New fossiliferous sites with Barremian Charophyta in the "Grès du Liban" *auct.* (Lebanon), with a critical perspective regarding the nature of *Munieria* DEECKE, 1883

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Abstract: The "Grès du Liban" *auct.* is the thick basal unit of the Lower Cretaceous series in Lebanon. There are two key levels in this dominantly siliciclastic unit: the "Banc de Mréjatt" and the "Calcaire à pisolithes", the latter of which includes limestones and marls with Charophyta. The rich charophyte assemblage described by GRAMBAST and LORCH (1968) from a site near Jezzine is Barremian (possibly Early Barremian) in age, not Bedoulian as previously stated. Besides gyrogonites and utricles, charophyte thalli are rather common; they are ascribed to two organ genera, *Munieria* DEECKE, 1883, and *Charaxis* HARRIS, 1939. Based on topotypic material (from the PIA Collection), *Munieria baconica* DEECKE, 1883, the type-species of the genus, is reassessed. In addition, the species *Clypeina parvula* CAROZZI, 1946, is transferred to the revised genus *Munieria*, and a new species of *Charaxis* is described.

Key Words: Grès du Liban; Barremian; Bedoulian; Aptian; Charophyta; utricles; *Munieria*; *Charaxis*.

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Résumé : *Nouveaux gisements fossilifères à Charophytes barrémiens dans les "Grès du Liban"* auct. *(Liban), avec un point de vue critique sur la nature de* Munieria *DEECKE, 1883.- Les "Grès du Liban" *auct.* constituent l'épaisse unité à la base des séries du Crétacé inférieur au Liban. Il y a deux niveaux-repères dans cette unité essentiellement silicoclastique : le "Banc de Mréjatt" et le "Calcaire à pisolithes" ; ce dernier comporte des passées calcaires ou marneuses à Charophytes. La riche association de Charophytes décrite par GRAMBAST et LORCH (1968) comme provenant d'un site proche de Jezzine est d'âge barrémien (peut-être Barrémien inférieur) et non bédoulien comme cela était indiqué précédemment. À côté des gyrogonites et des utricules, les thalles de Charophytes sont plutôt communs ; ils sont attribués à deux genres d'organes, *Munieria* DEECKE, 1883, et *Charaxis* HARRIS, 1939. Sur la base de matériel topotypique (provenant de la Collection PIA), *Munieria baconica* DEECKE, 1883, l'espèce-type du genre, est réexaminée. Pour compléter cette étude, nous transférons l'espèce *Clypeina parvula* CAROZZI, 1946, dans le genre *Munieria* révisé et décrivons une nouvelle espèce du genre *Charaxis*.

Mots-clefs : Grès du Liban ; Barrémien ; Bédoulien ; Aptien ; Charophytes ; utricules ; *Munieria* ; *Charaxis*.

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1. Introduction

In 1968, GRAMBAST and LORCH described new taxa of fossil Charophyta, *i.e.*, one genus and four species, from "Toumatt-Jezzine, Sud Liban" in the "Grès du Liban, Aptien inférieur" (Bedoulian). We first attempted to access the site but we could not for security reasons; however, we discovered three new Lebanese outcrops with similar assemblages and geological settings at Homsiyeh (near Jezzine), Ain Dara and Falougha (Fig. 1). The new material collected consists mostly of thalli, gyrogonites and utricles. The vegetative remains (*i.e.*, the thalli) are of particular interest to us because we identified two organ genera: *Munieria* DEECKE, 1883, and *Charaxis* HARRIS, 1939. But before addressing the systematics let us present the results of our preliminary geological investigation.

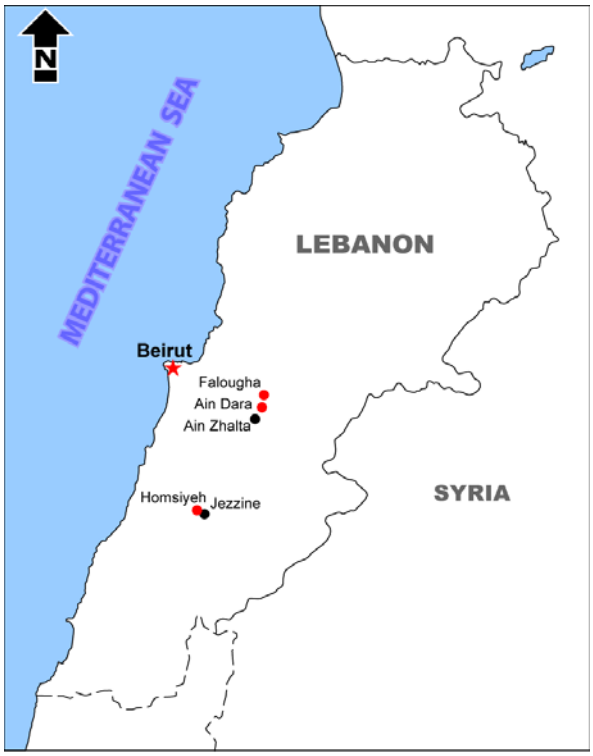

Figure 1: Location map of the three new fossiliferous localities (red dots) in Lebanon.

2. Geological context

Further to the abandonment of referring to "Muraille de Blanche" and the recent definition of a Jezzinian regional stage by MAKSOUD *et al.* (2014), there was a need to revise the underlying Lower Cretaceous unit, *i.e.*, the "Grès du Liban" *auct.* (Fig. 2). The lower Jezzinian unconformity (a transgressive surface) falls somewhere in the "Gastropodenzone von Abeih" of FRAAS (1878) and its counterparts (see MAKSOUD *et al.*, 2014: Table 1), namely: "Aptien" of DOUVILLÉ (1910), ZUMOFFEN (1926) and DUBERTRET (1934), "Aptien inférieur" of DUBERTRET and VAUTRIN (1937), "Couches à Gastéropodes" of HEYBROEK (1942), C2a of DUBERTRET (1963), … The uppermost part of this "Gastropodenzone von Abeih" is ascribed to the Jezzinian (MAKSOUD *et al.*, 2014).

The herein amended "**Grès du Liban**" is equivalent to the lower part of the "Gastropodenzone von Abeih" plus the unit below it, *i.e.*, the "Sandsteinformation des Libanon" of FRAAS (1878) or its counterparts, namely: "Grès à lignite" of DOUVILLÉ (1910), "Néocomien" of DOUVILLÉ (1910), ZUMOFFEN (1926), DUBERTRET (1934) and DUBERTRET & VAUTRIN (1937), "Grès lignitifères" of ZUMOFFEN (1926) and HEYBROEK (1942), "Grès de base" of DUBERTRET (1955), C1 of DUBERTRET (1955, 1963), …

Regarding the upper boundary of his "Grès du Liban", DUBERTRET (1955) noticed that "Le grès de base passe insensiblement, vers le haut, à des couches argileuses ou marneuses avec des bancs très fossillifères. Sa limite supérieure a été tracée à l'apparition des premières faunes" [The basal sandstone unit gradually changes upward to argillaceous or marly layers with very fossiliferous beds. Its upper boundary was placed at the first faunal appearance]. Later, DUBERTRET (1963) also added that these sandstones "ne sont pas partout de même âge" [are not given the same age across Lebanon]. As for any facies-driven lithostratigraphic unit, we assume that "This geometrical relationship is merely the signature of regular lateral changes in facies within a single time-unit" (MAKSOUD *et al.*, 2014), here in an overall transgressive trend. At Jezzine, the type-locality of the Jezzinian, MAKSOUD *et al.* (2014) reported the occurrence of lignite immediately underneath the lower Jezzinian unconformity, another fact that justifies the merger of the two former lithostratigraphic units (except for the upper part of the "Gastropodenzone", which belongs to the Jezzinian, see MAKSOUD *et al.*, 2014: Table 1) into the amended "Grès du Liban".

In some Lebanese sections one can identify in the "Grès du Liban" *auct.*:

- a key marine interval, *i.e.*, the "**Banc de Mréjatt**" of HEYBROEK (1942) or "falaise aptienne" of DUBERTRET and VAUTRIN (1937), found in the fossiliferous upper part of the "Grès du Liban" *auct.* (Fig. 2), and

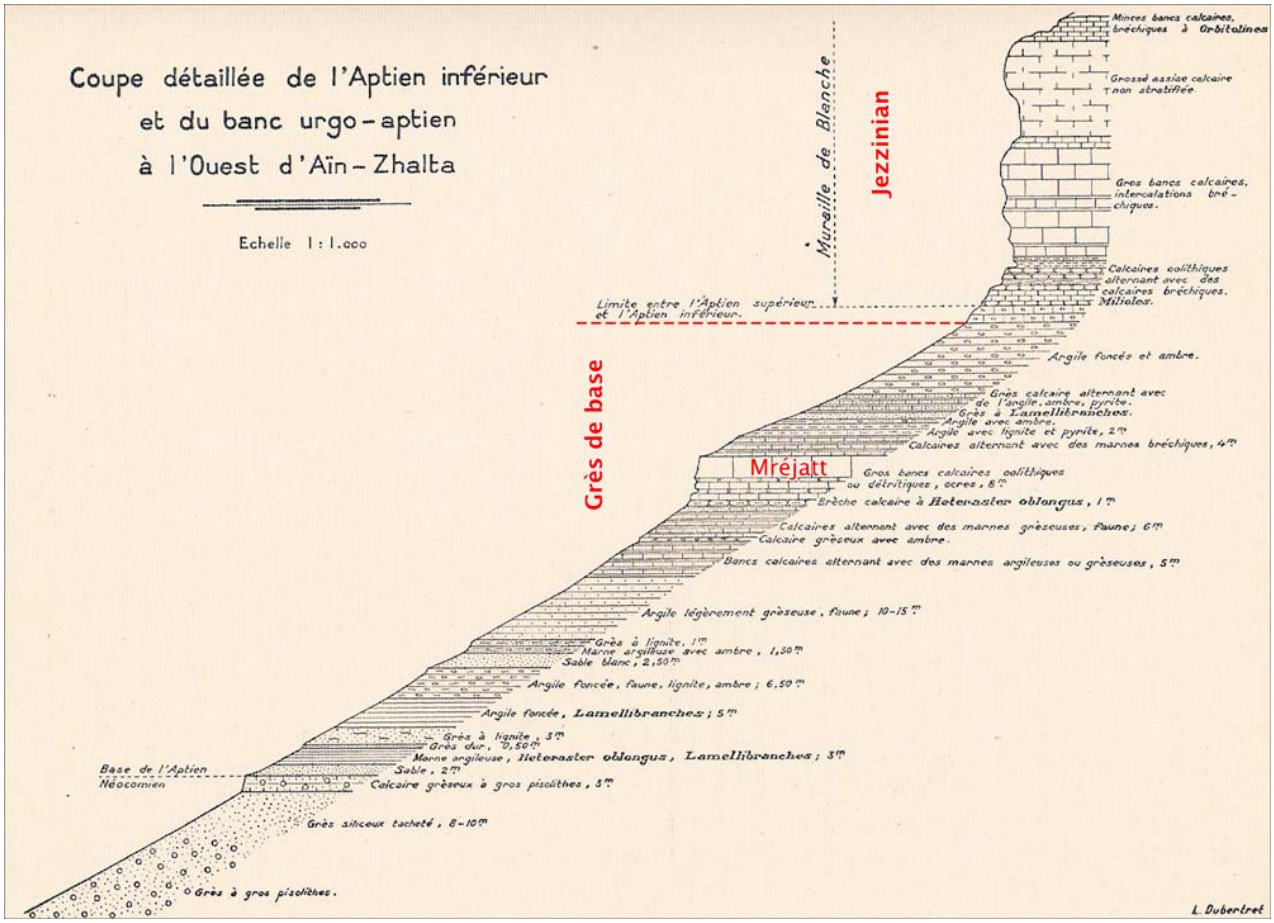

Figure 2: Section West of Ain Zhalta, some 5 km SSW of Ain Dara (excerpt from DUBERTRET & VAUTRIN, 1937: Fig. 28), displaying a typical succession from the "Calcaire à pisolithes" of HEYBROEK (1942) to the "Muraille de Blanche" of DUBERTRET & VAUTRIN (1937). The "Banc de Mréjatt" of HEYBROEK (1942) appears here as "Gros bancs calcaires oolithiques ou détritiques, ocres, 8m". In this figure, the strata of "Grès du Liban" *auct.* are ascribed "Néocomien" and "Aptien inférieur" ages; the "Muraille de Blanche" (*i.e.*, the Jezzinian) is ascribed an "Aptien supérieur" age.

- a particular and unique facies, *i.e.*, the "**Calcaire à pisolithes**" of HEYBROEK (1942), found below, near the top of the 'barren' lower part of the unit (Fig. 2). According to DUBERTRET (1934: p. 22), these "innombrables pisolithes" [countless pisolites] have "la grosseur d'une noix à celle d'une noisette" [the size of a walnut to that of a hazel nut] (Pl. 1, fig. C). Marls, mostly, and limestones with loose pisolites possibly represent lacustrine facies; locally there are few cross-bedded calcirudites with pisolites (Pl. 1, fig. D), which correspond to fluvial reworking of the previous facies. Last, there are few limestone layers with the foraminifer *Choffatella* gr. *decipiens* SCHLUMBERGER, 1905, and the Triploporellacean alga *Salpingoporella (Hensonella) dinarica* (RADOIČIĆ, 1959) representing either marine (peritidal to subtidal) environments or brackish coastal swamps. Charophyta remains (thalli, phylloids, gyrogonites and utricles) occur in such limestones and associated marls (GRAMBAST & LORCH, 1968); they are documented further ahead in the text.

The age of the "Grès du Liban" *auct.* is poorly constrained. The unit above it, *i.e.*, the Jezzinian, spans the latest Barremian - early Bedoulian transition (MAKSOUD *et al.*, 2014) and the limestones below are Late Jurassic in age (DUBERTRET, 1963), though we cannot completely exclude an earliest Cretaceous age for their higher beds.

In the upper part of the "Grès du Liban" *auct.*, there are few age-diagnostic macro- or micro- fossils:

- *Heteraster oblongus* (BRONGNIART, 1821). In southeastern Europe, the range of this irregular echinid spans the uppermost Barremian (top Giraudi ammonite Zone) and the lower "Bedoulian" (basal Forbesi ammonite Zone) interval; its occurrence corresponds to three Urgonian sequences of CLAVEL *et al.* (2007, 2013), *i.e.*, Ba5 to Bd2. In Lebanon, it occurs in the Jezzinian and below it. Actually, it looks like that this species spans a larger interval in Lebanon because it is already present some tens of meters underneath the "Banc de Mréjatt" (HEYBROEK, 1942);

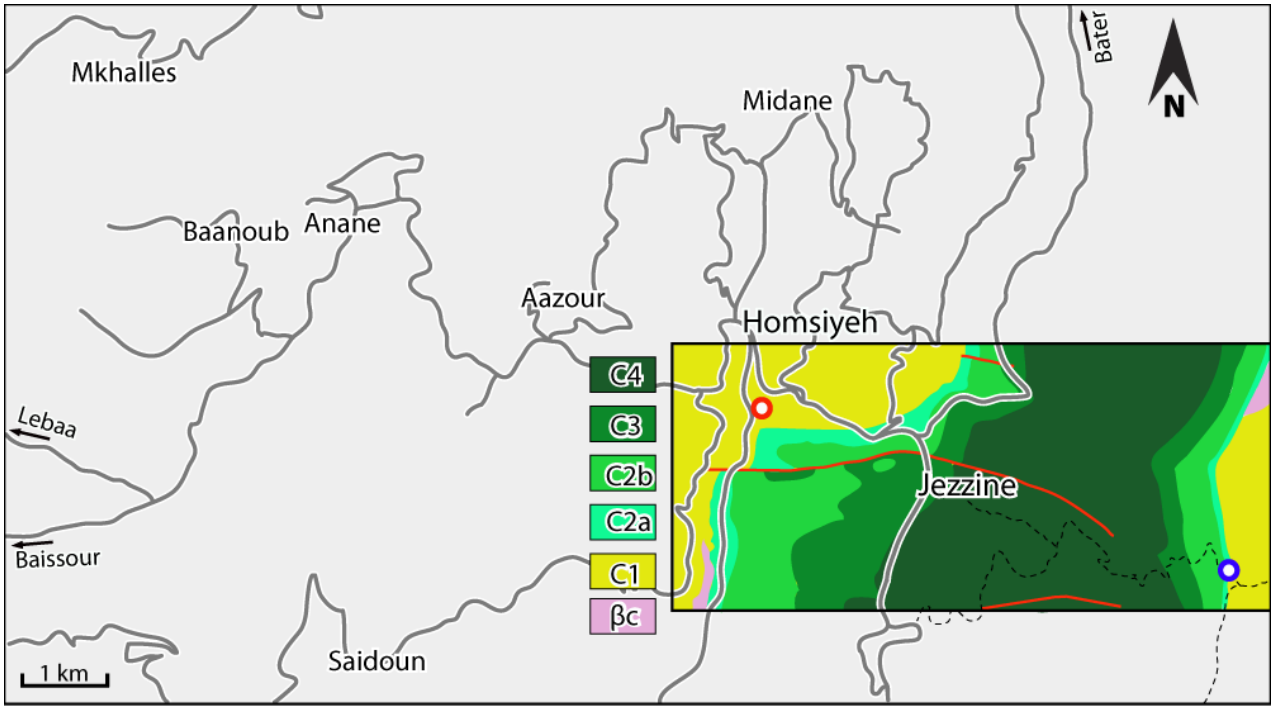

Figure 3: Location map of TIXIER's site, ESE of Jezzine (blue dot), and of the new site at Homsiyeh, WNW of Jezzine (red dot). Geological map of DUBERTRET (1950): ßc Cretaceous basalt; C1, "Grès de base"; C2a, "Aptien inférieur"; C2b, "Aptien supérieur"; C3, "Albien"; C4, "Cénomanien".

