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# FLORISTIC BIOSTRATIGRAPHY OF TERTIARY BASINS IN THE BOHEMIAN MASSIF AND CORRELATION WITH CENTRAL PARATETHYS

*(2 Figs.)*

A b s t r a c t : Present paper considers paleontological data on biostratigraphy of Tertiary basins and volcanic regions in the Bohemian Massif and their correlation with Central Paratethys. The correlation is based mainly on the macro- and microflora, mammals, molluscs and ostracods. Floristic comparison relies on index fossils or floral assemblages which can be correlated with the floristic zones in G.D.R. and stages of the Central Paratethys as well.

Р е з ю м е: В настоящей статьи обсуждаются палеонтологические данные о биостратиграфии третичных бассейнов и вулканических областей в Чешском массиве и их корреляция с Центральной Паратетидой. Эта корреляция основывается прежде всего на макро- и микрофлоре, млекопитающих, молюсках и остракодах. Флористическое сравнивание опирается на руководящие окаменелости или ассоциации растений которые можно коррелировать с флористическими зонами ГДР и тоже с ярусами Центральной Паратетиды.

## *Introduction*

Correlation of fresh-water deposits has proved for long to be a difficult task in areas, such as Tertiary lignite basins of Central Europe outside the Tethys-Paratethys realm. In the almost complete absence of faunal biostratigraphic evidence, most attempts have been focused on development of floras and inferred palaeoclimatic oscillations.

Palaeogeographical position of the Bohemian Massif between the Boreal region and Paratethys gives an opportunity for using stratigraphical scales of both regions, or better that of the latter. In other words, there is also a chance to try an indirect correlation of both regional scales by linking marine and non-marine, mostly fresh-water facies. The limnic basins of the Bohemian Massif were correlated with Paratethys already by F e j f a r (1974, in C i c h a et al., 1975) on the basis of mammals and we have followed this way using macrofloras.

In the Bohemian Massif, Tertiary deposits represent several isolated basins, volcanic areas or local occurrences. Palaeogeographically they are closely connected to the lignite basins in G.D.R., where a workable zonation of macrofloras has been suggested (M a i, 1967, 1970; M a i – W a l t h e r, 1983), of course without being linked exactly with chronostratigraphic scale. On the other hand, progressing palaeobotanical research in Central Paratethys has allowed us to compare macrofloras of our area with those in Central Paratethys (B ů ž e k – K v a č e k, 1985) and thus to estimate their age.

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The present correlation (Figs. 1,2) is combined as much as possible with the data based on faunal correlation (mammals by Fejfar, 1974, in Cicha et al., 1975; molluscs by Čtyroký – Fejfar, 1962; Čtyroký et al., 1964, and ostracods by Kheil, 1964). Our linking of the Ng-Zones of G.D.R. with the Central Paratethys stages widely departs from that of Hochuli (1978, Fig. 1) in the concept of the time span and the range of the Ng I and II Zones (see also below).

Before discussing the development of individual areas the following corrections of the G.D.R. zonation have to be stated. In the original concept of these zones, the differences in composition of floral assemblages due to geological setting, and palaeoenvironment (swampy

