Numeric age of the Sarmatian boundaries (Seuss 1866)

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Abstract: The revision of the numeric age of the chronostratigraphic Sarmatian boundaries (Seuss 1866) according to the proposal of Kokay et al. (1991), Oszczypko (1997, 1998) and to the implications from the work of Gaždzicka (1994) is premature. The magnetostratigraphic interpretation of the Sarmatian/Pannonian boundary, which served to Kokay et al. (1991) as a base for the lowering of the boundary to 12.3 Ma, is not unambiguous. The chosen borehole in the part, where the contact between the Sarmatian and Pannonian is recorded, is not applicable for that purpose. There are not unambiguous reasons to get younger the numeric age of the Sarmatian/Badenian boundary from 13.6 Ma to 13.0 Ma or to 11.8 Ma. The biostratigraphic data yielded from the Polish Carpathian Foredeep are not convincing. The younger age is not consistent with numerous radiometric ages of biostratigraphicaly well dated volcanic rocks and it also is not supported by magnetostratigraphy.

Key words: Parathetys, Sarmatian, radiometric age, magnetostratigraphy, chronostratigraphy, biostratigraphy

Introduction

The Sarmatian is chronostratigraphic stage of the Paratethys Miocene. Its time range is different in the Central and Eastern Paratethys. It is because it was defined by curious way and by two authors – Suess in the Cetral Paratethys (in the Viena Basin, the stratotype profile was in the Viena city part Hernals, the lectostratotype is in Nexing NE of Viena) and Barbot de Marny in the eastern Paratethys. Both definitions were published by Suess (1866). Today it is widely known that the Sarmatian according to Barbot de Marny has larger time range and it also includes the sediments originated later than the youngest Sarmatian sediments sensu Seuss. Biofacial evolution of the Sarmatian in the central and eastern Paratethys provided its more detail division, and, what is more worthy, it also provided mutual correlation. Generally the biostratigraphic correlation is accepted according to which the Sarmatian sensu Suess correlates with the Volhynian and Early Bessarabian i.e. with the older part of the Sarmatian sensu Barbot de Marny (Steininger et al., 1985). This stratigraphic correlation was also confirmed by radiometric ages of volcanic rocks interfingering the Sarmatian deposits in both parts of the Paratethys (Vass et al. 1987, Chumakov et al. 1992 and somewhere else).

Based on the radiometric dating of neovolcanics, the Sarmatian sensu Suess (1866) was numerically calibrated as follows: the base 13.6+-0.2 and the top 11.5 +-0.5 Ma (Vass et al. 1987). According to the calibration the Sarmatian stage lasted around 2 Ma. In the last years several correlation schemes of the Paratethys Miocene were published where the authors presented the Sarmatian as a stage with essentially shorter duration. Some of them shift its top downward and the others rise its base. It results in an absurd situation when Kokay et al. (1991) suggested numeric age 12.3 Ma for the top et Sarmatian and Oszczypko (1998) calibrates the Sarmatian base to some 11.8 Ma (Fig. 1).

Critical analysis of the reasons for the change of numeric calibration of the Pannonian/Sarmatian boundary

The tendency of decreasing the numeric age of the Sarmatian or the Pannonian/Sarmatian boundary commences with the cited work of Kokay et al. (1991). The result was, besides something else, redefinition of the numeric age of the Pannonian/Sarmatian boundary and its shifting from 11.5+-0.5 Ma to 12.3 Ma. The redefinition found a response in other Hungarian authors (i.e. Hámor 1995 in Czászár ed. 1997).

Kokay et al. (1991) analysed lithostratigraphy, biostratigraphy and magnetostratigraphy of sediments from the borehole Berhida 3 (Bh-3). The borehole was drilled in the southern part of the Várpalota brown coal Basin on the northern margin of the Bakony Mts., south of the town Várpalota. In the borehole the Pannonian/Sarmatian boundary was determined immediately beneath the 5 cm thick layer of dacite redeposited tuff having the radiometric age 12.6+-0.5 Ma, but the authors suggested slightly younger numeric age of the boundary. This only one radiometric age became a reference datum for numeric dating of the Pannonian/Sarmatian boundary for several Hungarian authors. In fact, the numeric date is also supported by local bio- and lithostratigraphy as well as by correlation of magnetic measurements of the borehole core with magnetostratigraphic scale (Berggren et al. 1985).

