across the southwestern area of the former earth science teaching basecamp of the Eötvös University. This artificial trench exposes more than 300 meters long, mostly composed of layers inclined at nearly 90° in a continuous section from Middle Jurassic radiolarites, through Upper Jurassic Ammonitico Rosso-type limestones to the Upper Tithonian to Hauterivian Maiolica-type cherty limestones (Fig. 2). The sequence begins with radiolaritic chert layers, representing the topmost part of the Lókút Radiolarite Formation. The age of the radiolarite is likely Upper Bajocian/Lower Bathonian to Lower Kimmerdigian but there is no biostratigraphic evidence for this, although from the Dosztály's section (see in Fig. 1.) is proved the Late Bajocian to Lower Kimmeridgian age by radiolarians (Dosztály 1998). The radiolarite is overlain by light 2.5 meters in thickness grey marl. The next 10 m thick interval is red nodular limestone rich in Saccocoma fragments and moulds of Ammonites (Pálihálás Limestone Formation). Based on Ammonites biostratigraphy data, this formation can be assigned to the Kimmeridgian to Lower Tithonian (Vigh 1984). This limestone is continuously graded into the more than 270 meters thick cherty limestone and calcareous marl (Mogyorósdomb Limestone Formation). The lowermost 1.5 meters' part of limestone is completely free of chert, but gradually pass upward into cherty limestone with smaller chert nodules or lenses, and these chert inter-beddings become typical. Upward, thicker chert layers appear, and the well-bedded limestone and chert alternation become quite rhythmically (Fig. 3).

Between 120 m and 200 m, the chert inter-beddings decrease and eventually disappear completely and the limestone is grading continuously upward into a thin-bedded (5 to 15 cm in thickness) argillaceous limestone and calcareous marl (Haas 1984). At the uppermost part (200 to 310 meter), the succession becomes lithologically more homogenous calcareous marl. The most important microfossils are the calpionellids and radiolarians in the Mogyorósdomb Formation. Calpionellids are quite abundant, whereas the first chert nodules occur 1.4 m above the lithological formation boundary. Based on calpionellids, the Jurassic-Cretaceous boundary could be marked about 2.5 m within the Mogyorósdomb Limestone Formation (Fülöp 1964, Haas 1984, Tardi-Filácz 1986). The limestone layers are typified by wackestone textures, although the micritic matrix is made up mostly of calcareous nannoplankton. Calpionellids are also abundant in some of the layers, whereas the others are rich in calcified radiolarians. The radiolarian-bearing beds are usually silicified and contain chert nodules. However, calpionella-rich layers may also be silicified due to the diagenetic mobilization of SiO_2. The alternation of

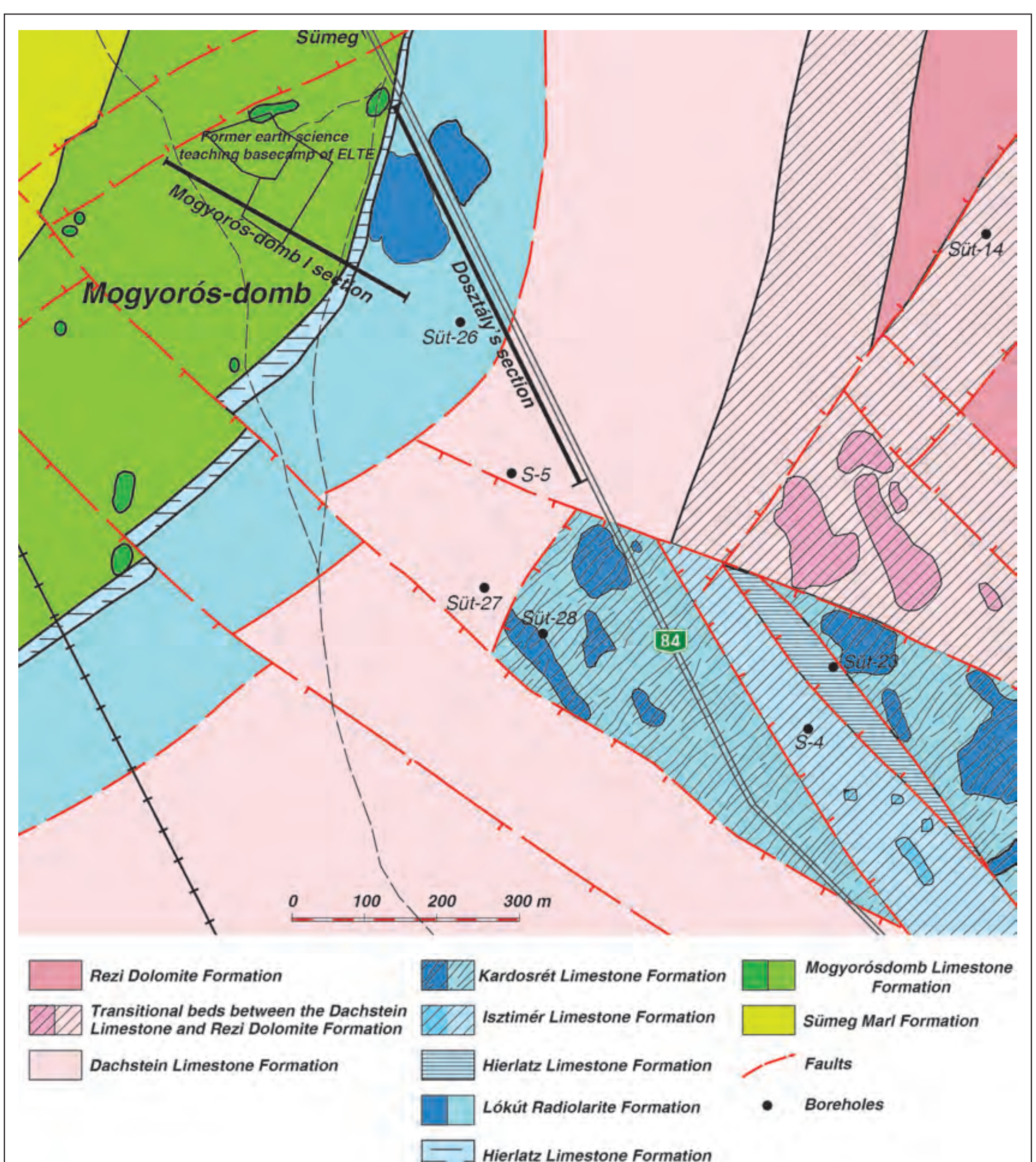
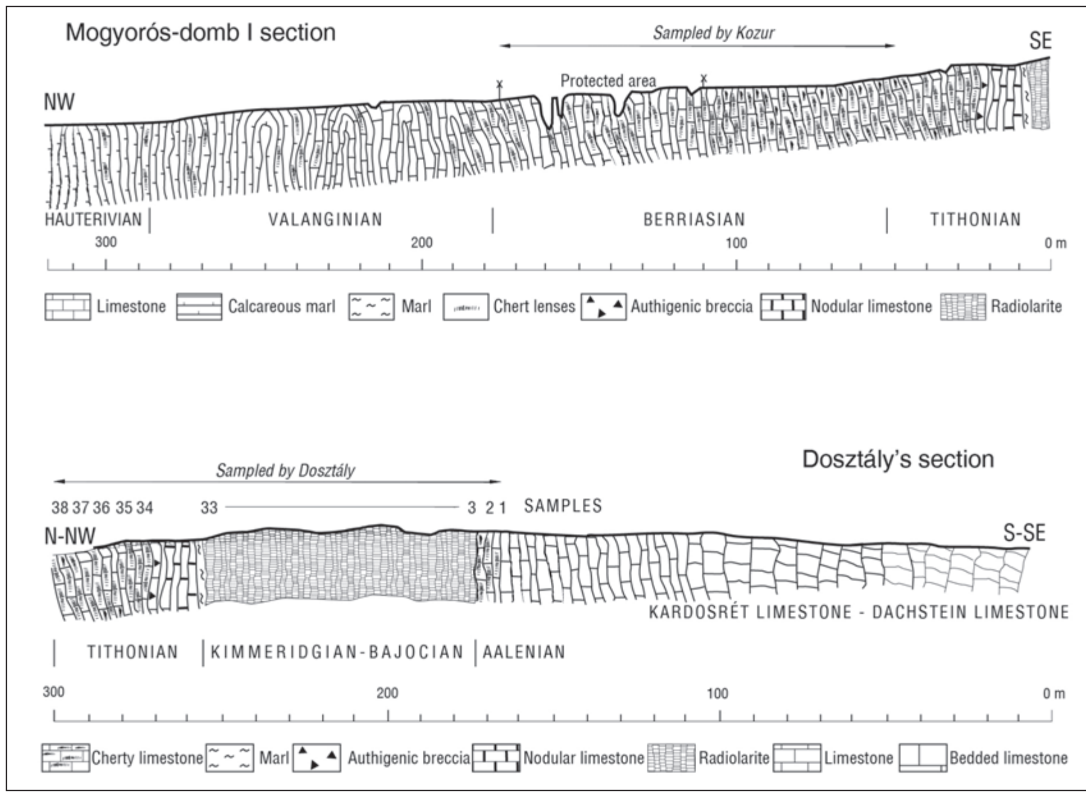


Figure 1 – Geological map of the locations of the reinvestigated sections at Sümeg, Transdanubian Range, Hungary (after Haas 1984)

Figure 2 – Stratigraphy and lithology of the Mogyorós-domb I section (after Haas 1984) and Dosztály's section



calpionella-rich and radiolarian-rich layers in the Berriasian layers may reflect orbitally forced climatic changes (Haas et al. 1994), while the appearance of calcareous marl in the Valanginian to Hauterivian part of the section might be related to the first Cretaceous anoxic (Weissert) event.

The Dosztály's section (Fig. 2) is also an artificial trench, approximately 100 meters to the east from the Mogyorós-domb I, which was extracted parallel to road 84 (Fig. 1). That artificial trench exposes a succession from Upper Triassic to the Lower Cretaceous as a whole in a length of about 500 meters. Almost in the entire section, the layers' dip is nearly vertical. The thick series start with Upper Triassic (Rhaetian) Dachstein Limestone which gradually pass upward the Lower Jurassic (Hettangian) Kardosrét Limestone Formation ("Dachstein-type limestone"), which is overlain by *Bositra*-bearing grey siliceous marl (Eplény Limestone Formation). According to Dosztály (1998), the samples from the Eplény Limestone Formation contain Upper Bajocian (UAZ 4 by Baumgartner et al. 1995) rich radiolarian fauna. The Lókút Radiolarites Formation evolves gradually from the Eplény Limestone, and the thickness of the exposed radiolarite sequence is about 100 m. The lowermost samples of the radiolarite contain Uppermost Bajocian and lowermost Bathonian radiolarians, while the uppermost part of the series contains Lower Kimmeridgian (UAZ 10) radiolarians. The radiolarite is followed by light grey limestone with smaller chert nodules and lenses (Mogyorósdomb Limestone Formation) with biostratigraphic evidence for the Upper Tithonian (UAZ 13) age (Dosztály 1998).