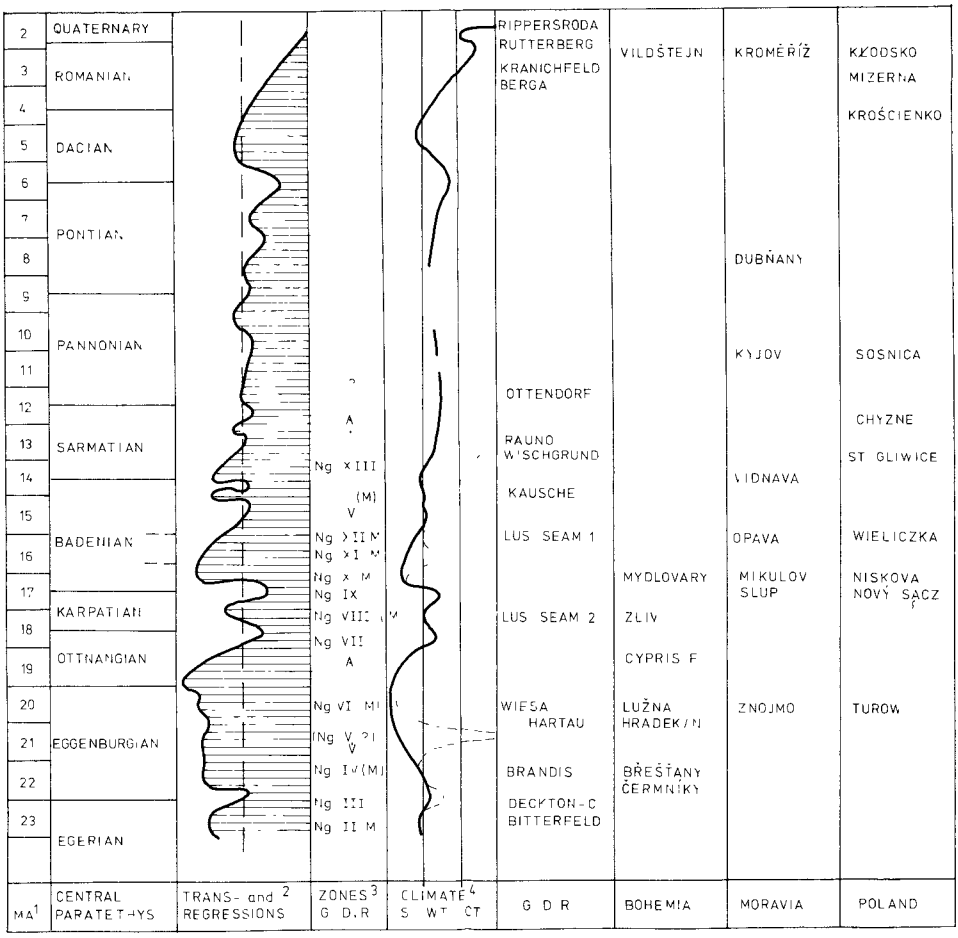


Fig. 1. Climatic, sea-level and floral fluctuation in Central Europe.
1 – Radiometric age according to Rögl – Steininger (1983) and Vass et al. (1985, 1987); 2 – transgressive/regressive cycles according to Rögl – Steininger (1983); 3 – floristic zonation according to Mai (1967), (M)-rare, M-regular, M!-abundant, M!!-maximum occurrence of *Mastixiaceae;* 4 – climatic oscillations according to Mai (1970), corrected and supplemented Mai's original interpretation (----). S-subtropical, WT-warm-temperate, CT-cold-temperate.

– riparian – mesophytic vegetation) were largely neglected (Ahrens–Lotsch, 1967: 51). Only later Mai and Walther (1979, 1983, 1985) when working on Palaeogene floras of the Weißelster Basin introduced a term „Florenkomplex", a palaeofloristic unit encompassing various biofacies/vegetation types of assemblages in a given area. In this view, their Thierbach complex of NW Saxony includes zones Ng I (Thierbach Formation, upper part) and Ng II (lowermost part of Bitterfeld seam) (see Walther, 1986). The lateral connection of these two levels was proved also by sedimentological study (Manewald, 1987).

In no section of our Tertiary, neither in G.D.R., the zone Ng V has ever been found in superposition over the zone Ng IV (note an error in Ahrens–Lotsch, 1967; Figs. 1,2 concerning core AD 7). We believe that its position near the main Lusatic fault has to be clarified and that the Ng V Zone might coincide with some deeper zones (probably with Ng III or I Zones), also in view of its composition (mass occurrence of *Picea, Fagus, Liriodendron).*

The last zone Ng XIII includes more levels of different age and deserves more detailed division.

The resulting palaeoclimatic curve after suggested corrections (Fig. 1) coincides suprisingly well with changes of sea level in Paratethys during the Neogene as presented by Rögl–Steininger (1983). Palaeoclimate and sea level oscillations are surely two closely connected phenomena, as it is becoming apparent from more and more studies not only in Tertiary (e.g. Kemper, 1987). Connection of some floral zones to the Paratethys stratigraphy is further supported by rare faunal data available in the Bohemian Massif (Bůžek et al., in press).

The following brief summary of our results outlines succession of ascertained floristic changes related to climatic conditions and the occurrence of mastixioid floras, on which our attempt of correlation between fresh-water Tertiary in the Bohemian Basin and Paratethys stages has been based (Fig. 2).

### *Hrádek part of the Zittau Basin*

The section includes three seam levels. A rich mastixioid flora characterizes the upper seam and its overlying beds (Holý, 1977a,b; 1978). It exactly matches with the zone Ng VI in G.D.R. (Hartau in the same basin) and its equivalents in Poland (the quarry Turów). The middle and lower seam strata bear less thermophilous floras, which can be compared with the zone Ng IV.

### *Volcanic complexes of the České středohoří Mts., Doupovské hory Mts. and Lužické hory Mts.*

The palaeobotanical research and also radiometric data suggest a long time span of the surface volcanism. It started already in the Upper Eocene and continued throughout the Oligocene up to the Egerian (Konzalová, 1977; Bůžek et al., 1968, 1976, 1978). The oldest floras (Kučlín, Lbín, Hlinná) include early Tertiary plants met with in the Tard clays and Bembridge Marls. These are at places underlain by the Upper Eocene floras of the Staré Sedlo Formation.

Most localities are characterized by an assemblage of *Platanus neptuni, Laurophyllum pseudoprinceps, Tetraclinis, Pteleaecarpum* (Markvartice) together with *Acer, Carya, Ostrya, Ampelopsis* (Kundratice, Bechlejovice) and *Taxodium* (Seifhennersdorf, Knížecí) and fall

obviously within the Middle Oligocene. It is confirmed by radiometric data (Shrbený, 1969; Kopecký, 1978) and the occurrence of the index pollen *Boehlensipollis hohlii* (Konzalová, 1981). The newly recovered florula of similar composition in the Menilitic Formation at Bystřice n.O. (NE Moravia, nannoplankton zone NP 23–NP 24) also attests such correlation (Kvaček – Bubík, in press).

### *North Bohemian Basin*

Studies in the Most part of the basin have revealed the development of the flora and vegetation from the beginning of the lignite sedimentation through the Main Seam Cycle to the Lom seam (Bůžek et al., in press).

Strata underlying the Main seam partly coincide with the uppermost Egerian (so called Basal seam p.p.) according to palynological studies (Konzalová in Bůžek et al., in press). The oldest macrofloras connected with the periphery and channel deposits between Žatec and Rakovník (Holedeč, Želeč, Nesuchyně, Hlavačov, Bendovka) include *Pseudolarix, Taxodium, Fagus, Liquidambar, Betulaceae* etc. (Bůžek – Kvaček, in press) and compare well with the Ng III Zone. The Main seam and the lower part of the overlying strata bear carpological flora (Bůžek – Holý, 1964), which was the basis of the correlation with the Ng IV Zone in G.D.R. (Mai, 1967). Different plant assemblages have been found in connection with the mica psammites to sandy pelites in the roof of the Main seam evidently of the Krušné hory Mts. provenience. They include abundant remains of pines, *Symplocos, Zanthoxylum, Schisandra,* at higher positions of clays also taxa known from younger phases of Lower Miocene like *Quercus kubinyi, Laurus abchasica* and in the Lom seam *Myrica undulatissima.* The floras of the basin filling indicate a trend of warming, which corresponds roughly to the extent of the (III-) IV and VI Zones in G.D.R. (Kvaček – Bůžek, 1983; Kvaček et al., 1983). Because of lack of *Mastixiaceae,* rather the beginning or the transition to the zone Ng VI is to be supposed.