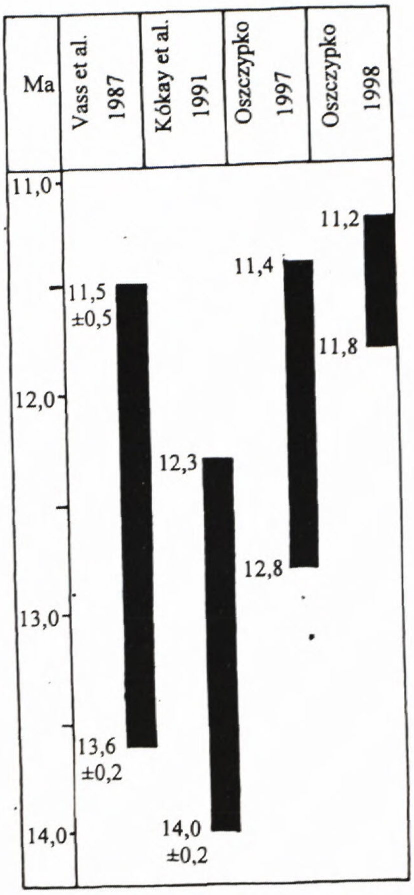

Fig. 1: Numeric age of Sarmatian stage according to Vass et al. (1987), Kokay et al. (1991) and Oszczypko (1997, 1998). The tendency to shortening of the Sarmatian time interval is evident.

It is possible to rise several substantial objections against the redefinition of the numeric age of the Pannonian/Sarmatian boundary based on the basis of the data obtained from the borehole Bh-3.

1) The thickness of the Sarmatian and Pannonian deposits in the borehole Bh-3 is very small. The Sarmatian, represented by three formations (Gyulafirátot, Kazárd and Tinnye), is thick only 138.4 m and it only represents a fragment of total thickness of the Sarmatian Stretava and Ptrukša Formations in the East-Slovakian Basin (3240 m; Král et al. 1990, Rudinec 1978, Vass et al. in lit.). In the Viena Basin, where the Sarmatian was described by Suess, the maximum thickness of its deposits is 1 000 m (Jiříček & Seifert 1990). Also in the Danube Basin is the thickness of the Sarmatian Vráble Formation two- to threefolds greater than in the borehole Bh-3. For example, in the borehole Iványka-1 is the Sarmatian thick about 420 m and some authors assume that the borehole only penetrated the Early Sarmatian (Čermák 1972, fide Biela 1978).

Similarly the Pannonian, representing in the Hungarian chronostratigraphic terminology the Early Pannonian or Peremárton Group, is only thick some 70 m (69.4 m), while the Pannonian in other parts of the Hungary attains the thickness several thousands of meters (e.g. in the Zala Basin about 1680 m, W of Tisza river 2850 m, in the Makó Basin 2940 m; Nagymarosi 1981).

From the above mentioned it is possible to imply that the Sarmatian and Pannonian deposits in the borehole Bh-3 are very condensed and most likely they represent uncontinuous profiles shortened by disconformities or by faults.

2) Particularly the lithologic profile of the formation from Ös, comprising the lower part of the Pannonian in the borehole Bh-3, suggests an interpretation of the formation as chronologicaly uncontinuous sedimentary succession, interrupted by periods without sedimentation. The formation from Ös originated in a shallow lagune. The interruption of the deposition resulting from repeating dessication of the lagune is proved by alternation of grayish-green and yellowish-red pelites (oxidation Fe^{2+} to Fe^{3+}), dessication cracks and anhydrite crystals (Kókay et al. 1991).

3) Radiometricaly dated dacite tuff was also by Kokay et al. (l.c.) assigned to the Pannonian because they assume it to be equivalent of the dacite tuff lying in other profiles of the SW foothill of the Bakony Mts. on the Pannonian deposits as stated by Jámbor (1988, fide Kokay et al.). The correlation may be, but does not have to be, right. There is many manifestations of acid explosive volcanism in the form of rhyolite, rhyodacite or dacite tuffs and intercalations of glassy volcanic ash in the Sarmatian of the central and also of the eastern Paratethys. The redeposited tuff from the borehole Bh-3, which radiometric age is 12.0+-0.5 Ma may be equivalent of some Sarmatian tuff.

