Earliest Aptian Caprinidae (Bivalvia, Hippuritida) from Lebanon

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Abstract: The presence in Lebanon of *Offneria murgensis* and *Offneria nicolinae*, two characteristic components of the Early Aptian Arabo-African rudist faunas, fills a distributional gap of the corresponding assemblage between the Arabic and African occurrences, on the one hand, and the Apulian occurrences, on the other hand. This fauna bears out the palaeogeographic placement of Lebanon on the southern Mediterranean Tethys margin established by palaeostructural reconstructions. The associated micropaleontological elements suggest an earliest Aptian age (early Bedoulian) for the *Offneria murgensis* - *O. nicolinae* assemblage found in the "Falaise de BLANCHE" stratigraphic interval, instead of a late Early Aptian age as proposed for most of the peri-Adriatic and Middle East occurrences recognized so far. These caprinid specimens are characterized by relatively modest sizes, moreover other rudists commonly part of the assemblage are lacking. The dominance of caprinids in the study area suggests a distal platform setting, *i.e.*, close proximity to the platform edge.

Key Words: *Offneria*; rudists; Aptian; Bedoulian; Jezzinian; Beirut; Lebanon.

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Résumé : *Caprinidae (Bivalvia, Hippuritida) de l'Aptien basal du Liban.-* La présence au Liban d'*Offneria murgensis* et d'*Offneria nicolinae*, deux membres clés des faunes de rudistes de l'Aptien inférieur africain ou arabe, comble un vide dans la répartition de ces associations entre sites africains ou arabes d'une part et sites apuliens d'autre part. Cette faune confirme la position paléogéographique du Liban sur la marge méditerranéenne téthysienne méridionale telle que présentée dans les reconstitutions de la tectonique des plaques. Les éléments micropaléontologiques associés suggèrent un âge Aptien basal (Bédoulien inférieur) pour l'association *Offneria murgensis* - *O. nicolinae* provenant de l'intervalle stratigraphique de la "Falaise de BLANCHE", au lieu d'un âge Aptien inférieur non basal comme ce qui est proposé pour la plupart des sites périadriatiques et moyen-orientaux connus jusqu'à présent. Les exemplaires de ces caprinidés sont caractérisés par des tailles relativement modestes ; de plus les autres rudistes faisant couramment partie de ces associations sont ici absents. La prédominance des caprinidés dans la région étudiée suggère un environnement distal sur la plate-forme, voire une proximité immédiate de sa bordure.

Mots-clefs : *Offneria* ; rudistes ; Aptien ; Bédoulien ; Jezzinien ; Beyrouth ; Liban.

Introduction

Early Cretaceous rudist bivalves have a significant record in the Mediterranean region where they are usually associated with shallow-water carbonate platforms (SIMO *et al.*, 1993). During Early Aptian times carbonate platforms were widely distributed on both the northern and the southern margins of the Mediterranean Tethys (MASSE *et al.*, 2000; PHILIP, 2003) and rudist faunas were highly diversified (MASSE, 1985, 1992; MASSE & GALLO-MARESCA, 1997; SKELTON & MASSE, 2000; MASSE *et al.*, 2002;

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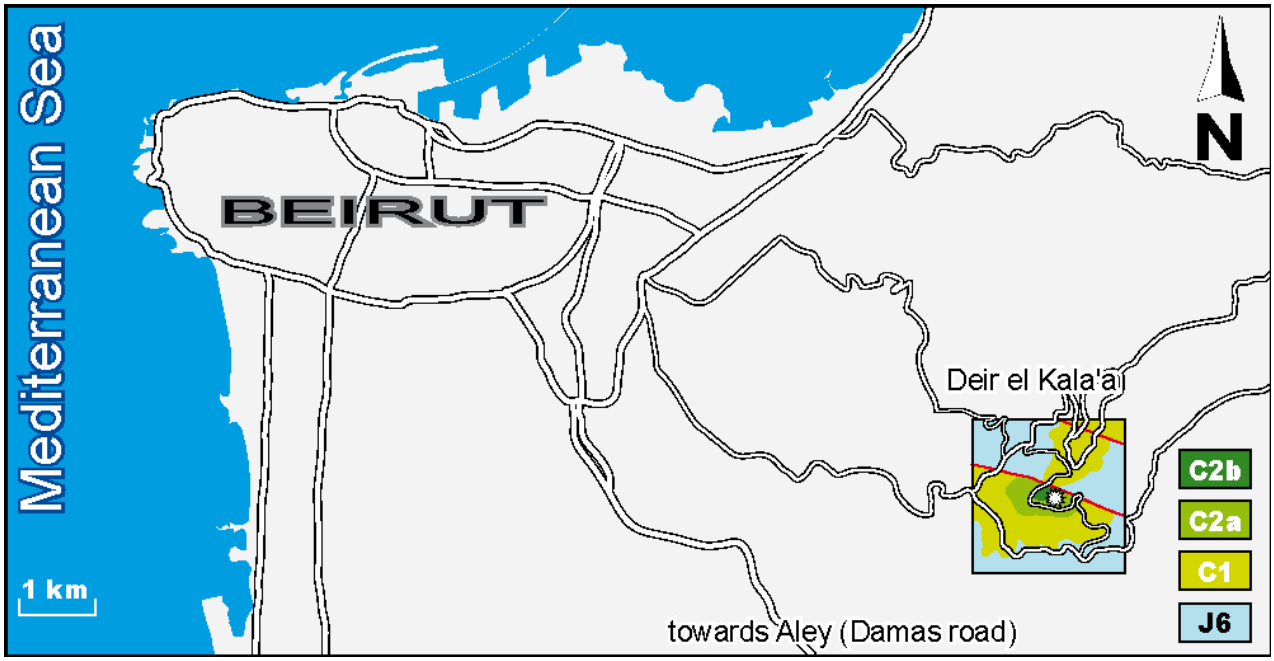

Figure 1: Location map of the area studied. J, Jurassic; C1, Grès de base; C2a, transitional beds; C2b, "Falaise de Blanche".

