LATE GLACIAL AND HOLOCENE FLUVIAL RESPONSE TO CLIMATE- AND HUMAN-INDUCED VEGETATION CHANGES IN THE NORTHERN UPPER RHINE GRABEN, GERMANY


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Observations (central figure):
1. continuous incision between 18 and 3 kyr BP (see outline central figure)
2. a transitional (braided/meandering) Lateglacial terrace level with no clearly developed younger Dyas terrace level
3. locally two meandering channels, inherited from the preceding transitional system, coexisted during the Early Holocene

Interpretation of development:
1. Initial major climatic warming (~18 cal kyr BP) transforming the transport-limited Pleistocene River Rhine, that used the Graben as sediment sink, to a river that used the Graben as a sediment source, provoking incision.
2. Initial climate warming (~18 cal kyr BP) started the transition from braided to meandering fluvial style. Large amounts of alpine melt water and the persistent vegetation cover (Dambeck & Bos, 2002) may have facilitated the transitional phase during the Lateglacial.
3. Persistence of a multi-channel system long into the early Holocene, implies that the complete transition from braided (Pleistocene) to single meandering system (Boreal) was slow. In the nURG, Lateglacial to early Holocene progressive terrace formation reflects slow response to climate amelioration in the Lateglacial.

MIDDLE HOLOCENE FLUVIAL DEVELOPMENT

Observations:
1. Middle Holocene (6000 - 3000 cal yr BP) overbank deposits are clayey and organic (Fig. 3).
2. In parts of the study area, the single Rhine channel belt straightened and formed several relative small secondary channels (central figure).

Interpretation of development:
1. The middle Holocene channel style change is a local phenomenon that we attribute to mobile or-less random meander cut-off events. Incision of the newly formed straight channel is explained by subtle gradient advantages in this very low gradient reach (4 cm/km). No external forcing (e.g. intra-Holocene climate change) is needed to explain this development.
2. The fine-grained overbank facies (black clay loam) developed in densely forested floodplains (hampering water flow). It reflects suspended load characteristics and prevailing climatic conditions (Dambeck & Bos, 2002).

Introduction to climate change

Adaptation to climate change

No external forcing

Adaptation to human impact

18 ka Lateglacial 10 ka Holocene 0 ka

Figure 2 Schematic overview of shifting dominance of both internal and external controls on the fluvial development in the nURG.

LATE HOLOCENE FLUVIAL DEVELOPMENT

Observations:
1) Late Holocene meanders occur at similar levels as middle Holocene meanders, breaking the incision trend (Fig. 4)
2) Overbank lithofacies are more siltier than before (Fig. 3).

Interpretation of development:
1) Two possible explanations: a longitudinal equilibrium profile was established or an increased sediment delivery.
2) The coarsening of overbank deposits (silt loam) reflects a break in trend and cannot be explained by autogenic processes alone. In addition, suspended sediment delivery considerably (200-300%) increased illustrated by overbank sediment budgets (Fig. 5, 6). Note that sediment trapping was less effective in the Late Holocene than in the Middle Holocene (Fig. 6: crossing of area and volume curve) which further strengthens the inferred increase of sediment delivery.

Floodplain sedimentation increase exceeds magnitudes expected from intra-Holocene climatic fluctuations. Large-scale deforestation took place in the Bronze Age, Iron Age and Roman times in the hinterland (e.g. Dambeck & Bos, 2002) and are the primary source to attribute increased (silty) loads to (e.g. Hoffmann et al., 2007).

References: