Δελτίο της Ελληνικής Γεωλογικής Εταιρίας τομ. XXXX, 2007
Πρακτικά 11ου Διεθνούς Συνεδρίου, Αθήνα, Μάιος 2007

Bulletin of the Geological Society of Greece vol. XXXX, 2007
Proceedings of the 11th International Congress, Athens, May, 2007

# SEDIMENTOLOGY AND BIOSTRATIGRAPHY OF AN UPPER TRIASSIC CARBONATE SUCCESSION OF TRIPOLITZA PLATFORM IN MARI AREA, PARNON MOUNTAIN, SE PELOPONNESUS, GREECE

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## Abstract

*The Upper Triassic succession in the base of Tripolitza carbonate platform, in the Mari area of the Parnon Mt. in SE Peloponnesus, mostly consists of dolomites and to a lesser extent of calcitic dolomites. A detailed facies analysis and biostratigraphical study revealed that during Norian – Rhaetian times inter-supratidal and subtidal (shallow lagoonal) facies presenting cyclic development were deposited in the inner platform, similar to those that were formed in most of the Alpine platforms of the southern margin of the Tethys during the same time period. Diagenetic considerations further indicate that this shallow marine carbonate sedimentation was interrupted by subaerial exposure intervals and subsequent early lithification of the recently deposited sediments. The extensive and, mainly, early dolomitization and recrystallization, the presence of meteoric-vadose cements and specifically the repeated appearance of dolocrete horizons in the upper parts of many peritidal cycles, clearly show periodic subaerial exposure of the sediments, as well as the prevalence of semi-arid conditions in the area.*
***Key words:*** *Upper Triassic, Tripolitza carbonate platform, peritidal facies.*

## Περίληψη

*Η Ανω-Τριαδική ανθρακική ακολουθία στη βάση της πλατφόρμας της Τρίπολης, στην περιοχή Μαρί στο όρος Πάρνωνα, Πελοπόννησος, αποτελείται κυρίως από δολομίτες και σε μικρό ποσοστό ασβεστιτικούς δολομίτες. Λεπτομερής ανάλυση φάσεων και βιοστρωματογραφική μελέτη ανέδειξαν ότι κατά τη διάρκεια του Νόριου-Ραίτιου αποτίθεντο μεσο-υπερπαλιρροιακές και υποπαλιρροιακές (ρηχές λιμνοθαλάσσιες) φάσεις με κυκλική ανάπτυξη στο εσωτερικό της πλατφόρμας, παρόμοιες με αυτές που σχηματίζονταν σε πολλές Αλπικές πλατφόρμες του νότιου περιθωρίου της Τηθύος κατά το ίδιο διάστημα. Διαγενετικές παρατηρήσεις υποδεικνύουν περαιτέρω ότι η ρηχή θαλάσσια ανθρακική ιζηματογένεση διακοπτόταν από διαστήματα υποαέριας έκθεσης και επακόλουθης πρώιμης λιθοποίησης των πρόσφατα αποτεθέντων ιζημάτων. Η εκτεταμένη και πρώιμη κυρίως δολομιτίωση και ανακρυστάλλωση, η παρουσία μετεωρικών συγκολλητικών υλικών κατεισδύοντος ύδατος αλλά ιδιαίτερα η επαναλαμβανόμενη εμφάνιση δολοκρητών οριζόντων στα ανώτερα τμήματα πολλών περιπαλιρροιακών κύκλων υποδεικνύουν σαφώς περιοδική υποαέρια έκθεση των ιζημάτων καθώς και την επικράτηση ημίξηρων κλιματικών συνθηκών στην περιοχή.*
***Λέξεις κλειδιά:*** *Άνω Τριαδικό, πλατφόρμα Τρίπολης, περι-παλιρροϊκές φάσεις.*

## 1. Introduction - Geological setting

The development of the carbonate platforms in the peri-Adriatic area is a typical example of shallow sea carbonate sedimentation along the passive margins of southern Tethys, while their evolution is directly connected to the Alpine orogenetic cycle.

In the Hellenides, during Triassic, an outer platform that comprises the Preapulian – Ionian – Gavrovo - Tripolitza area is separated by the Pindos Ocean from the inner Pelagonian platform. In the outer platform the Ionian trough, individualized during Middle Jurassic, separates Preapulian platform from the Gavrovo – Tripolitza one. Two tectonosedimentary units are distinguished in the single Gavrovo – Tripolitza platform. The stratigraphic series of the Gavrovo unit, the outer one, comprises a thick carbonate neritic sequence, known from the Late Jurassic up to Late Eocene, followed by flysch sedimentation. The sedimentary sequence of the Tripolitza unit, the inner one, is more complete. It is constituted by a volcanosedimentary series at the base of Upper Paleozoic – Upper Triassic age, the Tyros beds, followed by a carbonate neritic series of Upper Triassic up to Upper Eocene age, followed by flysch deposits (Fleury 1980, Thiebault 1982, Jacobshagen 1986, Robertson *et al.* 1991). This study presents the results of a detailed sedimentological and stratigraphical investigation on an Upper Triassic carbonate succession, at the base of the Tripolitza platform in Parnon Mountain, southeastern Peloponnesus (Fig. 1a).

