



**A new subfamily classification
of the Coskinolinidae MOULLADE, 1965,
Middle Jurassic-Paleogene Larger Benthic Foraminifera**

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Abstract: The Coskinolinidae are a family of Middle Jurassic to Paleogene, typically orbitoliniform, Larger Benthic Foraminifera (LBF) characterized by a pseudokeriothecal wall structure. The type genus, *Coskinolina* STACHE, 1875, lacks an exoskeleton (*i.e.*, beams, rafters), resulting in an undivided marginal chamber zone. However, other taxa within the family, such as the Upper Cretaceous *Lepinoconus* CRUZ-ABAD *et al.*, 2017, or the Paleogene *Coleiconus* HOTTINGER & DROBNE, 1980, are genera with vertical partitions (beams) that subdivide the marginal chamber zone. In the currently accepted classification of agglutinated benthic foraminifera, the nature of the exoskeleton is a criterion for distinction at subfamily level, *e.g.*, Cyclamminidae MARIE, 1941. Thus, here, the presence or absence of an exoskeleton in the marginal chamber lumen is treated as a criterion at the subfamily level within the classification of the Coskinolinidae, leading to a division into two subfamilies: the Coskinolininae MOULLADE, 1965 (lacking an exoskeleton), and the newly proposed Coleiconinae subfam. nov. (with an exoskeleton of vertical partitions), as exemplified by *Coleiconus* HOTTINGER & DROBNE, 1980.

Keywords:

- Larger Benthic Foraminifera (LBF);
- taxonomy;
- classification;
- exoskeleton

Citation: SCHLAGINTWEIT F. (2024).- A new subfamily classification of the Coskinolinidae MOULLADE, 1965, Middle Jurassic-Paleogene Larger Benthic Foraminifera.- *Carnets Geol.*, Madrid, vol. 24, no. 12, p. 179-186. DOI: [10.2110/carnets.2024.2412](https://doi.org/10.2110/carnets.2024.2412)

Résumé : Une nouvelle classification des Coskinolinidae MOULLADE, 1965, Foraminifères Benthiques de Grande Taille de l'intervalle Jurassique moyen-Paléogène.- La famille des Coskinolinidae regroupe des Foraminifères Benthiques de Grande Taille (FBGT), typiquement orbitoliniformes, datant du Jurassique moyen au Paléogène et caractérisés par une structure de paroi pseudokériothèque. Le générotype, *Coskinolina* STACHE, 1875, ne possède pas d'exosquelette (poutres/rayons et/ou poutrelles/mezzanines) ; par conséquent, la zone marginale des chambres est indivisée. Cependant, d'autres genres de la famille, tels que le *Lepinoconus* CRUZ-ABAD *et al.*, 2017, du Crétacé supérieur ou *Coleiconus* HOTTINGER & DROBNE, 1980, du Paléogène, présentent des séparations verticales (poutres/rayons) subdivisant la zone marginale des chambres. Dans la classification actuelle des foraminifères benthiques agglutinés, la présence ou l'absence d'un exosquelette est un critère permettant la distinction au niveau de la sous-famille, *e.g.*, les Cyclamminidae MARIE, 1941. Ainsi, la présence ou l'absence d'un exosquelette dans le lumen des chambres marginales est utilisée ici comme critère taxinomique au niveau de la sous-famille dans la classification de la famille des Coskinolinidae, conduisant à sa subdivision en deux sous-familles : les Coskinolininae MOULLADE, 1965 (sans exosquelette), et les Coleiconinae subfam. nov. (avec un exosquelette formé de séparations verticales), illustrée par *Coleiconus* HOTTINGER & DROBNE, 1980.

