Paleoceanographic Evolution of the Hungarian Paleogene Basin During the Early Oligocene by coupling of Micropaleontology and Sulfur Isotopes*

P. Ozsvárt[1], I. Vető[2], and A. Nagymarosy[3]

Search and Discovery Article #11310 (2020)**
Posted March 16, 2020

*Adapted from oral presentation given at 2019 AAPG Europe Region Regional Conference, Paratethys Petroleum Systems Between Central Europe and the Caspian Region, Vienna, Austria, March 26-27, 2019
 DOI:10.1306/11310Ozsvart2020

[1]MTA-MTM-ELTE, Research Group for Paleontology (ozsvart.peter@nhmus.hu)
[2]Consultant Geochemist (vetoie3840@gmail.com)
[3]Deceased

Abstract

We studied two coreholes (Csv-1 and Ad-3) with continuous sedimentary records across the Eocene-Oligocene climate transition from the eastern and western edge of the Hungarian Paleogene Basin (HPB) to better understand the paleoceanographic evolution of this basin. This greenhouse-icehouse transition has been extensively studied worldwide; however, few studies concentrated on isolated marginal seas, like the Central Paratethys. A coupled use of multivariate statistical analysis of benthic foraminiferal fauna (e.g. oxygen index (BFOI), Q-mode principal component analysis, diversity, etc.) and geochemical data (sulfur isotope ratio, TOC) shows the HPB underwent a progressive decrease of both of salinity and bottom-water oxygen level during the NP 22. During the earlier part of the NP 23 the water column was stratified, the O_2 content of the bottom water was very low (<0,2 ml/l) and the salinity of the upper water layer was below 12-14 per mil. The NP 22 and most of the NP 23 correspond the deposition of the Tard Clay, a marly then silty oil source rock, dominantly laminated in its upper part. The mainly negative values of $\delta^{34}S$ together with its strong upward decrease in the Csv-1 suggest appearance (and thickening?) of sulphidic bottom water during NP 23. On the other hand, the upward increase of $\delta^{34}S$ followed by its decrease during NP 23 in the Ad-3 reflect a decrease of salinity followed by its increase in the upper water layer while the bottom water remained suboxic. In the Ad-3 and in some other profiles described from the western margin of the area of development of the Tard Clay its uppermost part is discordantly covered by sandstone. In the Csv-1 and in numerous oil exploratory wells drilled E

from this marginal area the Tard Clay is abruptly replaced at the NP 23/24 boundary by the non-laminated Kiscell Clay, characterized by re-appearance of rich benthic foraminifera community and marine nannoplankton association. These phenomena suggest a rapid improvement of connection with the Mediterranean or other surrounding open ocean. The TOC is always below 2% in the Kiscell Clay covered Tard Clay profiles while in the Ad-3 it can be as high as 4-5%. These differences in bottom water O_2 content, in the contact of the Tard Clay and its cover and in TOC content make likely significant areal differences in the paleoceanographic evolution of this small basin during the NP 23.

References Cited

Bechtel A, Hámor-Vidó M, Gratzer R, Sachsenhofer RF, Püttmann W 2012 Facies evolution and stratigraphic correlation in the early Oligocene Tard Clay of Hungary as revealed by maceral, biomarker and stable isotope composition. Marine and Petroleum Geology, 35, 55-74.

