

Menaella bustamantei n. gen., n. sp. (Acervulinacea, Foraminiferida) from the uppermost Albian of northern Spain

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ABSTRACT - Whereas representatives of the foraminiferal superfamily Acervulinacea Schultze, 1854 are widespread in Paleocene to Holocene reef environments, our knowledge of pre-Tertiary acervulinaceans is still very incomplete. Therefore, the discovery of numerous specimens in the uppermost Albian of northern Spain (Caniego, Burgos province) is of major interest. In this note, the new taxon *Menaella bustamantei* n. gen., n. sp., representing the new family Menaellidae, is established. This new acervulinacean genus is characterized by a free-living conical juvenile stage, composed of a rectilinear series of chamber layers. Some of the larger acervulinacean fragments from the same locality could belong to the adult stage of this new taxon.

RIASSUNTO - [*Menaella bustamantei* n. gen., n. sp. (Acervulinacea, Foraminiferida) dell'Albiano sommitale del Nord della Spagna] - Mentre i rappresentanti della superfamiglia Acervulinacea Schultze, 1854 sono ampiamente diffusi negli ambienti di scogliera dal Paleocene all'Olocene, la presenza di Acervulinacea nei sedimenti pre-terziari è molto rara e la loro conoscenza è assai incompleta. Pertanto il ritrovamento di numerosi esemplari nell'Albiano sommitale della Spagna settentrionale (Caniego, Provincia di Burgos) riveste un grande interesse. In questa nota viene stabilito il nuovo taxon *Menaella bustamantei* n. gen., n. sp., appartenente alla nuova Fam. Menaellidae. Questo nuovo genere è caratterizzato da uno stadio giovanile libero, di forma conica e composto da una serie rettilinea di strati di camere. Alcuni frammenti di acervulinacee provenienti dalla stessa località potrebbero appartenere a stadi adulti di questo nuovo taxon.

INTRODUCTION

The superfamily Acervulinacea Schultze, 1854 comprises an important group of mostly sessile foraminifers encrusting hard and soft substrates (Langer, 1993; Ungaro, 1996). Acervulinaceans are sometimes significant components of reef communities, even being able to build true reefs up to several kilometres in length (Perrin, 1987, 1992; Plaziat & Perrin, 1992).

According to Loeblich & Tappan (1988), this foraminiferal group is characterized by spirally coiled early chambers, followed by a series of chambers arranged in one or several layers. The mostly irregular growth form of the test is mainly due to the different morphology of the substrate. Chamber roofs are pierced by coarse pores. Additionally, apertures in different positions may connect neighbouring chambers (Hottinger et al., 1993).

The superfamily Acervulinacea is generally believed to be only of Paleocene to Holocene age (Loeblich & Tappan, 1988). Some authors, however, mentioned the occurrence of acervulinid foraminifers as early as the uppermost Late Cretaceous. According to Moussavian (1992), they appear for the first time in the period from late Campanian to Maastrichtian. Moussavian & Höfling (1993) reported "*Acervulina* sp. indet. 1" from the Maastrichtian - Danian of Austria. Parente (1997: pl. 27, fig. 6) depicted an acervulinid crust attached to a rudist fragment from the upper Maastrichtian (Ciolo Limestone) of the Salento Peninsula (Puglia, southern Italy),

constituting, along with peysoneliaceans and corallinaceans, a typical example of a crust builder community.

The acervulinacean genus *Solenomeris* Douvillé, 1924, mainly occurring in the Paleocene - Eocene, was also reported from the Late Cretaceous. This taxon, which for considerable time numerous authors assigned to the algae, but already compared by Trauth (1918) and Hagn & Wellnhofer (1967) with acervulinid foraminifers, occurs in the "Sénonien" of Central Iran (Deloffre et al., 1977), in the upper Maastrichtian of Roquefort-Créon (central Aquitaine, France; Poignant & Blanc, 1974: pl. 13, fig. 4; pl. 14, figs. 1-3) and in the Maastrichtian of the Carpathians (Samuel et al., 1972: pl. 130, fig. 2).

Some citations of Cretaceous Acervulinas refer to species belonging to other genera. *Acervulina cretae* Marsson, 1878, occurring for the first time in the late Campanian (Bignot & Decrouez, 1982; Bignot & Neumann, 1991) and considered for a long time in treatises on foraminifers as the sole Cretaceous representative of this genus (Galloway, 1933; Cushman, 1950), is now attributed to the genus *Planorbulina* d'Orbigny, 1826. The Cenomanian *Planorbulina cenomana* Seguenza, 1882, the type species of *Archaeocyclus* Silvestri, 1908, cannot be regarded as an *Acervulina*, as was done by Bronnimann (1958). Sections of "*Acervulina* sp." (Samuel et al., 1972: pl. 109, figs. 1-4), found in Barremian - Aptian limestone pebbles of Santonian - Campanian and Ilerdian conglomerates of

the Váh Valley (western Carpathians) are in reality crusts of the microproblematicum *Koskinobullina socialis* Cherchi & Schroeder, 1979.

Jurassic acervulinaceans have up to now been exclusively represented by *Acervulina inhaerens* var. *huzimotoi* Hanzawa, 1939 from the Upper Jurassic Torinosu Limestone of Japan. The only specimen shows a group of tangentially cut, vesicular chambers with irregularly rounded outlines and coarsely perforated chamber roofs. Further details are lacking. Although the specimen seems to be an acervulinacean foraminifer, its specific and generic position is uncertain.

The Paleozoic genus *Aphralysia* Garwood, 1914, long regarded as a calcareous alga (Mamet & Roux, 1975), shows strong affinities with representatives of the family Acervulinidae (Belka, 1981). This important encrusting and rock-forming fossil in some algal limestones of Late Silurian and Carboniferous age is composed of irregularly arranged vermicular chambers, showing a partial subdivision by short septula. The finely perforated chamber walls consist of two calcitic layers, separated by a dark lamella.

