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Rectifying a substantial biostratigraphic error: There are no Hauterivian calpionellids in Busot (Alicante, Spain)

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Abstract: Earlier misidentifications of ammonites from Busot (SE Spain) led to two incorrect hypotheses regarding calpionellids, which are today attributed to the *Calpionellopsis* Zone (D) of the upper Berriasian. The first hypothesis suggested that some calpionellid species survived into Hauterivian times, while the second hypothesis proposed that these calpionellids were reworked into Hauterivian strata. However, the revision of the ammonitic material collected in 1993-1994, along with the study of new material collected in 2024, suggests a late Berriasian age, as the ammonite assemblages likely correspond to the *Fauriella boissieri* and *Tirnovella alpillensis* Standard Ammonites zones. Nannofossil assemblages and the presence of *Octahedronoides tethysianus* further support this dating. This reassessment calls for a reexamination of claims regarding the occurrence of calpionellids in strata younger than the Valanginian in the literature.

Keywords:

- biostratigraphy;
- biozones;
- ammonites;
- calpionellids;
- nannofossils;
- Berriasian;
- Hauterivian

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Résumé : ***Correction d'une erreur biostratigraphique majeure : Il n'y a pas de calpionelles hauteriviennes à Busot (Alicante, Espagne).-*** Les identifications antérieures d'ammonites provenant de Busot (sud-est de l'Espagne) étaient erronées ; elles ont conduit à deux hypothèses incorrectes concernant des calpionelles qui sont aujourd'hui attribuées à la Zone à Calpionellopsis (Zone D) du Berriasien supérieur. La première hypothèse suggérait que certaines espèces aient survécu jusqu'à l'Hauterivien, tandis que la seconde proposait que ces calpionelles aient été remaniées dans des strates hauteriviennes. Cependant, la révision des ammonites récoltées en 1993-1994 ainsi que l'étude de nouveaux spécimens récoltés en 2024 suggèrent un âge Berriasien supérieur, car ces associations d'ammonites correspondraient aux zones standards à *Fauriella boissieri* et *Tirnovella alpillensis*. Les associations de nannofossiles et la présence d'*Octahedronoides tethysianus* confirment également cette datation. Cette réévaluation appelle à une remise en question de la plupart des signalements de calpionelles dans des strates postérieures au Valanginien mentionnés dans la littérature.

Mots-clefs :

- biostratigraphie ;
- biozones ;
- ammonites ;
- calpionelles ;
- nannofossiles ;
- Berriasien ;
- Hauterivien

1. Introduction

As with any other component of the Tethys plankton (Granier, 2022), upon the death of the microorganisms, the calpionellid loricae sank from the upper layers of the water column down to the sea floor to contribute to pelagic and hemipelagic sedimentation. The specialists who initially examined the calpionellids from Busot (Alicante, SE Spain) attributed these microfossils to a Berriasian age. Then, upon discovering their association with supposedly Hauterivian ammonites, the same specialists promptly shifted their interpretation in favor of a reworking hypothesis. However, the abundance and relatively good preservation of the delicate calpionellid loricae found in the Busot material pleaded in favor of their post-mortem sinking as a part of the 'marine snow', rather than the downdip resedimentation hypothesis. Therefore, taking into consideration attested earlier records of late Valanginian to early Barremian calpionellids in the literature (see Granier *et al.*, 1995, for bibliographic references), Granier *et al.* (1995) advocated for a third option, suggesting that the stratigraphic ranges of some calpionellid taxa may have been longer than previously thought. However, both the reworking option and the Granier's 1995 hypothesis will be demonstrated as erroneous in this publication because today the original identifications of the Busot ammonites have proved to be wrong. According to one of us (S.R.), these ammonites are of Berriasian age and not Hauterivian, as initially suggested by the late L.G. Bulot and the late R. Busnardo in Granier *et al.* (1995), an opinion still upheld by Bulot (personal communication to the first author dated September 4, 2020). Similarly, the assemblage of calpionellids from Busot will be shown in this publication to be late Berriasian in age.

Figure 1: A) general view of Busot, with the Cabeçó d'Or in the background, and its three hills from left to right: Calvari, Castell, and Casamata; **B)** Calvari section viewed from the southwest; **C)** Casamata section viewed from the east; **D)** photo of the late Robert BUSNARDO during the 2010 campaign; **E)** contact between Berriasian strata (left) and Upper Cretaceous (Senonian) strata (right) along the road to Aigües, near the Casamata section. *Fauriella latecostata* bundle arrowed in B and C.

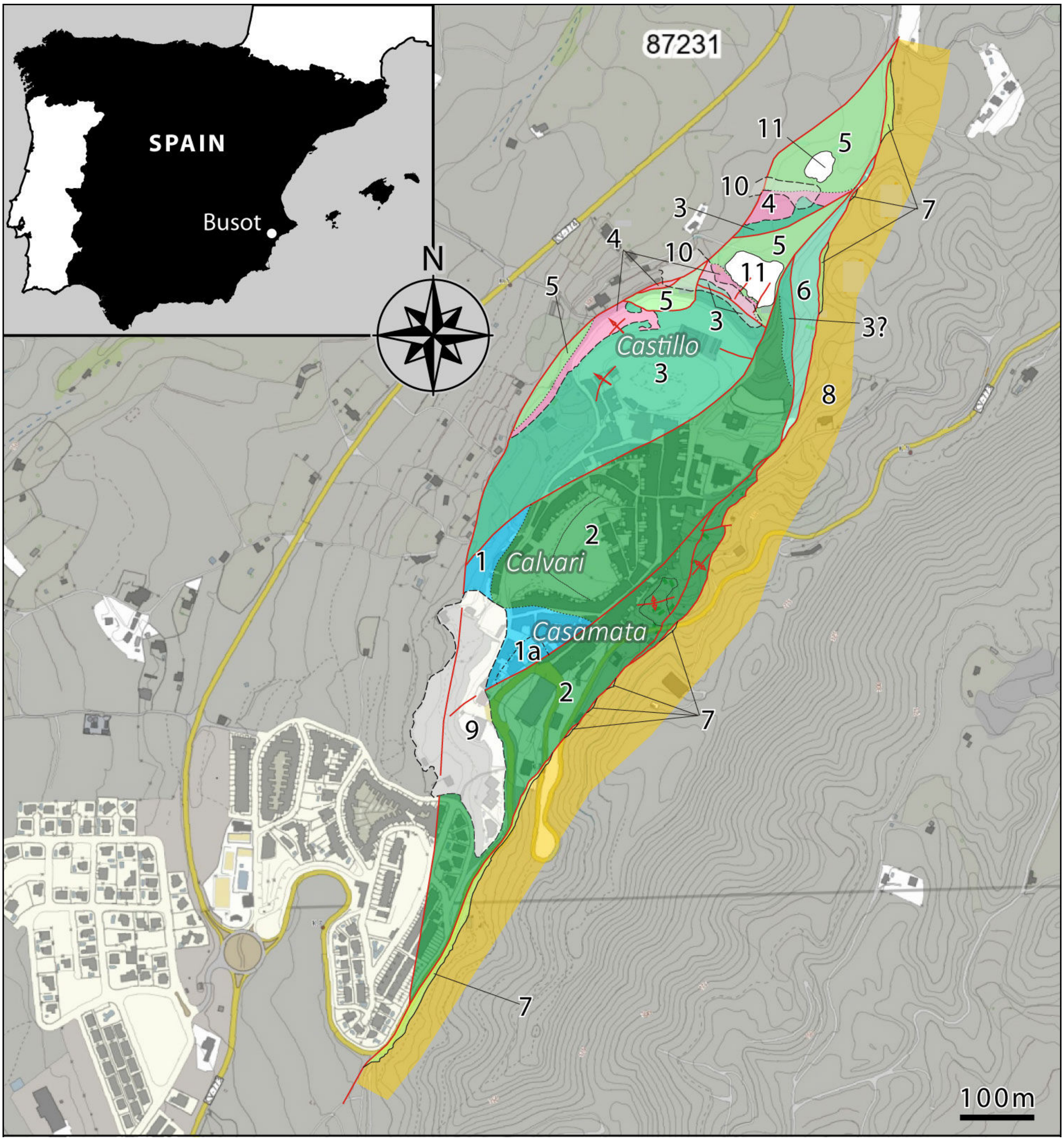

Figure 2: Geological map of Busot. Legend:
1) Massive granular limestones. Uppermost Jurassic (including the Berriasian). 1a: visible outcrop;
2) Alternation of limestones and clayey limestones, locally silty: contains calpionellids. Upper Berriasian;
3) Calcsiltites and calcarenites. Lower Valanginian;
4) Iron-rich oolitic limestones: contains ferruginous ooids and pisoids, and ammonites. Uppermost Hauterivian-Barremian;
5) Clayey limestones and marls: contains ammonites. Uppermost Barremian - lowermost Aptian;
6) Marls with ammonites and *Micraster*. Upper Albian-Lower Cenomanian;
7) Thin-bedded laminated clayey limestones and marls: contains Globotruncanids. Upper Cretaceous (Senonian);
8) Chaotic assemblage of marls with blocks. Eocene-Oligocene;
9) Travertines;
10) Alluvial. Quaternary;
11) Artificial fill.
Line symbols:
Red lines: faults;
Red lines with bidirectional arrows: axes of anticlinal folds;
Red lines with unidirectional arrow: flexures;
Thin black lines: stratification;
Dashed black lines: inferred contact.

2. Geological context

The village of Busot (Fig. 1.A) is sited on a structural anomaly, a small tectonic unit bordered by faults on all sides (Figs. 1.E, 2). This spot offers a unique exposure of uppermost Jurassic to lowermost Cretaceous strata contrasting with surrounding strata that range from the Middle Cretaceous to the Eocene. From a paleogeographic viewpoint, it was located on a slope in the transition zone from **1)** the 'Jurassic' Prebetic carbonate platform, drowned and later dislocated in Valanginian times, to **2)** the Pre- and Subbetic basinal domain. In earlier publications (GRANIER, 1987; GRANIER & PERTHUISOT, 2009), the sedimentary contrasts in both thicknesses and facies between **a)** the thin, condensed, or missing upper Valanginian to lower Barremian strata not only on the crests and slopes of paleotopographic highs [*i.e.*, in Serra Gelada, Puig Campana, Cabeçó d'Or (GRANIER, 1987)], and **b)** the slightly thicker, but still condensed coeval strata in nearby starved basinal areas [*e.g.*, Serra de Fontcalent (RASPLUS & FOURCADE, 1987)], were interpreted as resulting from the Neocimmerian distention (GRANIER, 1987; GRANIER & PERTHUISOT, 2009: Figs. 2-5) that affected both the Prebetic and Subbetic domains.

In the geological map of Alicante at scale 1:50,000 (LERET VERDÚ & LENDÍNEZ GONZÁLEZ, 1978), the small tectonic unit comprising three hills: Calvari (Figs. 1.A-B, 2), Casamata (Figs. 1.A, 1.C, 2), and Castell (Figs. 1.A, 2), with the latter located at the northern edge of the village, is labeled as C_{11-14}, *i.e.*, "Neocomiense-Barremiense". Strata in the Castell hill dip northwestward, whereas strata in the Calvari and Casamata hills form anticlines, and the detailed geological map presented here clarifies the situation (Fig. 2). Considering our knowledge of the local stratigraphic succession with, from base to top: **1)** a thick calcarenitic unit corresponding to the lower Valanginian (forming the core of the Castell hill), **2)** a condensed section spanning the upper Valanginian to Barremian and made of limestones, locally consisting of Barremian ammonite-rich ferruginous oolites, and **3)** Aptian ammonite marls, it was first assumed that the Calvari section (Fig. 3) could expose strata older than those of the Castell hill, *i.e.*, older than the Valanginian. However, the find of two supposedly Hauterivian ammonites, later identified by L.G. BULOT and R. BUSNARDO as "*Lyticoceras* gr. *nodosoplicatum* (KILIAN et REBOUL)" [UCBL-FSL 88816] (GRANIER *et al.*, 1995: Fig. 4.5) and "*Pseudothurmania grandis* BUSNARDO" [UCBL-FSL 88817] (GRANIER *et al.*, 1995: Fig. 4.7), altered our perspective regarding the calpionellid stratigraphic distribution, among other related issues.

3. History of previous geological work

On July 25, 1993, a section (Fig. 3, referred to as Busot II section in GRANIER *et al.*, 1995) on a small hill in the village center, the Mont del Calvari (Figs. 1.A-B, 2), was measured by two junior geologists (É.B. and A.V.), working under the supervision of the first author (B.R.C.G.).

Two small hills on the eastern side of the village (and on the western side of the road to Aigües / Aguas de Busot) exhibit some similarities with the Calvari outcrop. The more southern of these two hills is called Casamata. We measured section on Casamata hill (Figs. 1.A, 1.C, 2, 4). There, additional ammonites were collected including a "*Ps.* n. sp." *fide* BUSNARDO [UCBL-FSL 88814], the specimen of which is unfortunately missing in the GRANIER Collection.

On June 28, 1994, the same Casamata section (Fig. 4, referred to as Busot III section in GRANIER *et al.*, 1995) was measured by one of the two junior geologists (A.V.) under the supervision of the first author (B.R.C.G.). Thin sections were prepared exclusively from this section. The discovery of abundant and well-preserved calpionellids in association with supposedly late Hauterivian ammonites suggested that these calpionellids survived the Valanginian, leading to the publication of a preliminary paper the following year (GRANIER *et al.*, 1995). A subsequent paper (FERRÉ & GRANIER, 2000) included the description of a new *Roveacrinus* species (Pl. 13, fig. 1) from the Calvari section (Fig. 3, referred to as Busot II section in GRANIER *et al.*, 1995), which was then assigned an early Hauterivian age. The scale bars of the logs represent 5 m, not 10 m as erroneously indicated in both papers.

On September 24, 2010, two of us (B.R.C.G. and A.E.R.), along with the late R. BUSNARDO (Fig. 1.D) and the late B. CLAVEL, visited the eastern outcrops, including the Casamata section (Fig. 4, referred to as the Busot III section in GRANIER *et al.*, 1995), and the Calvari section (Fig. 3, referred to as the Busot II section in GRANIER *et al.*, 1995). New rock samples were collected, and thin sections were later prepared. However, no new ammonite findings were made. Additionally, outcrops located along 'Calleja Almazara' (38°28'56.3"N, 0°25'09.9"W) and at a bend of 'Carrer Sant Josep' (38°28'54.7"N, 0°25'10.8"W, with a dip of N15°E, 25°W), both in the southern part of the village (refer to the detailed map), were also sampled. These outcrops are composed of 'Jurassic' limestone (undifferentiated Tithonian-lower Berriasian).

