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Stratigraphy of the "Basin Fill" in the Early Miocene Lignite Opencast Mine Oberdorf (N Voitsberg, Styria, Austria)

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1 Text-Figure

Styria
Pannonian Basin
Styrian Basin
Lignite
Lithostratigraphy
Biostratigraphy
Magnetostratigraphy
Chronostratigraphy

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Stratigraphie der Beckenfüllung im untermiozänen Braunkohlentagebau Oberdorf (N Voitsberg, Steiermark, Österreich)

Zusammenfassung

Die siliziklastische Abfolge des Braunkohlentagebaues in Oberdorf gehört zur Köflach-Voitsberg-Formation. Basierend auf Blatt- und Diasporen-Vergesellschaftungen ist ein unter-Miozänes Alter für die gesamte Abfolge wahrscheinlich. Mit Hilfe einer reichen Wirbeltierfauna der Neogenen Säugetierzone MN4 aus den Sedimenten der höheren Hangendabfolge kann der normal magnetisierte Teil der Hangendabfolge biostratigraphisch mit dem Chron C5Dn und der liegende, invers magnetisierte Teil des Profils mit dem Chron C5Dr korreliert werden. Nach der GPTS ist das Alter des Polaritätswechsel C5Dr / C5Dn bei 17,6 Ma. Damit wird für die Lignit-Abfolge von Oberdorf ein ottnangisches Alter postuliert werden. Auf Grund von integrierten stratigraphischen Korrelationen kann nun die Grenze zwischen der Säugetierzone MN3 und MN4 auf ein Alter von 18,0 bis 17,8 Mill.J. und die Grenze zwischen der Säugetierzone MN4 und MN5 auf ein Alter von 17,0 Mill.J. eingeengt werden.

Abstract

The siliciclastic lignite deposits of the open pit mine in Oberdorf belong to the Köflach-Voitsberg Formation, and biostratigraphic data (leaf and diaspore assemblages) indicate an Early Miocene age. The rich mammal fauna from the upper part of the hanging wall sequence is indicative of Neogene Mammal Zone MN4 and allows a biostratigraphic correlation of the normally magnetized part of the section with Chron C5Dn and the lower, reversely magnetized, part of the section with Chron C5Dr of the GPTS. The age of the polarity change C5Dr/C5Dn falls according to the GPTS at 17.6 Ma and indicates an Ottnangian age for this part of the Oberdorf section. By cross correlations, the boundary of Mammal Zones MN3 and MN4 can be estimated at around 18.0 to 17.8 Ma and the boundary between Mammal Zones MN4 and MN5 at 17.0 Ma.

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1. Introduction

Neogene coal deposits of Austria, which have been exploited, are known from various tectonic units and different time slices (STEININGER et al., 1989). The Miocene of the Styrian Basin, especially the Western Styrian Basin was and still is a very rich brown coal province (WEBER & WEISS, 1983). However, detailed lithologic sequences are generally lacking for most of these brown coal mines in the Western Styrian Basin. This fact (1) hinders lithostratigraphic correlation across this brown coal province and its basins, and (2) hinders biostratigraphic correlation of these lignite deposits using the rich plant and vertebrate remains recovered from these mines in former times. From the Köflach-Voitsberg lignite district in particular a number of mostly larger mammal remains have been described from the former brown coal mines at Piberstein, Karlschacht Grube, Karlschacht Tagbau, Marienschacht, Karlschacht Tagbau 2, Piber, Bärnbach and Grubhof, Oberdorf, Zangtal and Kowald (MOTTL, 1970; WEBER & WEISS, 1983), but these are beyond the scope of this study.

The Neogene of the Styrian Basin was mapped by KOLLMANN (1965), who concluded that the lignite sequence of the Western Styrian Basin (e.g., Eibiswald, Vordersdorf, Wies and Köflach-Voitsberg) was deposited before the marine transgression of the Styrian Basin. The basal parts of this transgressive marine sequence of the Styrian Basin are characterized by *Globigerinoides bispherica* and can therefore be correlated to Plankton Zone M4b according to BERGGREN et al. (1995). Because of this correlation the underlying lignite sequence was also correlated in general with the upper Early Miocene, the basal part of the Karpatian Stage of the Central Paratethys Chronostratigraphic Time Scale (RABEDER & STEININGER, 1975; STEININGER et al., 1996).

