E E D E N

Environments and Ecosystem Dynamics of the Eurasian Neogene

Birth of the New World

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Preface

By Meulenkamp, J. & Fortelius, M.

A programme on *Environments and Ecosystem Dynamics of the Eurasian Neogene* (EEDEN) was funded by the European Science Foundation in 2000 for a five-year period. Its ultimate ambition is to arrive, through promoting truly multidisciplinary collaboration and exchange of information, at a "total system view" of the processes that controlled terrestrial ecosystem change in the Neogene. It is focussed in particular on understanding three high-resolution intervals, centred around 15, 10 and 5 million years ago, respectively. The previous plenary meetings have taken place at Lyon (2000: State of the Art), Sabadell (2001: Late Miocene to Early Pliocene Environments and Ecosystems), and Frankfurt (2002: The Middle Miocene Crisis).

The EEDEN plenary meeting of 2003 at Stara Lesna has as its topic the second of the high-resolution intervals and as its title *Birth of the Modern World.* The title refers to the fact that the beginnings of essentially modern palaeogeographic and climate systems were established at this time. The process was accompanied by major reorganisation of terrestrial ecosystems, abrupt and accompanied by mass extinction in some cases (in particular the "Vallesian Crisis" that strongly perturbed the mammal communities of western Europe), more gradual and without evidence of system collapse in others. A main question remains to what extent physical environmental forcing was directly responsible for the regional differences observed, and to what extent they reflect intervening evolutionary processes in the ecosystems. The meeting is designed to cover all the evidence that can be brought to bear on the second high-resolution interval and more generally on the central EEDEN questions of palaeoenvironment reconstruction and the evolutionary dynamics of terrestrial ecosystems on geological time scales.

Astronomically forced climate change in Late Miocene shallow lacustrine and distal alluvial fan sequences from the Teruel Basin

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An integrated stratigraphic and petrographic study of cyclically bedded distal alluvial fan to lacustrine/palustrine deposits in the late Miocene continental sections of Cascante and Cańizar (Teruel basin, NE Spain) is presented. The cyclostratigraphic analysis reveals that different scales of sedimentary cyclicity are present which have a ratio of about 1:2:5. Spectral analysis of colour records in the depth domain shows the presence of a significant peak at ~2.2 m, which corresponds to the average thickness of the basic small-scale, mudstone-carbonate, cycle. Other peaks correspond to the large-scale cycle, which consists of clusters of 5 basic cycles, and to a cycle twice the average thickness of the basic cycle. Magnetostratigraphic results, in combination with small-mammal biostratigraphy, indicate that the three normal polarity intervals recorded in our sections correspond to C5n.2n, C5n.1n and C4Ar.2n. However, using the CK95 ages for the polarity reversals implies a significant change sedimentation rate throughout the studied interval, which is not in agreement with the regularity of the sedimentary cyclicity. Spectral analysis results of high-resolution colour records in the time domain produce a spectrum that is very consistent with Milankovitch climate forcing, if several age tie-points are excluded. Consequently, we have calculated the astronomical durations for C4Ar.2n (87 kyr), C4Ar.3r (54 kyr), C5n.1n (141 kyr), and C5n.1r (33 kyr), which show significant discrepancies with CK95. The duration pattern of our polarity intervals is confirmed by many detailed magnetostratigraphic records from the ocean floor, indicating errors in the reversal ages of CK95.

The great variety in the internal build-up of the carbonate beds complicated establishing phase relations between the sedimentary cycles with eccentricity thereby hampering a reliable tuning of the cycles to the astronomical curves. Therefore, to better understand the origin and nature of the different types of carbonates and, subsequently, to determine the phase relations we performed a detailed microfacies analysis of the carbonates. Our results indicate that carbonate beds from the lower part of the Cascante section were deposited in a very shallow 'unstable' lake, which was subjected to extensive subaerial exposure. Based on the relative depth and energy of the lake system, several sub-facies can be distinguished varying between relatively wet to relatively dry. Carbonates from the upper part of the section were deposited in a shallow 'stable' lake, which underwent only minor subaerial exposure. Also in this facies a distinction can be made between wet and dry sub-facies. Using these petrographic results, we can determine the phase relation between the sedimentary cycles and the astronomical parameters. Carbonates where deposited during precession minimum, however, the wet sub-facies type from both 'stable' and 'unstable′ lake facies formed during eccentricity maximum while the dry sub-facies types during eccentricity minimum. An astronomical tuning of the cycles is presented and shows a good fit with our petrographic interpretations. Most obvious is the shift from 'unstable' to 'stable' lake environments starting at around 9.67 Ma, which seems to be related with the long term (2.1 Ma) eccentricity cycle. At present, detailed petrographic, cyclostratigraphic and small-mammal biostratigraphic studies from parallel sections in the study area are being carried out.

The evolution of the Vallesian Crisis

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The Vallesian Crisis was first recognized by Agustí & Moyŕ-Solŕ (1990) in the Vallčs-Penedčs Basin, being considered as a one of the main events that affected the Eurasian mammalian faunas in the late Miocene. The Vallesian Crisis was characterized by the sudden extinction of a number of taxa which characterized most of the early and middle Miocene. Among other large mammals, the Vallesian Crisis involved the disappearance of most of the humid elements that characterised the middle Miocene and early Vallesian faunas from Western Europe. This crisis particularly affected several groups of perissodactyls, such as rhinoceroses (*Lartetotherium sansaniense, "Dicerorhinus" steinheimensis*) and tapirs. Among the artiodactyls, the high diversity attained by the suids in the early Vallesian times suddenly dropped and several characteristic elements such as *Listriodon, Schizochoerus* and the tetraconodontines *Conohyus* and *Parachleuastochoerus* became extinct as well. The Vallesian Crisis also involved the final decline of the middle Miocene forest community of cervids (*Amphiprox*) and moschids (*Hispanomeryx)* and the spread of the boselaphine bovids like *Tragoportax,* which replaced their semiaquatic relatives of the genus *Protragocerus* (Köhler, 1993). Another group that was severely affected by the Vallesian Crisis was the large carnivores of the families Nimravidae (*Sansanosmilus*) and Amphicyonidae (*Pseudarctos bavaricus, Amphicyon major, Thaumastocyon dirus*). Their extinction was partly compensated with the entry of *Paramachairodus,* a new genus of machairodontine cat. Among the rodents, the Vallesian Crisis involved the disappearance of most of the hamsters (cricetids) and dormice (glirids) of early or middle Miocene origin (*Megacricetodon, Eumyarion, Bransatoglis, Myoglis, Paraglirulus, Eomuscardinus*), flying-squirrels *(Albanensia, Miopetaurista)* and beavers (*Chalicomys, Euroxenomys*). In Western and Central Europe this event coincided with the first dispersal of the murid rodents, the family that include the living mice and rats. After their entry into Europe, this group became the dominant rodents in the late Miocene communities and diversified into a number of genera: *Progonomys, Occitanomys, Huerzelerimys, Parapodemus.*

Since that time, considerable progress has been done regarding the dating and timing of the Vallesian Crisis (Agustí et al., 1997 and 1999) as well possible causes for such crisis (Agustí et al., 2003). However, question remains about the extent of the Vallesian Crisis outside Western Europe.

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Distribution patterns of foraminifera in Late Miocene eastern mediterranean sediments in relation to Environmental gradients: first results

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In this work, the succession of paleoenvironments and foraminifera assemblages are analyzed from two sections (Ah Giannis, Bo) from the Lower Tortonian in Gavdos Island, which forms the southernmost extension of the South Aegean Island Arc. The main objective of the present study is to gain a better understanding of the environmental factors controlling the distribution of faunal parameters. The paleoecological approach uses the available data on recent foraminiferal assemblages from the Mediterranean (see review in Murray, 1991). These ecological characteristics of foraminifera can provide assessments, at varying levels of accuracy of water depth, bottom water oxygenation, salinity.

To reach our goal, quantitative and statistical analysis on benthic foraminiferal assemblages were carried out. Foraminiferal data are compared to others micropaleontological data. A data set, constituted by counted samples of benthic foraminifera, has been subjected to cluster and principal component analyses, in order to demonstrate the linkage between taxa distribution and paleoenvironmental gradients.

The most important benthic constituents are biconvex *Cibicides, Uvigerina*, elongate *Bolivina, Bulimina, Globobulimina (Praeglobobulimina), V. complanata* and *O. umbonatus* and represent a typical deep-sea mud dwelling assemblage. Associations largely made up of these groups are found today in normal marine environments with a muddy substrate, at depths below 100 m and with bottom temperatures lower than 10^{o}. White marls are characterized by well distributed high diversity of benthic species indicating stable environmental conditions. On the other hand, *Ammonia beccarii* is a very common foraminiferal species, which grows in almost every brackish or shallow marine environment, form the tropic to temperate regions.

Our results suggest that oxygenation and trophic conditions of the near-surface sediments are the most important factors that control the community structure of the benthic foraminiferal fauna. In addition, upwelling phenomena evidenced by signals from the benthic foraminifera may have played a role in the study area.

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Late Miocene to Pleistocene paleoclimatic changes in eastern mediterranean

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The Mediterranean sediments are very sensitive in recording astronomically induced oscillations of climate, due to its latitudinal position in combination with its semi-enclosed basin configuration. The astronomical calibrated time scales, which were constructed for the Pliocene-Pleistocene (Hilgen, 1991a,b) and extended into the Miocene (Krijgsman et al., 1995) provided a solid basis for unraveling relationships between orbital forcing and climatic proxy records in the Late Miocene-Pliocene-Pleistocene (Lourens et al., 1992, 1996).

High-resolution planktonic foraminiferal records are presented in order to reconstruct the climatic history of the Eastern Mediterranean Basin during the time span of 9.7 to 1.2 Ma. The sections selected for this presentation is the Rosselo section, covering the entire Pliocene, the Singa section for the Upper Pliocene-Lower Pleistocene, Singa section for the Late Pleistocene and Metochia section for the Upper Miocene.

Quantitative and qualitative modifications of the planktonic foraminiferal communities observed in the sections exhibit a sequence of bioevents, defined by frequency peaks and/or local (re)-occurrences or (temporary) disappearances of some of the taxa, in association with more or less important fluctuations of the more common species.

The majority of the foraminiferal species are sensitive indicators of paleoenvironmental changes. Proxy records for Sea Surface Temperature (SST) and Sea Surface Productivity (SSP) were determined considering the foraminiferal assemblages and the relative abundance of each species as indicators of particular environmental conditions.

Spectral analysis has been carried out in all records in order to establish short-term variations and the possible influence of astronomical forcing.

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Pannonian organic-walled phytoplankton assemblages in Croatian part of Pannonian Basin

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The eastern Croatia was a part of the southern margins of Central Paratethys during the Miocene (Fig.1).

Palynological analyses were carried out on the sediments from the surface profile at locality Vranović near Našice, in order to define the boundaries between local formations: Kasonja Formation (Sarmatian), Croatica Formation (lower Pannonian), and Pavlovci Formation (middle Pannonian).

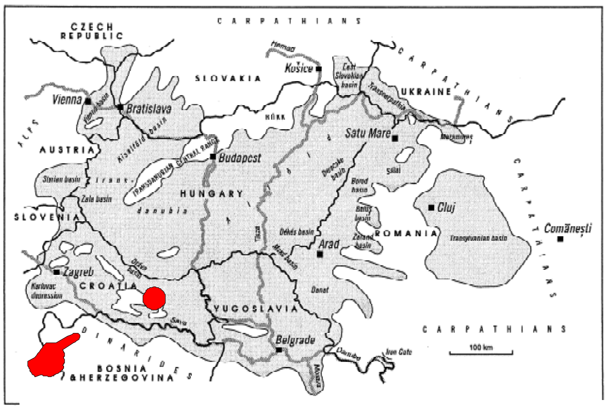

Fig. 1 Geographical features of the Pannonian basin. The modern basin area is shaded; outcrops of the basement (mostly Mesozoic and older) are white. (Magyar, I. et al 1999.)

Following the end-Badenian initial isolation brachihaline fauna began to evolve in the Pannonian Basin. Although some deepening occurred during the Sarmatian, its end was characterised by shallowing. The findings of molluscs *Ervilia disita disita, Mactra podolica* and *Irus* sp., define Sarmatian age of sediments. Palynomorph assemblages consist of marine dinocysts tolerant to decreased salinity: *Hystrichosphaeropsis obscura*, *Polysphaeridium zoharyi*, *Lingulodinium machaerophorum*, and brackish dinocysts *Spiniferites bentori budajenoensis*. This assemblage is also typical for the Late Sarmatian deposits in Hungary (Sütő-Szentai, 1988).

In the Early Pannonian, salinity was very low, and the environment became oligohaline, locally even fresh. Such environmental conditions enabled the expansion of endemic species. Macrofauna is dominated by *Radix croatica* and *Gyraulus praeponticus*, indicating Early Pannonian age ("Croatica-beds"). The deposits consist of lacustrine littoral to sublittoral limestones with marl intercalations. Ecological conditions were unfavourable for dinoflagellates, which is evident by absence of dinocysts in these sediments. Consequently, prasinophyts *Mecsekia ultima, Mecsekia spinosa* and *Mecsekia incrassata* dominate the phytoplankton assemblages.

Salinity increased and the basin became brackish again. Massive marls were deposited in a deeper part of the lake. The fossil association includes shells of *Congeria banatica* indicating the middle Pannonian ("Banatica-beds", Pavlovci Formation). The lake bottom was bioturbated due to activity of benthic organisms. The dinocyst assemblage of *Spiniferites bentori pannonicus*, *Spiniferites bentori granulatus*, and *Impagidinium spongianum* characterizes these deposits, which can be correlated with the assemblage of *Spiniferites bentori pannonicus* zone in Hungary (Sütő-Szentai, 1988). Within the succeeding deposits, *Spiniferites bentori pannonicus*, *Spiniferites bentori oblongus* dominate the palynomorph assemblages. *Nematosphaeropsis* sp. and membranous forms of *Spiniferites bentori* indicate water-level rise and a distal environment. This assemblage is similar to the assemblage of *Spiniferites bentori oblongus* zone from Hungary (Sütő-Szentai, 1988).

In conclusion, the sedimentation during the Late Sarmatian and Pannonian was continuous, and the dinoflagellate zones are correlative within Croatian and Hungarian part of the Pannonian Basin.

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Some Recent Advances in Understanding Old World Hipparionine Evolution, Biogeography and Paleoecology

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Hipparionine horses arose by 16 Ma in North America, evolved there until circa 4 Ma., and succeeded in making a broad and rapid prochoresis into Eurasia and Africa arguably between 11.1 and 10.7 Ma. Research on these hipparions over the last 30 years have led to the recognition of several superspecific groups and multiple geographically and chronologically defined lineages across all of Holarctica and Ethiopia.

Woodburne has recently undertaken the further resolution of the North American *Cormohipparion* group identifying *C. goorisi* as the earliest member of the clade. *Cormohipparion goorisi* first occurs in the early Barstovian Trinity River Pit fauna of Texas, dated at about 15.5 Ma based on biochronology. It is characterized by having the *Cormohipparion* signature of a large and strongly demarcated DPOF, with its anterior end very near the IOF; wide POB, and lacrimal that extends within the rear of the DPOF (retracted in more evolved species). *Cormohipparion goorisi* differs from other species of the genus in its smaller overall size and more mesodont dentition wherein the upper cheek tooth enamel pattern is less complex, and protocone more ovate. *Cormohipparion quinni* is known from late Barstovian Valentine Formation faunas of Nebraska, dated at between 14-13 Ma on radioisotopic and faunal grounds. *Cormohipparion quinni* is larger and more hypsodont than *C. goorisi*, has a more complex upper cheek tooth enamel pattern, a shorter dP1 relative to P2, stronger lower cheek tooth protostylids, better separated p2 metaconid-metastylid, and a less strongly pocketed DPOF. The *Cormohipparion occidentale* group ranges throughout the Clarendonian (ca 12.5 – 9 Ma). Studies underway suggest that this group contains as many as six species, all of which are larger and contain more complex cheek tooth dentitions than *C. quinni*, a much reduced dP1, and a more ovate rather than tear-drop shaped DPOF. Preliminary studies suggest that a species of *Cormohipparion* from the early Clarendonian MacAdams Quarry, Texas (ca 12 Ma) is a likely candidate for the ancestry of the Old World *Hippotherium* (‘*Hipparion*’) Datum.

It has been a long-held supposition that the first occurring Old World hipparion was *Hipparion primigenium*. Recent research on the Hőwenegg (Hegau, Germany) MN 9 assemblage of 14 skeletons has provided detailed anatomical information, and revealed that this and other similar Central European hipparions are best referred to the genus *Hippotherium*, not *Hipparion*; hence, our referral to the species *Hippotherium primigenium*. There are a number of skeletal characteristics of the skull, dentition, axial and postcranial skeleton that support this referral.

Hippotherium primigenium was pervasive through the Vallesian and Early Turolian of Central Europe, and would appear to occur in early MN9 of Western Europe. However, our recent work in the late Miocene sequence, and particularly the MN9 interval of Sinap, Turkey, has revealed that the first occurring hipparion there is referable to *Cormohipparion sinapensis*. Our extensive morphometric analyses of the Sinap hipparion assemblage have revealed that they underwent an extensive evolutionary radiation within MN9, with upward of 4 to 5 species occurring at the end of the interval within the local section. Morphologic diversity is found particularly in facial, snout and postcranial anatomy of this assemblage. This radiation included species of *Cormohipparion* and *"Hipparion"* and is most likely relevant to the evolution of the multispecific genera, *Hipparion* s.s and *Cremohipparion*.

We have also recently studied a small assemblage of hipparions from MN 9 correlative horizons of Chorora, Ethiopia. Chronologic and biostratigraphic information suggests an age of between 10.7 and 10.0 Ma. We have referred this assemblage to *"Cormohipparion"* sp., and have recognized that more complete skull and postcranial material will be needed to attain a secure species-level identification. Analysis of the cheek tooth mesowear however has revealed that this horse was a mixed feeder that incorporated C4 grass into its diet.

By the earlier Turolian it would appear that there were several multi-species lineages in place: *Hippotherium, Hipparion* s.s., *Cremohipparion, Sivalhippus* and *Eurygnathohippus*. These lineages had distinct morphologies and well defined biogeographic ranges. The basal Pliocene witnessed the apparent extinction of all these lineages except for *Eurygnathohippus* in Africa, which continued to evolve in adaptation to African grasslands. The "*Sivalhippus"* Complex evolved advanced multispecific lineages of *Plesiohipparion* and *Proboscidipparion* and extended their range from Asia into Europe.

Finally, we discuss further here our current work on the medial Turolian species diversity of hipparions at Samos (Greece), the extension of late members of the *Hippotherium primgenium* lineage from the Central Paratethys into Tuscany, and a lineage of tiny hipparions belonging to the genus *Cremohipparion* between Greece, Italy, Libya and Spain.

Migration history of air-breathing fishes reveal Neogene atmospheric circulation pattern

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The migration history of an Old World air-breathing fish group (Channidae; snakehead fishes) is used for reconstructing Neogene Eurasian precipitation and atmospheric circulation pattern. It could be shown that snakeheads are sensitive for summer precipitation maxima in subtropical and temperate regions and occur regularly if the wettest month exceed 150 mm precipitation and 20°C mean temperature. The analysis of 515 fossil freshwater fish deposites from Africa and Eurasia of the last 50 Myr show two continental scale migration events from their centre of origin in the South Himalayan region, which can be related to changes in the Northern Hemisphere circulation pattern.

The first migration at ~17.5 Myr into Western and Central Eurasia correlates with an northward shift of the Innertropical Convergence Zone (ITCZ) bringing Western Eurasia under the influence of trade winds which produced a zonal and meridional precipitation gradient in Europe. During the second migration between 8 and 4 Myr into Africa and East Asia snakeheads reached their present day distribution. This could be related with the intensification of the Asian monsoon bringing summer precipitation to their migratory pathways in East Africa/Arabia and East Asia.

Tortonian climate patterns in Europe based on plant-proxy data - and its development since Middle Miocene -

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An extended dataset of 42 late Neogene micro- and megafloras (~11-7 Ma) from Europe and western Asia was combined from data of Bruch et al. (in press), Olivares et al. (in prep.), and new climate data for additional localities. It is analysed with respect to various climate variables using the Coexistence Approach. The results are presented in maps showing spatial temperature and precipitation patterns and seasonal components.

In the time span between 11 to 7 Ma, mean annual precipitation (MAP) rates of over 1000 mm are observed in a region extending from NE Spain in the West to the Eastern Mediterranean, Anatolia and Armenia in the East, thus confirming the results of Bruch et al. (in press) where humid conditions all over Central Europe and the absence of major precipitation gradients are reported. Slightly lower MAP rates (<900 mm) result for a locality in western Central Spain, substantially dryer conditions, however, with MAP below 750mm are only reported from pollen localities in Northwestern Africa, so far (Suc, pers. comm.).

As shown by the analyses of the precipitation rates in the wettest and driest month, respectively, rainfall was not distributed homogenously throughout the year. The observed spatial pattern of seasonal aridification is well in accordance with results obtained from the analyses of small mammals showing almost the same regional trends for the time-span between 10 to 8 Ma (Van Dam, in press). The precipitation rates in the warmest month always exceeds the values for the driest month.. This contradicts the presence of a Mediterranean type climate with summer drought in the time interval regarded. The establishment of seasonally drier conditions observed in the lower latitudes of Europe most probably can be referred to the pronounced cooling at the beginning of the late Miocene leading to a reduction of atmospheric moisture in southern regions.

The ongoing reconstruction of climate maps for the Langhian/Lower Badenian and Serravallian/Sarmatian time slices will give more information about the development of climate patterns in time, showing the low temperature and precipitation gradients throughout the Middle and late Miocene in Central Europe, and an increasing seasonality on both, temperature and precipitation parameters.

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The project WINE and its goals

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The study of insectivores is reflected in individual work that gives emphasis either on systematics, or phylogeny, or ecology, or all of the above. That is why in November of 2002, European insectivore specialists gathered together in Frankfurt am Main to talk about giving insectivores a high profile and work in cooperation in solving the problems concerning this group. We decided then to work together on the Neogene insectivores, retaining the classic division, starting from the E. Miocene to the Villanian/Biharian boundary. Although most of our material comes from European localities, we thought that in order not to get biased information on migration, it would be best to include Asia. We have called our project WINE, Workgroup on Insectivores of the Neogene of Eurasia. Insectivores are the oldest placental mammals. Thinking of them, however, as primitive mammals is wrong because they combine a mixture of primitive and derived characters. Insectivores recently have been called Lipotyphla. However, this systematic has been proved to be useless to paleontologists. Presence or absence of “caecum” can not be detected in our fossils and the phylogeny of the group shows that only a part of the families can be assigned to Lipotyphla. Therefore our first decision was to return to the good old name of “insectivores “. However, previously the term “insectivores”, was used as a waste basket referring to unclear definition. Now we understand “insectivores” as a covering umbrella. Following this train of thought and in order not to create havoc in systematic we retain the subdivision suggested by BUTLER (1972): Erinaceomorpha and Soricomorpha. By doing this we eliminate the question of “Lipotyphla” which becomes a supraordinal taxon. During the Neogene lived all the extant families, Erinaceidae (hedgehogs), Talpidae (moles), Soricidae (shrews), Selonodontidae (solenodons), Chrysochloridae (golden moles) and Tenencidae (tenrecs), plus two extinct now families Plesiosoricidae and Dimylidae (ZIEGLER 1999). Dimylidae should be referred to Soricomorpha. Even though, insectivores are usually less abundant than rodents in fossil small mammal assemblages, valuable collections of good material in dental and post-cranial elements exist. In the study of insectivores the use of post-cranials is also important. We have set as our first goal to gather and publish a fossil record of the Neogene insectivores which contains for every known locality, next to a fauna list, local stratigraphy, plus coordinates when available, MN zones, a reference list and place of storage of the material. This publication is expected to come out in 2004 by “Scripta Geologica” (Leiden, NL). Colleagues from Austria, the Czech Republic, France, Germany, Greece, Holland, Poland, Spain, Switzerland and Ukraine are participating in this volume. With our first step, the fossil record, we are addressing the stratigraphic problem, mainly referring to local zonation. This is essential to be able to correlate to the MN zones. It has been proven that correlation to MN zones becomes problematic when you are geographically distant from the reference fauna and the local succession is not well known. After completing our fossil record, working groups should be formed, to work on mainly phylogeny and consequently to the other topics. Phylogenetic lineages, geographical patterns and in turn migration routes, should be studied. Knowledge of geographical boundaries is also important Insectivores are good ecological markers in the study of a fauna. Biostratigraphy information is normally taken from the rodent assemblages. For the understanding of ecosystems today, modeling is “on vogue”, not without a reason. Distribution and abundance of species can help in the reconstruction of humidity and temperature, or even more, in the seasonal aspects of climate. Small mammals, consequently insectivores, are good due to their short mean life expectancy, in calculating interannual variation.

