

Selected agglutinated larger foraminifera from the Font de les Bagasses unit (Lower Campanian, southern Pyrenees)

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Abstract: The Font de les Bagasses marls and marly limestones (Montsec Mountains, NE Spain) host a rich assemblage of larger foraminifera, that was described for the first time in the early 20th Century from the currently submerged locality of Tragó de Noguera (Marginal Mountains). In this paper, a detailed architectural study has been carried out on selected, agglutinated larger foraminifera, which include *Choffatella* aff. *rugoretis* GENDROT, *Hemicyclammina chalmasi* (SCHLUMBERGER), *Cuneolina conica* ORBIGNY, *Cuneolina cylindrica* HENSON, and *Dictyopsella kiliani* MUNIER-CHALMAS. Moreover, it presents their biostratigraphic range and the range of the associated porcellaneous and lamellar-perforate foraminifera in the study area. The assemblage is Early Campanian in age.

Key Words: Larger foraminifera; systematics; biostratigraphy; Upper Cretaceous; Pyrenees; NE Spain.

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Résumé : *Quelques grands foraminifères agglutinés de l'unité de la Font de les Bagasses (Campanien inférieur, Sud Pyrénées).* - Les marnes et marno-calcaires de la Font de les Bagasses (Serra del Montsec, Nord-Est de l'Espagne) présentent une riche association de grands foraminifères décrite pour la première fois au début du 20^e siècle dans la localité, aujourd'hui submergée, de Tragó de Noguera (Serres Marginales). Nous présentons ici une étude détaillée de l'architecture des grands foraminifères agglutinés : *Choffatella* aff. *rugoretis* GENDROT, *Hemicyclammina chalmasi* (SCHLUMBERGER), *Cuneolina conica* ORBIGNY, *Cuneolina cylindrica* HENSON et *Dictyopsella kiliani* MUNIER-CHALMAS. Ce travail est complété par les répartitions stratigraphiques de ces espèces et par celles d'autres grands foraminifères, porcelanés et lamellaires-perforés, qui leur sont associés dans le secteur étudié. L'association est attribuée au Campanien inférieur.

Mots-clefs : Grands foraminifères ; systématique ; biostratigraphie ; Crétacé supérieur ; Pyrénées ; NE Espagne.

1. Introduction

The larger foraminifera of the southern Pyrenees and particularly those attributed to the Late Cretaceous have been studied since the end of the 19th Century. The pioneer was the Spanish engineer Luis Mariano VIDAL who, during the works for the first geological map of Lleida province (NE of Spain), collected abundant material containing larger foraminifera. This material was sent to the French naturalist M.C. SCHLUMBERGER who, in 1899, described various genera and species (e.g., *Dictyopsella chalmasi*, *Dictyopsella kiliani*, *Vidalina hispanica*, *Nummofallotia cretacea*, and *Lacazina elongata*) from the locality of Tragó de Noguera (Marginal Mountains, Lleida, Fig. 1). After SCHLUMBERGER's work, the so-called "Tragó de Noguera fauna" became a reference

for the study of the "Upper Santonian" larger foraminifera until the 1960s, when the locality was submerged under the water of the Santa Anna reservoir. However, "Tragó de Noguera fauna" is well represented in the Font de les Bagasses Unit in the nearby Montsec Mountains and since that time studies have continued there (HOTTINGER 1966; HINTE, 1966; WANNIER, 1983; BOIX *et al.*, 2009; HOTTINGER & CAUS, 2009; ALBRICH *et al.*, 2014, among others). However, a detailed inventory on the larger foraminifer fauna has not been carried out yet. Some groups such as lacazinids (HOTTINGER *et al.*, 1989), meandropsinids (HOTTINGER & CAUS, 2009) or orbitoidids (ALBRICH *et al.*, 2014) have received the attention of researchers, while others lack detailed studies and an accurate biostratigraphic distribution.

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Figure 1: Location of the study area (about 75 km N of Lleida, Catalonia). Note the position of the Santa Anna reservoir with the submerged old locality of Tragó de Noguera. The capital letters refer to the stratigraphic sections studied in this paper: A. Font de la Plata section; B. Terradets section; C. Clot d'Olsí section, D. Montrebei section.

Therefore, the aim of this paper is to contribute to the knowledge of foraminifera from the Font de les Bagasses Unit by presenting a detailed architectural analysis of the main agglutinated larger foraminifera and their stratigraphic distribution. A tentative range chart including agglutinated forms, together with the main larger porcellaneous and lamellar-perforate foraminifera, is also given as an useful tool for future geological studies.

2. Geographical and Geological setting

The Montsec Mountains extend continuously E-W for more than 50 kilometers in the Southern Pyrenees, between the Tremp and Àger-Vilanova de Meià basins (Lleida, NE of Spain). The Boix, Noguera Pallaresa and Noguera Ribagorçana rivers, which run N-S, individualize three adjacent geographic units, from East to West: Montsec de Rúbies, Montsec d'Ares, and Montsec d'Estall (Fig. 1).

From a geological point of view, the Montsec Mountains belong to the Montsec Thrust Sheet, a Southern Pyrenean upper thrust sheet detached from its basement over Upper Triassic evaporites. At the South, it shows a simple anticline structure representing the front of the Montsec thrust, while northwards it develops a broad syncline supporting a piggyback basin filled with Palaeogene rocks, the Tremp-Graus Basin (MUÑOZ, 1992; TEIXELL & MUÑOZ, 2000). The Montsec Mountains include a complete Mesozoic sequence, mainly Upper Cretaceous, of about 1500 m in thickness (Fig. 2).

The deposits attributed to the Font de les Bagasses Unit ("Font de les Bagasses marls and clays" in PONS, 1977) uniformly extend E-W

along the southern slope of the mountain, dipping 35°-40° to the North. They rest unconformably on the deposits of the La Cova Unit (uppermost Lower Coniacian to Middle Santonian according to BOIX *et al.*, 2011), passing gradually upwards to the deposits of the Terradets Unit (PONS, 1977; SIMÓ, 1986), with a base dated latest Early to Middle Campanian (VILLALONGA, 2009).

Palaeogeographically, the Upper Cretaceous deposits of the Montsec Mountains were deposited in the southern margin of the Pyrenean Basin that extended approximately E-W and opened to the Atlantic Ocean (Bay of Biscay). The basin was located at about 30°N latitude (DERCOURT *et al.*, 1985; HAY *et al.*, 1999). The climate during the Santonian-Campanian was warm (PUCÉAT *et al.*, 2003) and the global sea-level curve indicates a level 50 m higher than the present day for the Early Campanian (MILLER *et al.*, 2005).

The age "Late Santonian" traditionally attributed to the Font de les Bagasses deposits (HOTTINGER, 1966; HINTE, 1966; PONS, 1977; CAUS & CORNELLA, 1983; CAUS & GÓMEZ-GARRIDO, 1989a, 1989b; CAUS *et al.*, 1999; among others) has been recently contested (ALBRICH *et al.*, 2014). New data published in this last paper, obtained by means of isotope strontium stratigraphy, indicate a younger age for the whole unit. Thus, the age attributed to the larger foraminifera from the Font de les Bagasses Unit is Early Campanian, corresponding to the ammonite zones of *Placenticerus tridorsatum* and *Menabites delawarensis*, and to the planktonic foraminiferal zone of *Globotruncanita elevata* (see the correspondence in the global time scale of GRADSTEIN *et al.*, 2012).

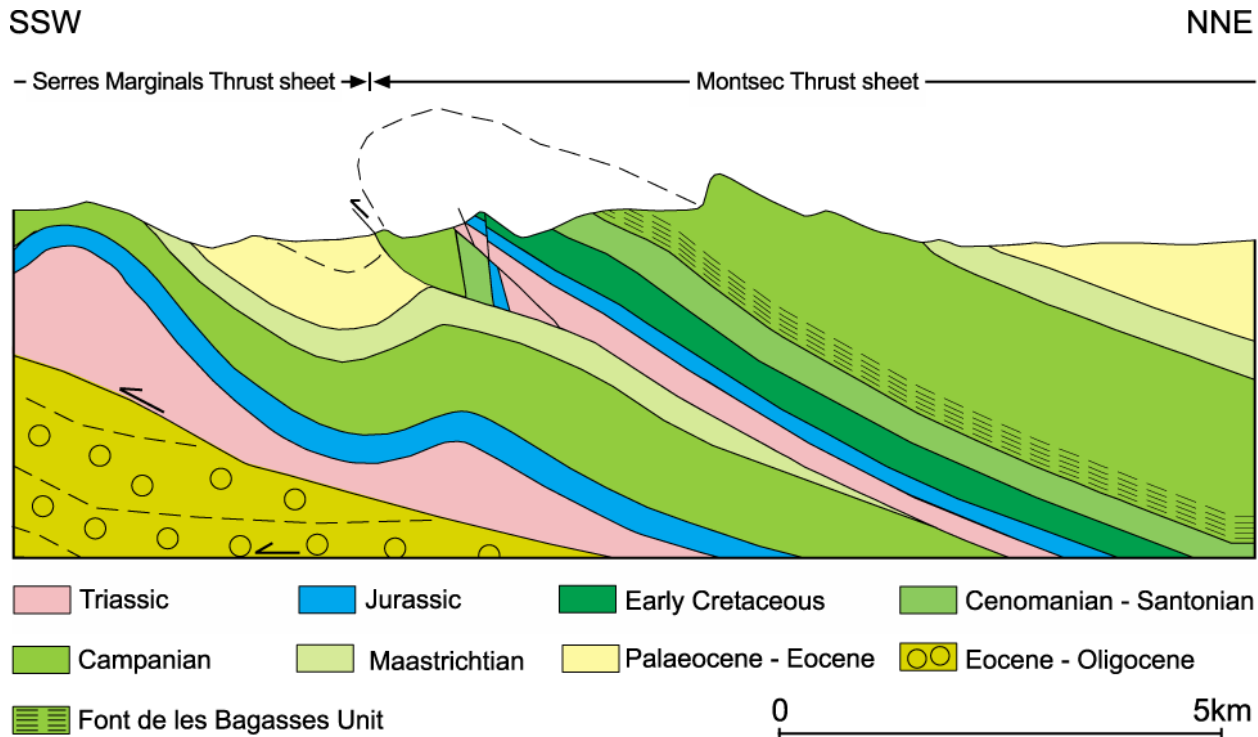


Figure 2: Simplified geological cross-section of the Montsec Thrust Sheet along the Montrebei pass (Noguera Ribagorçana River). Modified from TEIXELL & MUÑOZ (2000).

3. Methodology

The work is based on field observations and 137 samples collected from four stratigraphic sections on the well-exposed slopes of the Montsec de Rúbies and Montsec d'Ares. From East to West, the sections are (Figs. 3 - 4 - 5 - 6):

- A) Font de la Plata section measured in the Font de la Plata gully about 2 km east of the Rúbies abandoned village; coordinates: UTM ETRS89 31T X: 328852.3 and Y: 4654008.6. Samples from this section are labelled SG-7 to SG-43.
- B) Terradets section measured along the Noguera-Pallaresa River in the well-exposed trench of the C-13 road (a field picture of this section is shown in ALBRICH *et al.*, 2014, Fig. 4A); coordinates: UTM ETRS89 31T X: 324903.0 and Y: 4655864.0. Samples from this section are named MARG-122 to MARG-177.
- C) Clot d'Olsí section measured along the Pardina gully near the Ager-Alçamora road; coordinates: UTM ETRS89 31T X: 311246.8 and Y: 4657201.0. Samples from this section are labelled CO-28 to CO-68.
- D) Montrebei section measured along the left margin of the Noguera-Ribagorçana River in the Montrebei pass; coordinates: UTM ETRS89 31T X:

307891.0 and Y: 4660320.0. Samples from this section are named ME-23 to ME-40.

