

# Middle Triassic calcareous algae and microproblematica from south China

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**ABSTRACT:** The Yangtze carbonate platform (Southern China) recorded a long sedimentary evolution from Neoproterozoic to the basal Upper Triassic. During the Early and Middle Triassic, this platform was dominated by shallow-water carbonates. In various sectors of the platform, the Middle Triassic (Anisian-Ladinian) succession contain abundant assemblages of benthic foraminifera and calcareous algae. Following a previous paper about the Middle Triassic dasycladalean algae from SW Guizhou Province, the present study describes algae and microproblematic organisms from three sections: Honyan, Longtou and Guanling. Some dasycladalean algae are well known from the Alpine-Dinaric domain: *Diploporella annulatissima*, *D. annulata*, *Euteutloporella triasina*, *Macroporella dinarica*, *Oligoporella minutula*, *O. pilosa pilosa*, *Poncetella hexaster* and *Pseudodiploporella proba*. However, the dasycladalean association is dominated by species belonging to the genus *Kantia*, including *K. cf. dolomitica* and *K. cf. comelicana*. New *Kantia* species (*K. intusannulata* n. sp., *K. granieri* n. sp., *K. muxinanii* n. sp.) are characterized by the presence of intusannulation, a feature unknown from the *Kantia* species in the Alpine domain. The dasycladalean association also contains new species of the genus *Mizzia* and specimens belonging to the organo-genus *Acicularia* and/or *Terquemella*. Besides, rare specimens of “*Solenopora*” and *Rivularia*-type cyanobacteria are also present. The algal association is accompanied by microproblematic organisms including *Tubiphytes* sp., *Zornella obscura*, *Plexoramea cerebriformis*, *Ladinella porata*, and *Baccanella floriformis*. Anisian-Ladinian foraminifera complete the micropaleontological spectrum of the sections studied. The most important are *Meandrospira dinarica*, *Endotriadella wirzi*, *Paleolituonella meridionalis*, and *Turriglomina mesotriasica*.

The microfossils from the Middle Triassic Yangtze carbonate platform of south China belong to the Eastern Tethys province. Some of these species are also present in the Western Tethys (Alpine Domain). The new species presented in this study are absent from the Alpine Domain and probably represent endemic species for the Eastern Tethys.

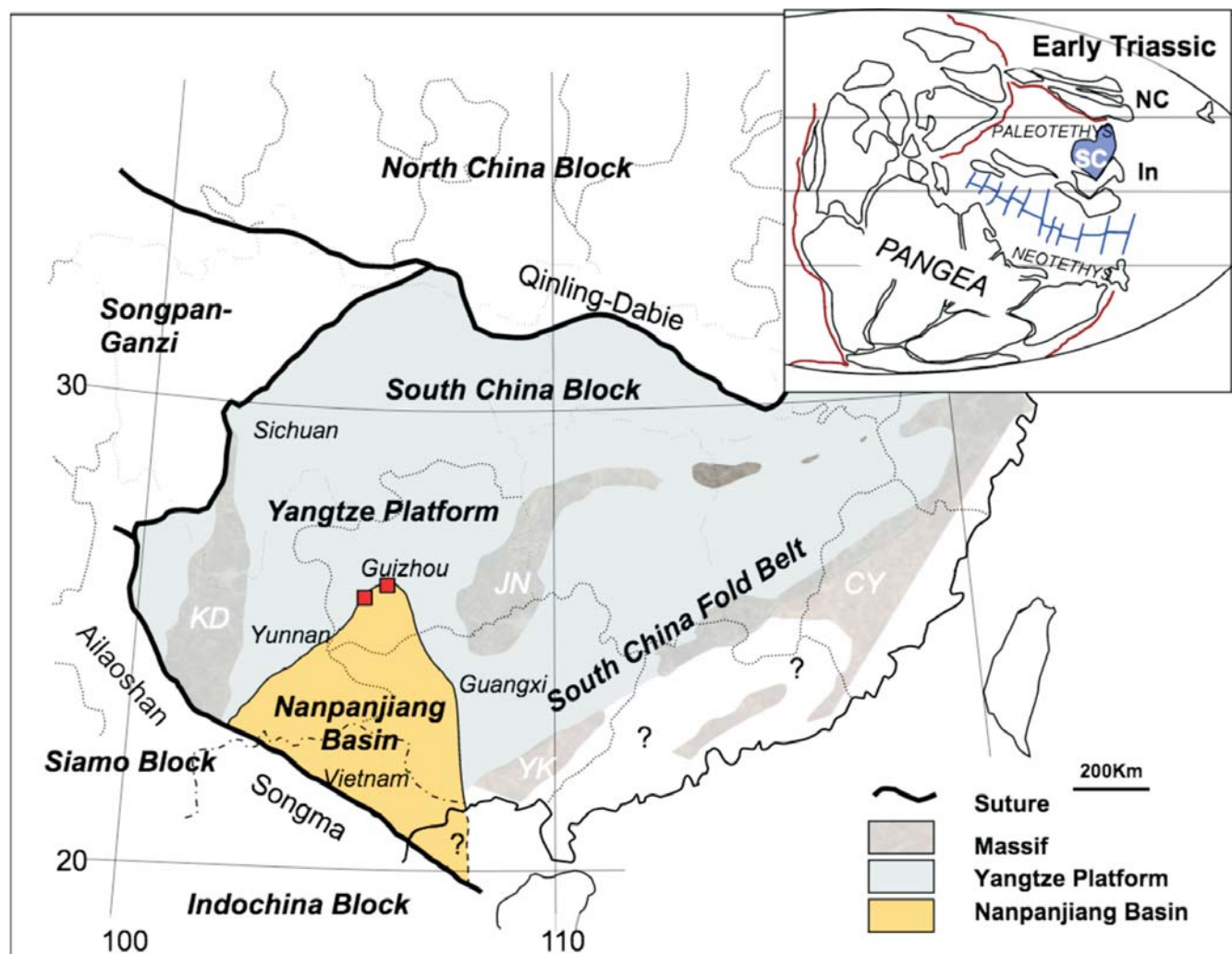
**Key words:** dasycladales, microproblematica, Triassic, China

## INTRODUCTION

The biological crisis at the end of the Permian was recorded by calcareous algae in general and Dasycladales in particular (Flügel 1991). If in the Early Triassic the calcareous algae are missing on a global scale, the Middle Triassic represents a period of recovering and in the Late Triassic we see a real flowering, especially among dasycladaleans.

Triassic dasycladaleans are well known from the Alpine-Dinaric domain, documented in a rich literature starting with the fundamental works of Pia (1912, 1920) and continuing with studies published in the following decades. In the Middle East (Oman, Iran) and the Far East (Eastern Tethys and Panthalassa) the calcareous algae and the accompanying problematic microorganisms are mainly known from Upper Triassic carbonate deposits and possibly also from the upper Middle Triassic (e.g., Fontaine et al. 1988; Flügel et al. 1989; Bernecker 1996, 2005; Senowbari-Daryan and Hamedani 2000; Senowbari-Daryan 2003; Senowbari-Daryan et al. 2011; Peybernes et al. 2015; Bucur et al. 2020).

The first description of calcareous algae from the Middle Triassic limestones of the Yangtze platform belongs to Xu Guirong (1992). This author described and illustrated an association of Dasycladales from Bazichang (Guanling, Guizhou Province) from the Poduan (Anisian), Longtou (Ladinian) and Zhuganpo (Carnian) formations. Four new genera and six new species were described. Unfortunately, all of these taxa are *nomina nuda* because incorrect designations of holotypes. Moreover, most of them belong, in fact, to well-known taxa from the Alpine-Dinaric realm, such as *Diploporella annulatissima*, *Julpiaella subtilis*, etc. or represent recrystallized-micritized specimens impossible to identify (see also comments in Bucur and Enos 2001, p. 317–318). The first accurate description of the dasycladalean assemblage from the Middle Triassic of Guizhou was published by Bucur and Enos (2001). Since then, new material was collected (first presented by Bucur et al. 2003), and the aim of the present paper is to further describe the algae and microproblematica of this region, including new species. The study is based on the micropaleontological analysis of 150 thin sections coming from three geological sections:



TEXT-FIGURE 1A

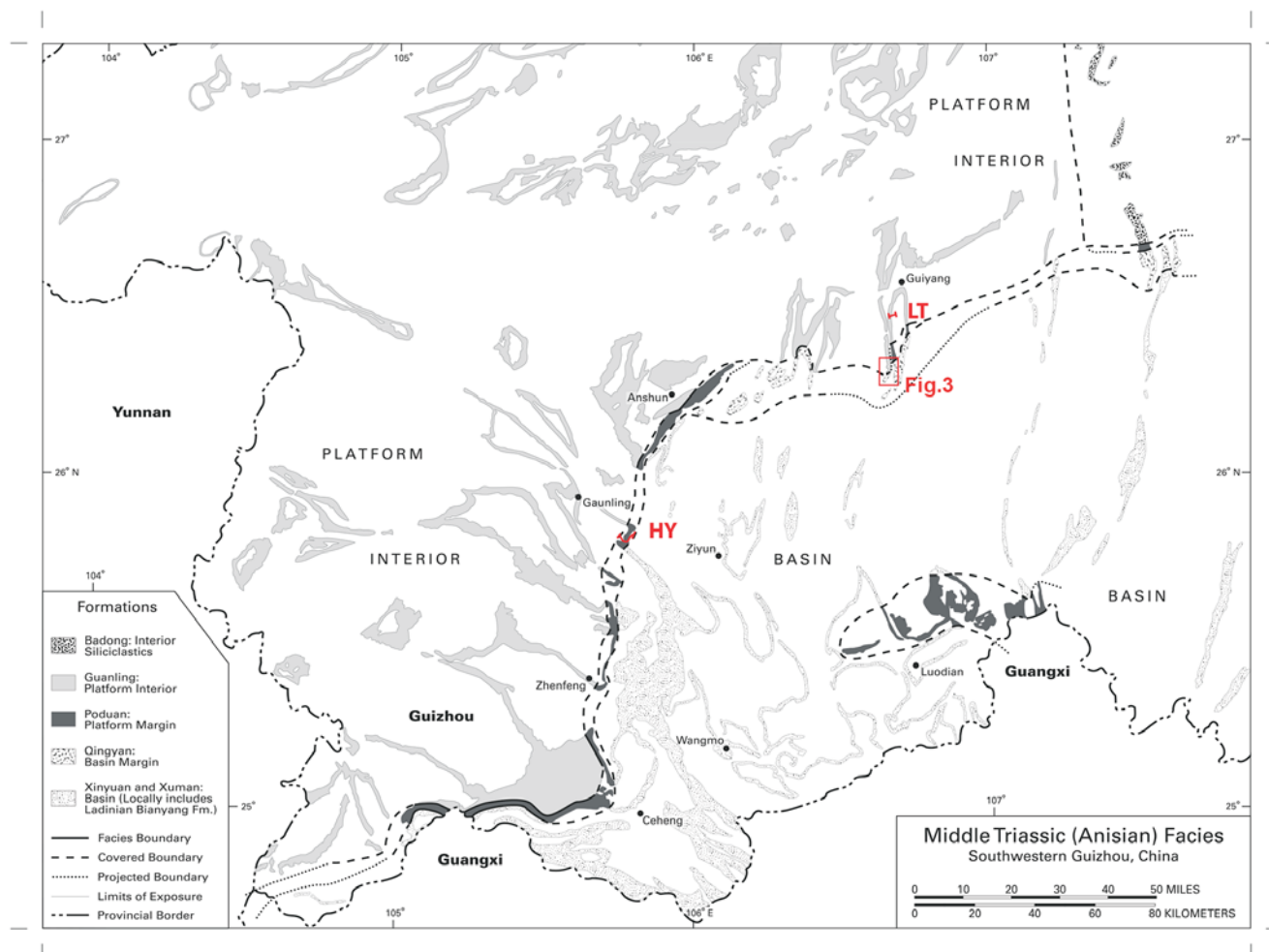
Location of the Yangtze platform and Nanpanjiang basin on the South China block. Block boundaries are sutures except with Songpan-Ganzi, which is primarily the SE-directed Longmenshan thrust. Shaded areas are Precambrian massifs: JN-Jiangnan, KD-Khamdian, YK-Yunkai, CY-Cathaysian. Modified after Minzoni et al. (2013). Red boxes are locations of Fig. 2B (lower left) and 3 (upper right). Inset, upper right, illustrates global plate reconstruction and position of south China block (SC), north China block (NC) and Indochina block (In) in the Early Triassic (after Golonka and Ford 2000).

Hongyan, Longtou and Gutong, in Guizhou Province. The calcareous algae and microproblematica were studied and measured under a petrographic microscope and microphotographs were taken with a non digital camera.

## GEOLOGICAL SETTING

The Yangtze platform covered much of the South China tectonic plate (text-fig. 1A), which sutured to the North China (Sino-Korean) plate, perhaps as early as the Silurian (Faure et al. 2008) or as late as the Triassic (Meng and Zhang 1999; Dong et al. 2011). Complex suturing with southeast Asian and Tibetan plates was probably between Late Permian and Late Triassic, with overtones extending through Early Cretaceous (Enos et al. 2006), but details of timing and mechanisms remain controversial (Cai and Zhang 2009; Faure et al. 2016; Liu et al. 2018; Gan et al. 2021). The South China plate reached the equator during the Permian and 10°N (Enkin et al. 1992) to 30°N (Metcalfe 1996; Zhao et al. 1996) by Late Triassic, thus

remaining in the tropics or sub-tropics. Deposition of shallow-water carbonates with intermittent shale and sandstone, extended from the Late Proterozoic (Late Sinian) through the Middle Triassic, from 850 to 230 Ma, punctuated by some intervals of erosion, reconfiguration, and terrigenous influx (Liu and Xu 1994; Enos et al. 2006). Lower and Middle Triassic platform deposits, predominately carbonates with minor mudrocks and evaporites, are as thick as 3140 m. Middle Triassic platform-margin deposits average about 740 m in the Poduan Formation (Anisian) and 970 m in the Longtou Formation (mostly Ladinian). Equivalent platform-interior deposits average 650 m in the Guanling Formation and 820 m in the Yanliujing Formation, respectively (Enos et al., 2006). Shallow-water carbonate deposition ceased abruptly at the transition to the Carnian (Late Triassic) over most of the platform, and from the Norian onward deposition on the former Yangtze platform was entirely terrigenous siliciclastics.



TEXT-FIGURE 1B

Anisian (early Middle Triassic) facies distribution of southwestern Guizhou showing location of sections Hongyan (HY) and Longtou (LT), and of text-fig. 3. Facies compiled from Geologic Map of Guizhou (1:500,000, Guizhou Bureau 1987); modified from Enos et al. (1997, 2006).

The southwestern border of the South China plate, a trailing edge through most of its history, subsided more rapidly to form the well-defined Nanpanjiang (aka Youjiang) basin in the Permian and Triassic (text-fig. 1). The basin fill is predominately siliciclastic, including extensive turbidites, with some intervals of deep-water limestones and sporadic carbonate breccias in the Early Triassic (Enos et al. 2006; Lehrmann et al. 2015).

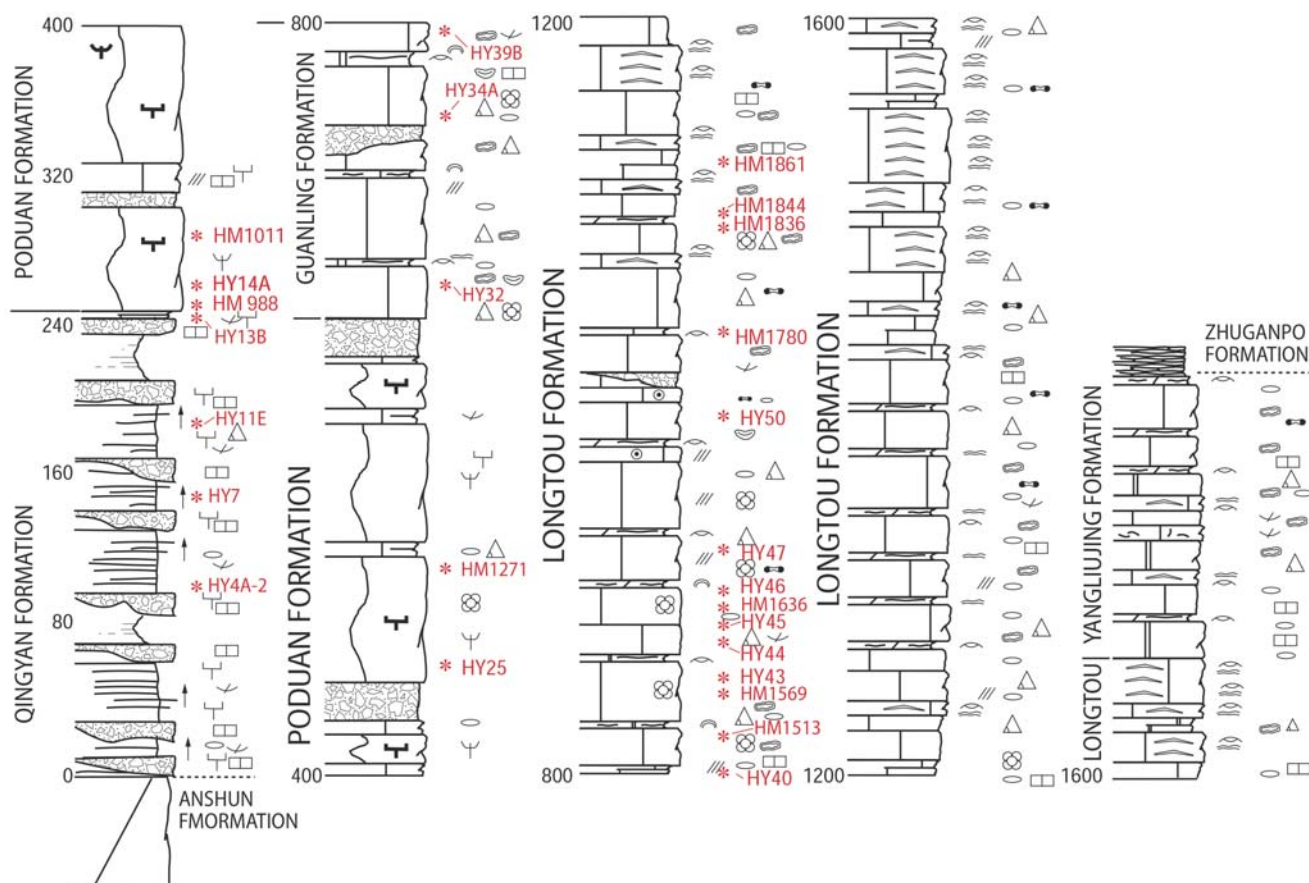
In light of the dearth of calcareous algae globally in the Early Triassic and of marine carbonates in south China in the Late Triassic, our focus is on the Middle Triassic biota.

A high-relief shelf margin rimming the Nanpanjiang basin first developed in the Anisian, built by a narrow reef zone of *Tubiphytes* Maslov, *Plexoramea cerebriiformis* Mello, and scleractinian corals with a diverse supporting cast of encrusters and sponges in the Poduan Formation (text-figs. 2A, 2B; Enos et al. 2006; Minzoni et al. 2013). This assemblage is represented here in samples from Gutong, Guizhou (text-fig. 3) of breccias and grainstone turbidites that formed in abundance along the basin margin concomitant with reef development. Mapped for decades as the Qingyan Formation (Guizhou Bureau 1987, 1997; Ma 2002), these narrow carbonate debris wedges are

lumped with the basinal siliciclastics of the Xinyuan Formation in the most recent map of Guizhou Province (Guizhou Geological Survey, 2015). The entire Middle Triassic was sampled from the Hongyan section (text-fig. 2) and the later Middle Triassic in the Longtou section (text-fig. 4). In addition to parts of the Qingyan and Poduan Formations, the Hongyan section includes the upper part of the Guanling Formation, also assigned to the Anisian. The Guanling consists of argillaceous dolostone and limestone with thin interbeds of siliciclastic mudrock and intervals of *in situ* breccia, apparently the result of evaporate dissolution and collapse. The overlying Longtou Formation consists of cycles of grain-supported limestone overlain by muddier, laminated, fenestral carbonates, commonly deformed by tepee structures. The dominant grains are peloids with lesser quantities of intraclasts, grapestones, and coated grains. Bioclasts are subordinate, but include a diverse assemblage of calcareous algae, foraminifers, and gastropods. Localized intervals of algal grainstone are particularly relevant to this study. These lithologies represent a broad, high-energy shelf margin that repeatedly aggraded to tidal flats. Approximately the lower third of the Longtou Formation is late Anisian in age (Bucur and Enos 2001; this study) and remainder Ladinian.