4) The mollusc assemblage occurring in the immediately underlying sediments of the redeposited tuff, which is interpreted belonging to the Sarmatian – Pannonian transition, consists of small, closely ribed, poorly preserved Cardium, small forms of *Modiolus incrassatus*; foraminifera assemblage is composed of numerous specimen of the species *Rotalia beccarii*. The assemblage does not need to indicate the Sarmatian – Pannonian transition as it is assumed by Kokay et al. (l.c.). It may represent an assemblage of shoreface, lower salinity, shallow-water facies of the Sarmatian.

5) Correlation of magnetic measurements with magnetostratigraphic scale may have more variants. One of them is correlation of two normal events measured in the borehole Bh-3 in the depth around 180 – 190 m with the upper part of chron C5r (events C5r 1n and C5r 2n; Berggren et al. 1995). The chron C5An, to which the events of normal polarization were correlated by Lantos in Kokay et al. (1991), is probably absent (Fig. 2).

6) For the proposal of modification or change of radiometric time scale it is unconditionaly necessary to substantiate the correction by more data, the best yielded by more laboratories. It is impervious to base this corrections only on one dating which questions the time scale based on numerous matching data.

Critical evaluation of new opinion on numerical age of the Sarmatian/Badenian boundary

As it already was indicated, several authors get younger the numerical age of the Sarmatian/Badenian boundary. I hold the following critical attitude to their opinions:

