Slovak Geol. Mag., 6, 2-3(2000), 95–100

Paleoecology and eustasy: Miocene 3rd order cycles of relative sea-level changes in the Western Carpathian - North Pannonian basins

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Abstract: Miocene 3rd order relative sea level cycles were defined in the Western Carpathian, Vienna, Danube, South Slovakian-North Hungarian (Pétervására & Novohrad) and the East Slovakian – Transcarpathian basins. They are marked by symbols from CPC1 to CPC6. Furthermore, correlation of the CPC 3rd order sea level changes with the global TB2.1 to TB2.6 sea level changes (sensu Haq et al. 1988, Haq 1991) was carried out and the results document the high portion of the tectonic influence on the basin development during the collisional orogene evolution.

Key words: Miocene, Central Paratethys, biostratigraphy, paleoecology, sequence stratigraphy

Introduction

Neogene paleogeography of the Western Carpathian - North Pannonian region (Fig. 1), as a combination of aquatic and continental environments, was influenced besides the geodynamic factors also by the regional manifestations of global sea-level changes (sensu Haq et al. 1988, Haq 1991, Hardenbol et al.1998).

Interaction of sea-level changes and tectonics had an important influence on the paleogeography and thereby also on the paleoenvironment of the Western Carpathian - North Pannonian basins, which formed the northern bays of the Central Paratethys epicontinental sea in the Miocene. The depth and the shape of the basins were predominantly controlled by the main tectonic events. Relative eustatic changes reflected in coastal onlaps were followed mostly by the rise of water paleodepth in the offshore environment. The correlation of the constructed curves for the coastal onlap and estimated paleodepth with the global reference curves (Haq et al. 1988, Haq 1991) shows some discrepancies, predominantly caused by tectonics during the basin development.

The correlation of the 3rd order relative sea-level cycles in the respective time intervals was enabled by new bio- and chronostratigraphic data. The proper determination of depositional systems tracts was carried out by means of geophysical methods and sedimentology, but also the study of relative sea-level cycles based on paleoecology played an important role (Kováč & Hudáčková 1997, Kováč & Zlinská 1998, Kováč et al. 1999). Simultaneously, the principal rule of the sequence stratigraphy was taken into account that the reflection of a sea-level changes can be strengthened, weakened or it may faint completely, in dependence on the value of tectonic subsidence and the rate of sediment input (Brown & Fischer1977, Vail et al. 1984, Posamentier et al. 1988, Van Steen & Winkler1988). Therefore the study of the relative sea-level cycles manifestations in the Western Carpathian - North Pannonian basins (Fig. 2) took into consideration besides the global sea-level changes (Haq et al. 1988, Haq 1991) also the data about the tectonic subsidence and detrital input rates proved by analysis of the subsidence history (Lankreijeret al. 1995, Baráth et al. 1997, Lankreijer1998).

In the following those relative 3rd order sea-level cycles will be described that can be traced by means of paleoecology in the Western Carpathian - North Pannonian region during the Miocen. These cycles of the relative sea-level changes are marked by symbols from **CPC 1 to CPC 6 (3rd order relative sea-level cycles in the Carpathian-Pannonian region).** Hence, the correlation of global sea-level changes with regional relative sea-level cycles in the studied region is very difficult due to its dramatic geodynamic evolution and sometimes also due to lack of relevant chronostratigraphic data.

Results

The relative sea-level changes in the Western Carpathian - North Pannonian basins, as can be deduced from the previous text, have been considerably shaped apart from eustacy, also by local tectonic events and thus they are neither always identical with the global cycles defined by Haq et al. (1988) and Haq (1991), nor with each others, found in different basins of the region. On the other hand, we were able to date many biostratigraphically and paleoecologically important paleogeographic events in the Western Carpathian - North Pannonian region, as well

