PAGES
PAST GLOBAL CHANGES

cirques & lakes
PN-II-RU-TE-2012-3-0386

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Late Pleistocene and Holocene Climatic Variability in the Carpathian-Balkan Region

ABSTRACTS VOLUME

Ştefan cel Mare University Press

Late Pleistocene and Holocene climatic variability in the Carpathian-Balkan region. Abstracts volume

Nov. 2014

Ştefan cel Mare University Press

Archaeological sites on large river's islands as records of Holocene climate and fluvial changes. A geomorphological case study in the Danube river section between Komárom and Paks, Hungary

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Introduction

The purpose of the research is the enhanced understanding of the Late Pleistocene and Holocene variability of fluvial dynamics affected by the climate changes in Hungary and its surrounding regions. The research area includes the islands of the Danube in the river section between Komárom and Paks, it spans 71 settlements. Two big islands: the Szentendre (55 km^2) and Csepel Island (242 km^2) are in the studied section of the Danube. In those islands there are also floodfree terrace surfaces (last glaciation) (Mari, L. 2002, Fiar S. 2004). Beside those large islands there are more than 50 smaller or formerly existing islands in the study area. The present studies focus on those islands, naturally in connection with the large islands and with the coastal areas along the river. The geomorphological study of the smaller and lower lying islands in large rivers offers a new, less applied aspect of fluvial dynamics. The advantage of the study of islands is that they react sensitively to environmental changes, while they are less affected by the geomorphological impact of areas lying beyond the river. The history of the islands intertwines with human history, while the period of the islands' evolution may be paralleled with human history. Traces of human inhabitation and land use from Neolithic times can be found on their surfaces despite the fact that they have been always limitedly suitable for inhabitation due to the floods. Yet they were repeatedly inhabited or used in the past, therefore historical data are readily available.

A change in the frequency and magnitude of floods is the main direct driving force that determines the response of river systems to climatic change (Macklin, M. G. et al 2012.) The river systems respond not only to climates and other natural factors (tectonism, volcanism etc.) but anthropogenic factors (deforestation, cultivation, pasture etc.) as well in complex ways (Starkel L. 1983, Kalicki T. 1991, Starkel L. et al. 1996, Gębica, P. 2013, Viczián, I. et al. 2013). It seems highly probable that important fluvial and geomorphological changes and related river floods have been formed as a result of long-term processes, on the other hand they are associated to transitional, short-term climatic phenomena of climate change. The Holocene climatic changes are reflected in the formation of fluvial terraces and geomorphological levels. In the German section of the Danube and its tributaries eight fluvial terraces were identified in the Holocene (Böhm, O. K.-F. Wetzel, K. F. 2010, Schielein, P. et al 2011). In the Hungarian section of the river and on the islands studied 3 horizons can be distinguished (Gábris et al. 2007, 2012): Holocene terrace, high

floodplain, low floodplain, in addition, a Pleistocene terrace (II.) on Csepel Island (Fiar S. 2004). The highest floods may inundate the entire surface of the islands except the two large ones.

The objective of the current study is to examine the relationship between man and the environment in different historic periods using data of archaeological sites, and to reconstruct Holocene environmental and climatic changes and the changes of the river's dynamics.

Materials and methods

Roughly 250 archaeological sites are known on the islands and most of the sites revealed artefacts from various historical periods. Data concerning the exact location and dating of archaeological sites were collected from the literature, manuscripts and archaeological databases. Age data were analysed in ArcGIS 10.1 and Microsoft Excel, the sites were shown on thematic maps and the islands were classified according to their geomorphological features.

In the study of the young Holocene variation of climate and fluvial environment, the following morphological-climatic model was applied (Horváth A. 2000, Gábris Gy. et al. 2007, 2012):

Whether an island or an area along the river is suitable for human inhabitation is primarily determined by floodsrisk of the site. The magnitude, length and frequency of high and low floods depend on the climate, the precipitation and geomorphological conditions related to fluvial dynamics.

During a humid climate the precipitation and the amount of water in the river are more uniform and balanced. The energy of the river is enhanced, the sediments deposited during the former dryer climatic periods are eroded, the river bed is cut into deeper levels. The river influences narrower areas, the floods reach their highest point lower and only rarely inundate the surrounding areas.

In the dryer climatic periods the load quantity in the water is higher, however, the amount of water and the energy of the river is less, therefore they fill up their bed, create islands, and the river splits into several channels. Because the base of the channel is higher, the river inundates the surrounding areas more easily, the river has a wider zone of influence. In the dryer periods the climate is more continental, the water level is more variable, the amplitude of the water level during spring and early summer floods is higher.

Geomorphological processes follow the variation of the climate; however, they are completed only with some delay, not immediately.

