

Cyclostratigraphy and Transgressions at the Early/Middle Miocene (Karpatian/Badenian) Boundary in the Austrian Neogene Basins (Central Paratethys)

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Abstract

Austrian Neogene basins with marine Karpatian-Badenian sedimentation are situated around the Alpine-Carpathian junction: Styrian Basin, Vienna Basin and Alpine-Carpathian Foredeep north of the Danube. A series of transgression and regression cycles mark the Lower/Middle Miocene, Karpatian/Badenian boundary and the Lower Badenian sedimentation. The marine transgression in the upper part of Lower Miocene, Karpatian, is correlated with TB 2.2 global 3rd order sequence. Tilting of Karpatian sediments and erosion mark the Bur5/Lan1 (Karpatian/Badenian) sequence boundary. A first Middle Miocene transgression in the Lower Badenian is correlated with the basal Langhian in the Mediterranean Basin. The transgression corresponds to sequence TB 2.3. After erosions at the Lan2/Ser1 sequence boundary, the main Badenian transgression covers the entire Central Paratethys in nannoplankton zone NN5. This phase is compared with sequence TB 2.4. The final transgression in the Upper Badenian is considered to belong to sequence TB 2.5. An additional sequence between TB 2.4 and TB 2.5, observed in the Vienna Basin, is discussed.

Introduction

In the Central Paratethys a strong paleogeographic turnover is observed around the Early/Middle Miocene boundary. The intra-Carpathian basin system developed (Kováč et al., 1998). Global transgression and regression cycles sometimes are obscured by tectonic activities. By the combined efforts of different research groups it was possible to solve some of the open problems of different transgression and regression cycles around this boundary. The observed Karpatian – Badenian sedimentary cycles have been compared to the global eustatic sea level curve and 3rd order sequences of Haq et al. (1988) and Hardenbol et al. (1998).

One of the most important areas in these studies was the Styrian Basin and its Neogene development. Especially in near shore regions 3rd order global cycles were pronounced. By means of nanno- and microfossils as well as paleomagnetic chronology, stratigraphic correlation between Mediterranean and Central Paratethys was possible. Extending the research into the Vienna Basin and the Alpine-Carpathian Foredeep, similar sequences have been identified.

Geological setting

Austrian Neogene basins influenced by Lower and Middle Miocene (Karpatian–Badenian) marine sedimentation are situated around the

Eastern Alpine-Carpathian junction: Alpine-Carpathian Foredeep, Styrian Basin, and Vienna Basin (Figure 1).

The geologic history of the Alpine-Carpathian Foredeep was strongly influenced by the Miocene tectonic extrusion of the Eastern Alps and the extension of the Pannonian basin system (Decker & Peresson 1996; Kováč et al. 1998, 2003). The elongated W-E stretching basins of the Western and Central Paratethys during Oligocene and Early Miocene lost this configuration by the end of Ottnangian. Westward, later marine transgressions ended at the southern spur of the Bohemian Massif, where the sea spread in the foredeep only north of the Danube in Austria.

During the Early Miocene the region of the later Vienna Basin was part of the foredeep. Karpatian sedimentation was still in a piggy-back-basin position, connecting the foredeep with the intra-Carpathian basins. Opening as a pull-apart basin, the Neo-Vienna Basin was covered by Badenian and younger Miocene sediments (comp. Wessely 2000, 2006).

The Styrian Basin belongs to the western part of the Pannonian basin system. Probably

during the Ottnangian, basin formation began with coarse-grained fan deposits, red beds, and extended lignite formation in the western part. The Eastern Styrian Basin was flooded by the Paratethys Sea in Karpatian time. Angular discordances and sedimentation gaps of the “Styrian Unconformity” the Styrian Tectonic Phase of Stille (1924) mark the Karpatian/Badenian boundary. Sediments of Lower Badenian transgressions followed on top of tilted Karpatian sediments (Kollmann 1965, Ebner & Sachsenhofer 1991, Sachsenhofer 1996).

Sedimentation cycles and sequence stratigraphic interpretation

A first transgression of the Karpatian Sea spread in the newly formed intra-Carpathian basins. This Lower Miocene, Karpatian transgression did not cover all the basins, but reached the western part of the Pannonian basin system and the Alpine-Carpathian Foredeep between Vienna and Poland only. The high-stand of Karpatian transgression is correlated with the global 3rd order cycle TB 2.2 of Haq et al. (1988).

