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ON SOMELOCAL RESTRICTED MAASTRICHTIAN ENVIRONMENTS OF THE "HAŢEG ISLAND" (TRANSYLVANIA, ROMANIA)

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Abstract

The continental Maastrichtian formations from Transylvania are notorious mainly for bearing peculiar fossils related to an island realm known as the "Haţeg Island". The thick piles of sedimentary rocks accumulated in fluvial environments. The "red beds" are in dominance. However, local peculiar environments are of interest for specific types of fossilization (plants, invertebrates or vertebrates), i.e. ox-bow lakes or fluvial temporary abandoned channels. In such deposits the fossil record can be different compared to the red beds, especially when the oxygen content was low. Case studies as the ones from Pui (Haţeg Basin) or Oarda de Jos (SW Transylvanian Basin) are exposed. The relationships of fossil taxa and these restricted environments are discussed.
Key words: *Latest Cretaceous, fluvial deposits, palaeontology.*

1. Introduction

TheMaastrichtian continental environments of Europe are of special interest for their peculiar plant, invertebrate, but mainly vertebrate fossils. A lot of them are documenting island evolutions during the late Cretaceous (Dalla Vecchia, 2002, 2006; Csiki et Benton, 2010). Among the areas of interest, Transylvania is notorious mainly for the respective dwarf dinosaur fauna. Although the first reported findings in southwestern Transylvanian Basin were discovered in 1866 (Téglas, 1886), the first who recognized their dinosaur origin was the Transylvanian palaeontologist baron Nopcsa (1897) based on some bones and teeth collected in the Haţeg Basin (South Carpathians). Afterwards, for over a century the research on the Maastrichtian continental deposits from Transylvania continued, more or less intensively. Hence, the knowledge on biodiversity, systematics, taphonomy, sedimentology, environment reconstructions etc. has progressed significantly.

This workis focused on some peculiar, although rare continental restricted environments preserving fossils that have been recorded in the southwestern Transylvanian and Haţeg sedimentary basins in specific manner.

2. Geological Setting

The studied Maastrichtian vertebrate localities (labelled 3 and 4 in Figure 1) are located in western Romania, in Transylvania, i.e. in the Transylvanian Depression and Southern Carpathians.

The last major overthrusts during the latest Cretaceous occurred both in the South Apuseni Mountains and the South Carpathians ("the second Getic phase"; Săndulescu, 1984). After the erection of the Transylvanian, Getic and Supragetic nappes, rather large areas became emerged and a long continental history began in Transylvania. The related continental deposits are parts of post-tectonic covers for Transylvanindes and Median Dacidic nappes.

The new born relief started to be eroded by rivers and large amounts of fluvial deposits accumulated since the Early Maastrichtian. Their impressive extent can only be understood if the thickness of these formations, exceeding 2 km, is take into consideration (Grigorescu, 1992). That means that the subtropical Maastricthtian climate (Van Itterbeek et al., 2004), with a mean temperature between 14 ^{0}C and 10 ^{0}C (Bojar et al., 2010)had at least a season rich in rainfalls, when the river debits considerably increased, even during short episodes.

Figure 1–Location of the Maastrichtian continental sedimentary exposures bearing vertebrate fossils in Romania: 1. Northwestern Transylvanian Basin (Jibou Formation; Jibou and Iara areas); 2. Southwestern Transylvanian Basin (Metaliferi sedimentary area, Șard Formation); 3. Haţeg Basin (Ciula-Densuș and Sânpetru formations); 4. Rusca Montană Basin.

This land was related to an island realm since Nopcsa's (1915) attempts to explain the dwarf-sized dinosaurs firstly described by him. This land is also known as the Haţeg Island. For instance, a clear, doubtless areal extension of this island could never be done, in spite of several geological surveys carried out in Transylvania. The island outline is difficult to be reconstructed because of several gaps in the existinggeological data. Parts or entireMaastrichtian continental sequences were probably erased by subsequent erosion, but also their original positions changed due to translation and rotations that occurred during the Cenozoic (Panaiotu, 2010). For instance, only a few Transylvanian areas are documenting such deposits and even fewer are bearing fossils: apart from Haţeg Basin (related references in Grigorescu, 2010), other evidence is coming from southwestern and northwestern Transylvanian basin (Codrea et al., 2010 a, b, c) and Rusca Montană Basin (Codrea et al., 2009, 2012a) (Figure 1).

