

University of Szeged, Faculty of Science and Informatics
Doctoral School of Earth Sciences

The tendencies of water level changes of Lake Balaton during the archaeological periods

Gábor Serlegi

PhD Thesis Abstract

external supervisor:

Dr. Mária Bondr, Csc (PhD)

senior research fellow

Research Centre for the Humanities of HAS

Institute of Archaeology

internal supervisor:

Prof. Dr. Pál Sümegi

Head of Department

University of Szeged, Faculty of Science and Informatics

Department of Geology and Palaeontology

Department of Geology and Palaeontology

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Justification of topic and previous research:

Due to the extreme values of the water level of Lake Balaton during the past two decades and in connection with the processes determining them, the issue of the maintenance of the lake capable of providing continuous and appropriate services has frequently become a topic of debate.

The maintenance of the current state of continuous usability of the lake is today secured by serious legal regulations, a water management plan and a system of measures. These are aimed at the preservation, maintenance and regulated development of an environmental state that is the result of practically irreversible processes and is significantly different from the natural state of the lake due to anthropogenic impact.

Although today the size, regulated maximum water level, shoreline and the character of the shore differ in significant ways from the earlier, natural state, the water level of the lake is still determined by the same – primarily climatic – factors as during the millennia before human impact.

The investigation of the causes of water level changes may help us understand the behavioural mechanisms of the lake and we may be able to predict the outcome of future processes.

The study of the historical fluctuations of the water level of Lake Balaton started primarily from geologically oriented researchers. In these early phases of research archaeological correlations, the geomorphologic position of lakeshore archaeological sites and the impact of the lake on the life of historical human communities were hardly mentioned; their main interest was Lake Balaton as a natural phenomenon. Later on, from the end of the 1960s, the work of two researchers, the archaeologist Károly Sági (1919-1997) and the geologists and surveyor László Bendefy (1904-1977) lay the foundations of the geoarchaeological approach in connection to Lake Balaton, according to which the investigation of the archaeological phenomena and the correlation of archaeological chronology with the tendencies of the changes of the water level can provide reliable data on the character and extent of water level fluctuations in the archaeological periods preceding the appearance of map-like

representations (Bendefy 1968; Bendefy 1970; Bendefy 1972; Bendefy-V. Nagy 1969; Sági 1968a; Sági 1968b; Sági 1970; Sági 1971; Sági-Füzesi 1973).

After the archaeologically relevant research on the water levels of Lake Balaton during the 1960-1970s, the topic became important again in the first decade of the 2000s due to the preventive excavations along the track of the M7 highway. This phase is still ongoing, and there are still research projects connected to the M7 excavations or the Late Antique-Early Migration Period history of Keszthely-Fenékpuszta and its vicinity, where environmental historical and environmental archaeological analysis is an organic part of the research. Dr. Pál Sümegi and the colleagues of the Department of Geology and Palaeontology play a significant role in these studies (Sümegi et al. 2004; Sümegi et al. 2007; Sümegi et al. 2011; Sümegi et al. 2014).

Aims:

The aim of my doctoral dissertation is to contribute to and, if necessary, place into a new framework a topic that obviously has a long research history, through environmental archaeological methods based primarily on archaeological data amassed during the past decades.

The basic task of the thesis is to infer the tendencies of water level changes within and between archaeological periods through the study of the geomorphologic position of known archaeological sites in the southwestern region of Lake Balaton.

With the help of the chronological system of archaeological periods – and based on geological, hydrological and environment historical data – we are able to determine tendencies in the changes of the water level of the lake that have a better temporal resolution than the geological scale. I studied the correlations between the water level tendencies of Lake Balaton and the geomorphology of the settlements at the natural state of the lake. This natural state ceased in the Late Roman period, with the draining of the lake by the Romans. As a result of this anthropogenic impact, however, not only Lake Balaton, but the whole hydrological system of Southeast Transdanubia changed. The study and detailed

elaboration of this complex intervention and its impact on an area much larger than the basin of Lake Balaton, was suitable as the topic of a doctoral dissertation.

Methods:

I studied the correlation between the geomorphologic position of human occupations in archaeological periods and the historical water levels of Lake Balaton through two complementary methods. Due to the surface movement processes of the area and the impact of modern features on topography and the groundwater level, the absolute level of the water in the various archaeological periods could not be determined. Consequently, in the thesis I primarily aimed at the identification of the tendencies of the water level changes within periods.

The basis of the first method was that from the experiences of the preventive excavations along the M7 highway it became clear that from the point of view of the location of the settlements of various periods on the loess ridges, one of the most important factors were the groundwater characteristics of the hill sides that depend on the water level of the lake. Starting from this principle, based on the soil mechanical cores taken in the area of the Balatonkeresztúr-Réti-dűlő site, excavated in 2003-2004 by Szilvia Fábíán (Fábíán 2004; Fábíán 2007), I prepared the reconstruction of the stratigraphical and groundwater conditions on a section of the eastern slope of the Marcali tableland. The results of the groundwater model were compared with the occupation zones in the archaeological periods attested at the site.

