MICROFOSSIL ASSEMBLAGES AND DIAGENESIS OF BALAMBO FORMATION FROM AZMER MOUNTAIN IN NORTH-EASTERN SULAIMANIYA, KURDISTAN REGION, IRAQ

Hyam Daoud[1], Ramona Balc[2], Ghafor Hama Sur[3]

ABSTRACT. A detailed Lower Cretaceous section of Balambo Formation, located in the Azmer Mountain, north-east of Sulaimani city (Kurdistan-Iraq) has been investigated. A number of 84 limestone samples have been studied for microfacies analyses and 52 clay and marl samples were investigated for calcareous nannofossils determinations. Most of the rocks consist of two main types of facies: wackestone and packstone with radiolarians. The main diagenetic processes are represented by dissolution, calcitization, dolomitization, stylolitization, silicification and cementation.

The calcareous nannofossils from Balambo Formation were first time studied here. Based on the identified calcareous nannofossil assemblages, the studied rocks were assigned to the Upper Barremian. The calcareous nannofossils assemblage is dominated by *Micrantolithus*, *Nannoconus* and *Rhagodiscus* spp.

Key Words: Calcareous nannofossils, diagenesis, Balambo Formation, Upper Barremian, Azmer Mountain, Kurdistan Region, Iraq.

المتحجرات الدقيقة و العمليات التحويرية لتكوين بالامبو
في جبل أزمر شمال- شرق السليمانية (كردستان, العراق)

هيـام داود,رامونا بالاك و غفور حمه سور

المستخلص:

تمت دراسة مقطع من الكريتاسي الأسفل لتكوين بالامبو في منطقة أزمر، شمال شرق مدينة السليمانية (كردستان، العراق). اجريت هذه الدراسة على 84 نموذج من الحجر الجيري لدراسة السحنات المجهرية و52 نموذج لدراسة الـ nannofossils الكلسي. المقطع يتكون في أغلبه من نوعين رئيسيين من الـسحنات: واكـستون باكـستون الغنيتين بالراديولاريا. ان العمليات التحويرية التي تم تحديدها تتمثل بالذوبان تحت الضغط والدلمتة تحت شروط الدفن التدريجي. ان دراسة الـ nannofossils الكلسي هي الاولى من نوعها اللتي تم تحديدها في تكوين بـالامبو في جبل أزمر. بالاستناد على تجمع الـ nannofossils الكلسي اللتي تم تحديده فان هذه التوضعات تعـود إلـى عصر الباريميان العلوي. ان تجمع الـ nannofossils الكلـسي غالبيتـه مـن الأنـواع *Micrantolithus* , *Nannoconus* و*Rhagodiscus* spp.

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INTRODUCTION

The Balambo Formation was first described by Wetzel (1947) in Bellen *et al*. (1959) from the Sirwan Valley near Halabja, NE Iraq. The age of this formation is Valanginian–Turonian (Buday, 1980). It was divided into two units: Lower Balambo Formation (Valanginian–Albian) and Upper Balambo Formation (Cenomanian–Turonian) (Buday, 1980).

Throughout the type locality, situated in a proximity of Halabja town (southern part of Balambo Mountains, in Sirwan Valley), the lower part of Balambo Formation comprises 280 m (Buday, 1980), and consists of thin layered bluish ammonites-rich limestone with interlayers of marls and clays, with beds of olive green marl and dark blue shale, followed by radiolarian-rich limestone (Bellen *et al*., 1959).

According to Bellen *et al*. (1959), Buday (1980) divided the Hauterivian–Valanginian parts of the formation into three faunizones, from the bottom upwards, these comprise:

- *Crioceras* Zone with: *Crioceras plicatilis, C. raricostatum, Neocomites houdardi, Olcosteohanus* sp*., Bochianites neocomiensis, Kilianella bochianenensis, K. ischnotera, Neocosmoceras* cf. *sayni,*.
- *Hoplites* Zone with: *Crioceras plicatilis, Crioceras* sp*., Neocomites houdardi, Olcostephanus* sp*., Distoceras* sp*., Acanthodiscus* sp*., Thurmannites* sp*., Holcodiscus* sp*., and Hoplites karakash.*
- *Duvalia* Zone with: *Hibolites* sp*., Phylloceras tethys,* and *Radiolaria*.

The Barremian-Aptian part of the formation contains *Radiolaria* and *Pseudohoploceras* sp. in the High Folded Zone (Buday, 1980).

The lower part of the Balambo Formation is deposited in deep bathyal environment (Buday, 1980). According to former author, the lower contact of the formation in the type section seems to be non sequential, without visible unconformity, the basal Valanginian and the Berriasian are missing here, the continuous sedimentation is evident in all areas where the Balambo Formation forms tongues within the Lower Sarmord or Lower Qamchuqa Formations, and the upper boundary of the Lower Balambo Formation is always gradational and conformable.

The upper part of Balambo Formation is homogeneous and consists of thin bedded globigerinal limestone, passing down into radiolarian limestone (Bellen *et al*., 1959). Throughout the type area, it comprises mostly of thin bedded (rarely thick bedded) light colored limestone with a pelagic globigerina–radiolarian–oligostegina assemblages, the Cenomanian part of the formation in the type area is (170–200) m thick and the Turonian part is (315–350) m thick (Bellen et al. 1959 and Buday, 1980). The upper part of Balambo Formation was deposited in an outer shelf to bathyal environment, relatively deep basin situated along the NE boundary of the Arabian Plate (Buday, 1980). Bellen et al. (1959) listed abundant fauna in the upper part of Balambo Formation, of Cenomanian–Turonian age. The lowermost beds of upper part of Balambo Formation comprise grey globigerinal limestone of Albian age, which conformably overlie blue ammonite bearing limestone of the upper part of the Lower Balambo Formation, the upper part of Balambo Formation crop out extensively in the Imbricated Zone of NE Iraq (Jassim and Buday, 2006). Based on planktonic foraminifera identified in the Balambo Formation from the Azmer Mountain, Ghafor (1993) defined three zones: *Hedbergella washitensis* zone (lowermost), *Rotalipora appenninica* zone, and *Marginotruncana* *helvetica* zone (uppermost); he claimed an Albian–Turonian age for the formation. The depocentre extends into SW Iran where it is referred to as the "Massive Limestone Group" (Kent *et al*., 1951). In North Iraq, the Balambo–Tanjero Zone is either overridden by the Northern Thrust Zone or completely missing. In this region the Balambo Formation is replaced by neritic limestones of the Herki, Rikan and Zibar areas (Hall, 1957).

