Facies associations of the late Cenomanian carbonate platform of Tripolitza subzone (Vitina, Central Peloponnesus, Greece): evidence of long-term/terrestrial subaerial exposure

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ABSTRACT

The facies distribution of the Late Cenomanian carbonate platform deposits of the Tripolitza zone, in central Peloponnesus (Vitina, Mainalon Mnt., Greece) is more or less uniform and supports a flat topography of the related platform sector during the above interval. Peritidal facies with shallow-upward cycloths predominate, containing a subaerial exposure evidence, while parts of the studied section correspond to vanished evaporites. Texturally, the Late Cenomanian limestone in central Peloponnesus, as well as, in central eastern Crete, appear principally as wackestone, lesser as wackestone-packstone and only randomly as packstone-floatstone. Peloidal wackestone are common, as well, characterized by irregular fenestrae and/or dissolution cavities. Grainstone (intrabioclastic) are minor in occurrence.

Facies associations include: fossiliferous limestone/dolostone and microbial laminites documenting a low-energy, restricted shallow subtidal environment to intertidal/supertidal settings in a ramp-like depositional system comparable with the Balearic ramp-like platforms; temporary high-energy conditions also periodically occurred; dolomites/dedolomites after preexistent evaporites assigned to supratidal conditions and intermittent subaerial exposure as well as pedogenic limestone-conglomerates support a long-term, terrestrial exposure environment. The thick shale interval detected in the Vitina section supports a long-lasting exposure (sedimentary hiatus) of the platform during the Late Cenomanian. Pedogenic alteration of the sediments is intensive along certain horizons, indicating a subaerial exposure evidence, while parts of the studied section reflect the presence of a great lacuna meteorica. The level argilloso, of notable thickness, cantered in the succession investigated is more or less uniform and testifies a continuous relationship of the sea-level. The horizontal and the vertical sedimentary evolution of the Tripolitza zone, in central Peloponnesus (Vitina, Mainalon Mnt, Greece) affords a sequence sedimentaria that characterizes the Late Cenomanian superiore of the general platform sector during the above interval. In the Cretaceous peri-Adriatic Carbonate Platforms, the Cenomanian successions were characterized by a significant turnover of facies and biota in relation with the development of complex pathworks of depositional environments. Previous investigations of Cenomanian shallow-water limestone that crops out in central eastern Crete (Greece, ZAMBE TAKIS-LEKKAS et ali, 1995, ZAMBE TAKIS-LEKKAS et ali, 2007) as well as, in the Central Peloponnesus (Greece, ZAMBE TAKIS-LEKKAS, 1988; ZAMBE TAKIS-LEKKAS et ali, 1995; ZAMBE TAKIS-LEKKAS & ALEXOPOULOS, 2007) enabled to us to detect a cyclic stacking pattern was prevailing in the analyzed successions. Successions are composed of shallow-upwards cycles in which the sedimentary composition and texture, sedimentary structures and fauna are consistent with intertidal-shallow subtidal flats in inner-shelf low-energy depositional settings. Intense dolomitization, significant processes of pedogenesis and, locally, clear evidences of pre-existing evaporites are common features of these carbonates representing an interesting topic to be investigate in order to interpret some of the Cenomanian depositional settings.

The aim of the present study was the recognition of facies distribution of the Late Cenomanian carbonate platform deposits of the Tripolitza zone, in central Peloponnesus (Vitina, Mainalon Mnt, Greece), the determination of the responsible environmental factors and the palaeoenvironmental reconstruction of the platform during the Late Cenomanian.
GEOLOGICAL SETTING


The Tripolitza zone constitutes the eastern (internal) part of the Gavrovo-Tripolitza platform, of the Hellenides. TSAILA-MONOPOLIS (1977), FLEURY (1980) and ZAMBETAKIS-LEKKAS (2006) present in a synthetic way the stratigraphy and the sedimentology of the Tripolitza zone. FLEURY (1980), presents a biozonation of the Cretaceous deposits of the Gavrovo-Tripolitza platform, determining 7 biozones for the Albian-Maestrichtian interval. The investigated in this paper series corresponds to the CsB2 Fleury's biozone of upper Cenomanian age. According to FLEURY (1980), BERNIER & FLEURY (1980), during this period subtidal conditions of sedimentation dominated in the Tripolitza zone, while intertidal/supratidal conditions of sedimentation in the Gavrovo zone. ZAMBETAKIS-LEKKAS (1988) and ZAMBETAKIS-LEKKAS et alii (1988) describe in central Peloponnesus, in the Vitina area an emergence episode during late Cenomanian in the Tripolitza zone. More detailed investigations in the region provided strong evidences of a local, long-term/terrestrial exposure environment. In this paper we document these evidences and we discuss about the duration and the responsible reasons for this emergence episode.

