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THE FAMILY CALCIFOLIACEAE EMEND., MISSISSIPPIAN-EARLY PENNSYLVANIAN ALGAE

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Abstract. The family Fasciellaceae was created as a group of red algae. It was emended as a tribe Fascielleae of *incertae sedis* algae, and related to the tribe Calcifolieae Shuysky emend. Vachard & Cózar. The tribes Fascielleae and Calcifolieae both constitute the family Calcifoliaceae emend. This family is actually a homogeneous group, and could be more or less closely related with some questionable Moravamminales and Aoujgaliales: Claracrustaceae, Labyrinthoconaceae and Donezellaceae. All these microfossils were successively considered as green algae, red algae, "phylloid" algae, or fibres of calcispongia. The genera included in Fascielleae are: *Fasciella*, *Praedonezella,* and ?*Kulikaella*. The genera *Calcifolium*, *Falsocalcifolium* and *Frustulata* are included in the Calcifolieae. The phylogeny of the Calcifoliaceae is reconstructed. Thus, the family appears to be ancestrally linked, in the early Mississippian and even earlier in the Devonian, to *Kulikaella, Stacheoidella, Pseudostacheoides*, *Pokorninella* and *Precorninella*. The Calcifoliaceae are important for the zonation of the Late Mississippian-earliest Pennsylvanian (early Bashkirian) interval (Asbian to Siuransky) in the carbonate platform facies from western Palaeotethys and Ural Oceans.

Riassunto. La famiglia Fasciellaceae é stata istituita per un gruppo di alghe rosse, ma in seguito è stata emendata come tribù Fascielleae di alghe *incertae sedis* e collegata alla tribù Calcifolieae Shuysky emend. Vachard & Cózar. Le tribù Fascielleae e Calcifolieae insieme costituiscono la famiglia Calcifoliaceae emend. Questa famiglia forma pertanto un gruppo omogeneo, e può essere avvicinata, sia pur con qualche dubbio, alle Moravamminales e Aoujgaliales: Claracrustaceae, Labyrinthoconaceae e Donezellaceae. Tutti questi microfossili sono stati poi considerati come alghe verdi, alghe rosse, alghe filloidi, o fibre di calcispongia. I generi inclusi nelle Fascielleae sono: *Fasciella*, *Praedonezella,* e ?*Kulikaella*. I generi *Calcifolium*, *Falsocalcifolium* e *Frustulata* sono inclusi nelle Calcifolieae. La filogenesi delle Calcifoliaceae qui ricostruita suggerisce che la famiglia sia connessa ancestralmente durante il Mississippiano inferiore, se non già prima nel Devonian, a *Kulikaella, Stacheoidella, Pseudostacheoides*, *Pokorninella* e *Precorninella*. Le Calcifoliaceae sono importanti per la zonazione del Mississippiano superiore-Pennsylvanian basale (Bashkiriano inferiore), cioè dall'Asbiano al Siuransky nelle facies di piattaforma carbonatica della Palaeotetide occidentale e dell'Oceano Uraliano.

Introduction

Palaeoecologic and taphonomic studies of the Calcifolieae (Cózar & Vachard 2004; Vachard & Cózar 2005), allowed to create the genus *Falsocalcifolium*, and reconstruct the probable importance of endosymbiotic cyanobacterial ramifications (the filaments) within the petals and the cups of the Calcifolieae. The algal nature of the Calcifolieae was accepted by us, but its attribution to the green algae was rejected. Two problems remained unresolved: (a) the macroevolution of the group is unknown; (b) the relationship of the Calcifoliaeae with other *incertae sedis* algae of the Carboniferous, the Algospongia, in the sense of H. Termier et al. (1977) and G. Termier et al. (1977), is controversial and needs revision (Vachard & Cózar in preparation).

Although the algae *Calcifolium* and *Fasciella* were firstly phylogenetically associated with each other by Perret & Vachard (1977), they were related by these authors to Calcispongia, because of the interpretation as an endoskeleton of calcitic mineralization as a basal fibre, and mostly on the interpretation of the filaments as connected aragonitic diapason-shaped spicules (Perret & Vachard 1975, 1977; G. Termier et al. 1977). The "pivot" of *Fasciella* was also interpreted as a spicule (Perret & Vachard 1977), although this hypothesis was

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later rejected by Vachard et al. (1991). The internal structures of *Praedonezella* are also controversial (Kulik 1973; Perret & Vachard 1977; Vachard et al. 2004), because it is generally filled by microsparite, but in rare cases, enlarged, or well preserved small chambers or rows of cells. The "pores" of *Frustulata* might correspond to incomplete filaments, thus the general morphology and the anastomosing wall structure is similar to *Calcifolium* and *Falsocalcifolium*.

In summary, some genera in the literature share the following characters (Figs. 1, 2): (1) a yellowish calcitic mineralization (all the genera), (2) a laminar skeleton, crusts and/or petals (*Fasciella, ?Kulikaella, Praedonezella, Falsocalcifolium* and *Calcifolium*), (3) irregular ramifications or anastomoses (*Fasciella*, *Praedonezella, Frustulata, ?Iberiaella*), (4) a permanent or episodic encrusting growth habit (*Fasciella, Praedonezella* and *Falsocalcifolium*), and (5) a secondary erect growth habit (*Fasciella*, *Praedonezella, Falsocalcifolium*, *Calcifolium*).

The aim of this work is to review the Calcifoliaceae, proposing the phylogenetic relationships of the tribe Calcifolieae with other *incertae sedis* algae of the tribe Fascielleae. The members of these two tribes have been recently re-studied (Vachard et al. 2004; Vachard & Cózar 2004, 2005).

Systematics

Kingdom **Plantae**

Phylum, Class, Order **incertae sedis**

Family Calcifoliaceae
G. Termier, Termier & Vachard, 1977

nomen translat. Vachard, Somerville & Cózar, 2004
pro Calcifoliidae, emend. herein