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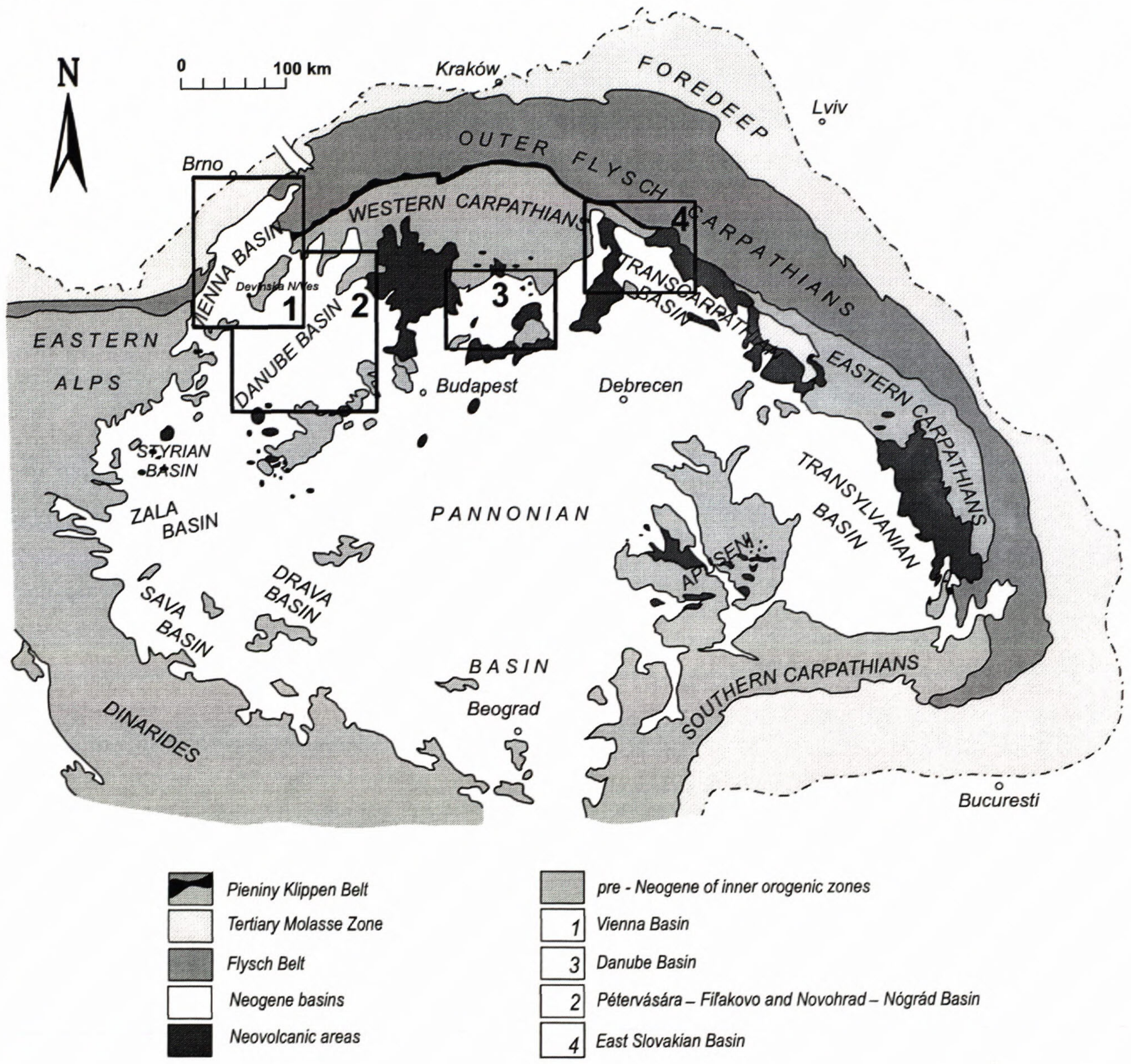


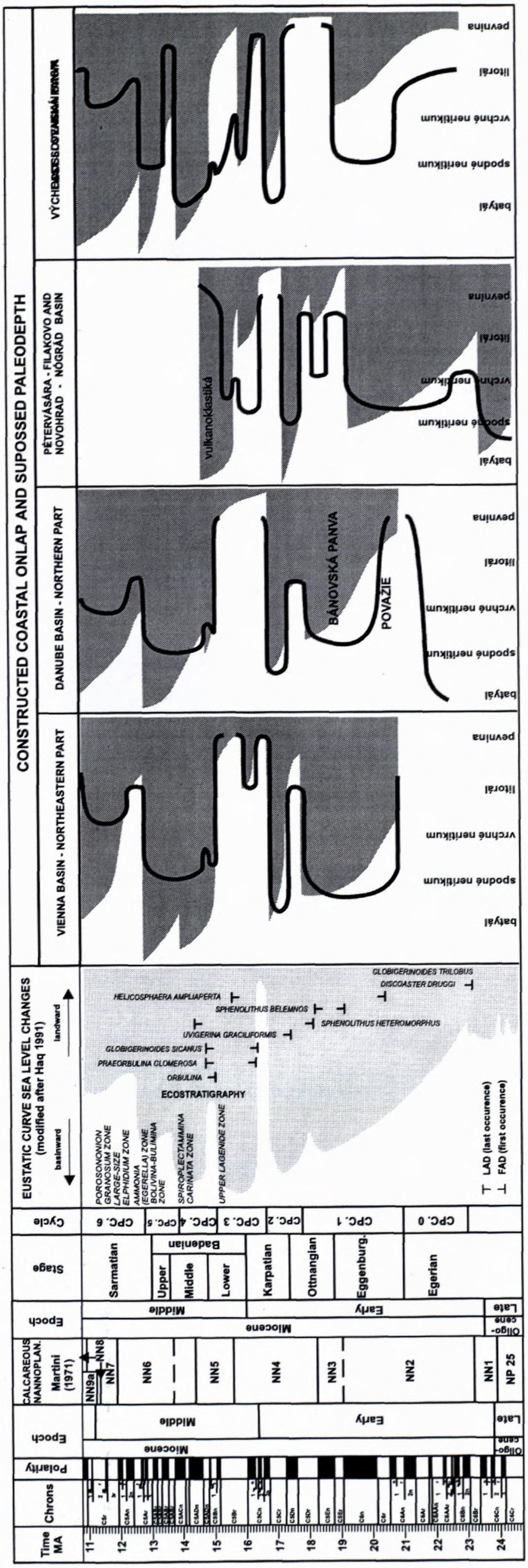
Fig. 1

as to correlate them with the events in the Central Paratethys and the Mediterranean area (Fig 3).

The Late Egerian – Early Eggenburgian SMST or LST in the Western Carpathian - North Pannonian area (23.5 - 21? Ma) have been performed by terminal deposition of the Biely potok Formation in the forearc Central Carpathian Paleogene basin at the active margin of the Western Carpathians and in the South Slovakian – North Hungarian (Pétervásara) Basin in the Western Carpathians hinterland by deposition of the Opatová beds deltaic sequences overlying the "Szészényi Schlier beds" of the Lučenec Formation.

The Eggenburgian transgression in the Western Carpathian - North Pannonian area is manifested by the sequence boundary of the SB1 type in **the Vienna Basin, the Bánovce Depression, in the Váh River Valley, the South Slovakian – North Hungarian (Pétervására) and the East Slovakian Basins.** Littoral sediments are characterized by occurrence of large pectinids and calcareous nannoplankton of the NN 2 zone (sensu Martini 1971). The sediments deposited in neritic zone (somewhat later) contain also *Helicosphaera ampliaperta* (BRAMLETTE ET WILCOXON) BUKRY in nannoflora assemblages (FAD 20.5 Ma, sensu Berggren et al. 1995).

In the South Slovakian – North Hungarian (Pétervásara) Basin the Eggenburgian transgression is followed by HST deposits of the Čakanovce beds of the Fiľakovo Formation (upper part of the Szészényi Schlier Formation in Hungary) covered by the terrestric Bukovinka Formation, Eggenburgian in age (Zagyvapálfa Formation in Hungary). Above mentioned deposits together with the Late Egerian sediments (SMST) form a **relative sea-level cycle (CPC 1a)** similar to cycle of the **East Slovakian Basin**, where the **Egerian – Early Eggenburgian LST** represents the Biely potok Formation and the **Eggenburgian TST and HST** is represented by the



Prešov Formation and the transgressive-regressive Čelovce beds in the terminal part.

In the **Danube Basin** southern part (Transdanubian range resp.) the **Ottnangian relative sea-level cycle (CPC 1b)** started by marine transgression in the Bántapusta region, in the South Slovakian – North Hungarian (Novohrad) Basin (Fig 6) is represented by lower coal bearing beds deposited in the alluvial plain environment and upper limnic to marine beds (TST, HST).

In the **East Slovakian Basin** the Ottnangian deposits are missing (uplift due to tectonic activity).

In the Vienna Basin, the Váh river valley and the Bánovce Depression (Fig. 7, 8) the large scale Eggenburgian transgression was followed by a deepening of the sedimentary environment and the end of the cycle is represented by the shallow-water, brackish sediments of the Ottnangian age. **The Eggenburgian to Ottnangian relative sea-level cycle (CPC 1)** in the Vienna Basin can be compared with the TB 2.1 global cycle (21 - 17.5 Ma, mfs 18.5 Ma, sensu Haq et al. 1988, Haq 1991).

