SEDIMENTARY CONTROL OF LATE MIOCENE-PLIOCENE SEQUENCE STRATIGRAPHY OF THE PANNONIAN BASIN

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Introduction

Despite a more than one hundred years of research devoted to the stratigraphy of the Pannonian Basin, the sedimentary architecture and structure of the basin, as well as its paleogeographic relations to the Mediterranean are still debated. After decades of litho- (e.g. Jámbor 1980, Gajdos et al. 1983), bio- (e.g. Bartha 1971, Korpás-Hódi 1983, Nagymarosy and Müller 1988, Fuchs and Sütő-Szentai 1991, Müller and Magyar 1992a,b) and radiometric studies, new physical methods were introduced as seismic- and electric log stratigraphy (e.g. Pogácsás et al. 1988), magnetostratigraphy (Lantos et al. 1992), and isotope studies (Mátyás et al. in press) leading to a better understanding of the intrabasinal stratigraphic relations. Meanwhile, Bérczi and Phillips (1985) showed that in deep parts of the basin, deltaic progradation dominates the lake sedimentation.

In the late 70's early 80's a new impetus was given to the research by a new system of theories and methods known as sequence stratigraphy. Pogácsás et al. (1988), studying composite seismic profiles throughout the basin, have found four hiatuses within the Late Miocene-Pliocene series which they correlated to the Haq et al. (1987) eustatic sea-level curve. Based on the same methodology, Vakarcs et al. (1994) recognised twelve third order sequence boundaries in the Late Neogene sedimentary fill and recognised higher-order sequences with an average duration of about 0.1-0.5 Ma.

Interpreting electric logs, Juhász Gy. (1993) distinguished at least five Pannonian s.l. sequences without defining their order (third or fourth). She stressed the importance of tectonics, climate and differential subsidence in relative lake-level fluctuations and showed that in an area of NE part of the Great Hungarian Plain offshore sediments appear repeatedly between shoreface or shoreline deposits.

More recently Csató et al. (in press), based on seismics and using a sedimentary modelling program (SEDPAK), showed how local subsidence overprinted the effects of lake level fall on a third and higher order scale. Moreover, they proved that onlapping and downlapping configurations could have formed without relative lake-level variations due to encroachment of shifting deltas.

The Basin Analysis Project of the Hungarian Geological Institute, established in 1992, described and interpreted about 17 000 m of continuous core from 14 wells with depth between 200 and 2000 m each and a limited number of outcrops throughout the basin. In our work, based on Van Wagoner's definition (1990, p. 22) we applied the terms and ideas of Homewood et al. (1992), see Juhász et al. (1993, 1995, in press).

Methods

Detailed sedimentological and palaeontological analyses were carried out on cores from 14 boreholes. On this basis, genetic depositional units (parasequences) and their stacking patterns (Homewood et al. 1992) were determined by plotting the palaeoenvironments (i.e. relative sea-level) against stratigraphic succession.

Sequence stratigraphy

Within the Late Neogene sequence there are three obvious unconformities: one occurs between the pre-Neogene and/or older Miocene and the Pannonian (SB3), the second between the Pannonian and the Pliocene (SB2) and the third between the Pliocene and the Pleistocene (SB1). Between SB3 and SB2 an apparently continuous series, called Pannonian, developed with four main units: the lowermost transgressive, a lower aggradational, a middle progradational and an upper aggradational.

Boundary 3

In the studied sections Pannonian sediments overlie Miocene or pre-Neogene rocks with unconformity, with a gap of minimum 1.8-2.0 Ma. Magnetostratigraphic data suggest, that the age of the oldest Pannonian ranges from 8.9 Ma to 10.2 Ma.

Boundary 2

A significant regional unconformity is observed between the Miocene and Pliocene sediments in each studied borehole. Above it flood plain facies is present with traces of paleosol. The thickness of the altered zone below the unconformity can be of few metres.

The Pliocene sequence starts with flood plain sediments. In the Transdanubian part of the basin it is poorly developed comparing to that of the Great Hungarian Plain. Between the Pannonian and the Pliocene there is a 1.5-2.0 Ma estimated gap.

Boundary 1

A subaerial erosional boundary is present between the Pliocene and Pleistocene sediments. In western Transdanubia 1-2 m thick soil occurs on the top of the Pliocene representing the Pleistocene cycle. In contrast, in the Great Hungarian Plain the thickness of the Pleistocene layers can be a few hundred metres.

Sedimentological cycles

Transgressive unit

In most of the studied boreholes, at the base of the Pannonian sequence, a few metres thick, poorly sorted conglomerate and sandstone layer occurs.

Lower aggradational unit

The some hundred metres thick lower aggradational unit, is built of laminated or bioturbated dark grey marl and silt, occasionally with turbidites. The stacking pattern of the strata is aggradational. The unit is built up with 1-6 smaller cycles, which facies oscillate within the offshore, or between the offshore and shoreface.

