BIOSTRATIGRAPHIC CORRELATIONS BETWEEN THE DACIAN AND PANNONIAN BASINS FROM ROMANIA

Victoria LUBENESCU

e-mail: victoria.lubenescu@gmail.com

Abstract. The author presents the Sarmatian to Dacian (Paludina beds), evolution of the mollusc faunas (markers), shared alike by the Dacian and Pannonian (eastern part) basins. The mollusc associations from the Congeria beds (Pannonian *s. str.*) correlate with the Maeotian mollusc assemblages from the Dacian Basin. The Upper Congeria beds, probably starting from the 'E Zone' (Papp, 1951), correlate with the Pontian associations in the Dacian Basin. The author suggests that the Pannonian *s.str./*Pontian boundary should be set out in a lower position compared to the similar Dacian Basin boundary; considering that the Dacian Basin faunas immigrated from the Pannonian *s. str.* ("E Zone") basin. Other elements, besides the biostratigraphic ones, also render evident these correlations, indicating the same evolution trend controlled by diastrophism (Attic and Rhodanian tectonic movements) and migration.

Key words: Pannonian Basin, Dacian Basin, marker-molluscs, correlation

1. INTRODUCTION

Presently, the molluscs are the main paleontological elements which allow the biostratigraphic separations of the Miocene, Pliocene and Quaternary deposits of the Paratethyan basins. The richness and the specificity of the malacofauna have attracted much interest from researchers, over the 150 years since the first biostratigraphic papers were published. Many bivalves and gastropod species, subspecies and varieties have been identified, impressive fossil inventories have been prepared and conclusions and correlations have been presented. Up to the middle of the previous century, the geological scientific investigations were mostly grounded on the outcrop study, but, afterwards, many subsurface data have been acquired in order to support geological prospecting and exploration works. The abundance of data contributed to the better knowledge of the geological formations which will be discussed further.

The isolation established between the three main Paratethian basins (the Pannonian, the Dacian and the Euxinian one) (Marten ter Borgh *et al*., 2013) (Fig.1), initiated since the Middle Sarmatian, the newly formed faunistic provinces drastically influenced the mollusc communities. The dominant opinion was in favor of the independent evolution of these basins, but new paleontological data contribute to the setting up of a new and more convincing stratigraphic picture. Excellent correlation information was provided by several mollusc groups, namely Congerias, fresh water limnocardiids bivalves, limneids, unionids, viviparids, and others (Eberzin *et al*., 1966). To start with, there is the group of Pannonian-type Congeria species occurring on large areas in Middle Sarmatian deposits (Jeanrenaud, 1963; Andreescu 1984). Their stratigraphic position, overlying the Middle Sarmatian beds (*Cryptomactra* beds and deposits with other Sarmatian molluscs) and, especially, the presence of Congerias of the 'ornithopsis' group and of Soceni-type carenated *Congerias (Congeria soceni, C. politioanei, C. ramphophora, C. zujovici,* and others) convey a special significance to them. These Congeria deposits extend along the pericarpathian zone, from the western extremity of the Dacian Basin (north of Turnu Severin and in the Lom bay from Bulgaria – Kojumdgieva, 1961, 1968) to the Eastern Carpathians bend zone, and, also, to the Moldavian Platform (described by Jeanrenaud, 1963), to the territory between Prut and Nistru rivers and in the eastern Ukraine (the western Euxinian Basin). This clearly shows their large southern extension. At the same stratigraphic po-

sition, deposits with Congeria were reported in the Subcarpathian depression of the Southern Moldavia, at Valea Sarii locality (Lubenescu *et al*., 1974) in the Comanesti Depression fron the Eastern Carpathians (Andreescu, 1984; Lubenescu *et al*., 1974), in the Borsec Depression from the northeastern Transylvania and at Borod, a small bay located in the northeastern Pannonian Basin (Marinescu and Istocescu, 1972). In view of this large areal distribution, the existence of connection ways is to be admitted to explain the migration of large mollusc groups (Fig. 1, Table 1) The Carpathians cannot be considered a continuous barrier between these three Paratethyan sedimentation domains.

The stratigraphic position of the Congeria beds provides information on the origin of the Pannonian mollusc fauna. *Congeria (Trigonopraxis) ornithopsis* together with other Congeria species of the *Mytilopsis* group, which are considered characteristic for the lower horizons of the Pannonian time ('A-B Zone', according to Papp, 1951), occur, actually, at a lower level, that is, in the Middle Bessarabian. In accordance to Marinescu and Istocescu (1972), they evolved even from the Late Badenian. Subsequent to the accumulation of a large volume of bibliographic material from all the Paratethis realm, it clearly appears that the Pannonian faunal association is not the direct descendant of the Sarmatian fauna which occurred after a slow process of salinity decrease (similar development with the Badenian Sea and the apparition of the "Buglovka Beds"). As several authors indicated, a short emmersion probably occured between the Middle Sarmatian and the Pannonian *sensu stricto*. Only after this event the faunas of the "lower Congeria beds" occurred, as the descendants of the limnic faunas developed even since the Miocene time, in marginal zones or in deltas, estuaries or small bays (Hoernes, 1900, Paucă, 1935a; Paucă,1935b; Jekelius 1935, 1943; Boda, 1959; and others). As the ancestors of the Pannonian fauna did not occur during the Sarmatian (Boda, 1959), a transition fauna, in the proper sense of the word, is not to be expected at the Sarmatian/Pannonian boundary. In the

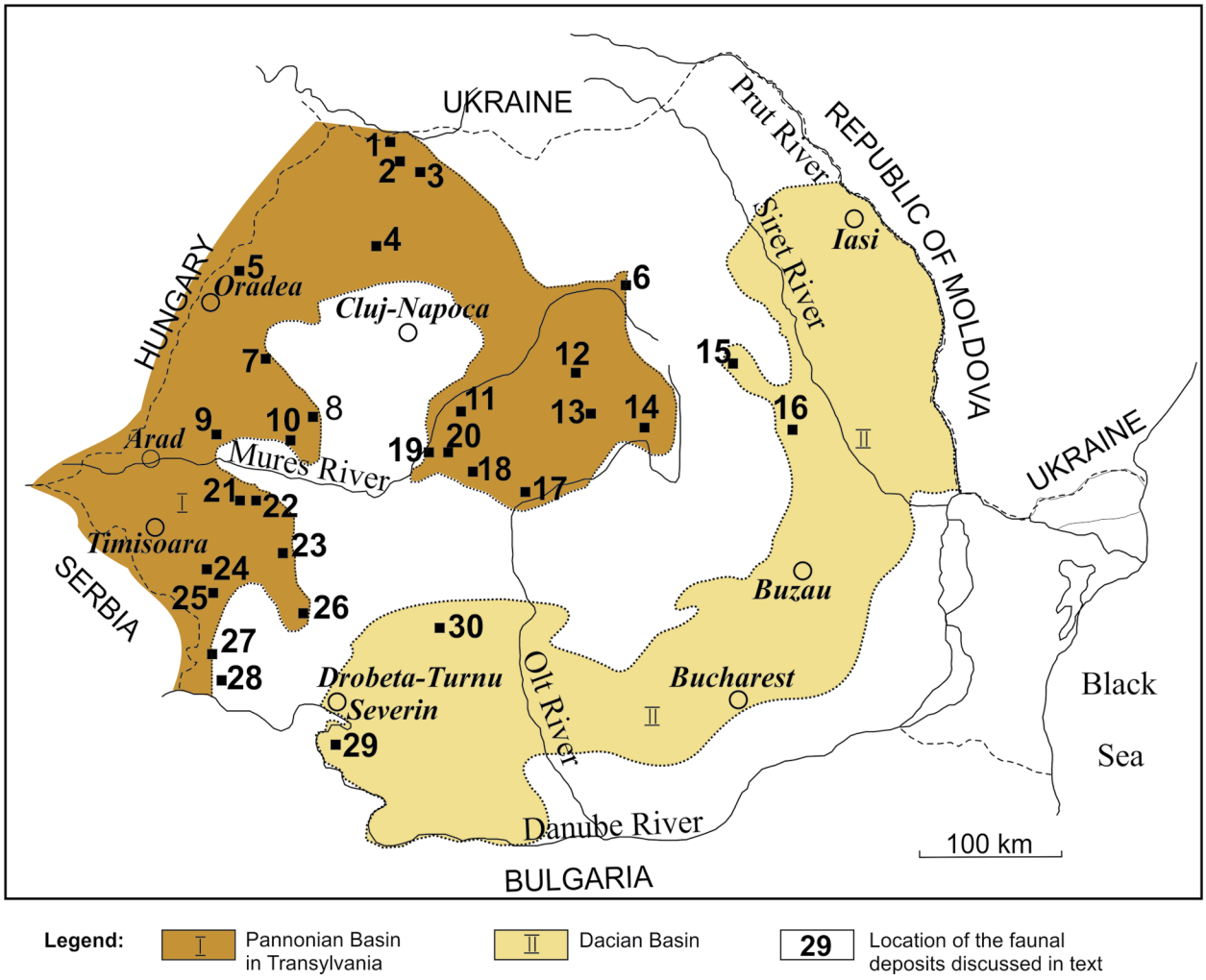
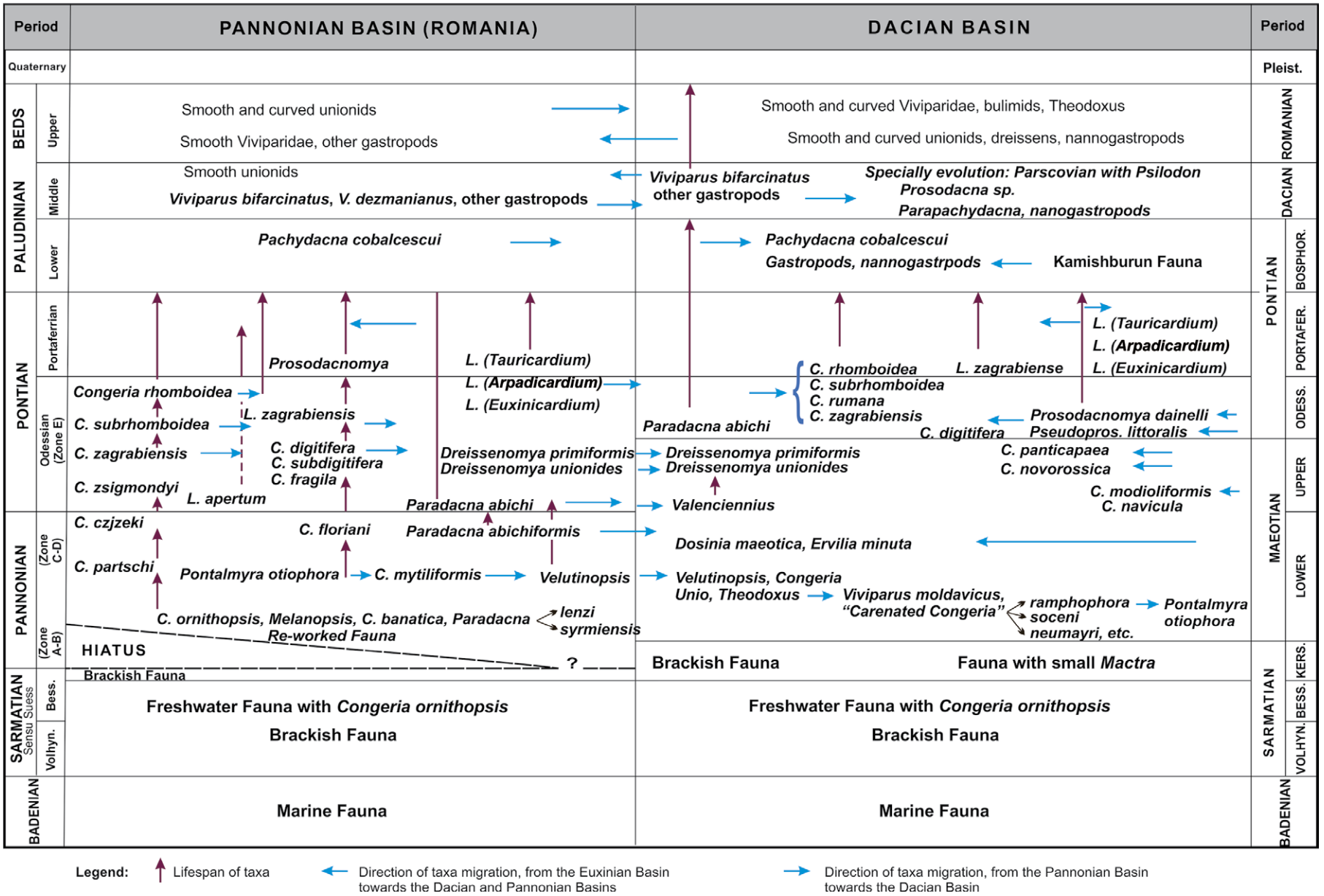