The latest Ottnangian to Karpatian relative sea-level cycle in the Western Carpathian - North Pannonian area - CPC 2, which is correlated with the TB 2.2 cycle of the global sea-level changes (17.5 - 16.5 Ma, mfs 17 Ma, sensu Haq et al. 1988, Haq 1991), is demonstrated by an increased intensity due to the synrift stage of the intra-Carpathian basins evolution, with high portion of tectonic subsidence **in the Vienna, Danube, South Slovakian – North Hungarian (Novohrad) and the East Slovakian Basins** (Lankreijeret al. 1995, Baráth et al. 1997, Lankreijer1998). The sequence boundary of the SB 1 type is covered by transgressive deposits of the latest Ottnangian or early Karpatian age. The end of the cycle is represented by erosional surfaces or by the Karpatian evaporites in the East Slovakian Basin, both transgresively overlain by the latest Karpatian to Early Badenian mostly deltaic strata.

The latest Karpatian to Early Badenian CPC 3 relative sea-level cycle in the Western Carpathian - North Pannonian area, which is correlated with the TB 2.3 cycle of the relative sea-level changes (16.5 - 15.5 Ma, mfs 16 Ma, sensu Haq et al. 1988, Haq 1991) started with a sharp boundary of the SB 1 type, documented by an angular unconformity between the Lower and the Middle Miocene sediments in most of the Western Carpathian basins. The CPC 3 cycle is however hardly determinable for

Fig. 2 Relations among Western Carpathian Neogene chrono and biostratigraphic classifications, cycles of the sea level changes (3rd order), paleontological events as well as the global eustatic curve and onlap curve (Haq 1991) correlation with constructed onlap and paleodepths curves in the Vienna, Donau, South Slovakian-North Hungarian and Eastern Slovakian Basins.

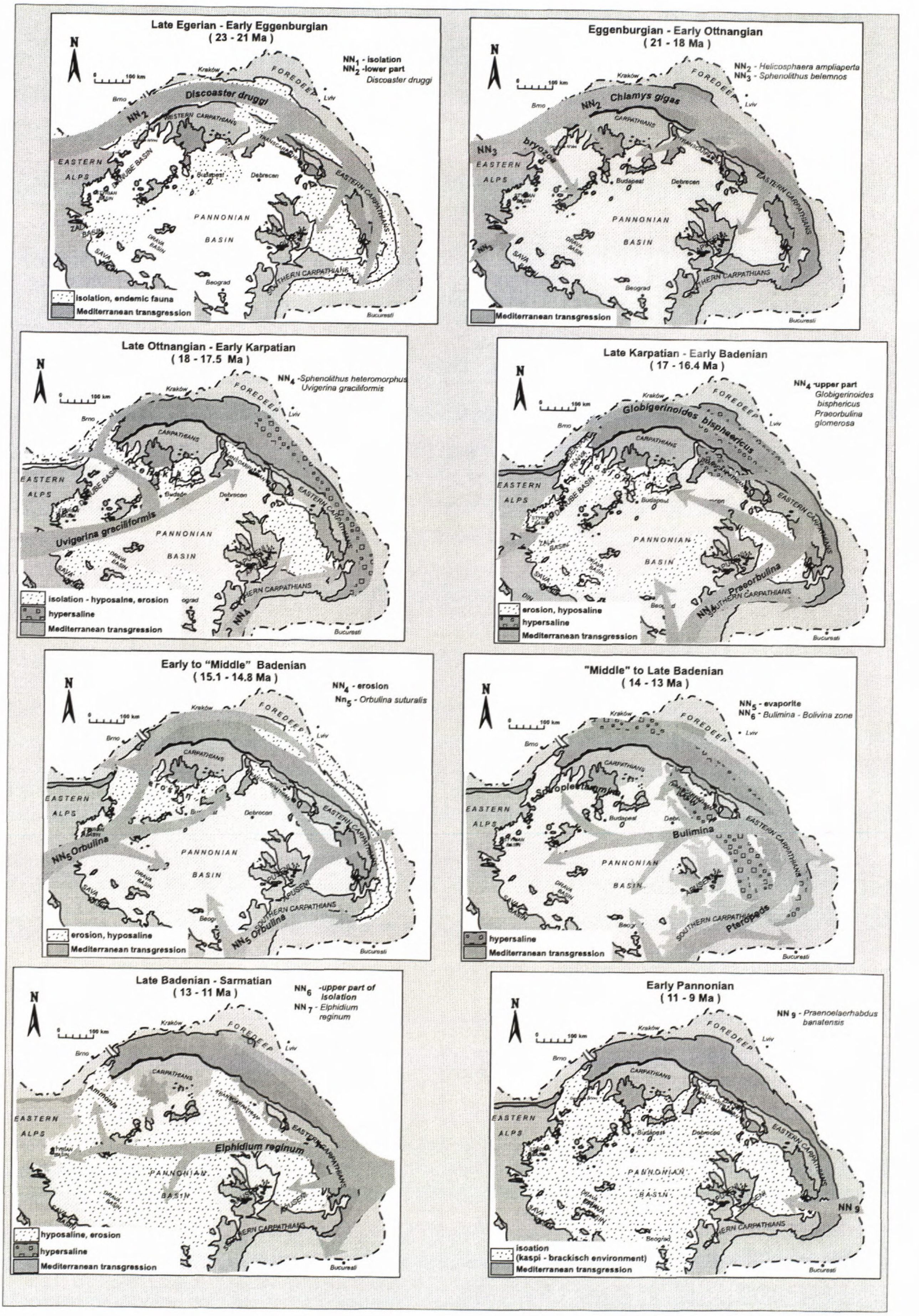

Late Egerian - Early Eggenburgian
(23 - 21 Ma)
NN1 - isolation
NN2 -lower part
Discoaster druggi
Discoaster druggi
isolation, endemic fauna
Mediterranean transgression
Eggenburgian - Early Ottnangian
(21 - 18 Ma)
NN2 - Helicosphaera ampliaperta
NN3 - Sphenolithus belemnos
Chlamys gigas
Mediterranean transgression
Late Ottnangian - Early Karpatian
(18 - 17.5 Ma)
NN4 -Sphenolithus heteromorphus
Uvigerina graciliformis
Uvigerina graciliformis
isolation - hyposaline, erosion
hypersaline
Mediterranean transgression
Late Karpatian - Early Badenian
(17 - 16.4 Ma)
NN4 -upper part
Globigerinoides
bisphericus
Praeorbulina
glomerosa
Globigerinoides bisphaericus
Praeorbulina
erosion, hyposaline
hypersaline
Mediterranean transgression
Early to "Middle" Badenian
(15.1 - 14.8 Ma)
NN4 - erosion
Nn5 - Orbulina suturalis
NN5 Orbulina
erosion, hyposaline
Mediterranean transgression
"Middle" to Late Badenian
(14 - 13 Ma)
NN5 - evaporite
NN6 - Bulimina - Bolivina zone
Bulimina
Pteropods
hypersaline
Mediterranean transgression
Late Badenian - Sarmatian
(13 - 11 Ma)
NN6 -upper part of isolation
NN7 - Elphidium reginum
Ammonia
Elphidium reginum
hyposaline, erosion
hypersaline
Mediterranean transgression
Early Pannonian
(11 - 9 Ma)
NN 9 - Praenoelaerhabdus banatensis
isoation
(kaspi - brackisch environment)
Mediterranean transgression
EASTERN ALPS
PANNONIAN BASIN
FOREDEEP
CARPATHIANS
EASTERN CARPATHIANS
SOUTHERN CARPATHIANS
Kraków
Lviv
Brno
Budapest
Debrecen
Beograd
Bucuresti

Fig. 3

an interference between the sea-level fall at the Early/ Middle Miocene boundary and considerable slowing of the subsidence (or uplift) which occurred at that time. The cycle was obviously completely controlled by tectonics acting the whole time of its duration, which disables an accurate correlation of the evolution of individual basins (heterochronous deposits of lowstand and transgression between the late Karpatian and the early Badenian).

In the East Slovakian Basin it is represented by the terrestric late Karpatian swashes in the Kladzany Formation deposits with *Globigerinoides bisphericus* Todd (their upper part resp.) whereas **in the South Slovakian–North Hungarian (Novohrad) Basin** this period is represented by the regressive-transgressive Lower Badenian deposits with the Karpatian redeposited foraminifera and *Praeorbulina* sp..

In the Vienna Basin (Fig. 7) the upper part of the Karpatian/Early Badenian conglomerates and sandstones of the Aderklaa and the Jablonica Beds and the conglomerates at the base of the "Lanzendorf Series" may be attributed to a new - "Langhian" cycle of the relative sea-level changes (TB 2.3). The upper boundary of the SB 2 type was identified in the Austrian part of the basin inside of the Upper Lagenide zone (Weissenbäck 1996)

The late Early Badenian "tectonically controlled" transgression started during the deposition of the Upper Lagenide zone **in all Western Carpathian basins** and is characterized by the onset of genus *Orbulina* (15.1 Ma ago, sensu Berggren et al. 1995).