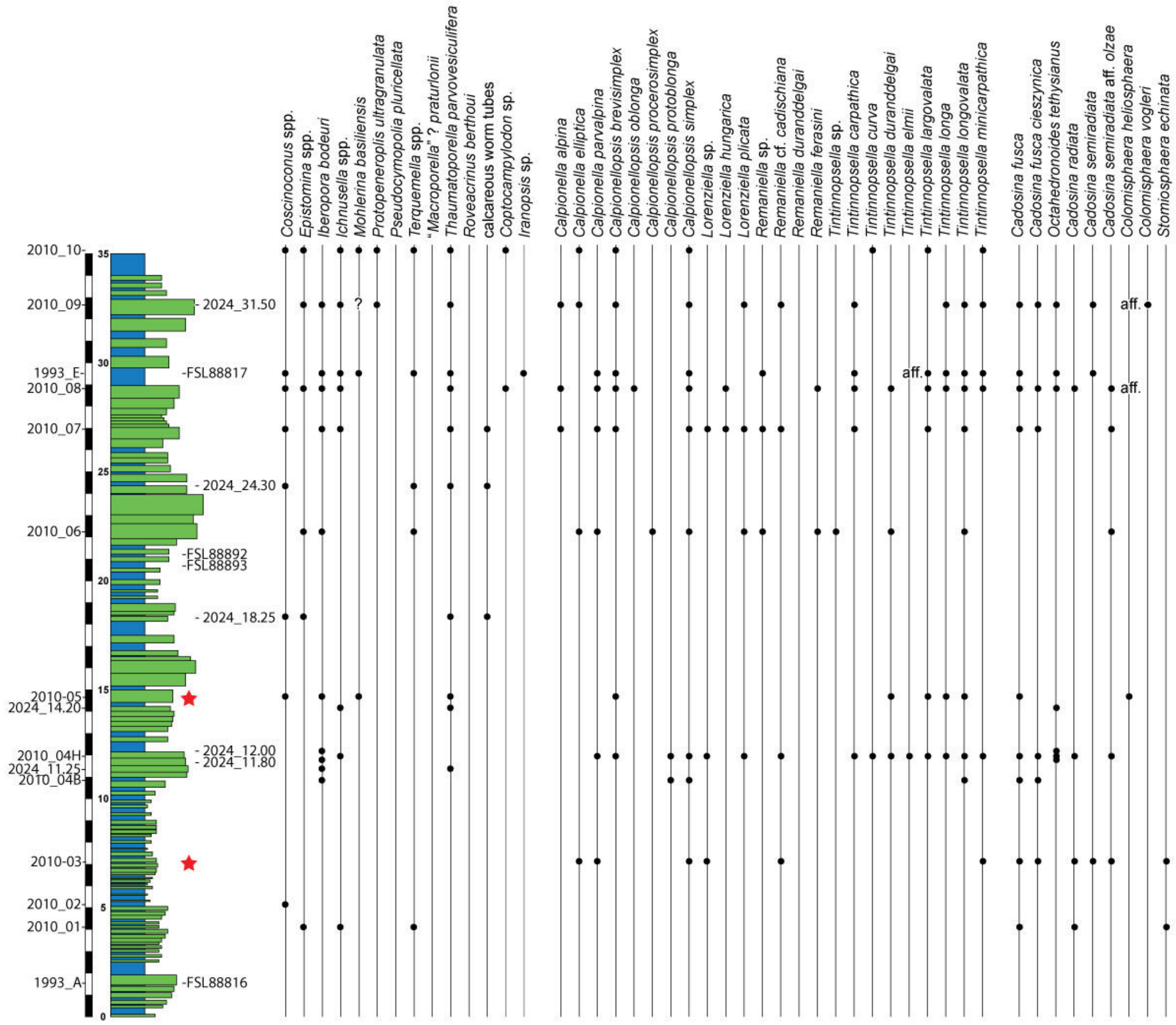

Figure 3: Mont del Calvari section referred to as Busot II section in Granier *et al.*, 1995. Red stars: nannofossil analyses.

Following the 11th International Symposium on the Cretaceous System (August 22-26, 2022), Roque Aguado Merlo and one of us (B.C.L.) were invited to examine the nannofossil contents of Busot hemipelagites. The first (R.A.M.) did not identify any age-diagnostic species and provided an inconclusive report whereas the second (B.C. L.) focusing on *Nannoconus* spp. and some other nannofossils attributed the samples studied to the Berriasian (most likely zones NK-1 and NK-2 of Bralower *et al.*, 1989), definitely excluding an Hauterivian age.

On April 20-22 and 24, 2024, two of us (B.R.C.G. and E.M.) visited the eastern outcrops (Fig. 4, Busot III section in Granier *et al.*, 1995) and the Calvari section (Fig. 3, Busot II section in Granier *et al.*, 1995), as well as the 'Calleja Almazara' and the 'Carrer Sant Josep' outcrops. The sixth author (A.E.R.) accompanied them on April 24, 2024. New rock samples and a few new ammonites were collected from both sections.

Finally, the first author (B.R.C.G.) introduced *Octahedronoides tethysianus* Granier, 2024b, to identify fossil coenobia consisting of clusters of leiospheres (Pl. 9, fig. 26; Pl. 11, figs. 22-25), formerly known as *Cadosina minuta* Borza, 1980, which are very common in the sections studied.

4. Material and methods

Ammonites appear to be rare in the Calvari and Casamata sections. Only a few specimens were collected by three of us (É.B., A.V., and the first author, B.R.C.G.) during the 1993 and 1994 campaigns. These specimens were initially identified by the late L.G. Bulot and the late R. Busnardo (see Granier *et al.*, 1995). However, in the current study, these ammonites were re-studied by one of us (S.R.). The collection has been recently supplemented by five additional specimens, collected by two of us (B.R.C.G. and E.M.) in spring 2024. In the ammonite descriptions below, the year of sampling is indicated in brackets next to the collection number.

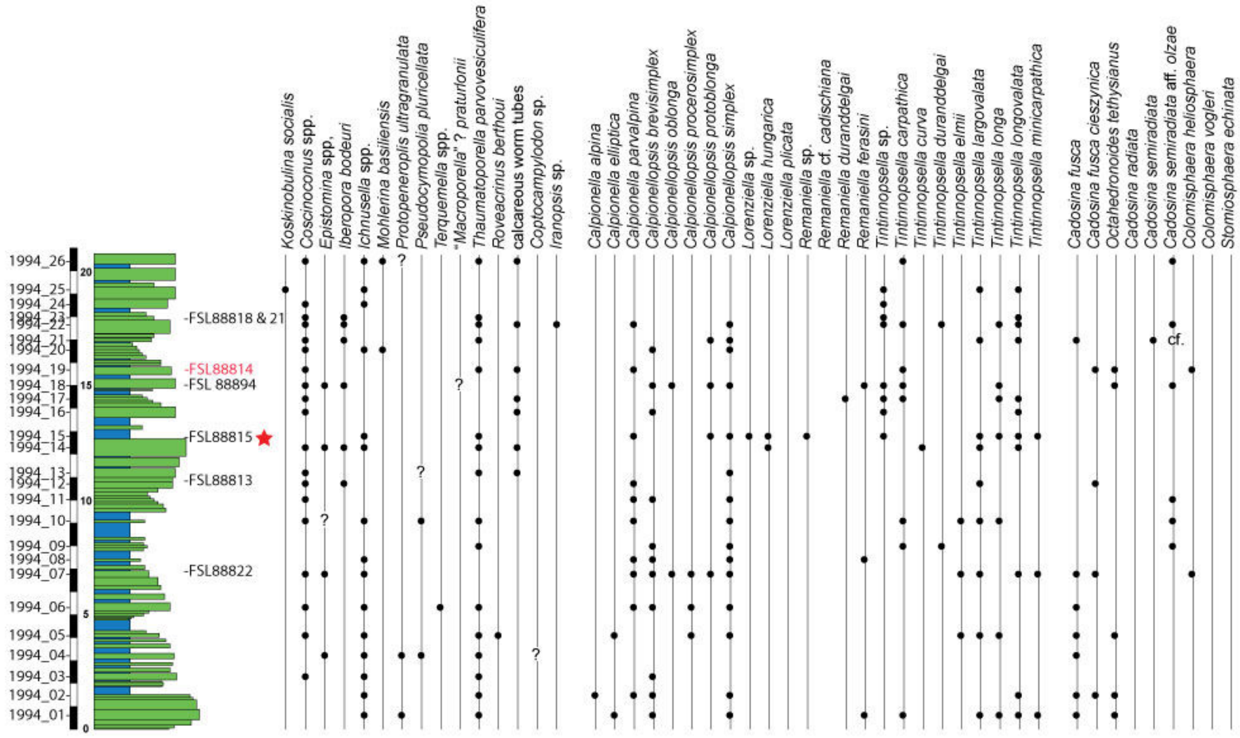

Figure 4: Casamata section, referred to as Busot III section in Granier *et al.*, 1995. Red star: nannofossil analysis.

The standard zonation defined by the ICS (International Commission on Stratigraphy) Kilian Group is applied here (*cf.* Reboulet *et al.*, 2018; Szives *et al.*, 2024; see also Kenjo *et al.*, 2021, for discussion on the zonal scheme on the interval around the Berriasian/Valanginian boundary). Standard zones and subzones are referred to as StZ and StSz, respectively. Zones and subzones used by other authors cited in this work are written in quotation marks as they appear in their original works, to avoid confusion between previous zonations and the Standard Zonation. Except for three specimens that retain the body chamber and a substantial portion of the phragmocone, most of the ammonites collected are relatively poorly preserved, exhibiting fragmentation and the loss of inner whorls. Some of these specimens were identified only at the family level. Specimens that are doubtfully identified at the generic or specific level are marked with a question mark. For certain individuals, measurements were taken at the maximum preserved shell size and indicated as follows: D = diameter of the shell; U = width of the umbilicus; H = height of the whorl; W = width of the whorl (the ammonites are not crushed). The ratios of U/D and H/D are also provided.

Due to the nature of the preservation, observing the suture lines is difficult. Shell dissolution is common, and the ammonites are preserved as internal calcareous molds. The studied and illustrated material is housed and cataloged as "Collection Granier" with the label UCBL-FSL, which stands for "Université Claude Bernard Lyon 1 - Faculté des Sciences de Lyon" (France).

The ammonite findings referenced in the text are associated with UCBL-FSL numbers, corresponding to specimens housed in the 'Collections de l'Université Claude Bernard Lyon 1'. Part of this material was initially pre-registered by R. Busnardo as UCBL-FSL 88813-88822. However, Busnardo retained the specimens at his home, and following his passing on March 24, 2018, it appears that specimen UCBL-FSL 88814 has likely been lost. In addition to the original collection, five new ammonite specimens were gathered in 2024, with four now registered under UCBL-FSL numbers 88892 to 88895.

The total set of petrographic thin sections studied consists of 47 thin sections, including 2 prepared from the matrix of ammonites collected in 1993, 26 from material collected in 1994, 11 from material collected in 2010, and 8 from material collected in 2024 (see Appendix). All these thin sections are now registered in the collections of the 'Musée d'Histoire naturelle de Genève' under the numbers MHNG-GEPI-2024-10031 to 10057 and MHNG-GEPI-2024-10060 to 10079. A few more thin sections, belonging to the collection of the sixth author (A.E.R.), Universidad de Alicante, are also used in this study: no. 6521-CALV-1 (Pl. 11, fig. 24; Pl. 15, figs. 6, 9), GPS coordinates: 38°28'59.61"N, 0°25'8.98"W; no. 6521-BAR-1 (Pl. 15, figs. 1-5, 8), GPS coordinates: 38° 28'54.7"N, 0°25'11.0"W. These thin sections were used for identification of calpionellids, cadosinids, and other calcareous dinoflagellate cysts, as well as benthic foraminifers and calcareous algae; they were also used for identification of other allochems and the microfacies. Photomicrographs of the petrographic thin sections were taken using a digital MU900 AmScope camera on a Leiz Diaplan microscope. Regarding the calpionellid zonations, although there are some differences among the schemes proposed by REMANE (1970), GRÜN and BLAU (1997), and BENZAGGAGH (2020), all concur on the extent of Zone D, also known as the Calpionellopsis Zone, as well as on its subdivisions.

Calcareous nannofossils were studied using smear slides without any special processing, *i.e.*, a small piece of sediment was crushed in a drop of distilled water, dried, and then sealed with Canada balsam. The analysis of the nannofossils encompasses only three samples (Busot-1994-03 = CLV_3; Busot-1994-05 = CLV_5; Busot-1994-15 = CLV_15). Preservation is moderate, and the concentration is notably low, requiring the preparation of multiple slides to secure a minimum count of 100 specimens. The nannofossil zonation used in this work follows BRALOWER *et al.*, 1989. For further comparison with other existing zonations, refer to the 'Nannofossils' chapter in the 2021 contribution by KENJO *et al.*

5. Biostratigraphic data

5.1. AMMONITES (S.R.)

Three large ammonites are identified as *Fauriella latecostata* (MAZENOT, 1939), and they are briefly described here. Their measurements are given in Table 1. According to LE HÉGARAT (1973: p. 161), a thin section was made from the rock containing the holotype (from Berrias, UCBL-FSL 13398; figured in MAZENOT, 1939: Pl. 17, fig. 1). The analysis allowed this sample to be dated to an interval covering the transition from D2 to D3 of the calpionellid subzones. For LE HÉGARAT (1973: Table 10, p. 148), the range of *F. latecostata* spans the "Callisto" ammonite Subzone, which approximatively corresponds to the current *Tirnovella alpillensis* Standard Subzone (StSz).

The best-preserved specimen is the UCBL-FSL 88892 (2024; Pl. 1), located at 21.15 meters in the Calvari section (Fig. 5, formerly the Busot II section). Compared to the holotype, the ribbing of the phragmocone is thicker and less dense. In the poorly preserved early inner whorls, most of the radial ribs appear to originate as simple ribs from the umbilicus. In the later inner whorls, the ribs are curved, slightly inclined toward the peristome, and fasciculate (in pairs) from small bullate umbilical tubercules. Toward the end of the phragmocone, the ribs and their tubercules progressively become coarser, and intermediate ribs occasionally occur. It seems that all ribs are interrupted on the venter. In these terms, the ornamentation of the phragmocone of the Spanish specimen is closer to that of the Moroccan ammonite figured by WIPPICH (2001: Pl. 14, fig. 1), dated to his "*Fauriella boissieri* Zone", "*Tirnovella alpillensis* Subzone", which likely corresponds to the *Tirnovella alpillensis* Standard Zone (StZ). For the three specimens mentioned above, the ribbing on the body chamber is similar. Umbilical tubercles become stronger and more widely spaced, with generally one rib originating from each tubercle. These main ribs are coarser on the lower part of the flank, with one intermediate rib arising low from the basal part of the flank between each pair of main ribs, sometimes merging with the main rib. All ribs are radial to weakly prosiradiate, rigid to slightly flexuous, and most bifurcate in the upper third part of the flank, continuing across the venter.

The ammonite UCBL-FSL 88813 (1994; Pl. 2), found at 10.90 meters in the median part of the Casamata section (Fig. 5, formerly the Busot III section), was initially identified as *Pseudothurmannia grandis* (within the framework of GRANIER *et al.*, 1995). However, this identification can be excluded, as the ornamentation of the body chamber is similar to that of the specimen UCBL-FSL 88892. Additionally, the ribs only cross the venter on the second part of the body chamber, not from the end part of the phragmocone, as would be expected for *Pseudothurmannia*.

The specimen UCBL-FSL 88815 (1994; Pl. 3), sampled at 12.75 meters in the Casamata section (Fig. 5, formerly the Busot III section), is less well-preserved and has been tentatively identified as *Fauriella latecostata*?. Its ribbing resembles that observed on the previous Spanish specimens, though a few constrictions occur. It was first identified as *Lyticoceras* sp. and later as *Pseudothurmannia pseudomalbosi* (within the framework of GRANIER *et al.*, 1995).

Table 1: Measurements (D, U, H, W in mm) of three *Fauriella latecostata* specimens.

UCBL-FSL	D	U	H	W	U/D	H/D
88892	191	80	62	35	0.42	0.32
88813	217	92	73	48	0.42	0.37
88815	209	86	68	40	0.41	0.33

The ammonite UCBL-FSL 88817 (1993; Pl. 4.A), sampled at 29.35 meters in the Calvari section (Fig. 5, formerly the Busot II section), was originally identified as *Pseudothurmannia* gr. *grandis* (GRANIER *et al.*, 1995; Fig. 4.7). However, the ornamentation does not match that of the genus. This fragment is mostly represented by the body chamber. The ribs appear to be isolated at the umbilicus edge, bifurcating approximatively two-thirds up the whorl height. In the lower half of the flank, the ribs are thicker, and on the last part of the body chamber, they cross the venter. Based on this description, the specimen is tentatively identified as "*Thurmanniceras*" cf. *gratianopolitense* (SAYN, 1907).