Fig. 1. Study area and location of the faunal deposits discussed in the text. **1**. Cămârzana; **2**. Oaş; **3**. Tigher (M.Gutăi); **4**. Cehu Sivaniei; **5**. Borod; **6**. Borsec; **7**. Beiuş; **8**. Mermeşti; **9**. Zarand; **10**. Almaş; **11**. Lopadea; **12**. Sovata; **13**. Odorheiu Secuesc; **14**. Baraolt; **15**. Comăneşti; **16**. Valea Sării; **17**. Săcădate; **18**. Miercurea Sibiului; **19**. Sebeş-Alba; **20**. Vingard; **21**. Rădmăneşti; **22**. Bucovăţ; **23**. Căvăran; **24**. Tirol; **25**. Soceni; **26**. Bolvaşniţa-Vârciorova; **27**. Nicolinţ (Câmpia); **28**. Socol; **29**. Ostrovu Mare; **30**. Prigoria (Oltenia); **31**. Râmnic (Buzău); **32**. Lom.

Table 1. Correlations between Pannonian and Bacian Basins, based on mollusc fauna studies



domain of the Pannonian from the Romanian territory, the faunal change at the Sarmatian/Congeria Beds boundary was rather abrupt. This modification can be understood only if it is accepted that the change from brackish water to sub-brackish water of the Lower *Congeria* Beds was made suddenly, not in a gradual way. Due to the closure of the Pannonian Basin in its southeastern part, triggered by the uplifting of the Carpathians, the transgression of the Lower *Congeria* Beds over various older deposits (Paleozoic, Mesozoic, crystalline rocks and so on) took place. This transgression process was also active in the western Dacian Basin area.

In the Pannonian domain from Romania the surface and subsurface exploration works provided data which demonstrate that, in most situations, at the base of the reworked Congeria beds Miocene fauna occur, especially, Badenian and Sarmatian gastropods, *Turritella, Cerithium, Pirenellas* or molluscs.

2. METHODOLOGY

This paper employs the term Pannonian (*sensu stricto*) for the stratigraphic interval between Sarmatian *s. str.* (Volhinian and Early Bessarabian) and Pontian.

The author of this paper adopted the classification of the brackish limnocardiids elaborated by Eberzin (1951, 1959, 1962, 1965). For the Congerias description the Andrusov (1895, 1897) classification revised by Marinescu *et al*. (1984) is used. So far, we do not have strong arguments to report some congeries to the '' Mytilopsis" genus, as preferred by Harzhauser and Binder (2004).

3. PRESENTATION AND INTERPRETATION OF DATA

As a result of the Middle and Upper Sarmatian tectonic movements, a significant decrease of the sedimentation areas, and, also, a faunal refreshment occurred in the Dacian and Pannonian basins. The privileged location of the Dacian Basin, between the two large Paratethyan basins (Pannonian and Euxinian), was duplicated by the continuous sedimentation recorded on most of its area. Accordingly, it was possible to document the migration moments, that is the moments areal advancement and spreading out of the faunas, usually made in a passive way and due to external factors.

3.1. Pannonian (*sensu stricto*)

In the Pannonian domain from Romania, these deposits, known as the "Lower *Congeria* Beds", show a large extension especially in the Transylvanian Depression, but also in several small bays of the basin and in Banat. Two main facies types are observed within these deposits: littoral or sublittoral siltic sediments, rich in mollusc and ostracod associations, and deep water deposits. The latter consist in clayey and silty sediments, with a less diverse mollusc fauna, which includes forms with delicate shell [especially, *Congeria (Filicarina) banatica*], often associated with limnocardiids bivalves: *Paradacna lentzi, P. syrmiensis* and ostracods. Over the last decades, investigations documented the equivalence of these facies (Papaianopol *et al*., 1984; Marinescu, 1992).

The basal Pannonian (*sensu stricto*) deposits (from Mehadia, Banat), were reported in Romania by Marinescu *et al* (1977) represented by coarse-grained deposits without fauna. The same stratigraphic level deposits occur in the Beiuş Bay, at the Şoimi locality, wherefrom Paucă (1935a) mentioned *Congeria (Trigonopraxis) ornithopsis*, associated with *Melanopsis sturi*, and varieties of *Melanopsis impressa*. This is the only basal Pannonian (*sensu stricto*) from Romania which was documented on faunistic data. Papp (1951) considered that these deposits are equivalent to the deposits of the 'B Zone' from the Vienna Basin.

3.1.1. Littoral and sublittoral deposits

The faunistic association from Soceni is considered representative for the "lower Congeria beds" from the eastern extremity of the Pannonian Basin. From this assemblages, Jekelius (1944) described (according to the frequency): *Congeria species: [Congeria (Mytilopsis) ramphophora, C. (M.) drzici, C. (M.) neumayri, C. (M.) politioanei, C. (Trigonopraxis) martonfii], melanopsis species [Melanopsis vindobonensis, M. fossilis, M. bouéi, M. inermis, M. stricturata, etc.], Limnocardium species (Limnocardium humilicostatum, L. promultistriata, L. spinosum, L. timisense)*, small gastropods, and others. Many of these taxons are also present in the Maeotian sediments of the Dacian Basin (Table II).

Numerous bays deeply infringed upon the dry land area existed at the Apuseni Mountains periphery (Fig. 3). Some of them continued with channels extending toward the Transylvanian area . Many fossiliferous deposits with Soceni-type faunas (stratigraphically equivalent to the Maeotian deposits from the Dacian Basin) have been identified in the Borod, Zarand, Silvania, Maramureş, Oaş bays. From these areas, Bethlen (1933), Lupu (1963), Lubenescu *et al* (1967), Sagatovici (1968), Istocescu (1970, 1971), Marinescu and Istocescu (1972), Lubenescu and Trifulescu (1995) collected Congerias: *Congeria (Mytilopsis) ramphophora, C (M.) soceni, C (M.) ringeiseni, C (M.) drzici, C (M.) politioanei, C. (Trigonopraxis) moesia, Caspia species (Caspia dybowschi, C. latior, C. ambigua) Pseudamnicola* species (*Pseudamnicola producta, P. unicarinata, P. minima, P. turislavica), Carasia* species, *Hydrobia* species, *Orygoceras* species, *Theodoxus* species and others, associated with ostracods.

3.1.2. Offshore (basinal) deposits

The deposits belonging to the offshore facies include a less diversified fauna with *Congeria (Filicarina) banatica, Paradacna lentzi, P. syrmiensis, Origoceras species, Radix kobelti*, different species of *Planorbi*s, associated with numerous ostracods. These faunas have been first investigated by Hoernes (1875) at Bolvaşniţa-Vârciorova in Banat. Outside this site the offshore deposits occur in the whole Romanian area of the Pannonian Basin. A special situation is in Transylvania, where

these deposits show large extension and considerable thickness (hundreds of meters). The surface geological investigations were supplemented with information from numerous boreholes. For practical reasons, the Sarmaţian/Pannonian *s. str.* boundary is traced at the level of the Bazna tuff, although it is a little bellow it. Everywhere, the Sarmatian deposits are overlayed by an offshore sedimentary succession consisting of alternating silt and clay. *Congeria (Filicarina) banatica, Paradacna lentzi, P. syrmiensis*, ostracods and frequent reworked Cretaceous, Badenian or Sarmatian foraminiferas (Vancea 1960, Ciupagea *et al*., 1970).

In the southern part of the Transylvanian Depression, on the Rodului River (Apoldu de Sus locality) there are Pannonian and Sarmatian outcrops, where the clay deposits with Sarmatian microfauna are overlaid in apparent continuity by ostracod clay (Pannonian). In turn, the ostracod clay are covered by dominantly pelitic sediments with a mollusc association: *Congeria (Filicarina) banatica, Pisidium protractum, Pisidium costatum, Paradacna* sp. associated with ostracods. The pelitic sequence continues with a more abundant fauna (*Paradacna lentzi, P. syrmiensis, Radix kobelty, Undulotheca pancici, U. Rotundata, Velutinopsis velutina,* and ostracods, beside *Congeria (Filicarina) banatica*). The sedimentary succession is similar to the succession investigated by Marten ter Borgh *et al*. (2013) at Beočin locality.

More evolved *Congeria (Filicarina) florianii*, which represent the connection between *Congeria (F.) banatica* and *Congeria (F.) digitifera,* have been observed in a succession of clay and sand from the southwestern Transylvania (Lubenescu and Popescu, 1984; Marinescu, 1992).

The *Velutinopsis velutina, Radix kobelti, Planorbis* species, various species of Origoceras and ostracods, pointed out from deposits of the offshore facies, have been also collected from deposits of Maeotian age in the Dacian Basin (Table II).

According to Marten ter Borgh *et al*. (2013), the isolation of the Pannonian beds coincides with the boundary between the Sarmatian and Pannonian. The Beočin deposits at the base the Pannonian also contain a small-sized Congeria sp. and ostracods.

3.2. Maeotian - Dacian Basin

The discussion concerning the Maeotian deposits will be focused on the faunas evidenced at the same stratigraphic level, both in the Dacian Basin and in the Pannonian Basin.

The Maeotian transgression acting during the Late Bessarabian and Kersonian in the Dacian Basin led to the accumulation of large volumes of detrital material. According to Marinescu (1978), the sediments of this age cropping out in Oltenia (western Dacian Basin) accumulated during the massive uplift of the surrounding dry land and the active lowering of the base level. The first post-Kersonian deposits from the western part of the basin have a different fauna from that of the Sarmatian, but also, unlike the Pannonian fauna. As a consequence of the lower salinity, several species of Unio (*Unio subrecurvus*, Teisseyreomya) and Theodoxus, together with western immigrant species proliferated in this environment. The western species consist mostly of carenated Congerias, well known from the Sarmatian and the Pannonian deposits in Soceni (Jekelius, 1944). It is to be mentioned that in this area of the Dacian Basin there is no section to show the transition between the Kersonian and the Maeotian deposits. Always the Maeotian deposits are discordant, or present sedimentary discontinuity, in relation to the older deposits. Between the Early Maeotian bivalves, the following species are also present at the same stratigraphic level in the basal Pannonian deposits (some of these taxons are known from the Sarmatian deposits of Soceni): *Congeria (Mytilopsis) ramphophora ramphophora, C. (M). ramphophora voesendorfensis , C. (M.) soceni , C. (M.) politioanei , C. (M.) carasi, C. (M.) drzici, C. (Trigonopraxis) martonfii , C. (T.) scenomorpha,C. (T.) zujovici C. (T.) zoisi.* The mollusc assemblages also include *Radix and Velutinopsis velutina* (Marinescu, 1978).