The late Early to Middle Badenian relative sea-level cycle CPC 4 in the Western Carpathian – North Pannonian region can be more or less correlated with the TB 2.4 global sea-level cycle (15.5 - 13.8 Ma, mfs 15 Ma, sensu Haq et al. 1988, Haq 1991), but its termination in the Western Carpathian - North Pannonian area is distinct only in the East Slovakian Basin, where it was manifested by the evaporitic sedimentation at the NN5/NN6 nannoplankton zone boundary, similarly to the Carpathian Foredeep, the Transcarpathian and the Transylvanian Basins (Buday et al. 1965, Kováčet al. 1989,1998, Rögl 1998). This period in the Central Paratethys area represents the chronostratigraphic boundary at 14.4 to 14 Ma (sensu Berggren et al. 1995, Rögl 1998).

The Late Badenian to Early Sarmathian relative sea-level cycle CPC 5 in the Western Carpathian - North Pannonian area can be approximately correlated with the TB 2.5 global cycle of the sea-level changes (13.8 - 12.5 Ma, mfs 13.4 Ma, sensu Haq et al. 1988, Haq 1991). In the Western Carpathian area the lower sequence boundary of the SB 1 type is known only from the East Slovakian Basin, followed by transgression of the Upper Badenian sediments. The Late Badenian pelites of the Bulimina-Bolivina zone (Grill 1941) are considered to be the deposits of the sea-level highstand during the NN6 nannoplankton zone in the all Carpathian basins. The end of sedimentation represents a transition into the brackish Ammonia bearing beds during the sea-level fall in the early samathian (basal part of the NN7 nannoplankton zone). In the mentioned cycle no influence of increased tectonic activity on the paleogeographical evolution of the intra-Carpathian basins was registered.

In the **South Slovakian – North Hungarian (Novohrad) Basin** (Fig. 6) the Early Badenian deposits with *Praeorbulina* sp. are transgressively overlain by deposits of the Upper Lagenide zone (Grill 1941, 1943) and at the same time the marine sedimentation terminated and it was replaced by deposition of the Middle to Late Badenian volcano-sedimentary complexes at the Novohrad Basin northern margin **(CPC 4)**.

In the Vienna and the Danube Basins a slight decrease in salinity and shallowing occurred (Cicha in Buday et al. 1965, Papp in Papp et al. 1978) at the end of the Upper Lagenide zone (Grill 1941, 1943). The boundaries between sedimentary bodies, displaying the relative sea-level oscillation in the Vienna and the Danube Basins at the Lower/Middle Badenian boundary, are interpreted as a result of decrease of the tectonic activity and increased sediment input. In the Vienna Basin this event is represented by a transgressive-regressive body of the Matzen Sands overlying the Upper Lagenide zone (Kreutzer & Hlavatý 1990) and it reflects development of a new drainage pattern and delta progradation at the western margin of the basin (paleo-Danube delta). The Middle Badenian deposits of the Spiroplectammina carinata zone (Grill 1941) possess a transgressive character in the Vienna and the Danube Basins (Buday et al. 1965, Hudáčková et al. 1998), passing into the highstand systems tracts. They are separated from the overlying sediments of the Bulimina-Bolivina zone (Grill 1941) by a conform surface **(CPC 4+5)**. These facts are consistent with the basins tectonic evolution at that time (Lankreijeret al. 1995, Kováčet al. 1997, Baráth et al. 1997).

In the **East Slovakian Basin** a continuous transition from the Upper Lagenide zone to the overlying Spiroplectammina (*Spirolutilus*) carinata zone (GRILL 1941) was documented. Late highstand of the **CPC 4** cycle represents the transition of the Vranov Formation to the evaporite bearing Zbudza Formation at the end of the Middle Badenian (Baráth et al. 1997). Transgression of the Bulimina-Bolivina zone deposits represent in the East Slovakian Basin the next **CPC 5** cyle relative sea-level cycle. These facts are consistent with the basin synrift (Baráth et al. 1997).

The Sarmatian to Early Pannonian relative sea-level cycle CPC 6 in the Western Carpathian - North Pannonian area can be approximately correlated with the TB 2.6 global cycle of the relative sea-level changes (12.5 - 10.5 Ma, mfs 11.5 ma, sensu Haq et al. 1988, Haq 1991), if correlable at all, due to the isolation of the intra-Carpathian region from the Mediterranean.