GEOLOGICAL SETTING

The studied area is located in the Zagros Fold-thrust Belt from Kurdistan Region, Northeastern Iraq. According to Buday and Jassim (1987), the studied section is located within the High Folded Zones while Jassim and Goff (2006) included it in the Balambo-Tanjero Zone. It is situated about 8km to the northeast of Sulaimaniya City, near Qula Rash village on the northeastern side of the Azmer Mountain (Fig.1). The mountain consists of asymmetrical large anticline which includes many smaller folds forming anticlinorium.

Field observation showed that the southwestern limb of the anticline is steeper which in some places form recumbent folds. The core of the anticline is exposed in the deep valleys such as Qaywan and Khamza valleys and the core consists of Balambo Formation which is sampled and studied in this paper. This formation consists of centimetric to 0.7 m thick layers of limestones which are rich in radiolaria and some planktonic foraminifera. Some of the limestone layers are silicified and contain siliceous nodules. Between the limestones layers, occur greenish marls and bluish-grayish calcareous shale (Figs. 2 and 3). The section is almost 150 m thick, including the areas covered by soil (Figs. 4 and 5). The beds are highly deformed and generally dipping about 74° toward Northeast with strike of about N55W. The upper part of the limbs are covered by Kometan Formation (Turonian–Lower Campanian which according to Bellen et al (1959) and Buday (1980) it consist of white well bedded and fine grain pelagic limestone with planktonic foraminifera. On the lower limb, the Shiranish and Tanjero formations are exposed. These formations are composed of marly limestone (hemipelagite) and clastic sediments (sandstone and calcareous shale) respectively as indicated on the geological map of Iraq by Sissakian, 2000).

MATERIAL AND METHODS

Fieldwork including direct outcrop observation and sampling of each individual layer were performed. The profile drawn in the field was subsequently modified according to the microscopic information, thus the final profile have been obtained (Fig. 5).

The laboratory preparation consisted in obtaining one or more thin sections of each sample. The microscopic study of thin sections (binocular and polarized microscope) was therefore performed, in order to identify and describe the carbonate microfacies and microfossils. The qualitative microfacies analysis was based on the methodology elaborated by Dunham (1962) and modified by Embry and Klovan (1971).

Samples investigated for calcareous nannofossils were prepared using the standard smear slide technique for light microscope (LM) observation. The investigations were carried out under a light microscope (Axiolab Zeiss) at a magnification of 1000x using parallel and crossed nicols. For biostratigraphic purposes the standard nannoplankton CC zones by Sissingh (1977) and Perch-Nielsen (1985) were used.

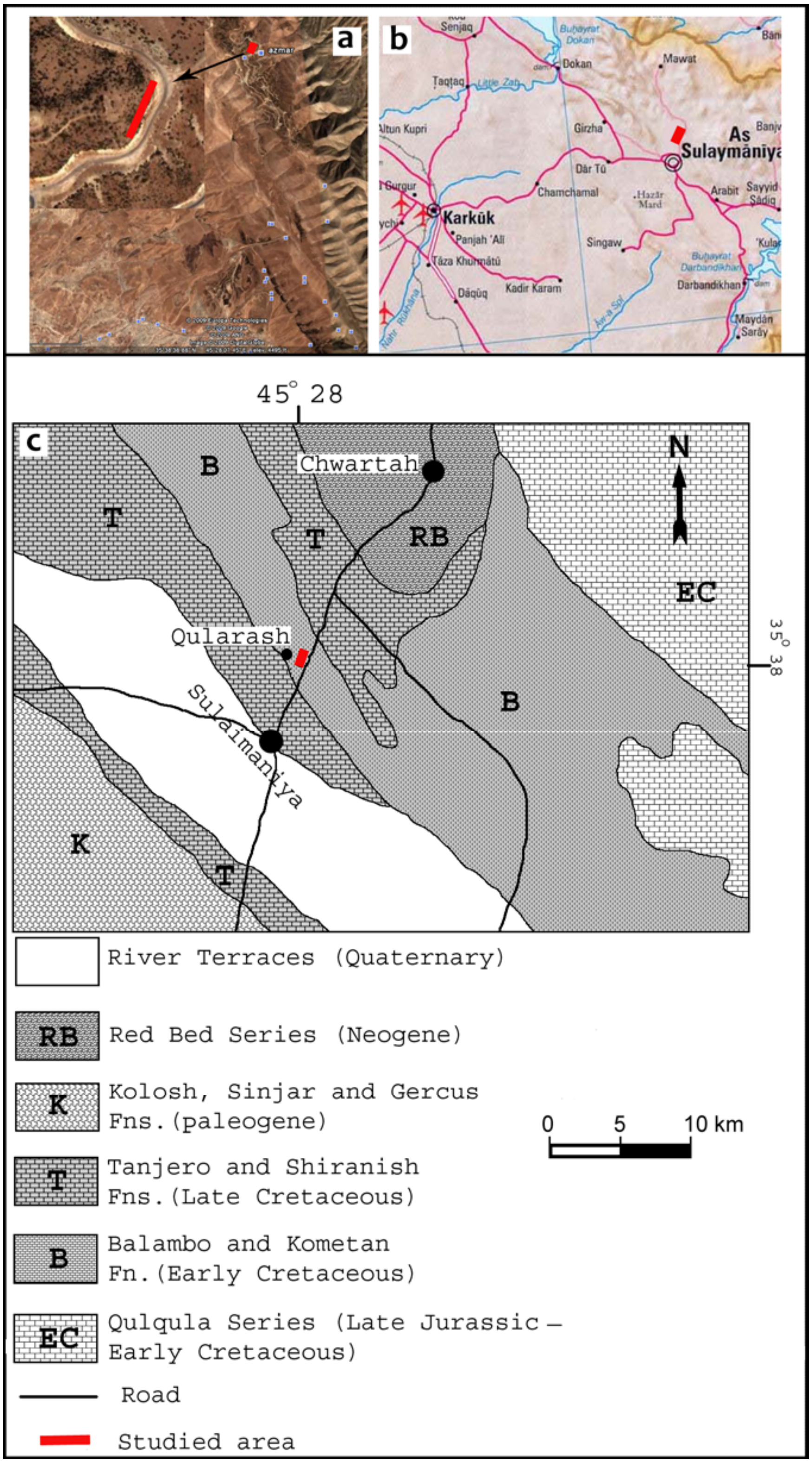

Fig. 1. Location of studied section: a) Google Earth, b) Map of Iraq, c) Geological map of Iraq (from Sissakian, 2000)