From other areas of the Dacian Basin, beside the taxons mentioned above, *Congeria (Mytilopsis) ringeiseni Jek., C. (Trigonopraxis) moesia Jek., C. (Andrusoviconcha) gitneri Brusina, C. (A.) sandbergeri Andrusov, Dreissena minima* have been collected from the basal Maeotian deposits. They are associated with a rich gastropod fauna, similar to the Soceni fauna: *Pseudamnicola sarmatica sarmatica* Jek., *P. (S.). depressa Jek., P. (Aluta) producta Jek., P. (Staja) turislavica Jek., P. (S.) soceni Jek., P. (S.) atropida Brusina, P. (S.) pseudoatropida Jek., P. (S.) carinata Jek., P. unicarinata Jek., P. (Andrussowiella) carasiensis Jek., P. (Aluta) producta Jek., Caspia latior (Sandberger), C. laevigata Jek., Carasia infida Jek., Littorina banatica Jek., L. politioanei Jek., Membranipora sp., Bythinella eugenii Jek., Hydrobia subsuturata Jek., H. imutata (Freuenfeld), H. syrmica Neumayr, H.moesiacensis Jek., Pyrgula atava Brus., P. ungarica Brus., Orygoceras fuchsi fuchsi Kittl., O. f. filocinctum Brus., Planorbarius thiollieri (Michaud).* (Pană 1962, 1969, 1972) *Dreissenomya (Sinucongeria) primiformis Papp, D. (Dreissenomya) unioides Fuchs, Theodoxus crenelatus semiplicatus (Neumayr), Th. zografi petralbensis Jek., Th. (Calvertia) ştefănescui* Fontannes are known from the Upper Maeotian deposits (Pană 1962, 1969, 1972; Andreescu 1973; Motaş and Papaianopol 1977; Marinescu 1969, 1978; Jipa *et al*., 2007).

As Pană (1969) pointed out, the eastern part of the Dacian Basin is also showing no transition between the Late Sarmatian fauna (with small Mactras and the Maeotian fauna). There are few zones where there is sedimentary continuity between Sarmatian and Maeotian, namely, Ruşavăţ synclines, Pârscov on Buzău River, Râmnic River and Motnău River, where shell beds made of congerias from the modioliforme group and some endemic species appear at the stratigraphic boundary. This is rather a cartographic limit (Pană, 1969).

3.3. Early Pontian (Odessian) – Dacian Basin

During the Pontian transgressive time the faunistic associations from the Dacian Basin are radically changed. This is due to the occurrence of the limnocardiids, which help dis-

tinguish at first sight the Pontian and the Maeotian faunas. With the exception of the transgressive characteristics of the Middle Pontian (Portaferrian), sedimentary continuity exists between the Lower Pontian and the Maeotian deposits. At the Early Pontian level two important lithofacies can be recognized: clayey deposits and littoral deposits. It is to emphasize that the basal Pontian deposits are stratigraphically situated above the deposits with taxons appearing in the two basins even from the "E Zone". This sedimentary succession, overlaid in the two basins by Portaferrian deposits, should be assigned to the Early Pontian. This solution is also supported by the rich ostracod associations identified in both basins, including the "E Zone" deposits of the Pannonian Basin.

3.3.1. Clayey deposits

For the topic discussed in this paper, the most significant geological sections are known from the western Oltenia (western part of the Dacian Basin). Clay deposits with *Congeria (Filicarina) digitifera, Pontalmyra (Pontalmyra) otiophora otiophora, Paradacna abichi, Dreissenomya (Sinucongeria) aperta, Congeria (Andrusoviconcha) zagrabiensis, C. (Congeria) marcovici* (Table II), occur above the boundary with the Maeotian. All these taxons are known from deposits with Congeria (Rombocongeria.) rhomboidea, or even from lower level deposits. Consequently, the first Pannonian forms which emigrate and acclimatize in the Dacian Basin are *Congeria (Filicarina) digitifera, Paradacna abichi, Pontalmyra (Pontalmyra) otiophora*, and others. Another group of Pannonian immigrants includes the limnocardiids [*Limnocardium (Limnocardium) zagrabiense*, *L. (L).riegeli*) and limneids: *Radix, Velutinopsis, Valenciennius*], and others, which are the first molluscs emigrated from the Pannonian Basin. Numerous species of Pontian ostracods accompanied the mollusc association (Marinescu and Olteanu, 1975; Hanganu and Papaianopol 1982; Stoica *et al*., 2007, 2012).

3.3.2. Littoral facies

The second lithofacies occur discontinuously and include numerous forms of *Prosodacnomya, Pontalmyra, Pseudocatillus*, and so on, associated with *Pseudoprosodacna littoralis littoralis* (Eichwald), *P. l. orientalis eichwaldi, Limnocardium (Euxinicardium) subodessae* and others. These molluscs are the witnesses of a supposed Mediterranean migration (Table II).

3.4. Middle Pontian (Portaferrian) - Dacian Basin

The strong ingression at the beginning of the Portaferrian led to the rapid faunistic enrichment, allowing the appearance of new elements, immigrated from both Pannonian and Euxinian basins. The wide communication between the three basins facilitated the faunal migration (Marinescu, 1978).

The Middle Pontian substage was an important stage, not only for the Dacian Basin, but for the entire Paratethys domain. During the Portaferrian the mollusc fauna experienced a high degree of prosperity and diversification. Many taxa were intensely radiating. With the starting point in the Pannonian Basin, the new migrations brought numerous new faunal elements, which adhered to the autochthonous association. The large communication ways made possible a marked uniformity of the mollusc populations, allowing for accurate large distance correlations. The early occurrence limit of the Rhombocongeria, the most characteristic mollusc group of the Middle Pontian, is marked by the appearance of the *Congeria (Rhombocongeria) rhomboidea* and *C. (R.) subrhomboidea*. In spite of the filletic relationship between these species (*Congeria subrhomboidea* is usually at a lower level), they occur, either together, or juxtaposed. The "Congeria subrhomboidea beds" are mostly clayey, but, sometimes, exhibit sandy, very fossiliferous interbeds (*Tauricardium, Bosphoricardium, Euxinicardium, Pontalmyra, Pseudocatillus, Plagiodacna, Phyllocardium, Parvidacna, Chartoconcha; Prosodacnomya, Dacicardium*, and so on). The Portaferrian, usually. showing sedimentary continuity, occasionally shows transgressive features. For example, in the Getic Depression area, the Portaferrian deposits overlay crystalline, Mesozoic or Early Miocene terrains. Also, during the Portaferrian there was the most important carbogenesis time of the Dacian Basin. Together with the mollusc fauna, a rich and diverse ostracod association developed (intensely studied by Hanganu and Papaianopol, 1982, and by Olteanu, 1979, 1999).

3.5. Late Pontian (Bosphorian) – Dacian Basin

At the beginning of the Late Pontian, the faunistic communication between the Dacian Basin and the Pannonian Basin discontinued, but the connections with the Euxinian Basin were still open. For the Dacian Basin, the Bosphorian time was the final stage of the Pontian fauna evolution.

The faunal association of the clayey facies is poorer and less diverse than the sandy facies fauna. Many taxons specific for the Portaferrian are missing, but endemic species occur. The main faunal elements of this facies are *Chartoconcha bayerni* and *Lunadacna lunae*. They are associated with faunas which continue their evolution, like *Paradacna abichi* (known from the "upper abichi beds"), *P. retowschi, Pseudocatillus*, and so on (Table 2), together with *Caladacna steindachneri* and *Dreissena* species.

The sandy facies Bosphorian association shows a considerable enrichment and diversification of the macrofauna belonging to the 'Phillocardium planum planum beds' (Phyllocardium, Bosphoricardium, Pontalmyra, Plagiodacna, Prosodacnomya, Congeria, Dreissena, Viviparus, and so on (Hanganu and Papaianopol, 1982). The Bosphorian includes deposits with fresh-water fauna (viviparids and unionids) and the coal facies extends the Eastern Carpathians bending zone (Andreescu, 1975). The Bosphorian assemblages also include a well-defined ostracod fauna.

The Late Pontian ingressive trends are locally evident in the foredeep area. Transgressive features are present in the Moesian platform area, where well aerated, brackish, littoral facies developed (Papaianopol *et al*., 1987).

After the Late Pontian time the Dacian Basin developed as a large gulf - with distinct characteristics - of the Euxinian Basin.

3.6. Pannonian s. str. Terminal - ?Early Pontian

The genetic relationships between the new and old Pontian fauna (of the lower Congeria beds) are quite close. That is why, in many areas, the lower limit of the Early Pontian is unclear and difficult to define. Characteristic Pontian taxons occur from the upper part of the lower Congeria beds. In the Vienna Basin, Papp (1951) assigned the fauna of these beds to the 'E Zone'. This author acknowledges the presence of a faunal threshold at this level, where, locally, the characteristic semi-brackish species of the lower Congeria beds disappear (Table II).

Table 2. Mollusc fauna common to the Pannonian Basin and Dacian Basin (post-Sarmatian). **1**. Pannonian *s. str.* (Lower Congeria Beds). **2**. Pontian (E Zone). **3**. Middle Pontian (Portaferrian) - Late Pontian. **4**. Paludina Beds. **5**. Maeotian. **6**. Early Pontian (Odessian). **7**. Middle Pontian (Portaferrian) - Late Pontian (Bosphorian). **8**. Dacian-Romanian.

Taxon	Pannonian Basin				Dacian Basin			
	1	2	3	4	5	6	7	8
Congeria (Mytilopsis) ramphophora ramphophora	+				+			
" " " voesendorfensis	+				+			
" " moldavica	+				+			
" " neumayri	+		+		+			
" " soceni	+				+			
" " carasi	+				+			
" " ringeiseni	+				+			
" " plana	+				+			
" " schmidti	+				+			
" " politioanei	+				+			
" " subcarinata subcarinata		+	+					
" " drzici	+				+			
" " simulans turgida			+				+	
" " " mutabilis			+				+	
" " " batuti			+				+	
Congeria (Trigonopraxis) martonfii	+				+			
" " moesia	+				+			
" " aff.zujovici	+				+			
" " scenomorpha	+				+			
" " zoisi	+				+			
" " ornithopsis	+				+			
Congeria (Andrusoviconcha) gitneri	+				+			
" " sandbergeri	+				+			
" " zagrabiensis		+			+			
" (Congeria) marcovici			+			+	+	
" " brandenburgi			+				+	
" (Filicarina) digitifera		+	+			+	+	
" (Rhombocongeria) rumana		+	+			+	+	
" " subrhomboidea		+	+			+	+	
" " rhomboidea			+				+	

Table 2 (continued)

Taxon	Pannonian Basin				Dacian Basin			
	1	2	3	4	5	6	7	8
Dreissenomya (Sinucongeria) primiformis		+						
Dreissenomya (Sinucongeria) aperta		+	+		+	+		
" " arcuata			+			+	+	
" (Dreissenomya) unioides		+	+		+	+		
" " rumana			+		+			
Dreissena polymorpha			+		+	+	+	+
" serbica oresacensis			+				+	
Paradacna abichi		+	+			+	+	+
" " minor		+				+		
" abichiformis		+				+	+	
" okrugici			+			+	+	
" radiata			+				+	
" retowskii			+				+	+
Pontalmyra (Pontalmyra) otiophora		+	+			+	+	
" " budmani			+				+	
" " rarissima			+				+	+
" " planicostata budmani			+				+	
" " deserta		+				+		
" " otiophora oriovacensis			+				+	
Limnocardium (Limnocardium) zagrabiense		+	+			+	+	
" (Tauricardium) petersi			+				+	
" (Arpadicardium) mayeri			+				+	
" (Bosphoricardium) emarginatum			+				+	
" (Euxinicardium) ochetophorum		+	+				+	
" " subodessae			+			+	+	
" " ursinae			+			+	+	
Phyllocardium planum planum			+				+	
" " stevanovici			+				+	
Pseudocatillus pseudocatillus		+	+			+	+	
Plagiodacna auingeri			+				+	
" carinata			+				+	+
Parvidacna planicostata			+				+	
Caladacna steindachneri	+	+	+			+	+	+
Chartoconcha asaphiopsis			+				+	
Pachydacna (Parapachydacna)cobălcescui		+	?+				+	+
Prosodacnomya dainelli			+			+	+	
Velutinopsis velutina	+	+			+	+		
Radix kobelti			+				+	
Valenciennius krambergeri			+				+	+
" reussi			+				+	