## HONGYAN SECTION



TEXT-FIGURE 2A

Sketch section of Middle Triassic strata from Hongyan, Guanling County, Guizhou (Location text-fig. 1B). Symbols are identified in legend of text-fig. 4. Contact between Longtou and Yangliujing Formations is delineated on facies change (Minzoni 2007), rather than on dolomitization (Guizhou Bureau 1987, 1997). Based on a detailed measured section (1:100 through Poduan Formation; 1:200 above) that includes strata from latest Permian to early Carnian (Minzoni 2007).

## SYSTEMATIC DESCRIPTIONS

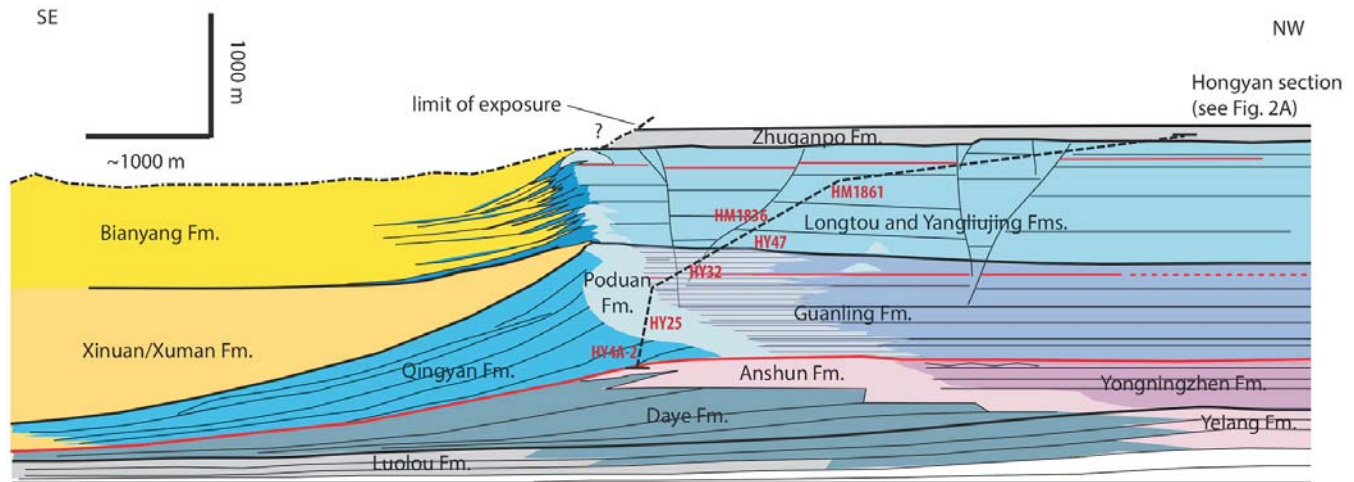
Note - For dimensions, we use the following abbreviations throughout the text:

L = length of the thallus  
D = external diameter of the thallus  
d = diameter of the stem/central cavity  
d/D = ratio between d and D  
l = length of the laterals  
p = diameter of the laterals  
h = distance between two consecutive verticils  
H = height of an article  
w = number of laterals/tufts in a verticil  
w' = number of laterals in a tuft

Phylum CHLOROPHYTA Pascher 1914  
Class ULVOPHYCEAE Stewart et Mattox 1978  
Order DAYCLADALES Parscher 1931  
Family TRIPLOPORELLACEAE (Pia 1920) Berger et Kaever 1992  
Tribe Salpingoporelleae Bassoullet et al. 1979  
Sub-tribe Salpingoporellinae Bassoullet et al. 1979

Genus *Oligoporella* Pia 1912 emend Grgasović 2022

Recognizing the difficulties in differentiating the species of *Oligoporella* and *Physoporella* based on the shape of the laterals, Grgasovic (1995, 2022) introduced a new concept for the two genera: species with double verticils were assigned to the genus *Oligoporella*, and species with single verticils to *Physoporella*. This concept was accepted in some recent papers (e.g., Rychlinski et al. 2013; Bucur and Matysik 2020; Gawlick et al. 2021).



TEXT-FIGURE 2B

Platform-margin facies relations in Hongyan area, Guanling County, Guizhou (Fig. 1B). Yangtze platform interior is to right; Nanpanjiang basin to left. Note location of Hongyan section. Based on measured sections and mapping. Modified from Minzoni (2007).

*Oligoporella* cf. *minutula* (Gümbel 1872) Grgasović 2022  
Plate 1, figure A

*Gyroporella minutula* n. sp. GÜMBEL 1872, p. 275, pl. DIII, figs. 4a, b.  
*Physoporella minutula* Gümbel spec. – PIA 1912, p. 45, pl. VI, figs. 5-12. – GRANIER and GRGASOVIĆ 2000, p. 126 (with extended synonymy). – NITTEL 2006, p. 100, pl. III, figs. 2, 3. – KOTANSKI, 2013, p. 81, pl. XXI, fig. 20  
*Oligoporella minutula* (Gümbel 1872) n. comb. – GRGASOVIĆ 1995, p. 15. – RYCHLINSKI et al. 2013, p. 31, pl. 2, fig. 9. – GAWLICK et al. 2021, p. 423, figs. 5i, l, r; Fig. 15h-j.  
*Oligoporella minutula* (Gümbel 1872) n. comb. – GRGASOVIĆ 2022, pl. 12, figs. 1, ?2, 3-9; pl. 13, figs. 2, 4; pl. 17, fig. 8.

*Remarks:* Pia (1912) gives the following description of this species: “Die Schale dieser Art zeigt alle Übergänge von einer fast glatten Oberfläche bis zu einer tief eingreifenden Gliederung, die sich beinahe schon dem Zustand von *Physoporella dissita* nähert [...]. Ich glaube, es ist hier vollständig klar, dass wir es nur mit einer gesteigerten Undulation zu tun haben. Die Äste stehen wieder in gedrängten, zweizeiligen Wirteln [...]. Abweichend von den bisher beschriebenen Arten ist jedoch ihre Form. Sie sind nämlich gegen aussen nicht oder doch kaum merklich zugespitzt. Ihre Gestalt ist vielmehr eine schlauch- oder, wenn man will wurstförmige, mit abgerundetem distalen Ende.”

English translation from Granier and Sanders (2013): “The calcareous skeleton of this species shows every transition from an almost smooth outer surface to deep decisive segmentation that almost approaches the state of *Physoporella dissita*. [...] I believe it is entirely clear here that we are dealing only with an enhanced undulation. Again the branches are arranged in closely spaced biserial verticils [...] However, their shapes differ from the species described previously. Their form does not taper outward, or the tapering is only scarcely perceptible. On the contrary their shape is a tube with rounded distal ends, or, if you will, “sausage-like.”

The specimen illustrated in Pl. 1, fig. A has smaller general dimensions compared with the specimens illustrated by Pia (1912), and a different shape of the distal end of the laterals, which in the Chinese specimen predominantly taper toward exterior. The illustrations of Gümbel (1872, pl. D III, fig. 4a) and of Kotanski (2013, fig. 20a, b) also show laterals that seem to taper towards exterior, and lack the sausage morphology noted by Pia (1912).

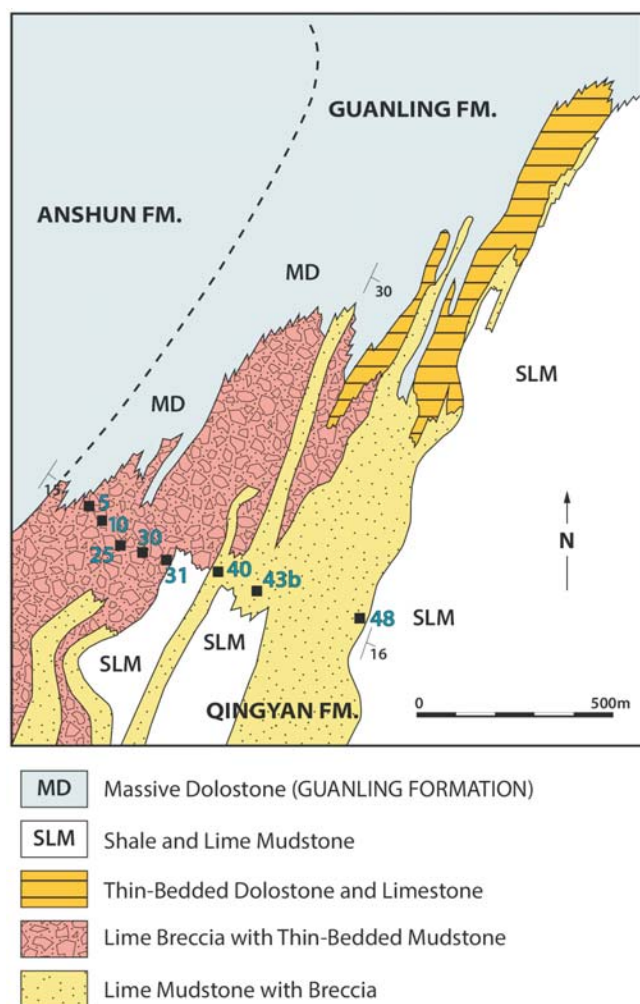
Dimensions (in mm): L = 6; D = 0.74; d = 0.36; h = 0.55; p (proximal) = 0.12-0.14.

*Oligoporella pilosa* Pia 1912 var. *pilosa* Pia ex Bystricky 1964  
Plate 1, figures B-D, F-H, J, K

*Oligoporella pilosa* nov. spec. PIA 1912, p. 42, pl. 4, figs. 1-8.  
*Oligoporella pilosa* forma *typica* PIA 1935, p. 205-211, text-figs. 5-12.  
*Oligoporella pilosa* Pia 1912 var. *pilosa* (nom. nov.). – BYSTRICKY 1964, p. 109, pl. X, figs. 2, 4, 6; pl. XI, figs. 2, 4. – GRGASOVIĆ 1995, p. 15.  
*Oligoporella pilosa* var. *pilosa* Pia ex Bystricky 1964 (= forma *typica* Pia 1935 nom. nud.) – GRANIER and GRGASOVIĆ 2000, p. 114 (with extended synonymy).  
*Oligoporella pilosa pilosa* Pia ex Bystricky 1964. – BUCUR 1997, p. 181, pl. 1, figs. 1-7. – GAWLICK et al. 2021, p. 423, Figs. 5j, n; figs. 15l, o, p.  
*Oligoporella pilosa pilosa* Pia. – PIROS 2002, p. 126, Pl. I, fig. 1; pl. II, fig. 2. – RYCHLINSKI et al. 2013, p. 31, pl. 2, fig. 11-12.  
*Oligoporella pilosa var pilosa* Pia 1935. – GRGASOVIĆ 2022, pl. 5, figs. 1-6, 8-11; pl. 6, figs. 1-8; pl. 7; pl. 8, figs. ?1, 2-10, 12; pl. 12, ?fig. 2; pl. 17, figs. 6, 7, 9; pl. 20, figs. 2-3, 5

*Remarks:* Several specimens in oblique (Pl. 1, figs. B-D, F-H) or transverse-oblique (J, K) sections displaying the typical trichophorous morphology of the laterals as well as the double-whorl arrangement.

*Dimensions* (in mm, except w): D = 0.74-1.4; d = 0.36-0.84; h = 0.50-0.55; p (proximal) = 0.12-0.14; w = 7-8



TEXT-FIGURE 3

Map of Anisian platform-margin facies in Gutong area (Location text-fig. 1B) with GT sample locations. The patterned facies are within the lower member of the Qingyan Formation. The shale and lime mudstone (SLM) at the lower right third of the map is predominantly terrigenous mudstone with little or no carbonate; it was mapped as the middle and upper members of the Qingyan Formation. Modified from 1:20,000 inset map from Qin et al. (1989) and from Enos et al. (1997).

? Tribe Mizzinae Bassoullet et al. 1979

? Genus *Mizzia* Schubert 1909 emend Rezak 1959

*Mizzia? toncii* Bucur, Enos and Minzoni n. sp.

Plate 2, figures A-J

**Derivation of name:** Dedicated to Tonci Grgasović for his important contributions to the study of Triassic calcareous algae

**Holotype:** specimen in Pl. 2, fig. A, thin section LT 149, deposited in the Museum of Paleontology, Babeş-Bolyai University, Cluj-Napoca, Romania, inventory number 24359.

**Paratypes:** specimens in Pl. 2, figs. B-J, thin section LT 149 (B, H) and LT149A (C-G, I, J), same repository. LT149A inventory number 24360.

**Type locality:** Longtou section, Longtou, Huaxi Country, Guizhou.

**Type level:** Ladinian, Longtou Formation, 276 m above base.

**Diagnosis:** Thallus moniliform, consisting of ovoid-elongated towards cylindroid superimposed articles. The axial cavity follows the general shape of the thallus. Phloioporous laterals, most likely with euspondyle arrangement. Reproductive cysts located inside the axial cavity (endospore). Weak calcification, around the axial cavity, partially covering the laterals.

**Dimensions** (in mm, except w): L (maximum observed) = 2.08; D = 0.45-0.71 (median = 0.58); d = 0.34-0.61 (median = 0.44); p (distal) = 0.075-0.10; l (maximum) = 0.10; H = 0.85-1.10; w = 21-25; Diameter of reproductive cysts = 0.05-0.06.

**Description:** *Mizzia? toncii* n. sp. is a relative small dasycladalean alga with moniliform thallus made up of superimposed articles. This character was observed in only one section (holotype, Pl. 2, fig. A) where three such articles are visible. The shape of the articles is ovoidal (Pl. 2, figs. A, B) to more or less cylindrical (Pl. 2, fig. C). The laterals are phloioporous (Pl. 2, figs. B, E, G, H), but the weak calcification and the recrystallization of the calcareous sheath make them less visible. Laterals were most likely arranged in a euspondyle manner. The reproductive cysts are located inside of the main stem (Pl. 2, figs. I, J). They are small spherical calcified bodies, either dispersed (Pl. 2, fig. I) or arranged in a chain around the internal side of the main stem (Pl. 2, fig. J).

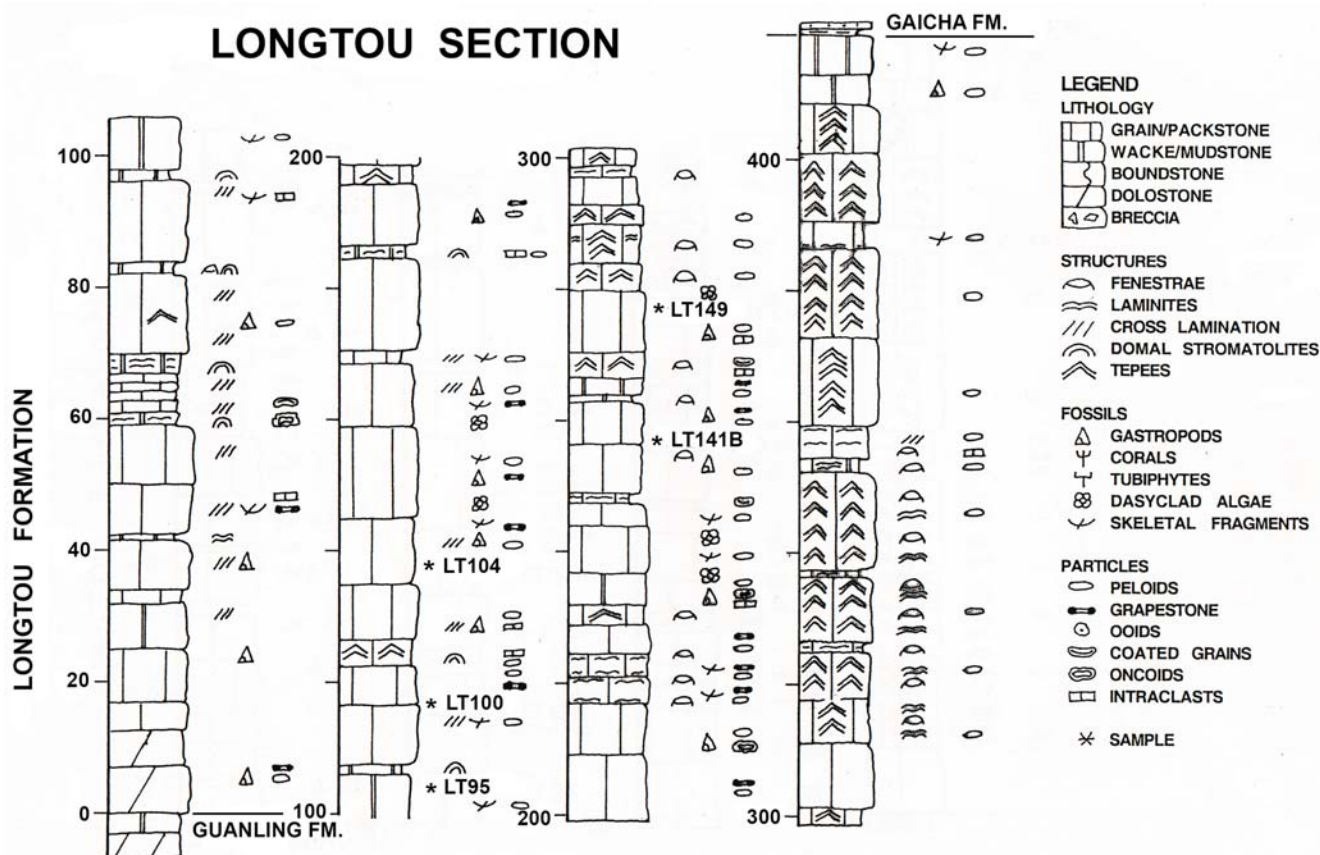
#### Remarks on the generic attribution and comparisons

The general thallus morphology led us to attribute this alga to the genus *Mizzia*. However, as the euspondyle character is not fully visible we prefer to maintain some uncertainty regarding this generic attribution.

The genus *Mizzia* was created by Schubert (1907) and then defined more precisely by the same author (Schubert 1909) with the description of the type species, *Mizzia velebitana*. Pia (1920) deduced that *Mizzia* possesses a moniliform thallus, formed by the overlapping of spheroidal, ovoid or more or less club-shaped segments, with laterals widening outwards (phloioporous type) and provided a reconstruction (Pia 1920, p. 21, fig. 4). In Pia's opinion (1920, p. 20), *Mizzia* was an aspondyl form: "Die Wirteläste sind ohne erkennbare Regel angeordnet." (The verticilar branches are arranged without any recognizable pattern). At the same time, Pia (1920) considered *Mizzia* as an endospore dasycladale (reproductive organs inside the main cavity). This alga was later frequently found in Permian deposits around the world, and several other species (see Granier and Grgasović 2000) were described, including *Mizzia yabei* (Karpinsky 1908) and probably *Mizzia cornuta* Kochansky-Devidé and Pantić 1960, which seem to be the only ones unlikely to fall in synonymy with *Mizzia velebitana* (e.g., Vachard 1980). Rezak (1959, p. 534) provided an emended diagnosis of the genus *Mizzia* in which he specifies that the laterals (rays) are "...arranged in regular alternating horizontal rows." That means the alga is euspondyle, and not aspondyle as stated by Pia.

The first Mesozoic *Mizzia*-like algae was described by Levy (1966) as *Neomizzia elongata* n. gen., n. sp. from Lower Jurassic deposits of Morocco. The given generic diagnosis (Levy 1966, p. 37) is the following: "Dasycladacée articulée (articles





TEXT-FIGURE 4

Sketch section of Longtou Formation at the type locality, Huaxi County, Guizhou (Location text-fig. 1B) showing sample elevations. Adapted from a measured section (scale 1:500) of the Guizhou Regional Geologic Mapping Team (unpublished).

disposés en chapelet). Les rameaux simples, disposés en verticilles, sont courts et s'ouvrent largement vers l'extérieur. La cellule axiale joue probablement le rôle de sporangium." [Articulated dasycladale (articles disposed in rosary). The branches simple, arranged in verticils, are short and widen towards the exterior. The axial cell probably plays the role of sporangium]. A characteristic of the species is the elongated (cylindroid) appearance of the articles. Because the author (Levy 1966) did not correctly designate a holotype, species validation was done by designating a lectotype by Bucur (2000) with the description of a new species *Neomizzia dacica* from the Lower Cretaceous (Barremian) of Romania.

