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# MIOCENE TO RECENT RADIOLARIANS FROM SOUTHERN PACIFIC COAST OF COSTA RICA

## RADIOLARIOS DEL MIOCENO AL RECIENTE DEL PACÍFICO SUR DE COSTA RICA

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**ABSTRACT:** Radiolarians from Miocene–Recent marine sediments are taxonomically reported for the first time in Costa Rica using samples from Sites U1381C and U1414 A of the Integrated Ocean Drilling Program CRISP A2 expedition. Both sites are presently located offshore Osa Peninsula, northeastern equatorial Pacific. The sediments retrieved from the two sites mainly consist of nannofossil calcareous ooze with foraminifera, sponge spicules, diatoms and radiolarians. In both sequences, radiolarians vary from absent to abundant and well preserved. This work presents the systematic paleontology of the radiolarians recorded including taxonomic notes and illustrations of the species. An associated publication provides the statistic and biostratigraphic data for the sites, spanning from the middle Miocene to the Recent (radiolarian zones RN5 to RN16). In total, 116 species (14 families and 41 genera) were found. Hole U1414 A yielded a total of 105 species and 65 taxa with conditional identifications ("species groups"), and Hole U1381C yielded a total of 90 species and 55 species groups.
**Keywords:** Radiolaria Polycystina, Cocos Plate, Cenozoic, Miocene, IODP 344 Expedition, Costa Rica, Eastern Equatorial Pacific.

**RESUMEN:** El presente estudio reporta por primera vez la taxonomía de radiolarios pertenecientes a sedimentos marinos de edad Mioceno-Reciente de Costa Rica. La identificación taxonómica se realizó utilizando los sedimentos obtenidos en las perforaciones U1381C y U1414 A de la Expedición CRISP A2 del Programa Integral de Perforación Oceánica, (IODP, por sus siglas en inglés). Ambos sitios están ubicados en mar abierto cercanos a la Península de Osa, Pacífico este ecuatorial. Dichos sedimentos consisten en un ooze calcáreo con nanofósiles, foraminíferos, diatomeas, espículas de esponja y radiolarios. En ambas secuencias, la recuperación de radiolarios varía desde ausentes a abundantes y bien preservados. El siguiente estudio presenta la sistemática paleontológica a detalle junto con las ilustraciones

de radiolarios. Una publicación previa asociada a este estudio proporciona los datos estadísticos y bioestratigráficos de los sitios, los cuales corresponden al Mioceno medio-Reciente (zonación RN5 a RN16). El número total de especies identificadas en las muestras es de 116, distribuidas en 14 familias y 41 géneros. La perforación U1414 A suma un total de 105 especies y 65 taxones con identificaciones condicionales (grupos), y la perforación U1381C un total de 90 especies y 55 grupos.
**Palabras clave:** Radiolaria Polycystina, placa Cocos, Cenozoico, Mioceno, Expedición 344, Costa Rica, Pacífico Este Ecuatorial.

## INTRODUCTION

Polycystine Radiolaria is a major group of marine planktonic protists. Their skeletons are composed of amorphous silica, allowing their preservation in the sediments. In Costa Rica, radiolarians are the oldest fossils present in the geological record. Neogene radiolarians from the sedimentary cover of the Cocos plate are the subject of the present study. Their taxonomy and biostratigraphy is based on continuously cored deep-sea successions. Radiolarian data have been correlated with that of other microfossils, such as calcareous nannoplankton and foraminifers, and compared with geomagnetic polarity, in order to constrain the ages of the deposits.

During the last forty years, several authors have contributed to the development of regional stratigraphic radiolarian zonations for the Equatorial Pacific area (Riedel, 1957, 1959; Nigrini, 1971; Moore, 1971; Riedel and Sanfilippo 1971, 1978; Goll, 1980). Radiolarians have also been used for paleoenvironmental reconstructions, identifying tropical, subtropical, cool temperate, polar and upwelling assemblages (Moore, van Andel, Sancetta & Pisias, 1978). The association of radiolarian assemblages with water masses (differing chiefly in temperature and nutrients) has been described from many areas, including, among others, the Pacific Ocean (Nigrini, 1970; Riedel, 1971a; Sachs, 1973; Renz, 1976; Molina-Cruz, 1977; Boltovskoy and Jankilevich, 1985; Boltovskoy and Riedel, 1987), the Indian Ocean (Johnson and Nigrini, 1980, 1982) and the Atlantic Ocean (Bjørklund, Cotesea, Swanberg & Schrader, 1998; Boltovskoy, 1998, 1999). Thus, radiolarian fossil remains can also provide valuable clues to the ecological settings (primarily temperature and productivity) of the overlying waters at the time when these populations dwelled in the water-column. Although this technique, as most others, has its shortcomings (Boltovskoy, 1994; Haslett, 2002), it has proven its usefulness in a numbers of detailed surveys world-wide.

Since the end of the 19th century, several high-level taxonomic schemes have been proposed for the polycystines. Haeckel (1887) produced one of the earliest comprehensive systems of radiolarian classification, describing thousands of new polycystine species. Haeckel's work is still a necessary reference guide, but it does not satisfactorily represent natural relationships, because groupings are only based on morphologic similarities of the skeleton only, and because the rigidity of these geometry-based diagnoses often ignores the ample intraspecific variability of these protists. Efforts to improve the classification schemes inherited from earlier workers have followed two different main approaches, which are cytological data and evolutionary studies. Several revisions that rely heavily on cytoplasmic features have been proposed (Hollande and Enjumet, 1960; Cachon and Cachon, 1972a, b; Petrushevskaya, Cachon & Cachon, 1976; Petrushevskaya, 1981). Although these schemes are probably sounder in biological terms, their application to fossil and subfossil materials lacking the protoplasm is problematic, which is one of the reasons for their very limited acceptance among radiolarian workers. Analyses of evolutionary lineages in geological sequences were used as a basis to assess the taxonomic value of key skeletal traits; it was concluded that

many of them (e.g. number of segments, number of supplementary concentric spheres, number of feet, number of rays and of equatorial spines in discoidal Spumellaria, presence and nature of thoracic wings) have little or no suprageneric value. In contrast, several others (e.g. cephalic structure, pore arrangement, shell terminations in Nassellaria), traditionally considered as of minor value, are conservative through time and reveal evolutionary lineages and, therefore, are relevant for higher-rank divisions (Riedel and Sanfilippo, 1986). Based on skeletal features only, several authors proposed alternative classifications, either for the entire order or for selected polycystine groups (Riedel, 1967a in Banner et al., 1967, 1971b; Petrushevskaya, 1965, 1971; Goll, 1968, 1969; Sanfilippo and Riedel, 1970; Dumitrica, 1989; De Wever, Dumitrica, Caulet, Nigrini & Caridroit, 2001). The presently most widely accepted classification for extant and Cenozoic radiolarians is still that of Riedel (1967a) and Riedel (1971b), which is adopted in this work. The clasification of Miocene polycystines is based on De Wever et al. (2001).

This study is based on open ocean drill sites and intends to provide the first detailed Miocene-Recent radiolarian inventory of Pacific sediments off Costa Rica. As opposed to most previous works in the area, especially those oriented at paleoceanographic reconstructions (see references above), which used restricted subsets of the fauna (usually 20-40 morphotypes), it covers all the radiolarians found in the samples.

## GEOLOGICAL SETTING

The western active margin off Costa Rica represents the subduction zone resulting from the interaction of the Cocos plate and the Caribbean plate. The drilled sites of the expedition CRISP A2 are located near the interaction between the two plates, with the objective to characterize the rocks and sediments of the plate's surrounds (Fig. 1). Hole U1381C is located about 4.5 km seaward of the accretionary prism, offshore the Osa Peninsula, on the incoming Cocos plate (8°25.7027′N, 84°9.4805′W, 2064.6 m water depth). Hole U1414 A is located on the incoming Cocos plate, about 1 km seaward of the deformation front (8°30.2304′N, 84°13.5298′W, 2459 m water depth) (Fig. 1). The hole U1381C is 109 m long and is dominated by pelagic and hemipelagic sediments intercalated by numerous tephra layers and a basaltic breccia layers at the bottom. The detail of the units is described by Harris et al. (2013) and Schindlbeck et al. (2015, 2016). The Hole U1414 A measures 471.6 m, including 375.25 m of sedimentary deposits and 96.35 m of oceanic basaltic basement. The biogenic fraction mainly consists of calcareous nannofossil-rich ooze with foraminifers, diatoms, sponge spicules and radiolarians.

## MATERIAL AND METHODS

Two cores of the Integrated Ocean Drilling Program (IODP) Expedition 344: Costa Rica Seismogenesis Project, were sampled. The two cores contain calcareous nannofossil-rich ooze with foraminifera, diatoms and radiolarians. Two hundred and ninety-five samples were prepared (69 from Hole U1381C and 226 from Hole U1414 A) using the following standard procedure methods for Neogene sediments (De Wever, Dumitrica, Caulet, Nigrini & Caridroit, 2001): (1) Sediments (10-20 g) were placed in beakers with 100-150 mL of 10% hydrogen peroxide. (2) Samples were boiled for a few minutes to achieve oxidation of the organic matter and disaggregation of the clay fraction. (3) Samples were rinsed with water and sieved through a 60 µm mesh. (4) The wet samples were placed again in beakers adding of a few drops of 10% hydrochloric acid to eliminate foraminifers, coccolithophorids, and other calcareous remains. (5) The samples were rinsed and sieved again through a 60 µm mesh. (6) A drop of the wet residue (1 mL) was placed onto a labeled glass slide, dried for a few minutes on a hot plate, embedded in Norland 60 mounting medium, and covered with a coverslip. (7) The slides were exposed for some minutes to ultraviolet light until dry. (8) The mounted samples were analyzed under a transmitted light microscope.

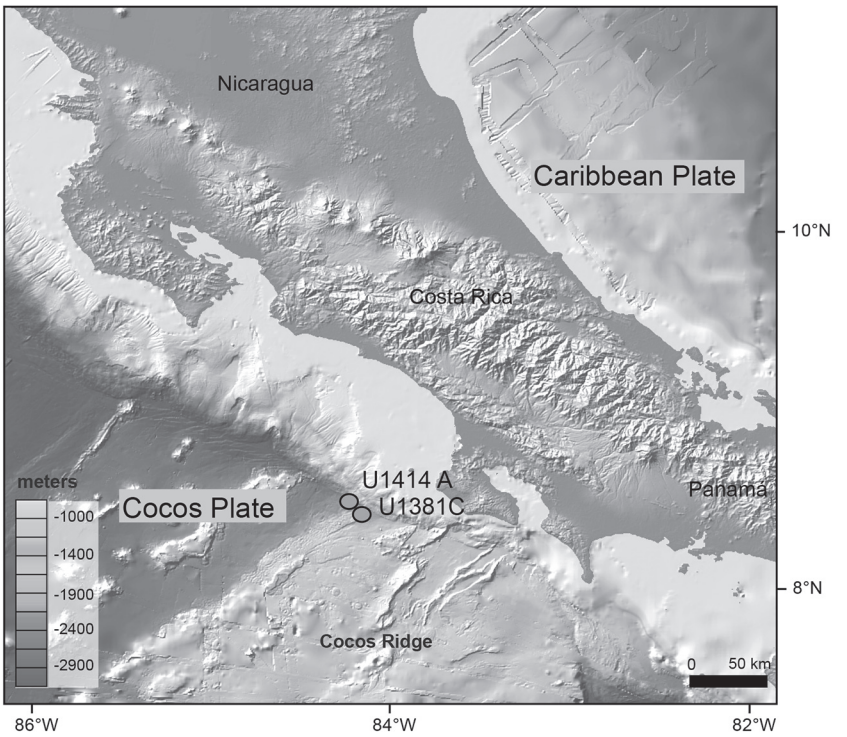


Figure 1: Location of of Holes U1414 A and U1381C from IODP Expedition 344 in the geological context of Costa Rica. The topographic map is adapted from www.geomapapp.org (Ryan et al., 2009).

The age model was established using radiolarian data (Sandoval, Boltovskoy, Baxter & Baumgartner, 2017), preliminary nannofossil shipboard data (Harris et al. 2013) and published tephra dating with 40Ar/39Ar (Schindlbeck et al., 2015, 2016).

Images of radiolarians were taken with an Olympus XC10 camera. In many cases, several photographs of the same specimen were obtained and processed with the aid of the Image J program (Extended Depth of Field), which allows merging a stack of photos in different focal positions into a single composite image (Forster, van de Ville, Berent, Sage & Unser, 2004).

## SYSTEMATIC PALEONTOLOGY

Class **ACTINOPODA** Calkins, 1909
Subclass **RADIOLARIA** Müller, 1858
Superorder **POLYCYSTINA** Ehrenberg, 1838, emend. Riedel, 1967a in Banner et al., 1967
Order **SPUMELLARIA** Ehrenberg, 1875, emend. Riedel, 1971a
Family **COLLOSPHAERIDAE** Müller, 1858

**Genus *Acrosphaera* Haeckel, 1881**

*Acrosphaera* sp. A (Fig. 2A)

Remarks: Regular sphere, covered with numerous, straight, radial spines, irregularly scattere over the whole surface. It presents some protuberances and depressions. Dimensions: ~100 µm in diameter, spines 20-40 µm.

*Acrosphaera* sp. B (Fig. 2B)

Remarks: Sub-circular sphere covered with numerous irregular pores. The size and shape of the spines is irregular. Dimensions: ~150-170 µm in diameter, spines 20-50 µm, pores size 10-50 µm.

*Acrosphaera murrayana* (Haeckel) (Fig. 2C)

*Choenicosphaera murrayana* n. sp. Haeckel, 1887, p. 102, pl. 8, fig. 4.

*Polysolenia murrayana* (Haeckel) - Nigrini, 1968, p. 52, pl. 1, figs. 1a-b - Nigrini and Moore, 1979, pl. 2, figs. 4a-b.

*Acrosphaera murrayana* (Haeckel) - Takahashi, 1991, pl. 1, figs. 6-10.

**Genus *Siphonosphaera* Müller, 1858**

*Siphonosphaera martensi* Brandt (Figs. 2D and 2E)

*Siphonosphaera martensi* n.sp. Brandt, 1905, p. 339, pl. 9, figs. 9-12 - Boltovskoy and Riedel, 1980, p. 104, pl. 1, fig. 8 - Takahashi, 1991, p. 59, pl. 4, figs. 4-5, 7-8.

Remarks: Circular sphere covered with numerous irregular polygonal pores. Surface is gently sharped. Dimensions: ~100-130 µm in diameter, pores size 10-25 µm.

*Siphonosphaera polysiphonia* Haeckel (Figs. 2F and 2G)

*Siphonosphaera polysiphonia* n.sp. Haeckel, 1887, p. 106 - Nigrini 1967, p. 18-19, pl. 1, figs. 4a-b.

**Genus *Collosphera* Müller, 1855**

*Collosphaera macropora* Popofsky (Figs. 2H, 2I, 2J and 2K)

*Collosphaera macropora* n.sp. Popofsky, 1914, p. 247, pl. 14, fig. 2 a-c - Boltovskoy and Riedel, 1980, p. 103, pl. 1, fig. 6 - Takahashi, 1991, p. 56, pl. 2, figs. 13-18.

*Collosphaera* sp.A (Fig. 2L)

Remarks: Spherical to sub-spherical sphere surrounded by numerous sub-circular pores, irregular arrangement of pores. In general the pores are small, it varies from ~20 to 5 µm. Few pointed spines. Dimension: ~150 µm in diameter.

*Collosphaera elliptica* Chen and Tan (Fig. 2M)

*Collosphaera elliptica* n.sp. Chen and Tan, 1989, p. 1, pl. 1, figs. 1-2 - Tan and Chen, 1999, p. 132, figs. 5-27.

*Collosphaera tuberosa* Haeckel (Fig. 2N)

*Collosphaera tuberosa* n.sp. Haeckel, 1887, p. 97 - Molina-Cruz, 1977, pl. 2, fig. 6 - Boltovskoy and Riedel, 1980, p. 104, pl. 1, fig. 7 - Takahashi and Honjo, 1981, p. 144, pl. 1, fig. 2.

**Genus *Otosphaera* Haeckel, 1887**

*Otosphaera polymorpha* Haeckel (Figs. 2O, 2P and 2Q)

*Otosphaera polymorpha* Haeckel, 1887, p. 116, pl. 7, fig. 6 - Nigrini and Moore, 1979, p. S9, pl. 1, fig. 5.

*Otosphaera* aff. *auriculata* Haeckel, 1887 (Figs. 2R and 2S)

aff. Haeckel, 1887, p.116, pl.7, fig.5

Remarks: The shell bears three short tubes with perforated walls whose distal end is circular. Pores are very small, irregular shape and arrangement. Dimensions: ~100 µm, pores 1-5 µm.

**Genus *Trisolenia* Haeckel, 1881**

*Trisolenia zanguebarica* Ehrenberg (Fig. 2T)

*Trisolenia zanguebarica* n.sp. Ehrenberg, 1872a, p. 321.

Family **ACTINOMMIDAE** Haeckel, 1862, emend. Riedel, 1967a in Banner et al., 1967

**Genus *Actinomma* Haeckel, 1862**

*Actinomma langii* (Dreyer) (Figs. 3A and 3B)

*Sphaeropyle langii* Dreyer, 1889, p. 89, fig. 54 - Foreman, 1975, p. 618, pl. 9, figs. 30-31 - Suzuki, 2006, p. 861, fig. 13.

**Genus *Cladococcus* Haeckel, 1860**

*Cladococcus cervicornis* Haeckel (Fig. 3C)

*Cladococcus cervicornis* Haeckel, 1860, p. 801 - Boltovskoy and Riedel, 1980, p. 108, pl. 2, fig. 5.

**Genus Diartus Sanfilippo and Riedel, 1980**

*Diartus hughesi* (Campbell and Clark) (Fig. 3D)

*Ommatocampe (Ommatocampula) hughesi* n.sp. Campbell and Clark, 1944, p. 23, pl. 3, fig. 12.

*Diartus hughesi* (Campbell and Clark) - Sanfilippo and Riedel, 1980, p. 1010 - Nigrini and Sanfilippo, 2001, p. 221.

*Diartus petterssoni* Riedel and Sanfilippo (Figs. 3E and 3F)

*Cannartus* (?) *petterssoni* Riedel and Sanfilippo, 1970, p. 520, pl. 14, fig. 3.

*Diartus petterssoni* (Riedel and Sanfilippo) - Sanfilippo and Riedel, 1980, p. 1010 - Nigrini and Sanfilippo, 2001, p. 223.

