Changing Rivers during the Roman Period: Climate and Human Action

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Have river features and their functioning been constant or changing throughout the past 2500 years or more in Europe? Does the present landscape provide a sound basis to describe the Roman river landscape and thus its capacity to support specific types of usage? These are important questions that require us to study the basic elements of river functioning in temperate regions and the causes and geography of change. The questions are all the more relevant because land occupation has deeply changed over centuries and climate change is a reality.

River Patterns and Responses to Catchment Changes

Natural rivers are physical 'organisms' transporting water, solutes and sediment from uplands to oceans. They are dynamic 'organisms' because their patterns and forms depend on the balance of water and mostly coarse sediments (gravel and sand) at the watershed scale. Meandering rivers develop when sediments are scarce and easily transportable by water, giving rivers a surplus of energy. Their sinuous design is a type of adjustment minimizing the expanse of energy through river course lengthening and slope reduction, bed incisions, and local landform adjustments, creating one unique and deep channel, alongside pools and riffles. When erosion on slopes produces too much sediment for the river flow to evacuate downstream, however, the excess is deposited inside the river channel itself. This pattern is called braiding because the water flow is divided into multiple channels across gravel and sand bars. Upstream deposition causes steep river slopes that better allow conveying sediment downstream. Steep braided rivers, able to transport gravel, display more energy than meandering rivers. A threshold of unit stream power[1] comprised between 35 and 50 $W.m^{-2}$ is the lower limit for braiding patterns; while lower energy values shape meanders.

Contrasting Conditions for Navigation in Rivers and Floodplains

Navigation was usually easier on sinuous or meandering rivers thanks to their low slope and cross profile character with deep channels. In contrast, braided rivers with an equivalent discharge have shallow and unstable channels hampering navigation. Water depths on riffles of braided channels in the 19th century, for instance, did not exceed 50–60 cm at low flow, compared to several meters in a meandering reach. Historically, this major difference was accommodated by adopting transportation techniques: flat

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boats and rafts in braided reaches instead of higher vessel draughts in meandering reaches.

Archaeology is affected also by the conditions of agriculture and settlement in the floodplains adjacent to different types of rivers. Braided patterns are prone to fast flowing floods, bank erosion, easy flooding over the alluvial plain, and sediment deposition onto the floodplain. Soils are sandy and poor close to the banks but marshes may extend in lateral depressions inducing conditions favourable to wet meadows, swamps and cattle raising. In contrast, thanks to less frequent flooding and finer sediments deposited over floodplains, agriculture enjoyed better conditions in plains adjacent to meandering rivers, with brownish soils (due to organic matter) and cereals, and better conditions for human settlement.

Basic Principles of Fluvial Metamorphosis in Europe

During the Holocene, some of the natural 'untrained' rivers of Europe adjusted their morphology to changing conditions at the watershed scale. The increase of sediment delivery from slopes to rivers whose flow was unable to evacuate the load (even if flood discharge increased), transformed meandering rivers into braided ones at the time scale of decades (or more). This change could last several centuries. River change could originate from climate change and erosive uses of the land, usually through deforestation. On the contrary, shortage of sediment supply to a braided pattern caused the reverse process. This type of change involving river patterns has been called fluvial or river metamorphosis.[2]

In watersheds and river reaches having experienced metamorphosis in Europe, the general scheme was the following sequence of pattern change: Meandering from ca. 400 BC to ca. AD 1350, a long period including some limited changes during the 1st c. AD and the 6th–8th c. AD. There were, however, very different degrees of intensity. This sequence of change, for instance, has been very pronounced along the Rhône from the Alps to the Camargue delta. Clearly the Rhône and its major tributaries, including mountain reaches, were meandering during the long sequence no. 2.

Geography of Fluvial Metamorphosis in Western Europe

To understand which reaches of Europe experienced changes in river patterns over time, we need to consider places where climate and basin-scale changes may have caused unit stream power to shift below or over 35–50 $W.m^{-2}$. Historical geography and palaeo-environmental studies have identified and documented river reaches that were meandering in the past as well as river reaches that have braided later during the Little Ice Age. In practice, metamorphosed rivers are ascertained in watersheds controlled by mountains having delivered large amounts of bed load during the LIA. Those river reaches may be found in large mountain rivers and on their piedmonts. This was the case in the French Alps (Rhône, Arve, Isere) and on the piedmont of the Vosges (upper Mosel); possible also in the valleys of the Loire and Allier (Massif Central), in the foreland of the Italian Alps, on the Rhine downstream of Basel, and maybe in the upper Rhine and Rhône rivers in Switzerland. Other foreland rivers may have experienced partial or complete metamorphoses. Changes monitored since the Late LIA are mostly related to impacted watersheds, making it is difficult to compare post-LIA conditions to conditions prior to the LIA. Rather than infer past conditions from unstable present ones, therefore, we can demonstrate more reliably which braided rivers of the LIA were in fact meandering previously. We argue that this is one of the tasks that archaeologists and specialists of past rivers have to face.

Notes

[1] Unit Stream Power (expressed in $W.m^{-2}$) takes the form $\omega = \rho.g.Q_{pb.}S/W$. In this equation ρ is a constant, g is the acceleration of gravity, Q_{pb} is the bankfull discharge in m^3/s (discharge occurring for the 1,5 or 2 years flood), and s is the slope of the energy line (m/m).

[2] Schumm 1977.

References

Schumm 1977

S. A. Schumm, The Fluvial System (Chichester 1977).