The first Mesozoic species attributed to the genus *Mizzia* was published by Hosseini et al. (2014) as *Mizzia zagarthica* from the upper Berriassian–lower Valanginian of Iran. According to these authors, *M. zagarthica* is a cladosporate species (the presence of inprints in the calcareous wall of the laterals interpreted as coming from reproductive cysts). This character was extended to the entire genus *Mizzia* and a new emended diagnosis of the genus was provided (Hosseini et al. 2014, p.105): "Thallus perannulated (moniliform), made of a string of barrel-like articles (segments), more or less elongated and calcified. Main axis (stalk) of the articles barrel-like, standing contiguous saucer-shaped whorls of laterals. Laterals typically inclined perpendicular to the curved surface of the axis, phloiophorous, not further ramified, distally forming a faceted

cortex. Laterals cladosporate, acting as gametophores." However, we have to note that the cysts are hardly visible within the laterals of *M. zagarthica*, and so it is for the specimens of *Mizzia velebitana* illustrated by the same authors (Hosseini et al. 2014, p. 511, fig. 13) on a figure of low magnification. Moreover, Granier and Lethiers (2017, p. 3) assume, related to *M. zagarthica*, that: "... most of their subtransverse sections are to be attributed to *Salpingoporella* spp." Hosseini et al. (2014) also transferred *Neomizzia dacica* to the genus *Mizzia* in the new combination *Mizzia dacica* (Bucur 2000).

Granier and Lethiers (2017) described *Draconisella mortoni*, a *Mizzia*-like dasycladalean alga from the Lower Cretaceous (Hauterivian–?Lower Barremian) of Oman. Similar to the other species described in the Lower Cretaceous, *Draconisella mortoni* is formed of separate articles, typically dispersed in the sediment. The reconstructions presented by the authors in Fig. 6 and 7 for *M. velebitana* and *D. mortoni* show two algae with an almost identical external morphology, the difference between them being given by the appearance of the main axis (wide at *M. velebitana* and narrow at *D. mortoni*) and by the presumed endospory (*M. velebitana*), in contrast to the presumed cladospory (*D. mortoni*), inferred from the shape of both the main axis and the laterals. The type species of the genus, *Draconisella genoti* Granier and Michaud 1989, differs from *D. mortoni* by its morphometric parameters.

In summary, we are dealing with the following situation:

- Genus *Mizzia* with a moniliform thallus, phloiophorous laterals with euspodyle arrangement, and edosporate type of reproduction (Rezák 1959; Granier and Lethiers 2017);

- Genus *Mizzia* with a moniliform thallus, phloiophorous laterals with euspodyle arrangement, and cladospore type of reproduction (Hosseini et al. 2014);

- Genus *Neomizzia*, with a moniliform thallus, phloiophorous laterals with euspodyle arrangement, and supposed edosporate type of reproduction (Levy 1966; Bucur 2000);

- Genus *Draconisella* with a moniliform thallus, phloiophorous laterals with euspodyle arrangement, and cladospore type of reproduction (Granier and Michaud 1989; Granier and Lethiers 2017).

It is important to note that the species *Draconisella genoti* Granier and Michaud 1989, *Neomizzia dacica* Bucur 2000, *Mizzia zagarthica* Hosseini et al. 2014 and *Draconisella mortoni* Granier and Lethiers 2017 were described only from separate articles dispersed in the sediment. The moniliform character of the thallus was assumed on the basis of the morphology of these articles.

Considering the above, in the interpretation given by Rezák (1959) and Granier and Lethiers (2017) the genus *Neomizzia* becomes a junior synonym of the genus *Mizzia* (a probability also stated by Hosseini et al. (2014), but these authors preferred to keep *Neomizzia* as a discrete genus). Consequently, *Neomizzia elongata* becomes *Mizzia elongata* (Levy 1966) nov. comb. By the same interpretation, if *Mizzia zagarthica* is a cladospore *Mizzia*-like alga, it should be transferred to the genus *Draconisella* as *Draconisella zagarthica* (Hosseini et al. 2014) nov. comb. However, the possibility that this alga belongs to the genus *Salpingoporella* is not excluded (cf. Granier and Lethiers 2017). The existence of *Mizzia* species with cladospore reproduction is, in our opinion, unlikely, as demonstrated by the new alga identified in the Middle Triassic deposits of China. To the authors' knowledge, *Mizzia? toncii* is the only *Mizzia*-like dasycladalean alga in which the reproductive cysts are undoubtedly visible inside the main stem.

Family DIPLOPORACEAE Pia 1920

Tribe Diploporae Pia 1920 emend Güvenç 1979

Sub-tribe Poncetellinae Güvenç 1979

Genus *Poncetella* Güvenç 1979

*Poncetella hexaster* (Pia 1912) Güvenç 1979

Plate 1, figure L

*Kantia hexaster* n. sp. PIA 1912, p. 46, pl. VI (V), fig. 13.

*Diplopore hexaster* Pia. – PIA 1920, p. 64, pl. III, figs. 26-32.

*Poncetella hexaster* n. gen, n. comb. – GÜVENÇ 1979, p. 631.

*Poncetella hexaster* (Pia 1912) Güvenç 1979 – GRANIER and GRGASOVIĆ 2000, p. 142, fig. 23 (with extended synonymy). – PIROS 2003, p. 54, pl. D-I, figs. 1-3. – RYCHLINSKI et al. 2013, p. 31, pl. 2, fig. 10.

*Poncetella hexaster* (Pia) – GAWLICK et al. 2021, p. 432, figs. 6b, c, e, g, h; fig. 11f, h.

**Remarks:** Pia (1912) ascribed this species to the genus *Kantia* and gave a brief description based on a single specimen. Subsequently the species was transferred to the genus *Diplopore* and more thoroughly described and more abundantly illustrated (Pia

1920). Following Pia's (1920) description, *P. hexaster* has a narrow and smooth central cavity (main stem), with obvious metasponyl branches (= laterals), and 6 to 7 branches (laterals) in each tuft. Each tuft starts from a low socle (0.02–0.06 mm), which represents a small expansion of the main stem. The branches (laterals) are arranged perpendicular to the main stem, and have a distinctive constriction above their midline. The resulting segments are connected by a small pore. The outer segment is thicker proximally and narrows outwards.

Pia (1920) distinguished two species: *Diplopore hexaster*, with trichophorous shape of the external segments, and *D. helvetica*, with phloiophorous shape of the external segments. Herak (1965) regarded both species as subspecies of *Diplopore hexaster*. They were considered as discrete species by Güvenç (1979) but as two varieties by Buček (1989). If, in agreement with Güvenç (1979), we consider that the shape of laterals is an important taxonomic character, then we have to consider the two taxa as discrete species.

**Dimensions** (in mm, except w):

D = 1.42; d = 0.50; p (max.) = 0.18; w = 9

Sub-tribe Diploporinae Pia 1920, emend Güvenç 1979

Genus *Diplopore* Schafhäütl 1863, emend Güvenç 1979

*Diplopore annulatissima* Pia 1920

Plate 3, figures A, B, G

*Diplopore annulatissima* nov. spec. PIA 1920, p. 67, pl. 4, figs. 11-16. *Kantia monregalensis* Baretto 1919. – GRANIER and GRGASOVIĆ 2000, p. 85-88, pars (with extended synonymy). – IETO and ROMANO 2001, p. 22, pl. I, figs. 7-8.

*Diplopore annulatissima* Pia 1920. – BUCUR and ENOS 2001, p. 324, pl. 3, figs. 1-13. – SENOWBARI-DARYAN and DI STEFANO 2001, p. 97, pl. 1, figs. 1-6. – BODZIOXH and LICHTARSKI 2007, p. 36, figs. 1-3. – PIROS 2008, p. 588, figs. 4c, d. – KOTANSKI 2013, p. 96, pl. XXVI, figs. 1-14; pl. XXVII, figs. 1-13; pl. XXVIII, figs. 1-16; pl. XXIX, figs. 1-30; pl. 30, Figs. 1-4. – BUCUR and MATYSIK 2020, p. 396, pl. 4A-I.

**Remarks:** Bucur and Enos (2001) rejected the synonymy between *D. annulatissima* and *Favoporella annulata* Sokač 1968 proposed by Ott (1972) based on laterals' morphology. Possible synonymy between *D. annulatissima* and *Kantia monregalensis* Baretto 1919 was suggested by Herak (1957), but he argued for retaining the name *Diplopore annulatissima*. However, Granier and Grgasović included *D. annulatissima* within the synonymy of *K. monregalensis*, a synonymy considered inappropriate by Bucur and Matysik (2020). See further remarks regarding the species *D. annulatissima*, *K. monregalensis*, and *F. annulata* in Bucur and Matysik (2020, p. 396). The specimens of *D. annulatissima* illustrated in Pl. 3, figs. A, B, G were collected from the lower part of the Longtou Formation in the Hongyan section (text-fig. 2) at about the same stratigraphical interval as those published in Bucur and Enos (2001).

**Dimensions** (in mm):

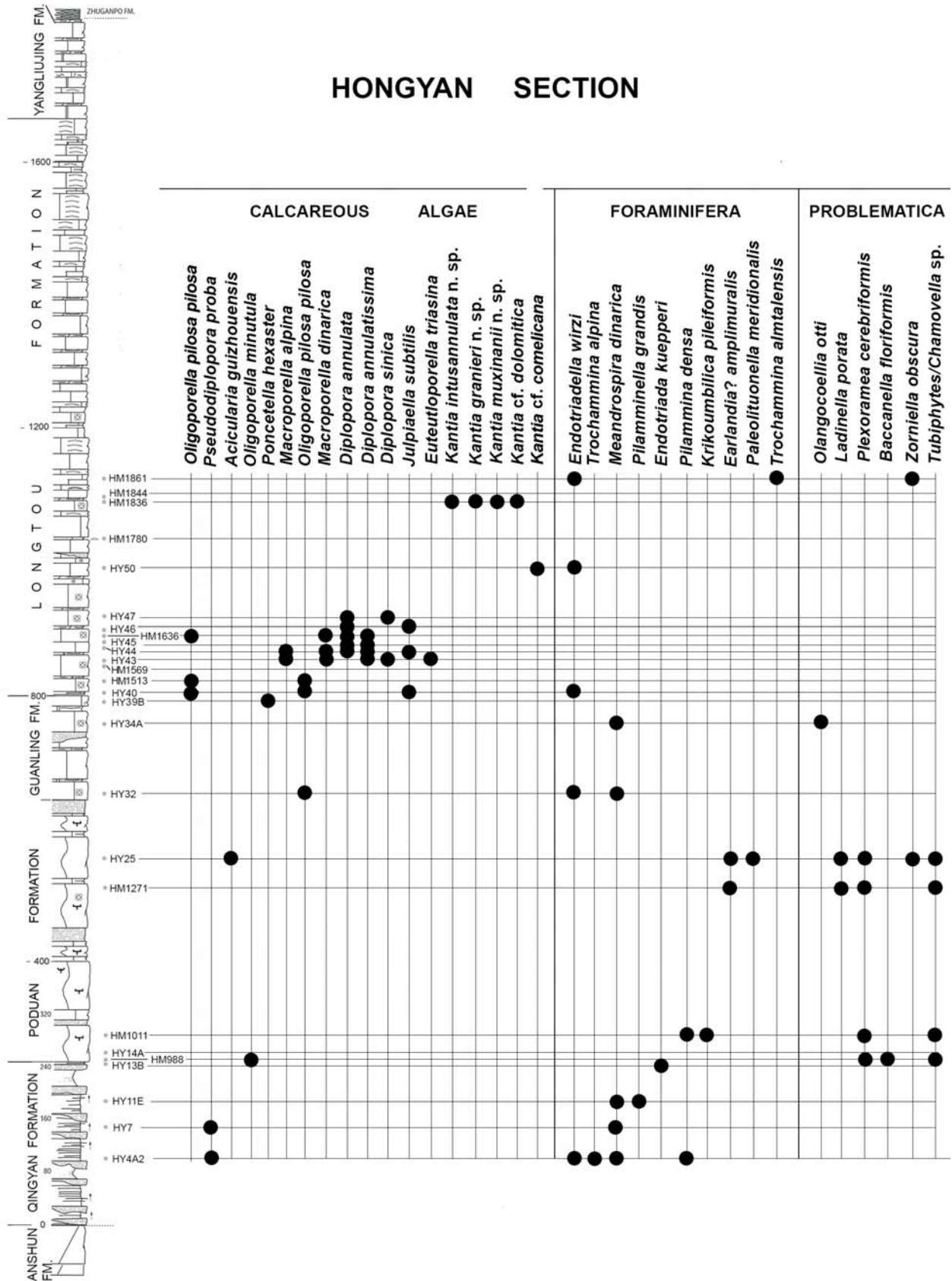
D = 1.7-2.9; d = 0.88-1.02; h = 0.6. Number of laterals in a bush = 5

*Diplopore annulata* (Schafhäütl 1853) Schafhäütl 1863

Plate 2, figures L, M; Plate 3, figures C-F, H-J

*Nullipora annulata* SCHAFFHÄÜTL 1853, p. 300-303, pl. VI, fig. 1a-f.





TEXT-FIGURE 5  
Stratigraphic levels of the most important microfossils identified in the Hongyan section (text-fig. 2).

*Diploporella annulata* (Schafhäütl 1853). – SCHAFFHÄÜTL 1863, p. 324, pl. 65a, fig. 6. – GRANIER and GRAGASOVIĆ 2000, p. 32 (not illustrated but with a complete synonymy list). – BUCUR and ENOS 2001, p. 323, pl. 2, figs. 1-14 (with extended synonymy). – IETO and ROMANO 2001, p. 22, pl. I, figs. 4-6, 10, 11. – PIROS and PRETO 2008, p. 585, figs. 4a, b. – BUCUR and MATYSIK 2021, p. 398, fig. 5A-C.

*Diploporella annulata annulata* Schafhäütl 1863. – VELLEDEITS et al. 2011, p. 238, fig. 14 (5a, 7, 8).

**Remarks:** *Diploporella annulata* has been widely discussed in the literature. The taxonomic adventures of this species began with the abandonment by Pia (1920) of the genus *Kantia* and the assignment of species with phloioiphorous and vesiculiform laterals to the genus *Diploporella*. The creation of varieties or subspecies (Pia 1920; Herak 1957; Ott 1963, 1966; Bystricky 1964; Zorn 1974) only added more confusion. Clarification came with the work of Güvenç (1979) who restricted the genus *Diploporella* to the forms with trichophorous laterals, respecting the initial concept of Pia (1912). This concept was followed by Bucur and Enos (2001), Kotanski (2013), Bucur and Matysik (2020), and is followed in this paper. For a detailed discussion on this topic see Bucur and Enos (2001, p. 318-320).

**Dimensions** (in mm): D = 1.36-3.75 (median = 2.65); d = 0.88-2.0 (1.45); l = 0.76-1.0 (0.87); p (prox.) = 0.18; H = 0.60-0.70.

Genus *Pseudodiploporella* Bucur et Enos, 2001

*Pseudodiploporella proba* (Pia 1935) Bucur et Enos 2001  
Plate 4, figures A-D, F-G

*Diploporella proba* n. sp. PIA 1935, p. 233, pl. V, fig. 1

? *Diploporella* aff. *proba* Pia. – BYSTRICKY 1986, p. 295, pl. III, fig. 5.

*Diploporella* aff. *proba* Pia. – BUCUR 1991, p. 29, Pl. 42, figs. 10, 18.

*Diploporella* sp. cf. *Diploporella proba* Pia. – BUCUR et al. 1994, p. 98, pl. 10, fig. 2 pars; pl. 13, figs. 7, 11. – BUCUR 1997, p. 29, pl. 17, figs. 10, 18.

*Pseudodiploporella proba* (Pia 1935) Bucur and Enos n. comb. – BUCUR and ENOS, p. 328, pl. 5, figs. 1-16.

**Remarks:** *Pseudodiploporella proba* is a dasycladalean alga very rarely identified in Middle Triassic deposits. Pia (1935, pl. 5, fig. 1, and text-fig. 47) provided only one section and a reconstruction. Subsequently, a form related to this species was found in the Middle Triassic of the West Carpathians (Bystricky 1964, 1986) and in equivalent deposits of the South Carpathians (Bucur 1991, 1997; Bucur et al. 1994). In contrast, *P. proba* proved to be quite abundant within the Anisian limestones from Guizhou Province (Bucur and Enos 2001). These authors transferred the species to the genus *Pseudodiploporella* and provided a description and multiple illustrations, confirming the description of Pia (1935). The newly identified specimens (Pl. 4, figs. A-D, F-G) correspond to this description.

**Dimensions** (in mm): D = 0.96-1.60 (median = 1.23); d = 0.40-0.62 (0.52); l = 0.29-0.55 (0.40); p (dist.) = 0.07-0.12 (0.10); w = 7-8; w' = 3-4.

Genus *Kantia* Pia 1912, emend Güvenç 1979

*Kantia intusannulata* Bucur, Enos and Minzoni n. sp.

Plate 5, figures A-G; Plate 6, figures A-J; Plate 7, figures A-B; Plate 9, figures A-C

**Derivation of name:** related to the internal annulation of the skeleton.

## PLATE 1

Dasycladalean algae from Guizhou Province, southern China.

A *Oligoporella minutula* (Gümbel 1972) Grgasovic, 2022. Longitudinal, slightly oblique section. Thin section HM988.

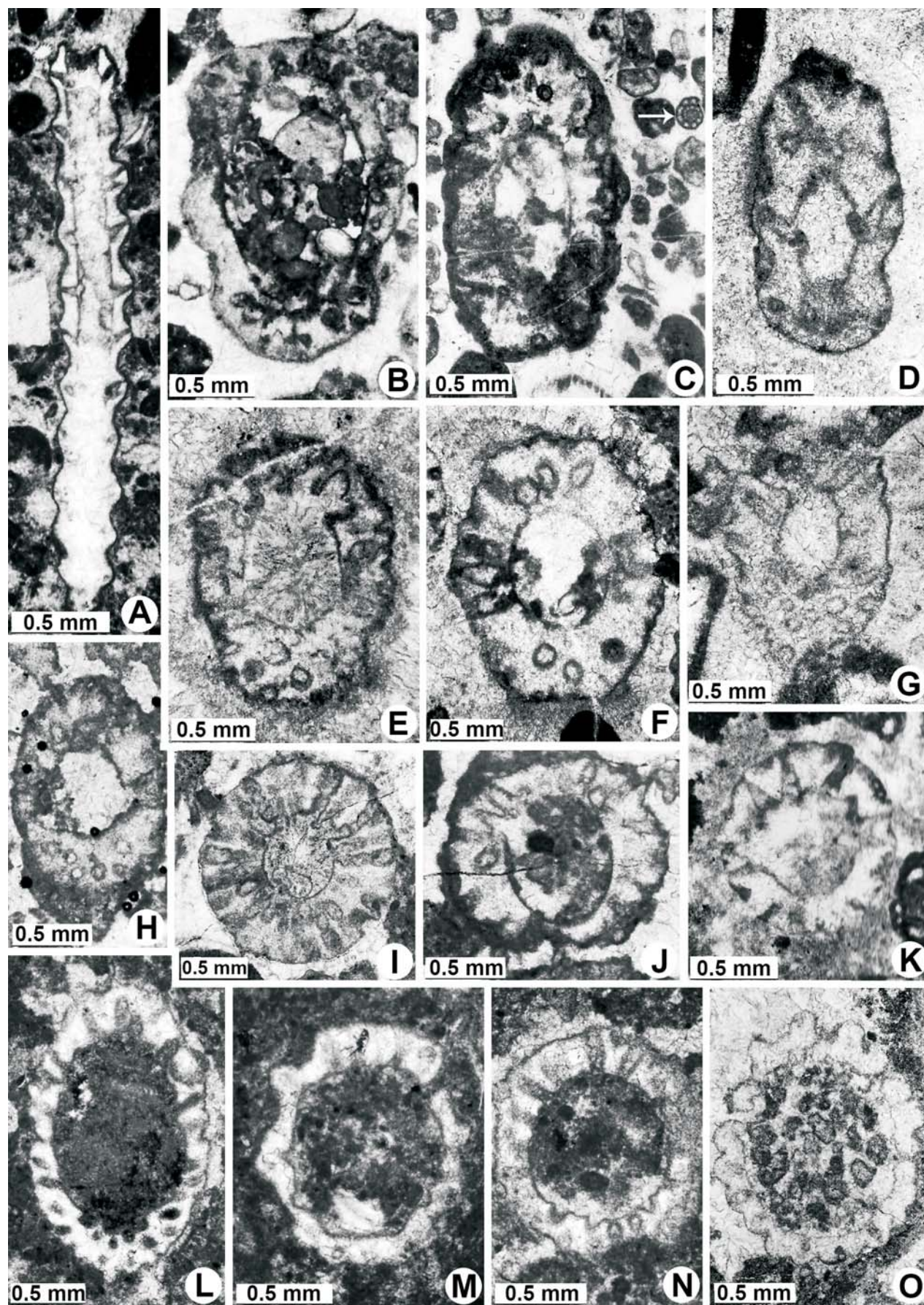
B-D, F-H, *Oligoporella pilosa pilosa* Pia ex Bystricky 1964.  
J, K B-D, F-H, oblique sections; J, K, transverse-oblique sections. Thin sections: LT141B (B); GT5(C); HM1513 (D, F); HM1636 (G); HY40 (H, J); GT40 (K).