Parnon Mountain is built up by several thrust sheets consisting of Upper Paleozoic to Cenozoic sedimentary rocks that detached from their basement, due to the convergence of Eurasian and African plates during the Upper Oligocene-Lower Miocene. These thrust-sheets represent tectonic units derived from different palaeogeographic environments, such as carbonate platforms and deep basins (Fleury 1980, Thiebault 1982, Skourtsos *et al.* 2004). The lower ones exhibit metamorphism and they were uplifted and finally exhumed in Upper Miocene-Lower Pliocene, along low-angle normal faults during an E-W extension. The lowermost of the non metamorphic units, Tripolitza Unit, represents a carbonate platform of Upper Triassic to Upper Eocene age with a volcanosedimentary sequence of Upper Palaeozoic-Upper Triassic at its base, known as Tyros Beds (Lekkas and Papanikolaou 1978, Thiebault 1982, Skarpelis 1982) and a flysch on the top. The original stratigraphic contact between Tyros Beds and the overlain carbonates is in most cases disturbed by later tectonic events (Thiebault 1982, Skourtsos 2002).

Along the eastern flanks of the Parnon Mt., Tripolitza platform extends to thousand square kilometres representing a huge fault block, bound to the west by the Eastern Parnon normal fault and to the east by the Gulf of Argos (Skourtsos 2002). Along the coastal area the volcanosedimentary Tyros Beds and Upper Triassic to Liassic carbonate successions are the dominant formations. An Upper Triassic carbonate succession in the Eastern Parnon Mt, is discussed in this paper.

## 2. Materials and Methods

Fieldwork included facies analysis, detailed measurements and sampling. Selected and directed samples were taken for microfacies and micropaleontological analysis. Macrofacies analysis was supplemented with the study of structural and textural characteristics in polished slabs as well as with more than one hundred uncovered thin sections, stained with Alizarin red S and potassium ferricyanide to distinguish calcite and dolomite and detect the presence of iron in carbonates. X-ray measurements on most of the samples were carried out in order to determine the percentage of CaO and MgO and also the probable presence of non-carbonate material.

## 3. Stratigraphy

The study area is situated 2 Km on the northeast of the Mari village, on the eastern flanks of the Parnon Mt. (Figs 1a, b), where the Upper Triassic carbonate facies display significant growth.