Ten samples are from washed sediments while 127 are from consolidated rocks. The samples from unconsolidated sediments were washed over two sieves with holes of 0.35 and 0.21 mm respectively, and larger foraminifera were picked, photographed and sectioned. The external features of the foraminifera shells were photographed using optical and scanning electron microscopes. Oriented sections were prepared following the classical techniques for studying internal characteristics in agglutinated foraminifera (see HOTTINGER, 1967). Larger foraminifera pictures are at standard magnifications of x25 and x50. More than 350 thin-sections were obtained from hard samples to study the larger foraminifera structures in random sections and the microfacies analysis. All the larger foraminifera presented in this paper were identified at genus and species levels. The genera were defined by the presence or absence of structural elements combined with chamber arrangement, while the species are defined by quantitative morphological characteristics.

All the material studied in this work was deposited in the collection of Paleontology of the Department of Geology (Universitat Autònoma de Barcelona). The figured specimens are labeled as PUAB 82410, 82412, and 84458-84473.

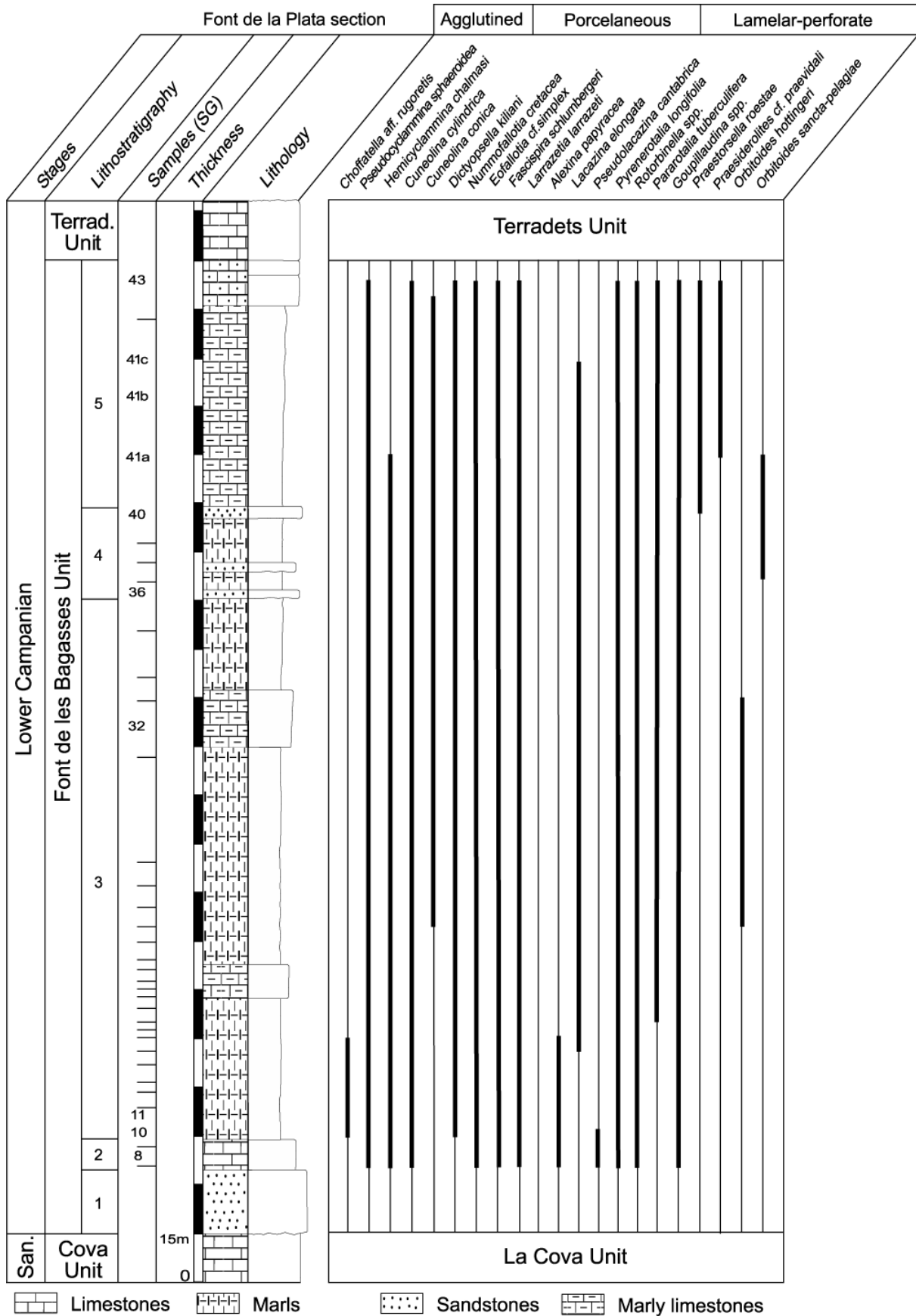


Figure 3: La Font de la Plata stratigraphic section with the larger foraminifera distribution.

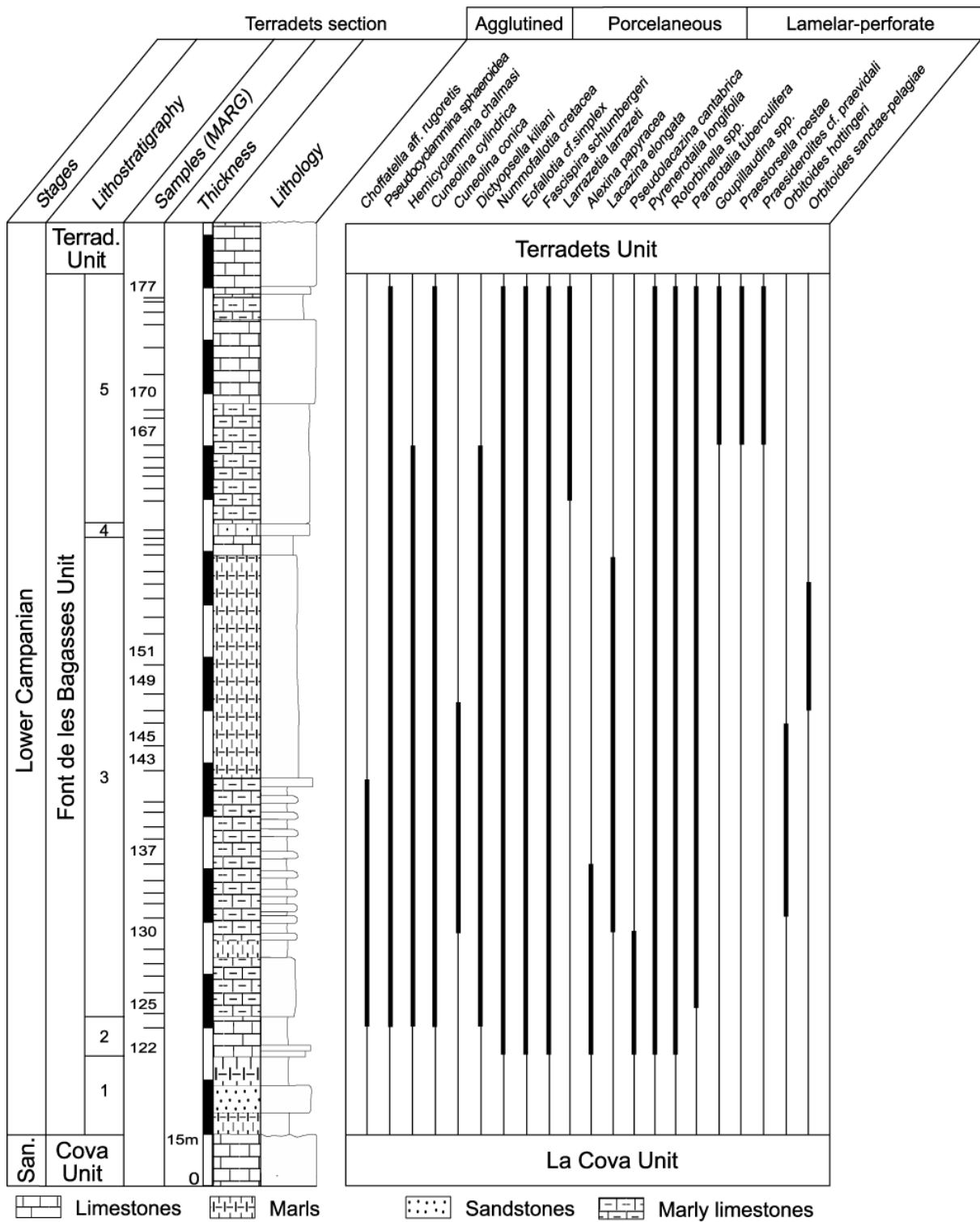


Figure 4: Terradets stratigraphic section with the larger foraminifera distribution.

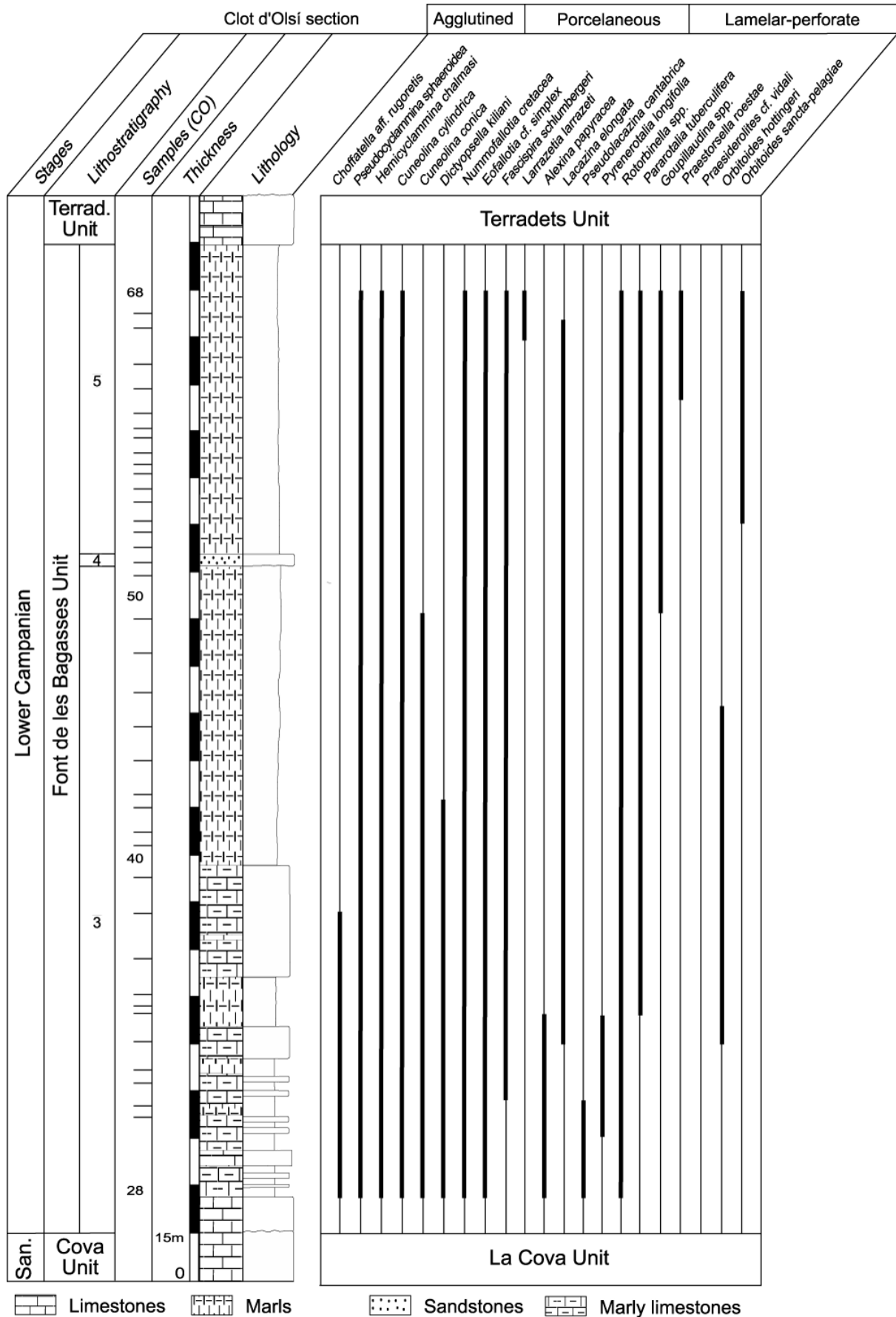


Figure 5: Clot d'Olsí stratigraphic section with the larger foraminifera distribution.