I *Poncetella hexaster* (Pia 1912) Güvenc 1979. Transverse section. Thin section HY39B.

L-N Unidentified dasycladalean algae. Thin section LT100-1.

M *Physoporella?* sp. Thin section HY34A







**Holotype:** the specimen in Pl. 5, fig. A, thin section LT 100-1, deposited in the Museum of Paleontology, Babeş-Bolyai University, Cluj-Napoca, Romania, inventory number 24358.

**Paratypes:** the specimens in Pl. 5, figs. B, C, E-G; Pl. 6, figs. A, H, J, thin section LT 100-1, same repository.

**Type locality:** Longtong section, Longtong, Huaxi County, Guizhou.

**Type level:** Ladinian, Longtong Formation, 116 m above the base.

**Diagnosis:** Thallus cylindrical with a wide axial cavity and vesiculiform laterals with metaspondyle arrangement. Calcification is stronger around the verticils of laterals and reduced between the verticils giving rise to a pronounced intusannulation in contrast with the smooth appearance of the external surface of the thallus.

**Dimensions** (in mm, except d/D, w and w'): L (maximum observed) = 7.8; D = 1.34-3.04 (median = 2.40); d = 0.82-2.30 (1.65); d/D = 0.55-0.80 (0.68); l = 0.32-0.60 (0.48); p (distal) = 0.13-0.20 (= 0.17); h = 0.45-0.60; w = 20-25; w' 3-4.

**Description:** The cylindrical thallus is unbranched as shown in the longitudinal and longitudinal-oblique sections (Pl. 5, figs. A-C, E). The laterals are vesiculiform, having a thin proximal portion (peduncular) and a distal portion in the form of an elongated bladder (Pl. 5, figs. A, E? F; Pl. 6, figs. A, D, G). Their metaspondyle arrangement is clearly visible both in the longitudinal or oblique sections (Pl. 5, fig. A, Pl. 6, fig. A) as well as in transverse sections (Pl. 6, fig. D). The number of laterals in a tuft is 3-4 (rarely 5), as seen in the tangential sections of Pl. 5, fig. C; Pl. 6, fig. I). Calcification is more intense at the level of

the lateral whorls and weaker between the whorls, so that it gives rise to a very obvious intusannulation (Pl. 5, figs. A, G; Pl. 6, figs. A, H; Pl. 9, figs. A, C). The outer surface of the thallus is more or less smooth, the whorls being externally covered by a thin film of calcium carbonate (Pl. 5, fig. F; Pl. 6, figs. A, D, F, H, J). The calcareous sleeve has in some places a fissuration separating the outer part of the skeleton into rings comprising 2, 3, or more lateral verticils (Pl. 5, figs. C, E; Pl. 6, fig. G).

**Comparisons:** The presence of intusannulation differentiates *K. intusannulata* from all European species (*K. philosophi*, *K. dolomitica*, *K. praecursor*, *K. uniserialis*, *K. debilis* and *K. comelicana*)

***Kantia* cf. *comelicana*** (Fois 1979) Bucur, Enos and Minzoni **nov. comb.**

Plate 7, figures C-E, G-I

*Diploporella comelicana* n. sp. FOIS 1979, p. 65, pl. 1, figs. 1-7; pl. 2, figs. 1-5; pl. 3, fig. 10a; pl. 4, figs. 1-12. – GRANIER and GRGASOVIĆ 2000, p. 40 (with synonymy).

*Kantia* cf. *comelicana* (Fois). – BUCUR et al. 2003, p. 12.

**Remarks:** Some rare specimens identified from the Hongyan and Longtong sections can probably be attributed to *Kantia comelicana*. However, the presence of only cross- or cross-oblique sections makes it difficult to compare with the type species. The latter was initially attributed (Fois 1979) to the genus *Diploporella*, but the presence of typically vesiculiform laterals requires its transfer to the genus *Kantia* (cf. Güvenç 1979; Bucur and Enos 2001). The new combination was first suggested by Bucur et al. (2003).

**Dimensions** (in mm): D = 1.42-2.75 (median = 2.06); d = 0.92-2.30 (median = 1.44); l = 0.37-0.47 (median = 0.41); p (distal) = 0.12-0.16 (median = 0.14).

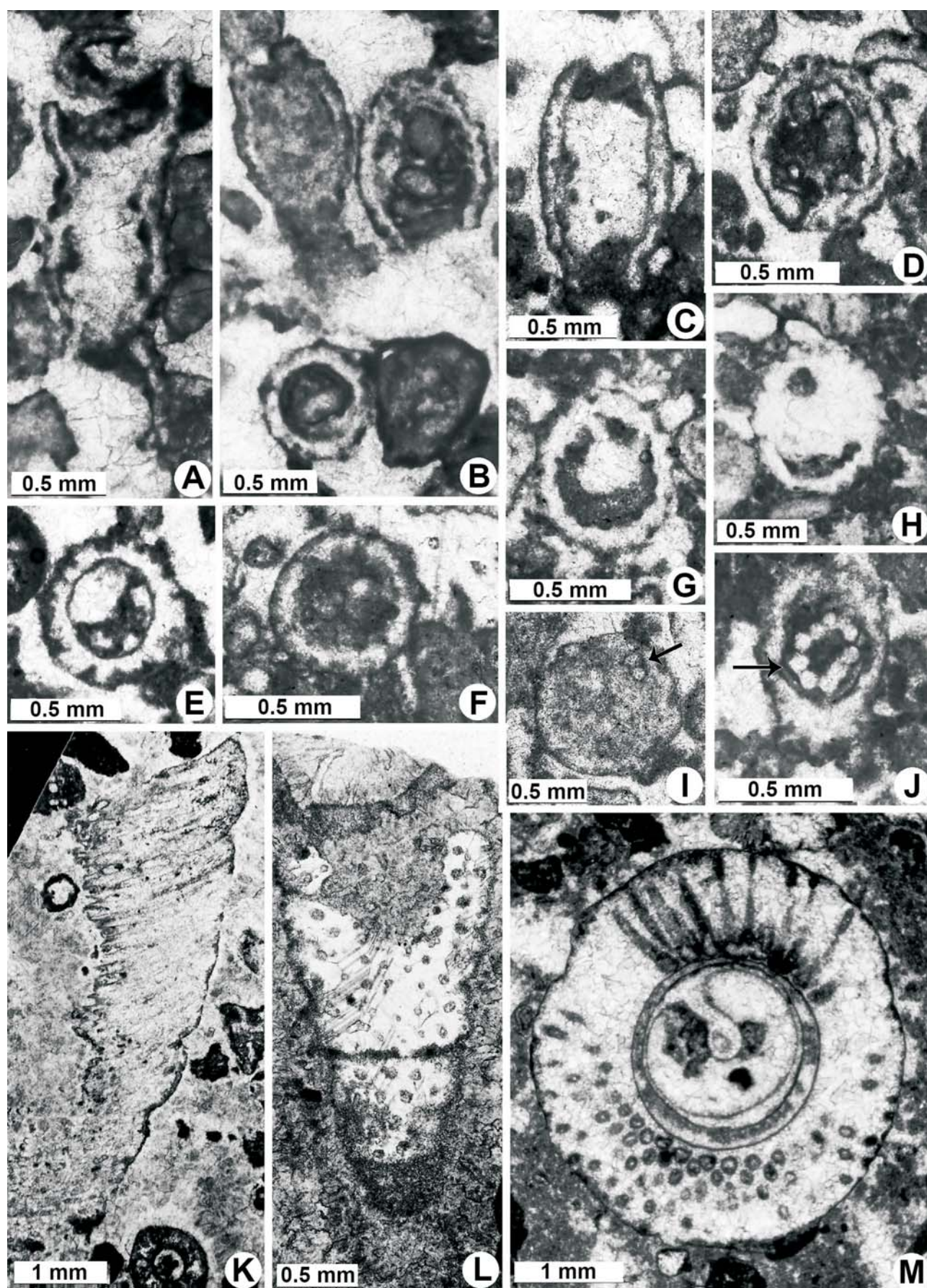
## PLATE 2

*Dasycladalean* algae from Guizhou Province, southern China.

A-J *Mizzia? toncii* n. sp. A, holotype. Longitudinal section; B-J, paratypes. B, oblique and transverse sections; C, longitudinal section; D, oblique section; E-J, transverse and transverse-oblique sections. Arrows in I and J point on the reproductive structures inside the central cavity. A, B, H, thin section LT149; C-G, I-J, thin section LT149A.

K *Euteutloporella triasina* (Schaueroth 1859) De Castro 1993. Oblique section. Thin section HY43.

L,M *Diploporella annulata* (Schafhäütl 1853) Schafhäütl 1863. Tangential-oblique (L) and transverse-oblique (M) sections. Thin sections: HM1836 (L); GT40 (M).





***Kantia granieri*** Bucur, Enos and Minzoni **n. sp.**  
Plate 8, figures A-H, Plate 11, figures C, F (Kg)

**Derivation of name:** dedicated to Professor Bruno Granier (Brest, France) for his important contribution to the study of fossil calcareous algae.

**Holotype:** the specimen in Pl. 8, fig. B, thin section HM1836, deposited in the Museum of Paleontology, Babeş-Bolyai University, Cluj-Napoca, Romania, inventory number 24361.  
**Paratypes:** the specimens in Pl. 8, figs. A, D, H, thin section HM1836, same repository.

**Type locality:** Hongyan section, Hongyan, Guanling County, Guizhou.

**Type level:** Ladinian, Longtou Formation, 288 m above base (1836 m in Hongyan section, Minzoni, 2007)

**Diagnosis:** Thallus cylindrical with a wide axial cavity and vesiculiform laterals with metaspondyle arrangement. Laterals enlarge more or less progressively towards exterior where they terminate in a bladder. Calcification, which is more intense around the lateral's tufts, gives rise to a slight intusannulation.

**Dimensions** (in mm, except d/D, w and w'): D = 1.85-2.45 (median = 2.15); d = 1.45-1.80 (median = 1.68); d/D = 0.73-0.78 (median = 0.76); l = 0.25-0.36 (median = 0.32); p (distal) = 0.10-0.17 (median = 0.15); h = 0.40-0.50; w = about 15-16; w' = about 5 to 6.

**Description:** Thallus cylindrical, unbranched, with a large central cavity (Pl. 8, figs. A, B, C, E) and a slight intusannulation (Pl. 8, figs. B-D) resulting from a stronger calcification at the level of lateral's tufts. Vesiculiform laterals, progressively enlarged from the central cavity towards the exterior (Pl. 8, figs. A, B, D, F, G) where they terminate in a bladder (Pl. 8, figs. C, F). Calcification commonly does not reach the external part of

the laterals, so they appear open to the exterior (Pl. 8, figs. B, E, G).

**Comparisons:** *Kantia granieri* resembles *K. dolomitica* but differs in the presence of intusannulation and smaller dimensions, as well as the smaller number of lateral's tufts in a whorl. *K. granieri* differs from *K. intusannulata* by the shape of the laterals, which have a thin proximal part and an ovoid bladder in *K. intusannulata* and the absence of fissuration, as well as by the weaker calcification which makes the laterals appear open to the exterior. The shape of the laterals also differentiates it from *K. muxinanii* n. sp.

***Kantia muxinanii*** Bucur, Enos and Minzoni **n. sp.**  
Plate 9, figures D-H; Plate 11, figures C, F (Km)

**Derivation of name:** dedicated to Professor Mu Xinan (Nanjing, China) for his important contribution to the study of fossil calcareous algae.

**Holotype:** the specimen in Pl. 9, fig. E, thin section HM1836, deposited in the Museum of Paleontology, Babeş-Bolyai University, Cluj-Napoca, Romania, inventory number 24361.

**Paratypes:** the specimens in Pl. 9, figs. D, G, thin section HM1836-2 (D) and HM1863 (G), same repository. HM1836-2 inventory number 24362.

**Type locality:** Hongyan section, Longtou Formation, Hongyan, Guanling County, Guizhou.

**Type level:** Ladinian, Longtou Formation, 288 m above base (1836 m in Hongyan section, Minzoni, 2007)

**Diagnosis:** Thallus cylindrical to slightly club-shaped. Laterals with metaspondyle arrangement, vesiculiform, with a narrow proximal portion and a spherical distal bladder. Calcification more pronounced at the level of lateral's tufts giving rise to an evident intusannulation.

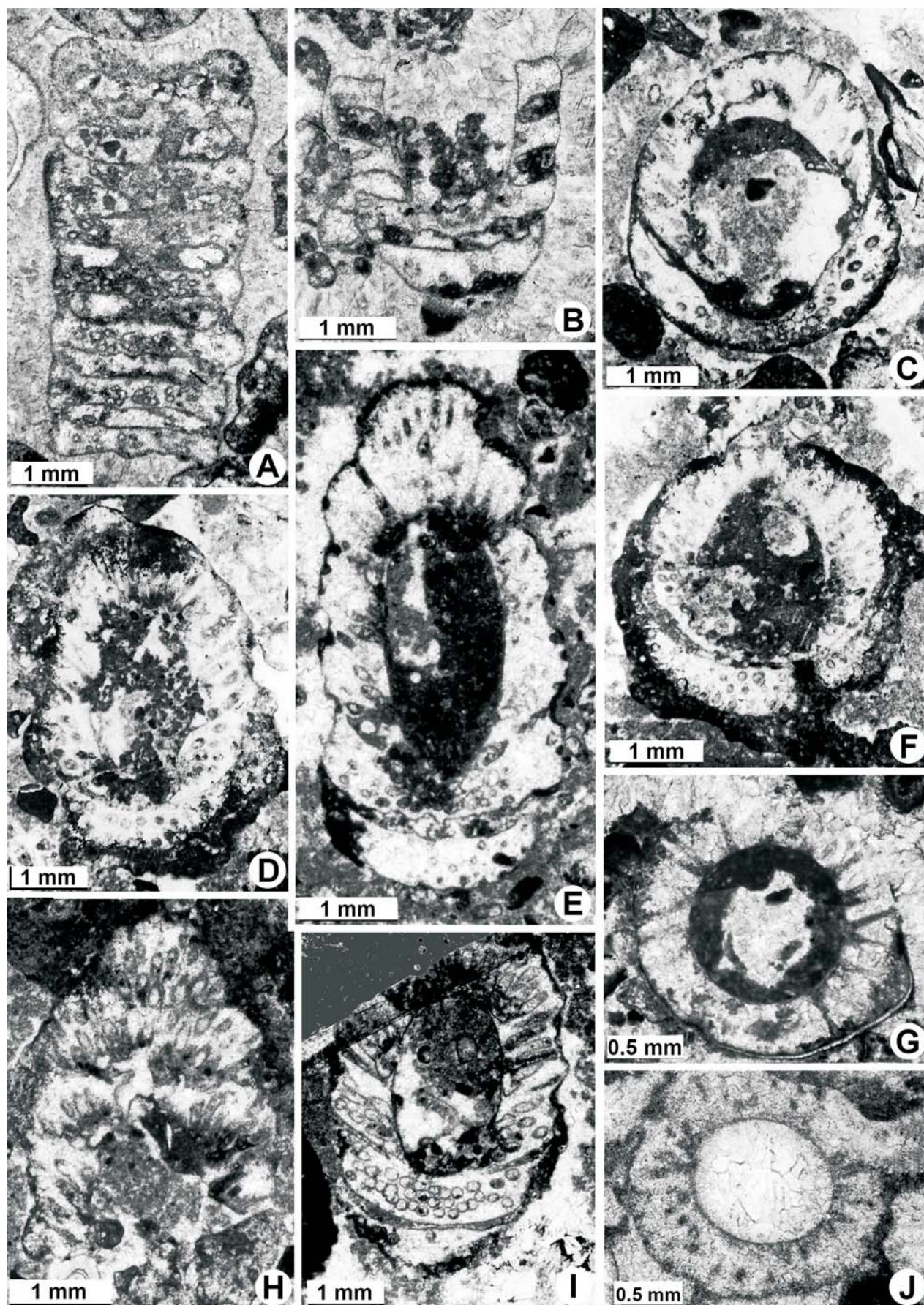
### PLATE 3

*Dasycladalean algae* from Guizhou Province, southern China.

A, B, ?G *Diplopora annulatissima* Pia 1920. Longitudinal-tangential (A), oblique (B) and transverse (G) sections. Thin sections: HM1636 (A, B); HM1569 (G).

C-F, H-J *Diplopore annulata* (Schafhäütl 1853) Schafhäütl 1863. Transverse-oblique (C, F, J) and oblique (D, E, H, I) sections. Thin sections: GT40 (C-F, H, I); HM1636 (J)







**Dimensions** (in mm except d/D, w and w'): D = 2.04-2.35 (median = 2.14); d = 1.10-1.92 (median = 1.38); d/D = 0.54-0.82 (median = 0.64); l = 0.24-0.36 (median = 0.31); p (distal) = 0.16-0.28 (median = 0.20). w = (estimated) 15-20; w' = (estimated) 4 to 5.

**Description:** The thallus is slightly club-shaped (Pl. 9, fig. E) with a large axial cavity and an evident intusannulation (Pl. 9, figs. E-G). The laterals have a narrow proximal part and a spherical distal bladder (Pl. 9, fig. F, arrow). The calcification surrounding the tufts of laterals give rise to an intusannulation. The external surface of the skeleton is more or less smooth, but commonly does not include the external part of the laterals so that they appear to be open to the outside (Pl. 9, figs. G, H).

**Comparisons:** *Kantia muxinanii* has been identified by only a few specimens, but the general shape of the thallus (slightly club-shaped) and the morphology of the laterals (with a narrow proximal part and a spherical terminal bladder) are characteristics that differentiate it from other species. The presence of intusannulation differentiates it from all European species of *Kantia*. It also differs from *K. intusannulata* in the shape of the distal part of the laterals (ovate-elongated in *K. intusannulata*, spherical in *K. muxinanii*) and in the commonly "open" distal end of the laterals. From *K. granieri* it is differentiated by the shape of the laterals and the general shape of the thallus (slightly club-shaped in *K. muxinanii*).

***Kantia cf. dolomitica*** Pia 1912 emend Güvenç 1979  
Plate 10, figures A-I, K.

*Kantia dolomitica* nov. spec. PIA 1912, p. 46, pl. VI, figs. 14-16. – GRANIER and GRGASOVIĆ 2000, p. 83 (not illustrated but with extended synonymy).

**Remarks:** Pia (1912) gave the following description of *Kantia dolomitica* (translated into English from Granier et al. 2013): "The weathered specimens of our species have an extraordinary resemblance to *Diplopora annulata* and at first I did not doubt its affiliation with this species. However, the study of thin sections, for which, by the way, the material was not very suitable, made it appear probable to me that I was dealing with a *Kantia*, and in fact with a species with much closer connection to a vesicular type than *Kantia philosophi*. It seems to me that the best evidence for this is Pl. VI, fig. 14 and the uppermost part of Pl. VI, fig. 16. In particular the first section shows clearly the bulbous dilation at the end of the branches, which unquestionably are arranged into tufts. This species is distinguishable from the two preceding ones by the much thinner shape of the branches. On Pl. VI, fig. 16 it is noticeable that the terminal widening can be seen clearly only in the upper part. Perhaps we should interpret this as indicating that only a part of the plant was fertile. An outer opening of the pores was never observed. Some of the branches are perpendicular to the main axis, some are oblique. Most are curved slightly. Too, the height of the segments is most

## PLATE 4

*Dasycladalean algae* from Guizhou Province, southern China.

