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Octahedronoides tethysianus n.gen., n.sp., enigmatic clusters of microspheres at the Jurassic-Cretaceous transition

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Abstract: In the literature, numerous accounts exist of microspheres scattered in the pelagic environments of the Tethys realm at the Jurassic-Cretaceous transition. These microspheres are commonly associated with genera such as *Cadosina*, *Colomisphaera*, or *Stomiosphaera*, and attributed to calcareous dinocysts. On the other hand, there are few records of the microsphere, initially described as *Cadosina minuta* BORZA, 1980, which are arranged in small clusters, likely comprising six cells. This distinctive grouping and its architecture preclude attribution to the calcareous dinocysts. A new genus and a new species (as *Octahedronoides tethysianus* n.gen., n.sp.) are introduced to define these clusters of leiospheres, which are here reascribed to the acritarchs.

Keywords:

- calcispheres;
- leiospheres;
- dinocysts;
- acritarchs;
- Berriasian

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Résumé : Octahedronoides tethysianus *n.gen., n.sp., des amas énigmatiques de microsphères à la transition Jurassique-Crétacé.-* Dans la littérature, on trouve de nombreuses références à des microsphères dispersées dans les environnements pélagiques du domaine téthysien à la transition Jurassique-Crétacé. Ces microsphères sont communément associées à des genres tels que *Cadosina*, *Colomisphaera* ou *Stomiosphaera*, et attribuées aux dinocystes calcaires. Toutefois, il est peu fait mention de microsphères, initialement décrites comme *Cadosina minuta* BORZA, 1980, qui sont disposées en petits amas, probablement constitués de six cellules. Ce type distinctif de regroupement et son architecture singulière excluent leur attribution aux dinocystes calcaires. Un nouveau genre (*Octahedronoides* n.gen.) et une nouvelle espèce (*Octahedronoides tethysianus* n.gen., n.sp.) sont introduits pour définir ces agrégats de léiosphères, qui sont ici réattribués aux acritarches.

Mots-clefs :

- calcisphères ;
- léiosphères ;
- dinokystes ;
- acritarches ;
- Berriasien

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1. Introduction

During the revision of the geology of Busot (Alicante, Spain: GRANIER *et al.*, 1995, nearing completion; FERRÉ & GRANIER, 2000), numerous calcispheres were found in thin sections alongside late Berriasian calpionellids. Amongst the smallest microspheres, some identified as *Cadosina minuta* BORZA, 1980, are commonly found in clusters (Pl. 1, figs. A-BI). BORZA (1980) described this species as having an "unilocular spherical shell" 28 to 32 µm in diameter "with a thin micritic wall" (translated from the original German diagnosis: "Gehäuse einkammerig, kugelförmig, Gehausewand dünn, von Mikrit-Kalzit gebildet"). He also noted "that the specimens mostly occur in clusters and only rarely occur individually" (translated from the original German description: "Es ist auffällig dass die Exemplare zumeist in Gruppen auftreten und nur selten einzeln vorkommen"), which is not the case in our thin sections, where one counts more solitary occurrences than combined duos, triplets, and quartets. According to PSZCZÓŁKOWSKI and MYCZYŃSKI (2004), the "Status of *Cadosina minuta* BORZA is not clear, as these microfossils differ from the typical representatives of the genus *Cadosina* (WANNER, 1940), by their thin and indistinct test wall in many specimens and common occurrence in groups composed of 2-6 specimens". The author fully supports this last opinion because most of these grouped arrangements cannot be accidental. In any case, there are compelling reasons to investigate these so-called cadosinas, supposedly representing calcareous dinoflagellate cysts.

2. Material and methods

All photomicrographs were taken using a digital MU900 AmScope camera mounted on a Leitz Diaplan microscope. The material analyzed below comes from the author's collection, which is now fully registered in the collections of the 'Muséum d'Histoire naturelle de Genève' (Switzerland). There his thin sections are ascribed the following registration numbers: MHNG-GEPI-2024-10032: Busot (East) 1994 no. 2, MHNG-GEPI-2024-10060: Busot (Calvario) 1993 no. D (BR2660), MHNG-GEPI-2024-10065: Busot (Calvario) 2010 no. 4H (BR2759)*, MHNG-GEPI-2024-10069: Busot (Calvario) 2010 no. 8 (BR2763), and MHNG-GEPI-2024-1007069: Busot (Calvario) 2010 no. 9 (BR2764).