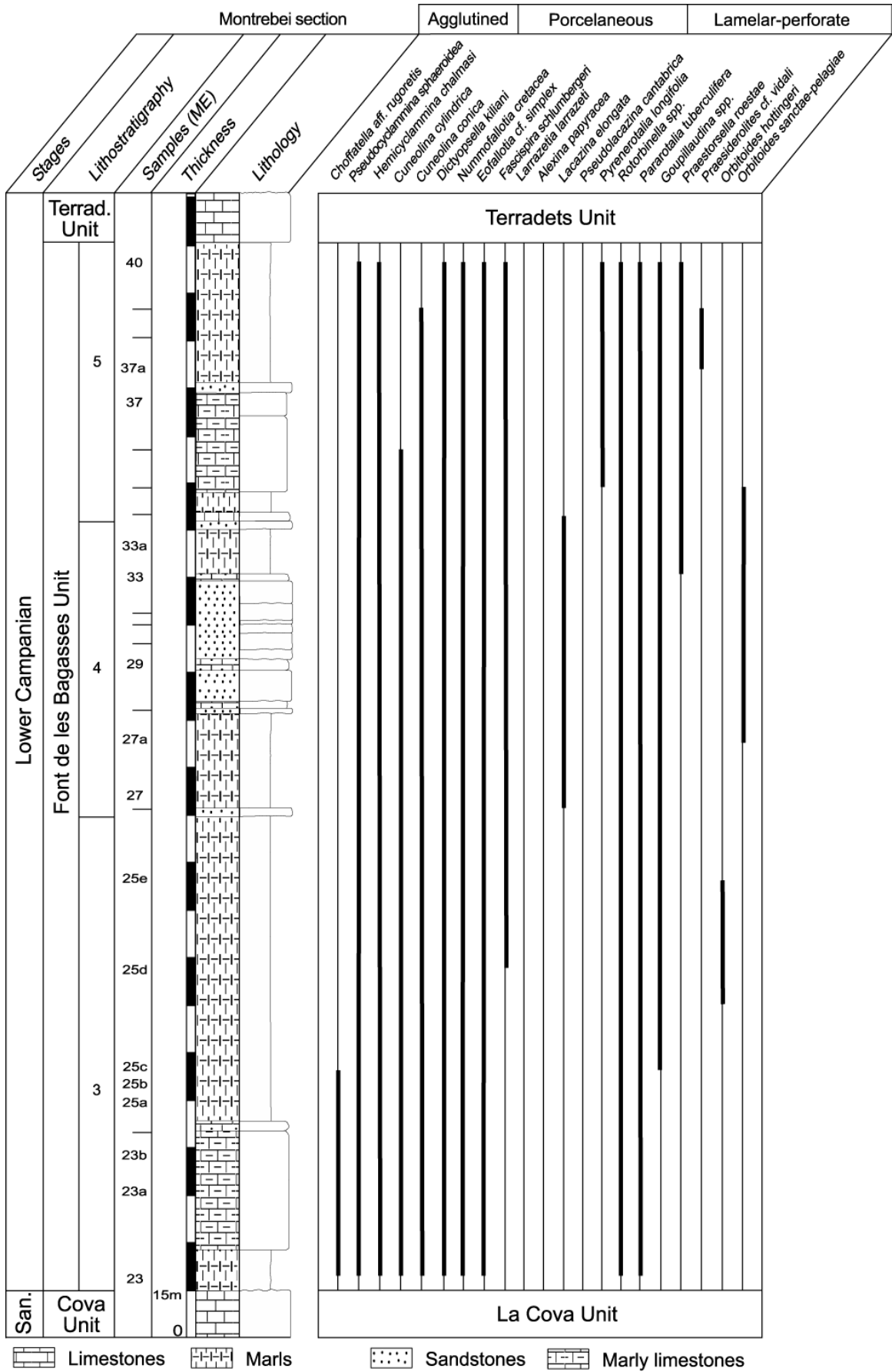


Figure 6: Montrebei stratigraphic section with the larger foraminifera distribution.

4. Stratigraphy and microfacies

Based on field work, palaeontological and sedimentological studies, the Font de les Bagasses Unit is divided into five stratigraphic subunits that are, from bottom to top (Figs. 3 - 4 - 5 - 6):

4. a. Subunit 1

This basal subunit, which overlies La Cova Unit by means of an erosive contact (CAUS *et al.*, 1999), is composed of yellow sands, clays and coarsely grained sandstones with some intercalated microconglomerate beds; it is interpreted to be deposited in a fluvial setting. This subunit is well represented in the Montsec de Rúbies, with a maximum thickness of 20m in the Font de la Plata section, but disappears to the West of the Terradets section (Figs. 3 - 4). In the uppermost part of the subunit, some sandy limestones with fragmented marine bivalves indicate the transition from fluvial to littoral marine deposits (CLAPÉS, 1997). This subunit lacks larger foraminifera.

4.b. Subunit 2

The subunit 2 (called "Boix River platform" in CAUS *et al.*, 1999) overlies the previous subunit in the sections of Font de la Plata and Terradets, disappearing to the West. It is composed of well-bedded nodular limestones with pelletoidal-packstone texture containing a diverse fauna of gastropods, bivalves (including rudists), echinoids, larger foraminifera and some sponge spicules (Fig. 7 A-B). Dasycladacean algae occurring in this subunit are frequently recrystallized. The unit reaches a maximum thickness of 10 m in the Font de la Plata section and disappears west of the Terradets section (Pla d'Escumó area). Among the foraminifera, the porcellaneous *Pseudolacazina cantabrica* HOTTINGER *et al.* and *Alexina papyracea* HOTTINGER & CAUS are the main components of the facies associated with the agglutinated foraminifera (Figs. 3 - 4).

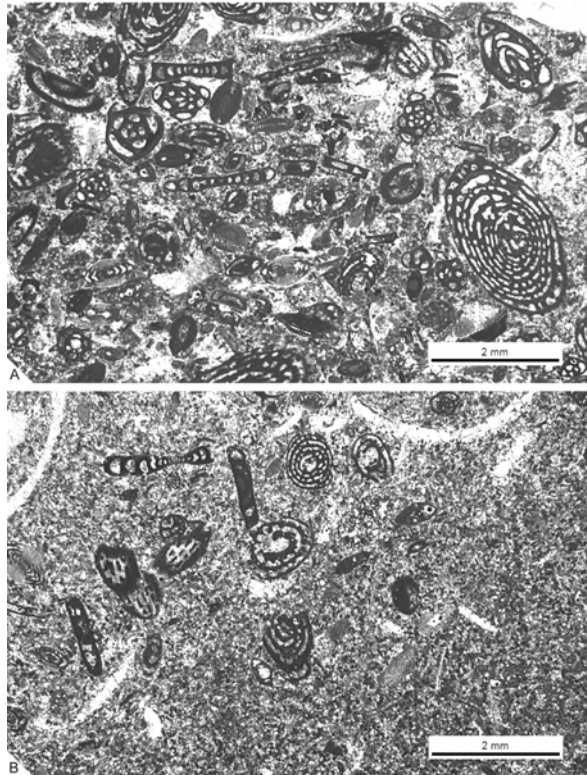


Figure 7: Microfacies of the subunit 2. **A.** Pelletoidal packstone with porcellaneous larger foraminifera as major components; from SG-8. **B.** Pelletoidal packstone-wackestone with agglutinated and porcellaneous foraminifera; from SG-10.

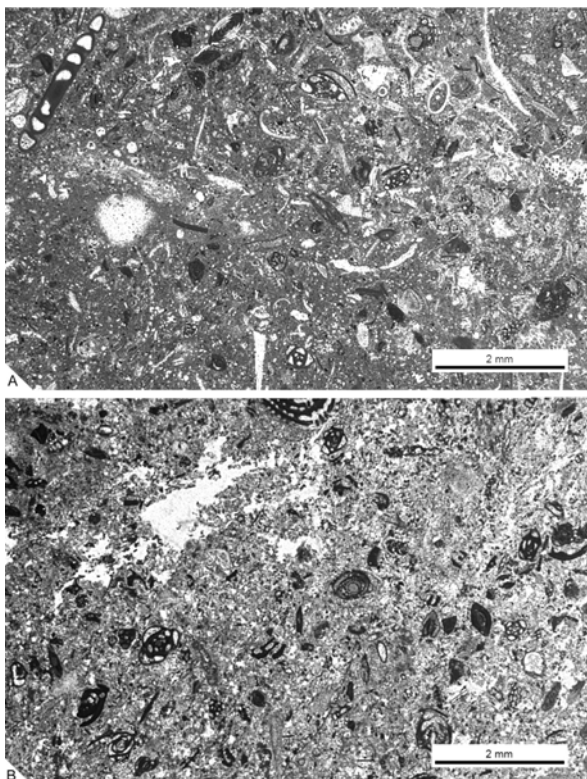


Figure 8: Microfacies of the subunit 3. **A.** Wackestone-packstone with *P. sphaeroidea*, porcellaneous foraminifera, spicule sponges and fragmented dasycladacean algae (close to the scale bar: an oblique transverse section of *Trinocladus tripolitanus* RAINERI); from samples M-125. **B.** Wackestone with agglutinated foraminifera, small benthic and dasycladacean algae; from M-145.

4.c. Subunit 3

In the Font de Plata and Terradets sections, the subunit 3 overlies the subunit 2 and in the Clot d'Olsí and Montrebei sections the subunit 3 overlies directly the deposits of the La Cova Unit (Figs. 3 - 4 - 5 - 6). It is composed of gray and yellow argillaceous marls intercalated with nodular marly limestone with pelletoidal-packstone texture, and more rarely wackestones (Fig. 8 A-B). Fine quartz grains are rare. In the Clot d'Olsí and Montrebei sections the subunit shows intraformational slumps. The thickness varies from 135 to 210m. The faunal content is abundant and diverse: foraminifera, gastropods, bivalves (oysters, rudists and indeterminate bivalves), corals, brachiopods, and echinoid fragments are the main components (NOGUÉS, 2000). Gastropods, rudists and other indeterminate bivalves are frequently recrystallized. Sporadically, green algae are also present in some levels, with fragments of crustose rhodophyte algae occurring in the uppermost part of the subunit. Larger foraminifera are abundant and highly diverse (see their distribution in Figs. 3 - 4 - 5 - 6).

4.d. Subunit 4

The boundary between this subunit and the underlying subunit 3 is marked by the presence of coarse-grained quartz in the Font de les Bagasses deposits. However, the coarse terrigenous deposits are not uniformly distributed in the unit: in the Font de la Plata and Montrebei sections, discontinuous lenticular-shaped calcareous sandstones are interbedded within argillaceous marls and marly limestones in intervals of 50-to-100m (Figs. 3 - 4 - 5 - 6), while in the Terradets and Clot d'Olsí sections the terrigenous intervals do not exceed a few meters (Figs. 4 - 5). The fauna of invertebrates and larger foraminifera appear frequently fragmented (Fig. 9 A-B).