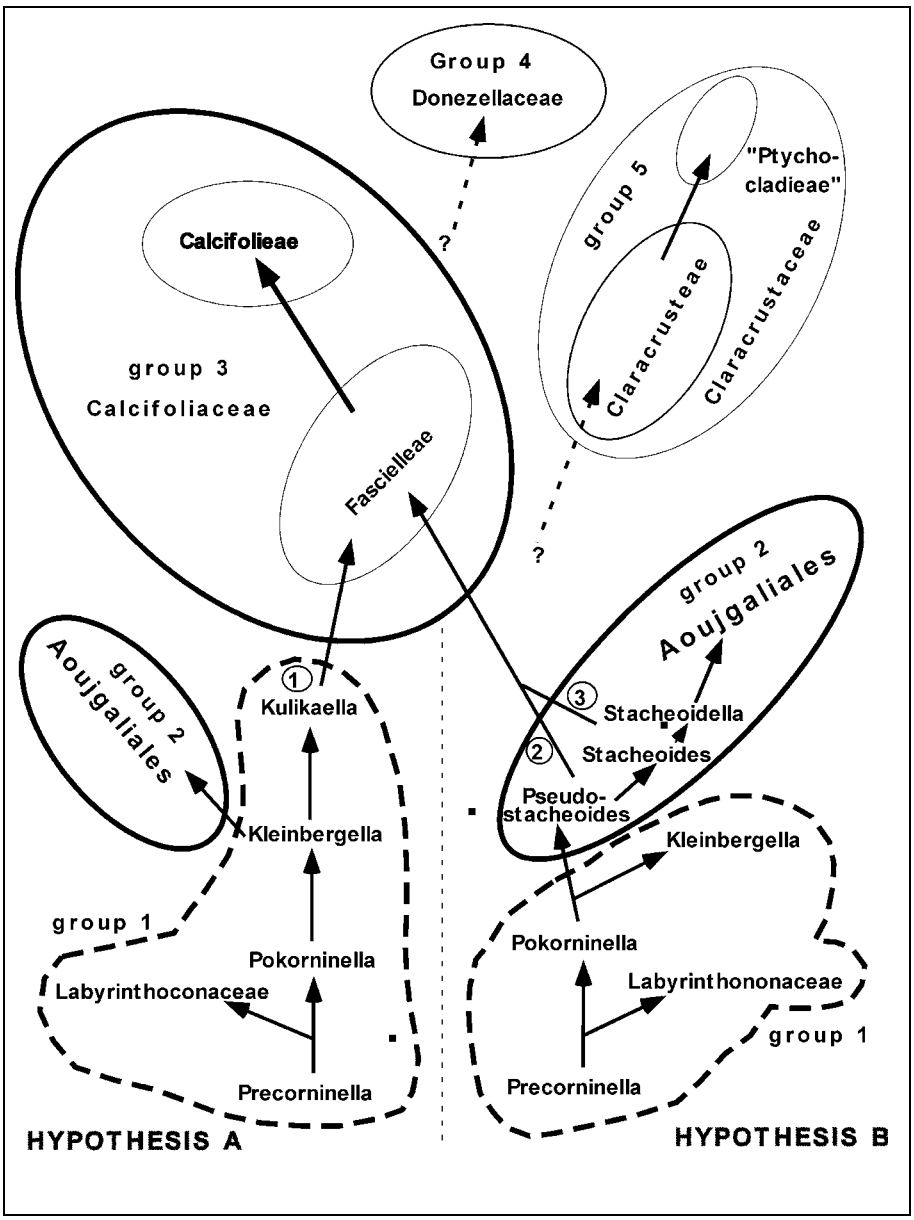

Fig. 1 - Calcifoliaceae emend., composition and hypothetical phylogeny. Two suggested hypotheses: hypothesis A: Calcifoliaceae (group 3) derived from relatively advanced Aoujgaliales (group 2); hypothesis B: Calcifoliaceae derived from more primitive Aoujgaliales (group 1). Abbreviations: 1-3 = probable ancestors; 1 = the poorly known genus *Kulikaella*; 2 = a taxon intermediate between *Pseudostacheoides* and *Stacheoides*; 3 = a taxon intermediate between *Stacheoides* and *Stacheoidella*.

Emended diagnosis. Colonies encrusting, laminar to erect ramose, petaloid or pseudophylloid. Skeleton thin, but generally rather strongly calcified. Central part reserved to the organic component, narrow and rarely fossilized. The calcified part is composed of a yellowish to dark calcite; diverse types of filaments can occur, of imprecise role, but they do not have external connection, and may be composite (e.g. cellular rows, microperforations, endosymbionts).

Remarks. As previously indicated (Vachard & Cózar 2005), pseudophylloid refers to a short laminar thallic structure in which horizontal development of the petaloid thallus is well developed, more than vertical growth of the thallus. Filaments correspond to the endoskeletal structures, to those diverse interpretations have been suggested in the literature: laterals (siphons of codiaceans), spicules, microperforations (Maslov 1956; Perret & Vachard 1977; Sebbar & Mamet 1996).

Composition. 2 tribes: (1) Fascielleae Shuysky, 1999 emend. herein; (2) Calcifolieae Shuysky in Chuvashov et al. 1987 emend. Vachard & Cózar, 2005.

Phylogeny. Two hypotheses are proposed for the origin of this family (Fig. 1): (A) it could be derived from *Kulikaella* Berchenko (Fig. 2A) and its unknown ancestor, perhaps related to the Frasnian genus *Kleinbergella* Mamet & Boulvain (Fig. 2B), and in this case, its lineage is independent of the Aoujgaliales (Fig. 1, hypothesis A); (B) the genera *Pseudostacheoides* Petryk & Mamet (Fig. 2C) or *Stacheoidella* Mamet & Roux (Fig. 2D) could be the ancestor of the Fascielleae, as well as the Claracrustaceae (Vachard et al. 2001); in that case, both lineages are related to the Aoujgaliales (Fig. 1, hypothesis B). *Pseudostacheoides* can be intensively bifurcated, and morphologically similar to *Fasciella* (see *Pseudostacheoides* sp. sensu Vieslet 1983, pl. 5, fig. 5).

Several problematic algae, difficult to include in the green algae, red algae, Moravamminales and/or Aoujgaliales (Kulik 1973; H. Termier et al. 1977; G. Termier et al. 1977; Berchenko 1982; Mamet et al. 1982; Mamet 1991, 2002; Vachard 1991; Vachard & Maslo 1996; Vachard et al. 2001), such as Claracrustaceae, Donezellaceae and Labyrinthoconaceae, have similarities with some members of Calcifoliales, especially with *Fasciella* and *Praedonezella*. The Claracrustaceae Vachard in Vachard et al. 2001 nomen translat. herein pro Claracrustinae, are composed of two tribes (Figs. 1, 3): Claracrusteae nomen translat. herein and "Ptychocladieae" Elias nomen translat. herein pro "Ptychocladiidae" Elias emend. H. Termier et al. 1977 (to emendate, see Vachard & Maslo 1996). The Donezellaceae Termier, Termier & Vachard nomen translat. Shuysky pro Donezellidae, are composed of true Donezelleae and questionably related genera: *Groenlandella* Mamet & Stemmerik and *Einorella* Saltovskaya (Fig. 3). The Devonian Labyrinthoconaceae Langer nomen translat. herein, are also considered as problematic algae (Mamet et al. 1982); they are more or less related to the genera *Pokorninella* Vachard and *Precorninella* Vachard (see Vachard 1991) (Fig. 1). The incomplete knowledge of these genera and their irregular geographic distribution does not facilitate the reconstruction of their precise phylogenetic lineage.