3. 2. Sümeg-17 (Süt-17) borehole

The Süt-17 borehole was drilled for geological mapping in 1974 at the northeast foot of the Vár-hegy of Sümeg (Fig. 4). The borehole penetrated ~520 m of sediments, of which uppermost Jurassic and Lower Cretaceous strata were recovered in nearly 400 meters (Fig. 5). Sedimentological and stratigraphical results from the Süt-17 borehole were published in Haas' monography (1984) while additional geophysical measurements are available in the archive of the Supervisory Authority of Regulatory Affairs (SARA). The entire Süt-17 core is archived in the core repository of the MFGI Szépvízér, Hungary.

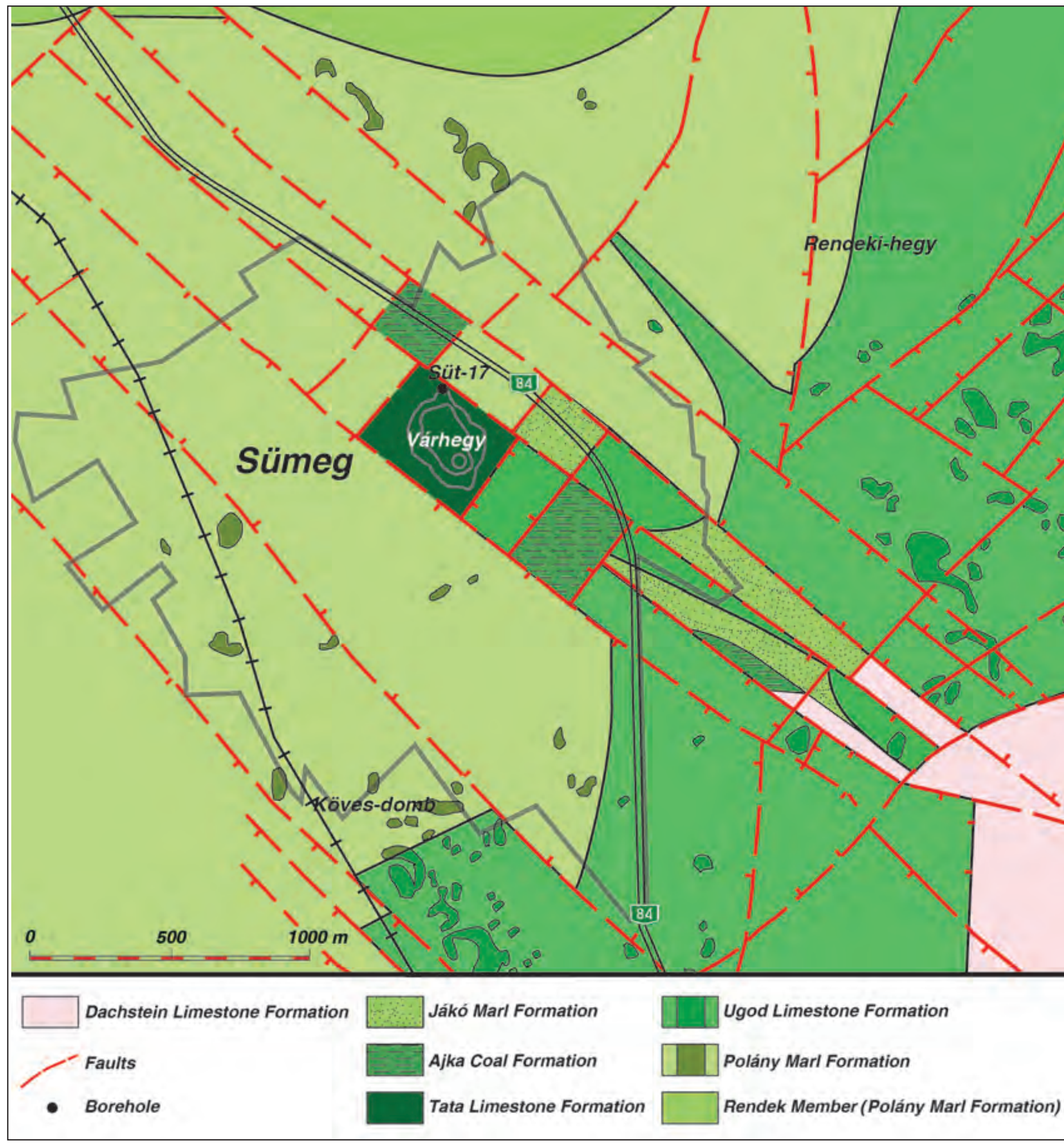
The borehole Süt-17 penetrated between 402.9 and 413.2 m a well-bedded Pálihálás Limestone Formation. The formation in this section overlies a 4-m-thick bed of Triassic-Liassic carbonate rock debris enclosed in a red clay above the Upper Triassic Kössen Formation. Upwards, between 389.9 and 402.9, the series consists of pure pinkish carbonate without chert, but gradually pass upward into cherty limestone (Mogyorósdomb Limestone Formation). The lower part belongs to the Upper Tithonian to Berriasian. The chert-free limestone is overlain with a sharp boundary, a characteristic hardground visible at 389.9 m. The 374.0 to 389.9 m interval shows a marked difference, even in microfacies, from the lower unit. Radiolarians appear (generally filled by calcite) and Calpionellidae almost completely disappears from the series. The texture is for the most part nannoplankton-micrite, less fre-

Figure 3 – Lithological features of Mogyorósdomb Limestone Formation in the Mogyorós-domb I stratotype section

The beds vary from 5 to 15 cm in thickness and completely light-coloured varying from greyish-white to yellowish-white. The bedding surfaces are slightly wavy in outline. The most characteristic feature of the limestone is the irregularly distributed grey chert nodules or interbeddings. The layers dip at 100 to 120°/75 to 85° in the fenced archeological site where these photos were taken by Tibor Cserny.

quently, radiolarian biomicrite (Haas 1984). The uppermost 5 meters (369.2–374.0 m) of the Mogyorósdomb Formation (Berriasian to Valanginian) represent a transition to the Sümeg Marl. This transition series consists of limestone with thin interbedded marl layers. These significant changes in the type of sedimentation may indicate the first, globally detected Cretaceous anoxic (Weissert) event. The topmost chert lens occurs at the base of the transitional unit. In the upper part of this marly unit increases the clay content, wavy, argillaceous bedding surfaces, thin interbedded clay layers being conspicuous. In the uppermost 1.5 m, chert content completely disappeared. A change can be seen in the microfacies as well, the radiolarians show a marked decrease in quantity, while the amount of land-derived mineral grains increases. The fossil elements are the same as those found in the lower part of the unit, but their quantity is reduced. Calpionellidae could be observed up to 374.2 m. The Sümeg Marl Formation between 98.5–369.3 m consists of calcareous silty marl with high carbonate content (229.0–369.3 m), the siltstone member (146.0–299.0 m) which is generally grey color often displaying a banded variation in tonality, with hardly any

Figure 4 – Pre-Cenozoic geological map of the Sümeg area showing the extension of the Upper Cretaceous formations and the position of the Süt-17 borehole (after Haas and Jocháné Edelényi 1984)



bedding surface interrupting the sequence, locally showing a bioturbated structure, being composed of silts, pelites and carbonate (Hauterivian). Between 291.2 m and 299.0 m, finely laminated and microlaminated structure occurs (Barremian). The thin lamination is due to the alternation of 2- to 4-cm-thick marl and sandstone laminae, the microlamination resulting from the mm-thick clay laminae within the sand layers (Haas 1984). This laminated part of the series might indicate the development of a suboxic or anoxic environment (Faraoni event). Upwards, between (211.7–291.2 m) the succession becomes lithologically more homogenous, this part is silty marl and siltstone with a large number of ammonites. The uppermost part of the Sümeg Marl Formation (98.5–146.0 m) is composed of grey sandy, silty marls, calcareous marls and limestones (Aptian). Upwards, the carbonate content increases indicating the transition towards the Tata Limestone (Haas 1984).

4. Radiolarian samples and methods

The radiolarian material from the classical Mogyorós-domb I section was investigated for the first time by the late Heinz Kozur in the early 1980s. Approximately 230 samples were collected from the middle part of the section. 200 samples from the lower part of the cherty limestone of Mogyorósdomb Formation between 50 and 105 m interval (Fig. 3) while 27 samples between 140 m to 164 m. Kozur made 10 plates from the extremely well-preserved radiolarians, but unfortunately, only photocopies of these plates have left, the original SEM pictures, radiolarian material and holders have been completely lost. The radiolarian samples from the Dosztály's section were collected by late Lajos Dosztály in the middle 1990s. He collected 38 samples (2 from the Eplény Limestone; 31 from the Lókút Radiolarite and 5 from the Mogyorósdomb Limestone), determined and illustrated in 5 plates (Dosztály 1998), although mainly from the Lókút Radiolarite part of the section. Therefore, we have re-photographed the radiolarian material of the upper four samples from the Mogyorósdomb Limestone part of the section (Fig. 3). Finally, 11 samples from the Süt-17 borehole were investigated between 323.7 m and 387.6 m, taken from the transition part of the Jurassic and Cretaceous.