Summing up, it may be said that our knowledge of pre-Tertiary acervulinacean foraminifers is still largely incomplete. In view of this situation, the discovery of numerous specimens belonging to this superfamily in the uppermost Albian of Northern Spain and described below is of major interest.

A part of the studied thin sections (labelled SMF...) are stored in the collections of the Forschungsinstitut und Museum Senckenberg (Frankfurt/Main); the others are deposited in the Cherchi-Schroeder collection (Frankfurt/Main).

REGIONAL AND STRATIGRAPHIC SETTING

The samples containing *Menaella bustamantei* n. gen., n. sp. come from the massive reefal Caniego Limestone bordering the northern part of the Villasana de Mena diapir (Burgos province, northern Spain; Fig. 1). This diapir pierces a thick series of Cenomanian-Turonian marls, limestones or marly limestones belonging to an outer platform setting in the Basque-Cantabrian region. Due to activities of the diapir, the Caniego Limestone appears as a zone of uplifted, locally overturned slices of very varying dimensions, located between the Triassic filling of the diapir (red clays, cellular dolomites, ophitic rocks) in the south, and an alternation of middle Cenomanian marls and argillaceous limestones in the north (Lotze, 1938, 1963; Schroeder & Willems, 1983a).

Schroeder (1979; observations presented during the "Iberian Field Conference 1977" of the IGCP project "Mid-Cretaceous Events") dated the Caniego Limestone by means of orbitolinid foraminifers as late Albian. For the first time, he pointed to the presence of Triassic lithoclasts (ophites, green shales, dolomites, bipyramidal Keuper quartz crystals) and resedimented red Keuper shales in the lowermost part of the series. These exotic elements indicate an (initial?) rise of the Villasana de Mena diapir and subsequent formation on its top of a small carbonate platform, locally pierced by the diapir, so that Triassic material could be extruded.

The acervulinaceans studied in this paper were discovered in an abandoned quarry in the Caniego Limestone (Fig. 2), located immediately north of the Caniego village, on the western side of the Villanueva

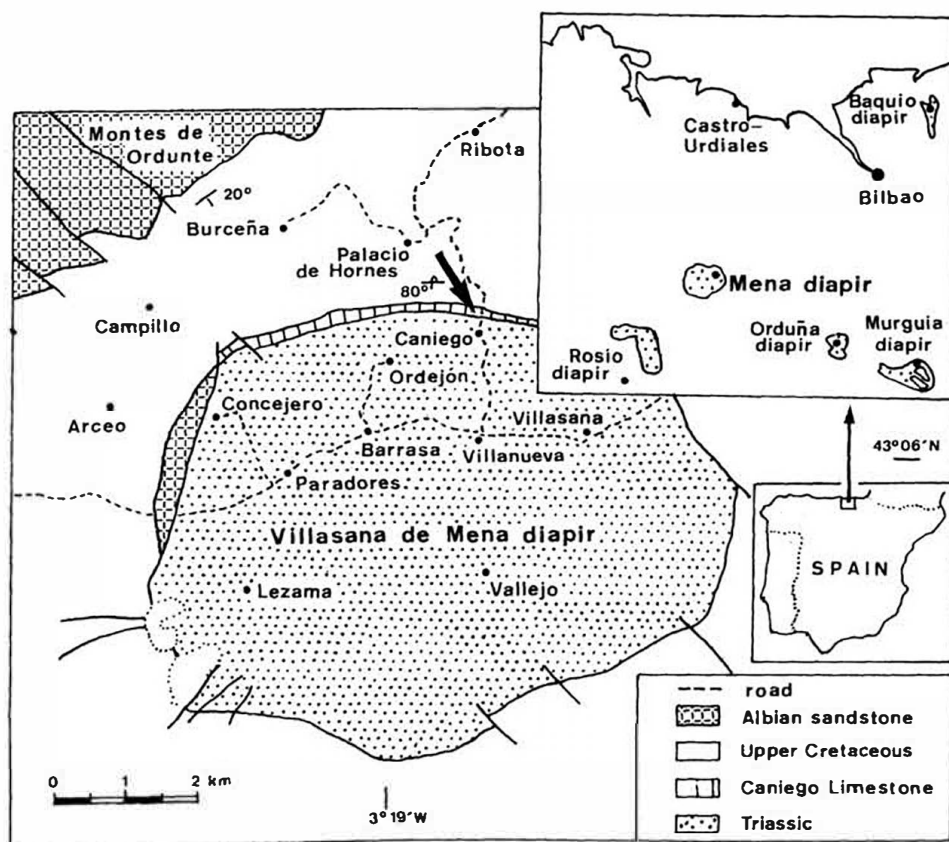


Fig. 1 - Location of the Caniego quarry (arrow) at the northern margin of the Villasana de Mena diapir (Burgos province, Northern Spain). Simplified geological map, based upon Lotze (1963) and Mapa geológica de España 1:50.000, sheet n° 85 Villasana de Mena.

de Mena - Ribota de Ordunte road (sheet nº 85 Villasana de Mena 1:50.000: long. 43°07'05"N; lat. 3°18'03"W). The outcrop shows three different lithological units (from south to north):

(1) Triassic diapir sediments (mainly cellular limestones, dolomites and shales) cropping out behind the ruins of the farmhouse, situated immediately at the southern edge of the quarry.