The systematics and stratigraphic distribution of this species are thoroughly discussed by KENJO (2014), KENJO *et al.* (2021), and other references therein. In COMPANY and TAVERA (2015), and REBOULET *et al.* (2022), the range of "*Thurmanniceras*" *gratianopolitense* is restricted at the lower part of the "*Thurmanniceras*" *pertransiens* StZ (lower Valanginian). However, according to the discussions by KENJO (2014), KENJO *et al.* (2021), and REBOULET *et al.* (2022), its range could begin in the upper part of the *Tirnovella alpillensis* StZ (see also WIPPICH, 2001, 2003; ETTACHFINI, 2004).

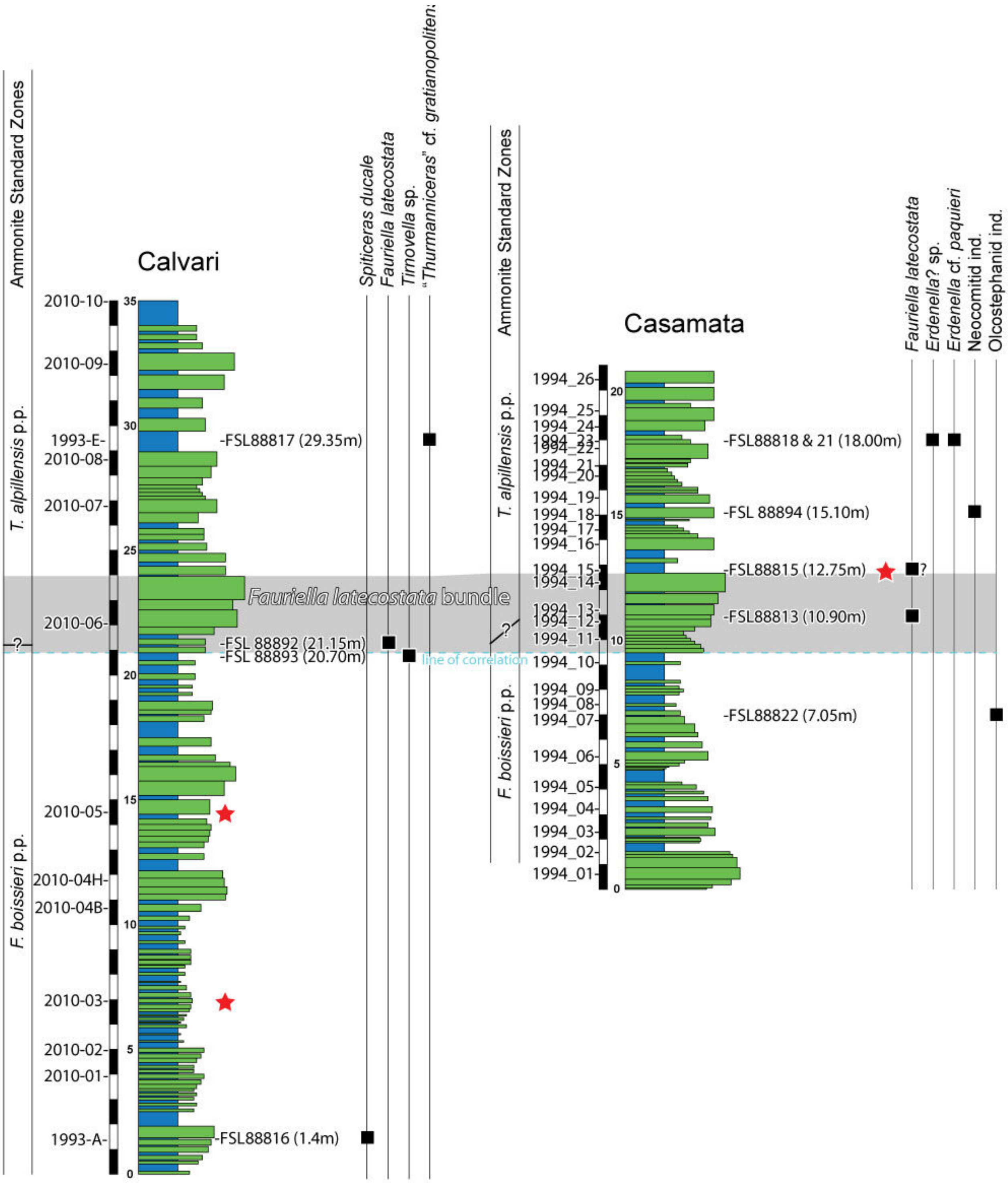

Figure 5: Correlation of Calvari and Casamata sections. Red stars: nannofossil analyses.

The specimen UCBL-FSL 88893 (2024; Pl. 4.B), collected at 20.70 meters in the Calvari section (Fig. 5, formerly the Busot II section), is attributed to the genus *Tirnovella*. The ribs are thin, dense, and nearly straight, slanting towards the peristome. Although the preservation of the umbilicus edge is poor, the ribs appear fasciculate (grouped by twos; as seen on the outer mold cast) from weakly bullate umbilical tubercles. Some ribs bifurcate around mid-flank. The ribs seem interrupted on the venter, which is crushed. Typical representatives of *Tirnovella* show more flexuous ribbing with more frequent bifurcations on the flank.

The specimen UCBL-FSL 88818 (1994; Pl. 5.A), found at 18.00 meters in the Casamata section (Fig. 5, formerly the Busot III section), was initially attributed to *Pseudothurmannia* sp. ind. (within the framework of GRANIER *et al.*, 1995). This fragment, a part of the body chamber, is here identified with uncertainty as *Erdenella* cf. *paquieri* (SIMIONESCU, 1899). The umbilicus appears wide. There are single, thick, relatively straight and widely spaced ribs, with weak umbilical and lateral tubercles. Between these main ribs, weaker ribs occur (without tubercules), but they tend to disappear in the lower part of the flank. The ribs bifurcate in the upper third of the whorl height. On the venter, the ribs are initially interrupted but then eventually seem to cross it. This ornamentation matches the pattern observed at the end of the shell figured by LE HÉGARAT (1973: Pl. 50, fig. 1; specimen from his "Callisto Subzone" of the Ginestous-la-Garenne section, Hérault, France). In his monography, LE HÉGARAT (1973: p. 200-201) noted the significant changes in ribbing observed on the body chamber of large specimens: "In these specimens, which reach a size of 180-220 mm, the rib bundles tend to separate towards the end of the last whorl. Gradually, the ornamentation is composed only of large ribs, bifurcated or not, which emerge individually from the umbilicus. The ribs that were part of the bundles still exhibit umbilical and lateral thickenings" [translated from the French: "Chez ceux-ci, dont la taille atteint 180-220 mm, les faisceaux tendent à se dissocier à la fin du dernier tour; progressivement l'ornementation ne se trouve plus formée que de grosses côtes, bifurquées ou non, qui partent isolément de l'ombilic. Celles qui participaient aux faisceaux portent encore des épaississements ombilicaux et latéraux"]. *E. paquieri* is recorded in the "*Fauriella boissieri* Zone", specifically in the "Picteti" and "Callisto" subzones (LE HÉGARAT, 1973: Table 13, p 191). WIPPICH (2001) and ETTACHFINI (2004) also documented the occurrence of *Erdenella paquieri* in their "*Fauriella boissieri* Zone". Additionally, COMPANY (1987), BULOT (1995), and AGUADO *et al.* (2000) noted its presence in their "Otopeta Zone" (currently the "*Thurmanniceras*" *otopeta* StSz). This observation was later confirmed by KENJO (2014) and KENJO *et al.* (2021), who identified *Erdenella paquieri* in both subzones of the *Tirnovella alpillensis* StZ.

The ammonite UCBL-FSL 88821 (1994; Pl. 5.B), collected at 18.00 meters in the Casamata section (Fig. 5, formerly the Busot III section), was initially identified as *Abrytusites* cf. *neumayri* (within the framework of GRANIER *et al*., 1995). However, it somewhat resembles *Luppovella*, a genus from the lower Valanginian, particularly its species *Luppovella superba* (SAYN, 1907), which is only known from the middle part of the substage (see details in KENJO *et al.*, 2021). Despite some similarities, the comparison with *Luppovella* is weak and unsatisfying. The specimen has a very large umbilicus and a subquadratic section. The ornamentation is strong and rigid, with two ribs arising from the umbilical tubercules. One of these ribs may bifurcate in the upper part of the flank, featuring a large lateral tubercle. Although the ribbing is coarser, this description can be compared to that provided by BULOT (1995, p. 163) for *Fuhriella*, specifically during the "*Erdenella* stage". On the Spanish specimen, only a single rib is visible due to the poor preservation of the venter. It is not possible to determine whether the ribs cross the venter continuously or with interruption. According to BULOT (1995) and BULOT and THIEULOY (1995), representatives of *Fuhriella* are recorded in the lower Valanginian, from the upper part of "*Thurmanniceras*" *pertransiens* StZ to the upper part of *Karakaschiceras inostranzewi* StZ (with further details provided by ETTACHFINI, 2004). WIPPICH (2001) noted the presence of *Fuhriella* sp. in this substage (lower part of "*Thurmanniceras*" *pertransiens* StZ), but also in the Berriasian, in the upper part of his "*Fauriella boissieri* Zone", which corresponds to the *Tirnovella alpillensis* StZ. Unfortunately, the inner whorls on the large specimen figured by this author (WIPPICH, 2001: Pl. 31, figs. 1-2) are not preserved, making it impossible to directly compare it with our small specimen. WIPPICH (2003) places the name of the genus in quotation marks, suggesting uncertainty. Thus, based on this discussion, the ammonite UCBL-FSL 88821 is not attributed to *Fuhriella* (a genus restricted to the middle part of the lower Valanginian; see BULOT, 1995) but is tentatively identified as *Erdenella*? sp. (cf. the '*Erdenella* ornamental stage' mentioned previously).

The specimen UCBL-FSL 88816 (1993; Pl. 6), found at 1.40 meters, near the base of the Calvari section (Fig. 5, formerly the Busot II section), was initially identified as *Lyticoceras* gr. *nodosoplicatum* (GRANIER *et al.*, 1995: Fig. 4.5). However, the ornamentation of the Spanish specimen, which is mainly represented by the body chamber, does not match that of this Hauterivian species. Several features highlight this discrepancy. The umbilicus is very large (Table 2), and the whorl section is ogival-shaped with a rounded venter. The ornamentation consists of relatively thick, radially elongated umbilical tubercles, while the flank is smooth. In the first part of the body chamber, some residual ribs crossing the venter can be faintly observed. This specimen could be identified as *Spiticeras ducale* (MATHERON, 1889). In the body chamber of the specimen figured by DJANÉLIDZÉ (1922: Pl. 17, fig. 1), the strength of the ribs tends to weaken around the mid-flank. A comparison can also be made with a large specimen illustrated by WIPPICH (2001: Pl. 7, fig. 1), collected in the *Tirnovella occitanica* Zone. The ribbing of the last whorl in that specimen is only represented by umbilical tubercles, and the flank appears smooth. WIPPICH (2001) indicated the presence of *Spiticeras ducale* in the lower part of his "*Fauriella boissieri* Zone" (a stratigraphic interval that should correspond to the *Fauriella boissieri* StZ, and with some uncertainty in his "*Tirnovella occitanica* Zone"). According to LE HÉGARAT (1973), the range of *Spiticeras* aff. *ducale* is restricted to his "*Fauriella boissieri* Zone", specifically within the "Picteti" Subzone, which roughly corresponds to the upper part of the *Fauriella boissieri* StZ.

Table 2: Measurements (D, U, H, W in mm) of the *Spiticeras ducale* specimen.

UCBL-FSL	D	U	H	W	U/D	H/D
88816	193	90	55	37	0.47	0.28

For the following specimens, identifications are made at the family level: one Olcostephanid ind. for UCBL-FSL 88822 (1994, from the Casamata section, formerly the Busot III at 7.05 meters: Fig. 5), previously identified as "*Olcostephanus* juv. gr. *astieri*", and two Neocomitids ind. for UCBL-FSL 88894 (2024; from Casamata section, formerly the Busot III at 15.10 meters: Fig. 5) and UCBL-FSL 88895 (2024; from a short section near the Casamata section at GPS coordinates 38°28' 59.6"N, 0°25'00.0"W).

Contrary to the late L.G. Bulot and the late R. Busnardo (in Granier *et al.*, 1995), who suggested a Hauterivian age for the Busot sections (from the *Lyticoceras nodosoplicatum* Zone to the *Pseudothurmannia ohmi* Zone), the revision of the ammonite fauna made by one of us (S.R.) in the present work has allowed us to date the studied interval to the late Berriasian. Due to the presence of *Spiticeras ducale*, the basal (or possibly even lower) part of the Calvari section can be dated to the *Fauriella boissieri* StZ (Fig. 5). Unfortunately, no other ammonites were found in the lower part of the section. However, the upper parts of the Calvari and Casamata sections could be dated to the *Tirnovella alpillensis* StZ, based on the presence of *Fauriella latecostata*. At present, in terms of ammonites, the First Occurrence (FO) of this species could serve to mark the base of the *Tirnovella alpillensis* StZ. The uppermost part of the Calvari section may correspond to the upper part of this zone due to the occurrence of "*Thurmanniceras*" cf. *gratianopolitense*. In the Casamata section, the base of the *Tirnovella alpillensis* StZ can be placed at the base of the bed where the FO of *Fauriella latecostata* is recorded (10.90 m). However, based on correlations with the Calvari section, the basal boundary of this zone (at 10.80 m) could be slightly lowered at Casamata (at 9.50 m), considering that *Fauriella latecostata* is observed in the basal part of the calcareous bundle (referred to here as the *F. latecostata* bundle: Fig. 5).

5.2. Calpionellids (M.B.)

The specific assemblage of calpionellids from Busot, comprising *Calpionellopsis* gr. *simplex/C.* gr. *oblonga*, is characteristic of a narrow time interval. More specifically, it corresponds to the subzones D1-D2, also referred to as the Simplex-Oblonga subzones of the Calpionellopsis Zone (Zone D).

The D1 (Simplex) subzone contains *Calpionellopsis brevisimplex* Nagy, 1986 (Pl. 7, figs. 16-20), *C. simplex* (Colom, 1939) (Pl. 7, figs. 21-26), *C. procerosimplex* Nagy, 1986 (Pl. 7, figs. 27-30), *Calpionella grandalpina* Nagy, 1986 (Pl. 7, figs. 1-5), and *C. elliptica* Cadisch, 1932 (Pl. 7, figs. 11-15). In the Calvari section (Fig. 3), *Calpionellopsis* gr. *simplex* occurs from thin section no. BR2757/no. 3 (2010) at 7.85 meters to BR2765/10 (2010) above 35 meters while, in the Casamata section (Fig. 4), it is found from thin section no. 94.1 (1994) at 0.5 meter to 94.22 (1994) at 17.75 meters. This subzone is also rich in *Cadosina fusca* Wanner, 1940 (Pl. 9, figs. 21-25).

The D2 (Oblonga) subzone contains *Calpionellopsis oblonga* (Cadisch, 1932) (Pl. 8, figs. 1-5) and *Calpionellopsis protoblonga* Nagy, 1986 (Pl. 7, figs. 31-35). This calpionellid assemblage also includes *Remaniella* spp., primarily known from zones C and D. *Remaniella* cf. *cadischiana* (Colom, 1948) (Pl. 8, figs. 21-25) is found in the Calvari section (Fig. 3) from thin section no. BR2757/no. 3 (2010) at 7.85 meters to BR2764/9 (2010) at 33.25 meters; it was not identified in the Casamata section. Other *Remaniella* representatives, *R. ferasini* (Catalano, 1965) (Pl. 8, figs. 13-17) and *R. duranddelgai* Pop, 1996 (Pl. 8, figs. 18-20), along with *Calpionella alpina* Nagy, 1986 (Pl. 7, figs. 1-5), and *C. parvalpina* Nagy, 1986 (Pl. 7, figs. 6-10), are present in the studied sections.