3. The original description of *Cadosina minuta* BORZA, 1980: Areas of ambiguity and new geometrical interpretation

WANNER (1940) regarded *Cadosina*, his new genus, with *Cadosina fusca* his new species, as an unilocular foraminifer. He describes them as "single-chambered foraminifera with spherical or ovoid shell of porcelain-like structure. Shell provided with a true aperture. Calcareous substance of the shell appears opaque, milky white under ordinary transmitted light, and in cross-polarized light without axial cross" (translated from the original German "Diagnose": "Einkammerige Foraminiferen mit kugeligem oder ovoidem Gehäuse von porzellanartiger Struktur. Gehäuse mit einer echten Mündung versehen. Die Kalksubstanz des Gehäuses im gewöhnlichen auffallenden Lichte opak, milchweiß, im durchfallenden polarisierten Lichte bei gekreuzten Nicols ohne Achsenkreuz"). Later most authors will regard all cadosinas as calcareous dinocysts (*e.g.*, REHÁKOVÁ & MICHALIK, 1996; LAKOVA *et al.*, 1999; IVANOVA & KEUPP, 1999; REHÁKOVÁ, 2000a, 2000b).

BORZA (1980) gave the following description of *Cadosina minuta,* his new species: "Unilocular shell, spherical or sometimes slightly oval, formed by microcrystalline calcite. In transmitted light, it is dark, rarely faintly brownish, sometimes difficult to distinguish from the micritic matrix. In reflected light, it is milky white. No opening has been observed. The shell is filled with sparite. It is noticeable that the specimens mostly occur in groups and only rarely occur individually" (translated from the original German "Beschreibung: Gehäuse einkammerig, kugelförmig, manchmal schwach oval, von Mikrit-Kalzit gebildet. In Durchlicht ist sie dunkel, selten schwachbräunlich, manchmal schwer von der mikritischen Grundmasse unterscheidbar. In Auflicht ist sie milchigweiss. Eine Mündung ist nicht beobachtet worden. Die Kammer ist von kristallischen Kalzit ausgefüllt. Es ist auffällig dass die Exemplare zumeist in Gruppen auftreten und nur selten cinzeln vorkommen.").

From the above description, a few points deserve a clarification:

1) According to BORZA (1980), "In transmitted light", the shell "is dark, rarely faintly brownish, sometimes difficult to distinguish from the micritic matrix" (translated from the original German description) with a "2-3 µm thickness of the wall" (translated from the original German "Abmessungen": "Dicke der Wand 2-3 mµ"). Considering the thickness of the petrographic slide on the thin section, which averages around 20 µm, and considering the larger dimension of the spheres, which never exceeds 30 µm, the microsphere outlines are blurred. Consequently, it is not possible to provide a reasonable estimate of the wall thickness. Therefore, it is suggested here that the wall mostly consists of a thin organic lining and that the microcrystals on both sides of it do not necessarily represent a shell. Subsequently, individual spheres should not be considered as cadosinas, *i.e.*, calcispheres, but as leiospheres.

2) Contrary to BORZA (1980), who never observed any opening, a single section out of many studied from Busot material (Pl. 1, fig. A) shows what appears to be an unusual appendix open at its tip in a two-dimensional view. This structure or break in the wall could be related to an excystment phase.