**Genus *Didymocyrtis* Haeckel, 1862**

*Didymocyrtis penultima* (Riedel) (Fig. 3G)

*Panarium penultimum* Riedel, 1957, p. 76, pl. 1, fig. 1.

*Didymocyrtis penultima* (Riedel) - Sanfilippo and Riedel, 1980, p. 1010 - Nigrini and Sanfilippo, 2001, p. 241.

*Didymocyrtis antepenultima* (Riedel and Sanfilippo) (Fig. 3H)

*Ommatartus antepenultimus* n.sp. Riedel and Sanfilippo, 1970, p. 521, pl. 14, fig. 14.

*Didymocyrtis antepenultima* (Riedel and Sanfilippo) - Sanfilippo and Riedel, 1980, p. 1010 - Nigrini and Sanfilippo, 2001, p. 233.

*Didymocyrtis laticonus* (Riedel) (Fig. 3I)

*Cannartus laticonus* n.sp. Riedel, 1959, p. 291, pl. 1, fig. 5.

*Didymocyrtis laticonus* (Riedel) - Sanfilippo and Riedel, 1980, p. 1010.

*Didymocyrtis antepenultima* - Nigrini and Sanfilippo, 2001, p. 237.

*Didymocyrtis mammifera* (Haeckel) (Fig. 3J)

*Cannartidium mammifer*um n.sp. Haeckel, 1887, p. 375, pl. 39, fig. 16.

*Cannartus mammiferus* (Haeckel) - Riedel, 1959, p. 291, pl. 1, fig. 4.

*Cannartus mammifer* (Haeckel) - Sanfilippo, Burckle, Martini & Riedel, 1973, p. 216, pl. 1, fig. 7.

*Didymocyrtis mammifera* (Haeckel) - Sanfilippo and Riedel, 1980, p. 1010 - Nigrini and Sanfilippo, 2001, p. 239.

*Didymocyrtis bassanii* (Carnevale) (Fig. 3K)

*Cannartidium bassanii* n.f. Carnevale, 1908, p. 21, pl. 3, fig. 12.

*Didymocyrtis bassanii* (Carnevale) - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 729, fig. 9H.

*Didymocyrtis tetrathalamus* (Haeckel) (Fig. 3L)

*Panartus tetrathalamus* n.sp. Haeckel, 1887, p. 378, pl. 40, fig. 3.

*Ommatartus tetrathalamus* (Haeckel) - Riedel and Sanfilippo, 1971, p. 1588, pl. 1C, figs. 5-7.

*Didymocyrtis tetrathalamus* (Haeckel) - Sanfilippo and Riedel, 1980, p. 1010.

*Didymocyrtis tetrathalamus tetrathalamus* (Haeckel) - Nigrini and Sanfilippo, 2001, p. 246.

**Genus *Saturnalis* Haeckel, 1881**

*Saturnalis circularis* Haeckel (Fig. 3M)

*Saturnalis circularis* n.sp. Haeckel, 1887, p. 131 - Nigrini, 1967, p. 24, pl. 1, fig. 9.

**Genus *Druppactractus* Haeckel, 1887**

*Druppotractus* sp. (Fig. 3N)

Remarks: Ellipsoidal shell consisting of a thick-walled external shell and a thinner internal one.

**Genus *Hexacontium* Haeckel, 1881**

*Hexacontium armatum/hostile* Cleve (Figs. 3O and 3P)

*Hexacontium armatum* n.sp. Cleve, 1900, p. 9, pl. 6, fig. 5 - Boltovskoy and Riedel, 1980, p. 112, pl. 10a-b.

**Genus *Stylosphaera* Ehrenberg, 1846**

*Stylosphaera* sp. (Fig. 3Q)

Remarks: Actinommid with two prominent three-bladed polar spines.

**Genus *Plegmosphaera* Haeckel, 1887**

*Plegmosphaera* spp. (Fig. 3R)

Remarks: A central sphere surrounded by an irregularly branched meshwork.

Family **PHACODISCIDAE** Haeckel, 1881

**Genus *Heliodiscus* Haeckel, 1862**

*Heliodiscus* spp. (Fig. 3S)

Remarks: Arrangement and abundance of pores quite different from H. asteriscus. Spherical microsphere is laterally located.

Family **COCCODISCIDAE** Haeckel, 1862

**Genus *Periphaena* Ehrenberg 1873**

*Periphaena decora* Ehrenberg (Fig. 3T)

*Periphaena decora* Ehrenberg, 1873, p. 246; 1875, pl. 28, fig. 6 - Riedel, 1957, p. 258, pl. 62, fig. 1 - Sanfilippo and Riedel, 1973, p. 523, pl. 8, figs. 8-10; pl. 27, figs. 2-5.

Remarks: Spherical microsphere is apparently located in the centre of the medullary shell.

Family **SPONGODISCIDAE** Haeckel, 1862

**Genus *Amphirhopalum* Haeckel, 1881**

*Amphirhopalum ypsilon* Haeckel (Fig. 4A)

*Amphirhopalum ypsilon* n.sp. Haeckel, 1887, p. 522 - Nigrini and Moore, 1979, p. S75-S77, pl. 10, figs. 1a-e.

**Genus *Dictyocoryne* Ehrenberg, 1860a**

*Dictyocoryne truncatum* (Ehrenberg) (Fig. 4B)

*Rhopalodictyum truncatum* n.sp. Ehrenberg, 1861, p. 301.

*Dictyocoryne truncatum* (Ehrenberg) - Nigrini and Moore, 1979, p. S89, pl. 12, figs. 2a-b.

*Dictyocoryne profunda* Ehrenberg (Fig. 4C)

*Dictyocoryne profunda* n.sp. Ehrenberg, 1860a, p. 767 - Nigrini and Moore, 1979, p. S87-S88, pl. 12, fig. 1.

**Genus *Euchitonia* Ehrenberg, 1860a**

*Euchitonia furcata/elegans* group (Ehrenberg) (Figs. 4D and 4E)

*Pteractis elegans* n.sp. Ehrenberg, 1872a, p. 319; 1872b, p. 299, pl. 8, fig. 3.

*Euchitonia elegans/furcata* group? (Ehrenberg) - Boltovskoy, 1998, fig. 15.70.

**Genus *Spongaster* Ehrenberg, 1860b**

*Spongaster tetras* Ehrenberg (Fig. 4F)

*Spongaster tetras* n.sp. Ehrenberg, 1860b, p. 833; 1872b, p. 299, pl. 4(3), fig. 8.

*Spongaster tetras tetras* Ehrenberg - Nigrini and Moore, 1979, p. S93-S94, pl. 13, fig. 1 - Boltovskoy, 1998, fig. 15.67.

*Spongaster* sp. A aff. *D. truncatum* (Fig. 4G)

aff. *Rhopalodictyum truncatum* Ehrenberg, 1861, p. 301

Remarks: Test with three spongy arms, having rounded corners

**Genus Spongurus Haeckel, 1862**

*Spongocore puella* Haeckel (Fig. 4H)

*Spongocore puella* n.sp. Haeckel, 1887, p. 347, pl. 48, fig. 6 - Nigrini and Moore, 1979, p. S59, S61, S69, pl. 8, figs. 5a-c.

**Genus *Stylodictya* Ehrenberg, 1846, 1847, emend. Kozlova in Petrushevskaya and Kozlova, 1972**

*Stylodictya aculeata* Jørgensen (Fig. 4I)

*Stylodictya aculeata* n.sp. Jørgensen, 1905, pl. 10, fig. 41a-c - Boltovskoy, 1998, fig. 15.62a.

*Stylodictya validispina* Jørgensen (Fig. 4J)

*Stylodictya validispina* n.sp, Jørgensen, 1905, p. 119, pl. 10, fig. 40 - Nigrini and Moore, 1979, pl. 13, fig. 5a-b.

**Genus *Spongodiscus* Ehrenberg, 1854**

*Spongodiscus* sp. (Figs. 4K and 4L)

Remarks: Test a spongy disc, thickened in the centre.

**Genus *Circodiscus* Kozlova in Petrushevskaya and Kozlova, 1972**

*Circodiscus* spp. (Figs. 4M, 4N, 4O and 4P)

Remarks: circular to sub-circular disc, with several internal concentric rings. Sometimes presents a pylome.

**Genus *Spongurus* Haeckel, 1860**

*Spongurus* spp. (Figs. 4Q, 4R and 4S)

Remarks: Oval-elongate spongy shell.

**Genus *Spongopyle* Dreyer, 1889**

*Spongopyle osculosa* Dreyer (Fig. 4T)

*Spongopyle osculosa* n.sp. Dreyer, 1889, p. 42, pl. 11, figs. 99-100 - Nigrini and Moore 1979, pl. 15, fig. 1.

**Genus *Spongotrochus* Haeckel, 1860**

*Spongotrochus* spp. (Figs. 5A, 5B and 5C)

Remarks: Spongy disc thickened in its central part, sometimes with spines.

Family **LITHELIIDAE** Haeckel, 1881

**Genus *Larcopyle* Dreyer, 1889**

*Larcopyle butschlii* Dreyer (Fig. 5D)

*Larcopyle bütschlii* n. sp. Dreyer, 1889, p. 124, pl. 10,70 - Molina-Cruz, 1977, p. 335, pl. 3, figs. 10-11 - Nigrini and Moore, 1979, p. S131-S132, pl. 17, fig. 1b - Boltovskoy, 1998, figs. 5B-B', 15.85.

*Larcopyle nebulum* Lazarus, Faust & Popova-Goll (Fig. 5E and 5F)

*Larcopyle nebulum* n.sp. Lazarus, Faust & Popova-Goll, 2005, p. 111, pl. 5, figs. 1-13.

**Genus *Lithelius* Haeckel 1862**

*Lithelius minor* Jørgensen (Figs. 5G and 5H)

*Lithelius minor* n.sp. Jørgensen, 1900, p. 65, pl. 5, fig. 24 - Boltovskoy and Jankilevich, 1985, pl. 3, fig. 17.

**Genus *Larcospira* Haeckel, 1887**

*Larcospira* spp. (Figs. 5I and 5J)

Remarks: Shell consists of an oval spiral from a common origin.

*Larcospira quandrangula* Haeckel (Figs. 5K and 5L)

*Larcospira quadrangula* n.sp. Haeckel, 1887, p. 696, pl. 49, fig. 3 - Nigrini and Moore, 1979, p. S133, pl. 17, fig. 2 - Takahashi and Honjo, 1981, p. 150, pl. 6, fig. 2.

Family **PYLONIIDAE** Haeckel, 1881, emend. Dumitrica, 1989

**Genus *Phorticium* Haeckel, 1881**

*Phorticium pylonium* group Haeckel (Figs. 5M, 5N and 5O)

*Phorticium pylonium* n.sp. Haeckel, 1887, p. 709, pl. 49, fig. 10.

**Genus *Pylonium* Haeckel, 1881**

*Pylonium* sp. *sensu* Benson (Fig. 5P)

*Pylonium* sp. Benson, 1966, p. 250, pl. 16, fig. 2 - Benson, 1983, p. 507, pl. 6, fig. 5.

**Genus Tetrapyle Müller, 1858**

*Tetrapyle octacantha* group Müller (Fig. 5Q)

*Tetrapyle octacantha* n.sp. Müller, 1858, p. 33, pl. 2, figs. 12-13; pl. 3, figs. 1-12 - Nigrini and Moore, 1979, p. S125, pl. 16, figs. 3a-b - Takahashi and Honjo, 1981, p. 150, pl. 6, figs. 5-6.

Spumell. gen and sp. indet. (Figs. 5R, 5S and 5T)

Order **NASELLARIA** Ehrenberg, 1875

Family **SPYRIDAE** Ehrenberg, 1846

**Genus *Amphispyris* Ehrenberg, 1872b**

*Amphispyris reticulata* (Ehrenberg) (Fig. 6A)

*Dictyospyris reticulata* n.sp. Ehrenberg, 1872b, p. 307, pl. 10, fig. 19.

*Amphispyris reticulata* (Ehrenberg) - Boltovskoy, 1998, fig. 15.95 - Tan and Chen, 1999, p. 279, fig. 5-198.

**Genus *Cantharospyris* Haeckel, 1887**

*Cantharospyris platybursa* Haeckel (Fig. 6B)

*Cantharospyris platybursa* n.sp. Haeckel, 1887, p. 1051, pl. 53, fig. 7 - Takahashi and Honjo, 1981, p. 152, pl. 7, fig. 32.

**Genus *Dendrospyris* Haeckel, 1881**

*Dendrospyris bursa* Sanfilippo and Riedel (Fig. 6C)

*Dendrospyris bursa* n. sp. Sanfilippo and Riedel in Sanfilippo, Burckle, Martini & Riedel, 1973, p. 217, pl. 2, figs. 9-13 - Nigrini and Lombari, 1984, p. N19, pl. 16, figs. 1a-f - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 736, fig. 14G.

**Genus *Giraffospyris* Haeckel, 1887, emend. Goll, 1969**

*Giraffospyris toxaria* (Haeckel) (Fig. 6D)

*Podocoronis (Dipocoronis) toxarium* n.sp. Haeckel, 1887, p. 980, pl. 83, fig. 7.

*Giraffospyris toxaria* (Haeckel) - Goll, 1969, p. 335, pl. 56, figs. 1-2, 4, 7 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 734, fig. 12P.

**Genus *Liriospyris* Haeckel, 1881**

*Liriospyris parkerae* Riedel and Sanfilippo (Fig. 6E)

*Liriospyris parkerae* n.sp. Riedel and Sanfilippo, 1971, p. 1590, pl. 2C, fig. 15; pl. 5, fig. 4 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 734, fig. 12E.

*Liriospyris* spp. (Figs. 6F, 6G and 6H)

Remarks: Sagittal ring sub-circular; joined directly to front, apex, and back of lattice shell. Vertical spine very short, projecting from approximate midpoint of sagittal ring; no frontal or axial spines.

**Genus *Lophospyris* Haeckel, 1881**

*Lophospyris pentagona pentagona* (Ehrenberg) Goll (Fig. 6I)

*Ceratospyris pentagona* n. sp. Ehrenberg, 1872a, p. 303, pl. 15, fig. 5.

*Dorcadospyris pentagona* (Ehrenberg) - Goll, 1969, p. 338-339, pl. 59, figs. 1-3.

*Lophospyris pentagona pentagona* (Ehrenberg) - Nigrini and Moore, 1979, p. N15-N16, pl. 19, fig. 5 - Takahashi, 1991, p. 102, pl. 28, figs. 9-14.

**Genus *Neophrospyris* Haeckel, 1887**

*Nephrospyris renilla* Haeckel (Fig. 6J)

*Nephrospyris renilla* n.sp. Haeckel, 1887, p. 1101, pl. 90, figs. 9-10 - Boltovskoy, 1998, fig. 15.99.

**Genus *Androspyris* Haeckel, 1887**

*Androspyris huxleyi* (Haeckel) (Fig. 6K)

*Lamprospyris huxleyi* n.sp. Haeckel, 1887, pl. 89, fig. 14.

*Androspyris huxleyi* (Haeckel) - Goll, 1980, pl. 4, figs. 4-5.

**Genus *Zygocircus* Butschli 1882, emend. Goll, 1979**

*Zygocircus productus* (Benson) (Fig. 6L)

*Zygocircus productus* n.sp. Benson, 1966, p. 288, pl. 19, figs. 14-15 - Goll, 1979, p. 381, pl. 2, figs. 4-9.

**Genus *Phormospyris* Goll, 1976**

*Phormospyris* sp. A (Fig. 6M)

Remarks: Bilocular cephalis, circular to elliptical pores. Sagittal ring asymmetrical, with a line of bigger pores compared to cephalis.

*Phormospyris stabilis stabilis* (Goll) (Fig. 6N)

*Desmospyris anthocyrtoides* Benson, 1966, p. 332, pl. 23, figs. 6-8.

*Dendrospyris stabilis* Goll, 1968, p. 1422, pl. 173, figs. 16-18, 20.

*Phormospyris stabilis* (Goll) stabilis Goll, 1976, p. 390, pl. 1, figs. 1-13; pl. 2, figs. 7-14 - Takahashi, 1991, p. 104, pl. 30, figs. 2-5 - Boltovskoy, 1998, fig. 15.100.

*Phormospyris stabilis capoi* Goll (Fig. 6O)

*Phormospyris stabilis capoi* n.sp. Goll, 1976, p. 392, 394, pl. 5, figs. 1-2; pl. 6-7 - Takahashi, 1991, p. 104, pl. 29, figs. 15-18.

*Phormospyris stabilis* (Goll) *scaphipes* (Haeckel) (Fig. 6P)

*Tristylospiris scaphipes* n.sp. Haeckel, 1887, p. 1033, pl. 84, fig. 13.

*Phormospyris stabilis scaphipes* (Haeckel) - Goll, 1976, p. 394, pl. 8-9.

*Tholospyris scaphipes* (Haeckel) - Molina-Cruz, 1977, p. 336, pl. 7, figs. 11-12.

**Genus *Tholospyris* Haeckel, 1881**

*Tholospyris* spp. (Figs. 6Q, 6R, 6S and 6T)

Remarks: Oval-shaped sagitally constricted skeleton with very heavy bars and circular to oval pores.

Family **PLAGONIIDAE** Haeckel, 1881, emend. Riedel, 1957

**Genus *Amphiplecta* Haeckel, 1887**

*Amphiplecta acrostoma* Haeckel (Fig. 7A)

*Amphiplecta acrostoma* n.sp. Haeckel, 1887, p. 1223, pl. 97, fig. 10 - Petrushevskaya, 1971, pl. 54, figs. 2-7.

**Genus *Cladoscenium* Haeckel, 1887**

*Cladoscenium* spp. (Fig. 7B, 7C and 7D)

Remarks: Cephalis large, sub-cylindrical with a rounded or dome-shaped top, with unequal, irregular pores of all shapes. Those specimens present a typical large horn above to the cephalis. The feet are three bladed.

**Genus *Clathrocanium* Ehrenberg, 1860a, emend. Petrushevskaya, 1971**

*Clathrocanium* sp. (Fig. 7E)

Remarks: Cephalis dome-shaped to globular, with irregular pores. Thorax with three large gates each between adjacent feet; the distal margins of the gates defined by convex downward arched bars developed between adjacent feet. Those specimens present a typical large horn above to the cephalis.

**Genus *Lophophaena* Ehrenberg, 1847**

*Lophophaena hispida* (Ehrenberg) (Fig. 7F)

*Dictyocephalus hispidus* n.sp. Ehrenberg 1872b, p. 202, 289, pl. 5, fig. 18.

*Lophophaena hispida* (Ehrenberg) - Boltovskoy, 1998, p. 66, fig. 15.109.

*Lophophaena* aff. *hispida* (Fig. 7G)

aff. Dictyocephalus hispidus Ehrenberg 1872b, p. 202, 289; pl. 5, fig. 18

Remarks: Cephalis spherical, with small pores, thin spines. Thorax conical, its pores decreasing in size toward the base.

*Lophophaena* aff. *capito* (Fig. 7H)

aff. *Lophophaena capito* Ehrenberg, 1873, p. 242; 1875, pl.8, fig.6

Remarks: Cephalis spherical, with medium pores, thin spines and a central robust spine in the center of the cephalis.

*Plagoniidae* group (Figs. 7I, 7J, 7K and 7L)

Includes many generally similar forms with a latticed cephalis and with or without a rudimentary thorax. The systematics of these sometimes extremely abundant forms is confused, and they are generally ignored in most surveys. They include species cited under a variety of generic names, such as *Amphiplecta, Arachnocorallium, Arachnocorys, Ceratocyrtis, Dimelissa, Lophophaenoma, Micromelissa, Peromelissa, Psilomelissa*, etc. (Boltovskoy, 1998).

*Pteroscenium* spp. (Fig. 7M)

Shell campanulate with irregular circular pores. Horn slender pyramidal. Three divergent feet twice as long as the horn strongly curved, thorny, three-edged.

**Genus *Pteroscenium* Jørgensen, 1905**

*Pteroscenium pinnatum* Haeckel (Fig. 7N)

*Pteroscenium pinnatum* n.sp. Haeckel, 1887, pl. 53, figs. 14, 16 - Takahashi, 1991, p. 114, pl. 36, figs. 8-9.

**Genus *Tetraphormis* (Haeckel), 1887**

*Tetraphormis dodecaster* (Haeckel) (Fig. 7O)

*Sethophormis dodecaster* n.sp. Haeckel, 1887, p. 1248, pl. 56, fig. 12.

*Tetraphormis dodecaster* (Haeckel) - Takahashi, 1991, p. 108, pl. 32, fig. 7.

*Clathrocorys* aff. *teuscheri* (Fig. 7P)

aff. *Clathrocorys teuscheri* Haeckel, 1887, p. 1220, pl. 64, fig.10

Remarks: it consists of a three-bladed central spine, which bifurcates in two perpendicular spines tree times along the central spine.

**Genus *Helothus* Jørgensen, 1905**

*Helothus histricosa* Jørgensen (Figs. 7Q and 7R)

*Helotholus histricosa* Jørgensen, 1905, pl. 16, figs. 86, 88 - Boltovskoy and Riedel, 1987, pl. 4, fig. 4 - Boltovskoy, 1998, 15.113 (a-c).

*Helothus* aff. *histricosa* (Fig. 7S)

aff. *Helotholus histricosa* Jørgensen, 1905, pl. 16, figs. 86, 88

Remarks: Test broad, conical, with generally a broadly rounded, partially hidden cephalis with two robust spines. The pores follow an arrangement compared to H. histricosa.

**Genus *Sethophormis* Haeckel, 1881**

*Sethophormis* sp. A (Fig. 7T)

Remarks: Shell in the form of a Chinese peasant hat, thorax with a very delicate lace-like meshwork of irregular pores decreasing in size toward the periphery and many radial sinuous ribs. Shell diameter: >300 µm.

Family **THEOPERIDAE** Haeckel, 1881, emend. Riedel, 1967a in Banner et al., 1967

**Genus *Artopilium* Popofsky, 1913**

*Artopilium undulatum* Popofsky (Fig. 8A)

*Artopilium undulatum* n.sp. Popofsky, 1913, p. 405-406, pl. 36, figs. 4-5.

*Lophocorys undulata* (Popofsky) - Takahashi, 1991, p. 120, pl. 40, figs. 9-10.

**Genus *Clathtrocyclas* Haeckel, 1881**

*Clathrocyclas alcmenae* Haeckel (Fig. 8B)

*Clathrocyclas alcmenae* n.sp. Haeckel, 1887, p.1388, pl. 59, fig. 6.

*Clathtrocyclas monumentum* (Haeckel) (Fig. 8C)

*Calocyclas monumentum* n.sp. Haeckel, 1887, p. 138.5, pl. 73, fig. 9 - Takahashi, 1991, p. 112, pl. 34, figs. 9-11.

**Genus *Corocalyptra* Haeckel, 1887**

*Corocalyptra kruegeri* Popofsky (Figs. 8D, 8E and 8F)

*Corocalyptra kruegeri* n.sp. Popofsky, 1908, p. 289, pl. 35, fig. 8 - Boltovskoy, 1998, p. 72, fig. 15.136.

*Corocalyptra* sp. (Fig. 8G)

Remarks: Cephalis with an apical horn. Thorax large, campanulate, with regular, polygonal pores in transversal rows increasing in size distally. Abdomen restricted to a narrow brim with several rows of pores.

*Corocalyptra cervus* (Ehrenberg) (Fig. 8H)

*Eucyrtidium cervus* n.sp. Ehrenberg 1872a, p. 308.

*Coracalyptra cervus* (Ehrenberg) - Takahashi, 1991, p. 112, pl. 33, figs. 9-12 - Boltovskoy, 1998, p. 71, fig. 15.128.

**Genus *Cornutella* Ehrenberg, 1838**

*Cornutella profunda* Ehrenberg (Fig. 8I)

*Cornutella clathrata* (?) *profunda* n.sp. Ehrenberg, 1854, p. 241.

*Cornutella profunda* Ehrenberg - Boltovskoy, 1998, p. 71, fig. 15.127 - Takahashi 1991, 113, pl.35, fig.3-9.

**Genus *Cycladophora* Ehrenberg, 1846**

*Cycladophora davisiana* Ehrenberg (Figs. 8J and 8K)

*Cycladophora* (?) *davisiana* n.sp. Ehrenberg, 1861, p. 297.

*Cycladophora davisiana* Ehrenberg - Molina-Cruz, 1977, pl. 7, fig. 19.

*Theocalyptra davisiana* (Ehrenberg) - Nigrini and Moore, 1979, pl. 24, figs. 2a-b.

*Cycladophora davisiana* Ehrenberg - Boltovskoy, 1998, fig. 15.131.

**Genus *Cyrtocapsella* (Haeckel) 1887**

*Cyrtocapsella cornuta* (Haeckel) (Figs. 8L and 8M)

*Cyrtocapsa cornuta* n.sp. Haeckel, 1887, p. 1513, pl. 78, fig. 9.

*Cyrtocapsella cornuta* (Haeckel) - Sanfilippo and Riedel, 1970, p. 453, pl. 1, figs. 19-20 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 731, fig. 10X.

*Cyrtocapsella tetrapera* (Haeckel) (Figs. 8N and 8O)

*Cyrtocapsa tetrapera* n.sp. Haeckel, 1887, pl. 78, fig. 5.

*Cyrtocapsella tetrapera* (Haeckel) - Sanfilippo and Riedel, 1970, p. 453, pl. 1, figs. 16-18 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 731, fig. 10Z.

*Cyrtocapsella cylindroides* (Principi) (Fig. 8P)

*Sticocapsa cylindroides* n.f. Principi, 1909, p. 20, pl. 1, fig. 66.

*Lithocampe (Cyrtocapsella) cylindroides* (Principi) - Petrushevskaya, 1975, p. 582, pl. 14, figs. 14-15.

*Cyrtocapsella cylindroides* (Principi) - Nigrini and Lombari, 1984, p. N103-104, pl. 23, fig. 2.

*Cyrtocapsella japonica* (Nakaseko) (Figs. 8Q, 8R and 8S)

*Eusyringium japonicum* n.sp Nakaseko, 1963, p. 193, pl. 4, figs. 1-3.

*Cyrtocapsella japonica* (Nakaseko) - Sanfilippo and Riedel, 1970, p. 452, pl. 1, figs. 13-15 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 731, fig. 10Y.

*Cyrtocapsella* sp. (Fig. 8T)

Remarks: Cephalis is spherical, cylindrical shape in general. Thorax is the same size of abdomen and post-abodominal chamber. The surface is rough. Pores are round and the approximately the same size in the entire specimen. ~150 µm of length.

**Genus *Dictyophimus* Ehrenberg, 1842, emend. Nigrini, 1968**

*Dictyophimus infabricatus* Nigrini (Figs. 9A and 9B)

*Dictyophimus infabricatus* n.sp. Nigrini, 1968, p. 56, pl. 1, fig. 6 - Takahashi, 1991, pl. 37, figs. 3-5.

*Dictyophimus hirundo* (Haeckel) (Fig. 9C)

*Pterocorys hirundo* n.sp Haeckel, 1887, p. 1318, pl. 71, fig. 4.

*Dictyophimus hirundo* group (Haeckel) - Nigrini and Moore, 1979, pl. 22, figs. 2-4.

*Dictyophimus* spp. (Figs. 9D, 9E and 9F)

Remarks: Cephalis partly submerged into thorax, bears a large apical horn. Thorax pyramidal or conical, with three conspicuous legs.

**Genus *Eucecryphalus* Haeckel, 1860**

*Eucecryphalus gegenbauri* Haeckel (Fig. 9G)

*Eucecryphalus gegenbauri* n.sp. Haeckel, 1860, p. 836 - Haeckel, 1862, p. 308, pl. 5, figs. 12-15.

*Theocalyptra gegenbauri* (Haeckel) - Boltovskoy and Riedel, 1980, p. 126, pl. 5, fig. 18.

*Eucecryphalus tricostatum* (Haeckel) (Figs. 9H, 9I, 9J and 9K)

*Theopilium tricostatum* n.sp. Haeckel, 1887, p. 1322, pl. 70, fig. 6 - Takahashi and Honjo, 1981, p. 152, pl. 8, fig. 12 - Boltovskoy, 1998, p. 78, fig. 15.149.

*Eucecryphalus* spp. (Figs. 9L, 9M, 9N, 9O, 9P, 9Q, 9R, 9S and 9T)

Remarks: Shell with a small cephalis. Thorax widely open, with small, regularly arranged pores, circular proximally and becoming larger and more polygonal distally. Abdominal brim flat with pores. In some specimens the abdominal brim is not observe because is broken.

**Genus *Eucyrtidium* Ehrenberg, 1847, emend. Nigrini, 1967**

*Eucyrtidium anomalum* Haeckel (Fig. 10A)

*Eucyrtidium anomalum* n.sp. Haeckel, 1862, p. 323, pl. 7, figs. 11-13 - Boltovskoy and Riedel, 1987, p. 100, pl. 5, fig. 1 - Boltovskoy, 1998, p. 75, fig. 15.138.

*Eucyrtidium calvertense* Martin (Fig. 10B)

*Eucyrtidium calvertense* n.sp. Martin, 1904, p. 450-451, pl. CXXX, fig. 5 - Chen, 1975, p. 460, pl. 15, fig. 9.

*Eucyrtidium cienkowskii* Haeckel (Figs. 10C and 9D)

*Eucyrtidium cienkowskii* n.sp. Haeckel, 1887, pl. 80, fig. 9 - Sanfilippo, Burckle, Martini & Riedel, 1973, p. 221, pl. 5, figs. 7-11 - Lazarus, 1990, pl. 6, figs. 1-3.

*Eucyrtidium hexagonatum* Haeckel (Fig. 10E, 10F and 10G)

*Eucyrtidium hexagonatum* n.sp. Haeckel, 1887, p. 1489, pl. 80, fig. 11 - Molina-Cruz, 1977, p. 336, pl. 7, figs. 4-5 - Takahashi, 1991, p. 124, pl. 42, figs. 18-19.

*Eucyrtidium hexastichus* (Haeckel) (Fig. 10H)

*Lithostrobus hexastichus* n.sp. Haeckel, 1887, p. 1470, pl. 80, fig. 15.

*Eucyrtidium hexastichum* (Haeckel) - Boltovskoy and Riedel, 1980, p. 124, pl. 5, fig. 10 - Takahashi, 1991, p. 125, pl. 42, fig. 22 - Boltovskoy, 1998, p. 75, fig. 15.139.

*Eucyrtidium teuscheri* Haeckel (Fig. 10I)

*Eucyrtidium teuscheri* n.sp. Haeckel, 1887, p. 1491, pl. 77, fig. 5 - Caulet, 1986, pl. 5, figs. 1-8.

*Eucyrtidium* spp. (Figs. 10J, 10K, 10L, 10M, 10N, 10O, 10P, 10Q, 10R, 10S and 10T)

Remarks: Small spherical to sub-spherical cephalis with small apical horn. Thorax small, inflated, thick-walled. Abdomen and three-five post-abdominal segments thin-walled, with pores arranged in longitudinal rows.

**Genus *Lampromitra* Haeckel, 1887**

*Lampromitra schultzei* Haeckel (Fig. 11A)

*Lampromitra schultzei* n.sp. Haeckel, 1887, p. 1214, pl. 60, figs. 7-7a. - Boltovskoy, 1998, p. 63, pl. 15.115.

**Genus *Litharachnium* Haeckel, 1860**

*Litharachnium tentorium* Haeckel (Fig. 11B)

*Litharachnium tentorium* n.sp. Haeckel, 1860, p. 836; 1862, p. 281, pl. 4, figs. 7-10 - Boltovskoy, 1998, p. 75, fig. 15.148.

**Genus *Lipmanella* Loeblich and Tappan, 1961**

*Lipmanella dictyoceras* (Haeckel) (Figs. 11C and 11D)

*Lithornithium dictyoceras* Haeckel, 1860, p. 840.

*Lipmanella virchowii* Boltovskoy and Riedel, 1987, p. 100, pl. 5, fig. 6.

*Lipmanella dictyoceras* Takahashi, 1991, p. 121, pl. 40, fig. 17 - Boltovskoy, 1998, fig. 15.134.

*Lipmanella* sp. (Fig. 11E)

Remarks: Cephalis large, hemispherical, with a conspicuous apical horn. Thorax thin-walled, conical-inflated, in this specimen the thorax is smaller than *L. dictyoceras*.

**Genus *Lithopera* Ehrenberg, 1846**

*Lithopera neotera* Sanfilippo and Riedel (Figs. 11F, 11G and 11H)

*Lithopera neotera* n.sp. Sanfilippo and Riedel, 1970, pl. 1, figs. 24-26 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 731, fig. 10AC.

*Lithopera renzae* Sanfilippo and Riedel (Figs. 11I, 11J, 11K and 11L)

Lithopera renzae n.sp. Sanfilippo and Riedel, 1970, p. 454, pl. 1, figs. 21-23, 27 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 731, fig. 10T.

*Lithopera thornburgi* Sanfilippo and Riedel (Fig. 11M)

*Lithopera thornburgi* n.sp. Sanfilippo and Riedel, 1970, p. 455, pl. 2, figs. 4-6 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 731, fig. 10 AE.

**Genus *Lithostrobus* Haeckel, 1887**

*Lithostrobus hexagonalis* Haeckel (Fig. 11N)

*Lithostrobus hexagonalis* n.sp. Haeckel, 1887, p. 1475, pl. 79, fig. 20 - Boltovskoy and Riedel, 1987, p. 100; pl. 5, fig. 11 - Takahashi, 1991, p. 122, pl. 41, figs. 1-3 - Boltovskoy, 1998, fig. 15.141.

**Genus *Lophocyrtis* Haeckel, 1881**

*Lophocyrtis brachythorax* (Sanfilippo and Riedel) (Fig. 11O)

*Cyclampterium* (?) *brachythorax* n.sp. Sanfilippo and Riedel, 1970, pl. 2, figs. 15-16.

*Lophocyrtis (Cyclampterium) brachythorax* Sanfilippo and Riedel, 1970, p. 457, pl. 2, figs. 15-16 - Sanfilippo, 1990, pl. IV, figs. 4-6 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 731, fig. 13D.

*Lophocyrtis tanythorax* Sanfilippo and Riedel (Fig. 11P)

*Cyclampterium* (?) *tanythorax* n.sp. Sanfilippo and Riedel, 1970, pl. 2, figs. 13-14.

*Lophocyrtis (Cyclampterium) tanythorax* Sanfilippo and Riedel, 1970, p. 457, pl. 2, figs. 13-14 - Sanfilippo, 1990, pl. 4, figs. 7-10.

*Lophocyrtis* spp. (Figs. 11Q and 11R)

Remarks: Shell robust, sub-spherical to sub-ellipsoidal in general form. Cephalis sub-spherical, poreless or with a few small pores, with a short apical horn. Thorax inflated, with pores arranged in groups of 8-10, surrounded by a bigger pore. Abdomen thick-walled, with sub-circular pores, it is slightly convex to inflated.

Nassell. gen. and sp. indet. (Figs. 11S and 11T)

**Genus *Pterocanium* Ehrenberg, 1846**

*Pterocanium grandiporus* (Figs. 12A and 12B)

*Pterocanium grandiporus* n.sp. Nigrini, 1968, p. 57, pl. 1, fig. 7.

*Pterocanium praetextum* (Haeckel) (Figs. 12C and 12D)

*Lychnocanium praetextum* n.sp. Ehrenberg, 1872b, p. 297, pl. 10, fig. 2.

*Pterocanium praetextum praetextum* (Ehrenberg) - Nigrini and Moore, 1979, p. N41-N42, pl. 23, fig. 2 - Takahashi, 1991, p. 115, pl. 36, figs. 15-18.

*Pterocanium praetextum* group? (Ehrenberg) - Boltovskoy, 1998, fig. 15.146.

*Pterocanium trilobum* (Haeckel) (Figs. 12E, 12F, 12G and 12H)

*Dictyopodium trilobum* n.sp. Haeckel, 1860, p. 839.

*Dictyopodium trilobum* Haeckel, 1862, p. 340, pl. 8, figs. 6-10.

*Pterocanium trilobum* (Haeckel) - Nigrini and Moore, 1979, p. N45-N46, pl. 23, figs. 4a-c - Boltovskoy, 1998, p. 78, fig. 15. 145.

**Genus *Stichocorys* Haeckel, 1881**

*Stichocorys armata* (Haeckel) (Figs. 12I and 12J)

*Cyrtophormis armata* n.sp. Haeckel, 1887, p. 1460, pl. 78, fig. 17.

*Stichocorys armata* (Haeckel) - Riedel and Sanfilippo, 1971, p. 1595, pl. 2E, figs. 13-15 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 731, fig. 10O.

*Stichocorys delmontensis* (Campbell and Clark) (Figs. 12K and 12L)

*Eucyrtidium delmontense* n.sp. Campbell and Clark, 1944, p. 56, pl. 7, figs. 19-20.

*Stichocorys delmontensis* Campbell and Clark - Sanfilippo and Riedel, 1970, p. 451, pl. 1, fig. 9 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 731, fig. 10Q.

*Stichocorys peregrina* (Riedel) (Fig. 12M)

*Eucyrtidium elongatum peregrinum* Riedel, 1953, p. 812, pl. 85, fig. 2.

*Stichocorys peregrina* Riedel - Riedel and Sanfilippo, 1970, p. 451, pl. 1, fig. 10 - Foreman, 1975, p. 622, pl. 9, figs. 1-4 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 731, fig. 10P.

*Stichocorys* sp. (Fig. 12N)

Remarks: Similar to S. peregrina, but the second segment is longer instead to be the third.

**Genus *Stichopilium* Haeckel, 1881**

*Stichopilium bicorne* (Figs. 12O and 12P)

*Stichopilium bicorne* n.sp. Haeckel, 1887, p. 1437, pl. 77, fig. 9 - Nigrini and Moore, 1979, p. N91, pl. 26, figs. 1a-b - Boltovskoy, 1998, p. 83, fig. 15.161.

**Genus *Theocorys* Haeckel, 1881**

*Theocorys* (?) spp. (Figs. 12Q, 12R and 12S)

Remarks: Test relatively small, consisting of a cephalis, thorax, and abdomen. Apical robust horn. Pores are distributed through the shell irregularly and dispersed.

*Theocorys veneris* Haeckel (Fig. 12T)

*Theocorys veneris* Haeckel, 1887 p. 1415, pl. 69, fig. 5 - Boltovskoy and Riedel, 1987, p. 100, pl. 5, fig. 19 - Takahashi, 1991, p. 120, pl. 40, figs. 11-14.

**Genus *Carpocanarium* Haeckel, 1887, emend. Nigrini and Moore, 1979**

*Carpocanarium papillosum* (Ehrenberg) (Figs. 13A and 13B)

*Eucyrtidium papillosum* Ehrenberg, 1872a, p. 310-311.

*Carpocanarium papillosum* (Ehrenberg) - Takahashi, 1991, p. 132, pl. 45, figs. 16-17.

*Dictyocephalus papillosus* (Ehrenberg) - van de Paverd, 1995, p. 255, pl. 76, fig. 24 - Boltovskoy, 1998, figs. 15.135 a-c.

*Carpocanarium* aff. *papillosum* (Figs. 13C and 13D)

aff. *Eucyrtidium papillosum* Ehrenberg, 1872a, p. 310-311

Remarks: Similar to this species, but rearrangement of the pores and peristome is different.

Family **CARPOCANIIDAE** Haeckel, 1881, emend. Riedel, 1971a

**Genus Carpocanistrum Haeckel, 1887**

*Carpocanistrum acutidentatum* Takahashi (Figs. 13E and 13F)

*Carpocanistrum acutidentatum* n.sp. Takahashi, 1991, p. 132, pl. 45, figs. 9, 13-15.

*Carpocanistrum* spp. (Figs. 13G, 13H and 13I)

Remarks: Shell outline sub-spherical to oval. Cephalis indistinguishable from thorax, included within its upper part. Peristome poreless, smooth or provided with teeth. Height of shell: 80-130 µm. (Boltovskoy, 1998)

**Genus *Carpocanopsis* Riedel and Sanfilippo, 1971**

*Carpocanopsis cristata* (Carnevale) (Figs. 13J and 13K)

*Sethocorys cristata* n.sp. Carnevale, 1908, p. 31, pl. 4, fig. 18.

*Carpocanopsis cristatum* (Carnevale) - Riedel and Sanfilippo, 1971, p. 1597, pl. 1G, fig. 16, pl. 2G, figs. 1-7.

*Carpocanopsis cristata* (Carnevale) - Sanfilippo and Riedel, 1973, p. 531.

Family **CANNOBOTRYIDAE** Haeckel, 1881

**Genus *Botryocyrtis* Ehrenberg, 1860a, b**

*Botryocyrtis scutum* (Harting) (Figs. 13L, 13M and 13N)

*Haliomma scutum* n.sp. Harting, 1863, p. 11, pl. 1, fig. 18 - Molina-Cruz, 1977, p. 338, pl. 6, fig. 14 - Takahashi, 1991, p. 135, pl. 46, figs. 6-7 - Boltovskoy, 1998, p. 88, fig. 15. 172.

*Botryocyrtis* sp. A (Fig. 13O)

Remarks: Eucephalic chamber is enclosed in a rounded cephalis shape. Cylindrical thorax with very small pores. Shell height: ~50 µm. Present two large feelers.

**Genus *Botryopyle* Haeckel, 1881, emend. Petrushevskaya, 1965**

*Botryopyle dictyocephalus* Haeckel (Figs. 13P and 13Q)

*Botryopyle dictyocephalus* Haeckel, 1887, p. 1113, pl. 96, fig. 6.

*Botryopyle* spp. (Figs. 13R and 13S)

Remarks: Large cephalis, from ovoid to pointed shape, thin-walled. Thorax cylindrical, with pores or poreless tube.

**Genus *Centrobotrys* Petrushevskaya, 1965**

*Centrobotrys thermophila* Petrushevskaya (Fig. 13T)

*Centrobotrys thermophila* Petrushevskaya, 1965, p. 115, fig. 20 - Nigrini, 1967, p. 49, fig. 26, pl. 5, fig. 7 - Boltovskoy, 1998, p. 88, fig. 15. 175.

Family **ARTOSTROBIIDAE** Riedel, 1967a in Banner et al., 1967 and Riedel, 1967b, emend. Foreman, 1973

**Genus *Artostrobus* Haeckel, 1887**

*Artostrobus annulatus* (Bailey) (Fig. 14A)

*Cornutella* (?) *annulata* Bailey, 1856, p. 3, pl. 1, figs. 5a-b.

*Artostrobus annulatus* (Bailey) - Molina-Cruz, 1991, fig. 2(12-13) - Boltovskoy, 1998, fig. 15.125.

**Genus *Botryostrobus* Haeckel, 1887**

*Botryostrobus aquilonaris* (Bailey) (Figs. 14B and 14C)

*Eucyrtidium aquilonaris* n.sp. Bailey, 1856, p. 4, pl. 1, fig. 9.

*Botryostrobus aquilonaris* (Bailey) - Nigrini, 1977, p. 246, pl. 1, fig. 1 - Takahashi, 1991, p. 128, pl. 44, figs. 9-13 - Boltovskoy, 1998, p. 84, fig. 15.163.

*Botryostrobus auritus* (Ehrenberg) (Figs. 14D and 14E)

*Lithocampe aurita* n.sp. Ehrenberg, 1844, p. 84.

*Artostrobium auritum* group (Ehrenberg) - Riedel and Sanfilippo, 1971, p. 1599, pl. 1H, figs. 5-8.

*Lithostrobus lithobotrys* (Ehrenberg) - Molina-Cruz, 1977, p. 336, pl. 7, fig. 17.

*Botryostrobus auritus/australis* - Boltovskoy, 1998, p. 84, fig. 15.168.

*Botryostrobus bramlettei* (Campbell and Clark) (Fig. 14F)

*Lithomitra (Lithomitrissa) bramlettei* n.sp. Campbell and Clark, 1944, p. 53, pl. 7, figs. 10-14.

*Botryostrobus bramlettei* (Campbell and Clark) - Nigrini, 1977, p. 248, pl. 1, figs. 7-8 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 730, fig. 10G.

Remarks: difference from B. aquilonaris by having a conspicuously swollen third joint, one of important distinguishing characters of species; cephalis small, rather smooth, caplike, not much pitted, apically rounded, and laterally convex.

**Genus *Phormostichoartus* Campbell, 1951, emend. Nigrini, 1977**

*Phormostichoartus corbula* (Harting) (Figs. 14G and 14H)

*Lithocampe corbula* n.sp. Harting, 1863, p. 12, pl. 1, fig. 21.

*Phormostichoartus corbula* (Harting) - Takahashi and Honjo, 1981, p. 154, pl. 10, figs. 13-14 - Boltovskoy and Riedel, 1987, p. 101, pl. 6, fig. 7 - Takahashi, 1991, p. 129, pl. 44, figs. 14-16 - Boltovskoy, 1998, p. 84, fig. 15.163.

*Phormostichoartus doliolum* (Riedel and Sanfilippo) (Fig. 14I)

*Artostrobium doliolum* n.sp. Riedel and Sanfilippo, 1971, p. 1599, pl. 1H, figs. 1-3; pl. 8, figs. 14-15.

*Phormostichoartus doliolum* (Riedel and Sanfilippo) - Nigrini, 1977, pl. 1, fig. 14 - Nigrini and Lombari, 1984, p. N181, pl. 31, fig. 5a-b.

*Phormostichoartus marylandicus* (Martin) (Fig. 14J)

*Lithocampe marylandica* n.sp. Martin, 1904, p. 450, pl. 130, fig. 4.

*Artostrobium* sp. aff. *A. doliolum* - Riedel and Sanfilippo, 1971, pl. 1H, fig. 4; pl. 21, figs. 1-8; pl. 3E, figs. 7-9.

*Phormostichoartus marylandicus* (Martin) - Nigrini, 1977, p. 253, pl. 2, figs. 1-3.

**Genus *Siphocampe* Haeckel, 1881, emend. Nigrini, 1977**

*Siphocampe* spp. A (Figs. 14K and 14L)

Remarks: Specimens present pore rows in the extended part of the abdomen.

*Siphocampe arachnea* (Ehrenberg) (Fig. 14M)

*Lithocampe lineata* n.sp. Ehrenberg, 1838, p. 130.

*Eucyrtidum lineatum arachneum* Ehrenberg, 1861, p. 299.

*Lithomitra lineata* group (Ehrenberg) - Riedel and Sanfilippo, 1971, p. 1600, pl. 1I, figs. 1, 3-11; pl. 21, figs. 14-16.

*Siphocampe arachnea* (Ehrenberg) - Nigrini, 1977, p. 255, pl. 3, figs. 7-8.

*Siphocampe lineata* (Ehrenberg) (Fig. 14N)

*Lithocampe lineata* n.sp. Ehrenberg, 1838, p. 130.

*Siphocampe lineata* (Ehrenberg) - Nigrini, 1977, p. 256, pl. 3, fig. 9-10.

**Genus *Siphostichoartus* Nigrini, 1977**

*Siphostichoartus corona* (Haeckel) (Figs. 14O and 14P)

*Cyrtophormis (Acanthocyrtis) corona* n.sp. Haeckel, 1887, p. 1462. pl. 77, fig. 15.

*Phormostichoartus corona* (Haeckel) - Riedel and Sanfilippo, 1971, p. 1600, pl. 1I, figs. 13-15; pl. 2J, figs. 1-5.

*Siphostichoartus corona* (Haeckel) - Nigrini, 1977, p. 257, pl. 2, figs. 5-6.

**Genus *Spirocyrtis* Haeckel, 1881, emend. Nigrini, 1977**

*Spirocyrtis gyroscalaris* Nigrini (Fig. 14Q)

*Spirocyrtis gyroscalaris* n.sp. Nigrini, 1977, pl. 2, figs. 10-11.

*Spirocyrtis gyroscalaris* Nigrini - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 730, fig. 10E.

*Spirocyrtis scalaris* Haeckel (Figs. 14R and 14S)

*Spirocyrtis scalaris* n.sp. Haeckel, 1887, p. 1509, pl. 76, fig. 14 - Nigrini, 1977, p. 259, pl. 2, figs. 12-13 - Takahashi, 1991, p. 127, pl. 44, figs. 1-2 - Boltovskoy, 1998, p. 85, fig. 15.166.

Spirocyrtis subtilis Petrushevskaya (Fig. 14T)

*Spirocyrtis subtilis* n.sp. Petrushevskaya in Petrushevskaya and Kozlova, 1972, p. 540, pl. 24, figs. 22-24 - Nigrini, 1977, p. 260, pl. 3, fig. 3 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 730, fig. 10L.

Family **PTEROCORYTHIDAE** Haeckel, 1881, emend. Riedel, 1967a in Banner et al., 1967, emend. Moore, 1972
Pterocorida Haeckel, 1881, p. 435
Pterocoryidae Riedel, 1967a in Banner et al., 1967, p. 296

**Genus *Anthocyrtidium* Haeckel, 1881**

*Anthocyrtidium ehrenbergi* (Stöhr) (Figs. 15A and 15B)

*Anthocyrtis ehrenbergi* n.sp. Stöhr, 1880, p. 100, pl. 3, fig. 21a-b.

*Anthocyrtidium ehrenbergi* (Stöhr) - Nigrini and Lombari, 1984, N147, pl. 27, fig. 1.

*Anthocyrtidium ophirense* (Ehrenberg) (Figs. 15C and 15D)

*Anthocyrtis ophirensis* n.sp. Ehrenberg, 1872b, p. 285, pl. 9, fig. 13.

*Anthocyrtidium ophirense* (Ehrenberg) - Molina-Cruz, 1977, p. 337, pl. 6, fig. 10 - Nigrini and Moore, 1979, p. N67, pl. 25, fig. 1 - Takahashi, 1991, p. 126, pl. 43, figs. 1-7 - Boltovskoy, 1998, fig. 15.152.

*Anthocyrtidium* spp. (Figs. 15E and 15F)

Remarks: Several variations in these specimens. In general consists of a cephalis elongate with a robust three-bladed apical horn. Thorax campanulate, with circular, regular pores arranged longitudinally, peristome distinct within small teeth or undulate. Abdomen is absent.

**Genus *Calocycletta* Haeckel, 1887**

*Calocycletta caepa* Moore (Figs. 15G and 15H)

*Calocycletta caepa* n.sp. Moore, 1972, p. 150, pl. 2, figs. 4-7 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 736, fig. 14E.

*Calocycletta virginis* Haeckel (Fig. 15I)

*Calocyclas (Calocycletta) virginis* n.sp. Haeckel, 1887, p. 1381, pl. 74, fig. 4.

*Calocycletta virginis* Haeckel - Riedel and Sanfilippo, 1978, p. 66, pl. 3, figs. 13-14.

**Genus *Lamprocyclas* Haeckel, 1887, emend. Nigrini, 1967**

*Lamprocyclas junonis* (Haeckel) (Fig. 15J)

*Theoconus junonis* n.sp. Haeckel, 1887, p. 1401, pl. 69, fig. 7.

*Lamprocyclas junonis* (Haeckel) - Caulet, 1986, pl. 4, fig. 10.

*Lamprocyclas maritalis* group Haeckel (Figs. 15K and 15L)

*Lamprocyclas maritalis* n.sp. Haeckel, 1887, p. 1390, pl. 74, figs. 13-14.

*Lamprocyclas maritalis maritalis* Haeckel - Nigrini, 1967, p. 74-76, pl. 7, fig. 5 - Molina-Cruz, 1977, p. 337, pl. 7, figs. 8-9 - Nigrini and Moore, 1979, p. N75, pl. 25, fig. 4 - Boltovskoy, 1998, fig. 15.158.

*Lamprocyclas* sp. A (Fig. 15M)

Remarks: Cephalis sub-spherical, elongate, with a large three-bladed apical horn. Thorax campanulate, thick-walled, with sub-regular, circular pores. Abdomen, with large, sub-regular, circular pores and with sub-terminal teeth.

**Genus Lamprocyrtis Kling, 1973**

*Lamprocyrtis nigriniae* (Caulet) (Fig. 15N)

Conarachnium nigriniae n.sp. Caulet, 1971, p. 3, pl. 3, figs. 1-4; pl. 4, figs. 1-4.

*Lamprocyrtis nigriniae* (Caulet) - Nigrini and Moore, 1979, p. N81-N82, pl. 25, fig. 7 - Takahashi, 1991, p. 127, pl. 43, figs. 17-19 - Boltovskoy, 1998, p. 82, fig. 15.157.

*Lamprocyrtis* spp. (Figs. 15O and 15P)

Remarks: Cephalis sub-spherical, with a large three bladed horn. Thorax campanulate, thin-walled, with large polygonal pores increasing in size distally. No abdomen.

**Genus *Pterocorys* Haeckel, 1881, emend. Petrushevskaya, 1971**

*Pterocorys minythorax* (Nigrini) (Fig. 15Q)

*Theoconus minythorax* n.sp. Nigrini, 1968, p. 57, pl. 1, fig. 8 - Molina-Cruz, 1977, p. 338, pl. 7, fig. 1.

*Pterocorys minythorax* (Nigrini) - Nigrini and Moore, 1979, p. N87, pl. 25, fig. 10 - Boltovskoy, 1998, p. 82, fig. 15.156.

*Pterocorys zancleus* (Müller) (Figs. 15R and 15S)

*Eucyrtidium zancleum* n.sp. Müller, 1855, p. 672.

*Pterocorys zancleus* (Müller) - Boltovskoy, 1998, p. 82, fig. 15.159 - Kamikuri, Motoyama, Nishi & Iwai, 2009, p. 732, fig. 11R.

*Pterocorys* sp. (Fig. 15T)

Remarks: Not well preserved specimen.

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The following figures illustrate the radiolarian with the sample code and the age assignment. In the supplementary data 1 and 2 are shown the entire samples list and the radiolarian abundance. Some of the species could not be find in this counting because it was counted within a group.

Each scale bar is 50 μm.