Scanty assemblages from the volcanogenic strata below the basin filling correspond to those of the adjacent Volcanic complexes of the Oligocene age.

### *Sokolov Basin*

The floras of the basal strata – the Staré Sedlo Formation – are correlatable with Upper Eocene in G.D.R. and elsewhere (Knobloch, 1963). This has been confirmed by palynological research (Konzalová, 1972) and cuticles (Kvaček et al., in press).

The lowermost seam Josef revealed in its upper part Oligocene florulas *(Tetraclinis, Platanus neptuni, Dryophyllum furcinerve)* that indicate early Oligocene age. The pollen spectra include the important marker *Boehlensipollis hohlii* (Konzalová, 1981) whose range spans early Oligocene–Lower Egerian with main occurrences in Rupelian. The volcanic strata between the Josef seam and the Main seam unit (the seams Anežka and Antonín) yielded floras of various habitats and levels. Floras of the Hroznětín area which are connected with lignite sedimentation, correspond to those of Middle Oligocene age of the Volcanic complexes. The floras from the pellocarbonates from Lipnice, Lomnice-Erica Mine and Vintířov-Jiří Mine are distinguished by a rich occurrence of a new element *Quercus rhenana,* those from the basin periphery (Počerny, Podlesí near Karlovy Vary) by a mastixioid assemblage with *Liquidambar, Fagus, Symplocos salzhausensis, Carya* etc. They are comparable with the flora of Linz environs (Kovar, 1982) of Egerian age in the Paratethys.

The floras of the Main seam unit are only known from the sands underlying the seam Antonín near Bukovany, which belong to mastixioid assemblages (Holý, 1977b). The floras of the Cypris Claystone overlying the Antonín seam are much the same as those from the Cypris Claystone in the Cheb Basin. According to the ichthyofauna-zonation they fall only within the lower part of the section in the Cheb Basin (Obrhel – Obrhelová, 1983, 1984). The equivalents of the warm temperate floras of the type of the North Bohemian Basin (zone Ng IV) have not been so far found there.

### *Cheb Basin*

During last years of persuing geological prospection cores it has been possible to suggest the sequence of floras from the whole vertical section of the basin ranging from Eocene to Lower Miocene and uppermost Pliocene.

The newly ascertained floras of the deepest deposits at Velký Luh (with *Doliostrobus, Hantsia pulchra, Palaeosinomenium*) confirm the Eocene sedimentation (Bůžek et al., 1969, 1982). Those of the basal strata near Nový Kostel match with the Staré Sedlo Formation (Konzalová, 1987; Kvaček et al., in press).

The succeeding sedimentary cycle that includes the Lower Seam, its equivalents and the lower part of the interseam strata with scanty volcanic bodies is referred to early Oligocene *(Dryophyllum furcinerve, Platanus neptunii, Trigonobalanopsis)*. Only the flora of Seussen in the adjacent basin of Arzberg, F.R.G. (Knobloch, 1971) is comparable with Egerian and partly with Thierbach Complex (Ng I–II) (Kvaček et al., in press).

The Miocene cycle begins in the uderlying strata closely below the Main seam, which yielded assemblages with *Taxodium, Pinus* and both evergreen and deciduous elements. These match best with those of the Main seam of the North-Bohemian Basin, i.e. the zone Ng IV.