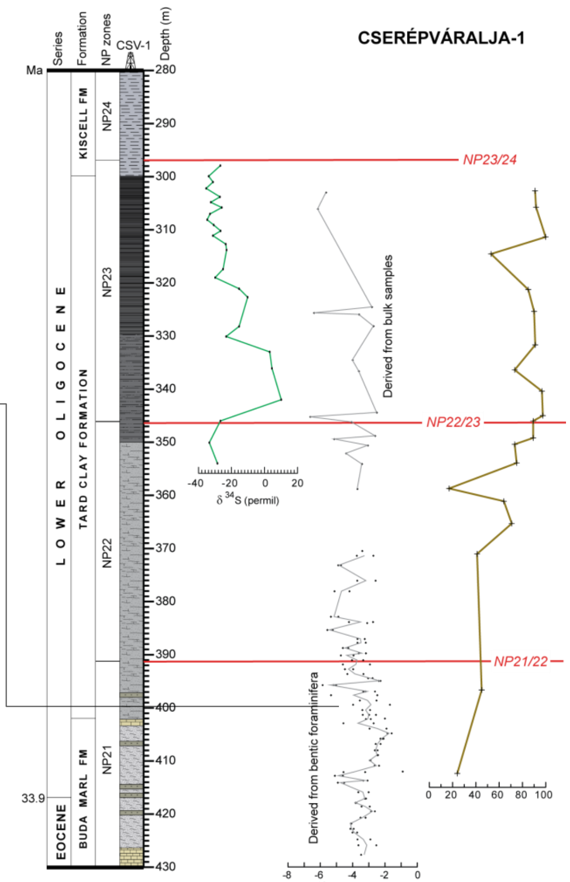
Ozsvárt P, Kocsis L, Nyerges A, Győri O, Pálfy J 2016 The Eocene-Oligocene climate transition in the Central Paratethys. Palaeogeography, Palaeoclimatology, Palaeoecology, 459, 471-487.

Vető, I. and Hertelendi, E. 1996 Sulphur isotope ratios in the laminated Tard Clay (Lower Oligocene of Hungary) reflect a salinity cycle. Acta Geologica Hungarica, 39, 204-207.

Paleoceanographic Evolution of the Hungarian Paleogene Basin during the Early Oligocene by coupling of Micropaleontology and Sulfur Isotopes

Ozsvárt P[1], Vető I[2] and Nagymarosy A[3]

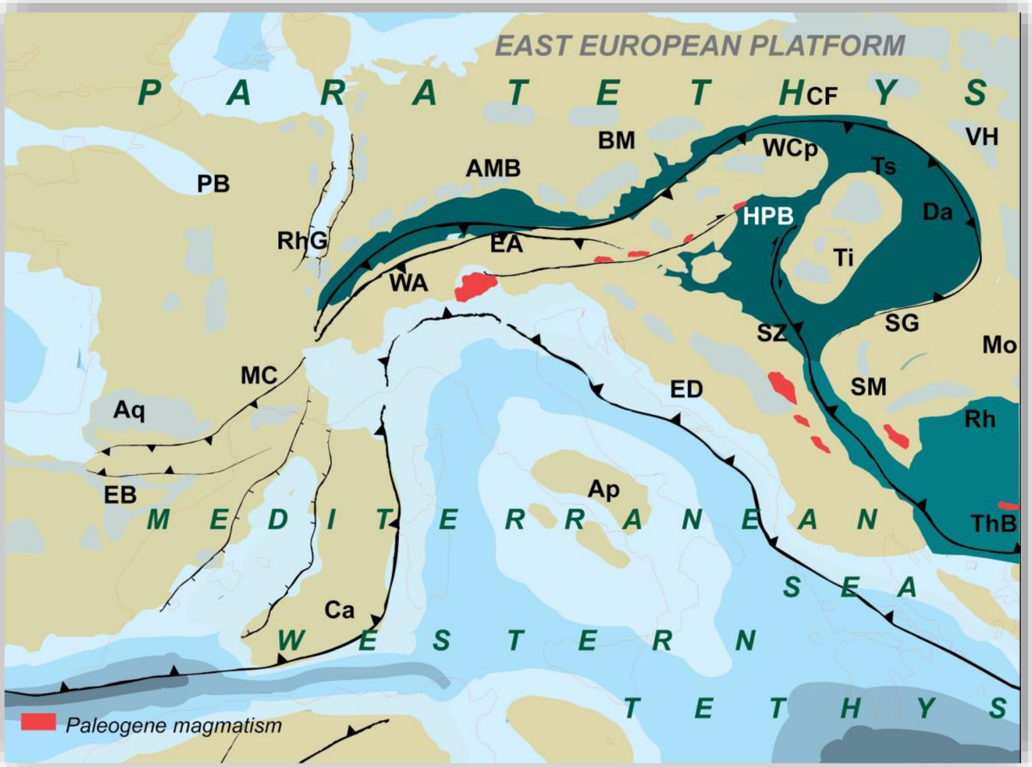
[1]MTA-MTM-ELTE, Resarch Group for Paleontology, ozsvart.peter@nhmus.hu
[2]Consultant GeoChemist, vetoie3840@gmail.com
[3]Deceased



