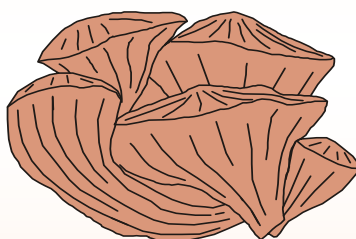


EIGHTH INTERNATIONAL CONGRESS ON RUDISTS

*CRETACEOUS RUDISTS
AND
CARBONATE PLATFORMS*

ABSTRACTS



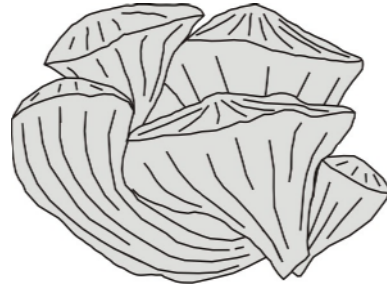
June 23-25, 2008
Dokuz Eylül University
İzmir-TUREY





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CONTENTS

SESSION-1: Palaeogeography and Depositional Environments of Cretaceous Carbonate Platforms.....	8
SESSION-2: Origins, Events and Demise of Rudist Palaeocommunities.....	26
SESSION-3: Mac Gillavry Session: Taxonomic and Phylogenetic Studies in Preparation for the Revision of Rudist Section in the Bivalvia Treatise.....	52



ABSTRACTS



SESSION-1

**PALAEOGEOGRAPHY AND
DEPOSITIONAL ENVIRONMENTS OF
CRETACEOUS CARBONATE PLATFORMS**



Cenomanian-Turonian rudist build-ups and geodynamic evolution of the Northern Chotts mountains (Tunisia)

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In Tunisia, the Cretaceous paleogeography includes the Saharan platform on the South, a platform to basin environments in the centre, and the Atlassic Tunisian basin on the North. From the Malm to the Lower Barremian, flat lying sands, clays, thin layered dolomite beds and massive gypsum were deposited. Later Cretaceous syndepositional tectonism affected both Central Tunisia and the Chotts range to the South. NW, SE-NW and locally SN-striking transcurrent faults were active from the Barremian throughout the Turonian. During this period, in the Chotts region of central Tunisia a prominent carbonate platform developed between a continental to shallow marine milieu on the Southern Saharan platform, and an open marine domain on the Northern Tunisian Trough. In addition post-Barremian sedimentation in the Chotts range was controlled by tectonic movements related to active syndepositional faults trending mainly S-N, NW-SE and E-W. In particular recurrent faulting resulted in a north- and northwestward stepped topography comprised of a series of tilted blocks bounded by major faults. These blocks delimited grabens and half-graben basins which were the sites for clayey, limy and debrite sedimentation.

From the Cenomanian to Early Turonian times a rudist-bearing carbonate platform developed in the region and was controlled mainly by eustasy and tectonism. Based on regional correlations, the analysis of lateral and vertical changes in lithofacies and thicknesses help reconstruct rudist build-ups formed during a period of sea level high stand. The Cenomanian-Turonian platform facies include abundant Rudists, particularly the radiolitids (*Eoradiolites*, *Radiolites*, *Biradiolites*, *Bournonia*,...), and are organized on a tectonically controlled shelf with raised rims. The platform growth was governed by either global eustatic or local tectonic factors; eustasy conditioned the initial establishment of the rudist-bearing platform, whereas, tectonics guided the geometry and aerial distribution of platform facies and Rudist build-ups.



Rudist build-ups observed at Khanguet Telmem (North of Gabès; Northern Chotts range, Southern Tunisia).



Distribution of rudists on the Saharan Platform during Cretaceous times

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Epicontinental seas covered the Saharan Platform during the Cretaceous period as a consequence of two main transgressive episodes that have been dated respectively as Cenomanian to Early Turonian and Late Campanian to Early Maastrichtian.

Rudist fossils are relatively abundant in the sediments deposited during the first episode. The genera *Caprinula*, *Radiolites*, *Durania*, *Sauvagesia*, and *Ichthyosarcolithes* are common in Late Cenomanian shallow marine rocks, while *Hippurites*, *Radiolites* and *Durania* occur in some Turonian outcrops. Abundance and diversity of the rudist fauna increases from South (Tinrhert) to North (Mzab, Saharan Atlas).

Deposits corresponding to Coniacien and Santonian generally consist of variegated marls with frequent gypsum beds intercalated. They are designated as “Sénonien lagunaire”, are poorly dated, and lacking of rudists.

Overlying limestones have been related to the second main transgressive episode; the occurrence of the ammonite genus *Libycoceras* dates them as Maastrichtian. Some rudists, attributed to the same age, were collected by Busson in the Tinrhert Plateau; the specimens are badly preserved inner moulds of requieniids and radiolitids.

Present data show that the palaeobiogeographic distribution of rudist is limited to the central and eastern part of the Saharan Platform. To the west, no mention of rudists is known in the western Tadmaït, the Tanezrouft, or in the coastal basins of the Gulf of Guinea. Rudists are present in the southern part of Morocco only as far as the Oued Ziz Valley. To the east, in the Maghreb region, rudists are found from Ghadamès to the Djeffara Plateau, in southern Tunisia and western Libya.

This restatement of rudists distribution allows to discuss the migration of some tethyan species and its relation with the geographic and climatic local conditions.



Cenomanian to Maastrichtian steepened ramp carbonate shelves and associated build-ups, Tunisia

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The northeastern edge of the African plate in Tunisia, is bordered to the north and northeast by the Mediterranean Sea and the Straits of Sicily. The uppermost crust bearing Meso-Cenozoic strata has long suffered Alpine and Atlasic orogenies. In the region, an Early Mesozoic rifting phase formed basins filled primarily by marls and limestones. This phase was followed by a Mesozoic-Cenozoic passive margin tectonic phase. Two distinctive periods are distinguished: i) a Triassic to Santonian transtensive epoch has structured and enlarged the Tethyan domain and has caused tilting of blocks forming horsts, grabens and half graben basins; ii) from the Late Cretaceous to Burdigalian-Langhian times, plate margin collision between Africa and Southern Europe and subsequent stress have governed transpression, reverse faulting, folding, and Triassic salts ascending in transcurrent reactivated shear-zones.

From the Cenomanian times throughout the Maastrichtian the rugged Tethyan paleogeography was covered by marls and limestones. Subsidence, blocks expulsion, tilting and uplift, and ascending Triassic evaporites as well, were controlled by master fault kinematics with great lateral/vertical changes in lithofacies and thicknesses of the Mesozoic sequences. Furthermore, the Upper Cretaceous is composed of almost flat-laying chalky limestones organized in distally steepened ramps and rimmed shelves (*sensu* Read, 1982, 1985) which pass upward to Cenozoic clays, lime- and dolostones. Field data, seismic profiles and well correlations help reconstruct reef buildups, which may either populate or rim isolated and distally steepened ramps of carbonate shelves. Three main provinces are distinguished:

In the Atlasic province of Central Tunisia, tectonically induced reef buildups were associated with stacked ramps on tilted block morphology. Other buildups are on fault-related and salt-cored folded antiforms, transitional between a platform and pelagic basin settings remote from continental detritus.

In the Gulf of Hammamet and the Pelagian block domain, distally steepened carbonate ramps were constructed during the Cenomanian-Maastrichtian, where reef buildups populated the outer ramp above fair weather base level. Some were eroded and in the resulting biotrital limestones form petroleum reservoirs.

In the Gulf of Gabès bioherm development was affected by tectonism and eustasy. These are oil prone (Isis, Miskar oil-gas fields) and formed prevalently on tectonically induced antiforms.

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Controls and evolution of Upper Cretaceous carbonate platforms developed within volcano-sedimentary cycles of the Upper Cretaceous of Southwestern Puerto Rico

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In the Late Cretaceous carbonate platforms of Santonian, Campanian and Maastrichtian age developed as part of volcano-sedimentary cycles in southwestern Puerto Rico. The platforms are preserved as carbonate lenses within thick sequences of volcanic and volcanoclastic deposits. The platforms developed during volcanic quiescence and subsidence of the magmatic arc and are interpreted to represent transgressive systems tracts (TST) in the lower part of the platform followed by the high stand system tracts (HST) in the top. In the case of the Cotui Limestone a paleokarst topography represents a type 1 sequence boundary. The Peñones Limestone, a narrow platform of Campanian age, is interpreted to represent carbonate deposition during the normal regression of the lowstand systems tract (LST). El Rayo Formation, of Maastrichtian age, is probably a carbonate ramp.

Rudistid bivalves within these platforms are key in this interpretation. Most rudistid are facies restricted. However *Durania curasavica* occur throughout the Cotui platform showing different morphotypes depending in the system tract that it occur.

This study includes the extension of the work done in southwestern Puerto Rico toward the east to include the Parguera, El Rayo, and Pico Rodadero Limestone. This last one is described here for the first time.



Rudist-bearing Campanian-Maastrichtian fore-arc sequences of the Amasya Region (Central Pontides, Turkey)

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In the Amasya Region, a Campanian-Maastrichtian fore-arc sequence developed over the basement rocks which comprise metamorphic Tokat Massif, Jurassic-Lower Cretaceous pelagic and neritic limestones with rudists and Cretaceous North Anatolian Ophiolitic Melange.

Transgressive sequence starts with fluvial reddish clastics, which grades into sandstones and limestones with in situ rudists. The rudist fauna comprise *Hippurites colliciatus* Woodward, *Vaccinites ultimus* (Milovanovic), *Vaccinites oppeli*, *Vaccinites loftusi* Woodward, *Yvaniella alpani* Karacabey, *Yvaniella maastrichtiensis* Milovanovic, *Yvaniella philipii n. sp.*, *Bournonia* sp., *Biradiolites* sp. and radiolitid sections. Corals and algae are also observed. Karacabey (1968) proposed a Campanian age for the rudist fauna. Steuber et al. (1998) also suggested an early Campanian age based on Sr-isotope analysis of rudist shells.

The rudistid limestones pass upward to volcanogenic flysch type rocks consisting of alternation of sandstones-pelagic mudstones and limestones, which include volcanic interclations, basaltic dykes, slumps and blocks of limestones with rudists such as *Hippurites colliciatus* Woodward, *Hippurites* sp., *Vaccinites* sp. and radiolitids, derived from the platform. The planktonic foraminifers indicate a late Campanian-Maastrichtian age for the volcanogenic flysch type rocks.

The upper part of the sequence is characterized by pyroclastic rocks, volcanic breccias, volcanics and tuffs showing very wide distribution in the region and also by the alternation of rudistid limestones and volcanics and yellowish-reddish volcanogenic sandstones. The rudistid limestones contain biradiolitid, radiolitid and canal-bearing rudist sections and some bivalves and algae.

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This study is supported by the TÜBİTAK Project No.106Y144.



Albian rudist fauna from the Karaburun Peninsula, Izmir Region, Western Turkey

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Platform carbonates bearing shallow water foraminifera and dasycladale assemblages with an Albian stratigraphic significance, outcrop at two localities from the Karaburun Peninsula: Barbaros and Zeytineli. Rudist faunas collected from these localities include: *Toucasia seunesi* Douvillé, *Pseudotoucasia catalaunica* Astre, *Mathesia* cf. *darderi* (Astre), *Petalodontia* ? sp., and *Eoradiolites* sp. aff. *murgensis*. The overall stratigraphic significance of this fauna is consistent with the Albian age derived from micropaleontological data. Some taxonomic elements, e.g. *Toucasia seunesi*, *Pseudotoucasia catalaunica* and *Mathesia darderi* possess a broad Mediterranean palaeobiogeographic distribution. By contrast *Eoradiolites* sp. aff. *murgensis*, an advanced form resembling *Eoradiolites murgensis*, restricted to the Mediterranean South Tethyan margin, has a potential to be a marker for the corresponding biome. These findings fill a gap in our knowledge on Mediterranean Albian faunas considered hitherto virtually absent from Anatolia.



Upper Cretaceous litho-biostratigraphy and evolution of the Bey Dağları carbonate platform, western Taurides, Turkey

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Detailed investigations on the planktonic foraminifera, benthonic foraminifera and rudist biostratigraphy and carbonate microfacies analysis of 1734 limestone samples from the 37 stratigraphic sections measured from the Upper Cretaceous sequences of the Bey Dağları Autochthon (western Taurides) yield new and important data, which clarify the Late Cretaceous evolution of the Bey Dağları carbonate platform.