Skelton & Gili, 2012). Due to a mid-Aptian crisis, the faunal assemblages of the Early and Late Aptian are quite different (see discussion on the various zonal schemes and definitions of the corresponding stages or substages in Reboulet *et al.*, 2011, and Moullade *et al.*, 2011, or Skelton *et al.*, 2013). More than 90% of the Mediterranean rudist species and 70% of the genera disappeared. This extinction event affected mainly the Family Caprinidae and also drastically reduced representatives of the Requieniidae, Monopleuridae and acellular Radiolitidae (Masse, 1989, 1998a, 1998b; Skelton & Gili, 2012; Masse & Fenerci-Masse, 2014).

In Lebanon initial investigations on Early Cretaceous rudists started in the late XIXth century and were summarized by Douvillé (1910), who mentioned two radiolitids of Late Aptian ?-Albian age: *Eoradiolites plicatus* (Conrad) and *E. lyratus* (Conrad). Douvillé (1913) also reported a single Early Aptian taxon that he identified as *Agria marticensis* (Orbigny). This form was subsequently reassigned by Astre (1930) to a new species, *Agria libanica*. Following its later transfer to *Agriopleura* by Kühn (1932), *Agriopleura libanica* (Astre) was merely ignored by most subsequent paleontologists (Masse & Fenerci-Masse, 2014).

The foregoing shows that all but one occurrences of Early Cretaceous rudists from the region were essentially Late Aptian ? - Albian in age. The present paper deals with the discovery of earliest Aptian representatives of the Family Caprinidae in the "Falaise de Blanche" or Jezzinian Regional Stage, as recently reappraised by Maksoud *et al.* (2014). Our goals are to define the taxonomic position of the corresponding fauna and to discuss its stratigraphic, palaeobiogeographic and palaeoenvironmental significances.

Regional context

The town of Beit Mery[1], Matn District (Lebanon), is located in Beirut's hinterland, overlooking the Lebanese capital and the Mediterranean Sea (Fig. 1). On one of its heights ("the southern hill"), some 10 km E of Beirut corniche, 5 km N of Aley area, is the historic Maronite Monastery (Fig. 2.A) of Saint-John the Baptist (Deir al-Kalaa[2]: 35°51'16. 99''N, 35°35'52. 30"E, altitude = 716 m), which was built on the ruins (Fig. 2.A & c-D) of old Phoenician and then Roman temples (Ronzevalle, 1900; Perrot & Reinach, 1903). While visiting the site we first identified rudist sections (Fig. 2.B) in some large pieces of columns of the temple of the Roman ruins, then on the monastery exterior sidings, before been able to locate the nearby Roman quarry (Fig. 2.E), on the edge of the "hill".

In the quarry the rudist facies is in the uppermost strata of the "Falaise de Blanche" (but, due to erosion, not necessarily representing the top of the stratigraphic unit). These limestones form the structural surface on which is sited the monastery; therefore in this locality we were unable to see the transition from the Jezzinian to the overlying unit, *i.e.*, the *Cardium* beds.

[1] *also spelt "Beit Mary" and "Beit Méry"*
[2] *also spelt "Deir el-Kal'a", "Deil el-Kaala", or "Deir-el-Qala'a"*