Vegetation reconstruction in West Eurasia during the interval 12 to 8 m.a. (HRI 2) based on the plant record and the taxonomic/physiognomic evaluation approach.

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The taxonomic/physiognomic evaluation approach is based on a taxonomic/physiognomic grouping of plant taxa that additionally reflects major sociological components in the fossil record. This method, which was introduced in 2001 in Prag (Kovar-Eder & Kvaček 2003), has meanwhile been applied to plant assemblages of the intervals 17 -14 m.a. (HRI 3) and 7-4 m.a (HRI 1). Here we present the results for the interval 12-8 m.a. (HRI 2) where, for the first time, we include also fruit- and, pollen assemblages.

Independent dating of the plant assemblages is one of the most essential prerequisits for our evaluation. Moreover, only floras with more than 10 woody zonal (hinterland) taxa are included to minimize the influence of azonal (mainly wetland) taxa in the overall picture.

Different attempts were performed: using plant assemblages from fissile sediments (so-called leaf assemblages, they include also associated, mostly winged, fruit taxa), and from sievable sediments (fruit and pollen assemblages). Reliably calibrated plant assemblages that are published in detail are available richest from fissile sediments (36) but are far less numerous from sievable sediments (fruits 8, pollen 15).

First the records of the different ogan assemblages were evaluated separately because their fossilisation is biased by different taphonomic factors.The respective results were compared then. The pictures for the different components in the leaf and the pollen record match rather well, e.g. both in the leaf- and pollen record the same trends in the region Central Europe / SE-Europe are evident regarding the broad leafed deciduous (BLD) and broad-leafed evergreen (BLE) components.

The picture provided by the fruit record ist too spotty to recognize trends. It appears less consistent with the leaves and pollen, although this may be an artifact due to the scanty fruit record. In the sclerophyll (SCL) component the consistency in percentages is well between the fruit, leaf, and pollen record. However, in the leaf record, there is a trend towards slightly increased values in SE-Europe versus Central Europe visible which is not evident from the pollen record.

For the Rhine Embayment the leaf and fruit records (BLD, BLE, and SCL+LEG (legume-like) components) are less consistent among each other than in other European regions. This fact has already been recognized earlier.

In our final attempt we fused all the records of the different organ assemblages. These maps show complementary north/south gradients both in the BLD and BLE components, and a trend towards slightly increased values of the SCL+LEG component southwards. The ratio (BLD+BLE)/(SCL+LEG) which may serve as indicator of humidity shows also a north/south gradient with higher values towards the north. The Rhine embayment can be recognized as humid region with higher values of the BLE component than in Central Europe but low values of the SCL+LEG component comparable to those in Central Europe.

Compared to the results for HRI 3 distinct differences can be stated in the percentages of the different components in Central Europe: lower values of the BLD component and higher ones of the BLE, and especially the SCl+LEG components for the HRI 3. The eventual strong meridional gradient in Central Europe cannot be traced in the HRI 2. The results provided for the latter interval are closer to those elaborated for HRI 1. The humidity gradient (higher values in the north than in the south) seems weaker in HRI 1, indicated by the percentage of the SCL+LEG component. Anyway, it has to be kept in mind, that for HRI 3 and HRI 1 we have used the leaf record only and still have to include the fruit and pollen record.

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Mammal community structure & primate dynamics during late Neogene

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We used a dataset from the NOW – database (http://www.helsinki.fi/science/now) to investigate how primates reacted to changes in humidity Europe. The results show that the distribution of primates followed the distribution of humid areas through time. A comparison between primate and non-primate localities shows differences in mammalian community structure between 11,2 Ma (MN9) and 3,4 Ma (MN15) ago, an interval that includes HRI 1 and 2.

A major change affecting the distribution pattern and occurrence context of primates took place within HRI 2. In the time slice 11,2-9,5 Ma (MN9) the distribution of primate localities in Europe was the widest during the entire Neogene. The whole mammal community was homogenous and almost no regional differences can be distinguished in humidity or community structure. In time slice 9,5-9,0 Ma (MN10) differences between East and West begin to appear. The distribution of primates is restricted to few localities, but no differences can be seen in community structure between primate and non-primate localities. The differences between East and West were greatest about 9,0-8,2 Ma ago (MN11).

After this the East-West contrast faded and instead a contrast began to develop between South and North. Hominoids were restricted to Mediterranean environments and the more terrestrially adapted cercopithecoid genus *Mesopithecus* was found in humid habitats throughout Europe. In time slice 8,2-7,1 Ma (MN12), when the differences in community structure between primate and non-primate localities became clearer, *Mesopithecus* was restricted to localities in Italy, the Balkans and Greece, close to water-bodies.

About 7,1-5,3 Ma ago (MN13) the hominoid primates disappeared, *Mesopithecus* was restricted to humid areas in central Europe, Italy and Greece, and we see the first appearance of the genus *Macaca* in Europe. *Macaca* is very flexible in it's habitat preferences and is known first from a relatively dry area in Spain. The community structures are very different in primate and non-primate localities. The primate localities have mammal communities consisting mainly of browsers and mixed feeders, indicating a relatively closed habitats. The non-primate localities have communities consisting mainly of grazers and mixed feeders, indicating more open-habitats.

In the time period 5,3-3,4 Ma ago (MN14-15), humid conditions returned to most of Europe and we see the appearance of *Dolichopithecus* (MN14) and *Paradolichopithecus* (MN15). The distribution of primates covered most of Europe. Also the community structure of non-primate and primate localities was again quite similar, reflecting in part a rise in the relative proportion of browsers in latter time period (MN15).

Evolution of the vegetation diversity in the Mediterranean region during the Neogene: Quantification method based on pollen data

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In the framework of a program of the French Institute for Biodiversity (IFB), we attempt to quantify the evolution of past vegetal diversity from pollen data. The aim of this project was to determine the respective impact, on vegetal diversity evolution, of global climatic variations and of regional geographic modifications since 6 million years, in 2 different contexts, before and after human action.

A survey of the past plant diversity in the Mediterranean region has been realised, based on pollen data and macrofloras and a method of quantification of the vegetal diversity using pollen data has been carried out.

The concept of diversity includes both the number of species in a sample (species richness) and the distribution of specimens within the species (equability). So far, a high diversity corresponds to a good equi-representation of each species. On the other hand, a very abundant species compared to the others in an environment will imply a decreasing diversity.

For what concerns the study of the vegetal diversity based on pollen data, it seems tricky to take into account the inter-taxonomic repartition of specimens. Indeed, all the plants have not the same pollen production and all the pollen grain types do not travel and are not preserved in the same way. It is thus not easy to transpose the variable “number of specimens by taxa” to the pollen data. We have thus chosen to work only on the species richness in a first attempt.

To know if the vegetal diversity may be estimated from pollen data, modern pollen samples have been taken in various vegetation zones and belts and floristic lists at the same places have been realised.

The correlation between total floristic richness and total pollen (taxonomic) richness has been calculated. The correlation shows a r˛ of 0.52 that substantially increase if we take into account only woody taxa (r˛=0.78). It seems thus that the woody taxa richness of a pollen spectra provide a good idea of the actual woody plants richness.

In addition, studies on modern vegetation showing a good correlation between woody plants richness and the total richness in an area, allow us to work on the woody taxa richness alone to estimate the diversity.

Using the relation obtained for the modern data (pollen samples and the respective floristic lists), a first attempt of quantification of the variation of the plants diversity in time has been realised.

Early Pliocene climate and vegetation modelling with PLASIM and CARAIB

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Proxy data for the Early Pliocene (5.3 to 3.6 Ma) suggest a climate which is different to the modern one. The Pliocene is mainly characterised by warmer high northern latitudes as compared to the present-day conditions. Related to this, the meridional temperature gradient is flatter than nowadays and the Pliocene Arctic Ocean was ice-free during summer. In order to better understand the climatic processes of the Pliocene, we have performed sensitivity studies with the climate model of intermediate complexity PLASIM and vegetation modelling studies with CARAIB. The spectral PLASIM model is used in its standard resolution of T21 (5.6° 5.6°) with 5 vertical layers. For our series of five Pliocene experiments, we successively adapted to the Pliocene (1) the palaeogeography, (2) the palaeorography, (3) the sea surface temperatures (SSTs), (4) the palaeovegetation, and (5) the sea ice cover of the Northern Hemisphere. The Pliocene boundary conditions are provided from the PRISM 2 data base (USGS Report 99-535). For all the Pliocene simulations, the atmospheric CO_2 is assumed to be 280ppm. The modern control experiment uses a pCO_2 of 360ppm.

Our PLASIM simulations demonstrate that the Pliocene climate is significantly different to the modern one. According to the PLASIM runs, the palaeogeography contributes to a warming of the coastal areas of Antarctica. The different land-sea distribution between the Pliocene and today also causes a warming of the European and North African realm. For Greenland, the Rocky Mountains and the Andes, our Pliocene simulations indicate that the lower palaeorography contributes to warmer-than-present conditions. The Pliocene runs demonstrate an additional warming of the high latitudes if the palaeo-SSTs are considered. On the one hand, the warmer Pliocene ocean water leads to a direct warming in the high northern latitudes. On the other hand, the feedback with the reduced Northern Hemisphere's sea ice cover induces a significant warming as compared to the modern situation. If the palaeovegetation is considered, the continental regions in the lower latitudes are cooled in the Pliocene simulation as compared to the modern control experiment. Thus, the Pliocene simulations demonstrate a successively reduced meridional temperature gradient. Particularly the Pliocene run with fully adapted boundary conditions indicates a temperature reduction between the equator and the high latitudes of the Northern Hemisphere of about 6°C. Generally, our results are consistent with other Pliocene modelling approaches (Chandler et al., 1994; Sloan et al., 1996).

The outputs of the PLASIM model (2m-temperature, precipitation, air relative humidity, wind speed and sunshine hours) are used to run the vegetation and carbon cycle model CARAIB. The modern temperature signal during the day is used, since it is not simulated by the PLASIM model. All these inputs to the CARAIB model are given as averages for each month along the last 10 years of the different Pliocene simulations (equilibrium). So, we need to produce random daily values with a stochastic weather generator. The soil water content is calculated for each grid point from a surface hydrological model (IBM, Improved Bucket Model). Then, the CARAIB model can reconstruct the potential vegetation according to the environmental conditions (air temperature, soil water content, air relative humidity, atmospheric CO_2 level, etc). The results have been compared to the Pliocene Europe and peri-Mediterranean vegetation as related by pollen records.

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Reconstruction of European vegetation during the Tortonian: Model comparison with proxy data

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A new version of CARAIB (CARbon Assimilation In the Biosphere) model is used to study the vegetation distribution and land carbon storage during the Tortonian. This new version involves a finer classification of plants, with respect to the former (global) version of the model. These new classes are referred to as bioclimatic affinity groups (BAG, Dubois et al., submitted). They correspond to the major plant types which are present in Europe today. The results from the ECHAM climate model are used as inputs to the CARAIB vegetation model. However, contrary to the previous reconstructions of Tortonian vegetation performed with CARAIB, the climatic anomalies (Tortonian minus Present) derived from ECHAM are now interpolated to a higher spatial resolution before being used in the vegetation model. These anomalies are combined with a modern climatology to produce climatic inputs with virtually higher spatial resolution (0.5°x0.5°). This procedure has the advantage of making apparent relief features which are smaller than the grid cells of the climate model and, hence, makes easier the comparison with local vegetation data, although it does not really improve the quality of the Tortonian climate reconstruction. The new version of CARAIB was run over Europe at this higher spatial resolution. This new version calculates the potential distribution of 13 different classes of European trees, together with their net primary productivities and biomasses. The resulting vegetation distribution reconstructed for the Tortonian is compared to available proxy data.

The Late Miocene Insectivora (Mammalia) assemblages in Spain: biogeographical and biostratigraphical patterns of distribution

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As it is well known, Spain is a land of great contrasts when referring to the environments. Its latitude, topography and situation (intermediate between South-Europe and North-Africa, and sorrounded by sea-waters) make possible a gradual distribution of some mammal groups. The north shows nowadays mid-european vegetation, fauna and climatical conditions, whileas the southeastern regions are dependent on Mediterranean temperatures and rainfalls. Some places in the south even show semi-arid conditions.

All mammals, but specially the small ones, are strongly dependent on the vegetation and the climatical conditions in their distribution. Thus, the Iberian Peninsula is a perfect place to evaluate the migration of this gradual boundary along the time taking micromammals as indicatives of it.

The Insectivora species, althought not depending directly on the vegetation (due to their main source of feeding, which are invertebrates), have been demonstrated to be relationed with the degree of humidity and the temperatures (Reumer, 1995). This is because invertebrates, like earthworms, insects or pulmonate gastropods are more abundant and diversified in humid environments. So that, a bigger number of species are able to share a more reduced area without strong competition for feeding resources.

In the present study, the distribution of Vallesian and Turolian insectivores is discussed. The bibliographical compilation for the Iberian Peninsula of the WINE Project (See Doukas, this volume) has been taken as the main source to evaluate the presence-absence of the different groups. That has enable the chance to appreciate some interesting facts concerning to the distributions of these animals along the Late Miocene.

The first one refers to the assemblage structure of the insectivores communities. Nowadays, the most diversified assemblages in Spain trend to live in the northern regions, were the rainfalls are frequent and the humidity degree is high (Real et al., 1996). That seems to have been controled by the same patterns during the Pleistocene (Sesé Benito, 1994; Furió, 2003). So that, the diversity of species (or at least the number of different genera) seems to be a good indicative of the kind of environment. Having a look to the Miocene record is also possible to recognize more and less diversified communities of insectivores, always showing a relationship with the latitude of the sites.

Another interesting point is the fact of the coexistence of two different species of burrower Talpidae in many localities. As it has been noticed in litterature, this fact is frequent during Pliocene and Pleistocene (Van Cleef-Roders & Van den Hoek Ostende, 2001), but this is also remarkable for some localities of Spain along the Late Miocene.

The last interesting point is the replacement of some specific groups of insectivores with analogous patterns of dentition. Both, dimily (absence of the third upper and lower molars) and exodaenodonty (bulbous cusps and increase of the enamel thickness) are repeated in *Plesiodimylus chantrei* (Fam. Dimylidae) and *Amblycoptus* (Tribe Anourosoricini, Fam.Soricidae). That has been explained as an adaption to similar diet, and thus similar environments.

P.chantrei is the most frequent species of Dimylidae in the Spanish record for Vallesian ages, and the longest survival species of the family for the Miocene in Europe, ranging from MN 4 to MN 11 (Ziegler, 1999). Despite of this, the Vallesian is the moment in which other groups arise, such as the shrews of the tribe Anourosoricini. The classical MN 9 localities in the Vallčs-Penedčs Basin (Can Llobateres, Can Ponsic I and Hostalets de Pierola Sup.) exhibit an assemblage in which *Crusafontina endemica* and *P.chantrei* represent a high percentage of the total insectivore remains. That means the beginning of the replacement which led until the complete substitution of the Dimylidae ecological niches by the Anourosoricine *Amblycoptus*. Finally, and from a biostratigraphical point of view, it is remarkable the end of MN 13 with the FAD of *Asoriculus gibberodon* (Tribe Neomyini, Fam.Soricidae). Althought it is present in classical MN 13 localities of other countries, it arrives to Spain close to the Turolian-Ruscinian boundary. Further research will shed light on the exact moment of arrival of this species to the Iberian Peninsula.

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Vegetation change during the Miocene in the Western Alpine area

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A palynological study has been carried out in several boreholes and sections along the Alpine arc during the Middle and Late Miocene (Fig. 1 & 2). A comparison of the pollen spectra has been done on samples from relatively close areas in France (Istres, Les Mées borehole, La Nčphe) and Switzerland (Haütligen, Montevraz, Le Locle and Nebelberg in the Bern and Fribourg areas). This comparison shows that samples from middle Miocene age are richer in megathermic and mega-mesothermic elements (such as *Avicennia* (mangrove), Caesalpiniaceae, Melastomataceae, Rubiaceae, Euphorbiaceae, *Buxus bahamensis*, Acanthaceae, *Bombax*, Arecaceae, Chloranthaceae, *Platycarya*, *Engelhardia*, Sapotaceae, Celastraceae, Taxodiaceae, etc.) than the ones from Tortonian age. The development of the mangrove (rich in *Avicennia*) in Southern France and Switzerland during the Miocene can be interpreted as corresponding to the Miocene climate optimum comparable to the lowest value of the $\delta^{18}O$ in Miller & Feigenson (1991). Therefore, cooler climate conditions are inferred for the Late Miocene.

Fig. 1. Distribution of the studied sites; 1: Istres area (Estagel & Bayanne sections), 2: Les Mées borehole, 3: La Nèphe section, 4: Bern & Fribourg areas (Montevraz, Haütligen, Le Locle & Nebelberg sections).

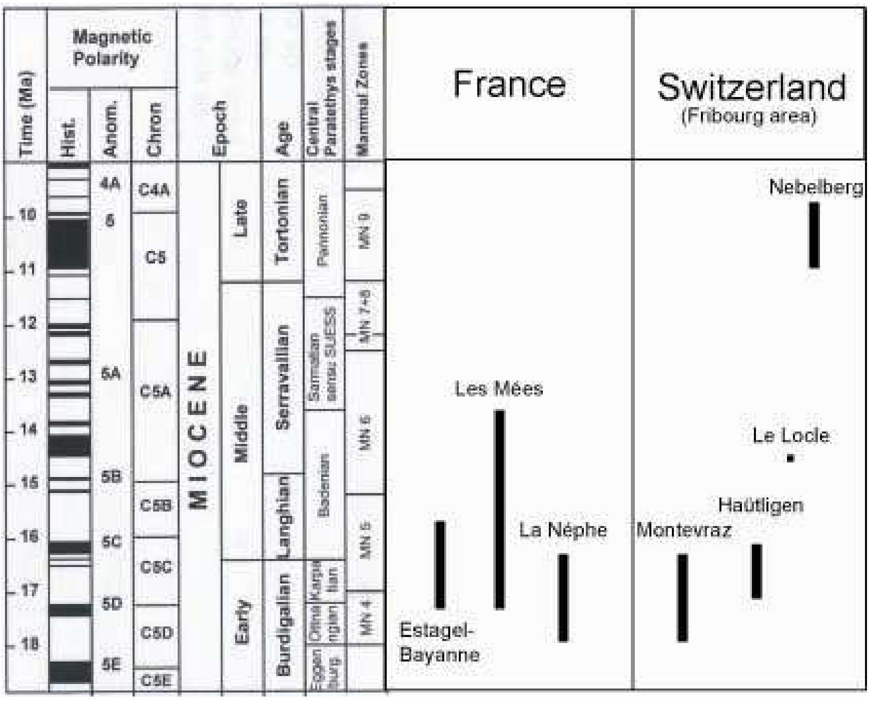

Fig. 2. Chronologic distribution of the studied sections and boreholes in the Alpine area.

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The Pannonian of the Styrian Basin - State of Knowledge

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The Styrian Basin is located at the southeastern margin of the Alps. The SW-NE trending South Burgenland Swell separates this basin from the Westpannonian realm. Internally basement spurs and swells divide it into several subbasins (Fig. 1). The basin filling can reach more than 4000 m and reflect trans- and regressions of the Central Paratethys from Ottnangian to Pannonian times and two phases of volcanic activity.

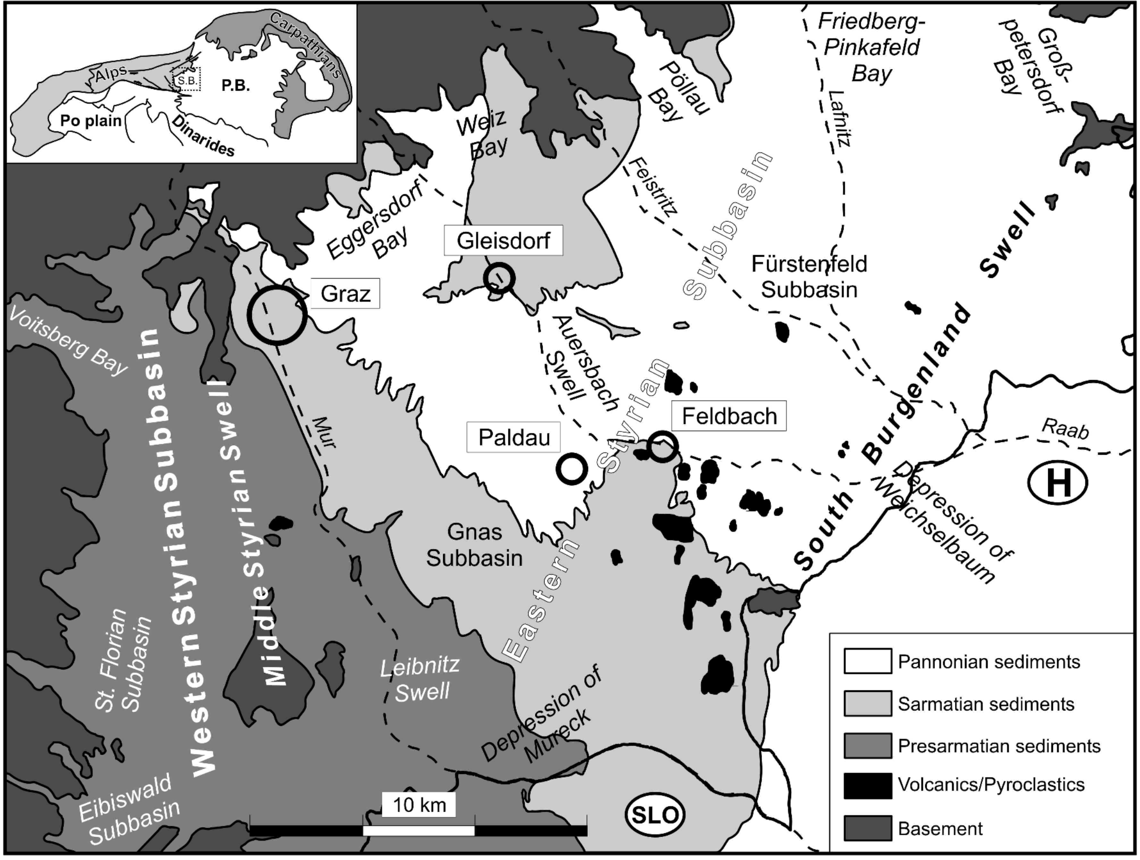

Fig. 1: Geological sketch of the Styrian Basin (S.B. = Styrian Basin, P.B. = Pannonian Basin).

Pannonian sediments are restricted to the Eastern Styrian Basin. They cover most of the area but are only a few hundred meters thick. Geological investigations approximately last for 150 years and exploration for hydrocarbon and thermal water reservoirs supplies a huge database. However these information often are unpublished and deal preferably with older rock columns and basin configuration. In recent times the need for correlating aquifers (e.g. public water supply) forced new stratigraphic research activities. >From paleontological and sedimentological point of view our knowledge of the Pannonian sediments is still fragmentary. Biostratigraphic division follows traditionally the “Papp-Zones”, especially based on the evolution of “*Congeria*” and the occurrence of the three toed horse *Hipparion*. Also other macrovertebrates (Mottl, 1970) and ostracods (Kollmann, 1965) are used for biostratigraphic investigations. But there are no modern publications on this topic. Recently sequence stratigraphic interpretations are available for central to distal basin areas (Kosi et al., 2003).