Distribution. Questionably in the Tournaisian (*Kulikaella*). Occasionally in the early-mid Viséan (*Fasciella),* common in the interval from the Asbian to early

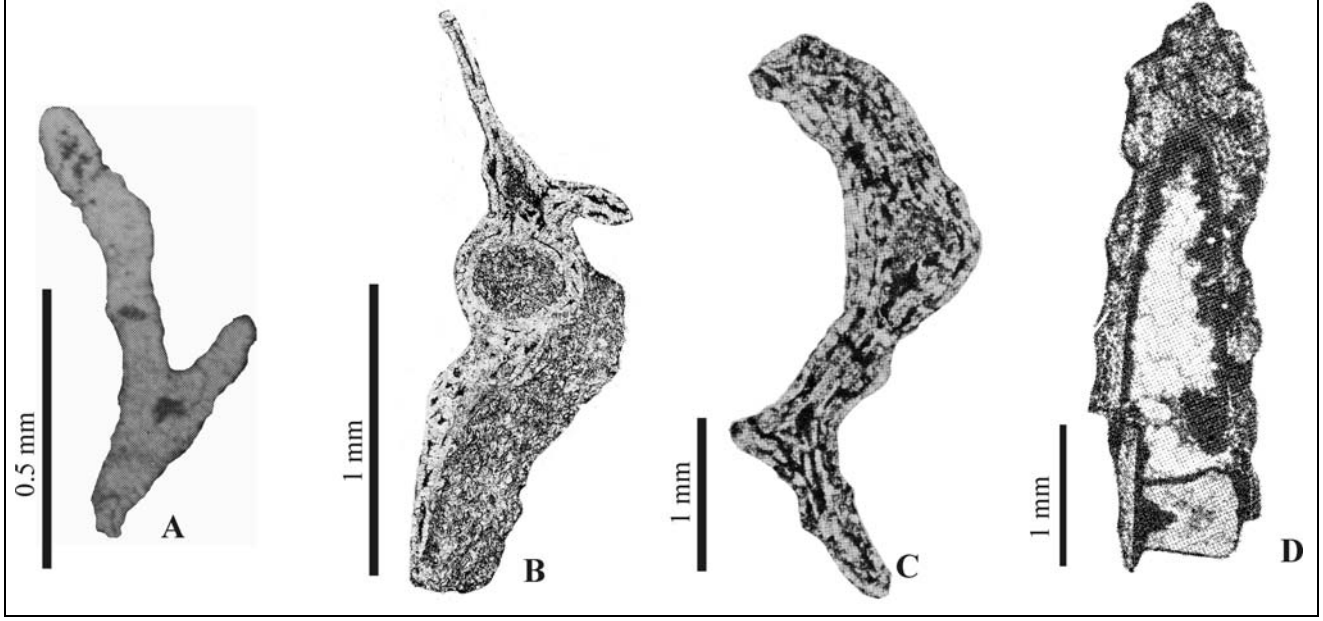

Fig. 2 - Possible ancestors of the family Calcifoliaceae. A: *Kulikaella* Berchenko, 1981, pl. 8, fig. 4; B: *Kleinbergella fibrosa* Mamet & Boulvain, 1992, pl. 3, fig. 19; C: *Pseudostacheoides loomisi* Petryk & Mamet, 1972, pl. 9, fig. 7; D: *Stacheoidella spissa* (Petryk & Mamet, 1972, pl. 5, fig. 5) Mamet & Roux in Mamet et al. 1987.

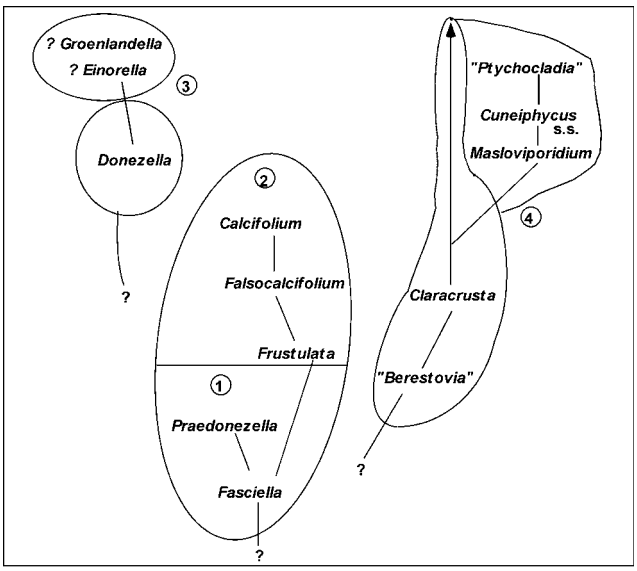

Fig. 3 - Generic composition of the four groups (orders, families or tribes) of problematic algae which show some morphological affinities, despite their different assignments in the literature.

Serpukhovian, and rare in the Bashkirian and early Moscovian.

Tribe Fascielleae Shuysky, 1999 nomen translat. Vachard, Somerville & Cózar, 2004 pro Fasciellaceae, emend. herein

Emended diagnosis. Encrusting, elongate, in some cases ramose Calcifoliaceae, mainly constituted by concentric laminae of calcite, separated by very narrow and irregular intervals.

Composition. *Fasciella* Ivanova, 1973 (= *Shartymophycus* Kulik, 1973 partim) (Pl. 1, figs 1-5, 8, 10), *Praedonezella* Kulik, 1973 (Pl. 1, figs 6-7, 9), ?*Kulikaella* Berchenko, 1981 (Fig. 2A).

Comparison. Fascielleae differ from Calcifolieae by the absence of pseudophylloid growth, the yellowish calcite of the wall (never dark), and the absence of a network of internal structures.

Remarks. *Fasciella* is generally described as an *incertae sedis* alga (Ivanova 1973; Chuvashov et al. 1987; Bogush et al. 1990; Mamet 1991). It was considered as a questionable "Moravamminida" by Vachard (1991). *Shartymophycus* (junior synonym of *Fasciella* according to Mamet & Roux 1977) was created and primarily admitted as a questionable green alga (Kulik 1973; Mamet & Roux 1975). However, Groves (1986) and Sebbar (2000) interpreted *Shartymophycus* as a questionable Rhodophyta. Shuysky (1999) defined Fasciellaceae as a family of red algae related to Stacheiaceae, and composed of *Fasciella (= Shartymophycus), Kulikaella* and *Frustulata*.

The continuous growth of calcite laminae are in some cases interrupted, with the occasional attachment of Tuberitinidae (in southwest Spain, interlaminae space can be encrusted by *Girvanella*), suggesting the exposure of the previously indurated calcified laminae (Ivanova 1973, pl. 27, fig. 4; Herbig 1984, pl. 7, fig. 4; Cózar et al. 2003, pl. 4, fig. 12, pl. 5, fig. 6; Vachard et al. 2004, pl. 1, fig. 4). In addition, in the material from Scotland, the laminae are interbedded with laminae of encrusting *Falsocalcifolium* (Pl. 1, fig. 10).

Distribution. Early Viséan (first occurrence of *Fasciella*); acme: late Viséan-late Serpukhovian (Arnsbergian = Zapaltiubinsky), e.g. limestones D_5^6 and D_5^7 from Donbass, Ukraine (Poletaev et al. 1988, p. 68); up to early Bashkirian; and occasionally in the early Moscovian (Sebbar & Mamet 1999).