Table 2 (continued)

Taxon	Pannonian Basin				Dacian Basin			
	1	2	3	4	5	6	7	8
Radix jaksici			+				+	
" lytostomopsis			+				+	
Pseudamnicola sarmatica	+				+			
" " depresa	+				+			
" inflata	+				+			
" unicarinata	+				+			
" (Aluta) producta	+				+			
" (Andrussoviella) carassiensis	+				+			
" (Staja) pseudoatropida	+				+			
" " turislavica	+				+			
" " soceni	+				+			
" " atropida	+				+			
" " carinata	+				+	+		
Caspia latior	+				+			
" laevigata	+				+			
Carasia infida	+				+			
Littorina banatica	+				+			
" politioanei	+				+			
Bythinella eugenii	+				+			
Hydrobia subsuturata	+				+			
" imutata	+				+			
" syrmica			+					+
" moesiacensis	+				+			
Pyrgula atava	+				+			
" ungarica	+				+			
Theodoxus zografi petralbensis	+				+			
" crenelatus semiplicatus	+				+			
" (Calvertia) stefănescui	+				+			
" rumanus	+				+			
Pyrgula incisa incisa			+				+	
" eugeniae			+				+	
" bicincta			+				+	
" archimedis " mathildaeformis			+ +				+ +	
Orygoceras fuchsi fuchsi	+				+			
" " filocinctum	+				+			
Melanopsis pygmaea pygmaea	+				+			
" (Melanopsis) decollata decollata			+	+			+	+
" " " tessellata				+			+	+
Bulimus(Tylopoma) clessini				+			+	

Table 2 (continued)

Taxon	Pannonian Basin				Dacian Basin			
	1	2	3	4	5	6	7	8
Lithogliphus acutus acutus			+				+	+
Litoglyphus decipiens				+			+	+
Lithoglyphus amplus				+				+
Planorbarius thiollieri	+				+			
Micromelania (Goniochilus) variabilis				+				+
" freyeri			+				+	
" fuchsiana			+				+	
Zagrabica naticina			+				+	
Valenciennius bonéi			+				+	

It is worth mentioning that, in the Pannonian Basin, the terminal deposits of the lower *Congeria* beds are usually transgressive. This was reported from the Belgrade area (Stevanovič, 1951), but also, from the Silvania basin (the southwestern part) in Romania, where deposits of a large fan (gravels with clayey interbeds) cover the older deposits. In the surroundings of the Cehu Silvaniei locality crop out sand and clay deposits. The Late Pannonian *s. str.* transgression is recognized in Late Maeotian of the Dacian Basin, when new faunal changes occur (this is the level with *Dreissenomya primiformis* fauna, a taxon also characteristic to the "E Zone"). This transgressive event is followed by a regression which determined the sediment fill in several areas. This regression occured in anticipation of the great Portaferrian transgression. In the Pannonian domain from the Romanian territory, the terminal Pannonian and basal Pontian geological formations are well-known, both the littoral and basinal (deep water) facies.

3.6.1. Basinal deposits (clayey-silty)

As it is reported from the Vienna Basin, the very rich mollusc fauna is collected from clayey deposits. The faunistic deposits from Câmpia (Langelfeld) in Banat, investigated by Halavats (1883,1887) are well-known. They can be assessed to the 'Congeria zsigmondyi zone', a frequent taxon which appears along with *Congeria czjzeki* and middle or large size limnocardiids of the *Limnocardium (Arpadicardium) winkleri* Halav., *L. (Pannonicardium) sp., L. apertum, L. böcki, Pontalmyra otiophora, Congeria czjzeki, Dreissenomya primiformis* group. Some taxons of this association evolved further during the Portaferrian. The *Congeria zsigmondyi* zone was also reported from the Socol borehole, located in the proximity of the faunal deposits mentioned above (Plate I-III). The borehole penetrated a clayey succession with intercalated shellbeds with Congeria zsigmondyi at 49.50m, 64.50m, 70.50m and 109.50m depths (Cornea *et al*., 1987). An association with *Limnocardium apertum, L.böcki, L.(Pannonicardium) sp., Pontalmyra otiophora, Congeria czjzeki, Dreissenomya primiformis* and ostracodes was mentioned in the 79.50 – 100.50m drilling interval. A rather poor and monotonous macrofauna with *Dreissenomya primiformis, Pseudocatillus sp., Brothya* sp. and many ostracods occurs in the 109.60-164m interval. The ostracod association from the cores of the Socol boreholes very rich and identical with the association studied by Olteanu (1989) in Câmpia deposits. This was interpreted as an 'E Zone' Pontian ostracod association. The presence of *Dreissenomya primiformis* is to be pointed out, a taxon also known from the Late Maeotian and Pontian deposits of the Dacian Basin, where it appears jointly with *Pontalmyra otiophora* and other bivalves occurring, in both Dacian and Pannonian basins. Accordingly, this taxon is of special biostratigraphic significance (Table 1).

At the same biostratigraphic level, a succession of clay with thin sand interbeds is known from outcrops or boreholes from the Beiuș and Borod bays. This succession has congerias of the *Congeria digitifera* group, together with *Paradacna abichiformis, P. abichi, Valenciennius pelta* and ostracodes (Istocescu, 1970, Lubenescu *et al*., 1994, Lubenescu, 1995, Olteanu, 2003).

3.6.2. Littoral deposits

Sediments of the littoral facies are well-developed in Groși area from Banat (Marinescu *et al*., 1977), in the Silvania area and in southwestern Transylvania. Fossiliferous sand or clayey sand deposits with *Congeria subglobosa, C. marcovici, C. spathulata, C. zsigmondyi, Limnocardium secans, L. inflatum* but also with the gastropode *Melanopsis* various species (Lubenescu *et al*., 1967) were reported from Silvania area and from west and southwest of the Cehu Silvaniei locality.

Fine-grained, yellowish and quartzous sands alternating with gray, microconglomeratic fossiliferous sands (5-6 m thick), overlaid by centimetre- and decimetre-thick lenticular clay (3-4 m thick) crop out in the central part of the Vingard locality (southwestern Transylvania). A fauna with *Congeria (Congeria) subglobosa* Partsch with the following varieties: *C. (C.)s. longitesta* Papp, *C. (C)s.giganthica* Pavlovič, *C.(C.)s. soproniensis* Vitalis, *C. (C) marcovici Brusina, C. (Mytilopsis) zahalkai (Špalek), Congeria (Congeria) pancici pancici* Pavlović, *C. (C.)*

zsigmondyi Halav., Limnocardium apertum rothi (Halav.), *L. decorum decorum (Fuchs), Melanopsis fossilis* var.ious species, *M. vindobonensis* various species, *Theodoxus*, was collected from the basal, coarse-grained sand. More fauna [*Congeria (Trigonopraxis) ungulacaprae* Münst, planorbids and unionids] was reported (Lubenescu, 1981) from the coarse-grained deposits in the upper part of the outcrop (Plate III).

Another outcrop (shelly sands with gravel interbeds), corresponding to the same biostratigraphic level occurs in the Râposul Hill from the eastern part of the Săcădate locality (southern part of Transylvania). From these deposits, Lubenescu (1981) collected *Congeria (Mytilopsis) ramphophora voesendorfensis* Papp (at the base of the outcrop), *(Congeria (C.) subglobosa* Partsch*, C. ex gr. C. partsci* Czjzek*, C. zsigmodyi* Halav., *C. (C.) pancici hemipticha* Brus., *C. (Trigonopraxis) ungulacaprae* Münst., many melanopsides of the group *Melanopsis (Canthidomus) defensa* various species, M.fossilis various species, *M.vindobobonensis* various species and *Theodoxus*.

Based on rich ostracod faunas from deep water and littoral deposits, Olteanu (1971, 1979, 1989, 1999, 2003) made a number of correlations between the Neogene geological deposits of the Dacian and Pannonian deposits.

3.7. Portaferrian-Pannonian Basin

In the Pannonian Basin, the Portaferrian is characterized by sedimentation continuity. In the brackish Portaferrian deposits from Romania, there are the well-known littoral faunal deposits from Zorlenţ, Rădmăneşti, Tirol (Gillet and Marinescu, 1971), Bucovăţ (in Banat), but also the less known deposits from Oaş, Zarand, Tigher Hill-Maramureş, Căvăran-Banat and so on. At this stratigraphic level, the bivalve associations enriched in new species, the main role played by the rhombocongerids. For the three Paratethyan basins, the species characteristic for this stage, *Congeria (Rhombocongeria) subrhomboidea* Andrusov and C.(R) rhomboidea M.Hoernes, are real markers. These species are associated with limnocardiids, pontalmyrids, paradacnas and several types of gastropods (Plate II). Some taxons of the terminal Pannonian deposits (E Zone) continue their evolution through *Pontalmyra otiophora, Limnocardium apertum, L.decorum, Dreissenomya aperta, Melanopsis (Canthidomus) defensa*, and others.

Other Portaferrian faunas have been evidenced through drilling, but also in some outcrops. Among the taxons occuring frequently at this biostrastigraphic level, there are *Congeria (Filicarina),* for ex: *digitifer*a Adrusov, *C. (Andrusoviconcha) zagrabiense Brus.,Paradacna abichi (M.Hoernes), P.okrugici (Brus.), Dreissenomya* various species, *Valenciennesia pelta* Brus. Northward of the Caransebeş locality (in Banat), on the Timiş River and its tributaries, the Portaferrian deposits discordantly cover different stratigraphic units (crystalline rocks, Mesozoic or Sarmatian deposits). Large-size Paradacnas (*Paradacna magna* Lubenescu) and numerous species of Paradacna abichi and Congeria digitifera were collected from the gray clay deposits. At the upper part these deposits become richly fossiliferous, with *Congeria (A.)zagrabiensis, C. (C.) marcovici, C. (Trigonopraxis) triangularis Partsch, C. (T.) ungulacaprae Münst., C. (T.) kyovensis Spalek, C. (T.) zahalkai Spalek, C (T.) halavatsi Brus., Limnocardium (Pannonicardium) dumicici Gorjanovic-Kramberger, Dreissenomya (Sinucongeria) aperta (Desh.), D. (Dreissenomya) intermedia (Fuchs), Valenciennius sp.* (Lubenescu and Ştefănuţ, 1986).

3.8. Paludina beds

The post-Portaferrian deposits of the Pannonian domains in Romania, known as Cămârzana formation, crop out in the northwestern part of Romania. Over a large area, they are covered by Quaternary deposits. The largest extension of these "Paludina beds" (Table 3, Plate IV) was outlined by drilling work southwest of Timişoara, in the area at the south of the Mureş River, in the Banat region. At this biostratigraphic level a succession of clay with coal beds and fossiliferous sand, rich in molluscs, was evidenced (Lubenescu and Lubenescu, 2006-2008). The faunal association might be of the same age with the Late Pontian and Dacian-Romanian faunas from the Dacian Basin.