- *Eopalorbitolina transiens* (CHERCHI & SCHROEDER, 1999). According to SCHROEDER *et al.* (2010), it is the zonal marker of the Lower to Upper Barremian transition: "Interval from first occurrence of *Eopalorbitolina transiens* CHERCHI and SCHROEDER to first occurrence of *Palorbitolina lenticularis* (BLUMENBACH)"[*]. SCHROEDER *et al.* (2010) say that "This species ranges from the end of the Early Barremian to the earliest Late Barremian", and their statement fits well with their Fig. 10. However, it is contradicted by their Fig. 3 where the species reaches the early Bedoulian. In Lebanon, this species is found in the "Banc de Mréjatt";
- *Palorbitolina lenticularis* (BLUMENBACH, 1805). According to SCHROEDER *et al.* (2010), it is the zonal marker of the Upper Barremian to lower "Bedoulian" interval: "Interval from the first occurrence of *Palorbitolina lenticularis* (BLUMENBACH) to first occurrence of *Praeorbitolina cormyi* SCHROEDER". However, it first occurs in Lower –but not lowermost- Barremian strata (Nicklesi ammonite Zone) as documented by GRANIER *et al.* (2013, 2014) and it last occurs in lowermost "Gargasian" strata (Furcata ammonite Zone) according to CLAVEL *et al.* (2013). In Lebanon, this species is found in Jezzinian strata, and possibly slightly below.

To summarize, whereas the "Grès du Liban" *auct.* are Barremian and possibly older in age, the charophyte strata therein could be restricted to the Barremian (possibly to the Early Barremian only).

3. New localities with Barremian Charophyta

When GRAMBAST and LORCH (1968) described their new fossil charophyte taxa from the Lower Cretaceous of Lebanon, they mentioned that the original material came from a section studied by TIXIER (1965, 1972). According to them, it was located "5 km Sud-Est de Jezzine". However, when we checked TIXIER's unpublished thesis (1965) looking for the precise location of the site, we found that it is actually on the side of an abandoned mountain road some 3 km only ESE of Jezzine (South Lebanon Governorate) in Mount Lebanon Governorate (Fig. 3, blue dot). Unfortunately, this strategic passage to the Bekaa valley still requires clearing from land mines. Fortunately, we discovered nearby a new outcrop in a similar setting, at Homsiyeh, 2.5 km WNW of Jezzine (Fig. 3, red dot; N 33°32'49.173", E 35°33'46.154", alt. 1081m); later we also identified two new localities some 30 km ESE of Beirut (and 30 km NNW of Jezzine), both in Mount Lebanon Governorate: 1.5 km N of Ain Dara (N 33°47'41.197", E 35°43'37.122", alt. 1272m) and 1 km E of Falougha (N 33°50'4.374", E 35°45'14.739", alt. 1530m).

[*] It is not a Total Range Zone.

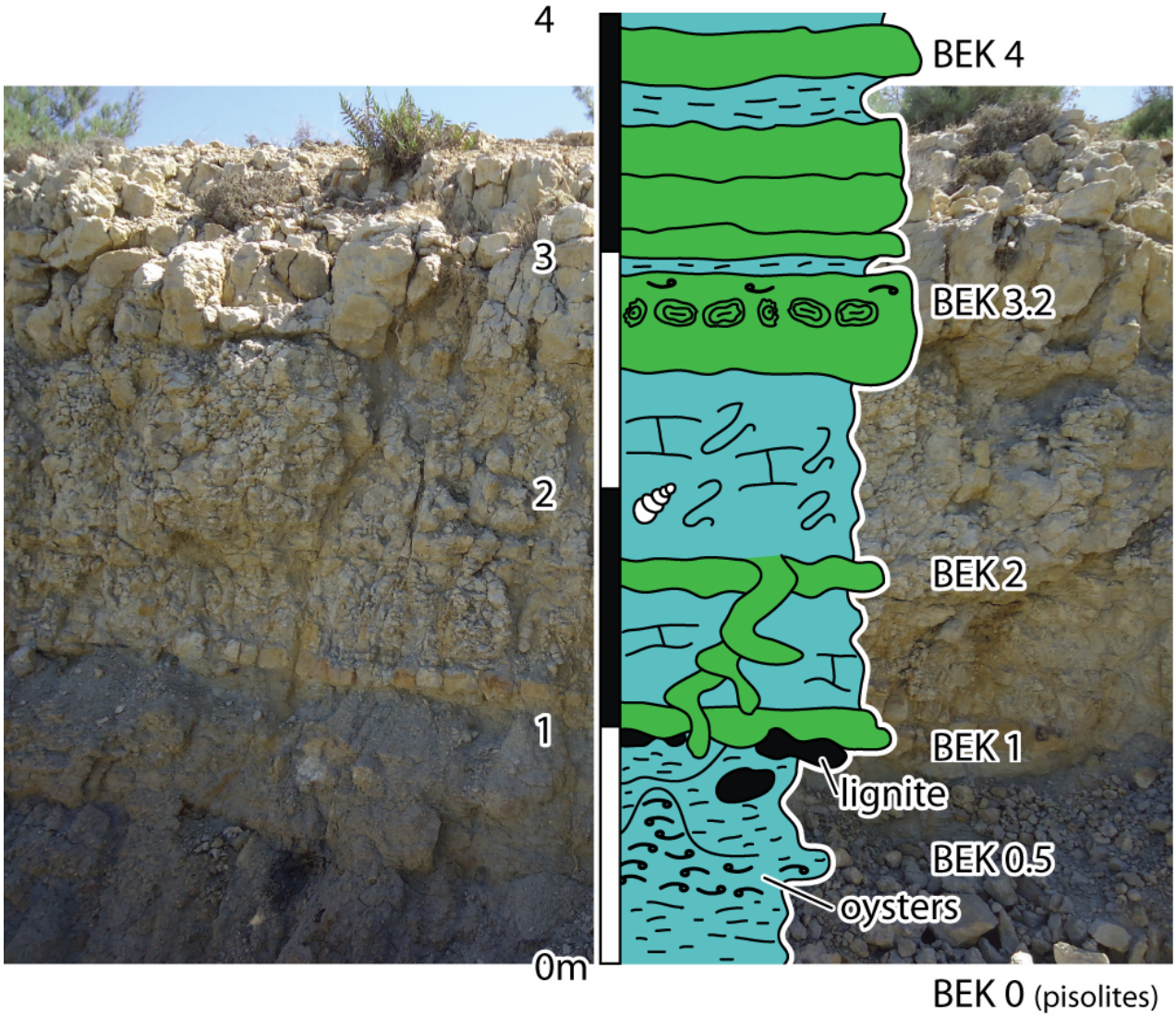

Figure 4: Detail of the section at Homsiyeh. BEK 0.5 is a floatstone of bored oysters with a bioclastic wackestone matrix. *Choffatella* gr. *decipiens* are abundant and sand-sized quartz grains are common. BEK 1 is a bioclastic wackestone with gastropods, *Choffatella* gr. *decipiens* and *Salpingoporella dinarica*. BEK 2 is a bioturbated mudstone with silt-sized quartz grains. BEK 3.2 is a floatstone of pisolites with a bioclastic wackestone matrix. Bioclasts consist of *Salpingoporella dinarica*, gyrogonites and Charophyta thalli (*Munieria parvula* n.comb.). BEK 4 is a bioclastic wackestone with abundant Charophyta remains (thalli, utricles and gyrogonites).

At Homsiyeh (Fig. 3, red dot), within the pisolitic marls, we identified a 3 m thick interval consisting of limestones with mudstone and wackestone textures (Fig. 4). The lower 1.5 m part, which is extensively bioturbated with large burrows up to 7 cm in diameter, corresponds to marine deposits. The upper 1.5 m part corresponds to deposits in brackish coastal swamps. Isolated charophyte remains (thalli, utricles and gyrogonites) were obtained after washing and sieving the sediment from the marly layers and thin sections were made from the limestones. Some sections of utricles observed in the limestone are shown in our Pl. 2, figs. A-G. Császár and Bodrogi (1983: Pl. IV, fig. 2; Pl. XIII, fig. 4) have described as "*Chara* gyrogonits" some Hungarian specimens similar to our material; specifically, sections of utricles with the characteristic 6 pores corresponding to the 6 spine-shaped bracts of the external utricular layer as documented in our material (Pl. 2, fig. A-G). We also illustrate some sections of small-sized *Muniera*-like thalli (Pl. 2, figs. H-K): *Munieria parvula* Carozzi, 1946, n.comb. (see § Systematics). In addition, in the marly levels, we identified *Clavator ampullaceus* (Grambast & Lorch, 1968) Martín-Closas, 1996 (Pl. 3, figs. A-E), *Clavator delteus* (Grambast & Lorch,

1968) n.comb. GRANIER, AZAR & MAKSOUD* (Pl. 3, figs. F-H), *Ascidiella reticulata* GRAMBAST & LORCH, 1968 (Pl. 3, figs. I-K), and the Triploporellacean alga *Salpingoporella (Hensonella) dinarica* (RADOIČIĆ, 1959) (Pl. 4, figs. H-I).

At Ain Dara (Fig. 1 ; Pl. 1, fig. B), we sampled marls above and below a thick bed consisting of lacustrine limestones, located some ten meters below the "Banc de Mréjatt". In the marly levels, we identified *Clavator ampullaceus* (GRAMBAST & LORCH, 1968) (Pl. 4, figs. A-F), *Atopochara trivolvis* var. *triquetra* GRAMBAST, 1968 (Pl. 5, fig. D) and a new representative of the organ genus *Charaxis* HARRIS, 1939 (Pl. 4, fig. G; Pl. 5, figs. E-I; Pl. 6, figs. A-E). The limestone bed (Pl. 6, fig. F) also contains an abundance of these *Charaxis*-like thalli (see § Systematics)

At Falougha (Fig. 1 ; Pl. 1, fig. A), we sampled marls within a set of beds consisting of lacustrine limestones, located a few meters below the "Banc de Mréjatt". In this marly level, we identified *Sphaerochara asema* (GRAMBAST & LORCH, 1968) n.comb. GRANIER, AZAR & MAKSOUD** (Pl. 5, fig. A) and *Ascidiella reticulata* GRAMBAST & LORCH, 1968 (Pl. 5, figs. B-C).

4. Systematics (B.G., D.A. & S.M.)

Article 11.1 of the "International Code of Nomenclature for algae, fungi, and plants" (MCNEILL *et al.*, 2012) states that "the use of separate names is allowed for fossil-taxa that represent different parts, life-history stages, or preservational states of what may have been a single organismal taxon or even a single individual (Art. 1.2)". This section on systematics deals with charophyte thalli ascribed to the organ genera *Munieria* DEECKE, 1883, and *Charaxis* HARRIS, 1939.

Division Charophyta MIGULA, 1897

Class Charophyceae SMITH, 1838

Order Charales LINDLEY, 1836

Organ genus *Munieria* DEECKE, 1883

Almost 40 years passed between the description of *Munieria baconica* by DEECKE (1883) and new illustrations of this species by PIA (1920); again another 40 years passed until new *Munieria* specimens were illustrated by DELMAS and DELOFFRE (1962). During this 1920-1960 period, new species were introduced; however, they were not ascribed to this genus but either to the Polyphysacean genus *Clypeina* (MICHELIN, 1845) or the charophyte genus *Charaxis* HARRIS, 1939. During this period, all the identifications of the species *baconica* were erroneous because the illustrated specimens were mainly representatives of the Polyphysacean genera *Clypeina* or *Actinoporella* GÜMBEL *in* ALTH, 1882. In addition, although the specimens of DELMAS and DELOFFRE (1962) belong to *Munieria*, they should not be ascribed to the species *M. baconica* mainly due to differences in sizes. To complete this story, we note that a new species was introduced by BYSTRICKÝ (1976) and a new variety by CHERCHI *et al.* (1981).

The question of the ascription of the genus *Munieria* to the Dasycladales (PIA, 1920; POIGNANT, 1969; FEIST *et al.*, 2003, 2005) or to the Charophytes (RADOIČIĆ, 1969; BASSOULLET *et al.*, 1978; CSÁSZÁR & BODROGI, 1983; SCHUDACK, 1989; GRANIER & DELOFFRE, 1993; MARTÍN-CLOSAS, 2000) was until now still in debate, despite the fact that all the elements necessary to establish that all *Munieria* species should be referred to as Charophytes (*i.e.*, random and oriented sections, isolated specimens, 3D reconstructions, mineralogy***, micropaleontological assemblages and paleoenvironments) were already present in RADOIČIĆ's paper (1969) and supported by the excellent illustrations of PECORINI (1972).

There is no original diagnosis for this monotypic genus. We cite the original description of its subordinate species (DEECKE, 1883, p. 9-11): "Das Fossil (Fig. 4) ist 5-7 mm lang, rund cylindrisch, oben rasch in eine stumpfe Spitze auslaufend. Es besteht aus einer Anzahl von gleichwerthigen, gleichgebauten, biconcaven Gliedern, deren immer 2 auf den Millimeter gehen, so dass man bei der Länge von 5-7 mm deren 10-14 zählen kann. Der Querschnitt in

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* The basyonim is *Lucernella deltea* GRAMBAST & LORCH, 1968, *Nat. Monspeliensia* (Ser. Bot.), 19: 50-51, Pl. II, fig. 10.a-b (holotype C-705-6); Pl. III, figs. 1-5.
Contrary to MARTÍN-CLOSAS' (1996) opinion, we do not consider *Lucernella ampullacea* GRAMBAST & LORCH, 1968, and *L. deltea* GRAMBAST & LORCH, 1968, as two varieties of a single species.

** The basyonim is *Peckisphaera asema* GRAMBAST & LORCH, 1968, *Nat. Monspeliensia* (Ser. Bot.), 19: 52-53, Pl. III, figs. 7 (holotype C-705-6) & 8-12.
The type-species of the genus *Peckisphaera* GRAMBAST, 1963, is *Sphaerochara verticillata* (PECK, 1937) 1957. However, MARTÍN-CLOSAS (2000) reverted this species to the original genus. Consequently, *Peckisphaera* GRAMBAST, 1963, should be treated as a junior synonym of *Sphaerochara* MÄDLER, 1952. However, MARTÍN-CLOSAS (2000) did not state explicitely on the status of the remaining species. Accordingly, we (B.G., D.A. & S.M.) agreed to transfer the species *Peckisphaera asema* GRAMBAST & LORCH, 1968, to the genus *Sphaerochara* MÄDLER, 1952.