Why this coupling?

- Palaeogeography of the Central and W. Paratethys during the EOT

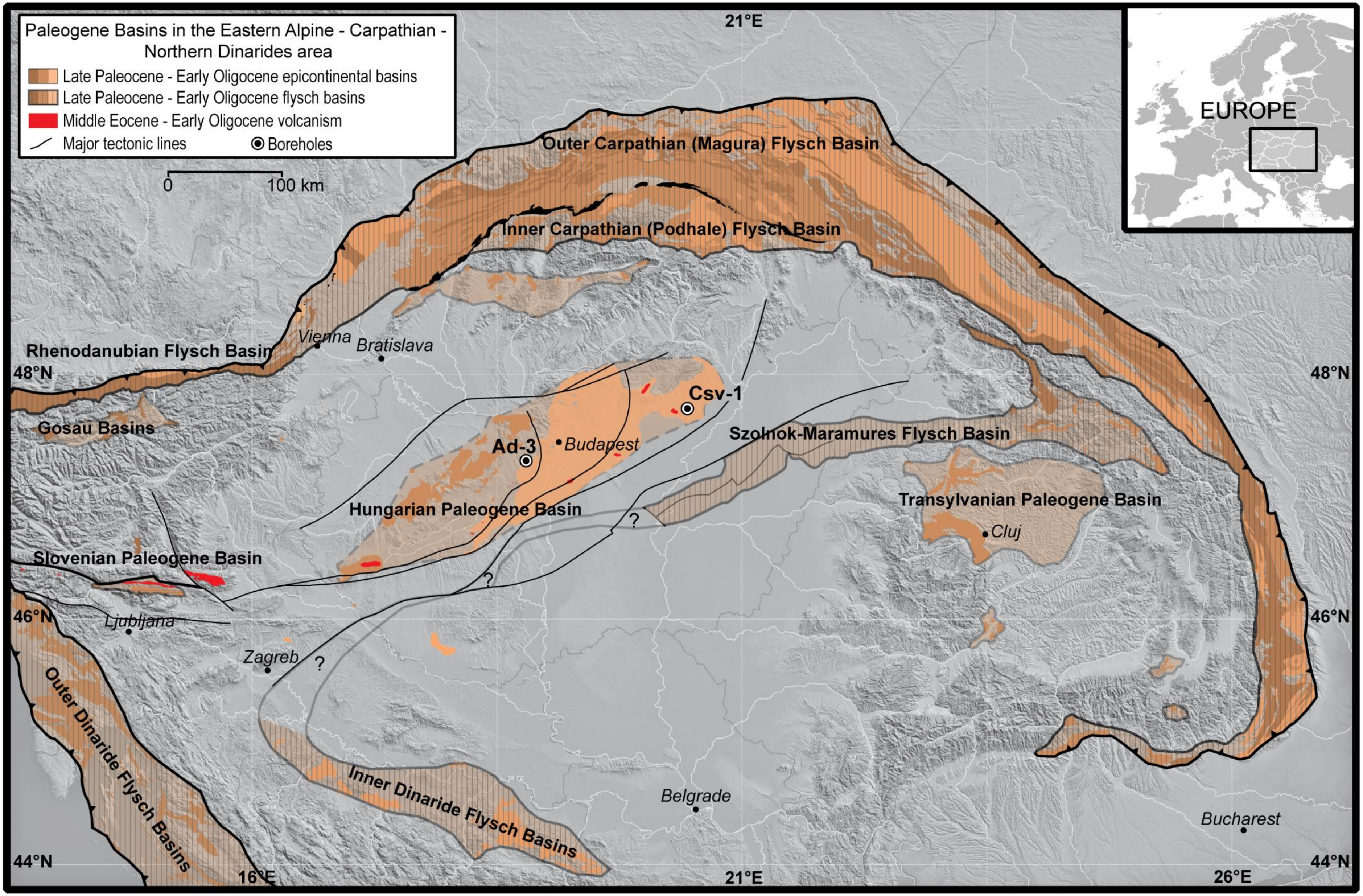
(Ozsvárt et al., 2016)