Table 3

Unio (Unio) partschi	R 2	Pal 3
Unio (Pictunio) pîctorum	R 3	Pal 3,Q
Psilunio (Psilunio) pannonicus	R 2	Pal 2
Psilunio (Psilunio) sibinensis	R 1	Pal 2
Psilunio (Psilunio) stoliczkai	R 2	Pal 2
Psilunio (Psilunio) otiliae	R 2	Pal 2
Pristinunio davilai	R 2	Pal 2
Cuneopsidea beyrichi	R 2	Pal 2
Cuneopsidea zitteli	R 2	Pal 2
Rugunio mojsvari	R 2	Pal 3
Rytia vukasoviciana	R 2	Pal 2,3
Rytia bielzi	R 2	Pal 1
Wenziella clivosa	R 2,3	Pal 2
Dreissena polymorpha	R 1,2	Pal 2
Pisidium slavonicus	R 1,2	Pal 2
Pisidium clesini	R 2	Pal 3,Q
Pisidium amnicum	R 3	Pal 3,Q
Viviparus neumayri	Dacian, R 1	Pal 1
Viviparus brusinai	Dacian, R 1,2	Pal 2
Viviparus stricturatus	R 1,2	Pal 2
Viviparus turgidus	R 2	Pal 3
Viviparus dezmanianus	R 2	Pal 2
Viviparus pilari	R 2	Pal 3
Viviparus strossmayerianus	R 2	Pal 2,3
Viviparus novskaensis	R 2	Pal 2,3

Table 3 (continued)

Viviparus woodwardi	R 2	Pal 2, 3
Viviparus sturi	R 2	Pal 2
Viviparus fasciatus	R 3	Pal 3, Q
Viviparus altecarinatus	R 2	Pal 3
Viviparus diluvianus	R 3, Pl	Pal 3, Q
Melanopsis (Melanopsis) sandbergeri	R 1,2	Pal 3
Melanopsis (Lyrcaea) slavonica	R 1,2	Pal 2
Melanopsis (Lyrcaea) friedeli	R 1	Pal 2
Melanopsis (Canthidomus) lanceolata	R 2	Pal 2
Melanopsis (Canthidomus) harpula	R 2	Pal 2, 3
Melanopsis lanzeana	R 1, 2	Pal 2
Melanopsis stricturatus	R 1, 2	Pal 2
Melanopsis rudis	R 1	Pal 2
Melanopsis pterochila	R 1, 2	Pal 2
Melanopsis pterochila onichia	R 1, 2	Pal 1
Bulimus (Bulimus) vukotinovici	R 1 ,2	Pal 3
Bulimus (Tylopoma) onchophorus	R 1, 2	Pal 3
Bulimus (Tylopoma) melanthopsis	R 1	Pal 2, 3
Bulimus (Tylopoma) pilari	R 1	Pal 2, 3
Theodoxus (Calvertia) capillaceus	R 2	Pal 2
Theodoxus (Calvertia) slavonicus	R 1	Pal 3
Theodoxus (Calvertia) militaris decostata	R 1	Pal 3
Theodoxus (Calvertia) nivosa	R 1	Pal 2
Theodoxus semiplicatus	R 3	Pal 2
Valvata (Cincina) sibinensis	R 1 , 2	Pal 2
Valvata (Cincina) sibinensis balteata	R 2	Pal 2
Valvata (Valvata) sulekiana	R 1, 2	Pal 1
Valvata (Valvata) simplex simplex	R 1, 2	Pal 2
Valvata (Valvata) simplex carinata	Dacian, R 1	Pal 1
Emericia candida	R 2	Pal 2
Acella acuaria	R 2	Pal 2
Hydrobia syrmica	R 3	Pal 3
Lythoglyphus acutus decipiens	R 2	Pal 2
Amphimelania fossariformis	R 1, 2	Pal 2
Fagotia esperi	R 3, Pl	Pal/Q
Fagotia acicularis	R 3, Pl	Pal/Q
Planorbis planorbis	Pl	Pal/Q

4. CONCLUSIONS

The development of the mollusc faunas in the Dacian and Pannonian basins during the post-Sarmatian to Late Pontian time (the southward withdrawal of the Pannonian Basin waters and the accumulation of the "Paludina beds), offers a convincing picture of the biostratigraphic relationships between these faunas (Table 1). In this paper it is presented the mollusc faunas investigation in both faunistic provinces, to understand the relationship between evolution and diastrophism. The faunal evolution in the Dacian Basin was carefully analysed, as this basin has a special location, between the other two Paratethyan basins. In the Dacian Basin the mutual exchanges of the faunas emigrated from both east and west areas are recorded. Table 1 illustrates this assertion.

This paper considered the tectonic context of the three basins' appearance, and its impact on the faunas. During the Bessarabian, the mollusc faunas (and other faunas) reached a quantitative and qualitative climax. It is important to pay attention to the communication ways between the Dacian and Pannonian basins, just before these ways were closed. As already mentioned, the Sarmatian deposits were covered by sediments, including a faunal association entirely different from the Sarmatian fauna, namely, the extra-Carpathian Maeotian fauna and the Pannonian fauna from Pannonia. An initial stage, when sediments were accumulated during a relative tectonic tranquility, is apparent in the evolution of the Pannonian sea, which made possible the accumulation of a more than thousand meter-thick clayey complex, with Congeria banatica, Paradacna lenzi, P.syrmiensis, limneides and numerous ostracods. As the sedimentation processes were controlled by block movements, the sediment thickness is not uniform, on the whole Pannonian domain. At the Maeotian stage, in the Dacian Basin, a transgression event began and the first Pannonian immigrants appear. They were represented by mytiliform congerias which accumulate as shellbeds, variable from one section to another. The main taxons are Congeria soceni, C. politioanei, C.ramphophora, C. martonfii, and others. This is the level of the "lower Congeria beds", with taxons typical of the Soceni faunal association. There are also other fossil groups, small size gastropods and ostracods, represented in the two sedimentation domains. In this period of time, the limneids mark a strong development. Since the older Maeotian levels, Radix sand deposits occur, followed by clayey sands with Velutinopsis velutina; which seems to be the equivalent of the Pannonian clay with Congeria banatica, Velutinopsis velutina, Undulotheca, ostracods, and so on. During the Late Maeotian, the congerias of the Andrusoviconcha group appear, marking an important moment (C.novorossica Sinzov), but the mytiliform congerias are also present (Congeria panticapea). During the terminal Maeotian, there were small size driessenomids, like Dreissenomya primiformis Papp. In the Pannonian domain, this taxon occurs in the terminal beds of the Pannonian *s.str.*- Lower Pontian, associated with Pontian taxons and many ostracods of the

same age (Câmpia stage). At this level, a real paleontologic threshold is apparent, when most of the molluscs belonging to the lower Congeria beds disappear, and the new Pontian taxons emerge. In the Early Pontian (slightly transgressive the regressive) Paradacna, Psedoprosodacna and Congeria occur, in littoral, as well as deep water deposits. Paradacna abichi and Congeria digitifera, from clayey deposits of the Pannonian domain, develop into characteristic species. They are associated with Congeria zagrabiensis, Pontalmyra otiophora, a.s.o., and are overlaied with continuous sedimentation by Portaferrian (Middle Pontian) deposits. That is why, in our opinion, the terminal beds of the Pannonian *s.str*. ("E Zone") should rather be reffered to as the Lower Pontian. The Pontian ostracod fauna provides arguments in favour of this idea. During the Middle Pontian (Portaferrian), after faunal exchanges, the bivalve associations become very rich, in both the Dacian and Pannonian basins. Some species which appeared during the Early Pontian, or even earlier, are continuing their evolution along with the characteristic species of this stage, like Congeria (Rhombocongeria) subrhomboidea and C.(R) rhomboidea. They are associated with a rich fauna, including Congeria turgida, C.zagrabiense, C.marcovici, C.digitifera, Limnocardium zagrabiensis species, Caladacna steindachneri, Paradacna abichi, P.okrugici. The well-known faunal deposits from Rădmăneşti, Tirol, Căvăran, Oaş, Maramureş accumulated during the Portaferrian.

The Late Pontian (Bosphorian) fauna show special features in both the Dacian and Pannonian basins. In the Dacian Basin the sedimentation evolves continuously, while in the Pannonian Basin emerged land areas appear, and the lacustrine waters retreat southward, where the "Paludina beds" accumulate. At this stage, the communication between the Dacian and the Pannonian basins continues. The first molluscs, like Stylodacna, Parapachydacna or Dacicardium appear, marking a moment of efflorescence and diversification, during the Dacian time. It is to be mentioned that the "Paludina beds" accumulated also in northwestern Romania (the small Oaș Bay and Silvania Basin, in Banat), but the largest development of these deposits was acknowledged in the area close to Timișoara (Banat) (Lubenescu and Lubenescu, 2006-2008). During the Late Dacian – Romanian – Pleistocene time, intense faunal exchanges took place. So far, at least 67 lamellibranches and gastropod taxons have been identified (Table III). The connection between the two basins was probably made through the south western Romanian and the northwestern Bulgarian territory.

Evolution, migration, as well as the genetic relationships of some of the characteristic Paratethyan molluscs, have been studied by various authors (Plate II).

Other elements, beside the biostratigraphic data, point out the presented correlations, making evident the same evolution controlled by diastrophism and underlined by prohoresis. The tectonic movements (Attic phase) of the Late Bessarabian led to the important reduction of the Dacian and Pannonian areal, but also to the regeneration of the entire fauna. The Dacian Basin Maeotian transgressions took place, revealed by the immigration of Dosinia and other higher salinity molluscs (probably, of Medditerranian origin). As a consequence of the Rhodanian tectonic phase, the concomitant transgressive process in the Pannonian Basin, is revealed by the accumulation of the lower Congeria beds covering different older stratigraphic units. Another transgression event, from the Early Pontian is marked by faunal changes on both sides of the Carpathians. These are three moments associated with faunal renewal, usually migrated from the west to the east.

As a final conclusion, it is our conviction that only after providing a complete and convincing picture of the evolution of the main mollusc groups, ostracods and other faunas of the Paratethyan basins, we will be able to speculate radiometric, magnetometric (and others) data. The situation on the field proves to be much more nuanced than the one in the office.

ACKNOWLEDGEMENTS

The author is grateful for the help provided by Dan Jipa (National Institute of Marine Geology and Geoecology, Bucharest) concerning the construction of this paper, as well as the information regarding the Dacian Basin evolution. Discussions with Marius Stoica (University of Bucharest) led to the clarification of several important problems related to the present paper. Corina Avram (National Institute of Marine Geology and Geoecology, Bucharest) kindly contributed to the better organization of some intricate figures. Rodica Macaleț (National Institute of Hydrology and Water Management, Bucharest) is acknowledged for the constructive and stimulating review.