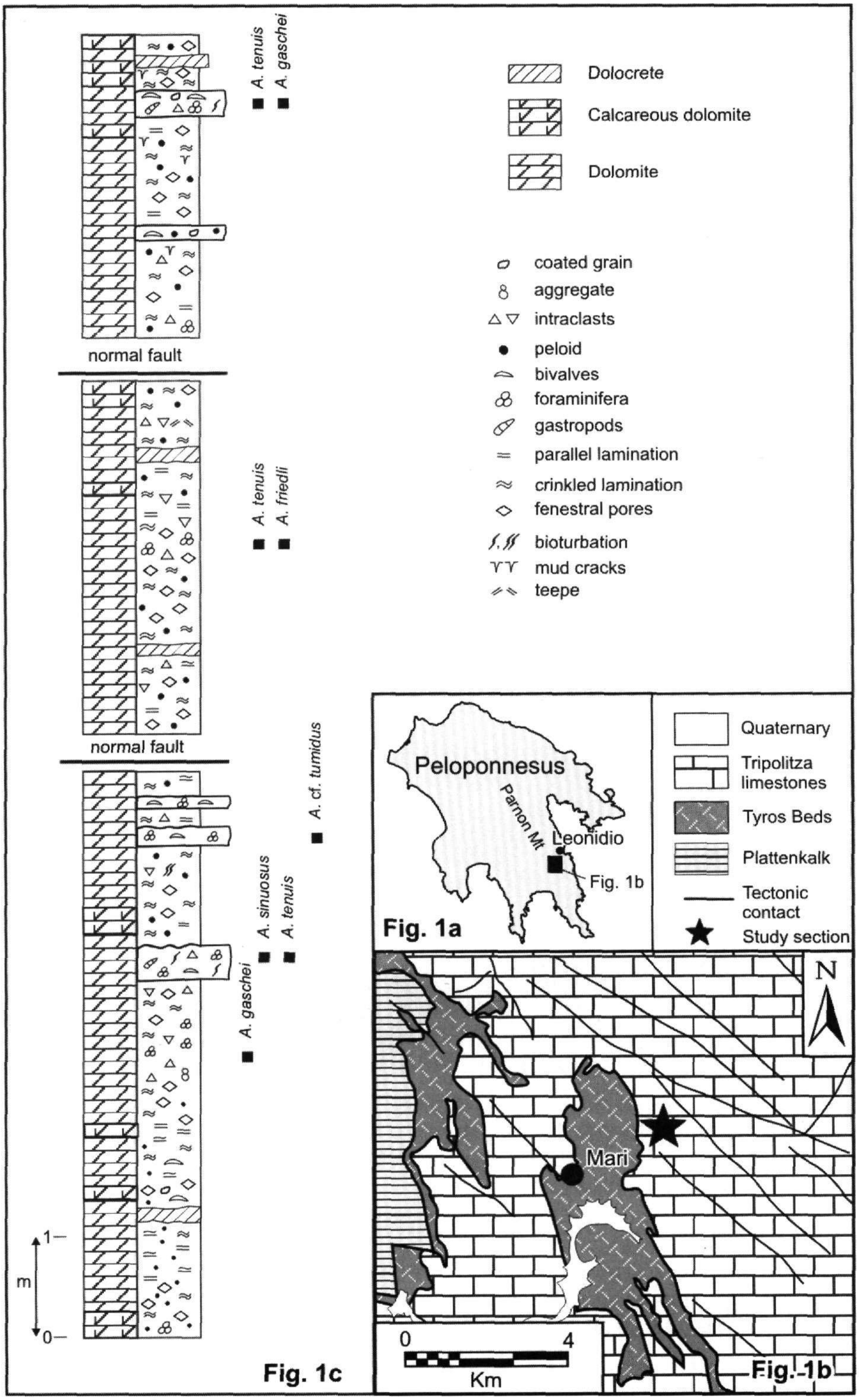


**Figure 1 – The study area is situated 2 Km on the northeast of the Mari village, on the eastern flanks of the Parnon Mt. (a, b), Geological map of the study area (b), modified from Skourtsos (2002) (c), Litho-biostratigraphy of the three studied Upper Triassic sections**

Three detailed sections are presented in this paper as they are observed in the field, separated by small normal faults. They consist exclusively of dolomites and calcitic dolomites.

Despite the intense dolomitization and the extensive recrystallization, several fossils and microfossils (foraminifera, ostracods, bivalves, gastropods) have been preserved (Fig. 2). Their distribution is presented in figure1c, beside the recognized depositional textural characteristics.

Among the foraminifera the species *Aulotortus sinuosus* WEYNSCHENK, *Aulotortus gaschei* (KOEHN – ZANINETTI & BRONNIMANN), *Aulotortus tenuis* KRISTAN, *Aulotortus* cf *tumidus* KRISTAN – TOLMANN 1964, *Aulotortus friedli* (KRISTAN – TOLLMANN) have been determined. The association of these foraminifera species date the succession as Norian – Rhaetian (Zaninetti 1976, Salaij *et al.* 1983, Ciarapica and Zaninetti 1984).

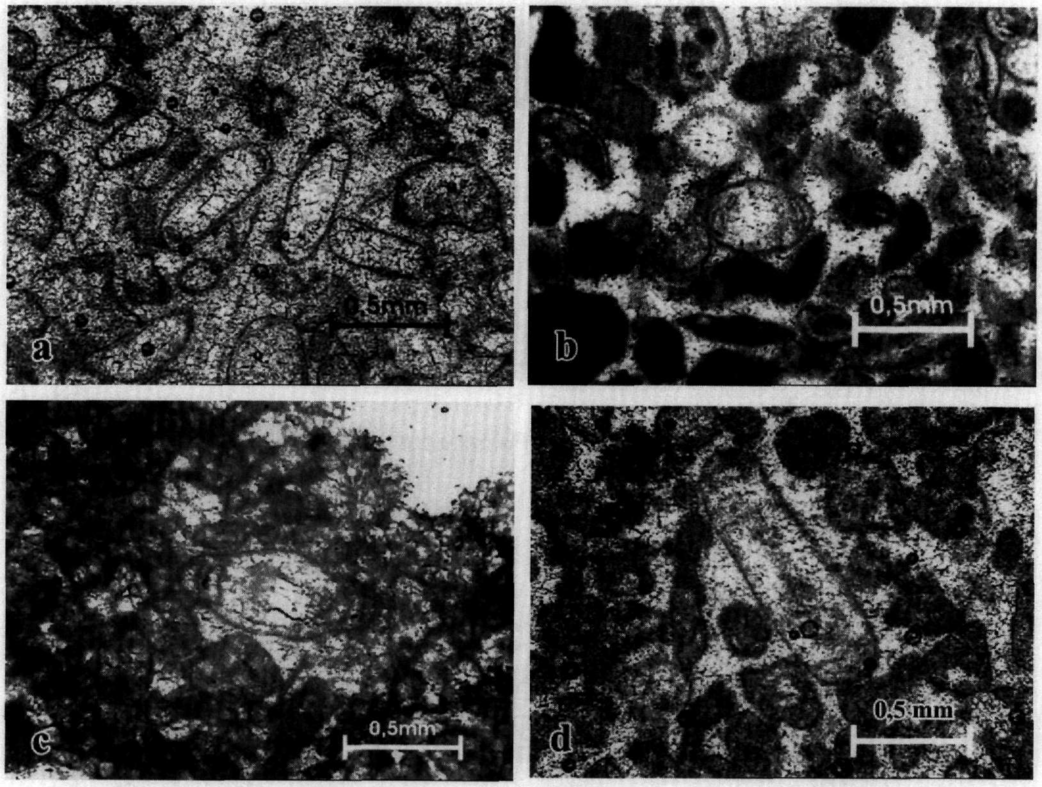


**Figure 2 – Facies of recrystallised Aulotortinae (a), *Aulotortus sinuosus* WEYNSCHENK (b), *Aulotortus gaschei* KOEHN – ZANINETTI & BRONNIMANN (c), *Aulotortus tenuis* KRISTAN (d)**

## 4. Lithofacies and environmental interpretation

Facies analysis showed a variety of lithofacies which can be grouped into two main units; the inter-supratidal and subtidal. As shown by the lithostratigraphical column (Fig. 1c) the inter-supratidal facies clearly dominate over the subtidal facies.