The material is housed at the Paleontological Collection of the Geological Directorate of the Supervisory Authority for Regulatory Affairs under the numbers K 2022.1.1. – K 2022.419.1. Scanning electron microscope photographs were obtained with the use of a Thermo Scientific Prisma E SEM at the GEOCORE Core Sample, Collection and Laboratory Knowledge Center of the Supervisory Authority for Regulatory Affairs, established from the GINOP-2.3.3-15-2017-00043 grant. Specimens were left uncoated and the SEM was used in Low Vacuum Mode with the LVD detector under various accelerating voltages for the specimens with different states of preservation to reduce charging

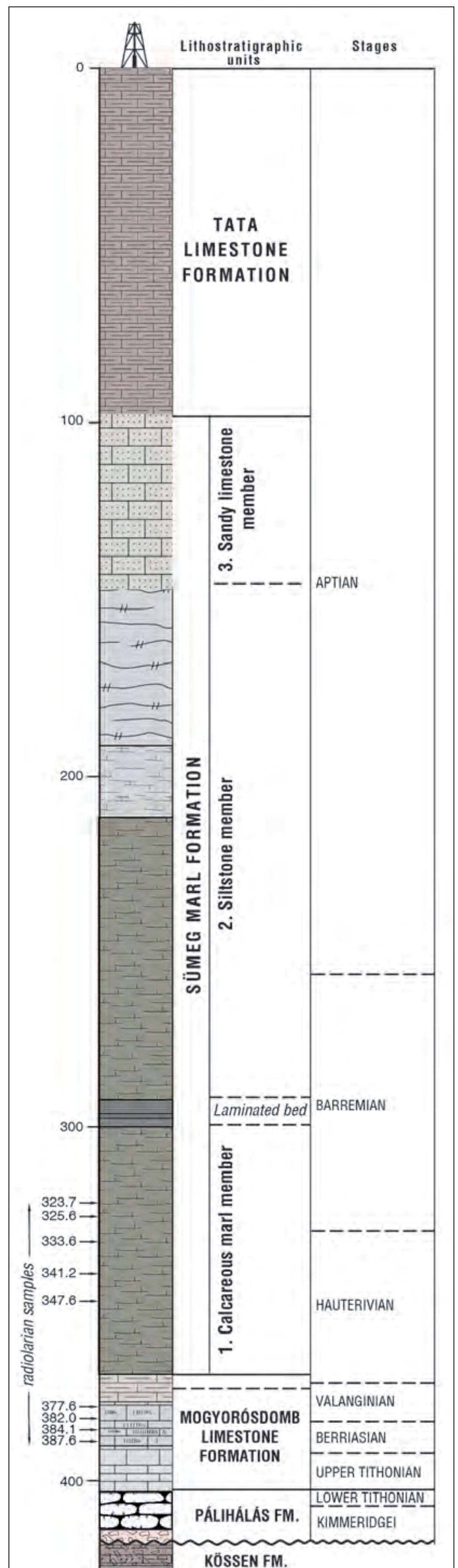


Figure 5 – Stratigraphy and lithology of the Jurassic-Cretaceous boundary section in the Süt-1 borehole (simplified after Haas 1984)

5. Upper Jurassic to Lower Cretaceous radiolarian fauna from the boundary sections

Two diverse and moderately well-preserved radiolarian faunas were recovered from the Süt-17 borehole and the Dosztály's section, while the fauna from the Mogyorós-domb I classical section could only be examined on the medium-quality photocopies plates left in the Kozur's legacy.

Although the preservation of radiolarian fauna in the latter is best, we do not have any information on the original location of the samples. The obtained radiolarians are listed in Table 1-3, while the species identified are illustrated in Plates 1–3. Radiolarian taxonomy follows chiefly the systematic classification of O'Dogherty et al. (2009), Jud (1994), Baumgartner et al. (1995), Dumitrica et al. 1997 and Steiger 1992. To establish the age of the radiolarian assemblages, the Unitary Association zonation of Baumgartner et al. (1995) was used.

5.1. Süt-17 borehole

Sample from 387.6 m yields the following characteristic, although poorly preserved radiolarians (see in detail in Table 1): *Sethocapsa* sp. A sensu Baumgartner, *Hsuum* cf. *brevicostatum* (Ozvoldova), *Pantenelluim squinaboli* (Tan). Although, the range of *Pantenelluim squinaboli* (Tan) is Late Kimmeridgian to Early Aptian (11-22 UAZones after Baumgartner et al. et al. 1995), co-occurrence of *Hsuum* cf. *brevicostatum* (Ozvoldova) and *Sethocapsa* sp. A sensu Baumgartner, latest Tithonian age (13-14 UAZ) is assigned to this horizon of the borehole.

Sample 384.1 m contains one of the most diverse radiolarian fauna of the section, characteristic species are the following: *Acaeniotyle* (?) *glebulosa* (Foreman), *Acaeniotyle diaphorogona* Foreman, *Acaeniotyle umbilicata* (Rüst), *Angulobracchia* (?) *portmanni* Baumgartner, *Archaeodictyomitra lacrimula* (Foreman), *Archaeodictyomitra mitra* Dumitrica, *Becus* cf. *helenae* (Schaaf), *Deviatus diamphidius* (Foreman), *Dicerosaturnalis trizonalis* (Rüst), *Dictyomitra pseudoscalaris* (Tan), *Ditrabs sansalvadorensis* (Pessagno), *Parvivacca magna* Jud, *Sethocapsa kaminogoensis* Aita, *Syringocapsa limatum* Foreman, *Tethysetta usotanensis* (Tumanda), *Thanarla elegantissima* (Cita), *Tritrabs ewingi* (Pessagno), *Xitus gifuensis* Mizutani and *Xitus spicularius* (Aliev). All of these species have a wider range, although the presence of *Xitus gifuensis* Mizutani constrains Late Kimmeridgian to Early Valanginian age (11-16 UAZ), most likely the latest Thitonian or Early Berriasian age (13-14 UAZ) is assigned to this sample.

Samples 382.0 m to 377.6 m contain a poorly preserved and limited number of identifiable radiolarian species which makes it difficult to determine the exact age at this stage of the section. The following species were identified from this zone: *Archaeodictyomitra excellens* (Tan), *Archaeodictyomitra lacrimula* (Foreman), *Dicerosaturnalis trizonalis* (Rüst), *Favosyringium affine* (Rüst), *Mirifusus dianae* (Karrer), *Suna echiodes* (Foreman), *Svinitzium columnarium* (Jud), *Syringocapsa limatum* Foreman, *Thanarla pulchra* (Squinabol) and *Tritrabs ewingi* (Pessagno). These samples are likely Berriasian to Valanginian (14-18 UAZ).

Samples 347.6 and 341.2 yield the following species: *Acaeniotyle diaphorogona* Foreman, *Acaeniotyle umbilicata* (Rüst), *Acaeniotyle vitalis* O'Dogherty, *Acanthocircus* cf. *breviaculeatus* Donofrio and Mostler, *Angulobracchia* (?) *portmanni* Baumgartner, *Archaeotritrabs gracilis* Steiger, *Becus* cf. *helenae* (Schaaf), *Becus gemmatus* Wu, *Cana septemporatus* (Parona), *Crolanium pythiae* Schaaf, *Crucella bossoensis* Jud, *Cyclastrum infundibuliforme* Rüst, *Dactyliodiscus lenticulatus* (Jud), *Deviatus diamphidius* (Foreman), *Dicerosaturnalis trizonalis* (Rüst), *Halesium* (?) *lieatum* Jud, *Halesium biscutum* Jud, *Hexapyramis* (?) *precedis* Jud, *Homoeoparonaella peteri* Jud, *Podobursa typica* (Rüst), *Pseudodictyomitra carpatica* (Lozyniak), *Pseudoeucyrtis tenuis* (Rüst), *Stylospongia* (?) *titirez* Jud, *Suna echiodes* (Foreman), *Suna hybum* (Foreman), *Tethysetta usotanensis* (Tumanda), *Thanarla elegantissima* (Cita) and *Tritrabs ewingi* (Pessagno). Based on the appearances of *Becus gemmatus* Wu, *Homoeoparonaella peteri* Jud, *Stylospongia* (?) *titirez* Jud and *Thanarla elegantissima* (Cita), these samples belong to the Hauterivian age (19 -20 UAZ).

Samples 333.6 m, 325.0 m and 323.7 m yield the most abundant and best-preserved radiolarian fauna of the section: *Acaeniotyle diaphorogona* Foreman, *Acaeniotyle umbilicata* (Rüst), *Angulobracchia* (?) *portmanni* Baumgartner, *Archaeodictyomitra excellens* (Tan), *Archaeodictyomitra lacrimula* (Foreman), *Archaeodictyomitra mitra* Dumitrica, *Archaeotritrabs gracilis* Steiger, *Becus gemmatus* Wu, *Cana septemporatus* (Parona), *Crolanium pythiae* Schaaf, *Crucella bossoensis* Jud, *Cyclastrum infundibuliforme* Rüst, *Deviatus diamphidius* (Foreman), *Dicerosaturnalis trizonalis* (Rüst), *Dictyomitra pseudoscalaris* (Tan), *Halesium sexangulum* Pessagno, *Lithotractus pusillus* (Cambell and Clark), *Praeconosphaera sphaeroconus* (Rüst), *Pseudoaulophacus* (?) *florealis* Jud, *Pseudodictyomitra carpatica* (Lozyniak), *Pseudodictyomitra lanceloti* Schaaf, *Pseudodictyomitra lilyae* (Tan), *Ristola asparagus* Jud, *Savaryella guexi* Jud, *Sciadiocapsa patera* O'Dogherty, *Stylospongia* ? *titirez* Jud, *Suna echiodes* (Foreman), *Suna hybum* (Foreman), *Syringocapsa spinosa* (Squinabol), *Thanarla pulchra* (Squinabol), *Triactoma tithonianum* Rüst and *Xitus spicularius* (Aliev). The co-occurence of *Pseudodictyomitra lanceloti* Schaaf and *Stylospongia* ? *titirez* Jud constrains the age of these samples to middle Hauterivian to Barremian age (20-22 UAZ).

5. 2. Mogyorós-domb composit section (Dosztály's section)

Sample 35 contains rather poorly preserved radiolarians, the following species were identified (see in detail in Table 2): *Becus helenae* (Schaaf), *Dicerosaturnalis trizonalis* (Rüst), *Emiluvia tecta* Steiger, *Halesium biscutum* Jud, *Pantanellium berriasianum* Baumgartner, *Pantanellium squinaboli* (Tan), *Parvicingula dhimaensis* Baumgartner, *Podobursa triacantha* (Fischli) and *Pseudodictyomitra carpatica* (Lozyniak). Based on the co-occurrence of *Parvicingula dhimaensis* Baumgartner, *Pantanellium berriasianum* Baumgartner *and Halesium biscutum* Jud, Late Tithonian age (13 UAZ) is assigned to this sample.