The Upper Cretaceous sequences of the Bey Dağları Autochthon are divided into three geographical areas (Southern, Northern and Eastern areas) as they show different biotic and sedimentary characteristics possibly related to the different evolutionary history. The Upper Cretaceous of the southernmost part of the autochthon (south of Susuzdağ) is represented by neritic limestones. The Eastern (Katran Dağ) area is characterized by the Middle-Upper Cenomanian rudist-rich limestones (caprinid lithosomes). The Northern area (between Susuzdağ and Çamlıdere) has important data explaining the evolution of the platform. Hence this study focuses on this area. The Bey Dağları Formation in the northern part of the autochthon can be divided into two parts. The approximately 700-m-thick middle Cenomanian-Coniacian inner platform-peritidal carbonates form the basal part and are capped with the 26-m-thick Coniacian-Santonian hemipelagic limestones that form the upper part. The 100-m-thick Late Campanian-Late Maastrichtian Akdağ Formation comprises planktonic foraminifera-bearing pelagic limestones and disconformably overlies the various stratigraphic levels of the Bey Dağları Formation along a prominent hardground or erosional surface. The Palaeogene pelagic marls disconformably rest over the different stratigraphic levels of the Upper Cretaceous sequence.

The lower part of the platform limestones (Middle-Upper Cenomanian) is represented by relatively rich benthonic foraminiferal assemblages, while the upper part (Turonian-Coniacian) contains poor assemblages. These data correlate well with the other Mediterranean successions. *P. reicheli*-*P. dubia* Concurrent Range Zone is defined from the Middle-Upper Cenomanian platform limestones. The biozone includes *C. lehneri* Subzone and *C. zubairensis* Subzone, which correspond to the Middle Cenomanian and Upper Cenomanian respectively. The first occurrences of *M. apenninica-compressa* and *P. sphaeroidea* indicate the Late Turonian and the Coniacian respectively. The uppermost part of the neritic succession in the northern part of the autochthon is represented by the abundance of rudist bivalve *Vaccinites praegiganteus* (Toucas) (hippuritid lithosomes). The lithosome can be traced patchily throughout the northernmost part of the autochthon as a marker level. Analysis of geochemically well-preserved low-Mg calcite of shells of *Vaccinites praegiganteus* (Toucas) for $^{87}\text{Sr}/^{86}\text{Sr}$ values has yielded a late Turonian age.

Analysis of planktonic foraminifera from the hemipelagic and pelagic limestones yields six biozones, from old to young, *Dicarinella concavata* Interval Zone (IZ), *Dicarinella asymetrica* Total Range Zone (TRZ), *Radotruncana calcarata* TRZ, *Globotruncana falsostuarti* Partial Range Zone (PRZ), *Gansserina gansseri* IZ and *Abathomphalus mayaroensis* IZ. *Dicarinella concavata* IZ and *Dicarinella asymetrica* TRZ are identified from the Coniacian-Santonian massive hemipelagic limestones of the Bey Dağları Formation, which are represented by rare planktonic foraminifera and abundant calcispheres content. The last four biozones are defined from the pelagic limestones of the Akdağ Formation and indicate a Late Campanian-Late Maastrichtian time interval. The planktonic



foraminifera observed in the last four biozones are diverse, large, thick-walled and complex morphotypes (K-selection), which dominate in open oceans, mainly during onset of high stands of sea level.

The data reveal that the global sea level rise at Cenomanian-Turonian boundary, which caused the general demise of many Tethyan carbonate platforms did not result in deepening on the Bey Dağları carbonate platform and neritic accumulation persisted from Middle Cenomanian to the Coniacian. The examination of the planktonic foraminifera shows that the platform was subsided after the Turonian (probably within the Coniacian) and yields recognition of two main sedimentary gaps within the Upper Cretaceous pelagic sequence. Lower to Middle Campanian and uppermost Maastrichtian-middle Palaeocene are absent in all measured stratigraphic sections except for the Çamlıdere area, from where we do not have enough data.

The incipient drowning of northern part of the platform after the Late Turonian produced a hemipelagic environment that would persist until the end of the Santonian. The platform was drowned after the Santonian and the pelagic deposits invaded the northern part of the platform. The drowning events were likely linked to the regional crustal extension, which may have been the driving force of subsidence of the carbonate platforms after Cenomanian times as a result of the extensional collapse caused by 'roll-back' of down going, north dipping Late Triassic-Jurassic oceanic crust located in the south of the platform. The Lower-Middle Campanian and uppermost Maastrichtian-middle Palaeocene hiatuses in the pelagic sequence are ascribed to the regional tectonics as the easternmost Mediterranean area was subjected to the important tectonic events during the Late Cretaceous. The second hiatus may have been related to the compressional tectonics as the Maastrichtian was the closure time for the Arabo-African and Eurasian plates and the initial stages of emplacement time of the Antalya complex in this particularly critical area of Tethys. Eustatic sea level changes may have had a secondary effect on the Upper Cretaceous carbonate successions of the Bey Dağları Autochthon.



**Sedimentological and taphonomic geodatabase of rudists from Senonian limestones
of the central-southern Apennines, Italy**

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Senonian carbonate sequences, cropping out in central-southern Italy, were deposited on wide open shelves occupied by foramol assemblages mostly dominated by rudist bivalves. Rudists occur in all shelf sectors, from more open, external to more internal areas, occupying different substrata and furnishing the bulk of the skeletal components.

In the carbonate domains of the central-southern Apennines two main rudist-rich depositional settings (end-members) have been documented. They have been referred to different hydrodynamic conditions (high energy vs. low energy) and are characterized by specific benthonic assemblages, forming depositional geometries of rudist lithosomes (Simone et al., 2003).

In order to document the rudist distribution and sedimentary features in the two main recognized hydrodynamic settings, the palaeontological database of rudist bivalves (Steuber and Löser, 2000; Steuber, 2002) has been updated. This database contains exclusively published data on the taxonomy, regional and stratigraphical distribution of rudist bivalves. Data from the central southern Apennines have been converted into a MS ACCESS database and then improved with data derived from additional publications and unpublished data of from studies carried out in the region. All references have been inserted by using bibliographic fields. The database also records data about the taphonomic and sedimentological features of the sequences described.

Moreover, each locality has been checked on a map in order to verify the correct geographical position (*Long, Lat, Easting, Northing*). The database is managed into a GIS project and allows to display the geographical distribution of species related to stratigraphy and hydrodynamic significance. The availability of informations about the sedimentology also permits regional and palaeogeographic interpretations.

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Cretaceous evolution of a rudist-bearing carbonate shelf (Matese Mountains, central-southern Apennines, Italy)

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The Matese Mountains (central-southern Apennines, Italy) are part of the Apulia Platform, according to recent studies. Cretaceous limestones, cropping out in central-eastern sectors of these mountains, previously interpreted as monotonous shallow water deposits have been re-evaluated as indicative of more complex and articulated depositional settings. Although in the lower Cretaceous successions (up to middle Aptian times), carbonate depositional systems have been recognized, in which uniform lagoonal muddy deposits were prevalent, since the late Aptian a dramatic change has been well documented. Sea level variations interacting with tectonic events resulted in a drastic reorganization of the depositional systems. Multiphase tectonic events delineated sectors which acted persistently or temporarily as either inner platform, or marginal or transitional areas, giving rise to a complex and articulated palaeotopography. In addition, some sectors underwent more or less prolonged subaerial exposure. Since the middle Aptian and throughout the Late Cretaceous, the older shallow water limestones were overlaid by open shelf carbonate deposits laterally passing to relatively deeper marginal deposits. As regard to the sedimentological and palaeoenvironmental evolution, two main sectors have been recognised. The central-northern sector documents rudist-dominated production areas throughout Cretaceous times although more or less prolonged emersion episodes occurred. The shelves were characterized by loose bioclastic covers in which scattered rudist congregations settled. The eastern sector shows a rapid shift from inner lagoonal areas to tectonically-controlled marginal areas during the middle Aptian-early Albian interval. Reworking and resedimentation episodes mainly controlled the deposition in these marginal-transitional areas. The early mid Aptian structuring event, which gave rise to a marginal setting in the eastern Matese sectors, is also readable in the shallow water central-northern Matese successions. The latter, in fact, evidence more open sea conditions starting from middle Aptian-early Albian times, with a dramatic increase in frequency and intensity of storm-related facies even in the innermost shelf sequences.



**Rudists and depositional environments of the Senonian limestones of Premuda,
Ist and Silba Islands (Adriatic Coast, Croatia)**

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Depositional environments with pelagic limestones have been studied from three localities in southwestern part of the Adriatic carbonate platform. Sections on Ist, Premuda and Silba islands allow us to reconstruct paleogeographical and paleoenvironmental conditions of investigated part of the carbonate platform during the Senonian.

In the studied sections Ist and Premuda, two lithotypes vertically exchange: (1) pelagic mudstones-packstones with intercalations of shallow water material (predominately rudist floatstone and wackestones-packstones with benthic fossils) and, (2) laminated mud supported limestones with pelagic fossils.

At Silba section, pelagic wackestones-packstones are in vertical exchange with rudist floatstones-rarely rudstones, which are more common in lower part of the succession.

Rudist shells present within floatstones and rudstones from all studied sections are elevators. According to the proximity of the shallow water carbonate platform interior (Moro & Jelaska, 1994) the depositional setting of analyzed sediments could be considered as platform-open sea transect with two major sedimentary groups: pelagic carbonates and resedimented shallow water carbonates (Flügel, 2004). Depositional environments of Ist and Premuda profiles could be interpreted as of more distal origin, while Silba profile represents more proximal part of the transect sediments.

Paleogeographically, depositional environments of these sediments, indicate that more open and relatively deeper depositional environments characterized the SW part of the Adriatic carbonate platform.

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Rudist-bearing Upper Cretaceous deposits of Medvednica Mountain, Northern Croatia

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The Upper Cretaceous deposits of Medvednica Mt. (Polšak, 1981) have been studied from four localities (Mikulić potok, Donje and Gornje Orešje and Vidovec-Planina). There rudist congregations within transgressive sediments overly Paleozoic or Triassic deposits.

Within transgressive sediments, the rudist floatstones could contain diverse shallow-marine fossil community, composed of corals, gastropods, corallinaceans and benthic foraminifers. These sediments at Mikulić potok and Donje Orešje localities passed into sediments deposited in deeper, open water pelagic environments.

The age of rudist bearing transgressive sediments at Mikulić potok, Donje Orešje and Gornje Orešje localities, based on the macro- and microfossil assemblages (pelagic foraminifers and nannoplankton) is Campanian.

At Vidovec-Planina locality, the transgressive sediments with rudist congregations are of the Maastrichtian (Polšak, 1985) age based on benthic foraminifers.

The depositional setting may be considered as transgressive system with relatively fast sea-level rise. This probably resulted with flooding of new areas of paleorelief and the outcome is the age differences in rudist bearing transgressive deposits. Facies transition from shallow water rudist bearing environments to deeper water environments is relatively sharp. Scarce presence of rudists within relatively broad area of transgressive deposits coincides with absence of distinct shoal/barrier deposits. It could be presumed that rudist congregations within transgressive sediments are scattered probably due to more or less favorable paleoecological conditions for their larval settlement.

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A geological and paleontological survey of the classical site of Bacevica (eastern Serbia)

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The rudist genus *Pseudopolyconites* was established in 1934 by the famous Serbian palaeontologist Milovanovic. The first specimens of this rudist were recovered close to the village of Bacevica which is considered the type-locality of the fore-mentioned genus. According to Milovanovic and Grubic (1971), specimens of the new genus together with a large variety of rudists created a well developed bioherm, the so-called "Vrbovac reef".

Two investigations on the spot were carried out by A.T. during 2006 and 2007 in the area between Vrbovac and Bacevica. No vestiges of the Vrbovac reef nor beds of limestones with rudists and corals have been observed in the explored territory. But rudist bivalves are abundant: they have also been found in fields, in soils derived from the weathering of dacitic/andesitic tuffs and/or tuffaceous arenites. In this case the rudists are found mostly in growth position with respect to the presumed bedding. They are intact, without evidence of bioerosion, and mostly articulated. No trace of carbonate matrix has been found on the shells. The filling sediment of the rudist shells is characterized by variable amounts of quartz and clayey minerals. The specimens are isolated from each other and no type of congregation of individuals has been detected. The lack of rudist-bearing strata does not permit to describe lithofacies, sedimentological features and microfossil content or to interpret the depositional setting.