(2) Caniego Limestone (uppermost Albian). It is separated from the diapir sediments (unit 1) by a thrust fault. The Caniego Limestone is 20 to 30 m thick, massive, overturned (dipping approx. 70° to south) and - mainly in the upper part of the quarry - strongly affected by tectonics. It consists of an alternation of micrites (in part finely laminated) and calcarenites (grainstone - rudstone) (Schroeder & Willems, 1983a; Fernández Mendiola & García Mondejar, 1997). The calcarenites show low-angle cross-bedding and include lithoclasts suggesting a more energetic environment.

The non-laminated micrites are very fossiliferous (Schroeder & Willems, 1983a), containing rudists (*Plagiotrypa* sp., *Caprina* gr. *adversa* d'Orbigny, *Polyconites* sp.; Feuillée, 1967), echinoderms, brachiopods, gastropods, sclerosponges, foraminifers (*Dictyopsella* cf. *libanica* Saint-Marc, *Pseudotextulariella cretosa* Cushman), dasycladaceans (*Trinocladus tripolitanus* Raineri, "*?Dissocladella* n. sp. 1" in Peybernès & Conrad, 1982), rhodophyceans (*Agardhiellopsis cretacea* Lemoine, *Paraphyllum amphiroaeforme* [Rothpl.] Pfender, *P. primaevum* Lemoine), calcispheres (among them *Bonetocardiella conoidea* [Bonet]) and microproblematica (*Koskinobullina socialis* Cherchi & Schroeder).

The calcarenites contain mainly fragments of echinoderms, pelecypods, gastropods and foraminifers (*Orbitolina* cf. *sefini* Henson, primitive *Conicorbitolina corbarica* Schroeder, *Trocholina arabica* Henson, *T. lenticularis* Henson).

The uppermost 1.30 m thick biomicrite on top of the Caniego Limestone is characterized by the abundant occurrence of the sclerosponge *Acanthochaetetes seumesi* Fischer and contains smaller benthic foraminifers (e. g. *Rotalia mesogeensis* Tronchetti), as well as planktic species (*Rotalipora appenninica* Renz, *Hedbergella* sp., *Favusella washitensis* [Carsey]), the latter indicating temporary and slightly deeper water conditions. This biomicrite has yielded the acervulinacean foraminifers described in the present paper and is the type horizon of *Menaella bustamantei* n. gen., n. sp. (Fig. 2). Moreover, *Acanthochaetetes slovenica* Flügel, the stromatoporoid *Actinostromaria turonica* Turnsek and the sphinctozoan *Stylothalamia budaensis* Wells were found and described by Schroeder & Willems (1983b). A horizon built by microsolenid corals (associated with rhodophyceans) occurs in the upper half of the biomicrite.

The surface of this uppermost biomicrite, respectively all the Caniego Limestone, shows a phosphatic hard-ground with occasional stromatolitic Fe-Mn crusts (Schroeder & Willems, 1983a; Fernández-Mendiola & García-Mondejar, 1993), indicating a relative sea-level fall at the end of the uppermost Albian. The Caniego Limestone underwent subaerial exposure and karst



Fig. 2 - Caniego quarry (Burgos province, Northern Spain). 1 - Triassic cellular limestones (diapir); 2 - overturned Caniego Limestone (uppermost Albian), the arrow indicates the type horizon of *Menaella bustamantei*; 3 - overturned alternation of marls and limestones (middle Cenomanian).

development. Karst fissures are filled by marls with *Rotalipora* cf. *micheli*, *R.* cf. *brotzeni* (Sigal) and *Praeglobotruncana stephani* (Gandolfi) (determined by Orue-Etxebarria in Fernández-Mendiola & García-Mondejar, 1997), indicating a new sea-level rise during the early Cenomanian. According to these latter authors, planktic foraminifers (*Rotalipora appenninica*, *R. ticinensis*, *Planomalina buxtorfi*, *Favusella washitensis*), determined by Noé (in Grötsch *et al.*, 1993) from supposed karstic cavities, belong instead to the host rock Caniego Limestone itself. This latter association is largely identical to that found by us in the type horizon of *Menaella bustamantei* and suggests an uppermost Albian age (*appenninica* zone; Caron, 1985), whereas the planktic foraminifers in the marls of the karst fillings indicate an early to lowermost middle Cenomanian age (*brotzeni* and *reicheli* zones) (Fernández-Mendiola & García-Mondejar, 1997).

(3) The Caniego Limestone is overlain by an overturned rhythmic alternation of marls and limestones (Fig. 2), which has yielded *Rotalipora brotzeni* (Sigal), *R. greenhornensis* (Morrow), *R. thomei* Hagn, *R. montsalvensis* Mornod, *Praeglobotruncana stephani* (Gandolfi) (determined by Lamolda in Schroeder & Willems, 1983a) 0.50 m above its base. This association indicates a middle Cenomanian age. The contact between the Caniego Limestone and the marl-limestone alternation is a fault, nearly parallel to the stratification.

DESCRIPTION OF THE ACERVULINACEAN FORAMINIFERS

The systematic suprageneric classification follows that given by Loeblich & Tappan (1988).

Order FORAMINIFERIDA Eichwald, 1830
 Suborder ROTALINA Delage & Hérouard, 1896
 Superfamily ACERVULINACEA Schultze, 1854
 Family MENAELLIDAE n. fam.

Type genus - *Menaella* n. gen.

Diagnosis - A family of the Acervulinacea, whose conical juvenile stage consists of an embryonic chamber at the tip of the cone and a following rectilinear series of chamber layers (as regards differences from the Acervulinidae Schultze, 1854 see last chapter of this paper).

Genus *Menaella* n. gen.

Type species - *Menaella bustamantei* n. sp.

Derivation of name - The name of the genus and the family refers to the Mena Valley (Valle de Mena, Burgos province, Northern Spain), where the type locality is situated.

Diagnosis - See diagnosis of the type species *Menaella bustamantei* n. sp.