Fig. 2. Limestone beds with interlayers of marls and calcareous shale in the studied section

Fig. 3. Silicified limestone beds in the upper part of the section

Fig. 4. The studied section of Balambo Formation in Azmer Mountain

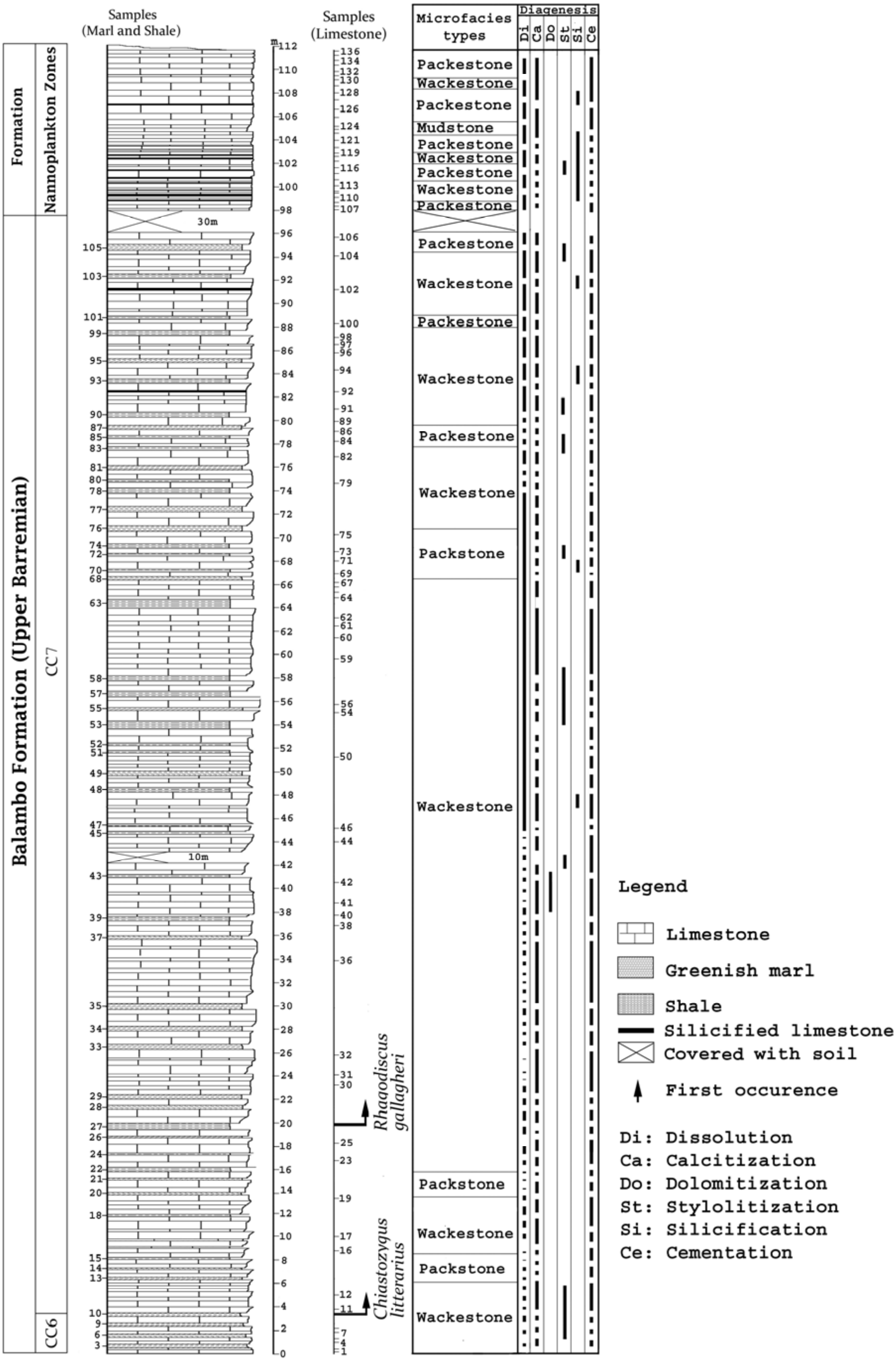

Fig. 5. Lithological column of the Balambo Formation in the studied area

RESULTS

• MICROFACIES

Two main facies types have been identified in the studied section:

A. **Pelagic radiolarian wackestone** with (10–25) % radiolarians (*Spumellaria* and *Nassellaria*) (Fig. 6.1, 6.2, 6.3 and 6.4). The components are composed mostly of radiolaria, spicules and calcified spines of radiolarian, besides planktonic foraminifera. The radiolarian tests were almost fully replaced by calcite, and in some cases they were only partly preserved (Fig. 6.2 and 6.3). The section is consisting mostly of this facies, especially in middle part and it intercalates with pelagic radiolarian packstone towards upper part of the section. Such facies is widespread, in carbonate deposits formed in bathyal environments (Flügel, 2004).

Radiolarians are exclusively marine planktonic unicellular organisms consisting of siliceous (opaline) skeletons with sizes less than 2mm, usually ranging between (100–250) µm. They populate open marine environments; in the present-day oceans, and can be found at depths ranging from 100 m to more than 4000 m (Flügel, 2004). Fossil radiolarians were found in basinal pelagic limestones (Kuhry *et al.*, 1976), but also in shallower sediments. Radiolarians were identified in deposits as old as the Cambrian and are used as long-term biostratigraphical markers, especially in Mesozoic and Cenozoic deposits (Kling, 1978). The Mesozoic and Cenozoic radiolarians are represented by various groups of *Spumellaria* and *Nassellaria*; the radiolarians have diversified at the end of Jurassic..

