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

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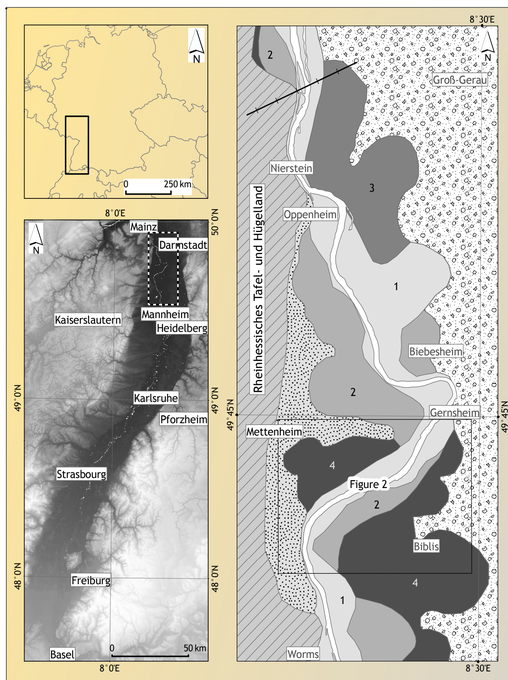


Figure 1 Research area and age of palaeo-meanders (modified from Dambeck & Bos, 2002)

The spine of this poster is a cartoon of fluvial development in the northern Upper Rhine Graben (SW Germany, Fig. 1)

INTRODUCTION

The northern Upper Rhine Graben (nURG) hosts a well preserved Late Glacial and Holocene fluvial terrace sequence (Fig. 1). Apart from elevation steps, differences in fluvial style of terrace deposits and overbank sediment characteristics have been mapped. Newly obtained borehole data and dating results completed reconstruction of nURG valley evolution from the Late Glacial onwards. This study aims to separate response to known allogenic forcings (climate change, human impact) from autogenic behaviour (Fig.2).

LATE WEICHSELIAN & EARLY HOLOCENE FLUVIAL DEVELOPMENT

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 Dryas 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 Pleniglacial 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 kyr cal 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 (Pleniglacial) to a 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.