Mots-clefs :

- Foraminifères Benthiques de Grande Taille (FBGT) ;
- taxonomie ;
- classification ;
- exosquelette

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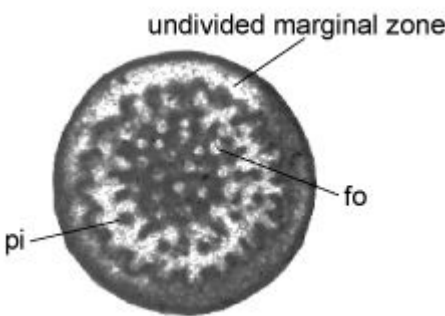
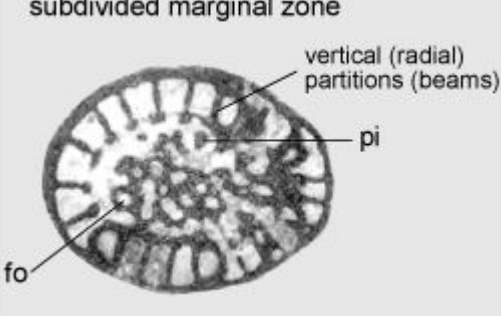
1. Introduction

With first representatives as old as Middle(?)–Late Jurassic (CUVILLIER *et al.*, 1968; BORDEA S. & BORDEA J., 1987; KAMOUN & PEYBERNÈS, 1993), orbitoliniform agglutinated conical Larger Benthic Foraminifera are widespread constituents in Cretaceous–Paleogene shallow-water carbonates (*e.g.*, SCHROEDER, 1962; HOTTINGER & DROBNE, 1980; MOULLADE *et al.*, 1985). With respect to these taxa, those displaying a pseudokeriothecal wall (*e.g.*, HOTTINGER, 2006) contrast with the non-canalliculate wall texture of the Orbitolinidae, as previously noted by DOUGLASS (1960) and SCHROEDER in SCHROEDER *et al.* (1975). In the original description of the Coskinolinidae, MOULLADE (1965) included forms having pillars in the central zone with undivided (*Lituonella* SCHLUMBERGER in SCHLUMBERGER & DOUVILLÉ, 1905) and subdivided marginal zones (*Coskinolina* STACHE, 1875) as well as a group having a reticulate central zone represented by *Kilianina* PFENDER, 1933, *Abrardia* NEUMANN & DAMOTTE, 1960, *Coskinolinooides* KEJZER, 1942, and *Orbiqia* MANGAIN & JAGANNATHA RAO, 1933. With *Lituonella* representing a junior synonym of *Coskinolina* (SCHUBERT, 1912; DOUGLASS, 1960; HOFKER, 1966; SCHROEDER, 1974) and the other four genera originally included in the Coski-

nolinidae now assigned to other families (LOEBLICH & TAPPAN, 1987; KAMINSKI, 2014), only *Coskinolina* remains from MOULLADE's original family concept. LOEBLICH's and TAPPAN's 1987 classification included five genera: *Coleiconus* HOTTINGER & DROBNE, 1980, *Coskinolina*, *Coskinon* HOTTINGER & DROBNE, 1980, *Lituonelloides* HENSON, 1948, and *Pseudolituonella* MARIE, 1955 (see also KAMINSKI, 2014). Later, *Cantabriconus* SCHLAGINTWEIT *et al.*, 2017, and *Lepinoconus* CRUZ-ABAD *et al.*, 2017, were added to the family. SERRA-KIEL *et al.* (2016a) included *Fallotella* MANGIN, 1954, in the Coskinolinidae without any remarks or discussion, a view that is rejected here since a pseudokeriothecal wall structure is seemingly absent (MANGIN, 1954; HOTTINGER & DROBNE, 1980; LOEBLICH & TAPPAN, 1987). The same can be stated for the inclusion of *Barattolites* VECCHIO & HOTTINGER, 2007, in the Coskinolinidae by BOUDAGHER-FADEL (2018), which is inconsistent with the original description of *Barattolites* by VECCHIO and HOTTINGER (2007) as a member of the Orbitolinidae MARTIN, 1890 (see SERRA-KIEL *et al.*, 2016b).

Herein a taxonomic update of the Coskinolinidae is provided including a new subfamily concept.

Table 1: New taxonomic concept of the Coskinolinidae MOULLADE, 1965, as presented herein: diagnoses, included genera, and differences. Further comments about genera in the text. Abbreviations: fo = foramen, pi = pillar. Left: *Coskinolina sistanensis* SCHLAGINTWEIT & HADI, 2018, from the Eocene of Iran (unpublished image). Right: *Coleiconus zansi* ROBINSON, 1993, from the Eocene of Jamaica (from ROBINSON & WRIGHT, 1993, Fig. 7.4).