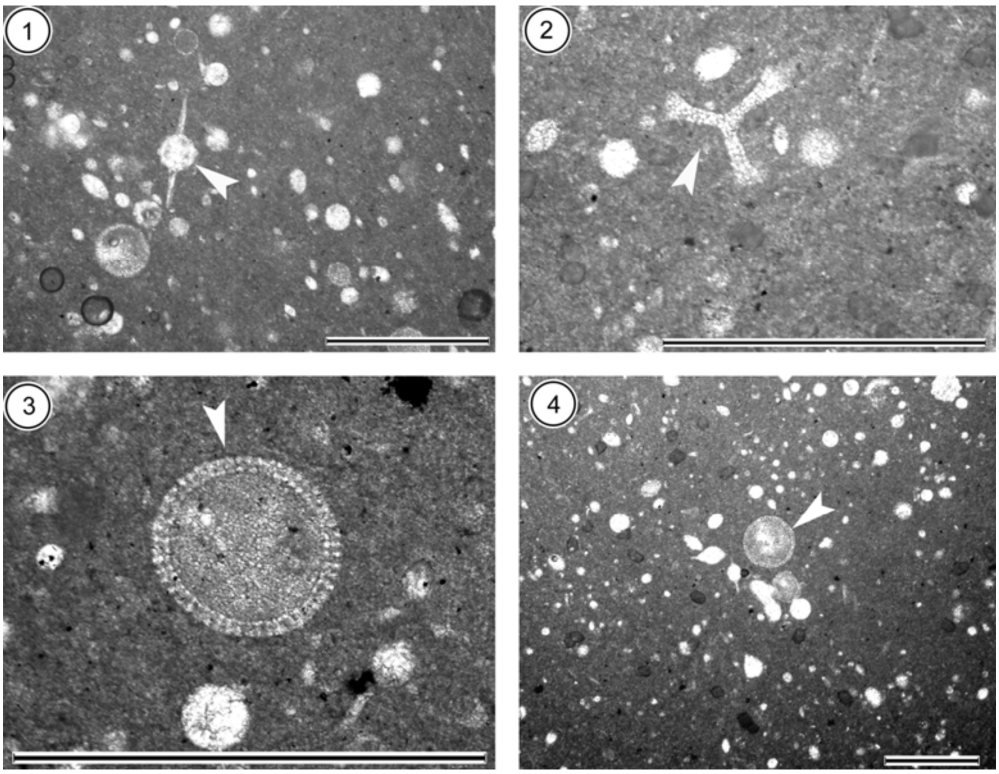

Fig. 6: 1 and 2) Pelagic radiolarian wackestone. Nassellarian radiolarian, indicated by arrow. The radiolarian skeleton is replaced by calcite, but it has still preserved its original morphology. (Samples 11 and 16). 3 and 4) Spumellarian radiolarian, indicated by arrow. The original silica has been replaced by equigranular fine calcite. (Sample 19). Note: The bar scale is 1mm.

B. **Pelagic radiolarian packstone** with large amounts of radiolarians (up to 60 % of the rock volume), consisting of radiolaria, spicules and calcified spines of radiolarian and planktonic foraminifera (Fig. 7.1, 7.2 and 7.3).

In the upper part of the section, a **laminated mudstones** with traces of reddish Fe-oxides were also identified. This facies consists predominantly of micrite and its thickness not exceeds more than 0.6 m (Fig. 8).

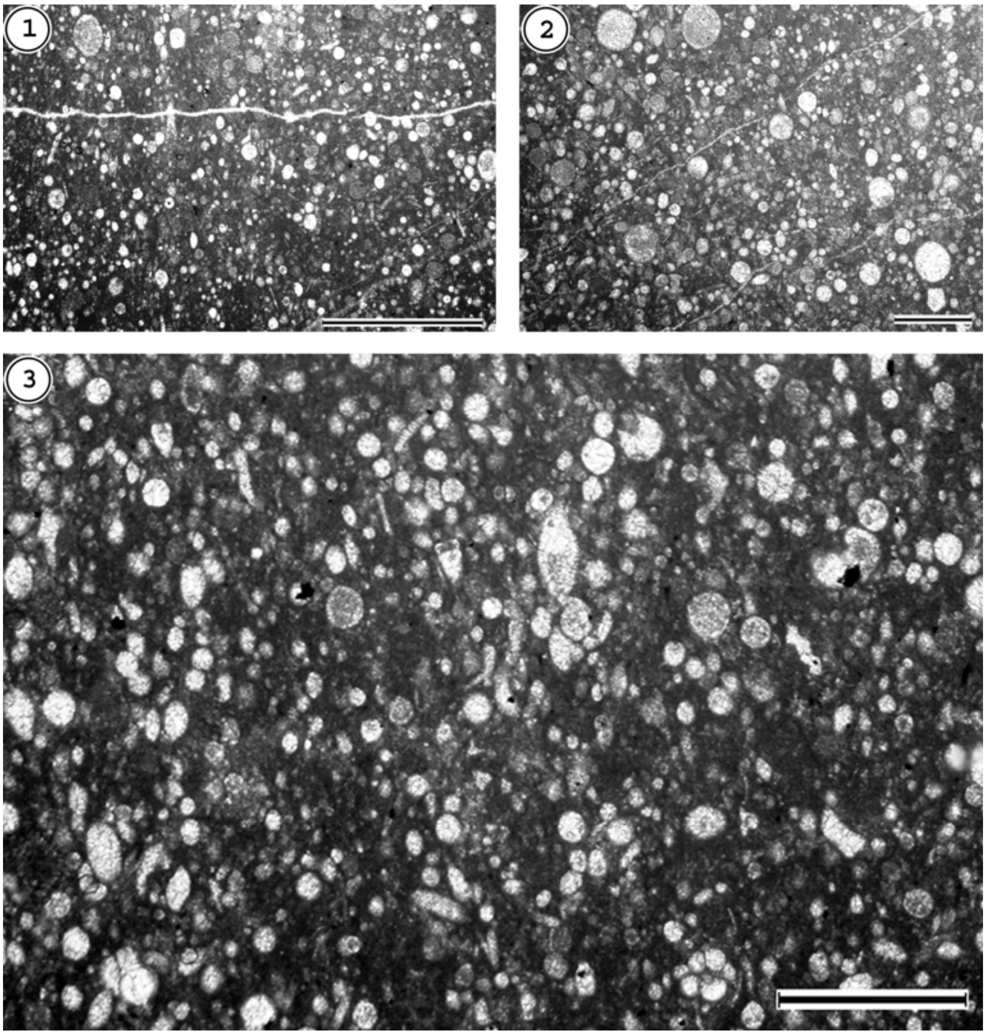

Fig. 7: 1, 2 and 3) Pelagic radiolarian packstone. Calcitized spumellarian radiolarians are recorded by circular sections of different sizes (Samples 69, 73, 75).
Note: The bar scale is 1mm.

