

MIDDLE MIOCENE DIATOMITE- BEARING FORMATIONS FROM WESTERN ROMANIA

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Abstract

In Western Romania diatomite occurs only in the Lower Sarmatian (Middle Miocene) formations, as a consequence of intense volcanism developed in Apuseni Mountains and evolution of peculiar sedimentary basins connected to the Pannonian realm. The main basins with diatomite successions are Zarand and Vad Borod. The diatomite preserves besides diatoms (centric and pennate) and other microfossils (dinoflagellates, ebruidinas, silicoflagellates, phytolites) assemblages a lot of macrofossils as plants (mainly foliar inprints), fish, reptiles and mammals. Several taxa are indicative for environment reconstruction. The Lower Sarmatian climate is estimate as wet warm temperate to subtropical. A tentative of both aquatic and land environments reconstruction is done.

Key words: Sarmatian, diatomite, fossils, environment reconstruction.

Περίληψη

Στη δυτική Ρουμανία διατομίτες εμφανίζονται μόνο στους σχηματισμούς του κατώτερου Σαρματίου (Μ. Μειόκαινο), ως αποτέλεσμα της έντονης ηφαιστειότητας που αναπτύχθηκε στα όρη Apuseni και της εξέλιξης των ιδιόμορφων ιζηματογενών λεκανών που συνδέονται με την ευρύτερη περιοχή του Παννόνιου. Οι κύριες λεκάνες με διατομιτικές αποθέσεις είναι η λεκάνη του Zarand και η λεκάνη του Vad Borod. Ο διατομίτης περιέχει εκτός από διάτομα και άλλα μικροαπολιθώματα (δινομαστιγωτά, περιτιομαστιγωτά, φυτόλιθοι), πολλά μακροαπολιθώματα όπως φυτά (κυρίως αποσπώματα φύλλων), ψάρια, ερπετά και θηλαστικά. Πολλά από τα περιγραφέντα taxa είναι κατάλληλα για την αναπαράσταση του χερσαίου και υδάτινου παλαιοπεριβάλλοντος καθώς και του κλίματος το οποίο, για το κατώτερο Σαρμάτιο, προκύπτει υγρό θερμό εύκρατο έως υποτροπικό.

Λέξεις κλειδιά: Σαρμάτιο, διατομίτης, απολιθώματα, αναπαράσταση περιβάλλοντος.

1. Introduction

In Western Romania, several geological events occurred in the Middle Miocene: a new generation of sedimentary basins was born and an intensive magmatic activity begun, with a paroxysmal period between 14.8-10 My (Săndulescu 1984, Roşu *et al.* 2000).

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A peculiar interest concern the sedimentary basins located on the western rim of the Apuseni Mountains, due to accurate data recorded into their Badenian and Sarmatian successions. Among these “gulf-basins” the Zarand Basin had a peculiar evolution: although the epoch of its genesis is nearly the same as in the other coeval basins (Șimleu, Vad-Borod, Beiuș, Mureșului passage way etc.), specific environments developed there in Sarmatian. Such an environment refers to the Lower Sarmatian (Volhynian) tuffaceous/diatomite-bearing successions which occurred due to the intense Sarmatian volcanic activity. Sarmatian diatomites are not completely missing from the other analogous Neogene basins (*e.g.* Vad-Borod, Beiuș) but there one can observe only short diatomitic episodes interbedding into various other lithologies.

This contribution deals with the peculiar Lower Sarmatian depositional environments, indicating the diatom assemblages which lead to the diatomite accumulations from the Middle Miocene sedimentary basins from Western Romania.

2. Geological setting

The Neogene basins from Apuseni Mountains were born as eastward extensions of the Pannonian Basin since Badenian. These basins evolved as margins of the Pannonian Basin realm, where the different eustatic events marked better vestiges than elsewhere. Excepting the Șimleu Basin, the other ones are trended NW-SE or W-E, betraying older fractures inherited from the Laramian tectogenesis. Their basements involve Paleozoic and Mesozoic rocks belonging to the Inner Dacides (Săndulescu 1994, Săndulescu and Dimitrescu 2004). Over the basement, Neogene molass fills all these basins (Fig. 1).