Family	Coskinolinidae MOULLADE, 1965, emended	
Common features	Orbitoliniform morphology; no horizontal partitions (rafters); thick wall with pseudokeriotheca	
Diagnosis	Test conical, early stage trochospiral, then becomes uniserial and rectilinear with broad, low chambers, interior subdivided by pillars and/or radial partitions; wall agglutinated, single-layered, with pseudokeriotheca ; aperture basal, cribrate; marginal foramina/apertures may be present (LOEBLICH & TAPPAN, 1987) emend. herein	
Subfamilies	Coskinolininae MOULLADE, 1965, emended	Coleiconinae subfam. nov.
Diagnosis	Coskinolinidae with undivided marginal zone (no rafters, no beams)	Coskinolinidae with marginal zone subdivided by beams forming alcoves; intercalary beams may be present; beams either aligned or alternating between subsequent chambers
Genera included	<i>Coskinolina</i> STACHE, 1875, <i>Lituonelloides</i> HENSON, 1948, <i>Pseudolituonella</i> MARIE, 1954, <i>Parurgonina</i> CUVILLIER <i>et al.</i> , 1968, <i>Coskinon</i> HOTTINGER & DROBNE, 1980, <i>Cantabriconus</i> SCHLAGINTWEIT <i>et al.</i> , 2017	<i>Coleiconus</i> HOTTINGER & DROBNE, 1980, <i>Lepinoconus</i> CRUZ-ABAD <i>et al.</i> , 2017, <i>Ebrahimiella</i> YAZDI-MOGHADAM & SCHLAGINTWEIT, 2021
Transverse sections	 <p>undivided marginal zone fo pi</p> <p><i>Coskinolina</i> STACHE</p>	 <p>subdivided marginal zone vertical (radial) partitions (beams) pi fo</p> <p><i>Coleiconus</i> HOTTINGER & DROBNE</p>



2. Systematic palaeontology

The classification of the agglutinated benthic foraminifera follows KAMINSKI (2014). The proposed new suprageneric classification does not affect the generic diagnoses (LOEBLICH & TAPPAN, 1987, and taxa established later), and therefore they are not repeated herein. Table 1 shows a comparison of the two subfamilies Coskinolininae and Coleiconinae including common features and differences.

Phylum Foraminifera (ORBIGNY, 1826)
PAWLOWSKI et al., 2013

Order Textulariida
(DELAGE & HÉROUARD, 1896) KAMINSKI, 2004

Order Loftusiida
KAMINSKI & MIKHALEVICH in KAMINSKI, 2004

Suborder Orbitolinina MARTIN, 1890

Superfamily Coskinolinoidea MOULLADE, 1965

Family Coskinolinidae MOULLADE, 1965,
emended herein

Type genus: *Coskinolina* STACHE, 1875.

Subfamily Coskinolininae MOULLADE, 1965

Remarks: A subfamily Coskinolininae was proposed by CIMERMAN (1969) (without diagnosis, included genera, etc.) for biserial textulariids including the genus *Pavonitina* SCHUBERT, 1914, morphologically completely different from *Coskinolina*. The Coskinolininae *sensu* CIMERMAN (1969) is invalid due to the priority of the Coskinolininae MOULLADE, 1965 (article 23 ICZN).

Included genera: *Coskinolina* STACHE, 1875; *Lituonelloides* HENSON, 1948; *Pseudolituonella* MARIE, 1954; ? *Parurgonina* CUVILLIER et al., 1968; ? *Coskinon* HOTTINGER & DROBNE, 1980; ? *Cantabri-conus* SCHLAGINTWEIT et al., 2017.

***Coskinolina* STACHE, 1875**

Type species: *Coskinolina liburnica* STACHE, 1875.

Remarks: The genus includes only Paleogene species (HOTTINGER & DROBNE, 1980; VICEDO et al., 2014; SCHLAGINTWEIT & HADI, 2018). The stratigraphic range of *Coskinolina* is Thanetian to Priabonian (VICEDO et al., 2014; SERRA-KIEL et al., 2016b).

***Lituonelloides* HENSON, 1948**

Type species: *Lituonelloides compressus* HENSON, 1948.