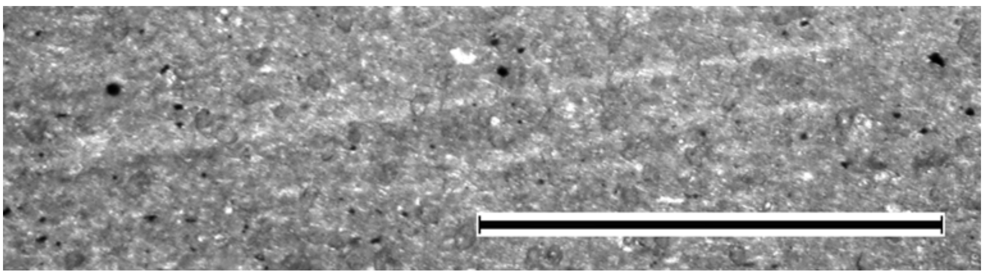

Fig. 8: Fine laminated mudstone with traces of Fe-oxides. (Sample 124)
Note: The bar scale is 1mm.

• DIAGENETIC PROCESSES

a. Dissolution: The dissolution of the radiolarian tests took place in immersed conditions, at or below the sediment/water interface. The process was controlled by the silica saturation of the pore fluids, by the intensity of the bioturbation and by the sedimentation rate (Flűgel, 2004). A high sedimentation rate leads to a good preservation of the radiolarian tests (Flűgel, 2004). The transformations of the radiolarian tests under burial conditions are much faster within limestones, as compared to clays, but the tests' preservation status is poorer in limestones, as compared to siliceous rocks (Kiessling, 1996). In the lower and middle part of the studied section, the tests of radiolarian, are good preserved because they were slightly affected by the dissolution processes (Fig. 6), towards upper part of the section, the dissolution become more influent and leads to poorly preservation of radiolarian tests (Fig. 10).

b. Calcitization: The calcitization of radiolarians is a common process in limestones. It starts during the early diagenetic stage, but continues during the shallow to deep burial stages. The radiolarian tests replaced by calcite may be sometimes misinterpreted as calcispheres; however, the peripheral zone of the radiolarian tests show an irregular, interlocked pattern, while the calcispheres show smooth contours. In some samples of studied section the radiolarian tests are replaced by calcite, but they have still preserved their original morphology (Fig. 6.3), in other samples, especially in upper part of the section the skeleton of radiolarian are completely replaced by calcite and can see only their ghosts (Fig. 10).

c. Dolomitization represented by equigranular, anhedral crystals of dolomite (Fig. 9.1 and 9.2). This process was observed only in one level of thickness of 3 m between 38-41 m of the section. The crystals of dolomite observed in thin sections are represented by equigranular, anhedral crystals, tightly packed anhedral and subhedral crystals, intercrystalline boundaries lobate and straight, some crystal–face junctions preserved, grain size between (0.1–0.3) mm, this fine crystalline mosaic dolomites were formed by replacement of crystalline calcite matrix. Such crystals suggest that dolomitization took place at a relatively low temperature and occurred at a relatively early stage of diagenesis (Sibley and Gregg, 1987). The need for the diagenetic fluids to move freely to dolomitize such limestones, may necessitate relatively early dolomitization when the rock was more porous and sufficiently permeable (Mresah, 1998). However, the dolomitization is a secondary diagenetic process that may take place during any of the diagenetic stage that affected the sediment (Purdy, 1968 and Septfontaine, 1976)

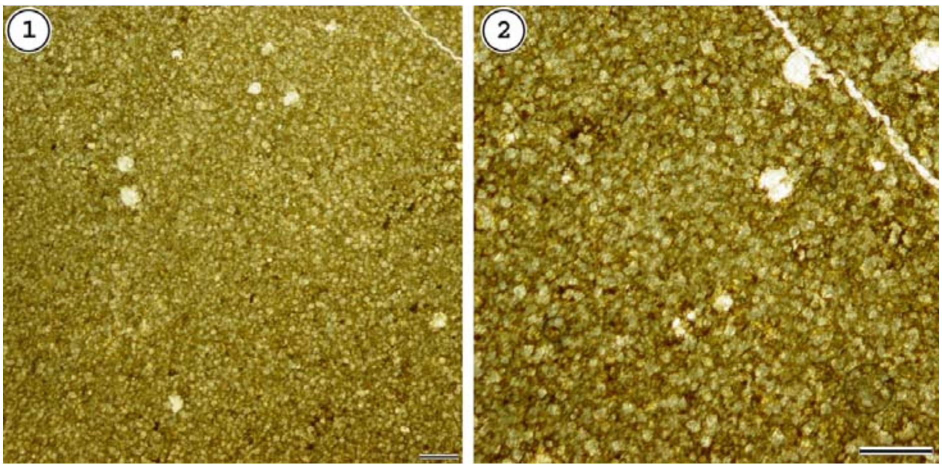

Fig. 9: 1 and 2) Dolomitization processes, observed in thin section (Samples 41 and 42). Note: The bar scale is 1mm.

d. Stylolitization resulted by dissolution under pressure, pointing to progressive burial diagenesis (Simpson, 1990 and Flügel, 2004) that resulted in the lithification and consolidation of the sediments. Most often, the stylolites formed after the first cementation stage and contributed to additional lithification of the sediment due to the $CaCO_3$ released by dissolution under pressure (Bathurst, 1975). The stylolites are composed of same material as the rock of which they are part, and are better developed in limestones and dolomites than in any other kinds of rocks (Mitsui, 1967). According to their morphology (Choquette and James, 1987), two types of stylolites were identified in the studied section; a sutured with small amplitude (Fig. 10.1), and sutured with high amplitude (Fig. 10.2 and 10.3). These types of stylolites usually, form in limestones with low amount of insoluble residual material and are the result of overburden pressure (Bathurst, 1975). Stylolites serve as permeability barriers and they have a considerable effect on later diagenetic processes, such as dolomitization.

