NEW CONTRIBUTION OF GEOPHYSICS TO GEOLOGY AND HYDROLOGY OF LAKE NEUSIEDL (NEUSIEDLERSEE/FERTŐ, AUSTRIA/HUNGARY)

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SUMMARY

In the nineties we carried out geophysical measurements in three areas in the Lake Neusiedl (in Hungarian: Fertő, in German: Neusiedlersee) region: two ones on the open lake and one in the vicinity of Mörbisch. In this paper a new interpretation of geophysical measurements is given. The geophysical (mainly geoelectric) anomalies have got reasonable geological explanation. In order to answer more geological questions, it would be necessary to carry out further geophysical measurements.

GEOLOGICAL OVERVIEW

Lake Neusiedl (shown in Figure 1) is a shallow water body, located on the Austro-Hungarian border, with an average depth of less than 1 m and it has had large water fluctuations over the historical period. More than one half of its total surface (of appr. 317 km^2) is now overgrown with uliginous plants.

The geological basement of the Lake Neusiedl area is built by the “Coarse gneiss formation” of the Leitha Mountains and the Rust-Fertőrákos Ridge. West of the lake “Rust Gravels” (upper Karpatian), “Leitha Limestones” (Badenian), Sarmatian gravels, sands and sandstones as well as Pannonian clays, sands and gravels superpose the basement. East of the lake Pannonian-Pontian layers directly overlay the crystalline basement (Tauber, 1959). A sinking (rapidly increasing towards East) took place in the Pontian. The basin formed in this way was filled later by limnic clays and sands with inserted lignites and gravel strata. Drillings near the lakeshore showed Pontian sediments immediately under the mud deposited within the lake.

At the beginning of the Pliocene the Pontian Sea definitively withdrew (Boroviczény et al., 1992). After this period the “Parndorf Plate” was accumulated as a Günz (early Pleistocene) deposit of the Danube River (Tauber, 1959). South of the “Parndorf Plate” the “Seewinkel Gravel” was deposited in the Würm period (upper Pleistocene) over an extensive part of the Seewinkel region. It has been interpreted as a deposit of the Danube (Frasl, 1961) or Raab (Rába) River (Fuchs, 1974). In the Pleistocene the Lake Neusiedl region was more elevated than the glacial gravel layers. Therefore it was exposed to a denudation oriented to East (Tauber, 1959). The recent lake basin sank down at the earliest during the late Pleistocene.

The tectonics in this region is characterised by an echeloned lowering of the Little Hungarian Plain (Kisalföld). Near the village Rust a cross fault striking from SW to NE with downfaulted NW block has been found (Tauber, 1959). Gravimetric measurements and deep drillings evidence a buried deep zone below the northern part of the Lake Neusiedl and below the village Weiden (Granser et al., 1992). At Podersdorf a W-E striking high zone has been found which is accompanied by a parallel syncline near the village Gols (Tauber et al., 1958). A fault system separates the northern part of the "Ikva Plate“ from the Lake Neusiedl (Boroviczény et al., 1992)