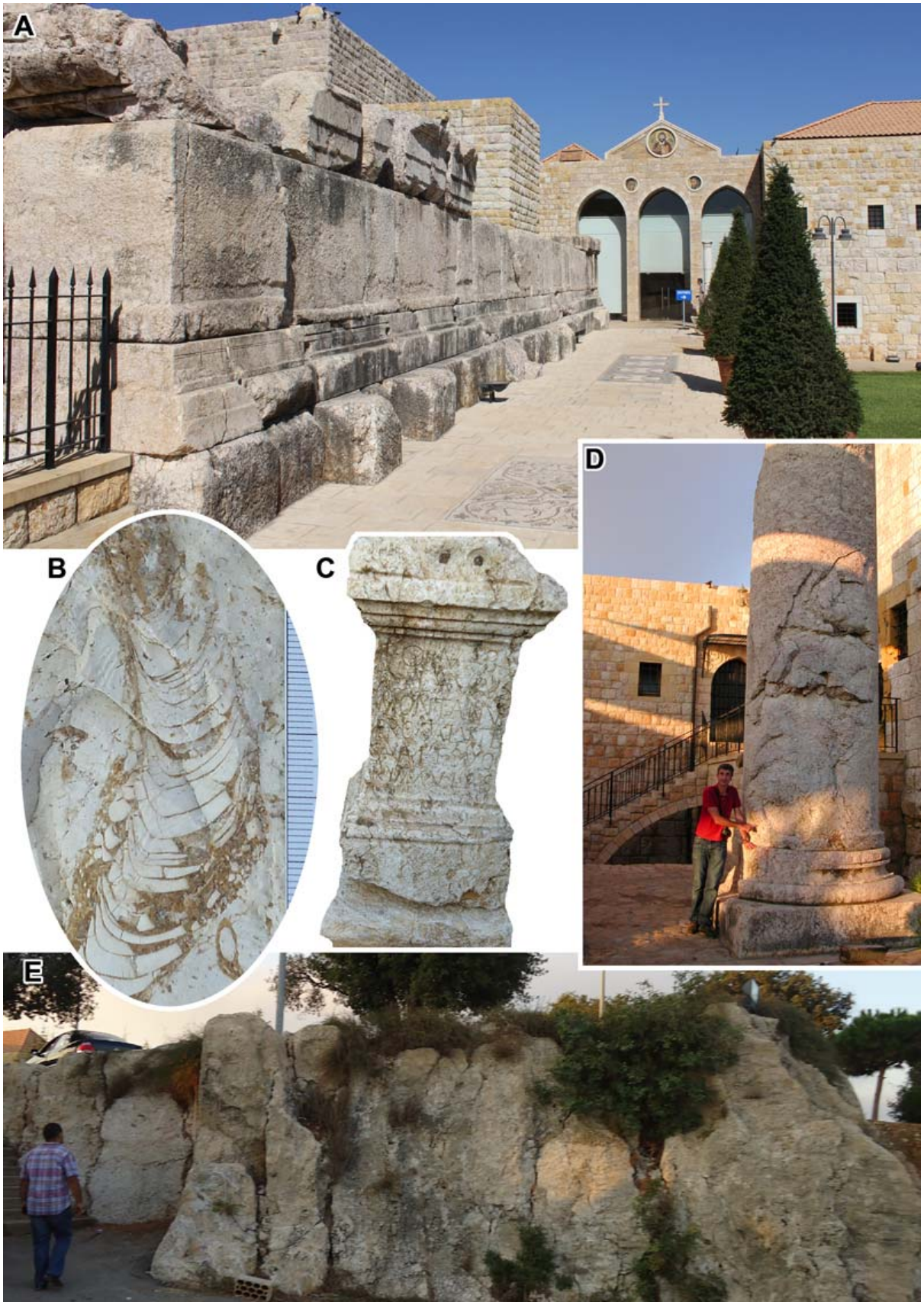

Figure 2: A) The Maronite Monastery of Saint-John the Baptist (Deir al-Kalaa), with the Roman temple basement on the left hand side of the picture; **B)** a rudist section on the side of a stele (Pl. 1, fig. I); **C)** a Roman stele with rudist sections in the garden of the monastery; **D)** a Roman column with rudist sections on the back of the monastery; **E)** the quarry, below the car park, at the entrance of the monastry.

DUBERTRET (1955) ascribes a Late Aptian to the "Falaise de BLANCHE", which appears with the label "c2b" (and ? "c2a") on the Beirut map (DUBERTRET, 1945; see Fig. 1). Below "Falaise de BLANCHE", Lower Cretaceous strata are referred to the "Grès de base" and labelled "c1" on the map. In the same area, near Beit Mery and W of Mansourieh, TIXIER (1965, p. 23-25) measured a 150 meter-thick section consisting mainly of sandstones below the first limestones bearing "Nérinées" representing the base of the "Falaise de BLANCHE".

Taxonomic aspects

Rudist occurrences in the "Falaise de BLANCHE" are mostly represented by sections photographed on natural or artificial (quarried) outcrops and polished slabs. Sections are ascribed to the genus *Offneria* PAQUIER, 1905 (Caprinidae), which is characterized by the presence of pallial canals on both valves. Canal walls are essentially radial and are associated with oblique or tangential, vertical partitions; in addition, transverse, concave cupules (*i.e.*, towards the commissure) are also present, giving the overall canaliculate structure a somewhat complex architecture; cupules are numerous in the RV - right valve - and much rarer in the LV - left valve - (PAQUIER, 1905; MASSE, 1992; CHARTROUSSE, 1998).

The identification of species is based on the descriptions of MASSE (1992), CHARTROUSSE (1998) and CHARTROUSSE and MASSE (1998).

***Offneria murgensis* MASSE (1992):** This species is represented by numerous sections of both valves. The antero-posterior diameter of sections of the LV is in the range of 3-4 cm, and the dorso-ventral dimension is in the same range. Longitudinal sections show a prosogyral, spirogyrate habit; low density of tabulae in the body cavity and low density of transverse partitions in the canals (Pl. 1, figs. A & C). There is a single row of ventral, ogival or pyriform canals with few radial bifurcations, except at the antero-ventral and postero-ventral edges (carina) with one or two orders of bifurcations (Pl. 1, figs. A-B & D). The ventral side is slightly depressed (Pl. 1, figs. A-B). Sections of the RV are poorly preserved but show the high density of cupulate canals giving to the tangential, longitudinal sections a grid-pattern (Pl. 1, figs. E-F). The overall transverse dimensions of the Lebanese specimens are slightly smaller than those of the type material from Italy (CHARTROUSSE, 1998); this may be due either to the fact that the recorded sections are not commissural or more probably to a more primitive evolutionary state. Another difference, having the same significance, is the scarcity of bifurcations of ventral canals, a common feature of apical sections of *O. murgensis* from Italy and the Middle East.

***Offneria nicolinae* (MAINELLI, 1983):** The recognition of this species is essentially based on longitudinal sections of the RV, which is characterized by a relatively small diameter (1.5 to 2 cm), a significant elongation (up to 10 cm), a high density of tabulae in the body cavity, and a high density of cupules in the shell wall (Pl. 1, figs. H-I). A transverse section of the LV with a small antero-posterior diameter (2.5 cm) and radially elongated, subrounded to ogival, simple (non-bifurcated) canals, lacking tabulae in the body cavity, is tentatively ascribed to *O. nicolinae*, because the ventral canals are not well preserved (Pl. 1, fig. G).

Palaeobiogeographic significance

The palaeobiogeographic distribution of Early Aptian *Offneria* species in the Mediterranean Tethys is not uniform and two assemblages with contrasting ages and spatial distributions have been recognized. The first assemblage with *O. rhodanica* PAQUIER (1905), *O. interrupta* PAQUIER (1905) is cosmopolitan. It extends from Western Europe to the Middle East, and is essentially documented from the earliest Aptian (MASSE, 1976, 1996; MASSE *et al.*, 1998b, 2004: "Early Bedoulian"). The second assemblage, essentially late Early Aptian, including *O. murgensis* MASSE, *O. italica* MASSE and *O. nicolinae* (MAINELLI) (MAINELLI, 1983; MASSE, 1992; "Late Bedoulian") is restricted to the Arabo-African domain: Italy, Greece, Algeria, Bosnia, Oman, Saudi Arabia, and United Arab Emirates (MASSE, 1992; CESTARI & SARTORIO, 1995; CHARTROUSSE, 1998; STEUBER, 1999; SKELTON & MASSE, 2000; MASSE *et al.*, 2004; HUGHES, 2004). *O. arabica* CHARTROUSSE & MASSE has not hitherto been identified outside Arabia (CHARTROUSSE & MASSE, 1998). The discovery in Lebanon of two key members, *i.e.*, *Offneria murgensis* and *O. nicolinae*, belonging to the Early Aptian Arabo-African assemblage of *Offneria* is consistent with the Early Cretaceous palaeogeographic configurations placing the Levant on the Mediterranean Tethyan southern margin (*e.g.*, MASSE *et al.*, 2000), as well as with the corresponding palaeobiogeographic reconstructions based on benthic foraminifera and calcareous algae (*e.g.*, PÉLISSIÉ *et al.*, 1982) or rudists (MASSE, 1985; MASSE *et al.*, 2002; MASSE & FENERCI-MASSE, 2008). The discovery of *Offneria murgensis* and *O. nicolinae* in Lebanon fills a distributional gap of the corresponding assemblages between the Arabic (Oman, UAE, Saudi Arabia) and African (Algeria) occurrences, on the one hand, and the Apulian (Italy, Croatia, Slovenia, Bosnia, Greece) occurrences, on the other hand.