* *Microspheres are particularly abundant in this sample.*

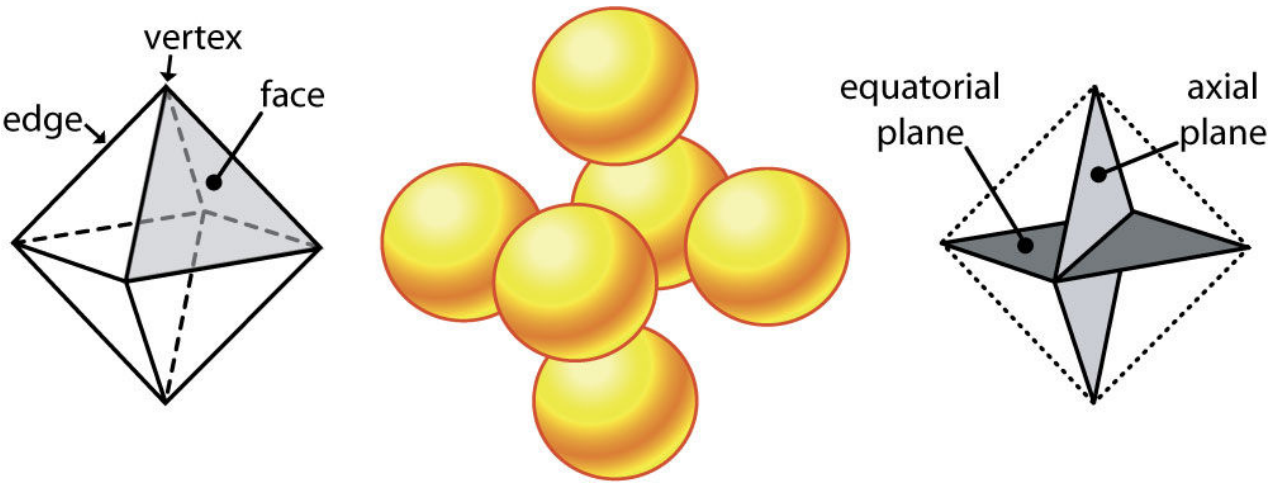

Figure 1: Possible arrangement of the microspheres as an octahedron.

3) As already mentioned by BORZA (1980), "the specimens mostly occur in groups and only rarely occur individually" (translated from the original German description). However, scattered specimens are quite common. PSZCZÓŁKOWSKI and MYCZYŃSKI (2004) also reported the peculiar nature of these "groups composed of 2-6 specimens" of representatives of *Cadosina* (WANNER, 1940). Actually, groups of microspheres appear in decreasing order of abundance as pairs (abundant), triplets (common), and quartets (rare). In contrast, groups with higher number of microspheres appear somewhat disorganized, as if they were composed of distinct clusters. Accordingly, it is suggested here that the most likely geometrical assemblage is 6 microspheres set in an octahedron (Fig. 1). As a matter of fact, this structure, with 12 edges, 8 faces, 2 axial planes and one equatorial plane best corresponds to the counting results of pairs (edges), triplets (faces), and quartets (planes).

4) Just as 'a bicycle wheel or a pair of them is not a bicycle' and vice versa, a structured assemblage made up of several microspheres should not be identified by the name of a single microsphere, *i.e.*, as a *Cadosina* sp. For this reason, a new genus is introduced here to name these peculiar assemblages.

5) The holotype of *Cadosina minuta* BORZA, 1980, does not fit in the definition of the new genus. Therefore, a discrete holotype is selected from the Spanish material, and a new species is introduced here as well.

4. Comparison with other assemblages of microspheres

Clusters of microspheres found in Busot can be compared with:

a) Groups of cysts, *i.e.*, pluricysts, of the Dasycladales, *e.g.*, *Terquemella*, *Frederica*, etc. (see the review in MAKSOUD *et al.*, 2021), including *Russoella* BARATTOLO, 1983, with its few cystic cavities. It is worth remembering that Dasycladales are marine benthic algae;

b) *Polysphaera camerounensis* LAMBERT & VILLAIN, 1996, an *incertae sedis* tentatively ascribed to the Calcisphaerulidae *sensu* VILLAIN or Thoracosphaeraceae, a family of the Class Dinophyceae. This phytoplanktonic option is more consistent with a pelagic setting at Busot. However, there are very few colonial Dinoflagellates, among which *Gymnodinium catenatum* H.W. GRAHAM, 1943, which forms long-chained colonies rather than small packed clusters. Unlike the aforementioned taxa, the Busot microspheres are not embedded in a common 'shell';