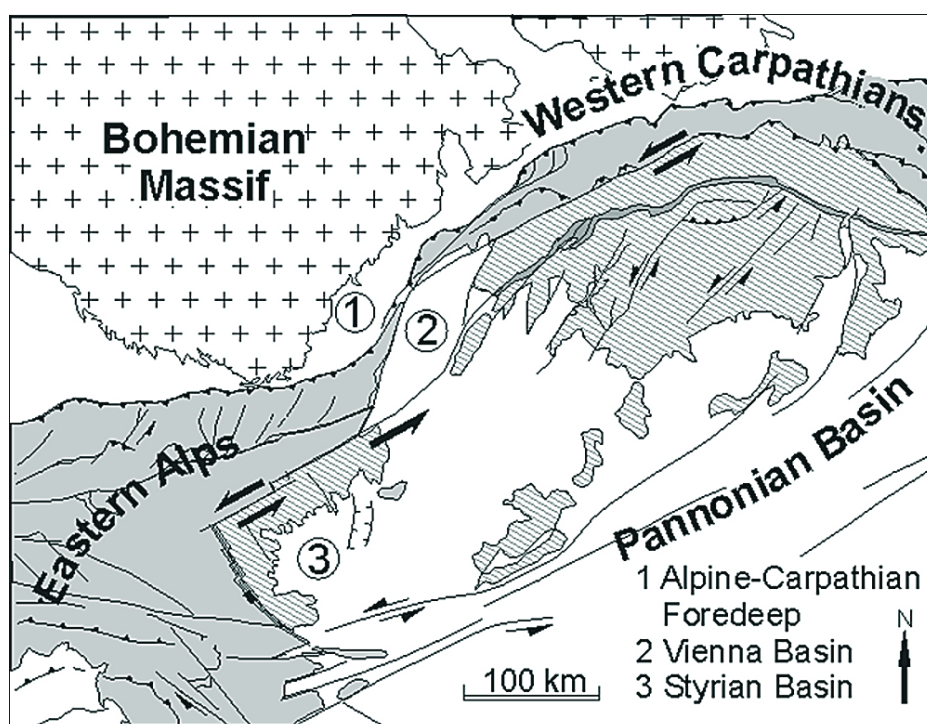


Figure 1. Position of Austrian Neogene basins with marine Karpatian – Badenian upper Lower to Middle Miocene sedimentation at the Alpine-Carpathian junction (kindly contributed by K. Decker, University Vienna).

The “Styrian Unconformity” with tilting of Karpatian sediments and erosions is compared with the Burdigalian/Langhian sequence boundary Bur5/Lan1 of Hardenbol et al. (1998). This boundary is observed in all marine basins. It is followed by the Langhian/first Lower Badenian transgression, culminating in cycle TB 2.3 during nannoplankton zone NN4. This transgression and sediments of this first Badenian cycle are obscured in many basins and also commonly eroded before the next transgression. In shallower areas sequence boundary Lan2/Ser1 is easily recognized by strong erosion.

During sequence cycle TB 2.4 a next Badenian transgression covers all the Central Paratethys basins. This was the transgression commonly believed to form the first Lower Badenian cycle, which was compared to the Lower Langhian sections in the Mediterranean. In this cycle the first appearances (FAD) of *Praeorbulina circularis* and *Orbulina suturalis* occur, all within nannoplankton zone NN5 (Rögl et al. 2002). From the base of Badenian/Langhian at 16.3 My to the last occurrence of *Helicosphaera waltrans* at 14.357 My (within NN5) and the first *P. circularis* at 14.89 My, a time-span of 1.5 to 2 My has to be considered in basin reconstructions. Therefore, the sequence cycles of Haq et al. (1988) and Hardenbol et al. (1998) have been re-calibrated according to the present values of paleomagnetic chrons of the ATNTS 2004 in Lourens et al. (2004) and accommodated to important stratigraphic boundaries (Figure 2).