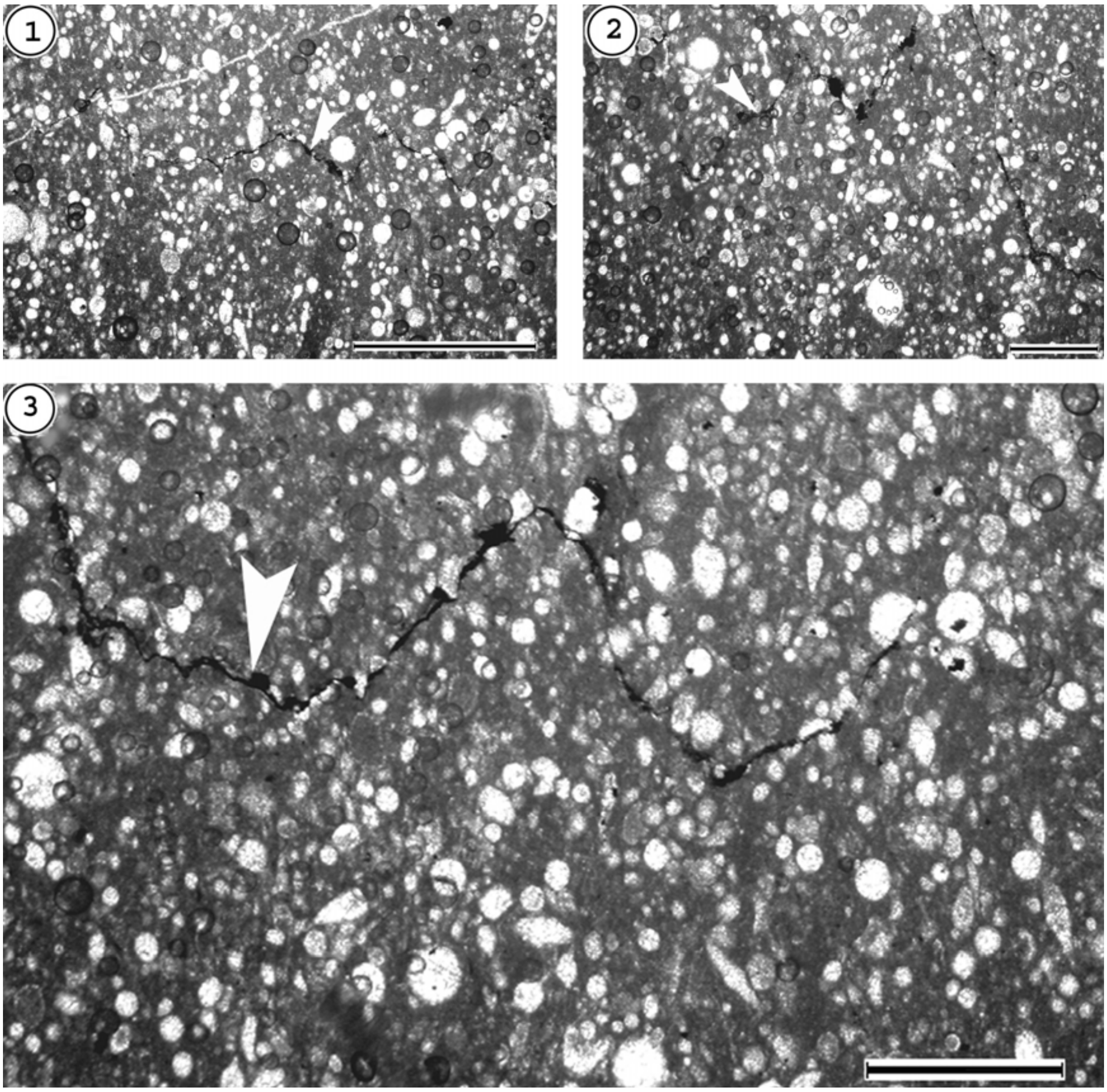

Fig. 10: 1) Sutured stylolite with low amplitude (Sample 84). 2 and 3) Sutured stylolite with high amplitude (Samples 91 and 104). Note: The bar scale is 1mm.

e. Silicification: In the upper part of the section, silicified layers of 5-20 cm thickness and layers of limestone with siliceous nodules of 20-40 cm thickness appear (Fig. 3). The silica responsible for silicification of these layers probably was derived by post-mortem dissolution of siliceous organisms (radiolaria) trapped in the sediment.
f. Cementation: The cementation is a physical-chemical or biochemical diagenetic process leading to the filling of the interstitial spaces due to precipitation from solutions in the empty spaces between the sedimentary particles. The cementation is a post-depositional process that provides the matrix for the pre-existing allochemes.
The cement in the studied section is consisted of calcite and micrite. Two types of calcite cement were identified in thin sections: 1) Drusy cement, consists of anhedral to subhedral crystals. The crystals grow from the pore walls towards their centre. 2) Granular cement, consisting of anhedral to subhedral, almost equigranular crystals of randomly-oriented calcite. Both cements fill some gaps, cracks and fractures and taking place after the sediment burial and lithification and represent the second generation of cement. The micritic cement is most commonly found in wackestone, packstone and mudstone microfacies identified in the whole studied section and connects allochemes cosisting mostly of radiolaria and partially of planktonic foraminifera.

• CALCAREOUS NANNOFOSSILS

Generally, the diversity of the assemblages proved to be high, with a total of 35 identified taxa (Fig. 11). The assemblages are dominated by the genera *Micrantolithus, Nannoconus* and *Rhagodiscus,* other species, such as *Watznaueria barnesae, Diazomatolithus lehmanii, Helenea chiastia*, *Retecapsa surrirella, R. crenulata,* being common. Less abundant but characteristic forms include *Assipetra terebrodentarius* and *Haquis circumradiatus.* According to their general composition, these assemblages were clearly Tethyan for the studied interval.