The second method consisted of the study of a 36 km by 24 km, slightly more than 860 sq. km large area covering the western end of Lake Balaton with Nagyberek, the northern part of the Marcali loess ridge and the eastern half of the basin of the Little Balaton. The choice of the study area is justified by the fact that from the vicinity of the Balatonkeresztúr site we have published and digitizable archaeological survey data that can be analyzed through GIS. This is due to the volume of the Hungarian Archaeological Topography covering the sites of the Keszthely and Tapolca parishes (MRT1 1966), the summary of the results of the excavations carried out during the reconstruction of the Little Balaton

(Évezredek, 1996), and the preliminary reports of the preventive excavations carried out along the relevant section of the M7 highway (Honti et al. 2002; Honti et al. 2004; Honti et al. 2007).

In order to carry out the analysis I created a GIS database that connects the measured points of the archaeological sites with data on the topographical and sedimentological characteristics of the area, the average depth of groundwater, and the soil types of the exploitable areas surrounding the settlements. These are the basic variables that usually determine the location of a settlement within an area of given characteristics (van Leusen et al. 2009, 138-143; Mesterházy-Stibrányi 2011, 13-16; Stibrányi et al. 2012, 28-39).

I calculated four schematic water coverage values in the database and examined how these values affected the location of the sites of various archaeological periods in the study area.

Results:

1. The results of the groundwater model confirmed, what had already been observed in the field: that on the slopes of the meridional hills occupation depended primarily on the depth and stability of the groundwater table.
2. The settlements on the lakeshore hillsides were always located in zones that were not directly impacted by the short-term water level fluctuations of the lake. The people who settled here occupied areas where the movement of the groundwater table influenced by the seasonal water level changes of the lake did not endanger their storage pits and semi-subterranean houses, and at the same time wells and sources providing water did not have to be dug too deeply in order to reach the groundwater level. To sum up, the settlements occupied that part of the hillsides where the depth of groundwater fulfilled both criteria at the same time.
3. In the case of the Balatonkeresztúr site it can be confirmed that in most of the archaeological periods under study occupation was preferred on the middle to low sections of the hillside, where groundwater level is fairly close to the surface.

4. Although as a function of the changes of the water level of the lake in certain areas of the groundwater table some movement may be assumed, in the most intensively occupied zone the fluctuation is not significant, and even at a very low lake level the groundwater level does not sink too deep.
5. In the light of the complex investigation of the Late Copper Age occupation at Balatonkeresztúr it seems obvious that there were no large-scale changes in the level of the lake during this long-term occupation that would significantly change the groundwater level (Fábián-Serlegi 2007; Serlegi et al. 2012).
6. Archaeological and stable isotope data from the Late Copper Age prove that even during a short-term climatic period with extreme characteristics the level of the lake does not rise to such an extent that it would compel the inhabitants to abandon their settlement (Fábián-Serlegi 2007, 2009; Demény et al. 2010; Serlegi et al. 2012; Schöll-Barna et al. 2012).
7. The section of the hillside characterized by the above-mentioned features was inhabited for longer periods a number of times at the natural state of the lake. Consequently, it may be established that the fluctuation of the water level of the lake did not exceed 1-2 m within a few hundred years interval, since that would have caused changes in the groundwater level that would have fundamentally influenced the existence of the settlement.
8. Due to the damming effect on the groundwater of the water of the Nyugati-övcsatorna (Western drainage canal), in contrast to the natural state of the lake, today there is no direct connection between the fluctuation of the groundwater level and that of the water level of the lake.
9. The location of the sites, irrespective of the archaeological period, show clearly observable patterns in the static water coverage model in the case of slope aspect, sedimentology, surface water coverage, location of water flows, average depth of groundwater level and soil types. This demonstrated well the determining role of these environmental factors in the choice of the location of the sites.
10. Through the study of the correlation between the threshold values of the water coverage model and the position of the sites in each period some general tendencies could be observed. These tendencies were confirmed mostly at those sites that were – similarly to Balatonkeresztúr – multi-component sites. At some

of these sites it could be observed based on the water level values used in the model that with the rise of the water level, a 2 m rise compared to the minimum water level would make human occupation impossible. Based on this observation and the fact that the occupations of the multi-period site cover the whole temporal interval under study we can conclude that during these archaeological periods the long-term fluctuation of the water level of Lake Balaton remained within this 2 m interval.

11. Since the 1-2 m long-term water level fluctuation of the lake during the archaeological periods was confirmed by two, complementary models, we should expect throughout most of the Holocene a balanced long-term water regime in the natural state of the lake, staying within the 1-2 m interval, which could have been interrupted by short-term extreme periods.

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