

# SEQUENCE STRATIGRAPHY OF THE COAL BEARING OTTNANGIAN (?) - KARPATHIAN SEDIMENT SERIES IN THE EAST BORSOD BASIN (N-HUNGARY)

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**Abstract:** We have performed the sequence analysis of the coal bearing Miocene series of the East Borsod Basin. We could separate 25 parasequences (5<sup>th</sup> order cycles), four 4<sup>th</sup> order cycles and one 3<sup>rd</sup> order cycle. The latter can be regarded as an eustatic cycle parallel with TB2.2 of Haq et al. (1988), the 4<sup>th</sup> order cycles were determined by tectonic events. Simultaneous interpretation of the available paleontological data and the eustatic curves prove the Karpathian age of the series.

**Key words:** sequence stratigraphy, Miocene, Karpathian stage, Borsod Basin, coal

## Introduction

In the East Borsod Basin a siliciclastic sediment series was accumulated during the Lower - Middle Miocene, within shallow marine paleoenvironments, with five enclosed paralic coal seams (V, IV, IIIa-III, II, Ia-I). In the western and central part of the basin its thickness is 100 - 200 m, while in the east it is more than 300-400 m. A detailed sequence stratigraphic analysis has not been performed yet. Now the comparative analysis of the logs of more than 150 boreholes was carried out to reconstruct vertical and horizontal structure of the sediment series (Fig. 1).

## Parasequences, parasequence sets, the order of the accumulation

The parasequences were formed by shallow marine siliciclastic masses controlled by tidal currents and waves (WAGONER et al. 1990), indicating the appearance of off-shore, foreshore and lagoonal paleoenvironments. The most important sediment characteristics are shown on Fig. 2., which reflect lateral and vertical connections of the facies belts within a given parasequence.

We were able identify 25 parasequences (Fig. 3 and 4). Transgressive character is well detectable in the whole series but basin environments became dominant only in the 17<sup>th</sup> parasequence.

Sediments of the initial transgression (parasequences from 1 to 5) filled up local depressions of the unevenly dissected paleosurface. The first general progradation in the 6<sup>th</sup> parasequence led to formation of coal beam IV in the East Borsod Basin. A transgression can be detectable indicated by *Ostrea*-beds above coal beam IV. Within the aleuritic facies of the 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> parasequences there are polyhaline mollusc associations indicating shallow sublittoral environments (e.g. Dgy-366, 220, 222 m, BOHN-HAVAS 1983, T-66, BOHN-HAVAS 1985).

The next transgression is detectable at the 10<sup>th</sup> parasequence, with aleuritic facies enclosing a polyhaline mollusc association (e.g. Dgy-366 291,7-296,7 m, 296,7-301,5 m, BOHN-HAVAS 1983). The 12<sup>th</sup>, 13<sup>th</sup>, 14<sup>th</sup>, 15<sup>th</sup> and 16<sup>th</sup> parasequences form an aggradational parasequence set with the coal beams III, IIIa and II.

Transgression became determinative within the 17<sup>th</sup> parasequence forming a transgressive sand bed just above coal beam II and thick aleuritic beds with poly- and euhaline macro- and microfauna (e.g. KORECZ-LAKY 1958, 1985). A progradation started within the 18<sup>th</sup> and 19<sup>th</sup> parasequences forming the coal beams Ia and I.

A transgressive sand bed above coal beam I indicates a further transgression with progradations in the 20<sup>th</sup>, 21<sup>st</sup>, and 22<sup>nd</sup> parasequences. The last transgression is in the 23<sup>rd</sup> parasequence followed by progradations in the 23<sup>rd</sup>, 24<sup>th</sup> and 25<sup>th</sup> parasequences. Fauna data indicate the dominance of euhaline environments.

### **Hierarchy and genetic interpretation of cycles**

The whole series can be regarded as the transgressive period of a 3<sup>rd</sup> order cycle, in which the transgressive character became dominant in the 17<sup>th</sup> parasequence, which is presumably the boundary between the transgressive and early highstand systems tracts of the 3<sup>rd</sup> order eustatic cycle.