Menaella bustamantei n. sp.
 Pl. 1, figs. 1-6, 9; Fig. 3

1998 *Menaella bustamantei* CHERCHI & SCHROEDER, p. 52 [*nomen nudum*].

Derivation of name - We dedicate the new species to our dear friend José Bustamante Bricio (Bilbao), author of numerous publications on the history of the Mena Valley.

Diagnosis - The juvenile stage is conical, consisting of the embryo at the tip of the test and a following rectilinear series of chamber layers; chambers alternating from one layer to the next. The adult stage consists of chamber layers which laterally surround the juvenile part.

Holotype - Axial section of a juvenile test illustrated on pl. 1, fig. 5.

Material - Nine specimens in random thin-sections.

Type locality - Canel de Caniego; abandoned quarry (Fig. 2) north of Caniego village (Valle de Mena, Burgos province, Northern Spain), on the western side of the Villanueva de Mena - Ribota de Ordunte road.

Type horizon - *Acanthochaetetes seumesi* horizon, Caniego Limestone, uppermost Albian.

Description - All specimens studied are megalospheric forms. Two growth stages can be differentiated: (1) a juvenile, free-living conical stage, consisting of the embryo at the tip of the test and a following rectilinear series of chamber layers, and (2) an adult sessile stage made up of chamber layers laterally surrounding the juvenile part.

Juvenile stage - The juvenile test of *M. bustamantei* is conical in shape (pl. 1, figs. 1-2, 4-5; Fig. 3). It has a diameter of 0.4 - 0.6 mm and a height of 0.22 - 0.34 mm; the apical angle varies between 70° and 130°.

The embryonic chamber of the holotype (height: 0.1 mm), situated slightly eccentrically at the tip of the test and surrounded by a relatively thick wall (pl. 1, fig. 5), communicates with the first, laterally located postembryonic chamber by means of a relatively large opening. The diameter of the other observed embryonic chambers (pl. 1, figs. 2, 4, 6) varies between 0.04 and 0.14 mm.

The embryo is followed by a rectilinear series of about 6-8 chamber layers, increasing progressively in diameter during ontogenesis. The chambers alternate more or less regularly from one layer to the next. Each chamber, moderately inflated on its free side, is delimited at its base by the roofs of two chambers of the following layer, whereas the upper part of each chamber borders on the base of two chambers of the preceding layer. Chamber height varies considerably; sometimes the layers seem to be strongly compressed (pl. 1, fig. 1; Fig. 3). Due to the lack of transverse sections, the

EXPLANATION OF PLATE I

Caniego quarry, Valle de Mena (Burgos province, Northern Spain). Uppermost Albian.

- Figs. 1-6, 9 - *Menaella bustamantei* n. gen., n. sp.
 1 - Oblique axial section. SMF 34628(1), x150.
 2 - Axial section. CAS 5, x150.
 3 - Axial section (cr - chamber roof). CAS 2, x150.
 4 - Tangential section. CAS 1, x150.
 5 - Holotype. Axial section (E - embryonic chamber). CAS 6, x150.
 6 - Oblique axial section (cv - calcite vein). CAS 4, x150.
 9 - Subaxial section (1, 2, 3, 4 - laminae of the adulte stage; cr - chamber roof) CNU-1, x150.

- Figs. 7-8 - Larger acervulinacean fragments.
 7 - Wall structure. SMF 34628(3), approx. x300.
 8 - Vertical section. Detail (right part) of pl. 2, fig. 9. CAS 3, x100.