Sample 36 yields fairly diverse radiolarian species of *Acaeniotyle diaphorogona* Foreman, *Angulobracchia portmanni* Baumgartner, *Archaeospongoprunum patricki* Jud, *Archaeotritrabs gracilis* Steiger, *Becus helenae* (Schaaf), *Bolena tetradactyla* (Conti and Marcucci), *Deviatus diamphidius* (Foreman), *Dicerosaturnalis trizonalis* (Rüst), *Ditrabs sansalvadorensis* (Pessagno), *Emiluvia tecta* Steiger, *Emiluvia hopsoni* Pessagno, *Halesium* (?) *lineatum* Jud, *Halesium biscutum* Jud, *Halesium irregularis* Steiger, *Halesium sexangulum* Pessagno, *Katroma milloti* Schaaf, *Katroma tetrastyla* Steiger, *Pantanellium berriasianum* Baumgartner, *Pantanellium squinaboli* (Tan), *Parvicingula dhimaensis* Baumgartner, *Podobursa triacantha* (Fischli), *Podobursa triacantha hexaradiata* Steiger, *Podobursa triacantha tetraradiata* Steiger, *Podocapsa amphitreptera* Foreman, *Pseudodictyomitra carpatica* (Lozyniak), *Pseudoeucyrtis* ? *fusus* Jud, *Pyramospongia barmsteinensis* (Steiger), *Triactoma jonesi* (Pessagno), *Triactoma luciae* Jud, *Triactoma tithonianum* Rüst, *Tritrabs ewingi* (Pessagno) and *Xitus gifuensis* Mizutani. The co-occurrence of *Triactoma jonesi* (Pessagno), *Halesium*

samples:	387.6	384.1	382.0	380.2	378.3	377.6	347.6	341.2	333.6	325.0	323.7	UAZones
Acaeniotyle (?) *glebulosa* (Foreman)		x										17-22
Acaeniotyle diaphorogona Foreman		x					x		x		x	4-22
Acaeniotyle umbilicata (Rüst)		x					x	x		x	x	10-22
Acaeniotyle vitalis O'Dogherty							x					
Acanthocircus cf. *breviaculeatus* Donofrio and Mostler							x	x				
"*Actinomma* " sp. A sensu Steiger							x					
Angulobracchia (?) *portmanni* Baumgartner		x					x	x			x	13-22
Archaeocenosphaera sp.	x											
Archaeodictyomitra excellens (Tan)						x			x			11-22
Archaeodictyomitra lacrimula (Foreman)		x	x					x	x			14-22
Archaeodictyomitra mitra Dumitrica		x								x	x	14-22
Archaeotritrabs gracilis Steiger							x				x	16-22
Becus cf. *helenae* (Schaaf)		x					x				x	11-22
Becus gemmatus Wu							x	x	x			19-22
Becus sp.									x			
Cecrops septemporatus (Parona)							x					17-21
Crolanium pythiae Schaaf							x		x			17-22
Crolanium sp.									x			
Crucella bossoensis Jud							x		x		x	16-22
Crucella cf. *collina* Jud									x			13-21
Crucella cf. *lipmanae* Jud							x					17-19
Crucella sp. 1		x				x					x	
Crucella sp. 2									x			
Cyclastrum (?) cf. *planum* Jud							x					19-22
Cyclastrum infundibuliforme Rüst							x		x	x		17-22
Cyclastrum sp.								x				
Dactyliodiscus lenticulatus (Jud)							x					15-22
Deviatus diamphidius (Foreman)		x					x				x	8-22
Dicerosaturnalis trizonalis (Rüst)		x	x	x		x	x	x			x	6-22
Dictyomitra pseudoscalaris (Tan)							x	x	x			17-22
Ditrabs sansalvadorensis (Pessagno)		x										11-21
Favosyringium affine (Rüst)						x						
Favosyringium ? sp.						x						
Godia lenticulata Jud								x				15-22
Godia cf. *coronata* (Tumanda)								x				18-20
Godia cf. *tecta* (Tumanda)									x			19-22
Godia sp.											x	
Halesium (?) *lieatum* Jud							x					13-22
Halesium biscutum Jud							x					14-22
Halesium sexangulum Pessagno											x	
Halesium sp.											x	
Hexapyramis (?) *precedis* Jud							x					17-22
Hexapyramis ? sp.									x			
Homoeoparonaella peteri Jud							x					19-22
Homoeoparonaella sp. B sensu Steiger		x										
Hsuum cf. *brevicostatum* (Ozvoldova)	x											
Lithotractus pusillus (Cambell and Clark)									x			14-22
Mirifusus cf. *chenodes* (Renz)									x			6-22
Mirifusus dianae (Karrer)						x						7-20
Napora sp.		x				x	x					
Novamuria sp.		x		x	x							
Novoxitus (?) *tuberculatus* Wu and Li									x			19-22
Obesacapsula cf. *lucifer* (Baumgartner)				x			x					13-16
Pantanellium masirahense Dumitrica								x				
Pantenelluim lanceola (Parona)									x			
Pantenelluim squinaboli (Tan)	x											11-22

samples:	387.6	384.1	382.0	380.2	378.3	377.6	347.6	341.2	333.6	325.0	323.7	UAZones
Pantenelluim sp.										x		
Parvivacca magna Jud		x										14-20
Podobursa cf. *triacantha* (Fischli)								x	x			
Podobursa sp.						x						
Podobursa triacantha tetraradiata Steiger								x			x	11-22
Podobursa typica (Rüst)							x	x				
Praeconosphaera sphaeroconus (Rüst)									x			
Pseudoaulophacus (?) *florealis* Jud									x			16-22
Pseudodictyomitra carpatica (Lozyniak)							x		x			11-21
Pseudodictyomitra lanceloti Schaaf									x			20-22
Pseudodictyomitra lilyae (Tan)									x			18-22
Pseudoeucyrtis cf. *hanni* (Tan)							x					17-18
Pseudoeucyrtis sp.							x	x				
Pseudoeucyrtis tenuis (Rüst)							x					15-20
Ristola asparagus Jud									x			15-22
Savaryella guexi Jud									x		x	14-21
Sciadiocapsa patera O'Dogherty									x			
Sethocapsa kaminogoensis Aita		x										13-21
Sethocapsa sp. 1							x		x			
Sethocapsa sp. A	x											3-13
Sethocapsa trachyostraca Foreman								x				7-22
Staurosphaera sp.		x										
Stylospongia ? *titirez* Jud							x		x		x	20-22
Suna echiodes (Foreman)						x	x	x			x	9-22
Suna hybum (Foreman)							x		x			18-22
Svinitzium columnarium (Jud)			x									13-20
Syringocapsa limatum Foreman		x		x								
Syringocapsa spinosa (Squinabol)									x			19-22
Syringocapsa sp. 1		x	x	x	x							
Syringocapsa sp. 2		x										
Tethysetta usotanensis (Tumanda)		x					x					15-22
Tetrarectangulum sp.						x						
Tetratrabs sp. A. sensu Steiger							x					
Thanarla cf. *brouweri* (Tan)							x					10-22
Thanarla elegantissima (Cita)		x					x	x				18-22
Thanarla pulchra (Squinabol)					x				x			15-22
Triactoma tithonianum Rüst									x			6-22
Triactoma sp.		x										
Tritrabs ewingi (Pessagno)		x				x	x				x	4-22
Tritrabs rhododactylus Baumgartner								x				3-16
Tritrabs sp. 1							x		x	x		
Tritrabs sp. 2							x					
Xitus gifuensis Mizutani		X										11-16
Xitus spicularius (Aliev)		X							x			10-22
Xitus sp.									x			
Xitus ? sp.								x				

Table 1 – List of radiolarians obtained from the Süt-1 borehole

(?) *lineatum* Jud and *Parvicingula dhimaensis* Baumgartner constrain the age of sample 36 to Late Tithonian age (11-13 UAZ)

Samples 37and 38 yield the following poorly preserved radiolarians: *Acanthocircus breviaculeatus* Donofrio and Mostler, *Becus helenae* (Schaaf), *Deviatus diamphidius* (Foreman), *Dicerosaturnalis trizonalis* (Rüst), *Ditrabs sansalvadorensis* (Pessagno), *Emiluvia hopsoni* Pessagno, *Halesium irregularis* Steiger, *Halesium sexangulum* Pessagno, *Katroma milloti* Schaaf, *Podobursa triacantha* (Fischli), *Podobursa triacantha tetraradiata* Steiger, *Pseudodictyomitra carpatica* (Lozyniak), *Ristola cretacea* (Baumgartner), *Sethocapsa dorysphaeroides* Neviani and *Tritrabs ewingi* (Pessagno). These last two samples likely belong to the latest Tithonian to the earliest Berriasian, but cannot be more precisely determined.

Table 2 – List of radiolarians obtained from the Dosztály's section

samples:	35	36	37	38	UAZones
Acaeniotyle diaphorogona Foreman		x			4-22
Acanthocircus breviaculeatus Donofrio and Mostler		x		x	
Alievium helenae (Schaaf)	x	x		x	11-22
Angulobracchia portmanni Baumgartner		x			13-22
Angulobracchia aff. *mediopulvilla* Steiger		x			
Angulobracchia sp.	x			x	
Archaeodictyomitra sp.	x	x	x		
Archaeospongoprunum patricki Jud		x			13-22
Archaeotritrabs gracilis Steiger		x			
Bolena tetradactyla (Conti and Marcucci)		x			
Crucella ? sp.		x			
Deviatus diamphidius (Foreman)		x		x	8-22
Dicerosaturnalis trizonalis (Rüst)	x	x	x	x	10-17
Ditrabs sansalvadorensis (Pessagno)		x		x	11-21
Emiluvia tecta Steiger	x	x			3-18
Emiluvia hopsoni Pessagno		x		x	6-15
Emiluvia pessagnoi multipora Steiger		x	x		8-14
Emiluvia sp.	x				
Favosyringium qaudriaculeatum Steiger		x			
Favosyringium sp.		x			
Gorgansium sp. B sensu Steiger	x	x			
Halesium (?) lineatum Jud		x			13-22
Halesium biscutum Jud	x	x			14-22
Halesium irregularis Steiger		x		x	
Halesium sexangulum Pessagno		x		x	
"*Heliosphaera*" sp. in Steiger		x			
Higumastra sp.	x				
Homoeoparonaella sp.		x			
Katroma milloti Schaaf		x		x	
Katroma tetrastyla Steiger		x			
Katroma sp.		x			
Napora sp.	x	x			
Pantanellium berriasianum Baumgartner	x	x			13-15
Pantanellium cf. *riedeli* Pessagno	x				
Pantanellium squinaboli (Tan)	x	x	x		11-22
Paronaella sp.		x			
Parvicingula dhimaensis Baumgartner	x	x			3-11
Pentasphaera sp. sensu Steiger		x			
Podobursa triacantha (Fischli)	x	x		x	
Podobursa triacantha hexaradiata Steiger		x			
Podobursa triacantha tetraradiata Steiger		x		x	
Podocapsa amphitreptera Foreman		x			9-18
Pseudodictyomitra carpatica (Lozyniak)	x	x		x	11-21
Pseudoeucyrtis ? *fusus* Jud		x			13-17
Pyramospongia barmsteinensis (Steiger)		x			13-20
Ristola cretacea (Baumgartner)				x	12-17
Sethocapsa dorysphaeroides Neviani				x	
Sethocapsa cf. *kaminogoensis* Aita		x			13-21
Sethocapsa cf. *tricomis* Jud		x			13-16
Tethysetta boesii (Parona)		x			9-22
Tetrapaurinella sp.		x			
Tetratrabs sp. B sensu Steiger				x	
Triactoma jonesi (Pessagno)		x			2-13
Triactoma luciae Jud		x			13-21
Triactoma tithonianum Rüst		x			6-22
Triactoma sp.		x	x		
Tritrabs ewingi (Pessagno)		x		x	4-22
Tritrabs sp.		x			
Xitus gifuensis Mizutani		x			11-16
Xitus cf. *spicularis* (Aliev)		x			1+A1:F610-22