The calpionellid assemblage from Busot also includes *Lorenziella* spp. and *Tintinnopsella* spp., which are present in both D and E zones. *Lorenziella hungarica* Knauer & Nagy, 1964 (Pl. 8, figs. 6-10) is found in the Calvari section (Fig. 3) from thin section no. BR2757/no. 3 (2010) at 7.85 meters to BR2763/8 (2010) at 29.35 meters while, in the Casamata section (Fig. 4), it is only found in two thin sections no. 94.14 (1994) and no. 94.15 (1994) at 12.30 and 12.80 meters, respectively. *L. plicata* Le Hégarat & Remane, 1968 (Pl. 8, figs. 11-12) is observed in various thin sections, including no. BR2759/no. 4H (2010) at 12.70 meters and BR2762/no. 7 (2010) at 26.90 meters. *Tintinnopsella longa* (Colom, 1939) (Pl. 9, figs. 1-5) is found in the Calvari section (Fig. 3) from thin section no. BR2759/no. 4H (2010) at 12.70 meters to BR2764/9 (2010) at 33.25 meters while, in the Casamata section (Fig. 4), it is found from thin section no. 94.1 (1994) at 0.5 meter to 94.22 (1994) at 17.75 meters.

Co-occurrences of *Lorenziella* spp., *Remaniella* spp., and *Tintinnopsella* spp., along with the lack of *Calpionellites* spp., confirm that all the material is characteristic of Zone D.

5.3. Nannofossils (B.C.L.)

Overall preservation is poor, with significant difficulties in properly identifying the various species. For this reason, we have chosen to present most of the calcareous nannofossils observed, including some doubtful specimens.

Nannoconus species are well represented, with *N. steinmanni steinmanii* Kamptner, 1931 (Pl. 10, figs. 10-15; Pl. 12, figs. 7, 24-27), and *N. steinmanni minor* Deres & Achéritéguy, 1980 (Pl. 10, figs. 1-9; Pl. 11, fig. 1; Pl. 12, figs. 1-6, 19-23) being the dominant species. No wide canal species were identified. Additionally, *N. wintereri* Bralower & Thierstein, 1989 (Pl. 10, figs. 28, 30-32; Pl. 12, fig. 32), *N. compressus* Bralower &

THIERSTEIN, 1989 (Pl. 10, figs. 21-23, ? 24; Pl. 11, fig. 2; Pl. 12, ? fig. 11), and *N. infans* BRALOWER, 1989 (Pl. 12, figs. 8-9) were observed, though they are present in minor quantities. These observations are consistent across all nannofossil assemblages.

The set of data suggests an age:

- not older than NK1 of the nannofossil zonation, *Tirnovella occitanica* Ammonite Standard Zone, or *Calpionella elliptica* Subzone (B3) of the calpionellids;
- not younger than NK2A of the nannofossil zonation, *Fauriella boissieri* Ammonite Standard Zone, or *Calpionellopsis simplex* Subzone (D1) of calpionellids.

Among the other nannofossils, stratigraphically significant species observed include *Diazomatolithus lehmanii* NOËL, 1965 (Pl. 11, fig. 17), *Cruciellipsis cuvillieri* (MANIVIT, 1966) THIERSTEIN, 1971 (Pl. 11, fig. 20), and *Haqius circumradiatus* (STOVER, 1966) (Pl. 11, fig. 15). *Polycostella beckmannii* THIERSTEIN, 1971 (Pl. 11, fig. 9; Pl. 12, figs. 14-18), and possibly *P. senaria* THIERSTEIN, 1971 (Pl. 12, ? figs. 35-36) were also identified.

These pieces of evidence suggest an age:

- not older than NK1 of the nannofossil zonation, *Tirnovella occitanica* Ammonite Standard Zone, or *Calpionella elliptica* Subzone (B3) of the calpionellids
- not younger than NK3A of the nannofossil zonation, "*Thurmanniceras*" *pertransiens* Ammonite Standard Zone, or *Calpionellites* Subzone (E) of the calpionellids.

The presence of *Polycostella beckmannii* could indicate a slightly older age, as its last appearances in the literature correspond to the equivalent of *Remaniella cadischiana* Zone (C) of the calpionellids. However, that is insufficient to challenge the calpionellid and ammonite data. *Polycostella beckmannii* is characteristic of the Tithonian/Berriasian boundary, abundant in the Crassicolaria Zone (A), with its frequency decreasing in the Calpionella Zone (B), and becoming extinct in *Remaniella cadischiana* Zone (C). Minor reworking, a common phenomenon in nannofossils due to their small size, cannot be excluded.

Based on the observed nannoflora, there is no evidence supporting a Hauterivian age. A Berriasian age is justifiable and aligns with the revised age given by ammonites and calpionellids.

5.4. MISCELLANEA (B.R.C.G.)

Octahedronoides tethysianus GRANIER, 2024b (Pl. 11, figs. 22-25), are planktonic organisms forming small colonies, ascribed to the acritarchs. Some were previously identified as *Cadosina minuta* BORZA, 1980. They are known from the middle Berriasian Elliptica Subzone of the Calpionella Zone to the lower Valanginian Calpionellites Zone. The 'Tethysianus zone' is based on the total range zone of this species and replaces the formerly 'Minuta zone' of ŘEHÁNEK (1992). These microfossils are commonly found in our thin section material, especially in thin section no. BR2758/no. 4H (2010) of the Calvari section (MHNG-GEPI-2024-10065) at 11.70 m (Fig. 3).

Some organisms living in the Cabeçó d'Or shallow-water areas have been transported off the platform and redeposited into the slope sediments at Busot. They consist of Dasycladales and benthic Foraminifera. Although they are reworked, they may provide some valuable information. For instance, some Dasycladales, such as *Macroporella*? *praturloni* DRAGASTAN, 1978, and *Pseudocymopolia pluricellata* BAKALOVA, 1973 (Pl. 15, fig. 9; Pl. 16, fig. 9), are respectively known from the middle Berriasian - lower Valanginian and upper Berriasian - lower Valanginian intervals (GRANIER, 2019). In addition, some foraminifers, including *Mohlerina basiliensis* (MOHLER, 1938) (Pl. 15, figs. 6-7; Pl. 16, fig. 1) and *Iberopora bodeuri* GRANIER & BERTHOU, 2002 (Pl. 16, fig. 12), are not know in strata younger than the Berriasian (see GRANIER, 2019 and 2024a, respectively).

6. Are Busot calpionellids reworked or not?

Studies with reworked calpionellids are few in the literature; those with illustrations are even fewer, but demonstrative. In such cases, the reworking can easily be detected because it is documented by occurrences of inframillimetric microlithoclasts or millimetric to centimetric pseudointraclasts containing calpionellids:

1) reworking of calpionellids has been reported in the "Cenomanian Flysch" of the province of Varese, northern Italy (REGGIORI, 1958: Pl. II, fig. 3; CITA, 1965: Pl. XLVI, figs. 1-2) in extraclasts whereas the matrix contains planktonic foraminifers;

2) BLAU and GRÜN (1992) have also documented examples from the Aptian and/or Albian of northern Austria. One specimen (BLAU & GRÜN, 1992: Pl. 1, figs. a-c) is clearly part of a microlithoclast. In other specimens (BLAU & GRÜN, 1992: Pl. 1, figs. d-h, m-s), the lorica infills look slightly coarser than the matrix; in such cases, it is suspected that the outer side of the lorica coincides with the microlithoclast border (as it is also the case with the left hand side of the specimen in their Pl. 1, figs. a-c);

3) while studying calciturbidites and associated breccias (debris and mud flows) from the Tithonian-lower Berriasian of SE France, GRANIER *et al.* (2020, 2023a, 2023b) documented pseudointraclasts containing calpionellids (GRANIER *et al.*, 2020: Pl. 3, figs. A-C; 2023a: Figs. 7.A, 7.L, 7.P, 8.C). They also illustrated inframillimetric microlithoclasts, commonly consisting of a single lorica with its micritic 'coating' and infill (GRANIER *et al.*, 2023a: Fig. 7.M), which are the main components of cryptoturbidites (GRANIER *et al.*, 2020: Pl. 2, figs. A-B; Pl. 3, fig. A; 2023a: Figs. 7.M, 8.G; 2023b: Figs. 6.L, 6.P).

Calpionellids are common in the matrices of the Busot limestones. Although the thin loricae of the calpionellids are assumed to be fragile, very few loricae or even their collar structures are broken in the studied material. None appear to be microlithoclasts, and very few are found in pseudointraclasts (Pl. 16, fig. 10). All these observations led GRANIER *et al.* (1995) to state that these microfossils were not reworked, a conclusion that will prove to be correct.

It is worth mentioning that, until 1995 with the publication of the Busot case (GRANIER *et al.*, 1995), some species of this Busot assemblage, *e.g.*, *Calpionellopsis simplex*, have never been reported from strata younger than the Valanginian. However, their association with supposedly Hauterivian ammonites led GRANIER *et al.* (1995) to state the stratigraphic ranges of some calpionellid taxa may have been longer than previously thought, a conclusion that will prove to be wrong.

7. Conclusions

Earlier misidentifications of ammonites have led to two incorrect hypotheses regarding the nature of the calpionellids from Busot:

1. these calpionellids were Hauterivian in age (GRANIER *et al.*, 1995);
2. these Berriasian calpionellids were reworked into Hauterivian strata (GRANIER *et al.*, 2022).

However, some ammonites are identified at the species or genus level, including *Fauriella latecostata*, *Spiticeras ducale*, *Tirnovella* sp., and others tentatively identified as "*Thurmanniceras*" cf. *gratianopolitense*, *Erdenella* cf. *paquieri*, and *Erdenella*? sp. These ammonite assemblages likely correspond to the *Fauriella boissieri* and *Tirnovella alpillensis* Standard Ammonite zones, which date to the late Berriasian.

The calpionellids from Busot belong to the Calpionellopsis Zone (D), which corresponds to the late Berriasian. While the nannofossil assemblages are less precise for dating than the ammonites, they indicate an age older than the NK1 zone and predominantly not younger than NK2A zone and, in any case, not younger than NK3A zone, pointing to a Berriasian age. Similarly, the common occurrence of *Octahedronoides tethysianus* supports the identification of the Tethysianus zone (formerly referred to as the 'Minuta zone' of the Cadosinas), which dates to the late Berriasian-early Valanginian interval.

The revision of part of the original ammonite finds in the 'Collections de l'Université Claude Bernard Lyon 1' (Villeurbanne, France), along with the study of additional ammonitic material collected in 2024, the analysis of the nannofossil assemblage, the reevaluation of the calpionellid assemblage (notably their relatively pristine preservation), and the occurrence of *Octahedronoides tethysianus* GRANIER, 2024b, all indicate that the studied sections at the Busot locality should be assigned to the upper Berriasian, rather than to the Hauterivian as previously stated (GRANIER *et al.*, 1995, 2022).

In conclusion, a third hypothesis is validated here. The late Berriasian calpionellids from Busot are not reworked into Hauterivian strata. Most corresponding species did not survive the decline of the group during Valanginian times. Consequently, every earlier reference in the literature (see GRANIER *et al.*, 1995) of upper Valanginian to lower Barremian occurrences of calpionellids should be reexamined with considerable scrutiny and caution.

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Plates

Plate 1: *Fauriella latecostata* (Mazenot, 1939), UCBL-FSL 88892, 21.15 meters, Calvari section (formerly the Busot II section). Scale bar = 1 cm. Arrow = end of the phagmocone.

Plate 2: *Fauriella latecostata* (MAZENOT, 1939), UCBL-FSL 88813, 10.90 meters, Casamata section (formerly the Busot III section). Scale bar = 1 cm. Arrow = end of the phagmocone.

Plate 3: *Fauriella latecostata*? (Mazenot, 1939), UCBL-FSL 88815, 12.75 meters, Casamata section (formerly the Busot III section). Scale bar = 1 cm. Arrow = end of the phagmocone.

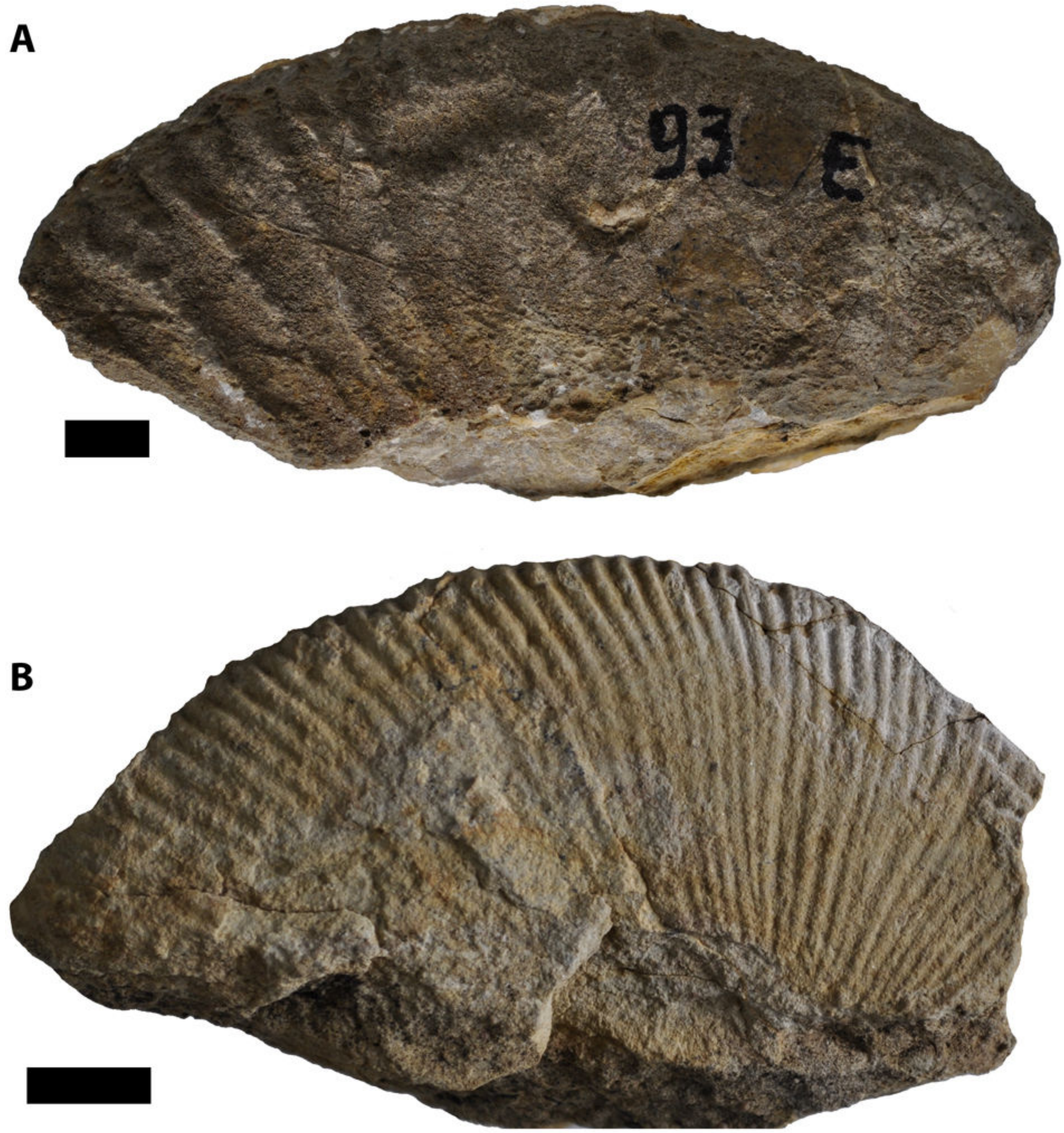

Plate 4: A) "*Thurmanniceras*" cf. *gratianopolitense* (Sayn, 1907), UCBL-FSL 88817, 29.35 meters, Calvari section (formerly the Busot II section); **B)** *Tirnovella* sp., UCBL-FSL 88893, 20.70 meters, Calvari section (formerly the Busot II section). Scale bars = 1 cm.