Remarks: *Lituonelloides* is a monospecific genus with its only species being *L. compressus* HENSON from the Maastrichtian Simsima Formation of Qatar (see WHITTAKER et al., 1998). It has been included in the Coskinolinidae by LOEBLICH and TAPPAN (1987). Particularly significant, the illustration (drawing) of the holotype provided in Fig. 2a by HENSON (1948) shows an undivided marginal zone, one of the characteristic features of the Coskinolininae (see also Pl. 64, figs. 1-2 in WHITTAKER et al., 1998). The presence of a pseudokeriothecal wall is not evidenced from the poor material available of just one thin-section image in the original description. The drawing in Fig. 2b of HENSON (1948) might possibly exhibit endoskeletal

pillars aligned between subsequent chambers, a feature not mentioned previously. *Lituonelloides* still represents a 'poorly known genus' (WHITTAKER et al., 1998).

***Pseudolituonella* MARIE, 1954**

Type species: *Pseudolituonella reicheli* MARIE, 1954.

Remarks: In his 'Note sur *Pseudolituonella*', REISS (1959) drew attention to the microgranular nature of the wall, being formed of a single layer, imperforate and non-lamellar (see also PRESTAT, 1985; LOEBLICH & TAPPAN 1987). SERRA-KIEL et al. (2016b) established the new species, *Pseudolituonella robineti*, from the Eocene of Yemen displaying a pseudokeriothecal wall. SERRA-KIEL et al. (2016b) were well aware that the wall structure of their Eocene species differed from the one reported for the type species *P. reicheli* (from the Cenomanian of France) and that an emendation might require study of type specimens of the Cenomanian species. In fact, the presence of a pseudokeriothecal wall structure in *P. reicheli* has been demonstrated in specimens from the Cenomanian Sarvak Formation of SW Iran (SCHLAGINTWEIT & YAZDI-MOGHADAM, 2020).

***Parurgonina* CUVILLIER et al., 1968**

Type species: *Urgonina (Parurgonina) caelinensis* CUVILLIER et al., 1968.

Remarks: The type species was originally described as the orbitolinid *Urgonina (Parurgonina) caelinensis* by CUVILLIER et al. (1968) from the Upper Jurassic of Italy. The presence of a pseudokeriothecal wall structure noted by SCHROEDER et al. (1975, p. 319) 'indicates that this form does not belong to the Orbitolinidae'. On the other hand, SCHROEDER et al. (1975) did not provide any information on the family status of *Parurgonina*. The adult stage was indicated as consisting of uniserial chambers (CUVILLIER et al., 1968; SCHROEDER et al., 1975; LOEBLICH & TAPPAN, 1987). LOEBLICH and TAPPAN (1987) assigned *Parurgonina*, in my opinion incorrectly, to the Chrysalidinidae NEAGU, 1968. LOEBLICH & TAPPAN (1987, p. 185) defined the Chrysalidinidae as having a 'test triserial, later biserial' while *Parurgonina* is defined as possessing a main 'uniserial stage' (p. 186), a contradiction in itself. SEPTFONTAINE (1988, p. 248) created the Parurgonininae as a subfamily within the family Valvulinidae BERTHELIN, 1880, claiming a trochospiral coiled test throughout (eight or more chambers in the adult stage) (= Jurassic 'praevalvulinids' in SEPTFONTAINE, 2020, tab. 8.4). In the current classification of KAMINSKI (2014), the Parurgonininae were given family status (Parurgoninidae). It appears that *Parurgonina* shares characters of both Chrysalidinidae (trochospiral 'helico-spiral' early stage with valvular toothplate) and Coskinolinidae (uniserial adult part). The undivided marginal chamber, marginal foramina and the pseudokeriothecal wall are present in both families (e.g., HOTTINGER & DROBNE, 1980; DE CASTRO, 1981; BANNER et al., 1991; SEPTFONTAINE, 2020). *Parurgonina* is herein placed tentatively within the subfamily Coskinolininae MOULLADE, 1965. Accord-



ingly, the family Parurgoninidae SEPTFONTAINE, 1988, with its only genus *Parurgonina*, would then become obsolete (see also KAMINSKI, 2014). It is worth mentioning in this context that specimens of *Parurgonina caelinensis* from the Upper Jurassic of Greece were named '*Coskinolines*' by BASSOULLET and GUERNET (1970) (SCHROEDER in SCHROEDER *et al.*, 1975). The stratigraphic range of *Parurgonina* is late middle Bajocian to Valanginian (KAMOUN & PEYBERNÈS, 1993; BASSOULLET, 1997; SCHLAGINTWEIT *et al.*, 2023).