The floras following upwards are those from the roof of the Main seam (incl. mastixioid assemblages from the Cheb environs) and the lower part of the Cypris Claystone. In them palaeosubtropical elements prevail *(Lauraceae, Trigonobalanopsis, Palaeocarya, Platanus neptuni, Mastixia amygdalaeformis, Eomastixia hildegardis, Tectocarya elliptica, Sphenotheca incurva, Symplocos lignitarum, Ehretia, Sinojackia, Polyspora hradekensis, Zizyphus)*. In the uppermost part of the Cypris Claystone (near Kaceřov and elsewhere) the flora becomes impoverished with prevailing 2-needled pine. But in the ichthyozone III *Lygodium* and ichthyozone IV *Engelhardia* have been still found. According to mammal fauna (Fejfar, 1974), stratigraphical position of the Cypris unit is fixed in the span of Ottnangian (the lower part) to Karpatian (the upper part) of the Paratethys chronostratigraphy.

The flora of the youngest unit – the Vildštejn Formation – which was deposited after a long hiatus, is assigned to Reuverian C to Praetiglian of the West European stratigraphy basing on the rate of exotic elements and palynological data (Bůžek et al., 1985). This agrees also with palynological study of the filling of the Tachov graben adjacent to the Cheb Basin (Gabrielová et al., 1970) correlatable with the lower part of the Vildštejn Formation. A comparison with the aid of palaeomagnetic studies in West Europe and Paratethys gives an age of Middle to Upper Romanian.

### *Plzeň Basin*

The Neogene flora of this area has been only preliminary studied (Němejc, 1968). The occurrence of *Pinus engelhardtii* MENZEL (= *Pinus* aff. *laricio* sensu PURKYNĚ) dates the