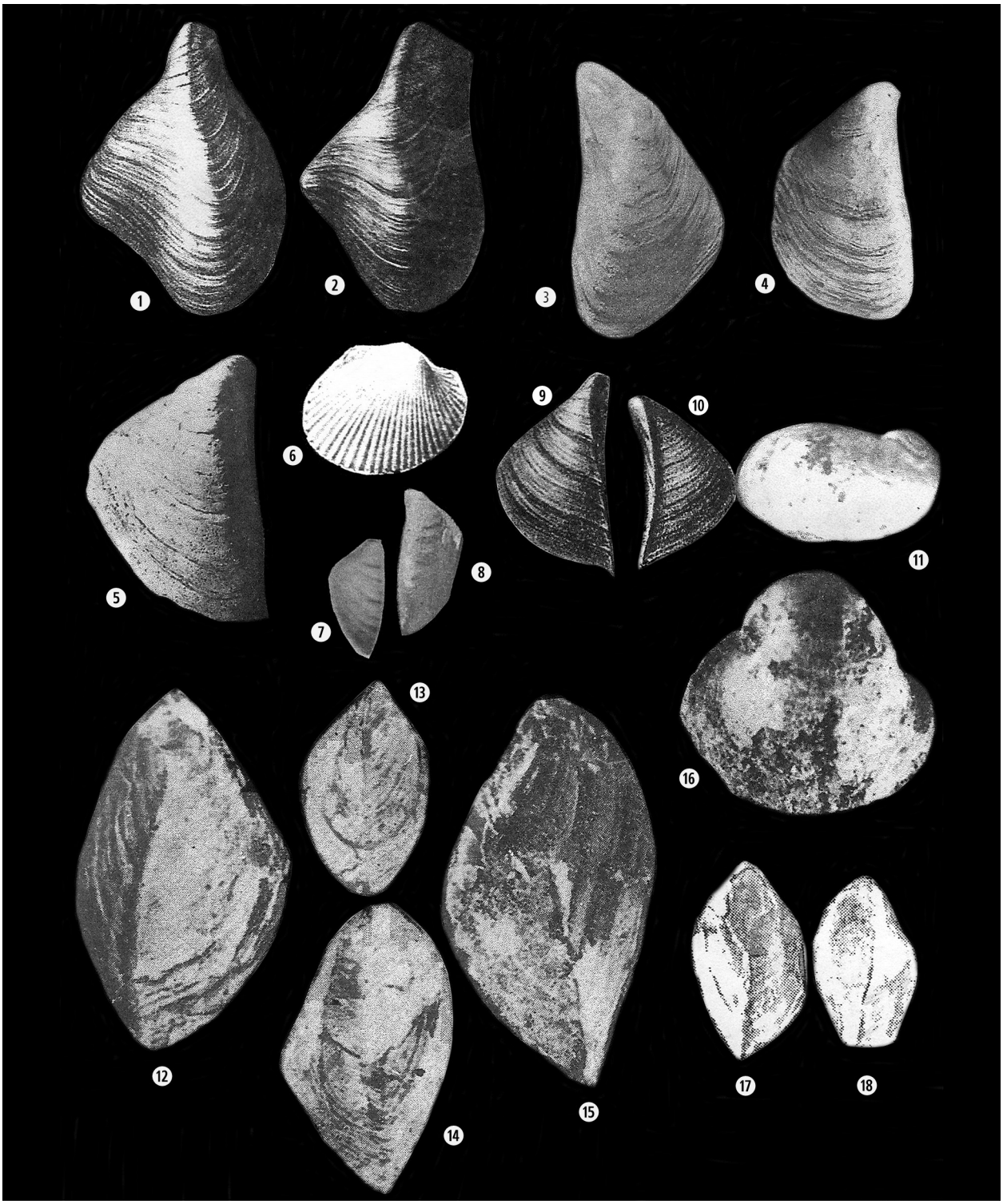


Plate I. Pannonian and Pontian mollusc fauna from Serbia and Romania. **a**. and **b**. *Congeria (Trigonopraxis) ornithopsis* (x 1), (Brusina, 1902), Sarmatian, Pannonian, *s. str*., Maeotian; **c**. *Congeria (Mytilopsis) neumayri* (x 2), (Jekelius, 1944), Sarmatian, Maeotian; **d**. *Congeria(Mytilopsis) soceni* (x 2), (Jekelius, 1944), Pannonian *s. str*., Maeotian; **e**. *Congeria (Mytlopsis) polițioanei* (x 2), (Jekelius, 1944), Pannonian *s. str*., Meotian; **f** and **g**. *Congeria (Trigonopraxis)martonfii* (x 6), (Jekelius, 1944), Pannonian s. rstr., Maeotian; **i** and **j**. *Congeria (Mytilopsis)ramphophora ramphophora* (x 2), (Brusina,1902), Pannonian *s. str*., Maeotian; **k**. *Theodoxus zografi petralbensis* (x 2), (Lubenescu, 1981),Pannonian *s. str*., Meotian; **l**. *Congeria (Filicarina) banatica* (x 3),(Lubenescu, 1995),Pannonian *s. str*.; **m**. *Congeria (Filicarina) floriani* (x 1,5), (Lubenescu, 1995), Pannonian *s. str*., Pontian Pannonian Basin; **n** and **o**. *Congeria (Filicarina) fragila,* (Lubenescu, 1995). Photo **n** (x 2); Photo **o** (x 2,5). Pontian, Pannonian Basin; **p**. *Velutinopsis velutina* (x 2), (Marinescu 1969), Pannonian *s. str*., Maeotian; **r** and **s**. *Congeria (Filicarina) digitifera* (x 1), (Marinescu, 1992), Pontian, Pannonian and Dacian basins.

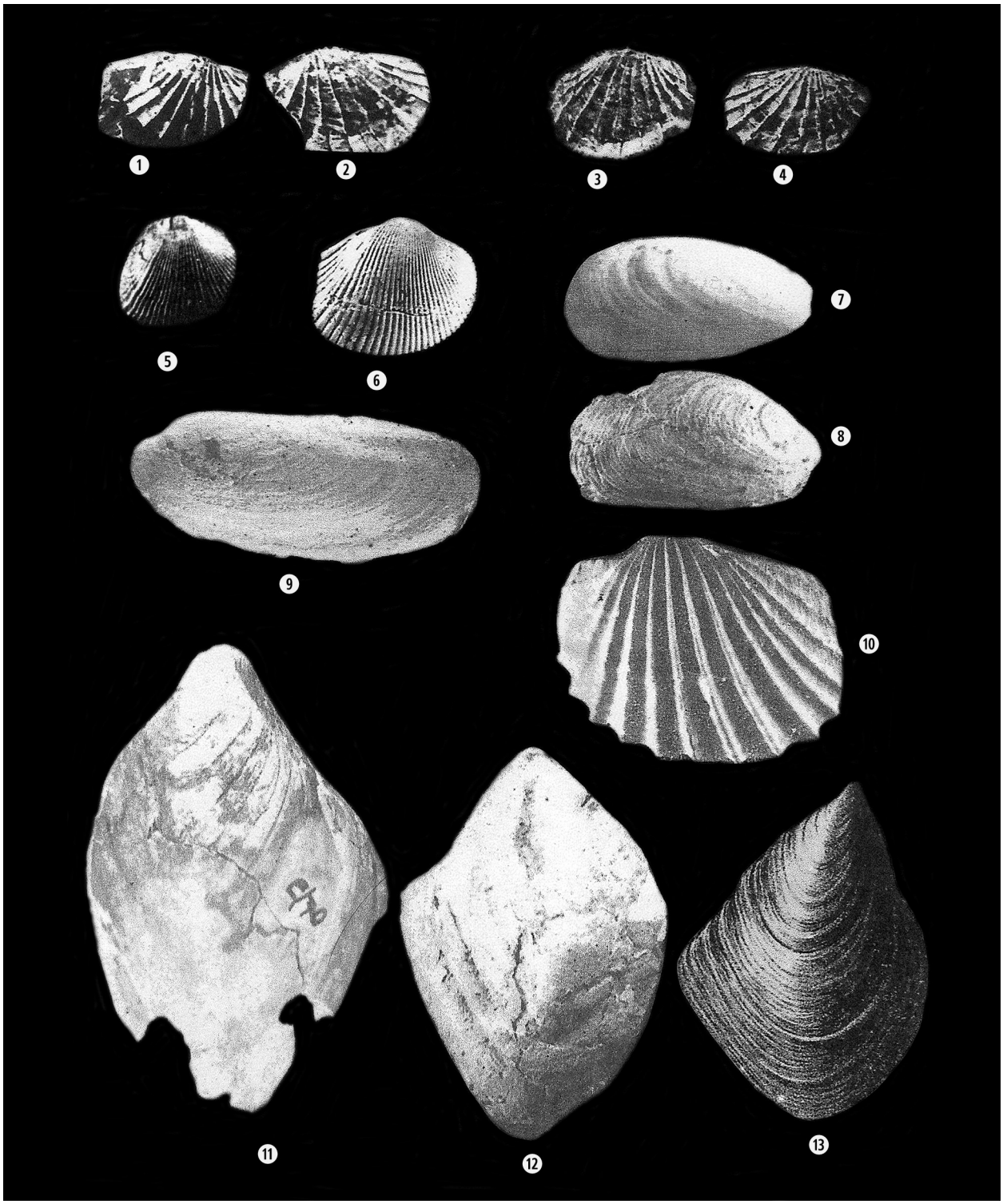


Plate II. Pontian mollusc fauna from the Pannonian Basin (in Romania and Serbia) and Dacian Basin. **a**, **b**. *Paradacna abichi abichi* (x 1) (Papaianopol *et al*., 1985), Pontian, Pannonian and Dacian basins; **c**, **d**. *Paradacna abichi abichiformis* (x 1) (Papaianopol *et al*., 1985), Pontian, Pannonian and Dacian basins; **e**. *Pontalmyra (Pontalmyra) otiophora* (x 2) (Marinescu *et al*., 1986), Pontian, Pannonian and Dacian basins; **f**. *Pontalmyra (Pontalmyra) deserta* (x 2) (Marinescu *et al.,* 1986), Pontian, Pannonian and Dacian Basin; **g**. *Dreissenomya (Sinucongeria) primiformis* (x 12) (Marinescu, 1977), Late Maeotian. Pannon *s.str*. terminal-Pontian; **h**. *Dreissenomya (Sinucongeria)aperta* (x 1) (Marinescu, 1977), Pontian, Pannonian and Dacian Basin;**i**. *Dreissenomya (Dreissenomya)unioides* (x 1,5) (Marinescu, 1977), Late Maeotian, Pannonian *s.str*.terminal-Pontian; **j**. *Limnocardium (Limnocardium)zagrabiense* (x 1) (Istocescu, 1971), Pontian, Pannonian and Dacian Basin; **k**. *Congeria (Rhombocongeria)subrhomboidea* (x 1) (Papaianopol, 1976), Portaferrian, Pannonian and Dacian Basin; **l**. *Congeria (Rhombocongeria) rumana* (x 1) (Papaianopol, 1976), Early Pontian-Odessian, Dacian Basin; **m**. *Congeria (Andrusoviconcha) zagrabiensis* (x 1) (Brusina 1902), Portaferrian.