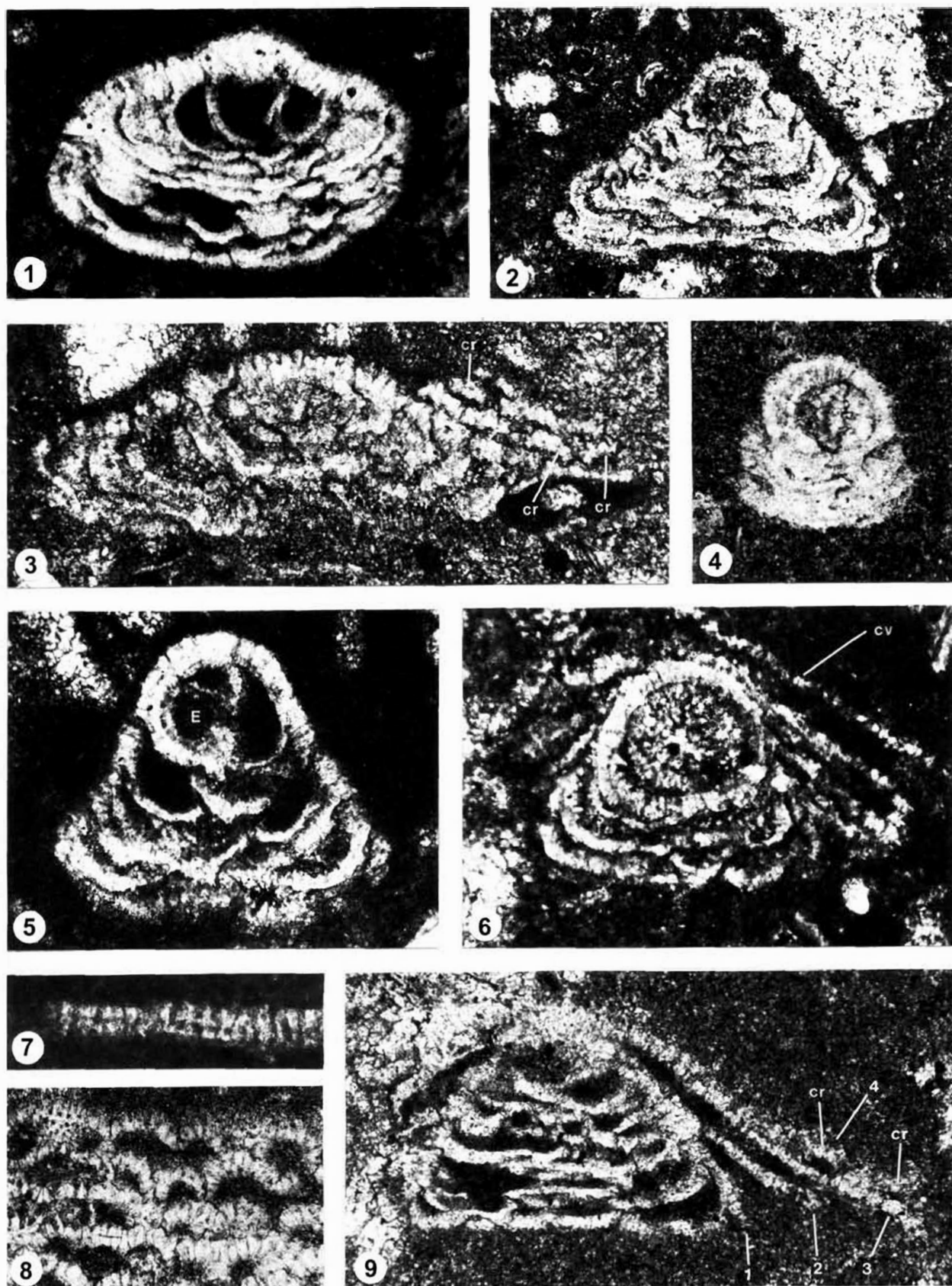




Fig. 3 - *Menaella bustamantei* n. gen., n. sp. Somewhat oblique vertical section. CAS 7, approx. x300. Caniego quarry, Valle de Mena (Burgos province, Northern Spain). Uppermost Albian.

outline of chambers in this direction is unclear; it seems to be isometric in the holotype (pl. 1, fig. 5), but radially elongated in the marginal sector of other specimens (pl. 1, fig. 9; Fig. 3).

The outer wall of the test is multilamellar and coarsely perforated (pl. 1, fig. 1; Fig. 3). The walls forming the chamber roofs respectively the floors seem to be imperforate (pl. 1, fig. 5; Fig. 3); however, this observation is not absolutely certain. Each chamber communicates by means of marginal (sutural) apertures with two adjacent chambers of the layer above and two of the layer below (pl. 1, fig. 5).

Adult stage - The juvenile conical stage of the specimen, represented in pl. 1, fig. 9, is laterally surrounded by at least four inclined, more or less linear and coarsely perforated lamellae, connected at their proximal end to the cone mantle and bordering

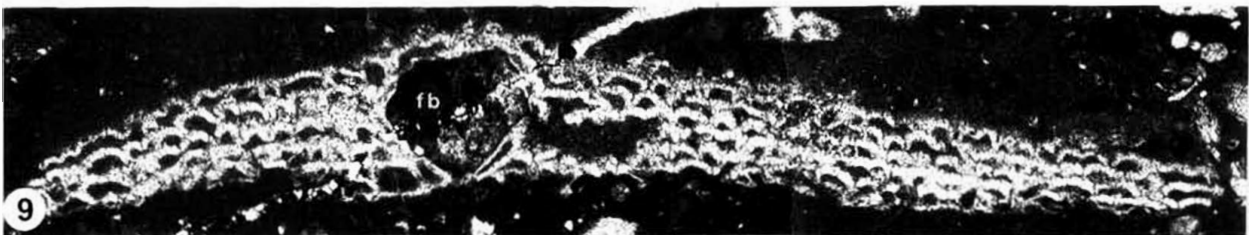
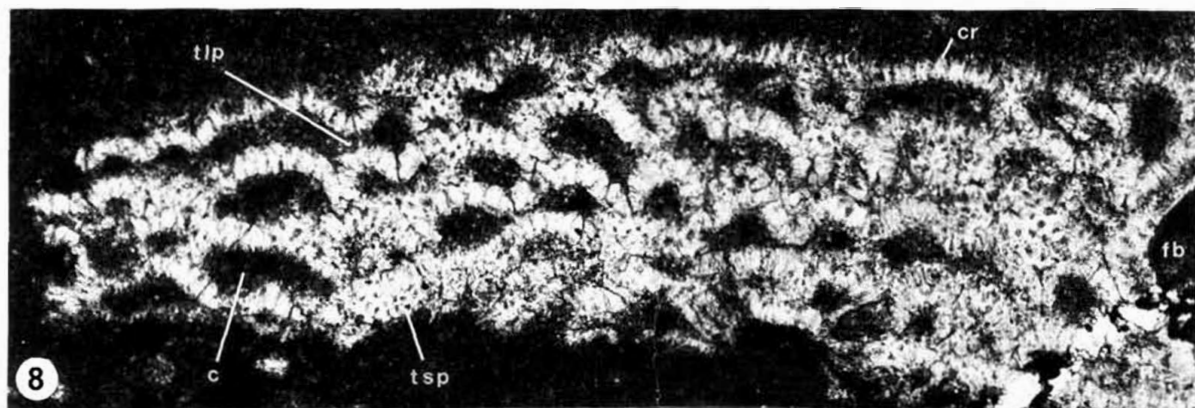
interlamellar spaces of varying height. These lamellae are well visible on the right side of the figured section, whereas they are largely obliterated by recrystallization on the left side. Comparable lamellae in the same position are also recognizable in the right half of the sections represented in pl. 1, figs. 3 and 6.