After a regression around the Sarmatian/Pannonian boundary, that seems to be related to a major eustatic sea level fall, most of the Eastern Styrian Basin was flooded by the brackish Pannonian Sea. Limnic pelits with rich occurrences of *Mytilopsis ornithopsis* form the lower part (Eisengraben Member) of the Feldbach Formation. The overlying coarsening upward sand-pelit-alternations indicate development of deltaic environment prograding towards the SE and are termed Sieglegg Member (Fig. 2).

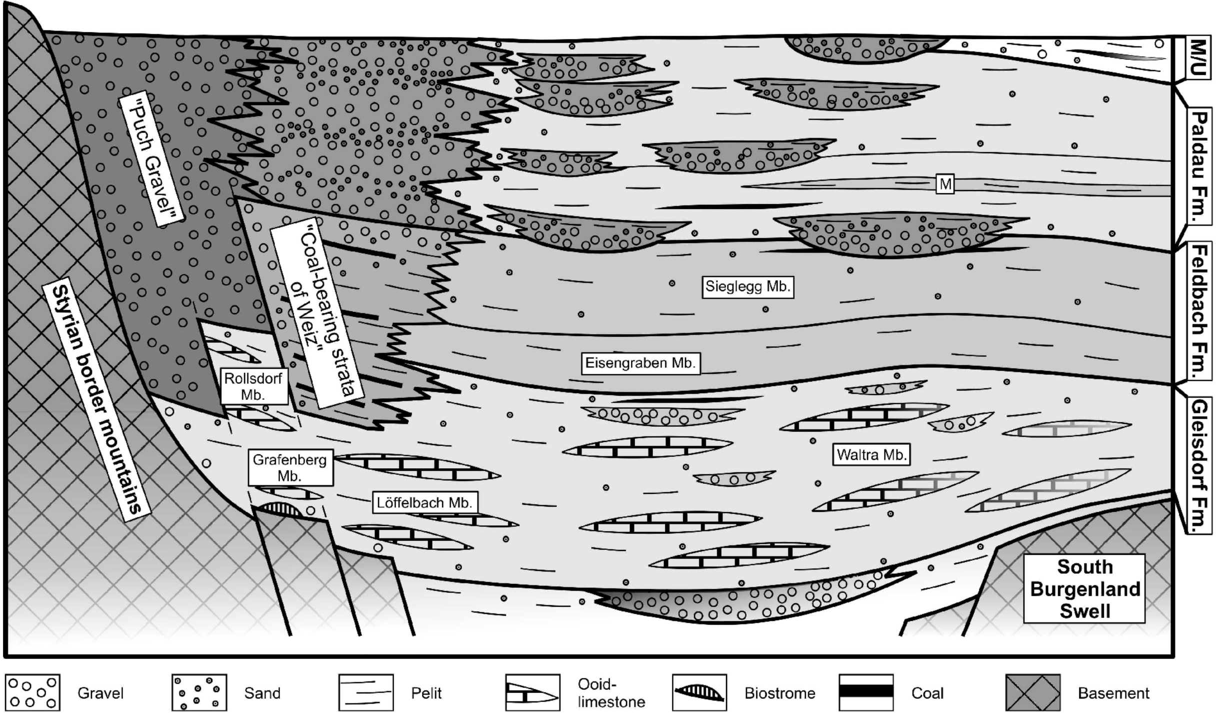

Fig. 2: Lithostratigraphic scheme of the Sarmatian and Pannonian rock column in a NW-SE-section through the Eastern Styrian Basin (M = Münzengraben Bed, M/U = Middle and Upper Pannonian strata; after Gross, 2003).

Afterwards (Upper Lower Pannonian) alluvial fans in proximal areas pass through the open basin into braided and subsequently into meandering river systems. In central position fluvial Members are closely related to limnic-deltaic environment. Many plant-bearing sites are known from these strata. In the lower part of this Paldau Formation (Münzengraben Bed) an ingression of the Pannonian Sea is proved by paleontological and sequence stratigraphic data. Autocyclic meander and delta lobe switching causes in connection with tectonic processes complex facies pattern. Some examples will demonstrate the lithological and paleontological contents of this Lower Pannonian units. New results of sequence stratigraphic investigations will be discussed.

Middle and Upper Pannonian sediments are known from the vicinity of the South Burgenland Swell. They consist of gravels, sand-pelit-intercalations and thin coal seams. Their bio-, litho- and sequence stratigraphic arrangement remains unclear up to now.

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Terrestrial environments and ecosystems during the HRI-2 in the Pannonian Basin – as interpreted on the basis of flora and vegetation

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Plants are quite suitable for the characterization of the former terrestrial ecosystems and environments. Plants are sensitive in responding to the change of climate and environment, i.e. the floral composition alters which results in the formation of various associations and vegetation types at various habitats.

During the HRI-2 of the Pannonian Basin a leaf-flora with a rather poor diversity can be found at several localities both at the western and eastern part of the basin, e.g. Dozmat, Iharosberény, Balatonszentgyörgy, Tiszapalkonya and sites in Transylvania. This flora is characterized by *Glyptostrobus europaeus*, *Alnus cecropiifolia*, *Byttneriophyllum tiliifolium.* In addition to the dominant taxa above few accessory elements with an extremely low number of specimens are recorded. Based on the ecological requirements of these taxa they must have formed a vegetation in swamp habitats.

Floras of fruits and seeds refer to an aquatic environment, like *Trapa praehungarica, nymphaea szaferi, Nuphar palfalvyi, Ceratophyllum, Lycopus* cf. *europaeus, Potamogeton sp., Stratiotes tuberculatus, Carex sp.* etc. This aquatic vegetation is known from relatively extensive areas of Visonta and Bükkábrány, from the aquatic, non-swampy areas of the former Pannonian Lake.

During the HRI-2 an additional floral assemblage is also significant in the Pannonian Basin which is characterized by *Platanus leucophylla*, *Liquidambar europaea*, *Alnus ducalis*, *Alnus gaudini* and *Ulmus*, *Populus*, *Salix* as accessory elements. These taxa must have existed in lowlands, in riparian or in gallery forests, thus they represent the remains of the former riparian vegetation. Localities yielding remains of this vegetation are known from Tihany and Győr. Another type of riparian vegetation was found near Sé where almost exclusively the leaf fossils of *Salix* were recorded.

All the three types of vegetation introduced above are intrazonal and edaphic, thus instead of the zonal climate first of all local edaphic factors, like the water balance and water table of soil, determinate their presence and formation. Since, during the HRI-2 the Pannonian Basin was characterized by these floras all over the basin it may be proper to suppose that there were no extensive terrestrial areas emerging out from the lake where zonal vegetation could have existed. Few traces of this vegetation were recorded only in marginal areas, e.g. Rudabánya, Mataschen, Nauhaus or in „inselbergs” like Aranyosgadány (Mecsek Mts.).

Intrazonal vegetation types are regarded as inadequate indicators of climate. Zonal vegetation types are much more useful from this point of view. Nevertheless, such taxa are recorded in these intrazonal vegetation types on the basis of which a subtropical climate is assumable. Among predominant swamp elements *Glyptostrobus* and *Byttneriophyllum* are thermophilous, as well as, *Smilax*, a subtropical liana occurring in the lowland floras.

In the Pannonian Basin, as it was mentioned above, remains of the zonal vegetation were recorded only in marginal areas and in „inselbergs”. In the nortern marginal areas, like in Rudabánya the occurrence of *Daphnogene* and *Engelhardia* proves the existence of thermophilous, subtropical taxa. In the western marginal areas the subtropical flora of Mataschen rich in lauraceous taxa refers to the survival of the subtropical flora in the Pannonian (see J. Eder in this volume).

The Late Miocene mollusc fauna of the classical sections Richardhof and Eichkogel in the Vienna Basin (Austria, Pannonian, MN 9-MN11)

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The sections Eichkogel and Richardhof represent two important reference faunas for the reconstruction of the Late Miocene continental faunas. New investigations with strong focus on the micro-vertebrate assemblages of the Pannonian in the Vienna Basin by G. DAXNER-HÖCK (NHMW) allow a rather precise dating of the Vallesian to Early Turolian faunas into the mammal zones MN 9 (samples Richardhof Golfplatz) and MN 11 (Eichkogel). In the literature the newly studied sections were often considered to be approximately of the same age and have been treated even as Pliocene. Up to now, the marly facies of the Late Pannonian along the margins of the Vienna Basin have been dated to the Pannonian "zone" H based primarily on lithological considerations. However, the actual dating based on the mammal assemblages documents a huge gap of about 2 ma between the faunas of Richardhof and those from the section Eichkogel. The dating implies rather steady conditions on the hinterland of the Vienna Basin adjacent to Lake Pannon throughout the Late Pannonian. Small-scaled "satellite-lakes" formed under more or less stagnant conditions. Pure freshwater settings clearly prevailed, whilst any influence by the highly aberrant water chemistry of Lake Pannon was missing. Therefore, the characteristic Lake Pannon melanopsids and congerias could not penetrate into the freshwater habitat. Elements of swift riverine settings such as *Unio atavus, Tinnyea escheri* or any theodoxids are completely missing in the fauna of the Richardhof and Eichkogel sections, indicating very low riverine influence. The investigation area along the eastern termination of the Calcareous Alps was obviously in a rather protected position.

A total of 84 species are documented for both sections. Of these, 58 are found at Richardhof and 71 at Eichkogel. Only 13 species (~15%) are unique to the Richardhof fauna, and 26 species (~31%) are recorded only from the Eichkogel. Of the 84 recorded taxa, 29 represent aquatic species and 55 terrestrial gastropods. This difference in the total numbers of documented species is easily explained by the much longer investigation history of the Eichkogel deposits, leading to an "overcomplete" documentation compared to the less exploited Richardhof. Furthermore, the material from Richardhof derives from a single section, whereas the Eichkogel fauna was collected for centuries in various strata and sections. The different compositions therefore probably partly reflect a sampling effect and thus reduce the expectations from a biostratigraphic perspective. However, some species do seem to bear some biostratigraphic significance. Among the species which are restricted in the Vienna Basin to the Vallesian zone MN9 are *Archaeozonites laticostatus* (SANDBERGER) and *Janulus* nov. sp. Similarly, *Pomatias conicum* (KLEIN) is unknown from Austrian localities younger than the section Richardhof (MN 9). In contrast, the otherwise mainly Pliocene *Fortuna clairi* appears in the Turolian fauna of the Eichkogel but is missing in the older Richardhof samples. Within the aquatic fauna, the obvious differences in composition are most probably ecologically triggered and should not be used for biostratigraphy. An exception might be *Prososthenia sepulcralis* (NEUMAYR & PAUL), which seems to be an index for the ecostratigraphic mollusc "zone" F in the Vienna Basin. However, the poor data on the exact dating of the non-Austrian occurrences renders a decision difficult if *Prososthenia sepulcralis* is confined to this level.

The faunas of both sections are strongly predominated by lacustrine species among the aquatic taxa, with *Bithynia, Anisus* and *Planorbarius* as characteristic snails. Among the terrestrial gastropods, woodland inhabitants predominate. Although these woodland inhabitants achieve only a rather small percentage of 50% of the total terrestrial species, the bulk of individuals represent this ecological group: *Zonites schaireri, Discus pleuradrus, Oxychilus, Aegopinella, Klikia* and *Tropidomphalus*. Additionally, more open area communities and meadows might be indicated at both sections by taxa such as *Vallonia* and *Cepaea*. Inhabitants of moist habitats were *Vertigo callosa* and *Carychium.* At both investigated sections the occurrence of *Potamon (P.) ibericum* coincides with that of *Melanopsis fuchsi* HANDMANN, which documents a very striking predation pressure based on numerous healed fractures of the body whorl. Although, molluscivore fishes such as cyprinids cannot be excluded as predators, it seems more likely that the fractures evidence a *Potamon-Melanopsis* relationship. The pattern of scars is highly reminiscent of that described by RUST (1997) for *Melanopsis* cf. *impressa* and *Esperania* cf. *acicularis* from the Pliocene of the northern Aegean Sea. These could be related to the decapod *Liocarcinus* sp.

Preliminary considerations on cyclic stratigraphy in the Pannonian of the Vienna Basin

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The Pannonian basin fill of the Vienna Basin attains up to 1500 m thickness. Lithologically it is characterised by a succession of coarse siliciclastic material alternating with pelitic layers. Due to hydrocarbon exploration, hydrogeological investigations and lignite mining a huge set of well data is available at date. However, up to now a log-log correlation throughout the Vienna Basin spanning the entire Pannonian succession is missing.
From the paleogeographical point of view, the Lower and Middle Pannonian deposits are related to the history of Lake Pannon, whereas the Upper Pannonian deposits reflect floodplain environments of the already dry Vienna Basin. The still active subsidence of the basin, however, allowed up to 500 m of Upper Pannonian sediments to accumulate. This development ceased in the Pliocene nearly completely due to basin inversion. Hence, a strong change in the log characteristics might be expected due to that change of the depositional environments from the Middle to Upper Pannonian**.**

The correlation of litho-log data with geophysical well-log data documents that the gravel/sand versus marl/clay successions of the Lower and Middle Pannonian correspond to about 16 distinct lake-level fluctuations which can be correlated throughout the basin. In the Upper Pannonian deposits a corresponding cyclicity is caused by successions of floodplain deposits alternating with braided river systems. The supposed cyclicity is most striking from 11.2 to 10.5 my and during the Late Pannonian starting at 10 my. In both intervals the cycles are regular coarsening upward cycles of 20-40 m thickness, reflected by serrated funnel shaped geophysical logs with sharp top. A comparison with Lower Pannonian wire-logs from the Styrian Basin furnished evidence, that this cyclicity is also fully developed outside the Vienna Basin, excluding local phenomena such as tectonics as driving force. These cycles are attenuated during the initial transgression of Lake Pannon in the Lower Pannonian and during its maximum extent in the upper Middle Pannonian.

Therefore, despite the different depositional environments, the cyclicity influencing the sedimentation in the Late Miocene Vienna Basin seems to continue but is conflicted by major events of lake history. However, the poor timing of large parts of the Pannonian deposits renders an interpretation of the driving force difficult. To solve this problem we focussed on the basal Upper Pannonian (Pannonian F according to local letter zonation), which offers the best magnetostratigraphic and biostratigraphic framework.

All wire-log and litho-log well data indicate that this lignitic series displays a uniform development in all parts of the basin, falling apart into 3 depositional cycles. These start with lignites and/or pelites and terminate in gravel and sand with fluvial sedimentary geometries. The corresponding mammal faunas derive from Götzendorf/Sandberg (2nd cycle) and Stixneusidel (3rd cycle). Götzendorf/Sandberg is calibrated by magnetostratigraphic data with the basal part of Chron C5n1n; underlying pelites are correlated to Chron C5n1r. The next available mammal fauna with magnetostratigraphic feedback derives from Vösendorf/Inzersdorf which lies in the upper part of Chron C5n2n and is already dated as Middle Pannonian. The "intervening" assemblage of Richardhof/Golfplatz is thus a candidate for the first cycle, but this correlation needs further confirmation. The slightly younger mammal fauna from Richardhof/Wald yields assemblages of the MN10 and is tentatively placed in chron C4Ar3n based on a normal polarity signal and the evolutionary level of the fauna. It is already younger than the 3rd cycle.

Considering this frame of data, the three cycles of the so-called lignitic series (Pannonian F = *Mytilopsis neumayri* Zone) seem to cover the time between ~10 and ~9.7 my. This, however, suggests a strong control by eccentricity cycles. A preliminary calibration to astronomical target curves indicates that the interval corresponds to a 400-kyr eccentricity maximum, including 3 strong amplitudes of the 100-kyr cycles.

Starting from that correlation we will attempt to extend this integrated stratigraphy to the entire Pannonian succession. First analyses suggest gaps in sedimentation during the Upper Pannonian during parts of the MN10. These gaps are also indicated by "irregularities" in the rhythm of sedimentary cycles. In contrast, the Lower and Middle Pannonian deposits seem to represent a rather continuous succession, which – based e.g. on the *Hippotherium* date – might allow a more detailed internal "real time" calibration.

The muddy bottom of Lake Pannon - a challenge for dreissenid settlement (Late Miocene; Bivalvia)

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The Late Miocene dreissenids of Lake Pannon – a long-lived eastern-central European lake – bear witness to two very different modes of life, which allowed these bivalves to successfully settle in what appears to be an inhospitable environment. The considered dreissenid paleocommunities formed during the Pannonian "Zone E" sensu Papp (1951a) or the *Spiniferites paradoxus* Biochron sensu Magyar et al. (1999a). At that time Lake Pannon attained its maximum areal extent, which can be roughly estimated at about 280,000 km^2. The rapid transgression seems to coincide with the establishment of oxygen-deficient muddy bottoms which provoked the development of especially adapted settlement strategies. Dreissenids are, at least as juveniles, bysally attached epibionts. The offshore environment of

Lake Pannon, which is dominated by muddy bottoms of clay and silt devoid of pebbles and clasts, is a poor base for byssate bivalves. Nevertheless, the mass occurrences document the ability of some species to compete for the sparsely available hardsubstrata.

One strategy represents r-strategists which tend to produce temporal boom-&-bust populations during ”time-windows” of improved ecological conditions. This guild is restricted to the genera *Mytilopsis* Conrad, 1858 and *Sinucongeria* Lőrenthey, 1894. Thin shellbeds of articulated *Sinucongeria* can be traced in contemporaneous outcrops across more than 800 m distance and seem to have covered enormous areas of the Vienna Basin, revealing them to be even more gregarious than most extant aquatic pest species such as *Dreissena polymorpha* or *Dreissena bugensis*. *Sinucongeria primiformis* and *Mytilopsis czjzeki* most likely fed on planktonic algae and zooplankton. The breakdown of populations after the sudden blooms might also be related to declining food resources. The excess of adults within the pavements might thus be explained by competition of already established animals with their larvae, hindering larval settlement on living colonies. The lack of population refreshment by juveniles would ultimately result in a population decline. There is no sedimentological feedback within these pavements which points to accelerations or slowing of the sedimentation rates. Therefore, the preservation of the articulated shells is hardly explained by rapid burial but might rather be correlated with low oxygenation and low energy conditions in the hypolimnion of Lake Pannon. Indeed, shell cavities are commonly incrusted with pyrite or marcasite, pointing to anoxia as a reliable cause both for their sudden death as well as for the missing displacement through bioturbation. There is an obvious pattern in the occurrence of such shell beds, which gather in four cycles. This cyclicity may be correlated best with orbital forcing, which caused periodic changes in the epilimnion/hypolimnion relation in the offshore zone of the Vienna Basin. The climatic back-lash within each cycle was answered by the formation of a more stable hypolimnion with oxygen-depleted bottom conditions, which hindered *Mytilopsis* and *Sinucongeria* from settlement.

Thus, extreme and short-lived environmental changes favoured these opportunistic species, which are typical within the dreissenids. K-strategists, however, could hardly compete within this unfriendly environment without developing special adaptations. Within that group, the genus *Congeria* Partsch, 1836 is most striking. Despite this rather unfriendly environment, the high number of heavy, full-grown individuals shows that *Congeria subglobosa* flourished and was optimally adapted to this kind of habitat. The paradox of the proliferation of a single species, characterised by extreme size and weight, in a muddy, oxygen-deficient lake environment avoided by nearly all other molluscs points to a ”hidden” mechanism not accessible to other species. The byssal/pedal gap of *Congeria subglobosa* is well developed, thus the shell was always open toward the bottom sediment, forming a considerable loop of up to 22 mm length and up to 11 mm width. Such a huge ”pseudo-byssal gap” would have meant excessive byssal attachment and is in harsh contrast to a muddy sediment without pebbles, sand grains or secondary hardgrounds. This discrepancy clearly indicates that this derived byssal gap has to be put in the perspective of another functional morphology. Moreover, the shells are often enclosed by pyrite concretions, indicating oxygen-depleted environments, which favoured the accumulation of sulphides in the sediment. The hypertrophied shell points to a surplus of available energy that was comfortably used for mineralisation. Hypertrophied bivalve shells are commonly explained as a result of symbiotic interaction with chemo- or photosynthetic micro-organisms. Indeed, based on the sediment- and biofacies analysis *Congeria subglobosa* was frequently habituated to environments with low light content. A symbiosis with photosynthetic organisms is therefore unlikely. In contrast, by utilising reduced sulphur as an energy source the chemosynthetic symbiontic bacteria present in the tissue of many bivalve groups highly benefit from reduced, sulphide-rich sediment and dissolved sulphide from interstitial water. In conclusion, *Congeria subglobosa* – in contrast to other herein described dreissenids – shows all features of a typical, highly adapted K-strategist which managed to settle otherwise poorly inhabited lake environments.

The remarkable distribution pattern of dreissenid bivalves on the muddy bottom of Lake Pannon during the Late Miocene is obviously triggered by the repeated but short-lived establishment of conditions favouring the sometimes even gregarious settlement by larvae. Nevertheless, the presented settlement types hardly co-occur, but rather seem to prove the ability of each species to settle very distinct habitats that are otherwise avoided by most other taxa. A rough succession of the *Mytilopsis spathulata* > *Congeria subglobosa* > *Mytilopsis czjzeki/Congeria zsigmondyi* > *Sinucongeria primiformis* assemblages can be documented during the Pannonian "Zone E" in the Vienna Basin. This succession is clearly linked to the changing bottom conditions due toe the rise of the lake level during a TST.

Late Pannonian Wetland Ecology of the Vienna Basin based on Molluscs and Lower Vertebrate Assemblages (Late Miocene, MN 9, Austria)

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The final disruption of marine connections and the disintegration of the Eurasian Paratethys Sea into several repeatedly isolated basins led to the formation of Lake Pannon during the Late Miocene. Extensive fresh-water discharge into the Pannonian basins altered the composition of the water-body from a Late Sarmatian "mature", maybe hypersaline and calcium-oversaturated sea into a hyposaline brackish water environment. The endemic mollusc fauna of that lake is extraordinarily well documented by numerous systematic papers, yielding an elaborated biostratigraphic concept. Hence, geologists often associate the term Pannonian solely with the deposits of the vast European lake system that originated at the Middle Miocene/Late Miocene boundary from the land-locked Sarmatian Sea but neglect the associated wetland deposits.

Lake Pannon experienced its maximum extension during the *Mytilopsis czjzeki* Zone (letter Zone E of Papp 1951) correlating with chron C5n2n. The corresponding sedimentary sequence is characterised throughout the Vienna Basin by predominantly pelitic deposits yielding a diverse endemic mollusc fauna. The subsequent highstand systems tract that became installed during the upper part of that zone triggered a beginning backstepping of the shoreline towards the basin. Thus, a fringe of freshwater lakes could establish along the margin of the Eastern Alps, probably already during the latest *Mytilopsis czjzeki* Zone, whilst the floodplains of the basin could not develop before the final withdrawal of Lake Pannon. The slight differences in the evolutionary levels of the smaller mammal assemblages between the "marginal" Richardhof and those of the "basinal" Götzendorf/Sandberg observed by G. Daxner-Höck (pers. comm.) might be explained by this diachronous establishment of freshwater settings in the Vienna Basin. With the dawn of the Late Pannonian (*Mytilopsis neumayri/Mytilopsis zahalkai* Zone), the lake completely retreated from the Vienna Basin and established its north-western coast in the Hungarian basins. Consequently, the drainage systems from the Alps and the Molasse Basin entered the Vienna Basin and formed extended floodplains. The course of the main river anastomosed roughly from NW towards SE across the Vienna Basin. It left the Vienna Basin through the Bruck Gate between the Leitha Mountains and the Hainburg Mountains and continued into the Pannonian Basin.