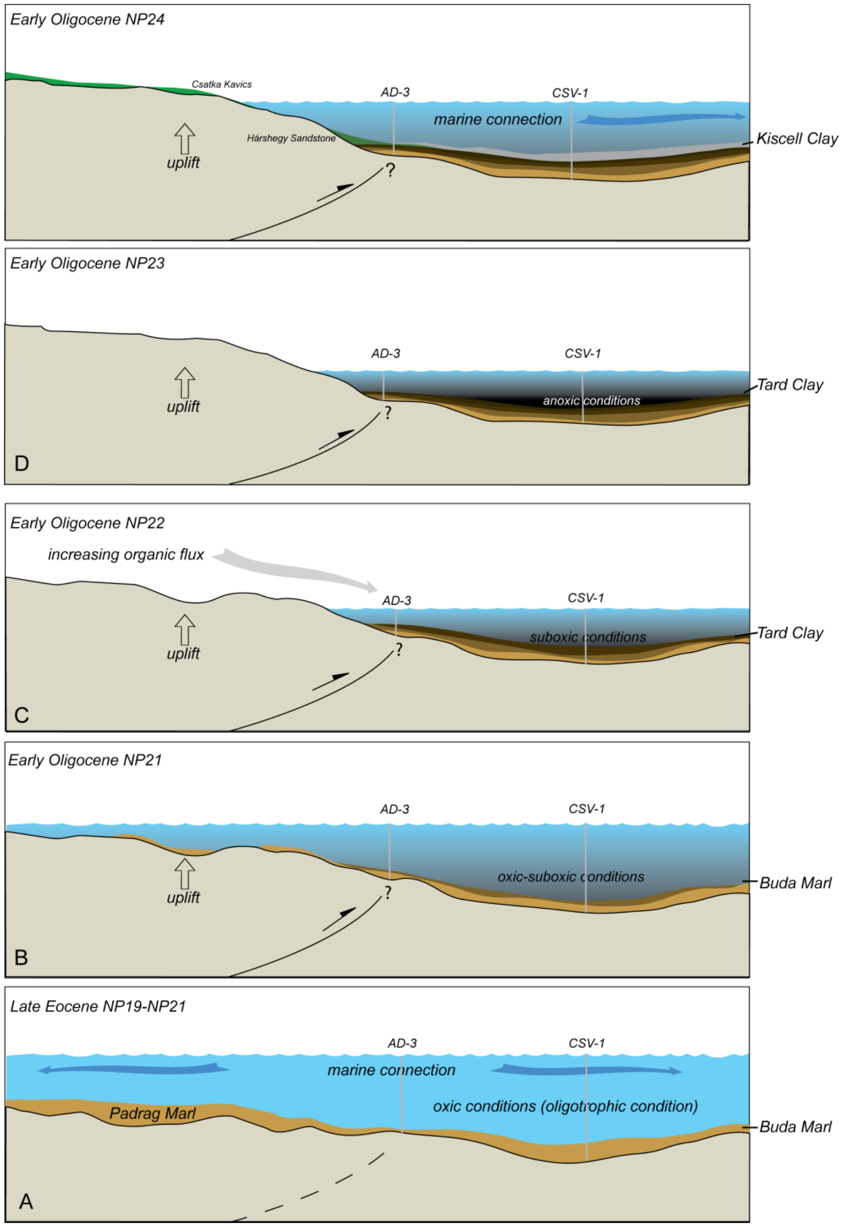
- Decrease of salinity, usual in many parts of the early Oligocene Paratethys, resulted in stable water stratification and enhanced oxygen depletion on the bottom in deep water setting.
- Calcareous microfossils are commonly used to follow these changes but they do not support extremely low salinity and/or oxygen depletion. Hence in case of extreme conditions other tools are needed to follow the evolution of paleoenvironment.
- Coupling of calc. microfossils and isotopy of reduced sulfur seems to be useful in these cases.
- Here using calcareous microfossils and sulfur isotopes we present a "2D study" of the evolution of the Hungarian Paleogene Basin during the early Oligocene, focusing on the Tard Clay, a good to excellent oil source rock.

