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BIOSTRATIGRAPHY AND SEDIMENTOLOGY OF THE IONIAN ZONE AMMONITICO ROSSO IN THE MAVRON OROS AREA (NW EPIRUS, GREECE) – PALEOGEOGRAPHIC IMPLICATIONS

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Abstract

New biostratigraphic and sedimentologic data on the Ammonitico Rosso (AR) formation in the Mavron Oros area (Ionian zone, NW Epirus) show that its thickness progressively reduces towards the N-NW (from 15 to 7m). Two sections were studied, in the thick (A) and thin succession (B) respectively. The ammonite fauna indicates a stratigraphic range for the AR from the early Toarcian to the Aalenian, in section A, and from the upper part of Middle Toarcian to the Aalenian, in section B. Thus, AR deposition was transgressive, confirming the stratigraphic pinching-out of the synrift formations, observed in the same area towards the N-NW. Sedimentologic observations showed that the AR in section B (where AR base is missing) consists of nodular mud-to wackestones with subsolved ammonite shells, and clear indices of early lithification and subsequent solution of fine carbonate material. These observations indicate low rates of sedimentation and repeated phases of non-deposition and submarine erosion, characteristic for seamount environment.
Key words: *Ionian zone, Ammonitico Rosso, half-graben, synrift formations.*

Περίληψη

Νέα βιοστρωματογραφικά και ιζηματολογικά στοιχεία για το Ammonitico Rosso (AR) στην περιοχή Μαύρον Όρος (Ιόνια ζώνη, ΒΔ Ήπειρος) δείχνουν ότι το πάχος του ελαττώνεται προοδευτικά προς τα Β-ΒΔ (από 15 σε 7 μέτρα). Μελετήθηκαν δυο τομές, η Α με AR μεγαλύτερου πάχους και η Β με AR μικρότερου πάχους. Η πανίδα των αμμωνιτών δίνει στρωματογραφικό εύρος για το AR της τομής Α, από το Κατώτερο Τοάρσιο ως το Ααλένιο, ενώ για την τομή Β, από το ανώτερο τμήμα του Μέσου Τοάρσιου μέχρι το Ααλένιο. Συνεπώς, η απόθεση του AR ήταν επικλυσιγενής, επιβεβαιώνοντας την στρωματογραφική αποσφήνωση των συνταφρογενών σχηματισμών, η οποία παρατηρείται στην ίδια περιοχή προς τα Β-ΒΔ. Οι ιζηματολογικές παρατηρήσεις έδειξαν ότι το AR της τομής Β (όπου λείπει η βάση του AR) αποτελείται από κονδυλώδεις ασβεστόλιθους (mud-ως wackestones) με υποδιαλυμένα αμμωνιτικά όστρακα και μεταγενέστερη διάλυση του λεπτομερούς ανθρακικού υλικού. Αυτές οι παρατηρήσεις δείχνουν χαμηλούς ρυθμούς ιζηματογένεσης και επαναλαμβανόμενες φάσεις μη απόθεσης και υποθαλάσσιας διάβρωσης που χαρακτηρίζουν υποθαλάσσιο ύβωμα.
Λέξεις κλειδιά: *Ιόνια ζώνη, Ammonitico Rosso, ημιτάφρος, συνταφρογενείς σχηματισμοί.*

1. Introduction

The Ionian zone of NW Greece (Epirus region) constitutes part of the most external zones of the Hellenides (Pre-Apulian zone, Ionian zone, Gavrovo zone; Figure 1). The evaporite base of the Ionian series, dated Scythian-Anisian (Pomoni-Papaioannou & Tsaila-Monopolis, 1983, Dragastan et al., 1985) is capped by the Foustapidima limestones, dated Ladinian-Rhaetian by Karakitsios & Tsaila-Monopolis (1990). These are overlain by the Pantokrator limestones, classically dated as Lower Jurassic (Aubouin, 1959; IGRS-IFP, 1966; Karakitsios & Tsaila-Monopolis; 1988). These neritic platform deposits give way to mainly carbonate, locally silicified, pelagic deposits of Pliensbachian age (Karakitsios, 1992, 1995). Pelagic deposits begin with either the Siniais limestones (with rare bands and lenses of replacement chert) or their lateral equivalent, the Louros limestones (no cherts). The facies and thickness variations of these deposits are indicative of active tectonic spreading related to the opening of the Pindos oceanic branch of Neo-Tethys Ocean (Karakitsios 1990, 1992, 1995; Karakitsios & Rigakis 2007). The period of Siniais and Louros limestones deposition is important in the history of Ionian zone in Greece and in Albania as it saw the onset of rifting. What until then had been extensive, monotonous carbonate platforms (e.g. Pantokrator neritic *Palaeodasycladus mediterraneus* limestones) broke up as a pelagic sedimentary basin formed.