The inter-supratidal unit, in the lower parts of the section, consists of alternations of light and dark grey beds of varying thickness, in the range of 30 cm to 1 m, comprising pure dololutite to calcareous dololutite. Locally, the dark grey beds show an internal brecciation, while the light-coloured beds are lightly laminated. Upwards, the lamination becomes more intense and finally the facies are represented by alternations of light-coloured laminated and non-laminated beds of about

35 cm thickness. Although lamination usually appears flat or planar and generally parallel to bedding, locally small-angle cross-laminated layers and also layers with distinct crinkled lamination are observed. In the last two cases, the change in lamination type is marked by a stylolitic surface associated to the pressure-dissolution processes and the accumulation of residual sediment, probably conveyed from vugs and fractures. Unfortunately, sampling from these surfaces, for further examination, was not possible. In the upper parts of the succession, the inter-supratidal unit is represented by an alternation of structureless to lightly laminated beds of 1m thickness with beds of the same thickness but, with intense growth of fenestral fabrics and some internal truncated surfaces. Overall, on the basis of these textural characteristics, the inter-supratidal unit is markedly characterized by the development of stromatolites, typical of the peritidal environments. The subtidal unit comprises a small percentage of the succession and macroscopically is not clearly separated from the former unit. Its study was mostly based on microscopic observation. In the field it is mainly recognized by the presence of arenitic to fine ruditic-sized components. The latter are found either scattered or in distinctive white-grey coloured layers of a few mm to some cm thickness, within the abovementioned structureless beds of the inter-supratidal unit.

XRD analysis and thin sections staining showed that both inter-supratidal and subtidal units are entirely dolomitized, excepting a few parts of the former that become calcareous mostly in the upper parts of the succession (Fig. 1c and following description). It should be noticed, that although this calcitic dolomite was clearly recognized in the X-ray patterns, in the stained thin sections it was difficult to observe such a selective dolomitization.

Detailed microfacies analysis included description and separation of the facies mostly on basis of the textural characteristics (Dunham 1962). Nevertheless, the presence of specific skeletal and non-skeletal grains as well as of sedimentary structures has been used in the discrimination of some microfacies. Finally, eight main microfacies were recognized belonging to the above two units:

**MF1 Mudstone / laminated bindstone:** This facies is not often observed throughout the sections and mostly constitutes a dolomitic mudstone with very few microfossils, especially ostracods and fragments of thin bivalve shells in a mudstone-wackestone fabric. Sometimes it evolves into a laminated fabric consisting of finer micrite layers of few millimeters thickness alternated with somewhat coarser sparite layers (Fig. 3a). Though the characteristic difference of this facies is the lack of fenestral fabrics, locally where these mudstones become unfossiliferous, they show a few scattered fenestral pores, probably representing shrinkage pores.

This facies is interpreted as tidal-flat deposits, whereas the occurrence of ostracods particularly suggests a tidal-flat pond environment. Similar facies have been described in tidal-flat deposits of the Dachstein-type platforms and inner ramps (Fischer 1964, Flügel 2004, Haas 2004).

**MF2 Microbial laminated bindstone:** This facies is primarily dolomitic and comprises a significant percentage of the succession. It is made up of very thin planar to wrinkled micritic layers, alternating with sparitic layers in a bindstone fabric (Fig. 3b). The micritic laminae usually exhibit undulate algal structures, while sometimes they consist only of small peloids. The presence of bedding-parallel fenestral cavities, filled with cement and/or internal sediment of dolomitic mud, is quite common. Fossils are not observed.

Thin or thick horizontal laminations, with or without crossbedding, are restricted to the supratidal and upper intertidal area (Shinn 1983) whereas the crinkly lamination, in combination with the presence of fenestral fabrics, suggests additional intermittent exposure and desiccation (Riding 1991). Consequently, this facies was formed in the tidal flat area that was periodically exposed. This facies is comparable to several contemporary analogs (Shinn 1983, Hardie and Shinn 1986) and is also a typical stromatolitic facies of many ancient peritidal carbonates, such as the Upper Triassic carbonates of the Dachstein platform, constituting the algal mat loferites (Fischer 1964).