The river divided the Vienna Basin into a northern and southern part. Its gravel load of the main channels is hardly preserved in surface outcrops (e.g. Prottes, Lower Austria) and a precise correlation with the ecozones is difficult. By contrast, the associated floodplain deposits are well preserved in the southern and northern part of the Vienna Basin. Small tributaries, rivulets and floodplain lakes, as suggested for Götzendorf/Sandberg, structured the wetland of the southern region. The swift rivulets carried oligotrophic, probably calcium-deficient water. Large stocks of *Margaritifera flabellatiformis* and the giant salamander *Andrias scheuchzeri* populated the bottom of the rivulets; the pebbles of the banks gave shelter to masses of *Theodoxus postcrenulatus*. Floodplain lakes and oxbow lakes settled by water chestnuts, pond weeds, numerous planorbids and newts passed into swamp forest and water meadows covering the interdistributary areas. In the northern Vienna Basin, similar swamp vegetation with *Nyssa* and *Glyptostrobus* is documented from the Čáry Formation.

Along the slope of the Alps, the influence of the main channel declined distinctly. The lakes and swamps, indicated by the fauna of the section Richardhof, were probably provided with drainage from the adjacent Calcareous Alps. Stagnant lakes with dense vegetation and a manifold herbivorous gastropod fauna developed. A supply of hard water from the Alps and the activity of characeans allowed the formation of marly deposits. Lotic environments are less important in this marginal setting. Consequently, rheophilic species such as the olm *Mioproteus caucasicus* or the gastropod *Theodoxus postcrenulatus* are distinctly less frequent or even absent. Instead, xerophilic taxa such as the lizard *Lacerta* and the xerophile and/or calciphile gastropods *Granaria* and *Truncatellina* are frequent constituents of these assemblages, because of the proximity of the sunny and dry slopes of the Alps.

Change and Continuity in Rhinoceros faunas of Western Eurasia from the Middle to the Upper Miocene

Heissig, K.

The diversity and species composition of rhinoceroses is compared in three regions of different faunal history. In Central Europe there is more continuity than change, not only from the Astaracian to the Vallesian, but also into the early Turolian. In Anatolia there is an abrupt break; no Middle Miocene lineage survives the beginning of the Vallesian, but the change to the Turolian occurs only on species level. In the Siwalik fauna, however, there occurs a gradual shift from the late Chinji to the Nagri beds, which is inverted during the more accentuated change to the Dhok Pathan. Nevertheless there is no fundamental change, but only a continuous decrease of diversity.

Western Europa shows a pattern comparable to Central Europe, but with some differences in Southwestern France and the Iberian peninsual. Eastern Europe is not yet thoroughly studied. Its development seems to be intermediate between Central Europe and Anatolia. There occur new Asian genera, but the date of their first occurrence is not quite clear. On the other hand the presence of *Lartetotherium* and *Aceratherium* in the Vallesian reminds the Central European faunas.

MN-Zone	Western Europe	Central Europe	Anatolia	Siwalik-Region	Siwalik Group
MN 11-13	■ ● □	■ ● □ ◊	◊ ► ► ▲ □	◄ ▄ #	Dhok Pathan
MN 9-10	◙ ■ ± □	■ □ ● ▄ ◙ ± *	◊ ▲ ■ □ ◄	+ ▄ ◄ ◘ ¤	Nagri
MN 7-8	◙ ● ±	▄ ± ◙ ● *	Δ ▄ ◙	+ ¤ ▄ ◘	Upper Chinji
MN 6	● ◙ ± ▄	▄ ● ± ♦ ◙ *	Δ ▄ ●	+▄ ¤ ◘	Middle Chinji

Fig. 1: Distribution of rhinocerotid genera during the Middle and Upper Miocene of Europe and Western Asia.

● *Hoploaceratherium*
■ *Aceratherium (Aceratherium)*
◙ *Aceratherium (Alicornops)*
▲*Acerorhinus*
◄ *Chilotherium (Subchilotherium)*
► *Chilotherium (Chilotherium)*
♦ *Prosantorhinus*
▄ *Brachypotherium*
◘ *Aprotodon*

± *Lartetotherium*
\+ *Rhinoceros (Gaindatherium)*
\# *Rhinoceros (Rhinoceros)*
* *"Dicerorhinus" steinheimensis*
□ *Dihoplus*
◊ *Ceratotherium*
Δ *Begertherium*
¤ *Caementodon*

The number of symbols corresponds to the number of species of the genus.
The symbols are arranged according to the frequency, decreasing to the right.

In nearly all the regions considered there is a diversity peak in the Vallesian, followed by a stepwise decrease in species number through the Turolian, with a breakdown at the end of Miocene by the loss of all Aceratheriini and Teleoceratini in Eurasia. This is also true for Anatolia, where the species number shown in the table corresponds to the lower Turolian, whereas in the uppermost Turolian, besides *Ceratotherium*, there survives only one *Chilotherium* species and *Acerorhinus* has disappeared already. The Turolian diversity in Central and Western Europe is generally biased by the few number of good loaclities, rhinoceroses forming only a small part of Turolian faunas. The best represented is Dorn-Dürkheim with three species. The presence of *Ceratotherium* in the Vienna Basin adds a fourth species to the list.

The diversity changes are clearly dependent of climatic conditions in the Siwaliks, where only a few bigger mammals immigrated from elswhere. A detailed analysis showed a fluctuation of more humid and more dry climates, affecting some sort of patchwork landscape. The result was a shrinking and growing of dry and wet areas and their special vegetation. Taking the generally low crowned Rhinocerotini as consumers of soft vegetation and the more high crowned genera *Subchilotherium* and *Aprotodon* as consumers of dry herbs and coarse shrubs the frequencies of species show some undulating pattern from intermediate conditions in the Lower Chinji to more dry conditions in the lower part of the Middle Chinji, in the upper part again intermediate and a maximum of humidity in the Upper Chinji. The Nagri formation shows again humid conditions with a rapid shift to the Dhok Pathan where rather dry conditons prevail. *Brachypotherium perimense* is most frequent in times of transition and rare during most humid and most arid times. So this species indicates in the Nagri formation the beginning of less humid conditions.

In Western Europe *Hispanotherium matritense* the last rhinoceros with high molar crowns disappeared already in the lower part of the Middle Miocene. During its higher part all species are low crowned and indicate more or less humid conditions. Also the "intermediate" *Brachypotherium* disappears soon. So the rhinoceroses are restricted to humid environments and their frequency within the whole faunas decreases more and more. In Central Europe there are no rhinoceroses adapted to dry conditions. The increasing frequency of *Aceratherium (Alicornops)* and *Aceratherium (Aceratherium)* does not rule out *Hoploaceratherium*, which is thought to be adapted to wet places. The Vallesian is marked by the immigration of *Dihoplus*, probably from Africa. The single specimen of *Ceratotherium neumayri* near Vienna shows some influence from the East.

No Middle Miocene species survives into the Upper Miocene of Anatolia. Middle Miocene faunas are dominated by high crowned Elasmotheriini, whereas European species inhabitated the few more humid places. Both groups are replaced by immigrants in the Vallesian, the African *Ceratotherium* and *Dihoplus*, the Central Asian *Acerorhinus* and the South Asian *Subchilotherium*, all less adapted to dry environments than the Elasmotheriini. The only rhinoceros of more humid places, *Dihoplus pikermiensis* is very rare. It disappears in the early Turolian as well as *Acerorhinus*, whereas *Subchilotherium* ist replaced by *Chilotherium. Ceratotherium* shows progressive development of higher molar crowns and cement. Probably other factors as humidity have been responsible for these changes.

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Palaeoenvironmental History of the Vallesian and Early Turolian reflected by vertebrate assemblages of the Vienna and Pannonian Basins

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The palaeogeographic distribution and lake level changes of the Lake Pannon is closely related with the development of different wetland environments throughout the Pannonian. A major regression at the Sarmatian/Pannonian boundary (11,5 Ma) caused progradation of braided deltaic systems along the margin of the Alps. The lake level rise during the Early Pannonian (letter Zones C-E Papp 1951) culminated in a last highstand (letter Zone E). With the beginning of the Late Pannonian (letter Zone F /around 9,9 Ma) the Lake Pannon retreated from the Vienna Basin to the East and a fluvial system and freshwater lakes established in the flat area of the basin.
From this region some rich vertebrate assemblages are known. They represent a chronological sequence from MN9 to MN11 and give insight in different environments and climatic conditions throughout the Vallesian and the Early Turolian.

The Vallesian rodent assemblages (1. -3.) of the Vienna Basin are characterized by highly diverse Petauristid-Sciurid-Glirid-Eomyid associations, by the large flying squirrel *Albanensia* and by the highly specialized cricetid *Microtocricetus.* Among large mammals *Hippotherium primigenium, Tetralophodon longirostris, Deinotherium giganteum, Aceratherium incisivum*, *Dorcatherium naui* and the antelope *Miotragocerus pannoniae* are most representative.

1. Hennersdorf, Vösendorf, Inzersdorf and Richardhof-Golfplatz (Early Pannonian, MN9): The faunas represent wetland and forested environments in the western margin of the lake Pannon (end of the last highstand; letter Zone E). LOD of a small *Megacricetodon* and FOD of *Eozapus* (in Richardhof-Golfplatz).
2. Götzendorf and Stixneusiedl (Late Pannonian, upper part of MN9): The faunas represent wetland environments in the eastern part of the Vienna Basin. After retreating of the lake Pannon a fluvial system crossed the basin. Vast floodplains and freshwater lakes accompanied by dense vegetation were established. FOD/LOD of *Anapithecus* in (Götzendorf).
3. Richardhof-Wald (Late Pannonian, lower MN10): The fauna represents forest environments close to freshwater lakes along the slopes of the Alps. FOD of murids (*Progonomys*), LOD of the large flying squirrel *Albanensia* and the cricetids *Eumyarion, Democricetodon, Microtocricetus* and *Anomalomys*.

The Turolian vertebrate assemblages Kohfidisch and Eichkogel (Late Pannonian, letter Zone H; MN11) are characterized by Murid (*Progonomys* and *Parapodemus*)-Cricetid (*Kowalskia*) dominated associations and by FOD of *Hystrix, Epimeriones, Vasseuromys, Graphiurops, Myomimus.* In the Early Turolian the number of carnivora (Hyaenidae) and ruminantia increased dramatically (11 ruminant species from the locality Kohfidisch/Turolian versus 6 species from 4 Vallesian faunas in Austria - VISLOVOKOVA pers. comm.).

Conclusion: Throughout the Early Vallesian (MN9) mammal assemblages remained relatively stabile. During the Late Vallesian (MN10) a significant change in abundance and diversity of mammals happened in the Vienna and Pannonian Basins. MN10 is the interval of 38% LOD and 12 % FOD of rodent species. 25% rodent FOD were observed in MN11, whereas only 25 % rodent species range from MN9 to MN11.

Vallesian (MN9 and the beginning of MN10): Rather humid forested environments and warm temperate climate are indicated by the arboreal Petauristid-Sciurid-Glirid-Eomyid assemblages, by the primate *Anapithecus* and by the salamander *Andrias scheuchzeri.*

Early Turolian (MN11): The dominance of ground-dwelling rodents *Kowalskia* (Cricetidae), *Progonomys* and *Parapodemus* (Muridae), the diversity of ruminants, and the occurrence of *Hystrix* hint to more dry conditions, a seasonal climate and to relatively open woodland-environments.

Distribution of planktonic and benthic foraminifera in correlation with calcareous dinocysts derived from the Devínska Nová Ves clay pit and their evidence for environmental reconstruction, sequence and biostratigraphy

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Mediterranean Sea and the intracontinental Paratethys formed as new marine realms during the Late Eocene. From the Oligocene through the Miocene the Paratethys underwent a complex evolution that produced deep environmental changes. The SSW-NNE oriented Neogene Vienna Basin represent a typical pull-apart basin situated along tensional fault zone between Eastern Alpine- and Western Carpathian mountain chains and the Bohemian Massif. The basin was filled by Miocene, Pliocene and Quaternary deposits. Lower and Middle Miocene sedimentation started in marine conditions. The traces of Middle Badenian transgression followed by a regression cycle are well distinguishable in the whole basin. The Late Badenian transgression caused a widening of the depositional areas towards the north with the sedimentation of shallow - marine character (Kováč 2000). The offshore sediments mostly consist of marine greenish, grey to dark grey calcareous clays of the Studienka Formation (Spička 1969).

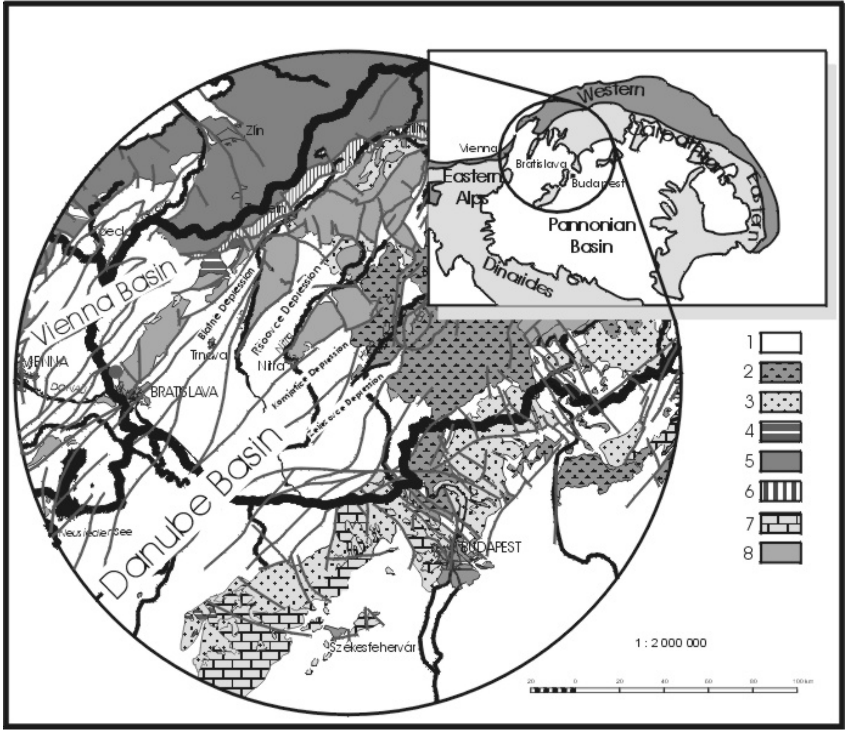

Fig. 1. Studied locality

Abandoned brickyard near the Devínska Nová Ves (Fig.1) encovers several etages of the Late Badenian sedimentary sequence. In the last time these sediments were investigated in great detail with respect to sedimentology, paleobiology, biostratigraphy, sequence stratigraphy (Hudáčková & Kováč, 1997). The sequence studied (Fig. 2) consisting of over twenty meters thick sequence of laminated grey clays to claystones and green-grey marls to marlstones rich in fossil remnants: nannoplankton, planktonic and benthic foraminifera, moluscs, fish skeletons and otholites as well as a rare flora fragments. The laminated clays comprised several apparently massive, bioturbated intervals. The laminae are 0,3 to 1,8 mm thick; they are formed by greenish grey clay with fine skeletal debris alternating with dark grey bituminous clay. This kind of alteration indicates seasonal climate with changing rainy season with stronger terrigenous input and more dry time intervals with raised organic matter productivity (Michalík et al. 2002). Late Badenian age of Studienka Formation was determined by the foraminifera assemblages belonging to the *Bolivina*/*Bulimina* Zone and nannofossils of NN6 Zone (Kováč & Hudáčková 1997). The presence of *Bolboforma* species (Protophyta, incertae sedis) characteristic for *Bolboforma badenensis* Zone (Spiegler & Daniels 1991) determined also its Late Badenian age (Banasová 2003). Numeric sequence age 13.58 Ma was performed on Sr ^{86}/Sr^{87} ratio in tests of *Pappina neudorfensis* (Toula) (Hudáčková & Kráľ 2000).

Foraminifera, calcareous nannoplankton and calcareous dinocysts represent planktonic remnants. The planktonic foraminiferal assemblage consists mainly of *Globigerina bulloides* and *Gl. diplostoma* supplemented by several benthic species. Benthic assemblages altered planktonic ones consist mainly of *Bolivina dilatata maxima*, *Uvigerina* sp. div. and *Pappina neudorfensis*.

The calcareous nannoplankton assemblages are rich in *Reticulofenestra* species (*R.minuta* Roth, *R. haqii* Backmann, to a lesser extent *R. pseudoumbilica* (Gartner), *Coccolithus pelagicus* (Wallich) Schiller. Common in occurrence are *Calcidiscus premacintyrei* Theodoridis, *Helicosphaera walbersdorfensis* Müller, *Helicosphaera wallichii* (Lohmann) Bodreaux-Hay, *Sphenolithus abies* Deflandre, *Holococcolithus macroporus* (Deflandre) Roth, *Rhabdosphaera sicca* Stradner, *Syracosphaera pulchra* Stradner, *Braarudosphaera bigelowii* (Gran&Braarud) Deflandre, *Micrantholithus vesper* (Gran&Braarud)Deflandre. *Rare are Triquetrorhabdulus rugosus* Bramlette-Wilcoxon, *T. rioi* Olafsson. In the sample 7 was observed sporadic *specimen Discoaster exilis*, which could be evidence of a deep episode. Calcareous nannofossils correspond with nanoplankton Zone NN6 Discoaster exilis (Martini 1971), Upper Badenian of the Central Paratethys. On the basis of detected nannofossils could be stated shallow water shelf environment. High number of *Braarudosphaera bigelowii* and *Micrantholithus vesper* specimens indicate decreased salinity of the basin in the upper part of the section.

The Studienka Formation clays have been investigated for their calcareous dinocyst content for the first time. The diversified dinocyst associations consist of genera as follows: *Bicarinellum*, *Calciodinellum*, *Calcicarpinum*, *Calciperidinium*, *Calcigonellum*, *Praecalcigonellum*, *Gonellum*, *Dimorphosphaera*, *Retesphaera*, *Bitorus*, *Pentapharsodinium*, *Caracomia*, *Saumuria*, *Sliteria*, *Pirumella*, *Pithonella*, *Scripsiella* and *Rhabdothorax*. Besided a diverse calcareous dinoflagellate cyst population, Bolboforma species of the *Bolboforma badenensis* Zone belonging to Protophyta (incertae sedis) was observed in the section studied. Rich holoturian (?) and sponge spines as well as less abundant organic wall dinoflagellates were identified too.

The ecological significance of benthic and planktonic foraminiferal species from the deeper water facies of the Studienka Formation was investigated through quantitative analyses; abundance curves were plotted for species and groups of species with similar ecological significance. Assemblage structures and environmental stress were investigated through the diversity indices (Hudáčková and Spezzaferri 2002). According the authors mentioned above, during the nannofossil NN6 Zone the sediments of Slovak part of the Vienna Basin were deposited in a water depth fluctuating from the inner to the outer shelf. The deepest intervals are recorded at the base and at the top of the studied section with a deep episode also in its middle part. Planktonic assemblages indicate a paleoclimatic trend from warm to more temperate conditions from the bottom to the top of the section during nannofossil NN6 Zone based on lower abundance of the *Globigerinoides* and *Praeorbulina*-

Orbulina groups. Data of planktonic foraminifera suggest also higher productivity in the upper part of the water column during the NN6 Zone, which is probably related to high nutrient availability. Generally increased organic carbon flux to the bottom and lower oxygenation of the sea floor were the consequence of high productivity.

Benthic foraminiferal assemblage investigated indicate that the sea floor was characterized by suboxic episodes, as is shown by positive excursions in *Uvigerina* abundance at the base of the section. Decreased oxygen levels (enhanced suboxia-dysoxia) at sea floor may have also occurred. This interpretation is supported by a drastic decrease in abundance (and sometimes disappearance) of benthic foraminifera and by sedimentological evidence such as cyclic dark lamination indicating a stagnant environment in the upper part of the section.

The stable isotopic composition was studied in both, the planktonic and benthic foraminiferal tests. Oxygen and carbon isotope data were compared with relative abundance of planktonic and benthic foraminifera. Study shows high positive oxygen isotope ratios of planktonic (-1.22 to +0.97 ‰ PDB) and of benthic (+1.5 to +2.11‰) foraminifera tests. However differences between $\delta^{18}O$ of planktonic and benthic tests are relative wide (1 to 2 ‰ linked with temperature fluctuation between 4 and 8 °C) and they could response either the stratification of water column and water composition or climatic variation. The $\delta^{18}O$ values of planktonic tests co-vary better with relative amount of temperature/depth related tests and could suggest adaptive response of foraminifera to climatic changes. The values of $\delta^{18}O$ measured in benthic species are generally high and could indicated glacial episodes which were interpreted in post Eocene climatic history.

Carbon isotope ratios are relatively low, respective negative; values of –1.33 to – 0,25 ‰ (PDB). The planktonic tests were more negative (–1,33 to – 0.36 ‰) however, the positive value in the sample N. 28 (1,19 ‰) could indicates a basic change in surface water composition. Negative values document enrichment on the light C (C^{12}) that generally is released into the water by biochemical decay of organic matter. Increased content of organic matter in water and sediment change the water environmental features (nutrient, redox, etc.) visible also through lithological variation. Nevertheless, there are also other interpretation of $\delta^{13}C$ depletion possible here (e.g. large meteoric water income (climatic response), vital effect, a role of symbiotic photosynthesised alge and other). The data obtained should be approved by next more detail isotope study.

All here recognized dinoflagellate cysts are benthic hypnozygotes, which remained as „resting cysts“ at the bottom. High diverse calcdinocysts association dominated by fine crystalline morphotypes is presumed to characterise the inner shelf environments. Most of the obliquipithonelloid cysts of the section studied have walls of small calcite crystals which corresponds to warm-water conditions. Predominance of obliquipithonelloids over all of another morphostructural types and presence of *Sripsiella regalis* and *Bolboforma badenensis* prove the transgressive conditions during the time interval studied and postulated outer shelf environments. Transgressive to high stand conditions is mirrored also in high diversity of morphotypes, due to the mixing of autochthonous and allochtonous oceanic taxa. Cooling trend indicated by change in composition of foraminiferal associations (Hudáčková & Spezzaferi 2002) is correlable with onset of dinoflagellates representing by: *Caracomia, Calciodinellum* and *Calcigonellum*. The compositional change in dinoflagellate association may be seen as a reaction on cooling. It coincides with the 3rd order sea-level eustatic fluctuation.

The correlation of calcareous dinoflagellate and foraminiferal associations shows that:

1) Intervals rich in planktonic foraminiferas contain rich and diversified associations of calcareous dinocysts.
2) Intervals rich in benthic foraminifera coincide with less abundant and less diversified dinocyst associations.

3) In dysoxic intervals which are lack in foraminifera, dinocyst associations persist still abundant. Nevertheless, the composition of dinocyst associations changes. *Scripsiella* forms (typical for cooler and more saline zones of the recent marine environments) dominate.

Lithology, stable isotops, microfaunal and microfloral spectra determine the sedimentation in a relatively stable deep neritic environment (around 200 m), with stratified water column and fluctuation of oxygen content (alternation of dysoxic and anoxic bottom conditions). The results obtained and paleoecological interpretation based on distribution of selected calcareous microfossil associations coincide very well with those shown by bivalves, fish and otolithes.