Radiolaria Spumellaria

Figure 2
Family Collosphaeridae Müller, 1858
A. *Acrosphaera* sp. A. U1381C 7H 6W 23–25 (middle Miocene)
B. *Acrosphaera* sp. B U1381C 7H 3W 73–75 (middle Miocene)
C. *Acrosphaera murrayana* (Haeckel) U1414 A 1H 1W 2–4 (Pleistocene)
D–E. *Siphonosphaera martensi* Brandt, D. U1414 A 29X 3W 24–26, E. U1414 A 29X 3W 24–26 (late Miocene)
F–G. *Siphonosphaera polysiphonia* Haeckel, F. U1414 A 2H 3W 23–28 (Pleistocene)
G. U1414 A 10H 2W 24–26 (Pleistocene)
H–K. *Collosphaera macropora* Popofsky, H. U1414 A 28X 7W 24–26 (late Miocene), I. U1381C 6H 1W 39–41 (middle Miocene), J. U1381C 7H 3W 73–75 (middle Miocene), K. U1381C 7H 6W 60–62 (middle Miocene)
**L.** *Collosphaera* sp. A U1381C 7H 6W 60–62 (middle Miocene)
**M.** *Collosphaera elliptica* Chen and Tan U1381C 7H 6W 45–47 (middle Miocene)
**N.** *Collosphaera tuberosa* Haeckel U1414A 1H 1W 2–4 (Pleistocene)
**O–Q.** *Otosphaera polymorpha* Haeckel, **O.** U1414A 25X 5W 24–26 (late Miocene), **P–Q.** U1381C 7H 1W 119–121 (middle Miocene)
**R–S.** *Otosphaera* aff. *auriculata*, **R.** U1414A 6H 5W 26–27, **S.** U1414A 1H 1W 24–26 (Pleistocene)
**T.** *Trisolenia zanguenica* U1381C 7H 6W 45–47 (middle Miocene)

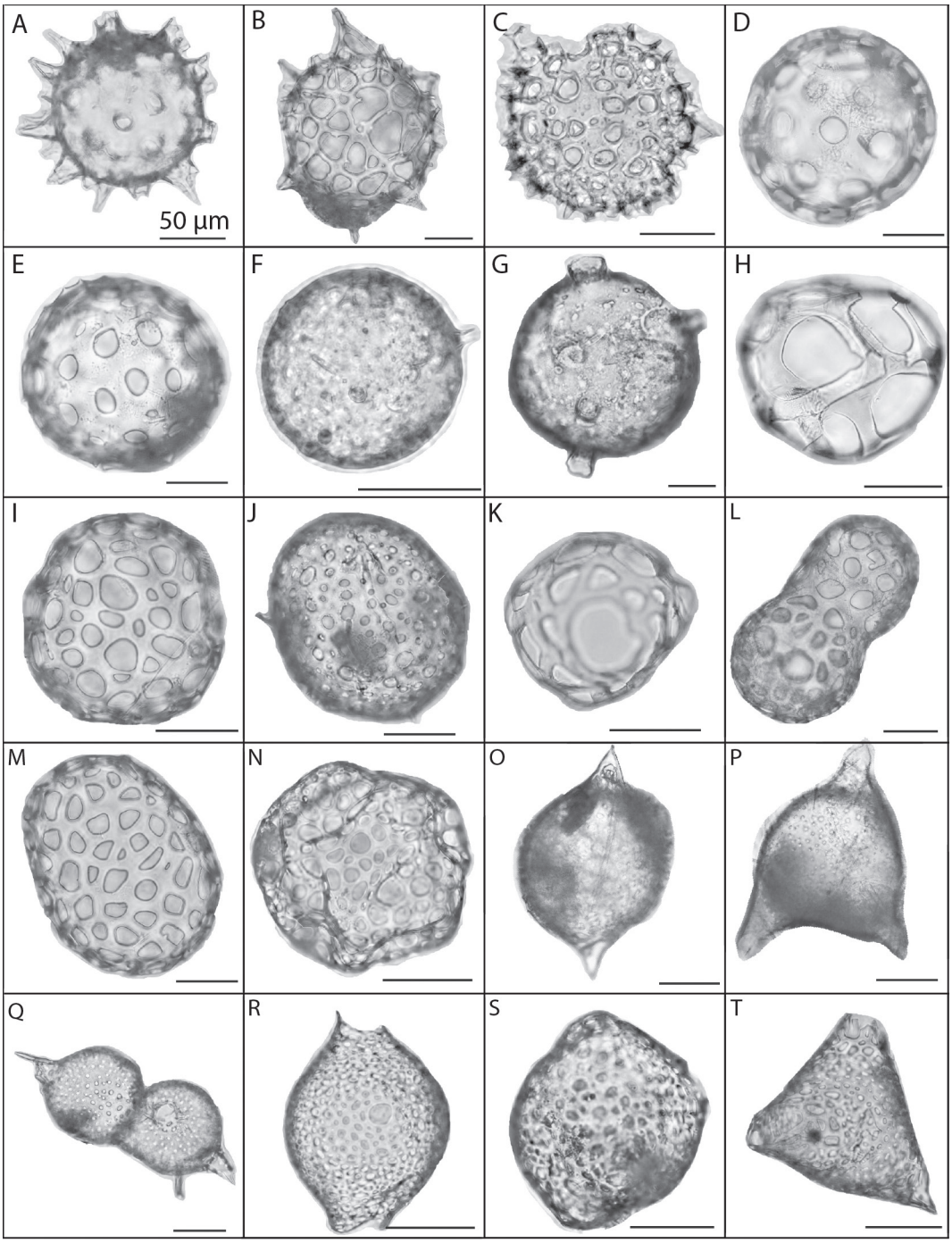
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Figure 3

Family Actinommidae Haeckel, 1862, emend. Riedel, 1971
**A–B.** *Actinomma langii* (Dreyer), **A.** U1414A 2H 5W 17–22 (Pleistocene), **B.** U1414A 1H 1W 2–4 (Pleistocene)
**C.** *Cladococcus cevicornis* Haeckel U1414A 1H 1W 24–26 (Pleistocene)
**D.** *Diartus hughesi* (Campbell and Clark) U1414A 26X 7W 16–18 (late Miocene)
**E–F.** *Diartus pettersoni* Riedel and Sanfilippo, **E.** U1414A 31X 1W 24–26 (late Miocene), **F.** U1414A 29X 3W 24–26 (late Miocene)
**G.** *Didymocyrtis penultima* (Riedel) U1414A 22H 6W 24–26 (late Miocene)
**H.** *Didymocyrtis antepenultima* (Riedel and Sanfilippo) U1414A 27X 4W 24–26 (late Miocene)
**I.** *Didymocyrtis laticonus* (Riedel) U1381C 7H 2W 133–135 (late Miocene)
**J.** *Didymocyrtis mammifera* (Haeckel) U1381C 8H 3W 50–52 (late Miocene)
**K.** *Didymocyrtis basanii* (Carnevale) U1381C 7H 6W 45–47 (late Miocene)
**L.** *Didymocyrtis tetrathalamus* (Haeckel) U1414A 1H 1W 24–26 (Pleistocene)
**M.** *Saturnalis circularis* Haeckel U1381C 7H 6W 106–108 (middle Miocene)
**N.** *Duppatractus* sp. U1414A 30X 8W 24–36 (late Miocene)
**O–P.** *Hexacontium armatum/hostile*, **O.** U1414A 30X 5W 22–24 (late Miocene), **P.** U1381C 7H 3W 73–75 (middle Miocene)
**Q.** *Stylosphaera* sp. U1381C 7H 6W 106–108 (middle Miocene)
**R.** *Plegmosphaera* sp. U1414A 1H 1W 2–4 (Pleistocene)

Family Phacodiscidae Haeckel, 1881
**S.** *Heliodiscus* sp. U1381C 7H 1W 66–68 (middle Miocene)

Family Coccosdiscidae Haeckel, 1862
**T.** *Periphaena decora* U1414A 30X 8W 24–26 (late Miocene)

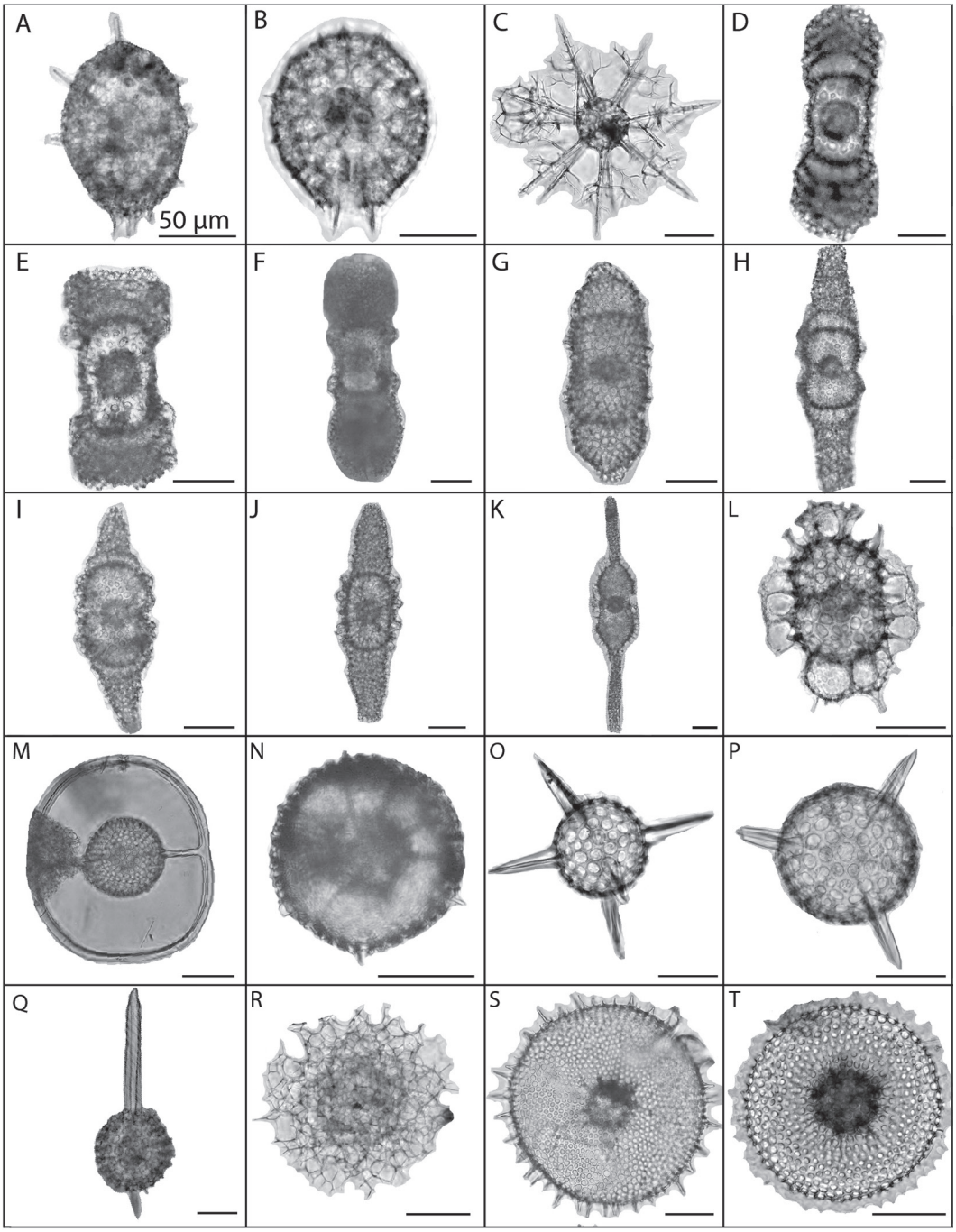
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Figure 4

Family Spongodiscidae Haeckel, 1862, emend. Riedel, 1967a in Banner et al., 1967
**A.** *Amphirhopalum ypsilum* Haeckel U1414A 1H 1W 24–26 (Pleistocene)
**B.** *Dictyocoryne truncatum* (Ehrenberg) U1414A 1H 2W 2–4 (Pleistocene)
**C.** *Dictyocoryne profunda* Ehrenberg U1414A 1H 1W 24–26 (Pleistocene)
**D–E.** *Euchitonia furcata/elegans group* (Ehrenberg), **D.** U1414A 30X 5W 22–24 (Pleistocene), **E.** U1414A 4H 6W 24–26 (Pleistocene)
**F.** *Spongaster tetras* Ehrenberg U1414A 1H 1W 24–26 (Pleistocene)
**G.** *Spongaster* sp. A U1414A 7H 1W 137–139 (Pleistocene)
**H.** *Spongocore puella* Haeckel U1414A 3H 5W 24–26 (Pleistocene)
**I.** *Stylodictya aculeata* Jørgensen U1414A 26X 7W 16–18 (late Miocene)
**J.** *Stylodictya validispina* Jørgensen U1414A 30X 5W 22–24 (late Miocene)
**K–L.** *Spongodiscus* sp. **K.** U1414A 1H 1W 2–4, **L.** U1414A 1H 1W 2–4 (Pleistocene)
**M–P.** *Circodiscus* spp. **M.** U1414A 1H 1W 2–4 (Pleistocene), **N.** U1381C 7H 6W 45–47 (middle Miocene), **O–P.** U1414A 30X 5W 22–24 (late Miocene)
**Q–S.** *Spongurus* spp. **Q–R.** U1414A 1H 1W 2–4 (Pleistocene), **S.** U1414A 23X 6W 24–26 (late Miocene)
**T.** *Spongopyle osculosa* U1414A 1H 1W 24–26 (Pleistocene)

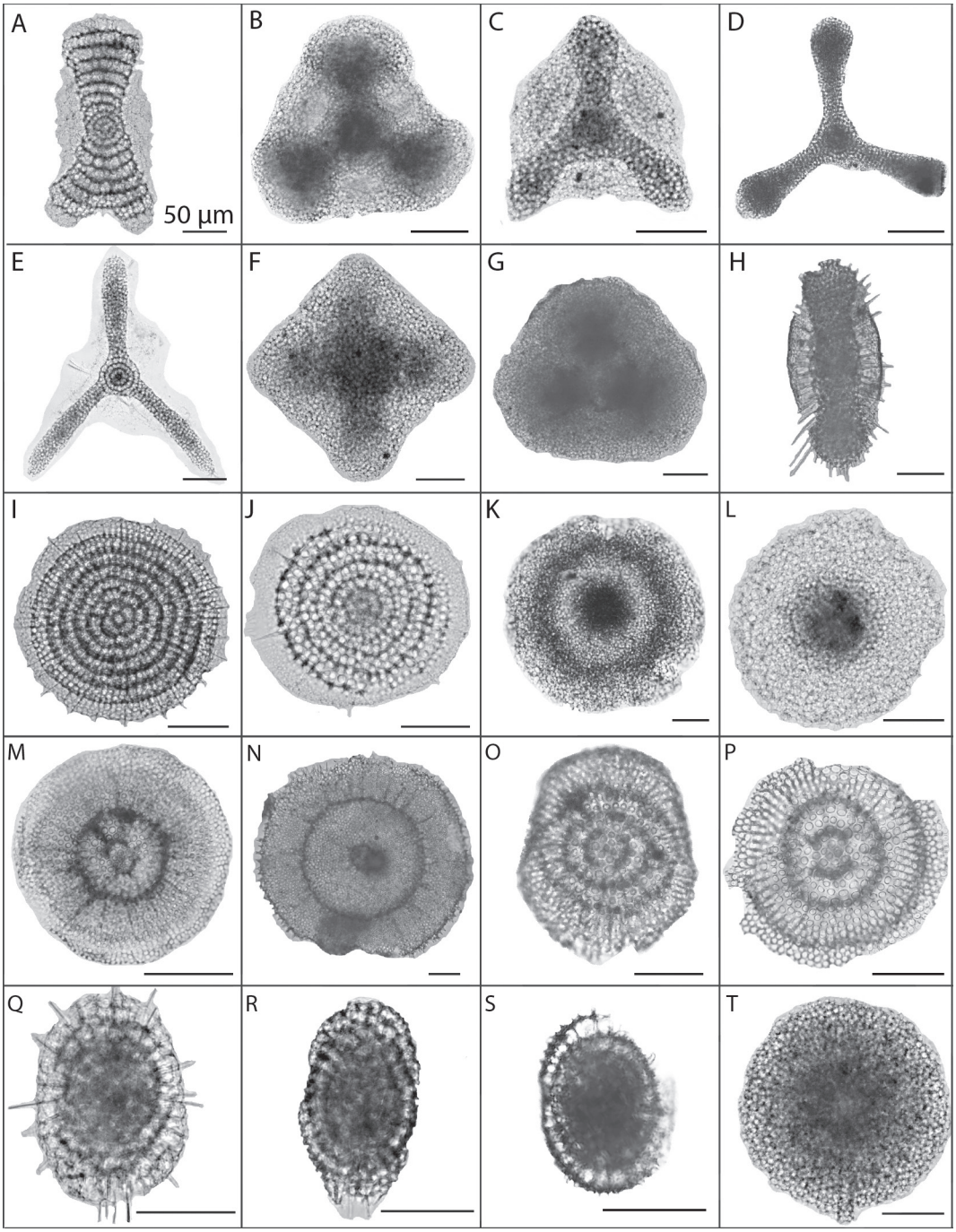
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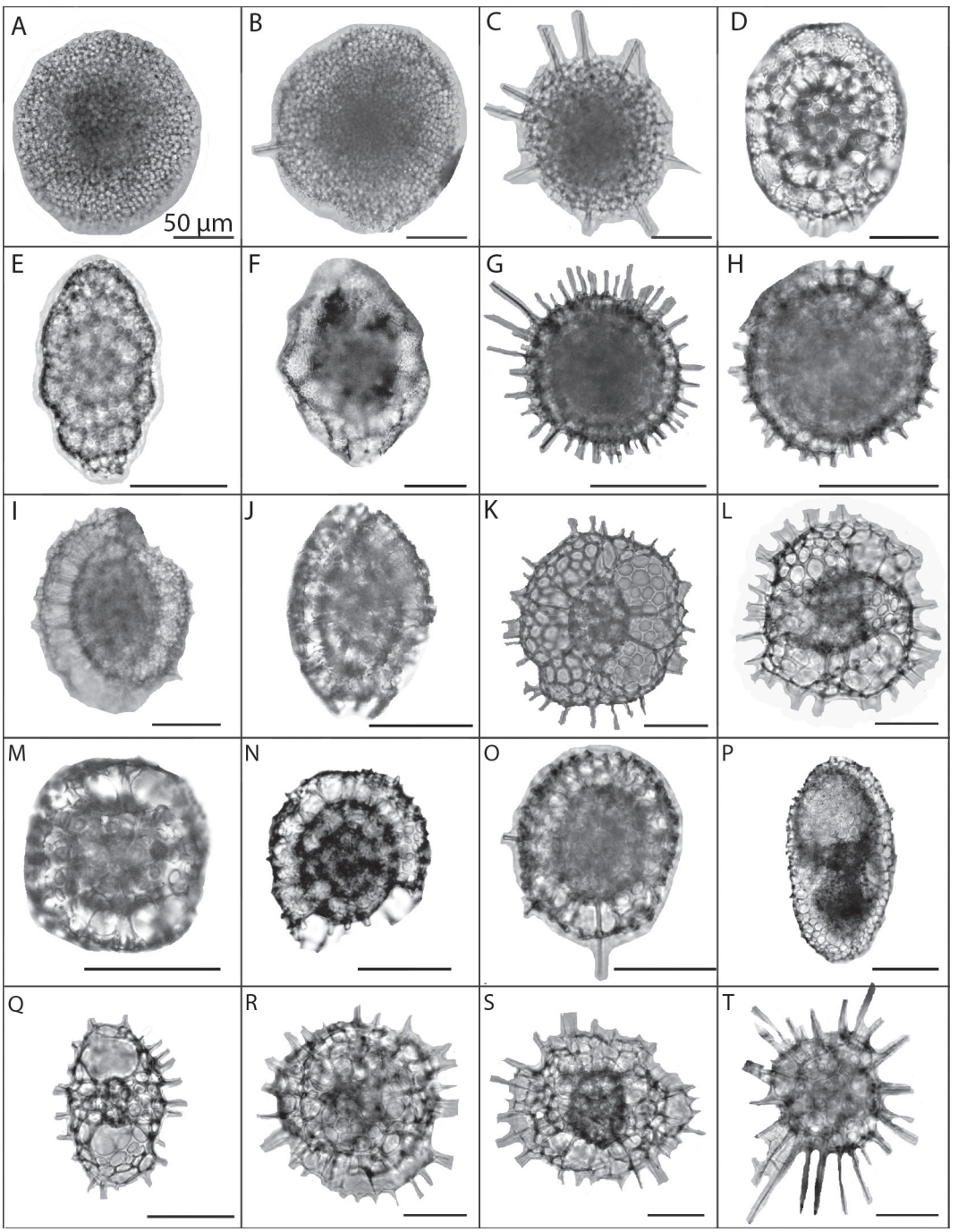
Figure 5