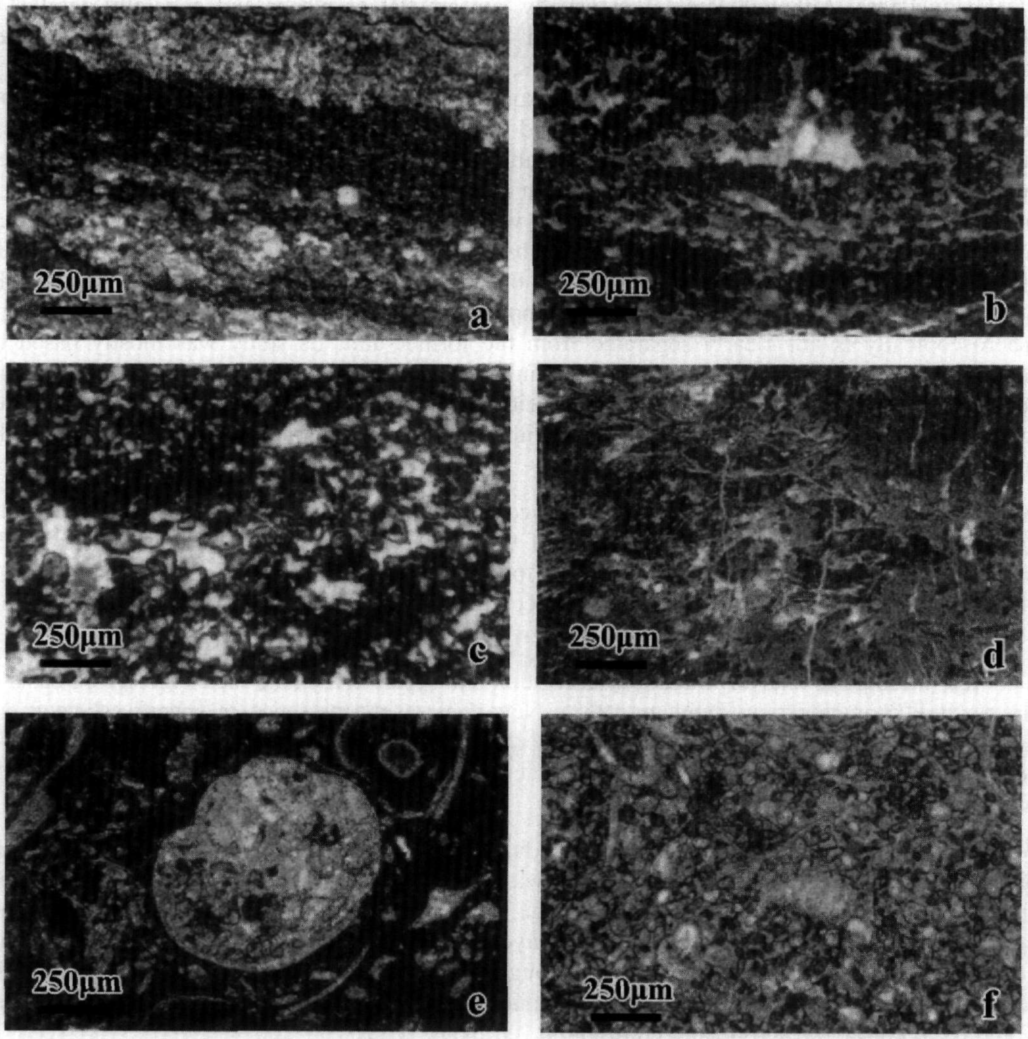


**Figure 3 – MF1. Laminated mudstone/bindstone (a), MF2. Microbial laminated bindstone with fenestral fabrics (b), MF3. Fenestral peloidal bindstone/packstone (c), MF4. Intraclastic breccia (d), MF5. Bioclastic floatstone/ wackestone (e), MF6. Coated grainstone (f)**

**MF3 Fenestral peloidal bindstone:** This is the most abundant facies of the succession and is mostly dolomitic, though in its upper part it becomes a calcareous dolomite, as suggested primarily through XRD analysis. It is characterized by intense lamination and large percentage of fenestral pores and larger voids (Fig. 3c). The planar or crinkled to microdomal laminations of millimeter-scale consist principally of very fine and densely packed peloids with microbial contribution; sometimes they are interbedded with finer layers composed of vesicular dolomite, probably representing molds of algae or other organisms which formed the mat. The biogenic grains are relatively few and are represented by recrystallized foraminifers, ostracods and more rarely gastropods and algae. Occasionally the laminations seem to be due to change of size of the peloids. Specifically, very thin layers of coarser peloids or/and small-sized micritic intraclasts, in a packstone fabric and with a distinct reverse grading, are observed. The other main characteristic of this facies are the many and variously sized fenestrae, mostly with laminoid fabrics, obviously representing desiccation structures. Some large prism cracks are also noted. Most of the fenestral cavities are filled mainly with sparite, while a few contain internal sediment in a geopetal fabric.

This facies has many common characteristics with the preceding one, constituting, as well, a typical stromatolitic facies and corresponding to the pellet loferites in Fischer's terminology. Its depositional environment is primarily the intertidal and supratidal area with periods of exposure and desiccation, as suggested by the lamination type and the presence of fenestrae (Shinn 1983, Riding 1991). Moreover, the coexistence of planar-horizontal with crinkled-microdomal lamination indicates an algal origin, although this is suggested with certainty only by the latter form (Shinn 1983). Specifically for the crossbedded laminated layers, a physical origin of the lamination is, however, not excluded but the prevalence of planar lamination against the crinkled and microdomal lamination forms suggests deposition under low energy conditions (Tucker and Wright 1990).

