Rhine-Meuse delta studies

Universiteit Utrecht

How extreme floods can trigger river avulsion beyond delta plain limits

Harm Jan Pierik[a*], Tim Schuring[a], Esther Jansma[b], Esther Stouthamer[a], Willem Toonen[c], Wim Hoek[a], Kim Cohen[a, d]

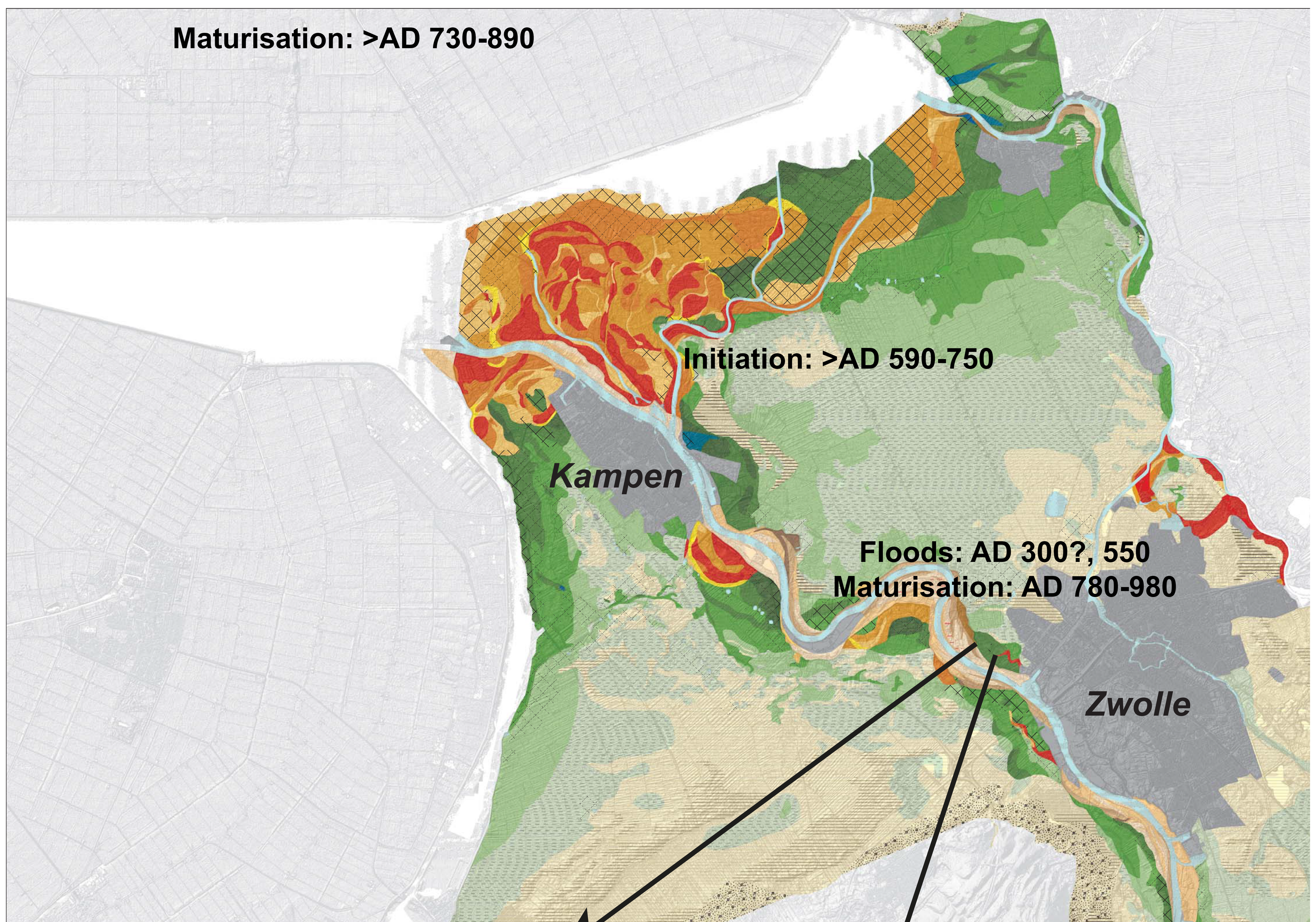
[a]Utrecht University, Department of Physical Geography, P.O. Box 80.115, 3508 TC, Utrecht, the Netherlands
[b]Cultural Heritage Agency, Ministry of Education, Culture and Science, P.O. Box 1600 3800 BP, Amersfoort, the Netherlands
[c]KU Leuven, Egyptology Unit, P.O. box 3313 3000, Leuven, Belgium
[d]Deltares, Dept. Applied Geology and Geophysics, PO box 85.467, 3508 AL, Utrecht, the Netherlands
*corresponding author: h.j.pierik@uu.nl

ABSTRACT

In lowland fluvial environments such as delta plains, rivers can create new branches through avulsion. This causes reorganizing of discharge diversion over the delta, in cases breaching former limits of floodplains to annexate new areas. Avulsions show a phased development, beginning with crevasse splay formation during floods, eventually maturing into a new single meandering river channel. This overall process can take several centuries and is affected by the flooding regime of the river. Periods of intensified flooding are thought to initiate avulsions, push ephemeral overflow routes to become permanent, and cause crevasse complexes to evolve into single channels. This means that studies of the pacing of geomorphological change can benefit from palaeohydrological studies focusing on the timing of larger flooding events.

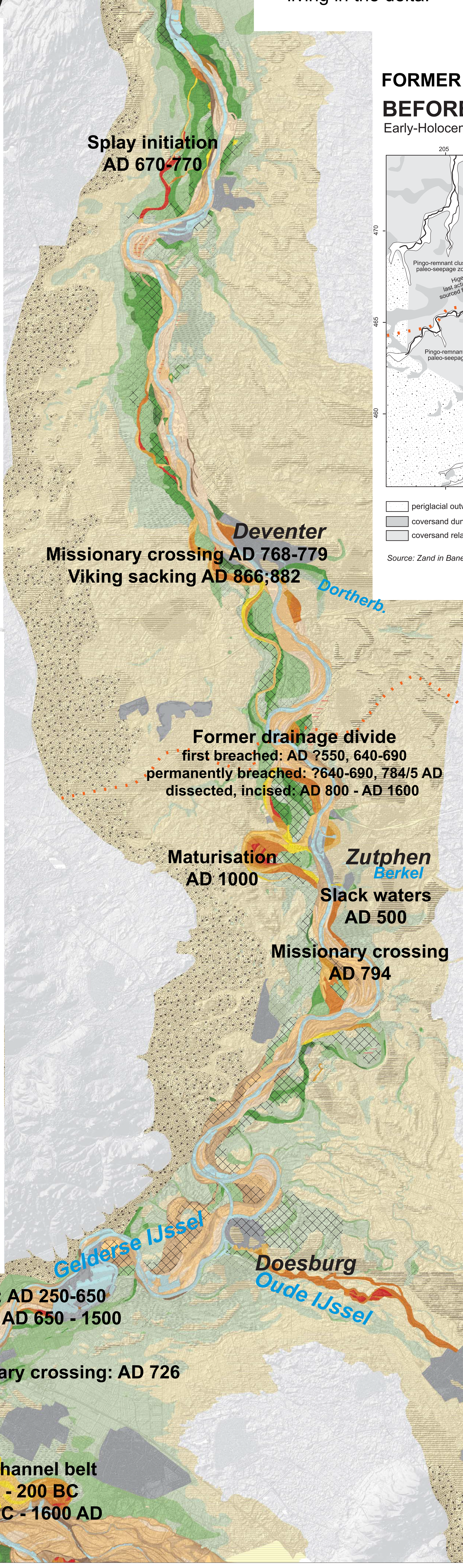
Here we show the role of major flood events in fluvial morphology for the Gelderse IJssel case in the eastern Netherlands. This 100 km long river resulted from a major avulsion in the Rhine delta that occurred in the first millennium AD. It annexed a peat filled brook valley and debouched into the Central Netherlands lagoon. This downstream valley hosts a unique geological dataset to track the phasing of avulsion, while the upstream delta has a complete record of major flood events. These flood events have been independently identified in sedimentary and dendrological palaeohydrological records.