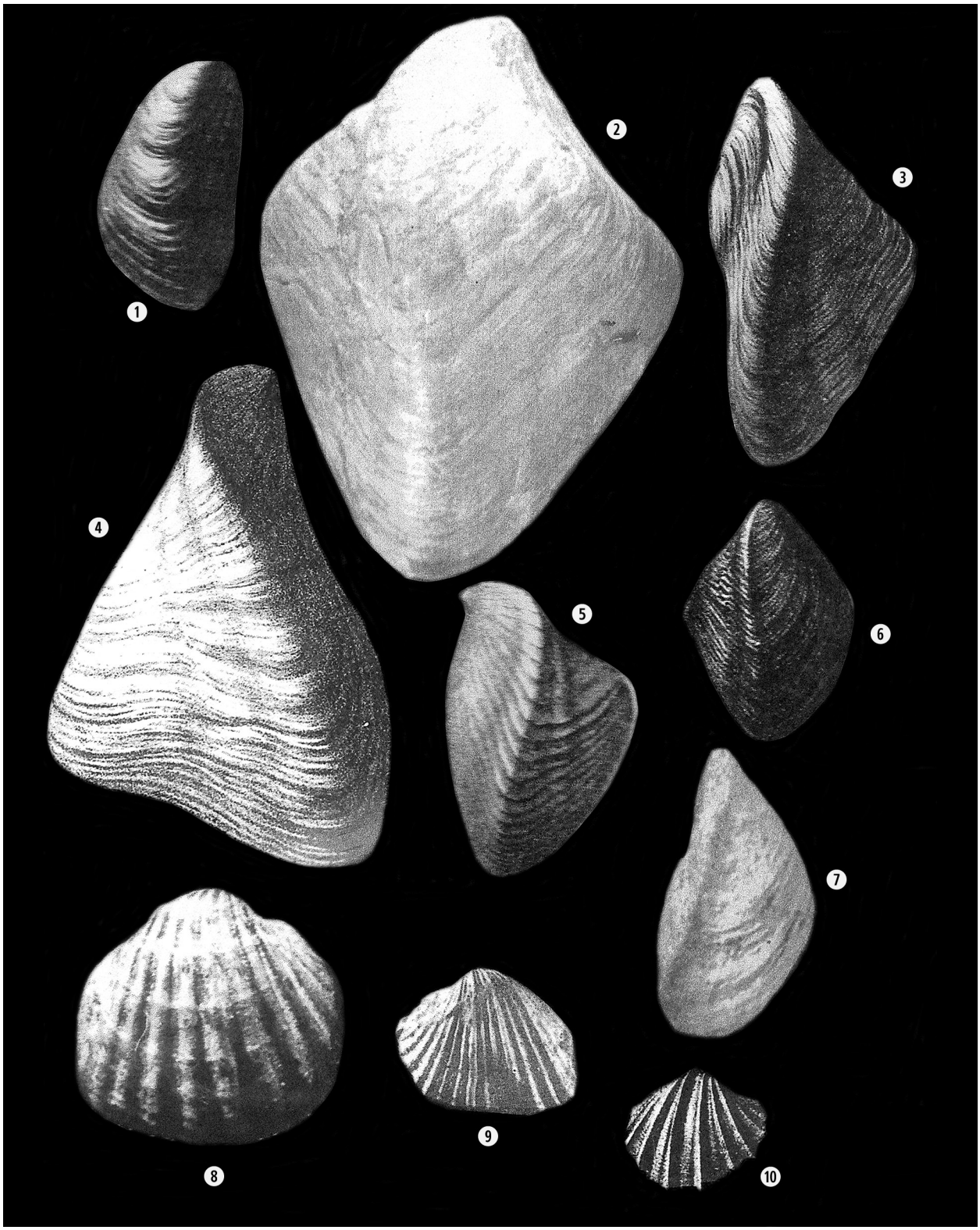


Plate III. Pontian mollusc fauna from the Pannonian Basin (in Romania and Serbia) and Dacian Basin. **a**. *Dreissenomya (Sinucongeria) arcuata* (x 1) (Brusina, 1902), Portaferrian; **b**. *Congeria (Rhombocongeria) rhomboidea* (x 1) (Papaianopol,1976), Portaferrian; **c**. *Congeria (Mytilopsis) balatonica* (x 1) (Brusina, 1902), Pontian, Pannonian Basin; **d**. *Congeria (Trigonopraxis) ungula caprae* (Brusina, 1902), Pontian, Pannonian Basin; **e**. *Congeria (Trigonopraxis) triangularis* (x1) (Brusina, 1902), Pontian, Pannonian Basin; **f**. *Congeria (Congeria) marcovici* (x 1) (Brusina, 1902), Pontian, Pannonian and Dacian basins; **g**. *Congeria (Mytilopsis) subcarinata subcarinata* (x 1) (Papaianopol, 1990), Portaferrian; **h**. *Limnocardium (Tauricardium) petersi* (x 1) (Papaianopol *et al*., 1985), Portaferrian; **i**. *Caladacna steindachneri* (x 1) (Istocescu, 1971), Portaferrian; **j**. *Limnocardium (Euxinicardium) ochetophorum* (x 1) (Brusina, 1902) Pontian, Pannonian and Dacian basins.

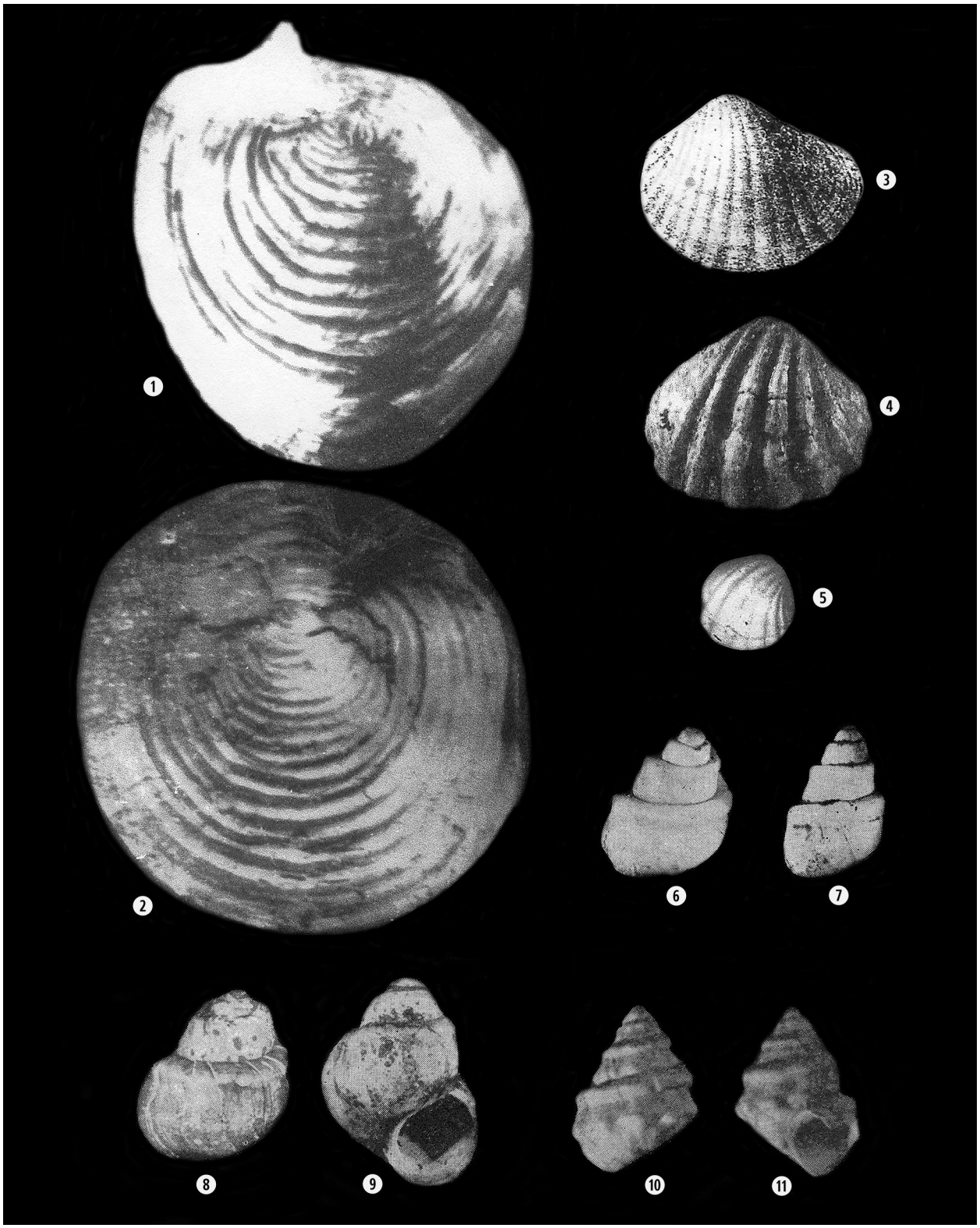


Plate IV. Pontian mollusc fauna from the Pannonian Basin (in Romania and Serbia) and Dacian Basin. **a**. *Valenciennius reussi* (x 1) (Marinescu *et al*., 1986), Portaferrian; **b**. *Valenciennius krambergeri* (x 1) (Marinescu *et al.,* 1986) Portaferrian; **c**. *Prosodacnomya dainelli* (x 1) (Brusina, 1902), Pontian, Pannonian and Dacian basins; **d**, **e**. *Pachydacna (Parapachydacna) cobalcescui.* Photo **d** (x 2) (Papaianopol *et al*., 1988), Early Dacian. Photo **e** (x 1) from Mihăilescu, 1966, Pontian, Pannonian Basin; **f**. *Viviparus bifarcinatus* (x 1) (Lubenescu and Zazuleac, 1981) Romanian and Middle Paludina Beds; **g**. *Viviparus stricturatus* (x 1) (Lubenescu and Zazuleac, 1981) Romanian and Middle Paludina Beds; **h**, **i**. *Viviparus rudis* (x 1) (Lubenescu and Zazuleac, 1981) Romanian and Middle Paludina Beds; **j**, **k**. *Viviparus sturi* (x 1) (Lubenescu and Zazuleac, 1981) Romanian and Middle Paludina Beds.

REFERENCES

Andreescu,I.,1973. Precizări asupra limitelor etajului Meotian. *Studii cerc. geol. geof. geogr*., Seria geol. **2**/*18*, 541-558.

Andreescu, I., 1975. Limitele şi subdiviziunile Ponţianului. *Studii cerc. geol. geof. geogr.,* Seria Geol. **20**/*2*, 235-246.

Andreescu, I.,1984. Paleogeographic significance of Sarmatian Congerias from the Dacian Basin. 75 years, Lab. Paleont. Univ. Bucureşti. Special volume, 219-228.

Andrusov, N.,1895. Kurze Bemerkungen über einige Neogenablagerungen Rumäniens. *Verh. d. k. k. geol. R. A*., 184-197.

Andrusov, N., 1897. Iskopaemie i jivuscie Dreisensidae Evrazii. *Izbranie* /1964, **III**,17-397.

Bethlen, G., 1933. Raport géologique et paléontologique sur les alentours nord de la montagne de cuivre de Bihar-Szeles. *Földt. Szemle*, 1-56.

Boda, J.,1959. Das Sarmat in Ungeren und seine Invertebraten Fauna. *Annales Instituti Geologici Publici Hungarici*, Budapest, **47**/*3*, 569-862.

Ciupagea, D. T., Paucă, M., Ichim, Tr.,1970. Geologia depresiunii Transilvaniei. Editura Academiei Române. 256 pp.

Cornea, C., Lubenescu, V., Munteanu, A., Sârbu, F., Cehlarov, A., 1987. Stratigrafia depozitelor neogen-superioare din zona Berzovia-Socol (Banatul de vest) pe baza datelor din foraje. *Dări Seamă Inst. Geol. Geof.* **72-73**/*4*, 103-114.

Eberzin, A. G. 1951. Solonovatovodnîe Kardiidî Pliotzena. S. S. S. R. *Tr. Paleont. Inst. Acad. Nauk. S. S. S. R.* **XXXI**/*II*, 116 pp.

Eberzin, A. G., 1959. Solonovatovodnîe Kardiidî Pliotzena S.S.S.R. tchiasti III. III Prosodacna, Prionopeura, Pachidacna. Akad. Nauk. S. S. S. R., Tr. Paleont. Inst. LXXIV, 196 pp.

Eberzin, A. G., 1962. Solonovatovodnîe Kardiidî Pliotzena S. S. S. R. Didacna podrodî Pontalmyra i Crassadacna. Akad. Nauk. *S. S. S. R. Trudî Paleont. Inst.* **XCI**, 179 pp.

Eberzin, A., 1965. Sistèma i filogenija solonovatovodnych Kardiid. Molljuski. Voprosy tcoretièckskoj i prikladnoj malakologii. Moskva-Leningrad.

Eberzin, A. G., Motaş, I. C., Macarovici, N., Marinescu, Fl., 1966. Afinitaţi pannonice şi euxinice ale Neogenului superior din Bazinul Dacic. *Stud. cerc. geol. geofiz. Geogr*., Seria Geologie **11**/*2*, 463-481.

Gillet, S., Marinescu, Fl., 1971. La faune malacologique pontienne de Rădmăneşti (Banat roumain). *Memoriile Inst. Geol. României* **XV**, 5-78.

Halavats, J.1883. Paläontologische Datten zur kenntniss der Fauna der südungarischen Neogen Ablagerungen I. Die Pontische Fauna von Langenfeld. *Mitt. Jb. Kgl. Ung. Geol. Anst* **IV**, 163-173.

Halavats, J., 1887. Paläontoligische Datten zur kenntniss der Fauna des südungarischen *s* Neogenablagerungen III. Die pontische Fauna von Kustély IV. Die pontische Fauna von Nicolincz. V. Die pontische Fauna von Csukies. *Jahr. d. kgl. ung. geol. Anst.* **III**/*VIII*, 27-45.