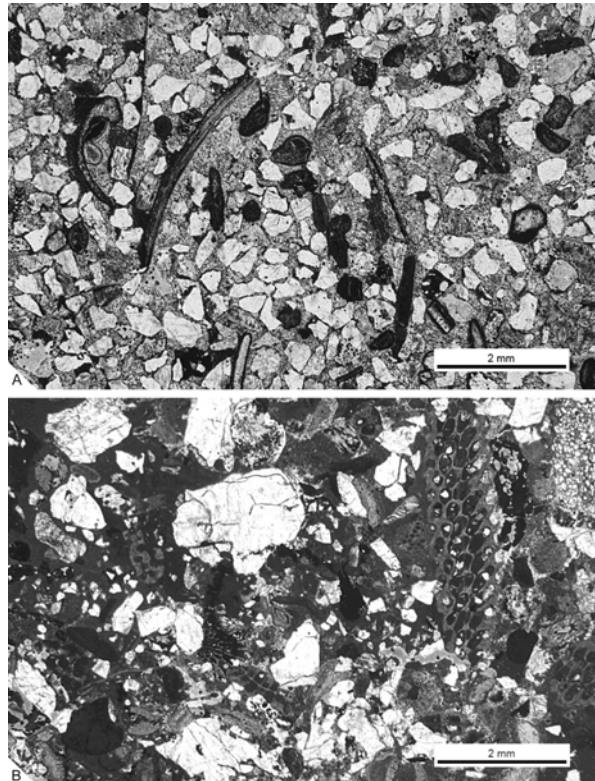


Figure 9: Microfacies of the subunit 4. **A.** Sandstone with isometric irregular quartz grains, elongate bivalve fragments, some rotaliids and agglutinated foraminifera; from SG-40. **B.** Packstone with irregular quartz grains, fragmented bryozoans, echinoids, bivalves, worms and lamellar-perforate foraminifera; from Me-29.

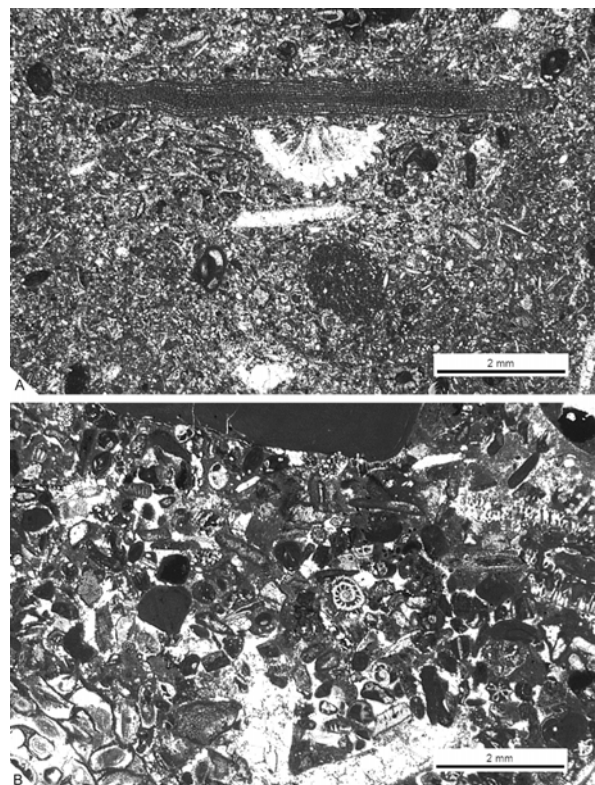


Figure 10: Microfacies of the subunit 5. **A.** pelletoidal wackestone with sponge spicules, fragmented bryozoans and lamellar-perforate foraminifera; from M-170. **B.** Packstone-grainstone with crustose rhodophyte algae, bryozoans and echinoid fragments, and small foraminifera; from M-167.

4.e. Subunit 5

This uppermost subunit is composed of grey or yellow marls and marly limestones alternating with nodular and, more rarely, bioclastic limestones. The microfacies study shows wackestone, packstone and grainstone textures (Fig. 10 A-B). Rarely, coarse-grained idiomorphic quartz grains are present. Bryozoans and sponge spicules are the dominant components of the marly limestones associated mainly with large specimens of *Larrazetia larrazetti* MUNIER-CHALMAS. The nodular limestones contain brachiopods, rudists and other bivalves, and echinoderms; the larger foraminiferal fauna is dominated by *Lacazina elongata* MUNIER-CHALMAS. In contrast, the bioclastic limestones include mainly *Praestorsella roestae* (VISSER), *Praesiderolites praevidali* (NEUMANN), and *Pararotalia tuberculifera* (REUSS). The limestones of the Terradets Unit conformably overlie this subunit.

5. Systematic micropaleontology

In the taxonomic classification of larger foraminifera, it is commonly accepted that genera are identified by the presence or absence of shell structures like exoskeleton, endoskeleton and supplemental skeleton combined with the chamber arrangement. Species are related mainly to the adult size and the size of chamber elements (HOTTINGER, 1978; CAUS, 1981), although a great number of oriented and random sections have been required for correctly interpreting the shell structures and comparing the biometric data of the shells at homologous growth stages. The ascription of genera to taxonomically higher-levels is controversial due to the lack of a comprehensive systematic classification based on phylogenetic characteristics. As a result, the successive classifications of LOEBLICH & TAPPAN (1964; 1988; 1992; 1994) have been mainly used in foraminiferal works, frequently without discussion.

In recent years, the integration of molecular data in foraminiferal studies has allowed the highest-levels foraminiferal classification (see for instance, PAWLOWSKI *et al.*, 2013, and the papers cited therein). For categories below the class, multiple classifications are proposed, but only a few of these are clearly presented, as the hierarchy of taxonomic criteria used for such classifications remains obscure and is often inconsistent. For the agglutinated foraminifera, KAMINSKI (2014) updated a new classification partially based on the LOEBLICH and TAPPAN (1988; 1992; 1994) and KAMINSKI (2004) classifications. However, some criteria proposed by KAMINSKI (2014) for grouping larger, complex foraminifera are only partially defined. Thus, in this paper the phylum and class categories proposed by PAWLOWSKI *et al.* (2013) are accepted, but KA-

MINSKI'S (2014) classification is only partially followed, and some remarks or new proposals are added to this classification (see below). Finally, the hierarchy of taxonomic criteria sketched by HOTTINGER (1978, Table 1) has been taken into account in the elaboration of our proposals. In order to facilitate the comparison between the architectural characteristics of the genera of agglutinated foraminifera described in this paper, the architectural and structural terms are those referred to by HOTTINGER (2006).

Phylum Foraminifera (ORBIGNY, 1826)

PAWLOWSKI *et al.*, 2013

Class Globothalamea PAWLOWSKI *et al.*, 2013

Order Loftusiida KAMINSKI & MIKHALEVICH *in* KAMINSKI, 2004

Remarks: Following the authors of the Order Loftusiida, it includes all agglutinated foraminifera with coiled arrangement of chambers in early stage, that later may be uncoiled, and with complex exoskeleton. The simple forms with the same chamber arrangement are grouped in the Order Lituolida LANKESTER, 1885. Therefore, in the future, further studies are needed to explore the relationship between taxa included in both orders.

Suborder Loftusiina KAMINSKI & MIKHALEVICH *in* KAMINSKI, 2004

Remarks: KAMINSKI (2014) refers to the Suborder Loftusiina as "test free or attached, multilocular, coiling or uncoiling; wall agglutinated, microgranular, with imperforate epidermis (outer layer) and an inner alveolar layer; aperture terminal in the initial stage, later multiple, rows of rounded areal openings". Therefore, with reference to the order description, the type and distribution of the apertures are added.

Observations: In KAMINSKI (2014) the term "epidermis" is used in a wider meaning than in its original description (HENSON, 1948), which restricted the term epidermis for walls with polygonal subepidermal network (HOTTINGER, 1967). The inner alveolar layer of KAMINSKI (2014) refers to the "alveolar network" of DOUVILLÉ (1906) comprising the alveolar and subepidermal exoskeleton types of HOTTINGER (1967). The former consists of a tapestry of one or several generations of rounded outline alveoli, with no differentiation between beams and rafters. The latter has differentiated beams and rafters forming a regular polygonal subepidermal network similar to the pigeonholes. The thin epidermis is restricted to this last group of exoskeleton type.

Superfamily Loftusoidea BRADY, 1884

Remarks: Foraminifera with planispiral (or streptospiral) arrangement of chambers that may become uncoiled, peneropliform or cyclical in the adult stage, with exoskeleton structures and one or several apertures.

KAMINSKI (2014) included the following four families in this superfamily: the Jurassic Mesendothyridae with a pseudokeriothecal exoskeleton (see SEPTFONTAINE, 1988, for details); the Late Jurassic to recent Cyclamminidae with an alveolar exoskeleton (*sensu* HOTTINGER, 1967); and the Jurassic-Cretaceous Spirocyclinidae with polygonal subepidermal exoskeleton. The fourth Family Loftusiidae has the same structural characteristics as Spirocyclinidae, but the axis of coiling is elongated. The Family Haurinidae SEPTFONTAINE, 1988, with similar disposition of chambers and exoskeleton structures, has been ascribed to the Suborder Orbitolina by KAMINSKI (2004, 2014) (see the discussion below).

Family Spirocyclinidae (MUNIER-CHALMAS, 1887) MAYNC, 1950

Remarks: The Family Spirocyclinidae was constructed by MUNIER-CHALMAS (1887) to include four agglutinated genera of larger foraminifera (*Spirocyclus*, *Dicyclus*, *Cuneolina* and *Orbitolina*), having in common exoskeleton elements forming a polygonal subepidermal network, but with a different chamber arrangement.

MAYNC (1950) emended the Spirocyclinidae, resulting in the following description: planispiral-to-peneropliform or uncoiled agglutinated shells with one or multiple apertures. Therefore, the biserial genera *Dicyclus* and *Cuneolina* and the uniserial *Orbitolina* were removed from Spirocyclinidae.

All representatives of the Spirocyclinidae have an exoskeleton constituted by beams and rafters forming a polygonal subepidermal network covered by a fine epidermis. According to MAYNC (1950), both taxa, with or without exoskeleton elements, were included in Spirocyclinidae. But LOEBLICH & TAPPAN (1988), not in accordance with MAYNC (1950), restricted the Family Spirocyclinidae to the genera with endoskeleton elements, while most of the genera lacking such elements were placed in the Family Cyclamminidae. The same classification was also followed by KAMINSKI (2014). However, *Cyclamina* (type-genus of the Family Cyclamminidae) possesses alveolar exoskeleton and not a regular polygonal subepidermal network as in Spirocyclinidae. Therefore, the two families should remain separate, and the genera with polygonal subepidermal patterns should be ascribed to the Family Spirocyclinidae instead of the Cyclamminidae. Following HOTTINGER (1978), the presence or absence of endoskeleton elements is considered here of lower category than the exoskeleton ele-

ments and the communication system of apertures.

Subfamily Choffatellinae MAYNC, 1958

Remarks: In this work, the Subfamily Choffatellinae, included by KAMINSKI (2014) in the Family Cyclamminidae, is removed from this last family and transferred back to Spirocyclinidae. Accordingly to MAYNC (1958), it is characterized by planispiral to uncoiled or peneropliform-to-cyclical shells with polygonal subepidermal exoskeleton, multiple aligned apertures, and lacking endoskeletal elements.

Choffatella SCHLUMBERGER, 1905

(Type-species: *C. decipiens* SCHLUMBERGER, 1905)

Description: Agglutinated, lens-compressed shell with multiple openings placed in one row in the median plane of the apertural face. The chambers are planispiral-evolute arranged. *Choffatella* has exoskeleton elements (beams and rafters) forming a well-developed polygonal subepidermal network. It lacks endoskeleton, although LOEBLICH & TAPPAN (1988) talked about an "endoskeleton formed by thick massive septa". The septa are pierced by multiple foramina aligned from one septum to the next.

Age: After LOEBLICH & TAPPAN (1988), the genus *Choffatella* ranges from the Late Jurassic to the Late Cretaceous (Cenomanian). GENDROT (1968) and SEPTFONTAINE (1980) enlarged its stratigraphic range to the Santonian. Our specimens attributed to this genus are collected in deposits attributed to the Lower Campanian (ALBRICH *et al.*, 2014).

Choffatella aff. *rugoretis* GENDROT, 1968 (Fig. 11 A-F)

Synonymies:

aff. 1968 *Choffatella rugoretis* GENDROT, Pl. 4, figs. 6-13.

aff. 1972 *Gendrotella rugoretis* (GENDROT) MAYNC, Figs. 5-6.