5. 3. Mogyorós-domb I section

The characteristic taxa in the assemblages of Mogyorós-domb I classical section include: *Pseudodictyomitra carpatica* (Lozyniak), *Praecaneta cosmoconica* (Foreman), *Emulivia tecta* Steiger, *Mirifusus dianae* (Karrer), *Xitus spicularius* (Aliev), *Neorelumbra kiesslingi* Dumitrica, *Podobursa triacantha tetraradiata* Steiger, *Acaeniotyle diaphorogona* Foreman, *Dicerosaturnalis trizonalis (Rüst)*, see in detail in Table 3.

The radiolarian assemblage of Sümeg area, Transdanubian Range, Hungary compare perfectly with the radiolarian fauna described previously from the Alpine – Mediterranean orogen (Baumgartner et al. 1980, Baumgartner 1984, Steiger 1992, Jud 1994, Goričan 1994, Baumgartner et al. 1995, Matsuoka 1998, Bragin & Tekin 1999, etc.). In total, 142 species have been determined from continuous and compiled Jurassic/Cretaceous sections of the Sümeg area, all of them moderate to poorly preserved. Genera represented in number of species and greatest abundance include: *Acaeniotyle, Archaeodictyomitra, Becus, Crucella, Dicerosaturnalis, Godia, Halesium, Podobursa, Pseudodictyomitra, Tritrabs* and *Xitus.* In both sections, number of species and genera of Spumellarians significantly outnumber the species of Nassellarians. Recent studies of radiolarian assemblages have demonstrated that the ratio between numbers of Spumellarians and Nassellarians indicates different depths in the oceanic basins (Takahashi 1991). In the modern ocean, the S/N ratio is a type of paleoceanographic water depth (e.g. Vishnevskaya & De Wever 1998): decreasing ratio of S/N indicates a deeper oceanic basin, while increasing ratio may indicate shallower water. Considering, that the radiolarian fauna of the sections around Sümeg shows a relatively high S/N ratio, we can assume that sedimentation took place on the outer shelf, not deeper than 4–500 meters.

One of the most characteristic radiolarian genera is the *Dicerosaturnalis* in our assemblage which is present in the Tithonian (Dosztály's section) and the Berriasian (Süt-17 and Mogyorós-domb I section) and even younger part of the section, as well. The species of this genus are *D. dicranacanthos* (forked spines) and *D. trizonalis* (simple spine) co-occurring practically in pairs in all J/K boundary sections all over the world. The taxonomic problem of these species was discussed in detail by Dumitrica & Zügel (2008) and they interpreted the appearance of various morphotypes as extreme varieties of a single species.

An additional important and interesting palaeontological element among the radiolarians is the *Novamuria* sp. This form has quite conservative morphology (latticed framework with spines) and was published by Carter et al. (1998) from the Lower Jurassic of Queen Charlotte Islands, Canada. Additional, certain species of this genus have been found in the Middle Triassic (Illyrian and Fassanian)" Buchenstein-Schichten" from the Southern Alps (Stockar et al. 2012). However, many comprehensive studies have been published from the Mesozoic around the world, and these "Lazarus taxa" disappeared from the palaeontological record until the lower to middle Hauterivian (19-20 UAZ). Consequently, their range can be updated and now expands until the lower Hauterivian (19-20 UAZ).

6. Radiolarian biostratigraphy: problems across the J/K

The most characteristic and globally widespread taxa of Tithonian – Berriasian radiolarians are the pantanellids (*Pantanellium*), saturnalids (e.g. *Dicerosaturnalis, Acanthocircus,* etc.), parvicingulids (e. g. *Parvicingula, Tethysetta, Mirifusus,* etc.), angulo- and patulibracchiids (e. g. *Paronaella, Homoeoparonaella, Halesium,* etc.) and tritrabids (*Tritrabs*, *Ditrabs*), in addition, many other diverse and abundant genera known from this period: *Becus, Crucella, Dicytomitra, Emiluvia, Pseudodictyomitra, Podobursa, Sethocapsa, Xitus*. Kiessling (2002) examined global biogeographic patterns in radiolarian diversity across the Jurassic/Cretaceous boundary and found that the highest number of species (865) for a single geologic time interval has been described in the Tithonian-Berriasian. For comparison, we currently know about 500 recent radiolarian species (Casey et al. 1990). Although, the Tithonioan–Berriasian radiolarian taxa seem to be fairly uniform and significant global changes in the radiolarian community are not known in the Late Jurassic–Early Cretaceous interval (Pessagno et al. 2009), a certain degree of provincialism can be already assumed from the Late Jurassic (Pessagno & Blome 1986), Pessagno et al. (1993), Kiessling & Scasso 1996). Based on qualitative and quantitative faunal characteristics, five large radiolaria provinces were recognized for the late Mesozoic time (Kiessling 1999, 2002). The greatest province including the paleo equator was the Tethyan Province symmetrically encompassed by Northern and Southern Boreal Provinces (Pessagno & Blome 1986, Vishnevskaya et al. 1999, Kiessling 2002, etc.). Although, low– to high–latitude faunal exchange was quite common, nonetheless, provinciality might played important role in regulating radiolarian diversity during the J/K boundary. The Late Jurassic to

Early Cretaceous interval has been extensively studied, particularly in the Western Tethyan region thanks to the outstanding work of Baumgartner's working group (e.g. Jud 1994; summarized in Baumgartner et al. 1995). Thanks to the vast amount of radiolarian taxonomic data and the development of the Unitary Associaton method (Guex 1977 1987, 1991, Guex et al. 2016), an easy-to-use radiolarian zonation were constructed by Baumgartner's working group in 1995. The UA method is based on graph theory and is designed for the construction of concurrent–range zones (Guex 1977). The UA Method accommodates best to the discontinuous stratigraphic record of radiolarians, i.e. to the highly diachronous FADs and LADs of individual taxa in different sections, resulting from the discontinuous nature of facies favouring optimal radiolarian preservation (Goričan et al. 2018). The method was first applied to correlate Upper Jurassic and Lower Cretaceous sections of the western Neotethys (Baumgartner et al. 1980) but today a detailed UA biozonation is available for Middle Jurassic to Lower Cretaceous for the Tethyan Realm (summarized in Baumgartner et al. 1995). Fig. 6 summarises the Upper Jurassic and Lower Cretaceous radiolarian zones and subzones including the Neotethys, North America, Japan, Caucasus and Russian Pacific Rim. The Jurassic–Cretaceous boundary is marked within the UAZ 13 by Baumgartner et al. (1995) the lower part of Zone D2 of Jud (1994) and species associated with the underlying Zone D1 (*Aacanthocircus sublongus*, *Ristola altissima*, *Triactoma blakei*, *Triactoma jonesi*, and *Podobursa spinosa*) are assignable to the Jurassic. The radiolarian assemblage of the Sümeg area includes only the *Triactoma jonesi* species, but the complete radiolarian assemblage from the samples 34–36 (Dosztály's section) and the sample 387.6 m from the Süt-17 borehole, clearly belong to the uppermost Tithonian. Unfortunately at the sample 384.1 m from the Süt-17, it is quite difficult to decide whether Uppermost Tithonian or lowermost Berriasian age. Species that are first found in Zone D2 (Jud 1994) such as *Sethocapsa kitoi*, *Wrangellium depressum*, *Obesacapsula rusconensis*, *Obesacapsula morroensis* and *Syringocapsa limatum* are mostly of Cretaceous age, but none of these can be found in Sümeg sections. In North America, Pessagno et al. (2009) placed the Jurassic–Cretaceous boundary in the boundary horizon between their Subzone $4\alpha_2$ and Subzone 5A, while in Japan, Matsuoka (1995) marked the K/J boundary in the lower part of the *Pseudodictyomitra carpatica* Zone. The faunal assemblages recorded from the Caucasus and mainly from the Russian Pacific Rim (Vishnevskaya 1993) are more difficult to correlate with the Mediterranean faunas of the Tethys because they show a strong Boreal influence (Goričan et al. 2018). Unfortunately, the precise and exact correlation among these radiolarian zones is still unclear (Lazarus et al. 2021).