The Early Sarmatian transgression in **the Vienna, Danube and the East Slovakian Basins**, is characterized by the onset of the large Elphidiums zone (Grill 1941). The transgression was enhanced by the tectonic subsidence in the northern part of the Vienna and the Danube Basins, as well as in the East Slovakian Basin (Lankreijeret al. 1995, Baráth et al. 1997). The overlying sediments of the Elphidium hauerinum zone (Grill 1941) can be considered to be the highstand systems tracts. During the global sea-level fall between 11.5 - 10.5 Ma ago the late highstand - Porosononion granosum zone (Grill 1941) was displayed in the Western Carpathian area by decreasing salinity and fresh water deposition (the Late Sarmatian coal bearing Kochanovce Formation of the East Slovakian Basin and the Late Sarmatian deposits of the Porosononion granosum zone overlain by relics of the terrestric-lacustrine deposits at the base of the Pannonian zone C (sensu Papp 1951) in the Vienna and the Danube Basins.

The tectonically controlled subsidence in the Late Miocene was a reflection of the second rifting phase of the Pannonian back-arc basin (Lankreijer1998) and started ca. 10.5 Ma ago, similarly as **the TB 3 cycles of the global sea-level changes (sensu Haq et al.1988, Haq 1991).** The isolation of the Western Carpathian - Pannonian basins, manifested by local biostratigraphy, practically disables to use paleoecology for correlation of the regional cycles with the TB 3 cycles of the global sea-level changes. It can be roughly said that the highstand falling stage depositional system represents the Pannonian zones A-B (Papp 1951). Appearance of a three-fingered ancestor of horse - *Hipparion* at the margin of the Vienna Basin during the B-C zone (Papp 1951) may be considered as one of the signs of the sea-level lowstand before the transgression in the zone C (Kováčet al. 1998). On the other hand, the highstand of the TB 3.1 global sea-level cycle is documented by a boom of dinoflagellates in the Pannonian E zone (Papp 1951), known from the Vienna Basin (Kováč& Hudáčková1997, Kováčet al. 1998).

Acknowledgement

The authors are grateful for the financial support to Slovak VEGA grant agency (VEGA grants No. 1/7087/20, No. 2/7215/20, No. 2/7068/20), to the Czech Republic agency No. 205/98/P251 and to the Slovak geological survay project: „Tectonogenesis of the Western Carpathian basins„.

References

Baráth, I., Kováč, M., Soták, J. & Lankreijer, A. 1997: Tertiary collision, metamorphism and basin forming processes in the Eastern Slovakia (central Western Carpathians). In: Grecula et al. (eds.): Geological evolution of the Western Carpathians. Miner. slov., Monograph, 65-79.

Berggren, W. A., Kent, D. V., Swisher III., C. C. & Aubry, M.-P. A, 1995: Revised Cenozoic geochronology and chronostratigraphy. In: Berggren, W.A., Kent, D.V. & Hardenbol, J. (eds.): Geochronology, Time scale and Global stratigraphic correlations: a unified temporal framework for a historical geology. Society of Economic Paleontologists and Mineralogists, Special Publication No.54, 129-212.

Brown, L. F. & Fischer, W. L. 1977: Seismic - stratigraphyc interpretation of depositional system: examples from Brazilian rift and pull - apart basins. In: Payton, C. E. (ed.): Seismic stratigraphy - aplication to hydrocarbon exploration. - Amer. Ass. Petr. Geol. Mem. 26, 213-248

Buday, T., Cicha, I. & Seneš, J. 1965: Miozän der Westkarpaten. GUDŠ, Bratislava, 295p.

Grill, R. 1941: Stratigaphische Untersuchungen mit Hilfe von Mikrofaunen im Wiener Becken und den benachbarten Molasse-Anteilen, Oel u. Kohle 37, Berlin, 595-602.

Grill, R. 1943: Über mikropaläontologische Gliederungsmöglichkeiten im Miozän des Wiener Becken, Mitt. Reichsanst., Bodenforsch., 6, Wien, 33-44.

Haq, B.U., Hardenbol, J. & Vail, P.R. 1988: Mesozoic and Cenozoic chronostratigraphy and cycles of sea level changes. In: Wilgus, C.K. et al.: Sea-level changes - an integrated approach. SEMP Spec. Publ., 42, 71-108.