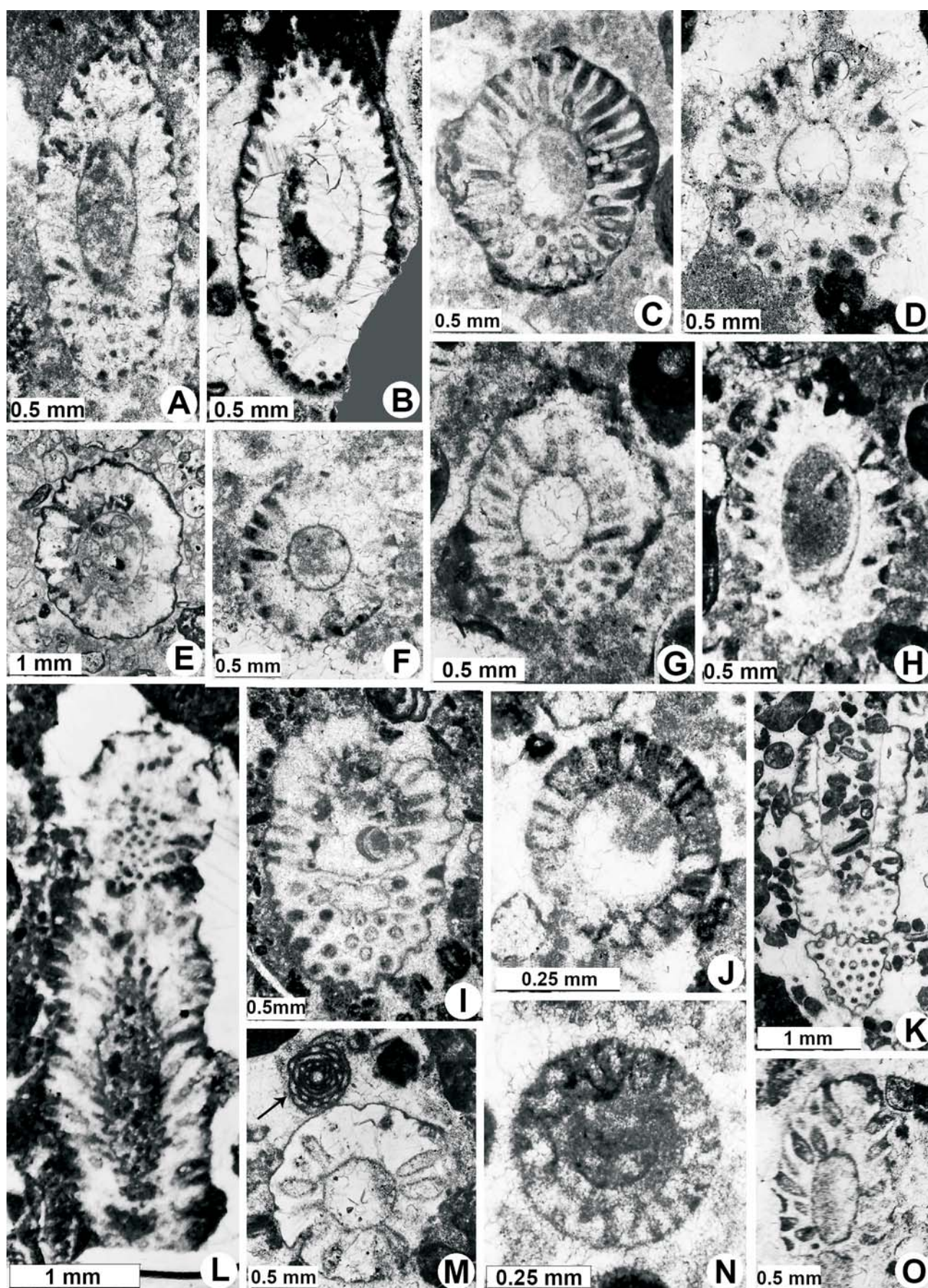
A-D, F-G *Pseudodiplopora proba* (Pia 1935) Bucur and Enos 2001. Tin sections: GT40 (A, C, F); HY4A2 (B); GT25 (D); HM1513 (G).

E, H, I, K, *Julpiaella* sp. E, transverse-oblique section; H, I, oblique sections; K, L, longitudinal-oblique sections. Thin sections: GT43b (E); HY7 (H); HM1011 (I); GT5 (K); GT10 (L).

J, N *Pseudodiplopora* sp. Transverse oblique (J) and transverse (N) sections. Thin section GT43.

M, O Unidentified diploporid dasycladales in transverse (M) and oblique (O) sections. Note the presence of the foraminifer *Pilamina densa* Pantic in M (arrow). Thin section GT25.







variable again. We must have to do with a highly specialized *Kantia*, as the geologic level confirms.”

The specimens from China show a vesiculiform morphology of the laterals typical to this species; however, they don't present the external annulation which caused Pia (1920) to ascribe the species to *Diploporella annulata* as a variety (*D. annulata* var. *dolomitica* forma *vesiculifera*). By the emendation of the genus *Kantia* Güvenç (1979) has reverted all the varieties of *Diploporella* with vesiculiform laterals into the genus *Kantia*, an approach that we discussed and accepted in a previous paper (Bucur and Enos 2001).

**Dimensions** (in mm except d/D, w and w'): D = 2.10-3.20 (median = 2.38); d = 1.37-2.60 (median = 1.80); d/D = 0.65-0.81 (median = 0.75); l = 0.27-0.35 (median = 0.31); p (distal) = 0.07-0.16 (median = 0.12); w = (approximate) 12; w' = 6-8

Family POLYPHYSAEAE (Kützing 1843) Berger et Kaever 1992

Tribe Acetabularieae Decaisne 1842

Organo-genus *Acicularia* Archiac 1843

***Acicularia guizhouensis*** Bucur, Enos and Minzoni **n. sp.**

Plate 13, figures A-D

**Derivation of name:** from the province of Guizhou, China, where type samples were collected.

**Holotype:** the specimen in Pl. 13, fig. A, thin section HY25, deposited in the Museum of Paleontology, Babeş-Bolyai University, Cluj-Napoca, Romania, inventory number 24356.

**Paratypes:** the specimens in Pl. 13, figs. B-E, thin section HY 25 (B-D) and HY 25-2 (E), same repository. HY 25-2 inventory number 24357.

**Type locality:** Hongyan section, Hongyan, Guanling County, Guizhou.

**Type level:** Anisian, Poduan Formation, 247 m above base.

**Diagnosis:** Ovoid spicules up to 1.35 mm long and 0.74–0.92 mm in diameter, with circular cross section, showing in the marginal area numerous small spherical or slightly ovoid spaces with a diameter of 0.05–0.075 mm corresponding to the reproductive cysts.

**Description:** The maximum observed length of the spicules of *Acicularia guizhouensis* n. sp. is 1.35 mm (Pl. 13, fig. A) but most likely it could reach 2 mm or more; unfortunately we do not have whole specimens in longitudinal section to prove this. The inner space of the spicules is filled with coarse sparitic calcite cement whereas the spherical or slightly ovoid spaces corresponding to the cysts and located on the outer edge of the spicules are filled with micrite or microspar.

**Dimensions** (in mm): L (maximum observed) = 1.35; D = 0.74–0.92; diameter of the cyst cavities = 0.050–0.075. Number of cyst cavities in transverse section = 35–40.

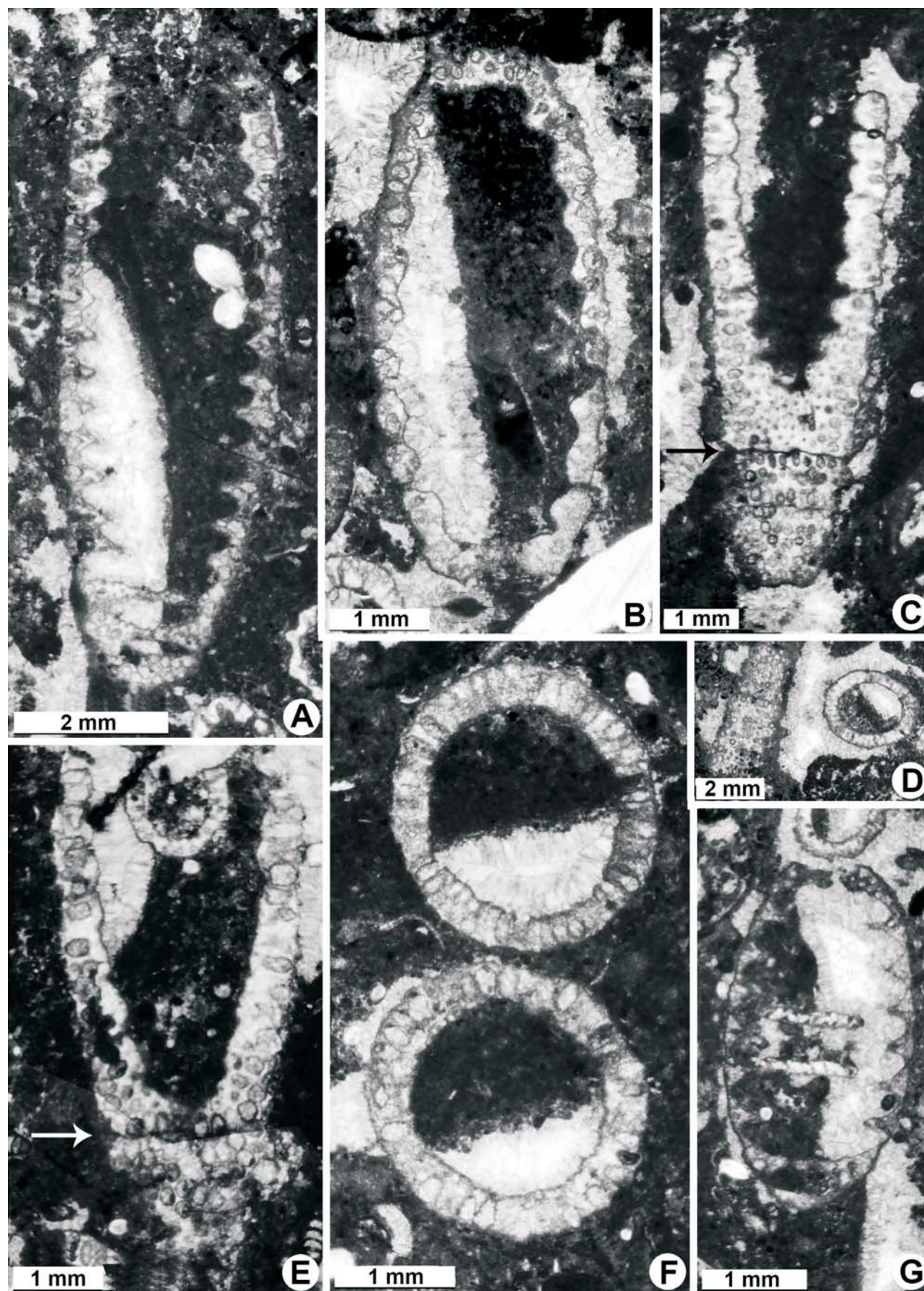
**Comparisons:** *Acicularia guizhouensis* can be compared with species of the genus *Acicularia*/*Aciculella* (see remarks below) described from rocks of different ages, from late Paleozoic to Cenozoic. The oldest representative attributed to the genus *Aciculella* seems to be *Aciculella preromangica* (Praturlon 1963) Ott 1974 from the Permian of the Dolomites (Italy) (ascribed by Praturlon to the genus *Macroporella*, later described

## PLATE 5

*Dasycladalean algae* from Guizhou Province, southern China.

A-G *Kantia intusannulata* n. sp. A-C, E, longitudinal-oblique sections. D, tangential and oblique sections. F, transverse-oblique sections. G, oblique

section. Arrows in C and E point to the fissuration of the skeleton. Thin section LT101-1. A = holotype; B, C, E-G; Pl. 6A, H, J = paratypes





by Elliott (1971) as *Aciculella oligvie-gordonae* sp. nov., a younger synonym of Pratulon's species). *Aciculella preromangica* is somewhat similar to *Acicularia guizhouensis* n. sp. but it differs by the smaller overall dimensions ( $D = 0.40\text{--}0.50$  mm) of the spicules and by the smaller number (approx. 24) of cyst cavities in cross section. Several species attributed to the genus *Aciculella* have been described from Triassic deposits (*A. bacillum* Pia 1930; *A. nikleri* Bystricky 1975; *A. sokaci* Bystricky 1975 and *A. spiculiformis* Bystricky 1975). *Acicularia guizhouensis* n. sp. differs from all these species by the much smaller diameter of the cyst cavities and by the larger number of cysts in cross section. The presence of *Acicularia* in Middle Triassic deposits was previously documented by Iannace et al. (1998 as *Acicularia boniae* Iannace, Radoičić et Zamparelli n. sp.; formerly illustrated as *Aciculella bacillum* var. *perforata* by Iannace et al. 1995) from Calabria (Italy). *Acicularia boniae* differs from *A. guizhouensis* n. sp. by the much larger dimensions of the spicules and by their elongated club-shaped appearance. Comparisons with representatives of the genus *Acicularia* described from Jurassic and Cretaceous rocks are difficult to make, given that many of the Jurassic-Cretaceous species do not correspond to this genus but to the genus *Terquemella* (see Bucur et al. 2008; Schlagintweit and Sanders 2011). However, the general appearance of the spicules and the small size and number of cyst cavities, distinguish *Acicularia guizhouensis* n. sp. from the Jurassic and Cretaceous species of the genus, as well as those described from Cenozoic deposits.

#### Remarks on generic assignment

Pia (1930) created the genus *Aciculella* for spiculiform fossil remains from the Triassic, which he interpreted as fructified main-stems of Dasycladales. Pia (1930, p. 180), as well as later authors (Elliott 1971; Bystricky 1975), mentioned the obvious

similarity that exists between the *Aciculella* remains and the *Acicularia* spicules described from Cretaceous and Cenozoic deposits. For stratigraphic and supposedly phylogenetic reasons (based on data known at the time), Pia rejected the idea that these fossils are representatives of Acetabulariaceae – the former name of the polyphysaceae – (inclusive of the genus *Acicularia*), considering that they are endospore Dasycladale with reproductive cysts that calcified post-mortem and that are located in the marginal area of the main stem.

Pia (1930) created the new genus *Aciculella* for *Acicularia*-like fossils from the Triassic based on two main arguments:

1. It is unlikely that *Aciculella* had "...the very specialised organisation of this much younger genus which seems to have developed from *Terquemella* in late Cretaceous time only".

2. He (Pia 1930, p. 180) could not "...detect any trace of a pointed end of [the] specimens of *Aciculella*."

The validity of the two arguments was later denied by Elliott (1971), who nevertheless accepted the first interpretation of Pia (1930), namely that *Aciculella* represents the calcified main stem of an endospore dasycladalean alga. However, the sequence of events illustrated in text-fig. 1 of Elliott (1971) is difficult to agree upon considering that Dasycladales generally exhibit extracellular calcification in connection with the mucilage surrounding the thallus (the main stem and laterals). Intracellular calcification of algal reproductive organs occurs (producing *Acicularia*-*Acetabularia*-like spicules), but it is by no means the massive calcification of the inside of the main stem envisioned by Pia (1930) and Elliott (1971). Such calcification must be post-mortem, and it is difficult to imagine how

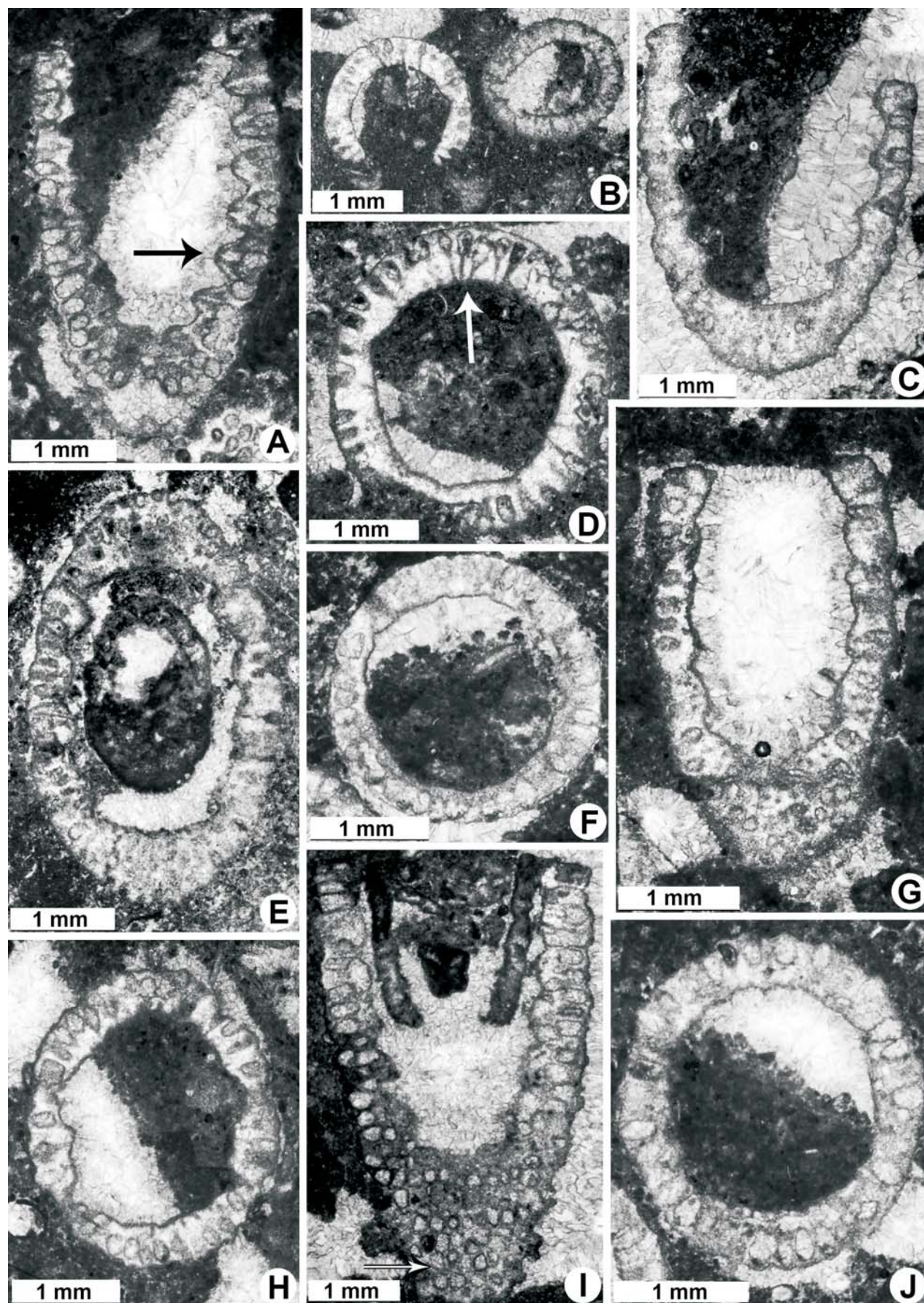
## PLATE 6

*Dasycladalean algae* from Guizhou Province, southern China.

A-J *Kantia intusannulata* n. sp. Longitudinal-oblique (A, G, I), oblique (C, E) transverse and transverse-oblique (B, D, F, H, J) sections. Arrows in A and D point to the

shape and metaspondyle arrangement of the laterals. Thin sections: LT100-1 (A, D, E-H, J); LT100-2 (B, C, I). A, C, H, J = isotypes





such volumes could precipitate. As De Castro (1997, p. 158) points out “...in Dasycladales calcification is a biologically induced event.” It is mainly extracellular. Intracellular calcification, when it occurs, is related to cysts or reproductive receptacles, but remains a biologically induced process, carried out during the life of the plant, not post mortem. Calcification of the main-stem during the life of the plant seems impossible because it would stop the circulation of the cytoplasm, as even Pia acknowledged (1930, p. 180). Bystricky (1975) also dismantled Pia’s (1930) arguments by showing that it is almost impossible to differentiate between Triassic specimens attributed to *Aciculella* and those from younger deposits attributed to *Acicularia*. However, like Elliott (1971), Bystricky (1975) still retained the generic name *Aciculella* for the type species and for the few new species he described from the Triassic of the Slovakia.

The “phylogenetic” argument of Pia (1930; argument 1. mentioned above) can no longer be invoked, given that cladospore and probably choristospore Dasycladales are now known from the Paleozoic, e.g., *Sinoporella* from Permian (Bucur et al. 2009), *Eoclypeina* from Carboniferous–Permian (Vachard 1985; ?Poncet 1987). Cladospore and choristospore Dasycladales are also well known from Triassic rocks, e.g., *Clypeina besici* Pantić and *Holosporella magna* Bucur et Fucelli (see remarks in Bucur et al. 2021).