In the Zarand Basin the Neogene deposits are of both sedimentary and volcanic origin (Istocescu 1971). The succession begin with Badenian formations (Botfei, Minișu de Sus and Mocrea; Codrea *et al.* 1999), followed by Sarmatian ones (Cărand, Camna, Urviș-Beliu and Paulian; Pestrea 1999). Pannonian *s.str.* and Pontian formations (Beliu, Hășmaș, Prunișor, Mărăuș) remain extremely poor outlined due to the unsuitable manner of definition and scarcity of data published by Marinescu *et al.* (1998).

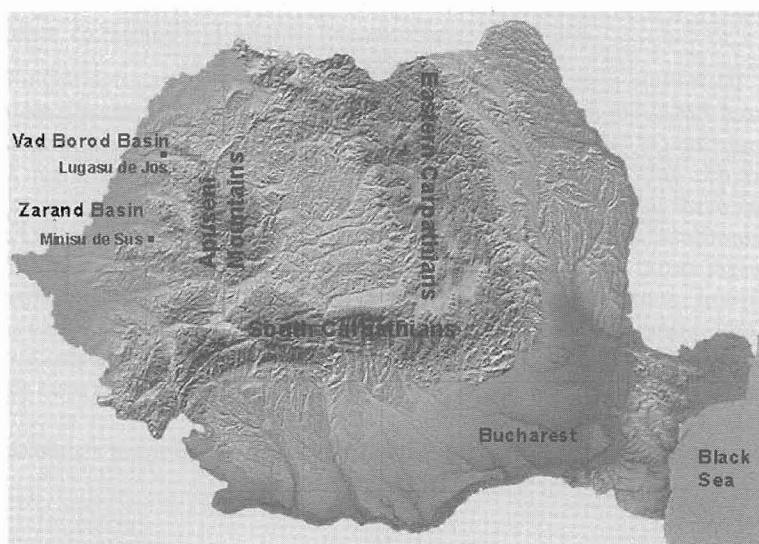


Figure 1 – Locations of the Vad-Borod and Zarand Neogene Basins in Western Romania

The Vad-Borod Basin is located northerly from Zarand. There, the Lower Sarmatian diatomite occurs only on restricted surfaces. The diatomite belongs to the Cornițel Formation (Popa 2000). However, one worth to be pointed out that the eastern sector of the Vad-Borod Basin, where Cor-

nițel Formation is originating from, can be somehow different from the western sector, where the diatomite occur.

3. Middle Miocene diatomite-bearing environments

3.1. Zarand Basin

The diatomite occurs into the Cărand Formation as a distinct facies, which Săsăran *et al.* (1999) described as FA1 (“the diatomite facies”) into the “diatomite-tuffaceous facies associations” (FA). The diatomite is laying unconformity on Mesozoic basement. The best diatomite exposures can be followed in the former diatomite open-pits, once mining this rock at Bârzăvița, Pârâul Nemțului or Stupii Surdului, all located in Minișu de Sus village neighbourhood. The diatomite occurs always next to the pyroclastic facies associations (FB), *i.e.* different tephra (lapillistones and andesite tuffs), pyroclastic breccia flows and lahar facies (Fig. 2).

In his papers Pantocsek (1886, 1889, 1905) illustrated several diatom species and genera from different sites belonging to Cărand Formation: Minișu de Sus, Camna, Cărand and Nemiș. For Minișu de Sus, Camna and the Bremia Valley (Volume II, 1889) he referred more thoroughly to diatomites. He considered two diatomite successions to belong to brackish-water environment (Minișul de Sus, Camna) and one deposit related to a marine basin (Bremia Valley, Camna).