Paleogene basins in the E-Alpine – Carpathian – N-Dinaric area

(Ozsvárt et al. 2016)



Evolution of the HPB based on microfossils, sedimentological features and organic geochemistry



- Rapid restoration of marine connections, normal marine conditions
- Brackish, shallow bathyal conditions, sulfidic bottom water, deposition of good to excellent source rocks
- Slightly brackish, shallow bathyal conditions, oxygen depleted bottom water, deposition of fair to good source rocks, uplift of the Eocene depocenter
- Beginning of the salinity decrease, bathyal conditions, oxygen depletion in the deepest parts, restricted marine connections
- Normal marine salinity, bathyal conditions, oxic bottom water, good connection with the surrounding seas

Processes constraining $\delta^{34}S$ of the pyrite

- Bacteria living in the porewater reduce sulfate and oxidize OM, producing H_2S and CO_2. A significant part of the H_2S reacts with iron minerals producing pyrite. This process is accompanied by great sulfur isotopic fractionation; $\delta^{34}S_p$ can be as negative as -30 ‰, while $\delta^{34}S$ of the sulfate dissolved in seawater is around 21-24‰.

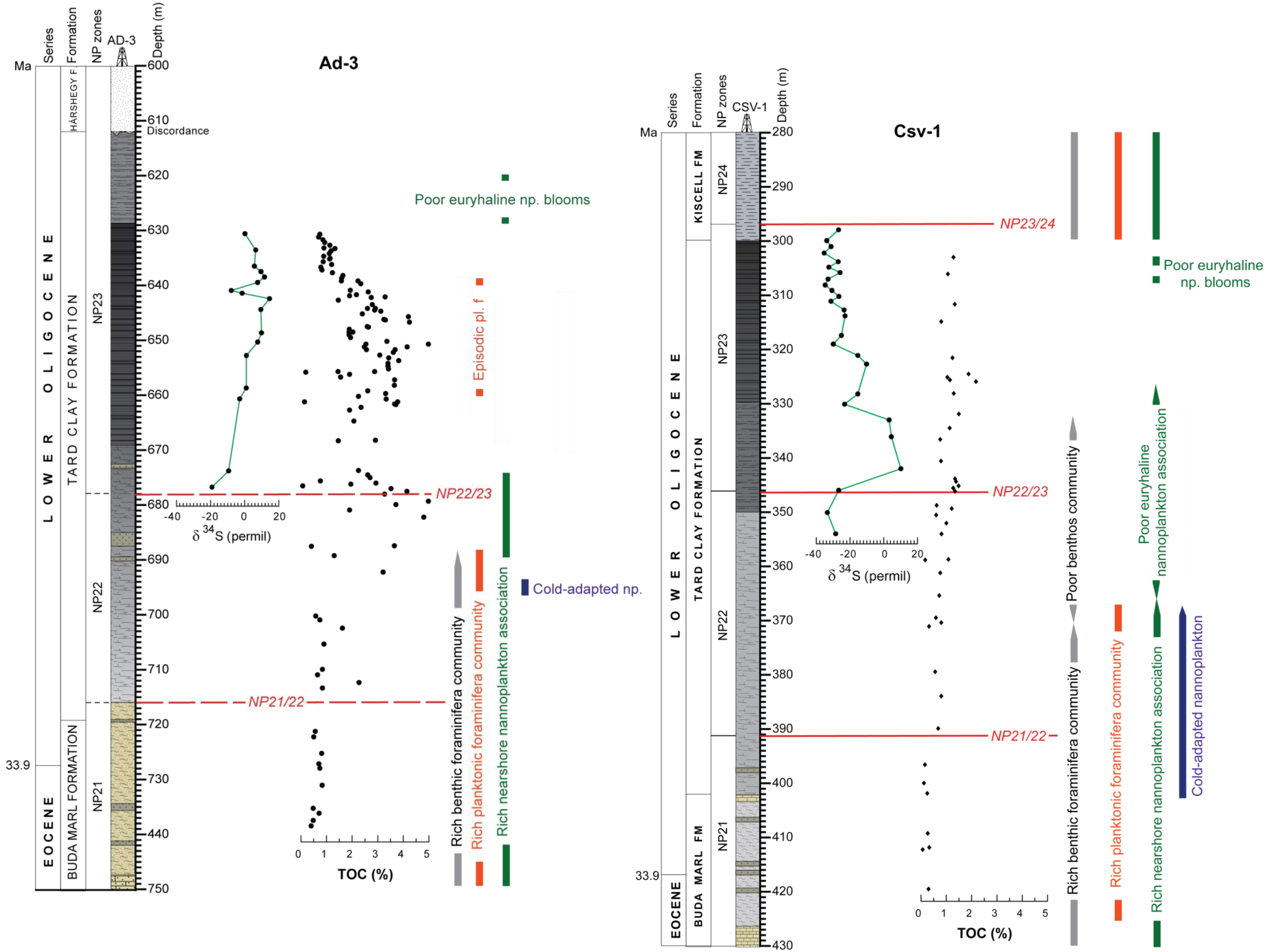
- In case of clayey/silty sediments with average Fe content $\delta^{34}S_p$ will be less negative if

- - bioturbation weakens or comes to an end
- or
- - the amount of reactive OM increases

