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Fluvial terrace formation in the northern Upper Rhine Graben during the last 20,000 years as a result of allogenic controls and autogenic evolution

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Even though the northern Upper Rhine Graben is a subsiding basin, an extensive terrace sequence was formed during the Late Weichselian and Holocene. The well preserved terrace levels differ from each other in elevation, morphology, overbank sediment characteristics and soil formation. We determined the relative importance of allogenic controlling factors versus autogenic evolution on the successive formation of these terraces. For a representative valley segment, results from previous research were integrated with newly obtained borehole data and dating results to construct palaeogeographic maps and cross-sections.

Climatic warming after the Last Glacial Maximum (∼20 cal kyr BP) triggered the onset of incision and the transition towards a meandering system. Remnants of a Younger Dryas terrace level were found, indicating that the River Rhine was in a transition phase from braided to meandering, but not longer fully braided by then. At the onset of the Holocene, the system became fully meandering. Locally two meandering streams, inherited from the multi-channel transitional system, were active until the middle Boreal (∼9 cal kyr BP). This indicates that climate change was the most important factor controlling fluvial development during the Late Weichselian, although response was complex and slow.

Terrace formation continued during the Holocene, forming three successive terrace levels. We suggest that early to middle Holocene (∼6 cal kyr BP) changes in fluvial style and associated overbank lithofacies are not necessarily controlled by climatic

change. Instead, they may be the result of autogenic evolution of the system combined with river reach-specific characteristics. Because intra-Holocene climate changes are small, autogenic fluvial evolution became dominant. At the beginning of the Subatlantic, incision of the river system ceased and overbank sediments became coarser, probably as a result of human impact in the hinterland.

Overall, the terrace sequence is explained by a complex interplay of both allogenic and autogenic controlling factors and site-specific characteristics such as preservation potential and tectonic background situation. Because the terrace levels form an event-like sequence, they are easily misinterpreted to be a result of specific events or changes. However, we argue that terrace level formation in this area is a continuous process because the three important factors (incision potential, preservation potential and time) are continuously present during terrace formation. The fact that terrace levels differ in characteristics should, therefore, not automatically be seen as indicators of changes in external controls. This interpretation differs from earlier work, which interpret Holocene terraces along the Rhine trunk valley (including the northern Upper Rhine Graben) to be a direct result of repeated changes in climate and human impact later in the Holocene. Consequently, attributing terrace levels over larger distances to a single allogenic factor must be done with care.