Later, Krestel (1970) focused her study on the Minișul de Sus diatomite and re-described the regions previously studied by Pantocsek, but new areas too: Stupii Surdului, Dealul Râtului, Bârzăvicioara, Drânovăț, Pârâul Neamțului and Câmpul Lat. She stressed that the diatoms assemblages comprise centric mostly planktonic and generally pennate benthic epiphytic forms. In addition to diatoms, there are also ebridiids, chrysomonads, silicoflagellates, sponge spicules and phytolites. She was considering that the diatomite from Minișu de Sus had a neritic zone genesis, in temperate climate, in Early Sarmatian (Volhynian).

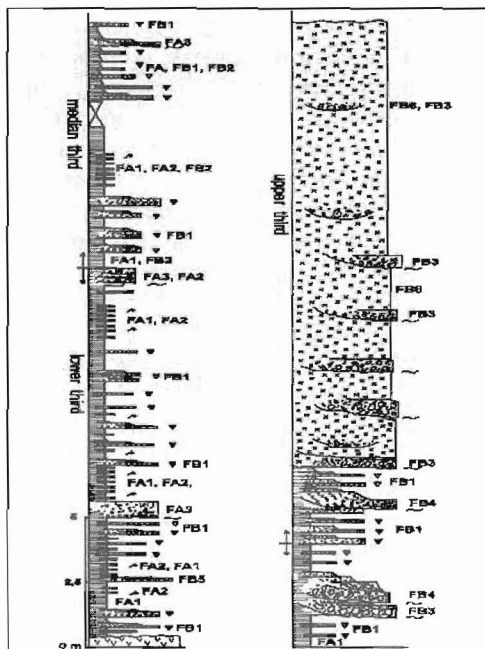


Figure 2 – Facies distribution of the Sarmatian deposits in Cărand Formation (according to Săsăran *et al.* 1999)

Another study on the same diatom assemblages has been recently carried out by Pestrea (1996, 1999), describing 240 species in 66 genera. There is a preponderance of pennate forms as to the centric ones. For the Cărand profile she also established three types of associations with biostratigraphic importance from the Volhynian – Bessarabian interval.

The last contributions on the diatom assemblages belong to Barbu (2002) and Barbu and Codrea (2002).

The study we carried on stressed the following list of taxa:

DIATOMS (109 taxa: 47 centric and 62 pennate)- *Melosira ambigua* (Grunow) O. Muller, *Melosira arenaria* Moore, *Melosira clavigera* Grunow, *Melosira rieuftii* Heribeaud, *Melosira undulata* (Ehrenberg) Kutzing, *Paralia sulcata* (Ehrenberg) Kutzing, *Podosira hyalina* Jouse, *Hyalina* *Ψηφιακή Βιβλιοθήκη Θεοφραστος - Τμήμα Γεωλογίας, Α.Π.Θ.*