The frequency of the inundation is higher during the longer dry climatic periods and at the beginning of the more humid periods. During the more humid climatic periods the flood areas and the islands become more protected from floods due to river bed incision. The same is typical for the beginning of the following dry period.

Results

Due to the fact that the islands have relatively low-lying surfaces, they are exposed to flood events. Naturally the flooding affects the islands every year to some extent, however, devastating high floods – inundating mostly or completely the surface of the island – occur more rarely, but may have taken place in any period of the Holocene. The islands were limitedly

suitable for inhabitation, however depending on the geomorphological and climatic conditions the areas suitable for inhabitation may be determined, just as the favourable and unfavourable times for settlement. By analysis of the age data of archaeological finds, periods rich in finds and periods poor in or free from finds can be separated. Naturally, the presence of man may have several other historical reasons independently of flood risk or climate; however, the higher importance of the areas along the river and on the islands and the growing number of archaeological finds are observable in the periods of more favourable environmental conditions and low flood risk.

The earliest archaeological finds occur in the Middle Neolithic Period, which can be considered as archaeological confirmation of the first age when the area became free of floods for longer time. The Neolithic period or Early and Middle Copper Age correspond to the Atlantic phase of Holocene, which has been a humid period after the preceding Boreal phase. The effect of the humid climate made the areas surrounding the river more protected from floods, more suitable for use and inhabitation. The incision of the river, the formation of the Early Holocene terrace of the Danube may be dated to the Boreal/Atlantic boundary and the first third of the Atlantic phase. In the Middle Neolithic already an incised river bed can be supposed (Horváth A. 2000). The numerous Middle and Late Neolithic finds on the islands indicate favourable environmental conditions.

The Early Copper Age and even more so the Middle Copper Age – *i.e.* the end of the Atlantic Period and the first centuries of the Subboreal phase – signify dry climate period in the Carpathian basin. This period is characterized by fluvial deposition, intense riverbed and shore sedimentation and augmented flood activity. More favourable environmental conditions appear in the humid period of the Late Copper Age and the dry Early Bronze Age. This is supported by the large number of archaeological finds from this period.

The cooler, wet climate of the Subboreal phase was attended by floods and a rise in the Danube's water level during the Middle Bronze Age. The formation of the high flood plain commenced at the end of the Middle Bronze Age the downcutting of the riverbed continued throughout the first period of the Late Bronze Age. By the end of this period conditions were apt for settlement, which is confirmed by the large number of Late Bronze Age archaeological sites (Urnfield culture).

At the very end of the Subboreal Period – the end of the Late Bronze Age and the Early Iron Age – significant amounts of precipitation and strong cooling occurred, first bringing forth the rise of flood levels, later incision of the river (Bouzek, J. 1993, Dreslerová, D. 2001). At the end of the Celtic Late Iron Age (which took place at the very beginning of the Subatlantic Period) as well as in the first two centuries of the Roman Empire the increasing number of settlements signify lower and steady water levels with warmer climate (Bóka, G. 2012). This is demonstrated by the numerous Roman finds aligned along the Danube and on its islands.

The climate becoming more wet from the 3rd century onwards brought forth more frequent flooding, indicated by the abandoned governor's palace and the Roman finds covered by silty floodplain sediments on Óbuda Island.

Relatively many finds remain from the Migration Period, just like from the Middle Age. Starting from the Middle Age written sources provide more information about the island's history and the environmental conditions, in which the impacts of the Medieval Warm Period and Little Ice Age can be recognized. Finds from these ages occur on the islands of Danube, similarly to the surrounding areas (Kiss, A. – Laszlovszky, J. 2013).

Discussion

Climate is the principal driving force in hydrologic systems. The periodic changes of the Holocene climate (large precipitation, droughty seasons), geologic events (volcanism, tectonic effects), natural and human impacts intensively shaped the area's environment. The formation of the islands studied and the incision of the Danube's riverbed took place progressively. The process came to a halt several times during the various Holocene climate periods: during the longer dry periods the island was the scene of flood silting, thus alternating favourable and unfavourable periods for settling. Archaeological finds prove the current hydrographic situation, the relative permanence of the islands and shores.

The Late Neolithic, the Late Copper Age, the Late Bronze Age, the Iron Age, the Middle Age and the Modern Age are among the periods favourable for settlement, while the periods in between are characterized by unfavourable environmental conditions for settlement.

Throughout history, the islands have been limitedly suitable for settlement. This limitation can be understood in terms of the different historic and climatic periods, but depends also on topography and geomorphology. Elevation differences of even just a few meters or less than a meter in the islands' surfaces may cause some parts to be suitable, while others to be unsuitable.