*** The extracellular calcification of the Dasycladales was/is mostly aragonitic and rarely consisted of yellowish calcite as in *Salpingoporella* (*Hensonella*) *dinarica* (RADOIČIĆ, 1959) or in *Salpingoporella urladanasi* CONRAD *et al.*, 1977, for instance (see GRANIER, 2012). In contrast the calcification of vegetative remains of charophytes can be partly in magnesium calcite and partly in aragonite (MARTÍN-CLOSAS, personal communication).

der Mitte der Kalkalge beträgt 0,75 mm und nimmt nach oben und unten nur ganz wenig ab, respektive zu. Aussen ist auf der Mitte eines jeden Gliedes ein einfacher Kranz von runden grossen Poren zu sehen, der meist ein klein wenig über dem übrigen Theile des Gliedes erhaben ist, was man wohl der Verwitterung zuschreiben darf. Sonst zeigte sich keine weitere Ornamentirung, und an gut erhaltenen Exemplaren reihen sich die Glieder ununterbrochen an einander, so dass selbst ihre Grenzlinien verschwimmen und ihre Zahl nur aus der Anzahl der Porenkränze geschlossen werden kann. Solche Individuen sind jedoch recht selten, meistens zeigen sich die Pflanzen gliederweise verschoben, so dass die einzelnen Glieder stufenweise auf und neben einander liegen."

[The fossil (Pl. I, fig. 4) is 5 to 7 mm long, roughly cylindrical, and ends abruptly in a blunt tip. It has a number of equal, similar, biconcave segments; there are always two per millimeter, that is, there are from 10 to 14 of them on the 5 to 7 mm long specimens. The diameter of this calcareous alga is 0.75 mm in the middle and tapers slightly in both directions. A single ray of large round pores surrounds the middle of each segment. The ray is slightly raised above the other parts of the segment perhaps due to weathering. There are no further ornaments and in well-preserved samples the segments are strung together without interruption so that even the boundaries are blurred. Therefore their number can be assessed only by the number of the rings of pores. However, such intact specimens are very rare because the individual segments separate and end up either next to each other or overlapped.]

"Ein Querschnitt (Fig. 5), in der Ebene des Porenringes geführt, zeigt uns in der Mitte eines jeden Gliedes einen runden ziemlich weiten Axenkanal, von dem radial 12-16 grosse, einfache Seitenkanäle ausstrahlen. Dieselben beginnen fein, erweitern sich dann mehr und mehr, bis sie sich dicht vor der Mündung wieder einschnüren. Dadurch erhalten sie eine keulenförmige Gestalt, an der sie in den Dünnschliffen leicht zu erkennen sind. Diese Porenkanäle liegen eingebettet in eine Kalkschicht (Fig. 5, k), welche den ringförmig cylindrischen Raum, der in jedem Gliede von dem Axenkanale und der Aussenwand umschlossen wird, in der Mitte horizontal durchsetzt und denselben in zwei getrennte Hälften zerlegt, die mit einander nur durch den Centralkanal kommuniziren. Ein Längsschnitt (Fig. 6) durch die Mitte des Axenkanales gelegt, zeigt uns, wie sich die äussere Wandung der Glieder von dem Porenkranze aus noch ein gutes Stück nach oben und unten erstreckt und sich dabei derart verdünnt, dass sie an der Berührungsfläche mit dem nächsten Gliede ihre geringste Dicke erlangt. Es erhalten hierdurch die Glieder eine eigenthümlich biconcave Form, welche für den Gesammtaufbau der Pflanze äusserst charakteristisch ist. Denn weil sich zwei solche Glieder nur an der Aussenwand in einem sehr schmalen Ringe und dann nur noch in dem Centralkanal berühren. so muss bei ihrer biconcaven Gestalt dadurch ein ringförmiger Hohlraum entstehen, der zwischen dem Kanal und der Wand herumläuft. Es scheint derselbe von der Aussenwelt und dem centralen Rohre abgeschlossen gewesen zu sein, wenigstens habe ich trotz langen Suchens keine Poren mehr finden können, die ihm mit dem einen oder der anderen eine Communikation erlaubt hätten. Als wahrscheinlicher muss aber doch angenommen werden, dass dieser Hohlraum mit Algenmasse erfüllt war, die sich von dem centralen Algenfaden aus durch die Intermittenz des centralen Kanales an der Berührungsstelle zweier Glieder in diese Zwischenräume hin erstrecke."

[A cross-section (Pl. I, fig. 5) through the level of the ring of pores reveals a round, wide axial channel in the middle of each segment from which 12 - 16 large simple side channels radiate. These side channels are at first thin and then gradually become wider until they become restricted near the end. The resultant club-shape is readily identified in thin sections. The pore channels are embedded in a calcareous layer (Pl. I, fig. 5, k) that accumulates in the middle at right angles to the circular, cylindrical space formed by the axial channel and outer wall of each segment. The space is separated into two halves which communicate with each other through the central channel. A longitudinal section (Pl. I, fig. 6) through the middle of the axial channel demonstrates that the outer wall of the segments extends considerably above and below the pore ring and becomes narrower in such a way that it has its smallest diameter at the contact surface with the next segment. Therefore the segments have a curious biconcave shape which is highly characteristic of the basic construction of the plant. If two such segments only touch each other on the outer wall in a small ring and in the central channel, the biconcave shape should lead to a ring-shaped cavity between channel and wall. This cavity seems to have been separated from the outside and the central pipe. In spite of intense search, I did not observe additional pores which would allow communication between one cavity and the other. It is possible that this cavity was filled with an algal mass which extended from the central alga thread through the central channel where two segments meet.]

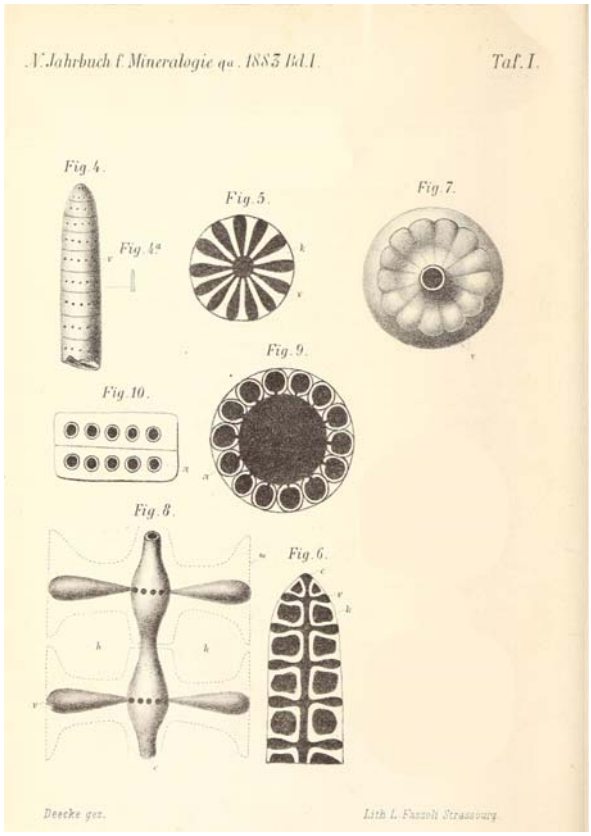

Figure 5: Excerpt from DEECKE (1883).

"Wie weiter der Längsschnitt lehrt, erweitert sich der Axenkanal an den Punkten, wo er die Verticillen entsendet, ein wenig und endigt oben in einem kleinen knopfartigen Vegetationspunkte."

[The longitudinal section also shows that the axial channel extends from the point of the origins of the whorls and terminates at the top in a small button-shaped point.]

"Ein derartiges leichtes, mit grossen Hohlräumen versehenes Kalkgerüst, muss natürlich rasch in seine Bestandtheile zerfallen, sobald dieselben nicht mehr von der Pflanzenmasse zusammengehalten werden. Als solche Trennungsstellen sind ja an und für sich schon die Berührungsflächen der Glieder charakterisirt; hier bei *Munieria* jedoch sind es dieselben in noch höherem Grade, weil sich an diesen Punkten sowohl die dünnste Stelle befindet als auch hinter derselben noch der grosse Hohlraum liegt. Bei schwachem seitlichen Drucke musste daher schon das Gerüst hier zerbrechen, und so erklärt sich die Seltenheit der unverletzten und das Vorwiegen der gliederweis zerbrochenen Exemplare. Auch solche einzelne Glieder hat H. M. v. HANTKEN angetroffen; dann zeigen dieselben aber noch einen viel weiter vorgeschrittenen Zustand der Zerstörung, derart, dass nach Abwitterung alles anderen eigentlich nur die mittlere Partie erhalten geblieben und ein solches Glied auf die Hälfte seiner ursprünglichen Höhe reducirt ist. Ich habe eines von ihnen in Fig. 7 wiedergegeben, da uns dasselbe die Beschaffenheit der Oberfläche der *Munieria*-Glieder ausgezeichnet erkennen lässt. Auf der Kalkschicht, welche, wie ich oben sagte, die Poren umschliesst, zeigen sich denselben ganz entsprechende Erhöhungen, die fein von dem Centralkanale ausstrahlend sich nach dem Rande zu keulenartig verdicken, ebenso wie ich es oben von einer einzelnen Verticille beschrieben habe. Man sieht aus der Zeichnung schon, dass die ganze Kalkschicht nichts anders als das Produkt der sich berührenden Verticillen ist."

[Clearly such a delicate calcareous structure with large cavities disintegrates rapidly into its elements if it is not kept together anymore by the mass of the plant. Characteristically, such parts separate at the contact surfaces of the segments; however, for *Munieria* this holds true even more since it is thinnest at these surfaces which are also in front of large cavities. The skeleton would already disintegrate with a slight lateral pressure. Therefore, intact skeletons are rare but there are numerous segments of broken specimens. Such single segments were observed by H. M. v. HANTKEN. However, these reveal an advanced state of deterioration so that with the continuing weathering of their entirety only the middle part is preserved and is reduced to half of its initial height. I show one of them in Pl. I, fig. 7 because it demonstrates very well the composition of the surface of the *Munieria* segments. As I mentioned above, the same elevations around the pores can be seen on the calcareous layer which surrounds them. They radiate from the central channel, where they are thin, to the rim, becoming club shaped on the way, just as I described above for the single whorls. One can see in the drawing that the whole calcareous layer is only the result of the whorls touching each other.]

"Wenn wir uns jetzt nach dem wirklich Beobachteten die Pflanze selbst wieder herzustellen suchen, so erhalten wir folgendes Bild. Der centrale Algenfaden Fig. 8) erstreckt sich von der Wurzel bis in die Spitze, wo er in dem knopfartigen Vegetationspunkte endigte. Er schied den Kalk des Axenkanales ab. Von Zeit zu Zeit erweiterte sich aber derselbe und entsandte dann 12-16 Verticillzweige (v), die gleichfalls mit der Eigenschaft sich zu inkrustiren ausgestattet waren und sich daber in ihrer ganzen Länge mit Kalk umgaben. Und so entstand die Kalkschicht (w) in der Mitte der Glieder."

[If we try to reconstruct the plant from the real observations we can make the following picture. The central alga thread (Pl. I, fig. 8) extends from the root to the tip where it terminates in a button-shaped point. The thread secreted the calcium of the axial channel. From time to time however, it widened and develo-

ped 12 - 16 branches of verticilles (v) (whorls), which also calcified and, therefore, in their whole length were surrounded by calcium. This is how the calcareous layer (w) in the middle of the segments arose.]

Emended generic diagnosis (B.G.): "Remains of Charophyte thalli consisting of the intercellular calcification of nodes and internodes, commonly broken at the level of the nodes in individual 'articles' (internodes) or short series of 'articles' (internodes plus nodes). At the level of a node, pores are arranged in a single whorl; they correspond to rather long nodal cells from each of which departs a set of cortical cells. The internodes are preserved in the form of hollow calcitic cylinders with the axial hole corresponding to one internodal cell and often displaying a ribbed outer surface where the grooves correspond to the mark of the contiguous cortical cells. The inner diameter of an internode is commonly less than half its outer diameter."

Type-species: *Munieria baconica* DEECKE, 1883.

Munieria baconica DEECKE, 1883

(Pl. 7, figs. A-G; Pl. 8, figs. A-F)

Synonymy list (years in red indicate papers with original, previously unpublished illustrations):

1883 *Munieria baconica* M. von HANTKEN.- DEECKE, p. 9-11, Pl. 1, figs. 4, 4a, 5-6 [Aptian *fide* CONRAD & RADOIČIĆ, 1972], 7-8 (reconstruction)

non **1883** *Munieria baconica* ("Fructifikationsorgane").- DEECKE, Pl. 1, fig. 9 {*Charaxis* sp.}

? **1883** *Munieria baconica* ("Fructifikationsorgane").- DEECKE, Pl. 1, fig. 10

1913 *Munieria baconica*.- STOPES, p. 240-242, Figs. 3-4 (excerpt from DEECKE, 1883)

1920 *Munieria baconica*.- PIA, p. 144-146, Fig. 25, 7-8 (reconstruction); Pl. VII, figs. 16-26 [Aptian *fide* CONRAD & RADOIČIĆ, 1972]

1927 *Munieria baconica*.- PIA *in* HIRMER, p. 70-71, Fig. 51 (excerpt from PIA, 1920)

non **1948** *Munieria baconica*.- CAROZZI, p. 147-149, Fig. 48(1-17); Pl. VI, fig. 3 {*Actinoporella podolica* (ALTH) *fide* CONRAD *et al.* (1974), *pro parte*, and *Clypeina* ? *solkani* CONRAD & RADOIČIĆ *fide* CONRAD & RADOIČIĆ (1972), *pro parte*}

non **1955** *Munieria baconica*.- CAROZZI, p. 47-49, Figs. 10(1-20)-11(1-17)-12(1-20); Pl. VI, fig. 2 {*Actinoporella podolica* (ALTH) *fide* CONRAD *et al.* (1974), *pro parte*, and *Clypeina* ? *solkani* CONRAD & RADOIČIĆ *fide* CONRAD & RADOIČIĆ (1972), *pro parte*}

non **1958** *Munieria baconica*.- DONZE, p. 190-191, Fig. 27 {*Clypeina* ? *solkani* CONRAD & RADOIČIĆ *fide* CONRAD & RADOIČIĆ (1972)}

non **1958a** *Munieria baconica*.- ELLIOTT, 255, Pl. 45, fig. 1 {*Actinoporella podolica* (ALTH) *fide* CONRAD *et al.* (1974)}

non **1958b** *Munieria baconica*.- ELLIOTT, Pl. 3, fig. 1 {*Clypeina* sp. *fide* ELLIOTT (1968)}

non **1958** *Munieria baconica*.- DUFAURE, Pl. 3, fig. 1 {*Actinoporella podolica* (ALTH) *fide* CONRAD *et al.* (1974)}

non **1958** *Munieria baconica*.- RADOIČIĆ, p. 83, Figs. 2-3; Pl. I, figs. 1-3 {*Clypeina* ? *solkani* CONRAD & RADOIČIĆ *fide* CONRAD & RADOIČIĆ (1972)}

non **1960** *Munieria baconica*.- RADOIČIĆ, Pl. VIII, fig. 2; Pl. IX, fig. 2 {*Clypeina* ? *solkani* CONRAD & RADOIČIĆ *fide* CONRAD & RADOIČIĆ (1972)}

1961 *Munieria baconica*.- PIA (French version by GUBLER), p. 144-146, Fig. 25; Pl. 7, figs. 16-26

1961 *Munieria baconica*.- JOHNSON, p. 131, Pl. 56, figs. 1-7 (excerpts from PIA, 1920)

non **1962** *Munieria baconica*.- SARTONI & CRESCENTI, Pl. XXXII, figs. 5-6 & 9

non **1968** *Munieria baconica*.- ELLIOTT, p. 57-58, Pl. 15, figs. 3-8 {*Clypeina* ? *solkani* CONRAD & RADOIČIĆ *fide* CONRAD & RADOIČIĆ (1972)}

1969 *Munieria baconica*.- JOHNSON, p. 67, Pl. 48, figs. 1-12 (excerpts from PIA, 1920)

1969 *Munieria* sp. 1.- POIGNANT, p. 235, Pl. 2, figs. 10-14 [Santonian]

1969 *Munieria* sp. 2.- POIGNANT, p. 235, Pl. 2, figs. 15-17 [Santonian]

non **1970** *Munieria baconica*.- SAINT-MARC, Pl. 2, figs. 6-7

non **1971** *Munieria baconica*.- BASSON & EDGELL, p. 422, Pl. 3, figs. 3-4

1972 *Munieria baconica*.- CONRAD & RADOIČIĆ, p. 88-89, Fig. 4; Pl. I, figs. 1-3 [Aptian]

non **1972** *Munieria baconica*.- PECORINI, p. 380 & 383, Fig. 4(k-l)

1976 *Munieria baconica*.- BYSTRICKÝ, p. 54-60, Pl. III, figs. 1-8; Pl. IV, figs. 1, 3-7 [Aptian]

non **1978** *Munieria baconica*.- GARCÍA-HERNÁNDEZ, Pl. XXVII, fig. 14 {*Clavatoraxis* sp.}

non **1979** *Munieria baconica*.- DRAGASTAN & BUCUR, p. 54-60, Pl. I, fig. 1 {*Montiella* sp.}

1983 *Munieria baconica*.- CSÁSZÁR & BODROGI, p. 171, Pl. I, figs. 1-3; Pl. II, figs. 1-3; Pl. IV, figs. 1-2; Pl. V, fig. 3; Pl. XII, figs. 1-4

1983 *Munieria* sp. A.- CSÁSZÁR & BODROGI, Pl. IX, figs. 1-2; Pl. X, figs. 1-2

non **1987** *Munieria baconica*.- GRANIER, p. 173, Pl. 30, figs. g-h {cf. *Clypeina parasolkani* FARINACCI & RADOIČIĆ}

non **1988** *Munieria baconien* [sic].- GRANIER, p. 59-60, Pl. 1, figs. g-h (excerpt from GRANIER, 1987)

2003 *Munieria baconica*.- FEIST *et al.*, p. 128-129, Figs. 8-15 [Aptian]

2013 *Munieria baconica*.- FŐZY & SZENTE, p. 156, Fig. p. 158(5) [Tés Marl Fm = Albian]

DEECKE (1883) drew an isolated specimen (*op. cit.*: Pl. 1, figs. 4 & 4a; herein Figs. 5.4 & 5.4a) and few sections and reconstructions of *Munieria baconica*, the type-species of the genus. One of his drawings (*op. cit.*: Pl. 1, fig. 9; herein Fig. 5.9) labelled "Fructifikationsorgane" probably represents a section of another charophyte thallus, a *Charaxis* sp. The more representative drawings are his Pl. 1, fig. 5 (herein Fig. 5.5), which is a transverse section at the level of an internode (see our Pl. 7, fig. F), and his Pl. 1, fig. 6 (herein Fig. 5.6), which is an axial section (see our Pl. 8, fig. F). This original material is possibly lost.