We interpret the successive interlamellar spaces as a series of chamber layers, and each lamella as all the chamber roofs of a single layer, forming a continuous, more or less straight line in vertical section. The delimitation of the different chambers within a single layer is not always clear (chamber layers between lamella 1 and 3 in pl. 1, fig. 9), but slightly vaulted parts of the lamellae (cr in pl. 1, figs. 3 and 9) sometimes indicate their position.

At the beginning of the formation of the adult stage, the growth direction and way of life of *M. bustamantei* fundamentally changed. The free-living juvenile

EXPLANATION OF PLATE 2

- Figs. 1-9 - Larger acervulinacean fragments.- Caniego quarry, Valle de Mena (Burgos province, Northern Spain). Uppermost Albian.
- 1 - Large crust fragment showing very irregularly arranged chambers. SMF 34628(1), x100.
 - 2 - Vertical section. CAS 2, x100.
 - 3 - Vertical section of a small fragment encrusting a molluscan shell. SMF 34628(3), x100.
 - 4 - Vertical section of a fragment consisting of irregularly arranged large chambers. SMF 34629(1), x100.
 - 5 - Vertical section. SMF 34629(3), x100.
 - 6 - Vertical section. CAS 2, x100.
 - 7 - Vertical section. SMF 34628(3), x100.
 - 8 - Detail (left part) of Fig. 9 (c - chamber; cr - perforated chamber roof; fb - foreign body; tlp - tunnel-like passage; tsp - chamber roof showing transversal sections of pores). CAS 3, x100.
 - 9 - Vertical section showing in its central part a foreign body. CAS 3, x30.



specimens settled on a substratum and began to encrust it, adding successive chamber layers around (and above?) the conical stage. Due to posterior mechanical destruction of the tests, the original dimensions of the adult growth stage are unknown. It seems as if only its proximal part is still preserved. We believe, however, that at least some of the larger acervulinacean fragments described in the following are parts of the adult stage of *Menaella bustamantei*.

Larger acervulinacean fragments

The samples studied not infrequently contain larger acervulinacean fragments, composed of only a few chamber layers. These specimens are either attached to acanthochaetetids and other hard substrates (pl. 2, fig. 3) or occur as isolated fragments of crusts, probably for the most part detached from phytal substrates.

The chamber walls consist of two layers of fibrous hyaline calcite separated by a median dark organic membrane (pl. 1, fig. 7).

The most significant fragment (pl. 1, fig. 8; pl. 2, figs. 8, 9) has a diameter of 4.3 mm and a maximal thickness of 0.7 mm, thinning out towards its edge. It is slightly curved and composed of at most six well-differentiated chamber layers. The oldest of these layers forms the central part of the fragment base; the following younger layers successively increase in diameter.

The chambers show upwardly arched roofs and alternate irregularly from one layer to the next (pl. 2, fig. 8). Their outline is rounded and probably oval. Generally, each chamber is delimited at its base by the roofs of two chambers of the following layer. The upper part of each chamber borders on the base of two chambers of the preceding layer.

The relatively thick walls are coarsely perforated (pl. 1, fig. 8; pl. 2, fig. 8). The pores are clearly visible in axial sections, but also in tangential sections through the chamber roofs. Adjacent chambers of the same layer are connected by horizontally oriented tunnel-like, perforated passages (tlp in pl. 2, fig. 8), which may be regarded as restrictions of the normal chamber lumen.

A large hollow (0.6 mm in diameter), located in the central part of the section (fb in pl. 2, fig. 9), indicates the presence of a non-preserved foreign body during the lifetime of the acervulinacean. This body was overgrown, laterally and above, by adjacent chambers of different layers.

The chamber layers of the acervulinacean crusts are not always so regularly arranged as in the previously described specimen. Some crust fragments (pl. 2, figs. 1, 4) show a very irregular arrangement of relatively broad and flat chambers. It is not clear whether these fragments represent tardontogenetic ("senile") stages or belong to a separate taxon.

The crust fragment, depicted in pl. 2, fig. 6, shows an increasing thickening of the chamber roofs, which are developed in the last two layers as nearly straight-lined lamellae. Parallel to this evolution, the chamber lumina became extremely reduced and cannot be clearly differentiated within a single layer. All these structural changes may point to a tardontogenetic evolutionary stage.

COMPARISONS WITH OTHER ACERVULINACEAN FORAMINIFERS

A comparison between *Menaella bustamantei* and other acervulinacean taxa is difficult due to the confused systematics of this foraminiferal group. Most of the original descriptions of type species are insufficient by present-day standards and need revision. For this reason, we can proceed on the assumption that many published acervulinacean determinations are incorrect.

A characteristic example illustrating this situation is represented by *Acervulina inhaerens* Schultze, 1854, designated by Galloway & Wissler (1927) as type species of the genus *Acervulina* Schultze, 1854. This species, found in beach sand near the harbour of Ancona (Adriatic coast, Italy), was described and depicted by its author as an irregular accumulation of a few, more or less globular and perforated chambers attached to a substrate. No further details (e. g. arrangement of juvenile chambers) were given. During the last 150 years, no one has published, to our knowledge, material coming from the type locality, although Hottinger et al. (1993: 123) mentioned (but did not depict) a species "from the Adriatic Sea", which shows an "irregular arrangement of much inflated and coarsely perforated chambers lacking ornamentation, but possessing numerous, irregularly placed sutural apertures with a short neck and heavy, peristomal rims". These authors consider "for the time being and pending further investigations" the Adriatic material "as typical for Schultze's *A. inhaerens* s. str.". In the absence of sufficient original characterization as well as revision of this species, *A. inhaerens* has thus far been interpreted in different ways by various authors. Finally, Perrin (1994) has presented criteria for the identification of *A. inhaerens*, which are, however, based exclusively on the study of specimens from the Plio-Quaternary reefal limestone of Mururoa Atoll (French Polynesia). This procedure is absolutely unacceptable, as it is by no means certain that the material from Ancona and Mururoa is congeneric or even conspecific. The Mururoa specimens show, indeed, a relatively complex juvenile stage, seemingly identical to that of the genus *Solenomeris* H. Douvillé, 1924.

