Different hydraulic position of paleo-maar lakes in subsurface flow systems, Tihany Peninsula, Hungary

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Groundwater-influenced lakes and wetlands are hydrologically and ecologically linked to adjacent groundwater bodies, but the degree of their interactions is highly variable in space and time (Born *et al*., 1979, Winter *et al*., 1998). The relationship depends on the water table configuration, location of stagnation points, relation of the lake water level to the water table and to the subsurface potential field, the geological framework, climate, and the vegetation (Winter 1976, Winter *et al*., 1998).

The lakes of Tihany Peninsula, Hungary are located in Neogene paleo-maar structures filled with lake sediments (Németh *et al*., 2001). The lakes were assumed to be recharged exclusively from precipitation. However, based on the above mentioned considerations, and on the numerical and theoretical studies of Winter (1976), connection of the lakes with the groundwater can be presumed. The goals of the study were to understand the hydraulic position of these lakes in the flow systems of the Peninsula and to find explanations for their different hydrological behaviour.

Cadastrial- and topographic map analysis, radio-magnetotelluric (RMT) measurements, hydraulic-, geochemical methods, time series analysis and two-dimensional numerical flow-simulations (FLONET/TR2; Molson & Frind, 2013) were used to understand the hydraulic position of the lakes (Fig. 1.).

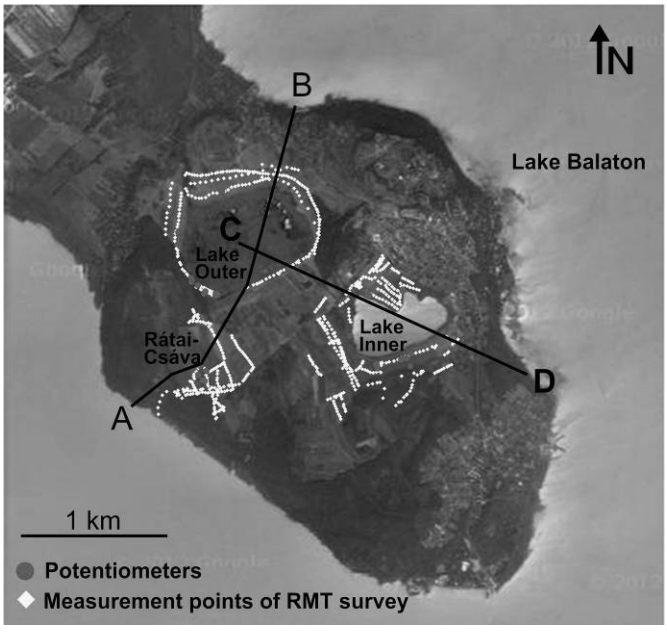

Fig.1.: Points of measurements and location of cross sections used in 2D numerical groundwater flow simulation

As a result, a hydraulically continuous subsurface flow field was recognised for the area, which is driven by topographic gradients. The geometry and hydraulic behaviour of the near-surface sediments was described with the help of the geophysical (RMT) measurements. Seasonal variability of the subsurface fluidpotential field and the groundwater-chemistry was revealed by the hydraulic and hydrogeochemical field data analyses. Based on this insight, a two-dimensional numerical simulation was carried out. The model indicated the different hydraulic position of the lakes. The transient lake (Rátai-Csáva) is a recharge type lake, the basin of the Outer Lake is a discharge area, however the Inner Lake is a through-flow type lake (Fig. 2.). The results are in good agreement with the field measurements.

As a conclusion, the paleo-maar lakes of the Tihany Peninsula are part of the water level, therefore the subsurface hydraulic connection between the lakes has been recognised. The different hydraulic behaviour of the lakes is strongly depending on their subsurface flow position.

These results can be significant concerning water balance and ecological aspects of the wetlands as well as in the management of the conservation of the area. These results can also initiate further research to understand the interaction between flow systems and paleo-maar lakes for other regions.

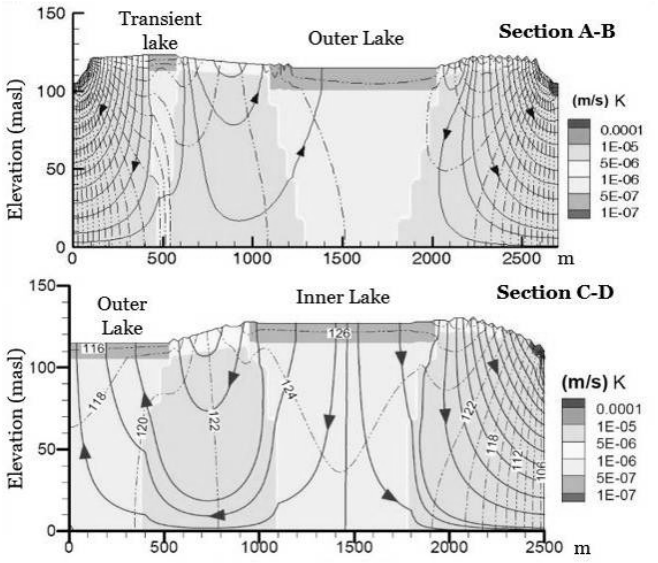

Fig.2.: The potential disribution and streamlines along the simulated sections by FLOWNET TR2

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