c) Modern green algae of the family Scenedesmaceae OLTMANNS, 1904, consist of colonies, also known as coenobia, where each one acts as a single organism. They exhibit various architectures with a variable number of cells embedded in the same mucilage. For instance, the number of cells is 4 in *Tetrastrum* R. CHODAT, 1895, commonly 4 or 8 in *Scenedesmus* MEYEN, 1829, and 4, 8, 16, 32, or 64 in *Coelastrum* NÄGELI, 1849, and *Hariotina* P.-A. DANGEARD, 1889. These numbers are part of geometric progressions starting from 4 and with common ratio of 2. They do not fit with the clusters of 6 cells characteristic of the Busot microfossils. Finally, very few fossil records of representatives of this family have been documented (*e.g.*, *Scenedesmus* sp. by FLEMING, 1989, in uppermost Cretaceous non-marine sediments).

c) Acritarchs are predominantly known from the Precambrian; there are fewer records from the Paleozoic (*e.g.*, Cambrian in KOVÁŘ *et al.*, 2023, or HARVEY, 2023), the Mesozoic (*e.g.*, Jurassic in SARJEANT, 1976; Cretaceous in HABIB & KNAPP, 1982, or SCHRANK, 2003), or the Cenozoic (*e.g.*, Oligocene in FECHNER, 1996). Palynological preparations from the Middle Cambrian of the Czech Republic (KOVÁŘ *et al.*, 2023) yield five acritarch genera, namely *Adara* (FOMBELLA, 1977), *Cymatiosphaera* WETZEL, 1933, *Eliasum* FOMBELLA, 1977, *Synsphaeridium* EISENACK, 1965, and *Timofeevia* VANGUESTAINE, 1978, which have been found to form monogeneric clusters. Because these clusters consist of a highly variable number of specimens, ranging from two to more than 100 hystrichospheres, they differ markedly in size and

organization. They may appear as "massive, densely packed accumulations", "specimens arranged in 'filament-like' rows", or "clusters of loosely aggregated specimens"; no common pattern of organization was observed. Similarly, palynological preparations from the Lower Cambrian of the Canada have been found to yield "strut-form" (...), "ring-form (*Kahfia*-like)" (...), and "plate-form (including *Tapetisphaerites*-like) colonies" (HARVEY, 2023). However, even though it is the best option in terms of structural convergence, none of these arrangements match with those of the clusters of microspheres observed in Busot thin sections. Today, additional rock samples are required to implement palynological investigative techniques. The Busot microspheres are not concatenated. They are not in direct contact with each other either, but commonly leave a space of approximately half a microsphere diameter. However, there likely existed strong, albeit invisible, links between them. It is presumed that these leiospheres were originally encased in a non-fossilized substance, likely a mucilage, which kept them together during the early stages of fossilization.

5. Systematics

Group: Acritarcha EVITT, 1963

Genus: *Octahedronoides* n.gen.

Etymology: From the supposed architecture of a cluster of six new microspheres.

Type species: *Octahedronoides tethysianus* n. gen., n.sp.

Diagnosis: Loose but orderly arranged (in rhombohedral- or tetragonal-sphenoidal manner) colonies of a few leiospheres, never arranged in filaments, nor in struts, rings, or plates.

Species: *Octahedronoides tethysianus* n.gen., n.sp.

(Pl. 1, figs. C-BI)

Synonymy:

? 1980 *Cadosina minuta* n.sp., BORZA, p. 263-264, Pl. (Taf.) I, figs. 1-4 [holotype: Pl. (Taf.) 1, fig. 1]
1980 *Cadosina minuta* n.sp., BORZA, p. 263-264, Pl. (Taf.) I, figs. 5-12
1992 *Cadosina minuta*, BUCUR, Fig. 2.h
1994 *Cadosina minuta*, VAŠICEK *et al.*, Pl. 8, fig. 4
1999 *Cadosina minuta*, LAKOVA *et al.*, Pl. III, fig. 16
2000a *Cadosina minuta*, REHÁKOVÁ, Pl. II, fig. 15
2000b *Cadosina minuta*, REHÁKOVÁ, Pl. IV, fig. 8
2003 *Cadosina minuta*, PSZCZÓŁKOWSKI, Fig. 13.9-10
2004 "*Cadosina*" *minuta*, PSZCZÓŁKOWSKI & MYCZYŃSKI, p. 152, Fig. 8.8
2007 *Cadosina minuta*, LUKENEDER & REHÁKOVÁ, Fig. 6.F
2011 *Cadosina minuta*, REHÁKOVÁ, Pl. 9, fig. 18
2017 *Cadosina minuta*, IVANOVA & KIETZMANN, Fig. 7.21-24
2020 *Cadosina minuta*, PETROVA, Fig. 5.w-y