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B

Plate 5: A) *Erdenella* cf. *paquieri* (SIMIONESCU, 1899), UCBL-FSL 88818, 18.00 meters, Casamata section (formerly the Busot III section); **B)** *Erdenella*? sp., UCBL-FSL 88821, 18.00 meters, Casamata section (formerly the Busot III section). Scale bars = 1 cm.

▶ **Plate 6:** *Spiticeras ducale* (MATHERON, 1889), UCBL-FSL 88816, 1.40 meters, Calvari section (formerly the Busot II section). Scale bar = 1 cm. Arrow = end of the phagmocone.

Plate 7: 1-5) *Calpionella alpina* LORENZ, 1902: 1) no. 94.2 (1994), 2) no. BR2764/no. 9 (2010), 3) no. BR2763/no. 8 (2010), 4-5) no. BR2762/no. 7 (2010); **6-10)** *Calpionella parvalpina* NAGY, 1986: 6) no. BR2762/no. 7 (2010), 7) no. BR2759/no. 4H (2010), 8) no. 94.15 (1994), 9) no. 94.22 (1994), 10) no. BR2761/no. 6 (2010); **11-15)** *Calpionella elliptica* CADISCH, 1932: 11) no. 94.1 (1994), 12) no. BR2765/no. 10 (2010), 13) no. BR2757/no. 3 (2010), 14) no. BR2764/no. 9 (2010), 15) no. 94.5 (1994); **16-20)** *Calpionellopsis brevisimplex* NAGY, 1986: 16) no. 94.7 (1994), 17-18) no. BR2759/no. 4H (2010), 19) no. 94.18 (1994), 20) no. 94.15 (1994); **21-26)** *Calpionellopsis simplex* (COLOM, 1939): 21) no. BR2764/no. 9 (2010), 22) no. BR2657/no. 93.D (1993), 23) no. 94.18 (1994) (= *Tintinnopsella longa* in GRANIER *et al.*, 1995: Fig. 4.15), 24) no. 94.10 (1994), 25) no. 94.22 (1994), 26) no. 94.7 (1994); **27-30)** *Calpionellopsis procerosimplex* NAGY, 1986: 27) no. BR2761/no. 6 (2010), 28) no. 94.7 (1994), 29) no. 94.6 (1994), 30) no. 94.5 (1994); **31-35)** *Calpionellopsis protoblonga* NAGY, 1986: 31) no. 94.15 (1994), 32) no. BR2759/no. 4H (2010), 33) no. 94.21 (1994), 34) no. 94.7 (1994), 35) no. BR2758/no. 4B (2010).

1, 8-9, 11, 15-16, 19-20, 23-26, 28-31, 33-34) Casamata section, 2-7, 10, 12-14, 17-18, 21-22, 27, 32, 35) Calvari section, Busot, Alicante. All photos with the same scale bar = 100 µm, on Photo 10.

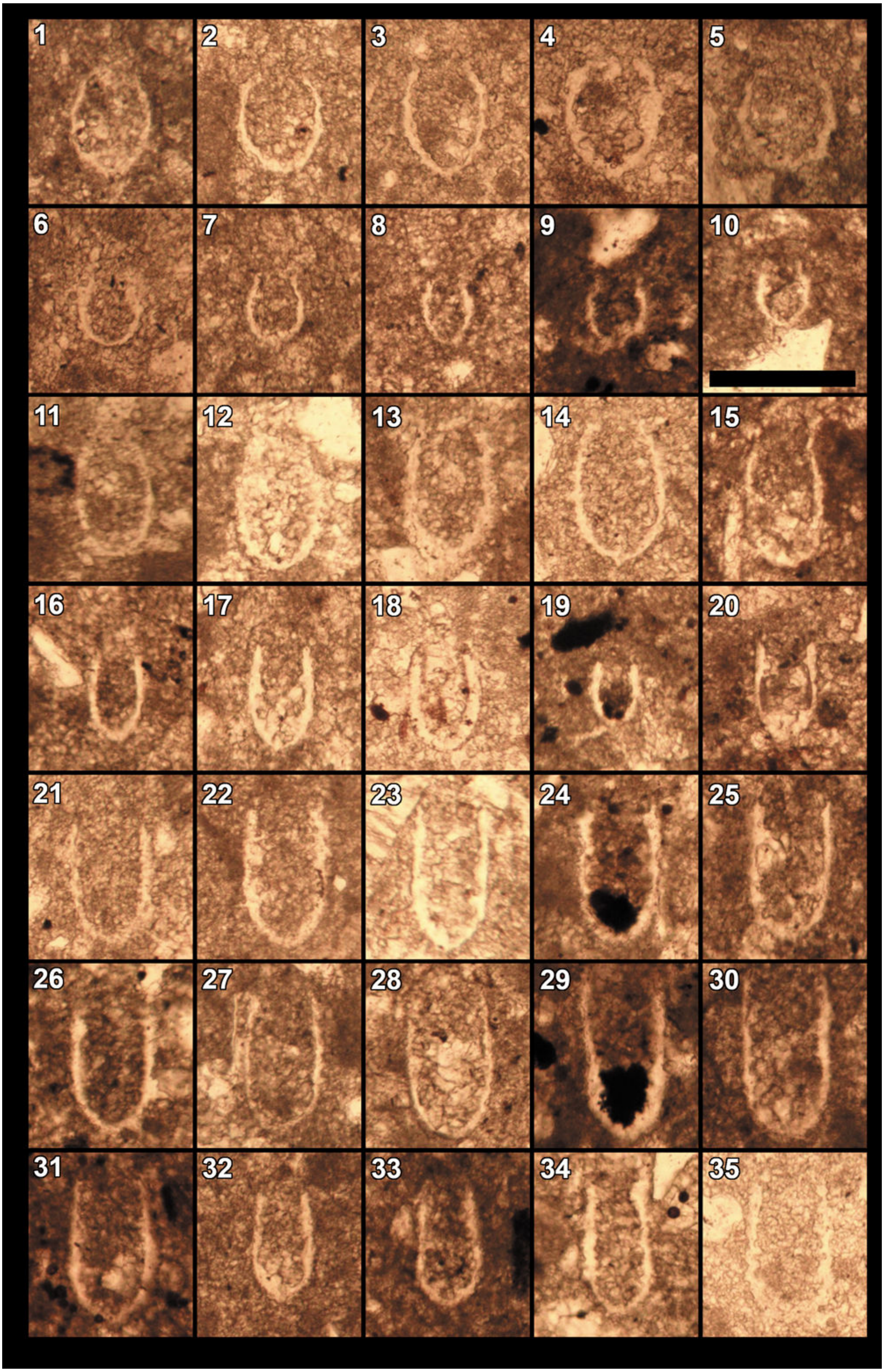
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Plate 8: 1-5) *Calpionellopsis oblonga* (CADISCH, 1932): 1-2) no. 94.18 (1994), 3-4) no. 94.7 (1994), 5) no. BR2763/no. 8 (2010); **6-10)** *Lorenziella hungarica* KNAUER & NAGY, 1964: 6) no. BR2757/no. 3 (2010), 7) no. 94.14 (1994), 8) no. 94.15 (1994), 9) no. BR2759/no. 4H (2010), 10) no. BR2762/no. 7 (2010); **11-12)** *Lorenziella plicata* LE HÉGARAT & REMANE, 1968: 11) no. BR2762/no. 7 (2010), 12) no. BR2759/no. 4H (2010); **13-17)** *Remaniella ferasini* (CATALANO, 1965): 13) no. 94.18 (1994), 14-15) no. BR2763/no. 8 (2010), 16) no. 94.18 (1994), 17) no. BR2761/no. 6 (2010); **18-20)** *Remaniella duranddelgai* POP, 1996: 18-20) no. 94.17 (1994); **21-25)** *Remaniella* cf. *cadischiana* (COLOM, 1948): 21) no. BR2757/no. 3 (2010), 22, 25) no. BR2762/no. 7 (2010), 23) no. BR2759/no. 4H (2010), 24) no. BR2764/no. 9 (2010); **26-30)** *Tintinnopsella carpathica* (MURGEANU & FILIPESCU, 1933): 26) no. 94.17 (1994), 27) no. BR2764/no. 9 (2010), 28) no. BR2763/no. 8 (2010), 29) no. BR2759/no. 4H (2010), 30) no. BR2660/no. 93.D (1993); **31)** *Tintinnopsella curva* BENZAGGAGH *et al.*, 2012: no. BR2759/no. 4H (2010);**32-35)** *Tintinnopsella duranddelgai* BENZAGGAGH *et al.*, 2012: 32) no. 94.22 (1994), 33) BR2761/no. 6 (2010), 34) no. BR2763/no. 8 (2010), 35) no. BR2759/no. 4H (2010).

1-4, 7-8, 13, 16, 18-20, 26, 32) Casamata section, 5-6, 9-12, 14-15, 17, 21-25, 27-31, 33-35) Calvari section, Busot, Alicante. All photos with the same scale bar = 100 µm, on Photo 10.

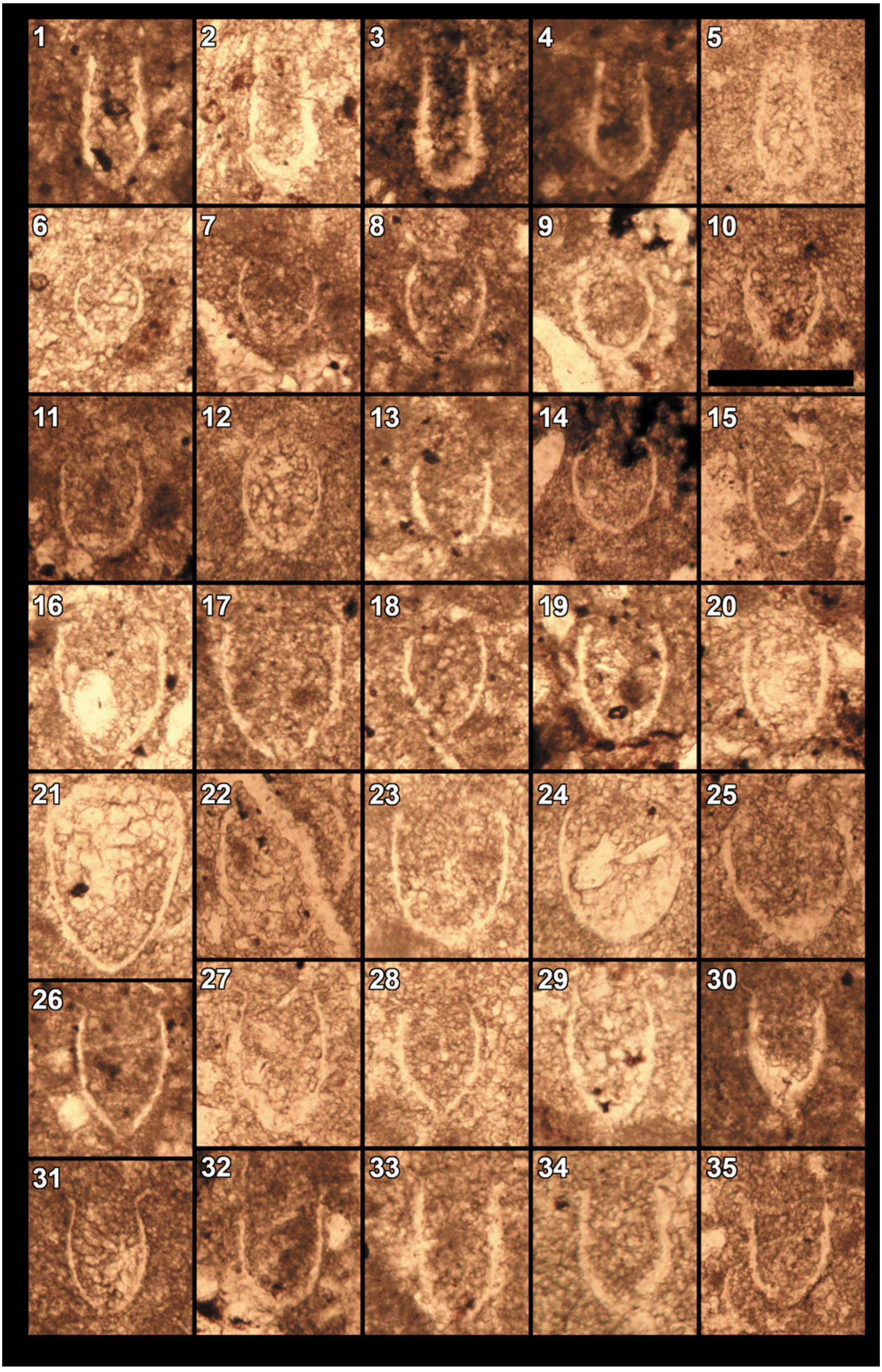
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Plate 9: 1-5) *Tintinnopsella longa* (Colom, 1939): 1) no. 94.10 (1994), 2) no. BR2660/no. 93.D (1993), 3) no. 94.22 (1994), 4) no. BR2763/no. 8 (2010), 5) no. BR2764/no. 9 (2010); **6-9)** *Tintinnopsella elmii* Benzaggagh *et al.*, 2012: 6) no. BR2759/no. 4H (2010), 7) no. 94.7 (1994), 8) no. 94.10 (1994) (= *Tintinnopsella longa* in Granier *et al.*, 1995: Fig. 4.13), 9) no. 94.5 (1994); **10-13)** *Tintinnopsella largovalata* Benzaggagh *et al.*, 2012: 10) no. 94.10 (1994), 11) no. BR2763/no. 8 (2010), 12) no. BR2759/no. 4H (2010), 13) no. 94.21 (1994); **14-17)** *Tintinnopsella longovalata* Benzaggagh *et al.*, 2012: 14, 16) no. BR2759/no. 4H (2010), 15, 17) no. 94.2 (1994); **18-20)** *Tintinnopsella minicarpathica* Benzaggagh *et al.*, 2012: 18) no. 94.15 (1994), 19) no. BR2763/no. 8 (2010), 20) no. BR2765/no. 10 (2010); **21-25)** *Cadosina fusca* Wanner 1940: 21) no. 94.7 (1994), 22) no. BR2757/no. 3 (2010), 23) no. BR2760/no. 5 (2010), 24) no. BR2759/no. 4H (2010), 25) no. BR2657/no. 93.D (1993); **26)** *Octahedronoides tethysianus* Granier, 2024b: no. BR2763/no. 8 (2010); **27)** *Colomisphaera heliosphaera* (Vogler, 1941): no. BR2760/no. 5 (2010); **28-29)** *Cadosina fusca cieszynica* Nowak, 1966: 28) no. 94.7 (1994), 29) no. BR2758/no. 4B (2010); **30)** *Stomiosphaera echinata* Nowak, 1968: no. BR2755/no. 1 (2010); **31)** *Cadosina semiradiata olzae* Nowak, 1968: no. BR2757/no. 3 (2010); **32-34)** *Cadosina semiradiata* aff. *olzae* Nowak, 1968: 32) no. 94.22 (1994), 33) BR2761/no. 6 (2010), 34) no. 94.18 (1994); **35-39)** *Cadosina semiradiata* Wanner 1940: 35) no. BR2757/no. 3 (2010), 36-37) no. BR2764/no. 9 (2010), 38) no. BR2660/no. 93.D (1993), 39) no. 94.21 (1994); **40)** *Cadosina radiata* Vogler, 1941: no. BR2755/no. 1 (2010).

1, 3, 7-10, 13, 15, 17-18, 21, 28, 32, 34, 39) Casamata section, 2, 4-6, 11-12, 14, 16, 19-20, 22-27, 29-31, 33, 35-38, 40) Calvari section, Busot, Alicante. All photos with the same scale bar = 100 µm, on Photo 10.