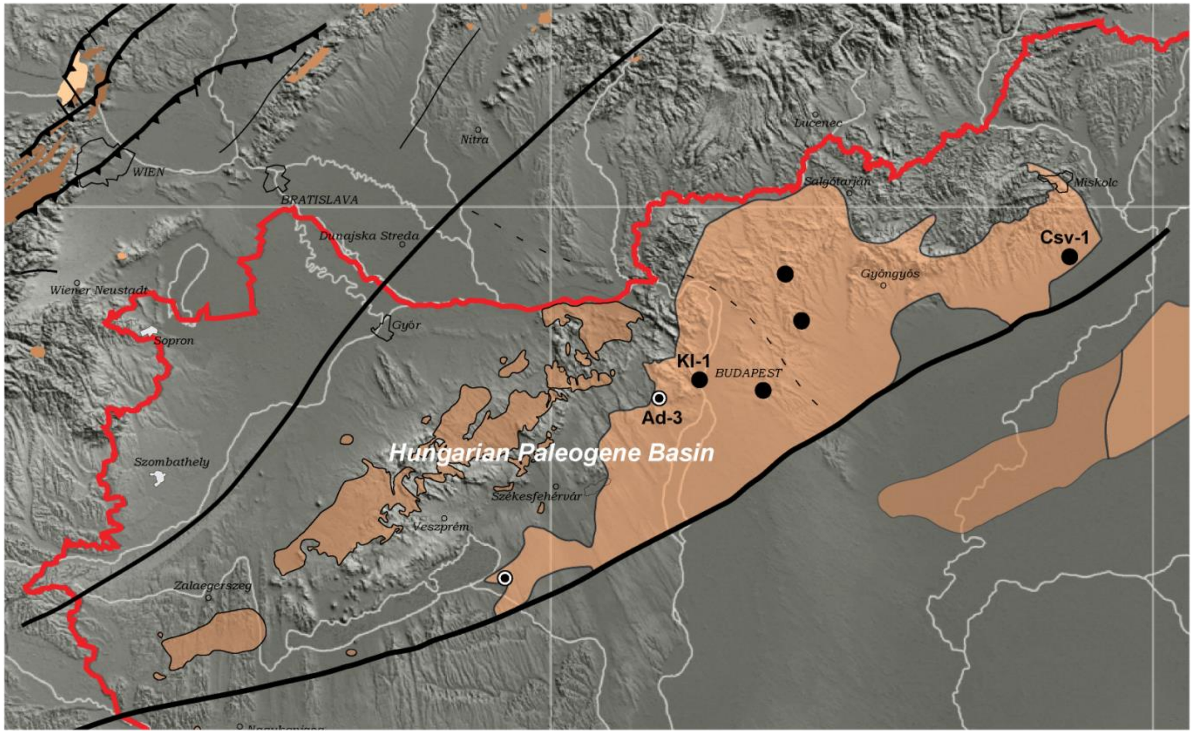
- or
- - salinity of the bottom water decreases
- or.
- - rate of sedimentation increases

- But if suboxia turns into sulfidic conditions, a part of the pyrite precipitates within the sulfidic water and the $\delta^{34}S$ of this part will be rather negative.

Sulfur isotope and TOC time series from the Csv-1 (eastern end) and Ad-3 (western margin?) coreholes plotted vs age (our published data, data of Bechtel et al, 2012, our unpubl. data and new results)



Good and excellent source rocks, where are they?



● The upper, strongly laminated part of the Tard Clay is concordantly covered by the silty Kiscell Clay

◉ The upper, slightly or non-laminated part of the Tard Clay is discordantly covered by sandstone

Wells drilled E of Budapest have found the Tard Clay covered concordantly by the Kiscell Clay and containing good but not excellent oil source rocks. In the Ad-3 and an other well drilled S of the lake Balaton, the Tard Clay is covered by sandstone and according to data obtained from the Ad-3 core, contains excellent oil source rocks.

All of these differences suggest that inside the Tard Sea relatively isolated parts existed.

CONCLUSIONS