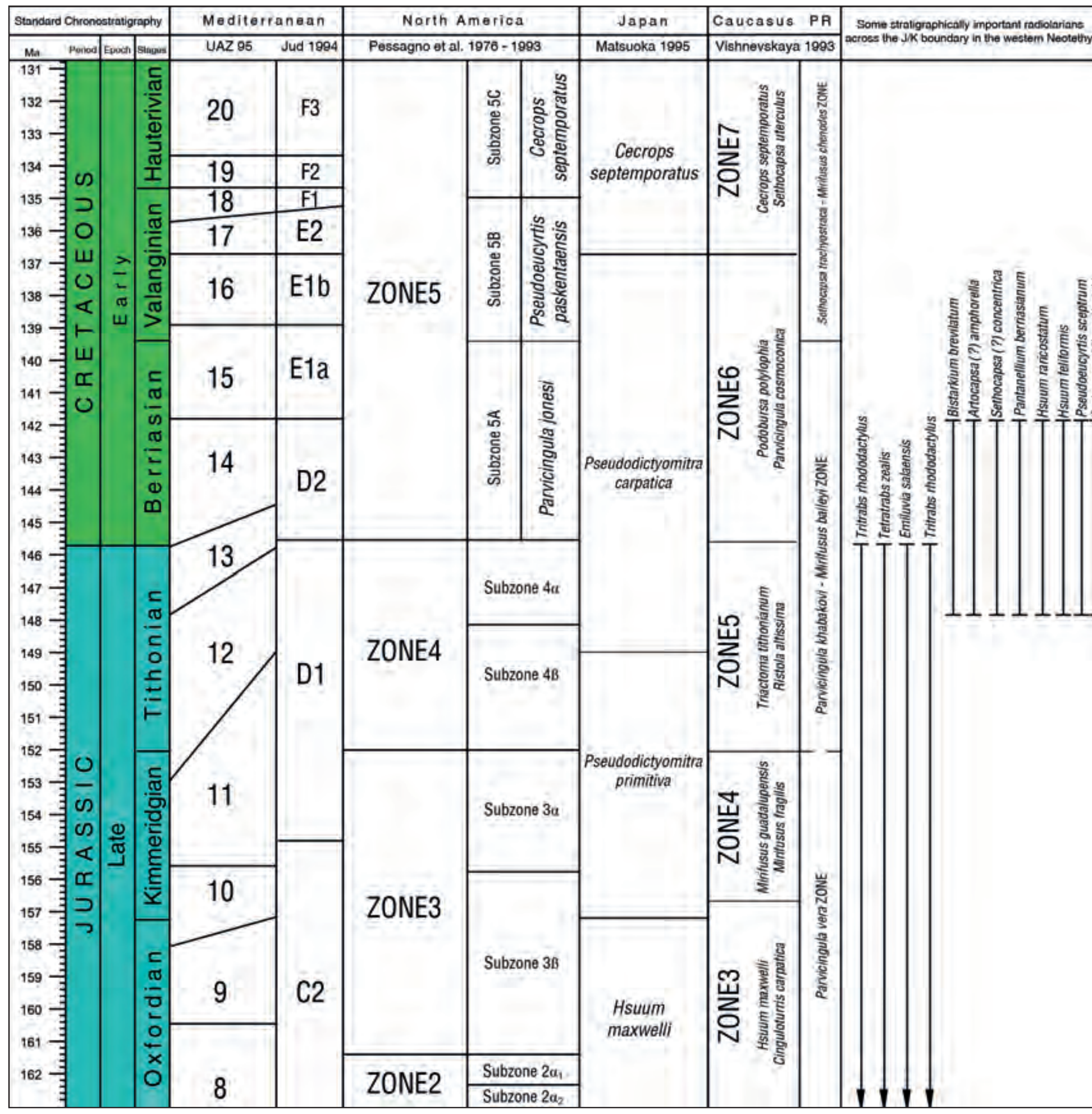
Table 3 – List of radiolarians extracted from the Mogyorós-domb I classical section

Acaeniotyle diaphorogona Foreman
Acanthocircus breviaculeatus Donofrio and Mostler
Angulobracchia portmanni Baumgartner
Archaeodictyomitra excellens (Tan)
Archaeodictyomitra vulgaris Pessagno
Archaeodictyomitra sp.
Archaeotritrabs gracilis Steiger
Alievium helenae (Schaaf)
Deviatus sp.
Dicerosaturnalis trizonalis (Rüst)
Emiluvia hopsoni Pessagno
Emiluvia pessagnoi Foreman
Emiluvia tecta Steiger
Favosyringium quadriaculeatum Steiger
Halesium sexangulum Pessagno
Halesium sp.
Hsuum brevicostatum (Ozvoldova)
Katroma millotti Schaaf
Katroma tetrastyla Steiger
Mirifusus dianae (Karrer)
Neorelumbra kiesslingi Dumitrica
Pantanellium masirahense Dumitrica
Pantanellium squinaboli (Tan)
Podobursa triacantha hexaradiata Steiger
Podocapsa sp.
Praecaneta cosmoconica (Foreman)
Pseudodictyomitra carpatica (Lozyniak)
Pseudodictyomitra sp. sensu Steiger
Spongocapsula sp.
Syringocapsa agolarium Foreman
Syringocapsa coronata Steiger
Tethysetta boesii (Parona)
Tritrabs ewingi (Pessagno)
Xitus spicularius (Aliev)
Pantanellium berriasianum Baumgartner
Savaryella guexi Jud

7. Diversification dynamics of radiolarians and their possible causes across the J/K boudary

The Late Jurassic to Early Cretaceous transition shows major faunal turnover in both the marine (e. g. Alroy 2010) and terrestrial realms (e. g. Tennant et al. 2017) with significant environmental and climate fluctuations (e.g. Weissert & Mohr 1996, Hart et al. 1997,

Figure 6 – Correlation of the Upper Jurassic and Lower Cretaceous radiolarian zones and subzones from the Mediterranean (Neotethyan Realm), North America, Japan, Caucasus and Russian Pacific Rim (PR)



Sager et al. 2013), although the lack of dramatic extinction events precludes of ratifying the J/K boundary based on the fossil record. Currently, there is relatively little understanding of how biotic and abiotic patterns through this interval are linked (e.g. Alroy et al. 2001, Upchurch et al. 2011, Benson & Druckenmiller 2014). There is some evidence for a decline in diversity in marine invertebrates (e. g. mollusks, ammonites, brachiopods) while a large amount of evidence proves a global revolution of marine plankton organisms (e.g. calcareous phytoplankton, planktonic foraminifera, radiolaria, etc.) during the Late Jurassic to Early Cretaceous period. Many studies demonstrate significant radiation among nannoplankton (Erba 2006) with enhanced rates of speciation (Bown et al. 2004) from the Middle Tithonian, while other groups' (e.g dinoflagellate) divergence growth rates have remained constant around the J/K boundary. The evolution history of siliceous micro-organisms during the Late Jurassic to Early Cretaceous shows a rather mosaic picture. The appearance and diversification of diatoms are known only from the Early Cretaceous (Falkowski et al. 2004) while the diversification rate of radiolarians shows general decline during the Late Jurassic (Kissling 2002). However, these declining trends changed to an increase in diversification rates in the Late Tithonian and Berriasian (Danelian & Johnson 2001, Kiessling 2002). O'Dogherty et al. (2009) demonstrate the Cretaceous radiolarian faunas in genera level remained rather similar to the Jurassic forms, although Kocsis et al. (2014) recovered a significant depressed in diversification rates at the end of the Jurassic with unchanged diversity during the J/K boundary. From the Middle to Late Jurassic, radiolarites are quite frequently formed sequences in western Tethys and proto–Atlantic Ocean (e.g. De Wever 1989, 1994; De Wever et al. 1995, De Wever & Baudin 1996, Baumgartner 2013, De Wever et al. 2014), therefore, this basin system was fueled by high–nutrient flux, leading to high levels of phytoplankton and radiolarites (Fig. 7.), possibly driven by shifting circulatory regimes as continental configurations changed (Baumgartner 1987, Danelian & Johnson 2001, Tennant et al. 2017). This led to the development of a globe–encircling equatorial current and the radiation of the coccolithophores and deposition of deep–sea phytoplankton carbonate, which is inferred to have caused the termination of upwelling and widespread radiolarite sedimentation from the Tithonian in most of the Neotethyan subbasins (De Wever 1989), while somewhat later, in the Early Aptian, in the Panthalassa oceanic basin (Lazarus et al. 2021). In the deep ocean, e.g. Mariana Trench (Matsuoka 1998) or the Site 801 of the ODP in the western Pacific, alternating red radiolarite and claystone beds formed instead of pure radiolarite (Matsuoka 1992). Although radiolarites occasionally can be found in younger rocks, the ocean's sedimentary mechanisms changed permanently, if gradually, across the Jurassic–Cretaceous boundary (Lazarus et al. 2021).

Additional evidence suggests that climate strongly influenced oceanic productivity and nutrient cycles at the J/K boundary (Danelian & Johnson 2001), which, combined with a eustatic lowstand (Miller et al. 2005), would have strongly impacted upon plankton organisms (Tennant et al. 2017). There is substantial evidence for a major sea–level regression at the J/K boundary (Haq et al. 1987) potentially driven by fluctuations in the extent of polar ice caps (Haq 2014). At the same time, the pCO$_2$ levels did not change significantly (Berner 2009), however, a distinct cooling trend is evident in the Tithonian (probably already started by the Kimmeridgian) and across the J/K boundary (Weissert & Channell 1989, Bice et al. 2003, Price & Rogov 2009, Jenkyns et al. 2012).