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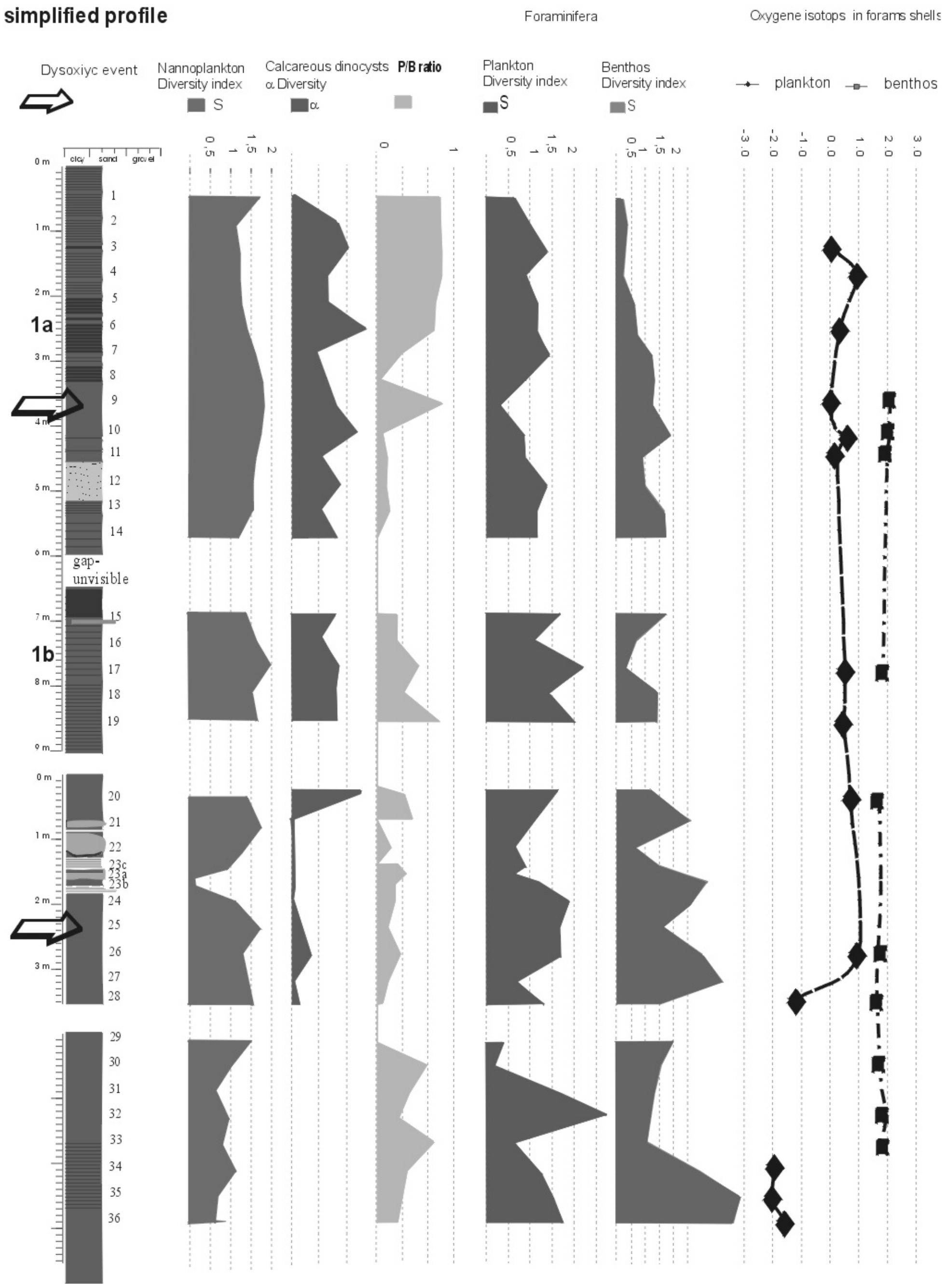

Fig. 2. Simplified lithological profile with distribution of the studied fossils, compared to $\delta^{18}O$ values content in planktonic and benthic foraminiferal tests. Diversity indices of the fossils were counted in according to Simpsons formula, except of calcdinocysts, where α diversity was used.

Database processing: fosFARbase a new relational online database

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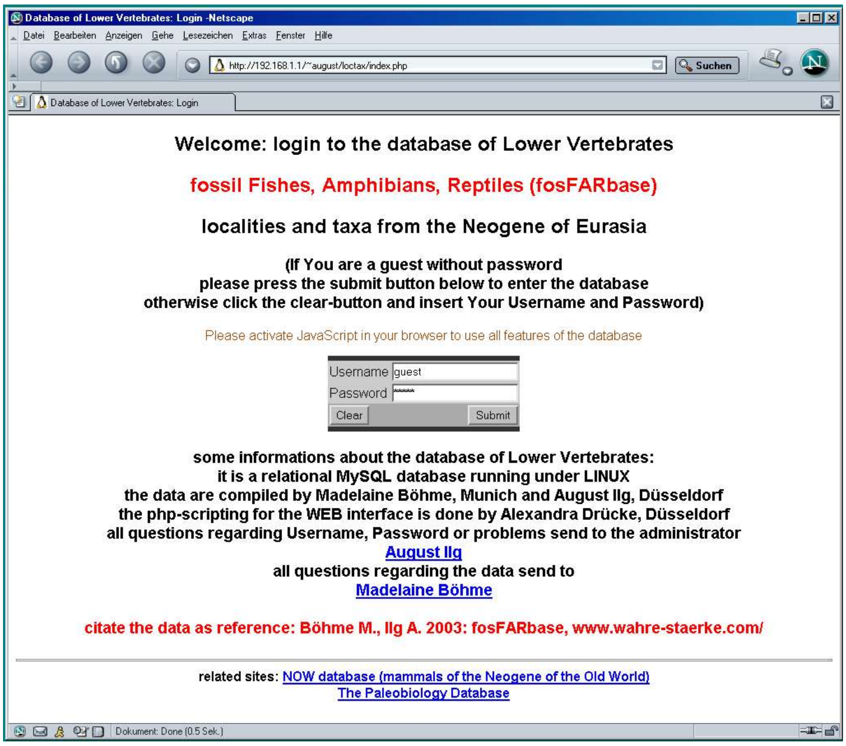
Encouraged by a stimulating paper from E.O. Wilson (The encyclopedia of life, Trends in Ecology and Evolution Vol.18 No.2, February 2003; free downloadable from Elsevier), we decided to bring all data of the singleplace database of Lower Vertebrates to a much better place: the INTERNET. Therefore the whole database was transformed in a relational MySQL database running under LINUX. The dababase fosFARbase (fossil Fishes, Amphibians, Reptiles) contains until now (September 2003) informations for 1086 localities with 4993 records of 713 taxa with 259 references to localities and taxa from 53 countries. Most datafields are the same as in the NOW (Mikael) and ETE (Smithsonian) databases containing taxonomic, taphonomic, stratigraphic, ecologic, environmental and geographic information, and the related references.

We have done some programming, writing php- and Java-scripts, to create a secure and comfortable interface for the internet. We created some input/submit forms to enable you to ask special questions, normally by selecting from lists of the database. The login site has a special function for authorisized people (with password) to correct/update or add new data directly on the web, the user/collaborator is automatically registered with name and timestamp in the database (for control of the administrator), without password guests can only search and read data.



Welcome: login to the database of Lower Vertebrates

fossil Fishes, Amphibians, Reptiles (fosFARbase)

localities and taxa from the Neogene of Eurasia

(If You are a guest without password
please press the submit button below to enter the database
otherwise click the clear-button and insert Your Username and Password)

Please activate JavaScript in your browser to use all features of the database

Username guest
Password *****

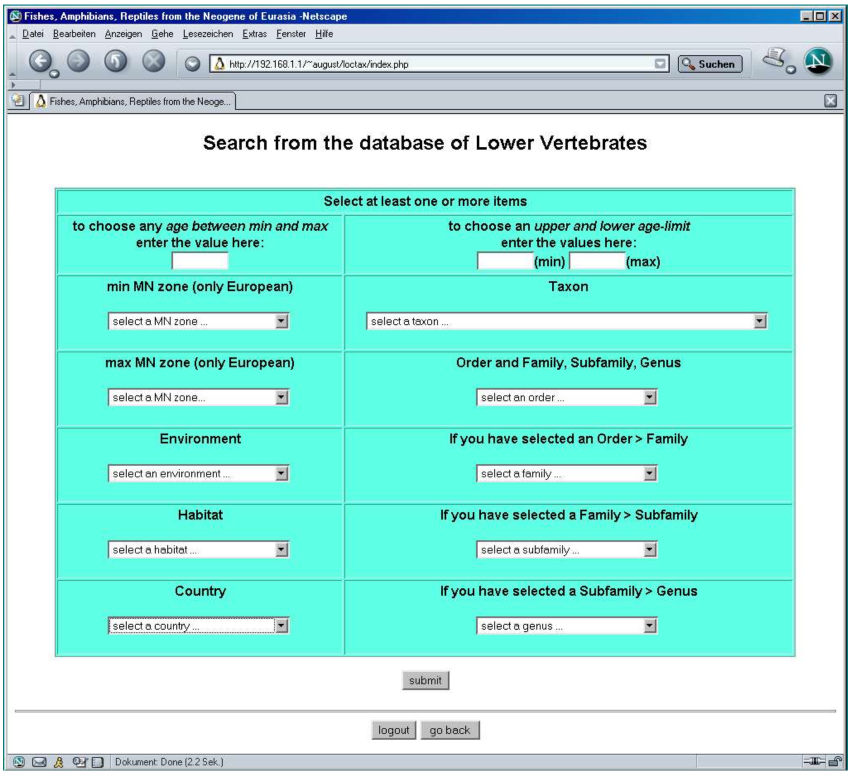
some informations about the database of Lower Vertebrates:
it is a relational MySQL database running under LINUX
the data are compiled by Madelaine Böhme, Munich and August Ilg, Düsseldorf
the php-scripting for the WEB interface is done by Alexandra Drücke, Düsseldorf
all questions regarding Username, Password or problems send to the administrator
August Ilg
all questions regarding the data send to
Madelaine Böhme

citate the data as reference: Böhme M., Ilg A. 2003: fosFARbase, www.wahre-staerke.com/

related sites: NOW database (mammals of the Neogene of the Old World)
The Paleobiology Database

All ideas, critics, comments, questions, proposals regarding the database and the WEB interface are requested. For the future, we will incorporate a GIS interface, to show informations on maps and make possible to select from datapoints on maps.The most important prerequisite to visualize our data is to achieve a very good quality of the data. This will be no easy task. The further step to plot and map the data is much easier.

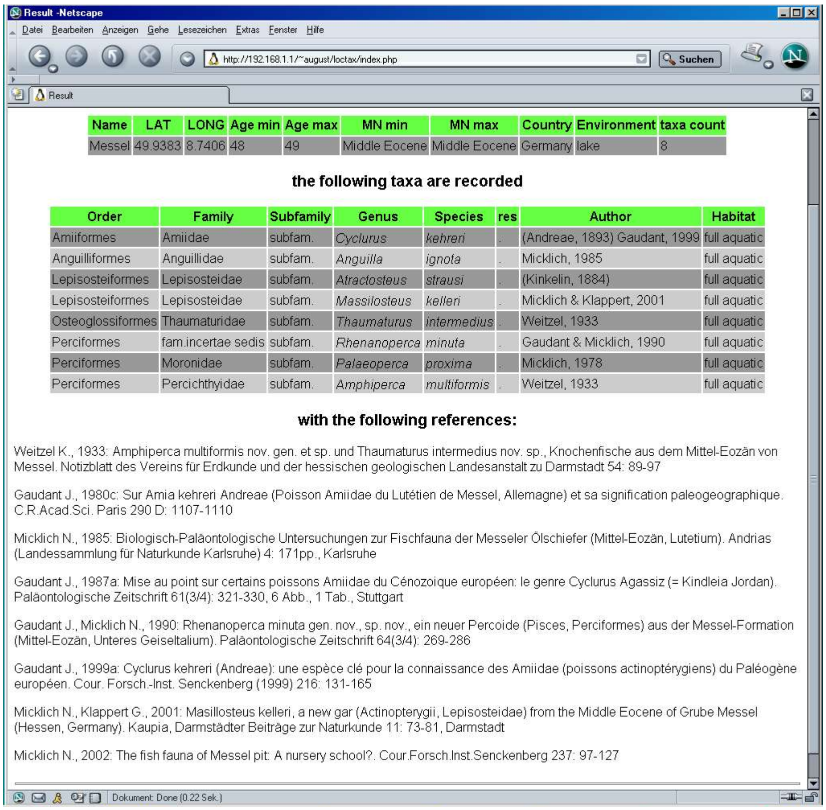
Example of a complex search form:



Search from the database of Lower Vertebrates

Select at least one or more items	
to choose any *age between min and max* enter the value here:	to choose an *upper and lower age-limit* enter the values here: (min) (max)
min MN zone (only European) select a MN zone ...	Taxon select a taxon ...
max MN zone (only European) select a MN zone...	Order and Family, Subfamily, Genus select an order ...
Environment select an environment ...	If you have selected an Order > Family select a family ...
Habitat select a habitat ...	If you have selected a Family > Subfamily select a subfamily ...
Country select a country ...	If you have selected a Subfamily > Genus select a genus ...

Example of a result form:



Name	LAT	LONG	Age min	Age max	MN min	MN max	Country	Environment	taxa count
Messel	49.9383	8.7406	48	49	Middle Eocene	Middle Eocene	Germany	lake	8

the following taxa are recorded

Order	Family	Subfamily	Genus	Species	res	Author	Habitat
Amiiformes	Amiidae	subfam.	*Cyclurus*	*kehreri*	.	(Andreae, 1893) Gaudant, 1999	full aquatic
Anguilliformes	Anguillidae	subfam.	*Anguilla*	*ignota*	.	Micklich, 1985	full aquatic
Lepisosteiformes	Lepisosteidae	subfam.	*Atractosteus*	*strausi*	.	(Kinkelin, 1884)	full aquatic
Lepisosteiformes	Lepisosteidae	subfam.	*Massilosteus*	*kelleri*	.	Micklich & Klappert, 2001	full aquatic
Osteoglossiformes	Thaumaturidae	subfam.	*Thaumaturus*	*intermedius*	.	Weitzel, 1933	full aquatic
Perciformes	fam.incertae sedis	subfam.	*Rhenanoperca*	*minuta*	.	Gaudant & Micklich, 1990	full aquatic
Perciformes	Moronidae	subfam.	*Palaeoperca*	*proxima*	.	Micklich, 1978	full aquatic
Perciformes	Percichthyidae	subfam.	*Amphiperca*	*multiformis*	.	Weitzel, 1933	full aquatic

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Climate change about 10 Ma ago in Paratethyan realm of Balkan Peninsula

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We analyzed quantitatively the palynological data from the Sarmatian (s. l.) sediments of the Euxinian and Forecarpathian Basins, Eastern and Central Paratethys area (Northern Bulgaria). The palynomorph assemblages were proceeded using the coexistence approach method (Mosbrugger & Utescher 1997) in order to obtain quantitative data for climate evolution in the studied area.

The vegetation during the Volhynian and the greater part of the Bessarabian (Lower – Middle Sarmatian) characterized by the development of mixed mesophytic forests, rich in warm-temperate and subtropical elements that indicate humid subtropical conditions. The climate was relatively stable, with annual temperatures between 16-18 ºC, and precipitation rate above 1100 mm (Ivanov et al. 2002).

At the end of Bessarabian and during Chersonian, around 10 Ma, changes in the climate parameters occurred, and probably the climate became more variable and dryer. In some cases we found lowering of the temperatures, but most significant are lower coexistence intervals for the precipitation – (559) 740-760 mm. These results coincide with sedimentological data (Ivanov & Koleva-Rekalova 1999) for the Bessarabian and Chersonian, when massive and laminated aragonite sediments deposited (probably as a result of chemical precipitation at high temperature, shallow water conditions, and limited inflow of terrigeneous components). Meanwhile, changes in the vegetation also took place, and herbaceous plants became more important in vegetation structure (grass communities of Apiaceae, Lamiaceae, Poaceae, Asteroideae, Cichorioideae, *Persicaria, Artemisia*, Chenopodiaceae). Highest distribution of grass vegetation was recorded for the upper part of Bessarabian and Chersonian with higher shares of its components. It is accompanied by increasing role of subxerophitic/xerophitic plants – species of *Celtis*, *Pistacia*, Oleaceae, *Ephedra*. In addition to these plants other subxerophytes were identified as macrofossils: *Quercus* (ex. sect. *Ilex*) *Robinia*, *Arbutus*, *Berberis*, *Paliurus*, *Celastrus*, and *Cesalpinites* (Palamarev & Ivanov 2001). Simultaneously the distribution of swamp forests contracted. These palaeobotanical data evidenced appearance of open landscapes and the development of xerophytic plant communities.

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The Late Miocene aridification of Europe: a diachronic process

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The application to the Late Miocene of Europe of new proxy methods for the estimation of mean annual and minimum monthly precipitation based on small mammals shows the presence of diachronic trends in aridification. A series of precipitation maps at 1 myr resolution shows that the basic present-day rainfall gradients existed already over Europe back to at least 12 Ma, but that major changes occurred as well since then. Between 12-10 Ma the European Temperate Wet Zone (ETWZ) was an area larger and wetter (800-1200 mm/yr) than today, extending from Northern Spain in the west to the Ukraine in the east. The reconstructions indicate a whole-year penetration of large amounts of moisture far into Europe, due to a largely zonal circulation with a relatively southern position of the Subtropical Convergence Zone (STCZ). This interval does not correlate with warming, but with a major Northern Hemisphere and probably global cooling.

Between 10 and 5 Ma, the ETWZ shrinks and/or moves northwards, which is reflected in a diachronous aridification across Europe (Fig. 1), most clearly recorded at intermediate latitudes (e.g. France, Hungary). Mean annual precipitation drops from values above 1000 mm/yr to levels of 6-700 mm/yr in these areas. Southern areas (Central Spain, Greece, Anatolia) show more modest drops from about 5-600 to 400 mm/yr. Between 10 and 8 Ma, aridification shows a strongly seasonal (probably summer) component, which could be associated with a northward approaching Subtropical Convergence Zone (STCZ). Various, partly interrelated factors may be held responsible for the late Miocene aridification of Europe, the most important being Tibetan uplift, a developing African monsoon system, changing North Atlantic atmospheric pressure gradients, and possibly reduction of atmospheric moisture by underground storage in expanding grasslands. As particularly shown by the higher-resolution record of Central Spain, there are shorter-term events of higher precipitation at 9.5 and 7 Ma superposed on the general trend, which seem to correlate with quasi-periodical third-order cycles of global cooling, ice expansion and eustatic sequence boundaries. Locally, transgression may have resulted in wetter conditions in off-wind areas close to water bodies in Anatolia and south Eastern Europe, particularly at 8-7 Ma.

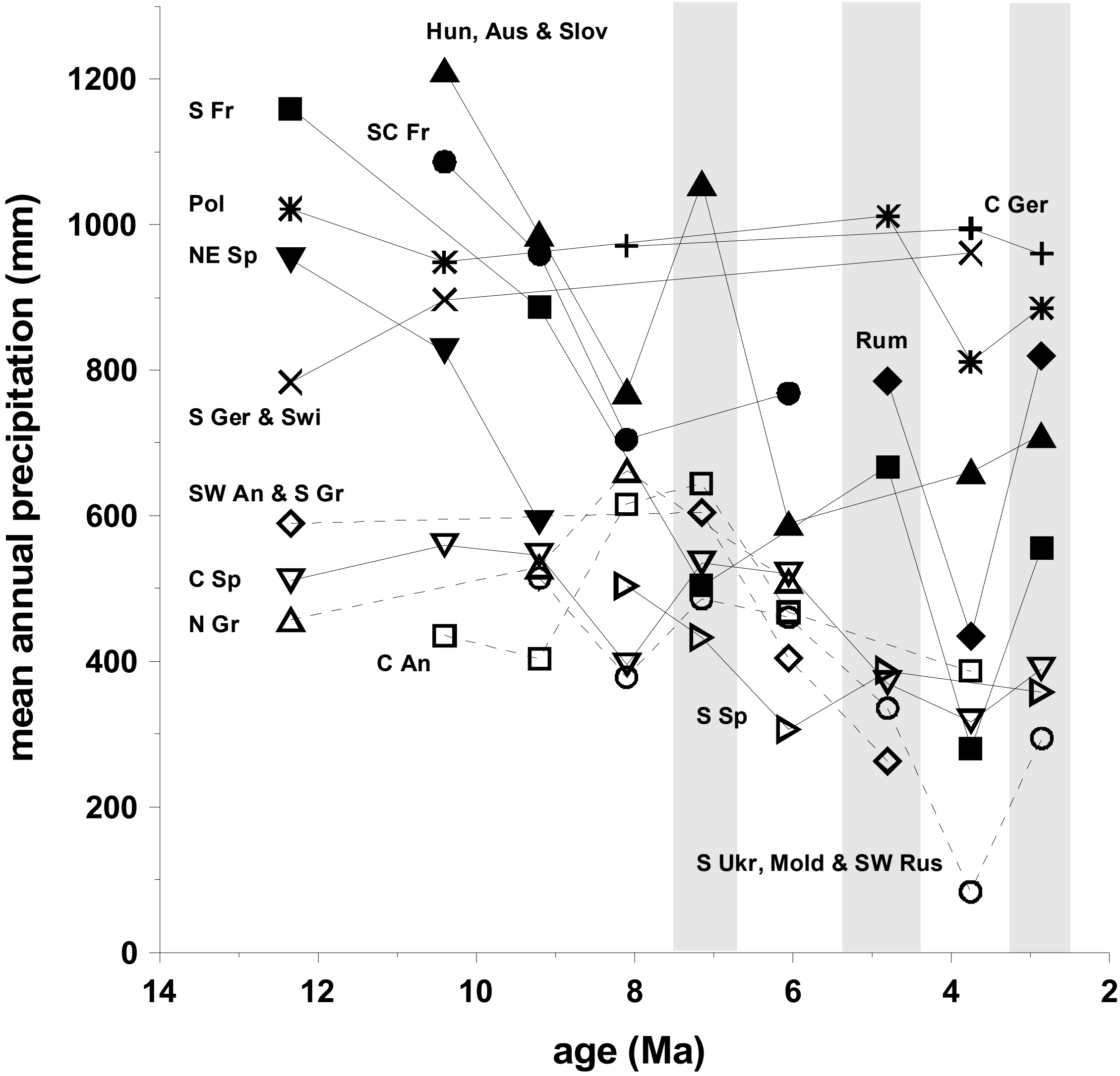

Figure 1.
Mean annual precipitation (MAP) trends per region based on small mammals. Localities are grouped into 14 regions: Central Spain, Southern Spain, Northeastern Spain, Southern France, South Central France, Southern Germany and Switzerland, Central Germany, Poland, Hungary-Austria-Slovakia, Rumania, Southern Ukraine-Moldavia-Southwestern Russia, Southwestern Anatolia-Southern Greece, Northern Greece.

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New Late Vallesian localities with small mammals from SW Slovakia.

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During the last years some new Upper Miocene localities with mammal fauna were discovered in Slovakia. All localities are situated in the Vienna Basin and Danube basin and well fill up the Austrian and the Hungarian succession of micromammal fauna. The most interesting localities are Borský Sv. Jur (Pannonian E , MN9) and Pezinok (Pannonian E-F, MN 9/10?).

Borský Sv. Jur is situated in northern part of the Vienna Basin. The most frequent fossils among the vertebrates are mammals; remains of the orders *Insectivora, Rodentia, Lagomorpha, Artilodactyla, Perissodactyla* and *Carnivora* are present**.** In the collected material from Borský Sv. Jur small mammals, especially rodents are dominating. Among presented rodent taxa *Megacricetodon minutus* Daxner-Höck, 1967 and *Democricetodon* sp. prevailed. *Megacricetodon minutus* Daxner-Höck, 1967 described from Inzersdorf (MN9) is commonly discussed taxon, because of his rare occurrence and poor type material. Findings from Borský Sv. Jur provide sufficient numerous material for redescribing and sustaining of this taxon.

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Paleogeographical maps of Turkey for some selected time intervals in Neogene

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In Neogene, except few localities in SE Anatolia, Central Taurides and some small E-W trending basins in Eastern Anatolia where marine conditions prevailed untill the end of the Serravallian, Turkey is generally dominated by continental conditions. Because, Neogene continental stratigraphy of Turkey has not been completed yet, in addition intense deformation that effected much areas of Turkey collectively make correlation of Neogene sequences and delineation of paleogeographical depositional environments very difficult. Fortunately, there is precise enough faunal and age information, accumulated for more than 20 years most of which produced by Hans de Bruijn and his co-workers. In addition to this, tese workers have re-visited most of the vertebrate sites published previously in the literature and revised the faunal content and age of these sites that makes up ca. 420 vertebrate fossil sites. For the marine sequences, previously published and unpublished literature data is used. In this study paleogeographical maps for Early Langhian (17-16 Ma), Early Serravallian (14-14-13 Ma), Mid-Tortonian (9-10 Ma), Late Messinian (6.5-5.5 Ma), and Mid-Pliocene (4-3 Ma) will be presented.