Hanganu, E., Papaianopol, I.,1982. Sur les limites du étage Pontien dans le Bassin Dacique. *Analele Stiinţifice ale Universităţii "Al.I.Cuza"-Iasi*, secţia 2b Geologie-Geografie **XXVIII**, 63-67.

Harzhauser, M., Binder, H., 2004. Synopsis of the Late Miocene mollusc fauna of the classical sections Richardhof and Eichkogel in the Viena Basin. *Arch. Molluskenkunde* **133**(*1/2*), 1-57.

Hoernes, R.1875. Tertiär Studien VII Valenciennesia Schichten aus den Banat. *Jahrb. D. k. k. geol.R.-A*. **XXV**, Wien.

Hoernes, R., 1900. Die vorpontische Erosion. Sitzungsber d.k. Acad. d. Wiss. 1 Wien, 109 Bd., Abt. 1, S. 811

Istocescu,D.,1970. Stratigrafia depoziteor pliocene din extremitatea vestică a Bazinului Crişul Alb. *Dări Seamă Inst. Geol.* **LVI**/*4*, 113-129.

Istocescu, D., 1971. Studiul geologic al sectoruui vestic al Bazinului Crişului Alb şi al ramei Munţilor Codru şi Highiş. *Studii tehn. econ. Seria J, Stratigrafie* **8**. 201pp.

Jeanrenaud, P.,1963. Contribution à l'étude des couches à faune d'eau douce du Sarmatien de la Plate-forme Moldave. *An. şt. Univ. Al. I. Cuza Secţ.* **II**/*9*, 36-39.

Jekelius, E.,1935. Die Parallelisierung der pliozen Ablagerungen Südost-Europas. *An. Inst.Geol. Rom*. **17**, 265-307.

Jekelius, E.,1943. Das Pliozän und die sarmatische stufe im Mittleren Donaubecken. *Anuarul Inst. Geol. Rom*. **XXII**,195-383.

Jekelius, E., 1944. Sarmat und Pont von Soceni (Banat). Memoriile Inst. Geol. Rom. 159 pp.

Jipa, D., Olariu, C., Marinescu, N., Olteanu, R., Brustur, T., 2007. A Late Neogene marker sequence in the Dacian Basin (Paratethis Realm). Genetic and stratigraphic significance. *Geo-Eco-Marina* **13**,121-138.

Kojumdgieva, E.,1961.Étude paléontoogique du Méotien inférieur de la Bulgarie de nord-ouest. *An. Dir. Gen. rech. geol*. **11**, 139-155.

Kojumdgieva, E.,1968. Les représentants du genre Congeria dans le Néàgène de la Bulgarie de nord-ouest et leurs philogénie et paléontologie. *Bul. Géol. Inst. Sér. Paléontologie* **17**,173-208.

Lubenescu,V., Crahmaliuc, G., Radu, M., 1967. Observaţii asupra stratigrafiei şi faunei depozitelor pannoniene din Bazinul Silvaniei. *Dări Seamă Inst. Geol.* **LII**/*3*, 63-72.

Lubenescu, V., Marinescu, Fl., Pavnotescu, V.,1974. Comentarii asupra faunei cu congerii din Bessarabianul superior de la Valea Sării (Depresiunea subcarpatică a Moldovei meridionale). *Dări Seamă Inst. Geol., Stratigrafie,* **LX**/*4*, 131-138.

Lubenescu, V., 1981. Studiul biostratigrafic al Neogenului superior din sud-vestul Transilvaniei. Anuarul Inst. geol. geof. LVIII, 123-202.

Lubenescu, V., 1982. Ponţianul de la nord de Caransebeş. *Dări Seamă Inst. Geol. Geofiz*. **LXVI**/*4*, 181-187.

Lubenescu, V., Popescu, A.,1984. Une nouvelle espèce de Congeria au Pannonien *s.restr.* (=Malvensien) de la Dépression de Transylvanie. *Dări Seamă Inst. geol. geof*. **LXIX**/*3*, 25-28.

Lubenescu, V., Ştefănuţ, V.,1986. Le Néogène supérieur de la vallée du Timiş (Banat). *Dări Seamă Inst. geol. geofiz*. **70-71**/*3*,19-33.

Lubenescu, V., Ionescu, St., Cornea, C.,1994. Limite Pannonien/Pontien, contributions fondée sur l'étude quelques forages du secteur de Beiuş-Rieni. The Miocen from the Transylvanian Basin-Romania. 179-185.

Lubenescu,V.,1995. Congeria (Filicarina) fragila n. sp. intermediary species between Congeria (Filicarina) banatica and Congeria (Filicarina) digitifera. *Romanian Jour. Paleontology* **76**, 101-104.

Lubenescu, V., Trifulescu, M.,1995. Consideration on the Neogene formations in the Almaş-Rădeşti-Musteşti-Secaş area (Zarand basin). *Romanian Jour. Stratigraphy*. **76**, 89-90.

Lubenescu, V., Lubenescu, D., 2006-2008. Neogenul superior - strate cu paludine din România. *St. cerc. Geologie* **51-53**, 77-88.

Lupu,D.,1963. Observaţii asupra Pannonianului de la Hălmagiu şi Mermeşti (Bazinul Crişului Alb). *Stud. cerc. geol.* **VIII**/*3*, 403-412.

Marinescu,Fl.,1969.,Precizări stratigrafice privind Sarmaţianul şi Meoţianul din Nordul Olteniei. *Dări Seamă Inst. Geol. Geofiz*. **LIV**/*3*,153-161.

Marinescu, Fl., Istocescu, D., 1972. Asupra unei faune cu Congeria ornithopsis din Sarmaţianul golfului Borod (vestul Bazinului Pannonic). *Dări Seamă Inst. Geol*., **LVIII**/*3*, 53-67.

Marinescu, Fl., Olteanu, R.,1975. Considérations sur les associations des mollusques et d'ostracodes du Méotien de la partie occidentale du Bassin Dacique. *Dări Seamă Inst. Geol. Geofiz.* **LXI**/*4*, 113-127.

Marinescu, Fl., Olteanu, R., Ţăranu-Rogge, E., Popescu, A., 1977. Le Pannonien du Banat. *Dări Seamă Inst. Geol. Geofiz*. **LXIII**, 65-133.

Marinescu, Fl., 1978. Stratigrafia Neogenului superior din sectorul vestic al Bazinului Dacic. Editura Academiei. 155 pp.

Marinescu, Fl., Papaianopol, I., Popescu, A., Olteanu, R., Ticleanu, N., 1984. Atlasul paleontoogic al României. Fascicolul 1, Arhiva Inst. Geol. Geofiz. (unpublished) 145 pp.

Marinescu, Fl., Papaianopol, I., Munteanu, E., Popescu, A., 1986. Studii în vederea elaborării atlasului paleontologic al R.S.România, Ponţianul II, Mollusca. Arhiva Inst Geol. Geofiz. (unpublished) 138 pp.

Marinescu, Fl.,1992. Filicarina, nouveau sous-genre de Congeria (Bivalvia, famille Dreissenidae). *Romanian Jour. Paleontology* **75**, 11-12.

Marten ter Borgh, Lazăr, I., Stoica, M., Knezević, S., Matenco, L., Krigsman, W., Rundić, L., Cloetingh, S., 2013. The isolation of the Pannonian basin (Central Paratethis. New constraint from magnetostratigraphy and biostratigraphy. *Global and Planetary Change* **103**, 99-118.

Motaş, I. C., Papaianopol, I., 1977. Les associations de mollusques index dans le Néogène supérieur du Bassin Dacique. *Rev. Roum. Géol. Géoph. Géogr*. **21**, 79-91.

Olteanu, R.,1971. Studiul ostracodelor din depozitele pannoniene superioare (zona E) de la Groşi (Banat). *Dări Seamă Inst. Geol*. **LVII**, 85-101.

Olteanu,R.,1979. Signification biostratigraphique des Ostracodes Méotiens et Pontiens du Bassin Dacique. *Rev. Roum. Géol. Géophys. Géogr*. **24**, 229-236.

Olteanu, R.,1989. The ‚Câmpia Moment" (Late Miocene Romania) and the Pannonian/Pontian boundary, defined by Ostracods. *Jour. Micropaleont*. **8**/*2*, 239-247.

Olteanu,R.,1999. The Loxoconca genus (Ostracoda, Crustacea) within Paratethis areas. *Memoriile Inst. Geol. României* **37**, 17-90.

Olteanu, R., 2003. A fi sau a nu fi sau dilema Pannonianului. *Studii cerc. geol.* **48**, 99-120.

Panã, I.,1962. Contribuţii la cunoaşterea moluştelor de talie mică din depozitele pliocene. *Annal. Univ. Bucureşti, Seria geol. geogr*. **XI**, 20-34.

Panã, I.,1969 .„Congerii din grupa mytiliforme întâlnite în depozitele meoţiene de la curbura estică a Carpaţilor. *Bul. soc. şt. geol.din R. S. România* **XI**, 327-335.

Panã, I.,1972. Rolul biostratigrafic al congeriilor în depozitele pliocene din Bazinul Dacic. *Dări Seamă Inst. Geol., Stratigr*., **LVIII**/*4*, 223-233.

Papaianopol, I., 1976. Faciesurile şi limitele Portaferrianului din zona cutelor diapire externe dintre valea Cricovul sărat şi valea Unghiului (Judeţul Prahova). *Dări Seamă Inst. Geol*. **LXII**/*4*, 245-263.

Papaianopol, I., Popescu, A., Olteanu, R., Ţicleanu, N., Roman, Şt., Hanganu, E., Panã, I. Sagatovici, A., Todiriţă, V., 1984. Atlasul paleontologic al României (Pannonian s. str.= Malvensian. Arhiva Inst. Geol. (unpublished) 145 p.

Papaianopol, I., Popescu, A., Sagatovici, Al.,1985. Studii în vederea atlasului paleontologic din România. Ponţianul I. Macrofauna. Arhiva Inst. Geol. Geofiz. (unpublished) 101 pp.

Papaianopol, I., Grigoraş, M., Popescu, A., Olteanu, R., Rogge, E., Iva, M., Costea, C., Păslaru, T., Munteanu E., 1987. L'étude du Néogène Supérieur de la partie orientale de la Plate-Forme Moesienne (secteur d'entre la vallée du Neajlov et le Danube) à considération sur le complexe houiller. *Dări de seamă. Institutul de Geologie şi Geofizică*. Bucureşti. **72-73** (*4*) : 209 - 260

Papp , A., 1951. Das Pannon des Wiener Beckens. Mitt. Geol. Gesel.133-223.

Paucă, M.,1935a. Le bassin néogène de Beiuş. *Anuarul Inst.geol*. **XVII**, 133-223.

Paucă, M.,1935b. Die vorpontische Erosion am Ostrand der pannonischen Senke. *Bul. Soc. Rom. Geol*. **II**, 49-55.

Sagatovici, A.,1968. Studiul geologic al părţii de vest şi centrale a bazinului Oaş. *Stud. tehn.şi econ*. Stratigrafie, Seria **J**/*5*, 8-146.

Stevanovič, P. M.,1951. Pontische Stufe inb engeren Sinne-Obere Congerienschichten Serbiens und der angrenzenden Gebiete. Serb. Akad. Wiss. Sonderausg. 187pp.

Stoica, M., Lazăr, I., Vasiliev, I., Krijgsman, W., 2007. Mollusk assemblages of the Topolog-Argeş area (southern Carpathian foredeep, Romania). *Geobios* **40**, 391-405.

Stoica, M., Lazăr, I., Krigsman, W., Vasiliev, I., Jipa, D., Floroiu, A. 2012. Paleoenvironmental evolution of the East Carpathian foredeep during the late Miocene-early Pliocene (Dacian Basin; Romania). *Global and Planetary Change* **103**, 135-148.

Vancea, A. (1960). Neogenul: din Bazinul Transilvaniei. A.R.S. România (Ed.). Editura Academiei Republicii Populare Romîne.