Styrian Basin

Sedimentary successions in the Styrian Basin are easily correlated with the global sea-level curve and 3rd order sequences, especially in the shallower sections along the Mid Styrian Swell. Throughout the basin Karpatian sediments are transgressive and culminated in cycle TB 2.2. The Lower/Middle Miocene boundary with tectonic tilting of the “Steirischer Schlier” and erosions corresponds to sequence boundary Bur5/Lan1. A first Badenian transgression within nannoplankton zone NN4, co-occurring with *Praeorbulina sicana* and *P. transitoria* is correlated to cycle TB 2.3, followed by a regression and sedimentation gap at the Lan2/Ser1 sequence boundary. The main Badenian transgression, covering all the Central Paratethys

followed in cycle TB 2.4, observed in the Weissenegg Formation. The most important section for the Karpatian – Lower Badenian sedimentary succession was studied in the old brickyard of Wagna along the river Sulm south of town Leibnitz (Spezzaferri et al. 2002, 2004; Gross et al. 2007). On top of the Karpatian deep-water sediments of “Steirischer Schlier” an erosion surface with pebbles of this Schlier is covered by silts and fine sands with shallow marine foraminifera, ostracods, and small oysters. These fine sands belong to nannoplankton zone NN4 and contain very rare *Praeorbulina sicana*, *P. transitoria*, and on top of an intercalated small patch reef also *P. glomerosa*. A next erosion surface (sequence boundary Lan2/Ser1) separates nannoplankton zone NN4 and NN5. The hanging wall sediments are formed by sandstone layers with molluscs casts, and with another erosion surface by coralline limestones of the Weissenegg Formation. Marly layers contain *P. circularis* and *O. suturalis*. According to paleomagnetic measurements (Auer 1996, Rögl et al. 2005, 2006) sedimentation gaps at the sequence boundaries could be dated. For the Karpatian/Badenian boundary (Bur5/Lan1) a gap of 400 ky, and for Lan2/Ser1 a gap of about 600 ky have been calculated.

Vienna Basin

Another case concerns the evolution of the Vienna Basin, which is strongly connected with different marine transgressions. Key sections for these problems were found at the southwestern border of the basin (Wessely et al. 2007). On top of Eastern Alpine Mesozoic basement a first Neogene polymict conglomerate was observed in a deep thermal-water well (probably Karpatian). The next horizon the Gainfarn Breccia consists of mainly dolomitic material and was dated in borehole Vöslauer 7 as nannoplankton Zone NN4 together with *Globorotalia transsylvanica* and correlated with the Badenian Lower Lagenidae Zone. In all other investigated samples of the Lower Lagenidae Zone of Baden outcrops and deep drillings (area of Lanzendorf Fauna) of the southern Vienna Basin the Zone NN4 and the horizon with *H. waltrans* in the lower part of Zone NN5 are missing. This *H. waltrans* horizon is present in boreholes of the Lanzhot Formation in