A large number of species of *Pseudopolyconites* collected near Bacevica has been established by the Serbian rudistologists. According to the Serbian workers, the change of the shape of the ligamental ridge head (and stem) in the middle and lower parts of the right valves is the fundamental criterion for distinguishing the different species of *Pseudopolyconites*. A careful reading of the specific literature, minute inspections of many slabs of different specimens and finally an approach based on biometrical analysis of the various species of *Pseudopolyconites* inclined us to believe that the existing ones should be reconsidered within the concepts of the inherent variability of the biological species.



The stratigraphical position of the rudist formations of the Sant Corneli anticline, southern central Pyrenees, based on strontium isotope analysis of the hippuritid rudist shells

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Two lithologically comparable rudist formations crop out around the Sant Corneli anticline, southern Central Pyrenees, the rudist formation of the Collades de Basturs on its southern flank and Sant Martí de Vilanoveta on its northern flank. Earlier biostratigraphical studies (Gallemí et al., 1983) assigned different ages to these two formations, the first being considered middle-upper Santonian, and the second, Coniacian-lower Santonian, although the benthic fossils (rudists and echinoids) contained in them comprise similar, broadly ranging taxa. The stratigraphy of the Sant Corneli Formation was revisited (Vicens et al., 1998), and the rudist formation of the Sant Martí de Vilanoveta (Sant Pere de Vilanoveta Member) was considered to be of middle Santonian age based on lithostratigraphical correlation with ammonite and inoceramid bearing sedimentary sequences of the region, so disagreeing with previous results. New biostratigraphical data based on calcareous nannofossils (Hughes et al., 2004) for the rudist formation of the Collades de Basturs (Collades Member) suggested an upper Turonian-Coniacian age that is inconsistent with the Santonian age determinations mentioned above.

The numerical age derived from strontium isotope stratigraphy (SIS) for the Sant Pere de Vilanoveta Member is consistent with the middle Santonian age that was inferred by stratigraphically sensitive taxa (inoceramids and ammonites) in laterally equivalent slope deposits and in deposits that overlie the rudist formation (Vicens et al., 1998). For the Collades Member, the middle Santonian age indicated by SIS agrees with the broadly established rudist, echinoid, and benthic foraminifer evidence for a Santonian age of the rudist formation (Gili, 1993), so casting doubt on the problematic upper Turonian-Coniacian age assignment of the nannofossils (Hughes et al., 2004). These conclusions imply a similar age of deposition of the two rudist formations.

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Numerical ages of Late Cretaceous (Campanian-Maastrichtian) rudist formations of southeastern Anatolia

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Numerical ages have been derived from strontium-isotope stratigraphy of rudist shells from localities in southeastern Anatolia. The elemental composition of the shells studies argues for the preservation of the original seawater Sr-isotope values.

All studied rudist formations were previously considered to be of Maastrichtian age, based on the biostratigraphy of larger benthic foraminifers. Some of the rudist formations studied are located on the former Afro-Arabian Plate while others have a European plate tectonic affinity. These different palaeogeographical settings are reflected in significantly different rudist associations.

Species-rich rudist associations with European affinity in the vicinity of Yazıhan and Hekimhan (Malatya Basin) are of Late Campanian age. A late Maastrichtian age was found for a low-diverse association dominated by *Miseia* near Sarıkız. In the Kahta-Adıyaman area, prolific rudist associations of the Terbüzek Formation are of Late Campanian age. The *Dictyoptychus*-bearing basal levels of the overlying Germav Formation are of Early Maastrichtian age. A similar age has been derived from shells of *Dictyoptychus* at Eskikahta. A Late Campanian age is evident for shells from Yayladağı, south of Antakya, the type locality of several rudist taxa endemic to the Afro-Arabian Plate.

As a result of our study, the age of many species-rich rudist associations of southeastern Anatolia must be revised to the Late Campanian. Maastrichtian associations of the Afro-Arabian Plate are dominated by *Dictyoptychus*. This genus is also abundant in the Upper Campanian Terbüzek Formation.



Distribution and abundance of rudist bivalves in the Cretaceous carbonate platform sequences in Egypt: Time and space

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The Rudist bivalves became an abundant element in the tropical carbonate platforms during the Cretaceous Period, adapting to shallow marine settings. Rudists had a relatively short stratigraphic range starting in Late Jurassic and becoming extinct by the end of the Cretaceous. In Egypt, rudists were first recorded in the early twentieth century (Fourtau, 1900, 1903; Dacqué, 1903; Douvillé, 1910, 1913). Because rudists represent important organic buildups, this study emphasizes vertical and spatial distribution of this group of bivalves in all geographic divisions of Egypt, including Western Desert, Eastern Desert and Sinai. Rudists are encountered in different rock facies ranging from mudstones to carbonates. About sixty species belong to nineteen genera are reported from Egypt. They belong to five families: Requieniidae, Monopleuridae, Caprinidae, Hippuritidae, and Radiolitidae. The Radiolitidae is the most diverse family, comprising ten genera and forty-five species, dominated by species of *Durania* and *Radiolites*. The elevator morphotypes of the Radiolitidae became the dominant species in the Turonian sequences. In general, rudist diversity at each site separately is not great. However the diversity (richness) peaks in the Turonian (36 species) and Cenomanian (22 species) with few records in Albian, Coniacian and Campanian (totally 5 species). As yet rudists are not recorded from Maastrichtian rocks. Geographically, rudists are highly represented in Sinai (51 species) restricted in the Cenomanian (19 species) and Turonian (32 species), followed by Western Desert (13 species) and Eastern Desert (7 species). Regarding abundance so far, the relatively highly abundant species in Egypt are *Eoradiolites liratus* (15 sites), followed by *Eoradiolites sinaiticus* (6 sites), *Durania humei* (6 sites), *Radiolites sauvagesi* (5 sites), and *Durania gaensis* (5 sites). The rare occurrence during the Campanian and complete absence during Maastrichtian may be attributed to deeper stagnant conditions related to deposition of black shales and phosphatic deposits. The disappearance of rudists from some segments of the sequence is attributed oceanic anoxia or related to shelf drowning especially at the basal Turonian, which may related to global warming. The fauna shows Tethyan affinities with close relationship to southern Europe, North America, North Africa, and Middle East.



Benthic association and microfacies in rudist bearing limestones. Upper Cretaceous, San Luis Potosi, Mexico

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The Upper Cretaceous shallow marine sequence in El Temazcal, San Luis Potosi, Mexico, contain rudist bearing carbonates with abundant radiolitids, scarce hippuritids, and occasional gastropods, algae, and corals. The matrix is mainly biomicrite with abundant benthic foraminifers (simple and complex agglutinated, simple miliolids, and small rotaliids), rudists fragments, and other uncertain mollusks shells, besides echinoderms, gastropods, bryozoans, brachiopods, and green and red algae. Pellets and peloids constitute the rest of components.

The taxonomic study of this rudist fauna was part of the Doctoral Thesis of Angélica Oviedo. It is to remark: *Radiolites acutocostata*, a big radiolitid with canaliculated left valve, *Barretia monilifera*, and a *Vaccinites* with a ligament ridge end so developed as the pillar's head. This rudist fauna, considered to be early-middle Campanian, has been recorded from some other fossil localities in San Luis Potosi State (Guadalcázar, Armadillo de los Infante, Villa Hidalgo).

The microfacies analysis indicates that these micrite rich deposits were formed in a normal marine lagoon with low energy and sporadic episodes of moderate to high energy.



SESSION-2

**ORIGINS, EVENTS AND DEMISE OF
RUDIST PALAEOCOMMUNITIES**



Late Jurassic-earliest Cretaceous rudists from the Torinosu-type limestones in Southwest Japan

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Three taxa of early rudists, *Epidiceras speciosum* (Münster), *Epidiceras guirandi* (de Loriol) and *Monopleura* sp., are described from the Torinosu-type limestones in Southwest Japan. The latter are lenticular limestone bodies (usually several hundred meter in lateral extent and several ten meter in thickness) containing abundant reefal fossils, such as corals and stromatoporoids, that were possibly reconstructed as carbonate mounds in the shallow marine shelf of the fore-arc basin, where the Late Jurassic–earliest Cretaceous Torinosu Group and its equivalents deposited. *E. speciosum* is recognized in all four areas: the Youra area in Kyushu Island, and the Shirokawa, Sakawa and Kahoku areas in Shikoku Island; its stratigraphical range extends from the Upper Kimmeridgian to the Lower Tithonian or possibly to the Berriasian. *E. guirandi* is found in Tithonian–Berriasian limestone bodies in the Sakawa area. *Monopleura* sp. is recorded from limestone blocks of Late Kimmeridgian–early Tithonian age in the Shirokawa area. These rudist records from the Torinosu-type limestones extend the biogeographical and stratigraphical distributions of these taxa, and possibly also contribute to our understanding of the early evolutionary history of rudists.

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Rudists of Tibet and Tarim Basin: Biostratigraphic and biogeographic significance

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Cretaceous carbonates in Tibet up to 3000 m thick are parts of tectonic slices that originated in the southern Tethys and were welded onto Asia during the Late Cretaceous and Paleogene. A survey of Chinese literature reveals Barremian to Maastrichtian shelf carbonates in two separate tectonic slices. Upper Cretaceous rudists also occur in the Western Tarim Basin, which was part of the Asian tectonic unit on the northern Tethyan margin. In far northwestern Tibet in the Xizang area, Barremian-Aptian orbitolinid foraminifera and Albian and Cenomanian rudists and orbitolinids are significant components of carbonates (Yang et al. 1982; Gao and Shi 1998). The Lower Albian Lanshang Formation is dated by *Mesorbitolina texana* (senior synonym of *Orbitolina kurdica* according to Simmons et al. 2000) and *Mesorbitolina pervia* together with *Praeradiolites hedinii*, *Praeradiolites biconvexus*, and *Praeradiolites ngariensis*. The Cenomanian Gambacunkou Formation yields *Mesorbitolina aperta*, *Orbitolina concava*, and *Conicorbitolina conica* with the rudists *Praeradiolites hedinii*, *Rutonia bangonghuensis*, and monopleurids. Rudists, corals and stromatoporoids comprise bioherms up to 10 m thick and several kilometers in lateral extent. Douvillé (1916) first reported Upper Cretaceous rudists from Tibet. The Campanian assemblage consisted of *Bournonia haydeni*, *Bournonia tibetica* and *Biradiolites*. The Maastrichtian was composed of *Plagiptychus tibeticus* with *Orbitoides*, *Lepidorbitoides* and *Omphalocyclus*. In southern Tibet these assemblages are part of the Zongshan Formation (Willems et al. 1996).

In southeastern Tethys mainly endemic rudists occupied carbonate platforms during the Albian-Cenomanian. During the Campanian-Maastrichtian mainly endemic radiolitids occupied the carbonate shelf of northern Indian plate near the equator. On the northern carbonate shelf now in the Western Tarim Basin Cenomanian strata yield a single rudist species, the Tethyan *Ichthyosarcolites tricarinatus*. Coniacian-Maastrichtian radiolitids and polyconitids are endemic. The greatest diversity was in the Campanian with six species of radiolitids and polyconitids (Lan and Wei 1995).

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Distribution pattern of Cretaceous rudists in western China and its tectonic significance

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1. Distribution pattern

In China, the rudists are distributed in six Cretaceous carbonate depositional zones extending from east to west. They, from south to north, are A) the southern Tethyan Himalayas zone, B) the northern Tethyan Himalayas zone, C) Gandise forearc basin zone, D) Shiquanhe-Xaiza arc-rear basin zone, E) Karakorum zone and F) Southwestern marginal Talimu zone. However, the rudists are rare in the zones of B and C, but relatively abundant in the zones of A, D, E and F, in which the rudist assemblages are summarized in the following.

2. Assemblages

Zone A. The rudists in this zone are mainly composed of Maastrichtian *Plagioptychus tibetica* Douvillé, *Bournonia tibetica* Douvillé and *B. haydeni* Douvillé (Douvillé, 1916). They are large-sized and often accumulated to reefs.

Zone D. *Radiolites*, *Praeradiolites*, *Eoradiolites*, *Requinia*, etc. have been recognized by Yang et al. (1982) and Gou (1994) from the zone. These rudists are Aptian-Albian in age.

Zone E. The rudists of the zone comprise *Rhedensia*, *Hippurites*, *Vaccinities*, *Praeradiolites*, *Medeella*, *Durania*, *Sauvagesia* and *Lapeirousia*, ranging from Turonian to Campanian (Wen et al., 2000).