- Time series of $\delta^{34}S_{red}$ in non-bioturbated sediments gives the possibility to follow
- the decrease of salinity and bottom water oxygen content beyond values tolerable for forams and calc. nannoplankton
- the first phase of restoration of normal marine conditions preceeding re-colonisation of the bottom water by microfossils.

András Nagymarosy (1949-2016)

We want to say how much we owe to all the interesting suggestions by András made at all stages of the preparation of the early version of our presentation and to big thank you for the time and trouble to him generously expended this project before his death.

References

Bechtel A, Hámor-Vidó M, Gratzer R, Sachsenhofer RF, Püttmann W 2012 Facies evolution and stratigraphic correlation in the early Oligocene Tard Clay of Hungary as revealed by maceral, biomarker and stable isotope composition. Marine and Petroleum Geology, 35, 55-74.

Ozsvárt P, Kocsis L, Nyerges A, Győri O, Pálfy J 2016 The Eocene-Oligocene climate transition in the Central Paratethys. Palaeogeography, Palaeoclimatology, Palaeoecology, 459, 471-487.

Vető, I. and Hertelendi, E. 1996 Sulphur isotope ratios in the laminated Tard Clay (Lower Oligocene of Hungary) reflect a salinity cycle. Acta Geologica Hungarica, 39, 204-207.