Progradational unit

A 70-200 m thick transitional unit occurs in the middle part of the sections. It is built up with claystone, coarse siltstone and fine sandstone. The dip of the inclined strata can be max. 7° . 1-4 smaller-scale cycles are included, the thickness of which range from 10 to 150 m. The site of deposition was on the slope from offshore up to shoreface or to delta plain. The stacking pattern is progradational. Paleomagnetic data give approximately a 0.3-0.4 Ma time interval for the deposition of this unit.

Upper aggradational unit

The upper part of the Pannonian sequence was built in a variety of paleo-environments including channel, lake, pond, marsh and flood plain. The thickness of the unit varies from 30 to 1300 m, while the thickness of the smaller-scale upward-fining cycles from 3 to 20 m. In most cases the sediment is of delta plain or flood plain facies, but in the case of the basinal areas (Kaskantyú, Iharosberény) the sedimentation could remain in the shoreface environment as well. The stacking pattern of the cycles is aggradational with slight progradation (the thickness of the sand layers increases upward). Within this unit, a striking oscillation of coal bearing or fine grained sandy cycles occur.

The Pliocene sequence

There is another aggradational unit between the SB2 and SB3. Its thickness varies from 20 m to 140 m. Predominantly it is built up of coarse, fining upward channel sand. The entire unit contains 1-5 smaller scale cycles with a cycle thickness of maximum 50 m. The facies oscillates within the fluvial regime in the marginal areas, while in the basinal areas between the delta plain and fluvial facies.

Discussion

The subsidence and infilling of the Pannonian basin occurred mainly during the Late Miocene and Pliocene. Along the three boundaries (SB1, SB2, SB3), sizeable erosion and hiatuses of few million years were detected, these can be interpreted as regional unconformities. The series between them can be regarded as 3rd order sequences. This means, that in most of the studied borehole sections there are two third order sequences: a Late Miocene and a Pliocene one.

The changes of the sedimentary environment picture the relative water level change of the Pannonian Lake. Above SB3 a relatively quick transgression occurred, what is expressed by rapid basinward shift of the facies. Subsequently deep water environment was established and a distinctive aggradational unit was deposited. The striking landward shift of the facies, which means a relative water level drop, is characteristic in each section. The upper aggradational unit, up to the Miocene/Pliocene boundary (SB2), refers to an equilibrium between sedimentation rate, accommodation potential and basin subsidence.

This Late Miocene 3rd order sequence consist of a transgressive system's tract (transgressive unit) and a highstand systems tract (two aggradational and one progradational units). The lowstand systems tract is lacking in the studied sections, probably because of erosion. In the deepest parts of the Pannonian basin, lowstand deposits could develop and be preserved also (Vakarcs et al., in press).

The Late Miocene 3rd order sequence is built up of higher order, commonly 60-200 m thick 4th or higher order sequences.

The fluvial character of the Pliocene sequence differs, mainly in paleosol development, from the upper part of the Late Miocene sequence in spite of the similar facies.

Conclusions

1/ On the basis of the detailed sedimentological studies two third order Late Neogene sequences were found in the Pannonian basin: a Late Miocene and a Pliocene one.

2/ There are no similarities between the Haq-curve and those of demonstrating the water level changes of the Late Miocene Pannonian Lake, suggesting that the sea level fluctuations had no direct influence on the lake level.

3/ There were certain water-level fluctuations in the Pannonian Lake as they were detected by the identifications of the fourth order sequences. These were probably caused generally by climatic changes, but in some instances by local or regional tectonics.

4/ Based on palaeomagnetic data it is obvious that neither the transgression, nor the striking landward shift of the facies, recorded in the Late Miocene sequence, coincide in time in the studied sections. The rapid landward shift of the facies can be followed clearly and is caused by progradation. It does not reflect the effect of eustatic sea-level changes.

5/ Borehole sections, arranged from north to south, show that the time of the progradation was more and more delayed going southward, reflecting its direction, as it was already suggested by Pogácsás et al. (1993), based on seismostratigraphic evidences.

6/ The SB2 boundary, at the top of the Late Miocene sequence, seems to reflect a major global or Mediterranean event. It may be correlated in time, and probably causally to the Messinian salinity crisis and Lago Mare event, as well. A similar conclusion was drawn by I. Csató (1993).

7/ The Pliocene fluvial sequence, between SB1 and SB2, is of an aggradational character, too. Abundance of calcretes point to a semiarid climate. This sequence is lacking on most of Transdanubia (West Hungary). Due to lack of reliable palaeomagnetic data, the time span of this sequence may be inferred from data from more distant areas (Elston et al. 1990). Krolopp (pers. comm.) suggests a late Pliocene age, based on molluscs from the Kaskantyú-2 beds.

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