Tribe Calcifolieae Shuysky in Chuvashov et al., 1987, orth. mut. pro Calcifoliae, emend. Vachard & Cózar, 2005

Diagnosis. Calcifoliaceae with pseudophylloid to conical forms. Wall yellowish, generally dark. Internal structures (filaments) irregular in the primitive forms, regular, dichotomous and diverging in advanced forms, filled by microsparite or iron oxides (cf. Vachard & Cózar 2005).

Comparison. The Calcifolieae differ from the Fascielleae by the pseudophylloid shape, the dark calcitic recrystallization of the petal, and the network of generally microsparitized internal structures (cf. Vachard & Cózar 2005).

Composition. *Frustulata* Saltovskaya, 1984 (= *Pseudodonezella* Mamet & Herbig, 1990 = ?*Iberiaella* Racz, 1984) (fig. 4), *Falsocalcifolium* Vachard & Cózar, 2005 (Pl. 1, figs. 10-14, Pl. 2, figs 1-4), *Calcifolium* Shvetsov & Birina, 1935 (Pl. 2, figs 5-17).

Distribution. Brigantian-early Bashkirian in western Palaeotethyan basins, and occasionally in Donbass, Moscow area, Volga area, southern Urals, Iran, Tian Shan (see Vachard & Cózar 2005).

Discussion

Some controversial problematic algae, looking like red algae, green algae, moravamminales or aoujgaliales but differing from all these groups, are grouped in the family Calcifoliaceae. A first reappraisal of this family is presented here. Common characters are not numerous and the palaeoecological, biogeographical or biostratigraphical value differ according to the genera (Figs. 5-6).

The different morphotypes of *Fasciella* can be interpreted as different habits of the skeleton, controlled

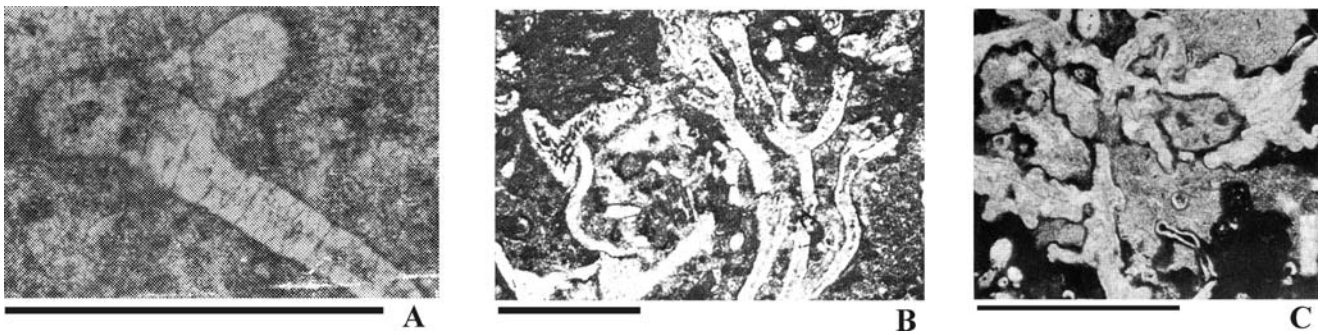

Fig. 4 - *Frustulata* Saltovskaya emend. Vachard & Cózar (A, modified from Saltovskaya 1984, pl. 37, fig. 3) and its possible synonyms, B: *Pseudodonezella* Mamet & Herbig, 1990, pl. 1, fig. 4, and C: *Iberiaella* Racz, 1984, fig. 3a. (Scale bar = 1 mm).

primarily by the nature of the substrate or concentric growth of the laminae (Vachard et al. 2004, fig. 1), and secondarily divided internally. The *Praedonezella* growth is controlled by the light, micritic mud input, and the available space; this genus can be semi-infaunal (Vachard & Aretz 2004). The morphotypes of *Falsocalcifolium* are controlled by several factors (Cózar & Vachard 2004; Vachard & Cózar 2005): the substrate must be hard to firm, the turbidity is low, the light is moderate, its resistance to weak turbulent bottom currents (in forming platose or conical cups, anastomosed into bindstones/bafflestones), the gregarity is probably caused by a poor dispersion of the spores. A semi-infaunal and dysphotic habit were postulated for the *Falsocalcifolium punctatum* from Guadiato area (SW Spain) (Cózar & Vachard 2004). *Calcifolium*, and perhaps *Frustulata*, share most of the morphotypes recognised in *Falsocalcifolium* (except the crustose habit), thus palaeoecological conditions interpreted for *Falsocalcifolium* may be also similarly interpreted for *Calcifolium*.

Biostratigraphically, the ancestors of Calcifoliales are poorly known (Fig. 1). The group is unquestionably present since the late early Viséan, because rare *Fasciella* occur in the Arundian of several areas: Montagne Noire (Vachard 1977), (Cf4β-Cf4γ = "V1b"-"V2a": Belgium, Vosges; D.V. unpublished data). Common *Fasciella* occur during the Asbian. First occurrences (FAD; first appearance datum) of *Frustulata* and *Praedonezella* are in the late Asbian/early Brigantian (Figs. 5-6) (as well as *Claracrusta*). The appearance and/or first local acme of *Falsocalcifolium* and/or *Calcifolium* is not synchronous according to the basins: Aleksinsky (= early Brigantian cf. Hecker 2002; = late Asbian cf. Brenckle 2004) in Russia, early/late Brigantian in Great Britain and Ireland (Figs. 5-6), early Serpukhovian in SW Spain, Libya and Iran.

Compiled data from the literature and our own work suggests that the interval of time, from the Asbian to the early Bashkirian in the western Palaeotethys region, can be subdivided into seven biozones of Calcifoliaceae (Fig. 5): (A) In the early Asbian, only *Fasciella* is present and consequently might characterise an interval zone. (B) In the late Asbian, *Fasciella* co-occurs with the first appearance (FAD) of *Praedonezella* with the species *P. primitiva*. (C) In the Brigantian, is observed the diversification of the Calcifoliales; because of the possible misinterpretations of Calcifoliaceae in the literature, it is difficult to use the respective FAD to subdivide the Brigantian, but several data (Cózar 2004; Cózar & Somerville 2004, 2005a-b) seem to indicate that the FAD of *Falsocalcifolium* characterises the early Brigantian, whereas the FAD of *Calcifolium* corresponds to the late Brigantian. (D) In the lower part of the early Serpukhovian, is recorded the acme zone of *Praedonezella* in some basins, such as Montagne Noire (Vachard & Aretz 2004). (E) In the upper part of the early Serpukhovian, is recorded the disappearance (LAD) of *Falsocalcifolium* and primitive species of *Praedonezella*. (F) in the late Serpukhovian, is found, for example in the French Pyreneees (Perret & Vachard 1977), a *Calcifolium okense*, *Praedonezella cespeformis* and *Fasciella kizila* biozone. (G) in the earliest Bashikirian, *Calcifolium* disappears (LAD). This attempt at general biozonation is difficult to use regionally. For instance, the regional stratigraphical distribution of these taxa in Ireland/Great Britain and SW Spain show marked differences (Fig. 6). Thus, palaeogeographical, sedimentological and palaeoecological factors seem to be conditioning by the stratigraphic distribution of the Calcifoliales.