The break-up of the carbonate platforms was followed by intense internal differentiation of the Ionian Basin. This differentiation separated the initial basin into smaller palaeogeographic units with half-graben geometry, as it is recorded in the abruptly changing thickness and facies of the synrift formations which take the form of synsedimentary wedges (Karakitsios 1995). In the deeper parts of the half-grabens, these include complete Toarcian-Tithonian successions with Ammonitico Rosso or Lower Posidonia beds at their base, while in the elevated parts of the half-grabens, the succession is interrupted by unconformities. The directions of synsedimentary structures (e.g. slumps, synsedimentary faults, and stratigraphic pinch-outs of the synrift formations) indicate that deposition was controlled by structures formed during extension related to the opening of the Pindos Ocean compounded by halokinesis involving the evaporites at the base of the Ionian carbonate sequence (Karakitsios, 1995). In the Early Cretaceous (Berriasian) the transgression is complete, as is it shown by the onset of the pelagic Vigla limestones deposition in the entire Ionian zone (Karakitsios 1992; Karakitsios & Koletti 1992). Thus, the base of the Vigla limestones represents the beginning of the Ionian basin postrift period. After Vigla limestones deposition, the pelagic conditions persisted (pelagic sedimentation accompanied by calciturbidites derived from the adjacent Gavrovo and Apulia platforms) until the Late Eocene, when flysch sedimentation began.

This work dates precisely the lower part of the complete synrift successions from the locally abundant macro-fauna (ammonites), and specifies the age distribution of the Ammonitico Rosso in a half-graben sub-basin of northwestern Greece (NW Epirus). Additionally, paleo-bathymetric and sedimentological observations related to the stratigraphic pinching out of the Ammoninico Rosso formation, attest the presence of a small sub-basin with half-graben geometry (due to the internal differentiation of the Ionian basin) and its transgressive synsedimetary filling.

2. Geological Observations

According IGRS-IFP (1966) and Karakitsios (1990, 1992), Mavron Oros hill allows to distinguish, from south to north (for a length of less than two kilometers), the passage from a palaeogeographic zone with complete Siniais limestones-Lower Posidonia beds-limestones with Filaments-Upper Posidonia beds succession, to a zone where the Lower Posidonia beds are replaced by the Ammonitico Rosso and then progressively pass to a hiatus zone where the Vigla limestones repose directly on the Pantokrator limestones. This facies passage was attributed to a synsedimentary fault, which could serve as barrier between Lower Posidonia beds and Ammonitico Rosso facies.