Westwards, the continuity of these deposits can only be presumed, buthard evidence is still lacking. It would be possible that a large surface actually belonging to the Apuseni Mountains could once have bared the same sedimentary cover, but the long Cenozoic erosion episodes removed these rocks. One can even extend this supposition to some structures now forming the basement of

the Pannonian basin. However,such rocks were never recorded in the numerous boreholes drilled either in western Romania (Paraschiv et al., 1975) or in eastern Hungary (Haas et al., 2001).

The dominant Maastrichtian fluvial deposits are *red beds*. However, inside these red beds one can also distinguish on restricted vertical and lateral extensions some peculiar deposits, the sedimentation of which evolved in local environments like ox-bow lakes or abandoned channels. Such deposits worth special attention for their fossils, being far richer compared than the red beds. The following analysis concerns the study of two case-study localities.

The lithostratigraphy of the Maastrichtian localities of interest for this workconcernsthe following rock formations:

- in southwestern Transylvanian Basin the main formation bearing Maastrichtian land fossils is the fluvial Şard Formation (Codrea et Dica, 2005; Codrea et al., 2010 a, b, c) with Oarda de Jos as the most interesting locality;
- in Haţeg Basin, the fluvial Sânpetru Formation (Grigorescu et Anastasiu, in Grigorescu et al., 1990) with the exposures on the Bărbat River, at Pui (Codrea et Solomon, 2012) stands out.

3. Peculiar restricted Maastrichtian environments in Transylvania

3.1. Oarda de Jos

This locality belongs to the Metaliferi sedimentary area (Codrea and Dica, 2005). There, the continental Maastrichtian exposures can be observed mainly along the Mureş, Ampoi, Sebeş and Secaş valleys. Two main outcrops are located in this locality, on Sebeş River, Oarda A and B (Codrea et al., 2010a; a different separation of the Oarda outcrops in Vremir, 2010). Although both are exposing nearly similar deposits, for this study only Oarda A is of interest. Red mudstones are interfingering with extensive channels filled by microconglomerate and various sized sands.

All these deposits yielded various fossils like tree trunks (*Mastixia amygdalaeformis* was reported by Givulescu et al., 1995), but the vertebrates are prevailing. Dinosaur taxa include sauropods, the hadrosaur *Telmatosaurus transsylvanicus* and possibly, the euronithopod *Zalmoxes* (Codrea et al., 2010 a, b). Besides dinosaurs, other associated reptiles concern turtles (*Kallokibotion*, Dortokidae indet.), crocodiles (*Allodaposuchus precedens*; Delfino et al., 2008) and pterosaurs. Some bird remains (eggs, eggshells and bones) interpreted as an enantiornithine breeding colony have been also reported (Dyke et al., 2012). These fossils are not very numerous, but their preservation can be considered as fair or even exceptional. The bones are dark coloured, indicating a fast burial after the death of animals. However, for instance no partial or complete skeleton has been recorded. The vertebrate remains always are occurring isolated, indicating that the carcasses were decomposed and the bones were scattered before their final burial. All these taxa lived either inside the fluvial waters, or innerby related environments.

In contrast with this kind of deposits there is a lens-like channel filled by light coloured fine grained sediments, recorded at the top of the Oarda A succession.The lateral extension of the lens-like deposits is ranging close to four meters, while the maximum thickness is nearly one meter. Laterally, this deposit is gradually balking until its gets vanished completely passing into red mudstone.

Being different from the other deposits, this one is extremely rich in vertebrate remains, mainly microvertebrates, but also in medium and even large vertebrates, as well as in plants (charophytes) and some invertebrates. The vertebrate fossils are not uniformly ranged inside the sediment, their richness being high just at the base of the channel on near 15-20 cm. Above this level, such remains are very rare are even missing. Just above the channel bottom there is also a level of calcretions, removed from their original position and rolled by water flows, with diameters usually under a dozen of centimetres. Sometimes, these calcretions are bearing small fragments of bones.

The plant remains refer exclusively to charophyte gyrogonites (Pl. I, Figure 1) where*Microchara cristata*is clearly dominant. Apart frombeing a stratigraphic marker (*M. cristata* – zone), this species is indicative for the presence of Maastrichtian shallow freshwater lakes (*e.g.*Villalba-Breva et al., 2012) and ponds.