Some newly recorded, possibly high-resolution pollen genera from the Bohemian Neogene

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The contribution is aimed at morphology/taxonomy of selected and newly recorded well definable palynotaxa found in the Miocene sediments of the Bohemian Massif.

They include particularly angiosperm taxa, tricolporate and tricolpate pollen but also ferns reproducing trilete spores.

A common feature of the selected taxa is their non-arboreal appearance and close habitats in which they occur. These are mostly components of the riparian forest as indicated by the whole accompanying pollen spectrum, some of them were growing in convenient habitats within the cypress swamps. They are not common in the spectra, being represented by rare finds. Where possible, they were compared with the relevant modern taxa and with the occurrences in the closely neighbouring territories.

The selected pollen and spores were recorded in coal-bearing deposits in the North Bohemian rift area and in the relic fluviolacustrine deposits of western Bohemia. Based on the rare but significant vertebrate fossils, they belong predominantly to the Miocene vegetation within the time span of the mammalian Biozone NM 3 (Lower Miocene, Eggenburgian – Orleanian) and Biozone MN 5 (Karpatian, Upper Orleanian), some are comparable with the deposits of the Badenian (Badenian/Sarmatian) age.

THE VALLESIAN OF EASTERN MEDITERRANEAN; IMPLICATIONS ON THE STRATIGRAPHY AND PALAEOECOLOGY

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The Vallesian in Eastern Mediterranean was almost unknown except of some old references with limited data. Untill the beginning of 70's the excavations carried out in the area were very few and occasional. For a long time all the late Miocene faunas were correlated to the Pikermi one and they referred as "Pontian" or as late Miocene/Pliocene. During the last thirty years several new localities have been found in the area and a great amount of fossils have been unearthed. The study of the new material, as well as the revision of the old collections provided significant data and allow the distinction of the Vallesian and Turolian faunas. New datings also allowed a better age determination of the faunas and consequently a better definition and division of the Vallesian. In the present contribution all the available data are summarized and used for the stratigraphy and palaeoecology of the Vallesian in Eastern Mediterranean (Balkan Peninsula, Asia Minor, Iran Afganistan, Black Sea). The faunal lists of NOW (2003) are used with some minor additions or corrections.

The definition of the Vallesian in Eastern Mediterranean is a subject of discussion, as until now the available faunal data were few and still remain limited, especially for the early Vallesian (MN 9). The beginning of the Vallesian in Eurasia is defined by the appearance of *Hipparion.* In Eastern Mediterranean the *Hipparion*-datum is recognized in Sinap Loc. 4 (Turkey) with an age of 10.7 Ma, as well as in Siwaliks (Pakistan) at 10.7Ma. This age must be that of the Astaracian/Vallesian boundary in Eastern Mediterranean and does not coincide to that of Western-Central Europe where the *Hipparion*-datum is dated at ~11Ma. The boundaries of the Vallesian MN-zones are also discussed, based on the new chronological data and an effort for their definition is made by the mammalian taxa and the absolute datatings.

For the study of the palaeoecology and palaeoenvironment the studied region is divided in two sub-regions: Black Sea and Southeastern Eurasia. The faunal composition of each Vallesian MN zone of the examined areas is discussed and compared each other for each sub-region, between the sub-regions, as well as with the corresponding faunas of Central and Western Europe. The faunal composition is compared with recent faunas from certain environments for the definition of the palaeoenvironment of each MN zone. The Vallesian faunas of Eastern Mediterranean are compared with those of Western and Central Europe to see their palaeoecological differences. The so-called "Middle Vallesian crisis" recognized in Western-Central Europe is also examined in the two sub-regions and seems to be absent in Southeastern Europe.

PALEOGEOGRAPHY OF THE Central Paratethys during the Early phase of the High resolution Interval HRI 3 - Karpatian.

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The paleogeographic – palinspastic model of the Karpatian (Late Burdigalian) time span corresponds approximately to the middle part of the NN 4 zone of calcareous nannoplankton and M4 zone of BERGGREN et al. (1995). The beginning of this period can be characterized by the first appearance of *Uvigerina graciliformis* in marine deposits and with the appearance of *Globigerinoides bisphericus* in their upper part in the Central Paratethys region (RÖGL 1998). First appearance of *Praeorbulina* in foraminifera associations documents the beginning of the Early Badenian and can be regarded as a marker of the Early/Middle Miocene boundary.

All paleogeographic - palinspastic reconstructions (models) in the Central Paratethys area (Eastern Alps, Carpathians, Pannonian Basin System, Dinarides) are based on two important parts: (1) model of sedimentary basins in the subduction zone and accretionary wedge region and (2) model of overriding plate movement and extent of the stretching during the basin formation processes.

The presented model of the Carpathian–Pannonian region takes into consideration the position of an active subduction zone in front of the moving lithospheric fragments - microplates at the end of the Early Miocene (BALLA 1984, CSONTOS et al. 1992, KOVÁČ et al. 1994, KOVÁČ et al. 1998, KOVÁČ 2000, KONEČNÝ et al. 2002). Configuration of microplates can be characterized by presence of at least two separated fragments: Alcapa, situated in the north and Tisza–Dacia microplate, which was situated in the south. At the beginning of the Karpatian the microplates moved separately (FODOR et al. 1998), by the end of the Karpatian the microplates were juxtaposed along the Mid-Hungarian Zone (CSONTOS et al. 1992, CSONTOS 1995). Therefore, the Karpatian (17.3 - 16.4 My) can be regarded as a very dynamic period within the Neogene evolution.

The geodynamic background of the Karpatian structural changes in the Outer Carpathians, as well as changes in paleogeography can be characterised by continuing subduction in front of the Alpine - Carpathian orogene accompanied with final phase of the accretionary wedge development. At the beginning of the Karpatian north vergent thrusting of the East Alpine units stopped. Continuing subduction in front of the geometrically complex Carpathian loop resulted in oblique collision of the Western Carpathians along the southeastern margin of the Bohemian Massif. Subduction of the Outer Carpathians basement was associated with folding and thrusting in externmost zone of the accretionary prism. The Karpatian front of the orogene was built up by different nappe units: Waschberg-Ždánice, Subsilesian-Silesian in the Western Carpathians and by the Skole-Skiba-Tarcau in the Northeastern and Eastern Carpathians. By the end of the Karpatian other units like the

Boryslav-Pokuttya (Ukraine) and the Marginal Folds Unit (Romania) were also accreted to the front of the Outer Carpathians.

Palinspastic reconstruction of the Outer Carpathian accretionary wedge is very complicated because we can not balance the space only by pushing the overthrusted nappe units back, but we need to assume the oblique movement between the nappe units during the collision with the platform margin. The shortening accross the Miocene accretionary wedge was estimated to a minimum of 100 km in the west, and about 200 km in the eastern part of the orogene (OSZCZYPKO & ŚLĄCZKA, 1985, KOVÁČ et al. 1989a,b). This realistic estimation did not lose its value until now (MORLEY 1996) and was supported by study of volcanic arc along the Carpathian loop (LEXA et al. 1993). The relatively short time interval of volcanic activity in the Eastern Carpathians in the same time indicate, that the subduction (downgoing plate size) does not overstep 250 - 300 km (SANDULESCU 1988, LINZER et al. 1998, KONEČNÝ et al. 2002). The timing of the volcanic activity and its geometry reflects the geodynamic evolution of the Carpathian arc. These connections as well as the final migration of volcanic centres toward the subduction zone reflect verticalisation of sinking slab and its stepwise break down during the Neogene (ROYDEN 1993a,b, SPAKMAN 1990, SPAKMAN et al. 1993, LANKREIJER 1998, NEMČOK et al. 1998, BADA 1999, KONEČNÝ et al. 2002).

Paleogeographic - palinspastic modeling of the paleo and mesoalpine consolidated Carpathian chain and Pannonian Basin System needs therefore to take into consideration the very important horizontal displacements between the two major microplates Alcapa and Tisza-Dacia, and along other strike-slip zones, as well as the extensive lithospheric stretching which led to basin formation. Royden (1993a,b) estimates the amount of Neogene extension to 200 - 300 km. This estimation pointed out, that the original extent of microplates (present area of the Pannonian basin) was much smaller in size than recent and the crustal and lithosphere thickness reached also much higher values.

The Karpatian structural pattern of the intra-Carpathian-Pannonian region was influenced by two factors. On the one hand the continuing Alpine subduction and post-collisional shortening was characteristic in the western part. The initial extrusion of the Alcapa microplate from the East Alpine domain occurred along transform boundaries caused by indentation and push of the Adriatic plate (RATSCHBACHER et al. 1989, 1991a,b). On the other hand, the Carpathian-Pannonian microplate movement was conditioned by eastward retreating subduction (ROYDEN 1993b). The subduction retreat and transmission of the slab pull towards the back-arc basin facilitated the stretching of overriding microplates. This pulling effect also accelerated the extrusion of the western part of the Alcapa domain (BADA 1999).

The development of the Karpatian paleogeography in the Central Paratethys area was bound to the so-called „Styrian orogenic phases“. Although, the term „orogenic phases“ has very limited meaning if any, because tectonic movements (e. g. subsidence, thrusting) were continous.

During the Karpatian the sedimentation in residual flysch troughs ended and their sedimentary fill suffered tectonic inversion and was accreted to the orogene accretionary wedge of the Outer Carpathians. In front of the Carpathian loop foredeep basin depocentres migrated onto the European Platform margin, due to deformations of the subducting lithosphere (ZOETEMEIER et al. 1999). In the hinterland of the mountain chain the initial rifting phase was accompanied by synrift sedimentation in the basins and depocentres of the Pannonian back arc basin system. The rifting process was connected or even driven/preceeded by the uplift of the asthenospheric mantle (KONEČNÝ et al. 2002).

At first, the basin subsidence caused accumulation of terrestrial, alluvial, deltaic and brackish sedimentary successions in many places. Marine deposits are documented from the Eastern Slovenia basins (presumed „Trans Dinaride Corridor“), North Croatia, from the Mura-Zala Basin, in the Styrian Basin, along the southern margin of the Transdanubian Range from the Várpalota Basin (KÓKAY, 1991), vicinity of the Mecsek Mts., from the South Slovakian - North Hungarian (Novohrad-Nógrád) Basin, Northern Danube Basin, Vienna Basin, Western Carpathian Foredeep and East Slovakian Basin. The lagoonal, brackish to freshwater deposits of the Ottnangian – Karpatian stage are known from the Transylvanian Basin and Eastern Carpathian Foredeep. Marine deposits containing *Praeorbulina* in foraminifera associations can not be regarded as Karpatian because they belong to the Langhian (Early Badenian) transgression.

The probem of the sea way (connection) between the Mediterranean and Central Paratethys area remains still open. The „Trans Dinaride Corridor“ (called also „Trans Tethyan Trench Corridor“) was somewhere in Slovenia or Northern Croatia, but it can not be proved as no Karpatian to Lower Badenian marine sediments are recorded in middle to western Slovenia. The sea connection can not be also along the Peri-Adriatic-Line, because in the Veneto Basin are only littoral deposits. This would be the obligation of „tectonics“ to find the corresponding fault system, where we can put our “Paratethys Gibraltar Gate”.

A second possibility of the Badenian transgression is recommended from the south to southeast, as the marine fauna in the Transylvanian Basin exhibits the richest assemblages. The basin. was already transgressed in the calcareous nannoplanton Zone NN4 with *Praeorbulina glomerosa* (DUMITRICA et al. 1975). A direct southern gate to the Mediterranen was not possible, as the Morava Basin south of Beograd is filled with limnic-fluvial sediments. In the Dinarides the „Dinaride Lake System“ is developed (see VUJNOVIC et al. 2000) and the Badenian transgression along the southern coast of the Pannonian Basin from the Tuzla Basin to Beograd comes from the north. The only open access would be to southeast, along the Moesian Platform, as there is similar Early Badenian sedimentation in the western Bulgaria. But from there to the Mediterranean a marine connection is not proved.

The possibility of an other transgression from the south (?) probably through southern Pannonian Basin System (Transylvanian Basin) within calcareous nannoplankton NN5 Zone with *Praeorbulina circularis* and *Orbulina suturalis* (together) can be represented by the next regional sequence stratigraphy cycle (transgression/highstand) crossing the Outer Carpathian Foredeep basins from the southeast towards northwest.

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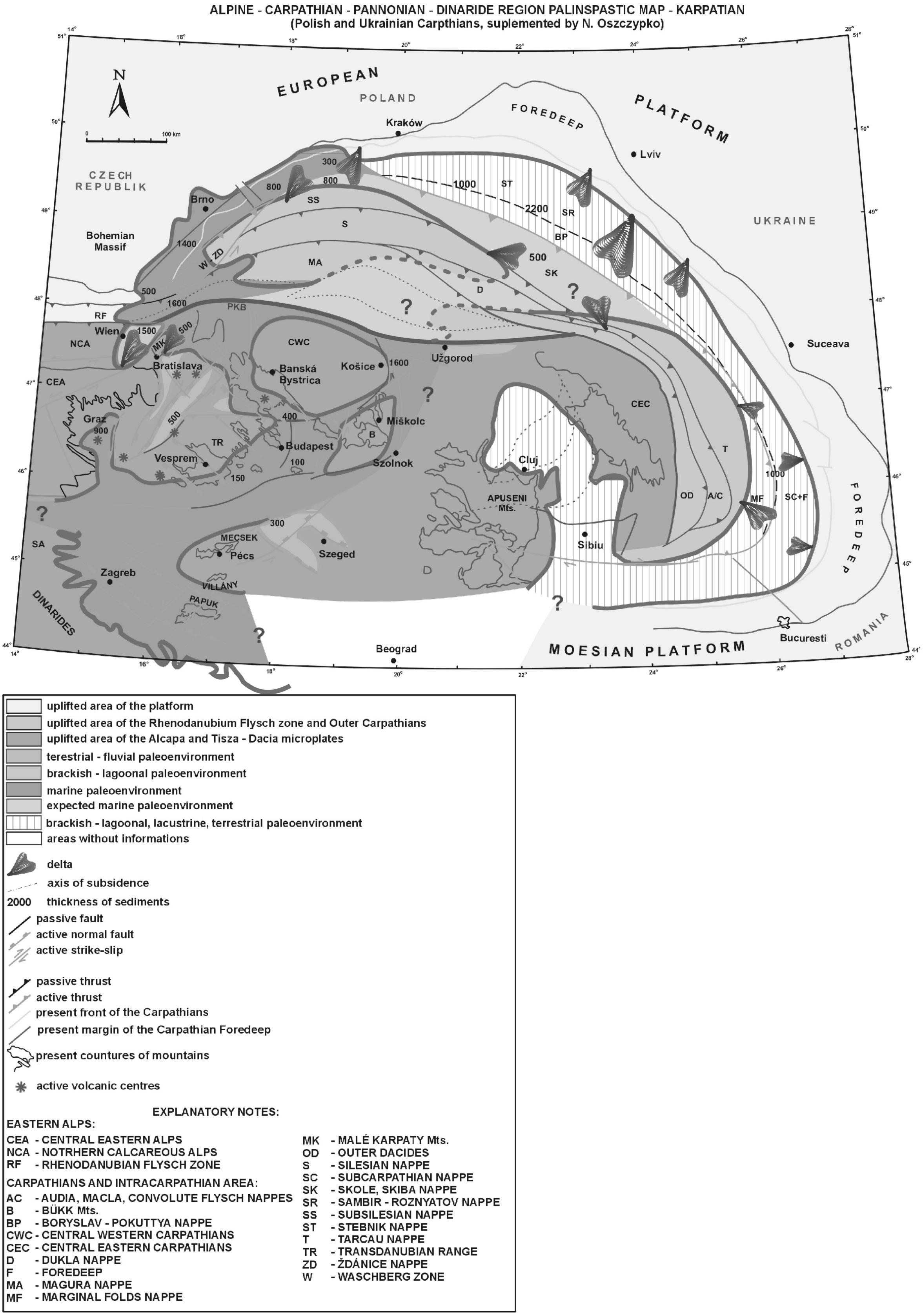

Comparison of vegetation dynamics in HRI I to III based on plant magefossil record

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Differences in the development of the flora and vegetation during the transitions between the Early/Middle Miocene, Middle/Late Miocene and Late Miocene/Pliocene (HRI I, II, III) will be characterised on the basis of plant megafossil assemblages available. A more general framework of palaeogeographic settings, extent of coal deposits and climate proxies obtained from other methodologies will be employed for a better understanding of the processes involved.

The Vallesian Crisis in the Iberian and European mammal records

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The Vallesian (early Late Miocene) is a period of profound changes in global climate and in the European environments and mammal fauna. For the first time land ice accumulated on the northern hemisphere, more or less coincident with the onset of the Vallesian, while an important faunal break in the middle of the Vallesian suggests an important climatic change.

In the Iberian Peninsula, as well as in the two other study areas "West & central Europe" and "East Europe & Anatolia", the earlier part of the Late Aragonian shows a lesser faunal diversity and relatively many taxa adapted to dry or open landscapes. In at least two phases, of predominant dispersals and few extinctions this fauna is enriched to the typical Vallesian fauna.

Just before the Aragonian-Vallesian (or MN8-9) transition, *Dryopithecus*, *Palaeotragus* and *Propotamochoerus* arrived in the Iberian Peninsula. This seems to have been also the case in West & central Europe. At the Aragonian-Vallesian transition, *Hipparion*, *Tapirus*, *Amphiprox*, *Decennatherium*, *Machairodus* and *Aceratherium incisivum* dispersed into the Iberian Peninsula, while *Hemicyon* and *Anchitherium* (but not the larger *Sinohippus*) went extinct. The latter persisted in West & central Europe, where *Taucanamo grandaevum*, unknown from the Iberian Peninsula, went extinct and *Hippopotamodon antiquus* arrived. In East Europe & Anatolia, the record seems to be less complete, but it coincides with the West & central European record in the arrival *Hippopotamodon antiquus* at the Aragonian-Vallesian transition. These two changes, resulted in a more diverse fauna, with more taxa adapted to humid or closed environments in all areas.

The Vallesian Crisis consists mainly of extinctions, but also of dispersals, which occur around the transition of the Early to the Late Vallesian (or MN9 to 10).

A first change, just before the MN9-10 transition, includes the apparition of *Pliohyrax* (which had a long previous record in East Europe & Anatolia) and *Indarctos*, while *Tragoportax* seems to have replaced bovids of the *Protragoceros / Miotragoceros* type. This change in the bovids may have occurred also in the other parts of Europe. These events may have coincided with the final extinction of *Anchitherium* in West & central Europe.

At the MN9-10 transition, when *Progonomys*, *Schizochoerus* (both with a long previous record in east Europe and Anatolia) and various other taxa appeared, quiet a number of taxa went extinct, including: *Palaeotragus*, *Propotamochoerus*, *Tapirus*, *Amphiprox*, *Listriodon*, *Conohyus*, *Propotamochoerus steinheimensis*, *Ursavus*, *Keramidomys*, *Myoglis*, *Paraglirulus*, *Bransatoglis*, *Eumyarion*, *Megacricetodon* and others. This change is also noted in West & central Europe, where in addition *Plesiosorex*, which is not known from the Iberian Peninsula, went extinct. However, *Amphiprox*, *Bransatoglis*, *Ursavus*, *Keramidomys*, *Myoglis* and *Paraglirulus* persisted in West & central Europe. *Microstonyx major* replaced *Hippopotamodon antiquus* in West & central Europe and East Europe & Anatolia. In East Europe & Anatolia, *Palaeotragus* persisted.

Just after the MN9-10 transition, *Schizochoerus*, *Protictitherium*, *Amphichyon*, *Hispanomeryx*, the *Parachleuastochoerus hunermanni-crusafonti* lineage, *Dryopithecus* and the Crouzeliinae went extinct. In West & central Europe, the MN10 record is not very abundant, but *Amphycyon* seems to have persisted also into the earlier part of MN10, like some of the taxa that went extinct at the MN9-10 transition in the Iberian Peninsula (eg. *Myoglis*, *Paraglirulus*).

Compared to the previous events, the Vallesian-Turolian (or MN10-11) transition is not very spectacular and involves the extinction of *Pliohyrax* and *Alicornops* and the dispersal of *Lucentia* and *Hystrix*. The porcupine had a long previous record in the other two areas, and *Pliohyrax* persisted in East Europe & Anatolia.

The three Vallesian changes and the Vallesian-Turolian change are similar in that many taxa went extinct, above all those that were adapted to stable humid or closed environments and that were frugivores or folivores. The taxa that were most affected by extinctions are Primates, Palaeochoeridae, Suidae, and Gliridae. The taxa that appeared by dispersal may have been more adapted to dry or open landscapes or more impredictable environments. This suggests, that the climate became more dry, cold or seasonal. Of particular interest are the taxa that went exinct or appeared at different moments in different areas. The presumable adaptations of taxa that went extinct in the Iberian Peninsula, but lived on longer in West and central Europe, suggest that the change towards dry or open landscapes occurred there later, or was not so strong. The taxa that had a long record in East Europe and Anatolia, previous to their dispersal in the Iberan Peninsula, suggest that similar dry or open environments may have occurred in both areas, but that the Iberian Peninsula was to some extend isolated from the more extensive central Asian open or arid landscapes by the closed or humid environment in West & central Europe. Due to this restricted access of taxa adapted to dry or open landscapes and lack of competition by these animals, taxa adapted to more humid or closed landscapes (eg. *Ursavus*, *Bransatoglis*, *Keramidomys*, *Myoglis*, *Paraglis*) may have been over represented in Spain, resulting in a more accentuated effect of the Vallesian Crisis.

Paleogeography of the Pannonian basin 9-10 and 5-6 million years ago

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Uplift in the Eastern and Southern Carpathians and/or contemporaneous eustatic sea level fall caused the isolation of the Central Paratethyan brackish Lake Pannon from the Eastern Paratethyan Sarmatian Sea about 12 million years ago. Like in other long-lived lakes, a special aquatic ecosystem evolved in Lake Pannon. The endemic biota came partly from eurytopic marine, partly from freshwater ancestors. Due to the lacustrine biota, the sedimentary deposits of the lake, which are widespread in the entire Pannonian basin system with thicknesses of up to 4 km, cannot be biostratigraphically correlated to the global chronostratigraphic system. The development of a consistent intrabasinal biostratigraphic subdivision was also hindered by the poor understanding of basin fill processes and geometry. Lake Pannon was filled up by prograding deltas of rivers that charged into the lake in the NW and NE. As progradation proceeded from N to S, the lacustrine basin was gradually turned into alluvial plains. The basin fill geometry in seismic reflection profiles is thus characterized by a succession of sigmoids; the sediment packages (systems tracts) follow each other in lateral direction. As a consequence, the profundal environment of the lake gradually shrank, and the littoral to sublittoral environments continuously shifted from N to S. The implications of this geometry to mollusc biostratigraphy are straightforward: because the overwhelming majority of the endemic mollusc species of Lake Pannon lived in littoral and shallow sublittoral environments, temporal (chronostratigraphic) successions have to be looked for in horizontal directions, whereas vertical successions in any location can be regarded as almost coeval, even if they include very (environmentally) different fossil assemblages.

Based on earlier biostratigraphic observations and the above discussed basin fill geometry, a stratigraphic correlation chart was compiled for Lake Pannon deposits. Radiometric age measurements, magnetostratigraphic investigations, and mammal biozonation have been used to connect the Lake Pannon system to standard chronostratigraphy and geochronology. A paleogeographic map series was constructed by mapping the geographical distribution of some biozones. According to these maps, Lake Pannon reached its largest extent about 9.5-10 million years ago; the northern shoreline was subsequently shifted southwards, whereas the southern shoreline of the lake hardly changed. In the southern part of the Pannonian basin the lake existed even in the Early Pliocene.

Detailed environmental reconstructions have been made for high resolution intervals HRI-2 and HRI-1 of the EEDEN program. For these reconstructions we used seismic stratigraphy and magnetostratigraphy, and explored the response of the biota to the environmental changes.