Consequently, a study of topotypes of *Acervulina inhaerens*, type species of the genus *Acervulina*, is the principal precondition for a future definition of the superfamily Acervulinacea.

According to the present definition of the Acervulinacea (Loeblich & Tappan, 1988), the early chambers of their representatives, forming the diagnostically important juvenile stage, are generally coiled and frequently arranged in a flat planospiral. The specimens depicted by Perrin (1994: pl. 1, figs. 1-2) under the name "*Acervulina inhaerens*" from the Plio-Quaternary of Mururoa Atoll and "*Solenomeris ogormani*" (pl. 2, figs. 1-3; text-fig. 5) from the Eocene of the Alaric Mountains (Aude, France) show that this planospiral (or "equatorial disc" in Perrin) is followed by some layers of "lateral chambers" completely surrounding the equatorial disc and forming a flat ovoid (Fig. 4A). The arrangement of chambers of this ovoid suggests centrifugal growth in all directions and a free-living mode of life at this stage. Subsequently, the

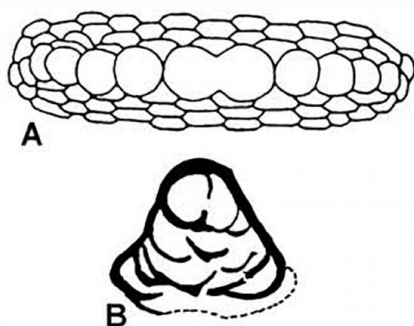


Fig. 4 - Axial sections through free-living, juvenile stages of (A) *Solenomeris ogormani* Douvillé, 1924 (after Perrin 1994: text-fig. 5) (x80) and (B) *Menaella bustamantei* n. gen., n. sp. (x 82).

organism attached itself to a substratum, thus beginning the sessile phase of its existence.

Menaella bustamantei likewise shows a change from a juvenile free-living stage to an adult sessile mode of life. However, the growth direction and chamber arrangement in the juvenile stage of this new taxon are completely different. In contrast to other acervulinacean foraminifera, whose initial part is made up of a series of chambers arranged in a flat planospiral, this stage consists of rectilinearly arranged chamber layers forming a conical test (Fig. 4B). This diverse arrangement leads us to establish not only a new genus (*Menaella*), but also a new family (Menaellidae) within the superfamily Acervulinacea.

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REFERENCES

Belka Z. (1981). The alleged genus *Aphralysia* is a foraminifer. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte*, 1981 (5): 257-266.

Bignot G. & Decrouez D. (1982). Un Planorbulinidae (Foraminiferida) nouveau du Priabonien et de l'Oligocène de l'Europe méridionale et occidentale. *Revue de Paléobiologie*, 1 (2): 141-163.

Bignot G. & Neumann M. (1991). Les "grands" Foraminifères du Crétacé terminal et du Paléogène du Nord-Ouest européen. Recensement et extensions chronologiques. *Bulletin d'Information des Géologues du Bassin de Paris*, 28 (2): 13-29.

Bronniman P. (1958). New Pseudorbitoididae from the Upper Cretaceous of Cuba, with remarks on encrusting foraminifera. *Micropaleontology*, 4 (2): 165-185.

Caron M. (1985). Cretaceous planktic foraminifera. In Bolli H.M., Saunders J.B. & Perch-Nielsen K. (eds) *Plankton stratigraphy*, University Press, Cambridge: 17-86.

Cherchi A. & Schroeder R. (1998). The uppermost Albian at the Caniego quarry. In Lamolda M. (ed.), 24^o Coloquio Europeo de Micropaleontología. Libro Guía: 51-52.

Cushman J.A. (1950). *Foraminifera, their classification and economic use* [4th edition]. 605 pp., Harvard University Press, Cambridge.

Deloffre R., Poignant A.F. & Teherani K. (1977). Algues calcaires de l'Albo-Aptien au Paléocène de l'Iran central. *Bulletin des Centres de Recherche Exploration-Production Elf-Aquitaine*, 1 (1): 29-57.

Douvillé H. (1924). Un nouveau genre d'Algues calcaires. *Compte Rendu Sommaire des Séances de la Société Géologique de France*, 4: 169-170.

Fernández-Mendiola P.A. & García-Mondejar J. (1993). A major paleokarst on an upper Albian carbonate platform (Caniego, northern Spain). In Alencaster G. & Buitrón B.E. (eds), *Third International Conference on Rudists. Proceedings*: 23-24.

Fernández-Mendiola P.A. & García-Mondejar J. (1997). Isolated carbonate platform of Caniego, Spain: A test of the latest Albian worldwide sea-level change. *Bulletin of the Geological Society of America*, 109 (2): 176-194.

Feuillée P. (1967). Le Cénomanien des Pyrénées basques aux Asturies. Essai d'analyse stratigraphique. *Mémoires de la Société Géologique de France*, n. ser., 46 (3) [Mém. 108]: 1-343.

Galloway J.J. (1933). *A manual of Foraminifera*. 483 pp., Principia Press, Inc., Bloomington (Ind.).

Galloway J.J. & Wissler S.G. (1927). Pleistocene Foraminifera from the Lomita Quarry, Palos Verdes Hills, California. *Journal of Paleontology*, 1: 35-87.

Grötsch J., Schroeder R., Noé S. & Flügel E. (1993). Carbonate platforms as recorders of high-amplitude eustatic sea-level fluctuations: the late Albian *appenninica*-event. *Basin Research*, 5: 197-212.