Biostratigraphic significance

In Oman *Offneria murgensis* and *O. nicolinae* are locally present in beds corresponding with the upper part of the Kharaib Formation (just below the Hawar Formation), where they are associated with *Offneria rhodanica* and *Praecaprina* sp. However *Offneria murgensis* and *O. nicolinae* are the cardinal forms found in the overlying Shu'aiba Formation where they are associated with *Offneria italica*, a rare species (MASSE *et al.*, 1998a). This Shu'aiba assemblage post-dates the OAE1a event (GRANIER, 2012, 2014; GRANIER & BUSNARDO, 2013) and its age is late Early Aptian [Note: BUSNARDO & GRANIER (2013) have reported and illustrated an ammonite assemblage typical of the Furcata Zone from the condensed section of the Shu'aiba in the Bab basin, definitively validating earlier ascriptions of GRANIER (2000, 2008) and GRANIER *et al.* (2003)]. The presence of *Palorbitolina lenticularis* (BLUMENBACH), *Palorbitolina ultima* CHERCHI & SCHROEDER, and *Praeorbitolina cormyi* SCHROEDER corroborates a late Early Aptian age (SCHROEDER *et al.*, 2010). The extent of the two *Offneria* species in the "Upper Aptian" of Saudi Arabia, as proposed by HUGHES (2004) on the basis of an erroneous calibration of benthic foraminifera (*e.g.*, *Palorbitolina lenticularis*) to calcareous nannofossils, is regarded untenable. Actually the genus *Offneria* and other associated caprinid species disappeared at the Early-Late Aptian boundary (MASSE, 1989; MASSE *et al.*, 1998a; at the boundary of the Furcata and the Martini ammonitic zones). *Offneria murgensis* is a common member of *Praeorbitolina*-bearing limestones in Italy and Algeria (LUPERTO-SINNI & MASSE, 1992; MASSE, 2003).

In Lebanon, the presence of *Praeorbitolina cormyi* SCHROEDER identified by MOULLADE and SAINT-MARC (1975), that of *Praeorbitolina wienandsi* SCHROEDER, formerly reported by HENSON as *Orbitolina discoidea* var. *libanica* (see discussion in SIMMONS *et al.*, 2000) and by SAINT-MARC as *Mesorbitolina lotzei* (see discussion in SCHROEDER *et al.*, 2010), and the possible co-occurrence of *Mesorbitolina parva* identified by MOULLADE and SAINT-MARC (1975) in the "couches à Orbitolines" (SAINT-MARC, 1970), *i.e.*, strata referred to the "Falaise de BLANCHE", may support a similar late Early Aptian age. Actually new micropaleontological data from MAKSOUD *et al.* (2014) based on re-sampling in the context of an accurate regional field survey provide a contrasting picture and suggest an earliest Aptian age for the genuine "Falaise de BLANCHE" interval, which is characterized by a *Palorbitolina lenticularis - Montseciella arabica* - ? *Rectodictyoconus giganteus* assemblage. The "couches à Orbitolines" bearing the *Praeorbitolina* assemblage are no longer referable to the "Falaise de BLANCHE" (*i.e.*, not to the Jezzinian), but to the lowermost part of the overlying *Cardium* beds. MAKSOUD *et al.* (2014) identify a discontinuity separating both discrete units. In addition to the foraminifer *Praeorbitolina*, MAKSOUD *et al.* (2014) report specimens of the ammonite *Cheloniceras cornuelianum* above this "transgressive surface". Therefore the age of the *Cardium* beds is not Late Aptian, as proposed by SAINT-MARC (1970), but late Early Aptian (MAKSOUD *et al.*, 2014).

The foregoing stratigraphic interpretation suggests that the Lebanese *Offneria* assemblage may be older than those recognized in both the Apulian and Arabian regions of the Middle East. Owing to a common trend of increasing size through time reported for rudist lineages (*e.g.*, SKELTON & MASSE, 1998; GOURRAT *et al.*, 2003, among others) the peculiar timing of this assemblage may give a clue for interpreting the relatively modest size of the specimens, compared to their younger representatives from adjacent regions, as well as for interpreting the absence of advanced forms of *Offneria* such as *O. italica*, for instance. Placing the "Falaise de BLANCHE" in the lowermost Aptian has some implications for the stratigraphic interpretation of *Agriopleura libanica* (ASTRE) (ASTRE, 1930), a species assumed to have been collected from the lower part of the stratigraphic unit studied (see DOUVILLÉ, 1913), and recently revised (MASSE & FENERCI-MASSE, 2014). *Agriopleura libanica* has a wide extent in Lower Aptian strata of the Apulian and Arabo-African regions where its age is essentially late Early Aptian. Data from Lebanon, the type region, do not match this age; therefore one can expect that the collection of new specimens will confirm the existence of this species in the earliest Aptian times.