The internal structures in *Falsocalcifolium* show diverse stages of preservation, and were interpreted as related to three hypotheses, mostly related with the "precipitation" of the iron oxides: (a) reduction-oxidation of the organic matter, (b) reduction-oxidation of the symbiotic bacteria or, (c) oxidation by subaerial exposure (Vachard & Cózar 2005).

The final result could be interpreted as composite, and they were interpreted as a response to an evolutionary pattern in the distribution of the organic matter/bacteria in the genera of the family.

Fasciella: exclusively external to the wall, or only located within the "pivot".

Praedonezella: external to the wall at the base of the colonies and the ramifications. Probably, an incipi-

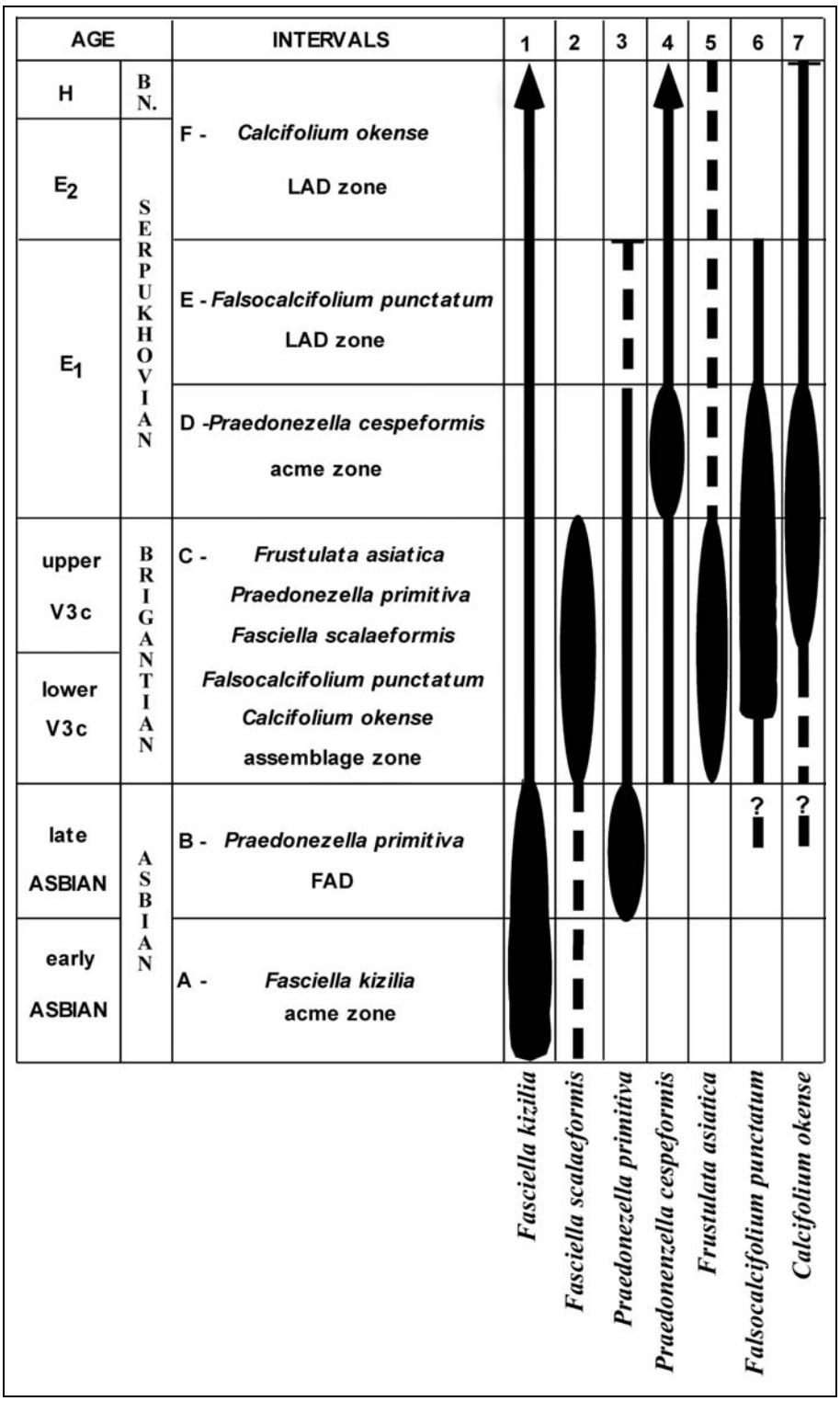

Fig. 5 - The seven biozones (A-G) with Calcifoliaceae in the interval Asbian-earliest Bashkirian, by combination of seven taxa (1-7). 1 = *Fasciella kizilia* Ivanova, 2 = *Fasciella scalaeformis* Vachard, Somerville & Cózar, 3 = *Praedonezella primitiva* Vachard Somerville & Cózar, 4 = *P. cespeformis* Kulik, 5 = *Frustulata asiatica* Saltovskaya, 6 = *Falsocalcifolium punctatum* (Maslov), 7 = *Calcifolium okense* Shvetsov & Birina. Abbreviations: E1, E2, H = goniatite zones with *Eumorphoceras* and *Homoceras*; BN. = earliest Bashkirian; FAD = first appearance datum; LAD = last appearance datum; V3c = Belgian equivalent of the Brigantian, or the Russian Okian superstage updated by Hecker (2002), with successively Aleksinsky, Mikhailovsky and Venevsky horizons.

ent "colonization" of the internal cavities can be suggested in the ramifications.

Frustulata: internal to the wall, in the "pores", or labyrinthine cavities.

Falsocalcifolium: internal to the skeletal wall and in the filaments.

Calcifolium: exclusively internal to the wall. The filaments contain more rarely iron oxides.

This hypothesis reflects a better protected and more internal position of the symbiotic bacteria during the lineage *Fasciella* →*Praedonezella* →*Frustulata* →*Falsocalcifolium* →*Calcifolium* (Fig. 7).