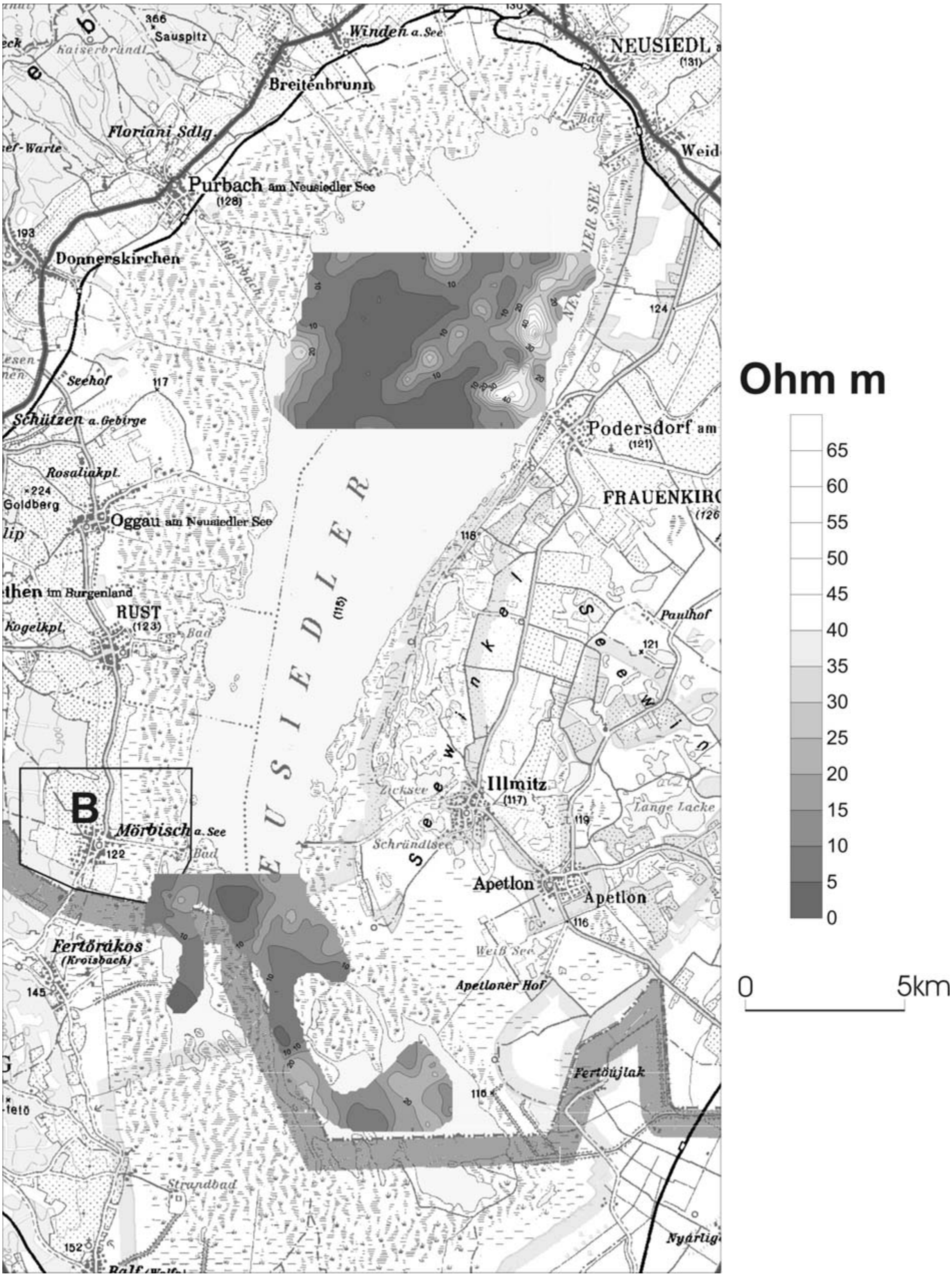


Figure 1: Lake Neusiedl (Fertő, Neusiedlersee), with the political border between Austria and Hungary and three areas where geophysical measurements were made in the nineties. (Geoelectric maps in area 1 (N of Podersdorf) and 2 (Mörbisch-border area) give inverted resistivity values at a depth of 20 m. The third area is denoted by B.)

GEOPHYSICAL INVESTIGATIONS IN THE NINETIES

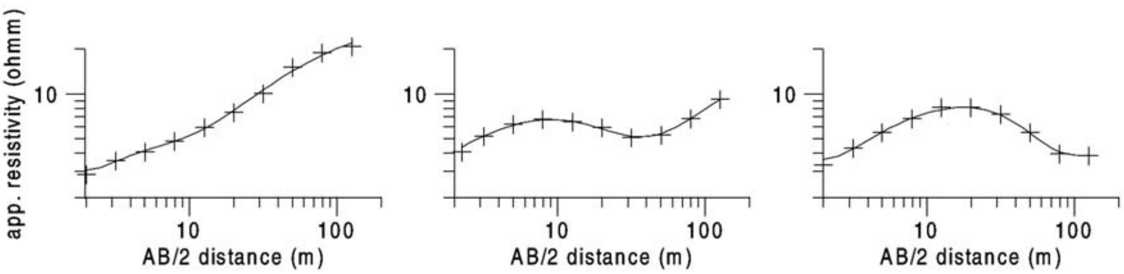
Several groups carried out geophysical and hydrological investigations around the lake during the past ten years. Our measurements covered in total an area of more than 50 km². The largest part of our geophysical measurements has remained unpublished (with exception of Kohlbeck et al. 1993, 1994).

Podersdorf region. DC measurements made in the open area of the lake North of Podersdorf now demonstrate the filling of the lake with new sediments. Figure 1 shows the map about the inverted resistivity distribution at a depth of 20 m. (We have also produced a colour slide show illustrating a three-dimensional insight into the sedimentation between the depth of 50 m and the surface.

Mörbisch – village and lakeside. Intense measurements including DC Schlumberger, DC multielectrode, EM, VLF, gravity and seismics have been performed in the area denoted as B in Figure 1. While the VLF measurements could not be geologically interpreted (neither on land nor on the open lake), the other measurements fit together within the expected accuracy. Gravity measurements with a measurement distance of 50 m along three lines indicated the location of faults. (From the practical point of view, gravity was the only method that could be applied without troubles in the town.) Seismics carried out along the Austrian Hungarian border in the open lake showed a slight velocity gradient ranging from 1700 m/s to 1800 m/s without any recognizable layering, neither with refraction nor with reflection down to a depth of about 300m.