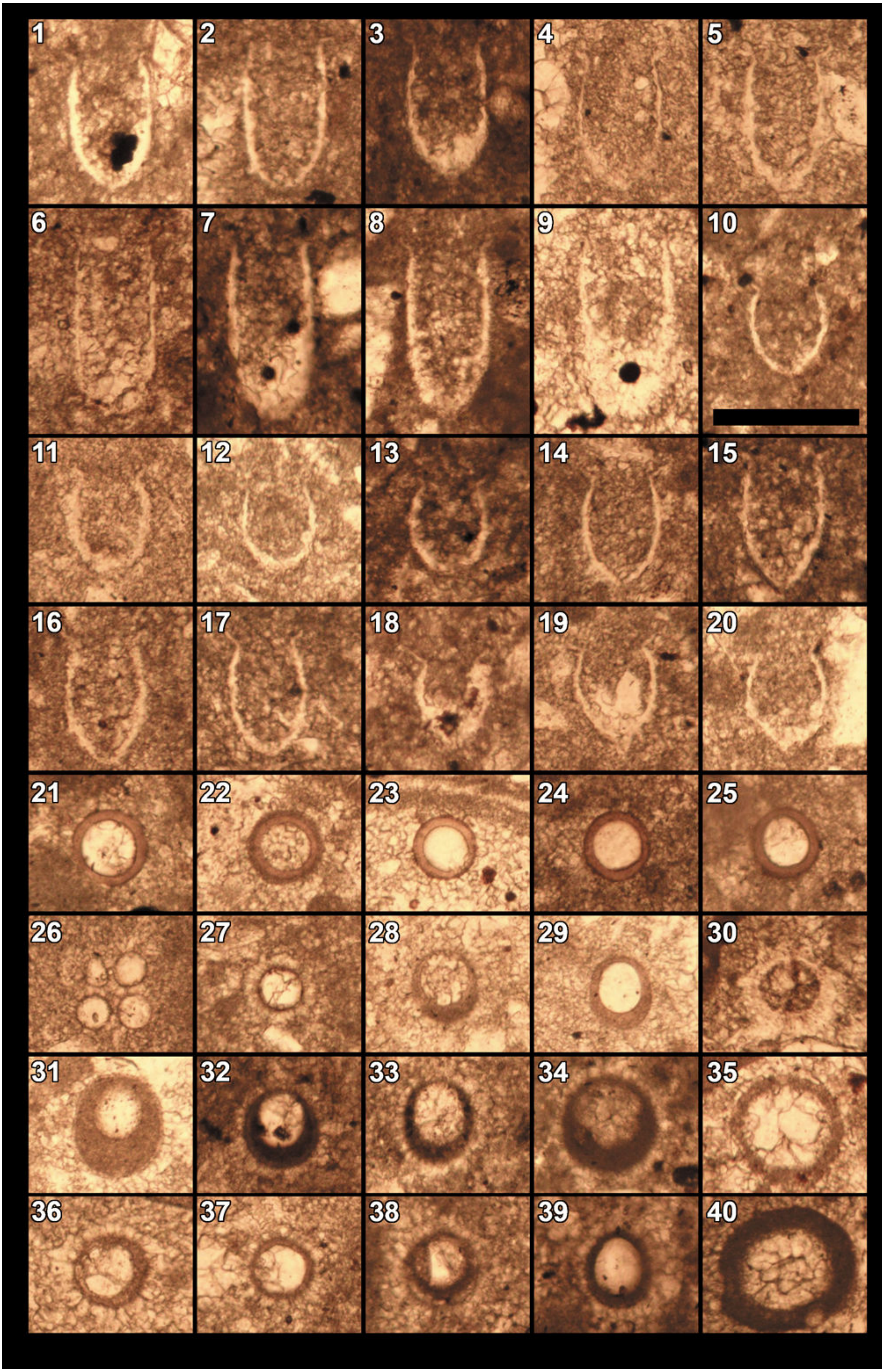
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Plate 10: Due to the relatively poor preservation of the specimens, we have chosen to illustrate most of the observed nannofossils, including those that are non-diagnostic. **1-9)** *Nannoconus steimannii* subsp. *minor* DERES & ACHÉRITÉGUY, 1980; **10-15)** *Nannoconus steinmannii* subsp. *steinmannii* KAMPTNER, 1931; **16-17)** *Nannoconus globulus* subsp. *minor* BRALOWER, 1989; **18-19)** *Nannoconus* sp.; **20)** *Nannoconus* sp. (? group *compactus*); **21-24)** *Nannoconus compressus* BRALOWER & THIERSTEIN, 1989 (24, doubtfull specimen); **25-26)** *Nannoconus kamptnerii* subsp. *minor* DERES & ACHÉRITÉGUY, 1980; **27, 29)** *Faviconus* ? sp., 27) LN, 29) LP (doubtfull specimen); **28, 30-32)** *Nannoconus wintereri* BRALOWER & THIERSTEIN, 1989; **35)** *Nannoconus* sp.; **33-34, 36)** *Assipetra* or ? Nannoconid.

1-36) All specimens from no. 94.15 (1994), 11.95 m, Casamata section, Busot, Alicante; 22-23) no. BR2764/no. 9 (2010), Calvari section, Busot, Alicante. All photos with the same scale bar = 10 µm, on Photo 8.

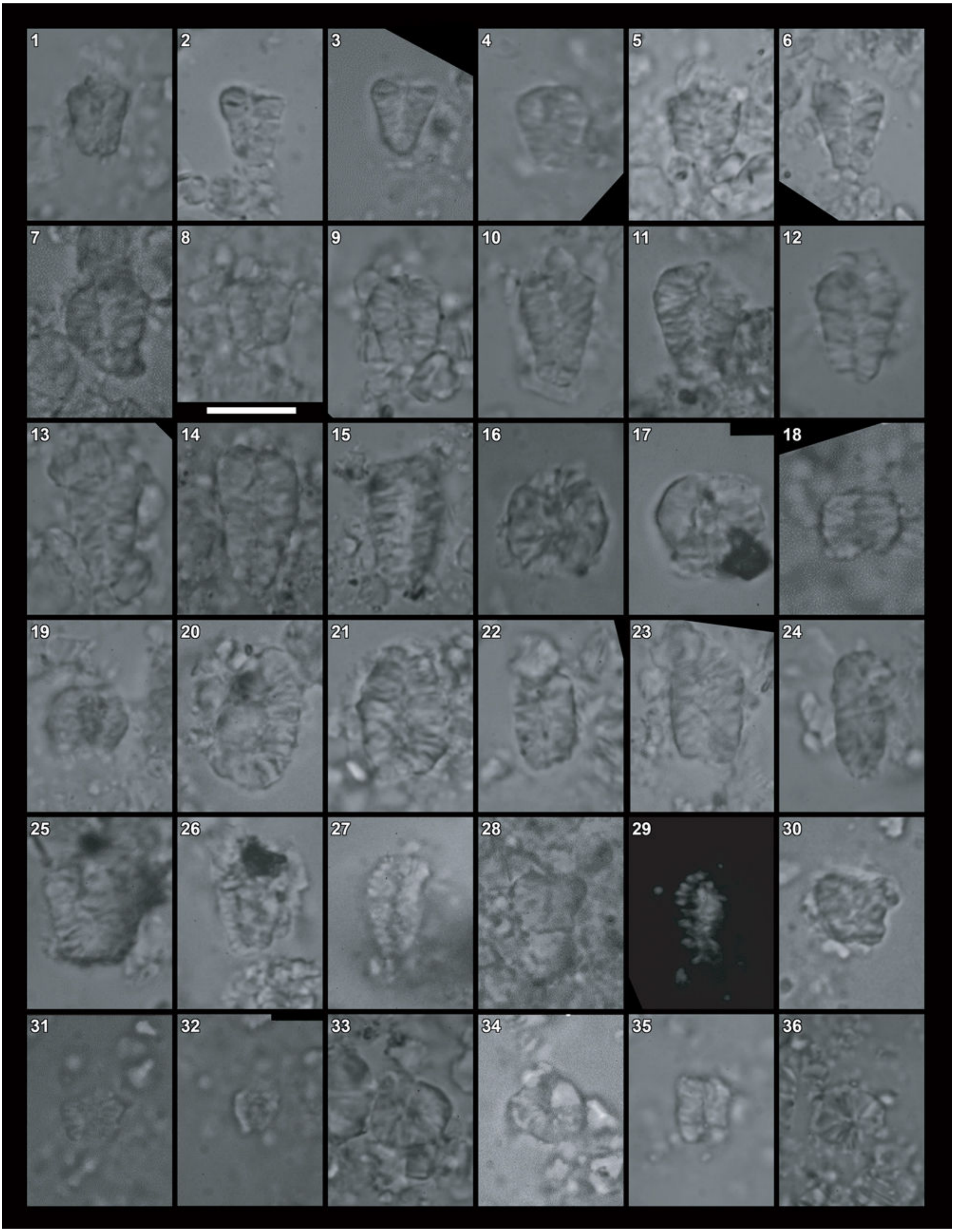
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Plate 11: 1-2) Cluster 1: 1) *Nannoconus steimannii* subsp. *minor* DERES & ACHÉRITÉGUY, 1980; 2) *Nannoconus* sp. cf. *compressus* BRALOWER & THIERSTEIN, 1989; **3-5)** Cluster 2: 3-4) *Polycostella beckmannii* THIERSTEIN, 1971 (doubtfull specimens); 5) *Rucinolithus irregularis* THIERSTEIN, 1972; **6)** *Braarudosphaera regularis* (BLACK, 1973);**7)** *Watznaueria* sp.; **8-11)** *Polycostella beckmannii* THIERSTEIN, 1971, 10) LN, 11) LP (8 & 10-11 doubtfull larger specimens); **12)** *Watznaueria barnesiae* (BLACK, 1959); **13)** *Watznaueria biporta* BUKRY, 1969; **14)** ? *Cyclagelosphaera margerelii* NOËL, 1965 (large form); **15)** *Haqius circumradiatus* (STOVER, 1966); **16)** C*yclagelosphaera* sp., small form; **17)** *Diazomatolithus lehmanii* NOËL, 1965; **18-19)** *Zeugrhabdotus embergeri* (NOËL, 1958); **20)** *Cruciellipsis cuvillieri* (small form) (MANIVIT, 1966); **21)** *Rhagodiscus* sp.; **22-25)** *Octahedronoides tethysianus* GRANIER, 2024b.

1-21) no. 94.15 (1994), 11.95 m, Casamata section, Busot, Alicante; 22-23) no. BR2764/no. 9 (2010), Calvari section, Busot, Alicante; 24) 6521-CALV-1 (Antonio ESTÉVEZ RUBIO Collection, Alicante), Calvari section, Busot, Alicante; 24-25) no. 94.2 (1994), Casamata section, Busot, Alicante. Photos 1-11 with the same white scale bar = 10 µm, on Photo 11; photos 12-21 with the same yellow scale bar = 10 µm, on Photo 21; photos 22-25 with the same orange scale bar = 100 µm, on Photo 25.

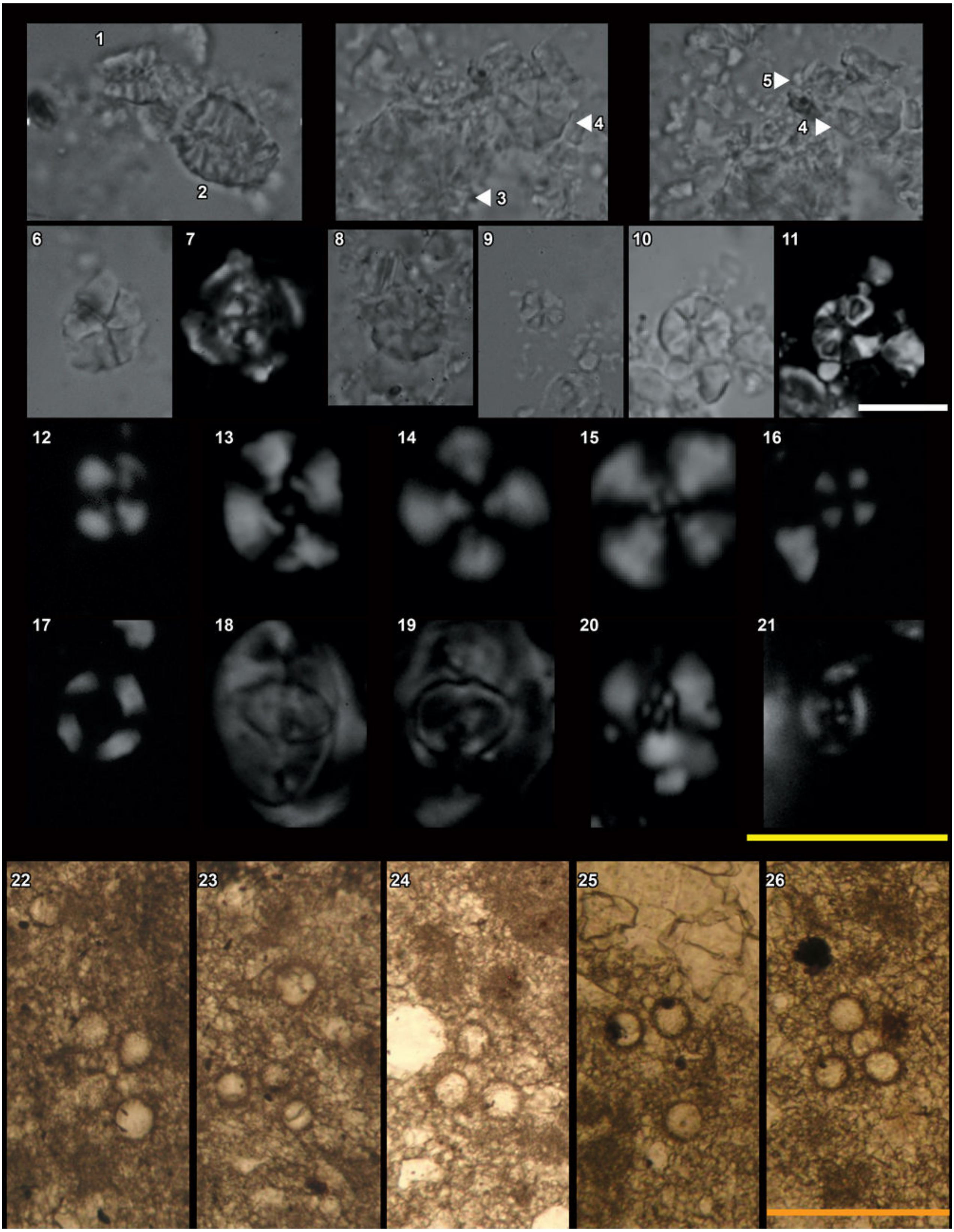
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Plate 12: 1-6, 19-23) *Nannoconus steimannii* subsp. *minor* Deres & Achéritéguy, 1980; **7, 24-27)** *Nannoconus steinmannii* subsp. *steinmannii* Kamptner, 1931; **8-9)** *Nannoconus infans* Bralower, 1989; **10)** *Nannoconus* sp. (aff. *globulus minor*); **11)** ? *Nannoconus compressus* Bralower & Thierstein, 1989; **12)** *Nannoconus cornuta* Deres & Achéritéguy, 1980; **13)** *Assipetra* sp.; **14-18)** *Polycostella beckmannii* Thierstein, 1971, 14-15) same specimen LN; **16-18)** same specimen, 16-17) LN, 18) LP; **28-31)** indeterminate *Nannoconus*; **32)** *Nannoconus wintereri* Bralower & Thierstein, 1989; **33)** *Assipetra* sp. (doubtfull specimens); **34)** *Polycostella beckmannii* Thierstein, 1971; **35-36)** ? *Polycostella senaria* Thierstein, 1971, 35) LN, 36) LP.

1-18) no. 3 (2010), (CLV_3), 6.95 m; 19-36) no. 5 (2010), (CLV_5), 14.45 m, Calvari section, Busot, Alicante. All photos with the same scale bar = 10 µm, on Photo 18.