Zone F. In this zone, the rudists are Cenomanian-Maastrichtian age and consist of *Ichthyosarcolithes*, *Lapeirousella*, *Sauvagesia*, *Gyropleura*, *Biradiolites*, *Osculigera*, and so forth. Individually, they are usually relatively small-sized and rarely formed a reef.

3. Tectonic significance

In zone A, the southern Tethyan Himalayas zone, Maastrichtian rudists occur in the middle and upper parts of the Zongshan Formation, a 278m thick section of limestone and shale. The lower Zongshan Formation is Campanian age and yields numerous bivalves, gastropods, foraminifers and echinoids, but no rudist. Besides the relatively abundant rudists, the middle and upper Zongshan Formation contains foraminifers, echinoids, corals, ostracods, gastropods and non-rudist bivalves. Furthermore, the zone A includes many Aptian-Albian Austral forms and endemic taxa.

These facts indicate that the Indian subcontinent had just been separated from Australia-Antarctic of Austral continent and drifted northwards, but it was still located in the remote south area during the Early Cretaceous Aptian-Albian (Wen, 1999). In Campanian, zone A probably had entered the area near the subtropic area because there are carbonate but no rudist deposits in the lower Zongshan Formation. However, it did not enter the tropic Tethys until the end Cretaceous, Maastrichtian, when the abundant Maastrichtian rudists deposited in the middle-upper Zongshan Formation.

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Albian demise of the Tethyan biota in the North Pacific and the establishment of the North Pacific Biotic Province

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The Tethyan biota dwelled on tropical–subtropical shallow marine shelves and/or on carbonate platforms, and is an essential indicator of the Cretaceous tropical biotic realm and climate. This study aims at analyzing spatiotemporal changes in the distribution of taxa constituting the Cretaceous Tethyan biota (e.g., rudists, nerineacean gastropods, orbitolinid and a non-rudist bivalve *Neithea*) in the North Pacific (i.e., Japan and Russian Far East, northern California), in order to recognize new global biotic changes.

As a result of our analysis we recognized the following trends of temporal biotic changes in the North Pacific: 1) Continuous distribution of the Tethyan biota during the Early Cretaceous, 2) Step-wise demise of the Tethyan biota in the Albian, and 3) Long-term absence of the Tethyan biota and development of the North Pacific Biotic Province throughout the Late Cretaceous.

Mid-Cretaceous step-wise demise of the Tethyan biota in the Northwest Pacific might be summarized as follows: A) All Mesogean key taxa (e.g., rudists), some Mesogean indicators (e.g., corals), and nerineaceans disappeared at the latest Aptian–Early Albian transition (Iba & Sano, 2007), B) Other Mesogean indicators (e.g., orbitolinids) disappeared at the Early–middle Albian transition (Iba & Sano, 2007), C) The Tethyan non-rudist bivalve *Neithea* disappeared in latest Albian. This biotic turnover has not been recorded either in the Mediterranean or Caribbean, nor in any other regions of the Tethys. Therefore, it should be considered as an unique bio-event of the Pacific during the greenhouse Cretaceous.

Demise of the Tethyan biota from the North Pacific strongly supports the idea that the North Pacific became gradually independent from the Tethyan Realm during the Albian. It also suggests a long-term deterioration of the faunal interchange between the North Pacific Province and Tethyan Realm throughout the Late Cretaceous.

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**Rudistid bivalves of the Coamo Formation of the Central Aguirre,
southeastern Puerto Rico**

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A new exposure in the Central Aguirre Quadrangle in southeast Puerto Rico shows an abundant rudistid bivalves fauna. Berryhill (1960) mapped this exposure as the Coamo Formation. This formation was named by Glover (1961, field work 1956-57) to describe a thick sequence of tuff breccias, conglomerates, sandstones and lenses of limestone in the Coamo Quadrangle. Recent construction exposed the rocks in this hill with a near vertical dip. The exposure consists of interbedded volcanoclastic sandstones and limestone that grade into bedded limestone with abundant coral and rudist in growth position, to massive limestone with scattered rudist fragments. The rudists that occur within the interbedded limestone and volcanoclastic sandstone are weathered resistant and can be collected as complete specimens. The rudistid fauna exposed in this outcrop consist of *Titanosarcolites giganteus* (Whitfield), *Parastroma guitarti* (Palmer) and *Macgillavryi nicholasi* (Whitfield). The rudistid fauna reported for the Coamo Formation by Glover (1961, identified by Norman F. Sohl) consist of *Barrettia gigas* (Chubb) and *Praebarrettia sparcilarata* (Whitefield) both faunas associated with a late Campanian to Maastrichtian age.

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**New insights on the Lower Cretaceous rudist fauna of the Tehuacan valley,
Puebla, SE Mexico**

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The first work involving the occurrence of pre-Albian rudists in America was surveyed at the valley of Tehuacán (Puebla- México) on the late 19th century. However, this region has remained practically ignored since the 1930's when Muellerried performed the last formal expedition in search for rudist assemblages. Some authors have noted the lack of detail regarding the location and stratigraphy of Muellerried's outcrops, thus being only marginally referred on a few selected papers that address the systematics and evolution of Lower Cretaceous rudists on countries such as South U.S.A., Cuba, Trinidad, Jamaica and México. This represents the first study of the rudist fauna that flourish at the region for over seventy years.

The main fossiliferous outcrops are located near the settlements of San Antonio Texcala and Plan de Fierro, within the Zapotitlán (Barremian) and Agua del Burro (Upper Barremian) – San Juan Raya Formations (Lower Aptian) respectively. Three rudist taxa are described: *Toucasia* sp., *Retha tulae* and *Amphitriscoelus primaevus*.

Retha tulae and *Amphitriscoelus primaevus* were found associated within the same biostromes on all the localities, indicating a Barremian – Lower Aptian distribution for both species. This assemblage resembles those previously reported for Jamaica (Jubilee-Benbow Limestone) and Michoacán (San Lucas and Comburindio Formations). Although micropalaeontological analysis of the referred localities suggest a Barremian – Lower Aptian age, authors have maintained a conservative approach on whether *R. tulae* and *A. primaevus* actually belong to Lower Aptian strata due to the absence of additional index fossils, therefore restricting distribution of these species to the Barremian.

The present work supports the existence of synchronous populations of *R. tulae* and *A. primaevus* during the Barremian – Lower Aptian in America and serves as a starting point to propose a phylogenetic model for the Lower Cretaceous Caprinids in this region on the basis of palaeobiogeographic, biostratigraphic and evolutionary evidence.



Blending rudists with technology; non-destructive examination of the internal and external structures of rudists using high quality scanning and digital imagery

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Certain formations within the Cretaceous of Texas include zones of silicified rudists. Such diagenetic alteration, combined with the timing of alteration, has enabled the retention of many structural features of the rudist and generates ideal specimens for computed tomography (CT scanning). The excellent density differences between those skeletal structures (silica) and the internal sediment (calcitic mud) or later crystallization (calcite), fulfill a fundamental requirement for successful CT analysis. The Jackson School of Geosciences at The University of Texas provides access to a high resolution computed tomography scanning system. This equipment is not identical to medical scanners, providing much higher resolution and sophisticated software to analyze the imagery. Several rudist specimens have been scanned using this facility, such as *Caprinuloidea perfecta*, collected from the Lower Cretaceous Edwards Formation (Albian).

Other rudist specimens from this same formation are preserved in a different manner; structures were replaced with single crystal calcite. External skeletal intricacies are especially well preserved. Other scanning and high resolution digital imagery of specimens preserved in both ways are being acquired as part of an ongoing NSF sponsored project to image and conserve the type and figured collection.

This presentation describes how such imagery can be used to further many aspects of rudist research. Using the first method (CT scanning) serial sections of minute thickness are attained without destroying a valuable specimen by creating the necessary physical serial sections, a more traditional method of analytical study. The second method produces images of great resolution and clarity which can be analyzed further and can also become a surrogate for physical peels of rare or fragile specimens. Both these methods of imagery can be made available on-line and can be studied by scientists throughout the world, thus developing a broader resource for global scientists who may be unable to travel to this repository.



Albian *Eoradiolites* from Jabal Naïmia, Gafsa region, Tunisia

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The lower part of the Zebbag Formation's lower member, known as "*Knemiceras* beds", crops out at Jabal Naïmia. It consists of alternate green clays and bioclastic limestones, followed upwards successively by bioclastic, micritic and dolomitic limestones, with a total thickness of 63 m. A monospecific rudist bed with *Eoradiolites* is intercalated within the upper beds with *Knemiceras* and *Engonoceras*. These ammonite genera are currently considered characteristic of shallow marine environments and, correlated with the standard ammonite zones, of late Middle Albian - early Late Albian age.

The *Eoradiolites* bed yielded enough isolate and complete specimens as to illustrate their wide diversity on external morphology. Moreover, good preservation allowed detailed study of the myocardial apparatus and the shell structure of both valves.

Most specimens are found standing upright. Some right valves are long and narrow (e.g. more than 12 cm high and 3.5 cm wide) while other are short and wide (e.g. 3 cm high and 5 cm wide), and all intermediate morphologies exist. Transverse section is quadrangular or triangular, depending on development of radial folds, particularly the anterior fold and the posterior radial band. Ventral radial band corresponds either to a flat surface ventral to the anterior fold or to a slightly protruding flat fold. Posterior radial band corresponds always to a protruding flat fold, either somewhat or considerably more developed than the ventral band, particularly in adult stages. Interband is a narrow smooth furrow. Outer shell layer presents non compact structure of continuous radial ridges pattern.

Left valves are extremely concave; the outer shell layer may develop upwards, following the deeply inclined commissure, up to 3 cm high on a specimen not wider than 4 cm. The two small teeth of the cardinal apparatus are located close to a long and thin ligament ridge and the posterior myophore is more developed than the anterior one.



Late Cretaceous rudists of the Gafsa region, Tunisia

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Several Upper Cretaceous units recognised in the Gafsa region provide rudist occurrences. From bottom to top: (1) Zebbag s.s., (2) Bahloul, (3) Gattar, (4) Beïda Anhydrites, (5) Annaba Clays, and (6) Biréno. Member 4 is a part of the Gattar Formation. The uppermost part of the unit 1 and the formations 2-3 correspond to the C/T depositional sequence (S1), and members 5-6 to the second sequence (S2). Late Cenomanian to Turonian ammonites and microfossils reported from some of these units allow dating and correlation of the successive rudist horizons.

Few meters below the limestones with *Neolobites vibrayeanus*, in the alternating marls and limestones of the uppermost part of the Zebbag s.s. Formation, one bed yielded abundant *Praeradiolites biskraensis* at Jabal Ben Younès, Oued Berda, and Jabal Zitouna together, in this last, with *Ichthyosarcolithes triangularis*.

Ammonite fauna of Bahloul indicates the upper Cenomanian-lower Turonian transition. Isolate *Durania arnaudi* and *D. blayaci* occur in this formation, as well as *Vaccinites* cf. *rousseleti* in its uppermost part, at Jabal Chemsî. Sections of *Durania* sp. have also been identified in the early Turonian ammonite bearing limestones of the lower part of Gattar Equivalent Formation at Oued Berda.

Several horizons, frequently monospecific associations of radiolitids but also of hippuritids, occur in the dolostones of the Gattar at Jabal Zitouna and within the Beïda Anhydrites at Jabal Ben Younès. *Bournonia africana*, *Eoradiolites liratus*, and *Hippurites* cf. *resectus* have been identified. Small *B. africana* were collected within a limestone bed in the middle part of the Annaba Clays at Jabal Ben Younès.

In the limestones of the Biréno at Jabal Morra, Jabal Zitouna, Jabal Ben Younès, and Jabal Askar, or in their equivalent carbonates and gypsum at Sidi Bouhlel, Oued Berda, and Jabal Chemsî, radiolitids are abundant, diversified, and sometimes well preserved thus allowing the revision of some Maghrebi taxa. Hippuritids, monopleurids and requieniids also occur.



Campanian-Maastrichtian *Pseudosabina* from different regions of Turkey

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The specimens of *Pseudosabina* Morris & Skelton are found from the Campanian-Maastrichtian transgressive mixed siliciclastic-carbonate successions of the Hereke area (Kocaeli Peninsula), Hekimhan-Yazihan-Darende areas (Malatya region), Divriği area (Sivas region) and Elazığ area in the eastern Anatolia and also Kahta and Antakya areas in the southeastern Anatolia.