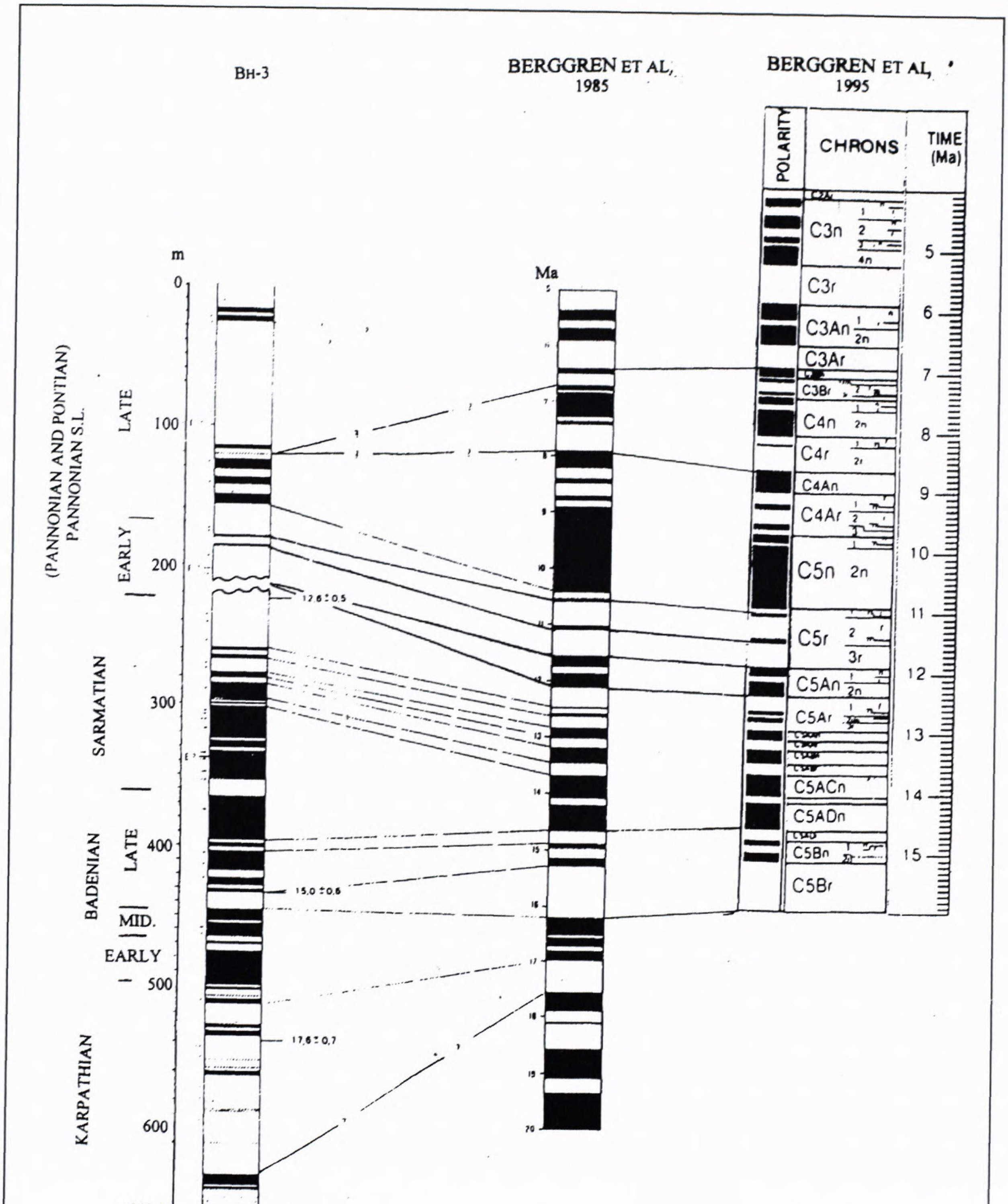

Fig. 2: Scheme showing the tentative correlation of the author of this paper. Two normal events found in the borehole Berhida – 3 (Bh-3) in the depth 180-190 m are corelated with two normal events in the upper part of the chron C5r (events C5r1n and C5r2n). Chron C5An with two normal events in the borehole Bh-3 is missing because of the hiatus.

1) Gaždzicka (1994) found in the Machov Formation – the Polish Foredeep- assemblage of calcareous nanoflora with *Discoaster calcaris* in sediments overlying evaporites (equivalent of the Wieliczka Formation). The first occurrence of this assemblage is in the zone NN 8. *Discoaster kugleri*, the leading form of the zone NN 7, does not occur in the assemblage. Based on this she deduced that the deposits above the evaporites are younger

as zone NN 7 and they may be assigned to the zone NN 8 and partly also to the zone NN 9. According to Gaždzicka the NN8/NN7 zone boundary occurs either above the evaporites (as she depicted in the Fig. 4) or within it, or beneath the evaporites (in the Figs. 2 and 3). The numeric age of the NN 8/NN 7 is represented on the time scale of Berggren et al. (1995) in two variants: 11.5 Ma or 10.8 Ma. The Sarmatian base in the Polish Foredeep, which occurs within the Machov Formation between brackish Krakowiec Bed (the Sarmatian) and marine Pecten Bed (the Late Badenian) should be according to Graždzicka younger than 11.5 Ma or 10.8 Ma. It seems, that Oszczypko (1997) considered the younger age of the Sarmatian base as not possible and therefore he also assigned evaporitic formation (Wieliczka) to the Sarmatian and he defined the Sarmatian base on the level around 12.8 Ma. A drawback of this correlation is fact, that the deposits of the halite associated with the evaporitic formation, should originate in saline lagunes of low-salinity sea providing they are of the Sarmatian age. The low-salinity environment is indicated by fauna occurring in the Sarmatian deposits everywhere in the Paratethys, suggesting brackish or even lower-salinity environment. The origin of halite deposits in brackish sea is unprobable and maybe from that reason Oszczypko (1998) later modified his stratigraphic correlation. He correlated the evaporitic formation from Wieliczka and Pecten marine beds with the Late Badenian and numeric age of the Sarmatian/Badenian boundary shifted higher on the level around 11.8 Ma. He defined the Pannonian/Sarmatian boundary on the level 11.2 Ma. Other authors in the last works i.e. Rogl (1996, 1998) Rogl, Krhovský & Hamršmíd (1997) define the Sarmatian base on the level 13 Ma.