2. Stratigraphy of the Lignite Deposits of the Oberdorf Open Pit Mine

2.1. Lithostratigraphy

The siliciclastic lignite deposits of the Oberdorf open pit mine belong to the Köflach-Voitsberg Formation of the lignite-bearing sequence in the Köflach/Voitsberg lignite mining district. In general the Köflach-Voitsberg Formation is associated at the Oberdorf open pit mine with sediments of a marginal fluvial environment, characterized by flood plain and flood basin sediments alternating with crevasse splay deposits and channel fillings. Paleosols occur frequently and are characterized either by red earth, or bluish-greenish, siderite-bearing horizons that are evidence for waterlogged soils in a swampy environment. The frequent occurrence of fusain layers implies palaeoforest fires.

A composite section of the Köflach-Voitsberg Formation of approximately 165 meters of sediment can be reconstructed in the Oberdorf open pit mine. The lower part, the footwall sediments, are about 15 meters thick, dominated by clayey sediments with a sandy silt part at the base and a prominent gravel bed in the middle. Above the gravel bed, ripple crossbedding, root remains and fossil wood become frequent and a layer with diaspores and leaves is known just below the main seam.The main coal seam of the Eastern subbasin is about 35 meters thick, divided into a lower and an upper seam by a seam-parting member with a maximal thickness of 17 meters. This seam-parting member exhibits ripple crossbedding, wood and root remains, and two horizons with leaves and diaspores in the upper part, and a tree stump horizon near the top of the seam-parting member (HAAS and HAAS et al., this volume).

The hanging wall sequence is about 115 meters thick, dominated by clayey silts in the lower part (approx. 30 meters), sandy partly marly silts with gravel horizons, several distinctive carbonaceous clay horizons and minor coal seams in the middle part (approx. 40 meters) and marly clay and clayey silts in the upper part of the hanging wall sequence (approx. 45 meters). In the middle part of the hanging wall sequence we have horizons with vertebrates (O3, O4; DAXNER-HÖCK et al., this volume), tree stumps, plant remains and molluscs (mainly gastropods).

The heavy mineral distribution allows the differentiation of two distinct erosional areas: a low grade metamorphic upper greenschist facies source area in the main seam parting, and a medium grade metamorphic amphibolite facies source area in the upper hanging wall sediments and in the Zangtal main seam parting. The modeling of the coal seam distribution shows the transition of the coal seam from the Oberdorf eastern subbasin to the adjacent Oberdorf western subbasin and its connection with the lower seam in the Zangtal open pit mine. This demonstrates the complexity of the subsidence history within the basins (HAAS and HAAS et al., this volume).

The Early Miocene lignite deposits of the Oberdorf open pit mine are unconformably overlain by the Middle Miocene Stallhofen Formation, which includes tuffs/tuffites (Lobmingberg Member) in its basal parts. These rhyolitic tuffs are partly altered to bentonite and interpreted as subaqueous fallout tephras (EBNER et al., this volume).

2.2. Biostratigraphy

2.2.1. Paleobotanical Results

Leaf flora

Leaf elements assigned to mesophytic forests, represented in the rich fossiliferous basal layers of the sequence, are of some biostratigraphic interest.

Among the Lauraceae, *Laurophyllum markvarticense* has been reported so far from Oligocene/Early Miocene deposits while *L. pseudovillense* is restricted to the Early/Middle Miocene. Nevertheless it should be noted that these taxa are extremely rare. This fact may be a reflection of the actual fossil record as well as of identifications, which are based exclusively on cuticular analysis.

Trigonobalanopsis rhamnoides (ROSSMÄSSLER) KVACEK & WALTER, an evergreen Fagaceae (fruits and pollen have also been identified at Oberdorf), is a widespread and very characteristic element in Northern and Middle Europe during (Late) Oligocene to Lower Miocene time. Even younger records exist in climatically favorable regions.

Among the conifers, *Tetraclinis salicornioides* (UNGER) KVACEK is numerous in one sample but extremely rare in all the others. This Cupressaceae is also regarded as a common accessory element in Oligocene and Early (Middle) Miocene plant assemblages. Sporadic occurrences are characteristic of Late Miocene assemblages in Central Europe.

Both the presence of single taxa as well as the overall floristic composition must be taken into consideration for biostratigraphic analysis. Conservative taxa restricted to

the Paleogene are lacking, as are progressive taxa which are well known from Middle to Late Miocene floras. These facts support a Lower Miocene age for the plant-bearing deposits (KOVAR-EDER et al., in press).

