Climate change and human activity recorded in the river valleys of Central Europe

River History

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You can't step into the same river twice, as they say. But it's also not easy to stand on the same riverbank twice, as rivers are constantly altering their own beds. Which, in the long run, has had a greater impact: nature or mankind?

Research on the impact of the climate and human activity on river courses and valley shapes has long been underway at many centers. Various approaches and highly diverse methods have been used, yielding on the one hand very interesting and multifaceted findings but on the other making paleogeographic data highly non-uniform. That problem also applies to Central Europe, where the quantity of research material and the number of methods used in individual countries are both very large. That is why it is still hard to conclude which factor - climate or human activity - has been dominant in the process of floodplain formation.

The Vistula River floodplain between Kraków and where it meets its Raba tributary is one of the most thoroughly studied river valley sections not just in Poland but also in Europe, perhaps even in the world. Several thousand drillings and diverse laboratory tests make it possible to identify its geological structure in detail, with the age of individual layers pinpointed by several hundred radiocarbon, dendrochronological (tree rings), and palynological (plant pollen) datings. The very large amount of data has enabled studies to shift from a qualitative to a quantitative approach and for them to be confronted with the findings of other, especially geophysical research.

The Vistula turns out to have undergone many distinct phases of heightened activity: the Younger Dryas, 9800-9600, 8800-8000, 6700-6000, 5500-5000, 4500-4000, 3500-3000, 2700-2600, 2350-1800 years ago, the 5th-6th, 10th-11th, and 13th-14th centuries, and

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Lowland rivers exhibit a natural tendency to meander and change their channels. Since the beginning of history, mankind has tried to counteract this

the 16th to mid-19th century. Studies of tributary valleys in the upland and subalpine areas near Kraków as well as the more distant Carpathian valleys have managed to link many of these changes to the timing of Beskid landslides, debris flows in the Tatra Mountains, and other geological phenomena. The human impact on the evolution of large valley systems made its mark only starting in the Middle Ages. River deposits (alluvium) began to accumulate faster and start to evidence mineral material originating from outside the river channel, attesting to the onset of agricultural activity and human modification of river channels.

Black oaks

From the mid-2nd to the latter half of the 4th century, the Kraków region underwent intensive economic development (the Przeworsk culture). In the region of Zofipole and Igołomia several dozen pottery kilns have been discovered. Such development gave rise to great demand for wood, and supplying it hampered the regeneration of the oak forests in the river's floodplain. The subsequent waning of human settlement along the Vistula, coinciding with a hiatus in the cut-down of trees, was probably the main reason for the strong oak germination dated to the late 4th and early 5th century. Similar phases of regeneration known from other Central European valleys may also be the result of a cessation of human exploitation.

This led to the discovery of an interesting fact about the widespread technique of dating river alluvia using buried subfossil tree trunks called "black oaks." Detailed geomorphological and dendrochronological analysis has shown that due to the Vistula's natural meandering only a few such fossil trunks can be used to identify the age of the deposits they rest in. A vast majority of them are in fact older than their surrounding deposits, frequently by several thousand years. When the river shifted its channel, it swept up old deposits and redeposited the trunks in new ones. On the other hand, these black oaks do serve as good indicators of climate changes because their age documents periods of heightened flooding, when bank erosion felled trees growing on the floodplain.

This thorough methodology developed near Kraków has since been utilized in research on lowland river system evolution in Belarus. For nearly 20 years, extensive material was collected from the catchment areas of the Nemen, Dvina, and Dneper Rivers, selected because Neolithic colonization of Central Europe had proceeded unevenly. In Germany, the Czech Republic, and Poland, it is hard and controversial to distinguish between the impact of mankind and climate over the past several thousand years. In Belarus, however, predominantly hunter-gatherer cultures survived nearly until the early Middle Ages. Information obtained there was compared to data on various types of rivers in Germany, Austria, and the Czech Republic, including rivers flowing at the foot of young mountains (both with and without glaciers), old-mountain rivers, and lowland rivers flowing across post-glacial landscapes of various ages.

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Cross-section of an old meander of the Tsna River in Belarus. Dark peat deposits appeared around 9575 years ago, when the meander was cut off from the river and changed into a swamp. Lighter sandy-silt deposits only began to fill in the old swamp starting 1510 years ago

Climate after all

Analysis of all the data so collected indicates that periods of heightened river channel changes coincided - for a given latitude - for all the subalpine, upland, and lowland rivers studied, despite their environmental differences. This happened despite the fact that Neolithic cultures colonized the areas studied at quite different time intervals, signaling that these phases had primarily climate-related causes. Interestingly, the climate factor has also remained dominant over the past several thousand years, when many of these areas were already permanently deforested and in agricultural use. Despite numerous indirect and later direct human interventions, European rivers have therefore preserved their natural rhythm of change stemming from long-term average temperature fluctuations, overall precipitation, and the occurrence of a clustering of extreme weather events.

Stages of heightened river activity have had a decisive impact on shaping the valleys of regions situated some distance away from the Pleistocene ice sheet. Closer to it, especially in its immediate vicinity, they had a much weaker impact, because there river valley evolution was guided by other factors, especially at the beginning. But since more or less 9,000 years ago, changes in river activity related to climate changes began to play an increasingly important role also in valleys situated in areas affected by the last glaciation. ■

Further reading:

Kalicki T. (2006). Zapis zmian klimatu oraz działalności człowieka i ich rola w holoceńskiej ewolucji dolin środkowoeuropejskich [Record of Climate Changes and Human Activity and Their Role in the Holocene Evolution of Central European Rivers]. *Prace Geograficzne IGiPZ PAN, 204.*

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