Environmental significance of the caprinid assemblage

In Lebanon *Offneria* representatives appear to be the dominant forms of a "caprinid bearing facies", reminiscent of the "distal caprinid facies" of the Middle East (MASSE *et al.*, 1998a, 1998b) and closely resembling the European "caprinid facies" observed in Bedoulian Urgonian carbonate platforms from SE France (MASSE, 1976). This facies is characterized by the paucity of requienid and monopleurid rudists and by a close spatial or stratigraphic relationship with coral facies. A peculiar feature of the Lebanese rudist assemblage is the dominance of caprinids, whereas poorly-preserved forms (caprinids?) are present, but never abundant, and whereas both requieniids and monopleurids are absent. For instance, *Glossomyophorus costatus* MASSE *et al.*, 1984, a form very common in the Middle East and the peri-Adriatic regions (MASSE *et al.*, 1984, 2004; MASSE, 1992; SKELTON & MASSE, 1998; HUGHES, 2004), has not yet been recorded in Lebanon.

Conclusions

The discovery in Lebanon of *Offneria murgensis* and *O. nicolinae*, two key members of early Aptian Arabo-African rudist faunas, fills a distributional gap between occurrences of this assemblage in the Arabic (Oman, UAE, Saudi-Arabia) and African (Algeria) regions, on the one hand, and the Apulian (Italy, Croatia, Slovenia, Bosnia, Greece) area, on the other hand. This fauna bears out the palaeogeographic placement of Lebanon on the southern Mediterranean Tethyan margin as established by palaeostructural reconstructions. The associated micropaleontological elements suggest an earliest Aptian age for the *Offneria murgensis-O. nicolinae* assemblage instead of a late Early Aptian age as proposed for most peri-Adriatic and Middle East occurrences recognized so far. This age has some implications for dating some rudist forms, *e.g.*, *Agriopleura libanica*, found earlier in the "Falaise de BLANCHE". The studied caprinid specimens are characterized by relatively modest sizes. Other rudists that are commonly part of the assemblage (*e.g.*, in the Middle East) are lacking here. The dominance of caprinids in the area studied suggests distal platform settings and close proximity to the platform edge.

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Bibliographic references

ASTRE G. (1930).- Sur un *Agria* du Liban.- *Compte-Rendu de l'Association Française pour l'Avancement des Sciences*, Paris, (3e Groupe - Sciences naturelles, 8e Section - Géologie et Minéralogie), 54e session (Alger, 1930), p. 149-151.

BUSNARDO R. & GRANIER B. (2013).- Aptian ammonites of Abu Dhabi (United Arab Emirates).- *Carnets Géol.*, Madrid, CG2011_L04, p. 117-135.

CESTARI R. & SARTORIO D. (1995).- Rudists and facies of the periadriatic domain.- AGIP, San Donato Milanese, 207 p.

CHARTROUSSE A. (1998).- Les Caprinidae (Rudistes) du Crétacé inférieur.- Thèse Université de Provence, 128 p.

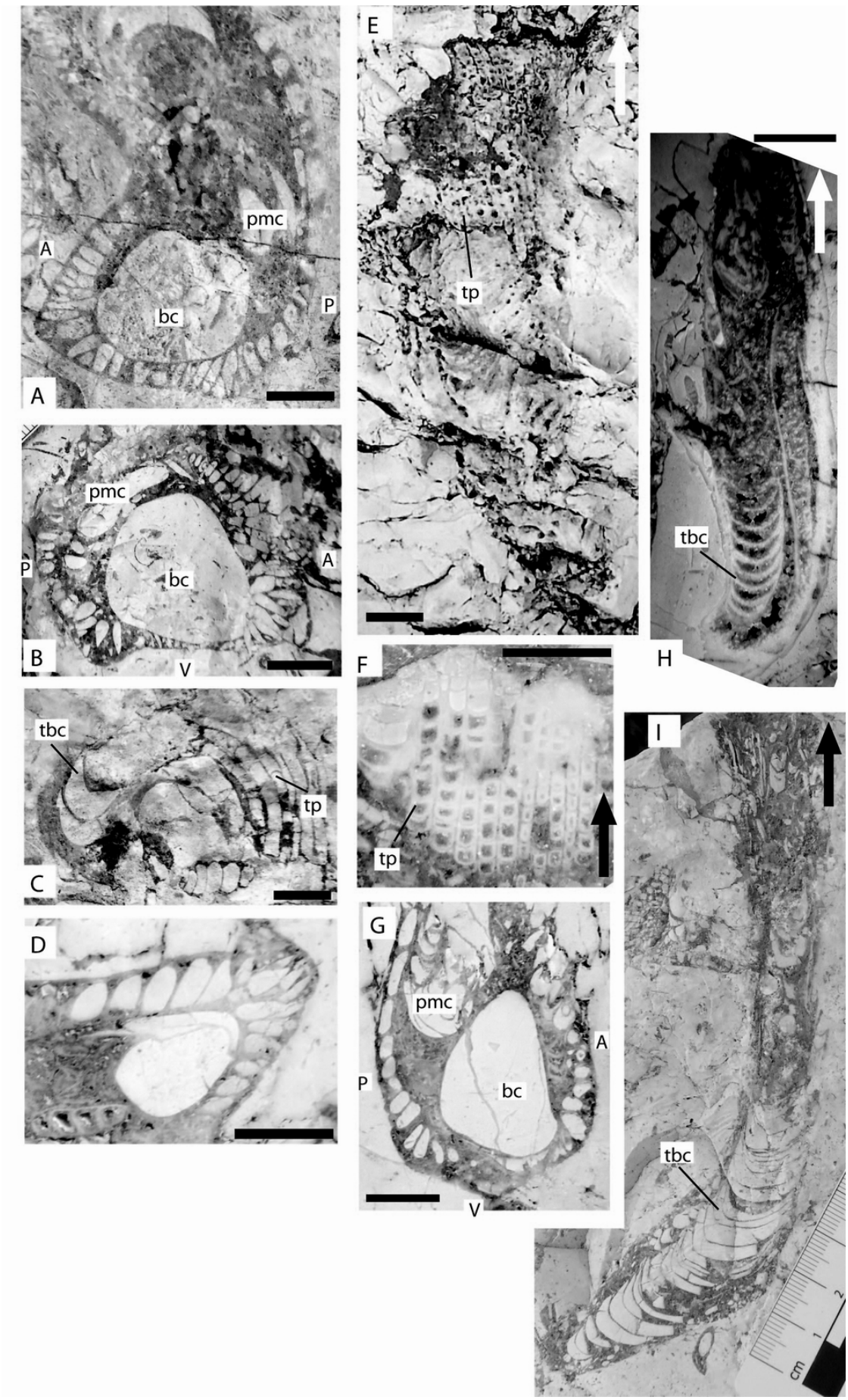
CHARTROUSSE A. & MASSE J.-P. (1998).- *Offneria arabica* nov. sp. (rudiste, Caprinidae) de l'Aptien inférieur du Djebel Madar (Sultanat d'Oman).- *Cretaceous Research*, vol. 19, p. 827-841.