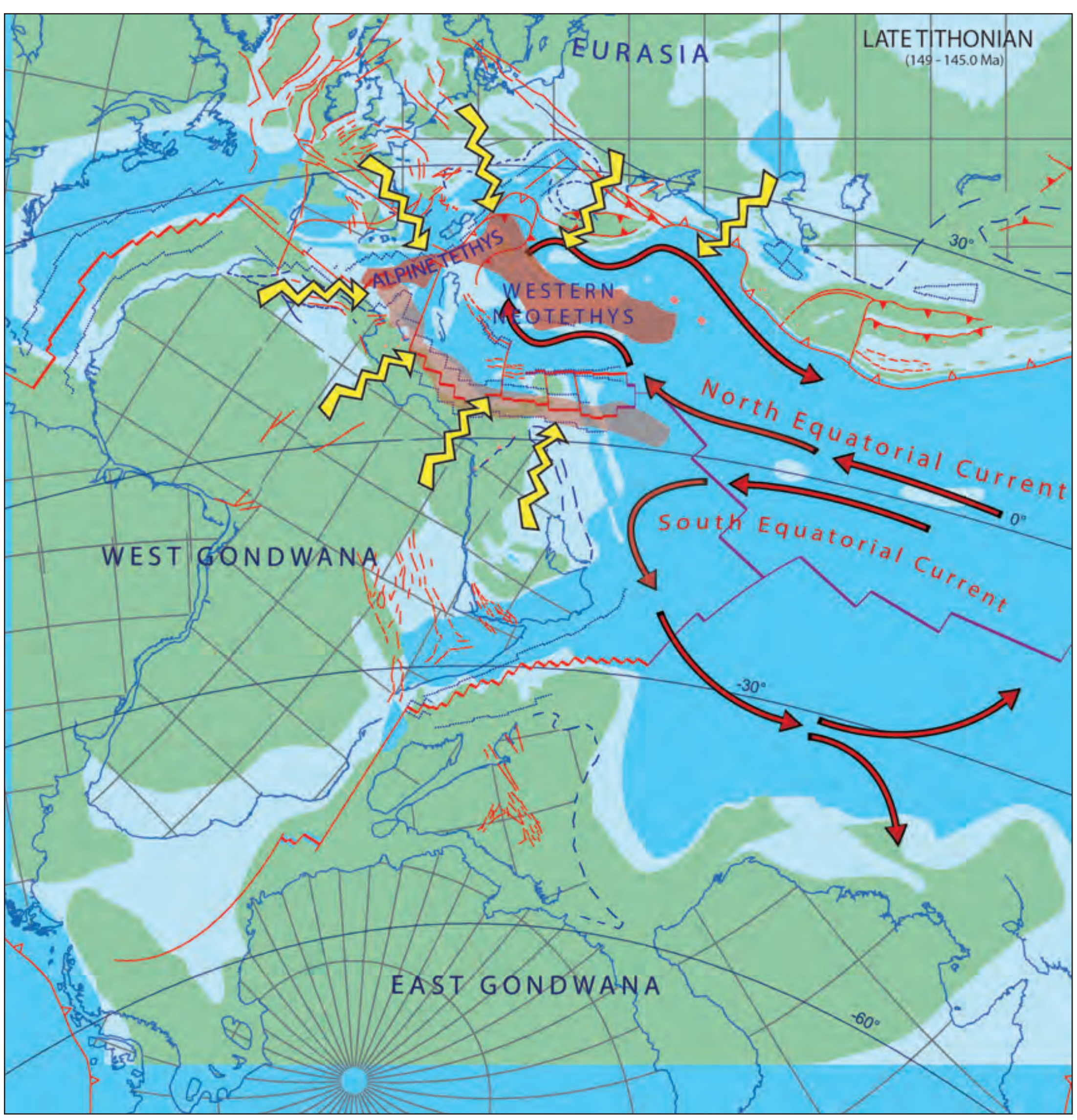


Figure 7 – Late Jurassic (Tithonian) paleotectonic reconstruction for the Neotethys (Barrier et al. 2018)

Yellow arrows indicate organic matter and nutrient input into the oceanic basin. Red area shows radiolarite formation in the oceanic basin. The theoretical models for the accumulations of Mesozoic radiolarite is summarised in Baumgartner (2013).

8. Conclusion

The Late Jurassic – Early Cretaceous interval represents the highest peak in radiolarian diversity on the species level, although there is no significant revolution or extinction event across the J/K boundary. Globally, the oceanic conditions favored radiolarians, however, the radiation of the calcareous phytoplankton caused the termination of widespread radiolarite sedimentation from the Tithonian. A continuous and compiled Jurassic/Cretaceous sequences were reinvestigated from the Sümeg area, Transdanubian Range, Hungary. In total, sixty–four genera and 142 moderate to poorly preserved radiolarian taxa have been identified and documented from the Süt-17 borehole and the compiled Mogyorós-domb section (Mogyorós-domb I classical section and Dosztály's section). Radiolarian biostratigraphic studies indicate uppermost Tithonian (UAZ 13) age to Middle Hauterivian (UAZ 20–22) in the Süt-17 borehole, while uppermost Tithonian (UAZ 13) in the Dosztály's section and Berriasian to Hauterivian (UAZ 14–20) age for the Mogyorós-domb I classical section. Based on the obtained radiolarian assemblage from the Sümeg sections, there is no definable boundary based on radiolarians in the Jurassic – Cretaceous transition interval.

Acknowledgments

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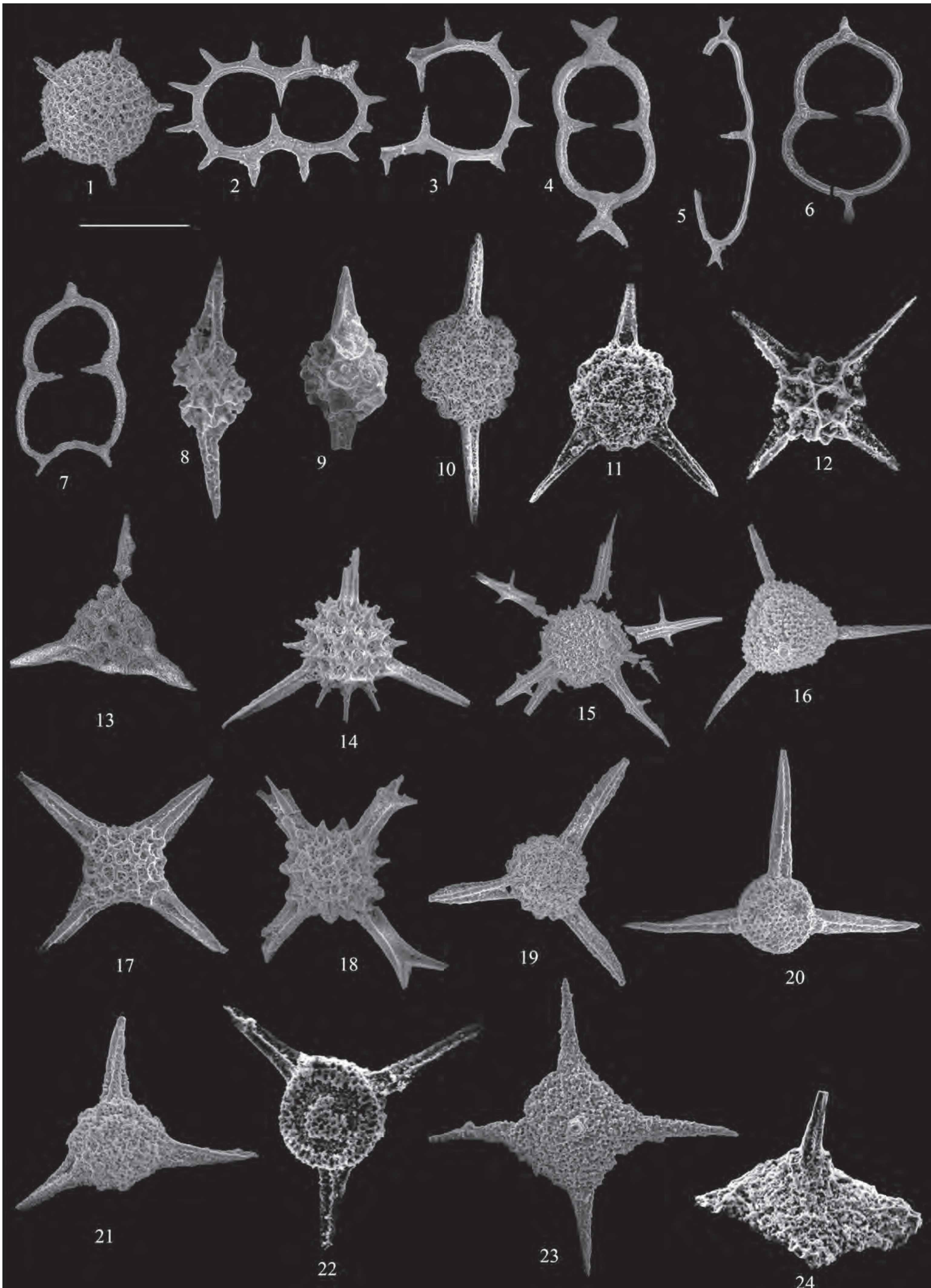
Plate 1 – Radiolarians from Süt-17 borehole and from Dosztály's section

Scale bar = 200μ

1. *Novamuria* sp., Süt-17 borehole: 384.1 m
2. *Acanthocircus* cf. *breviaculeatus* Donofrio & Mostler, Dosztály's section sample 36
3. *Acanthocircus* cf. *breviaculeatus* Donofrio & Mostler, Dosztály's section sample 36
4. *Dicerosaturnalis trizonalis* (Rüst), Süt-17 borehole: 384.1 m
5. *Dicerosaturnalis trizonalis* (Rüst), Dosztály's section sample 36
6. *Dicerosaturnalis trizonalis* (Rüst), Süt-17 borehole: 347.6 m
7. *Dicerosaturnalis trizonalis* (Rüst), Süt-17 borehole: 323.7 m
8. *Pantenelluim squinaboli* (Tan), Dosztály's section sample 36
9. *Pantenelluim* sp., Süt-17 borehole: 323.7 m
10. *Acaeniotyle umbilicata* (Rüst), Süt-17 borehole: 384.1 m
11. *Acaeniotyle diaphorogona* Foreman, Süt-17 borehole: 384.1 m
12. *Cecrops septemporatus* (Parona), Süt-17 borehole: 384.1 m
13. *Gorgansium* sp. B sensu Steiger, Dosztály's section sample 34
14. *Alievium* cf. *helenae* Schaaf, Dosztály's section sample 36
15. *Bolena tetradactyla* (Conti & Marcucci), Dosztály's section sample 36
16. *Tetrapaurinella* sp., Dosztály's section sample 36
17. *Emiluvia tecta* Steiger, Dosztály's section sample 36
18. *Emiluvia hopsoni* Pessagno, Dosztály's section sample 36
19. *Triactoma tithonianum* Rüst, Dosztály's section sample 38
20. *Suna echiodes* (Foreman), Süt-17 borehole: 347.6 m
21. *Suna echiodes* (Foreman), Süt-17 borehole: 323.7 m
22. *Suna hybum* (Foreman), Süt-17 borehole: 384.1 m
23. *Stylospongia* ? *titirez* Jud, Süt-17 borehole: 323.7 m
24. *Stylospongia* ? *titirez* Jud, Süt-17 borehole: 347.6 m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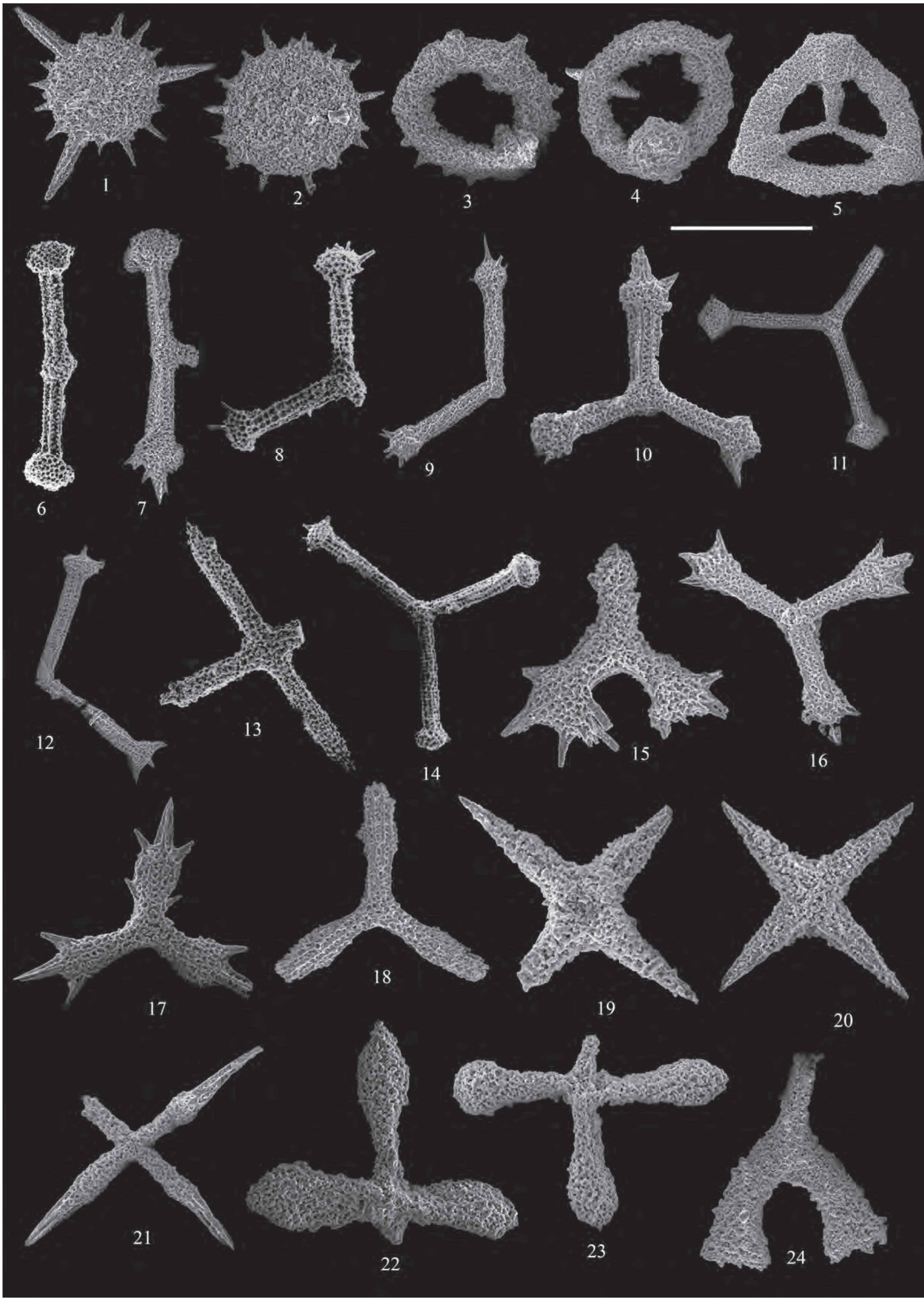
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Plate 1 – Radiolarians from Süt-17 borehole and from Dosztály's section