The invertebrates are documented by small-sized freshwater gastropods (Pl. I, Figure 2) and frequent crab chelae (Pl. I, Figure. 4). The largest collected crab claw has a dimension of 31 mm in length. It is notclear if these crabs were freshwater dwellers or if they are allochthonous representatives originating from further marine environments that arrived in this fluvial deposit as prey of some other animals.

The fish remains are numerous (several hundreds of scales and isolate teeth), but the systematic diversity is rather poor, restricted only the dominant gar-fish (Lepisosteidae) (Pl. I, Figure 5) and Characidae (Codrea et Jipa, 2011)(Pl. I, Figure 6), which have been documented only by a small sample. These freshwater fish were autochtonous dwellers of this environment.

A rich sample of amphibians was recovered by wet sieving nearly 2.5 tons of sediments.There are numerous for instance indeterminate frog remains, but also frequent Albanerpetontids (Pl. I, Figure 9), which lived at somewhat further distances from this channel.

Other documented small reptiles consist of lizards (their study, in progress) (Pl. I, Figure 10 a,b,c).

Two kinds of turtles have been recorded: the cryptodire *Kallokibotion bajazidi* (Pl. I, Figure 14) and a plurodire, dortokid representative (Pl. I, Figure 12). Their remains are represented always by isolate carapace or plastron plates. The preference of dortokids for lake and pond-like environments is obvious, if considering the frequency of finds in such environments either in Maastrichtian deposits (Codrea et Solomon, 2012) or thebasal Cenozoic ones(Gheerbrant et al., 1999; Lapparent de Broin et al., 2004).

A rich sample of osteoderms, cranial fragments and post-cranial bones document the crocodiles. Moreover, this environment seems to have been infested by crocodiles if considering the frequency of such remains as well as the signs of their presence, as numerous bite-marks (Codrea et al., 2010a).The crocodilian diversity was probably high. Apart fromthe obvious presence of *Allodaposuchus* (Pl. I, Figure 16), some other crocodile taxa have been also present in this environment, such as *Doratodon* and *Acynodon* (Pl. I, Figures 19 and 17).

The dinosaur remains are less frequent. However, several taxa have been recorded in these sediments: the euornithopod *Zalmoxes*(Pl. I, Figure 30), the hadrosaur *T. Transylvanicus* (Pl. I, Figure 26), sauropods (Pl. I, Figure 28) and various remains of indeterminate theropods (Pl. I, Figures 22 and 23), in majority small-sized. The dinosaur teeth and bones are always isolated, without signs of long weathering before their definitive burial. These preservations are in concordance with some of the taphonomic mode C21 (Csiki et al., 2010). These dinosaurs lived either close to the rivers, or to a certain distance, visiting the area just for drinking water.

Other reptiles represented in this accumulation are the pterosaurs (medium-sized). Their remains, although not very frequent, have been sometimes recovered. The pterosaurs were allochthonous representatives, their remains arriving in the channel fill by fortuitous processes.

Other remains belong to Enanthiornithinae birds and mammals. The mammals that have been recovered until now at Oarda belong exclusively to the multituberculate Kogaionidae, documented only by isolate teeth (Pl. I, Figure 31). Some of these teeth expose marks of at least medium distance water transport. After processing the sediment, 73 multituberculate teeth are available for study. All the cheek teeth from Oarda can be related rather to *Barbatodon*, based on their morphology.Several differences in cheek teeth morphology are now mentioned, probably reflecting intra-specific variations. Kogaionids are a European group, which crossed the K/T boundary and until now it has been recorded only in Romania, France, Spain and Belgium. Their origin remains

unclear, but it may be presumed that they have originate from ancestors probably living in early Cretaceous(Codrea et al., 2012b).

Besides bones and teeth, this level at Oarda yielded also numerous egg shells (Pl. I, Figure 3a,b). Several morphotypes are already recorded, with their study being in progress. The first investigations revealed ?*Pseudogeckoolithus* as well as Megaloolithidae (Codrea et al., 2010a).