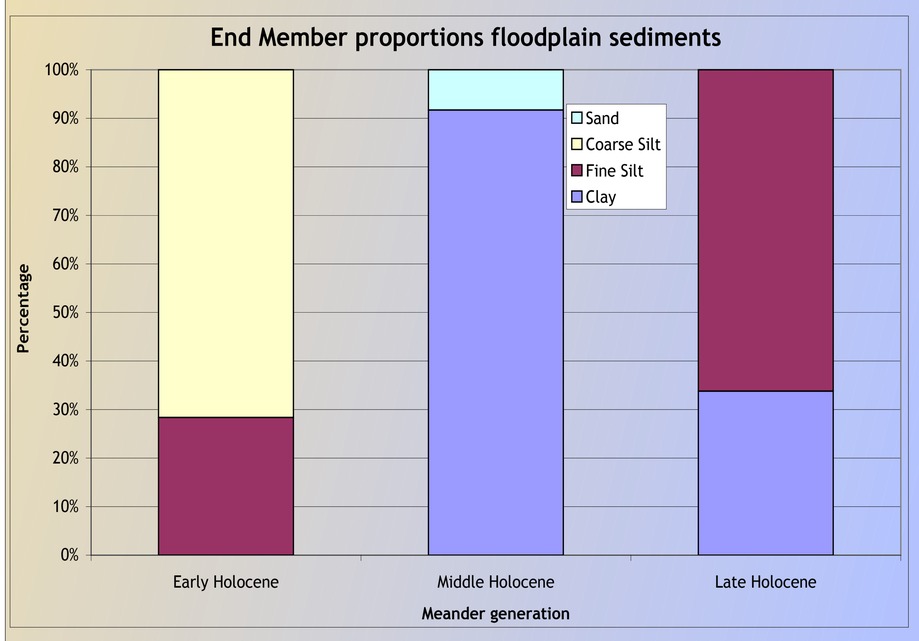


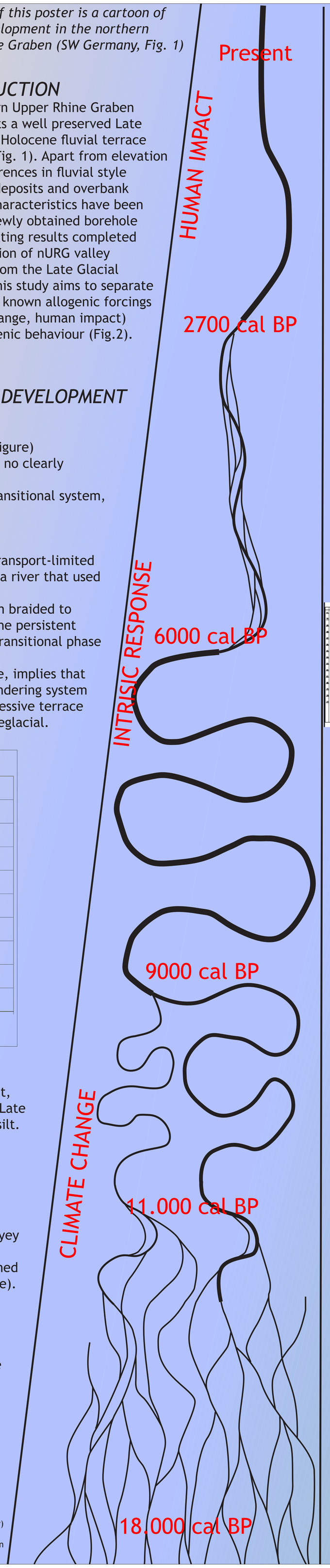
Figure 3
Overbank grain size characteristics
Early Holocene overbank deposits predominantly consist of coarse silt, Middle Holocene overbank deposits contain much more clay and the Late Holocene overbank deposits are characterised by abundance of fine silt.

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 more-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).

References:
- Dambeck, R. and Bos, H.J.A. (2002). Fluvial history of the northern Upper Rhine River (Southwest Germany) during the Lateglacial and Holocene times. Quaternary International 93-94, 53-63.
- Hoffmann, Th., Erkens, G., Cohen, K.M., Houben, P., Seidel, J. & Dikau, R. (2007) Holocene floodplain sediment storage and hillslope erosion within the Rhine catchment. The Holocene 17 (1), 105 - 118



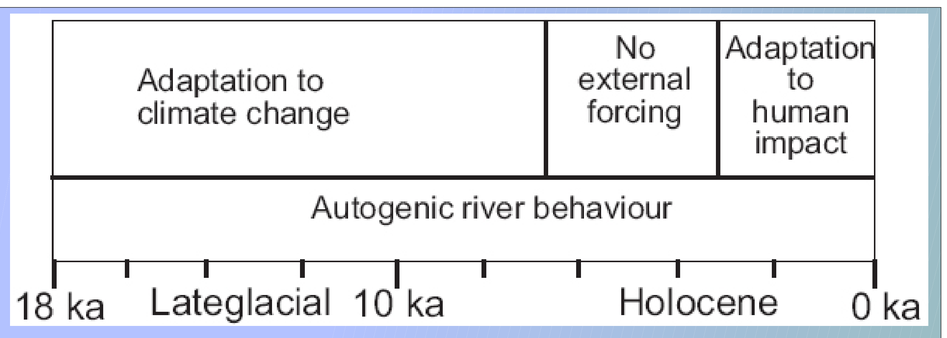


Figure 2 Schematic overview of shifting dominance of both internal and external controls on the fluvial development in the nURG.

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 silty 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).

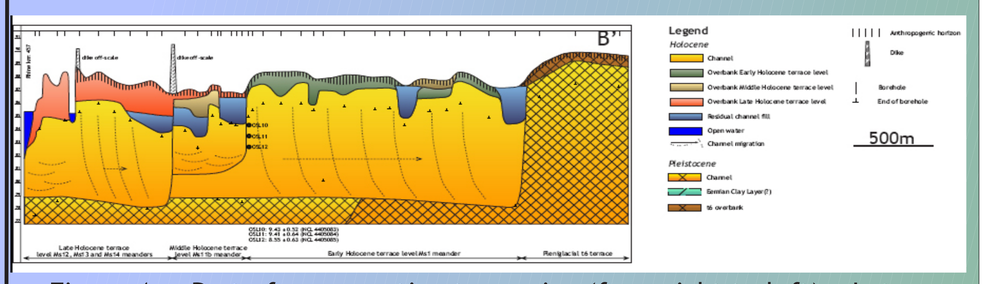


Figure 4 Part of cross-section traversing (from right to left) a Late-glacial, early, middle and late Holocene terrace level. Note that incision from the middle to the late Holocene terrace level is almost absent.