2) Numeric age of the Sarmatian 11.2 – 11.8 Ma i.e. 0.6 Ma as suggested by Oszczypko (1998) is not realistic considering the thickness of the Sarmatian deposits, for example in the East-Slovakian Basin. The entire thickness of the Sarmatian is 3240 m and the thickness of Early Sarmatian deposits (zone of large Elphidia or zone with *Elphidium reginum*) is 2410 + 1/3 after decompaction. Totally it comprises 3 213 m. If the Early Sarmatian represents the half of the time of the entire Sarmatian sensu Oszczypko, i.e. 0.3 Ma, then the sedimentation rate in the East-Slovakian Basin at that time should be 10 710 m Ma^{-1}. Even the higher sedimentation rate should be in the East-Slovakian Basin if we accepted conclusions of Gaždzicka (1994), suggesting that the the Early Sarmatian is only a part of the zone NN 8. The maximum mean sedimentation rate in the epicontinental seas is only 500 m Ma^{-1} and in big ocean bays 383 m Ma^{-1} (Gulf of Texas). The sedimentation rate only increases to 70 000 m Ma^{-1} in large rivers (Volga) but these rates are measured on modern deposits and in deltas with big catchment area. The sedimentation rate calculated from the sediment column originated in longer period is essentially lower (all data on sedimentation rate are gathered by Kukal, 1964).

3) Against the tendencies suggesting shifting the lower boundary of the Sarmatian upward are up to now unquestioned radiometric ages of the Sarmatian volcanic rocks. The numeric calibration of the Sarmatian (sensu Suess 1866) in the last radiometric scale of the Paratethys Neogene (Vass et al. 1987) is supported by 47 ages of volcanic rocks from the central, but also from the eastern Paratethys. Their Sarmatian age is reliably proved by biostratigraphic data. From these analyses, 26 ages document radiometric age of the Early Sarmatian in range 12.2 – 14.2 Ma. It is also possible to include among these ages the three later datings of volcanic glass from the base and one dating from the top of the Volhynian from two localities on the river Dnester and another two datings from the Kerch Pennninsula (Chumakov et al. 1992). The radiometric ages were performed by K-Ar and F.T. methods in several laboratories (Pisa, Italy; Campinas, Brasil; Jerevan, Armenia; Vladivostok, Russia; Bratislava, Slovakia; Debrecen, Hungary). Based on these ages the Sarmatian/Badenian boundary was assigned the numeric age 13.6 ± 0.2 Ma (Vass et al. 1987) or 13.5–14 Ma (Chumakov et al. 1992).

4) The substantiation of the calibration is supported by magnetostratigraphy from the borehole Berhida-3. Above we questioned correctness of the paleomagnetic measurement interpretations of the Pannonian/Sarmatian boundary from the borehole. However, we did not find a reason to object the measurement correctness on the Sarmatian/Badenian boundary. The magnetostratigraphic measurements imply (Fig. 2) the Sarmatian/Badenian boundary in time interval of chrons C5ACn and C5ADn i.e. between 13.65 and 14.6 Ma (compare Kokay et al. 1991 and Berggren et al. 1995).

Discussion to numeric calibration of the Sarmatian/ Badenian boundary

Biostratigraphic data of Gaždzicka (1994) concerning the Late Badenian and Sarmatian of the Foredeep in the Poland are based on the correlation of the identified calcareous nanoplankton assemblages with the standard zones of Martini (1971). The correlation with the zone NN 8 is not done on the base of index form *Catinaster coalitus* which does not occur in the assemblages identified by Gaždzicka. It was done on the base of the species *Discoaster calcaris*, which datum of the first occurrence (FAD) is in the zone NN 8. Considering the uncertainty around the numeric calibration of the zone NN 8 (Berggren et al. 1995), very short duration of the zone (Fig. 3) and basic contradictions with actual chronostratigraphic and numeric scales, one can suspect if the FAD of *Discoaster calcaris* should be not shifted down in the time scale or if just the Carpathian Foredeep is not one of the places where this species occurred much earlier than in tropic or subtropic zones of the Pacific or India ocean. The absence of the index species of the zone NN 7 *Discoaster kugleri*, except for one specimen as referred by Gaždzicka, may reflect unfavourable conditions for flourishing of marine calcareous nanoflora (brackish Sarmatian sea) resulting in the absence of the species *D. kugleri*.