However, the species is better known from PIA's 1920 book on "Die Siphoneae verticillatae vom Karbon bis zur Kreide" (or its 1961 French

version as "Les Siphonées verticillées du Carbonifère au Crétacé"). The thin sections studied by PIA in 1920 are part of the collection hosted by the Naturhistorisches Museum Wien, but they were not inventoried because they were part of a small set of thin sections that were not given a label*. One of us (B.G.) identified the material studied by PIA (1920: Pl. VII, figs. 16-26; herein under Pl. 7, figs. A-E & G and Pl. 8, figs. A-E): eight (8) drawings that illustrate specimens from thin section M.F.I. 70 (Fig. 6), from a rock sample collected at Pénzesgyőr (Hungary) and sent to PIA either by M. HANTKEN (the collector of the material originally studied by DEECKE), L. LOCZY or H.V. TAEGER; two (2) drawings from thin section M.F.I. 73 (Fig. 6), Sűrű-hegy (Hungary), and one (1) drawing from thin section M.F.I. 72 (Fig. 6), Tündér-major (Hungary). All these localities are situated within a 5 kilometre radius from Zirc in the Veszprém county (Hungary).

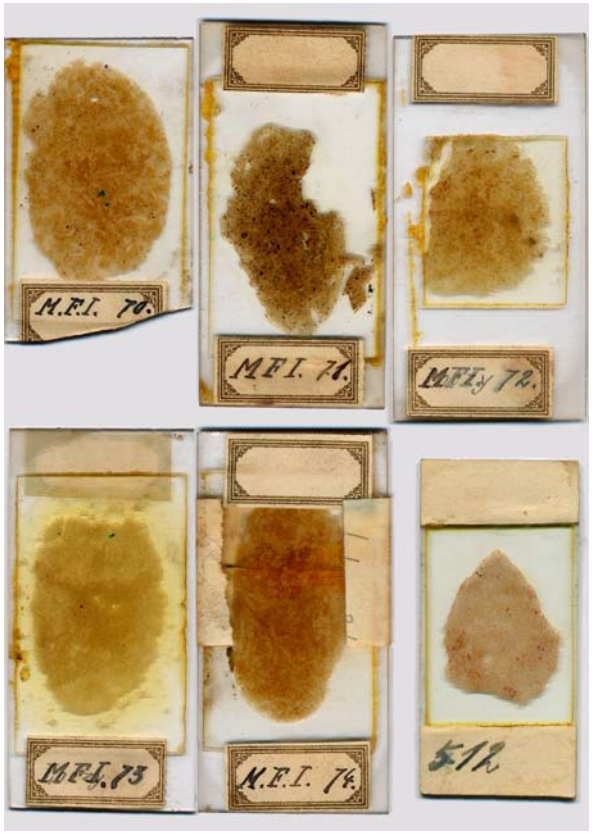

Figure 6: Original thin sections (6) labelled 512 and M.F.I.** 70 to 74 from the PIA Collection with *Munieria baconica* DEECKE, 1883. PIA (1920) illustrated specimens from thin sections M.F.I. 70 (*op. cit.*: Pl. VII, figs. 17-21 & 24-26), 72 (*op. cit.*: Pl. VII, fig. 23) and 73 (*op. cit.*: Pl. VII, figs. 16 & 22). Details are shown on Pls. 7 - 8.

* There are two discrete batches in the referenced collection, one with Roman numerals and the other with Arabic numerals.

** M.F.I. possibly stands for the Magyar Földtani Intézet.

We select the specimen first illustated by PIA (1920) in his Pl. 7, fig. 16 (herein under Pl. 7, fig. B) from thin section M.F.I. 73 (Sűrű-hegy, Hungary) as the neotype of the species.

In this set of thin sections (Fig. 6), the assemblage is almost monospecific, largely dominated by *Munieria* thalli, with rare *Charaxis* thalli and few utricles. In their Hungarian material, FEIST *et al.* (2003) have also "found together (…) *Muniera* thalli and the utricles of *Atopochara trivolvis* PECK". However, there are no remains of Dasycladales, of Foraminifera or of Echinids in the wackestone matrices of PIA's Hungarian material, which suggests rather brackish (hyposaline) water than normal sea water. Accordingly, paleoenvironments also help us in proposing a charophyte nature and arguing against the Dasycladalean interpretation.

Originally described from Aptian strata in Hungary (DEECKE, 1883), the species occurs at least up to the Santonian (POIGNANT, 1969).

Munieria parvula CAROZZI, 1946, n.comb.

(Pl. 2, figs. H, I *pars*, J *pars,* K *pars* & L)

Synonymy list (years in red indicate papers with original, previously unpublished illustrations):

1946 *Clypeina parvula* n.sp. [basyonym].- CAROZZI, p. 24-26, Fig. 1 (A-H) ["Purbeckien" = Upper Tithonian - Lower Berriasian]
1948 *Clypeina parvula*.- CAROZZI, p. 151-154, Figs. 50(1-18)-51; Pl. VI, fig. 2 ["Purbeckien"]
1955 *Clypeina parvula*.- CAROZZI, p. 52-53, Figs. 13(1-13)-14(1-9); Pl. VI, fig. 2 ["Purbeckien"]
non **1956** *Clypeina parvula*.- RADOIČIĆ-BRSTINA & MILAKOVIĆ, Pl. XIV, figs. 1(b) - 2(b)
1957 *Charaxis striatus* n.sp.- PECK, p. 40, Pl. 3, figs. 10-12 [Bear River Fm, ? Cenomanian]
1958 *Clypeina parvula*.- DONZE, p. 187-188, Fig. 25.1-4 ["Purbeckien"]
1960 *Clypeina parvula*?- RADOIČIĆ, Pl. XX, fig. 1; Pl. XXII, fig. 1 [Aptian-Albian]
1962 *Munieria baconica*.- DELMAS & DELOFFRE, p. 216 & 218, Pl. 3, figs. 19-32 ; Pl. 4 *pars* [Albian or Cenomanian]
non **1962** *Clypeina parvula*.- ANIČ, Pl. VIII, fig. 12 (number "10" in caption!)
non **1962** *Munieria baconica*.- SARTONI & CRESCENTI, Pl. XLII (XXXII), figs. 7-8 {*Salpingoporella* sp.}
? **1967** *Clypeina parvula*.- NIKLER & SOKAČ, p. 121, Pl. VI, figs. 8-9
1968 *Munieria baconica*.- BOUROULLEC & DELOFFRE, p. 232, Pl. 6, figs. 10-13 ["passage Jurassique-Crétacé"]
? **1969** *Clypeina parvula*.- BARTHEL, p. 44
non **1969** *Munieria* sp.- BARTHEL, p. 45, Pl. 3, fig. 7
1969 *Munieria baconica*.- JOHNSON, p. 67, Pl. 49, figs. 19-32 (excerpts from DELMAS & DELOFFRE, 1962)
1969 *Charaxis striatus*.- JOHNSON, p. 84, Pl. 60, figs. 1-3 (excerpt from PECK, 1957)
1969 "stems of Charophyta previously entitled to Dasycladacaea (*Munieria baconica*, *Clypeina parvula*)".- RADOIČIĆ, p. 72-73, Fig. 4 (a-g)

[Cenomanian]
non **1971** *Clypeina parvula*.- BASSON & EDGELL, p. 422, Pl. 6, fig. 3
1971 *Septorella*.- FABRE-TAXY & CHATELET, p. 3021-3023, Pl. I, figs. 1-13 ["Bégudo-Rognacien" = Maastrichtian]
1972 *Munieria baconica*.- SAMUEL *et al.*, Pl. CXV, figs. 1-4; Pl. 2, figs. 1-10 [Barremian-Aptian, reworked in Santonian-Campanian]
1972 *Clypeina parvula*.- PECORINI, p. 374-378, Figs. 1(a-k)-2(a-q) ["Purbeckiano" = Upper Tithonian - Lower Berriasian]
1973 *Munieria baconica*.- JAFFREZO, p. 81, Pl. 1, figs. 13-15 [Barremian]
1976 *Munieria grambasti* n.sp.- BYSTRICKÝ, p. 48-54, Pl. I, figs. 1-14; Pl. II, figs. 1-16, 18, 20-21, 24-26; Pl. IV, fig. 2 [Lower Cretaceous]
1978 *Clypeina parvula*.- BASSOULLET *et al.*, p. 52-55, Pl. 4, fig. 8 (excerpt from CAROZZI, 1946) - 9 (excerpt from PECORINI, 1972)
1979 *Munieria* cf. *baconica*.- AZÉMA *et al.*, p. 54-60, Pl. XXII, fig. 2; Pl. XXV, fig. 3 [Aptian]
1981 *Munieria grambasti sarda* n.ssp.- CHERCHI *et al.*, p. 142-143, Fig. 2(1-4) ; Pl. 1, figs. 1-7; Pl. 2, figs. 1-10 [Cenomanian]
1982 *Munieria grambasti sarda*.- GELLAI & TÓTH, p. 268-270, Pl. I., fig. 1; Pl. II, figs. 2-3; Pl. III, figs. 4-5 [Ajka Fm = Senonian]
1983 *Munieria* sp. B.- CSÁSZÁR & BODROGI, Pl. XI, figs. 1-3 [Albian]
1983 *Munieria tésense* n.sp. (*nomen nudum*).- CSÁSZÁR & BODROGI, Pl. XIV, figs. 1-2 [Albian]
1984 "*Clypeina parvula*".- BERNIER, p. 497, Pl. 14, fig. 1 ["Purbeckien"]
1989 *Clypeina parvula*.- CAROZZI & DECROUEZ, p. 260
1991 *Munieria* ex gr. *grambasti*.- SCHLAGINTWEIT, p. 51, Pl. 1, fig. 2; Pl. 18, figs. 14-16
1992 *Munieria grambasti sarda*.- SCHLAGINTWEIT & WAGREICH, p. 23-24, Fig. 2 ; Pl. 1, figs. 1-7 [Santonian-Lower Campanian]
1994 *Munieria grambasti sarda*.- BODROGI *et al.*, p. 467, Pl. 2, figs. 5-6; Pl. 3 figs. 1 & 4-7 [Santonian-Campanian]
2000 *Charaxis baconicus* n.comb.- MARTÍN-CLOSAS, p. 180-182 & 287-288, Pl. 20, figs. 4-7 [Lower Barremian]
2009 *Munieria*.- CLIMENT-DOMÈNECH & MARTÍN-CLOSAS, Figs. 5(a-b) & 8(f)
2009 *Munieria grambasti sarda*.- PIPÍK *et al.*, p. 467, Fig. 5(M-O) [Santonian-Campanian]
2011 *Munieria grambastii*.- VILLALBA-BREVA & MARTÍN-CLOSAS, Fig. 6(C-D) [Maastrichtian]
2013 *Munieria grambastii*.- VILLALBA-BREVA & MARTÍN-CLOSAS, Figs. 6(c), 8(a) & 11(c) [Maastrichtian]

Clypeina parvula CAROZZI, 1946, was originally described from "Purbeck" facies at the Tithonian-Berriasian transition in Switzerland. The synonymy list above that includes later reports suggests that this species spans the whole Cretaceous. We found it at Homsiyeh.

FABRE-TAXY & CHATELET (1971) and PECORINI (1972) illustrated nice specimens respectively as *Septorella* sp. (FABRE-TAXY & CHATELET, 1971: Pl. I, figs. 1-13) and as *Clypeina parvula* (PECORINI, 1972: Figs. 1(a-k)-2(a-q)). As a matter of fact, this species has all the main features of the genus *Munieria* DEECKE, 1883, which justifies its transfer to this organ genus. It is very close to, though smaller (commonly half the size) than, the type-species, *Munieria baconica* DEECKE, 1883.

Organ genus *Charaxis* HARRIS, 1939

Original diagnosis (HARRIS, 1939, p. 69): "Vegetative charophyte organs agreeing in so far as they are known with *Chara*. Stem consisting of nodes and internodes; internodes composed of a central cell surrounded by a ring of primary cortical cells which grow up and down from the nodes; and may cut off secondary cortical cells at their sides, primary cortical cells giving rise to spine cells; leaves as in *Chara*, either corticated in the same way as the stem, or uncorticated".

Type-species: *Charaxis durlstonense* HARRIS, 1939.

Charaxis martinclosasi n.sp.

(Pl. 4, figs. E-I; Pl. 5, figs. E & G-I; Pl. 6, figs. A-F)

Synonymy list:

1968 "fragment de tige au niveau d'un nœud ; affinités non connues".- GRAMBAST & LORCH, p. 422, Pl. IV, fig. 12

Origin of the name: This species is dedicated to Prof. Carles MARTÍN-CLOSAS (Universitat de Barcelona) for his seminal contribution to the knowledge on fossil Charophyta (see MARTÍN-CLOSAS, 2000, among many other papers).

Holotype: Pl. 5, fig. H

Paratypes: Pl. 4, fig. G; Pl. 5, figs. E, G & I; Pl. 6, figs. A-F

Type-locality: 1.5 km N of Ain Dara (Mount Lebanon Governorate).

Type-level: "Grès du Liban" *auct.*, below the "Banc de Mréjatt"

Age: Barremian, possibly Early Barremian.

Material: One thin section (BGAD) with several random sections (Pl. 6, fig. F) from the limestone bed and a significant number of isolated tridimensional remains from the marly layer above it.

Description: Remains of Charophyte thalli consisting of nodes and internodes, commonly broken in "articles" at the median part of the internodes. Individual articles look roughly like a double cone, up to 1.2 mm in length. At the level of the nodes, which are up to 0.75 mm in diameter, there are 10 pores arranged in a whorl and corresponding to 10 rather short nodal cells ("primaries") from each of which departs a dozen of grooves corresponding to cortical cells ("secondaries"). The internodes are preserved in the form of calcitic cylinders, straightened in their median part where the grooves, which up to 50 µm in width, issued respectively from their lower and upper

internodes met; usually this median zone corresponds to a point of failure. The inner diameter of an internode is commonly more than half its outer diameter. The internodes are formed by one internodal cell coated by the same contiguous cortical cells ("secondaries"). In average there are 50 grooves corresponding to the impressions of cortical cells ("secondaries") per half internode.

