Middle-Holocene palaeoflood extremes of the Lower Rhine

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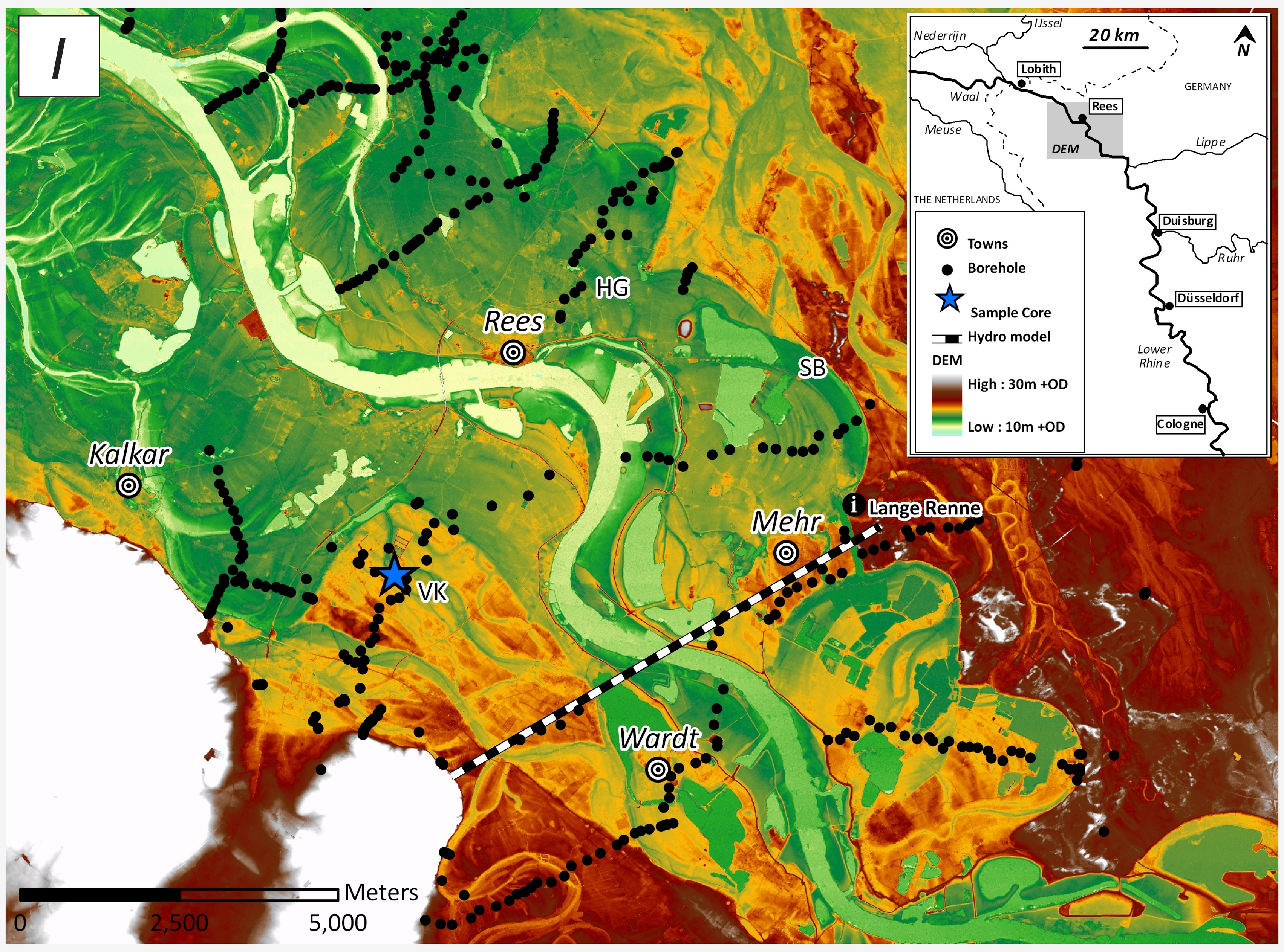
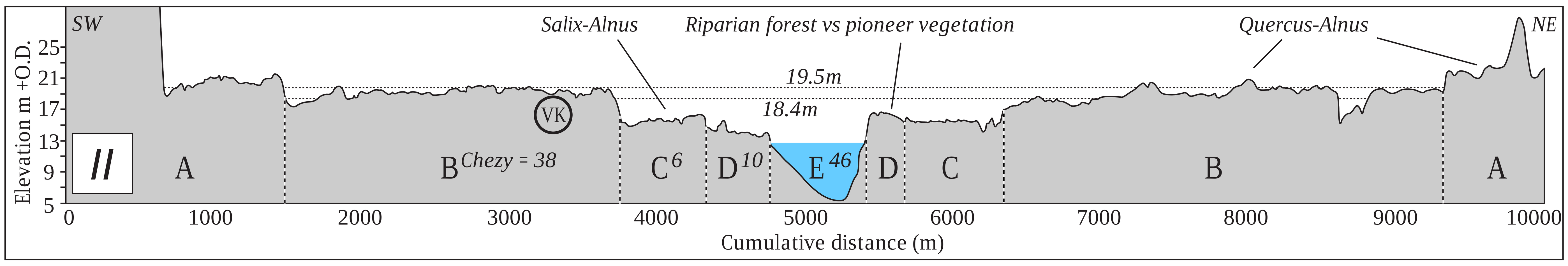
INTRODUCTION