1977 *Choffatella rugoretis* (GENDROT) CORNELLA, Fig. 3.
1978 *Choffatella rugoretis* GENDROT, CAUS *et al.*, Fig. 2.

Description: Finely agglutinated, lens-shaped foraminifera with one row of openings aligned in the median plane of the apertural face. The A-generation consists of an embryo formed by a spherical protoconch and a hemispherical deuteroconch followed by planispiral-evolute chambers disposed in two or two and half whorls. The earliest chambers have a quadrangular outline, but they become rapidly low and elongate to build an operculiniform spire. The number of chambers in the last whorl varies from 24 to 27. The septa are arched and pierced by multiple, regularly distributed intercameral foramina. The average size of the adult megaspheric shells is 2.6 mm. The scarce and poorly preserved B-forms can reach 3.0 mm and up to three whorls of planispiral chambers.

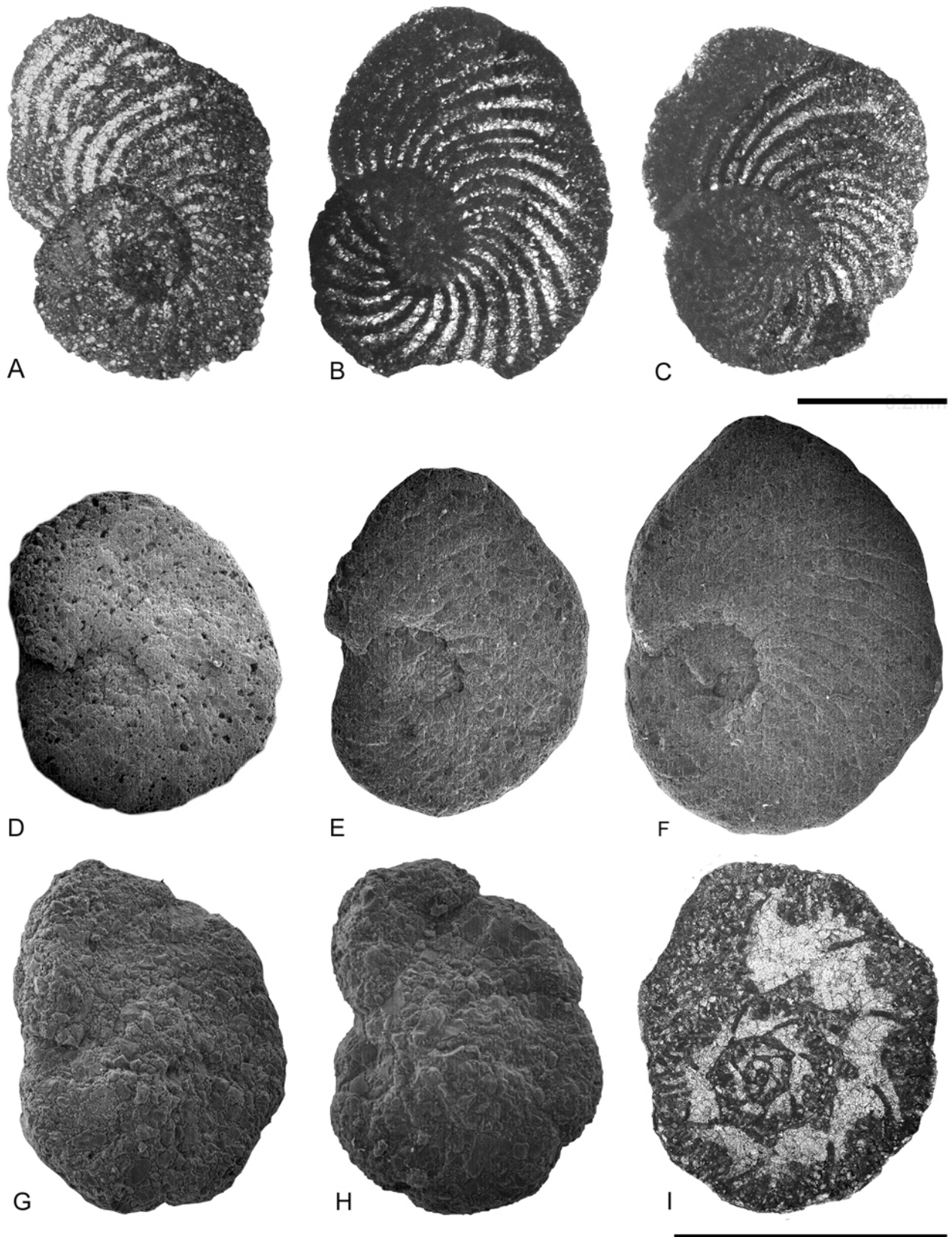


Figure 11: A-C. *Choffatella* aff. *rugoretis*: subequatorial sections (near the equatorial plane) showing the planispiral, partially evolute chamber arrangement and multiple aligned intercameral foramina; from CO-32. D-F. *Choffatella* aff. *rugoretis*: lateral view showing the elongated chambers and sutures (scanning microphotography); the epidermis is poorly preserved. from SG-36. G-I: *Hemicyclammina chalmasi*: G-H; *Hemicyclammina chalmasi*: external views showing the inflate chambers and depressed sutures (scanning microphotography); from SG-36. I. *Hemicyclammina chalmasi*: equatorial section of an extraordinarily well preserved specimen showing the large intercameral foramen and its particular position in the septum (hemi-septum from MAYNC, 1953); from SG-36. Scale bar 1 mm.

Remarks: MAYNC (1972) re-studied the GENDROT's types of *C. rugoretis* and he concludes that the species attributed by GENDROT (1968) to the genus *Choffatella* lacked an exoskeleton. Thus, MAYNC (1972) stated that GENDROT's taxon cannot be assigned to the genus *Choffatella*, a Jurassic-Early Cretaceous genus exhibiting an exoskeleton consisting of beams and rafters organized in a polygonal subepidermal network. Therefore, he erected the new genus *Gendrotella* for it.

However, material from the type locality (Martigues, Bouches-du-Rhône, South-East of France) has yielded specimens morphologically identical to those described by GENDROT (1968) and bearing exoskeleton elements; moreover, the specimens of *C. rugoretis* showed by GENDROT (1968, Pl. 4, figs. 9-10) exhibit short beams and rafters forming a delicate network in the inner surface of the chamber, interpreted here as a subepidermal type of exoskeleton. Thus, the species is re-installed within the genus *Choffatella*, and *Gendrotella* becomes a non-valid genus after the ICNZ.

Similarities and differences: The specimens from the Font de les Bagasses Unit are larger (almost the double size) than the size of Martigues (type-locality of *C. rugoretis*), and designated as *Choffatella* aff. *rugoretis*. Further studies are needed to determine if the size difference is due to evolution (Santonian in the GENDROT's specimens and Early Campanian in the Pyrenean specimens) or related to a deeper water environment in the Font de les Bagasses Unit than in the Martigues deposits.

Stratigraphical distribution: In the Font de les Bagasses, *C. aff. rugoretis* occurs in the four measured sections. It has been identified mainly in the washed sediments, but some random sections also occur in the consolidated rocks. See the distribution in Figs. 3 - 4 - 5 - 6.

Geographical distribution: It has been only mentioned from the Pyrenean basin (North of Spain and South and South-East of France).

Subfamily Hemicyclammininae **BANNER, 1966**

Remarks: Agglutinated foraminifera with polygonal subepidermal exoskeleton. The chambers with planispiral-involute arrangement have only one aperture. It lacks endoskeletal elements.

***Hemicyclammina* MAYNC, 1953**

(Type-species: *Hemicyclammina sigali* MAYNC, 1953)

Description: Agglutinated, lens-shaped foraminifer with rounded-to-subacute periphery. The chambers have a planispiral-involute arrangement. The aperture is unique, large, located near the base of the septum and with circular-to-elliptic outline (hemi-septum after MAYNC,

1953). *Hemicyclammina* has a well-developed polygonal subepidermal network with two orders of beams. It lacks endoskeleton.

Age: After LOEBLICH & TAPPAN (1988), the age of *Hemicyclammina* is Early Cretaceous and Cenomanian for this genus but, with the ascription of "*Dictyopsella*" *chalmasi* to this genus (CAUS *et al.*, 1979), the range extends as far as the Early Campanian.

Hemicyclammina chalmasi **(SCHLUMBERGER, 1899)** **(Fig. 11 G-I)**

Synonymies:

- 1899 *Dictyopsella chalmasi* SCHLUMBERGER, Pl. 8, fig. 4.
- 1977 *Hemicyclammina chalmasi* (SCHLUMBERGER) CORNELLA, Figs. 4-5.
- 1978 *Hemicyclammina chalmasi* (SCHLUMBERGER) CAUS *et al.*, Figs. 1-5.
- cf. 1999 *Hemicyclammina chalmasi* (SCHLUMBERGER) POLAVDER, Pl. 1, figs. 1-6.
- cf. 2004 *Hemicyclammina chalmasi* (SCHLUMBERGER) SCHLAGINTWEIT & WAGREICH Pl.1, figs. 1-9.
- cf. 2010 *Hemicyclammina chalmasi* (SCHLUMBERGER) RADOIČIĆ *et al.*, Pl. 1, figs. 1-5.

Description: Coarsely agglutinated, lens-shaped shells with a more or less rounded periphery. The diameter varies from 1.3 to 1.5 mm. The slightly inflated chambers have a planispiral-involute arrangement, with two-to-three spiral whorls. The sutures are depressed, exhibiting a lobate outline. Two generations have been observed, interpreted as A and B generations (CAUS *et al.*, 1978, Figs. 1-4), although the adult size does not present any differences. The A-generation consists of a spherical embryo followed by two whorls of planispiral chambers, which generally number 8 or 9 in the last whorl, but some specimens can reach 11 chambers. In the B-generation, the small microsphere is followed by three whorls of spiral-involute chambers with 6-8 chambers in the last whorl. The septa are oblique. The exoskeleton is well developed with long beams and less pronounced rafters, but can only be observed in the thin-sections of the isolated specimens (Fig. 13 I). The *Hemicyclammina* sections coming from hard rocks (Fig. 13 A-F) are difficult to identify and are designated in this work as *H. cf. chalmasi*. However, they coincide with the sections shown by POLAVDER (1999), SCHLAGINTWEIT & WAGREICH (2004) and RADOIČIĆ *et al.* (2010).

Similarities and differences: The specimens of the Font de les Bagasses Unit are identical to those described by SCHLUMBERGER (1899) from the Tragó de Noguera under the name of *Dictyopsella chalmasi*, that have been transferred to the genus *Hemicyclammina* by CAUS *et al.*, 1978.

Hemicyclammina chalmasi differs from *H. sigali* MAYNC (species-type of the genus) due to its larger size, the complexity of the skeleton, and the septa perpendicular to the external wall.

Stratigraphical distribution: The age of *H. chalmasi* is Early Campanian. In the Font de les Bagasses Unit, it is observed in all sections, although infrequently. The sections from consolidated rocks are badly preserved.

Geographical distribution: It has been mentioned in the Pyrenees and the central Europe (SCHLAGINWEIT & WAGREICH, 2004) and Balkans (POLAVDER, 1999; RADOIČIĆ *et al.*, 2010).

Subfamily Amijiellinae
SEPTFONTAINE, 1988

Remarks: After SEPTFONTAINE (1988), the Subfamily Amijiellinae consists of planispiral to uncoiled shells with polygonal subepidermal exoskeleton, multiple cribrate apertures, and lacking endoskeletal elements. SEPTFONTAINE (1988) and also KAMINSKI (2014) included the Subfamily Amijiellinae in the Family Haurinidae (SEPTFONTAINE, 1988), which is characterized by planispiral to peneropliform shells with a polygonal subepidermal (hypodermal in SEPTFONTAINE, 1980) network. However, such characteristics are shared with the Family Spirocyclinidae (see above), which has priority. However, further studies are needed to clarify the relationship between the two families: Haurinidae used mainly for the Jurassic taxa (see the excellent work of SEPTFONTAINE, 1980, 1988), and Spirocyclinidae for the Cretaceous taxa.