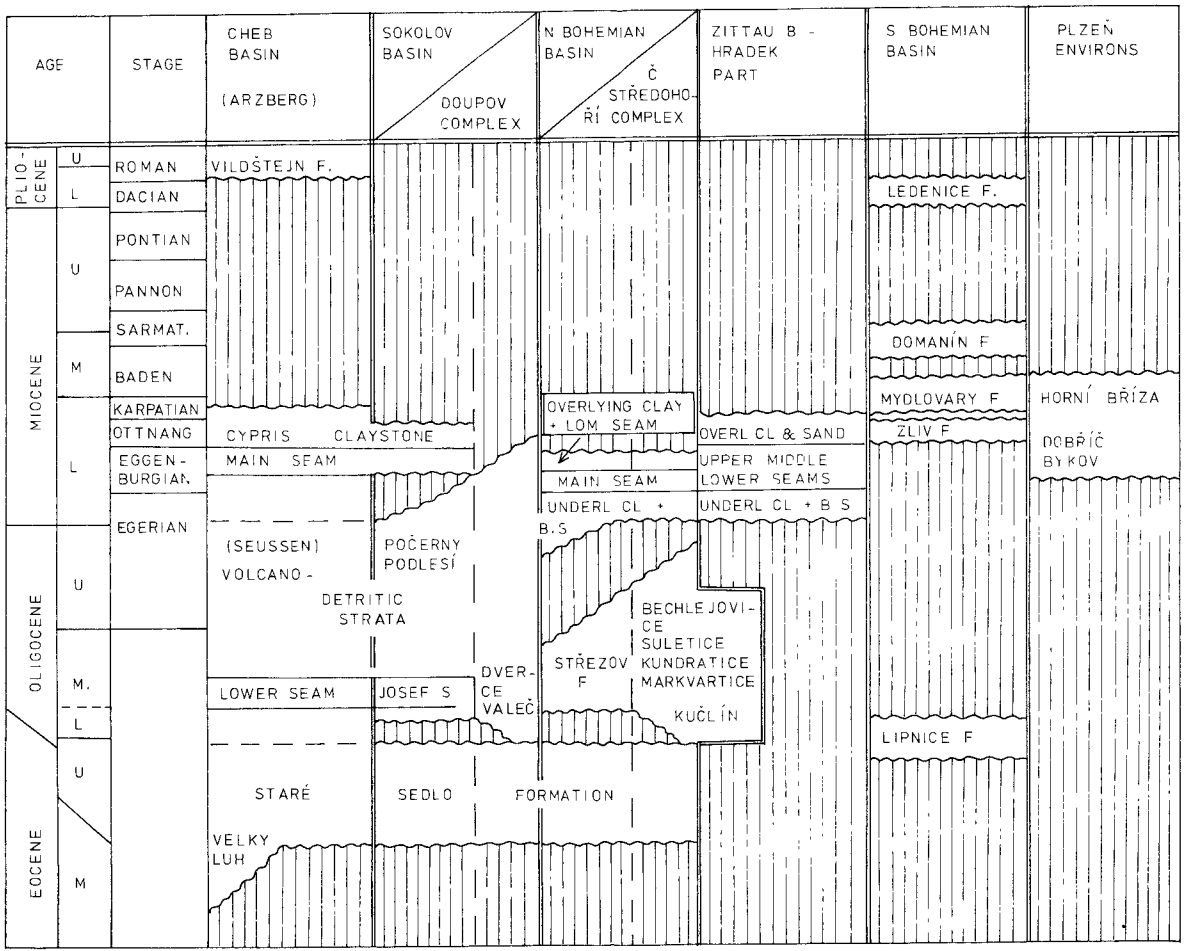


Fig. 2. Correlation of the Tertiary on the Bohemian Massif. S. – Seam, B. S. – Basal Seam, F. – Formation.

siliceous sandstones at Býkov to Lower Miocene (a parallel to sandstones at Hradiště near Černovice). The assemblages of Dobříč *(Sequoia couttsiae, Laurophyllum pseudoprinceps, L. acutimontanum, Daphnogene)* may fall within Ng IV or VI Zones. The assemblages of Horní Bříza are related on one side to the floras of the Cypris Claystone, on the other side to those of the Mydlovary Formation in S. Bohemia, thus making an important link between both areas.

### *South Bohemian Basins*

The information received so far concerns mainly the leaf assemblages of the Mydlovary Formation (Knobloch, 1964, 1968; Němejc, 1968) and an important occurrence of the mastixioid flora in the overlying strata connected with the lignite sedimentation near Hluboká/Vlt. (Holý, 1977b; in Knobloch – Konzalová, 1978; in Knobloch, 1986). Together with recently determined *Quercus kubinyi, Engelhardia, Laurus abchasica, Laurophyllum hradekense* (Kvaček, unpubl.) the Mydlovary leaf flora well corresponds to the Middle Miocene (Lower Badenian) climatic optimum. A close relation between the Mydlovary Formation and the underlying Zliv Formation is supported by many facts including palaeobotanical and palynological data (Pacltová, 1960; Gabrielová et al., 1964).

The Ledenice Formation is assigned to early Pliocene on palynological data (Pacltová, 1963).

### *Comparison with some floras of Central Paratethys*

The floras of the Carpathian fore-deep and the Vienna Basin in S. Moravia which are close to the Bohemian Massif, have brought important information in the case of a mastixioid flora of Mikulov of Lower Badenian age (Holý in Knobloch – Konzalová 1978).

This occurrence and the mastixioid floras of Wieliczka in Poland (Middle Badenian) prove the last existence of this type of vegetation in the Middle Miocene. Further opportunities of comparing the Miocene floras of the Bohemian Massif with the Paratethys region are afforded by the floras of the Western Carpathians at Velká Čausa (Sitár – Takáč, 1982) and Lipovany (Němejc – Knobloch, 1973) in central and southern Slovakia. The former represents a faciostratotype of the Eggenburgian, the latter has recently been assigned to the uppermost Eggenburgian (Čtyroký, 1982) on the basis of correlatable rhyodacite tuffites in the environs of Znojmo and at the Slovak/Hungarian frontier and corresponds also to the flora of Ipolytarnóc (Hably, 1983).

During Upper Miocene (Pannonian, Pontian) exotic elements decreased in diversity and frequency, as it is documented by floras from South Moravia (Knobloch, 1969, 1981). *Symplocaceae, Styracaceae, Meliosma* are absent and *Lauraceae* as well as *Taxodium,* quite rare. In woody and undergrowth floras new elements appeared (e.g. *Acer vindobonense, Alnus cecropiaefolia, Pilea, Itea, Oenanthe).* This type of vegetation evolved, after some changes during Lower Pliocene, into floras, known from the basal strata of the Vildštejn Formation.

### *Summary*

The results of the floristic correlation can be summarized as follows.

The uppermost part of the Volcanic strata in western Bohemia can be correlated with the Egerian on the basis of matching of mastixioid assemblages with *Fagus* at Počerny, Podlesí and Seussen (F.R.G.) with the leaf flora of Linz environs (Austria), which includes palaeosubtropical elements *(Tetraclinis, Trigonobalanopsis, Laurophyllum acutimontanum, Buxus egeriana)* beside *Fagus* and other Arctotertiary elements as well.

The prevailing part of the filling of the North Bohemian Basin (including the Main seam and the lower part of its overlying strata) bear warm-temperate floras without *Mastixiaceae* and are compared with the zone Ng IV in G.D.R. The mammal fauna and molluscs of the base and close underlying of the Main seam are of Eggenburgian age (B ů ž e k et al., in press). The best floristic match is afforded by the locality of Velká Ćausa. Warm-temperate of non-mastixioid floras in the Lower and Middle seams in the Hrádek part of the Zittau Basin as well as the uppermost floras underlying the Main seam of the Cheb Basin are assigned to the same level.

Higher up warming trends have been encountered in all basins. The upper part of the North Bohemian Basin filling incl. the Lom seam represents the beginning (or transition) to a climatic optimum, which is expressed by mastixioid floras in the Cheb Basin (the roof of the Main seam), the Sokolov Basin (within the Main seam unit) and the Zittau Basin (the roof of the Upper seam). The latter occurrence is directly connected with the zone Ng VI of G.D.R. This climatic optimum, which lasted to the time of deposition of the Cypris Claystone is estimated to the Upper Eggenburgian and the Lower Ottnangian. The fauna at Dolnice of Ottnangian age (F e j f a r, 1974) dates the base of the Cypris strata. The climatic optimum is attested also by the Upper Eggenburgian floras at Lipovany and Ipolytarnóc with *Tetraclinis, Platanus neptuni, Laurophyllum acutimontanum, L. pseudoprinceps* (S i t á r – K v a č e k, in prep.). Their correlation with the Ng II Zone (H a b l y, 1983) is, however, questioned by the present study.

The upper part of Cypris Claystone is dated by the fauna of Františkovy Lázně (F e j f a r, 1974) to Karpatian and the scanty floras of that part of the Cheb Basin suggest already certain cooling trends, probably as a result of drier precipitation regime. The Zliv Formation flora and the flora of Horní Bříza at Plzeň may fall within the same levels, which can be correlated with Karpatian. The Mydlovary Formation of the S. Bohemian Basins, which bears a mastixioid flora (probably Ng X–XII Zones), is assigned to the uppermost Karpatian to Lower (or even Middle) Badenian on faunal evidence.

This level correlates with the mastixioid floras of Lower Badenian age at Mikulov or even with those of Middle Badenian age from Wieliczka. The latter site bears probably the latest mastixioid flora in Central Europe.

The equivalents of Upper Miocene floras (Pannonian–Pontian), which attest to climatic decline towards Messinian event with more continental climate, have not been recovered in the Bohemian Massif.

The pollen spectra of the Ledenice Formation in the S. Bohemian Basins correspond probably to Brunssumian in W. Europe and attest to a renewed optimal climatic trend, supposed for Dacian in Paratethys.

The rich flora of the Vildštejn Formation of the Cheb Basin enabled correlation with Reuverian C to Praetiglian in W. Europe. Their direct correlation with the type sections of Romanian are not possible on floristic basis because of more southerly positions of floras known so far from this level in Romania and Bulgaria. The sharp cooling of Praetiglian seems to fall within Upper Romanian, documented by faunas in the stratotype area.

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