Etymology: The new specific epiteth refers to the Tethys Ocean (with the superfluous qualifier *tethysianus*), not to the goddess Tethys (with the qualifier *tethyanus*, see discussion in GRANIER, 2022).

Locality: Busot, Alicante, Spain (GRANIER *et al.*, 1995, nearing completion; FERRÉ & GRANIER, 2000).

Paleoenvironmental setting: The microfacies of the thin sections correspond to bioclastic wackestones, slightly silty (quartz), with a mixture of hemipelagic and reworked shallow-water material. They indicate sedimentation occurring on a paleoslope, *i.e.*, on the transitional zone between the Prebetic platform and the Subbetic basin.

Holotype: The quartet in Plate 1, fig. AG, MHNG-GEPI-2024-10065: Busot (Calvario) 2010 no. 4H (BR2759).

Additional studied material (paratypes): Plate 1, figs. C, H-X, Z-AD, AF, AH-BI, MHNG-GEPI-2024-10065: Busot (Calvario) 2010 no. 4H (BR2759).

Stratigraphic horizon: Calpionellopsis Zone (zone D), upper Berriasian; lower part of the "Minuta zone", upper Berriasian-lower Valanginian.

Diagnosis: Aggregates of at least two spherical to ovoid unilocular microspheres with a diameter rarely exceeding 30 µm, commonly 25 µm. In thin sections, microspheres appear in decreasing order of abundance as pairs (abundant), triplets (common), and quartets (rare). Accordingly, it is suggested here that the most likely geometrical assemblage is 6 microspheres set in an octahedron (Fig. 1), *i.e.*, a structure exhibiting 12 edges, 8 faces, 2 axial planes, and one equatorial plane. The largest dimension of a colony may reach 80 µm.

Stratigraphic range: The species is known from the lower Berriasian Elliptica Subzone of the Calpionella Zone (BORZA, 1980; MICHALÍK *et al.*, 1990; ŘEHÁNEK, 1992) to the lower Valanginian Calpionellites Zone (BORZA, 1980; REHÁKOVÁ, 2000a, 2000b). ŘEHÁNEK (1992) created a 'Minuta zone' based on its total range whereas REHÁKOVÁ (2000a) introduced a 'Minuta acme zone' that should be restricted to the upper part of the lower Valanginian. Considering the observed abundance of this microfossil in sample MHNG-GEPI-2024-10065: Busot (Calvario) 2010 no. 4H (BR2759), dated as late Berriasian by calpionellid biostratigraphy, it is suggested to abandon the acme zone and only refer to the newly renamed 'Tethysianus zone', a total range zone (instead of the former 'Minuta zone').

6. Conclusion

Octahedronoides tethysianus n.gen., n.sp., are planktonic organisms forming small colonies, a feature which excludes their ascription to the calcareous dinocysts, but justifies their transfer to the acritarchs. More rock samples should be collected because palynological techniques of investigation need to be implemented to definitively validate the reascription of these assemblages of organic-walled microspheres.