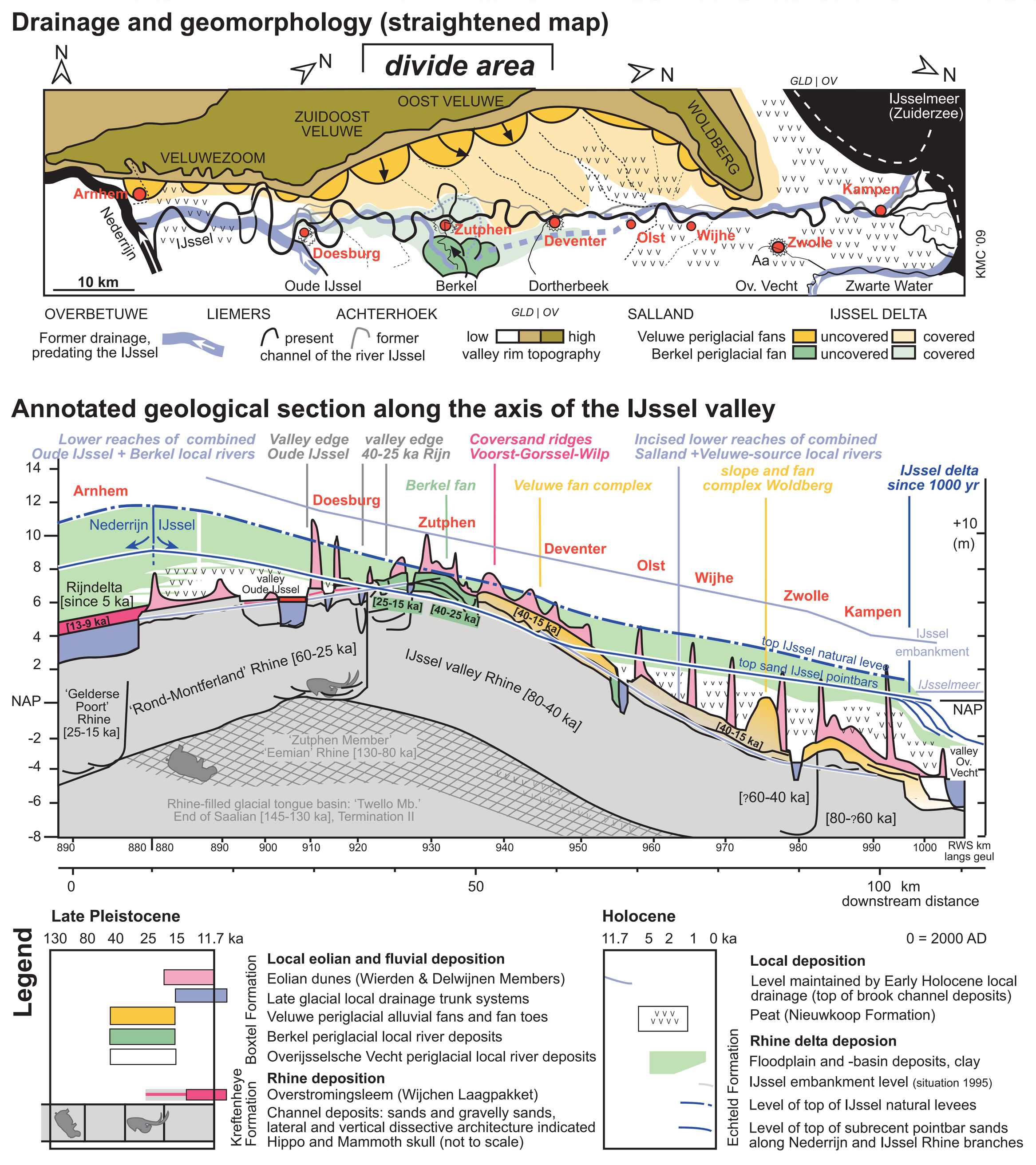
Triggering of the avulsion occurred while increased fine-sediment loads doubled due to deforested hinterland and when flooding intensified from the 6th to the 8th century AD. From the 7th century onwards a crevasse complex had permanently breached the rim of the former floodplain. A final extreme flood (c. AD 784/5) appears to have triggered maturation into a single meandering channel, that by 1000 AD was fully developed. These dates are in agreement with geological data upstream and with abundant archeological and historical evidence along the river, such as the rise of the cities of Deventer and Zutphen. This case highlights the importance of extreme flood events for fluvial morphology, delta-network evolution and the impact on people living in the delta.