DOUVILLÉ H. (1910).- Études sur les rudistes : rudistes de Sicile, d'Algérie, d'Égypte, du Liban et de la Perse.- *Société géologique de France*, Paris, (Paléontologie), *Mémoire* n° 41, t. XVIII, fasc. n° 1, 84 p. (7 Pls.).

DOUVILLÉ H. (1913).- Sur quelques rudistes du Liban et sur l'évolution des Biradiolitinés.- *Bulletin de la Société géologique de France*, Paris, (4ème série), t. XIII, p. 409-421.

DUBERTRET L. (1945).- Carte géologique au 50.000ème Feuille de Beyrouth.- Ministère des Travaux Publics, Beyrouth.

▶ **Plate 1: *Offneria murgensis*: A)** Transverse oblique section of a LV showing the canaliculate shell structure, the arcuate prosogyrate shape and tabulae of the body cavity; **B)** transverse section of a LV showing the canaliculate habit with pyriform canals, ventral side somewhat damaged; **C)** Longitudinal section of a LV showing the arcuate shell habit, tabulae in body cavity and sparse transverse partitions; **D)** Close up of the antero-ventral edge of a LV showing the bifurcation (several orders) of canals; **E)** Longitudinal section of a RV showing the high density of cupules within the canals; **F)** Close up of the grid like pattern of canal system of a RV. ***Offneria* cf. *nicolinae*: G)** Transverse oblique section of a LV showing the canaliculate habit, posterior canals ogival (becoming rectangular-tangential towards the apex, due to the obliquity of the section), ventral portion damaged. ***Offneria nicolinae*: H)** Longitudinal section of a RV showing the high density of concave tabulae in the body cavity; **I)** *Ibidem* [Scale bar 1 cm].
A part of the studied material will be registered with MHNUL numbers in the collections of the Muséum d'Histoire naturelle, Université Libanaise, Fanar - El-Matn (Lebanon).
Legend: A - anterior, P - posterior, V - ventral, D - dorsal, tp - transverse partitions, tbc - tabulae of the body cavity (bc), pmc - posterior myocardinal cavity (LV), arrows point to the commissure.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DUBERTRET L. (1951).- Notice explicative de la Carte géologique au 50.000ème Feuille de Beyrouth.- Ministère des Travaux Publics, Beyrouth, 66 p. (12 Pls.).

DUBERTRET L. (1955).- Notice explicative de la Carte géologique du Liban au 200.000ème.- Ministère des Travaux Publics, Beyrouth, 74 p. (30 Pls.).

FENERCI-MASSE M. (2006, unpublished).- Les communautés à rudistes du Crétacé inférieur de la marge ouest européenne de la Téthys.- PhD thesis, Université de Provence (Aix-Marseille I), 436 p.

FENERCI-MASSE M., MASSE J.-P., ARIAS C. & VILAS L. (2006).- *Archaeoradiolites*, a new genus from the Upper Aptian of the Mediterranean region and the origin of the rudist Family Radiolitidae.- *Palaeontology*, vol. 49, p. 769-794.

GOURRAT C., MASSE J.-P. & SKELTON P.W. (2003).- *Hypelasma salevensis* (FAVRE, 1913) from the Upper Kimmeridgian of the French Jura, and the origin of the rudist Family Requieniidae.- *Geologia Croatica*, Zagreb, vol. 56, nº 2, p. 139-148.

GRANIER B. (2000).- Lower Cretaceous stratigraphy of Abu Dhabi and the United Arab Emirates - A reappraisal.- The 9th Abu Dhabi International Petroleum Exhibition & Conference, October 15th-18th, Conference Proceedings, Abu Dhabi, ADIPEC 0918, p. 526-535.

GRANIER B. (2008).- Holostratigraphy of the Kahmah regional Series in Oman, Qatar, and the United Arab Emirates.- *Carnets Géol.*, Madrid, CG2008_A07, 33 p.

GRANIER B. (2012).- Geochemical correlations of Shu'aiba sections: Stop trusting the trends! *In*: GAWLICK H.J. & MISSONI S., chairpersons, Sedimentology in the hearth of the Alps.- CD-ROM, 29th IAS Meeting of Sedimentology, 10th-13th September, Schladming, p. 361 (abstract).

GRANIER B. (2014).- Comment on "Early Aptian paleoenvironmental evolution of the Bab Basin at the southern Neo-Tethys margin: Response to global-carbon cycle perturbations across Ocean Anoxic Event 1a" by K. Yamamoto et al.- *Geochemistry, Geophysics, Geosystems*, vol. 15, n° 5, p. 2086-2090.

GRANIER B., AL SUWAIDI A.S., BUSNARDO R., AZIZ S.K. & SCHROEDER R. (2003).- New insight on the stratigraphy of the "Upper Thamama" in offshore Abu Dhabi (U.A.E.).- *Carnets Géol.*, Madrid, CG2003_A05, 17 p.

GRANIER B. & BUSNARDO R. (2013).- New stratigraphic data on the Aptian of the Persian Gulf.- *Cretaceous Research*, vol. 39, p. 170-182.

HUGHES G.W. (2004).- Palaeoenvironments of selected Lower Aptian rudists from Saudi Arabia.- *Courier Forschungsinstitut Senckenberg*, vol. 247, p. 233-245.