Between about 9.7 and 9.2 million years ago, the shelf edge of Lake Pannon shifted from the western Kisalföld (Danube) basin to the Transdanubian Central Range in Hungary. The movement of the shelf edge was mapped by arbitrarily selected horizons of seismic reflection profiles. The ages of the horizons were assessed by interpretation of magnetostratigraphic records from 4 wells located in the basin margin. Within the investigated time interval, the entire Kisalföld basin turned from a lake bed to a fluvial plain. This environmental change and the consequent withdrawal of the endemic lacustrine fauna from the basin was gradual. The morphological differences that we can observe in the littoral mollusc faunas between the start and the end of this process is interpreted as evolutionary.

About 4 million years later the northern shelf edge of Lake Pannon was already situated in southeastern Hungary. A three-dimensional seismic survey offers an excellent opportunity to study the gradual southward shift of the shorline in detail. Individual fluvial channels meandering through the fluvial plain, delta front sand bars, slope channels, slumps, and turbidite channels have been imaged by amplitude maps. Between the purely lacustrine and purely fluvial deposits, thick delta plain sediments reveal the frequent alternation of various freshwater, marsh, and shallow lacustrine environments. These environments are best identified by paleontological methods. The profound environmental changes that took place in the Mediterranean at about this time (and during the Late Miocene in general) have apparently left no obvious marks in Lake Pannon deposits and fossil biota.

Towards an integrated stratigraphy of the Upper Miocene of the Pannonian basin: a critical approach

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The Upper Miocene of the Pannonian basin mostly includes sedimentary rocks that were deposited in Lake Pannon and in adjacent deltaic and fluvial environments. Correlation of this thick sedimentary succession with coeval marine sediments has been problematic since the 19th century. Efforts to create a regional, intrabasinal stratigraphic system also failed, mainly due to the misunderstanding of the stratigraphic architecture of the basin fill. In practice, the subdivision and correlation of Lake Pannon deposits was mostly based on lithological characteristics, and lithostratigraphy was clearly preferred to biostratigraphy in assessing a chronostratigraphic framework.

The appearance and combination of new methods, such as magnetostratigraphy and seismic stratigraphy, have dramatically improved our understanding of stratigraphic architecture and geochronology of Lake Pannon deposits. During the last decade, however, a number of papers were published where the authors seemed to underestimate the inherent limits of these methods. It was claimed that the preciseness of our stratigraphic resolution is improved to ten thousand years. It was also suggested that the lacustrine and fluvial succession of the Pannonian basin can be correlated to the standard chronostratigraphic system through sequence stratigraphic analysis. It was argued that the Messinain salinity crisis coincides with a major sequence boundary (lake level drop) in the Pannonian basin. All these statements, however, can be regarded as more or less useful hypotheses rather than well-founded models. Interpretation of the paleomagnetic polarity record requires close mineralogical, lithological, and biostratigraphic control, which is often disregarded by users of magnetostratigraphic data. Similarly, seismic stratigraphy needs the control of other methods, such as biostratigraphy, and sequence stratigraphic interpretations carried out on a single two-dimensional seismic profile can often be misleading.

An integrated stratigraphic system should rely on careful interpretations of data from all available stratigraphic methods. These data will always show some inconsistencies and contradictions; they should be constructed into a uniform stratigraphic chart in a way that results minimum contradiction. An attempt to create such a system is shown in Fig. 1 (Magyar et al., 1999). This system is partly based on earlier biostratigraphic observations, but the mollusc assemblages of various paleoenvironments are carefully separated here, and the biozones – where possible – are based on anagenetically evolving species. The average resolution of the biozones is approximately 1 million year, being better than that of coeval marine sediments. Radiometric age determinations from interbedded volcanics, magnetic polarity profiles from reference boreholes, and vertebrate biostratigraphy are the tools by means of which the Lake Pannon stratigraphic system can be connected to the global geochronological scale. There is a difference in the amount of available data and, consequently, in the reliability of the correlations between the lower (older than approximately 9.5 million years) and upper parts of Lake Pannon deposits; the former is relatively well-established, whereas a scarcity of radio-isotopic ages from the upper part of the sequence results in more uncertainty. In addition, the biostratigraphic subdivision of the last ca. 3 million year interval of the lacustrine sequence is almost entirely lacking.

Attempts to correlate the Lake Pannon sedimentary succession with the Eastern Paratethyan sediments (mostly with the Pontian Stage) have been based on mollusc assemblages since the 19th century. The results of these efforts, however, are highly contradictory. For instance, the base of the Pontian Stage as interpreted in the Pannonian basin implies a 1.5-3.5 million year (!) uncertainty. In order to overcome these problems, the geochronology of the Pannonian basin and that of the Eastern Paratethys should be established independently, and faunal migrations between the respective basins investigated subsequently, in the light of these correlations.

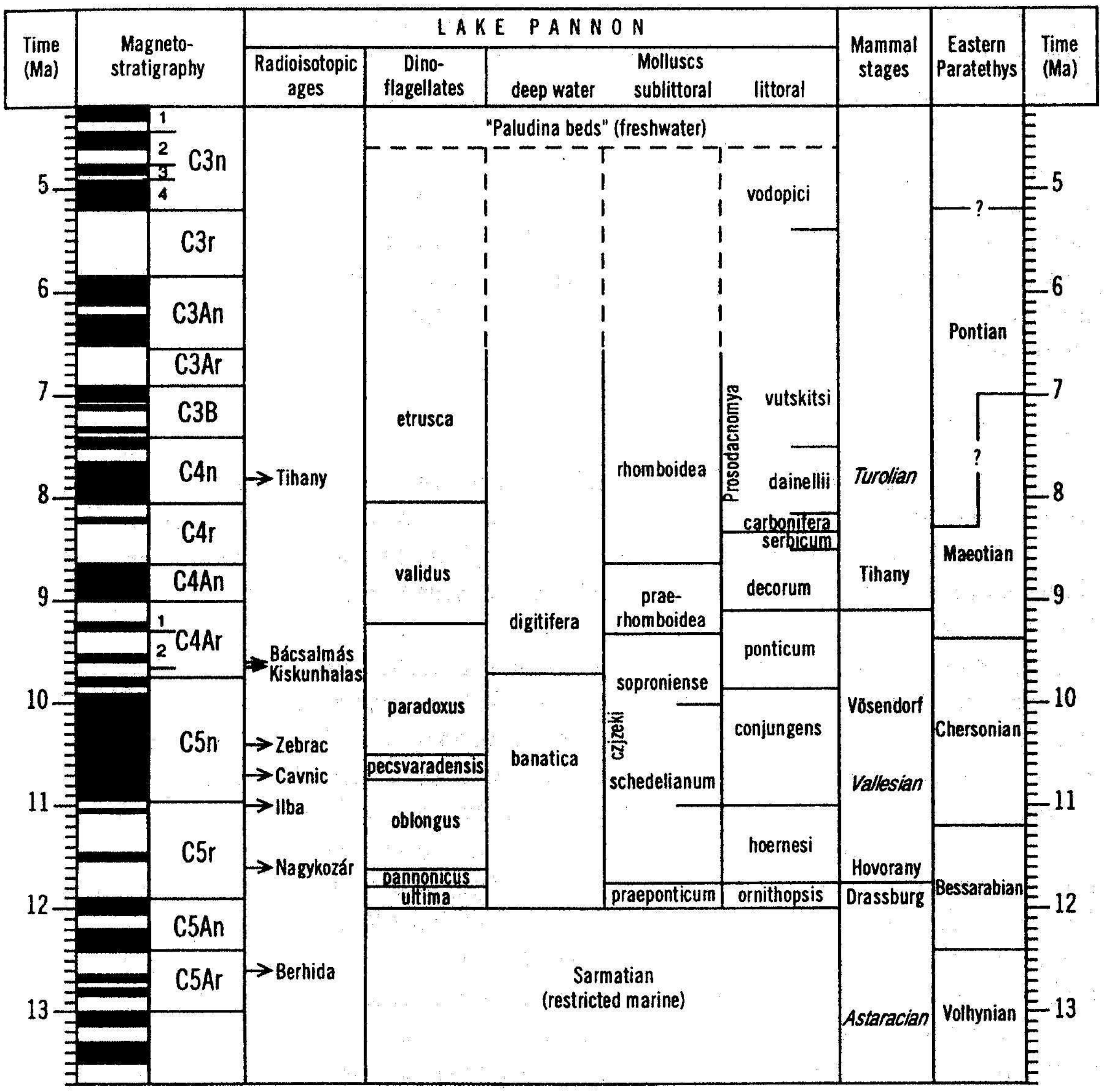

Figure 1. Stratigraphic correlation chart for the Late Miocene Lake Pannon deposits

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Changes of rodent-community structure during the Aragonian in Spain

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General environmental conditions (disturbance, humidity, temperature) determine the realised spectrum of r-K strategists in local communities. Under disturbed conditions this realised range lies more to the r side, while under stable optimal conditions more to the K side, of the continuum. From our study of Miocene rodent communities from Spain it appears that long-haul community members are more to the r-side of the spectrum. This we hypothesize is due to the fact that the environment was pervasively disturbed, and hence that the conditions favoring K-selected species were unpredictable. Disturbance was strongest during the Middle Aragonian, as indicated by the fact that those communities consisted exclusively of r-strategists, indicating open environment. During the Early and Late Aragonian, vegetational succession reached more advanced stages characterized by shrubs and trees, and occasionally by true forests. During the Early Aragonian there was only one resident associated with trees, while during the Late Aragonian there are several such residents. That means that during more adverse episodes in the early and late Aragonian (as compared to the Middle Aragonian), enough suitable patches persisted where more K-selected residents survived. Nevertheless, the dominant species during the Early and Late Aragonian are associated with open habitats. This leads us to the conclusion that residents, which define and continue the communities in a form of coordinated stasis, belong to the (more) r-selected side of the r to K continuum represented in the communities.

Late Miocene climate modelling and its validation with proxy data

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For the Tortonian (11 to 7 Ma, Late Miocene), proxy data suggest a different climate than today. Generally, the Tortonian was warmer, more humid and particularly the meridional temperature gradient was flatter than nowadays. The atmospheric global circulation model (AGCM) ECHAM4 coupled to a mixed-layer (ML) ocean model simulates the Tortonian climate. This allows to understand the relevant climatic processes. In order to check whether the ECHAM4/ML model is able to realistically simulate palaeoclimate situations, the results of the Tortonian model run are quantitatively compared with terrestrial proxy data.

To run the ECHAM4/ML model for the Late Miocene, the lower boundary conditions are adapted. We use a generally lower palaeorography, a weaker northward ocean **heat** transport and a palaeovegetation, which is mainly characterised by a larger forest cover. The Tortonian model experiment with ECHAM4/ML indicates that the Tortonian is globally +0.6°C warmer than today. The Tortonian run demonstrates a global average precipitation, which is +27mm/a higher than in the present-day's control experiment. A strong warming particularly in the high latitudes causes a shallower meridional temperature gradient in the Tortonian simulation as compared to the modern control run. The Asian monsoon in the Tortonian run is weaker as compared to nowadays, which is due to the lower elevation of the Himalayan during the Miocene. In North Africa, the denser palaeovegetation causes a high increase in precipitation, which tends to weaken the Hadley circulation in the Tortonian run. However, the down branch of the Hadley cell is displaced towards the Mediterranean region, which leads to more arid conditions in the south-eastern Mediterranean realm during the Tortonian. For Central Europe, the Tortonian run demonstrates more humid conditions than today.

A quantitative comparison demonstrates that the results of the Tortonian model run are basically consistent with terrestrial proxy data. Particularly in Europe, the simulated Tortonian precipitation rates are supported by small and large mammal, and botanical proxy data. However, some discrepancies are evident. In the northern high latitudes, the Tortonian run indicates cooler conditions than proxy data suggest. In the Mediterranean region, the model is slightly too warm as compared to proxy data. Thus, the meridional temperature gradient is too steep in the Tortonian run. Regarding the precipitation in the European region, the Tortonian run tends to be slightly more arid than proxy data indicate.

We identify the weak palaeocean heat transport, the palaeorography and the palaeovegetation as processes, which are important for the Tortonian climate being different from the present-day's one. From the comparison to proxy data, we conclude that the Tortonian simulation is quite realistic. However, due to some inconsistencies between the model simulation and proxy data, further sensitivity studies have to be performed to fully understand the Late Miocene climate.

Vegetation reconstruction in West Eurasia during the interval 12 to 8 m.a. (HRI 2) based on the plant record and the taxonomic/physiognomic evaluation approach.

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The taxonomic/physiognomic evaluation approach is based on a taxonomic/physiognomic grouping of plant taxa that additionally reflects major sociological components in the fossil record. This method, which was introduced in 2001 in Prag (Kovar-Eder & Kvaček 2003), has meanwhile been applied to plant assemblages of the intervals 17 -14 m.a. (HRI 3) and 7-4 m.a (HRI 1). Here we present the results for the interval 12-8 m.a. (HRI 2) where, for the first time, we include also fruit- and, pollen assemblages.

Independent dating of the plant assemblages is one of the most essential prerequisits for our evaluation. Moreover, only floras with more than 10 woody zonal (hinterland) taxa are included to minimize the influence of azonal (mainly wetland) taxa in the overall picture.

Different attempts were performed: using plant assemblages from fissile sediments (so-called leaf assemblages, they include also associated, mostly winged, fruit taxa), and from sievable sediments (fruit and pollen assemblages). Reliably calibrated plant assemblages that are published in detail are available richest from fissile sediments (36) but are far less numerous from sievable sediments (fruits 8, pollen 15).

First the records of the different ogan assemblages were evaluated separately because their fossilisation is biased by different taphonomic factors.The respective results were compared then. The pictures for the different components in the leaf and the pollen record match rather well, e.g. both in the leaf- and pollen record the same trends in the region Central Europe / SE-Europe are evident regarding the broad leafed deciduous (BLD) and broad-leafed evergreen (BLE) components.

The picture provided by the fruit record ist too spotty to recognize trends. It appears less consistent with the leaves and pollen, although this may be an artifact due to the scanty fruit record. In the sclerophyll (SCL) component the consistency in percentages is well between the fruit, leaf, and pollen record. However, in the leaf record, there is a trend towards slightly increased values in SE-Europe versus Central Europe visible which is not evident from the pollen record.

For the Rhine Embayment the leaf and fruit records (BLD, BLE, and SCL+LEG (legume-like) components) are less consistent among each other than in other European regions. This fact has already been recognized earlier.

In our final attempt we fused all the records of the different organ assemblages. These maps show complementary north/south gradients both in the BLD and BLE components, and a trend towards slightly increased values of the SCL+LEG component southwards. The ratio (BLD+BLE)/(SCL+LEG) which may serve as indicator of humidity shows also a north/south gradient with higher values towards the north. The Rhine embayment can be recognized as humid region with higher values of the BLE component than in Central Europe but low values of the SCL+LEG component comparable to those in Central Europe.

Compared to the results for HRI 3 distinct differences can be stated in the percentages of the different components in Central Europe: lower values of the BLD component and higher ones of the BLE, and especially the SCl+LEG components for the HRI 3. The eventual strong meridional gradient in Central Europe cannot be traced in the HRI 2. The results provided for the latter interval are closer to those elaborated for HRI 1. The humidity gradient (higher values in the north than in the south) seems weaker in HRI 1, indicated by the percentage of the SCL+LEG component. Anyway, it has to be kept in mind, that for HRI 3 and HRI 1 we have used the leaf record only and still have to include the fruit and pollen record.

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The dinocysts: a revisited proxy for understanding environmental changes in the Neogene of the Paratethys realm

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Dinoflagellates are famous by respect both to their motile and encysted forms. The latter (i.e. the dinocysts) only interest geologists because of their preservation in old to recent marine sediments. The conditions of passage from the motile to the encysted forms and vice versa are not well known, but it is generally assumed that, apart from the annual cycle of life, some influence may be due to environmental stresses.

The morphological response of dinocysts to stress in salinity has been evidenced in the Holocene deposits of the Black Sea (BLKS 9810 core) when it was invaded by the Mediterranean salted waters. These morphological changes concerned the endemic species as well as the immigrants. Quite similar morphotypes have been observed in the DSDP Site 380A when the Mediterranean waters entered the Black Sea just after the Messinian salinity crisis (Fig. 1).

Comparable causes producing similar effects, it has been decided to revisit the Miocene of the Paratethys. The approach is based on (1) pollen record in order to identify climatic changes, (2) dinocyst record which informs on paleotemperature and paleosalinity i.e. on the occurrence of Mediterranean water influxes into the Paratethys realm. A special effort has been done on the time span going from Sarmatian to Dacian. It is first concluded that taxonomy needs to be seriously revised (more than 50% of the species being invalid with respect to the international nomenclature) in the light of the successive changes noted in dinocyst morphology forced by changes in salinity. The method uses cultures of living dinoflagellates submitted to various stresses in salinity and observations on Scanning Electronic Microscope of the resulting dinocysts to be compared to the fossil ones from the Paratethyan Late Neogene.

A new understanding of the Mediterranean-Paratethys relationships and exchanges is expected from this investigation.

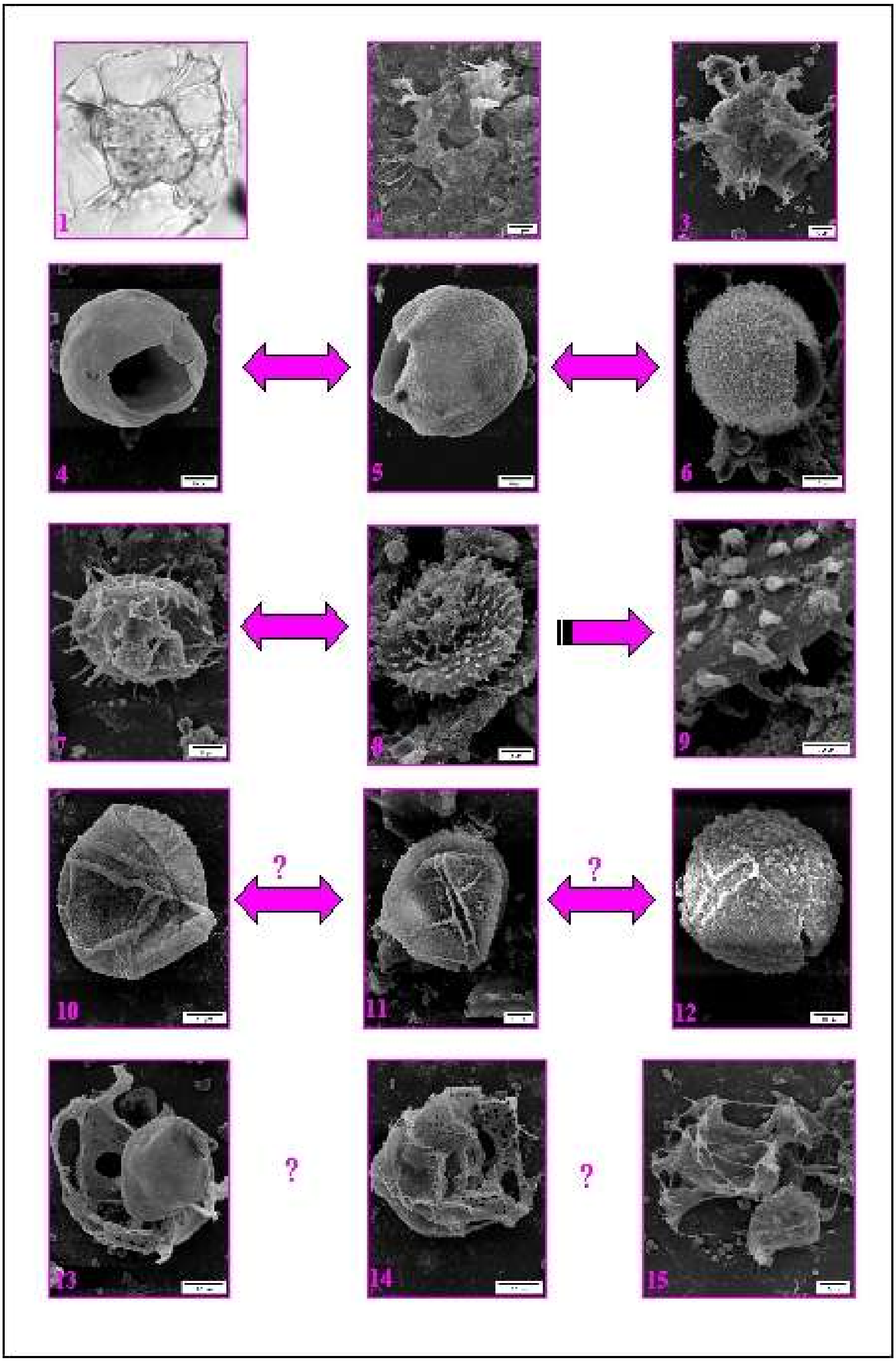

Fig. 1. Morphological response of Zanclean dinocysts from DSDP Site 380A to environmental stress.

1-2, *Spiniferites cruciformis* (1, *sensu* holotype; 2, morphotype);
3, *Spiniferites sp*. (probably morphotype);
4-6, *Pyxidiniopsis psilata* (4, *sensu* holotype; 5-6, morphotypes);
7-9, *Lingulodinium machaerophorum* (7, *sensu* holotype; 8-9 morphotypes);
10-12, *Spiniferites* devoid of processus;
13-14, *Galeacysta etrusca* (= *Romanodinium arveolatum*);
15, unknown species.

The report and theses at EEDEN meeting, Slovakia, Nov. 12-16, 2003

Paleobiogeographic terminology and some aspects of Cenozoic evolutionary biogeography of the Western Eurasia

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The methods of the biogeographical analysis and the terminology, used in paleobiogeography, basically are borrowed from the Recent biogeography. Therefore they are adapted to researches on the fixed time slices or intervals in the past when the situation cardinally did not vary in time. As well as in Recent biogeography, a basis of the analysis is allocation of a phyto- or zoochory - the territory populated with certain type of flora or fauna. However at studying enough long history of chorions, in crisis situations the taxonomic structure of biotas essentially varied. If such changes in time were accompanied also by spatial changes in distribution of the biotas, they are usually fixed in paleobiogeographic terms and biochory receives the new name. If changes of biota structure and composition occur in the same territory they usually have no adequate reflection in the paleobiogeographic nomenclature. So at existing tradition of the biochory name are adhered to geography (recent or paleo), more than to type of fauna, that it is wrong in our opinion.

Let's illustrate told on an example. Term "Tethys" was entered by E.Suess as a paleogeographic concept for the Mesozoic latitudinal-extended equatorial basin and at once began to be used for biogeographical divisions of a different rank. Terms “Tethys Region (Province, Realm)” were repeatedly applied, alongside with names “Mediterranean Region (Province)”, also originally for Mesozoic faunas, and then and for the Late Paleozoic and Cenozoic. So, for the Cenozoic the term "Tethys Region" was used by M.Harzhauser, W.Piller, F.Steininger (2002), up to the mid-Burdigalian, when the collision of the Afro-Arabian continent with Eurasia has resulted in occurrence of the land bridge between Arabia and system of Zagros mountains.

However, such argument based on paleogeographic events, and do not taking into account change of biota taxonomic composition and structure, usual in paleobiogeography, is represented to us wrong. In our opinion, the biogeographical terms used both in space, and in time should reflect first of all an originality of that biota which occupied examined territory, and criteria of comparison in space and in time should be similar. Thus we believe, that in process of biota change in time, the paleobiogeographic nomenclature should vary. Therefore terms even so a high rank as a realm or a region offered for the Mesozoic biota can not be applied for the Eocene - Miocene faunas, in which even generic and family composition do not compare with the Mesozoic. According to many authors up to 50% of genera and 75% of species existed in the terminal Mesozoic, had extinct to the beginning of the Paleogene, and the greatest changes had taken place in structure of sea faunas (Russel, 1977; Shimansky, Soloviev, 1982). Rates of new taxons occurrence during the early Paleogene were not less significant.