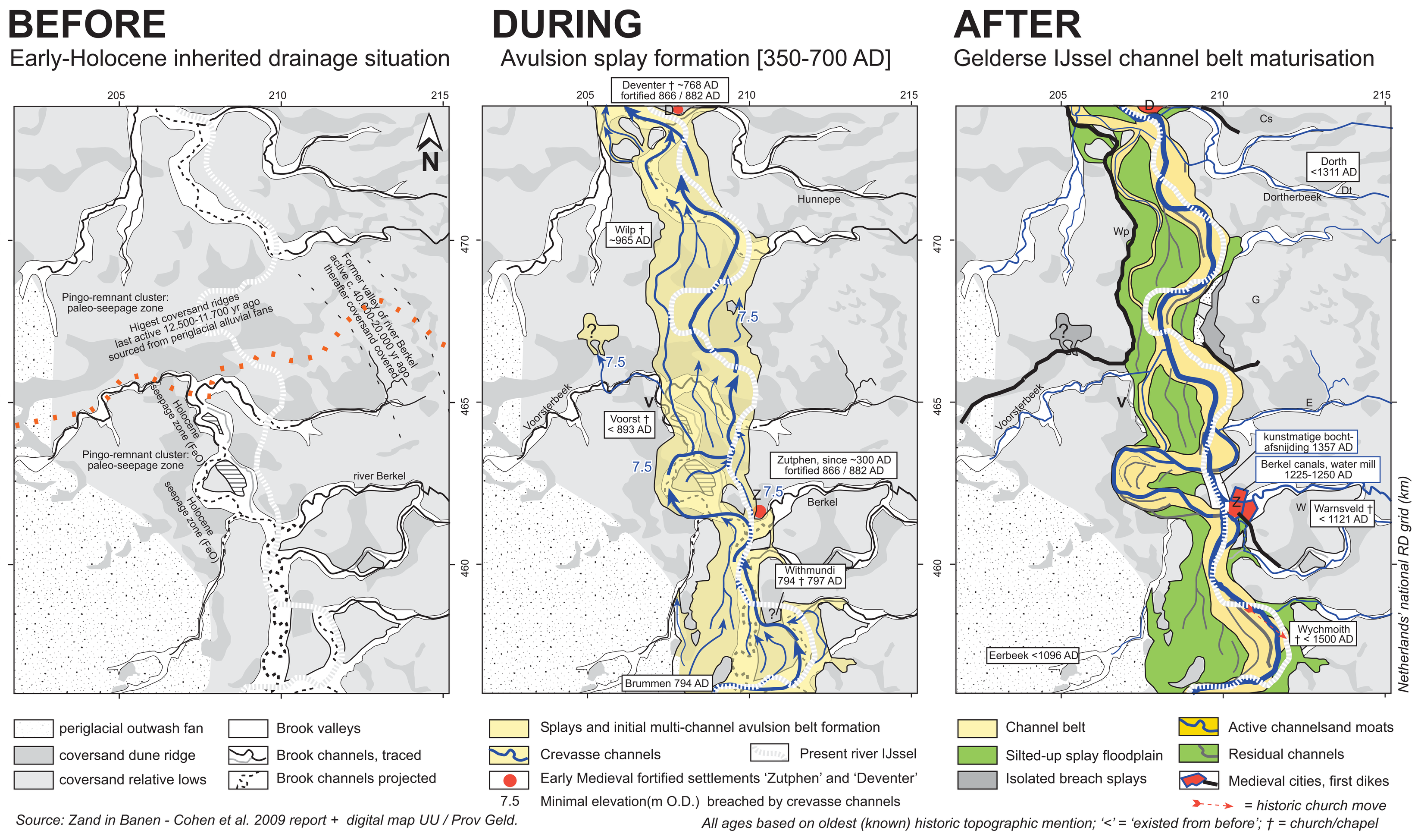
Trees rings indicate stress: AD 300, AD 550

