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First, Second and Third Habsburg Military Surveys: documents of the transition of Lake Balaton from natural to artificial hydrologic regime

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The hydrology of Lake Balaton, the largest lake in Central Europe has a long history of human impact, which probably started in prehistoric times through agricultural expansion. The most important change in the water regime of the Lake is considered to be the opening of the Sió Canal in 1863. This resulted in the lowering of the average water level by more than a meter and is known to have had a strong effect on the immediate shore zone of the lake and on the adjoined wetland areas. However, since the sluice and canal could only drain a restricted amount of water, these widespread effects were probably also caused by other changes on the watershed of the lake.
The First Military Survey of the Habsburg Empire was measured nearly 100 years before the opening of the canal and is the first detailed survey of this area, and it can be considered as a benchmark of the situation before major human-induced changes on the catchment of the lake. The sheets of the Second Military Survey were mapped in an interval of 6-11 years before the drainage, so they show the situation with major anthropogenic impacts on the wetlands and the drainage basin but with the canal still not opened. The Third Military Survey shows the situation with major anthropogenic changes on the catchment and also the effect of the canal opening. Water level measurement data exists continuously since the Canal was opened but not before that time.
The First Military Survey has no geodetic projection, so a seamless georeferenced mosaic of the Lake Balaton catchment had to be created by constrained polynomial georeferencing. The Second and Third Military Surveys were mapped using a projected coordinate system so these could be simply reprojected into a GIS. The second military survey has a unified map legend system and visual interpretation of these maps is easy, but most of the Third military survey only survived in form of black-and-white copies and these are more difficult to read. The elevations of the shorelines of wetlands around the lake for all three surveys were measured by digitizing and overlaying on a present-day DEM, and the area of wetlands inside the boundary of the lake were also measured by digitizing. Major changes influencing the hydrology of the catchment area were also digitized and measured, including deforestation, canalization of wetlands, regulation of rivers, damming of valleys for fishponds and expansion of agriculture.
The second military survey shows that the water level of the lake was already significantly lower than the historic water level and large stretches of the shore which were submerged on the First Military Survey are uncovered on the Second. The drastic lowering of the water level changed the slope of the shore areas of the lake bottom (the original, steep shores ran dry and the new shore was much more flat) which resulted in the marked expansion of the reed areas between the First and Second Survey which is shown by the Third Military Survey to have stabilized. The water levels of the wetlands adjoining Lake Balaton also show a marked drop on the second military survey compared to the first, which also documents canalization of several large wetland areas, and this has also remained relatively stable between the second and the third surveys. The water level of Lake Balaton on the Third Survey shows no major differences compared to the water level on the Second Survey, but the water level of the lake in the 1880-s is documented to have been unusually high, reaching the highest water level since the start of regular measurements, but still remaining about a meter under the 18th century water level. The weather of these periods is also documented in hydrologic records, and the 1850-s and 1860-s were known to have been relatively dry years while the 1880-s were wet. The effect of these weather tendencies is shown by the water level of the Lake and could not be controlled by opening or closing of the canal lock gates.
The scale and accuracy of the georeferenced First, Second and Third Habsburg Military surveys allows them to be used for such reconstructions, and demonstrates the value of historic maps as documents of hydrologic regime changes. The results show that the canalization and land use change on the catchment of the lake had a significant

long-term effect of the water level that was comparable to the effect of the single event of opening the canal.