Scale bar = 200μ

1. *Becus* sp., Süt-17 borehole: 323.7 m
2. *Godia* sp., Süt-17 borehole: 323.7 m
3. *Godia lenticulata* Jud, Süt-17 borehole: 341.2 m
4. *Cyclastrum infundibuliforme* Rüst, Süt-17 borehole: 347.6 m
5. *Cyclastrum infundibuliforme* Rüst, Süt-17 borehole: 323.7 m
6. *Ditrabs sansalvadorensis* (Pessagno), Süt-17 borehole: 384.1 m
7. *Ditrabs sansalvadorensis* (Pessagno), Dosztály's section sample 36
8. *Tritrabs ewingi* (Pessagno), Süt-17 borehole: 384.1 m
9. *Tritrabs ewingi* (Pessagno), Dosztály's section sample 36
10. *Tritrabs ewingi* (Pessagno), Dosztály's section sample 36
11. *Archaeotritrabs gracilis* Steiger, Dosztály's section sample 36
12. *Archaeotritrabs gracilis* Steiger, Süt-17 borehole: 323.7 m
13. *Tetratrabs* sp. A. Steiger, Süt-17 borehole: 347.6 m
14. *Homoeoparonaella peteri* Jud, Süt-17 borehole: 347.6 m
15. *Paronaella* sp., Dosztály's section sample 36
16. *Halesium sexangulum* Pessagno, Dosztály's section sample 36
17. *Halesium irregularis* Steiger, Dosztály's section sample 36
18. *Angulobracchia portmanni* Baumgartner, Dosztály's section sample 36
19. *Crucella bossoensis* Jud, Süt-17 borehole: 323.7 m
20. *Crucella bossoensis* Jud, Süt-17 borehole: 333.6 m
21. *Crucella* sp., Dosztály's section sample 36
22. *Savaryella guexi* Jud, Süt-17 borehole: 323.7 m
23. *Savaryella guexi* Jud, Süt-17 borehole: 323.7 m
24. *Deviatus diamphidius* (Foreman), Süt-17 borehole: 323.7 m

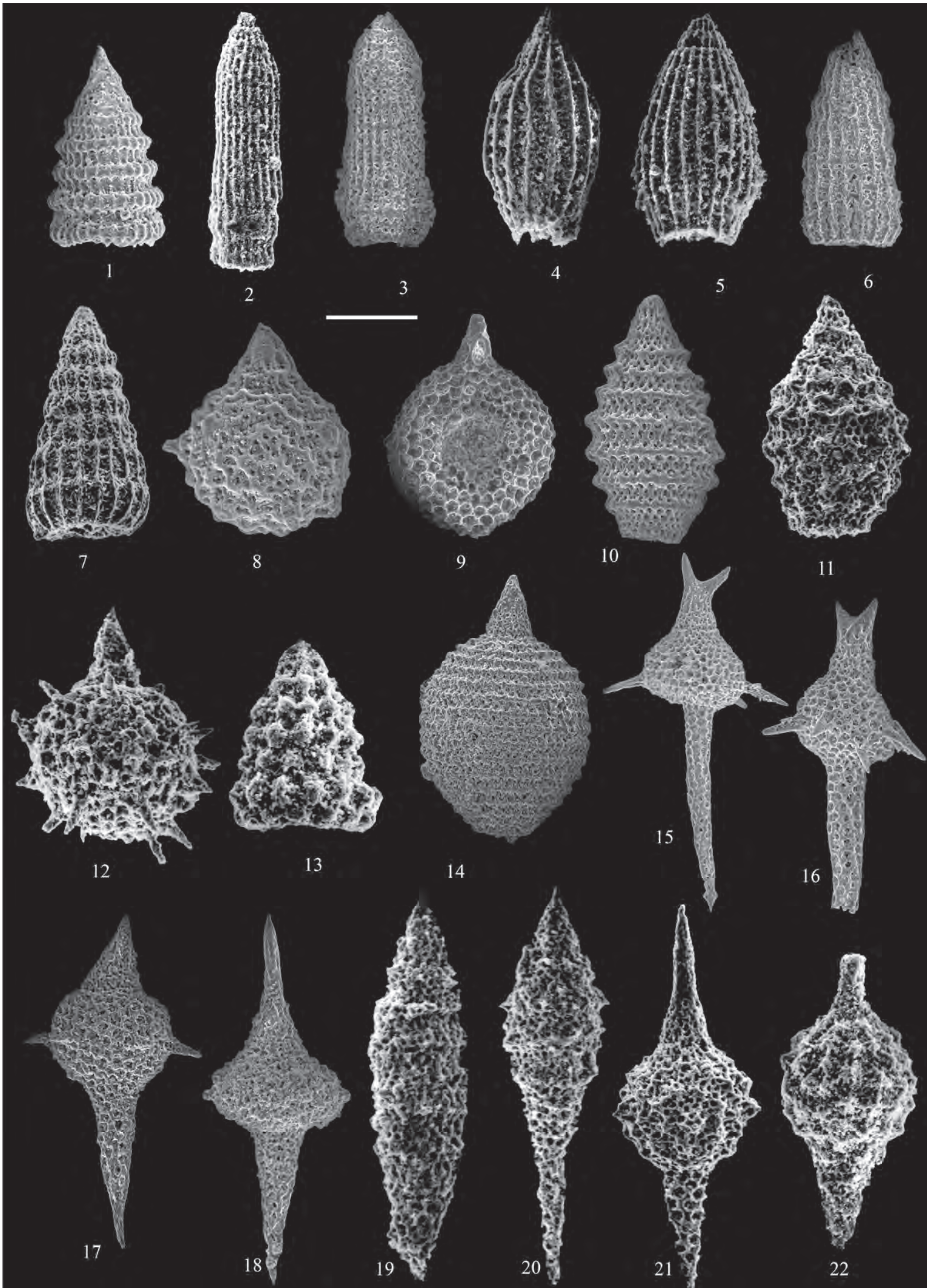
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Plate 3 – Radiolarians from Süt-17 borehole and from Dosztály's section

Scale bar = 200μ

1. *Pseudodictyomitra carpatica* (Lozyniak), Dosztály's section sample 36
2. *Archaeodictyomitra excellens* (Tan), Süt-17 borehole: 333.6 m
3. *Archaeodictyomitra excellens* (Tan), Süt-17 borehole: 377.6 m
4. *Archaeodictyomitra lacrimula* (Foreman), Süt-17 borehole: 384.1 m
5. *Archaeodictyomitra mitra* Dumitrica, Süt-17 borehole: 384.1 m
6. *Dictyomitra pseudoscalaris* (Tan), Süt-17 borehole: 341.2 m
7. *Dictyomitra pseudoscalaris* (Tan), Süt-17 borehole: 384.1 m
8. *Sethocapsa trachyostraca* Foreman, Süt-17 borehole: 333.6 m
9. *Sethocapsa* sp. 1, Süt-17 borehole: 347.6 m
10. *Tethysetta boesii* (Parona), Dosztály's section sample 36
11. *Tethysetta usotanensis* (Tumanda), Süt-17 borehole: 347.6 m
12. *Obesacapsula* cf. *lucifer* (Baumgartner), Süt-17 borehole: 347.6 m
13. *Xitus spicularius* (Aliev), Süt-17 borehole: 333.6 m
14. *Mirifusus dianae* (Karrer), Süt-17 borehole: 377.6 m
15. *Katroma tetrastyla* Steiger, Dosztály's section sample 36
16. *Katroma* sp., Dosztály's section sample 36
17. *Podobursa triacantha tetraradiata* Steiger, Süt-17 borehole: 323.7 m
18. *Favosyringium affine* (Rüst), Süt-17 borehole: 377.6 m
19. *Pseudoeucyrtis tenuis* (Rüst), Süt-17 borehole: 347.6 m
20. *Pseudoeucyrtis* sp., Süt-17 borehole: 347.6 m
21. *Syringocapsa limatum* Foreman, Süt-17 borehole: 384.1 m
22. *Syringocapsa spinosa* (Squinabol), Süt-17 borehole: 333.6 m

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