Comparison: In the literature, we can find several examples of articles or broken pieces of thalli with scours and grooves on the outer side. For instance, PECORINI (1972: Fig. 2.a-l) illustrated several "articoli isolati" of "*Clypeina*" *parvula*. However, in most cases, the point of failure being at the node level, each article, which is roughly cylindrical, corresponds to a single internode. FEIST *et al.* (2003: Fig. 24) refer to the genus *Septorella* GRAMBAST, 1963, an hollow unbranched segment with scours and grooves and bearing an utricle on one side. The same pattern is observed in our material with an utricle (Pl. 3, figs. F & H) ascribed to *Clavator delteus* GRAMBAST & LORCH, 1968, n.comb., but again its cylindrical shape and the location of the point of failure suggest no direct relationship between this segment with an utricle and the larger pieces of thalli discussed here. SIRNA (1963: Fig. 6) illustrated a specimen, which he called "vegetative part, possibly from *Atopochara*", that has some affinity with our material: this article looks like a double cone and the point of failure is located at the median part of the internode. However, there are two or three rows of pores at the node level, as opposed to one single row in our new species.

5. Conclusions

GRAMBAST and LORCH (1968) described from the "Grès du Liban" *auct.* a rich Charophyta association consisting of *Ascidiella reticulata* GRAMBAST & LORCH, 1968, *Atopochara trivolvis* var. *triquetra* GRAMBAST, 1968, *Clavator ampullaceus* (GRAMBAST & LORCH, 1968) n.comb., *C. delteus* (GRAMBAST & LORCH, 1968) n.comb., *Sphaerochara asema* (GRAMBAST & LORCH, 1968) n.comb., and *Charaxis martinclosasi* n.sp. Based on biostratigraphic data recently acquired from the "Banc de Mréjatt", which is part of the "Grès du Liban" *auct.*, and from the overlying Jezzinian regional stage (MAKSOUD *et al.*, 2014), this charophyte assemblage is now ascribed a Barremian age (possibly Early Barremian), not a Bedoulian age as previously stated.

In the process of carrying out this investigation, material of *Munieria* DEECKE, 1883, from the historical PIA Collection was revised. This taxon is treated here as an organ genus belonging to the charophytes; accordingly, we follow the views of RADOIČIĆ (1969), SCHUDACK (1989), and MARTÍN-CLOSAS (2000), *inter alia*. In our present state of knowledge, *Munieria* includes at least two species: the type-species, *i.e.*, *M. baconica* DEECKE, 1883, as well as a species that occurs in Lebanon: *Clypeina parvula* CAROZZI, 1946, that is consequently renamed here *Munieria parvula* CAROZZI, 1946, n.comb.

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A part of the Lebanese material studied (SEM samples) is registered with MHNUL numbers in the collections of the Muséum d'Histoire naturelle, Université Libanaise, Fanar - El-Matn (Lebanon); another part, consisting of the thin sections, is deposited with LPB numbers in the collections the Département des Sciences de la Terre et de l'Univers, Université de Bretagne Occidentale, Brest (France).

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Bibliographic references

ANIČ D. (1958).- Prilog poznavanju Jure i Krede istočnog dijela Biokova [Ein Beitrag zur Kenntnis des Jura und der Kreide des östlichen Teiles von Biokovo - Gebirge].- *Geolosˇ ki Vjesnik*, Zagreb, Svezak 15, Broj 1, p. 161-175 (XIV Pls.).

AZÉMA J., FOUCAULT A., FOURCADE É., GARCÍA-HERNÁNDEZ M., GONZÁLEZ-DONOSO J.M., LINARES A., LINARES D., LÓPEZ-GARRIDO A.C., RIVAS P. & VERA J.A. (1979). Las microfacies del Jurasico y Cretacico de las zonas externas de las Cordilleras Bébeticas.- Uuniversidad de Granada, 83 p. (XLV Pls.).

BARTHEL K.W. (1969).- Die obertithonische, regressive Flachwasser-Phase der Neuburger Folge in Bayern.- *Bayerische Akademie der Wissenschaften*, *Abhandlungen*, München, Mathematisch-naturwissenschaftliche Klasse, (Neue Folge), Heft 142, 174 p. (14 Pls.).

BASSON P.W. & EDGELL H.S. (1971).- Calcareous algae from the Jurassic and Cretaceous of Lebanon.- *Micropaleontology*, New York, vol. 17, nº 4, p. 411-433.

BASSOULLET J.-P., BERNIER P., CONRAD M.A., DELOFFRE R. & JAFFREZO M. (1978).- Les Algues Dasycladales du Jurassique et du Crétacé.- *Geobios*, Villeurbanne, Mémoire spécial 2, 330 p. (40 Pls.).

BERNIER P. (1984).- Les formations carbonatées du Kimméridgien et du Portlandien dans le Jura méridional. Stratigraphie, micropaléontologie, sédimentologie.- *Documents des Laboratoires de Géologie de Lyon*, nº 91, fasc. 2, p. 445-803 (36 Pls.).

BODROGI I., EBNER F., LOBITZER H., PAŠAVA J. & SACHSENHOFER R.F. (1994).- Die Bitumenmergel der Kainacher Gosau (Steiermark, Österreich). *In*: LOBITZER H., CSASZAR G. & DAURER A. (eds.), Jubiläumsschrift 20 Jahre geologische Zusammenarbeit Österreich-Ungarn, Wien, Teil 2 - A 20 éves magyar-osztrák földtani együttműködés jubileumi kötete, Bécs, rész 2.- Geologische Bundesanstalt, Wien, p. 127-144 (4 Pls.).

BOUROULLEC J. & DELOFFRE R. (1968).- Les algues du Néocomien d'Aquitaine.- *Bulletin du Centre de Recherches de Pau - SNPA*, vol. 2, nº 2, p. 213-261 (7 Pls.).

BYSTRICKÝ J. (1976).- *Munieria grambasti* sp. nov. in Kalk-Geröllen der "Upohlav-Konglomerate" des mittleren Váh-Gebietes (Klippenzone, Westkarpaten).- *Geologica Carpathica*, Bratislava, vol. 27, nº 1, p. 45-64.

CAROZZI A. (1946).- Sur quelques Dasycladacées du Purbeckien du Jura.- *Compte rendu des Séances de la Société de Physique et d'Histoire naturelle de Genève*, vol. 63, nº 1, p. 24-26.

CAROZZI A. (1948).- Étude stratigraphique et micrographique du Purbeckien du Jura suisse.- Thèse Doctorat ès Sciences géologiques et minéralogiques, Université de Genève, nº 1122, 175 p. (VI Pls.).

CAROZZI A. (1955).- Dasycladacées du Jurassique supérieur du bassin de Genève.- *Eclogae Geologicae Helvetiae*, Bâle, vol. 48, nº 1, p. 31-67 (Pls. V-VI).

CAROZZI A. & DECROUEZ D. (1989).- Les collections du département de géologie et des paléontologie des inverstébrés du Muséum d'Histoire naturelle de Genève. 31. la collection micropaléontologique (5ème partie).- *Revue de Paléobiologie*, Genève, vol. 8, nº 2, p. 259-262.

CHERCHI A., GUŠIĆ I., SCHMIDT M. & SCHROEDER R. (1981).- Lacustrine middle Cretaceous with *Munieria grambasti sarda* n.ssp. (Charophyta ?) of Alghero (NW Sardinia).- *Revue de Micropaléontologie*, Paris, vol. 23, nº 3-4, p. 138-150.

CHERCHI A. & SCHROEDER R. (1999).- *Montseciella*, a new orbitolinid genus (Foraminiferida) from the Uppermost Hauterivian - Early Barremian of SW Europe.- *Treballs del Museu de Geologia de Barcelona*, vol. 8, p. 5-23.

CLAVEL B., CHAROLLAIS J., CONRAD M., JAN du CHÊNE R., BUSNARDO R., GARDIN S., ERBA E., SCHROEDER R., CHERCHI A., DECROUEZ D., GRANIER B., SAUVAGNAT J. & WEIDMANN M. (2007).- Dating and progradation of the Urgonian limestone from the Swiss Jura to South-East France.- *Zeitschrift der Deutschen Gesellschaft für Geowissenschaften*, Stuttgart, vol. 158, nº 4, p. 1025-1062.

CLAVEL B., CONRAD M., BUSNARDO R., CHAROLLAIS J. & GRANIER B. (2013).- Mapping the rise and demise of Urgonian platforms (Late Hauterivian - Early Aptian) in southeastern France and the Suisse Jura. *In*: SKELTON P., GRANIER B. & MOULLADE M. (eds.), Special issue: Spatial patterns of change in Aptian carbo-nate platforms and related events.- *Cretaceous Research*, vol. 39, p. 29-46.

CLIMENT-DOMÈNECH H. & MARTÍN-CLOSAS C. (2009).- Charophyte-rich microfacies in the Barremian of the Eastern Iberian Chain (Spain).- *Facies*, Erlangen, vol. 55, p. 387-400.

CONRAD M.A., PRATURLON A. & RADOIČIĆ R. (1974).- The genus *Actinoporella* GUEMBEL *in* ALTH 1882, Dasycladales, green Algae. A revision.- *Geologica Romana*, vol. XIII, p. 1-15.

CONRAD M.A. & RADOIČIĆ R. (1972).- On *Munieria baconica* DEECKE (Characeae) and *Clypeina* ? *solkani*, n.sp. (Dasycladaceae). A case of homeomorphism in calcareous green algae.- *Compte rendu des Séances de la Société de Physique et d'Histoire naturelle de Genève*, (nouvelle série), vol. 6, fasc. 2-3 (1971), p. 87-95 (Pls. I-II).

CSÁSZÁR G. & BODROGI I. (1983).- Munieriák a Magyarországi Krétában [*Munieria* in the

Cretaceous of Hungary].- *Magyar Állami Földtani Intézet Évi Jelentése*, Budapest, Évről 1983, p. 167-212.

DEECKE W. (1883).- Ueber einige neue Siphoneen.- *Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie*, Stuttgart, Jahrgang 1883, Bd. I, p. 1-14 (Taf. I). URL : https://archive.org/stream/neuesjahrbuchfrm18831leon#page/n37/mode/2up

DELMAS M. & DELOFFRE R. (1962).- Un niveau à algues calcaires au passage Albien – Cénomanien en Aquitaine.- *Revue de Micropaléontologie*, Paris, vol. 5, nº 3, p. 214-223 (4 Pls.).

DONZE P. (1958).- Les couches de passage du Jurassique au Crétacé dans le Jura français et sur les pourtours de la "fosse vocontienne" (Massifs subalpins septentrionaux, Ardèche, Grands-Causses, Provence, Alpes Maritimes).- *Travaux des Laboratoires de Géologie de la Faculté des Sciences de Lyon*, Paris, vol. 3, 221 p. (6 Pls.).
URL: https://tel.archives-ouvertes.fr/tel-00814640

DOUVILLÉ H. (1910).- Études sur les rudistes : rudistes de Sicile, d'Algérie, d'Égypte, du Liban et de la Perse.- *Société géologique de France*, Paris, (Paléontologie), *Mémoire* nº 41, t. XVIII, fasc. nº 1, 84 p. (7 Pls.).

DRAGASTAN O. & BUCUR I.I. (1979).- Upper Aptian microfossils from the Cameniţa Valley - Sasca Română (Reşiţa - Moldova Nouă Zone, Banat - Romania).- *Revue roumaine de Géologie, Géophysique et Géographie*, Bucureşti, (Géologie), t. 23, nº 1, p. 111-115 (VI Pls.).

DUBERTRET L. (1934).- Première partie. La carte géologique au millionième de la Syrie et du Liban *In*: Présentation d'une carte géologique générale au 1:1.000.000e de la Syrie et du Liban.- *Revue de Géographie physique et de Géologie dynamique*, Paris, t. VI (1933), fasc. 4, p. 269-318 (2 maps, 2 logs, Pls. XV-XXIV).

DUBERTRET L. (1950).- Notice explicative de la Carte géologique du Liban au 200.000ème.- Ministère des Travaux Publics, Beyrouth, 74 p. (30 Pls.).

DUBERTRET L. (1955).- Feuille géologique au 50.000e de Djezzine.- Notice explicative, Ministère des Travaux Publics, Beyrouth, 80 p. (XII Pls.).

DUBERTRET L. (1963).- A. Liban et Syrie. Chaîne des grands massifs côtiers et confins à l'Est. *In*: DUBERTRET L. (ed.), Liban, Syrie, Jordanie.- *Lexique Stratigraphique International*, Paris, vol. III, Asie, fasc. 10 c1, p. 7-155.

DUBERTRET L. & VAUTRIN H. (1937).- Révision de la stratigraphie du Crétacé du Liban. *In*: Dubertret L. (ed.), Contributions à l'étude géologique de la côte libano-syrienne.- *Haut-Commissariat de la République Française en Syrie et au Liban*, *Notes et Mémoires*, Paris, (Section d'études géologiques), tome II, p. 43-85.

DUFAURE P. (1958).- Contribution à la connaissance du Crétacé basal au Liban.- *Revue de Micropaléontologie*, Paris, vol. 1, nº 24, p. 87-115.

ELLIOTT G.F. (1958a).- Algal debris-facies in the Cretaceous of the Middle East.- *Paleontology*, London, vol. I, part 3, p. 254-259 (Pls. 45-48).

ELLIOTT G.F. (1958b).- Fossil microproblematica from the Middle East.- *Micropaleontology*, New York, vol. 4, nº 4, p. 419-428 (3 Pls.).

ELLIOTT G.F. (1968).- Permian to Palaeocene calcareous Algae (Dasycladaceae) of the Middle East.- *Bulletin of the British Museum* (*Natural History*), Geological (Palaeontological) series, London, Supplement 4, 111 p. (24 Pls.).

FABRE-TAXY S. & CHATELET H. (1971).- Précisions paléontologiques sur les algues *Munieria* DEECKE et *Septorella* GRAMBAST.- *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, Paris, (série D), t. 272, nº 24, p. 3021-3023 (Pl. I).

FEIST M., GÉNOT P. & GRAMBAST-FESSARD N. (2003).- Ancient Dasycladales and Charophyta: convergences and differences, with special attention to *Munieria baconica*.- *Phycologia,* Lawrence, vol. 42, nº 2, p. 123-132.

FEIST M., GRAMBAST-FESSARD N., GUERLESQUIN M., KAROL K., LU H.-N., MCCOURT R.M., WANG Q.-F. & ZANG S.-Z. (2005).- Part B - Protoctista 1. Volume 1: Charophyta.- *Treatise on Invertebrate Paleontology*, the Geological Society of America, Boulder, and the University of Kansas, Lawrence, 170 p.

FŐZY I. & SZENTE I. (2013).- Fossils of the Carpathian region.- Indiana University Press, Bloomington, 508 p.

FRAAS O. (1878).- Aus dem Orient: Geologische Beobachtungen am Libanon.- Schweizerbart, Stuttgart, 278 p.

GARCÍA-HERNÁNDEZ M. (1978).- El Jurásico terminal y el Cretácico inferior de las Sierras de Cazorla y del Segura (Zona Prebética).- Tesis doctorales de la Universidad de Granada, 190, 344 p. (XXXV Pls.).

GELLAI M. & TÓTH K. (1982).- Munierák a Sümeg-Gyepükaján környéki szenonból (ajkai formáció).- *Földtani közlöny*, Budapest, köt. 112, sz. 3, p. 267-274.

GRAMBAST L. (1963).- Classification de l'Embranchement des Charophytes.- *Naturalia monspeliensia*, (sér. Bot.), fasc. 14 (1962), p. 63-87-56.

GRAMBAST L. & LORCH J. (1968).- Une flore de Charophytes du Crétacé inférieur du Proche-Orient.- *Naturalia monspeliensia*, (sér. Bot.),

fasc. 19, p. 47-56 (Pls. I-IV).