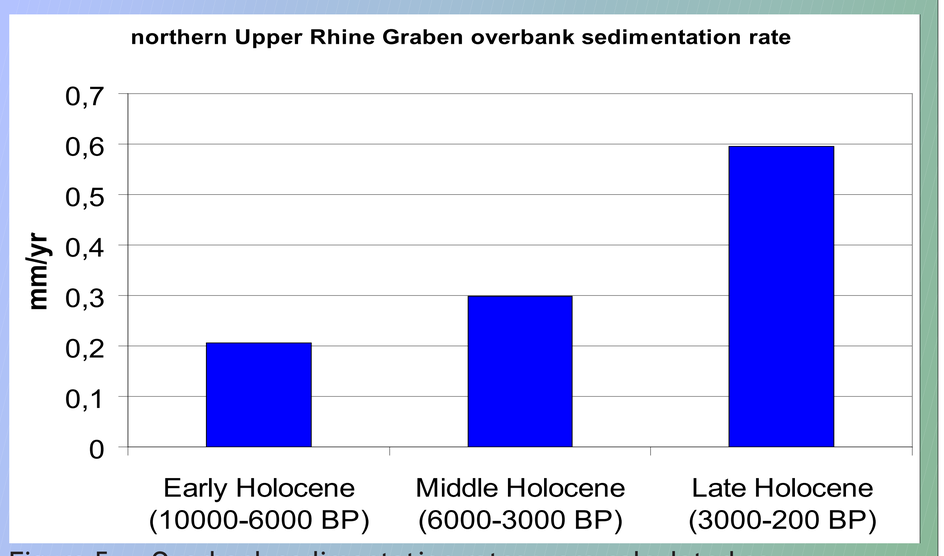


Figure 5 Overbank sedimentation rates were calculated as [RECONSTRUCTED AREA * THICKNESS) / DEPOSITION TIME], for three time slices (based on overbank characteristics, Fig. 3). AREA as mapped in Fig. 1; THICKNESS calculated from cross-sections. Rates significantly increase during the Holocene, with a doubling in the Late Holocene.

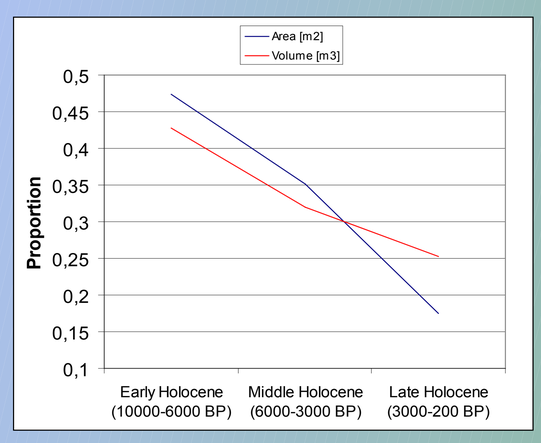


Figure 6 Proportion of floodplain area vs. deposited volume for 3 time slices. Due to the decreasing floodplain size, the total volume of deposited overbank sediments (thickness * area) also decreases, proportional to floodplain size until the middle Holocene, but much less during the Late Holocene.

CONCLUSIONS

- The Late Glacial to Middle Holocene fluvial development marks one prolonged phase of slow complex response, initiated by climatic amelioration from ~18 ka BP onwards (Fig. 2). Channel style change was relative fast, reduction of number of channels was slower and establishment of climax floodplain environment (widespread deposition of finest grained sediment) was slowest.
- As a break in depositional trend, the Late Holocene units reflect human impact in the hinterland caused increased, siltier, overbank deposition and ceased incision (Fig. 2). Fluvial response to human influence is less complex and near-instantaneous because it affected suspended load composition predominantly – whereas Lateglacial climate change also affected discharge regime and bed-load transport capacity.