lodiscus constrictus (Pantocsek) Kanaya, *Hyalodiscus frenguelli* Hanna, *Hyalodiscus scoticus* (Kutzing) Grunow, *Endictya oceanica* Ehrenberg, *Stephanopyxis schulzii* Stein, *Thalassosira decipiens* (Grunow) Jorgensen, *Coscinodiscus lineatus* Ehrenberg, *Coscinodiscus marginatus* Ehrenberg, *Coscinodiscus nitidus* Gregory, *Coscinodiscus oculus-iridis* Ehrenberg, *Coscinodiscus radiatus* Ehrenberg, *Coscinodiscus sarmaticus* Pantocsek, *Coscinodiscus subtilis* Ehrenberg, *Liradiscus rugulosus* Forti, *Xanthiopyxis leguminiformis* Jouse, *Xanthiopyxis ovalis* Lohman, *Actinoptychus reinholdii* Hajos, *Actinoptychus senarius* (Ehrenberg) Ehrenberg, *Actinoptychus splendens* (Schadbolt) Ralfs, *Actinoptychus undulatus* (Bailey) Ralfs, *Actinoptychus* sp., *Asteromphalus loczyi* Pantocsek, *Auliscus caelatus* Bailey, *Actinocyclus ehrenbergii* Ralfs, *Actinocyclus ehrenbergii* var. *tenella* (Brebison) Hustedt, *Rhizosolenia* sp., *Chaetoceros aculeatus* Makarova, *Chaetoceros affinis* Lauder, *Chaetoceros dentatus* Korotkevich, *Chaetoceros muelleri* Lemmerman, *Chaetoceros subtilis* Cleve, *Chaetoceros* sp.1, *Chaetoceros* sp.2, *Triceratium formosum* f. *pentagonale* A. Schmidt, *Biddulphia tuomeyi* (Bailey) Roper, *Cerataulus* sp., *Pseudopyxilla capreolus* Forti, *Pterotheca* sp., *Anaulus minutus* Grunow, *Anaulus simplex* Hajos, *Gephyria media* Arnott, *Gephyria media* f. *rinnboeckii* Jurilj, *Rhabdonema adriaticum* Kutzing, *Grammatophora arctica* Cleve, *Grammatophora marina* Kutzing, *Grammatophora hamulifera* Kutzing, *Grammatophora robusta* Dippel, *Plagiogramma truani* Pantocsek, *Plagiogramma* sp., *Dimerogramma marinum* (Gregory) Ralfs, *Cymatosira* sp., *Opephora pacifica* (Grunow) Petit, *Fragilaria brevistriata* Grunow, *Fragilaria brevistriata* var. *elliptica* Heribeaud, *Fragilaria construens* (Ehrenberg) Grunow, *Fragilaria construens* var. *subsalina* Hustedt, *Fragilaria construens* var. *venter* (Ehrenberg) Grunow, *Rhaphoneis debyi* Pantocsek, *Rhaphoneis amphicerus* Ehrenberg, *Rhaphoneis obesula* Hanna f. *trigona* Hajos, *Synedra parasitica* (W. Smith) Hustedt, *Synedra tabulata* var. *obtusula* Pantocsek, *Synedra tenera* W. Smith, *Synedra ulna* (Nitzsch) Ehrenberg, *Eunotia* sp., *Cocconeis placentula* Ehrenberg, *Cocconeis placentula* Ehrenberg var. *euglypta* (Ehrenberg) Cleve, *Cocconeis scutellum* Ehrenberg, *Cocconeis* sp., *Achnanthes baldjickii* var. *podolica* Missuna, *Achnanthes brevipes* Agardh, *Achnanthes brevipes* var. *intermedia* (Kutzing) Cleve, *Rhoicosphenia curvata* (Kutzing) Grunow, *Mastogloia splendida* (Gregory) Cleve, *Mastogloia aquilegiae* Grunow, *Dictyoneis* sp., *Dilponeis vacillans* (A. Schmith) Cleve, *Dilponeis chersonensis* (Grunow) Cleve, *Dilponeis* sp., *Anomoeoneis spaerophora* (Kutzing) Pfitzer, *Navicula distans* (W. Smith) Ralfs, *Navicula hennedyi* W. Smith, *Navicula humerosa* Brebisson, *Navicula latissima* var. *elongata* Pantocsek, *Navicula lyra* Ehrenberg, *Navicula placentula* f. *rostrata* A. Mayer, *Navicula pennata* A. Schmidt, *Pinnularia* sp., *Caloneis* sp., *Amphora gibberula* Missuna, *Cymbella helvetica* Kutzing, *Cymbella ventricosa* Kutzing, *Gomphonema ventricosum* Gregory, *Deticulopsis hustedtii* Simonsen & Kanaya, *Epithemia* sp., *Rhopalodia gibberula* var. *magana* (Missuna) I. Kiss, *Rhopalodia musculus* (Kutzing) O. Muller, *Nitzschia navicularis* (Breb. ex. Kutzing) Grunow, *Nitzschia punctata* var. *aralensis* Borszczow, *Nitzschia spectabilis* (Ehrenberg) Ralfs, *Suriella baltjickii* var. *podolica* Missuna, *Camylodiscus* sp.;

DINOFLLAGELLATES ENDOSKELETONS - *Calicipedinium quadripes* Dumitircă, *Carduifolia gracilis* Hovasse;