Hagn H. & Wellenhofer P. (1967). Ein erratisches Vorkommen von kalkalpinem Obereozän in Pfaffing bei Wasserburg. *Geologica Bavarica*, 57: 205-288.

Hanzawa S. (1939). On the occurrence of *Acervulina*, an encrusting form of Foraminifera in the Jurassic Torinosu Limestone from the Kwantō Mountainland, Central Japan. *Journal of the Geological Society*, 46: 45-47.

Hottinger L., Halicz E. & Reiss E. (1993). Recent Foraminiferida from the Gulf of Aqaba, Red Sea. *Razred za naravoslovne vede*, classis IV, historia naturalis, 30: 1-179.

Langer M.R. (1993). Epiphytic foraminifera. *Marine Micropaleontology*, 20 (3-4): 235-265.

Loeblich A.R.jr. & Tappan H. (1988). *Foraminiferal genera and their classification*. 2 vols.: 1: 970 pp.; 2: 212 pp., 847 pls., Van Nostrand Reinhold, New York.

Lotze F. (1938). *Steinsalz und Kalisalz*. Geologie. 936 pp., Gebrüder Borntraeger, Berlin.

Lotze F. (1963). Die Kreide-Schichtfolge am Nordwestrande des Salzstockes von Valle de Mena (Nordspanien). *Neues Jahrbuch für Geologie und Paläontologie Monatshefte*, 1963 (11): 616-624.

Mamet B. & Roux A. (1975). Algues dévoniennes et carbonifères de la Téthys occidentale. *Revue de Micropaléontologie*, 18 (3): 134-187.

Marsson T. (1878). Die Foraminiferen der weissen Schreibkreide der Insel Rügen. *Mitteilungen des Naturwissenschaftlichen Vereins für Neu-Vorpommern und Rügen in Greifswald*, 10: 115-196.

Moussavian E. (1992). On Cretaceous bioconstructions: composition and evolutionary trends of crust-building associations. *Facies*, 26: 117-144.

Moussavian E. & Höfling R. (1993). Taxonomische Position und Palökologie von *Solenomeris* Douvillé, 1924 und ihre Beziehung zu *Acervulina* Schultze, 1854 und *Gypsina* Carter, 1877 (Acervulinidae, Foraminiferida). *Zitteliana*, 20: 263-276.

Parente M. (1997). Dasycladales from the Upper Maastrichtian of Salento Peninsula (Puglia, Southern Italy). *Facies*, 36: 91-122.

Perrin C. (1987). *Solenomeris* un Foraminifère Acervulinidae constructeur de récifs. *Revue de Micropaléontologie*, 30 (3): 197-206.

- Perrin C. (1992). Signification écologique des Foraminifères Acervulinidés et leur rôle dans la formation de faciès récifaux et organogènes depuis le Paléocène. *Géobios*, 25 (6): 725-751.
- Perrin C. (1994). Morphology of encrusting and free living acervulinid Foraminifera: *Acervulina*, *Gypsina* and *Solenomeris*. *Palaeontology*, 37 (2): 425-458.
- Peybernès B. & Conrad M.A. (1982). Une association de Dasycladales (algues vertes) du passage Albien - Cénomanien dans les Pyrénées et les régions voisines (Chânes cantabriques, Provence). *Géobios*, 15 (5): 775-781.
- Plaziat J.C. & Perrin C. (1992). Multikilometer-sized reefs built by Foraminifera (*Solenomeris*) from the early Eocene of the Pyrenean domain (S. France, N. Spain) - paleoecologic relations with coral reefs. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 96 (3-4): 195-231.
- Poignant A.-F. & Blanc P.-L. (1974). Les algues calcaires du Crétacé supérieur des rides de Villagrains - Landiras et Roquefort - Créon (Aquitaine centrale). *Géobios*, 7 (1): 71-75.
- Samuel O., Borza K. & Köhler E. (1972). Microfauna and lithostratigraphy of the Paleogene and adjacent Cretaceous of the Middle Váh Valley (West Carpathian). 246 pp. Geologický ústav Dionýza Stúra, Bratislava.
- Schroeder R. (1979). Le Calcaire de Caniego: témoin d'une montée du diapir de Valle de Mena (Prov. Burgos, Espagne) dans l'Albien supérieur (note préliminaire). *Cuadernos de Geología Ibérica*, 5: 221-225.
- Schroeder R. & Willems H. (1983a). Über einen submarinen Durchbruch des Diapirs von Villasana de Mena (Prov. Burgos, N-Spanien) an der Wende Unter-/Oberkreide. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*, 166 (1): 65-85.
- Schroeder R. & Willems H. (1983b). Chaetetiden, Sphinctozoen und Stromatoporoiden aus dem Caniego-Kalk (Ober-Alb) des Valle de Mena (Prov. Burgos, N-Spanien). *Senckenbergiana lethaea*, 64 (2-4): 337-362.
- Schultze M.S. (1854). Über den Organismus der Polythalamien (Foraminiferen) nebst Bemerkungen über die Rhizopoden im allgemeinen. Engelmann, Leipzig.
- Trauth F. (1918). Das Eozänvorkommen bei Radstadt im Pongau und seine Beziehungen zu den gleichalterigen Ablagerungen bei Kirchberg am Wechsel und Wimpasing am Leithagebirge. *Denkschriften der Kaiserlichen Akademie der Wissenschaften Wien, mathematisch-naturwissenschaftliche Klasse*, 95: 171-278.
- Ungaro S. (1996). Adaptive morphological strategy of *Gypsina* (encrusting Foraminifer). *Bollettino della Società Paleontologica Italiana*, Spec. Vol. 3: 233-241.

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