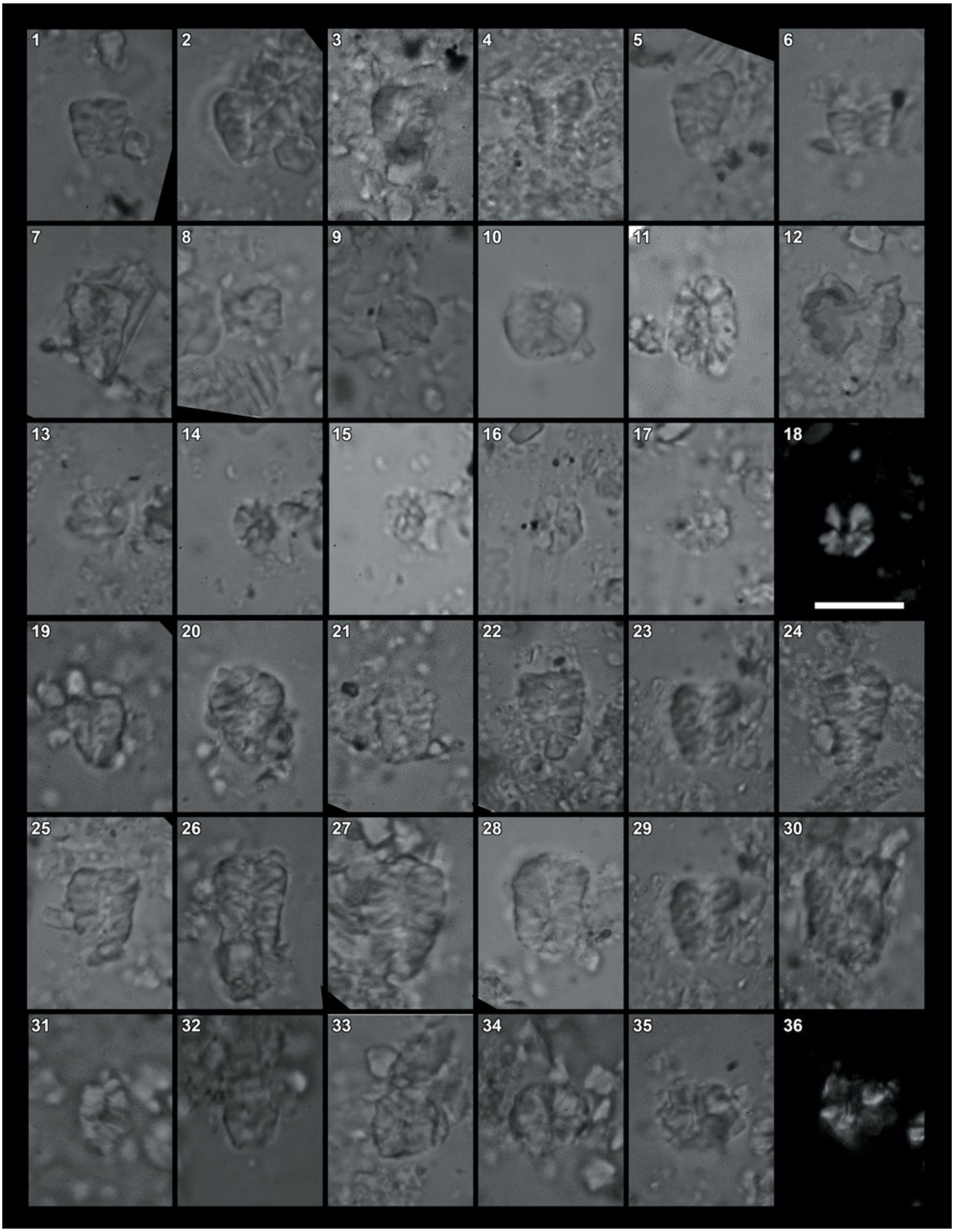
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Plate 13: 1) *Roveacrinus berthoui* Ferré & Granier, 2000, holotype, no. 94.5 (1994); **2-7)** *Epistomina* spp., 2) no. 94.14 (1994), 3) no. 94.18 (1994), 4) no. BR2761/no. 6 (2010), 5, 7) no. BR2763/no. 8 (2010), 6) no. BR2764/no. 9 (2010); **8-9)** *Mohlerina basiliensis* (Mohler, 1938), 8) no. 94.20 (1994), 9) no. BR2657/no. 93.D (1993).

1-3, 8) Casamata section, 4-7, 9) Calvari section, Busot, Alicante. All photos with the same scale bar = 250 µm, on Photo 8.

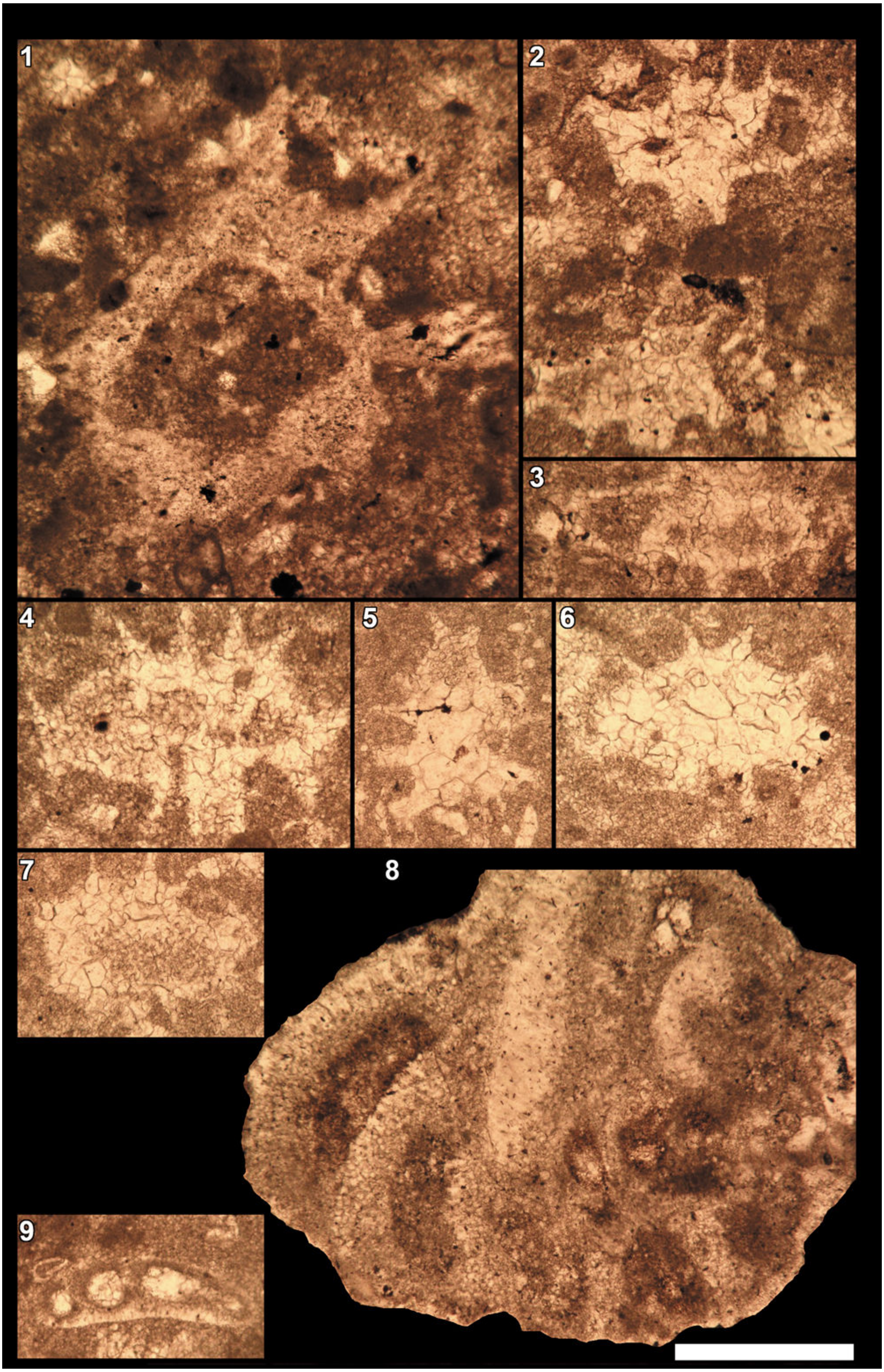
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Plate 14: 1-24) *Ichnusella* gr. *infragranulata* (NOTH, 1951) - *reicheli* (NEAGU, 1995), 1-2) no. BR2660/no. 93.D (1993); 3, 9, 13) no. 94.25 (1994); 4) no. 94.26 (1994); 5, 21) no. 94.7 (1994); 6) no. 94.8 (1994); 7) no. 94.10 (1994); 8) no. 94.15 (1994); 10, 22, 26) no. 94.26 (1994); 11) no. BR2755/no. 1 (2010); 12) no. 94.12 (1994); 14-15, 18-20, 24) no. BR2765/no. 10 (2010); 16) no. BR2764/no. 9 (2010); 17) no. BR2763/no. 8 (2010); 23) no. BR2762/no. 7 (2010); **25)** *Coscinoconus* sp. as the nucleus of a superficial ooid, no. BR2765/no. 10 (2010); **26)** broken ooid or more likely a small lithoclast, no. BR2765/no. 10 (2010); **27)** bored ooid, no. BR2755/no. 1 (2010); **28)** bored lithoclast with ooids, no. BR2755/no. 1 (2010).

1-2, 11, 14-20, 23-28) Calvari section, 3-10, 12-13, 21-22, 26) Casamata section, Busot, Alicante. All photos with the same white scale bar (on Photo 26) = 250 µm, except for photos 27-28 with the same black scale bar (on Photo 27) = 250 µm.

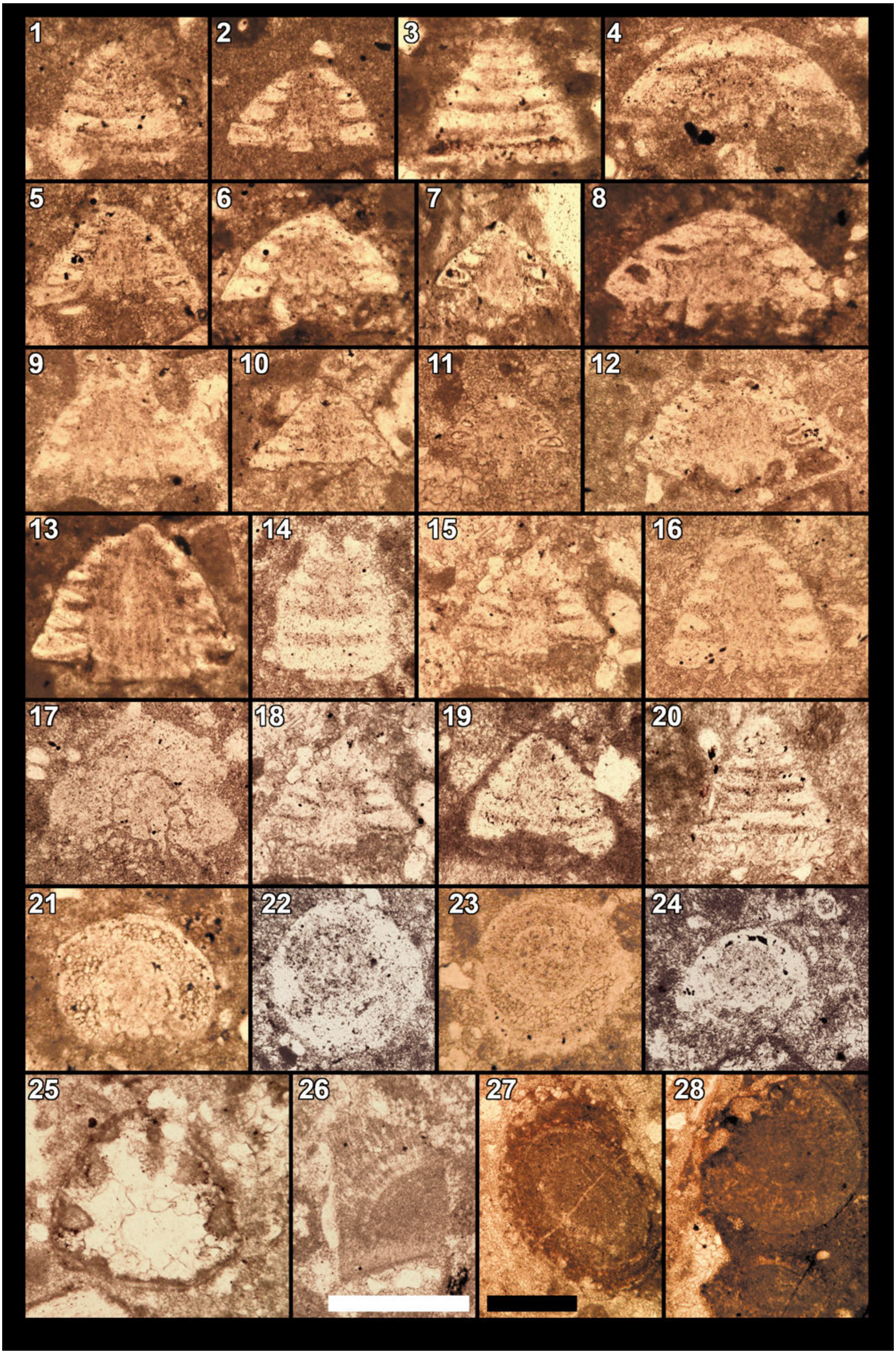
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Plate 15: 1) *Coscinoconus* sp. 6521-BAR-1; **2, 8)** *Frentzenella* sp.; **3-5)** *Protopeneroplis ultragranulata* (GORBACHIK, 1971); **6-7)** *Mohlerina basiliensis* (MOHLER, 1938); **9)** *Pseudocymopolia pluricellata* BAKALOVA, 1973.

1-5) no. 6521-BAR-1, Antonio ESTÉVEZ RUBIO Collection, Alicante; 6, 9) no. 6521-CALV-1, Calvari section, Antonio ESTÉVEZ RUBIO Collection, Alicante; 8) no. BR2765/no. 10 (2010), Calvari section, Busot, Alicante. All photos with the same white scale bar (on Photo 5) = 250 µm, except for photo 9 with black scale bar = 500 µm.