3.2. Pui

This locality is a classical one for the Haţeg Basin, being the southeasternmost one in this basin. The fluvial deposits from Pui have been reported since the beginning of the 20th century by Nopcsa (1905).These Uppermost Cretaceous fluvial deposits have been related since a rather long time ago to the Sânpetru Formation (Nopcsa, 1905; Grigorescu et al., 1985; Grigorescu et Anastasiu, 1990; Grigorescu, 1992). However, Therrien et al. (2002) pointed out differences between the Sânpetru Formation deposits exposed on the Sibişel Valley and the ones at Pui. Later, Therrien (2005) called the exposures from Bărbat River as "Pui beds", but suggested also a distinct name for this continental sequence i.e. "Bărbat Formation", underlining the difficulties in correlating the terrestrial Uppermost Cretaceous sequences exposed in different areas of the basin.

The Lower Maastrichtian age of these deposits is documented either by pollen (Van Itterbeeck et al., 2005) or microvertebrates (e.g. Folie et Codrea, 2005), but also by palaeomagnetic studies (beginning of the Chron C32n.1n - end of the Chron 31n; Panaiotu et Panaiotu, 2010).

At Pui, the *red beds* dominate. Van Itterbeeck et al. (2004) considered the sub-horizontal red beds as a result of the evolution of an ancient fluvial system trended ENE-WSW. The Maastrichtian climate has been interpreted as semi-arid, with seasonal control of rainfall. The micaceous red silts (rich in smectite and illite, besides smaller amounts of chlorite and kaolinite) dominate the red beds, bearing calcrete horizons, with intercalations of green conglomerates and sandstones.

Inside these *red beds*there are three levels of black silt rich in white mica, bearing also pyrite concretions, sharply contrasting with the dominant red beds usually exposed in the riverbed. These three successive levels have been recently named from base to top, "Pui Gater", "Pui Depozit" and "Pui Islaz" (Codrea et Solomon, 2012). The lowermost level is rather rich in plant, invertebrate and vertebrate fossils (Codrea et Solomon, 2012; Vasile et Panaitescu, 2012), while the uppermost is very scarce in such remains. The richest silt levelin fossils is the middle one, yielding plant remains, invertebrates (large-sized ostracods, snails), but mainly vertebrates. Different from Oarda, is the colour of the teeth and bones. Commonly, the bones preserved in the red beds at Pui are white, with cracked surfaces filled by red clay, indicating a rather long weathering before their burial. With very few exceptions, such bones are always isolated, devoid of anatomical connections, but exceptionally, parts of associated skeletons can also be observed (the case of at least two *Zalmoxes* partial skeletons). These processes are related toa well-drained floodplain environment (Csiki et al., 2010). On the contrary, in these dark coloured mudstones, the bones are fossilized in a very different manner, being black or gray, sometimes covered by pyrite (i.e. *Telmatosaurus* tibia, Pl. I, Figure 25 c). The pyrite is in abundance as concretions into the sediment too. The teeth and bones are in their absolute majority, isolated. Only two ornithopod metacarpals could possibly be in connection. However, it is possible that this dominance of isolate skeleton parts could be just the result of the digging bias.

The systematic similarities and differences between Oarda and Pui Depozit will be further underlined. At Pui, the gar-fish is extremely rare, documented by only a single scale (Pl. I, Figure 6). The Characidae are missing.Among amphibians, the Albanerpetontids are frequent, documented mostly by a rich sample of skull (Pl. I, Figure 8) and limb fragments being comparable to Oarda. Among lizards, *Becklesius* cf. *nopcsai* is present at Pui (Pl. I, Figures 10 a, b, c), but the remains are not, too numerous. Like in Oarda, the Dortokidae turtle remains (Pl. I, Figure 13) are present, in larger numbers than *Kallokibotion*(Pl. I, Figure 11). Same environmental conditions like in Oarda have to be concluded for Pui too. The crocodiles are documented both by

numerous teeth, but also by bite-marks (Codrea and Solomon, 2012). The crocodiles (Pl. I, Figures 15 and 18) were seemingly numerous and are specific for these pond-like environments. Among dinosaurs, one can note theropods (Pl. I, Figures 20 and 21), sauropods (Pl. I, Figure 27 a, b), the same hadrosaur species (Pl. I, Figures 24, 25a, b, c) as well as the euornithopod *Zalmoxes* (Pl. I, Figure 29).