Figure 2: The three types of sounding curves measured on Lake Neusiedl. The inversion results (in terms of layer number: resistivity in Ωm (uncertainty), layer thickness in m (uncertainty)) are as follows:

a) No 196:	b) No 17	c) No 275
1: 5.3 (± 8.9%), 1.42 (± 8.53%)	1: 3.76 (± 69.5 %), 0.9 (± 57.2%)	1: 4.2, 1.8
2: 4.74 (± 1.2%), 8.83 (± 1.6%)	2: 7.95 (± 2.7 %), 6.94 (± 8.02%)	2: 9.83 (± 0.5 %), 17.51 (± 6 %)
3: 29.89 (± 1.1%)	3: 4.02 (± 3 %, 33.29 (± 7.58 %)	3: 2.45 (± 23.4 %), 32.1(± 74.9%)
	4: 22.85 (± 9.9 %)	4: 4.82 (± 20.2 %)



Mörbisch – border. The existence of water lenses with high concentrations of various minerals has been known for a long time and has been exploited from depth down to about 200 m. With DC geoelectric soundings we could delineate large areas of the lake that contain with highest probability near-surface mineral water. Figure 2 shows the three principal types of Schlumberger sounding curves that were obtained on the lake. One-dimensional calculations with electrodes and layers placed on the lake bottom were carried out. Several quite different interpretations that match the sounding curves within the error bars are possible. Due to the inherent ambiguity of geoelectric soundings, true resistivity depth-profiles can only be obtained with either additional information or in the context with measurements at adjoining locations with smoothly varying layer thickness from one location to the next. Curve a) is obtained where new sediments (having resistivities less than 10 Ωm) simply cover old ones (resistivity higher than 20 Ωm). Curves b) and c) indicate a layer of very low resistivity, less then 5 Ωm covered by a layer with somewhat higher resistivity. This very low resistivity layer can be interpreted by formation water with high concentration of solute salt.

NEW GEOLOGICAL INTERPRETATION OF GEOPHYSICAL MEASUREMENTS

Podersdorf region. The distribution of resistivity indicates a progressive deepening and filling with more than 40 m of late Pleistocene and Holocene lake sediments. The Western part is separated from the Eastern part by a SW-NE striking structure with relatively high resistivity values. Its steep NW edge points to a downfaulted NW block along the "Neusiedl Fault" or in the joint area with the "Rust Fault". The deepening area on the eastern side is probably connected with the "Neudorf Flexure". Zones >30 Ωm indicate the tertiary lake subsoil. The results confirm the theory of a very late origin of the lake, caused by very young tectonic movements.

Near the Western lakeshore at about 2.5 m below the lake bottom and deeper a zone with relatively high resistivities was observed. This result can be explained by an alluvial fan from the "Angerbach" rivulet. However, the sedimentation is already finished because 1 m below the lake bottom there were no significant differences in the observed resistivity values. The interpreted alluvial fan is a first obvious indication of the postulated fillings of erosional channels from the time before the existence of the lake (Tauber, 1959).

Mörbisch – village and lakeside. Gravity, EM and DC-multielectrode measurements confirmed and specified the knowledge of the step fault system on the western edge of Lake Neusiedl. Along the lake mole over nearly 2 km a significantly stepped lowering of the crystalline surface to E by 140 m was found. Furthermore, the crystalline surface showed differences in elevation by 60 m in N-S direction, which indicate a W-E striking system of cross faults (Kohlbeck, 1995, Kohlbeck et al., 1997).

Mörbisch – border. Geoelectric measurements near Mörbisch (along the border between Austria and Hungary) show impressively the filling of the Pleistocene relief with >40 m thick lake deposits. The increase of the electric resistivities often – but not always – correlates with the nearness of shore or islands. The eastern and middle part of the investigated area showed resistivity maxima at a depth of 2.5 m below the lake bottom and deeper, which can be explained by the occurrence of "Seewinkel Gravel". The evidence of gravels between 97 and 118 m absolute altitude near the lakeshore west- and southwards of Apetlon (Haas et al., 1992) as well as fluviatile deposits on the southern lakeshore correspond to this finding (Kohlbeck, 1995). Nevertheless, this interpretation is uncertain because the gravels may be structurally lowered on the Eastern block of the "Mönchhof Fault". Furthermore, in two drillings beside the shore no gravel was found. Linear structures indicating fracture tectonics were not observed.

CONCLUSIONS

A few geological questions have been answered, but some of them remained yet open. It is evident that a continuation of geophysical measurements in the future would be very useful. Comparing our profiling and mapping investigations we can conclude, that it is worthwhile to perform mapping, which gives by far more information about the subsurface then profiling.

ACKNOWLEDGEMENTS

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