EBRIIDIANS - *Anmodochium rectangulare* (Schultz) Deflandre, *Hermesinum schultzi* Hovase, *Parathranium* sp., *Podamphora* sp.;

SILICOFLAGELLATES - *Distephanus crux* Ehrenberg, *Deflandriocha* sp.; chrysomonads - *Archaeomonas* sp.1, *Archaeomonas* sp.2; sponge spicules (which are very frequently found and are 3-4 mm in);

PHYTOLITES - *Lithostylidium* parasp., *Lithomestites clepsammidium* (Ehrenberg) Deflandre, *Lithomestites* parasp.1, *Lithomestites* parasp.2, *Lithostylidium biconcavum* Ehrenberg, *Lithodionium* parasp.

Out of the total number of taxa, 58.1 % originated from marine environments, 16.2 % from marine-brackish ones, 4.1% from brackish ones, 8.1 % from both brackish and fresh water ones and 13.5 % from fresh water.

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Although the presence of different diatom taxa is not uniformly distributed within the profiles, two large types of assemblages can still be pointed out.

The first one involves the preponderance of pennate diatoms with dominance of *Fragilaria* and *Navicula* genera, next to *Cymbela*, *Cocconeis*, *Synedra*. The centric diatoms that can be mentioned are mainly *Melosira ambigua* and *M. arenaria*. This assemblage is indicative for brackish environment. It includes not only diatoms but also: chryomonads and numerous sponge spicules.

The second assemblage is completely different from the first one, comprising other genera of centric and pennate diatoms. Its peculiarity involves the following taxa: *Paralia sulcata*, *Coscinodiscus*, *Actinoptycus*, *Chaetoceros*, *Grammatophora*, *Plagiogramma*, *Mastogloia* and *Navicula*, all indicating a marine-brackish environment. There are many *Coscinodiscus* and *Chaetoceros* species - the latter being extremely abundant - as well as *Navicula* ones too. In addition to diatoms, there are also new groups of siliceous representatives such as: silicoflagellates, ebridiids and dinoflagellates.

The distribution of these assemblages along the succession is irregular: the brackish water diatom assemblage is dominating almost in the whole sequence, with some qualitative and quantitative variation from one level to another, whereas the marine-brackish diatom one occurs only in four restricted levels within the profile.

Some index species as *Anaulus simplex*, *Coscinodiscus sarmaticus*, etc. have a wide regional extension, e.g. the Czech Republic, Slovakia, Croatia, Hungary, Bulgaria, led to the conclusion that the studied deposits can be included within the *Anaulus simplex* (Hajos 1986, 1990) zone of the Lower Sarmatian (Volhynian).

As compared with the previous studies 15 new genera were identified: *Paralia*, *Endictya*, *Auliscus*, *Cerataulus*, *Anaulus*, *Plagiogramma*, *Eunotia*, *Mastogloia*, *Dictyoneis*, *Anomoeoneis*, *Gomphonema*, *Denticulopsis*, *Epithemia*, *Surirella* and *Campylodiscus* with 27 species, forms and varieties.

Two genera were pointed out for the silicoflagellates and erbidians: *Deflandriocha* and *Podamphora*. We should mention a novelty for this area, the presence of dinoflagellates: two species had been identified: *Carduifolia gracilis* Hovase and *Calicipedinium quadripes*.

In addition to the microflora one can mention some other elements allowing the reconstruction of the Lower Sarmatian paleoenvironment. Some of them refer to taxa originating into the basin water assemblages, as fish (mostly clupeids) or dolphins (probably Kentriodontidae representatives) (Codrea *et al.* 1991a, b). Sometimes, during the fresh water episodes, turtles as *Trionyx stiriacus* Peters occurred too (Vremir *et al.*, 1997). The turtle remains could also be buried into diatomite as a result of rework of their carcasses from the surrounding areas, carried into the basin by the river streams. A tentative of reconstruction of the Lower Sarmatian water life is illustrated in Fig. 3.

The emerged environments bordering the basin are documented either by macroflora, or by the vertebrates (Fig. 4).