Reproductive organs of the representative of the family Calcifoliaceae are unknown, which would clarify their taxonomic status. For the first time, possible reproductive structures are recognised in specimens of *Calcifolium okense* from the Midland Valley in Scotland (Pl. 2, figs 9-10, 12-17). Those structures are rounded to elongated, situated in a internal position in the petals, and commonly connected with the basal part of the

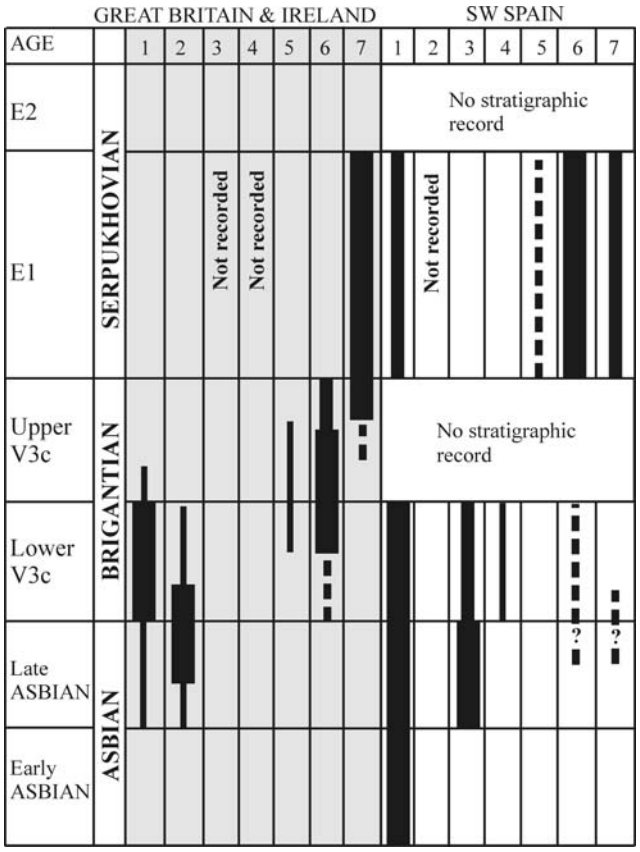

Fig. 6 - Two examples of local biozonations (Great Britain-Ireland and SW Spain), by means of Calcifoliaceae and other algae, showing the differences that exist between basins (compare also with the idealized succession of Fig. 5). Abbreviations 1-7 as in Fig. 5, i.e. 1 = *Fasciella kizilia*, 2 = *Fasciella scalaeformis*, 3 = *Praedonezella primitiva*, 4 = *P. cespeformis*, 5 = *Frustulata asiatica*, 6 = *Falsocalcifolium punctatum*, 7 = *Calcifolium okense*.

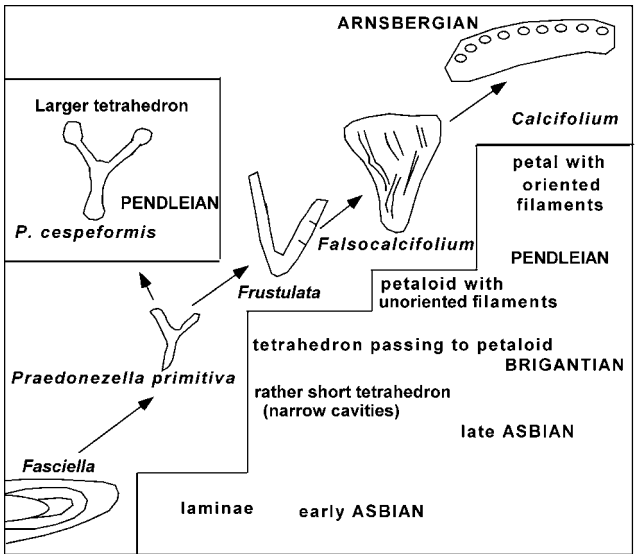

Fig. 7 - Hypothetical evolutionary trends between *Fasciella, Praedonezella*, *Frustulata*, *Falsocalcifolium* and *Calcifolium*.

filaments. The illustrated structures, although of questionable interpretation, might represent sporangium-like reproductive organs, as those described in somes families of Rhodophyta (e.g. Woerkerling 1988). If that is the case, the Calcifolieae, and thus, the entire Calcifoliaceae could be assigned to the red algae. This assessment would be in agreement with previous authors (Groves 1986; Shuysky 1999; Sebbar 2000). Nevertheless, those possible reproductive structures need a further investigation.

Palaeobiogeographically, *Fasciella* is the only genus that could be regarded as cosmopolitan, but its

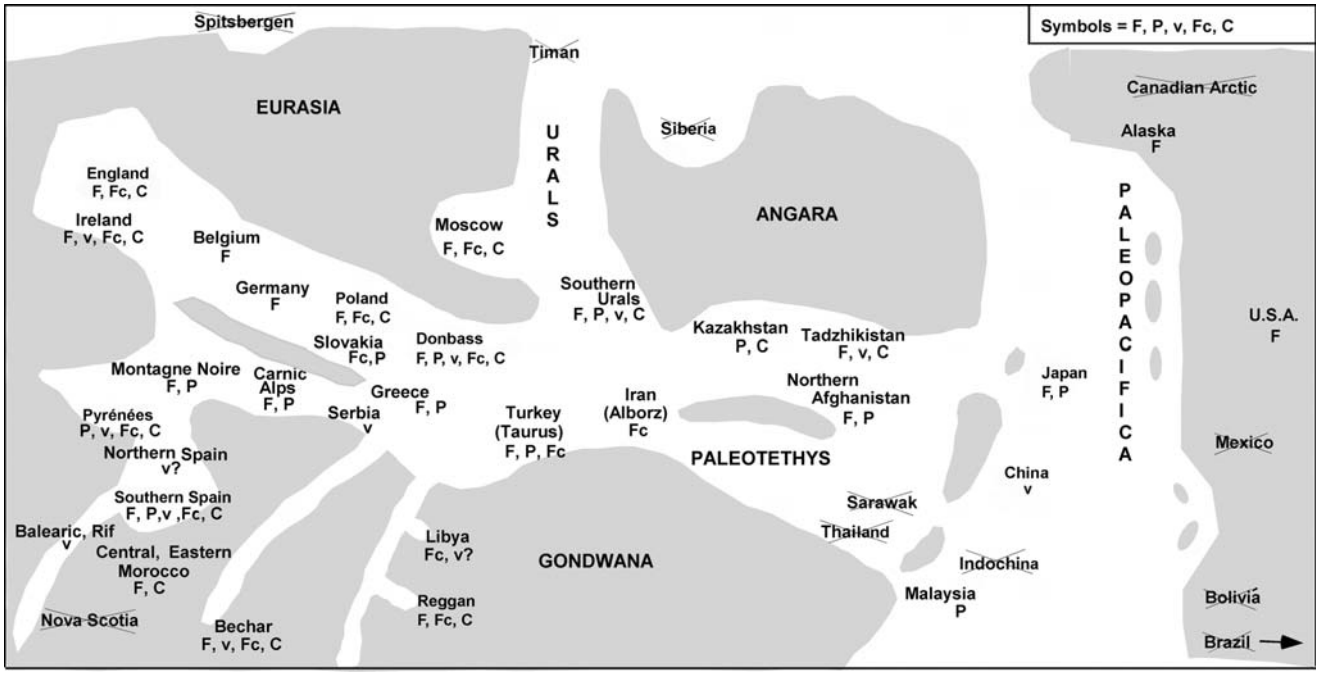

Fig. 8 - Palaeobiogeographical distribution of the main genera of Calcifoliaceae. Abbreviations: F = *Fasciella*, P = *Praedonezella*, v = *Frustulata*, Fc = *Falsocalcifolium*, C = *Calcifolium*. Crossed names indicate well known Carboniferous areas, where calcifoliacean algae are apparently absent.

presence has not been documented in China up to now. In fact, most calcifoliacean genera are restricted to the western Palaeotethys and Ural seaways (Perret & Vachard 1977; Vachard & Cózar 2005), but the occasional occurrences in eastern Palaeotethyan regions (China, Japan) suggest a probably incomplete knowledge of the palaeogeographic distribution (Fig. 8).