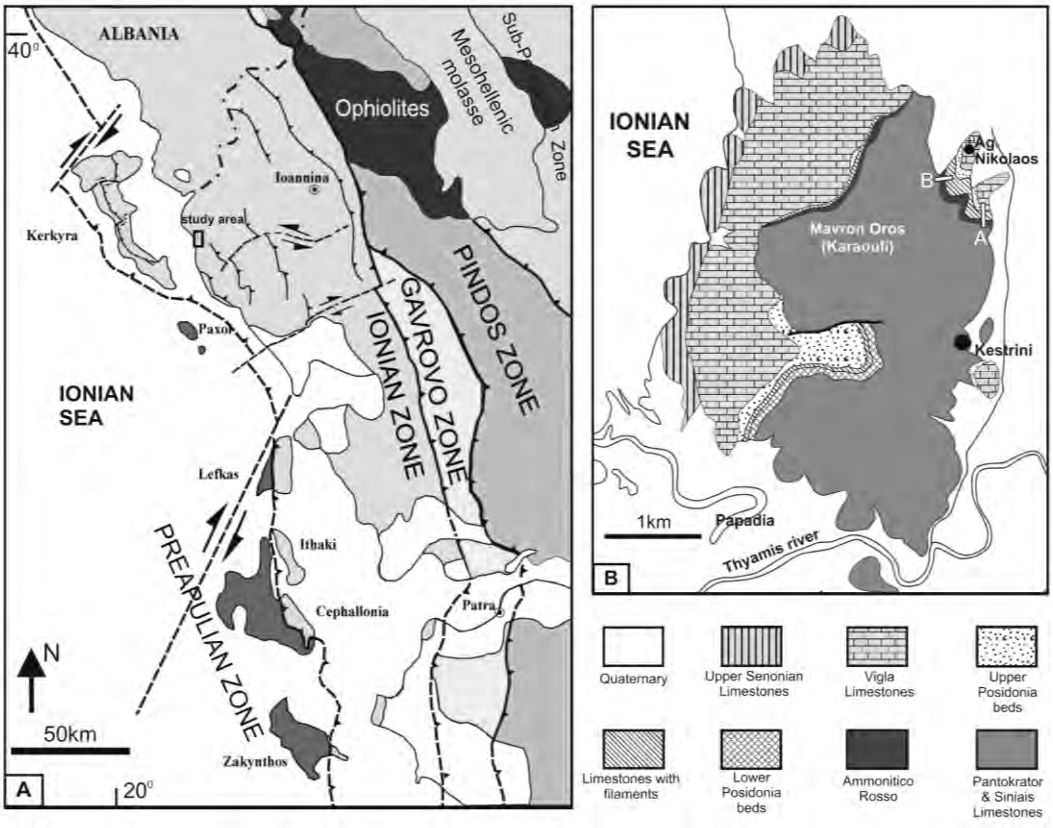

Figure 1 - A: Simplified geological map of Western Greece. B: Geological map of the study area (A and B location of the sections of Figure 2).

We undertook again the study of this area in order to conduct; firstly detailed field observations and secondly, by using detailed biostratigraphical and sedimentological data to verify the above hypothesis.

2.1 Field Observations

In the south part of the hill, which is tectonically lowered by at least 100 meters relative to the northern part, the stratigraphic succession, over the well developed Siniais limestones, is:

-30 m of Lower Posidonia beds: bleu frequently bituminous marls, being red at the upper part of the formation. In all stratigraphic levels the marls are rich in lamellibranches Bosistra buchi (Posidonia). It is very clear in the field (Figure 1B) that this formation abuts by fault against the Siniais limestones of the north compartment. It is clear too, that this fault does not affect the Vigla limestones; thus it corresponds to a synsedimentary fault separating two different sub-basins.

-5 m of Limestones with filaments: intraformational limestone breccias in a limonitic matrix;

-more than 50 m of Upper Posidonia beds: cherty beds with green siliceous argillite interbedding. Abundant radiolaria are present in all stratigraphic levels, while Posidonia fossils are restricted to the lower part of the formation.

In the northeastern part of the hill (north of the synsedimentary fault) over the moderately developed Siniais limestones, are observed:

-15 to 7 m Ammonitico Rosso (which will be studied in detail below),

-8 to 6 m Limestones with filament,

-6 to 3 m Upper Posidonia beds.

At the extreme north of the Mavron Oros hill, Vigla limestones repose uncomfortably directly on the Pantokrator limestones, by progressive disposition of Upper Lias-Malm formations, except for some levels of limestone breccias with filaments intercalated between Vigla and Pantokrator limestones. Thus, there is a hiatus of the total synrif succession (Upper Lias-Malm), which is found in the deeper part of the half-grabens where sedimentation is continuous during the internal differentiation of Ionian zone.

These observations clearly show that in Ionian basin, the sedimentary filling of the half-graben with the synrift formations toward the elevated part of the half-graben, is transgressive (Figure 4). This transgression is completed in the early Cretaceous (Berriasian), as it is deduced by the onset of the pelagic Vigla limestones deposition in this area, and generally in the entire Ionian zone (Karakitsios 1992; Karakitsios & Koletti 1992). Thus, the Vigla limestones blanket the earlier irregular Ionian basin bottom topography and their base represent the beginning of the Ionian postrift deposition.

In order to observe when the sedimentary filling of the half-grabens with the synrift formations started, and to verify whether they stratigraphically pinch-out (which should be recorded by a gap in the base of the Ammonitico Rosso toward the N-NW direction) we undertook two geologic sections in the thicker and less thick part of the Ammonitico Rosso outcrop (Figure 2).