Genus *Coskinon* HOTTINGER & DROBNE, 1980

Type species: *Coskinolina (Coskinon) rajkae* HOTTINGER & DROBNE, 1980.

Remarks: The Paleogene genus *Coskinon* was originally described by HOTTINGER and DROBNE (1980) as a subgenus of *Coskinolina* later established as an independent genus within the Coskinolinidae by LOEBLICH and TAPPAN (1987) and then treated as a member of the Pfenderinidae SMOUT & SUGDEN, 1962, by DI CARLO *et al.* (2010). The presence of pseudokeriotheca in *Coskinon* has not been demonstrated (HOTTINGER & DROBNE, 1980; DI CARLO *et al.*, 2010). As a consequence, *Coskinon* is herein kept with some reservations in the Coskinolinidae.

Genus *Cantabrichonus* SCHLAGINTWEIT *et al.*, 2017

Type species: *Cantabrichonus reocinianus* SCHLAGINTWEIT *et al.*, 2017.

Remarks: The genus includes the two species *C. reocinianus* SCHLAGINTWEIT *et al.*, 2017 (upper Aptian-lower Albian of northern Spain; Fig. 1) and *Cantabrichonus? meridionalis* SCHLAGINTWEIT & BUCUR, 2020 (lower Aptian of Romania). Note that *Cantabrichonus* is considered a trochospiral pfenderinid or valvulinid morphotype by SEPTFONTAINE (2020). In fact, some genera of typical orbitoliniform morphology that possess a pseudokeriothecal wall structure and a central zone with variously shaped pillars have been assigned to the Pfenderinidae SMOUT & SUGDEN, 1962, namely *Conicopfenderina* SEPTFONTAINE in KAMINSKI, 2000 (type species *Lituonella mesojurassica* MAYNC, 1972), and *Moulladella* BUCUR & SCHLAGINTWEIT, 2018 (type species *Meyendorffina (Paracoskinolina) jordanensis* FOURY & MOULLADE, 1966). While *Conicopfenderina* displays an undivided marginal zone as one characteristic feature of the Coskinolininae, it has been placed into the Palaeopfenderininae SEPTFONTAINE, 1988. According to SEPTFONTAINE (1988), the Eocene genus *Lituonella* (= *Coskinolina*) '*should not be used for Middle Jurassic orbitoliniform foraminifera, as it has a different phylogenetic history*' (KAMINSKI, 2000, p. 215). This highlights the problem that stratigraphically markedly separated taxa of identical morphology and inner structure are recorded from the Coskinolininae. An example is the Cenomanian *Pseudolituonella reicheli* MARIE, 1954, and the distinctly larger Eocene homeomorph *Pseudolituonella robineti* GALLARDO-GARCIA & SERRA-KIEL, 2016, which are separated not only by a long interval of time, but also two mass extinctions (at the Cenomanian/

Turonian and Cretaceous/Paleogene boundaries). Phylogenetically they might well be distinct, but morphologically they are near-identical. Further discussion of this principal problem in foraminiferal taxonomy is beyond the scope of this article.

Subfamily Coleiconinae subfam. nov.

Diagnosis: See Table 1.

Type genus: *Coleiconus* HOTTINGER & DROBNE, 1980.

Included genera: *Coleiconus* HOTTINGER & DROBNE, 1980; *Lepinoconus* CRUZ-ABAD *et al.*, 2017; *Ebrahimiella* YAZDI-MOGHADAM & SCHLAGINTWEIT, 2021.

***Coleiconus* HOTTINGER & DROBNE, 1980**

Type species: *Coleiconus zansi* ROBINSON, 1993.