**MF4 Intraclastic breccia:** This facies takes up a small percentage of the studied sections, in contrast to other settings in the wider area wherein it constitutes a major facies of the Upper Triassic sequence (Zambetakis-Lekkas *et. al.* 2006). In specific, it appears in thin layers consisting of angular clasts in a wackestone to floatstone texture with some vertical desiccation cracks (Fig. 3d). The clasts belong to the microbial stromatolite and/or mudstone/bindstone facies and have calcareous dolomitic composition. The same composition is shared by the micritic to microsparitic matrix, as indicated by XRD analysis. Furthermore, variously sized subangular to subrounded micrite intraclasts are very frequently observed in the fenestral peloidal bindstone facies constituting thin interlayered horizons.

This facies is formed in the supratidal area and is regarded as an indication of desiccation of semi-lithified sediment followed by reworking and redeposition by storms (Shinn 1983). It also corresponds to the "intraformational conglomerate" in Fischer's terminology, making up a typical facies of the loferites of the Dachstein platform and suggesting also supratidal reworking.

**MF5 Bioclastic floatstone/wackestone:** This -and the remaining- facies, is exclusively dolomitic and is interbedded in the abovementioned supra-intertidal facies, even if the observation of its boundaries, either macro- or microscopically, has not been possible. The bioclasts are represented mainly by gastropods and bivalves, while foraminifers and in a lesser degree echinoderms and algae are also observed (Fig. 3e). The non-skeletal grains are mostly micritic intraclasts and a few coated and aggregate grains. The matrix is a mudstone-wackestone to a fine-grained packstone with variously sized peloids and a few bioclasts mainly of micritized and or recrystallized benthic foraminifera. The most important sedimentary structure is burrowing. Large and distinct burrows are filled with pellets, probably of fecal origin and small bioclasts in a packstone texture. Other characteristics of this facies are the common appearance of geopetal infilling in the internal of the larger skeletal components, particularly of the gastropods, as well as the dissolution of the aragonitic parts of the fossils, leaving molds that filled with sparry dolomite.

The association of the fossils and the composition of the matrix imply a protected shallow subtidal area as the depositional environment. In particular, the presence of the gastropods indicates the area parts with little circulation. Similar facies generally characterize shallow lagoons with relatively restricted conditions (Enos 1983).

**MF6 Coated grainstone:** This facies is overlain the bioclastic floatstones with abrupt and erosive boundary and consists exclusively of well sorted, sand-sized coated grains in a grain-supported fabric (Fig. 3f). The coated grains are mostly skeletal grains that have been preserved only by their micrite envelopes, corresponding to cortoids, or appear as completely micritized grains. Foraminifera, fragments of molluscs (bivalves) and echinoids were the main bioclasts. Additionally, in this facies the presence of peloids is significant, while some more spherical grains with a poor concentric development are also present, representing probably micritized ooids. The pore space between the grains has been filled mainly with sparry cement.

This facies is formed in shallow marine environment with normal salinity and constant wave action near the platform margin constituting winnowed sands (Tucker and Wright 1990).

Additionally, the aggregation of the fossils characterizes the open-marine parts of platform interior settings (Flügel 2004). The low frequency of this facies, however, and its embedding within the former facies, indicates that it was most probably deposited through periodic storm reworking.

**MF7 Aggregate-grain grainstone/rudstone:** This facies appears in a small percentage in the succession and is located over the floatstone with gastropods. It consists of arenitic- to ruditic-sized aggregate grains associated with variously sized peloids and many coated grains in a grain-supported fabric (Fig. 4a). The aggregate grains consists mainly of angular to subrounded micritized grains (lumps) and composite grains of cemented peloids and micritized skeletal grains exhibiting a lobate outline (grapestones). To a lesser extent some microbial clasts and a few oncoids are observed. Most skeletal grains are strongly micritized or recognized only from their shape due to the micritic envelopes that they had developed. The main fossils are foraminifera, bivalve fragments, algae and a few gastropods. The sorting is poor and the matrix is completely absent. Many grains show rims of fibrous marine cement while the remaining interparticle pores are mainly occluded by sparry cement.

This grapestone facies is interpreted as shallow subtidal with restricted to open circulation, so as to effect stabilization of grains and also cementation on the sea bottom. It is a characteristic facies of the contemporary deposits of the Great Bahamas Bank, where they are formed in very shallow depth, and also of ancient deposits mostly in rimmed carbonate platforms (Enos 1983, Tucker and Wright 1990, Flügel 2004).