2.2. Sections and Faunas

Mavron Oros hill in NW Epirus (NW Greece), emerge from Quaternary sediments of the Kalamas River Delta. This hill, allows the observation of the Early Jurassic to Middle Cretaceous Ionian sequence. Two sections were realized, the first (A) in the thick and the second (B) in the thin AR formation respectively. The zone attribution of the collected ammonites in the different stratigraphic levels of the sections is conformable to the Tethyan standard established by Elmi et al. (1994). The Ammonites of the present work are deposited in the Laboratory of Historical Geology & Paleontology (collection of Professor V. Karakitsios).

2.2.1. Mavron Oros Section A (Figure 2)

This section is located NE of the eastern side of Mavron Oros hill (1.5 km north of Kestrini village, two hundred meters south of Agios Nikolaos chapel). The Ammonitico Rosso overlies in stratigraphic continuity some 60 meters thick of white, well-bedded bioclastic lime wackestones with rare bands and lenses of black replacement chert, corresponding to the Siniais limestones formation (Karakitsios 1990, 1992). The overlying Ammonitico Rosso presents a total thickness of 15 meters. It commences by some 5 meters of green to reddish marls with some breccias intercalations, and marly nodular limestones as well. It follows 10 meters of nodular limestones alternating with red marls which are becoming scarce to the formation top, where Limestones with filaments formation is beginning. The Ammonitico Rosso formation has delivered in almost all levels a rich ammonite fauna, among which were determined (Karakitsios, 1990, 1992):

-1st level (upper part of marls and first meter of the base of nodular Amonitico Rosso): *Polyplectus pluricostatus* (HAAS), and *Hildaites* gr. *serpentinum* (REINECKE). This fauna attributes an Early Toarcian age to the corresponding stratigraphic level (*Serpentinum* zone).

-2nd level (the following two meters of nodular Amonitico Rosso): *Nodicoeloceras* sp., and *Nodicoeloceras* sp. close to *N. incrassatum* (SIMPSON). This fauna corresponds to the Early Toarcian or the base of the Middle Toarcian.

-3rd level (next two meters of nodular Amonitico Rosso): *Mercaticeras mercati* (HAUER), *Phymatoceras* ? *caroli* (MERLA), *Hildoceras lusitanicum* (MEISTER), *Hildoceras* sp. This fauna attributes this stratigraphic level to the base of the Middle Toarcian (*H. graecum* zone of KOTTEK).