Diaspores

In addition to numerous diaspore taxa with a wide stratigraphic range, some species are well known from European localities considered to be of Oligocene/Early–Middle Miocene age: *Poliothyrsis eurorimosa* MAI from Germany and Denmark and *Manglietia germanica* MAI from several localities in Saxony and the Oberpfalz lignite area (Germany). *Litsea sontagii* GREGOR is known only from Hofenstetten (Oberpfalz lignite area, Germany, Early or Middle Miocene) and *Gironniera verrucata* MAI in MAI & WALTHER has been described before from Salzhausen (Germany, Middle Miocene) and Niederheide (Germany, Late Oligocene). Records of *Zanthoxylum giganteum* (GREGOR) GREGOR have been documented from the Oberpfalz lignite area (Germany; Early/? Middle Miocene) and recently from Northern Italy (pers. comm. GREGOR). *Trigonobalanopsis exacantha* (MAI) KVACEK & WALTHER is a common element at numerous localities: the Oberpfalz lignite area, Wiesa (Germany; Early/Middle Miocene), Germany; Hradek, Czech Republic, (Early Miocene). The records from older and younger sites are less numerous. The Late Miocene and Pliocene localities, for example in the Lower Rhine Embayment (Hambach, Germany) and Ca' Vietone near Turin (Italy), are thought to have been climatically favorable regions at that time, where warm/temperate taxa may have survived for a longer period of time.

The ages cited for outcrops in these regions are largely based on regional geology or on the plant remains themselves. Only the Northern Italian locality and some in the Lower Rhine Embayment have been dated by correlations based on marine organisms.

The overall floristic composition of diaspores in the Oberdorf open pit mine lacks species characteristic of the Eocene and Oligocene. The overlapping ranges of the species present indicate an Early (? to lowermost Middle) Miocene age for the lignite-bearing deposits (MELLER, in press; MELLER et al., in press).

2.2.2. Paleozoological Results

Vertebrate fauna

As noted in the introduction, vertebrate fossil remains were collected during many years of mining activity from different sites in the Köflach-Voitsberg area (MOTTL, 1970). These old collections consist mainly of isolated large mammal remains. However, because of their uncertain lithostratigraphic position, these old finds cannot be used for reliable biostratigraphic correlations and therefore are not taken into consideration here.

The more recently recovered faunas are restricted to two fossil horizons (O3 and O4) from the hanging wall of the open pit mine at Oberdorf (see Lithostratigraphy and HAAS, this volume). Because of their almost identical faunas the two horizons are thought to be time-equivalent. The vertebrate fauna from both layers is rich in small vertebrates and 88 % of the mammals belong to small species that in some cases are excellent biostratigraphic markers. Stratigraphic conclusions can be drawn only from these stratified fossil horizons. No vertebrate fossils have been recovered recently from the main seam sequence, compared to the other parts of the section in the Oberdorf open pit mine.

The Oberdorf fauna is thought to be of Early Miocene age by all authors who have studied the various vertebrate groups (DE BRUIJN, 1998; DAXNER-HÖCK, 1998a; DAXNER-HÖCK, this volume; ZIEGLER, 1998; RÖSSNER, 1998; SZYNDLAR, 1998; VAN DER MADE, 1998a,b; SANCHIZ, 1998; MLIKOVSKY, 1998). Following MEIN's (1975, 1989) biozonation, the mammals indicate Mammal Zone MN4 (Text-Fig. 1). The majority of identified small mammal species range from Mammal Zone MN3 to MN4, others are restricted to MN4, and a small group ranges into Mammal Zone MN5. Despite the presence of the primitive small mammals *Ligerimys antiquus, Bransatoglis fugax, Microdyromys* cf. *legidensis, Peridyromys murinus, Myxomygale hutchisoni, Chainodus intercedens* and others, the presence of *Democricetodon gracilis, Eumyarion* aff. *weinfurteri, Anomalomys minor*, and *Neocometes similis*, which invaded Europe in MN4, indicates a maximum MN4 age for Oberdorf. On the other hand, more-modern species (*Keramidomys thaleri, Democricetodon mutilus, Microdyromys koenigswaldi, Prodryomys satus*) which occurred in Europe for the first time in MN5 are not known from Oberdorf. That indicates a minimum MN4 age for these Oberdorf mammal horizons.