Remarks: In axial sections, the two Paleogene taxa, *Coskinolina* and *Coleiconus*, are not distinguishable from each other. For *Coleiconus* HOTTINGER & DROBNE, 1980, and *Coskinolina* STACHE, 1875, LOEBLICH and TAPPAN (1987) noted a '*wall with keriothecal structure*', nowadays termed '*pseudokeriotheca*' (HOTTINGER, 2006, p. 29). The principal difference between the two genera, clearly visible in transverse sections, is an undivided marginal zone in *Coskinolina* versus a subdivided with one order of beams in *Coleiconus* (Table 1). *Coleiconus* includes two species, *C. zansi* ROBINSON, 1993, and *C. christianaensis* ROBINSON, 1993. The recently established species *C. minimus* BABAZADEH, 2022, is considered a *nomen dubium* by HADI and SCHLAGINTWEIT (2024).

***Lepinoconus* CRUZ-ABAD *et al.*, 2017**

Type species: *Lepinoconus chiochinii* CRUZ-ABAD *et al.*, 2017.

Remarks: The taxon is monospecific with the type species *Lepinoconus chiochinii* CRUZ-ABAD *et al.*, 2017, described from the Campanian of southern Italy. This steeply conical taxon is characterized by an exoskeleton of beams and intercalary beams (one between two beams) aligned between subsequent chambers. The absence of marginal foramina (apertures) in *Lepinoconus* is noteworthy, as other genera within the Coskinolinidae exhibit this feature.

Ebrahimiella

YAZDI-MOGHADAM & SCHLAGINTWEIT, 2021

Type species: *Valdanchella dercourtii* DECROUEZ & MOULLADE, 1974.

Remarks: *Ebrahimiella* is monospecific with the type species being '*Valdanchella dercourtii* DECROUEZ & MOULLADE, 1974, from the upper Albian-Cenomanian of Greece. SCHROEDER (1985, p. 62) noted the presence of a pseudokeriothecal wall-structure in "*V.*" *dercourtii* concluding that '*it is neither a species of Valdanchella CANÉROT and MOULLADE nor a representative of the Orbitolinidae but a form that shows some affinities with Coskinolina STACHE*'. SCHROEDER (1985), however, did not assign the Greek species to either an existing genus or a new genus. YAZDI-MOGHADAM and SCHLAGINTWEIT (2021) introduced the new genus *Ebrahimiella* for the Greek taxon having beams and intercalary beams (alternating between sub-