The well-preserved specimens of the *Pseudosabina klinghardti* (Boehm) were collected from the type locality of the species, Tavşanlı village, around Hereke. Some specimens of the species were also determined from the Kahta-Adıyaman area. The specimens show characteristic internal and external features of the valves of the species. The right valve is conical, ornamented by very rare longitudinal costae and growth lines. The anterior and posterior radial bands are marked by deep grooves. The ligamental ridge is long and bifurcate at the extremity, teeth and myophores are well-developed. The left valve is inclined towards posterior-dorsal part and two grooves corresponding to the radial bands of the left valve are clearly observed. A single row of pyriform, two or three rows of suboval, polygonal and quadrangular canal sections are observed from the periphery to the internal part of the left valve. These canal are also presence between the ligamental ridge, teeth and myophores.

Pseudosabina rtanjica (Pejovic) shows widely distribution in the eastern Anatolia. The specimens of this species are found in the Malatya, Sivas and Elazığ regions. It is very characteristic that the valves have very different dimensions in all specimens such as the right valve is conical and very little than left valve. The left valve is remarkably developed and fortly inclined and coiled towards the dorsal side and generally passes the commissure line. This species is characterized by the canal organization of the left valve consisting of the little radial canals in the periphery of the valve, irregular polygonal canals in all parts of the valve and especially by one row of hexagonal or pentagonal canals separating the myophores from the central cavity. The teeth are very developed and have a structure fiber calcite.

Pseudosabina triangularis Karacabey was only determined from the Divriği area (Sivas). However, the specimens of this species are also found in the Hekimhan-Yazihan area (Malatya). This species presents similar characters of *Pseudosabina rtanjica*, however it differs by triangulaire canals in the left valve and the siphonal grooves well-marked.

Around the Alıdamı-Kahta (Adıyaman) and Yaylaçiftliği (Antakya), some specimens belonging to *Pseudosabina* are also found. These specimens show fortly coiled left valve including polygonal and quadrangular canal sections.

Our studies show that *Pseudosabina* Morris & Skelton is widely represented by all species in different regions of Turkey, except *P. serbica*.



The morphology and function of the upper valve of *Vaccinites vesiculosus* (WOODWARD)

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In comparison with “normal” lamellibranchs (inclusive most rudists) the construction of the upper valves of several hippuritid species show fundamental differences. The left valves have a massive lowermost layer. On its surface a system of radial canals exists running from the middle of the shell to the shell margin. The width of the canals does not vary within one species, therefore a specific branching exists, that means the number of the canals is increasing with the distance from the shell centre.

The ridges between the canals are denticulated. The uppermost part of the valve forms a sieve-like cover. This cover is fixed on the top of the denticulation of the ridges between the canals, so the particle-controlling waters can flow into neighbouring canals too.

Each canal has an aperture at the shell margin whereon the controlled water flows inside. This construction is principally known since long times. There are informations by Douville (1897), Klinghardt (1930), Zapfe (1937), Milovanovic (1957) and Vogel (1960;1970). Most of the informations are based on more or less well-preserved surfaces and/or thin sections. To get good 3-dimensional reconstructions by thin sections is very hard.

The most comprehensive constructional and biological study was given by Skelton (1976). However, I did not find a good study of the upper valve of *V. vesiculosus*, an evolutionary very advanced example. Amongst my Omani stuff I found about 200 specimens with preserved upper valves, several dozens of them with best preservation of the sieve. They show several details: Morphological variations of the sieve-structure, spatial “problems” in the arrangement of the canalization and fine crenulations around the pillars, graceful net-structures onto the outermost margin a. s. o.. Further implications will be discussed in the presentation.

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Measuring Calcite/Aragonite ratios in rudist bivalves



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Calcite/Aragonite (C/A) ratios in marine carbonate production have changed significantly during the Phanerozoic. On the long scale, the Ca/Mg ratio hampers or favours the precipitation of Aragonite or Calcite (calcite versus aragonite seas). On short scales, the supersaturation of seawater with respect to calcite or aragonite is also modified by the acidity of seawater which reflects past atmospheric CO₂ levels.

The C/A ratio in rudist bivalves may be influenced by changing seawater conditions, in this case it would be a potential tool to obtain high resolution palaeoenvironmental proxies, e.g. on past ocean acidification events.

Unfortunately, the measurement of C/A ratios in rudists bivalves is a difficult task. Qualitative estimations among different families is possible with simple commissure-near cross sections. However, measurements of ratio changes are not possible at the genus level or even inside monospecific populations, based on a commissural cross section. Ratios obtained from single cross sections differ significantly and the potential measurement error is up to an order of magnitude higher than the presumed ratio changes we want to observe. In addition, we do not know about the natural C/A ratio variations on the species or the genus level.

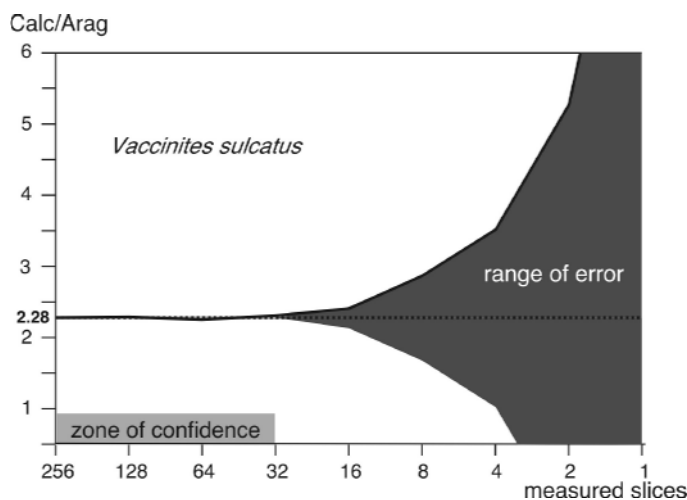


Fig. 1: Volume C/A ratio measurements based on 256, 128, 64, 32, 16, 8, 4, and 2 layers. The ratio stays stable down to 32 measured layers.

Volume calculation based on tomographical data obtained from serial grinding of complete rudist specimens appears to be a possibility to solve the problem. I segmented rudist individuals into (sub)millimetric slices and measured the C/A ratio on every slice. The result shows that the ratios differ by an order of magnitude dependent on the cutting level (e.g. in *H. sulcatus* between 249,64 and 1,04). The overall (actual) ratio based on 256 slices in *H. sulcatus* was 2,28. In a second step, I reduced the amount of equally spaced slices stepwise from 256 to 128, 64, 32, 16, 8 and 4 slices in order to evaluate how robust this result stays. The ratio remained remarkably stable down to 32 layers counted (2,30) and only below this number the error increased exponentially (Fig.1).

This preliminary results show that a robust and precise C/A ratio measurement is possible by using only 32 equally spaced slices in a rudist individual (*H. sulcatus*). In consequence, it should be possible



to measure both the natural C/A variability at the genus and species level and environmentally induced C/A shifts. This new approach probably has the potential to provide first quantitative data on the the pattern and the timing of shallow water calcification crises in the Cretaceous and allows for new insights on how rudists adopted to these environmental perturbations.



Ontogeny and functional morphology of a Lower Cretaceous caprinid, Comanche Shelf, US Gulf Coast

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Caprinuloidea rudists are locally abundant and widespread in Lower Cretaceous Edwards Formation in Texas. On the shallow marine interior Comanche Shelf rudists built circular and elongate bioherms with coarse-grained flank deposits. Elongated attached valves lived as elevators above the substrate and arcuate specimens with coiled free valves were recumbent upon mobile grain flats.

Three-dimensional internal structures of silicified specimens are imaged by X-ray computerized tomographic (CT) scanning (Molineux et al. 2007). In the Edwards Formation *Caprinuloidea perfecta* Palmer is the abundant species, which is characterized by two rows of polygonal canals on its ventral and anterior margins. X-ray CT images reveal allometric ontogeny of the left-free valve (LV-FV). Although not preserved plots suggest that the prodissoconch was similar to the prodissoconch of *Cardiacea*. Pallial canals and the accessory cavity developed very early in the growth of this species suggesting that these structures served a biological function rather than a structural function.

The LV-FV is trochospirally coiled with translation toward the posterior so that from the anterior view the shell is coiled clockwise. This form would be adaptive to a recumbent position on the anterior side so that the FV grew up above the substrate. This position would maintain the commissure at or above the substrate with the posterior margin approximately normal to the substrate as in most siphonate bivalves.

The coiling shell parameters of the LV-FV of *C. perfecta* fall outside of the “traditional” fields of bivalves and gastropods. The coil is slightly trochospiral and the translation is greater than most bivalves; but the distance of the generating curve from the coiling axis is much greater than of most bivalves and gastropods. This coiling style suggests that the FV functioned differently than either the basic bivalve shell or the gastropods shell.

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**First record of Late Albian canaliculate rudists from northern California, U.S.A. –
a preliminary report**

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Newly collected rudist specimens of Late Albian age from the Upper Chickabally Mudstone Member of the Budden Canyon Formation, Great Valley Sequence, in northern California, U.S.A., are identified as a canaliculate rudist based on shell morphology and mineralogy. Since they are incomplete right valves without cardinal and myophoral parts, their systematic placement is difficult, though their canal characters are similar to those of relatively derived caprinuloidinid rudists such as *Texicaprina* and *Jalpania* (Caprinidae) of the Caribbean/Gulf region. Re-assessment of the holotype specimen of *Durania? californica* Anderson, 1958 from the Upper Albian of northern California moreover reveals that it does not belong to the Radiolitidae, but is also a canaliculate rudist. The distribution of canaliculate rudists, of probably caprinuloidinid affinity, in the mid-latitudes of the Northeast Pacific suggest that this area belonged to the Tethyan Realm at that time, and a faunal connection existed between the Northeast Pacific and the Caribbean and/or the Central Pacific at least in the Late Albian.

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First report of Turonian rudists from the Pacific Coast of North America

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The first Turonian rudists to be discovered on the Pacific Coast of North America were recently collected from Black Star Canyon in the northern part of the Santa Ana Mountains, Orange County, southern California. The stratigraphic horizon of the fossil locality is in the lower part of the Holz Shale Member of the Ladd Formation and within the interval that is transitional from the underlying sandstone of the Baker Canyon Conglomerate Member of the same formation. The Turonian age of the horizon is based on the presence of the ammonite *Subprionocycclus neptuni* (Geinitz, 1849), one of the proposed global markers for the base of the Upper Turonian, at laterally equivalent stratigraphic sections exposed in the area. The rudists were found in a bed of calcite-cemented, biotite-rich, arkosic sandstone with abundant bioclastics of small rudists, oysters, other bivalves, gastropods, and serpulids. The depositional environment of the Ladd Formation is mainly middle and outer continental shelf upward through this section, but prominent submarine fan deposits also occur. The sedimentology and paleontology of the rudist-bearing bed indicate that the actual source of the material was in a shallower marine habitat, thus it is likely that the material was transported down a submarine fan and deposited in the deeper setting. None of the rudists was in living position. The lower valve of the rudist species possesses a wall with a thin, solid inner layer and a relatively thick cellular outer layer, but it lacks a ligamental infold and ligamental ridge. Externally, the lower valve possesses well developed siphonal bands and robust concentric flanges. The upper valve, which is preserved in position on the lower valve of some of the specimens, is operculiform, very thin, and flat to slightly concave. The structural characteristics of the valves indicate that this species belongs to the Radiolitidae.



Late Aptian(?) caprinid and polyconitid rudists from Southwest Japan

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Classic studies of Japanese rudists mainly focused on material from the Late Aptian of the Miyako and Yezo groups, both in Northeast Japan. Although rudist occurrences of the same age in Southwest Japan have been mentioned for the last two decades, systematic study of them remained incomplete.

Tanaka et al. (1996) described the occurrence of “*Pachytraga japonica*” from calcareous sandstones of the Late Aptian(?) Osaka Formation in western Kyushu, Southwest Japan. In contrast, re-examination of specimens collected by Tanaka, and investigation of newly-collected specimens from the Osaka area reveal the presence of a polyconitid, *Praeacprotina yaegashii* (Yehara) and a caprinid in the Osaka Formation. Skelton and Masse (1998) previously mentioned that the holotype of “*Pachytraga japonica*” is probably referable to *Praeacprotina*, which was established based on material from the Miyako Group. Hence it is suggested that “*Pachytraga japonica*” from other localities can also probably be assigned to *Praeacprotina*.