The macroflora, when it occurs is very well preserved, either as foliar imprints or silicified trunk fragments. The following taxa had been collected from the diatomite or pyroclasts: *Cystoseirites partschi* Sternberg, *Fucus* sp.1, *Fucus* sp.2, *Pteris radobojana* Unger, *Glyptostrobos europaeus* (Brongniart) Unger, *Thuja* sp., *Pinus* sp. aff. *Pinus taedaeformis* (Unger) Heer, *Pinus* sp.-ace quaternae, *Pinus* sp., ex. gr. *quinae* Beissner- type 1, *Pinus* sp., ex. gr. *quinae* Beissner- type 2, *Daphnogene polymorpha* (Al. Br.) Ettingshausen, *Lindera antiqua* (Heer) Givulescu & Barbu,



Figure 3 – Reconstruction of the Lower Sarmatian aquatic environment at Minișu de Sus (drawing by Flaviu Săsăran)

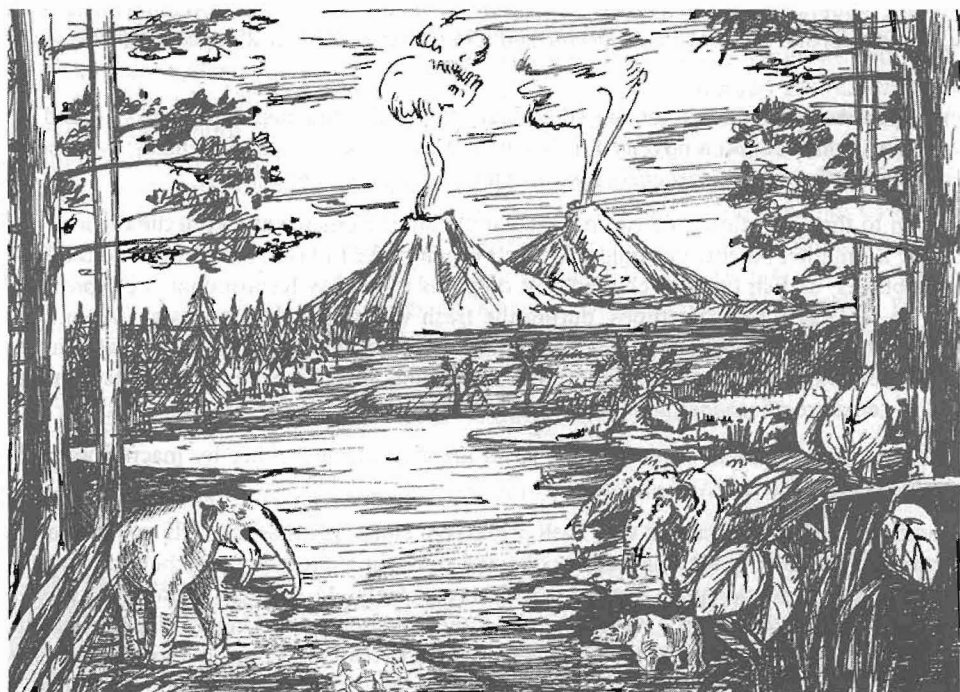


Figure 4 – Reconstruction of the Lower Sarmatian land environment at Minișu de Sus (drawing by Flaviu Săsăran)

Laurophyllum braunii (Heer) Nemejc & Knobloch, *Laurophyllum* ? sp., *Platanus leucophylla* (Unger) Knobloch, *Quercus* cf. *ilex* Linné, *Quercus* sp. or *Castanea* sp., *Myrica lignitum* (Unger)

Saporta, *Myrica vindobonensis* (Ettingshausen) Heer, *Carya denticulata* (Weber) Iljinskaia, *Acacia parschlugiana* Unger, *Cassiophyllum berenices* (Unger) Krausel, *Gleditsia lyelliana* (Heer) Hantke, *Gleditsia knorii* (Heer) Gregor, *Zanthoxylon europaeum* Unger, *Rhus prisca* Ettingshausen, *Populus populina* (Brongniart) Knobloch, *Chamaerops humilis* Linné *fossilis* Kolakovski, *Dicotylophyllum* sp.1, *Dicotylophyllum* sp.2, *Dicotylophyllum* sp.3. (Givulescu *et al.* 1995, 2002).