Specimens of endospore dasycladales with calcified cysts, e.g., *Diplopore phanerospora* Pia, *D. tubispora* Ott, *D. interiecta* Fenninger, and *Pseudodiplopore borzai* (Bystricky), clearly show that biologically induced calcification is limited to reproductive cysts and does not occlude the entire space of the main

stem (see also De Castro 1997, p. 160). However, Granier and Hofmann (2002, Pl. 2, fig. 6) in re-examining Pia’s standard material identified a specimen that demonstrates the presence of a peduncular part of the thallus. Granier and Hofmann (2002, p. 138) provide an emended diagnosis of the genus: “Heavily calcified spiculiform bodies with cysts regularly displayed on their surface. At least one of the ends has a short peduncular portion without cysts.” The illustrated specimen has a clear truncation at the top and, in our opinion, the ‘peduncular portion’ could result from abrasion producing an apparent cyst-free portion of the central area of the spicule. Notably, Barattolo and Romano (2005) consider *Acicularia boniae* as representing a calcified central stem and belonging to the Upper Paleozoic genus *Atractyliopsis* Pia, rather than to *Acicularia*. Following Barattolo and Romano (2005, p. 138) “...*Acicularia boniae* is more conveniently ascribed to the genus *Atractyliopsis* because this species shows a wide longitudinal inner cavity opened at its lower end.” In our opinion, such a “morphological” argument is not convincing, and we consider the alga described by Iannace et al. (1998) as a genuine *Acicularia*.

Given all of the above, the hypothesis initially formulated by Pia (1930) and adopted by Elliott (1971) and Bystricky (1975) is difficult to accept. An interpretation of these fossil remains as spicules of Polyphysaceae of the *Acicularia-Terquemella* type seems to us much more probable.

As the name *Acicularia* applies only to fossil spicules or aggregates of spicules spread in the sediment (Barattolo et al. 2019), it is considered an organo-genus (see Maksoud et al. 2021, table 1 for comparisons).

## PLATE 7

*Dasycladalean algae* from Guizhou Province, southern China.

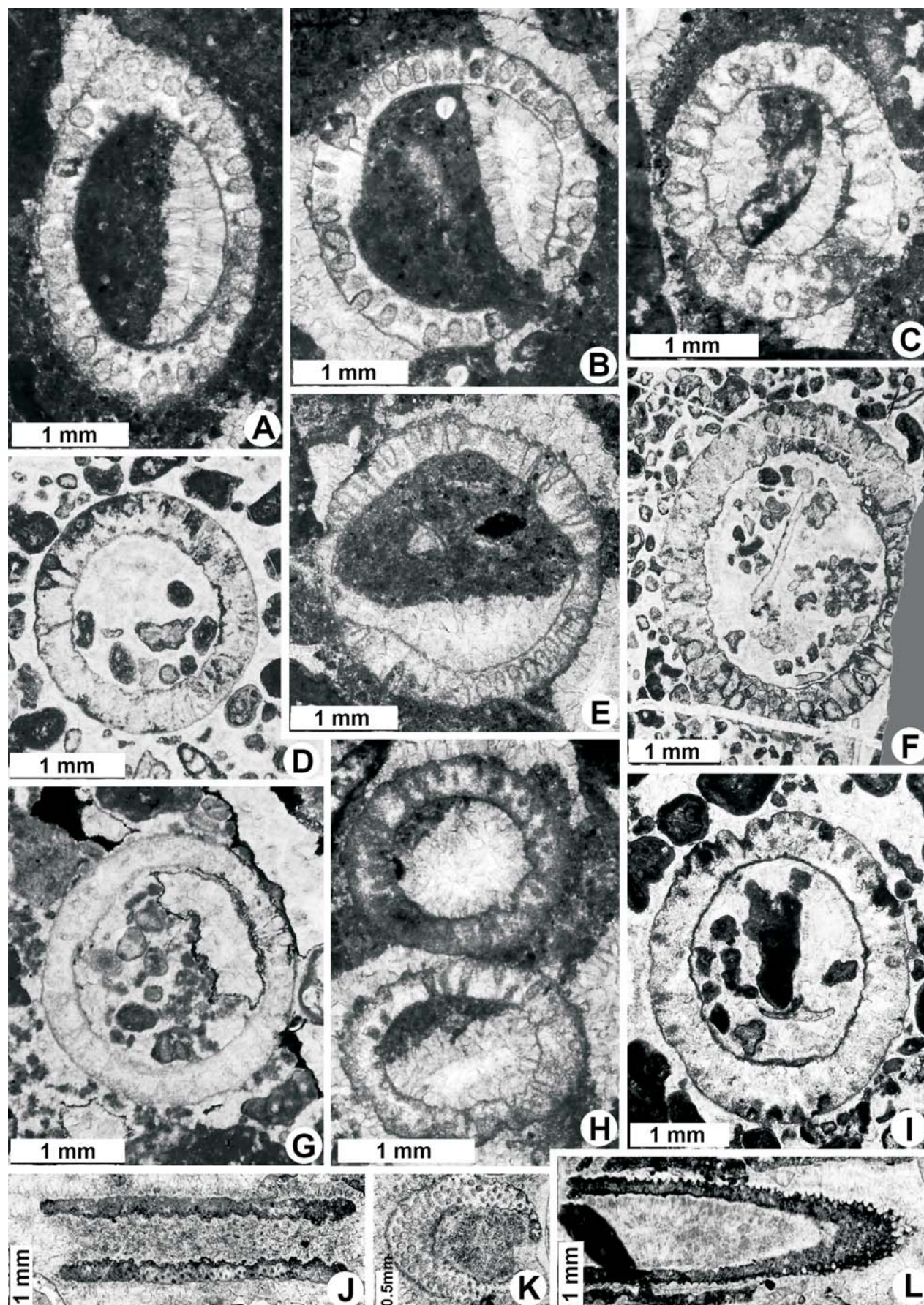
A-B *Kantia intusannulata* n. sp. Oblique (A) and transverse (B) sections. Thin section LT100.

C-E,G-I *Kantia* cf. *comelicana* (Fois 1979) Bucur et al. 2003, tranverse-oblique (C, H, I) and transverse (D, E, G) sections. Thin sections: LT100-1 (C); HY50 (D, I); LT100-2 (E, H); LT59 (G).

F *Kantia* sp. Oblique section. Thin section HY50.

J,K,L Unidentified dasycladalean algae. Longitudinal (J), oblique (K) and longitudinal-oblique (L) sections. Thin section HM1836. Note the dark-micritic skeleton in L (compare with Pl. 12, A-B).





### Associated dasycladalean algae

In addition to the fossil Dasycladales described above, are specimens too rare or poorly preserved to be attributed confidently to a known species or even to allow a thorough description. Some of the rarely found specimens are tentatively identified as *Euteutloporella triasina* (Schauroth 1859) (Pl. 2, fig. K), *Macroporella dinarica* Pia 1912 (Pl. 12, fig. N (Md)), *Salpingoporella* cf. *sturi* (Bystricky 1968) (Pl. 12, fig. L), *Physoporella*? sp. (Pl. 1, fig. M), *Julpiaella* sp. (Pl. 4, figs. E, H, I, K, L; Pl. 12, fig. N(J)), *Pseudodiploporella* sp. (Pl. 4, figs. J, N), *Kantia* sp. (Pl. 7, fig. F; Pl. 8, figs. I, J; Pl. 9, fig. D; Pl. 10, fig. M; Pl. 11, figs. A, B, D, E, G, H), *Gyroporella* sp. (Pl. 10, figs. L, N; Pl. 12, figs. A-C; *Holosporella* sp., (Pl. 12, figs. D-J), and *Acicularia/Terquemella* div. sp. (Pl. 13, figs. E-K). Other specimens are rare “*Solenopora*” (Pl. 13, fig. L) and many *Rivularia*-like cyanobacteria (Pl. 13, fig. M).

Some *Gyroporella* species described from the Triassic deserve closer consideration. Pia (1920) described *Gyroporella maxima* n. sp., illustrated by several specimens in longitudinal-oblique, oblique and transversal-oblique sections (Pia 1920, pl. 1, figs. 27-33). This species was later illustrated by Herak (1965, pl. 2, fig. 4) by an incomplete specimen in cross section, and by Bystricky (1966, Pl. V, figs. 4-5; Pl. VI, fig. 1) through two cross-oblique sections and an oblique section. As Herak (1965, p. 14) pointed out, “...Generical determination is very difficult if there are only cross-sections, because of similarities, in the shape of pores, with *Diploporella annulata* subsp. *dolomitica*” (i.e., *Kantia dolomitica*, Pia 1912). Numerous dasycladalean specimens attributed to the genus *Gyroporella* have been described and illustrated from cross-sections (e.g., Kotanski and

Catalov 1973, pl. XII, figs. 1-6 as *Gyroporella* cf. *ampleforata* Gumbel, and pl. XII, figs. 7-11 as *Gyroporella vesiculifera* Gumbel). In such sections it is not possible to determine whether the arrangement of the laterals is of the aspondyl or metaspondyl type. For instance, the specimen illustrated by Bystricky (1966, Pl. V, fig. 4) seems to show in the lower left a convergence of the laterals at the same point on the inner side of the calcareous sleeve, as such a metaspondyl type arrangement. Thus, the specimens illustrated would belong to the genus *Kantia* rather than to *Gyroporella*. The characteristics mentioned above can be observed in some of our specimens (Pl. 7, figs. D, F, G, I) with cross sections of species of *Kantia* in which it is difficult to ascertain a metaspondyl arrangement of the laterals. As such, we fully agree with Herak (1965) that it is difficult to assign cross-sections to either *Gyroporella* or *Kantia* in the absence of associated longitudinal or oblique sections, which could provide reliable evidence of metaspondyle arrangement of the laterals.

### Microproblematica

Genus *Zorniella* Senowbari-Daryan et Di Stefano ex Senowbari Daryan et Bucur 2021

*Zorniella obscura* Senowbari-Daryan et Di Stefano ex Senowbari Daryan et Bucur 2021

Plate 13, figures O-Q

Problematicum 1, ZORN 1971, pl. 17, fig. 7. – ZORN 1972, p. 131, pl. 3, fig. 1.

*Zornia obscura* SENOWBARI-DARYAN and DI STEFANO 2001, p. 100, pl. IV, figs. 1-5, text-fig. 2. – EMMERICH et al. 2005, p. 586, fig. 14(10). – PIROS and PRETO, 2008, fig. 4P.

*Zorniella obscura* SENOWBARI-DARYAN and BUCUR 2021, p. 49.

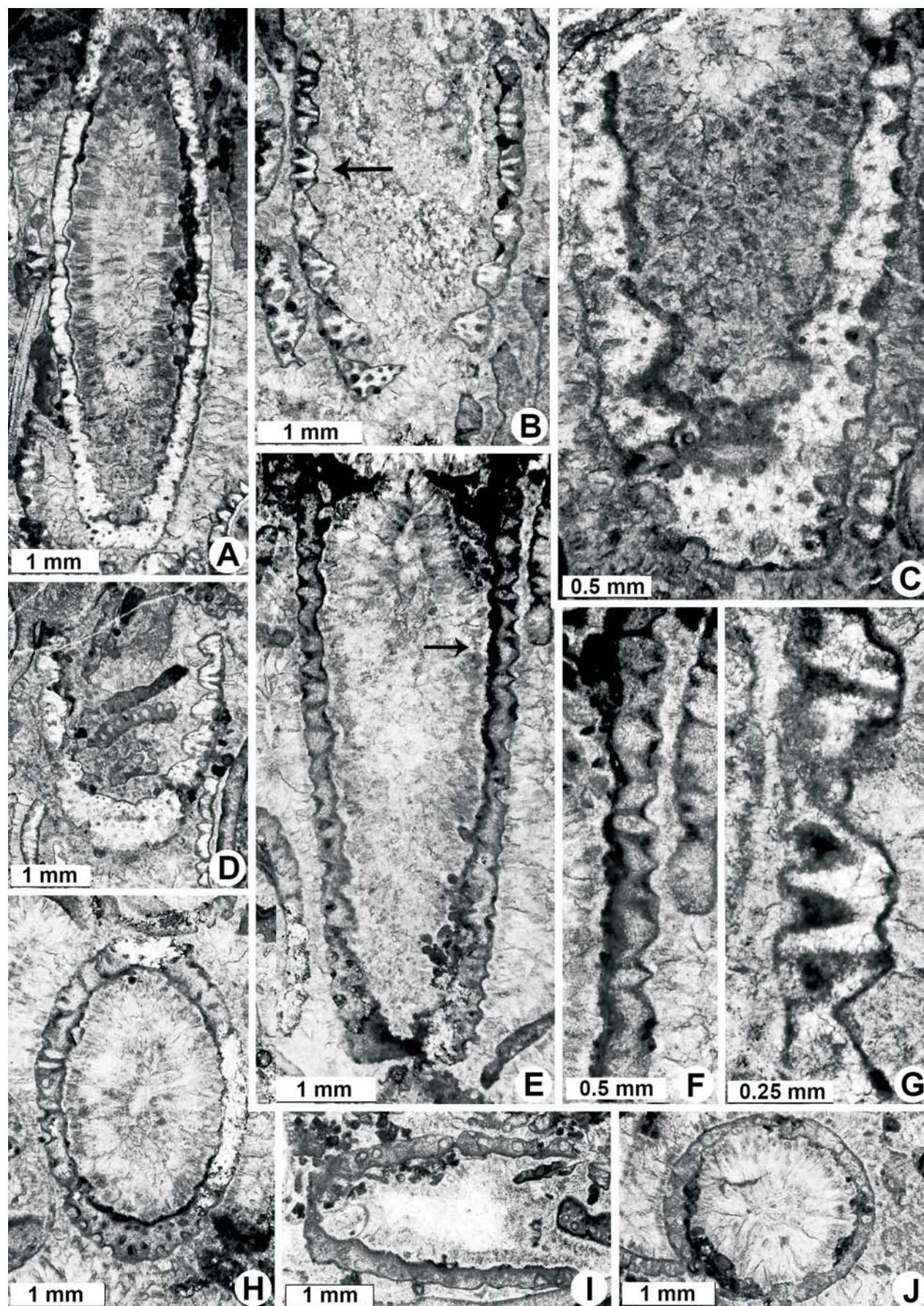
## PLATE 8

*Dasycladalean algae* from Guizhou Province, southern China.

A-H *Kantia granieri* n. sp. Longitudinal-oblique (A-C, E), and oblique (D, H) sections. Thin section HM1836. Arrows in B, and H point to the respective location of the close-up views in G and F. B = holotype; A, D, H = paratypes.

I, J *Kantia* sp. Longitudinal-oblique (I) and transverse (J) sections. Thin section MH1836.







**Remarks:** Originally illustrated by Zorn (1971, 1972), this problematic organism has been described in detail by Senowbari-Daryan and Di Stefano (2001, p. 100) with the following diagnosis: “Calcareous aggregates of horseshoe or crescent-shaped,  $\frac{3}{4}$  circular to circular or irregular skeleton. Relatively thick skeletal wall with an inner and outer micritic rim (diagenesis?). The wall may be pierced by pores.” It is rarely found in Middle Triassic limestones. Because the genus name *Zornia* was pre-occupied by another plant, Senowbari-Daryan and Bucur (2021) proposed changing the generic name to *Zorniella*. To our knowledge, this is the first mention of this fossil organism in China.

Genus *Plexoramea* Mello 1977

*Plexoramea cerebriformis* Mello 1977

Plate 14, figures A-D

*Plexoramea cerebriformis* n.g., n. sp. MELLO 1977, p. 191, pl. XCI, figs. 1-6; pl. XCII, figs. 1-9. – FLÜGEL et al. 1988, p. 625, pl. 1, figs. 1-4; pl. 2, figs. 1-2; pl. 3, figs. 1-4. (with synonymy). – BRANDNER et al. 1991, p. 284, pl. 72, figs. 9-10. – RÜFFER and ZAMPARELLI 1997, p. 118 (tab. 1), pl. 29, figs. 6-7. – ENOS et al. 1997, p. 579, fig. 25-26. – SENOWBARI-DARYAN et al. 1999, p. 330, pl. 1, fig. 9. – EMMERICH et al. 2005, p. 597, fig. 16 (23-24). – ENOS et al. 2006, p. 49, fig. 33. – VELLEDDITS et al. 2011, p. 248, fig. 22 (3). – SENOWBARI-DARYAN 2013, p. 23, fig. 11a-d. – PEYBERNES et al. 2015, p. 16, fig. 7e, f. – MIRCESCU et al. 2019, p. 33, fig. 5c. – GALE et al. 2020, p. 7 (tab. 1), fig. 11b.

*Tubiphytes gracilis* n. sp. SCHÄFER and SENOWBARI-DARYAN 1983, p. 128, pl. 10, figs. 1, 8

*Plexoramea gracilis* (Schäfer and Senowbari-Daryan 1983) n. comb. – SENOWBARI-DARYAN 2013, p. 97, figs. 12a-h, 13, 18f-i.

*Plexoramea omanica* n. sp. SENOWBARI-DARYAN and BERNEKER 2009, p. 35, pl. 10, fig. H; pl. 11, figs. A-G, text-fig. 5. – SENOWBARI-DARYAN 2013, p. 101, figs. 6d, 16f-g, 18b-c.

*Plexoramea cylindrica* n. sp. SENOWBARI-DARYAN 2013, p. 99, figs. 14a-d, 15k, 16a-c.k

*Plexoramea* was described by (Mello 1977, p. 190) as “A tangle of intertwined, discontinuous, uneven and irregularly ramifying twig and leaf-like partitions, in thin sections showing bush-like appearance with chaotic intertwined dead twigs. “Twigs” are made of dark aphanitic mass with very irregular thickness. Interspace material is sparitic. The twig tangle is either loose and free or dense and close, thus making a very irregular network”. Flügel et al. (1988, p. 265) consider that the structures built by this organism are irregularly delimited, spheroidal, flabby or bush-shaped and can reach up to 2 cm. The micritic filaments, which can branch several times, start from an empty central space that may also be branched. Micritic filaments, 10 to 50 microns thick, form a typically loose mesh that has no clear boundary with the sediment. As shown by the list of synonymy presented by Flügel et al (1988), *Plexoramea* has often been mistaken for the Permian species *Tubiphytes carinthiacus* (Flügel 1966). Starting from the morphological and ecological characteristics, Flügel et al. (1988) discussed the possible attribution of this organism to algae or fungi. Attribution to a known group of calcifying algae is unlikely in our opinion. It can be assumed instead that *Plexoramea* is a microbial construction somewhat similar to some bacinellid-type structures. Senowbari-Daryan (2013) described other species attributed to the genus *Plexoramea*: *Plexoramea gracilis* (Schäfer et Senowbari-Daryan 1983), *Plexoramea omanica* Senowbari-

## PLATE 9

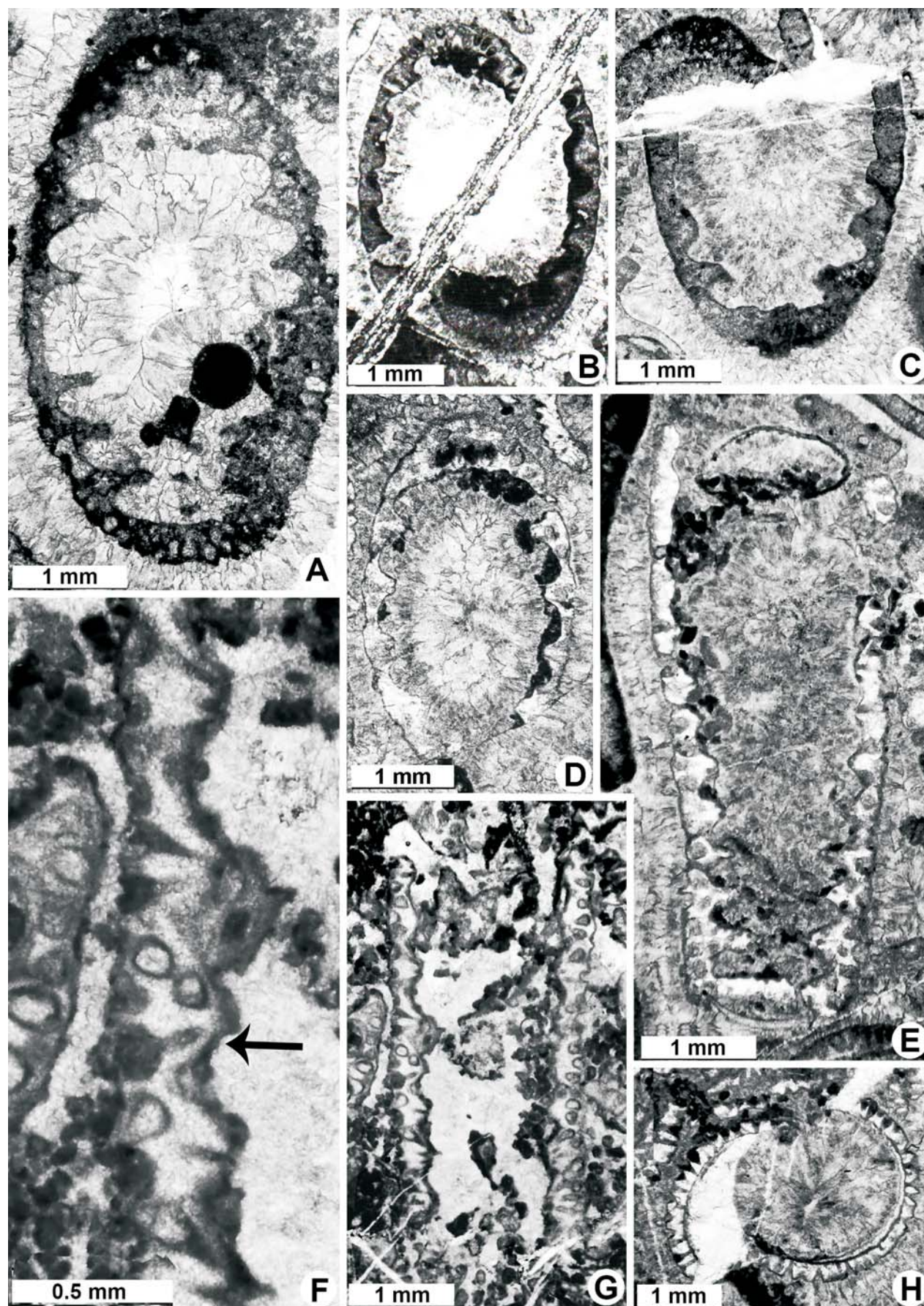
*Dasycladalean algae* from Guizhou Province, southern China.