On the other hand it is not possible to omit the discrepancy in radiometric data. The radiometric ages of

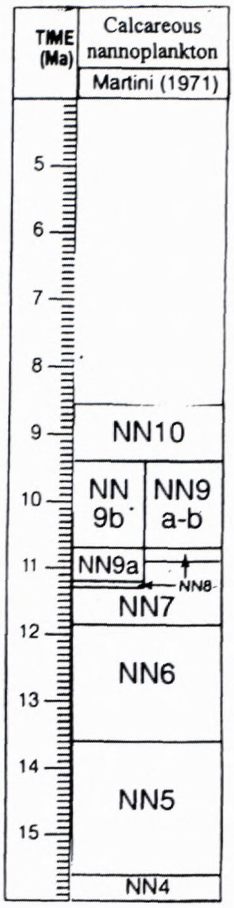

Fig. 3: Zones of the calcareous nannoplankton of the Middle and the early Late Miocene according to Martini (1971), numerically calibrated by Berggren et al. (1995). See the extremly short time interval of the zone NN8 as well as uncerteinly of its stratigraphic position.

redeposited tuffs in the Polish Foredeep, particularly the redeposited tuff from the uppermost part of the Skawina Formation (underlying evaporites from Wieliczka) 12.5 Ma (Banas & Bukowski 1997 fide Oszczypko 1997) and redeposited tuff from Chodenice Bed (overlying evaporites and underlying Krakow Bed, i.e. Sarmatian) around 12 Ma (Van Couvering 1981) are much younger than they should be according to the stratigraphic position and radiometric scale of the Neogene. However, it is necessary to add that redeposited tuff is the most unsuitable material for radiometric dating.

Conclusion

Revision of numeric age of the Sarmatian chronostratigraphic stage (Suess 1866) as suggested by Kokay et al. (1991), Oszczypko (1997, 1998) and as it is implied from the work of Gaždzicka (1994) is premature. Magnetostratigraphic interpretation of the Pannonian/ Sarmatian boundary, served as a base for Kokay et al. (1991) for proposal of the lowering of boundary age to 12.3 Ma, is not unambiguous. The chosen borehole in the part where the contact between the Sarmatian and Panonian is recorded, is not suitable for this purpose.

Biostratigraphic data from the Polish side of the Carpathian Foredeep are generally poor and unsuficient to introduce literally a revolutionary change of chronostratigraphy and numeric scale of the Neogene.

Radiometric ages, served as a base for the construction of the Neogene numeric time scale, are partly compromised by radiometric data from the Polish Carpathian Foredeep and they would totally compromised by biostratigraphy of the foredeep after cross correlation with the time scale of the Middle and Late Miocene constructed by Berggren et al. (1995). Radiometric dating of redeposited tuffs from the Carpathian Foredeep is not reliable according to the quality of the rocks dated. Also it is possible to doubt about the biostratigraphic correlation of the Middle Miocene in this area.

Because the statement against statement without new convincing evidence is unfruitful discussion, it will be very desirable to repeat or to do new radiometric dating of the Sarmatian volcanics by the technique of the 3rd millenium and also to continue in biostratigraphic and ecostratigraphic studies reaching by this way a new or more detail numeric calibration of the Sarmatian chronostratigraphic stage boundaries. Magnetostratigraphy applied to continuous profiles and profiles without hiatuses in the Sarmatian deposits would also be very helpful.

References

Berggren,W.A., Kent, D.V., Aubry,M.-P. & Hardenbol, J. (eds.), 1995: Geochronology, time scales and global stratigraphic correlation SEPM Spec. publ. 54, Tulsa, 1-386.

Berggren,W.A., Kent, D.V., Flynn, J.J. & von Couvering, J.A., 1985: Cenozoic geochronology. Geol. Soc.Am. Bull. 96/11, 1407-1418.

Biela, A., 1978: Hlboké vrty v zakrytých oblastiach vnútorných Západných Karpát. Záhorská nížina, Podunajská nížina. Regionálna geológia 10, Geol. Ústav D. Štúra, Bratislava, 1-224.

Chumakov, I.S., Byzova, S.L. & Ganzey, S.S., 1992: Geochronologia i korreljacia pozdnego kajnozoja Paratetisa. Nauka, Moskva, 1-96.

Császár, G. (edit.) et al., 1997: Basic litostratigraphic units of Hungary. Geol. Inst. of Hungary, Budapest, 1-114.

Gaždzicka, E., 1994: Nannoplankton stratigraphy of the Miocene deposits in Tarnobrzeg area (NE part of the Carpathian Foredeep). Geological Quarterly 38/3, Warszawa, 553-570.