Oberdorf is correlative with the following Central European faunas of the early to middle part of Mammal Zone MN4 (DAXNER-HÖCK et al., 1998): It is situated between the faunas of Petersbuch 2 (Germany; MN4a; see WU 1993), Dolnice 1, 2 (Czech Republic; MN4a; see FEJFAR, 1989) and Forsthart, Rembach, Rauscheröd (Germany; MN4b; see ZIEGLER & FAHLBUSCH, 1986), Tägernaustraße (Schweiz; MN4b;), Dolnice 3, Orechov (Czech Republic; MN4b; FEJFAR, 1989) and La Romieu (France; MN4b, the reference locality for MN4).

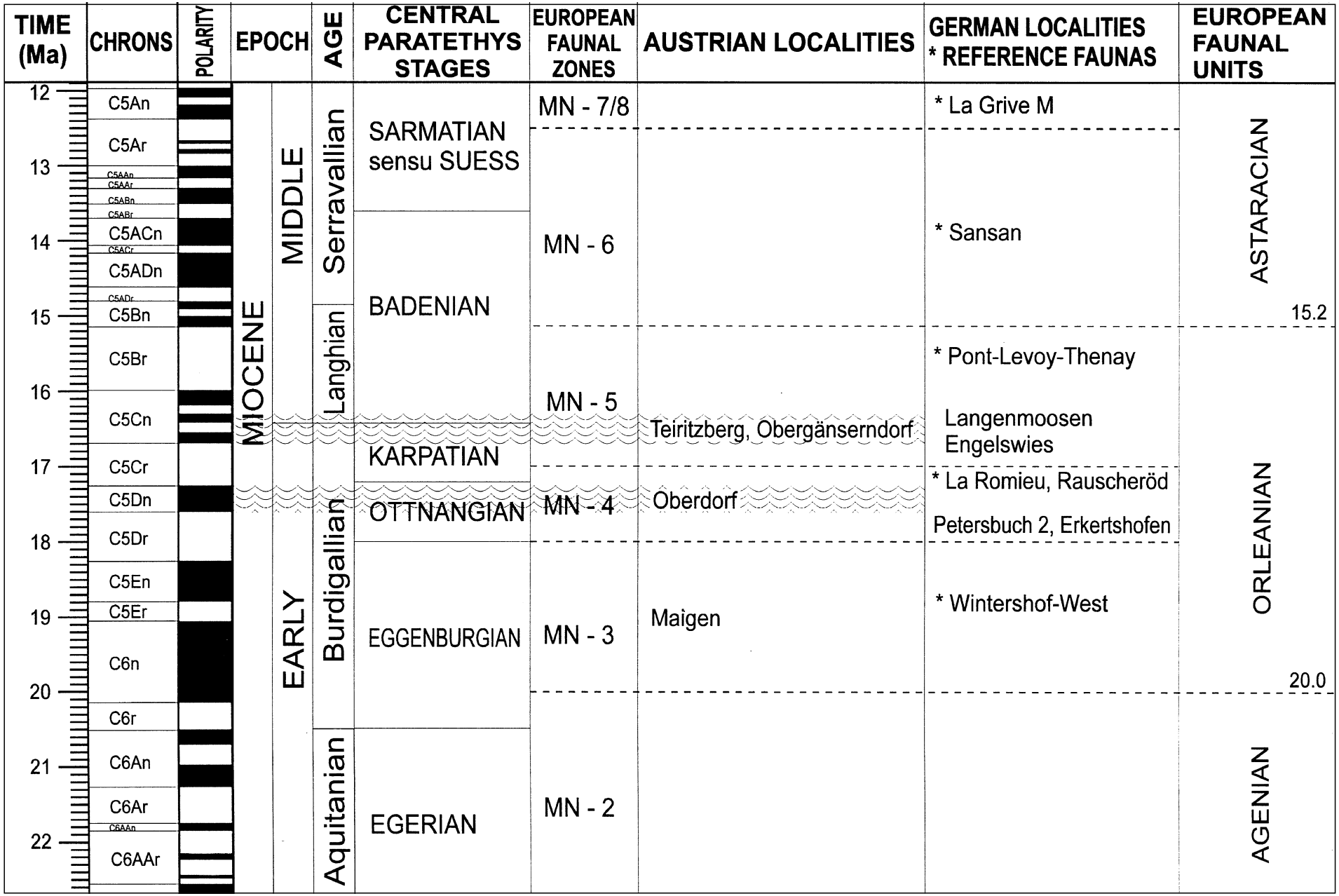
In the early to the middle part of Mammal Zone MN4 (MN4a) the vertebrate faunas are characterized by the eomyid species *Ligerimys antiquus*, which is replaced by the large *Ligerimys florancei* in late MN4 (MN4b). The eomyid genus *Ligerimys* itself is replaced by *Keramidomys* in Mammal Zone MN5.

