



## **Swaths of topographic sink depressions interpreted as remnants of paleomeanders in the vicinity of Lake Balaton, Hungary: evidences of young uplift or base level drop?**

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### ***Introduction***

The area of the eastern embayment of the Lake Balaton, Hungary is a very interesting region for several reasons. The lake itself is a very young feature: the earliest lake sediments are dated as young as ca. 15,000 years old, while the underlying strata are of Pannonian (Late Miocene) age separated by a complex shaped unconformity suggesting considerable erosional gap in the sedimentary sequence. Next to the lake Post-Pannonian volcanic tuffs can be found, showing the complex Quaternary evolution of the area.

Moreover, the present level of the lake (ca. 105 m a.s.l.) is situated substantially lower than the eastern-southeastern rim of the lake: the Pannonian strata form a spectacular, unexpectedly steep wall of some 50 meters of height, the so-called *Kenesei-magaspart*. In this several km long, slightly curved wall there are a number of hanging valleys (the most renowned is called *Macskatorok*) represented by some 25-30 m elevation difference between the valley bottom and the present level of the lake.

Another interesting feature of the area, which is common in the Transdanubia, south of the lake: the valley pattern is dominated by WNW-ESE directed, parallel valleys (hereafter referred as to quasi-meridional valleys) which are dewatered typically by

NE-SW directed trunk valleys, parallel to the long axis of the Lake Balaton and to the main tectonic lines like the Mid-Hungarian Shear Zone. The existence of this conspicuous pattern has attracted the attention of numerous researchers: GERNER (1994) summarized and grouped these theories including his own transpressional scenario.

From microtectonic investigations MAGYARI *et al.* (2004) found Late Pleistocene ENE-WSW and NNW-SSE compression, and a Late Pleistocene-Holocene NW-SE compressional component with an echelon and Riedel faults.

### ***Geomorphology of the quasi-meridional valleys and its neighbourhood***

The elevation pattern of the quasi-meridional valleys shows a certain conformity: the though the valley bottoms are situated more or less in the same elevation, the strike-perpendicular extent of the ridges and valleys varies considerably. There are some low-lying wide valleys (106-110 m a.s.l.) that were even partly or completely inundated by the Lake Balaton in historical times. On the other hand, at some places the ridges are quite wide forming plateau-like NNW-SSE elongated geomorphic forms made of Pannonian material with a thin loess cover at elevation of 140-160 m a.s.l.

The latter system of plateaus is the target of our current study, because at the top of these flat areas there are several dozens of topographic depressions forming sinks without any outlet. The horizontal extent of these depressions varies from some 20 meters up to 500 meters, and most of them are elongated except the largest ones. The elongation axes are not always in line with the direction of the quasi-meridional valleys: the direction varies, however, they are situated in confined swaths, and these swaths follow the typical NNW-SSE direction.

Local people report that some of these sinks are filled with rainwater during the rainy early summer months for several weeks, though the mean annual precipitation is only 550 mm/a.

One of the widest plateaus forms the aforementioned elevated rim on the shore of Lake Balaton: it seems that the lake itself washed away the missing western part of the elongated plateau. This is possible because it is known that the 77 km long and 5 km wide lake produces long-wave water level variations along the large axis, which motion has huge sediment removal capacity, so the slumped material of the elevated rim is quickly leveled in the basin of the lake.

A further important geomorphic phenomenon should be mentioned: in the eastern side of this elevated plateau the Creek of Cinca-Csíkgát dewatering a smaller basin at elevation of 110 m a.s.l. cuts through in an elevated region (at elevation of some 120 m) forming well developed meanders. There is no other creek, where other meanders can be detected, but in-between the Cinca-Csíkgát and the elevated plateau, incised in

the slope there is a dry valley, showing meander-like course.

### ***Interpretation of geomorphic features***

We interpret the aforementioned system as remnants of a previous floodplain with meandering creeks/small rivers, similar to the Great Hungarian Plain situated some 80 km further to the east. The present sinks are considered to be abandoned water-courses that are not yet reached by fluvial erosion to join them to the main trunk of the neighbouring catchment. On the eastern hillside of plateau the dry valley represents an intermediate form: it is already joint to the main trunk, but because of the limited discharge the valley can develop only during catastrophic rainfall/torrential discharge events.

### ***Multielectrode geoelectric survey results***

To evaluate our theory we have carried out multi-electrode geoelectric surveys perpendicular to the assumed meander at several places: at the side of the obvious meanders of the Cinca-Csíkgát creek and in the dry valley, and also on the plateau-like area. It was expected to detect here the point bars of the evolving and now abandoned meanders

We have measured several geoelectric lines with various electrode spacing ranging from 2 m up to 8 meters. The calculated penetration of the current varies according to the length of one measured section, the maximum inverted depth is ca. 40 m in the flat region, while in the vicinity of the meanders it is in the order of magnitude of 10 meters.

The results are completely in-line with our expectations: there is a topmost layer showing horizontal apparent resistivity changes characterized by somewhat higher resistivity, while below this structured zone a more or less homogeneous, low resistivity layer can be interpreted. In some places this can be interpreted as the depth of the water table, while in the dry valley this structure crosses the surface, so here this should be due to a lithological difference.

### ***Conclusion and outlook***

The existence and spatial pattern of numerous shallow depressions south of the Lake Balaton in Pannonian and Quaternary sediments is an unusual feature. The interpretation of the sink and valley system as remnants of a previous meandering floodplain seems to be plausible according to the geoelectric survey results. If this interpretation holds, it implies a major change in the fluvial regime in the region. However, it is not clear, that the abandoned meanders, now sinks have been left over due to a sudden base level drop or the consequence of the on-going/Late Quaternary deformation

as described by e.g., MAGYARI *et al.* (2004). Several other observations (e.g. recent earthquake activity along the Berhida line and differential uplift in the Transdanubia according to repeated precise levelling) can be interpreted as vertical components of crustal deformation.

To answer this question further studies are necessary including multi-electrode surveys, shallow borehole sampling, geomorphic mapping and GIS integration of the observations.

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### ***References***

GERNER, P. (1994): Dél-dunántúli neotektonikai modellek a magyar földtani szakirodalom alapján. (Neotectonic models of the southern Transdanubia in the Hungarian geological literature; in Hungarian) *Földtani Közl.* **124**(3), 381-399.

MAGYARI, Á., MUSITZ, B., CSONTOS, L. VAN VLIET-LANOË, B. & UNGER, Z. (2004): Késő negyedidőszaki szerkezetfejlődés vizsgálata Külső-Somogyban terepi mikro- és morfolitektónikai módszerekkel (Late Quaternary neotectonic investigation in the Somogy Hills (SW Hungary) in combination with micro- and morphotectonical field approach; in Hungarian with English abstract). *Ann. Rep. of Hung. Geol. Surv.* **2002**, 111-128