4. Maastrichtian Environments at Oarda de Jos and Pui

Fluvial Maastricthian deposits at Oarda de Jos should be considered as documenting a poorly drained floodplain. Inside this floodplain sometimes abandoned channels occurred, like the one already described. In such channels, the water flow was just episodic, probably related to the rainy season. The lateral and especially vertical extensions at Oarda are very restricted, not exceeding few meters reflecting ephemeral existence. The sediments are of light color. Large vegetal remains are missing, the only plants documented in this taphocoenosis being the charophytes. In spite of such an evolution, the water probably never had low oxygen tendencies. Some of the fossils were autochthonous (fish, frogs, crocodiles, turtles) or had been transported from minor distances (hadrosaur or sauropod remains). On the opposite, some others originated from a longer distance, like theropods or mammals. The majority of vertebrate fossils belong to micro- or medium-sized vertebrates, the large ones being almost rare. Some taxa, such as the multituberculate mammals are well represented in the faunal record at Oarda, while they are completely missing from Pui Depozit.

The Maastrichtian terrestrial deposits of Pui are related to a braided fluvial system (Therrien, 2005). The floodplain was well drained, its distal status being documented by the dominance of fine sediments*vs.* rough channel fills. The black mudstone here reported at Pui Depozit is sharply contrasting with the dominant red beds, but the restricted vertical and probably, lateral extensions are indicating that these rocks accumulated just for short episodes. They issued from closed abandoned channels that occurred randomly in the floodplain, which evolved in this case to true ox-bow lakes where fine sediments and organic matter accumulated (Collinson, 1996). The black color of this sediment, now rich in diagenetic pyrite indicates that the environment was poorly oxygenated, with clear tendency to anoxic stagnant pond-like waters.

5. Conclusions

In Transylvania, the Maastrichtian fluvial deposits that occurred after the last major tectonogenesis that erected nappes in the Apuseni Mountains or in the Southern Carpathians can now be observed only on small exposures. Apart from the notorious Haţeg Basin, interesting complementary data can be added in the Transylvanian and Rusca Montană basins. In these areas the dominance of red beds is obvious. However, a closer look to these deposits allowsdistinguishing local restricted environments, related to abandoned channels or to true ox-bow lakes. The first situation is illustrated by the case study at Oarda de Jos on Sebeş River, while the second one appears in a repetitive manner at Pui, on Bărbat River. The main difference between these two cases concern the highest tendency to low oxygen water at Pui compared to Oarda de Jos. As a consequence, the lithology is specific for each deposit. The sediments of Oarda de Jos are light colored, reflecting differences with Pui, where the sediments are dark. Same colors are recorded for the fossil teeth and bones collected in these localities.
Such local environments are of interest for their fossil record, notably for its richness and fair preservation of fossils. While the plants could be interpreted as originating from the channel waters or the river banks, the vertebrates had more diverse environmental origins, being either autochthonous, or allochthonous representatives.