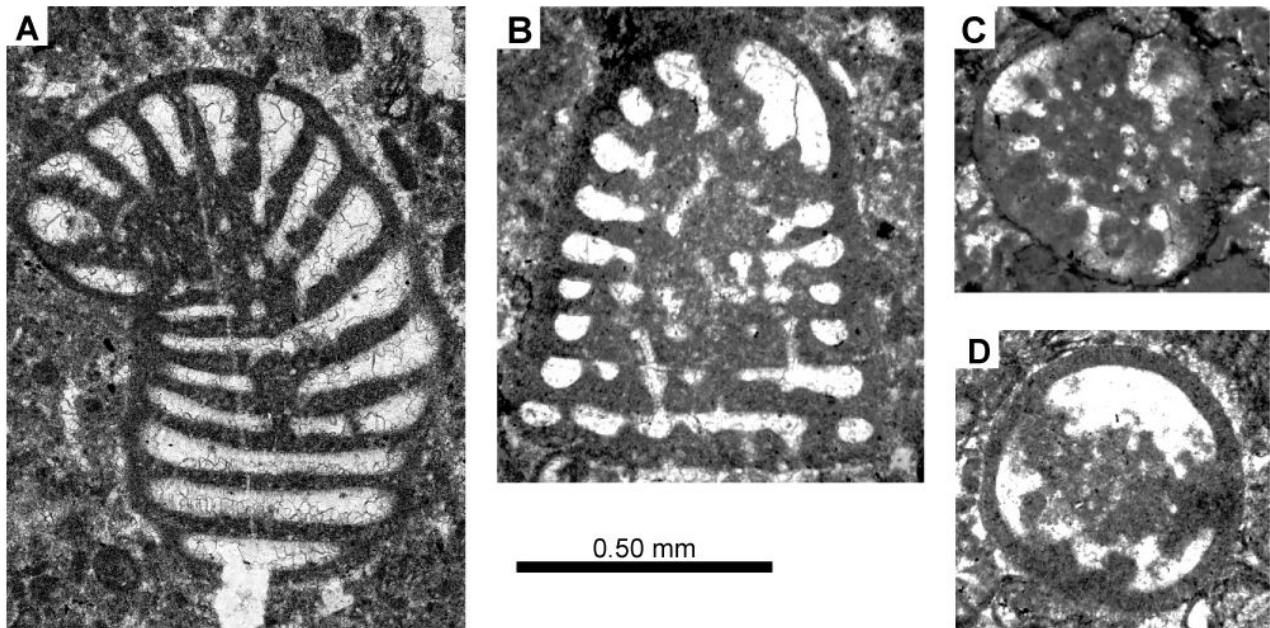


Figure 1: *Cantabriconus reocinianus* SCHLAGINTWEIT *et al.*, 2017, from the upper Aptian-lower Albian of northern Spain. **A)** Tangential section (RAMÍREZ DEL POZO collection, unpublished). **B)** Subaxial section (from SCHLAGINTWEIT *et al.*, 2017, Fig. 6E). **C-D)** Transverse sections (from SCHLAGINTWEIT *et al.*, 2017, Figs. 4G, 6G).

sequent chambers) and a pseudokeriothecal wall structure (SCHROEDER, 1985) rarely visible due to an often relatively thin wall.

3. Discussion

The family Coskinolinidae as summarized herein includes nine genera, among which six or seven clearly display a pseudokeriothecal wall structure (DOUGLASS, 1960; HOTTINGER & DROBNE, 1980; SCHROEDER, 1985; SERRA-KIEL *et al.*, 2016b; SCHLAGINTWEIT & YAZDI-MOGHADAM, 2020; MITCHELL *et al.*, 2020). The definition of the family provided by MOULLADE (1965, p. 4033, translated from the French) includes a 'mono-lamellar wall structure, grossly granular, fibrous-like (? perforated)'. In the monograph of LOEBLICH and TAPPAN (1987, p. 155) the wall of the Coskinolinidae is defined as 'agglutinated, of granular calcite, single layered'. It appears however that a pseudokeriothecal wall is common to all coskinolinids and is herein integrated into the definition of the wall structure as provided by LOEBLICH and TAPPAN (1987). Note that this type of wall structure is not restricted to the Coskinolinidae (*e.g.*, SCHLAGINTWEIT & YAZDI-MOGHADAM, 2022). The Coleiconinae exhibit both a pseudokeriotheca and homogeneous (imperfect) radial partitions thus refuting the statement of SEPTFONTAINE (1981, 2020, p. 138) that the two features are incompatible with each other. The presence/absence of an exoskeleton subdividing the marginal zone of the chambers is taken as a criterion of subfamily status allowing the distinction of forms lacking an exoskeleton, the Coskinolininae (referring to the type genus), and a second group, Coleiconinae subfam. nov., with vertical partitions (*i.e.*, beams, and in the case of *Ebrahimiella* YAZDI-MOGHADAM & SCHLAGINTWEIT, 2020, also with intercalary beams). Note that the different type of exo-

skeletons are used as a subfamilial criterion in the Cyclamminidae MARIE, 1954 (SEPTFONTAINE, 1981, 1988; LOEBLICH & TAPPAN 1987).

4. Conclusions

The new subfamily Coleiconinae incorporates all coskinolinids exhibiting a marginal zone subdivided by vertical partitions (beams, optional with intercalary beams). The new taxonomic concept presented here is in accordance with the hierarchical order of structural features in agglutinated Larger Benthic Foraminifera. Generic features within this subfamily include the arrangement of the main partitions (alternating or aligned), the order of beams and intercalary beams, and the presence or absence of marginal apertures or foramina. The subfamily Coskinolininae is retained for those genera lacking a subdivided marginal zone.

Acknowledgements

The author expresses his sincere gratitude to the reviewers, François LE COZE (Saint-Étienne) and Mike SIMMONS (London), for their insightful remarks, and to Bruno GRANIER (Brest) for his meticulous editing.

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Nomenclatural note:

Life Sciences Identifier (LSID)

<https://zoobank.org/References/D44B31DA-A54E-4EFE-99F0-299AA7095817>

- Coleiconinae SCHLAGINTWEIT, 2024

<https://zoobank.org/NomenclaturalActs/f5f9aee6-2cde-487d-a6d7-7626658c66b9>