The most important transgressions divide the series into four well separable 4<sup>th</sup> order cycles. The first contains parasequences 1-6 with a long transgression and a fast progradation, the second contains parasequences 7-16 with transgressions and progradations changing into aggradation on its top. The third cycle is introduced by a transgression (17<sup>th</sup> parasequence) followed by progradation changing into aggradation (18<sup>th</sup> and 19<sup>th</sup> parasequences). The fourth has also been started by a strong transgression (20<sup>th</sup> parasequence). These 4<sup>th</sup> order cycles divide the 3<sup>rd</sup> order eustatic cycles into semicycles reflecting periodical fast increase of accumulation space, which may have been the consequence of tectonic development of the basin

indicating at least three tectonic events in the region. The periodical increase of depth may have been in connection with the tectonic subsiding of the basement.

The separated parasequences (25) were presumably formed by 5<sup>th</sup> order cycles, which may have been caused by the climatic changes of Milankovic, initiated by oscillation of the Earth's orbital factors (precession). The fact that the 5<sup>th</sup> order cycles are well detectable in the series proves a rather intensive accumulation and important lateral movement of facies belts according to sea-level changes reflecting an elevated swell-status of the area during the sedimentation.

### **Cronological consequences**

A few years ago the coal bearing series was regarded as an Ottnangian series, but malacological (Rzehakia socials - BÁLDI 1976) and micropaleontological (Sütő-Szentai in Radócz 1983, Sütő-Szentai 1994, 2000) data indicate Carpathian age (CICHA et al. 1967) for at least a part of the series. Although its exact age is not cleared yet, the upper part of the series is Carpathian (Radócz 1987).

The Ottnangian and Carpathian stages of the Miocene are characterised by two (Bur-3, Bur-4) of the glacioeustatic sea-level changes evidenced by isotopic data (ABREAU AND HADDAD IN VAKARCS 1997 p. 157). The Ottnangian - Carpathian age range from 19 m.y. to 16,2 m.y. and the boundary of the two stages is at 17,2 m.y. The whole series can be divided into 25 parasequences and considering the genetic model of the parasequences (5<sup>th</sup> order climatic cycles), they represent 24 000 y. per parasequence. As the average thickness of the parasequences is not more than 20 m, the sedimentation rate is not more than 100 cm/1000 y, so the accumulation time of the whole series is not more than 600 000 y.

Considering that the whole series represent only one 3<sup>rd</sup> order cycle that is why there is no sequence boundary indicating eustatic regression within the coal bearing series, and considering that the upper parts of the sequence have Carpathian age, the 3<sup>rd</sup> order cycles can be correlated mainly with the Bur-4 eustatic event (TB2.2 in HAQ et al. 1988).

This is in good agreement with the appearance of 4<sup>th</sup> order cycles, which are well detectable because of the very sensitive sedimentary conditions (important facies drifting due to the sea-level changes). These cycles reflect tectonic events that can be led back to the Styrian orogenic phase parallel with Bur-4 eustatic cycles. The 4<sup>th</sup> order cycles are in good correlation with those detected by the sequence

stratigraphic analysis of the Kladzany Formation having similar age in the East Slovakian Basin (VASS et al. 2000).