From these positions to use for the Mesozoic and Paleogene biochories names “Mediterranean Region”, which naturally associates with the Recent fauna and flora of Mediterranean sea, seems to us even less successful. Terms "boreal", "tropical" etc., which reflect latitudinal-climatic zonality and can be based on much other data, than the analysis of similarity - distinction of biotic associations are undesirable too for biogeographical subdivisions. At the same time frequently these terms already are too widely used, is especial in phytogeography that it was possible to refuse them.

The Tethys Basin and the circum-tropical stream providing a similarity of biotas from the Caribbean sea up to southeast Asia continued to exist in first half of the Cenozoic. Shelves of this basin undoubtedly remained the major centers of formation of shallow warm-water faunas. Therefore for the Paleogene, taking into account differences of these biotas from the Mesozoic, probably, we apply the term “Neotethyan Realm or Superregion”) which included the Proto-Mediterranean Region. Later, during reduction of the Tethys, a progressive falling of temperature, formation of psichrosphaera and more intensive termohaline circulation in World ocean, the structure of fauna once again had essentially exchanged in the end of the Paleogene - the beginning Neogene though and it is not so fast as on the Cretaceous-Paleogene transition. The center of the Neogene benthos faunas formation in the Western Eurasia had passed to the Mediterranean and the Eastern Atlantic. Therefore the term " Proto-Mediterranean - Atlantic Region " (Harzhauzer et al., 2002) seems to us successful enough for the Miocene of the Mediterranean and Paratethys.

At such approach there is a question of time frameworks for paleobiogeographic terms application, which however essentially does not differ from an establishment of such borders in space. It is necessary to reveal, when in time there were sharpest changes between two essential various fauna or flora. Global changes of many groups of benthos, zoo- and phytoplankton, vertebrates had taken place on the Maastricht - Danian transition. Taxonomic composition was changed in all latitudinal belts (zones), but it was especially sharply had an effect on richer Tethys faunas. Therefore this change, probably, it is necessary to date the bottom border of application of terms Neotethys Superregion, Proto-Mediterranean Region and North European Region.

It is much more difficult to establish of final top borders of these name using. Despite of the doubtless importance of changes from the Early Cenozoic (Paleocene - Eocene faunas and floras) to the Miocene, undoubtedly, that they passed in some steps and in different time in the different groups. Therefore the top time boundary can be various for different groups in limits from the mid-Oligocene up to the Burdigalian.

The Messinian crisis of salinity and, probably, repeated invasions of fauna of the Atlantic origin to the Mediterranean have shown, that the Mediterranean was lost role of the center of sea fauna formation to the terminal Miocene and this center has passed to the Eastern Atlantic. Based on data of S. Raffi, S.M.Stanley, R.Marasti (1985), M.S Barash, O.B.Dmitrienko et al. (in "Neogene - Quaternary Paleooceanology", 1989) etc. up to 60 % of species of benthos and 30-40% plankton species in the Pliocene are the Recent ones and their communities had a similar generic structure and domination. Therefore the term North Boreal Region, used in the Recent biogeography, is correct from the beginning Pliocene. At the same time change of fauna on this border was considerably less significant, than at transition from the Eocene to Miocene one and the more so - on the Cretaceous / Paleogene boundary.

Fiume Santo (Sardinia, Italy), a faunal assemblage with a very late Miocene Ape in Europe

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The Late Miocene site at Fiume Santo, the recentmost documentation of the extinct insular faunal assemblage of the Tusco-Sardinian paleobioprovince, has yielded a rich endemic fauna of fossil vertebrates including *Oreopithecus*, a highly derived extinct ape.

The Fiume Santo site has been discovered in 1994 and since then only two short notes (Cordy & Ginesu, 1994; Cordy et alii, 1995) have been published by the team originally charged of the excavation and study of the site. In September 2001, the Soprintendenza per i Beni Archeologici per le province di Sassari e Nuoro charged the University of Florence for the excavation and study of the site and fauna. The present contribution represent the first result of the new study of a small portion of the Fiume santo assemblage.

The discovery of the *Oreopitheus*-bearing deposits at Fiume Santo was made thanks to deep excavations carried out for the constructions of a parking area within the area of a thermo-electric power station of the Italian State Electricity Company. The site has then been notified by the local office of the Italian Ministry for Cultural Heritage and Archaeology (Soprintendenza per i Beni Archeologici per le province di Sassari e Nuoro) and has been declared as protected site. The fossiliferous area is extending for about 0,02 km^2 within the industrial complex of the electricity company.

The basin of Fiume Santo is located in northwestern Sardinia, on the costal area at the Asinara Gulf. The entire area is characterized by a landscape dominated by gently hills of low altitude. The detailed geology of the Fiume Santo fossiliferous deposit is at present not clear. The same is true for the relationships of the fossiliferous succession with the tectonic and geodynamic evolution of the Mediterranean in the context of the late Miocene opening of the Tyrrhenian sea. A stratigraphic study of the Tertiary sedimentary succession is lacking. The only available data rely on geomorphologic and "morphostratigraphic" approaches (Ginesu et alii, 1994; Cordy et alii, 1995). According to the latter authors, two different formations have been recognized within this Tertiary complex. The first one is the "Scala Erre Fmt". This is characterized by coarse alluvial detritus and sandy-clay levels; its upper portion is recognizable by the occurrence of sub-tropical paleosoils. The second formation, "Fiume Santo Fmt", shows precise characteristics of coastal environments, with alternation of beach deposits and aeolian levels. The vertical and lateral relationships between the two formations are still unclear.

Basing on direct observations during preliminary survey of the site, vertebrate fossil remains are found in pockets of sand and silts lying on a carst-like surface of a calcareous substratum. The exact correspondence of these lithologic terms within the two formation described in literature is, at present, unclear. Our preliminary geological outline suggests that the calcareous substratum may represent a local expression of the early Messinian reef-building z-corals in northern Tyrrhenian (Rosen, 1999). Fossil remains are in a relatively good state of conservation. The teeth have enamel perfectly preserved, while dentine and roots are often chemically eroded or are - in some cases - completely absent; bones also generally appears "decorticated" being exposed in most cases the most inner fibrous layers.

The revision of the fossil vertebrates from the sites until now has been performed on a very small part of the collection, basically the remains collected during 1994-1995 excavations. These consist in more than 1,000 specimens representing 12 vertebrate taxa: Testudinae indet., Crocodilia indet., *Oreopithecus bambolii*, Mustelidae indet., cf. *Tyrrhenolutra*, ? *Eumaiochoerus* sp., ?*Umbrotherium azzarolii* (*nomen nudum* Hürzeler & Engesser, 1976), Bovidae indet. (2 forms), *Etruria viallii* (*nomen nudum* Hürzeler & Engesser, 1976), *Maremmia* cf. *lorenzi,* Neotraginae indet., *Tyrrhenotragus* cf. *gracillimus*.
Despite the abundance of Bovidae, Giraffidae and Primates, Suidae as well as Carnivora are represented by extremely poor material (one to three fragments per taxon). The erpethofauna is represented by remains of crocodiles and turtles. No small-sized reptile or amphibians have been identified until present. Crocodiles are unfortunately represented only by isolated teeth (with very low diagnostic value), while the turtle remains are mainly represented by carapax or plastron fragments. By size, the latter allow to exclude an attribution to marine turtles.
The taxonomic diversity seen in Fiume Santo is comparable with the well-known fauna from the same paleobioprovince in southern Tuscany (Baccinello, Monte Bamboli etc.). The fossil ape *Oreopithecus,* represented by about twenty specimens (only dental remains, no postcranial element has been until now identified), shows at a preliminary analysis, no differences with the rich population of southern Tuscany. Also the bovids remains appear comparable with those from the Tuscan localities, except but *M.* cf. *lorenzi* which is slighlty larger in size respect to *M. lorenzi*.
It has been demonstrated that the survival of the latest Miocene extremely derived Ape *Oreopithecus bambolii* in Maremma (southern Tuscany) is linked to a peculiar combination of paleogeographic and paleoclimatic conditions (Rook et alii, 2000) and that the terminal Miocene paleogeographic change in the Tyrrhenian area - consequence of intensive Messinian tectonism which itself produced the Apennine mountain chain - lead to the end of the Tusco-Sardinian paleobioprovince and, evidently, the extinction of the *Oreopithecus bambolii* insular fauna in Tuscany. The Fiume Santo chronology is yet far from being clarified. Its general setting in the geological context of northern Sardinia seems however suggestive of a very latest Miocene age (Messinian?). If confirmed, such a chronologic assessment would imply that *Oreopithecus* and related faunal assemblage was surviving even longer in the Sardinian island, well after the opening of the Thyrrenian sea and the extinction of the corresponding faunal assemblages in peninsular Italy.

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Mammals' paradise: late Early to late Middle Miocene Molasse Basin

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Changes in palaeoecological conditions of the limno-fluviatil Bavarian Molasse Basin in late Early to early Middle Miocene are expected to be reflected by the immense and diverse large mammal record of the stratigraphically well studied area. Therefore based on the large mammal material from the Upper Freshwater Molasse (MN4 to MN9) of the Bavarian State Collection of Palaeontology and Geology in Munich locality/species distribution maps were done for the European Miocene mammal zones MN4 (18.0 to 17.0 MA), MN5 (17.0 to 15.0 MA), MN6 (15.0 to 13.5 MA), and MN8+9 (## to 9.7 MA). While MN4 is poorly represented MN5, MN6 and MN8+9 are each documented by more than 35 localities and 130 species occurences along the axis of the basin. Correlation with the ecomorphological parameter diet category and body size produces coloured maps indicating the distribution of the mean diet category and respectively mean body size of a fauna. For a more detailed look into the taxonomic community structure species occurences were plotted over the ecomorphological background.

The patterns in the spatio-temporal distribution of the ecomorphological parameters reflect communities dominated by small sized browsers in MN4 to MN6, communities dominated by large sized mixed feeders in MN8+9, highly diverse large mammal communities in MN5/MN6, and a diversity decrease especially in cervids in MN8+9. Because diet category and body size are correlated with vegetation of the habitat the environmental changes in the Middle Miocene can be assumed as changes from a closed to more open vegetation structure. A bovid-vacuum in MN5 indicates the sensibility of early bovids to yet still unknown ecological conditions in a wetland area.

The possible reasons for those ecosystem changes are various. The Mid-Miocene cooling might have caused species richness and commonness in MN5/MN6. Decrease of species richness and commonness as well as increase in body-size and mixed feeders might be caused by basin morphology with changing seasonality and/or aridification.

An overview of Tortonian pollen records and the inferred climatic values around the Mediterranean
by

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Eighteen Mediterranean *s.l.* pollen localities, well analysed from the botanical viewpoint, belong to the Tortonian period (12-6.7 Ma), some of them can be set within the EEDEN HR2 interval (Fig. 1). Most of the localities benefit from a chronostratigraphic assignment (foraminifers, nannoplankton, mammals, radiometric ages). They are due to several authors (Ain Mediouna, Oued Msoum, Taza Mine, MSD1: Bachiri Taoufiq, 2000; Zaratan: Rivas-Carballo *et al.*, 1994; Cerdanya and Montredon: Bessedik, 1985; Mirabel: Naud and Suc, 1975; Ambérieu: Farjanel, 1985; Cap Bon Hammamet: Tayech, 1984; Capodarso: Suc *et al.*, 1995; Pont d'Aiguines: Guida, 1998; Nestos 2 and Naf 2: Drivaliari, 1993; Makrilia: Sachse, 1997; Deleina: Ivanov *et al.*, 2002; Schimatari: Mettos *et al.*, 1988; Mavradzei: Ioakim and Solounias, 1985).

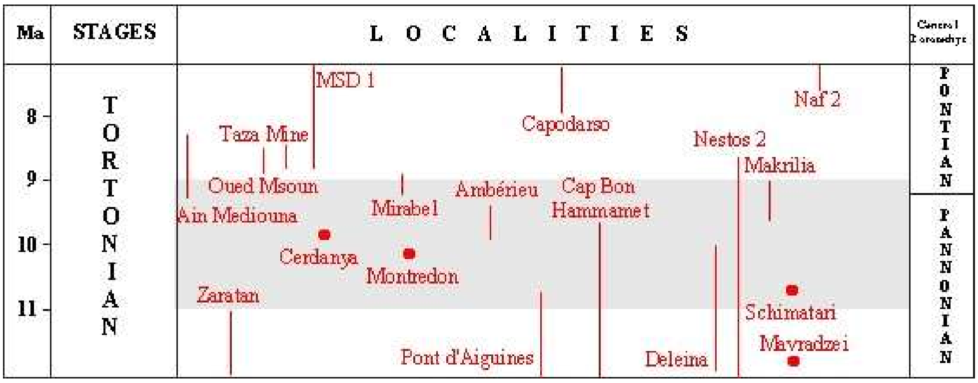

Fig. 1. Chronological location of the considered pollen diagram within the Tortonian with respect to the EEDEN HR 2 interval (grey strip).

The Tortonian vegetation feature is almost similar to that of the Messinian (Fauquette *et al.*, in press) and the Zanclean (Suc *et al.*, 1999; Popescu, 2001) (Fig. 2):

- dry open vegetation developed in the Southern Mediterranean region (where some forests existed on relief), with a special tropical influence close to the Nile delta; the impoverished *Avicennia* mangrove inhabited the South Mediterranean shoreline;
- forests dominated in the Northwestern Mediterranean region where altitudinal belts (*Cathaya*, then *Tsuga* and *Cedrus*, at last *Abies* and *Picea*) extended on reliefs;
- similar conditions characterised the Northeastern Mediterranean region, including an enrichment in herbs from the North to the South.

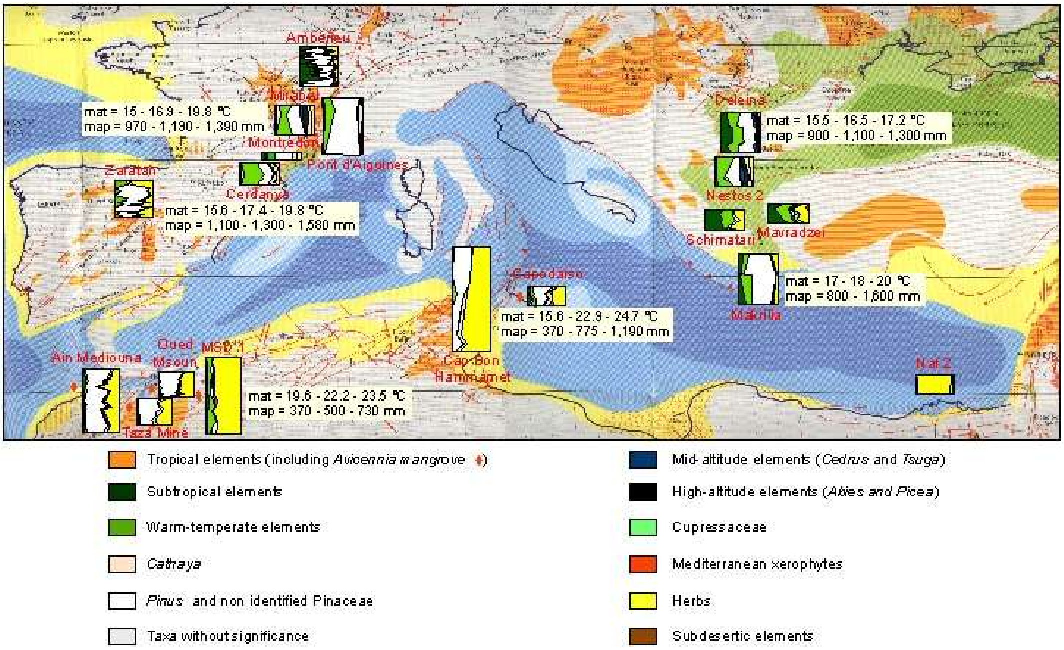

Fig. 2. Synthetic pollen diagrams of eighteen Tortonian Mediterranean *s.l.* pollen localities. The paleogeographic map belongs to Late Tortonian (Meulenkamp *et al.*, 1998). Climate quantifications have been done for some of them (mat = mean annual temperature; map = mean annual precipitations)**.**

Climate quantifications have been done on some localities according to various methods: Mirabel, Cerdanya, MSD1 and Capodarso by S. Fauquette (unpublished), Makrilia by M. Sachse (1997) and Deleina by V. Mosbrugger (Ivanov *et al.*, 2002).

They evidence a clear North-South thermic gradient while the range in temperature is almost the same as during the Messinian and the Early Zanclean (Fauquette *et al.*, in press). The contrast in rainfall is very high between the North and the South Mediterranean region as it was during the Messinian and the Early Zanclean (Fauquette *et al.*, in press). Influence of reliefs was important in the Northern Mediterranean region, that of desert prevailed in the South Mediterranean region. In the Northwestern Mediterranean region, some humidity was forced by the Atlantic Ocean air masses; in the Northeastern Mediterranean region, an actual effect of the Asian monsoon existed.

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Trace fossils in Lake Pannon shoreface deposits, Late Miocene, Hungary

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Two examples of epizodic deposition and pauses are presented here from the Late Miocene (10-9 Ma) Lake Pannon, a large, long-lived, brackish lake with a very high degree of endemism in its biota. Between the main deltaic feeder systems large shallow lacustrine embayments were formed in which claymarls and silts (Somló Formation; Kozma Street outcrop, Budapest). These bays were rimmed by wind-dominated sandy shores (Kálla Sand, Hegyesd and Kisörspuszta, Kál basin) and swampy coastal plains (Tihany Formation). Although the biota of Lake Pannon was widely studied, less attention was paid to the trace fossils in its various facies. No wonder traces are rare due to the endemic, lacustrine nature of the biota.

At the Kozma Street outcrop, Budapest four facies units were identified, as follows. *Massive bluish-gray clays* form the majority of the sequence with thin sand intercalations. Small and larger sand-filled burrows also may occur within the clay as hyporelief or full relief of the overlying sand beds. Both the sand beds and the burrows show a brown aura indicating more oxidized conditions of the sediment. Laminated to bioturbated *brownish-gray silty clays with uneven bedding*, mm thick strings and lenses of coarse silt to very fine sand also occur in the sequence. In the blue clay there are 1 to 30 cm thick intercalations of *parallel-laminated, cross-laminated fine sand* with sharp lower and upper contacts. There is a characteristic order of lamination from bottom to top: A. low angle, low amplitude, long wavelength cross-lamination; B. plane lamination; C. cross lamination. A indicates washed-out ripples, C represents current ripples and B was formed as upper stage plane beds. The sequence from A to B indicates transition towards upper flow regime, from B to C a decrease of energy back to lower flow regime. Often only BC couplets are found. The uppermost 2-3 cm is relatively densely woven with few-mm thick, cm-long, mostly simple vertical to oblique sand-filled or mainly oblique to horizontal, mm thick mud-filled burrows. A few small sand-filled vertical traces penetrate several cm deeply within the sand. Rarely cm-thick, several cm-long sand-filled horizontal burrows with distinct lining are also found in the blue clay. *Medium-grained, fully bioturbated limonitic sands* in 20-30 cm thickness are intercalated either within the blue or the brown clays. The upper bedding contacts are plane and sharp. The lower bedding plane is irregular: a few cm wide and up to 10 cm deep sand-filled burrows, funnels are penetrating downward. In a few cases articulated shells of *Dreissenomya* sp. can be found in the burrows. These are regarded as a combination of domichnia (prior to deposition of sand) and fugichnia (as a consequence of sudden deposition). Rarely thin U-shaped *Arenicolites* isp. is also found.

The clays were deposited in sublittoral brackish-waters, mainly below fair-weather wave base. Alternating preservation of lamination, lack of fossils and the colour of the clay may possibly indicate temporary anaerobic conditions at or near the bottom, perhaps due to stratification of the water mass. The mm to 30 cm thick intercalations of fine sand are interpreted as tempestites. The storm induced currents brought not only sand but oxygen to the lake bottom, thus opportunistic species speedily could colonize the sandy substratum, sometimes excavating burrows far below the sand. Fully bioturbated coarse limonitic sand layers may indicate longer periods of bottom ventillation.

The sedimentary facies at Hegyesd and the nearby Kisörspuszta in the Kál Basin is somewhat different due to the lack of clays and silts. At Hegyesd cyclic repetition of structureless (laminated-to-scrambled, D), cross-laminated (C) and horizontally laminated (B) very fine to fine sands were observed. The base of the bioturbated units is sharp, undulatory, rarely small burrows are "hanging"directly from the base. Plane lamination is often cut by solitary simple vertical or Y-shaped sand-filled burrows. There are smaller ones (1-2 mm in diameter) and larger ones (0.5-2 cm in diameter) with backfill structures. Towards the top of the outcrop both the length (from 1-3 cm up to 50 cm) and the density of the larger burrows increases. The traces are mainly *Skolithos* isp. and *Arenicolites* isp. A well balanced rhytm of pauses of deposition (D) and a relatively slow increase of current energy accompanied with quick sedimentation from C to B is indicated by the above series. At Kisörspuszta a 15 m thick succesion of well-sorted fine sand is found with repeated limonitic colouring and cementation. No sedimentary structures can be observed most likely due to excellent sorting. However spacing, thickness and intensity of limonitic cementation increases upwards, parallel with the appearance of burrows. Trace density index also increases upwards from 2 to 5. The uppermost limonitic sandstone horizons are full of finger-sized vertical to horizontal winding sand-filled burows, ocassionally with backfill lamination. A U-shaped and a few small funnel-like forms were also described.

Although the lack of physical sedimentary structures prohibit direct correlation, the stratigraphic and geographic position as well as similarities in their ichnofacies may indicate a close palaeogeographic relation between these two outcrops. They may have been formed in the agitated water of the shoreface, but not far from the wave base, where unfavourable life conditions (C) are alternating with storm deposition (B) followed by the appearance of burrowing biota (D).

None of the above trace assemblages nor the sedimentary features indicate terrestrial deposition. Even the possible deepest deposits are not much below wave-base. The associated traces are mainly not horizontal, neither grazing or feeding traces were observed, thus the lacustrine *Mermia* ichnofacies can be excluded. The low diversity of the traces, the dominance of domichnia in the form of *Skolithos* isp. with *Arenicolites* indicate the lacustrine occurrence of a marine-like *Skolithos* ichnofacies.

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Middle Miocene planktonic foraminiferal biostratigraphy: a comparison between Mediterranean and Paratethys

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During the Middle Miocene the connections between the Mediterranean and the Paratethys were intermittently open. After the first interruption during the late Burdigalian, a transgressive event widened the connections between the Mediterranean and the Indian Ocean affecting also the Paratethys, as testified by the deposition of the pelagic *Globigerina* marls during the early Langhian (early Badenian). The connections between Mediterranean and Paratethys ended during the early Serravallian (late Badenian), but were re-opened during the middle Serravallian (early Sarmatian) and during the middle Tortonian (Pannonian) (Roegl, 2001).

The stratigraphic intervals characterised by open connections are suitable for a comparison of the planktonic foraminiferal biostratigraphy between the Mediterranean and the Paratethys.

A high-resolution quantitative biostratigraphy was obtained from Mediterranean deep-marine successions (Hilgen et al., 2000, 2003; Iaccarino, 2002 and papers therein; Turco E. et al., 2002; Foresi et al., 2003) showing the complete sequence of the Middle Miocene bioevents and some additional faunal changes, which increase the biostratigraphic resolution.

In this study, which focuses on the Badenian interval, we present preliminary biostratigraphic results based on planktonic foraminiferal assemblages from the Romanian Carpathians (Piatra Verde Hill and Prahova Valley, north of Bucarest) and a comparison of the main bioevents and the additional faunal changes with those of the Mediterranean to test their potential in biostratigraphic correlations.

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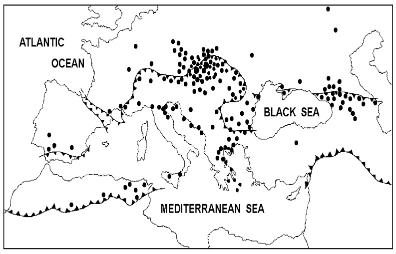

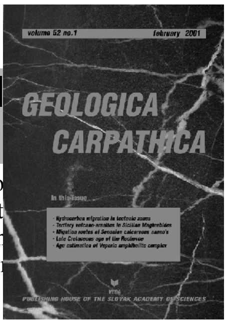
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