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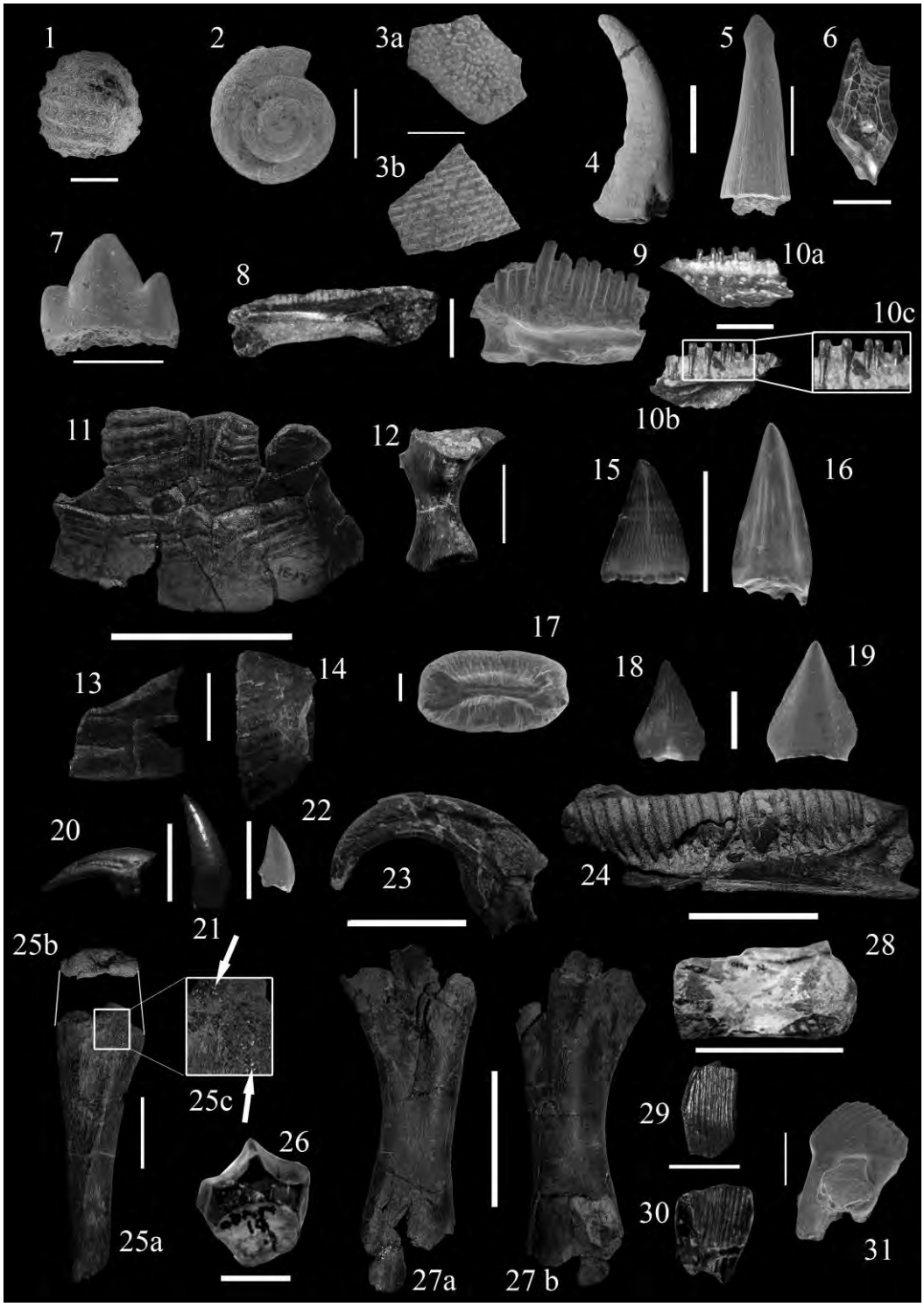
Plate I – Maastrichtian fossils from Oarda de Jos and Pui

1. Charophytegyrogonite (Oarda de Jos); 2. Gastropode (Oarda de Jos); 3. Egg shells (Oarda de Jos); 4. Crabe claw (Oarda de Jos); 5. Lepisosteidae indet., tooth (Oarda de Jos); 6. Idem, scale, external view (Pui); 7. Characidae indet., tooth (Oarda de Jos); 8. *Albanerpeton*sp., dentary in lingual view (Pui); 9. Idem, dentary in lingual view (Oarda de Jos); 10. *Becklesius* sp., fragment of dentary in labial(a) and lingual (b) views, and (c) a detail of the teeth in lingual view (Pui); 11. cf. *Kallokibotion bajazidi*,carapace fragment dorsal view (Pui); 12. Dortokid turtle, illium in lateral view (Oarda de Jos); 13. ?Dortokid, peripheral plate in dorsal view (Pui); 14. cf. *Kallokibotion bajazidi*, pleural plate in dorsal view (Oarda de Jos); 15. *Allodaposuchus precedens*,isolated tooth in lingual view (Pui); 16. Idem, isolated tooth in lingual view (Oarda de Jos); 17. *Acynodon*sp., posterior tooth in occlusal view (Oarda de Jos); 18. *Doratodon* sp., isolated tooth in lingual view (Pui); 19. Idem., isolated tooth in lingual view (Oarda de Jos); 20. Theropoda *incertae sedis*,ungual phalanx in lateral view (Pui); 21. Idem: *Richardoestesia* morphotype, isolated tooth in lateral view (Pui); 22. Velociraptorine dromeosaurid, isolated tooth in lateral view (Oarda de Jos); 23. Theropoda *incertae sedis*,ungulal phalanx in lateral view (Oarda de Jos). 24. *Telmatosaurus transsylvanicus*, left lower jaw, medial view (Pui); 25. Idem, left tibia in lateral(a) and proximal (b) views, with a detail (c) of a high pyrite concentration on bone surface (arrows indicate some pyrite crystals) (Pui); 26. Idem, isolated maxillary tooth, in lingual view (Oarda de Jos); 27. Titanosauria indet., incomplete left humerus in cranial(a) and caudal(b) views (Pui); 28. Idem, caudal vertebra in lateral view (Oarda de Jos); 29. *Zalmoxes* sp., isolated tooth fragment in lingual view (Pui); 30. Idem, isolated tooth fragment in lingual view (Oarda de Jos); Kogaionid multituberculate, right p4 in lingual view (Oarda de Jos).