A-C *Kantia intusannulata* n. sp. Oblique sections. Thin sections: LT100-2 (A); HM1836 (B, C).

D-G,H *Kantia muxinanii* n. sp. Oblique (D), longitudinal-oblique (E), longitudinal (G), and transverse (H)

sections. F, close-up view of the middle-left part in G; arrow points to the shape of the laterals. Thin section HM1836 (E-H), HM1836-2 (D). E = holotype; D, G = paratypes.





Daryan et Bernecker 2009, and *Plexoramea cylindrica* n. sp. In our opinion, the three species represent synonyms of the species *Plexoramea cerebriformis*, a consequence of the wide morphological variation of this organism.

The specimens identified in the Middle Triassic in Guizhou show an interesting bush morphology that has a “stem” at the bottom from which an upper “crown” develops (Pl. 14, fig. A).

Genus *Baccanella* Pantić 1971

***Baccanella floriformis*** Pantić 1971

Plate 14, figures C, G

*Baccanella floriformis*, n. gen., n. sp. PANTIĆ 1971, p. 270, fig. 1. – BORZA 1975, p. 220, pl. 4, figs. 13–17. – SÂNDULESCU et al. 1976, p. 175, pl. IV, figs. 1–4. – MELLO 1977, p. 197, pl. XCVI, figs. 1, 2, 6. – BALTRES et al. 1981, p. 95, pl. VI, figs. 7, 8; pl. IX, fig. 2. – FONTAINE et al. 1988, p. 159, fig. 7c. – PFFEIFER 1988, pl. 10, fig. 7. – SENOWBARI-DARYAN et al. 1999, p. 330, pl. 1, fig. 2. – EMMERICH et al. 2005, p. 599, fig. 16 (25, 28). – ENOS et al. 2006, p. 51 not illustrated. – POPESCU 2008, p. 120, 136, pl. 22, figs. 508. – VELLEDDITS et al. 2011, p. 248, fig. 22 (8). – PEYBERNES et al. 2015, p. 16, fig. 7j. – MIRCESCU et al. 2019, p. 33, fig. 5h. – GALE et al. 2020, p. 7, tab. 1, figs. 6a, c; 8e.

**Remarks:** Spheroidal calcite aggregates whose attribution to algae (e.g., Pantić 1971; Mello 1975) is highly unlikely. It is possible that these aggregates, which often appear as small colonies, are the result of the precipitation of calcium carbonate induced by microbial organisms. An abiogenic origin of similar microfossils from the Carnian of the Northern Calcareous Alps (*Muranella sphaerica* Borza) was inferred by Ebli and Schlagintweit 1989. However, *Bacanella floriformis* has been

found commonly associated with other microproblematica (e.g., *Ladinella porata*, *Plexoramea cerebriformis*, *Tubiphytes* div. sp.) in limestones of the Middle and Late Triassic, and are considered a characteristic fossil for this time interval and biotic assemblage.

Genus *Ladinella* Ott 1968

***Ladinella porata*** Ott 1968

Plate 14, figures E, F

*Ladinella porta* n. g. et n. sp. OTT in KRAUS and OTT 1968, p. 273, pl. 18, figs. 1–6; pl. 20, fig. 1. – SÂNDULESCU et al. 1976, p. 182, pl. X, fig. 2. – BALTRES et al. 1981, p. 94, pl. VI, figs. 2, 4. – MELLO 1977, p. 192, pl. XCV, figs. 3–5. – FONTAINE et al. 1988, p. 159, fig. 7f, g, j. – BRANDNER et al. 1991, p. 284, pl. 71 (11). – FLÜGEL et al. 1992, p. 46, pl. 5, fig. 5. – PANTIĆ-PRODANOVIC 1995, p. 166, pl. 4, fig. 2. – RÜFFER and ZAMPARELLI 1997, p. 118, tab. 1, pl. 29, fig. 9. – SENOWBAI-DARYAN 1997, p. 437, pl. 45, fig. 3. – EMMERICH et al. 2005, p. 597, fig. 16 (27). – ENOS et al. 2006, p. 51, 53, figs. 34, 35. – NITTEL 2006, p. 111, pl. XI, figs. 13–14. – POPESCU 2008, p. 133, 136, pl. 22, figs. 1–4. – VELLEDDITS et al. 2011, p. 248, fig. 22 (9). – PEYBERNES et al. 2015, p. 18, fig. 7h. – MIRCESCU et al. 2019, p. 33, fig. 5g. – GALE et al. 2020, p. 7 (tab. 1), p. 18, figs. 8d, 9d.

**Remarks:** The diagnosis given by Ott (in Kraus and Ott 1968, p. 273) is the following (translated from German): “Nodular or tongue-shaped epibionts (crusts) of the order of one millimeter, consisting of a colony of narrow-lumen tubes from 0.025 to 0.040 mm. The tubes are bent from the center to the periphery so that they open more or less perpendicular to the surface. In cross section they appear angular-rounded, some have pseudo-septa; No transverse walls in the tubes were observed”.

## PLATE 10

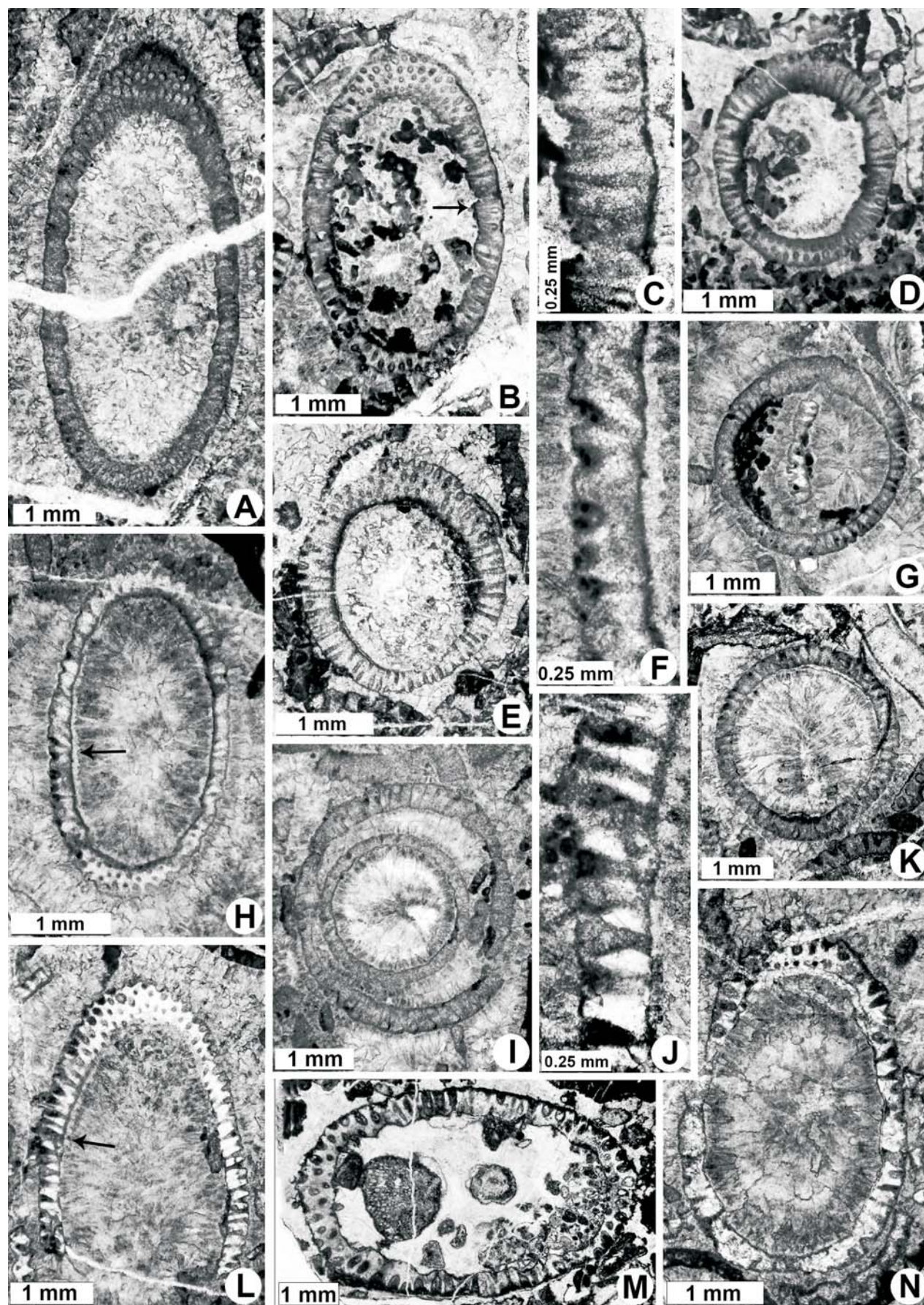
*Dasycladalean algae* from Guizhou Province, southern China.

A–I, K *Kantia* cf. *dolomitica* Pia (1912) Güvenc 1979. Oblique (A, B, H), transverse=oblique (D, R, I), and transverse (I, G, K) sections. Arrows in B, and H point to the respective location of the close-up views in C and F, showing the metaspondyl arrangement of laterals. Thin section HM1836.

L, N *Gyroporella* sp. Oblique sections. The arrow in L points to the location of the close-up view in J.

M ?*Kantia* sp. Oblique section. Thin section HM1844.







The systematic position of this organism remains uncertain, but its frequent occurrence in Ladinian-Cordevolian Wetterstein-type limestones makes it a relatively good biostratigraphic marker.

In association with the four problematic organisms presented above, specimens attributable to the genus *Tubiphytes* (Pl. 13, fig. N) appear commonly in the thin sections studied. This problematicum is well known from the Triassic (Anisian-Carnian) deposits of the Yangtze platform and the Great Bank of Guizhou (e.g., Enos et al. 1997, 2006; Lehrmann et al. 1998, 2015, 2020; Payne et al. 2006a, 2006b).

## STRATIGRAPHIC RANGE AND PALEOGEOGRAPHY

The stratigraphic succession of the Middle Triassic formations in the southwest of the Yangtze platform was extensively presented by Enos et al. (2006). Conventionally, the Qingyan, Poduan and Guanling formations are attributed to the Anisian, and the Longtou Formation to the Ladinian (Guizhou Bureau 1987, 1997).

The dasycladalean algae assemblages identified in the limestones of the Qingyan, Poduan and Guanling formations (Appendix) contain species that are characteristic of Anisian in the entire Tethysian area (Ott 1972; Bystricky 1985; Granier and Deloffre 1994; Bucur 1999): *Macroporella alpina*, *M. dinarica*, *Oligoporella minutula*, *O. pilosa*, *Poncetella hexaster*, *Julpiaella subtilis*, and *Pseudodiploporella proba*. The lower part of the Longtou Formation contains a dasycladalean assemblage dominated by *Diploporella annulata* and *D. annulatissima*, an association that in the Alpino-Dinaric domain indicates the Upper Anisian (Illyrian) (Ott 1972; Bystricky 1985; Granier and

Deloffre 1994; Bucur 1999; Kotanski 2013; Bucur and Matysik 2020). Consequently, the boundary between the Anisian and Ladinian, conventionally considered to coincide with the base of the Longtou Formation (Guizhou Bureau 1987, 1997) should be drawn above the lower fifth of these limestones (above sample HY47, 120 m above the base of Longtou Fm. and below the first occurrence of clearly Ladinian forms in sample HY1836, 292 m above the base in text-figs. 2 and 5; see also remarks in Bucur and Enos 2001, p. 318). On the other hand, the dasycladalean association dominated by representatives of the genus *Kantia* (*Kantia* cf. *comelicana*, *K. cf. dolomitica*, *K. intusannulata* n. sp., *K. granieri* n. sp., *K. muxinanii* n. sp.) is clearly Ladinian.

The calcareous algae in the samples studied are accompanied by an association of well-known foraminifera and problematic organisms from the Alpine-Dinaric Triassic. As shown in text-fig. 5 the majority of foraminifera is characteristic of Anisian. The most important are: *Meandrospira dinarica* Kochanski-Devidé and Pantić, *Pilammina densa* Pantić, *Pilammina grandis* (Salaj), *Endotriadella wirzi* (Koehn-Zaninetti), *Palaeolituonella meridionalis* (Luperto), and *Turriglomina mesotriassica* (Koehn-Zaninetti). Of these, *M. dinarica*, *P. densa*, *P. grandis* do not extend above the Anisian/Ladinian boundary (Zaninetti 1976; Salaj et al. 1983; 1989; Rettori 1995; Martini et al. 1998; Kobayshi et al. 2005; Velledits et al. 2011; Altiner et al. 2021; Gawlick et al. 2021). More interesting is the situation of problematic microorganisms. The association of *Baccanella floriformis*, *Ladinella porata*, and *Plexoramea cerebriiformis* is well known in the Alpino-Carpatho-Dinaric area, especially in the Ladinian (Ott 1968; Pantić 1971, 1972; Mello 1977; Brandner et al. 1991). In contrast, in Guizhou, this association is

## PLATE 11

*Dasycladalean algae* from Guizhou Province, southern China.

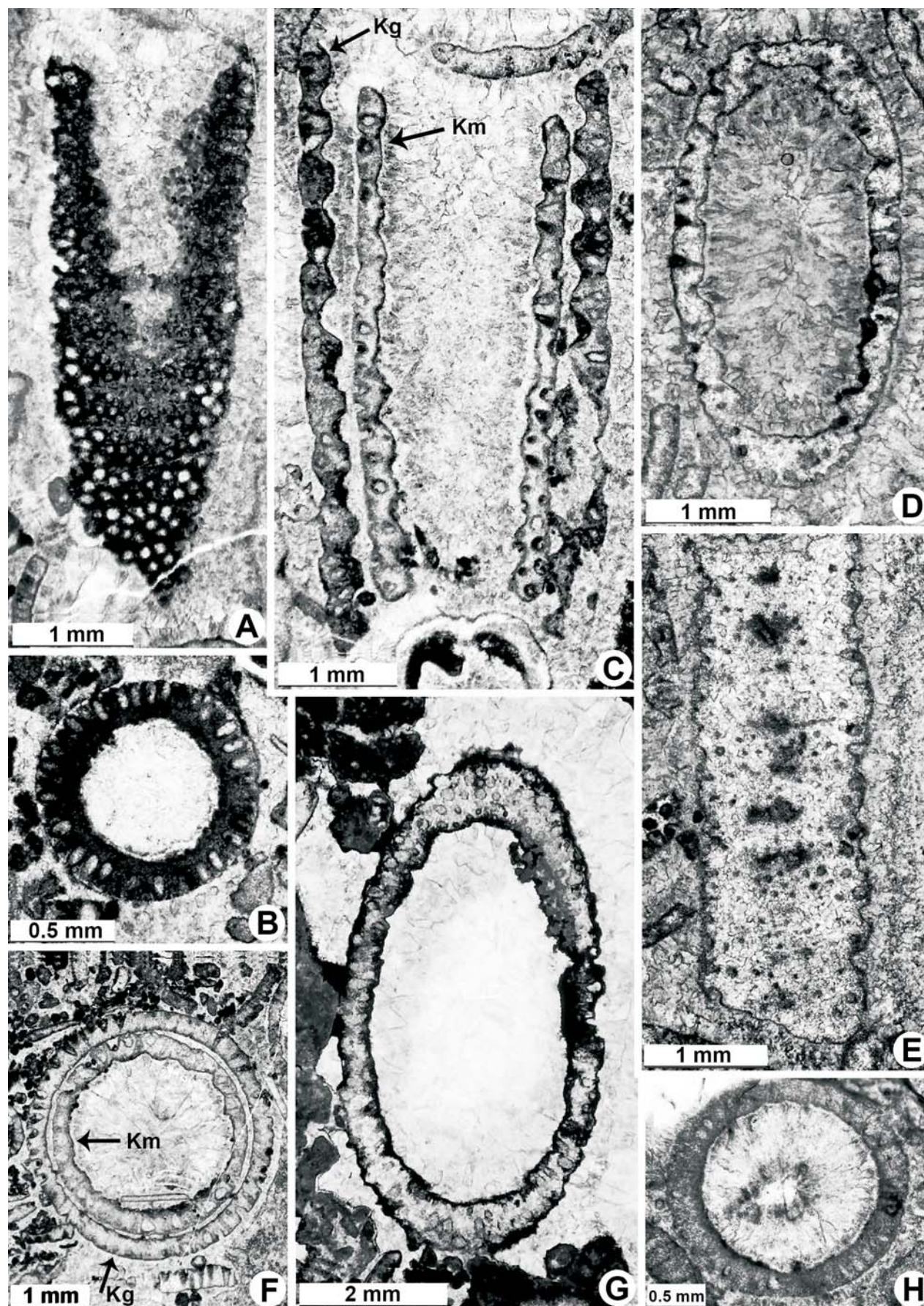
A,B *Kantia* sp. Oblique-tangential (A) and transverse (B) sections. Specimens with strongly micritised skeleton. Arrow in A points to the metaspondyle arrangement of laterals. Thin section HM1836.

C,F Specimens of *Kantia granieri* n.sp. (Kg) having in interior, probably mechanically trapped specimens of

*Kantia muxinanii* n. sp. (Km). Longitudinal (C) and transverse (F) sections. Thin section HM1836-2.

D,E,G,H *Kantia* sp. Relatively poorly preserved specimens in oblique (D, G), tangential (E) and transverse (H) sections. Thin sections: HM1836 (D, H), HM1836-2 (E), LT95 (G).







much more common in limestones attributed to Anisian (see Appendix). Several papers cite one or more of these problematic organisms in Anisian as well, especially the Upper Anisian (Fois and Gaetani 1984; Senowbari et al. 1993; Emmerich et al. 2005). The above statements are also valid for *Zornella obscura*, much less known than the other microproblematica. The explanation for this stratigraphic difference could be the relationship between the problematic organisms and facies: they are mainly related to reef or peri-reefal limestones. Such limestones are more common in Guizhou in platform edge or slope debris deposits of the Anisian (Enos et al. 2006). Moreover, the upper Hongyan section sampled more platform-interior facies (Guanling, Longtou, and Yanliujing Formations; text-fig. 2B).

Regarding the paleogeographic framework, the association of calcareous algae described from the Triassic limestones of the Yantze platform representing the Eastern Tethys, includes well-known species from both the Western Tethys (especially the Alpino-Carpatho-Dinaric area) and the southern border of Tethys. Exceptions are the new *Kantia* species described in this paper (*K. granieri*, *K. intusannulata*, *K. muxinanii*) and *Mizzia? toncii* n. sp., which seem to represent endemic forms in the Eastern Tethys.

## CONCLUSIONS

The limestones of the Middle Triassic in the southwest of the Yantze platform (Guizhou Province) contain a rich association of calcareous algae (especially Dasycladales) and problematic organisms. Twenty-two dasycladalean taxa were identified (19 at the species level and 3 at the genus level) of which 5 are new species, probably endemic to the Eastern Tethys. The calcareous algae from the sections studied are mainly of species attrib-

uted to the Anisian; they co-occur with Foraminifera, also characteristic of this stratigraphic interval. The exception is the association of new *Kantia* species that most likely correspond to the Lower Ladinian. The dasycladalean association identified in the lower part of the Longtou Formation, namely the association *Diplopora annulata*-*D. annulatissima*, suggests that at least the lower 120 m of this formation at Hongyan belongs to the Upper Anisian (Illyrian) and not the Ladinian, as conventionally assigned.