Within the context of Austrian vertebrate faunas (Text-Fig. 1) the Oberdorf fauna is placed biostratigraphically between the fauna from Maigen (Eggenburgian, MN3; MEIN, 1989) and the faunas from Teiritzberg and Obergänserndorf (Karpatian, MN5; DAXNER-HÖCK, 1998b).

2.2.3. Palaeomagnetic Results

Within the framework of the multidisciplinary study of the Köflach-Voitsberg lignite mining district in Styria, Austria, palaeomagnetic analyses provide evidence for a 200-degree counterclockwise rotation of the basin with respect to present North. All sediments of the footwall sequence and parts of the hanging wall sequence up to 13 meters above the uppermost main coal seam are reversely magnetized, whereas the rest of the hanging wall sequence sediments are normally magnetized (MAURITSCH & SCHOLGER, this volume). The rich mammal fauna from the upper part of the hanging wall sequence, indicative of Neogene Mammal Zone MN4, allows a biostratigraphic correlation of the normally magnetized part of the section with Chron C5Dn and the lower, reversely magnetized part of the section with Chron C5Dr of the GPTS (Text-Fig. 1 and BERGGREN et al., 1995). The age of the polarity change C5Dr/C5Dn is based on the GPTS at 17.6 Ma. and indicates an Ottnangian age for the section within the Central Paratethys Time Scale (Text-Fig. 1 and STEININGER et al., 1996).

Text-Fig. 1.
Early–Middle Miocene time scale (modified correlation chart of the Early–Middle Miocene from: F.F. STEININGER et al. [1996]).



2.3. Stratigraphic Correlation of the "Basin Fill" from the Early Miocene Lignite Deposits of the Oberdorf Open Pit Mine

The lithostratigraphic sequence of the Oberdorf open pit mine belongs to the Köflach-Voitsberg Formation. The leaf and diaspore floras point to an Early Miocene age for the entire sequence. The rich mammal fauna from the middle part of the hanging wall sequence (Horizons O3 and O4) is indicative of Neogene Mammal Zone MN4, which is the maximum age of this fauna. This vertebrate fauna allows biostratigraphic cross-correlations with various other European localities of MN4 Mammal Zone age. Based on these cross-correlations the age of Mammal Zone MN4 can be estimated between 17.8 and 16.9 Ma, as shown by STEININGER et al. (1996). These rich mammal faunas from the middle part of the hanging wall sequence, indicative of Neogene Mammal Zone MN4, also allow a biostratigraphic correlation of the normally magnetized part of the section with Chron C5Dn and the lower, reversely magnetized part of the section with Chron C5Dr of the GPTS (BERGGREN et al., 1995). The age of the polarity change C5Dr / C5Dn is 17.6 Ma according to the GPTS and indicates an Ottnangian age for the section according to the Central Paratethys Time Scale. This indicates that the vertebrate-bearing strata from the middle part of the hanging wall section must be 17.6 Ma or younger in age (Text-Fig. 1), and the lower part of the hanging wall section and the entire footwall section must therefore be older than 17.6 Ma.

The Köflach-Voitsberg-Formation is discordantly overlain by the Stallhofen Formation, which includes tuffs/tuffites (Lobmingberg Member) in its basal parts. Volcanic rocks are widespread in the Styrian Basin with a Karpatian to Middle Miocene, Lower Badenian age.

These results allow for a more precise correlation of Mammal Zone MN4 with respect to the European Mammal Zonation, and the correlation of the boundaries between Mammal Zones MN3 and MN4 with respect to MN4 and MN5. The boundary of Mammal Zones MN3 and MN4 must fall around 18.0 to 17.8 Ma. The boundary between Mammal Zones MN4 and MN5 must have an age of 17 Ma. These correlations are also supported by the mammal fauna sequences: the Oberdorf mammal fauna is biostratigraphically younger than the MN3 fauna from Maigen (MEIN, 1989b) and the MN4a mammal faunas known from Petersbuch 2, Erketshofen and Orechov, older than the MN4b faunas from La Romieu and Rauscheröd, and older than the new and well-dated MN5 faunas from the localities at Teiritzberg and Obergänserndorf in the Korneuburg Basin of Lower Austria (Text-Fig. 1 and DAXNER-HÖCK et al., 1998b).

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