Scale bars : 200 ɥm for 1; 400 ɥm for 7; 1 mm for 2, 5, 17; 2 mm for 3a, 3b, 6, 8, 9, 10a, 10 b, 18, 19, 31; 3 mm for 20, 21, 22; 5 mm for 15, 16; 1 cm for 4, 26, 29, 30; 2 cm for 12, 23; 3 cm for 13, 14; 5 cm for 24, 25a, 25b; 10 cm for 11, 27a, 27b, 28.


1
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3a
3b
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8
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10a
10b
10c
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25a
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27a
27 b
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CLIMATIC VS TECTONIC CONTROL ON THE EARLY LATE MIOCENE TECTONO-STRATIGRAPHIC DEPOSITS OF THE PRE-APULIAN ZONE, WESTERN GREECE

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Abstract

Here, we elucidate the relationship between tectonics and climate and their influence on sedimentation. A number of marine sediment samples were collected from a section located in the northern margin of the Agios Petros Basin (Early Tortonian, Levkas Island, W. Greece) for micropalaeontological analysis, in order to establish and interpret of the palaeoenvironmental and palaeobathymetric changes. The distribution patterns of the dominant and associated benthic foraminiferal species (Siphonina reticulata and Cibicidoides kullenbergi), together with the decreased Benthic Foraminiferal Number (BFN) values, elevated diversities and higher planktonic-to-benthic ratios, suggest deposition at bathyal water depths with moderate organic matter fluxes and elevated oxygen contents of the bottom water, typical for this water depth interval. The early Late Miocene infilling of the Agios Petros basin is related to the westward advances of the Ionian zone which induced flexural loading and subsequent relative sea-level rise.
Key words: *Early Tortonian, foraminifera, palaeobathymetry, tectonics, climate.*

Περίληψη

Στην εργασία αυτή διευκρινίζεται η σχέση μεταξύ τεκτονικής και κλίματος και η επιρροή τους στην ιζηματογένεση. Για το σκοπό αυτό μελετήθηκε ένας αριθμός θαλάσσιων δειγμάτων από μία τομή που βρίσκεται στο βόρειο περιθώριο της λεκάνης του Αγίου Πέτρου (Κατ. Τορτόνιο, Λευκάδα, Δυτική Ελλάδα), προκειμένου να διαπιστωθούν και να ερμηνευθούν οι παλαιοπεριβαλλοντικές και παλαιοβαθυμετρικές αλλαγές. Τα πρότυπα κατανομής των κυρίαρχων και των συναφών βενθονικών τρηματοφόρων (Siphonina reticulata και Cibicidoides kullenbergi), σε συνδυασμό με τον μειωμένο αριθμό βενθονικών τρηματοφόρων (BFN), την αυξημένη ποικιλότητα και την υψηλή αναλογία πλαγκτονικών-βενθονικών τρηματοφόρων, δείχνουν εναπόθεση στη βαθύαλη ζώνη με μέτρια εισροή οργανικής ύλης και αυξημένη περιεκτικότητα σε οξυγόνο. Οι ιζηματογενείς αποθέσεις της λεκάνης του Αγίου Πέτρου, ηλικίας Κατώτερο Τορτόνιο σχετίζονται με την προς τα δυτικά προέλαση της Ιόνιας ζώνης η οποία προκάλεσε κάμψη λόγω φόρτισης και την επακόλουθη άνοδο της σχετικής στάθμης της θάλασσας.
Λέξεις κλειδιά: *Κατώτερο Τορτόνιο, Τρηματοφόρα, Παλαιοβαθυμετρία, τεκτονισμός, κλίμα.*