Several right valves of a caprinid were recovered from the Osaka Formation. Canals develop at least in the dorsal marginal part of the shell and the wall that separates the anterior tooth socket from the body cavity. The marginal canals are similar to those of *Caprinuloidea*, though *Caprinuloidea* has a compact internal shell wall. Thus we tentatively assign the Osaka caprinid to new genus aff. *Caprinuloidea*, although the presence of canals in the inner shell wall is a surprisingly derived character for such a supposedly early caprinuloidinid. Discovery of this caprinid from Japan indicates that a faunal connection existed between the Northwest Pacific and the Caribbean across the central Pacific at the time.

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The way from biogenic aragonite to agate

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The skeletons of the Anthozoa (and partly of the rudists) consist of aragonite and/or calcite. These minerals, built under the protection of living tissues, are enveloped by organic matter. The steps of the recrystallization(s) of aragonite to calcite **after** the protection of the soft body are well documented.

In Oman we found big colonial corals (up to 1m) with well-preserved surfaces, but they were **hollow inside**. The 5-10 cm thick outer wall of the colonies shows sequences of different chalcedonic layers and innermost of fine-grained idiomorphic quartz crystals. Altogether they form structures similar or corresponding to **volcanic agate**. Surprisingly this diagenetic pattern migrates stepwise **from inside**.

This uncommon phenomenon can be explained by the historical pathways of the Campanian reefs in Oman.

1. The reefs were overlain by marine carbonate sediments.
2. In the Tertiary we know of locally distributed mainly limnic sedimentation. The reefs are located now in a depth of not less than 60-80 m below the land surface.
3. During the Tertiary and Quarternary local tectonic uplifts occur within the whole region, followed by extensive erosion. The first desertification took place during the Pliocene and Pleistocene. Since these times the **migrating sands** existed, overlying nearly the whole region.
4. Surface waters, saturated with siliceous substances, migrated (and still do so) through the sands into the carbonate formations. Thus, the fossil biogenic structures were soluted and replaced by siliceous materials. Finally the whole interior was replaced by siliceous layers. But the process did not stop. The daily temperatures, ranging from 0-50°/60°C, caused (and still do so) a permanent chemical activity leading from idiomorphic quartz layers to **amorphic agatitic structures**:

The exact chemical processes are yet partly unclear.



Coniacian rudists in the northern margin of Tremp Basin (south-central Pyrenees, Spain)

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Coniacian rudist bearing limestones and marly limestones crop out quite continuously along the northern margin of Tremp Basin (south-central Pyrenees, Spain); lateral changes, both in lithology and fauna, are evident from the West to the East.

In the westernmost locality studied (Serra de Sant Gervàs) rudists appear in synsedimentary coarse limestone breccias deposited basinward (Campo Breccia Formation).

Eastwards, in the middle part, a deep gorge (Congost d'Erinyà) cut by Flamicell River exposes a 40 meter succession of rudist bearing wackestone limestones, with some interbedded grainstones, overlying a thick body of massive carbonate rocks interpreted as a coral reef (Congost Formation). The succession evolves progressively to deeper echinoid bearing marly limestones (Anseroles Formation). Rudist fauna is composed mainly by hippuritids: metric scale *Hippurites* thickets, small *Hippurites* bouquets, and isolated *Vaccinites*. *Radiolites* is scarce.

At the eastern part (Riu de Carreu Valley and Prats de Carreu), rudist bearing marly limestones are interlayered in an ammonite-inoceramid-echinoid rich marly sequence, interpreted as representing the transition from carbonate platform to upper talus and deep shelf (Clot de Moreu Member of Carreu Formation). Rudist fauna is more abundant and diversified than in the two other localities.

Ammonites and inoceramids provide a precise biostratigraphic framework to locate the identified rudist taxa, and that facilitates the correlation with the other areas. Abundance and good preservation of rudist specimens allow the study of intraspecific variability in some taxa, and thus contributes to solve some involved taxonomical issues.



**Campanian *Pseudosabinia* from Pučišća Formation on the island of Hvar
(Adriatic Sea, Croatia)**

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The Upper Cretaceous carbonates on the Island of Hvar are typical of the central Tethyan ('peri-Adriatic') intra-oceanic carbonate platforms. During the Late Cretaceous, the carbonates were deposited within the southern part of the Adriatic-Dinaridic carbonate platform. The Upper Cretaceous stratigraphy of the Adriatic carbonate platform (s.str.) has been described in detail from the island of Brač, and has been subdivided into a few lithostratigraphical units. The Pučišća Formation (Santonian to Campanian) was deposited mainly within migrating rudist-bearing marginal facies of intra-platform basin(s).

Within the uppermost part of the Pučišća Formation, in the Križna luka locality (town of Hvar, island of Hvar), we collected rudist valves characterized by a complex canaliferous inner shell structure. Shell symmetry, myocardinal arrangements, and cellulo-prismatic structure of the right valve outer shell layer lead us to refer the specimens to the family Radiolitidae.

The valves are embedded in white peloidal-bioclastic limestones, along with abundant foraminifera (orbitoids and siderolitids) and small radiolitids, as well as rare hippuritids and *Mitrocaprina* sp. The limestones were probably deposited on the fore-slope of a migrating marginal bank.

The right valves are massive, conical in shape, and ellipsoidal (oval) in transverse section. The slightly depressed posterodorsal parts of the shells mark the radial bands. Outer shell layers are mostly eroded, while the inner shell layers are recrystallized, but nicely preserved. The inner shell has relatively big quadrangular canals in its thicker inner part and radially elongated canals in its thinner outer part. The ligamental ridge is well developed, with a thin neck and relatively thick oval T-form tip. Sockets of cardinal teeth and myophore scars are well developed within the inner shell layer.

The left valves are also massive and conical in shape, while centrally placed body cavity covers less than a quarter of the transverse section.

The shells are referred to *Pseudosabinia klinghardti* (Boehm), probably the most widely distributed species of the genus.



**Re-description of *Paracaprinula syriaca* Piveteau (Plagioptychidae)
from southeastern Turkey**

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Paracaprinula syriaca, Piveteau 1939, is described in detail for the first time. The original description did not provide evidence for any characters that would have justified the genus of being different from *Mitrocaprina* Boehm, as only part of the left valve inner shell structure with *Mitrocaprina*-type pallial canals were shown. Specimens collected at the type locality at Yaylaçiftliği (Hatay), and from Alıdamı (Kahta-Adıyaman) have a vesicular structure of the inner shell layer of both valves, including the cardinal teeth and myophores. Other diagnostic features such as the myocardial arrangement, the relative thickness of outer shell layer in both valves, and the complex pallial canals in the left valve are characteristic for a derived genus of the Plagioptychidae. *Paracaprinula* is restricted to the Arabian platform of the Afro-Arabian Plate, and the Late Campanian age derived from strontium-isotope stratigraphy of specimens from the localities studied is consistent with the theory of allopatric speciation.

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Turonian rudists from Abu-Roash area, North Western Desert, Egypt

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Five radiolitid rudist species are described from the Turonian section of Abu Roash area. They are recognized in three rudist biostromes that occur in two informal units; the “Rudistae series” and the “Acteonella series”. The three biostromes show autochthonous and parautochthonous fabrics and moderate to high packing potential. The first rudist biostrome at the base of the “Rudistae series” contains *Durania gaensis* (Dacqué, 1903), *Praeradiolites ponsianus* (d’ Archiac, 1835), and *Distefanella lombricalis* (d’ Orbigny, 1842). The majority of the shells are preserved in life position, but some individuals and clusters are disoriented and were deposited not far from their original biotope. The second rudist biostrome in the “Rudistae series” mainly consists of *Bournonia fourtaui* Douvillé, 1910, an elevator form embedded in chalky limestone. The third rudist biostrome has been frequently reported in the Upper Turonian “Acteonella series”. This biostrome is particularly significant because it has yielded well preserved, complete and long cylindrical right valves of *Durania arnaudi* (Choffat, 1891). The shells are in an erect life position or are subparallel to the substrate as though they fell from living position.

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**Maastrichtian rudist fauna from Tarbur Formation, (Zagros region - SW Iran),
preliminary observations**

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The Tarbur Formation was deposited in the eastern part of Neotethys at the end of a thick sequence of Cretaceous sediments now preserved in the Zagros region. Extending across the internal Fars and Lurestan, the formation is mainly of siliciclastic composition, comprising shales, sandstones and polygenic conglomerates, though also incorporating some carbonate units that include frequent rudist lithosomes, accompanied by corals, other non-rudist bivalves, gastropods and algae.

Two sections of this formation have been chosen for the study of their rudist fauna, one located SW of Semirom, and the other to the east of Gerdbisheh village (SW Iran).

Four rudist lithosomes are recorded in the Semirom section and three in the Gerdbisheh section all showing lateral changes in thickness and facies. In some parts of these lithosomes, rudists are found in life position, as bouquets and compact gregarious associations. Sampling was done after measuring and recording the position of these lithosomes in stratigraphic columns.

Preliminary investigation of the specimens reveals a diverse fauna in the Semirom section, especially in A3 (third lithosome), which contains the most concentrated specimens with good preservation, comprising genera belonging to the Hippuritidae (*Hippurites*, *Vaccinites*), Radiolitidae (*Radiolites*, *Praeradiolites*, *Biradiolites*, *Colveraia*, also Sauvagesiinae and Lapeirousiinae), Dictyoptychidae (*Dictyoptychus*) and Plagioptychidae (*Mitrocaprina*).

In the Gerdbisheh section, associations show lesser diversity and density, though with relatively good preservation. The collected samples are referable to the Hippuritidae (*Hippurites*, *Vaccinites*), Dictyoptychidae (*Dictyoptychus*), Radiolitidae and Plagioptychidae.

These assemblages of rudists show some similarity to those recorded in the Upper Cretaceous (mainly Maastrichtian) of Turkey and the southern Persian Gulf region (UAE and Oman). Further studies on the systematic palaeontology, palaeoecology and palaeogeography aim to clarify the relationship between the Tarbur fauna and those of adjacent areas.



A new Upper Cretaceous radiolitid rudist bivalve from Temazcal, on the Vallesan Luis Potosi Platform, East-Central Mexico

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It is reported an Upper Cretaceous association of rudist bivalves and benthic larger foraminifers from Temazcal, located 66 km NE of the city of San Luis Potosí, on coordinates 22°24' Lat. N- 100°31' Long. W. The sedimentary sequence cropping out in the studied locality, consists of a gray massive limestone unconformably overlaid by a medium to thick bedded argillaceous limestone weathering to a brown reddish color.

The massive limestone provides an assemblage of rudists, among which a new genus dominates by being the most abundant, large and clearly distinguishable. The description of this genus is the main objective of this article. The study of the larger foraminifers is in process and will help to precise the age of the deposit.

About this new genus a preliminary study was made by Dr. Angélica Oviedo in her Doctoral Dissertation, and hence she is the first author, and myself (G. A.) the second one. The genus and species are named informally as *Potosites tabulatus* Oviedo and Alencáster. The name will have validity until be published on a scientific journal. Therefore, the description is now informal. The genus belongs to the Family Radiolitidae because the right valve (RV) poses a celluloprismatic structure on the outer shell layer.

It is a large taxon, the largest specimen measures about 60 cm height and 25 cm diameter. The RV is conical, with acute apex, the outer shell layer is very thick, but irregular, varying from 7 to 4 cm in a large specimen. The lamellae are arranged in different types of microstructures the more common is a polygonal reticular tissue.

The surface (limb) of the commissure presents radial round crested ribs, separated by furrows of the same width- The RV outer surface poses longitudinal round costae. The left valva (LV) is tall, convex smooth, with the umbo wide and projected, curved downward overhanging the ventral wall of LV. The outline of the body cavity is circular with a thin compact inner layer. The external layer is formed by canals which are large and square, made by thin septa perpendicular to the outer surface. At the dorsal side is the miocardinal apparatus, consisting in the anterior and posterior teeth and the myophores. On the dorsal side of the RV there are two smooth sockets excavated on the inner shell layer. There is not in any valve crest or ridge ligamental, not any signal of radial bands. As a peculiar character of the genus, both valves are completely full of tabulae, thick and horizontal, besides the LV poses between the tabulae, vesicles of irregular and varied shapes, which are round, or elongated. This genus presents many peculiar features which distinguish it from all radiolitid genera with canals or pseudocanals.