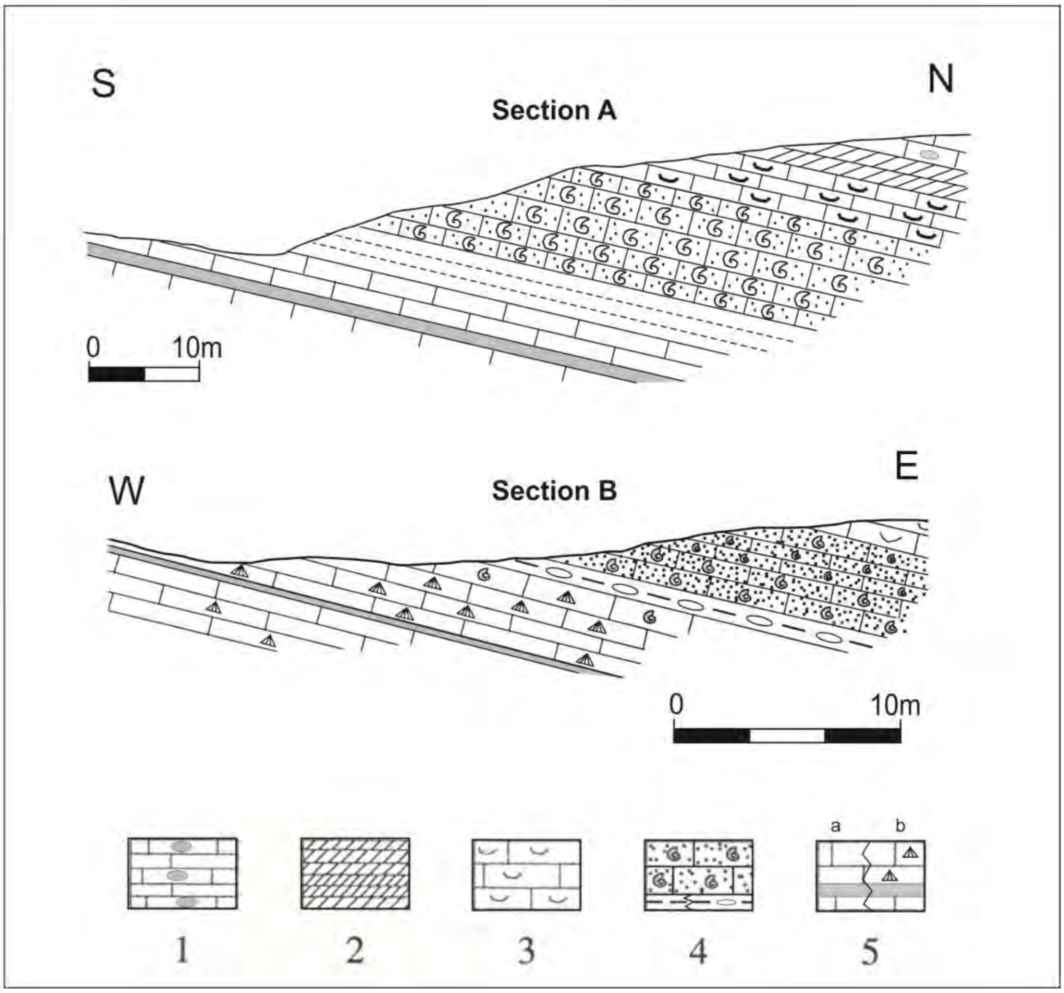

Figure 2 - Mavron Oros sections (locations are referred in Figure 1); 1: Vigla limestones; 2: Upper Posidonia beds; 3: limestone with filaments; 4: Ammonitico Rosso and base marls and/or breccias intercalations; 5: a. Siniais limestones, b. Siniais-Louros transitional limestones.

-4th level (next two meters of nodular Amonitico Rosso): *Brodieia* sp., *Phymatoceras* gr. *erbaense* (HAUER), *Polyplectus* sp., *Calliphylloceras* sp., *Phymatoceras fabale*? (SIMPSON), *Phylloceras* sp. This fauna indicates a Middle Toarcian age (*B. bayani* zone of KOTTEK).

-5th level (next meter of nodular Amonitico Rosso): *Harpoceras* sp., *Pseudogrammoceras* cf. *aratum* with very thin edges, *Peronoceras*? sp. fragment. This fauna corresponds to the upper part of Middle Toarcian.

-6th level (next meter of nodular Amonitico Rosso): *Phylloceras perplanatum* (PRINZ), *Catulloceras dumortieri* (THIOL). This association indicates the middle interval of Late Toarcian (Meneghinii zone).

-7th level (last meter of nodular Amonitico Rosso): *Erycites* sp., showing a time interval extended from the Toarcian top (?) to Aalenian.

This section, corresponding to continuous sedimentation during the syn-rift period of the Ionian basin, shows that the stratigraphic extension of the Ammonitico Rosso formation is Toarcian to Aalenian (p.p.), without any hiatus with the underlying Siniais limestones. It should be noted that at the same section, IGRS-IFP (1966) and Galbrun et al. (1994), attributed the Ammonitico Rosso to the Middle Toarcian (Bifrons and Gradata zones). The observed ammonite fauna in this work extends the age of the Ammonitico Rosso formation to the entire Toarcian which was also found in analogous complete synrift successions in other places of Epirus (Aubouin, 1959; IGRS-IFP, 1966. Karakitsios, 1990, 1992).

2.2.2. Mavron Oros Section B (Figure 2)

This section is located some 400 meters NW of the previous section (a hundred meters W-SW of Agios Nikolaos chapel). Below the Ammonitico Rosso, lies a predominantly packstone limestone formation (some 50 meters thick), whose facies is intermediate between the Louros and the Siniais limestones formations (Karakitsios & Tsaila-Monopolis 1988; Karakitsios 1990, 1992). From the final bed before the Ammonitico Rosso, which is rich in brachiopods and ammonites (particularly difficult to remove from), Dommergues et al. (2002) collected an Ammonite fauna indicative of Late Pliensbachian age (Middle Domerian; Bertrandi and Algovianum horizons). The overlying Ammonitico Rosso presents a total thickness of 7 meters. It commences by some decimeters of nodular marls, followed by mainly nodular limestones alternating with red marls until the end of the formation. The Ammonitico Rosso formation has delivered in almost all levels a rich ammonite fauna, among which were determined:

-1st level (lower two meters of the section): *Phymatoceras cornucopiae* (MERLA), *Phymatoceras caroli* (MERLA), *Phylloceras* sp., *Porpoceras* sp., *Crassiceras* sp. This fauna indicates the upper part of Middle Toarcian (Gradata zone).