Haq, B. U., 1991: Sequence stratigraphy, sea-level change and significance for the deep sea. Spec.Publ. Int. Ass. Sediment., 12, 3-39.

Kováč, M. & Hudáčková, N. 1997: Changes of paleoenvironment as a result of interaction of tectonic events with sea level changes in the northeastern margin of the Vienna Basin. Zbl. Geol. Palaont. Teil I, 5/6, 457-469.

Kováč, M. & Zlinská, A. 1998:Change of paleoenvironment as a result of interaction of tectonic events and sea level oscillation in the east Slovakian Basin. Przeglad geologiczny, 46, 5, 403-409.

Kováč, M., Bielik, M., Lexa, J., Pereszlényi, M., Šefara, J., Túnyi, I. & Vass, D. 1997: The Western Carpathian Intramountaine basins. In: Grecula, P., Hovorka, D. & Putiš, M. (eds.): Geological evolution of Western Carpathians. Mineralia slov. - Monograph, Bratislava, 43- 64.

Kováč, M., Baráth, I., Kováčová - Slamková, M., Pipík, R., Hlavatý, I. & Hudáčková, N. 1998: Late Miocene paleoenvironments and sequence stratigraphy: Northern Vienna Basin. Geol. Carpath.,49, 6, 445-458.

Kováč, M., Holcová, K. & Nagymarosy, A. 1999: Paleogeography, paleobathymetry and relative sea-level changes in the Slovakian Danube Basin and adjacent areas. Geol. Carpath., 50, 4, 1-13

Kreutzer, N. & Hlavatý,V. 1990: Sediments of the Miocene (mainly Badenian) in the Matzen area in Austria and in the southern part of the Vienna Basin in Czechoslovakia. In: Minaříková, D. & Lobitzer, H. (eds.): Thirty years of Geological Cooperation between Austria and Czechoslovakia. UUG (Praha), 110-123

Lankreijer, A. 1998: Rheology and basement control on extensional basin evolution in Central and Eastern Europe: Variscan and Alpine - Carpathian - Pannonian tectonics. Vrije Universiteit, NSG Publ. no.980101, 158p.

Lankreijer, A., Kováč, M., Cloetingh, S., Pitoňák, P., Hlôška, M. & Biermann, C. 1995: Quantitative subsidence analysis and forward modelling of the Vienna and Danube Basins. Tectonophysics, 252, Amsterdam, 433-451.

Martini, E. 1971: Standard Tertiary and Quaternary calcareous nannoplankton zonation. In: Proceeding of 2nd planktonic conference, Roma 1970, 739-785.

Papp, A. 1951: Das Pannon des Wiener Beckens. Mitt. Geol. Gesell. (Wien), (1946–1948), 39–41, 99–193.

Papp, A., Cicha, I., Seneš, J. & Steininger, F., (eds.) 1978: Chronostratigraphie und Neostratotypen. Miozän der Zentralen Paratethys M4 Badenien. VEDA (Bratislava), 1-593.

Posamentier, H. W. & Vail, P. R., 1988: Eustatic controls on clastic deposition II. - Sequence and system trackt models. In: Wilgus, C. K.,Hastings, B. S., Kendall, C. G. Stc., Posamentier, H. W., Ross, C. A. & Van Wagoner, J. C. (eds): Sea - level changes: an integrated approach. -Soc. Econ. Paleont. & Miner., Spec. Publ. 42., 125 – 154.

Rögl, F. 1998: Paleogeographic Considerations for Mediterranean and Paratethys Seaways (Oligocene to Miocene). Ann. Naturhist. Mus. Wien, 99A, 279-310.

Vail, P. R., Hardenbol, J. & Todd, R. G., 1984: Jurasic unconformities, chronostratigraphy and sea-level changes from seismic stratigraphy and biostratigraphy. In: Schlee, J. S. (ed.): Interregional unconformities and hydrocarbon accumulation. Amer. Ass. Petr. Geol. Mem. 36, 129 -144.

Van Steen Winkel, M., 1988: The sedimentary history of the Dinant platform during the Devonian - Car boniferous transition. PhD thesis, Kathol. Univ. Leuven, Belgium., 173p. Van Steen & Winkler 1988 – to je v texte

Weissenbäck, M. 1996: Lower to Middle Miocene sedimentation model of the central Vienna Basin. In: Wessely, G. & Liebl, W. (eds.): Oil and Gas in Alpidic Thrustbelts and Basins of Central and Eastern Europe. EAGE Spec. Publ. No.5, 355-364.