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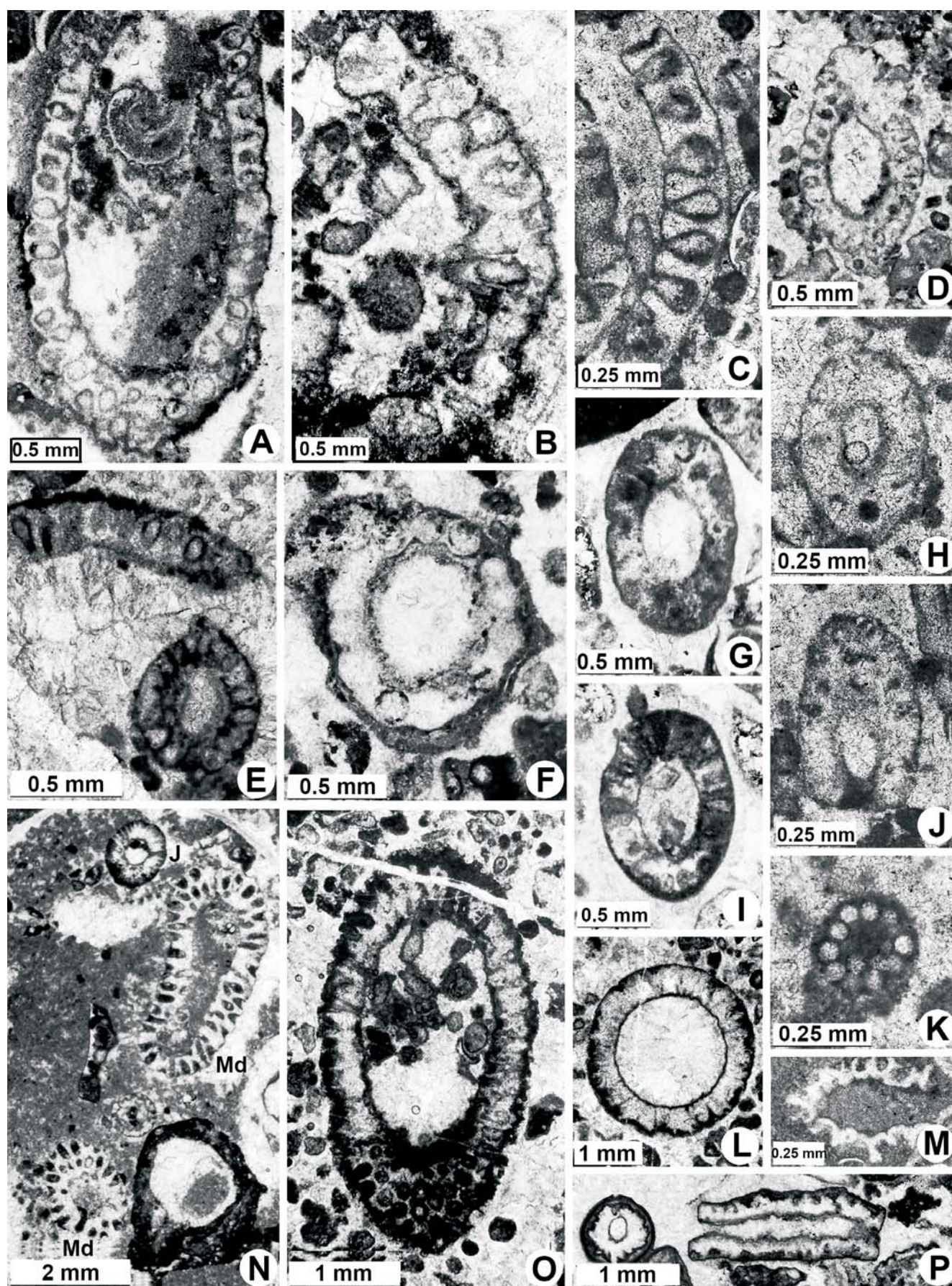
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## PLATE 12

*Dasycladalean algae* from Guizhou Province, southern China.

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| <p>A-C <i>Gyriporella</i> sp. Oblique (A) and fragments in oblique (B, C) sections. Thin sections: HY13B (A); HM1636 (B); HM1836 (C).</p> <p>D,E-J <i>Holosporella</i> div. sp. Oblique sections. Thin sections: HM1836 (D, E, H, J); GT30 (G, I).</p> <p>F <i>?Patruluspora</i> sp. Transverse-oblique section. Thin section LT141B</p> <p>K <i>?Terquemella</i> sp. Transverse section. Thin section HY25.</p> | <p>L,O <i>Salpingoporella</i> cf. <i>sturi</i> (Bystricky 1968) Conrad et al. 1973. Transverse (L) and longitudinal-oblique (O) sections. Thin section HY50.</p> <p>N <i>Macroporella dinarica</i> Pia, 1912 (Md) in oblique and transverse-oblique sections, and <i>Julpiaella</i> sp. (J) in transverse-oblique section. Thin section GT40.</p> <p>M,P Unidentified dasycladalean algae. Thin section: HM1861.</p> |
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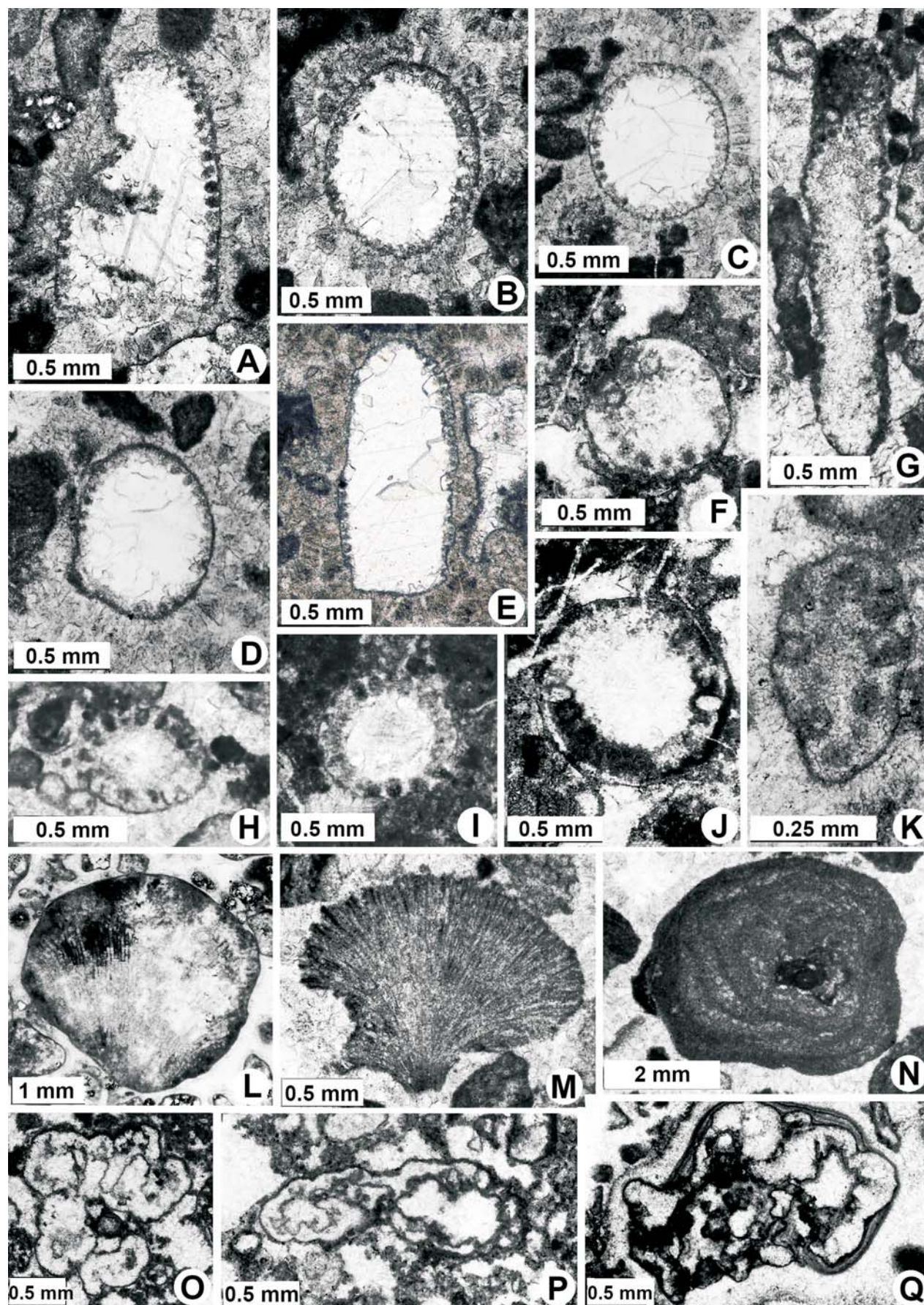
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### PLATE 13

Calcareous algae and microproblematica from Guizhou Province, southern China.

- A-E *Acicularia guizhouensis* n. sp. Longitudinal-oblique (A, E) and transverse-oblique (B-D) sections. Thin section HY25 (A-D) and HY25-2 (E). A = holotype; B-E = paratypes
- F,H,K *Acicularia/Terquemella* div.sp. Thin sections: HM1836 (E, H); HM1844 (F, J); T100-1 (I); LT104 (K).
- G *Acicularia* sp. Longitudinal section. Thin section HM1836.
- L “*Solenopora*”sp. Thin section GT30.
- M Rivulariacean-type cyanobacteria. Thin section HY25.
- N *Tubiphytes/Shamovella* sp. Thin section HY25
- O-Q *Zornella obscura* Senowbari-Daryan and Di Stefano ex Senowbari-Daryan and Bucur, 2021. Thin section HM1861.

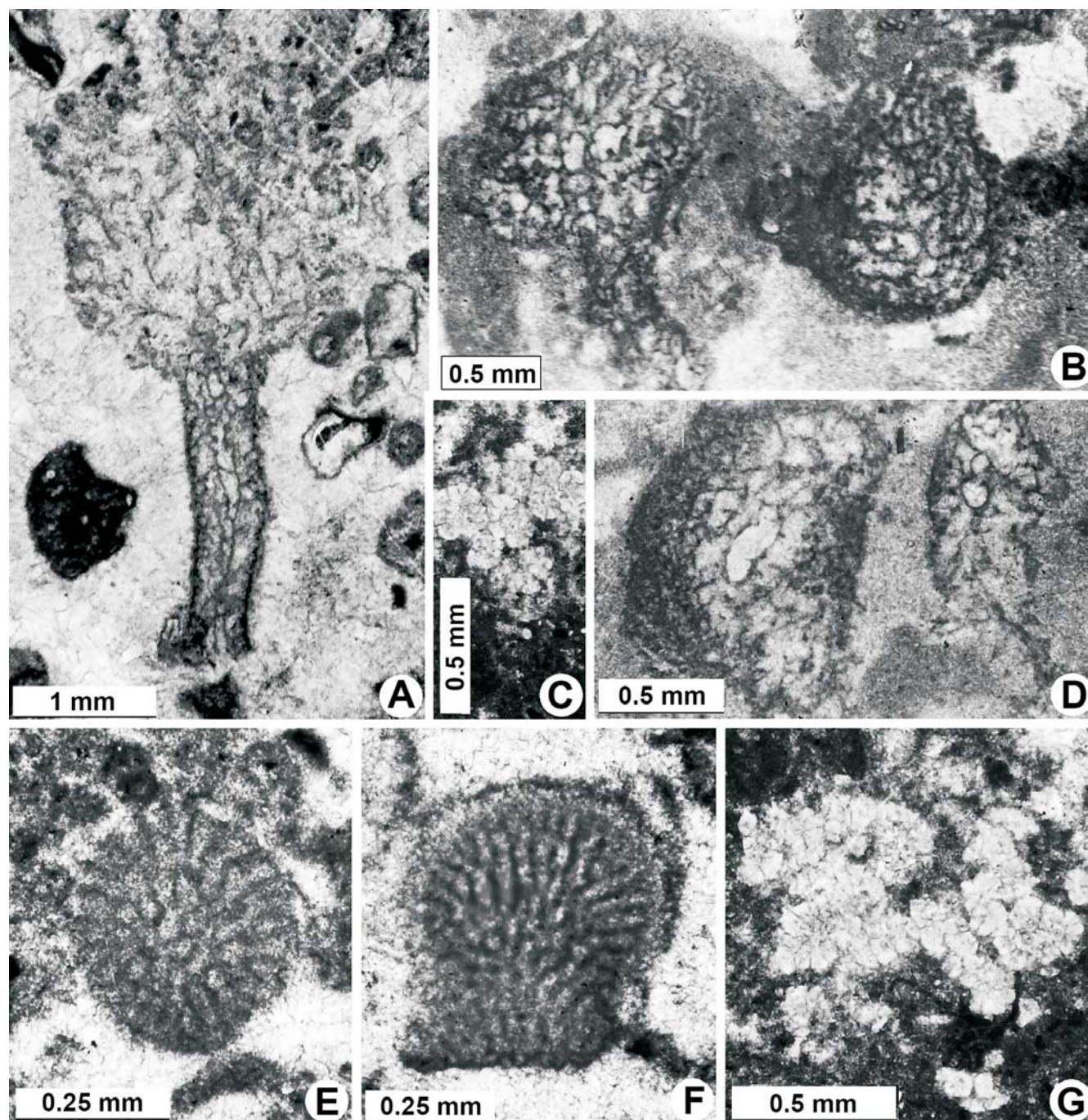






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# **PLATE 14**

Microproblematica from Guizhou Province, southern China.

A,B,D *Plexoramea cerebriformis* Mello 1977. Thin sections: Hy11E (A); GT31 (B, D).

C,G *Bacanella floriformis* Pantic 1971. Thin section SM6.

E,F *Ladinella porata* Ott. Thin sections: SH6 (E); HM1271 (F).

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## APPENDIX 1

Micropaleontological content of the Middle Triassic carbonate formations of Guizhou (Calcareous algae, Foraminifera and Microproblematica).

### Qingyan Formation

Calcareous algae

*Acicularia* sp.

*Diploporella* cf. *annulata* (Schafhäütl 1853) Schafhäütl 1863

*Diploporella* sp.

*Diploporella sinica* Bucur and Enos 2001

*Holosporella* sp.

*Julpiaella subtilis* (Pia 1935) Bucur and Enos 2001

*Julpiaella* sp.

*Macroporella* cf. *dinarica* Pia 1912

*Oligoporella pilosa* Pia 1912 var. *pilosa* Bystricky 1964

*Physoporella*? sp.

*Pseudodiploporella proba* (Pia 1935) Bucur and Enos 2001

“*Solenoporella*” sp.

Rivulariacean-type cyanobacteria

Foraminifera

*Ammobaculites* sp.

*Aulotortus*? *eotriassicus* Zaninetti, Rettori and Martini 1994

*Aulotortus* sp.

Duostominidae

*Earlandia*? *amplimuralis* (Pantić 1972) Zaninetti 1976

*Earlandia*? *tintinniformis* (Mišik 1971)

*Endoteba* sp.

*Endotebanella* sp.

*Endotriada kuepperi* (Oberhauser 1960) Vachard et al. 1994

*Endotriada* sp.

*Endotriadella wirzi* (KoeHN-Zaninetti 1969) Vachard et al. 1994

*Glomospira* sp.

*Glomospirella* sp.

*Meandropsira dinarica* Kochansky-Devidé and Pantić 1966

*Meandropsira pusilla* (Ho 1959) Salaj, Borza and Samuel 1983

Nodosaroea

*Pilamina densa* Pantić 1965

*Pilaminella gemerica* (Salaj in Salaj, Biely and Bystricky 1967) Salaj, Borza and Samuel 1983

*Pilaminella grandis* (Salaj in Salaj, Biely and Bystricky 1967) Salaj 1978

*Pilaminella* cf. *kuthani* (Salaj, Biely and Bystricky 1967) Salaj, Borza and Samuel 1983

*Reophax* sp.

*Trochammina alpina* Kristan-Tollmann 1964

*Trochammina* sp.

Trocholinidae

„*Valvulina*” *azzouzi* Salaj 1978

Microproblematica

*Ladinella porata* Ott 1968

*Plexoramea cerebriformis* Mello 1977

*Radiomura cautica* Senowbari-Daryan and Schäfer 1979

*Tubiphytes/Shamovella* sp.

?Sponges

*Olangocoellia otti* Bechstädt and Brandner 1970

### Poduan Formation

Calcareous algae

*Acicularia guizhouensis* n. sp.

*Gyroporella* sp.

*Julpiaella* sp.

*Macroporella dinarica* Pia 1912  
*Oligoporella minutula* (Gümbel 1872) Grgasović 2022  
*Oligoporella pilosa pilosa* Pia 1912 ex Bystricky 1964  
 Rivulariacean-type cyanobacteria

Foraminifera  
*Agathammina austroalpina* Kristan-Tollmann and Tolmann 1964  
*Earlandia? amplimuralis* (Pantić 1972) Zaninetti 1976  
*Endotriada* sp.  
*Endotriadella wirzi* (Koehn-Zaninetti 1969) Vachard et al. 1994  
*Endotriadella* sp.  
 Duostominidae  
*Glomospirella* sp.  
*Meandrospira dinarica* Kochansky-Devidé and Pantić 1966  
*Palaeolituonella meridionalis* (Luperto 1966) Zaninetti, Ciarapica and Martini 1986  
*Pilamina* cf. *densa* Pantić 1965  
*Reophax* sp.  
*Trochammina alpina* Kristan-Tollmann 1964  
 Trocholinidae  
*Turrioglobina mesotriasica* (Koehn-Zaninetti 1969) Limongi et al. 1987

Microproblematica  
*Baccanella floriformis* Pantić 1971  
*Ladinella porata* Ott 1968  
*Plexoramea cerebriiformis* Mello 1977  
*Radiomura cautica* Senowbari-Daryan and Schäfer 1979  
*Tubiphytes/Chamovella* sp.

?Sponges  
*Olangocoellia otti* Bechstädt and Brandner 1970

#### Guanling Formation

Calcareous algae  
*Julpiaella subtilis* (Pia 1935) Bucur and Enos 2001  
*Macroporella alpina* Pia 1912  
*Oligoporella* cf. *pilosa* Pia 1912  
*Physoporella* cf. *pauciforata* (Gümbel 1872) Steinmann 1903  
*Poncetella hexaster* (Pia 1912) Güvenç 1979  
*Pseudodiploporella* sp.  
 Rivulariacean-type cyanobacteria

Foraminifera  
*Meandrospira dinarica* Kochansky-Devidé and Pantić 1966

?Sponges  
*Olangocoellia otti* Bechstädt and Brandner 1970

#### Longtou Formation

Calcareous algae  
*Acicularia* sp.  
*Diploporella annulata* (Schafhäütl 1853) Schafhäütl 1863  
*Diploporella* cf. *annulata* (Schafhäütl 1853) Schafhäütl 1863  
*Diploporella annulatissima* Pia 1920  
*Diploporella sinica* Bucur and Enos 2001  
*Euteutloporella triasina* (Schauroth 1859) De Castro 1993  
*Holosporella* sp.  
*Julpiaella subtilis* (Pia 1935) Bucur and Enos 2001  
*Kantia* cf. *comelicana* (Fois 1973) Bucur, Enos and Minzoni nov. comb.  
*Kantia* cf. *dolomitica* Pia 1912  
*Kantia granieri* n. sp.  
*Kantia intusannulata* n. sp.  
*Kantia muxinanii* n. sp.  
*Kantia* sp.  
*Macroporella alpina* Pia 1912  
*Macroporella dinarica* Pia 1912  
*Mizzia? toncii* n. sp.  
*Oligoporella* cf. *pilosa* Pia 1912  
*Oligoporella* sp.  
*Patruluspora* sp.  
*Pseudodiploporella proba* (Pia 1935) Bucur and Enos 2001  
 Rivulariacean-type cyanobacteria

Foraminifera  
 Duostominidae  
*Endoteba* sp.  
*Endotebanella* sp.  
*Endotriada* sp.  
*Endotriadella wirzi* (Koehn-Zaninetti 1969) Vachard et al. 1994  
*Endotriadella* sp.  
*Glomospira* sp.  
*Glomospirella* sp.  
*Krikoumbilica pileiformis* He 1984  
*Meandrospira dinarica* Kochansky-Devidé and Pantić 1966  
 Nodosariacea  
*Trochammina* sp.  
*Trochammina almtalensis* Koehn-Zaninetti 1969  
*Turrioglobina mesotriasica* (Koehn-Zaninetti 1969) Limongi et al. 1987