Family Spongodiscidae Haeckel, 1862, emend. Riedel, 1967a in Banner et al., 1967
**A–C.** *Spongotrochus* spp. **A.** U1414A 30X 4W, 20–22 cm, late Miocene) **B–C.** U1414A 1H 1W, 2–4 cm (Pleistocene)
Family Litheliidae Haeckel, 1882
**D.** *Larcopyle butschlii* Dreyer U1414A 1 H 1W 2–4 (Pleistocene)
**E–F.** *Larcopyle nebulum* Lazarus, **E.** U1381C 9H 4W 52–56 (middle Miocene), **F.** U1414 A 29X 3W 24–26 (late Miocene)
**G–H.** *Lithelius minor* (Jørgensen) U1414A 4H 3W 24–26 (Pleistocene)
**I–J.** *Larcospira* spp. U1414A 1H 1W 24–26 (Pleistocene)
**K–L.** *Larcospira quandrangula* Haeckel U1414A 1H 2W 22–24 (Pleistocene)

Family Pyloniidae Haeckel, 1881, emend. Dumitrica, 1989
**M–O.** *Phorticium pylonium group* Haeckel, **M.** U1414A 30X 5W 22–24 (late Miocene), **N.** U1414A 30X 6W 24–26 (late Miocene), **O.** U1414A 1H 1W 2–4 (Pleistocene)
**P**. *Pylonium* sp. *sensu* Benson U1414A 2H 5W 17–22 (Pleistocene)
**Q.** *Tetrapyle octacantha* Müller U1414A 6H 5W 26–27 (Pleistocene)
**R–T.** Spumell. gen and sp. indet. U1414A 1H 1W 24–26 (Pleistocene)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Radiolaria Nasellaria

Figure 6

Family Spyridae Ehrenberg, 1847, emend. Petrushevskaya, 1971
**A.** *Amphispyris reticulata* (Ehrenberg) U1414A 3H 1W 24–26 (Pleistocene)
**B.** *Cantharospyris platybursa* Haeckel U1414A 1H 2W 24–26 (Pleistocene)
**C.** *Dendrospyris bursa* Sanfilippo and Riedel U1414A 30X 7W 24–26 (late Miocene)
**D.** *Giraffospyris toxaria* (Haeckel) U1381C 7H 5W 126–128 (middle Miocene)
**E.** *Liriospyris parkerae* Riedel and Sanfilippo U1381C 7H 3W 28–30 (middle Miocene)
**F–H.** *Liriospyris* spp. **F.** U1414A 30X 5W 22–24 (late Miocene), **G.** U1381C 11H 1W 40–44 (middle Miocene), **H.** U1414A 31X 1W 24–26 (late Miocene)
**I.** *Lophospyris pentagona pentagona* (Ehrenberg) U1414A 1H 2W 24–26 (Pleistocene)
**J.** *Neophrospyrs renilla* Haeckel U1414A 6H 1W 26–27 (Pleistocene)
**K.** *Androspyris huxleyi* Haeckel U1414A 1H 1W 2–4 (Pleistocene)
**L.** *Zigocircus productus* Haeckel U1414 1H 1W 2–4 (Pleistocene)
**M.** *Phormospyris* sp. A U1414A 27X 4W 24–26 (late Miocene)
**N.** *Phormospyris stabilis stabilis* Goll U1414 1H 1W 24–26 (Pleistocene)
**O.** *Phormospyris stabilis capoi* Goll U1414A 5H 5W 24–26 (Pleistocene)
**P.** *Phormospyris stabilis scaphipes* (Haeckel) U1414A 4H 6W 24–26
**Q–T.** *Tholospyris* sp., **Q.** U1414A 30X 5W 24–26 (middle Miocene), **R.** U1381C 7H 3W 109–111 (middle Miocene), **S–T.** U1381C 7H 6W 106–108 (middle Miocene)

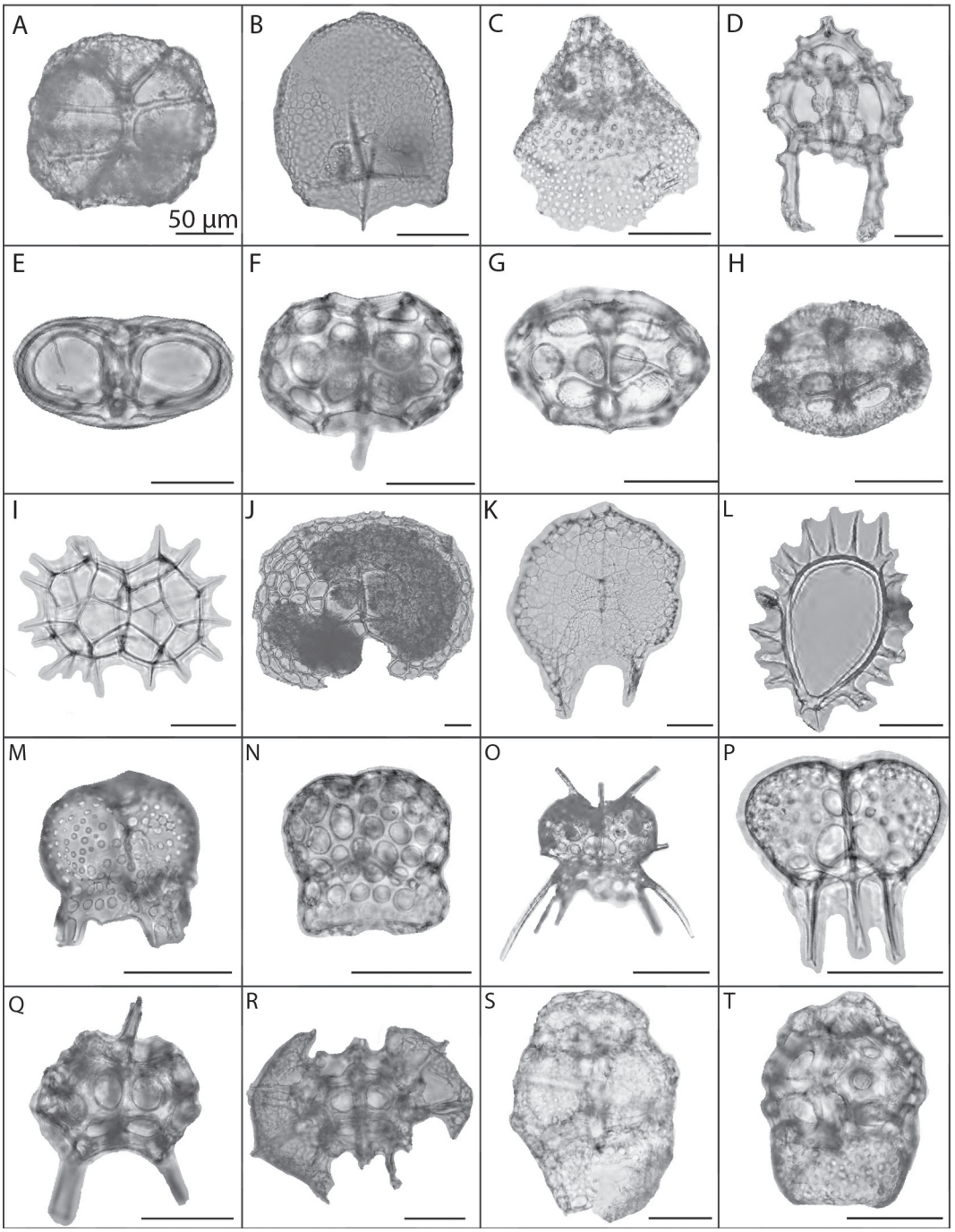
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Figure 7

Family Plagoniidae Haeckel, 1881, emend. Riedel, 1967a in Banner et al., 1967
**A.** *Amphiplecta acrostoma* Haeckel U1414A 1H 1W 24–26 (Pleistocene)
**B–D.** *Cladoscenium* spp. **B.** U1414A 1H 1W 2–4 (Pleistocene), **C.** U1414A 1H 1W 24–26 (Pleistocene), **D.** U1414 3H 1W 24–26 (Pleistocene)
**E.** *Clathrocanium* sp. U1381C 8H 3W 50–52 (middle Miocene)
**F.** *Lophophaena hispida* (Ehrenberg) U1414A 1H 2W 24–26 (Pleistocene)
**G.** *Lophophaena* aff. *hispida* U1414A 4H 6W 24–26 (Pleistocene)
**H.** *Lophophaena* aff. *capito* U1381C 7H1W 2–4 (middle Miocene)
**I–L.** Plagoniidae group, **I.** U1414A 1H 1W 2–4 (Pleistocene), **J.** U1414A 2H 3W 23–25 (Pleistocene), **K.** U1381C 7H 6W 1–3, **L.** U1381C 7H 6W 23–25 (middle Miocene)
**M.** *Pteroscenium* sp. U1414A 1H 2W 24–26 (Pleistocene)
**N.** *Pteroscenium pinnatum* Haeckel U1414 29X 3W 24–26 (late Miocene)
**O.** *Tetraphormis dodecaster* (Haeckel) U1414A 1W 1H 2–4 (Pleistocene)
**P.** *Clathrocorys* aff. *teuscheri* U1414A 1H 1W 24–26 (Pleistocene)
**Q–R.** *Helothus histricosa* Jørgensen, **Q.** U1381C 7H 6W 23–25 (middle Miocene), **R.** U1414A 30X 5W 24–26 (late Miocene)
**S.** *Helothus* aff. *histricosa* U1381C 7H 6W 23–25 (middle Miocene)
**T.** *Sethophormis* sp.A U1381C 8H 3W 50–52 (middle Miocene)

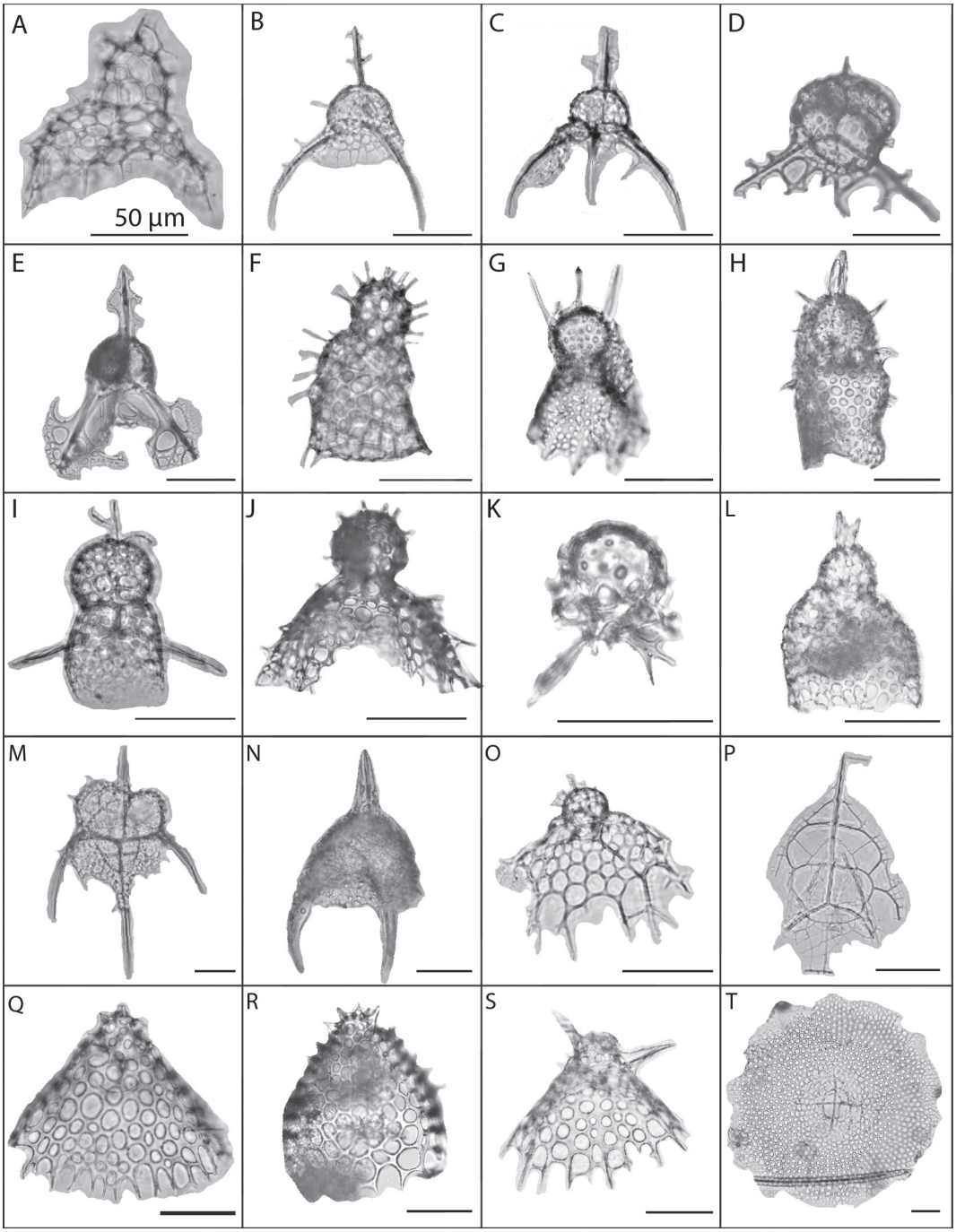
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Figure 8

Family Theoperidae Haeckel, 1881, emend. Riedel, 1967a in Banner et al., 1967
**A.** *Artopilium undulatum* Popofsky U1414A 8H 1W 24–26 (Pleistocene)
**B.** *Clathrocyclas alcmenae* Haeckel U1414A 7H 2W 24–26 (Pleistocene)
**C.** *Clathrocyclas monumentum* Haeckel U1414A 1H 1W 24–26 (Pleistocene)
**D–F.** *Corocalyptra kruegeri* (Popofsky), **D.** U1381C 7H 6W 106–108 (middle Miocene), **E.** U1414A 30H 5W 22–24 (late Miocene), **F.** U1381C 7H 3W 4–6 (middle Miocene).
**G.** *Corocalyptra* sp. U1414A 2H 5W 17–22 (Pleistocene)
**H.** *Corocalyptra cervus* Ehrenberg U1414A 1H 1W 2–4 (Pleistocene)
**I.** *Cornutella profunda* Ehrenberg U1414 2W 5W 17–22 (Pleistocene)
**J–K.** *Cycladophora davisiana* (Ehrenberg), **J.** U1381C 2H 4W 66–68, **K.** U14141 A 1H 1W 24–26 (Pleistocene)
**L–M.** *Cyrtocapsella cornuta* Haeckel U1414A 27X 4W 24–26 (late Miocene)
**N–O.** *Cyrtocapsella tetrapera* (Haeckel) **N.** U1414A 30X 8W 24–26 (late Miocene), **O.** U1381C 11H 1W 40–44 (middle Miocene)
**P.** *Cyrtocapsella cylindroides* (Principi) U1381C 7H 1W 137–139 (middle Miocene)
**Q–S.** *Cyrtocapsella japonica* (Nakaseko), **Q–R.** U1414A 30X 7W 24–26 (late Miocene), **S.** U1414A 30X 8W 24–26 (middle Miocene)
**T.** *Cyrtocapsella* sp. U1381C 7H 1W 137–139 (middle Miocene)

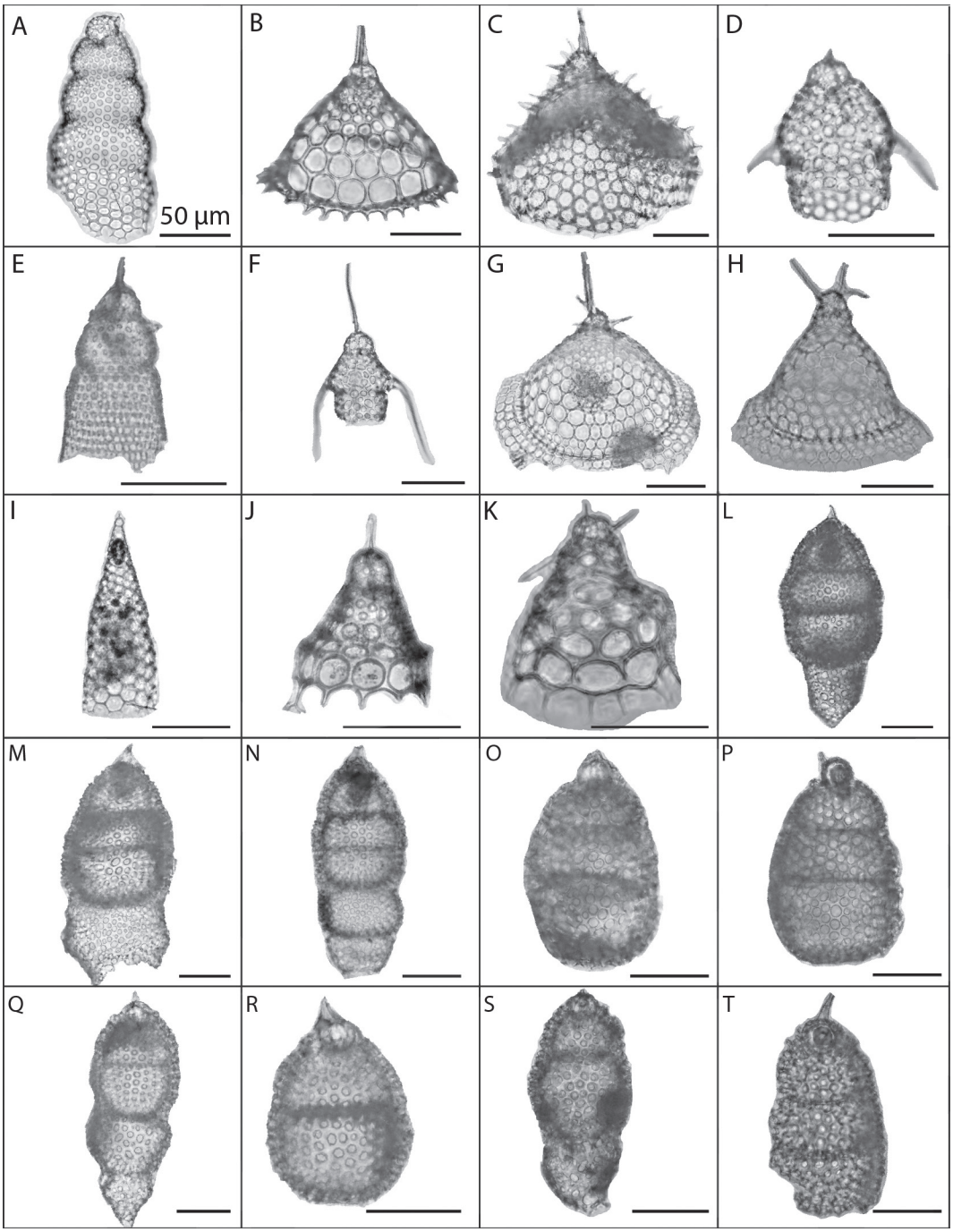
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Figure 9