GRANIER B. (1987).- Le Crétacé inférieur de la Costa Blanca entre Busot et Altea, Alicante (Espagne) : biostratigraphie, sédimentologie, évolution tectono-sédimentaire.- Thèse, Docteur de l'Université Paris VI (nouveau régime), 23 Novembre 1987 ; *Mémoires des Sciences de la Terre, Université Pierre et Marie Curie*, Paris, 87-49, vol. I (texte): 281 p. ; vol. II (planches): 54 Pls.

GRANIER B. (1988).- Algues Chlorophyceae du Jurassique terminal et du Crétacé inférieur en Alicante.- *Mediterranea*, Alicante, nº 5 (1986), p. 5-96 (12 Pls.).

GRANIER B. (2012).- The contribution of calcareous green algae to the production of limestones: a review. *In* : BASSO D. & GRANIER B. (eds.), Calcareous algae and the global change: from identification to quantification.- *Geodiversitas*, Paris, vol. 34, nº 1, p. 35-60.

GRANIER B., BUSNARDO R., CLAVEL B., MOULLADE M., CHAROLLAIS J., TRONCHETTI G. & DESJACQUES P. (2014).- Refurbishing the Urgonian biostratigraphy: A key section at L'Estellon, Drôme, France. *In*: ROCHA R., PAIS J., KULLBERG J.C. & FINNEY S. (eds.), STRATI2013. First International Congress on Stratigraphy at the cutting edge of stratigraphy.- Springer, Heidelberg, p. 1095-1097.

GRANIER B., CLAVEL B., MOULLADE M., BUSNARDO R., CHAROLLAIS J., TRONCHETTI G. & DESJACQUES P. (2013).- L'Estellon (Baronnies, France), a "Rosetta Stone" for the Urgonian biostratigraphy.- *Carnets Geol.*, Madrid, CG2013_A04, p. 163-207.

GRANIER B. & DELOFFRE R. (1993).- Inventaire des algues Dasycladales fossiles. II^{e} partie- Les Algues Dasycladales du Jurassique et du Crétacé.- *Revue de Paléobiologie*, Genève, vol. 12, nº 1, p. 19-65.

HARRIS T.M. (1939).- British Purbeck Charophyta.- British Museum (Natural History), London, 83 p. (17 Pls.).

HEYBROEK F. (1942).- La géologie d'une partie du Liban Sud.- Thesis, Dr in de Wis- en Natuurkunde aan de Rijksuniversiteit Groningen; *Leidsche Geologische Meddedeelingen*, vol. XII, fasc. 2, p. 251-470.

JAFFREZO M. (1973).- Les algues calcaires du Jurassique supérieur et du Crétacé inférieur des Corbières. Première partie.- *Revue de Micropaléontologie*, Paris, vol. 16, nº 2, p. 75-88.

JOHNSON J.H. (1961).- Limestone-building algae and algal stromatolites.- Colorado School of Mines, Golden, 297 p. (139 Pls.).

JOHNSON J.H. (1969).- A review of the Lower Cretaceous algae.- *Professional Contributions of the Colorado School of Mines*, Golden, nº 6, 180 p. (68 Pls.).

MAKSOUD S., GRANIER B., AZAR D., GÈZE R., PAICHELER J.-C. & MORENO-BEDMAR J.A. (2014).- Revision of "Falaise de Blanche" (Lower Cretaceous) in Lebanon, with the definition of a Jezzinian Regional Stage.- *Carnets Geol.*, Madrid, vol. 14, nº 18, p. 401-427.

MARTÍN-CLOSAS C. (1996).- A phylogenetic system of Clavatoraceae (fossil Charophyta).- Review of Palaeobotany and Palynology, vol. 94, nº 3-4, p. 259-293.

MARTÍN-CLOSAS C. (2000).- Els caròfits del Juràssic superior i Cretaci inferior de la Península Ibèrica.- Arxius de les Seccions de Ciències, Institut d'Estudis Catalans, 125, 304 p.

MCNEILL J., BARRIE F.R., BUCK W.R., DEMOULIN V., GREUTER W., HAWKSWORTH D.L., HERENDEEN P.S., KNAPP S., MARHOLD K., PRADO J., PRUD'HOMME van REINE W.F., SMITH G.F., WIERSEMA J.H. & TURLAND N.J. (2012).- International Code of Nomenclature for algae, fungi, and plants (Melbourne Code). Regnum Vegetabile 154.- Koeltz Scientific Books, Koenigstein, xxx + 240 p. URL: http://www.iapt-taxon.org/nomen/main.php?page=title

NIKLER L. & SOKAČ B. (1967).- Fosilne Dasycladaceae gornje jure Velebita i sjeverozapadne Velike Kapele [Fossil Dasycladaceae from Upper Jurassic of the Mount Velebit and the NW part of the mount Velika Kapela]. – *Rad Jugoslavenska Akademija Znanosti i Umjetnosti*, Zagreb, Knjiga 345, p. 101-134 (VIII Pls.).

PECK R.E. (1957).- North American Mesozoic Charophyta.- Shorter Contributions to General Geology 1956, *Geological Survey Professional Paper*, Washington, 294, 44 p. (8 Pls.).

PECORINI G. (1972).- Microflora "purbeckiana" della Nurra (Sardegna).- *Bolletino della Società Geologica Italiana*, Roma, vol. 91, p. 373-385.

PIA J. von (1920).- Die Siphoneae verticillatae vom Karbon bis zur Kreide.- *Abhandlungen der zoologisch-botanischen Gesellschaft in Wien*, Band XI, Heft 2, 263 p. (VIII Pls.). URL: https://archive.org/details/diesiphoneaevert00piaj

PIA J. von (1927).- 1. Abteilung: Thallophyta. *In*: HIRMER M. (ed.), Handbuch der Paläobotanik.- Oldenbourg, München & Berlin, Band I: Thallophyta - Bryophyta - Pteridophyta, p. 31-136.

PIA J. von (1961).- Les Siphonées verticillées du Carbonifère au Crétacé.- Éditions Technip, Rueil-Malmaison, 258 p. (8 Pls.).

PIPÍK R., SÝKORA M., COLIN J.-P. & HAVRILA M. (2009).- A new phytal limnic ostracod *Rosacythere carpathica* sp. nov. from the

Upper Cretaceous of the Western Carpathians: implications for evolution of the Timiriaseviinae.- *Cretaceous Research*, vol. 30, p. 465-476.

POIGNANT A. (1969).- Les algues du toit des bauxites des environs de Mazaugues (Var).- *Revue de Micropaléontologie*, Paris, vol. 11, nº 4, p. 233-240.

RADOIČIĆ R. (1958).- *Munieria baconica* DEECKE u donje krednim slojevima okoline Titograda [*Munieria baconica* DEECKE dans les couches du Crétacé inférieur aux environs de Titograd].- *Vesnik Zavoda za Geološka i Geofizička Istraživanja NR Srbije*, Beograd, t. XVI, p. 79-86 (Pl. I).

RADOIČIĆ R. (1960).- Mikrofacije Krede i starijeg Tercijara spoljašnjih Dinarida jugoslavije [Microfaciès du Crétacé et du Paléogène des Dinarides externes de Yougoslavie].- *Paléontologie des Dinarides yougoslaves*, Titograd, (Série A : Micropaléontologie), t. IV, Livre 1, 172 p. (LVIII Pls.).

RADOIČIĆ R. (1969).- A new Lower Cretaceous Dasycladacea, *Clypeina pejovici,* and note on some Clypeinae.- *Geologica Romana*, vol. 8, p. 71-84.

RADOIČIĆ-BRSTINA R. & MILAKOVIĆ B.B. (1956).- Beleška o nalasku krečnjačkih algi u mezozojskim naslagama Crne Gore [Mitteilung über den Funde von Kalkalgen in den mesozoischen Ablagerungen in Crna Gora (Montenegro)].- *Geološki Glasnik* [*Bulletin géologique*], Cetinje, Livre 1, p. 233-238 (Pls. XII-XIV).

SAINT-MARC P. (1970).- Contribution à la connaissance du Crétacé basal au Liban.- *Revue de Micropaléontologie*, Paris, vol. 12, nº 4, p. 224-233.

SAMUEL O., BORZA K. & KÖHLER E. (1972).- Microfauna and lithostratigraphy of the Paleogene and adjacent Cretaceous of the Middle Váh Valley (West Carpathian).- Geologický ústav Dionýza Štúra, Bratislava, 246 p. (CLXXX Pls.).

SARTONI S. & CRESCENTI U. (1962).- Ricerche biostratigrafiche nel Mesozoico dell'Appennino meridionale.- *Giornale di Geologia*, Bologna, vol. XXIX, (serie 2a), p. 161-302 (Pls. XI-LII).

SCHLAGINTWEIT F. (1991).- Allochthone Urgonkalke im Mittleren Abschnitt der Nördlichen Kalkalpen: Fazies, Paläontologie und Paläogeographie.- *Münchner Geowissenschaftliche Abhandlungen*, Reihe A, Geologie und Paläontologie, 20, 119 p. (19 Pls.).

SCHLAGINTWEIT F. & WAGREICH M. (1992).- Über ein Vorkommen von *Munieria grambasti sarda* CHERCHI *et al*. in der Gosau Gruppe des Miesenbachtales (Niederösterreich).- *Mitteilungen der Gesellschaft der Geologie- und Bergbaustudenten in Österreich*, Wien, vol. 38, p. 21-29 (Pl. 1).

SCHUDACK M. (1989).- Charophytenfloren aus den unterkretazischen Vertebraten-Fundschichten bei Galve und Uña (Ostspanien). - *Berliner Geowissentschaftlche Abhandlungen* (A), 106, p. 409-443.

SCHUDACK M. (1990).- Bestandsaufnahme und Lokalzonierung der Charophyten aus Oberjura und Unterkreide des Nordwestdeutschen Beckens.- *Berliner Geowissentschaftlche Abhandlungen* (A), 124, p. 209-245.

SCHROEDER R., BUCHEM F.S.P. van, CHERCHI A., BAGHBANI D., VINCENT B., IMMENHAUSER A. & GRANIER B. (2010).- Revised orbitolinid biostratigraphic zonation for the Barremian - Aptian of the eastern Arabian Plate and implications for regional stratigraphic correlations.- *GeoArabia*, Manama, vol. 1, p. 49-96.

SIRNA G. (1963).- Aptian Charophyta of southern Latium.- *Geologica romana*, vol. II, p. 279-290.

STOPES M.C. (1913).- Catalogue of the Mesozoic plants of the Department of Geology, British Museum, Natural History. Part V.- Taylor & Francis, London, 285 p. (II Pls.).

TIXIER B. (1965, unpublished).- Contribution à l'étude des grès de base du Liban.- Thèse 3º cycle, Université de Paris, Centre d'Orsay, 89 p. (29 Pls.).

TIXIER B. (1972).- Le "grès de base" crétacé du Liban : étude stratigraphique et sédimentologique.- *Notes et Mémoires sur le Moyen-Orient*, Paris, tome XII, p. 187-215.

VILLALBA-BREVA S. (2012).- Els caròfits de les fàcies continentals i transicionals del Garumnià basal (Cretaci superior) del Pirineu Oriental.- PhD Thesis, Universitat de Barcelona, p. 319-345.

VILLALBA-BREVA S. & MARTÍN-CLOSAS C. (2011).- A characean thallus with attached gyrogonites and associated fossil charophytes from the Maastrichtian of the Eastern Pyrenees (Catalonia, Spain).- *Journal of Phycology*, vol. 47, nº 1, p. 131-143.

VILLALBA-BREVA S. & MARTÍN-CLOSAS C. (2013).- Upper Cretaceous paleogeography of the Central Southern Pyrenean Basins (Catalonia, Spain) from microfacies analysis and charophyte biostratigraphy.- *Facies*, vol. 59, p. 319-345.

ZUMOFFEN G. (1926).- Géologie du Liban.- Henry Barrère, Paris, 165 p.

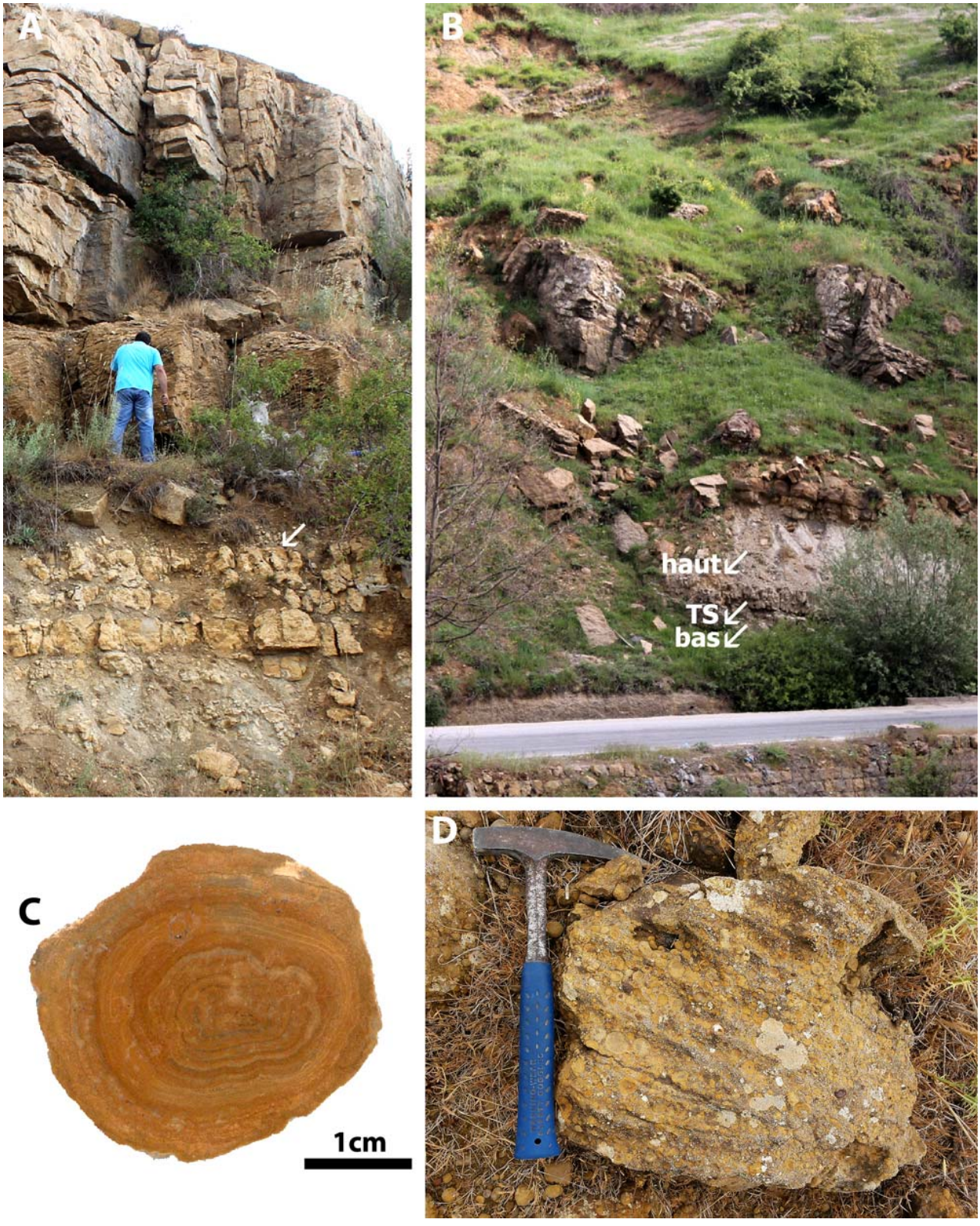
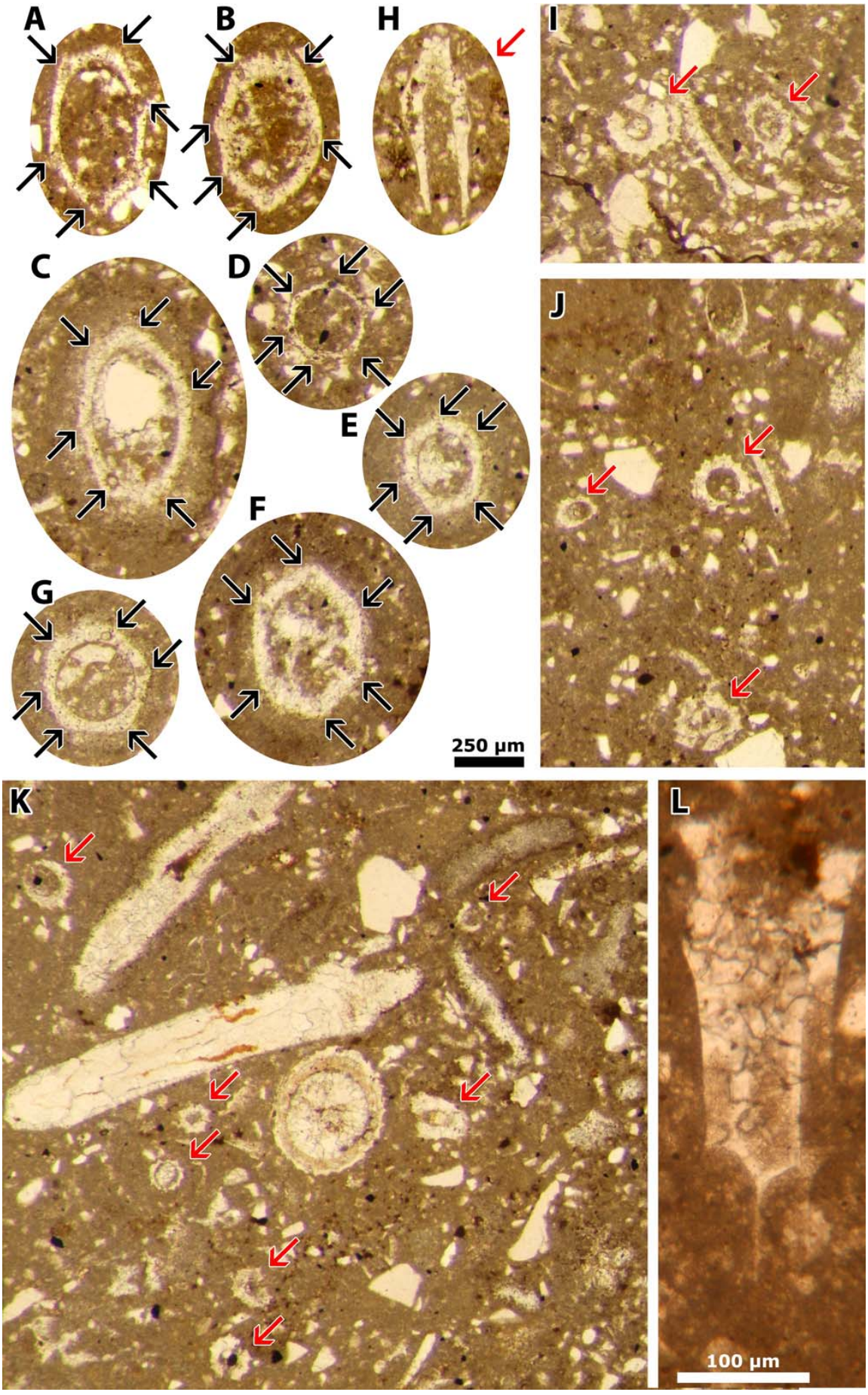