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**Figure 1** Boreholes exploring Salgótarján Lignite Formation

**Figure 2** Horizontal and vertical connections between facies belts of an upward coarsening parasequence

**Figure 3** Sequence stratigraphic model of the Karpathian coal bearing sediment series in the East Borsod Basin

**Figure 4** Sequence stratigraphic model of the Karpathian coal bearing sediment series in the East Borsod Basin

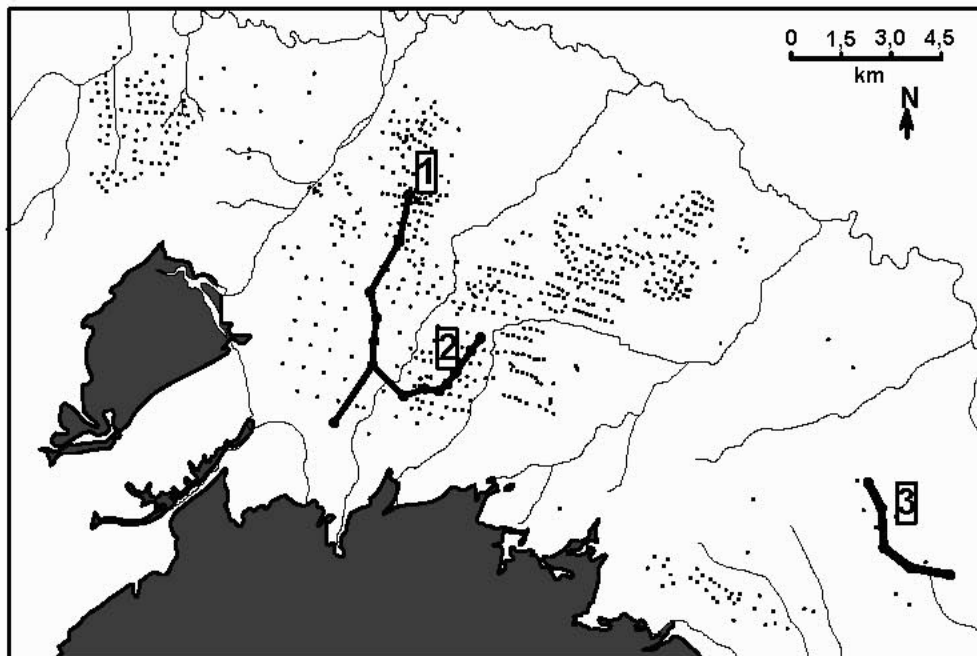


Figure 1 Boreholes exploring the Sarmatian series and the direction of the sections