KÜHN O. (1932).- Fossilium Catalogus, 1, Animalia.- pars 54: Rudistae, Berlin, W. Junk, 200 p.

LUPERTO-SINNI E. & MASSE J.-P. (1992).- Biostratigrafia dell'Aptiano in facies di piattaforma carbonatica delle Murge baresi (Puglia, Italia meridionale).- *Rivista italiana di paleontologia e stratigrafia*, Milano, vol. 98, nº 4, p. 403-424.

MAINELLI M. (1983).- Nuove rudiste del Cretacico inferiore-medio di Monte la Costa (San Polo Matese, Campobasso).- *Bolletino della Societa Paleontologica Italiana*, Modena, vol. 22, nº 3, p. 189-208.

MAKSOUD S., GRANIER B., AZAR D., GÈZE R., PAICHELER J.-C. & MORENO-BEDMAR J.-A. (2014).- Revision of "Falaise de Blanche" (Lower Cretaceous) in Lebanon, with the definition of a Jezzinian Regional Stage.- *Carnets Géol.*, Madrid, vol. 14, nº 18, p. 401-427.

MASSE J.-P. (1976).- Les calcaires urgoniens de Provence (Valanginien-Aptien inférieur). Stratigraphie, paléontologie, les paléoenvironnements et leur évolution.- Thèse Doctorat ès Sciences, Université d'Aix-Marseille II, 3 vols., 445 p. (60 Pls.).

MASSE J.-P. (1985).- Paléobiogéographie des rudistes du domaine péri-méditerranéen à l'Aptien inférieur.- *Bulletin de la Société géologique de France*, Paris, (8ème série), vol. I, nº 5, p. 715-721.

MASSE J.-P. (1989).- Relations entre modifications biologiques et phénomènes géologiques sur les plates-formes carbonatées du domaine périméditerranéen au passage Bédoulien-Gargasien.- *Géobios*, Villeurbanne, Mémoire Spécial, nº 11, p. 279-294.

MASSE J.-P. (1992).- Les rudistes de l'Aptien inférieur d'Italie continentale : aspects systématiques, stratigraphiques et paléobiogéographiques.- *Geologica Romana*, vol. 28, p. 243-260.

MASSE J.-P. (1996).- Lower Cretaceous rudist biostratigraphy of southern France - a reference for Mesogean correlations. *In*: ALENCÁSTER G. & BUITRÓN-SÁNCHEZ B.E., eds., Number devoted to the Third international Conference on Rudists.- *Revista mexicana de Ciencias geológicas*, México, vol. 12, nº 2 (1995), p. 236-256.

MASSE J.-P. (1998).- Crises biologiques des peuplements benthiques des plates-formes carbonatées éocrétacées péri-méditerranéennes : caractérisation et origine. *In*: CHAROLLAIS J., CLAVEL B., SCHROEDER R., BUSNARDO R. & MASSE J.-P., eds., La plate-forme urgonienne.- *Publications du Département de Géologie et Paléontologie*, Université de Genève, (Série guide géologique), nº 8, p. 1-17.

MASSE J.-P. (2003).- Integrated stratigraphy of the Lower Aptian and applications to carbo-

nate platforms: a state of the art. *In*: GILI E., NEGRA M. & SKELTON P.W., eds., North African Cretaceous Carbonate Platform Systems.- Kluwer Academic publishers, p. 203-214.

MASSE J.-P., BORGOMANO J. & AL MASKIRY S. (1998a).- A platform to basin transition model: the Lower Aptian carbonates (Shu'aiba) of the northeastern Jabal Akhdar (Sultanate of Oman).- *Sedimentary Geology*, vol. 113, p. 269-280.

MASSE J.-P., BOUAZIZ S., AMON E.Q., BARABOSHKIN E., TAKORWSKI R., BERGERAT F., SANDULESCU M., PLATEL J.-P., CANÉROT J., GUIRAUD R., POISSON A., ZIEGLER M., RIMMELE G. & VRIELYNCK B. (2000).- Map 13 - Early Aptian (114-112 Ma). *In*: DERCOURT J., GAETANI M., VRIELYNCK B., BARRIER E., BIJU-DUVAL B., BRUNET M.-F., CADET J.-P., CRASQUIN S. & SANDULESCU M., eds. (2000).- Atlas Peri-Tethys, palaeogeographical maps.- Commission de la Carte Géologique du Monde / Commission for the Geological Map of the World (CCGM/CGMW), Paris, 24 maps, explanatory notes I-XX, 269 p.

MASSE J.-P., CHARTROUSSE A. & BORGOMANO J. (1998b).- The Lower Cretaceous (Upper Barremian-Lower Aptian) caprinid rudists from Oman.- *Géobios*, Villeurbanne, Mémoire Spécial, nº 22, p. 211-233.

MASSE J.-P. & FENERCI-MASSE M. (2015).- Evolution of the rudist bivalve *Agriopleura* KÜHN (Radiolitidae, Hippuritida) from the Mediterranean region.- *Palaeontology*, vol. 58, nº 1, p. 71-100.

MASSE J.-P., FENERCI-MASSE M., KORBAR T. & VELIĆ I. (2004).- Lower Aptian rudist faunas (Bivalvia, Hippuritoidea) from Croatia.- *Geologica Croatica*, Zagreb, vol. 57, nº 2, p. 117-137.

MASSE J.-P., FENERCI-MASSE M. & OZER S. (2002).- Late Aptian rudist faunas from the Zonguldak region, western Black sea, Turkey (taxonomy, stratigraphy, palaeoenvironment and palaeobiogeography).- *Cretaceous Research*, vol. 23, p. 523-536.

MASSE J.-P. & GALLO MARESCA M. (1997).- Late Aptian Radiolitidae (rudist bivalves) from the Mediterranean and southeast Asiatic regions: taxonomic, biostratigraphic and palaeobiogeographic aspects.- *Palæogeography, Palæoclimatology, Palæoecology*, vol. 128, p. 101-110.