Jiříček, R. & Seifert, P., 1990: Paleogeography of the Neogene in the Vienna Basin and the adjacent part of the foredeep. In: Minaříková, D., Lobitzer, H. (eds.): Thirty years of Geological cooperation between Austria and Czechoslovakia. Stratigraphy and paleogeography Federal Geol. Survey Vienna, Geol. Survey, Prague, 89-104.

Kókay, J., Hámor, T., Lantos, M. & Müller, P., 1991: A Berhida 3. sz. fúrás paleomagneses es földtani vizsgaláta. A Magyar áll. földt. intézete Evi jeleutése áz 1989. évröl, Budapest, 45-63.

Král, M., Pereszlényi, M. & Vass, D., 1990: Vzťah rýchlosti akumulácie sedimentov ku genéze východoslovenskej neogénnej panvy a k ložiskám uhľovodíkov. Konferencie, sympóziá, semináre. 50. rokov výuky geológie..., Geologický ústav D. Štúra, Bratislava, 107-114.

Kukal, Z., 1964: Geologie recentních sedimentů. Naklad. Čs. ak. věd, Praha, 1-441.

Martini, E., 1971: Standard Tertiary and Quaternary calcareous nannoplankton zonation. In: Farinacci,A. (edit.): Proceedings of the Second Planktonic Conference, Roma 1970, Tecnoscienza, 739-785.

Nagymarosy, A., 1981: Subsidence profiles of the deep Neogene basins in Hungary. Earth Evolution Sciences 3-4, 218-224.

Oszczypko, N., 1997: The Early-Middle Miocene Carpathian peripheral foreland basin (W.Carpathians, Poland). Przeglad geologiczny 45/10-2, Warszawa, 1054-1063.

Oszczypko, N., 1998: The Western Carpathian foredeep-development of the foreland basin in front of the accretivnary wedge and its

Slovak Geol. Mag., 5, 3(1999), 227–232

burial history (Poland). Geologica carpathica 49/6, Bratislava, 415-431.

Rőgl, F., 1996: Stratigraphic correlation of the Paratethys Oligocene and Miocene. Mitt. Ges. Geol. Bergbaustud. Österr. 41, Wien, 65-73.

Rőgl, F., 1998: Paleogegraphic considerations for Mediterranean and Paratethys seaways (Oligocene to Miocene). Ann. Naturhist. Mus. Wien, 99A, Wien, 279-310.

Rőgl, F., Krhovský, J. & Hamršmid, 1997: Neue Beiträge zum Oligozän von Ottenhal der Waschbergzone, Niederősterreich. In: Hofmann,T. (edit.): Das Land um Laa an der Thaya, Excursionführer Nr.17, Österr. geol. Gesellschaft, Wien, 83-96.

Rudinec, R., 1978: Paleogegraphical, lithological and tectogenetic development of the Neogene in Eastern Slovakia and relation to volcanism and deep tectonics. Geol. Zbor. Geol. Carpathica 29/2, Bratislava, 225-240.

Seuss, E., 1866: Untersuchungen über den Character der österreichischen Tertiarablaage-rungen. II. Über den Character der brackischen Stufe oder der Cerithienschichten. Sitzber. Österr. Akad. Wiss. math.–naturwiss. Kl, 54, Wien, 218-357.

Steininger, F. F., Seneš, J., Kleeman, K. & Rögl, F. (eds.), 1985: Neogene of the Mediterranean Tethys and Paratethys, University of Vienna, vol. 1-2, Wien1-189, 1-536.

Van Couvering, J., A., Aubry, M.P., Berggren, W.A., Buják, J.P., Neasen, C.W. & Weiser, T., 1981: Terminal Eocene event and the Polish connections. Palaeogeogr. Palaeoclimatol. Palaeoecol. 36, 321-362.

Vass, D., Elečko, M., Janočko, J., Karoli, S., Pereszlényi, M., Slávik, M. & Kaličiak, M., in lit.: Paleogeographic reconstruction of the East-Slovakian Neogene Basin and tectonic background of the paleogeographic evolution. Geologica Carpathica.

Vass, D., Repčok, J., Balogh, K. & Halmai, J., 1987: Revised radiometric time-scale for the Central Paratethys Neogene. Ann. Inst. Geol.Publ. Hung. Proceedings of the VIIth RCMNS Congress, 70 Budapest, 423-434.