Conclusions

1. Calcifoliaceae are interpreted as algae without modern representatives, and are possibly also related with the groups of *Claracrusta* and *Donezella*. All are *incertae sedis* algae distinct from the green and red algae, although novel records of reproductive-like structures might relate the family to the red algae.

2. The Calcifoliaceae emend. are subdivided into two tribes: Fascielleae emend. and Calcifolieae.

3. The origin of the lineage is unknown, and is located in the Tournaisian with *Kulikaella*, or prior to this in the Early Devonian with *Precorninella*.

4. The family Calcifoliaceae is characterized by crusts of calcite passing to erect tetrahedric skeletal elements, to petaloids and phylloid thalli.

5. *Fasciella* is cosmopolitan, whereas the other genera are relatively restricted to the western Palaeotethys and Urals seaways.

6. Their biostratigraphic value, although relatively neglected, is important. The first attempt at dating allows us to propose at least seven intervals: a relative abundance of *Fasciella*, the FAD (first appearance) of *Praedonezella*, a Calfoliacean diversity, an acme of *Praedonezella*, the LAD (disappearance) of *Falsocalcifolium*, an assemblage of survivals with *Calcifolium*, *Praedonezella* and *Fasciella*, and finally, the disappearance of *Calcifolium*, in ascending order from Asbian to earliest Bashkirian.

7. Due to the rapid evolution of the Calcifolieae, and the continuity of the biostratigraphic record, the evolution of *Praedonezella* to *Falsocalcifolium*, via *Frustulata*, can correspond to a good indication of the Viséan/Serpukhovian transition.

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PLATE 1

Tribes Fascielleae and Calcifolieae (pars), late Brigantian, Midland Valley (Scotland). All the thin-sections from the Collection of Iain Burgess (British Geological Survey at Edinburgh). Scale bar = 1 mm.

Figs. 1-5, 8 - *Fasciella crustosa* Vachard, Somerville & Cózar. Figs. 1, 3 – *Fasciella crustosa* encrusting a crinoid article (IB 1149) and a gastropod (IB 1140) respectively; Dockra Limestone, Hindog Glen, North Ayrshire. Fig. 2 - *Fasciella crustosa* encrusting a rugose coral; IB 276A, Hawthorn Limestone, River Nethan, Lanarkshire. Figs. 4, 5 - *Fasciella crustosa* encrusting crinoids, molluscs, and covered by micrite films. Note the occurrence of fragmented petals of *Calcifolium okense* in the matrix; IB 1347, Blackhall Limestone, River Avon, Stratharon, Lanarkshire. Fig. 8 - Large *Fasciella crustosa* encrusting a dissolved bioclast; IB 234, Main Limestone, Telglann Burn, Birkwood, Lanarkshire.

Figs. 6-7, 9 - *Praedonezella primitiva* Vachard, Somerville & Cózar. Fig. 6 - Close-up view of the erected parts of *Praedonezella* arising from the encrusted *Fasciella*-like initial parts; IB 330, Main Limestone, Calder River, Caldewood Castle, Lanarkshire. Figs. 7, 9 - Typical view of the intervals in the erected parts of *Praedonezella*; IB 335, Netherfield Limestone, Calder River, Caldewood Castle, Lanarkshire.

Figs. 10-14 - *Falsocalcifolium punctatum* (Maslov). Fig. 10 - Encrusting morphotype, note that the specimen is interbedded with *Fasciella* crustosa laminae; IB 276A, Hawthorn Limestone, River Nethan, Lanarkshire. Figs. 11, 12 - Tangential sections of cups; IB 263, Main Limestone, River Nethan, Lanarkshire. Fig. 13 - Encrusting and pseudophylloid morphotypes; IB 618 Main Limestone, River Nethan, SW Auchlockan House, Lanarkshire. Fig. 14 - Pseudophylloid growth; IB 1084, Hurlet Limestone, Thornthonhall Quarries, Lanarkshire.

PLATE 2

Tribe Calcifolieae, late Brigantian, Midland Valley (Scotland). All the thin-sections from the Collection of Iain Burgess (British Geological Survey at Edinburgh). Scale bar = 1 mm.

Figs. 1-4 - *Falsocalcifolium punctatum* (Maslov), erect massive cups. Fig. 1 - (IB 234), Fig. 2 - (IB 235), Main Limestone, Teiglann Burn, Birkwood, Lanarkshire. Fig. 3 - IB 1084, Hurlet Limestone, Thorntonhall Quarries, Lanarkshire. Fig. 4 - IB 618, Main Limestone, River Nethan, SW Auchlockan House, Lanarkshire.

Figs. 5-17 - *Calcifolium okense* Shevtsov & Birina. Figs. 5-8, 11 - Typical aspect of cups, with "embase" joints. Figs. 5-7 - IB 1347, Blackhall Limestone, River Avon, Strathaven, Lanarkshire. Fig. 8 - IB 1305, Blackhall Limestone, Wankmill, Strathaven, Lanarkshire. Fig. 11 - IB 615, Hawthorn Limestone, River Nethan, SW Auchlockan House, Lanarkshire. Figs. 9-10, 12-17 - Close-up view of the reproductive-like structures. Figs. 9, 10, 12, 14-17 - IB 1347, Blackhall Limestone, River Avon, Strathaven, Lanarkshire. Fig. 13 - IB 615, Hawthorn Limestone, River Nethan, SW Auchlockan House, Lanarkshire.