This typically Sarmatian flora is in complete concordance with the other Early Sarmatian floras from Transylvania. It belongs to the type flora with *Cystoseirites*, but without *Palaeocarya*, an element which has not been stressed up to the present stage of our research (Givulescu 1992).

The taphocaenosis is not very rich. The fossils are made up of having been brought from the surrounding land areas at different moments and, as we shall show later, from various different assemblages.

From a statistic point of view, within this flora there are: 16 families with 20 genera and 24 species + 3 uncertain ones. Therefore, it is a flora with a low number of samples, but still sufficiently rich in families and genera. It is also worth mentioning that, out of the identified forms, 10 are arctotertiary, 6 palaeotropical, *i.e.* 62.50 % : 37.50 %; there are 15 trees and 7 shrubs, *i.e.* 68.18 % : 31.82 %; we found 9 types with dentate leaves and 7 with whole margin leaves, *i.e.* 56.25 % : 42.75 %.

We should point out as a significant fact the presence of a palm tree in the Early Sarmatian, *Chamaerops humilis fossilis* (Givulescu and Barbu 1999). The remaining flora is common for the Early Sarmatian. Anyway, we are also stressing *Lindera antiqua*, and *Quercus* cf. *ilex*, which had their first appearance datum in the Transylvanian floras, just like *Carya denticulata*. On the other hand, *Myrica vindobonensis* and *Acacia parschlugiana* are relicts, because they are peculiar to the Early Miocene and Oligocene. It is very interesting to note the numerous *Pinus* types and the discovery of a *Pinus* with *quaternae* needles.

The foliar remnants belong to several environments. Putting aside the brackish water environment with *Cystoseirites*, two categories can be distinguished on the surrounding basin land: one of flooded swamps with *Glyptostrobus*, *Gleditsia*, *Myrica*, *Platanus*, probably *Pinus taedaeformis* and maybe even *Carya*; another with drier areas with Lauraceae, other vegetables and especially *Chamaerops* and *Quercus* cf. *ilex*., which forms assemblages even in actual occidental Mediterranean region. The shrub *Zanthoxylon* as well as the fern *Pteris* were also present too.

The Early Sarmatian climate had been estimate on the percentage of whole margin leaves. One can presume a subtropical wet climate (Cfa *sensu* Koppen) or according to Dilcher (1973), a wet or even very wet warm temperate one.

For over a decade of field missions a sample of Sarmatian land vertebrate fossils have been collected. It concerns mammals, as water-chevrotain (*Dorcatherium crassum* (Lartet)), listriodon (*Listriodon splendens splendens* Von Meyer), a small rhino (*Alicornops simorreense* (Lartet)), dinothere (*Deinotherium giganteum* Kaup) and mastodon (*Gomphotherium angustidens* (Cuvier)) (Nicorici 1976, Codrea *et al.* 1991 a, b, Codrea 1992, 1996). In addition, an *Anchitherium calcaneum* exists in the collection of the Hungarian Geological Institute (MAFI) in Budapest (unpublished). The whole assemblage can be related to the MN 7+8 unit, *i.e.* the terminal Astaracian.

In order to understand the context in which diatomite sediments were laid, we should refer to the Volhynian palaeogeography of this area. After the low marine level tendency which happened at the end of the Late Badenian, in Volhynian there were ingressive tendencies due to which the Zarand area turned into an archipelago belonging to the Central Paratethys. The surface covered by the Sarmatian waters overcame the Badenian one. In this manner the Sarmatian happen to lye in unconformity over the Permian-Mesozoic basement.