METHODS

The section has been lithologically, sedimentologically and biostratigraphically described, the repetitive facies patterns have been interpreted and a detailed stratigraphic log has been constructed.

STRATIGRAPHY

The outcrop investigated is located on the road Vitina-Tripolis 6 km from Vitina (fig. 1). It belongs to the Cretaceous carbonate sequence of Mainalon (ZAMBETAKIS-LEKKAS, 1988). The outcropping limestone is intensively faulted and its upper Cenomanian part, reaching up to 150m in thickness, is dated by Pseudorhapydionina dubia,
Fig. 2 - Lithostratigraphic log of the Vitina section.
– Colonna stratigrafica della sezione esaminata di Vitina.
Pseudorhapydionina laurinensis, Pastrikkella balcanica, Pseudonommmoloculina regularis, Biplanata peneropliiformis, cf. Merlingina cretacea. Nezzazatinae, discorbids, opthalmidiids, Aeiolissacus kotori, ostracods gastropods and Thaumatoporella. In addition, peloids are locally abundant. Bioclastic packstones-grainstone (packed biomicrites/biopelmicrites to biopsparites) with rich benthic fossil assemblages are observed along some horizons. Fauna includes miliolids, discorbids, Aeolissacus kotori, rudists, gastropods, Nezza- zatidae, and Pseudonommmoloculina regularis (Pl. I/2). Grainstones (pelsparites-intrapelsparites) with ellipsoidal to round peloids–nodules are locally common (Pl. I/3). Selective secondary porosity, due mainly to gastropod shells dissolution, occurs as well as thin sheet cracks and irregular pore spaces (ped and fenestrae textures).

Microbial laminites occur at many levels and are characterized by high-organic content. In places the stromatolitic laminae are rich in ostracods whose shells are parallel orientated (Pl. I/4).

Desiccation cracks, in-situ brecciation and irregular fenestrae, of bird’s eyes type with geopetal filling, are very common (Pl. II/1) witnessing to significant, although effemeral subaerial exposure episodes. Microepikarstic cavities, filled with speleotheme-like cement occur in places (Pl. II/2). The former presence of evaporites is implied by anhydrite and gypsum pseudomorphs (crystals and/or nodules), authigenic idiomorphic quartz crystals and disseminated pyrite (Pl. II/3). Replacing calcite/dolomite textures characterized by variation in crystallinity and «pile-of-bricks» texture remind preexistent anhydrite (Pl. II/4).

The above facies association is commonly interrupted by pedogenic limestone and conglomerates (see «Facies Association 3»). It has to be noted, that in the upper part of Unit C a thick shale interval (20–50 cm), mineralogically composed of illite, has been detected interrupting the carbonate sequence. Upon that layer, sediments contain abundant intraclasts from the substrata (fig. 2).

Interpretation

On the whole, this facies association witness to very-shallow, low-energy, restricted subtidal to supratidal environments, with salinities ranging from nearly normal marine to hypersaline. It consists of a classical peritidal facies association, arranged in shallowing-upward cycles.

The rich in benthic fauna assemblage wackestone-packstones witness to a protected shallow subtidal setting (e.g.: low-energy lagoonal environment. Washed packstones and grainstones indicate temporary high-energy conditions. Microbial-stromatolitic laminites grew in, and/or close to the shallow lagoons. Intertidal-supratidal laminites are witnessed by loeritic laminae in which the abundance of dissication features suggests significant although effemeral subaerial exposures. «Intermittent» subaerial exposures as well as salinity fluctuations may also be inferred from the former presence of evaporites. The thick shale interval of Unit C presumably reflects a very-long lasting exposure during the late Cenomanian. The rich in carbonate intraclasts horizon marks the starting of sedimentation above this discontinuity (fig. 2).

**Facies Association 2: dolomites/dedolomites after preexistent evaporites**

This is the principal facies association of Units A and D. It is characterized by textures assigned to preexistent evaporites, although evaporites are entirely replaced by dolomite or curved rhombic calcite crystals (dedolomite)
Pseudomorphs after nodular and "pile-of-bricks" textures are common. The variation in crystallinity and the crystals habit, strongly remind preexisting evaporites. Along certain horizons, solution-collapse breccias, resulting by dissolution of evaporites, occur. Disseminated pyrite, curved rhombic or radial dolomite crystals are also indices of vanished evaporites. Due to further dedolomitization and recrystalization, most evaporite-related textures have been obliterated.

Thin argillaceous intercalations are common.