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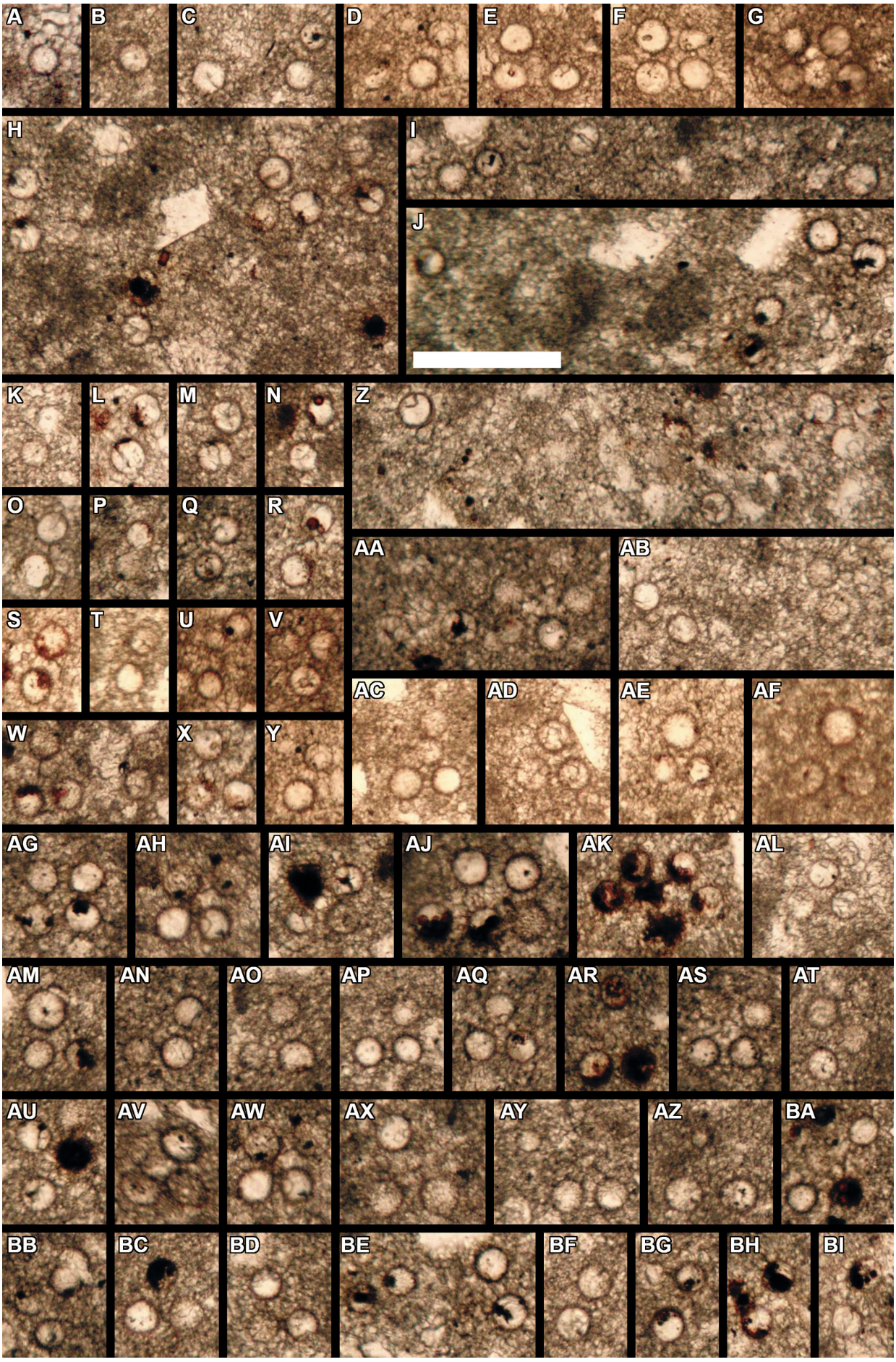
Plate

Plate 1: ? *Cadosina minuta* BORZA, 1980 **(A-B)**, and *Octahedronoides tethysianus* n.gen., n.sp. **(C-BI)**. Most photomicrographs are from thin section MHNG-GEPI-2024-10065: Busot (Calvario) 2010 no. 4H (BR2759), except for: a) figs. D, F, Y from thin section Busot (Calvario) 2010, no. 8; b) fig. E from thin section Busot (East) 1994, no. 2; c) fig. G from thin section Busot (Calvario) 1993, no. D60; and d) fig. AE from thin section Busot (Calvario) 2010, no. 9. Scale bar (on fig. J) = 100 µm.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