The group of *Rhagodiscus* spp. is indicative of warm surface-water temperatures (Erba, 1987 and Crux, 1989). Other warm water indicator is *Nannoconus* spp., too (Mutterlose, 1991). Bischoff and Mutterlose (1998) observed a good correlation between those two species, in a NW Europe site.

The microfossil assemblages analysis enabled the identification of the *Micrantholithus hoschulzii* and *Chiastozygus litterarius* Zone, according to the zonation of Sissingh (1977) and Perch-Nilesn (1985).

The lowermost samples in the section (up to sample no. 10) should be assigned to the *Micrantholithus hoschulzii* Zone (CC6) (Sissingh, 1977 and Perch-Nilesen, 1985), defined as the interval between the last occurrence (LO) of *Calcicalathina oblongata* and the first occurrence (FO) of *Chiastozygus litterarius*. The rest of the section belongs to *Chiastozygus litterarius* Zone, defined as the interval between the FO of *Chiastozygus litterarius* to the FO of *Prediscosphaera cretacea.* In the lower part of this zone, *Rhagodiscus gallagherii* was identified (sample no. 27); this species appear sporadically in the rest of the section. This interval is also characterized by the presence of large specimens of *Assipetra terebrodentarius.*

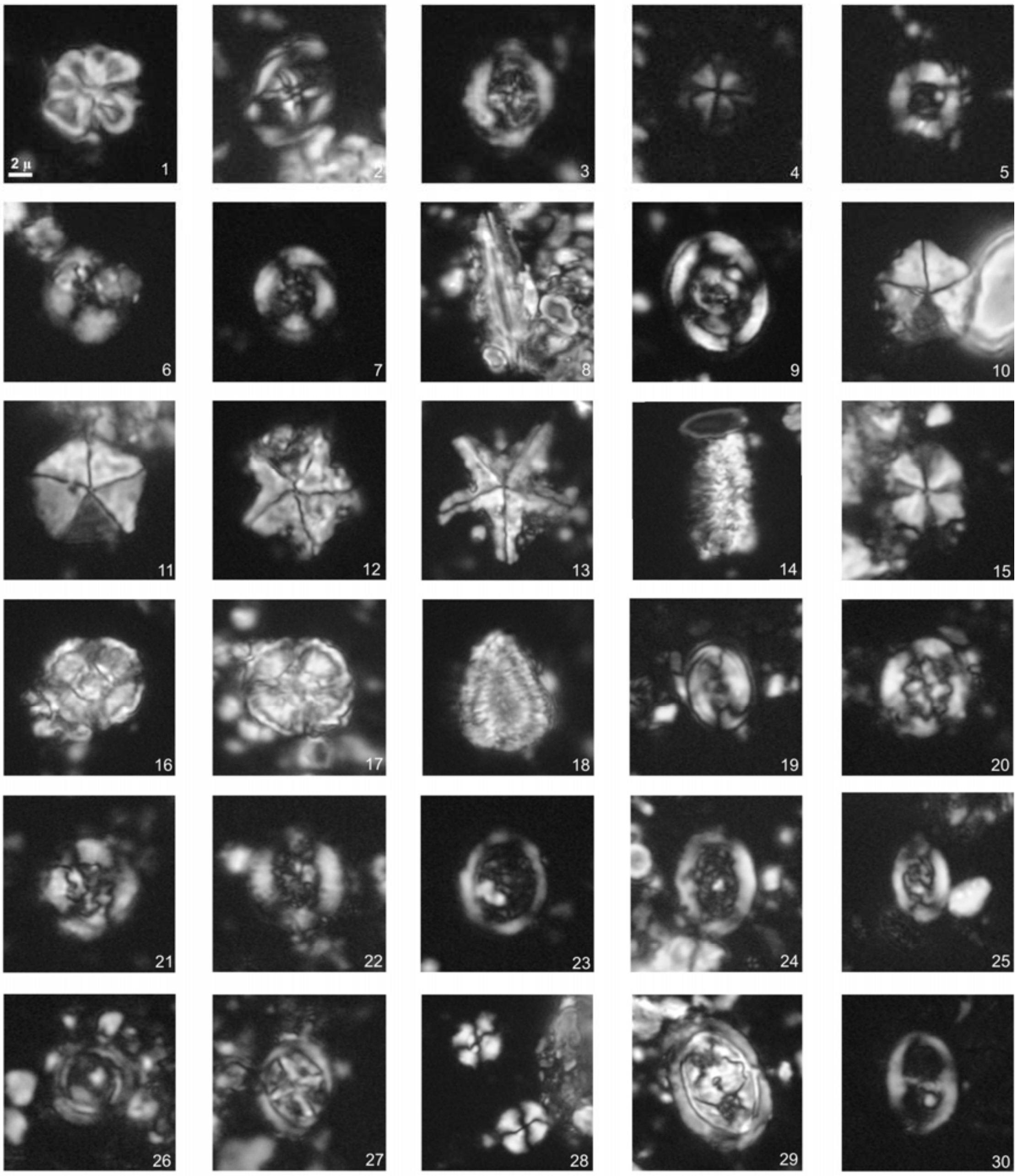

Fig. 11: 1) *Assipetra terebrodentarius* (Sample 43); 2) *Chiastozygus litterarius* (Sample 57); 3) *Cretarhabdus striatus* (Sample 105); 4) *Discorhabdus ignotus* (Sample 57); 5) *Diazomatolithus lehmanii* (Sample 55); 6) *Haquis circumradiatus* (Sample 57); 7) *Helenea chiastia* (Sample 43); 8) *Lithraphidites alatus* (Sample 49); 9) *Manivitella pemmatoidea* (Sample 43); 10 and 11) *Micrantolithus hoschulzii* (Samples 47 and 105); 12) *Micrantolithus obtusus* (Sample 105); 13) *Micrantolithus stellatus* (Sample 105); 14) *Nannoconus elongatus* (Sample 47); 15) *Nannoconus ligius* (Sample 51); 16) *Nannoconus quadricanalis* (Sample 49); 17 and 18) *Nannoconus steinmannii* (Samples 49 and 57); 19) *Percivalia fenestrata* (Sample 58); 20) *Retecapsa angustiforata* (Sample 43); 21) *Retecapsa crenulata* (Sample 48); 22) *Retecapsa surirella* (Sample 48); 23) *Rhagodiscus amplus* (Sample 105); 24) *Rhagodiscus asper* (Sample 57); 25) *Rhagodiscus gallagheri* (Sample 58); 26) *Rotelapillus laffittei* (Sample 43); 27) *Staurolithites siesseri* (Sample 48); 28) *Watznaueria barnesae* (Sample 43); 29) *Zeugrhabdotus embergeri* (Sample 43); 30) *Zeugrhabdotus scutula* (Sample 45).