Plate 1:

A) Falougha section (behind the water bottling plant) with the "Banc de Mréjatt" of HEYBROEK (1942). The arrow points to the marly sample for Charophyta above lacustrine limestones; B) Ain Dara section with the "Banc de Mréjatt" of HEYBROEK (1942). The arrow labelled "TS" points to the limestone sample (thin section BGAD) and the arrows "bas" and "haut" point to the marly samples; C) Polished slab of a loose pisolite from Homsiyeh; D) Cross-bedded calcirudites with pisolites, near Falougha (N 33°50'38.781", E 35°45'6.604", alt. 1484m).

Plate 2: (Homsiyeh)

A-G) sections of utricles with the location (black arrows) of the 6 pores corresponding to the 6 spine-shaped bracts of the external utricular layer; H-K) sections of thalli of *Munieria* (red arrows); K) toward the center of the photomicrograph, an utricle with its gyrogonite; L) tangential section. The zigzag pattern corresponds to the median part of an internode where the grooves (*i.e.*, the contiguous cortical cells) issued respectively from its lower and upper internodes met. All photomicrographs with the same magnification, except L.


A
B
H
I
C
D
J
E
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G
250 µm
K
L
100 µm

Plate 3: (Homsiyeh)

Clavator ampullaceus (GRAMBAST & LORCH, 1968) MARTÍN-CLOSAS, 1996 [formerly *Lucernella ampullacea* GRAMBAST & LORCH, 1968]

A) ventral face, anterior view (showing one impression of a phylloid); B) dorsal face, posterior view; C) basal view (showing one impression of a phylloid); D-E) apical views.

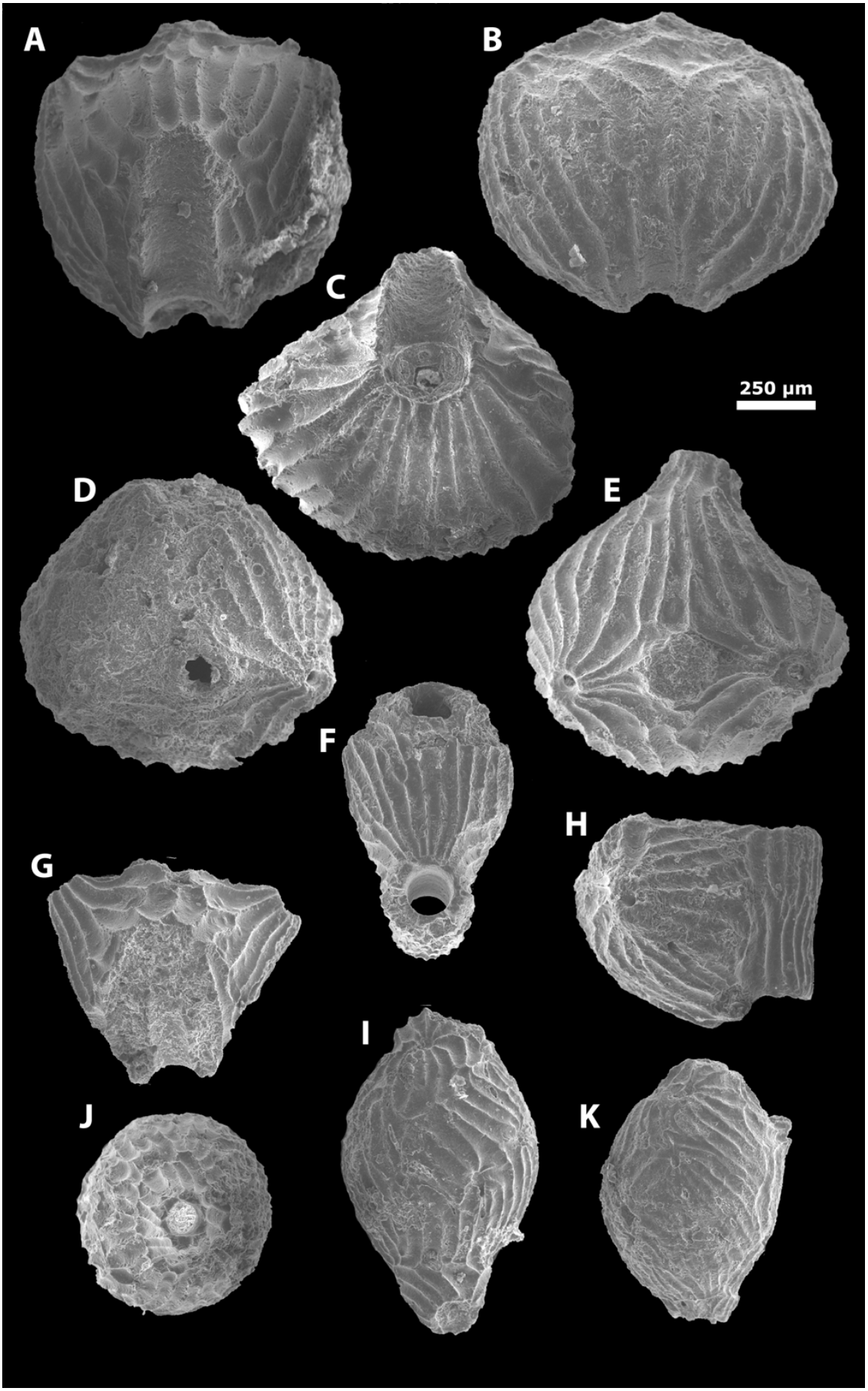
Clavator delteus (GRAMBAST & LORCH, 1968) n.comb. GRANIER, AZAR & MAKSOUD [formerly *Lucernella deltea* GRAMBAST & LORCH, 1968]

F) apical view (showing a fragment of a phylloid). FEIST *et al.* (2003: Fig. 24) refer a similar specimen, *i.e.*, an utricle fixed to a hollow unbranched thallus, to the genus *Septorella* GRAMBAST, 1963; G) ventral face, anterior view; H) lateral view (showing a fragment of a phylloid). See above comment in F.

Ascidiella reticulata GRAMBAST & LORCH, 1968

I) lateral view; J) apical view; K) lateral view.

All photomicrographs with the same magnification.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C
250 µm
D
E
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K

Plate 4: (Ain Dara and Homsiyeh)

Clavator ampullaceus (GRAMBAST & LORCH, 1968) MARTÍN-CLOSAS, 1996 [formerly *Lucernella ampullacea* GRAMBAST & LORCH, 1968] (loc.: Ain Dara)

A) ventral face, anterior view (showing one impression of a phylloid); B) dorsal face, posterior view; C) basal view (showing one impression of a phylloid); D-E) apical views; F) lateral view.

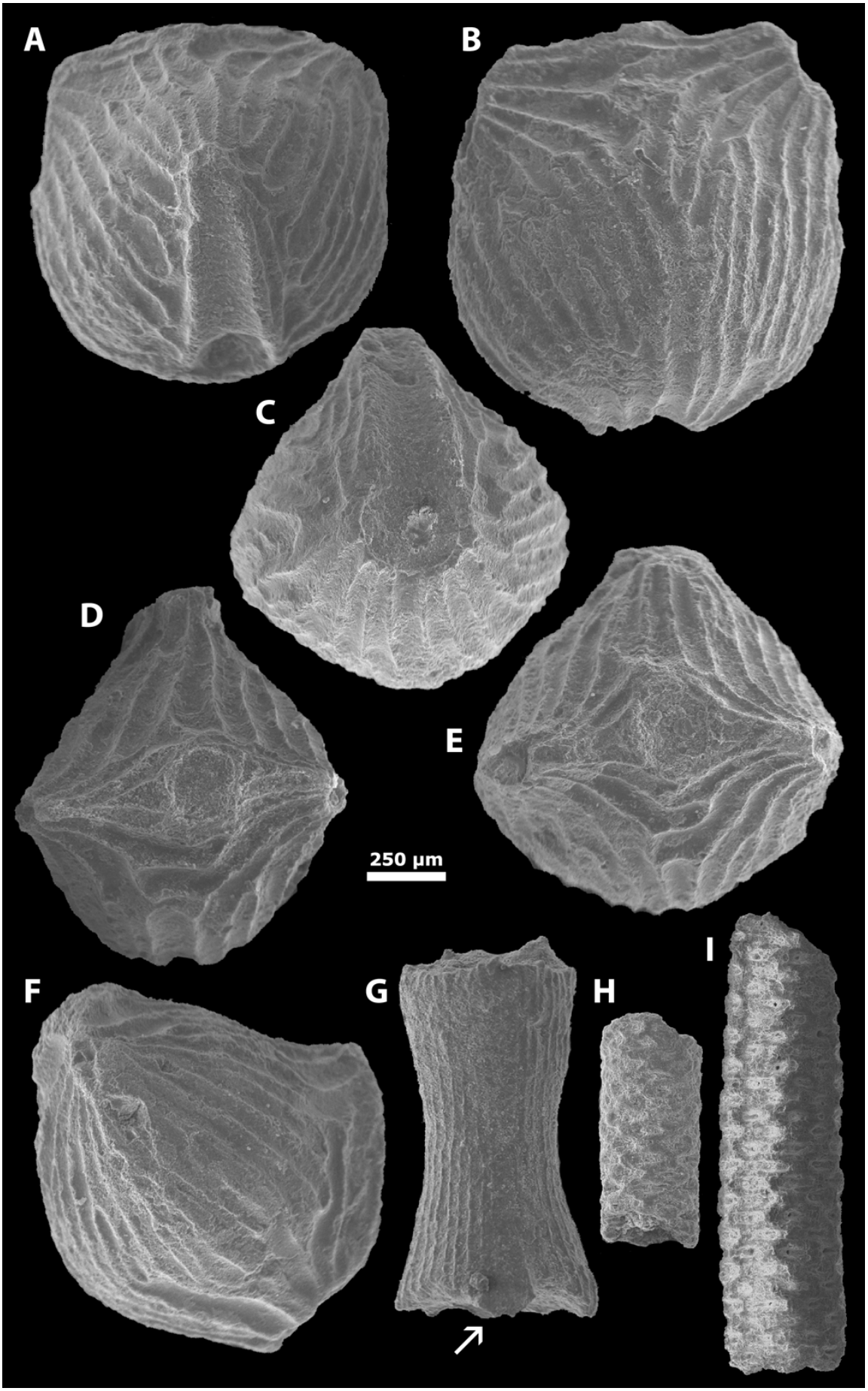
Charaxis martinclosasi n.sp. (loc.: Ain Dara)

G) internode showing the impression of a phylloid above the node (arrow).

Salpingoporella (*Hensonella*) *dinarica* (RADOIČIĆ, 1959) (loc.: Homsiyeh)

H-I) thalli.

All photomicrographs have the same magnification.


A
B
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D
E
250 µm
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G
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I

Plate 5: (Ain Dara and Falougha)

Sphaerochara asema (GRAMBAST & LORCH, 1968) n.comb. GRANIER, AZAR & MAKSOUD [formerly *Peckisphaera asema* GRAMBAST & LORCH, 1968] (loc.: Falougha)

A) apical view of a gyrogonite, see the calcification pattern (arrows).

Ascidiella reticulata GRAMBAST & LORCH, 1968 (loc.: Falougha)

B) apical view; C) lateral view.

Atopochara trivolvis var. *triquetra* GRAMBAST, 1968 (loc.: Ain Dara)

D) lateral view.

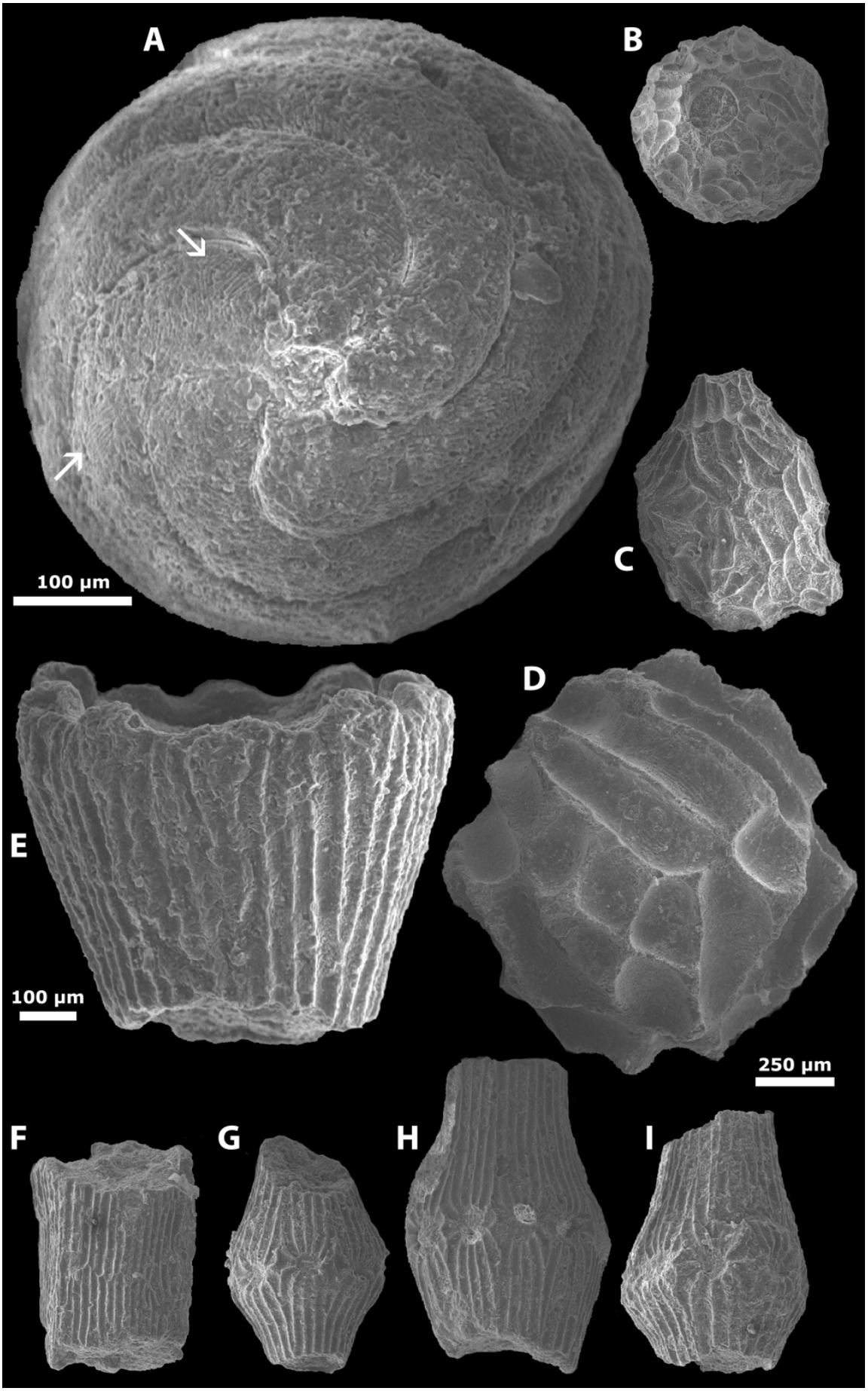
Charaxis martinclosasi n.sp. (loc.: Ain Dara)

E) half internode; G-I) two halves of intenodes, with the verticillate node in medial position (H is the holotype).