MASSE J.-P. & PHILIP J. (1986).- L'évolution des rudistes au regard des principaux évènements géologiques du Crétacé.- *Bulletin du Centre de Recherches et d'Exploration-Production elf-Aquitaine*, Pau, vol. 10, nº 2, p. 437-456.

MASSE J.-P., SKELTON P.W. & SLISKOVIC T. (1984).- *Glossomyophorus costatus*, nov. gen. nov. sp., rudiste (Caprotinidae) nouveau de l'Aptien du domaine Méditerranéen central et oriental.- *Géobios*, Villeurbanne, vol. 17, nº 6, p. 723-732.

MOULLADE M., GRANIER B. & TRONCHETTI G. (2011).- The Aptian Stage: Back to fundamentals.- *Episodes*, Bangalore, vol. 34, nº 3, p. 148-156.

MOULLADE M. & SAINT-MARC P. (1975).- Les "Mésorbitolines" : révision taxinomique, importance stratigraphique et paléobiogéographique.- *Bulletin de la Société géologique de France*, Paris, (7ème série), t. XVII, nº 5, p. 828-842.

PAQUIER V. (1905).- Les rudistes urgoniens. 2ième partie.- *Mémoire de la Société Géologique de France, Paléontologie*, Paris, vol. XIII, p. 49-95.

PÉLISSIÉ T., PEYBERNÈS B. & REY J. (1982).- Tectonique des plaques et paléobiogéographie des grands foraminifères benthiques et des algues calcaires du Dogger à l'Albien sur le pourtour de la Mésogée.- *Bulletin de la Société géologique de France*, Paris, (7ème série), t. XXIV, nº 5-6, p. 1069-1076.

PERROT G. & REINACH H. (1903).- Inscription bilingue de Deir el Qala'a dans le Liban, près de Béryte - *Revue Archéologique*, Paris, (série IV), tome II, p. 29-49.

PHILIP J. (2003).- Peri-Tethyan neritic carbonate areas distribution through time and driving factors.- *Palæogeography, Palæoclimatology, Palæoecology*, vol. 196, nº 1-2, p. 19-37.

REBOULET S., RAWSON P.F., MORENO-BEDMAR J.A., AGUIRRE-URRETA M.B., BARRAGAN R., BOGOMOLOV Y., COMPANY M., GONZALES-ARREOLA C., IDAKIEVA-STOYANOVA V., LUKENEDER, A., MATRION B., MITTA V., RANDRIANALY H., VASICEK Z., BARABOSHKIN E.J., BERT D., BERSAC S., BOGDANOVA T.N., BULOT L.G., LATIL J.-L., MIKHAILOVA I., ROPOLO P. & SZIVES O. (2011).- Report on the 4rd International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the "Kilian Group" (Dijon, France, 30th August 2010).- *Cretaceous Research*, vol. 32, p. 786-793.

RONZEVALLE S. (1900).- Notes sur les ruines de Deir-el-Qala'a.- *Comptes rendus des séances l'Académie des Inscriptions et Belles-Lettres*, Paris, 44ème année, nº 2, p. 232-259.

SAINT-MARC P. (1970).- Contribution à la connaissance du Crétacé Basal au Liban.- *Revue de Micropaléontologie*, Paris, vol. 12, nº 4, p. 224-233.

SCHROEDER R., BUCHEM F.S.P. van, CHERCHI A., BAGHBANI D., VINCENT B., IMMENHAUSER A. & GRANIER B. (2010).- Revised orbitolinid biostratigraphic zonation for the Barremian - Aptian of the eastern Arabian Plate and implications for regional stratigraphic correlations.- *GeoArabia*, Manama, Special Publication 4, vol. 1, p. 49-96.

SIMMONS M.D., WHITTAKER J.E. & JONES R.W. (2000).- Orbitolinids from Cretaceous sediments of the Middle East - a revision of the F.R.S. HENSON and Associates Collection. *In*:

HART M.B., KAMINSKI M.A. & SMART C.W., eds., *Proceedings of the 5th International Workshop on Agglutinated Foraminifera*.- GRZYBOWSKI Foundation Special Publication, Krakow, vol. 7, p. 411-437.

SIMO J.A., SCOTT R.W. & MASSE J.-P. (1993).- Cretaceous carbonate platforms: an overview. *In*: SIMO J.A., SCOTT R.W. & MASSE J.-P., eds., Cretaceous carbonate platforms.- *AAPG Memoir*, vol. 56, p. 1-14.

SKELTON P.W. & GILI E. (2012).- Rudists and carbonate platforms in the Aptian: a case study on biotic interactions with ocean chemistry and climate**.-** *Sedimentology*, vol. 59, nº 1, p. 81-117.

SKELTON P.W., GRANIER B. & MOULLADE M. (2013).- Introduction to thematic issue, "Spatial patterns of change in Aptian carbonate platforms and related events". *In*: SKELTON P.W., GRANIER B. & MOULLADE M., eds., Special issue: Spatial patterns of change in Aptian carbonate platforms and related events.- *Cretaceous Research*, vol. 39, p. 1-5.

SKELTON P.W. & MASSE J.-P. (1998).- Revision of the Lower Cretaceous rudist genera *Pachytraga* PAQUIER and *Retha* COX (Bivalvia: Hippuritacea), and the origins of the Caprinidae.- *Géobios*, Villeurbanne, Mémoire Spécial, nº 22, p. 331-370.

SKELTON P.W. & MASSE J.-P. (2000).- Synoptic guide to the Lower Cretaceous rudist bivalves of Arabia.- *Society of Economic Paleontologists and Mineralogists*, *Special Publication*, vol. 69, p. 89-99.

STEUBER T. (1999).- Cretaceous rudists of Boeotia, central Greece.- *Special Papers in Palaeontology*, vol. 61, 229 p.

TIXIER B. (1972).- Le "grès de base" crétacé du Liban : étude stratigraphique et sédimentologique.- *Notes et Mémoires sur le Moyen-Orient*, Paris, tome XII, p. 187-215.