-2nd level (next meters of the section): *Phylloceras perplanatum* (PRINZ), *Catulloceras dumortieri* (THIOL), *Phymatoceras* sp., *Pseudogrammoceras* sp., *Brodieia* sp., *Erycites* sp. This fauna attributes this stratigraphic level to Upper Toarcian-Aalenian.

Consequently, the total Ammonitico Rosso formation of section B is attributed to the upper part of Middle Toarcian to Aalenian (p.p.) time interval, with a clear hiatus of the lower part of the complete Toarcian-Aalenian formation observed in the previous section. This data confirms the stratigraphical pinching-out of the Ammonitico Rosso. A number of age significant ammonites are illustrated in Figure 3.

2.3 Sedimentological Analysis of the *Ammonitico Rosso* Facies

The sedimentological analysis of the nodular Ammonitico Rosso facies in section A shows that the hall facies corresponds to wackestone-packstone with peloids, radiolaria and planktonic foraminifera, pelagic bivalves, and gastropods. Additionally, the ammonite shells are not -or are moderately- subsolved, and the carbonate material presents low degree of early lithification and subsequent solution. This is in contrast with the corresponding observations in section B, as we will see below. The nodular Ammonitico Rosso facies in section B, allowed the distinction of the following sedimentological groups:

1st group. The lower part corresponds to wackestone-packstone with peloids, radiolaria and planktonic foraminifera and pelagic bivalves, and probably a gastropod.

Figure 3 - 1: *Polyplectus pluricostatus* HAAS, 2: *Hildaites* gr. *serpentinus* (REINECKE), 3: *Mercaticeras mercati* (HAUER), 4: *Brodieia* sp., 5: *Phymatoceras* gr. *erbaense* (HAUER), 6: *Phymatoceras*? *caroli* (MERLA), 7: *Catulloceras dumortieri* THIOL, 8: *Phylloceras perplanatum* PRINZ.

2nd group. This part of the formation is consisted mainly of wackestone with ammonite nuclei, small low-spiraled gastropods, planktonic foraminifera, and small radiolaria.

3rd group. The lower part of this unit corresponds to wackestone with planktonic and benthonic foraminifera, radiolaria, and filaments. Sponge spicules together with radiolaria dominate in the lowermost part of this stratigraphic level, while filaments presence increases in its upper part.

4th group. This part is mainly consisted of wackestone with radiolaria, small ammonites, filaments, planktonic foraminifera, crinoids, sponge spicules, and fragments of echinoderma.

In all stratigraphic levels of section B it is observed that ammonite shells are subsolved, and there are clear indices of early lithification and subsequent solution of fine carbonate material. These phenomena indicate low rates of sedimentation characteristic for seamount environments. Consequently, this section occupies an intermediate position of the sub-basin with half-graben geometry (closer to its elevated part), in which the first section occupies its deeper part. As far as the stratigraphic disposition at the extreme north of the Mavron Oros hill is concerned, after a progressive disposition of Upper Lias-Malm formations (s. supra), the Vigla limestones finally repose directly on the Pantokrator limestones (Figure 2A); thus it corresponds to the most elevated part of the same half-graben.

3. Discussion and Conclusions

Field observations together with biostratigraphical and sedimentological data clearly show that in the Ionian basin the sedimentary filling of the half-grabens with the synrift formations, started in the Lower Toarcian. This is confirmed by the ammonite fauna observed at the base of the complete succession of the Ammonitico Rosso (section A). Towards NW direction of the Mavron Oros hill, the progressive reduction of the Upper Lias-Malm formations thickness leads to the direct unconformity of the Vigla limestones over the Pantokrator limestones (except for some 2-3 m of filament limestone's breccias intercalated between Vigla and Pantokrator limestones).