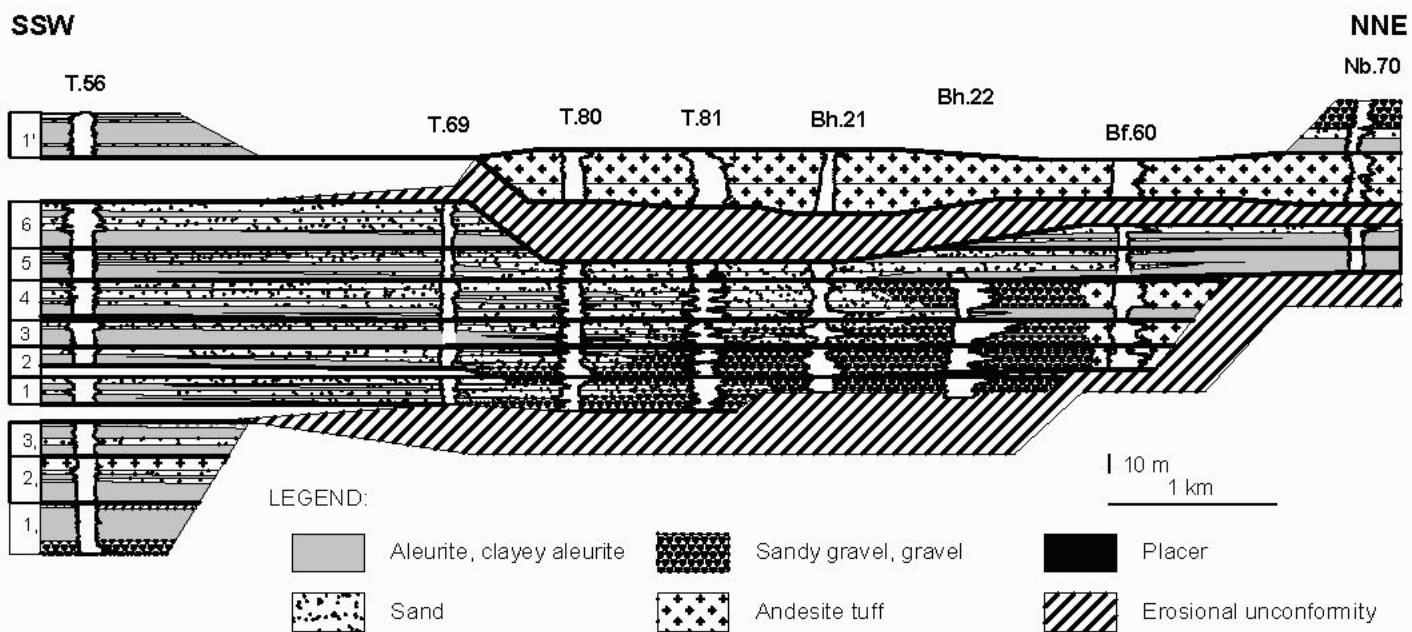
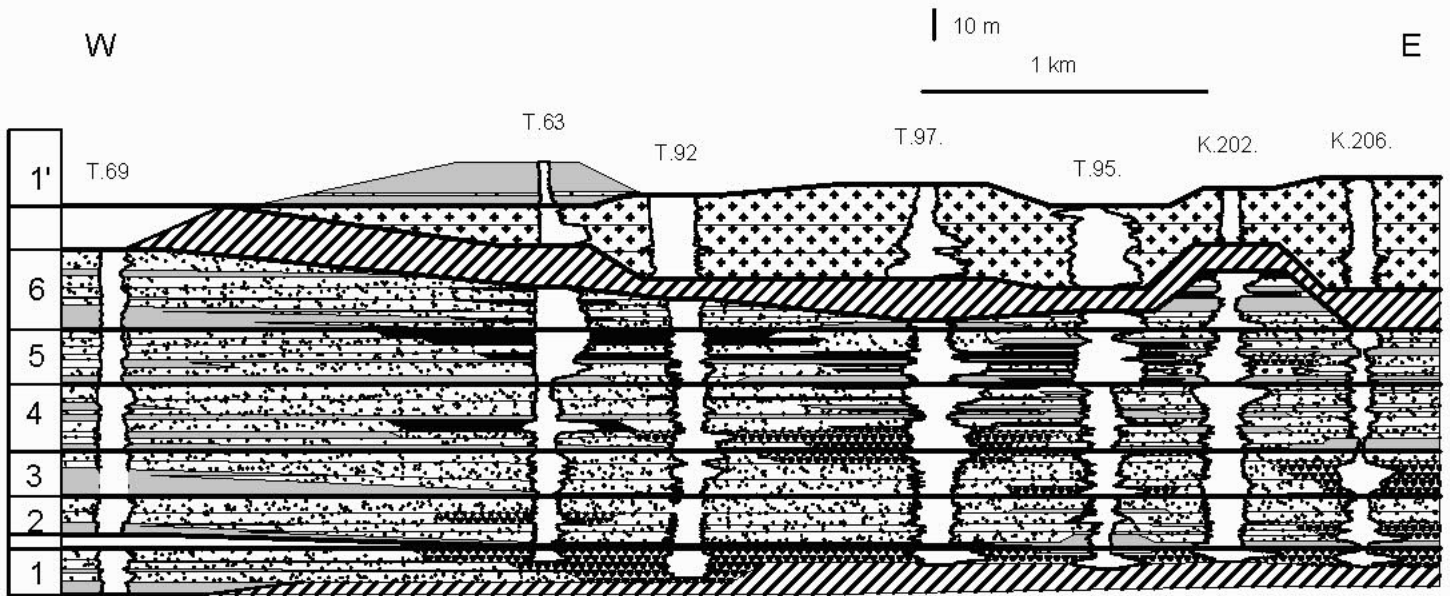
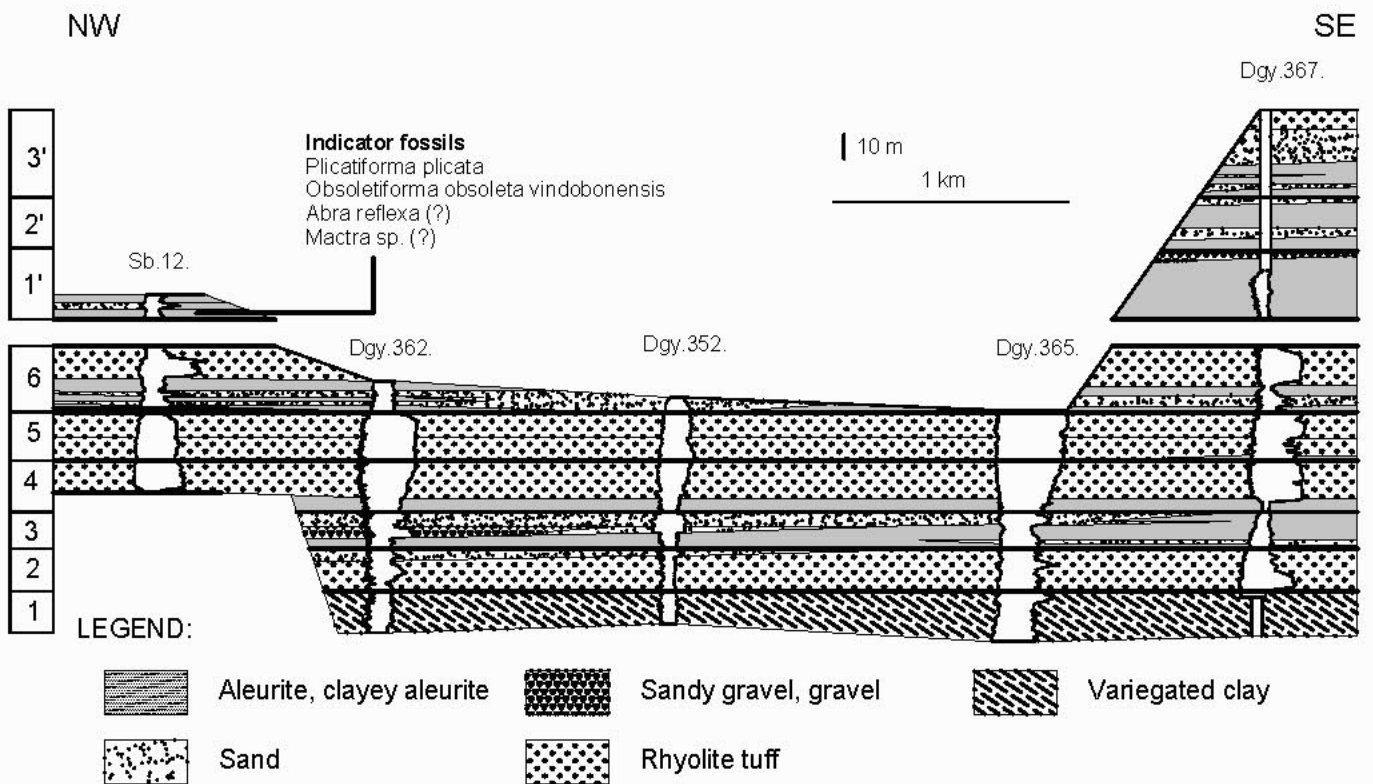


Figure 2 Spatial distribution of the facies belts along section 1 (for its direction see Fig. 1)



**Figure 3 Spatial distribution of the facies belts along section 2**  
(for its direction see Fig. 1, for legend see Fig. 2)



**Figure 4 Spatial distribution of the facies belts along section 3**  
(for its direction see Fig. 1)