This work is supported by DGAPA PAPIIT (UNAM) Project IN119290



Mac Gillavry Session:

**TAXONOMIC AND PHYLOGENETIC
STUDIES IN PREPARATION FOR THE
REVISION OF RUDIST SECTION IN THE
BIVALVIA TREATISE**



Proposed revisions of rudist bivalve classification

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The rudist classification of Dechaseaux *et al.* (1969) needs revision based on monophyletic taxa (Skelton & Smith, 2000). Recognition of fundamental divisions within rudists requires their taxonomic promotion from superfamily to order. Thus ‘Megalodontoidea’ is rejected from the Order Hippuritoidea Newell, which becomes limited to the rudists. This order might – controversially – be renamed ‘Rudista’, as type-based names are not mandatory above family-group level (Ride *et al.*, 1999). A basal dichotomy separates rudists attaching by the right valve from those attaching by the left valve, yielding two monophyletic superfamilies: the first retains the name Hippuritoidea Gray, by priority, while the name proposed for the second is Requienioidea Douvillé. One monophyletic family, Requieniidae Douvillé, is recognized in the latter, leaving a paraphyletic residue (‘parafamily’) of basal genera, ‘Epidiceratidae’. Within Hippuritoidea, the parafamily ‘Diceratidae’ accommodates the primitive *Diceras* and *Valletia*, which retain an external ligament. Other hippuritoideans have an invaginated ligament, and most can be divided among monophyletic families, including Caprinidae d’Orbigny, *sensu stricto* (Skelton & Masse, 1998), perhaps separated from a distinct *Neocaprina/Caprinula* clade (Steuber & Bachmann, 2002), as well as Plagiptychidae Douvillé, Hippuritidae Gray and Radiolitidae d’Orbigny. Outstanding problems include certain enigmatic derived clades and a paraphyletic residue of primitive uncoiled rudists.

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***Mathesia mainelli* (Hippuritacea, Monopleuridae) from the late Aptian-Albian
of the Mediterranean region, a revision**

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Agria darderi Astre, subsequently transferred to *Agriopleura*, and *Mathesia terticolloquirudistarum* Mainelli represent a single taxonomic entity: *Mathesia darderi* (Astre). *Mathesia* is characterized by a posterior myophoral plate and an anterior myophoral crest on LV, RV myophores being on shell wall; a peculiar shell structure is observed on RV: the junction between the outer calcitic shell layer and the inner formerly aragonitic shell layer is marked by a tubular microstructure. The overall morphological traits and myocardial organisation of *Mathesia* are similar to those of *Debrunia* which lacks the tubular shell microstructure of the former. *Debrunia* is regarded the ancestor of *Mathesia*. The palaeobiogeographic distribution of *Mathesia darderi* includes the Southern and Northern margins of the Mediterranean Tethys, its stratigraphic range being the Late Aptian-Albian.



A new species of *Polyconites* from the uppermost Lower Aptian of Spain

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Polyconitid rudists possess a distinctive ectomyophoral cavity inserted behind a reflexed posterior myophoral plate in the left valve (*LV*) (Skelton & Smith, 2000). The only pre-Upper Aptian polyconitid taxon unambiguously recognized in the current literature is *Horiopleura dumortieri* (Matheron). Barremian specimens from SE France clearly show the prominent posterior myophoral shelf in the right valve (*RV*) that is diagnostic of *Horiopleura* (Masse, 1996), and the lineage continues into the Upper Aptian as *H. baylei* (Coquand). *Polyconites*, by contrast, has a more depressed *LV* and its posterior adductor inserted on an inward-sloping swelling on the *RV* inner wall, with no projecting shelf. Until now, the earliest known species of *Polyconites* was *P. verneuili* (Bayle), ranging from within the Upper Aptian. However, smaller specimens (of similar size to *H. dumortieri*) from the uppermost Lower Aptian (*Dufrenoya furcata* zone) of the Maestrat region of eastern Spain, show the depressed *LV* and myophoral configuration of *Polyconites*, to which genus we refer them as a new species. Its similarity to *P. verneuili* suggests direct chronospecific descent of the latter, with phyletic size increase, as seen in many other rudist lineages. Recognition of this *Polyconites* lineage resolves the status of certain mid-Aptian polyconitids previously assigned to *H. baylei* but recognized as problematical by Malchus (1998).

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Barremian-Aptian “petalodontid” Monopleuridae (Bivalvia, Hippuritacea): a reappraisal

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The genus *Petalodontia* proposed by Pocta (1889) for Cenomanian forms from Bohemia was subsequently, as a subgenus of *Monopleura*, applied to Albian species from the New World (Douvillé 1900) then to a group of cylindro-conical monopleurids from the Barremian of SE France (Douvillé 1918). Actually a reappraisal of these forms shows that their myophoral organisation does not conform to that of *Petalodontia* as described by Pocta. In the same way as the American “*Petalodontia*” *felixi* Douvillé as been assigned to the new genus *Pseudopetalodontia* (Masse et al. 2007), Barremian-Aptian forms from SE France are to be placed into a new genus characterized by a posterior myophoral plate and an anterior myophoral crest on left valve, myophores of right valve being on shell wall. This genus, ascribed to the Monopleuridae, is described from a new species found in the early Aptian of Ardèche (SE France), and also applies to the former *Monopleura (Petalodontia) bruni* Douvillé (1918) and *Monopleura mutabilis* Matheron (1878). Evolutionary relationships with *Pseudopetalodontia* and *Mathesia* are pointed out.

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***Dictyoptychus* Douvillé-morphology, phylogeny and biogeography**

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Dictyoptychidae Skelton contain three genera which are *Dictyoptychus* (Douvillé), *Eodictyoptychus* Skelton & El-Asa'ad and *Semailia* Morris & Skelton. *Dictyoptychus* shows a very wide geographic distribution according to other two genera and eight species of this genus, except *Dictyoptychus morgani* (Douvillé), are found and determined in the southeastern Anatolia (Karacabey-Öztemür, 1979; Özer, 1986, 2002, 2005).

The genus *Dictyoptychus* is characterized by the presence of canals in both valves. Left valve contain radial canals just below the thin lamellar layer and right valve have different type of canals such as large polygonal, fusiform, round and rectangular. According to the organisation of the right valve's canals, eight species like *D. striatus* (Douvillé), *D. paronai* (Kühn), *D. leesi* (Kühn), *D. euphratica* Karacabey-Öztemür, *D. orontica* Karacabey-Öztemür, *D. morgani* (Douvillé), *D. quadrizonalis* Özer and *D. vanensis* Özer, have been described until today and these species will be presented in this study.

The study of the species allowed us to propose a phylogenetic approach as follows: The specimens of *D. quadrizonalis* lack greatly expanded polygonal canals that are characteristics of the right valve in *Dictyoptychus*. Instead, they show numerous smaller canals, as seen *Eodictyoptychus*. On the other hand, *D. vanensis* includes many smaller canals, in contrast *D. morgani*, beside enlarged polygonal canals in the right valve. These data appear to be transitional between *Dictyoptychus* and its presumed ancestor, *Eodictyoptychus*. So, the two species are accepted as the most primitive forms of *Dictyoptychus*. A *morgani* group consisting of the species *D. morgani*, *D. euphratica* and *D. orontica*, is constructed because of the very close similarities of the enlarged polygonal canal organisation of these species. *D. striatus*, *D. paronai* and *D. leesi* are the large forms showing very different greatness and shapes of canals. The *morgani* group shows a phylogenetic relation with the primitive forms and the large forms.

The genus *Dictyoptychus* was determined from the Campanian-Maastrichtian of the southeastern Anatolia, Iran, United Arab Emirates, Oman and Somalia (Steuber, 2002). This biogeographic significance indicates that *Dictyoptychus* is an endemic canaliculate rudist genus showing only a distribution in the Arabian platform of the Tethyan realm (Özer, 1992 a and b).

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Taxonomy of rudists from the Campanian transgressive sediments of Brašljevia, Orešje and Kalnik Mt., Northern Croatia.

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Rudists are common fossils in transgressive Upper Cretaceous deposits in three localities placed in northwestern part of Croatia. Their appearances coincide with the beginning of transgressive sequence through floatstones-thickets. Within rudist community *Vaccinites*, *Hippurites* and *Hippuritella* could be differentiated according to their general or generic morphological elements.

The age of deposits were obtained from Sr-isotope composition of rudist shells as well as nannofossil community from marly sediments which overlaying rudists-bearing sediments at Orešje and Brašljevia localities. According to this data the age of transgressive sediments are determined as Campanian.

Morphological elements (ligamental ridge, teeth, pillars, inner diameter, length of the contour around the inner margin of the outer shell layer and the ratio between this length and the distance between the sutures of the pillars) from the transverse shell sections permit possible definition of different species within the family. Transverse shell sections of analyzed *Vaccinites*, *Hippurites* and *Hippuritella* specimens show different values of measured morphological elements as well as their ratios which, subjected to Cluster analysis (Ward's and Unweighted pair-group methods), represent ground for possible taxonomic determination of the hippuritids from three different localities.



The radiolitid genus *Distefanella* Parona, 1901. Restudy of the type material

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Parona (1901) proposed genus *Distefanella* for some long slender thin shelled radiolitids from San Polo Matese (southern Apennines, Italy), describing three species (*D. bassanii*, *D. guiscardii* and *D. douvillei*) besides the type species erroneously attributed to *D. lumbricalis* (d'Orb.). Parona (1912) corrected himself proposing *D. salmojraghii* as type species, after the detailed description of *Biradiolites lumbricalis* (d'Orb.) given by Toucas (1909). Nevertheless, the original mistake, together with some misinterpretation of the radial bands and inner shell structures, caused considerable taxonomical confusion leading to the misfortune of the genus.

The study of Parona's types, together with other specimens kept in museums and new material, allowed us to recognise the diagnostic characters of the radiolitid genus *Distefanella*.

Right valve is long cylindrical, frequently curved or multi-geniculate. Outer shell layer is extremely thin. Laminae are deeply inclined and show compact structure. Acute down-folds of the laminae are responsible for the regularly spaced acute radial ribs present at the external shell surface. The two radial structures correspond to wide flat down-folds of the laminae and appear externally as depressed radial bands, ornamented with rounded radial ribs thinner than those in the rest of the valve. There is no ligament ridge. Inner shell layer is also thin, more developed at the cardinal region to form the grooves where the two left valve teeth glided. Spaced inner tabulae are present.

Left valve is domelike. Outer shell layer is rarely preserved. Two distant long teeth are located far away from the dorsal margin and connected all along by a cardinal lamina. Myophores, joined with corresponding tooth, are thin and laterally wide. The myo-cardinal apparatus forms a tubular structure that, introduced in the upper part of the right valve, gives notable strength to a relatively thin shell.

Genus *Distefanella* is almost exclusively found in shelf margin contexts with a high sediment accumulation rate.

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***Yvaniella* of Turkey: description a new species, morphologic
and biogeographic remarks**

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Yvaniella Milovanovic has a hippuritid left and right valves. But it differs from the other genera of the hippuritids by the presence of excrescences with oscules separating by cloisons and also oscules very close to the siphonal area. The pores, excrescences and oscules travers the left valve and allows to develop an active filtration system to the genus.

Yvaniella has been only found around Amasya region (central Pontides) in Turkey. Two known species of the genus are determined from this region: *Yvaniella maestrichtiensis* Milovanovic has one excrescence with two oscules, however *Yvaniella alpani* Karacabey has two excrescences with two oscules in the left valve.

New material allows us to describe a new species of the genus: *Yvaniella philippii n.sp.* New species is characterised and differentiated from the other species of the genus by the structure of the left valve consisting of three layers and also two very developed excrescences. The posterior excrescence with three oscules is very close to the ligamental area and the anterior one with four oscules is located at the center of the valve. The oscules of the excrescences are installed at the top of the remarkably developed tubes. The small tubes with oscules are also observed in the siphonal area. The very little, round and oval pores are observed in all parts of the left valve and they are also well-developed in the flanks of the excrescences and tubes. The left valve is fortly inclined towards the interior. The anterior and posterior radial bands are very close, approximately occupies 1/6 of the circumference and they are well marked by longitudinal grooves along the right valve.

The transverse section of the right valve of *Yvaniella*, possedes slightly developed siphonal pillars and a lamellar external layer composed of fibrous structure. These morphologic characters are identical with those of *Hippuritella heritschi* (Kühn). Our recent knowledge show that the numerous determinations of *H. heritschi* have been only made by considering the right valve sections. This rises a problem as to which of these determinations belongs to *Yvaniella* or *H. heritschi*. On the other hand, *Yvaniella* shows a geographic distribution only at two localities such as Bačevica (eastern Serbia) and Amasya (north of Turkey) in the Mediterranean Province. This very restricted geographic distribution may be related with the determination problem of *H. heritschi*.