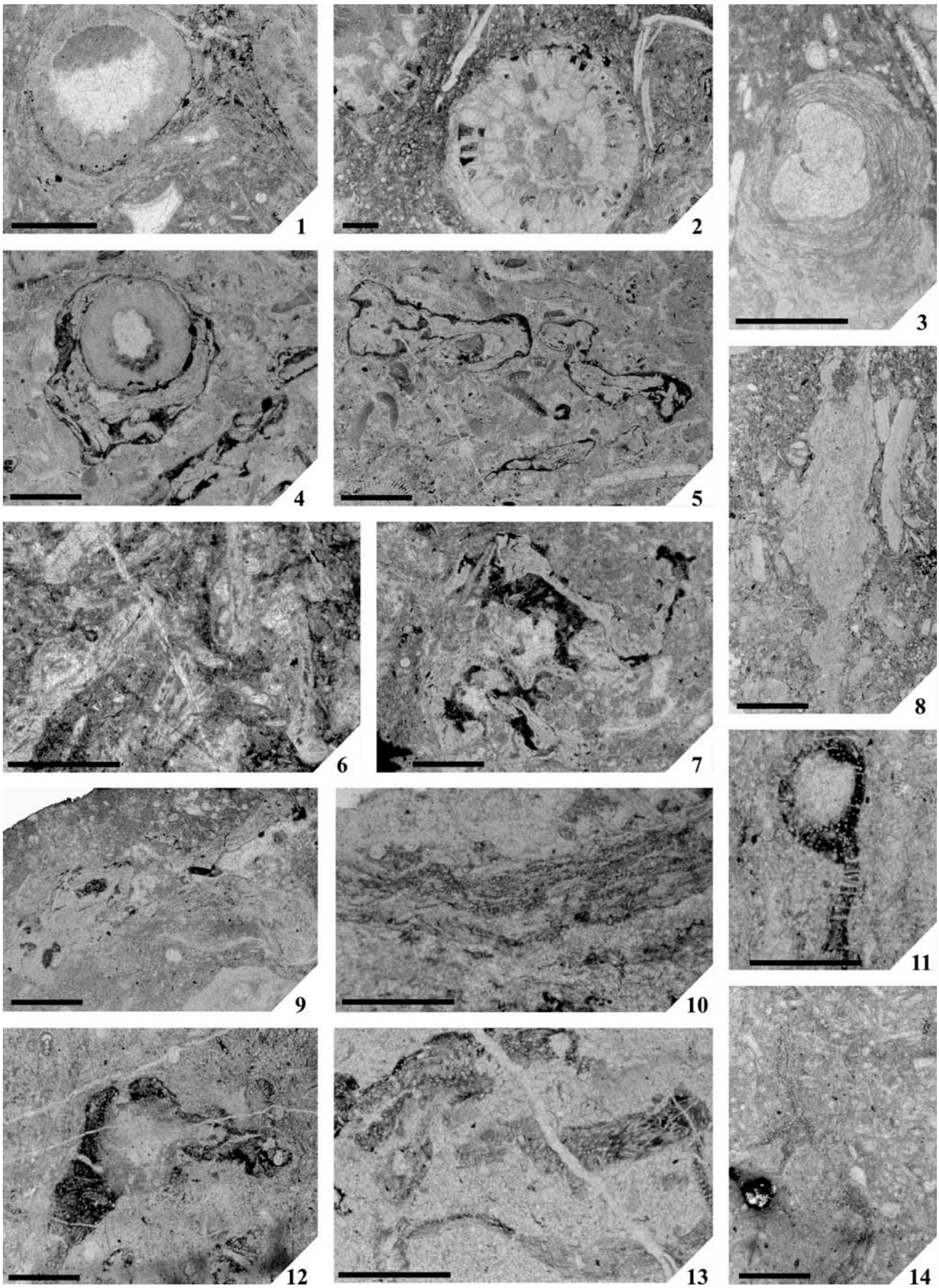

PLATE 1

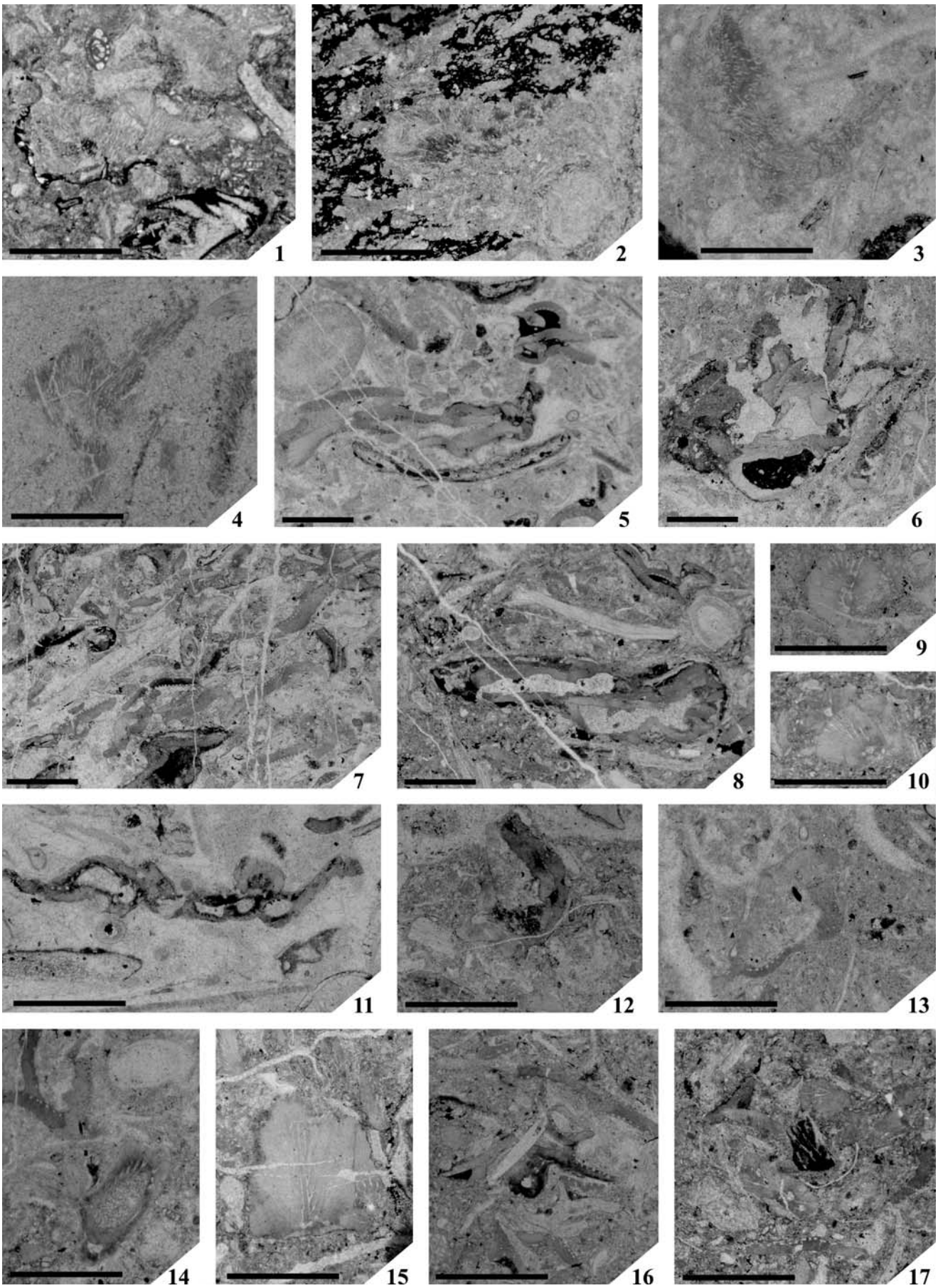

PLATE 2

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