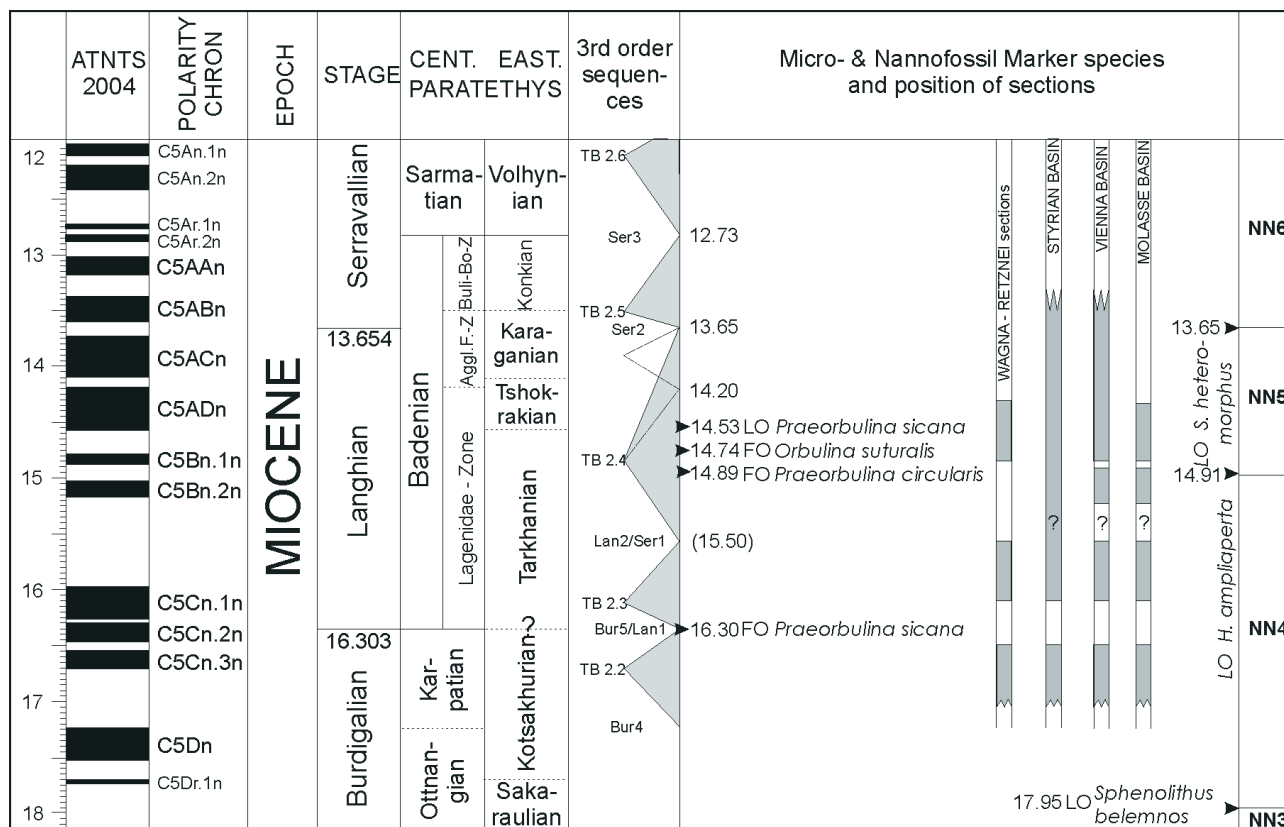


Figure 2. Stratigraphic column with global 3rd order sequences for late Early Miocene to Middle Miocene in the Central Paratethys. Marine sediment successions in Austrian Neogene basins are correlated to global 3rd order sequences.

the Slovakian north-eastern part of the basin (Andrejeva-Grigorovich et al. 2001), but also at the north-western border in the Austrian localities Frättingsdorf and Niederleis. The *H. waltrans* horizon was also recorded in marly intercalations of the Aderklaa Conglomerate. This indicates different earlier transgression and erosion phases in the Vienna Basin, not considered in the basin model of Weissenböck (1996) and Strauss et al. (2006). Otherwise Strauss et al. (2006) detected an important sea-level drop in the upper part of Upper Lagenidae Zone (sequence boundary SB 2), which was correlated with a first Antarctic cooling step at 14.2 My (Shevenell et al., 2004). In the calibrated global sequence curve this regression is not recorded. It may be a local event in the Central Paratethys. The lower part of Middle Badenian Zone of Agglutinated Foraminifera (*Spirorutilus carinatus* Zone) is transgressive again in the Vienna Basin and indicates a new cycle.

Alpine-Carpathian Foredeep

Similar to the Styrian Basin, global sequences TB 2.1 to TB 2.4 and corresponding se-

quence boundaries are recorded in the Alpine-Carpathian Foredeep north of the Danube. The best example presents deep well Roggendorf 1 (Ćorić and Rögl, 2004). Karpatian Laa Formation (3rd order cycle TB2.2) is transgressive on regressive Ottangian *Rzehakia* Beds, followed by a first Badenian transgression with basal gravels. This first cycle (TB 2.3) consists mainly of clastic sediments and is dated by calcareous nannoplankton as Zone NN4, followed by NN5 assemblages in the upper part. The base of the next cycle, representing the Grund Formation, forms a 10 m thick conglomerate bed. The Grund Formation with nannoplankton of Zone NN5, belongs to the *H. waltrans* horizon and yields *P. circularis* and *O. suturalis* as planktonic foraminiferal markers. This transgression is correlated with sequence TB 2.4.

Conclusions

The Karpatian – Badenian marine transgression and regression cycles in the Austrian Neogene basins can be correlated with global

3rd order sequences and corresponding sequence boundaries. Additionally, a further cycle was observed by Strauss et al. (2006) within the upper part of Lower Badenian and lower part of Middle Badenian, which may correspond to a Central Paratethys event. To evaluate these sequences it was necessary to re-calibrate the Haq et al. (1988) and Hardenbol et al. (1998) sequences to the new ATNTS polarity chrons of Lourens et al. (2004). Sedimentary sequences have been compared between the Styrian and Vienna Basin, and the Alpine-Carpathian Foredeep. In all basins a similar succession of events has been recorded (Figure 2).

The main success of these combined researches of different projects was the evaluation of a first Lower Badenian transgression in nannoplankton zone NN4, comparable to the basal Langhian in the Mediterranean. Only the second main transgression within nannoplankton zone NN5 covered all the Central Paratethys, including also the Transylvanian Basin. It is necessary therefore to re-consider the basin development in Central Paratethys basins according to the newly developed order of sequences.

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