The large mammals and the macroflora, both are evidence for the processes taking place on land environments. The macroflora remnants show that the coasts were dense forested areas, where *Anchitherium*-type fauna occurred. The presence of *Listriodon* as well as that of *Dorcatherium* is evidence in this respect. Water-chevrotain seems to account for the presence of gallery-forests, just like *Alicornops simorreense* which could even be indicative for swamps, also documented by *Glyptostrobos europaeus*, *Myrica lignitum*, *M. vindobonensis*, *Glaeditsia lyelliana* etc.

As a conclusion, mainly the diatomite assemblages indicate that at Minișu de Sus only the Volhynian can be proved, a different situation compared to the Carand site, where Pestrea (1999) found the Bessarabian too.

3.2. Vad-Borod Basin

The small diatomite outcrops we have studied from the Cornițel Formation (Popa 2000) are located near Lugașu de Jos, ten km westward from Aleșd town. The succession is analogous with the one from Minișu de Sus, with diatomite interbedding in tuff. There, Pantocsek (1886, 1889, 1905) mentioned a list including 104 taxa. Among the peculiar forms, there are: *Clavicula biharensis* Pantocsek, *Actinocyclus circumdatus* Pantocsek., *Actinoptychus kymatodes* Pantocsek., *Coscinodiscus biharensis* Pantocsek., *Coscinodiscus martonfi* Pantocsek, *Epithemia biharensis* Pantocsek., *Melosira biharensis* Pantocsek, *Navicula (didyma Ehrbg. var.?) elesdiana* Pantocsek., *Navicula halionata* Pantocsek, *Navicula pseudofusca* Pantocsek., *Plagiogramma biharensis* Pantocsek., *Surirella (striatula Turp.?) antiqua* Pantocsek, *Surirella biharensis* Pantocsek, *Surirella rotunda* Pantocsek, *Triceratium (acutangulum Grev. var.?) grovei* Pantocsek, *Triceratium (antillarum Clev. var.?) laetum* Pantocsek, *Triceratium polygibbum* Pantocsek. As one can observe, all were new species described by Pantocsek.

From the diatomite, leaf imprints as well as fish skeletons had been collected. The macroflora comprises: *Daphnogene polymorphum* (Braun) Ettingshausen, *Tetraclinis salicornioides* (Unger) Kvacsek and *Myrica lignitum* (Unger). They prove the same climate as at Minișu de Sus. The fish are represented by skeletons and otoliths belonging to *Blennius* sp., *Gobius* sp., *Dapalis* sp., *Prolebias* sp., *Pomatoschistus triangularis* (Weiler), *Acentrogobius* sp., *Prolebias senesi* Brzobobathy and Stancu. According to the number of fish vertebra, the basin had brackish waters, probably 29 ‰. Considerable amount of fresh water probably come into the basin as an input carried on by the river streams.

4. Conclusions

In the Western Apuseni Middle Miocene sedimentary basins the diatomite occurs as consequence of the Neogene volcanism, in Sarmatian. All this kind of basins was related to the great Pannonian Basin realm, since the Badenian. The main diatomite sequences can be followed in Zarand and Vad Borod basins. However, thinner diatomite episodes can occur also in the other analogous basins from Western Romania.

All this diatom assemblages (centric and pennate) as well as the micro organisms occurring besides (dinoflagellates, ebridinas, silicoflagellates, phytolites) formed rocks which afforded exceptional fossilisations. Leaf imprints, fragments of siliceous woods, bones and teeth of fish, reptiles or mainly large mammals had been collected from the different outcrops. Several taxa are good markers for the Sarmatian environment reconstructions. The Lower Sarmatian (Volhynian) landscape in both in Zarand and Vad-Borod basins concerned dense forested areas, sometimes with swampy tendencies, in a wet warm temperate climate. The vertebrate fauna belongs to final Astaracian, i.e. MN 7+8 unit. The rims of the Sarmatian basin crossed several salinity changes. The brackish water dominance had been interrupted by fresh water episodes, documented by different diatom assemblages.

Several decades, mining had been carried on for the Western Romania Sarmatian diatomite (Brană 1967). The reserves there are still important and would legitimate the continuation of mining mainly in Zarand Basin.

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