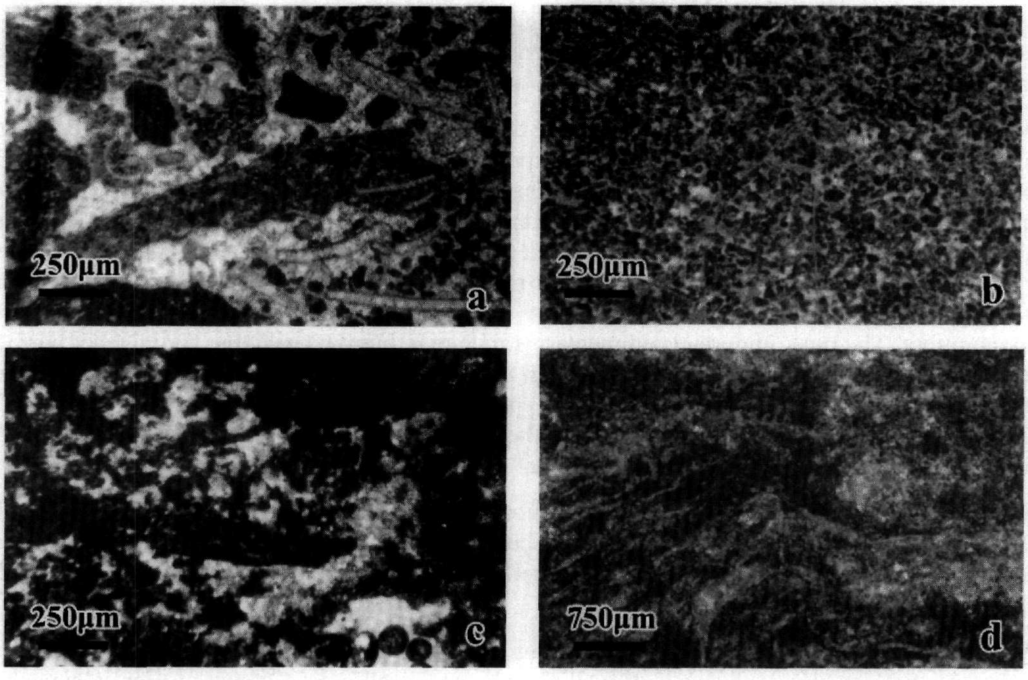


**Figure 4 – MF7. Aggregate-grain grainstone (grapestone facies) (a), MF8. Fine-grained peloidal grainstone (b), Vadose cements in dolocrete horizon (c), Microteepe structure (d)**

**MF8 Fine-grained peloidal grainstone:** This facies appears only in the uppermost section and is characterized by the prevalence of very fine, subangular to subrounded peloids in a grain-supported fabric (Fig. 4b). Several of the peloids are fecal pellets and others are very small micritic intraclasts, the latter mainly originating from the reworking of mud. The fossils are very few and are mostly represented by small foraminifera and ostracods. This facies generally displays good sorting. The cement is to some extent microsparite from the recrystallization of micrite. In some cases, very thin pelmicrite layers and/or irregular micritic laminae are observed. In a very few samples, scattered ruditic-sized, subangular fenestral peloidal intraclasts or fragments of bivalve shells, evidently transported, are noticed. The reworking of these very coarse-grained components is obvious, so much from the irregular shape of intraclasts, as much from the presence of borings on the bivalve shells. The latter clearly indicate the bioturbation of the sediment and, further on, it indirectly interprets the origin of many peloids.

This facies is formed in protected shallow-marine environment with moderate water circulation as in an inner platform lagoon and also in settings with increased salinity, such as in evaporitic arid platform interior (Flügel 2004). Similar facies have been observed in the upper subtidal or lower intertidal area, forming a resistant cemented crust which limits the channel deposition to the intertidal zone (Shinn 1983).

## 5. Diagenetic features

Though the primary objective of this study is facies analysis and the recognition of the depositional environments of these Upper Triassic rocks, in order to better understand the conditions of their formation, it is worthwhile to make a short reference to the diagenetic alterations. The main reason for this is that the carbonate peritidal sediments, very soon after their deposition, suffer intense early diagenetic modifications, mainly due to an intermediate subaerial exposure interval after the deposition of an individual cycle. As a result thereof, the diagenesis can change the original depositional texture completely. Further on, we shall chiefly deal with the diagenetic features that mainly show the subaerial exposure and early lithification of the sediments.

The most characteristic texture indicating periods of emergence and exposure of the platform is the presence of dolocrete horizons that have been located in the upper parts of some inter-supratidal facies and, more specifically, the peloidal stromatolitic facies. In particular, these horizons show non-homogeneous texture with coarse to very coarse sand-sized subangular to subrounded micritic clasts in a nodular fabric, densely packed peloids in a clotted texture, grains with variously thick coatings which sometimes occur only in one side of the grain, and spar-filled cracks surrounding the micritic clasts. In other horizons micritic grains of similar size or slightly larger are subspherical and show a poor concentric lamination probably constituting small pisoids or vadois (Esteban and Pray 1983). Additionally, these micritic grains are often connected by meniscus cements, while, usually they are also accompanied by gravitational (microstalactitic) cements (Fig. 4c). These types of cement have meteoric-vadose origin (Müller 1971). Finally, most of the horizons display a distinctive reverse graded bedding. All the above textural characteristics reveal typical features of dolocrete, which indicate periods of subaerial exposure and also semiarid climate (Esteban and Klappa 1983, Wright 1994).