Family Theoperidae Haeckel, 1881, emend. Riedel, 1967a in Banner et al., 1967
**A–B.** *Dictyophimus infabricatus* Nigrini, **A.** U1414A 1H 1W 2–4 (Pleistocene), **B.** U1414A 1H 1W 24–26 (Pleistocene)
**C.** *Dictyophimus hirundo* Haeckel U1414A 1H 2W 24–26 (Pleistocene)
**D–F.** *Dictyophimus* spp. **D.** U1414A 1H 1W 24–26 (Pleistocene), **E.** U1414A 3H 1W 24–26 (Pleistocene), **F.** U1414A 30X 5W 22–24 (late Miocene)
**G.** *Eucecryphalus gegenbauri* Haeckel U1414A 1H 1W 2–4 (Pleistocene)
**H–K.** *Eucecryphalus tricostatum* Haeckel, **H.** U1414A 1H 2W 24–26 (Pleistocene), **I.** U1381C 7H 3W 28–30 (middle Miocene), **J–K.** U1414A 7H 2W 24–26 (late Miocene)
**L–S.** *Eucecryphalus* spp. **L.** U1381C 7H 1W 66–68 (middle Miocene), **M.** U1414A 30X 5W 22–24 (middle Miocene), **N.** U1381C 2H 4W 66–68 (Pleistocene), **O.** U1381C 7H 1W 37–39 (middle Miocene), **P.** U1414A 1H 1W 24–26 (Pleistocene), **Q.** U1381C 7H 3W 118–120, **R–S.** U1381C 5H 3W 89–91 (late Miocene), **T.** U1414A 29X 3W 24–26 (late Miocene)

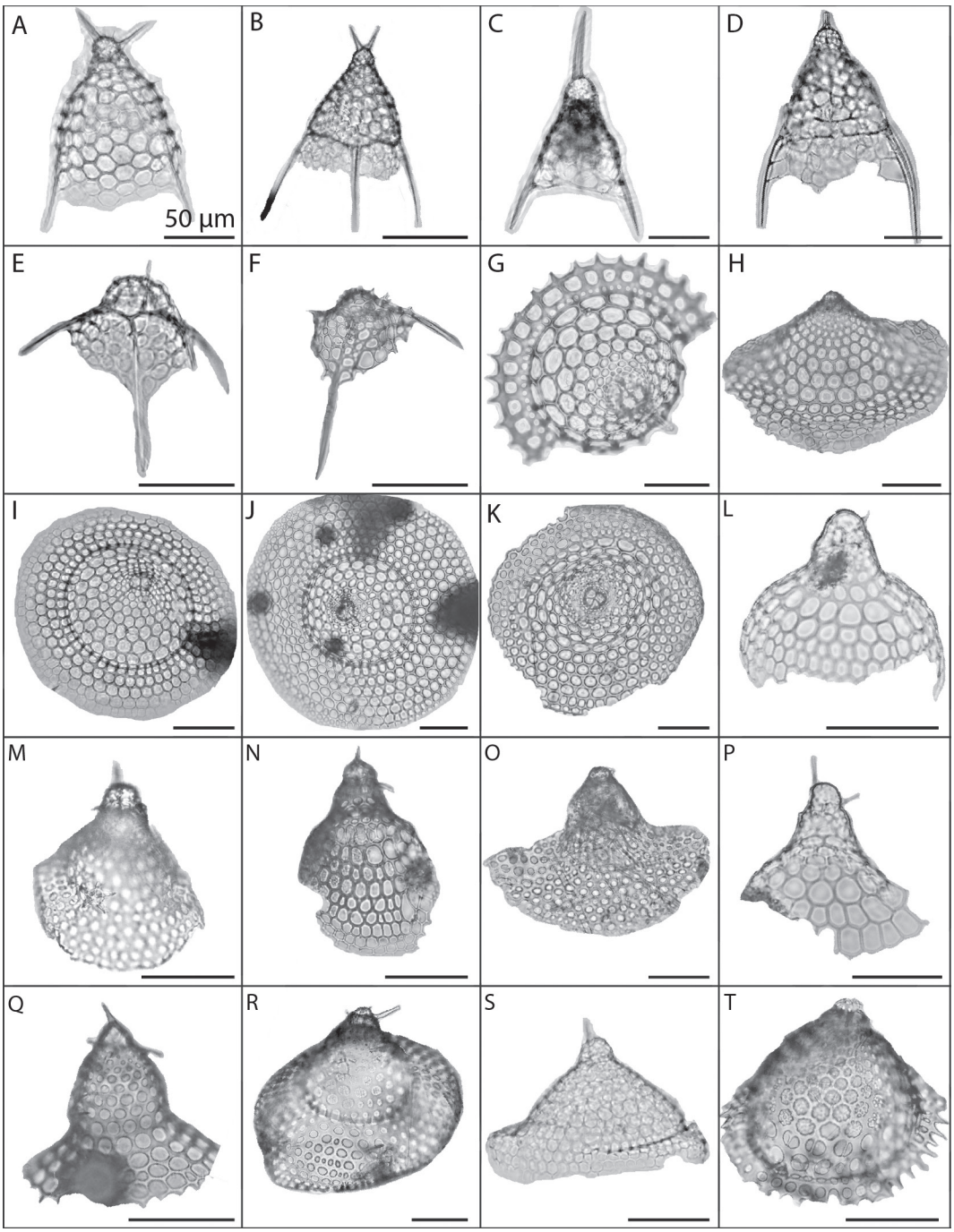
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Figure 10

Family Theoperidae Haeckel, 1881, emend. Riedel, 1967a in Banner et al., 1967
**A.** *Eucyrtidium anomalum* (Haeckel) U1414A 24X 1W 24–26 (late Miocene)
**B.** *Eucyrtidium calvertense* Martin U1414A 22H 4W 24–26 (late Miocene)
**C–D.** *Eucyrtidium cienkowskii* Haeckel, **C.** U1414A 30X 5W 22–24 (late Miocene), **D.** U1381C 7H 1W 37–39 (middle Miocene)
**E–G.** *Eucyrtidium hexagonatum* Ehrenberg, **E.** U1414A 2H 5W 17–22 (Pleistocene), **F.** U1414A 1H 1W 2–4 (Pleistocene), **G.** U1414A 3H 1W 24–26 (Pleistocene)
**H.** *Eucyrtidium hexastichus* Haeckel U1381C 5H 1W 27–31 (late Miocene)
**I.** *Eucyrtidium teuscheri* Haeckel U1414A 3H 1W 24–26 (Pleistocene)
**J–L.** *Eucyrtidium* spp. **J–K.** U1414A 1H 1W 2–4, **L.** U1414A 2H 1W 17–22 (Pleistocene), **M–N.** U1414A 1H 1W 2–4 (Pleistocene), **O.** U1381C 5H 1W 27–31 (Pleistocene), **P.** U1414 28X 2W 24–26 (late Miocene), **Q–R.** U1381C 7H 6W 106–108 (middle Miocene), **S.** U1381C 7H 6W 3W 73–75 (middle Miocene), **T.** U1381C 7H 6W 60–62 (middle Miocene).

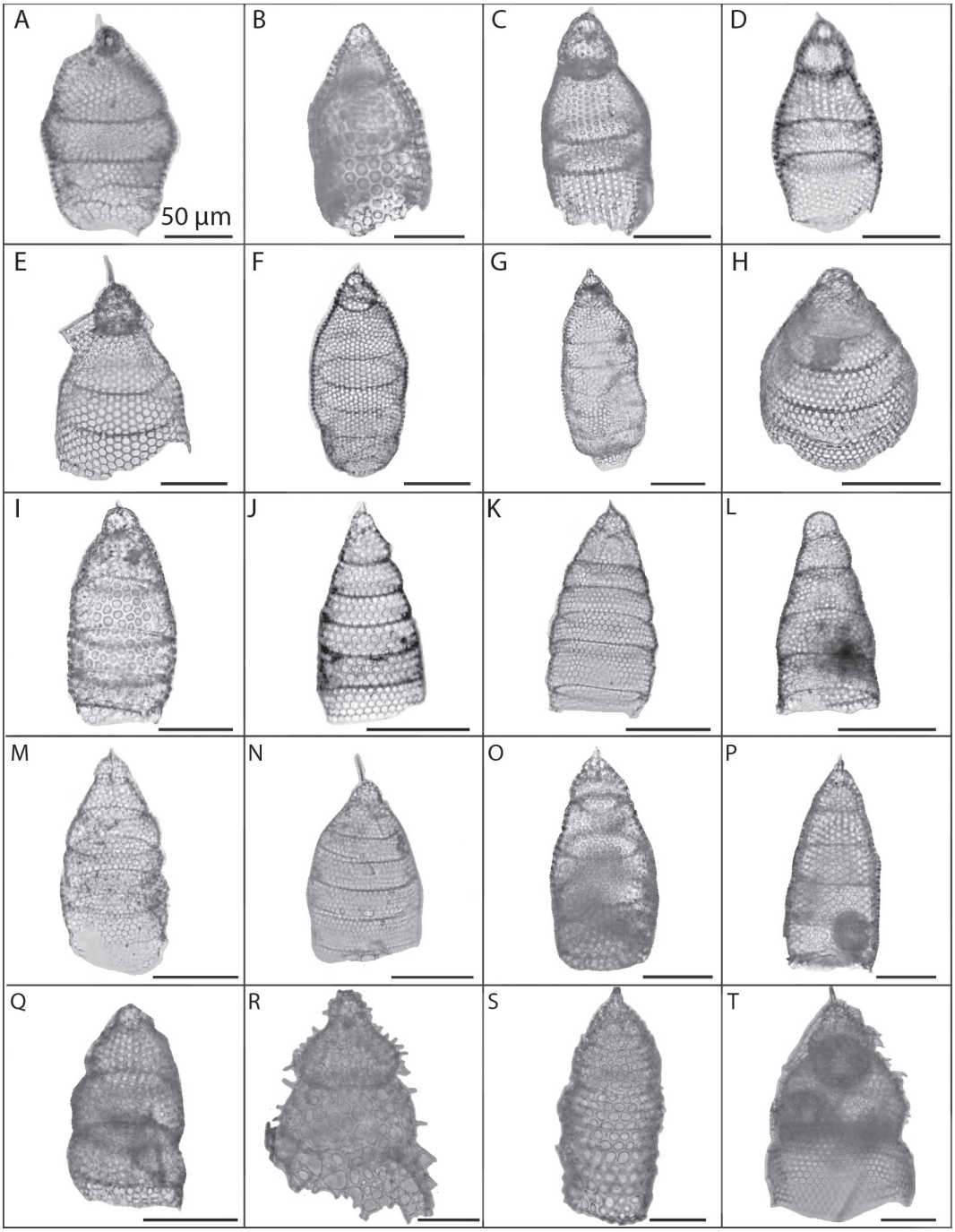
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Figure 11

Family Theoperidae Haeckel, 1881, emend. Riedel, 1967a in Banner et al., 1967
**A.** *Lampromitra schultzei* Haeckel U1414A 1H 2W 24–26 (Pleistocene)
**B.** *Litharachnium tentorium* Haeckel U1414A 3H 5W 24–26 (Pleistocene)
**C–D.** *Lipmanella dictyoceras* (Haeckel), **C.** U1414A 4H 3W 24–26 (Pleistocene), **D.** U1381C 7H 2W 1–3 (middle Miocene)
**E.** *Lipmanella* sp. U1381C 10H 4W 36–40 (middle Miocene)
**F–H.** *Lithopera neotera* Sanfilippo and Riedel, **F.** U1414A 31X 1W 24–26 (late Miocene) , **G.** U1414A 28X 7W 24–26 (late Miocene), **H.** U1414A 30X 7W 24–26 (late Miocene)
**I–L.** *Lithopera renzae* Riedel and Sanfilippo, **I.** U1381C 7H 3W 73–75 (middle Miocene), **J.** U1381C 7H 3W 73–75 (middle Miocene), **K.** U1414A 30X 8W 22–24 (late Miocene), **L.** U1381C 7H 6W 24–26 (middle Miocene)
**M.** *Lithopera thornburgi* Sanfilippo and Riedel U1414A 28X 7W 24–26 (late Miocene)
**N.** *Lithostrobus hexagonalis* Haeckel U1414A 4H 6W 24–26 (Pleistocene)
**O.** *Lophocyrtis brachythorax* (Sanfilippo and Riedel) U1414A 29X 3W 24–26 (late Miocene)
**P.** *Lophocyrtis tanythorax* Sanfilippo and Riedel U1381C 7H 1W 66–68 (middle Miocene)
**Q–R.** *Lophocyrtis* spp. **Q.** U1381C 7H 1W 119–121 (middle Miocene), **R.** U1381C 7H 1W 37–39 (middle Miocene)
**S–T.** Nassell. gen. and sp. indet., **S.** U1381C 9H 4W 52–56 (middle Miocene) , **T.** U1381C 7H 3W 73–75 (middle Miocene)

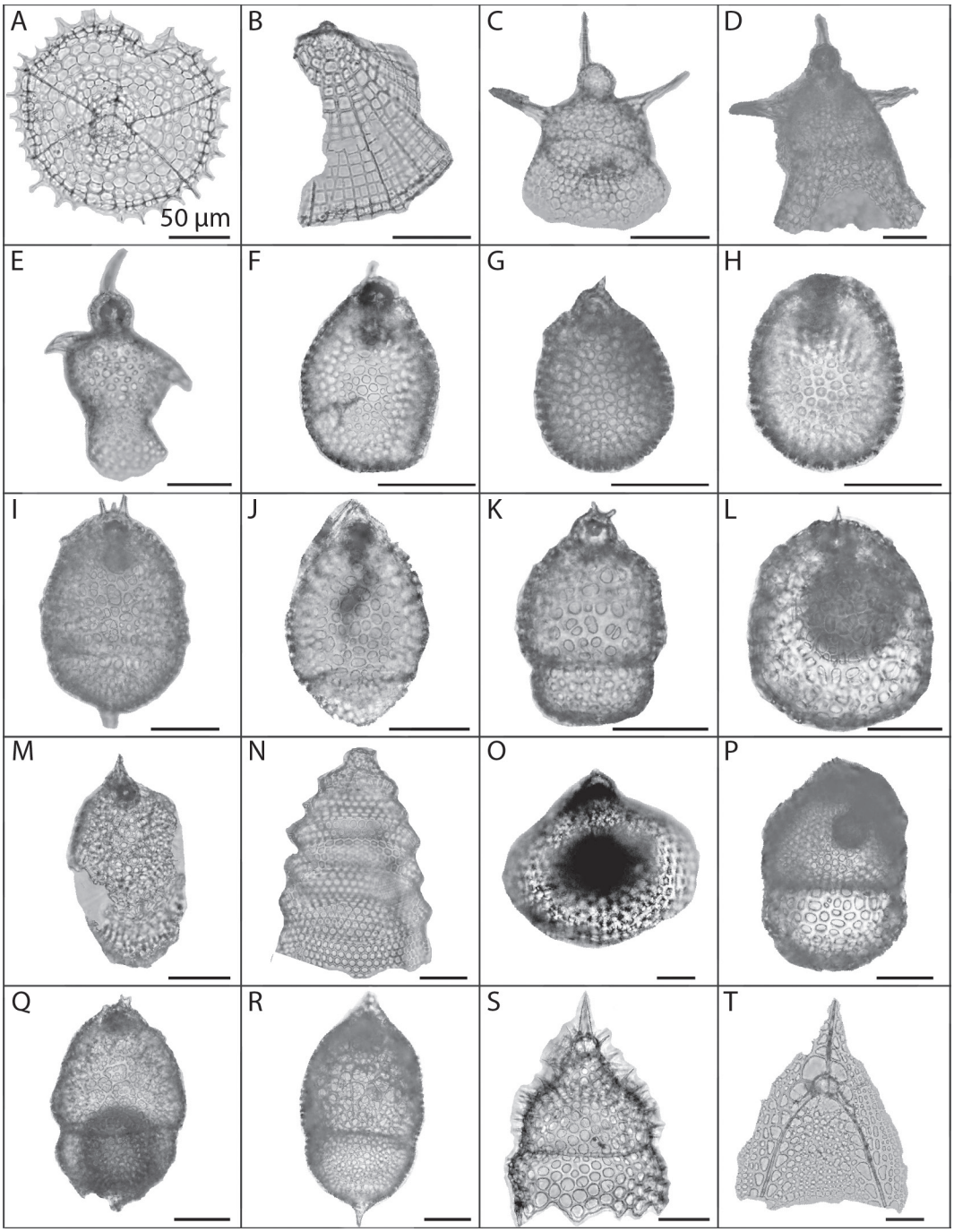
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Figure 12