References

Bóka G. 2012. Településtörténeti változások a Körös-vidéken a késő bronzkorban és a vaskorban, Vízrajz, térszínek és települések.(Changes in settlement patterns in the Late Bronze and Iron Ages in the Körös Region Hydrogeology, reliefs and settlements) – In: Kreiter A. – Pető Á. – Tugya B. (ed.) Környezet – Ember – Kultúra, A természettudományok és a régészet párbeszéde. (Environment – Human – Culture, Dialogue between applied sciences and archaeology) Hungarian National Museum Centre for National Cultural Heritage, Budapest, pp. 57-66.

Bouzek, J. 1993. Climatic changes: new archaeological evidence from the Bohemian Karst and other areas. – Antiquity 67. pp. 386-393.

Böhm, O. K.-F. Wetzel, K. F. 2010. Flood history of the Danube tributaries Lech and Isar in the Alpine foreland of Germany. Hydrological Sciences Journal, 51:5, pp. 784-798.

Brown, A. G. 1997: Alluvial geoarchaeology. Floodplain archaeology and environmental change. Cambridge Manuals in Archaeology. – Cambridge University Press. 377 p

Dreslerová, D. 2001. Dynamic changes in the central Bohemian Holocene alluvial landscape. In: Darvill, T.– Gojda, M. (ed.): One land, many landscapes. – BAR International Series 987. pp. 47-53.

Fiar S. 2004. A Csepel-sziget későpleisztocén-holocén fejlődéstörténete és természetföldrajzi szempontú tájértékelése (Late Pleistocene to Holocene evolution of Csepel Island and its landscape evaluation from a physical geographic aspect). – PhD thesis, manuscript, 118 p.

Gábris, Gy. – Horváth, E. – Novothny, Á. – Ruszkiczay-Rüdiger Zs. 2012. Fluvial and aeolian landscape evolution in Hungary - results of the last 20 years research, Geologie en Mijnbouw – Netherlands Journal of Geosciences 91: (1-2) pp. 111-128.

Gábris, Gy. – Nádor, A. 2007. Long-term fluvial archives in Hungary: response of the Danube and Tisza rivers to tectonic movements and climatic changes during the Quaternary: a review and new synthesis. — Quaternary Science Reviews 26, 2758–2782.

Gębica, P. 2013. Geomorphological records of human activity reflected in fluvial sediments in the Carpathians and their foreland. Landform Analysis 22. pp. 21–31.

Horváth A. 2000. Hazai újholocén klíma- és környezetváltozások vizsgálata régészeti adatok segítségével (Investigation of Middle and Late Holocene climatic and environmental changes in Hungary by means of archeological data). – Földrajzi Közlemények 48. pp. 149-158.

Kalicki T. 1991. The evolution of the Vistula river valley between Cracow and Niepołomice in Late Vistulian and Holocene times. In: Starkel, L. (ed.) Evolution of the Vistula river valley during the last 15 000 years, part IV, , Geographical Studies, Special Issue 6, IGiPZ PAN, pp. 11-37.

Kiss, A. – Laszlovszky, J. 2013. 14th-16th-Century Danube Floods and Long-Term Water-Level Changes in Archaeological and Sedimentary Evidence in The Western and Central Carpathian Basin: an Overview with Documentary Comparison. Journal of Environmental Geography 6:(3-4) pp. 1-11.

Macklin, M. G. – Lewin, J. – Woodward C. 2012. The fluvial record of climate change. Phil. Trans. R. Soc. 370, pp. 2143-2172.

Mari, L 2002. A Szentendrei-sziget kialakulása és felszínének változása a holocénben (The formation of the Szentendre Island and changes in its surface during the Holocene). Földtani Közlöny 132. pp. 185-192.

Schielein, P. – Schellmann, G. – Lomax, J. 2011. Stratigraphy of Late Quaternary fluvial terraces at the confluence of the Lech and Danube valleys. E&G – Quaternary Science Journal 60/4, pp. 414–424.

Starkel L. Kalicki T., Krąpiec M., Soja R., Gębica P., Czyżowska E., 1996. Hydrological changes of valley floor in the upper Vistula basin during Late Vistulian and Holocene. In: L. Starkel (ed). Evolution of the Vistula river valley during the last 15 000 years, VI/9, Geographical Studies, IGiPZ PAN, 1-158.

Starkel L., 1983. The reflection of hydrologic changes in the fluvial environment of the temperate zone during the last 15000 years. In: Background to Palaeohydrology, ed. K.J. Gregory, J. Wiley, Chichester, 213-234.

Viczián, I. – Nagy, B. – Deák M. – Szeberényi J. – Rupnik L. 2013. Environmental reconstruction of the area of Roman Brigetio (Komárom, Hungary) Studia Geomorphologica Carpatho-Balcanica 47(1) pp. 95-105.