As known, another common characteristic structure of the peritidal carbonates is the tepee, which appears as 'pseudoanticlines' with irregular polygonal crests. Although desiccation and related processes can result in such a small polygonal cracking, large peritidal tepees have complicated histories (Kendall and Warren 1987). In the studied area, even if large-scale tepee structures have not been observed, small scale ones have been microscopically recognized inside the intraclastic breccia facies (Fig. 4d). The presence of these microtepee structures, thought it is not a specific diagnostic feature, is usually associated with the formation of caliche facies (in this case dolocretes) indicating subaerial exposure (Esteban and Klappa 1983).

A strong indication of early lithification of the sediments is the preservation of the fenestral pores, desiccation cracks, prism cracks and also of larger vugs through their rapid infilling by cement and/or internal sediment. The filling of the various pores and vugs, however, shows complicated diagenetic history due to the periodical subaerial exposure and the subsequent mixing of meteoric and marine waters. In particular, the overall filling of the larger cavities, originating primarily from dissolution, usually includes: an initial fill with carbonate mud and/or pellets often in geopetal fabric, radiaxial fibrous or bladed cement, probably of marine phreatic origin, lining on the wall of the cavities and coarse blocky/equant spar, probably of meteoric origin, in the center of the cavities. Further, quite often gravitational cements of meteoric-vadose origin have also been observed to have filled some of the vugs.

Finally the almost complete dolomitization of the studied carbonate succession and also the extensive recrystallization evidently constitute primary diagenetic processes which are connected to the exposure and contributed directly to the early lithification of the sediments. In particular, as far as dolomitization is concerned, two major dolomite generations have been recognized on the basis of textural characteristics: for the most part a very finely to finely crystalline (5-40 $\mu$m) replacement dolomite and or cement, and to a lesser extent finely to medium crystalline mosaic (60-160 $\mu$m) of anhedral dolomite. The former dolomite generation is considered as an early diagenesis product, during which the textural depositional characteristics have been well preserved, while the latter generally precipitated during a later diagenetic stage. Similar early diagenetic, very fine-grained dolomites are formed even at the present time in intertidal-supratidal sediments of the Bahamas, Florida and Trucial Coast but are also found in many ancient peritidal sequences (Tucker and Wright 1990, Purser *et al.* 1994). In order to further investigate the mechanisms by which the dolomitization fluids moved through the rocks, an additional petrographic and geochemical study is required, something which can be the object of a future work.

## 6. Conclusions

Sedimentological and stratigraphic study of the Upper Triassic succession of the Tripolitza platform in the Mari area on the eastern flanks of the Parnon mountain indicates that during the Norian-Rhaetian there prevailed conditions of tidal to lagoon sedimentation with cyclicity similar to those of the same time period in nearly all the Alpine platforms on the margins of Neotethys.

Macrofacies and microfacies analysis showed that this Upper Triassic carbonates consist mainly of dolomites and to a lesser extent of calcitic dolomites, which exclusively make up cyclic peritidal facies, deposited in the inner platform. More specifically, the inter-supratidal facies, that are mainly represented by microbial and peloidal stromatolitic bindstones and to a smaller degree by intraclastic breccias, alternate with subtidal, shallow-lagoonal facies consisting mostly of bioclastic wackestones/floatstones. In the latter, a few thin intercalations of grainy facies, such as grapestones and coated grainstones are mainly considered as storm deposits. Overall, the various lithofacies formed in different subenvironments on the tidal flat, such as intertidal and supratidal area and pond, to shallow lagoon with the prevalence of low energy conditions.

This shallow marine sedimentation was, however, periodically interrupted by subaerial exposure intervals, as mainly suggested by the presence of dolocrete horizons within the inter-supratidal facies and also of some diagenetic characters, such as vadose meteoric cements and microtepee structures. More specifically, the repeated appearance of dolocrete horizons mostly implies extended subaerial exposure under semiarid climatic conditions. Consequently, the alternating influence of meteoric and marine waters caused various diagenetic phenomena, which contributed substantially to the early lithification of the sediments. Characteristic of the latter is the preservation of the abundant fenestral pores and larger cavities, through their filling up with multiple types of cements and/or internal sediment. Besides, the recrystallization and especially the dolomitization, which almost completely influenced the succession, played an important role in the lithification of the sediments during early diagenesis.

The studied Upper Triassic succession shows many common characters with cyclic successions of Dolomia Principale of the Southern Alps (Italy) and particularly of the Dachstein Dolomite or Hauptdolomit (Lofer Facies) of the Northern Alps (Austria) Northern Calcareous Alps (Fischer 1964, Bosellini and Hardie 1988, Goldhammer *et al.* 1990, Satterley 1996, Enos and Samankassou 1998). Corresponding shallowing- or deepening- upward cycles in the area of study are, however, hard to interpret, since the position of the subaerial disconformities, which are evidently represented by the dolocrete horizons, cannot be definitively clarified. Moreover, the rare appearance of the intraclastic breccias (corresponding to Member A of Fischer 1964) in these sections, as well as the presence of some truncated surfaces in the internal of the inter-supratidal unit mostly show incomplete cyclicity. Lastly, the repeated occurrence of subaerial exposure conditions and the vadose alterations may suggest allocyclic (eustatic or tectonic) controls of cyclicity (Wright and Burchette 1996).

## 7. Acknowledgments

Thanks are due to SARG of National and Kapodistrian University of Athens for financial support.

## 8. References

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