**Interpretation**

Preexisting evaporites are assigned to supratidal conditions and "intermittent" subaerial exposure, which prevailed during certain time intervals. The argillaceous intercalations mark preexisting erosional surfaces.

(Plate III/1). Pseudomorphs after nodular and "pile-of-bricks" textures are common. The variation in crystallinity and the crystals habit, strongly remind preexistent evaporites. Along certain horizons, solution-collapse breccias, resulting by dissolution of evaporites, occur. Disseminated pyrite, curved rhombic or radial dolomite crystals are also indices of vanished evaporites. Due to further dedolomitization and recrystalization, most evaporite-related textures have been obliterated.

Thin argillaceous intercalations are common.

**Facies Association 3: Pedogenic Limestone and Conglomerates**

Pedogenic limestone intervenes very often along the studied stratigraphic section and occur mainly above certain disconformities, representing the result of pedogenic alteration of the previously described peritidal facies. In thin sections they usually exhibit floatstone textures, with caliche pisoids (Plate III/2), meniscus-like cement, clotted micrite, rhizocretions, alveolar-septal texture, soil glaebules, black pebbles, nodules, irregular fenestrae, circumgranular cracking, ferroan dolomite/dedolomite, laminar calcrites, black pebbles and displacive-growth brecciation fabrics. In places, ostracods are common.

Poorly-sorted pedogenic conglomerates (soil breccias) represent an *in-situ* type of brecciation, due to intensive brecciation. Relics from the primary deposited carbonate...
Interpretation

The conglomeratic levels, clearly have a pedogenic origin. Features as caliche pisoids, rhizocretions, alveolar-septal texture and black pebbles are very strong indices of this origin.

Facies 3 consists a complex subaerial exposure assemblage of «long-term/terrestrial» type.

According to the exposure index of Ginsburg et alii (1977), the «long-term/terrestrial» exposure corresponds to an exposure index of 100%, and normally is not flooded by marine waters. The terrestrial subaerial exposure of carbonate platforms is indicative for relative sea level fall, and can only be produced by allocyclic processes. During this extended exposure the carbonate platform is meteorically altered and development of variable pedogenic features, such as alveolar textures and soil glaebules, are favoured. Instead, during the «intermittent» subaerial exposure, which characterizes the supratidal and the intertidal environment, time is too short for the development of pedogenic features and the most common features are desiccation cracks and bird’ eyes. Therefore, the recognition of intermittent and terrestrial exposure environments in carbonate platforms is very significant for the reconstruction of the global sea-level fluctuations.

DISCUSSION

The lithofacies associations of the Vitina section, support a flat topography of the Tripolitza zone in Late Cenomanian, because the depositional environments were not deeper than the shallow subtidal zone. The studied shallow-marine deposits probably built up at or close to sea level, filling accommodation. This resulted in a generally flat topography, which in turn favoured a more or less uniform facies distribution.
During intermittent subaerial exposure episodes, supratidal conditions prevailed, giving birth to evaporites formation. Strong evidence of vanished evaporites consist of horizons with solution-collapse breccias and pseudomorphs after evaporite crystals/nodules and textures.

According to the most recent European sequence chronostratigraphy framework (HARDENBOL & ROBASZYN-SKI, 1998), the Late Cenomanian corresponds to the post-Ce 5-6 interval, and it is well known, that this interval coincides with a global sea-level rise perhaps resulted in (HAQ et alii, 1987). However, in the Upper Cenomanian carbonate lithostratigraphic section of Vitina, it has been shown, that most discontinuity surfaces correspond to long-term terrestrial subaerial exposure environment and are marked by pedogenic limestones and conglomerates. On top of the subaerial exposed facies, subtidal facies are found corresponding to transgressive facies. The prevalence of such a complex subaerial attestation of terrestrial type supports the fact that during the Late Cenomanian, which is known to reach the highest sea-level stand of the entire Phanerozoic, several relative sea-level lowering episodes, of allogetic origin, took place. Local tectono-sedimentary conditions presumably ruled the sea-level fluctuations.

CONCLUSIONS

The sedimentological study of the Late Cenomanian platform deposits of the Tripolitza zone (Vitina, Mainalon Mnt, Greece) shows a facies distribution of a classic peritidal environment, which undergo to effemeral subaerial exposure episodes. The depositional environment was not deeper than the shallow subtidal zone supporting a flat topography of the Tripolitza zone in Late Cenomanian. The repeated discontinuities, which correspond to long-lasting and more complex subaerial exposure events wit-
ness to long-term/terrestrial intervals. This supports intervening sea-level lowering intervals, of allogenic origin, in the frame of the general global sea-level rise of the Late Cenomanian.

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REFERENCES