The data of the present work would integrate to the palaeogeographic interpretation of Figure 4. According to this interpretation, during Toarcian-Tithonian times, the sections' area corresponded to a half-graben bounded by synsedimentary faults. The section A corresponds to the deeper part of this half-graben, the section B to an intermediate position, whereas the stratigraphic disposition at the extreme north of the Mavron Oros hill (with hiatus of the Upper Lias-Malm formations) corresponds to the elevated part of the half-graben. Following Westermann (1988) and Batt (1989) bathymetric interpretations of the observed ammonite morphotypes, both methods give

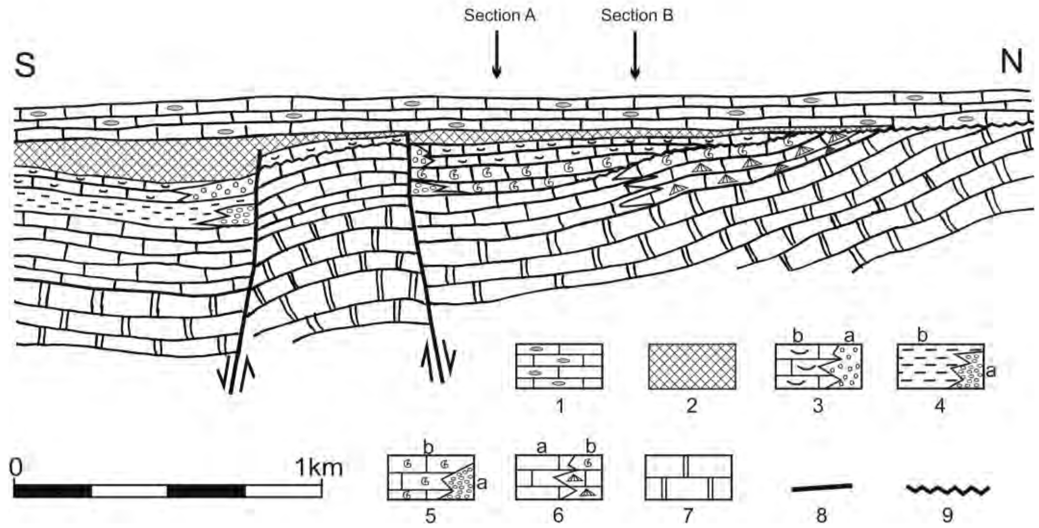

Figure 4 - Reconstruction of the deposit's architecture during Early Cretaceous; 1: Vigla limestones; 2: Upper Posidonia beds; 3: intraformational breccias (a), limestone with filaments (b); 4: intraformational breccias (a), LowerPosidonia beds (b); 5: debris flow (a), Ammonitico Rosso (b); 6: Siniais limestones (a), Louros limestones (b); 7: Pantokrator limestones; 8: fault; 9: uncomformity.

approximately the same water depth, ranging between 80 and 250 m at the upper part and more than 200 m at the lower part of both sections. Nevertheless, compared the section A and B faunas, there is a trend indicating a somewhat shallower depositional depth of the section B. Concerning the above methodologies, it seems that the composition of the faunas is only indirectly related to water depth as the relatively large forms (chiefly macroconchs) were most probably adapted to swimming in an deep marine environment (Guex, 1969) and might also have undergone post-mortal dispersal. Besides, as these methods are based on the composition of ammonite assemblage, the number of collected ammonites, due to the difficulty of their extraction from the nodular limestone, is not representative of the real number of genera present in the rock. Consequently, it is difficult to arrive at any well-reasoned bathymetric estimation from the faunal content. However, the relative depths estimated by these methods are not incompatible with the proposed palaeogeographic scheme of the present work and the palaeogeographic position of the two sections in the corresponding half-graben sub-basin (Figure 4).

Concerning the sedimentary filling, it coincides with the well-known regression/transgression passage at the Lower Toarcian observed in the epicontinental seas of NW Europe (Mouterde et al. 1980; Brandt 1986; Haq et al. 1988; de Graciansky et al. 1988; Wignall & Maynard 1993, Morard et al. 2003).

The sedimentary filling is transgressive as it is shown by the pinching-out of the Ammonitico Rosso (section B) and the rest of the synrift formations toward the elevated part of the half-graben. The transgression is completed in the Early Cretaceous (Berriasian), as it is deduced by the onset of the pelagic Vigla limestones deposition in this area (Figure 1B and 4) and generally in the entire Ionian zone (Karakitsios 1992; Karakitsios & koletti 1992). The base of the Vigla limestones which covers all the earlier sea bottom topography of the Ionian basin consequently represents the beginning of the Ionian basin postrift period.

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