In addition, KAMINSKI (2014) placed the Subfamily Amijiellinae (and the Family Haurinidae) in the Suborder Orbitolinina KAMINSKI, 2004, that was defined as "trochospiral to conical, later stage may have reduced number of chambers per whorl, or may become uniserial and rectilinear". However, neither the Subfamily Amijiellinae nor the Family Haurinidae possesses such characteristics and, in the current state of knowledge, they should be removed from Orbitolinina and included in Loftusiina. They are presented in this paper this way.

Pseudocyclammina
YABE & HANZAWA, 1926

(Type-species: *Cyclammina lituus* YOKOHAMA, 1890)

Description: Agglutinated shell with subcylindrical-to-subspherical morphology with multiple cribrate apertures piercing the apertural face. The arrangement is planispiral-involute, but may become uncoiled in the late stage of growth. *Pseudocyclammina* presents exoskeleton composed of beams and rafters resulting in a polygonal subepidermal network. It lacks endoskeleton.

Age: After LOEBLICH & TAPPAN (1988), the age of *Pseudocyclammina* ranges from the Early Jurassic to Coniacian, but the presence of *P. sphaeroidea* in the Santonian (GENDROT, 1968) and in the Early Campanian (this paper) indicates a younger age for this genus.

Remarks: Although the "plexus" *Pseudocyclammina* (SEPTFONTAINE, 1980; 1988) is mentioned as having a long stratigraphic extension, the idea of a polyphyletic group is recurring in the literature (see SEPTFONTAINE, 1980, and the papers cited therein). BANNER (1970) placed the genus *Pseudocyclammina* together with *Choffatella* in the Choffatellinae; however, both genera differ in the foraminal pattern: aligned in *Choffatella* and cribrate in *Pseudocyclammina*.

Pseudocyclammina sphaeroidea
GENDROT, 1968
(Fig. 12 A-L)

Synonymies:

1968 *Pseudocyclammina sphaeroidea*, GENDROT, Figs. 1-5.

2013 *Pseudocyclammina sphaeroidea*, CAUS *et al.*, Fig. 7g.

Description: Small and globular *Pseudocyclammina* (the observed diameter varies from 0.6 mm to 1.1 mm). Dimorphism is not observed in our material from the Font de les Bagasses: all the specimens have similar size at the same growth stage. Where visible, a small and spherical protoconch is followed by a small hemispherical deuteroconch. The post-embryonic chambers exhibit a planispiral-involute arrangement, resulting in two and half to three whorls of spire, rarely three and half whorls. Specimens showing uncoiled stage are not frequent in our material. The earliest chambers are quadrangular in shape, but in the latest stage the chambers become low and elongated with peneropliform morphology. The number of chambers in the last whorl varies from 10-12 in the small forms to 13-14 in the largest ones. The external wall (epidermis) of our specimens is diagenetically altered. Moreover, the specimens incorporate angular, coarse quartz grains in the external wall and in the septa, frequently masking the exoskeleton structures. Where they are visible; these structures show short beams and rafters forming a poorly developed subepidermal network. The chamber lumen is free of endoskeletal elements. The septa are massive and pierced by small, cribrate intercameral foramina.

Similarities and differences: The Pyrenean specimens are similar to those described by GENDROT (1968) from the Martigues deposits. However, the French specimens do not present grains of quartz in their shells, suggesting that the presence of this type of agglutination in our specimens has an environmental significance.

Specimens attributed to *P. aff. sphaeroidea* also occur in the Coniacian deposits of the Pyrenees (CAUS *et al.*, 2013). The specimens designed as *P. sphaeroidea* in the Turonian of the Tethyan deposits are smaller than the Pyrenean ones (see for instance, FRIJIA & PARENTE, 2008; CHIOCCHINI *et al.*, 2012; FRIJIA *et al.*, 2007; ARRIAGA *et al.*, in press).

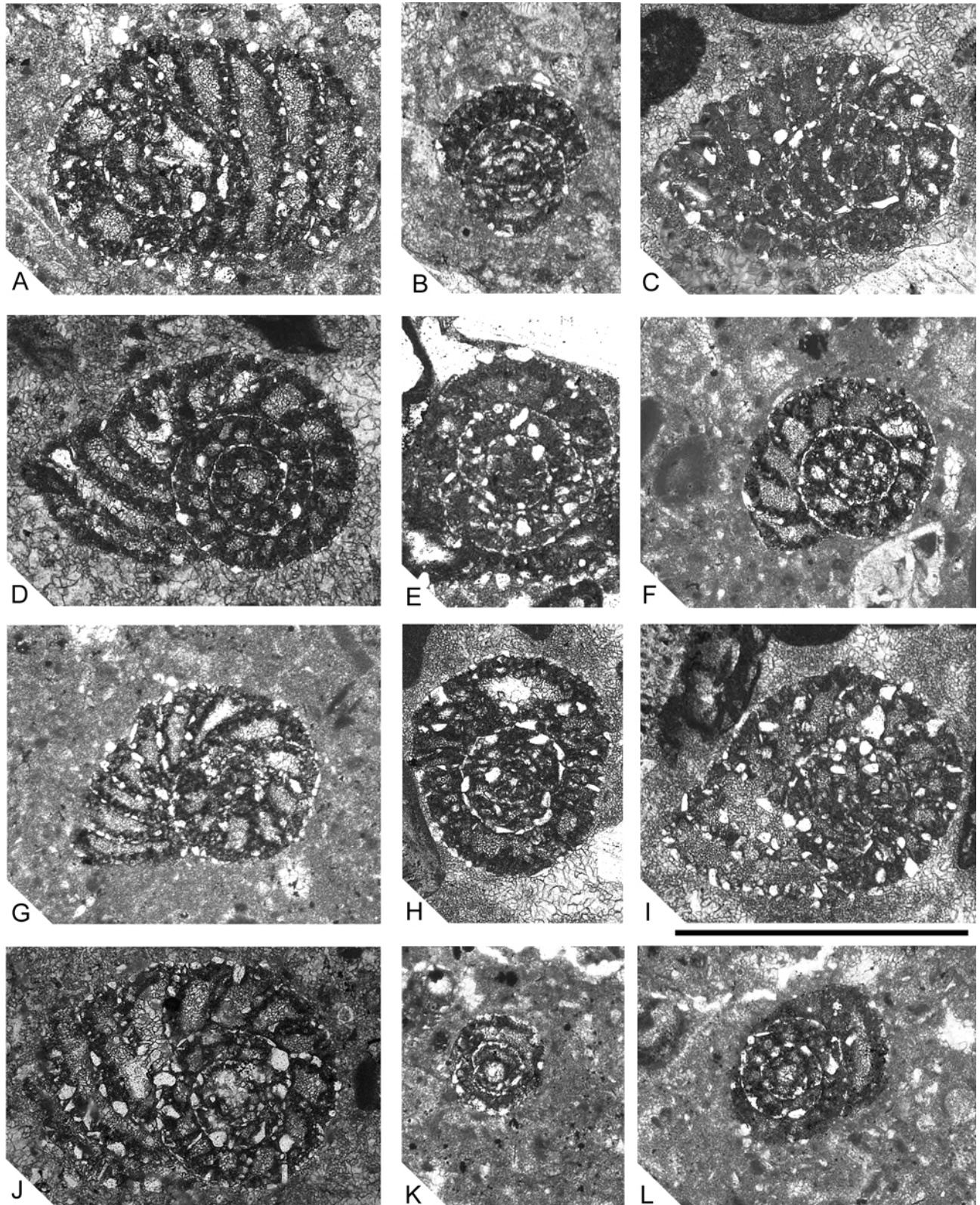


Figure 12: *Pseudocyclammina sphaeroidea*. **A.** Oblique section showing three spiral whorls in a large specimen. **B, E, H, K.** Axial and subaxial sections. **C-D, F-J.** Equatorial and subequatorial sections. **L.** Centred oblique section. **A, B, J** from CO-30; **C-E, H, I** from CO-1; **F, G, K, L** from M-125. Scale bar 1 mm.

Stratigraphical distribution: This small and globular *Pseudocyclamina* characterizes all deposits of the Font de les Bagasses Unit, although it is most frequent in its lower part. At certain levels it occurs as isolated specimens, but is more abundant in hard rocks. In the Pyrenees, the species is known from Coniacian to Lower Campanian. However, it is also mentioned from the Turonian (FRIJIA & PARENTE, 2008; CHIOCCINI *et al.*, 2012; FRIJIA *et al.*, 2007; among others).

Geographic distribution: *P. sphaeroidea* type is reported from the Pyrenean basin, while the small forms have a wider occurrence (see for instance: SCHLAGINTWEIT, 1992; FRIJIA *et al.*, 2007).

Suborder Ataxopragmiina FURSENKO, 1958

Remarks: KAMINSKI (2014) included in this suborder "agglutinated high trochospiral foraminifera with an asymmetrical spire that may reduce to a biserial or uniserial arrangement. The chambers may have exoskeletal and endoskeletal structures. The aperture forms a wide horizontal slit at the base of the apertural face". However, some genera included in the suborder have multiple apertures.

Superfamily Ataxopragmioidea SCHWAGER, 1877

Remarks: After LOEBLICH & TAPPAN (1988), this Superfamily is characterized by its early trochospiral growth that may be reduced to biserial or uniserial in later stages. The chambers have skeletal elements partially dividing the chamber lumen.

Family Dicyclinidae LOEBLICH & TAPPAN, 1964, emended

Remarks: ARRIAGA *et al.* (in press) considered the Family Dicyclinidae LOEBLICH & TAPPAN, 1964, synonymous with Cuneolinidae SAIDOVA, 1981. LOEBLICH & TAPPAN (1964, 1978) defined the Family Dicyclinidae as "test free, discoidal, chambers cyclical, biserially added, partially subdivided by transverse or radial partitions with imperforate epidermal layer; peripheral multiple aperture". Whereas, the Family Cuneolinidae SAIDOVA, 1981, was described as "conical to sublabelliform, trochospiral in early stage, with up to five chambers per whorl, rapidly reduced to biserial; chambers subdivided by many septula extending from the outer wall toward the junction of the two series of chambers, agglutinated wall with imperforate outer layer and reticulate subepidermal layer; aperture simple to multiple".

According to SCHLAGINTWEIT (1992), ARNAUD-VANNEAU & SLITER (1995) and the present work, *Cuneolina* ORBIGNY, 1839 (type-species: *C. pavonia* ORBIGNY, 1846) shows a large and structured deuteroconch followed by chambers biserially

arranged, and not trochospirally arranged in the early stages of growth as defined by LOEBLICH & TAPPAN (1964). Other characteristics, like a deep subepidermal network exoskeleton, the multiple apertures and the lack of endoskeleton are identical to *Dicyclina* characteristics. Thus, in accordance with ARRIAGA *et al.* (in press), the genus *Cuneolina* needs to be placed in the Family Dicyclinidae.

Therefore, the Family Dicyclinidae is emended here to include the non-cyclical forms as follows: test free, conical to fan-shaped or discoidal, chamber biserially arranged, exoskeleton composed of beams and rafters forming a regular subepidermal network covered by a fine epidermis. Multiple apertures are placed at the base of the chamber. It lacks endoskeletal structures.

Subfamily Cuneolininae SAIDOVA, 1981

Remarks: ARRIAGA *et al.* (in press) maintained the Subfamily Cuneolininae for the conical to fan-shaped morphotypes. However, further studies are needed to prove the validity of this subfamily, comprising also small and less complex forms from the Lower Cretaceous.