IJssel clays on peat sampling: AD 780-980

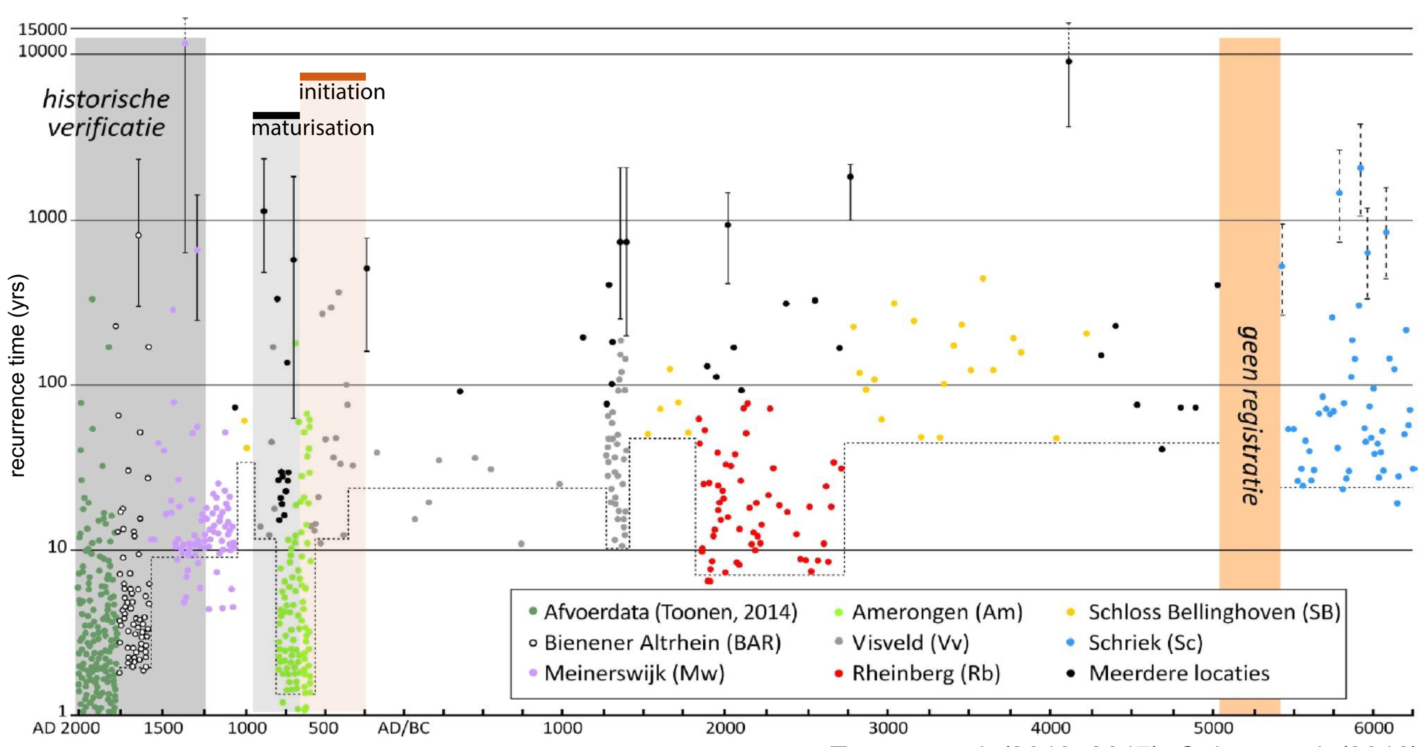




FORMER DRAINAGE DIVIDE:

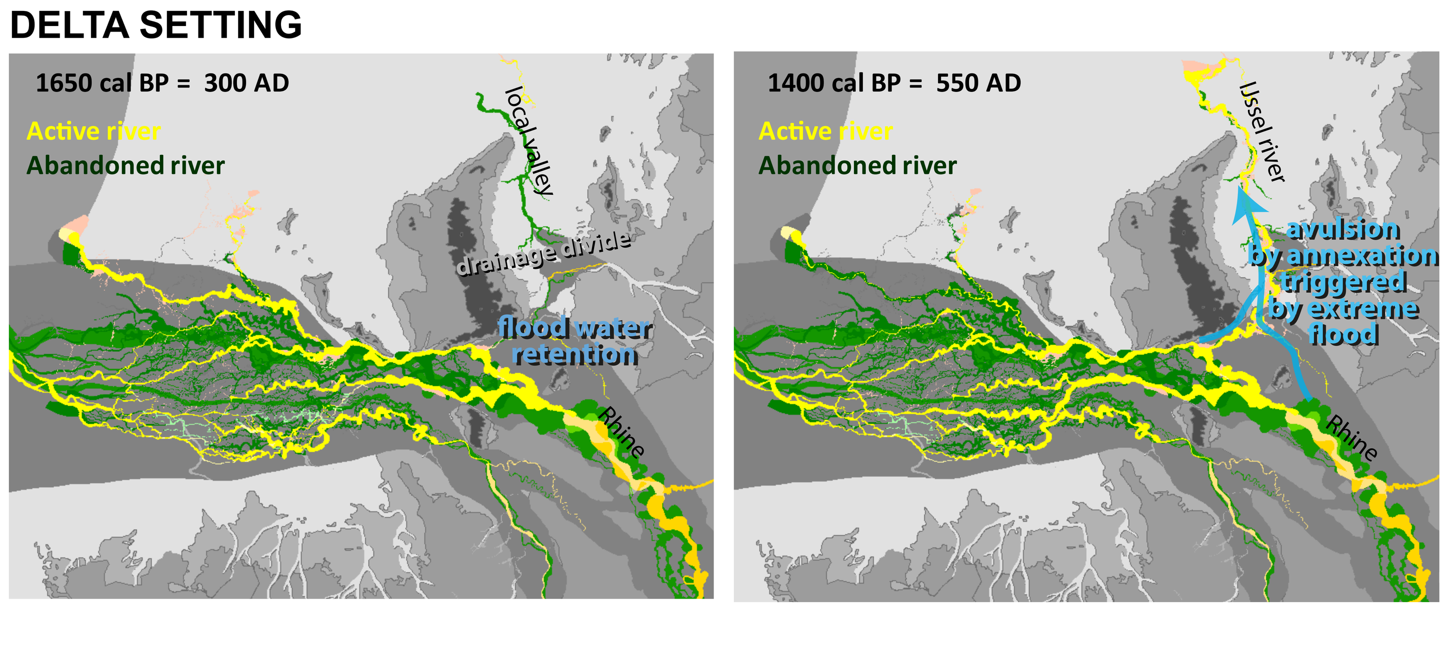


PALAEOFLOOD HISTORY AND INTENSITY



Toonen et al. (2013, 2017); Cohen et al. (2016)

DELTA SETTING



CONCLUSION

- IJssel river is a Rhine branch that annexated a former local brook valley after tipping over a local drainage divide.
- **Initiation phase AD ca. 350-700**, flood water retention upstream, occasional overtipping of the drainage divide, crevasse formation and floods downstream. Driven by delta apex aggradation, helped by floods.
- **Mature single channel development and permanent drainage** ca. AD 700-1000, most likely triggered by large floods.