DISCUSSION

The assemblages are largely composed of cosmopolitan and tethyan species but we can also point out some striking absences: First, there is a total absence of *Hayesites irregularis,* which first occurs shortly before the FO of *Chiastozygus litterarius*. Second, the total absence of the Boreal species. The FO of *Hayesites irregularis* was proposed by Thierstein (1973) as a nannofossil event coinciding with Barremian–Aptian boundary. Other authors (Applegate and Bergen, 1988; Channel and Erba, 1992 and Coccioni *et al*., 1992) documented the FO of *H. irregularis* in the Uppermost Barremian, below the base of CM0, in the upper part of CM1n magnetostratigraphic zone. The absence of this species and the presence of *Chiastozygus litterarius*, in thestudied section ascertain that, the studied sequence is below the Barremian–Aptian boundary.

First occurrence of *Chiastozygus litterarius* has been used by Thierstein (1973 and 1976), Roth (1983) to define the Barremian/Aptian boundary, but other authors pointed out that *Chiastozygus litterarius* was present even during Upper Barremian (Bralower *et al*., 1994).

CONCLUSIONS

• Two main facies types were recognized, pelagic radiolarian wackestone and pelagic radiolarian packstone. They were overprinted by 1) dissolution under pressure, 2) cementation and 3) chemical compaction processes in a burial diagenetic environment that resulted during the sediment lithification and consolidation.
• Six diagenetic processes have been recognized and represented by dissolution, calcitization, dolomitization, stylolitization, silicification, and cementation.
• The nannofossil assemblages recorded from the Balambo section have a marked Tethyan character. The *Micrantolithus hoschulzii* and *Chiastozygus litterarius* Zone have been identified.
• In addition to the biohorizons containing the zonal markers, the FO of *Rhagodiscus gallagherii* have also been identified.
• Due to the outcrop conditions, the upper part of the *Chiaztozygus litterarius* Zone is not represented. This fact is indicated by the absence of *Hayesites irregularis* within the uppermost part of the studied section. It is known from other sections that the FOs of these species is recorded near the Barremian–Aptian boundary, immediately above the FO of *Chiastozygus litterarius.*

Appendix: List of calcareous nannofossil species in Balambo Formation

HETEROCOCCOLITS

I. Muroliths

a. Imbricating muroliths (laxoliths)

Family Chiastozygaceae

1. Central area with axial cross

Staurolithites Caratini (1963)
Staurolithites crux (Deflandre and Fert, 1954) Caratini (1963)
Staurolithites siesseri Bown (2000)

2. Central area with tranverse bar

Zeugrhabdotus clarus Bown (2005)
Zeugrhabdotus embergeri (Noël, 1958) Perch–Nielsen (1984)
Zeugrhabdotus scutula (Bergen, 1994) Rutledge and Bown (1996)

3. Central area with diagonal cross

Chiastozygus litterarius (Górka, 1957) Manivit (1971)
Family Rhagodiscaceae
Percivalia fenestrata (Worsley, 1971) and Wise (1983)
Rhagodiscus Reinhardt (1967)
Rhagodiscus amplus Bown (2005)
Rhagodiscus asper (Stradner, 1963) Reinhardt (1967)
Rhagodiscus gallagherii Rutledge and Bown (1996)
Rhagodiscus robustus Bown (2005)

b. Non-imbricating muroliths (protoliths)
Family Stephanolithaceae
Rotelapillus laffittei (Noël, 1956) Noël (1973)

II. Placoliths

a. Non-imbricating placoliths
Family Biscutaceae
Discorhabdus ignotus (Gorka, 1957) Perch–Nielsen (1968)
Family Cretarhabdulaceae
Cretarhabdus striatus (Stradner, 1963) Black (1973)
Helenea chiastia Worsley (1971)
Helenea quadrata (Worsley, 1971) Bown and Rutledge (1998)
Retecapsa angustiforata Black (1971)
Retecapsa crenulata (Bramlette and Martini, 1964) Grün (1975)
Retecapsa surirella (Deflandre and Fert, 1954) Grün in Grün and Allemann, (1975)
Family Tubodiscaceae
Manivitella pemmatoidea (Deflandre, 1965) Thierstein (1971) emend. Black (1973)

b. Imbricating placoliths
Family Watznaueriaceae

1. Genera with type rim
Cyclogelosphaera margerelii Noël (1965)
Watznaueria barnesae (Black, 1959) Perch-Nielsen (1968)
Watznaueria ovata Bukry (1969)

2. Genera with modified rim
Diazomatolithus lehmanii Noël (1965)

c. Heterococcoliths with uncertain affinities – placoliths
Haqius circumradiatus (Stover, 1966) Roth (1978)

NANNOLITHS
Family Braarudospheraceae
Micrantolithus hoschulzii (Reinhardt, 1966) Thierstein (1971)
Micrantolithus obtusus Stradner (1963)
Micrantolithus stellatus Aguado (1997)
Family Microrhabdulaceae
Litrhaphidites alatus Thierstein (1972)
Family Nannoconaceae
Nannoconus Kamptner (1931)
Nannoconus elongatus Brönnimann (1955)
Nannoconus circularis Deres and Achéritéguy (1980)
Nannoconus ligius Applegate and Bergen (1988)
Nannoconus quadricanalis Bown and Concheyro (2004)
Nannoconus steinmannii Brönnimann (1955)

Family Policiclolithaceae

Assipetra terebrodentarius (Applegate *et al*. in Covington and Wise, 1987) Rutledge and Bergen in Bergen (1994)

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