***Cuneolina* (ORBIGNY, 1839) ARNAUD-VANNEAU & SLITER, 1995**

(Type-species: *Cuneolina pavonia* ORBIGNY, 1846)

Description: Conical to fan-shaped foraminifera with agglutinated wall. The chambers are biserially arranged. They are generally broad and low, and commonly compressed in the plan of the biseriality. They have a complex exoskeleton composed of beams and rafters forming a regular subepidermal polygonal network covered by a fine epidermis. The beams frequently penetrate deep into the chamber lumen leaving only a narrow passage near the apertural face. It lacks endoskeleton elements. Multiple intercameral foramina are aligned at the base of the septa. For more details see ARNAUD-VANNEAU & SLITER (1995).

Age: *Cuneolina* is known from the Aptian to Maastrichtian (LOEBLICH & TAPPAN, 1988).

***Cuneolina conica* ORBIGNY, 1850 (Fig. 13 H, O ; Fig. 14 C-D)**

Synonymies:

1850 *Cuneolina conica* ORBIGNY, Pl. 1, figs. 7-9; Pl. 2, fig. 1.

1899 *Cuneolina conica* ORBIGNY, SCHLUMBERGER, Pl. 8, figs. 8-10

1968 *Cuneolina conica* ORBIGNY, GENDROT, Pl. 4, fig. 16

Description: Fan-shaped shell, biserially arranged, with low and broad chambers occupying an opening angle of about 70°. The number of chambers is about 20. The shell varies from 0.7mm to 1.2 mm in length. The exoskeleton consists of well-developed beams and rafters. The number of beams per chamber can reach about 20 in the last chamber.

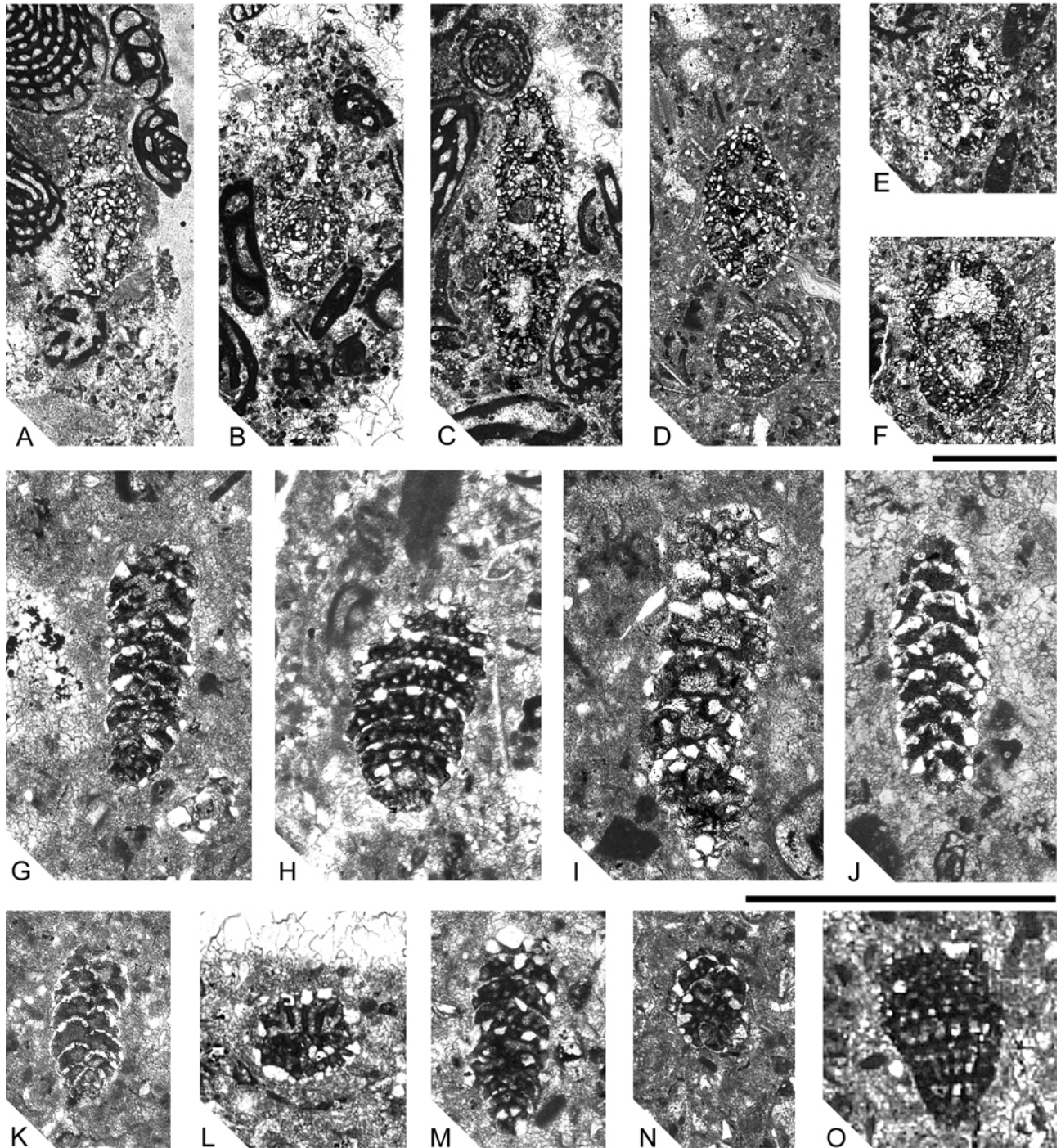


Figure 13: **A, C.** *Hemicyclammina cf. chalmasi*: subaxial sections; from SG-8 and SG-10. **B.** oblique section not far from the equatorial section; from SG-8 and SG-10. **D, E.** *Hemicyclammina cf. chalmasi*: Oblique sections; from SG-8 and SG-10. **F.** *Hemicyclammina cf. chalmasi*: slightly oblique near the subaxial section; note in all of the pictures the coarse agglutinating quartz grains masking the wall structure; from SG-8 and SG-10. **G, J, K, M.** *Cuneolina cyclindrica*: axial sections; G, from M-130; K, from M-125; J, M from M-151. **I.** *Cuneolina cyclindrica*: slightly oblique section almost subaxial; from M-149. **L.** *Cuneolina cyclindrica*: basal section showing the beams penetrating deep into the chamber lumen and leaving a narrow passage; from M-130. **N.** *Cuneolina cyclindrica*: oblique section showing fifth chambers; from M-130. **H, O.** *Cuneolina conica*: longitudinal-oblique sections; respectively from M-143 and from M-130. Scale bar 1 mm.

Similarities and differences: Our specimens from the Font de les Bagasses are identical to those described by SCHLUMBERGER (1899) from Tragó de Noguera.

Stratigraphical distribution: It is known only from the Upper Cretaceous.

Geographical distribution: *Cuneolina conica* has been mentioned in the Pyrenean deposits.

***Cuneolina cylindrica* HENSON, 1948**
(Fig. 13 G, I-N ; Fig. 14 A-B)

Synonymies:

- 1948 *Cuneolina cylindrica* HENSON, Pl. 14, fig. 7.
1968 *Cuneolina cylindrica* HENSON, GENDROT Pl. 4, fig. 14.

Description: Agglutinated, cylindrical, small shell with biserially arranged chambers. The chambers grow regularly and have a subglobular to slightly elongated morphology, opening with an angle of 10°-15° (7° to 14° in HENSON, 1948). The shell varies from 0.5mm to 1.1 mm in length. The wall consists of a fine epidermis (recrystallized) and few developed beams and rafters. A maximum of six beams per chamber have been measured. The external wall and septa agglutinate coarse and angular quartz grains, as occurs in many other foraminifera located in the Les Bagasses deposits (see for instance, *Pseudocyclammia sphaeroidea*).

Stratigraphical distribution: This species is known from the Santonian and Campanian deposits.

Geographical distribution *Cuneolina cylindrica* was described from the Middle East, but is a poorly known species. It is common in the Pyrenees.

Family Dictyopsellidae
BRÖNNIMANN *et al.*, 1983

Remarks: Low trochospiral shell with polygonal subepidermal network. The adjacent chambers communicate by a main aperture in an interiomarginal position.

***Dictyopsella* MUNIER-CHALMAS, 1899**

(Type-species: *Dictyopsella kiliani* MUNIER-CHALMAS in SCHLUMBERGER 1899)

Description: Finely agglutinated shell, with low conical shape showing a convex dorsal side and a plane or plano-convex umbilical side. The chambers are arranged in a low trochospire. In the dorsal side, the chambers have the typical half-moon shape, while in the ventral side they are triangular leaving an open umbilicus in the center of the shell. The main aperture is arched and placed at the base of the apertural face. Small supplementary openings are developed in the septal sutures. The interior of the chambers is occupied by a deep exoskeleton, composed of numerous beams and rafters forming a fine subepidermal polygonal network covered by the

epidermis. They lack endoskeleton.

Age: The age attributed by LOEBLICH and TAPPAN (1988) to this genus is Cenomanian-to-Maastrichtian.

Dictyopsella kiliani

MUNIER-CHALMAS *in* SCHLUMBERGER, 1899
(Fig. 14 E-M ; Fig. 15 A-F)

Synonymies:

- 1899 *Dictyopsella kiliani* MUNIER-CHALMAS *in* SCHLUMBERGER, Pl. 8, figs. 5, 7; Pl. 11, fig. 20.
1967 *Dictyopsella kiliani* MUNIER-CHALMAS *in* SCHLUMBERGER, HOTTINGER, Pl. 10, figs. 7-10.
1968 *Dictyopsella kiliani* MUNIER-CHALMAS *in* SCHLUMBERGER, GENDROT, Pl. 5, figs. 7-10.
1981 *Dictyopsella kiliani* MUNIER-CHALMAS *in* SCHLUMBERGER, TRONCHETTI, Pl. 9, figs. 7-10; Pl. 10, figs. 1-3
1985 *Dictyopsella kiliani* MUNIER-CHALMAS *in* SCHLUMBERGER, LOEBLICH & TAPPAN, Pl. 4, figs. 1-7; Fig. 3.
1992 *Dictyopsella kiliani* MUNIER-CHALMAS *in* SCHLUMBERGER, SCHLAGINTWEIT, Figs. 7-10.

Description: All the specimens found in the Font de les Bagasses unit are attributed to the type-species of the genus: *D. kiliani*. The main characteristics of this species are reflected in the generic description of SCHLUMBERGER (1899) from the deposits of the Tragó de Noguera. The shell forms a low cone with its base plane or slightly convex. The periphery is circular and slightly lobulated. The maximum diameter of the measured specimens varies from 0.9 to 2.2 mm (A-forms). In the dorsal side, they show 20-21 half-moon-shaped chambers arranged in two and half whorls, with the last whorl having 8-10 chambers. The dorsal sutures are arched and slightly depressed. In the ventral side, the chambers are triangular and the sutures appear precisely at 2/3 of its inner part of the shell and slightly curved at the 1/3 of the external margin. The embryo consists of a spherical protoconch and a reniform to subglobular deuteroconch with exoskeleton.

Remarks: Although GENDROT (1968), in the material from Martigues, attributed the small specimens (with a diameter of about 1.3 mm) to the A-generation and the large ones (up to 2 mm) to the B-generation, all the measured specimens from the Font de les Bagasses Unit are A-forms

Similarities and differences: HOTTINGER (1967), using material from Tragó de Noguera, described the species *D. muretae*. This species, according to the author, differs from *D. kiliani* in its larger number of chambers in the last whorl (about 15) and the bigger size of the embryo compared with the embryo of *D. kiliani*. Moreover, HOTTINGER (1967) indicated that the walls of the ventral side of the successive chambers are superposed, forming a columellar plate, suggesting a higher degree of evolution for this last species. However, in the studied specimens collected from the Font de les Bagasses Unit, such characteristics have not been observed.