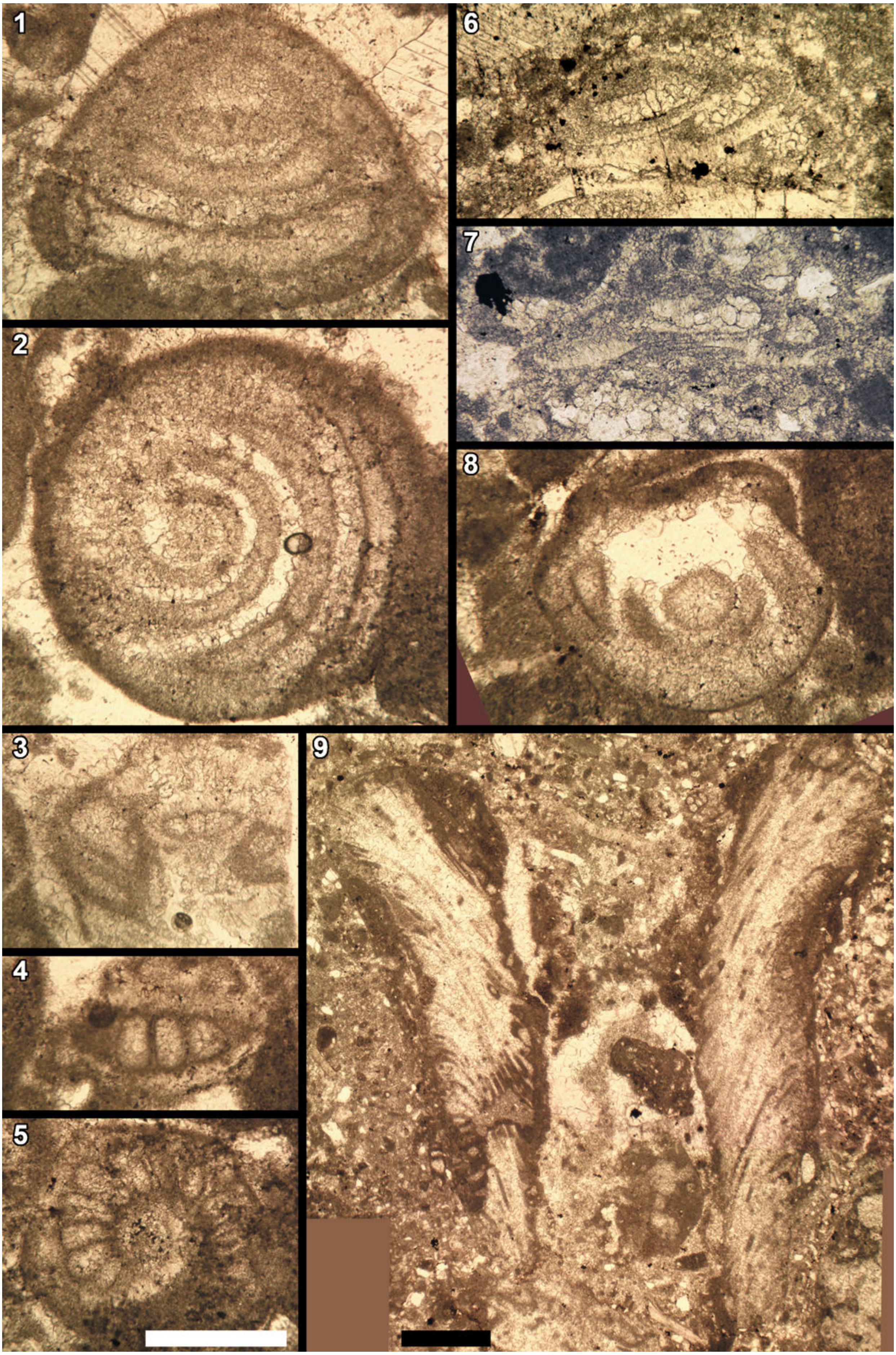
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Plate 16: 1) *Mohlerina basiliensis* (MOHLER, 1938); **2-6)** *Protopeneroplis ultragranulata* (GORBACHIK, 1971); **8)** "*Girvanella*"-like microbial structure; **9)** *Pseudocymopolia pluricellata* BAKALOVA, 1973; **10)** pseudointraclast with a calpionellid; **11)** rhyncholite; **12)** *Iberopora bodeuri* GRANIER & BERTHOU, 2002; **13)** calcareous tubeworm, *Carpathiella triangulata* MIŠÍK *et al.*, 1999 ("cf. *Haliotus*" *sensu* SAMUEL *et al.*, 1972).

1) no. BR2763/no. 8 (2010); 2) no. 94.25 (1994); 3) no. 94.1 (1994); 4-5, 7) no. BR2764/no. 9 (2010); 6) no. BR2765/no. 10 (2010); 8) no. BR2762/no. 7 (2010); 9) no. 94.10 (1994); 10) no. BR2764/no. 9 (2010); 11) no. BR2756/no. 2 (2010); 12) no. 94.26 (1994). 1, 4-8, 10-11) Calvari section; 2-3, 9, 12) Casamata section, Busot, Alicante. All photos with the same black scale bar (on Photo 9) = 250 µm, except for photo 13 with white scale bar = 500 µm.

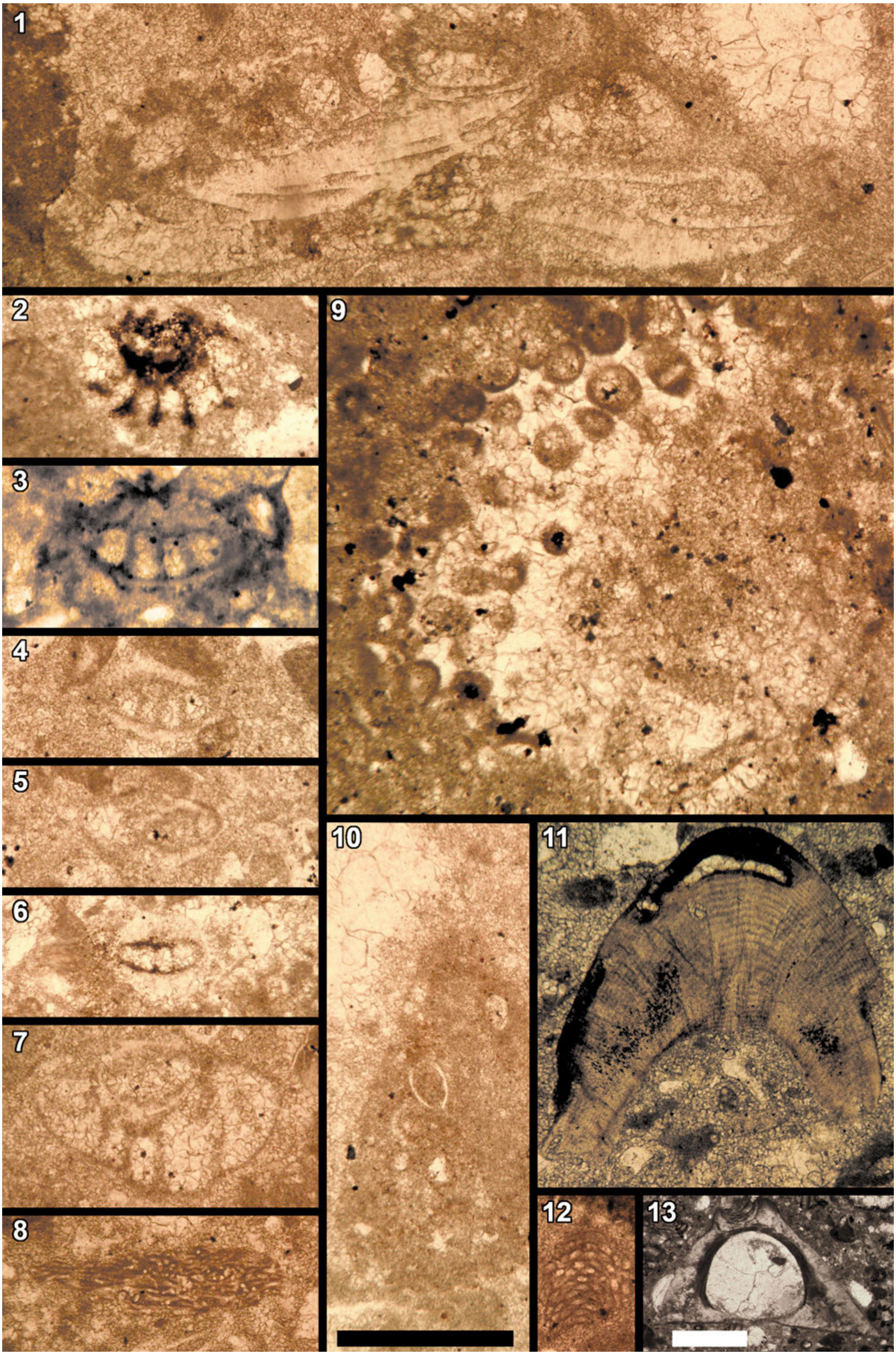
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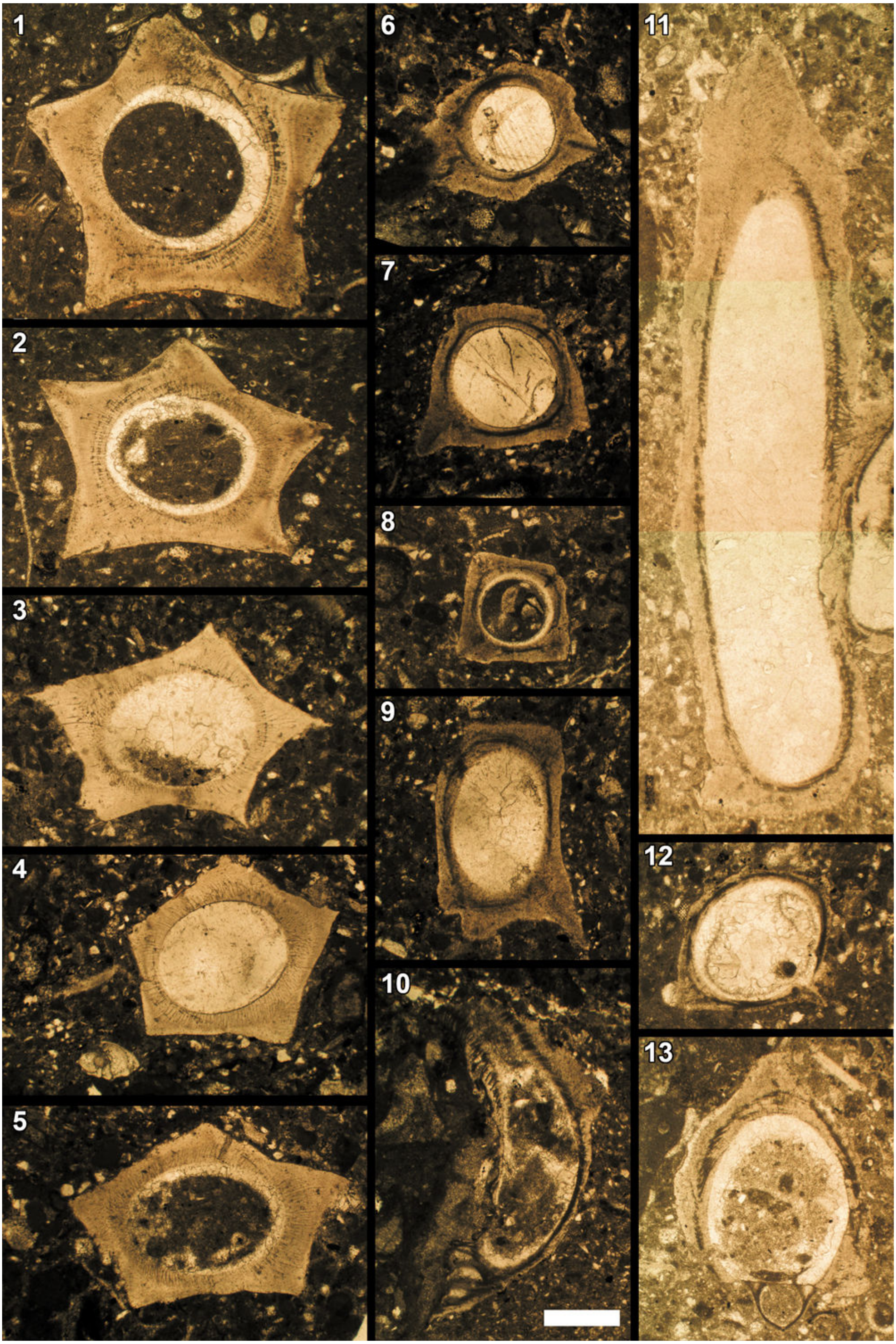
Plate 17: 1-13) calcareous tubeworms, serpulids.

1-2, 12) no. BR3427/no. 18.25 (2024); 3) no. 94.19 (1994); 4-5) no. no. 94.13 (1994); 6) no. 94.22 (1994); 7) no. 94.17 (1994); 8) no. 94.14 (1994); 9) no. 94.16 (1994); 10) no. 94.21 (1994); 11, 13) no. BR2762/no. 7 (2010). 1-2, 11-13) Calvari section; 3-10) Casamata section, Busot, Alicante. All photos with the same black scale bar (on Photo 10) = 500 µm.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Appendix

List of thin sections housed at the 'Muséum d'Histoire Naturelle de Genève', Switzerland.

MHNG-GEPI-2024-10031: no. 94.1 (1994),	Casamata section
MHNG-GEPI-2024-10032: no. 94.2 (1994),	Casamata section
MHNG-GEPI-2024-10033: no. 94.3 (1994),	Casamata section
MHNG-GEPI-2024-10034: no. 94.4 (1994),	Casamata section
MHNG-GEPI-2024-10035: no. 94.5 (1994),	Casamata section
MHNG-GEPI-2024-10036: no. 94.6 (1994),	Casamata section
MHNG-GEPI-2024-10037: no. 94.7 (1994),	Casamata section
MHNG-GEPI-2024-10038: no. 94.8 (1994),	Casamata section
MHNG-GEPI-2024-10039: no. 94.9 (1994),	Casamata section
MHNG-GEPI-2024-10040: no. 94.10 (1994),	Casamata section
MHNG-GEPI-2024-10041: no. 94.11 (1994),	Casamata section
MHNG-GEPI-2024-10042: no. 94.12 (1994),	Casamata section
MHNG-GEPI-2024-10043: no. 94.13 (1994),	Casamata section
MHNG-GEPI-2024-10044: no. 94.14 (1994),	Casamata section
MHNG-GEPI-2024-10045: no. 94.15 (1994),	Casamata section
MHNG-GEPI-2024-10046: no. 94.16 (1994),	Casamata section
MHNG-GEPI-2024-10047: no. 94.17 (1994),	Casamata section
MHNG-GEPI-2024-10048: no. 94.18 (1994),	Casamata section
MHNG-GEPI-2024-10049: no. 94.19 (1994),	Casamata section
MHNG-GEPI-2024-10050: no. 94.20 (1994),	Casamata section
MHNG-GEPI-2024-10051: no. 94.21 (1994),	Casamata section
MHNG-GEPI-2024-10052: no. 94.22 (1994),	Casamata section
MHNG-GEPI-2024-10053: no. 94.23 (1994),	Casamata section
MHNG-GEPI-2024-10054: no. 94.24 (1994),	Casamata section
MHNG-GEPI-2024-10055: no. 94.25 (1994),	Casamata section
MHNG-GEPI-2024-10056: no. 94.26 (1994),	Casamata section
MHNG-GEPI-2024-10057: no. BR2657/no. 93.D (1993),	Calvari section
MHNG-GEPI-2024-10060: no. BR2660/no. 93.D (1993),	Calvari section
MHNG-GEPI-2024-10061: no. BR2755/no. 1 (2010),	Calvari section
MHNG-GEPI-2024-10062: no. BR2756/no. 2 (2010),	Calvari section
MHNG-GEPI-2024-10063: no. BR2757/no. 3 (2010),	Calvari section
MHNG-GEPI-2024-10064: no. BR2758/no. 4B (2010),	Calvari section
MHNG-GEPI-2024-10065: no. BR2759/no. 4H (2010),	Calvari section
MHNG-GEPI-2024-10066: no. BR2760/no. 5 (2010),	Calvari section
MHNG-GEPI-2024-10067: no. BR2761/no. 6 (2010),	Calvari section
MHNG-GEPI-2024-10068: no. BR2762/no. 7 (2010),	Calvari section
MHNG-GEPI-2024-10069: no. BR2763/no. 8 (2010),	Calvari section
MHNG-GEPI-2024-10070: no. BR2764/no. 9 (2010),	Calvari section
MHNG-GEPI-2024-10071: no. BR2765/no. 10 (2010),	Calvari section
MHNG-GEPI-2024-10072: BR3435/route (2024),	below Calvari section
MHNG-GEPI-2024-10073: BR3423/C11.25 (2024),	Calvari section
MHNG-GEPI-2024-10074: BR3424/C11.80 (2024),	Calvari section
MHNG-GEPI-2024-10075: BR3425/C12.00 (2024),	Calvari section
MHNG-GEPI-2024-10076: BR3426/C14.20 (2024),	Calvari section
MHNG-GEPI-2024-10077: BR3427/C18.25 (2024),	Calvari section
MHNG-GEPI-2024-10078: BR3428/C24.30 (2024),	Calvari section
MHNG-GEPI-2024-10079: BR3429/C31.50 (2024),	Calvari section