Taxonomy and evolutionary development of the Antilocaprinidae

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The Antilocaprinidae represent a distinctive family of canal-bearing rudists that occur in the Santonian to Maastrichtian of the Caribbean region. The family arose from a monopleurid ancestor and underwent extensive diversification, particularly in the Maastrichtian. Four nominal genera (*Antilocaprina*, *Titanosarcolites*, *Antillosarcolites*, *Parasarcolites*) have been described. Extensive collections from Jamaica demonstrate the morphological features of the Antilocaprinidae and how viable genera can be defined. Morphospecies range from equivalve to strongly inaequivalve, and adopted either elevator or recumbent lifestyles. The inner aragonite shell layer of both valves is very thick and filled with pallial canals, whereas the calcite outer shell is vestigial. In 'primitive' elevator forms three teeth (PT and AT in the LV, CT in the RV) are present, CT may lie between PT and AT or PT and AT may be in contact with CT shifted dorsally; two flat myophores (PM and AM) are present in these forms. In 'advanced' recumbent forms the myophores rotate to form tooth-like projects in the LV, these tend to be radially elongated in early forms but strongly modified and sometimes bi-lobed in later forms. One or two additional toothlets (AAT and PAT) may also be developed in the LV of some forms. The sockets for the teeth and myophores may be filled either by concave tabulae or by pallial-canal-bearing shell material. The form of the myophores, presence or absence of one or two additional toothlets, and the nature of the socket fill provide obvious means of distinguishing genera. Several stocks of recumbent also develop large canals or tubes in the inner shell layer, formed by infolding of the margin and subsequent division; their presence or absence and distribution can also be used to recognize genera. These features, used in conjunction, allow the recognition of at least eight different genera.



American Late Cretaceous radiolitids

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American late Cretaceous (Santonian-Maastrichtian) radiolitids are diverse and can be divided into a range of distinct genera.

Biradiolites. RV funnel plates with radial muri, LV compact, radial bands in furrows.

Parabournonia (*Bournonia* of authors). RV funnel plates with putules in irregular radial or unorientated.

Thyrastylon. RV funnel plates with muri in sectors, LV with pores.

Durania. RV funnel plates with polygonal cells, radial bands in furrows, LV low dome.

Tampsia. RV funnel plates with polygonal cells, RB2 a slit, LV low dome.

Macgillavryia. RV with funnel plates with polygonal amoeboid cells, LV domed.

Contraspira. RV with funnel plates with polygonal cells, LV domed and overhanging commissure.

Neoradiolites? (*Sauvagesia*, *Radiolites*, *Praeradiolites?*). RV with ligament and funnel plates with polygonal cells, RB on costae, LV domed with pallial canals in inner layer.

Chiapasella. RV with funnel plates with polygonal cells, RB on costae, LV coiled with pallial canals in inner layer.

Lapeirousia. RV with funnel plates with polygonal cells, RB with pseudocanals, LV a low dome.



Review of the genus *Ichthyosarcolites* in America

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Ichthyosarcolites is a canaliculate rudist widespread in the Cenomanian of the Mediterranean Tethys. Morphology of the shell is reasonably well known for most characters, although some doubts still remain for others.

The presence of the genus in America has been quoted since the middle nineteenth century, although following papers have questioned the *Ichthyosarcolites* identifications, proposing to ascribe the originally referred specimens to any of the American caprinid genera or adducing they can't be certainly identified because of lack of characters.

Current study of the genus *Ichthyosarcolites*, within the context of a wider survey on American rudists, involving specimens in museum collections (held at Universitat Autònoma de Barcelona and Universidad Nacional Autónoma de México), as well as new material from different localities in Europe and Mexico, confirm the presence of *Ichthyosarcolites* in the mid-Cretaceous of Mexico and provide useful evidence on some morphological characters of the shell. This new evidence confirms the interpretation of the myocardinal apparatus of the genus proposed by Douvillé that has been neglected in subsequent works.



***Thyrastylon*-morphology, taxonomy and lifestyle of a unique radiolitid rudist bivalve**

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The Caribbean radiolitid genus *Thyrastylon* is revised using large stratigraphic collections from Jamaica including exceptionally preserved material; two chronospecies, *T. adhaerens* (= *B. coryi*, *B. semiannulosus*) and *T. chubbi*, are recognized. RV is conical to cylindrical, has a thin inner shell layer, and a thick outer shell layer composed of radial plates. The radial bands consist of grooves (RB1, a spatula-shaped upfold; RB2, a flat-topped crenulated upfold), with the relative width of the bands and interband enabling the distinction of *T. chubbi* from *T. adhaerens*. The apertural surface may be smooth or plicated. The shell microstructure on naturally split specimens consists of sectors of parallel straight or curved muri, with the muri of individual sectors orientated radially, concentrically or at an oblique angle to the radius; muri may be broken up to form granules. The LV may be convex, flat or have a central dome and a broad brim. The central region is clearly distinguished from the brim and ornamented with flat-topped ridges alternating with 15-20 flat-floored grooves. The brim rises up toward, and is folded around the protuberances formed by the radial bands on the apertural surface sometimes forming oscules. The outer ends of the flat-floored grooves of the central boss penetrate the LV as a series of concentric, slit-like pores. The pores are orientated outwards and downwards and open onto the inner part of the funnel plates close to the body cavity. The myocardial apparatus consists of two teeth that fit into grooves on the inner layer of the RV, and two myophores. The pores of *Thyrastylon* are unique amongst radiolitids, suggesting a highly modified arrangement for filtering seawater. *Thyrastylon* grew in dense, bedding-parallel carpets with valves in close association. The development of slit-like pores in the LV may be an adaptation benefitting closely associated individuals.



***Karacabeyia*-A new rudist genus from eastern Anatolia.
Description and phylogeny**

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Malatya region (eastern Anatolia) is known by the presence of very rich rudist fauna containing new genera and species. So, this region is accepted as an endemic rudist center in the eastern Mediterranean Province. The specimens collected from the Campanian-Maastrichtian limestones of the transgressive mixed siliciclastic-carbonate successions of this area, around Yazıhan and Hekimhan, allow us to describe a new rudist genus: *Karacabeyia melitena* n.gen., n.sp.

The right valve of the new genus is conical ornamented with thin radial costae. The anterior and posterior radial bands are slightly developed, but generally they are not differentiated with other ornamentation of the valve. The external layer of the right valve is thick and composed of regular prismatic cells. The ligamental ridge is formed by a long and thin stem and large head. The teeth and myophore apophyses are very well-developed and observed.

The left valve is also conical with an apex located in the center of the valve. The shell wall is composed of three layers, from the periphery to the inward, which are lamellar, middle and pseudocanal layer. The lamellar layer is thin and composed of fine lamellae. The middle and pseudocanal layer contain different type of canals. The thick middle layer have numerous radial canals. In the eroded parts of the lamellar layer of the valve the orifices of the radial canals are clearly observed. The pseudocanal layer contains pyriform canals which are radially arranged on one row all over the layer.

The new genus shows some similarities by the presence of radial canals in the middle layer of the left valve with *Miseia* Patruşius, and but very close resemblances by the shape and ornamentation of both valves and especially by numerous radial canals in the left valve with *Joufia reticulata* Böhm. However, it differs from these genera by the presence of the fusiform canals in the pseudocanal layer. In this point, it may be correlate with *Colveraia* Klinghardt, *Balabania* Karacabey-Öztemür and *Branislavia* Sladic-Trifunovic. However, it is separated clearly from these genera by the presence of radial canals in the middle layer and slightly developed radial bands and very simple ornamentation of the right valve. Because of the presence of the canals both middle and pseudocanal layer in the left valve, the new genus can be correlate with *Kurtinia* Karacabey-Öztemür. But, the numerous radial canals are observed in the middle layer of the new genus instead of one row of canal of *Kurtinia*. The pyriform pseudocanals of the new genus are also subrectangular in shape in the *Kurtinia*.

These resemblances and differences indicate that *Karacabeyia* n.gen. is a transition form between *Joufia* and *Miseia* one part and *Colveraia*, *Balabania* and *Branislavia* in the other part. So, the new genus fills the phylogenetic gap between them.



Revision of *Gorjanovicia* species (Radiolitidae, Hippuritoidea) based on quantitative analysis

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The genus *Gorjanovicia*, first described by Polšak (1967) from Istria (Croatia), is currently known from the Coniacian-Maastrichtian of the peri-Adriatic and Balkan regions and includes 23 nominal species, defined mainly on shell ornamentation and radial bands. However, a re-appraisal of “*Radiolites*” *endrissi* Boehm (1927) shows the type species of the genus *Gorjanovicia*, *G. costata* Polšak (1967), to be a junior synonym of Boehm’s species, which thus takes priority as the type species of *Gorjanovicia*. Our revision of the 24 species described from the literature is based on a set of 21 characters concerning dimensions, shape and ornamentation of the right valve. Sixteen variables are defined from combinations of these 21 characters and treated by Principal Component Analysis (PCA), with hierarchical analysis, which has allowed us to distinguish three taxonomic groups, each defined after a key species: *Gorjanovicia endrissi* (Boehm), *G. ugarensis* Slišković and *G. kvarneri* Polšak. Hierarchy analysis of the variables shows the grouping of characters to match that of samples, and that a limited number of characters may be used to characterize the above taxonomic entities. PCA performed on four variables (posterior band and interband shapes, and two ratios, width of anterior band versus that of posterior band, and outer shell thickness versus width of the posterior band) documents three groups of samples in correspondence with those obtained through the analysis using 16 variables. We conclude that the four variables in question may be used as specific diagnostic characters and that the genus *Gorjanovicia* is represented by three species: *Gorjanovicia endrissi*, *G. ugarensis* and *G. kvarneri*, instead of the 24 described in the literature.

Low oceanic productivity, which also limited sponge development, was associated with the onset of *Gorjanovicia* characterized by a compact outer shell structure, whereas most Radiolitidae possess a cellular structure having the potential to avoid infestation by boring sponges. Specific assemblages from the Peri-Adriatic, Pre-Apulian and western Pontides regions are nearly identical, a pattern which suggests faunal exchanges within the distributional area of the genus *Gorjanovicia*. The palaeobiogeographical distribution of species corresponds with a relatively narrow palaeolatitudinal range in the subtropical portion of the eastern Mediterranean Tethys.

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Review of the generic affinity of American hippuritids

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The American hippuritid rudists are moderately to high diverse with representatives from the Turonian to Maastrichtian. Many forms however are poorly understood in terms of their relationship with Old World forms and in need of extensive revision. The following criteria are available for understanding the New World forms and their relationships with Old World forms.

- A. The structure of the outer layer of the RV. Low taxonomic value.
- B. The presence or absence of a ligamental infold. High taxonomic value.
- C. The arrangement of the Myocardinal system. High taxonomic value.
- D. The presence of canals in the inner layer of the LV. Possible high taxonomic value but probably homeomorphic.
- E. The form of the pores in the LV. High taxonomic value.
- F. The presence of multiple rays.

New World hippuritids fall into distinctive groups. As follows.

1. *Hippuritella* (based on B and E above). Turonian (Mexico); Maastrichtian (Mexico, Cuba, Jamaica).
2. *Vaccinites* (based on B and E above). Lower-Middle Campanian (Mexico, Curaçao, Jamaica, Cuba, Puerto Rico).
3. *Torreites* (based on B, D and E). Lower-Middle Campanian (Curaçao, Jamaica, Cuba, Puerto Rico).
4. *Barrettia* s.s. (based on C, D, E and F). Upper Santonain to Lower Maastrichtian (Mexico, Jamaica, Cuba, Puerto Rico, Californian, Peru, Haiti).
5. '*Whitfieldiella*' (based on C, D, E and F). Lower Campanian - Upper Campanian (Mexico, Jamaica, Cuba, Puerto Rico).
6. *Praebarrettia* (based on C, D, E and F). Upper Campanian(?) and Maastrichtian (Mexico, Boniare?, Jamaica, Cuba, Puerto Rico).
7. *Parastroma* (based on C, D and E). Middle Campanian-Lower Maastrichtian (Cuba, Jamaica, Puerto Rico)

Some forms are too poorly known to be included in the taxonomic framework at present, whereas others are based on incorrect interpretations (*Pseudobarrettia*, *Caribbea*) or preoccupied (*Gloria*).