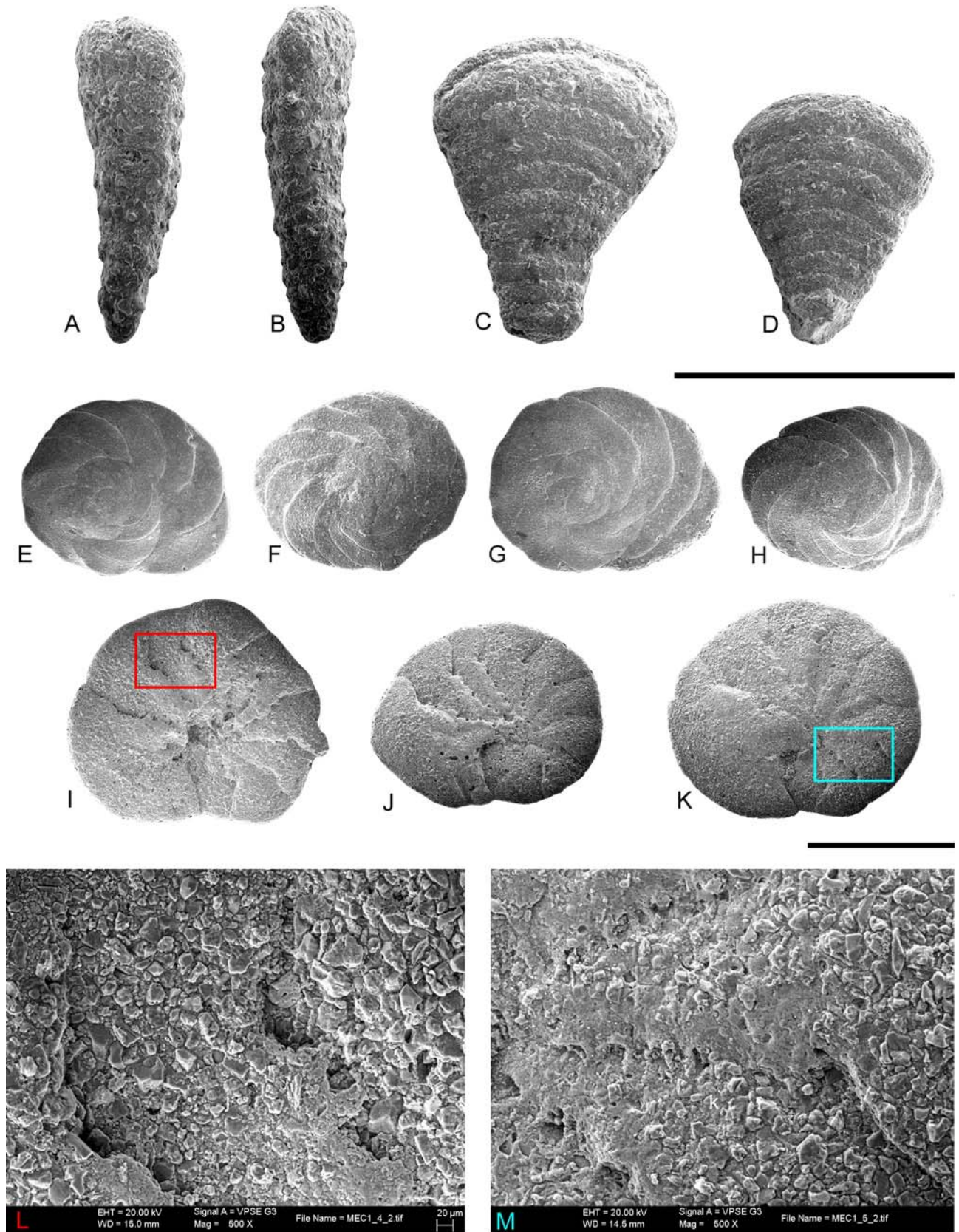


Figure 14: A-B. *Cuneolina cylindrica*: external view of isolated specimens (scanning electron microphotographs); note the cylindrical morphology of this species. C-D. *Cuneolina conica*: lateral view of well preserved specimens. E-I. *Dictyopsella kiliani*: external view of the dorsal side showing the spiral half-moon shaped chambers (scanning microphotographies). J-L. *Dictyopsella kiliani*: ventral side with the chambers of the last whorl showing the main aperture and small septal openings. M-N. Details of J and L specimens. All from SG-36. Scale bar 1 mm.

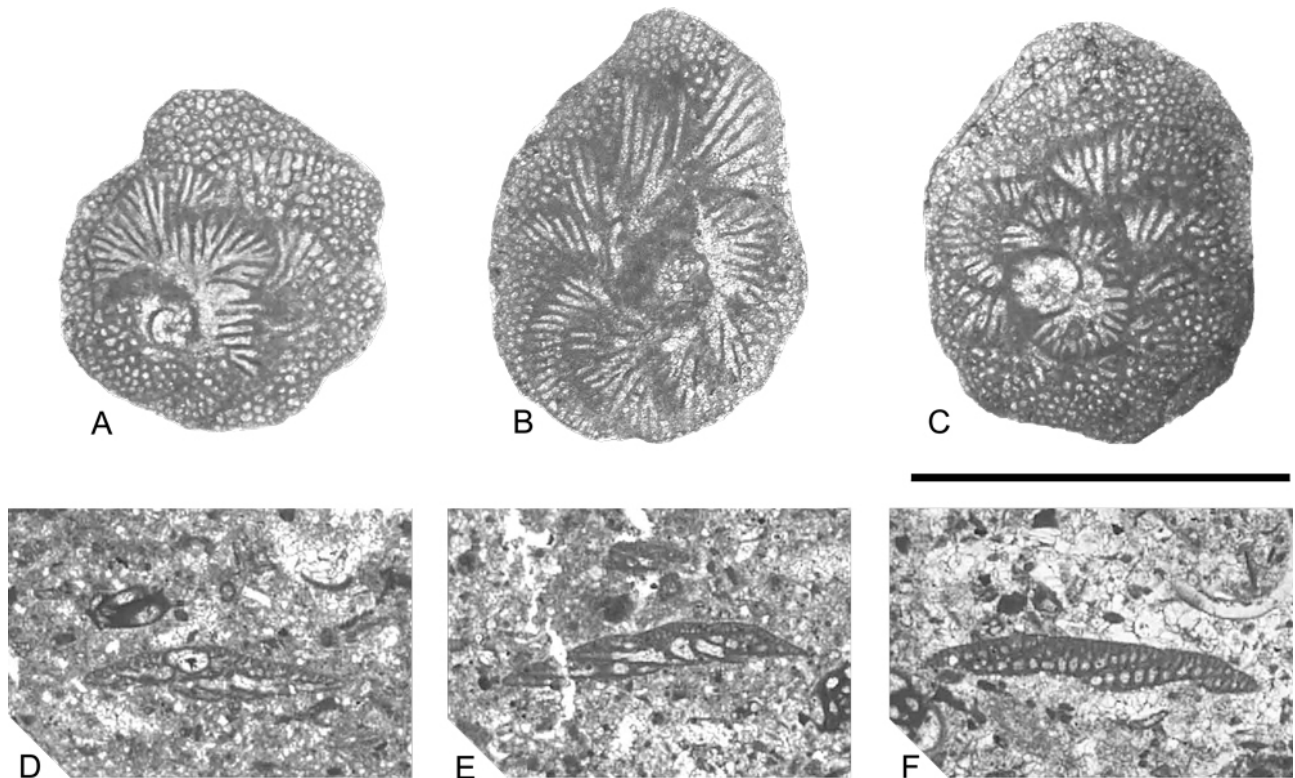


Figure 15: A-C. *Dictyopsella killiani* from SG-36. A, C. traverse sections showing the disposition of chambers in the spiral side. B. traverse section showing the disposition of chambers in the last whorl. D. axial section of a small specimen showing the spherical protoconch and a reniform deutoconch, from M-148. E- F. Subaxial sections, from M-150. Scale bar 1 mm.

GENDROT (1968) described from Martigues, under the name of *D. cuvillieri*, a small, thin and flat species with circular outline, which was used by LOEBLICH & TAPPAN (1985) to erect their new genus *Dictyopselloides*. LOEBLICH & TAPPAN (1985) based the new genus on the presence of an exoskeleton formed only by beams or, if they exist, a few rafters (see LOEBLICH & TAPPAN, 1988, p. 150), while *D. killiani* has well developed beams and rafters. However, the pictures presented by GENDROT (1968, Pl. 5, fig. 5) clearly indicate the presence of rafters; therefore, the validity of the genus *Dictyopselloides* is questioned here. GENDROT (1968) differentiated *D. cuvillieri* from *D. killiani* by its smaller size, flatter morphology, and the number of chambers in the last whorl, four to five. In our material, morphotypes similar to those described by GENDROT (1968) as *D. cuvillieri* occur only sporadically in thin-sections, not permitting a detailed study.

Stratigraphical distribution: Coniacian-Lower Campanian.

Geographical distribution: *Dictyopsella killiani* is mentioned frequently from western and central Europe.

6. Comments on the associated porcellaneous and lamellar-perforate foraminifera

In the Font de les Bagasses Unit the agglutinated larger foraminifera are frequently

associated with porcellaneous and lamellar-perforate foraminifera. Among the former group, lacazinids and meandropsinids are dominant, while the latter group is dominated by rotaliids and orbitoidids.

The lacazinids are represented by two species that have replaced each other in time: *Pseudofabularia cantabrica* HOTTINGER *et al.*, 1989, and *Lacazina elongata* MUNIER-CHALMAS, 1899 (generic and specific characteristics of these two taxa are treated in HOTTINGER *et al.*, 1989). Meandropsinids are represented clearly by two small, apparently nondimorphic forms: *Nummofallotia cretacea* (SCHLUMBERGER, 1899) and *Eofallotia cf. simplex* HOTTINGER & CAUS, 2009, which are present within complete unit. The large and extremely dimorphic species *Alexina payracea* HOTTINGER & CAUS, 2009, is frequent only in the lower part of the sections, whereas the larger B forms of *Larrazetia larrazeti* (MUNIER-CHALMAS in SCHLUMBERGER, 1899) occur only in the upper part. The specimens designated in the charts as *Fascispira cf. schlumbergeri* HOTTINGER & CAUS, 2009, need to be further studied. *Meandropsina vidali* SCHLUMBERGER, 1899, described from the facies of the Tragó de Noguera, has been identified only in some washed samples collected in the middle part of the unit, and is omitted in the chart range (for more information see HOTTINGER & CAUS, 2009).

Among the lamellar-perforate foraminifera, the small *Orbitoides hottingeri* HINTE and *O. santae-pelagiae* ASTRE are frequent, and they replace

each other in time (ALBRICH *et al.*, 2014). The Family Rotaliidae (*sensu* HOTTINGER, 2014) is represented by *Rotorbinella* spp., and *Pyrenotalia longifolia* BOIX *et al.*, 2009. The very small, heavily ornamented forms with areal foramina, umbilical flaps and tooth-plate are designated in this work as *Pararotalia tuberculifera* (REUSS, 1861), but the ensemble should be further studied. The list of hyaline foraminifera ends with the well-known *Praestorsella roestae* (VISSEER, 1951), *Praesiderolites praevitali* (NEUMANN, 1987), and probably several species of the genus *Goupillaudina*.

7. Conclusions

The detailed architectural study of the foraminifera collected in the Font de les Bagasses Unit, in the Montsec Mountains, has allowed the following agglutinated foraminifera to be identified: *Choffatella* aff. *rugoretis*, *Hemicyclammina chalmasi*, *Pseudocyclammina sphaeroidea*, *Cuneolina conica*, *C. cylindrica* and *Dictyopsella killiani*. All of these share the same type of exoskeleton composed of beams and rafters with a fine epidermis (polygonal subepidermal network) that is combined with different arrangements of chambers to conform:

1. Planispiral to uncoiled, peneropliform or cyclical (Spirocyclinidae);
2. Biseriate (Dicyclinidae);
3. Low trochospiral (Dictyopsellidae).

In the suprageneric classification *Choffatella* is included in Choffatellinae MAYNC, *Hemicyclammina* in Hemicyclammininae BANNER, and *Pseudocyclammina* in Amijiellinae SEPTFONTAINE within the Spirocyclinidae. *Cuneolina* is included in the Family Dicyclinidae.

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