Family Theoperidae Haeckel, 1881, emend. Riedel, 1967a in Banner et al., 1967
**A–B.** *Pterocanium grandiporus* (Haeckel), **A.** U1414A 2H 5W 17–22 (Pleistocene), **B.** U1414A 3H 5W 24–26 (Pleistocene)
**C–D.** *Pterocanium praetextum* (Ehrenberg), **C.** U1414A 1H 1W 2–4 (Pleistocene), **D.** U1414A 1H 1W 24–26 (Pleistocene)
**E–H.** *Pterocanium trilobum* (Haeckel), **E.** U1414A 4H 6W 24–26 (Pleistocene), **F.** U1414A 10H 2W 24–26 (Pleistocene), **G.** U1414A 26X 7W 16–18 (late Miocene), **H.** U1414A 2H 5W 17–22 (Pleistocene)
**I–J.** *Stichocorys armata* (Haeckel), **I.** U1381C 7H 1W 119–121 (middle Miocene), **J.** U1381C 7H 1W 119–121 (middle Miocene)
**K–L.** *Stichocorys delmontensis* (Campbell and Clark), **K.** U1381C 7H 1W 137–139 (middle Miocene) , **L.** U1381C 7H 3W 28–30 (middle Miocene)
**M.** *Stichocorys peregrina* (Riedel) U1414A 31X 1W 24–26 (late Miocene)
**N.** *Stichocorys* sp. U1414A 30X 5W 22–24 (late Miocene)
**O–P.** *Stichopilium bicorne* Haeckel, **O.** U1414A 3H 1W 24–26 (Pleistocene), **P.** U1414A 3H 1W 24–26 (Pleistocene)
**Q–S.** *Theocorys* (?) spp. **Q.** U1381C 7H 6W 1–3 (middle Miocene), **R.** U1381C 7H 2W 1–3 (middle Miocene), **S.** U1381C 7H 1W 37–39 (middle Miocene).
**T.** *Theocorys veneris* (Haeckel) U1414A 1H 2W 24–26 (Pleistocene)

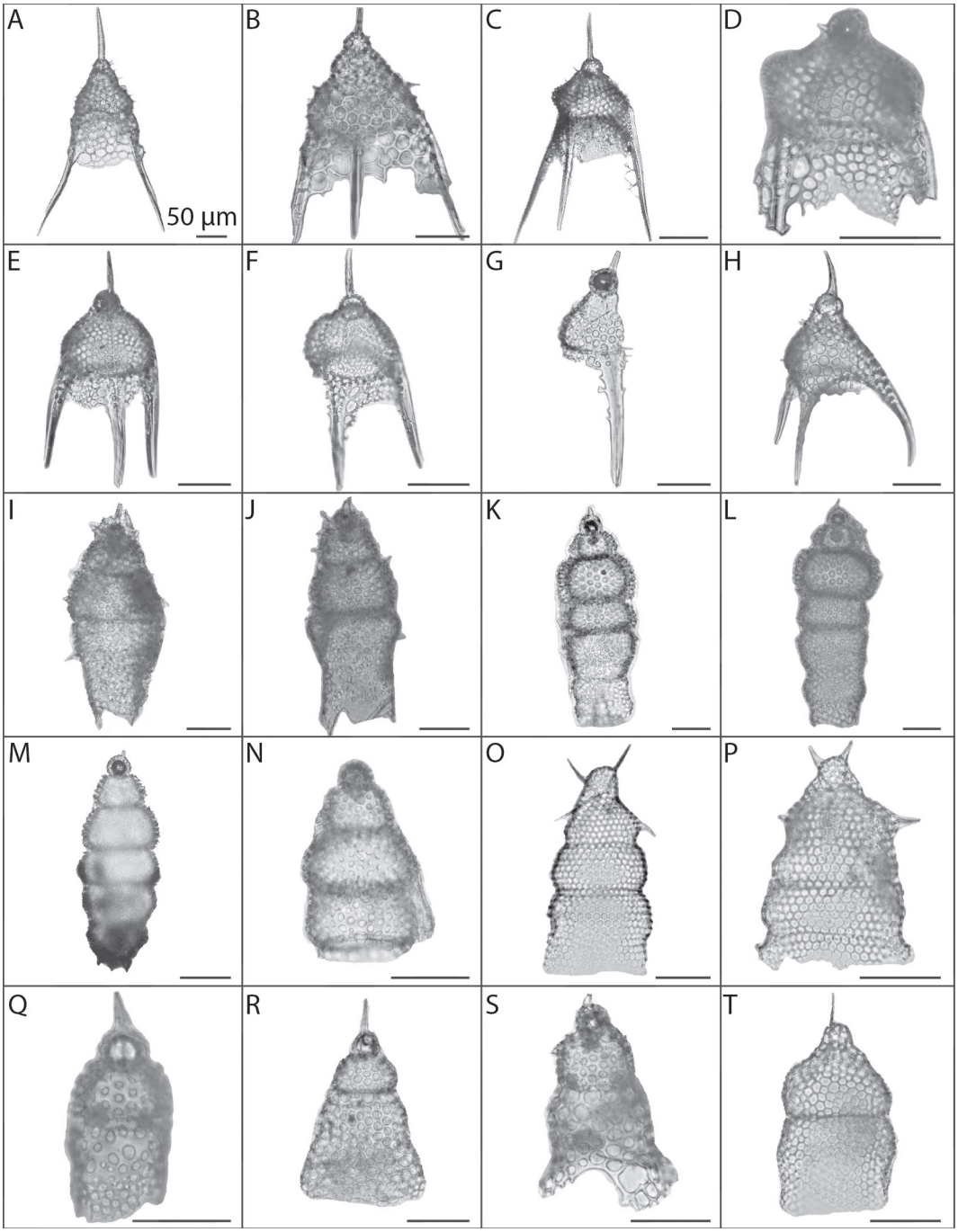
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Figure 13

Family Theoperidae Haeckel, 1881, emend. Riedel, 1967a in Banner et al., 1967
**A–B.** *Carpocanarium papillosum* Ehrenberg, **A.** U1414A 27X 4W 24–26 (late Miocene), **B.** U1414A 28X 7W 24–26 (late Miocene)
**C–D.** *Carpocanarium* aff. *papillosum*, **C.** U1414A 29X 3W 24–26 (late Miocene), **D.** U1414A 30X 8W 24–26 (late Miocene)

Family Carpocaniidae Haeckel, 1881, emend. Riedel, 1967a in Banner et al., 1967
**E–F.** *Carpocanistrum acutidentatum* Takahashi, **E.** U1414A 2H 5W 17–22 (Pleistocene), **F.** U1414A 4H 6W 24–26 (Pleistocene)
**G–I.** *Carpocanistrum* spp. **G.** U1414A 3H 1W 24–26 (Pleistocene), **H.** U1414A 4H 6W 24–26 (Pleistocene), **I.** U1414A 10H 2W 24–26 (Pleistocene)
**J–K.** *Carpocanopsis cristata* (Carnevale), **J.** U1414A 31X 1W 24–26 (late Miocene), **K.** U1381C 7H 4W 52–56 (middle Miocene)

Family Cannobotryidae Haeckel, 1881
**L–N.** *Botryocyrtis scutum* (Harting), **L.** U1414A 2H 5W 17–22 (Pleistocene), **13M.** U1414A 3H 5W 24–26 (Pleistocene), **N.** U1414A 30X 8W 24–26 (late Miocene)
**O.** *Botryocyrtis* sp. U1381C 5H 1W 27–31 (middle Miocene)
**P–Q.** *Botryopyle dictyocephalus* Haeckel U1381C 7H 2W 1–3 (middle Miocene)
**R–S.** *Botryopyle* sp. **R.** U1381C 7H 1W 119–121 (middle Miocene), **S.** U1381C 7H 3W 4–6 (middle Miocene)
**T.** *Centrobotrys thermophila* (Petrushevskaya) U1381C 7H 1W 37–39 (middle Miocene)

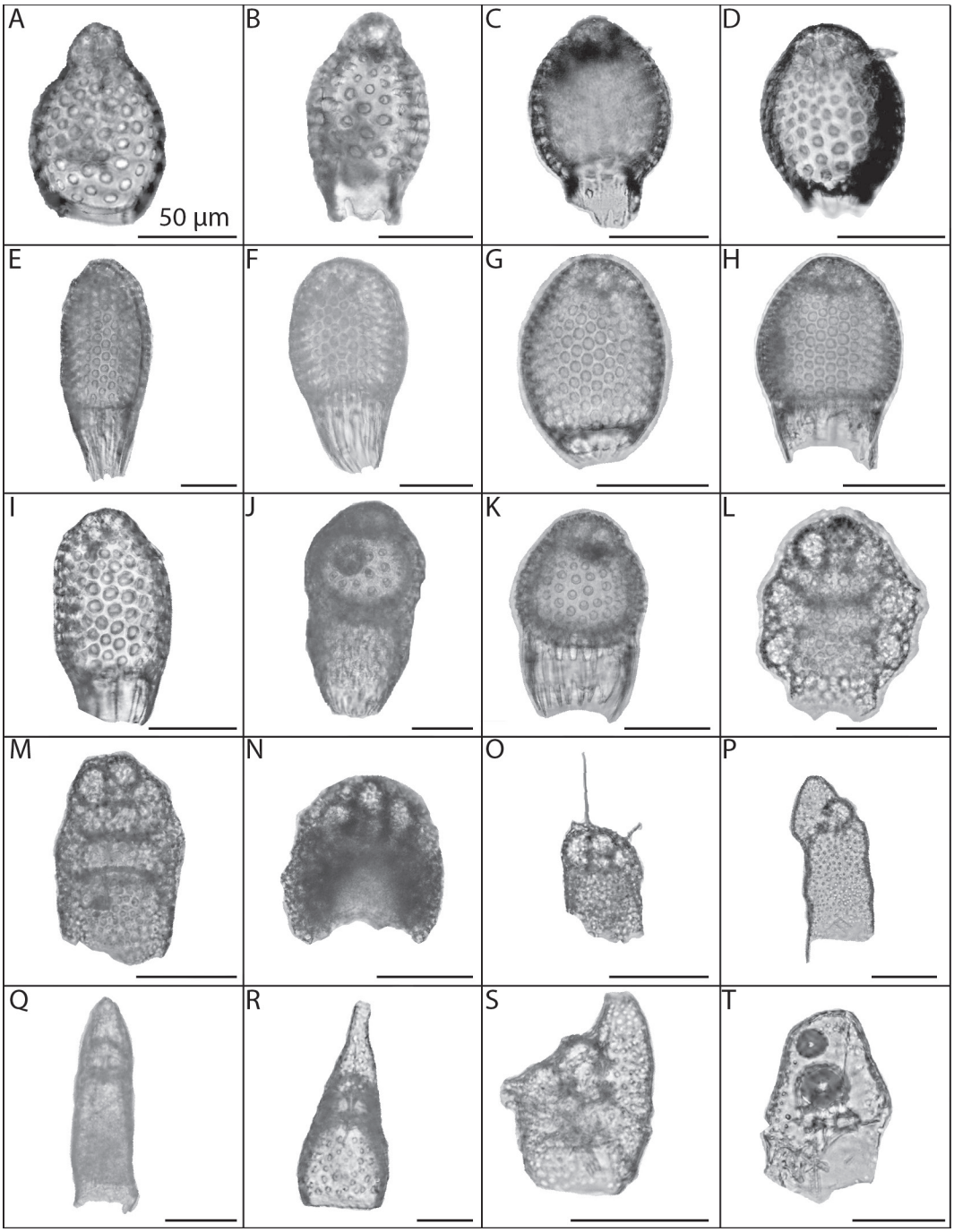
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Figure 14

Family Artostrobiidae Riedel, 1967a in Banner et al., 1967 and Riedel, 1967b
**A.** *Artostrobus annulatus* (Bailey) U1414A 30X 5W 22–24 (late Miocene)
**B–C**. *Botryostrobus aquilonaris* (Bailey), **B.** U1414A 1H 1W 24–26 (Pleistocene), **C.** U1414A 3H 5W 24–26 (Pleistocene)
**D–E.** *Botryostrobus auritus* (Ehrenberg), **D.** U1414A 1H 2W 24–26 (Pleistocene), **E.** U1414A 4H 6W 24–26 (Pleistocene)
**F.** *Botryostrobus bramlettei* (Campbell and Clark) U1414A 30X 5W 22–24 (late Miocene)
**G–H.** *Phormostichoartus corbula* (Harting) U1414A 8H 1W 24–26 (Pleistocene)
**I.** *Phormostichoartus doliolum* (Riedel) U1414A 26 X 7W 16–18 (late Miocene)
**J.** *Phosmostichoartus marylandicus* (Martin) U1381C 7H 6W 60–62 (middle Miocene)
**K–L.** *Siphocampe* sp.A, **K.** U1414A 26X 7W 16–18 (late Miocene), **L.** U1381C 6H 7W 21–23 (middle Miocene).
**M.** *Siphocampe arachnea* (Ehrenberg) U1414A 30X 5W 22–24 (late Miocene)
**N.** *Siphocampe lineata* (Ehrenberg) U1381C 7H 6W 23–25 (middle Miocene)
**O–P.** *Siphostichoartus corona* (Haeckel), **O.** U1414A 26X 7W 16–18 (late Miocene), **P.** U1414A 30X 5W 22–24 (late Miocene)
**Q.** *Spirocyrtis gyroscalaris* Nigrini U1414A 28X 7W 24–26 (late Miocene)
**R–S.** *Spirocyrtis scalaris* Haeckel, **R.** U1414A 1H 2W 24–26 (Pleistocene), **S.** U1414A 1H 1W 2–4 (Pleistocene)
**T.** *Spirocyrtis subtilis* Petrushevskaya U1381C 7H 6W 23–25 (middle Miocene)

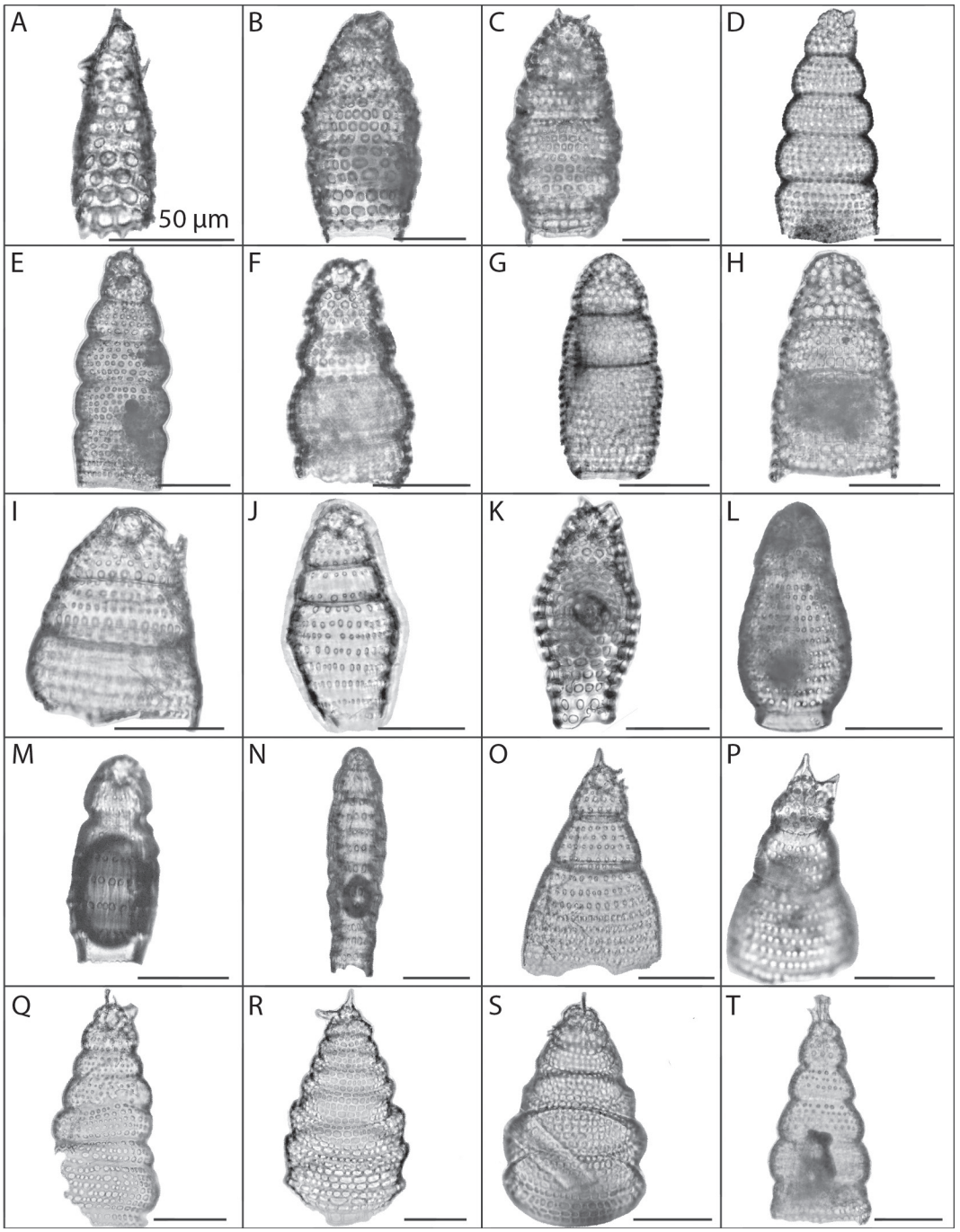
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Figure 15

Family Pterocorythidae Haeckel, 1881, emend. Riedel, 1967a in Banner et al., 1967, emend. Moore, 1972
**A–B.** *Anthocyrtidium ehrenbergi* (Stöhr), **A.** U1381C 7H 5W 126–128 (middle Miocene), **B.** U1381C 7H 1W 37–39 (middle Miocene)
**C–D.** *Anthocyrtidium ophirense* (Ehrenberg), **C.** U1414A 3H 5W 24–26 (Pleistocene), **D.** U1414A 4H 6W 24–26 (Pleistocene)
**E–F.** *Anthocyrtidium* spp. **E.** U1414A 4H 6W 24–26 (Pleistocene), **F.** U1381C 7H 1W 137–139 (middle Miocene)
**G–H.** *Calocycletta caepa* Moore, **G.** U1381C 7H 6W 60–62, **H.** U1381C 7H 6W 106–108 (middle Miocene)
**I.** *Calocycletta virginis* Haeckel U1381C 7H 2W 133–135 (middle Miocene)
**J.** *Lamprocyclas junonis* (Haeckel) U1414A 7H 2W 24–26 (late Miocene)
**K–L.** *Lamprocyclas maritalis* Haeckel, **K.** U1414A 11H 3W 33–35 (Pleistocene), **L.** U1381C 7H 1W 137–139 (middle Miocene)
**M.** *Lamprocyclas* sp. A U1414A 28X 2W 24–26 (late Miocene)
**N.** *Lamprocyrtis nigrinae* Caulet U1414A 3H 5W 24–26 (Pleistocene)
**O–P.** *Lamprocyrtis* sp., **O.** U1414A 1H 1W 2–4, **P.** U1414A 4H 6W 24–26 (Pleistocene)
**Q.** *Pterocorys minythorax* (Nigrini) U1414A 1H 1W 24–26 (Pleistocene)
**R–S.** *Pterocorys zancleus* (Müller), **R.** U1414A 1H 1W 2–4 (Pleistocene), **S.** U1414A 1H 2W 24–26 (Pleistocene)
**T.** *Pterocorys* sp. U1414A 28X 2W 24–26 (late Miocene)