Charaxis sp. (loc.: Ain Dara)

F) part of an internode showing interdigitations of cortical cells issued from both the upper and the lower nodes.

All photomicrographs have the same magnification, except A and E.


A
B
C
100 µm
D
E
100 µm
250 µm
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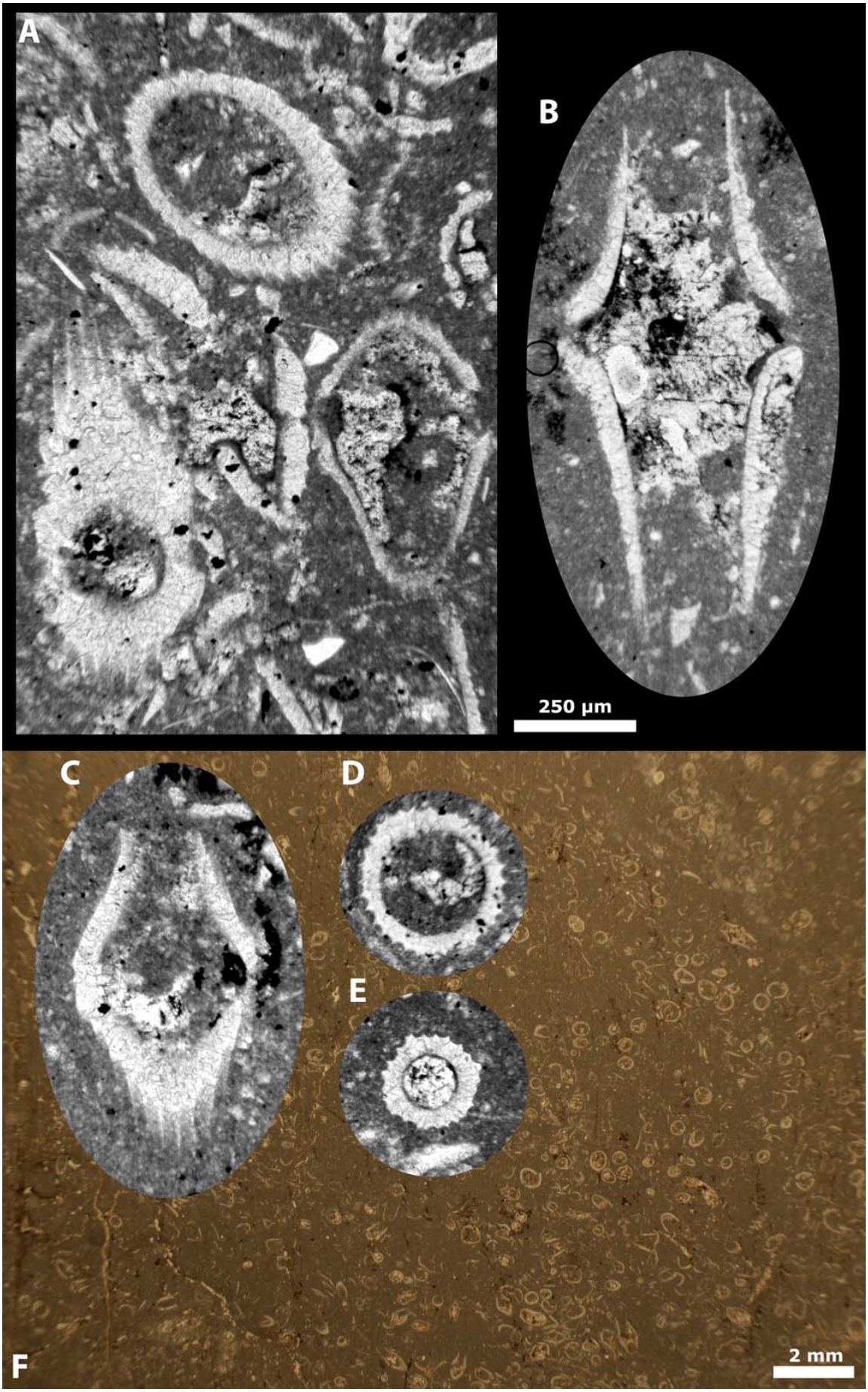
G
H
I

Plate 6: (Ain Dara). Thin section (BGAD)

Charaxis martinclosasi n.sp.

A) various oblique sections of articles; B) a subaxial section of an article with the node at its median part; C) an oblique section with the node at its median part. In the lower part, scours and grooves corresponding to the cortical cells ("secondaries") can be seen on the internode; D-E) transverse section at an internode level; F) the microfacies is a wackestone of Charophyta articles.

All photomicrographs with the same magnification, except F.


A
B
250 µm
C
D
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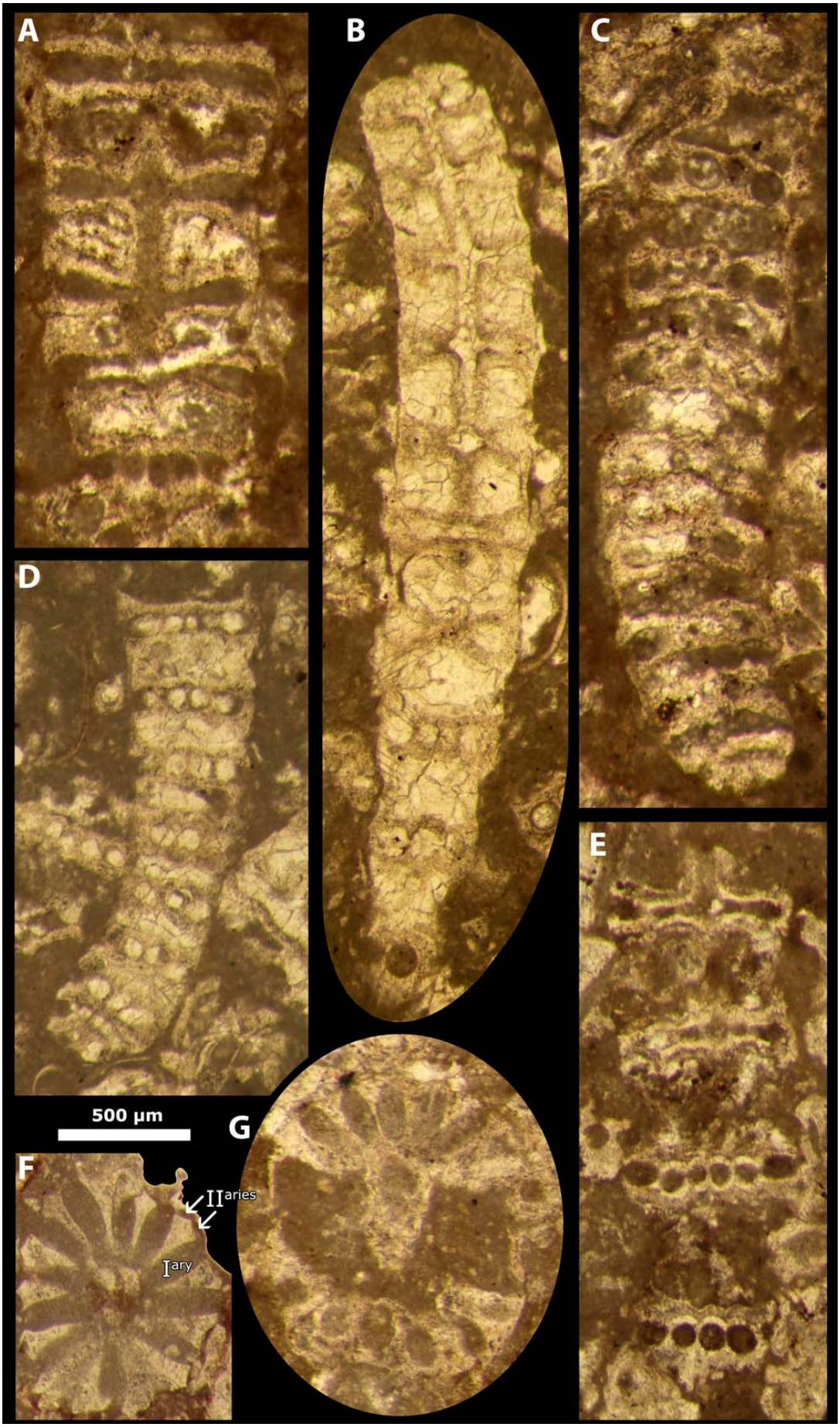
2 mm

Plate 7: *Munieria baconica* DEECKE, 1883 (PIA, 1920)

A) PIA, 1920: Pl. 7, fig. 19 – Thin section M.F.I. 70, not Kerteshegy *fide* PIA (1920), but probably "Penzeskut" = Pénzesgyőr (Hungary); B) PIA, 1920: Pl. 7, fig. 16 - Thin section M.F.I. 73, Sűrű-hegy (Hungary) *fide* PIA (1920); C) PIA, 1920: Pl. 7, fig. 17 – Thin section M.F.I. 70, Pénzesgyőr (Hungary) *fide* PIA (1920); D) PIA, 1920: Pl. 7, fig. 22 – Thin section M.F.I. 73, Sűrű-hegy (Hungary) *fide* PIA (1920); E) PIA, 1920: Pl. 7, fig. 23 – Thin section M.F.I. 72, Tündérmajor (Hungary) *fide* PIA (1920); F) a whorl made of 12 nodal cells ("primaries"). Arrows point to grooves corresponding to the proximal part of the cortical cells; ("secondaries"). Compare with Pl. 1, fig. 5 (herein Fig. 5.5) in DEECKE (1883) – Thin section 512; G) PIA, 1920: Pl. 7, fig. 25 – Thin section M.F.I. 70, Penzeskut (Hungary) *fide* PIA (1920). All photomicrographs with the same magnification.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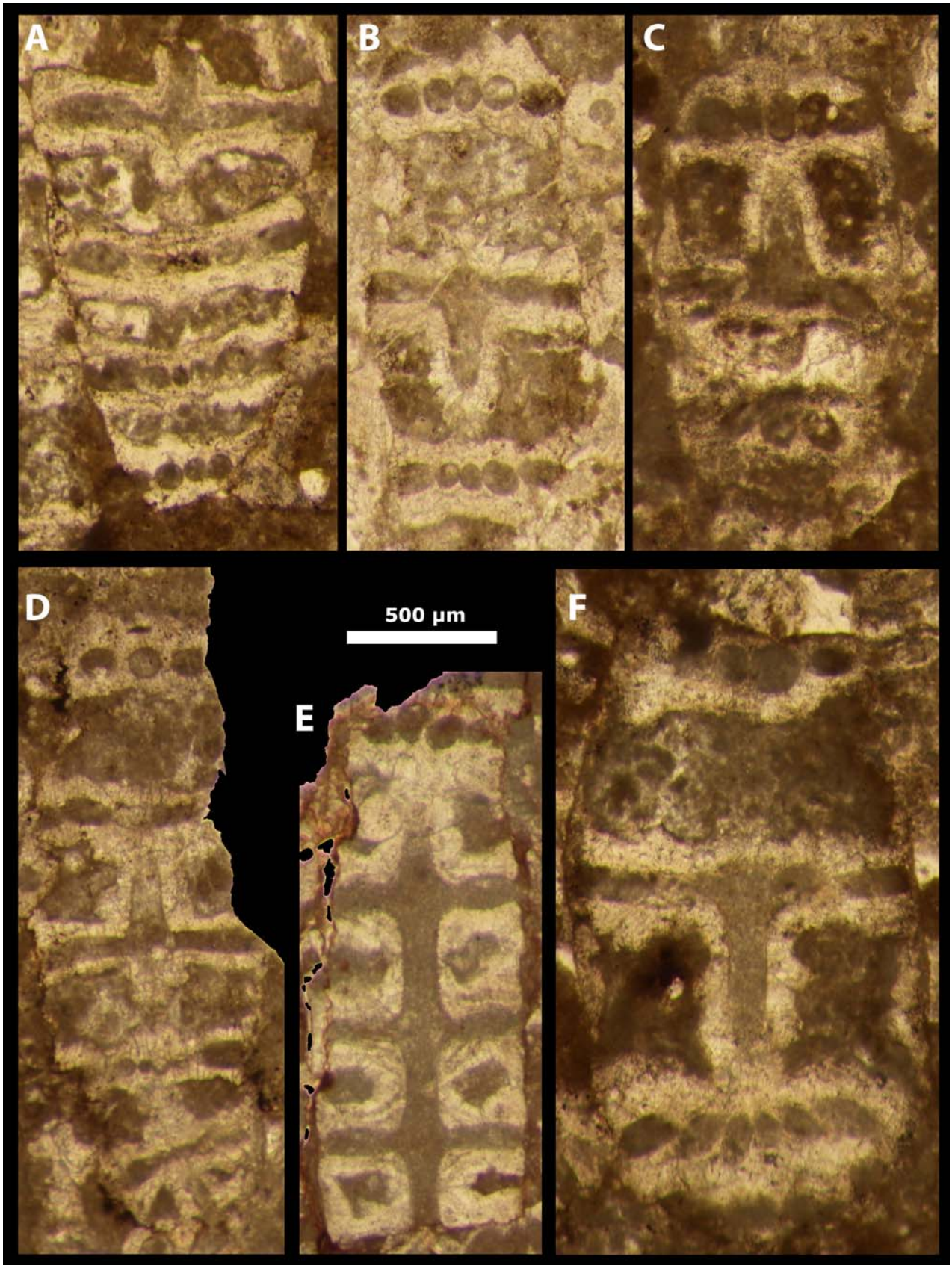
IIaries
Iary

Plate 8: *Munieria baconica* DEECKE, 1883 (PIA, 1920)

A) PIA, 1920: Pl. 7, fig. 20 – Thin section M.F.I. 70, Pénzesgyőr (Hungary) *fide* PIA (1920); B) PIA, 1920: Pl. 7, fig. 21 - Thin section M.F.I. 70, Pénzesgyőr (Hungary) *fide* PIA (1920); C) PIA, 1920: Pl. 7, fig. 26 – Thin section M.F.I. 70, Pénzesgyőr (Hungary) *fide* PIA (1920); D) PIA, 1920: Pl. 7, fig. 24 – Thin section M.F.I. 70, Pénzesgyőr (Hungary) *fide* PIA (1920); E) PIA, 1920: Pl. 7, fig. 18 – Thin section M.F.I. 70, Pénzesgyőr (Hungary) *fide* PIA (1920); F) Compare with Pl. 1, fig. 6 (herein Fig. 5.6) in DEECKE (1883) – Thin section 512. All photomicrographs with the same magnification.


A
B
C
D
500 µm
E
F