Assesment of design discharges for dikes requires knowledge on the frequency and magnitude of extreme flooding events. Current estimates for the magnitude of the design flood are based on the extrapolation of ~100 year of instrumental data, which lacks the registration of rarely occurring extreme events. The reconstruction of palaeoflood magnitudes and frequencies from sedimentary records provides insight in the potential maximum size of Rhine floods. This helps to improve the estimation of the magnitude of the design discharge with a reduced uncertainty.

The magnitude of a Middle-Holocene flood was reconstructed along a transect (*II*) in the Lower Rhine valley (Germany) based on the highest slackwater deposits found in a palaeochannel fill located on an elevated terrace level, which flanks the Middle Holocene floodplain (*I*).



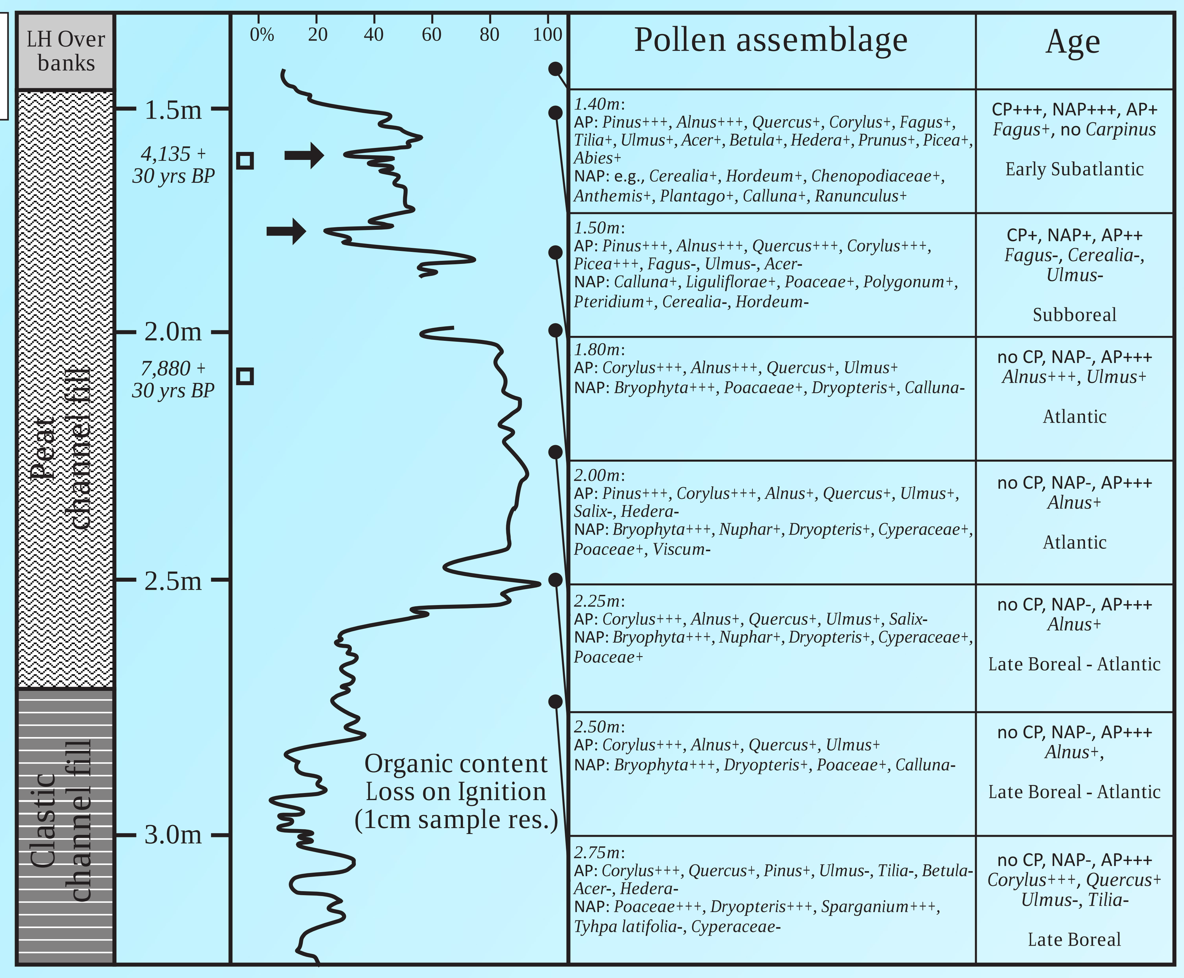


I) Digital elevation model of the research area with the location of the model transect, boreholes, the Vossekuhl sample core (VK), and the Middle Holocene palaeochannels 'Schloss Bellinghoven' (SB) and 'Haus Groin'.

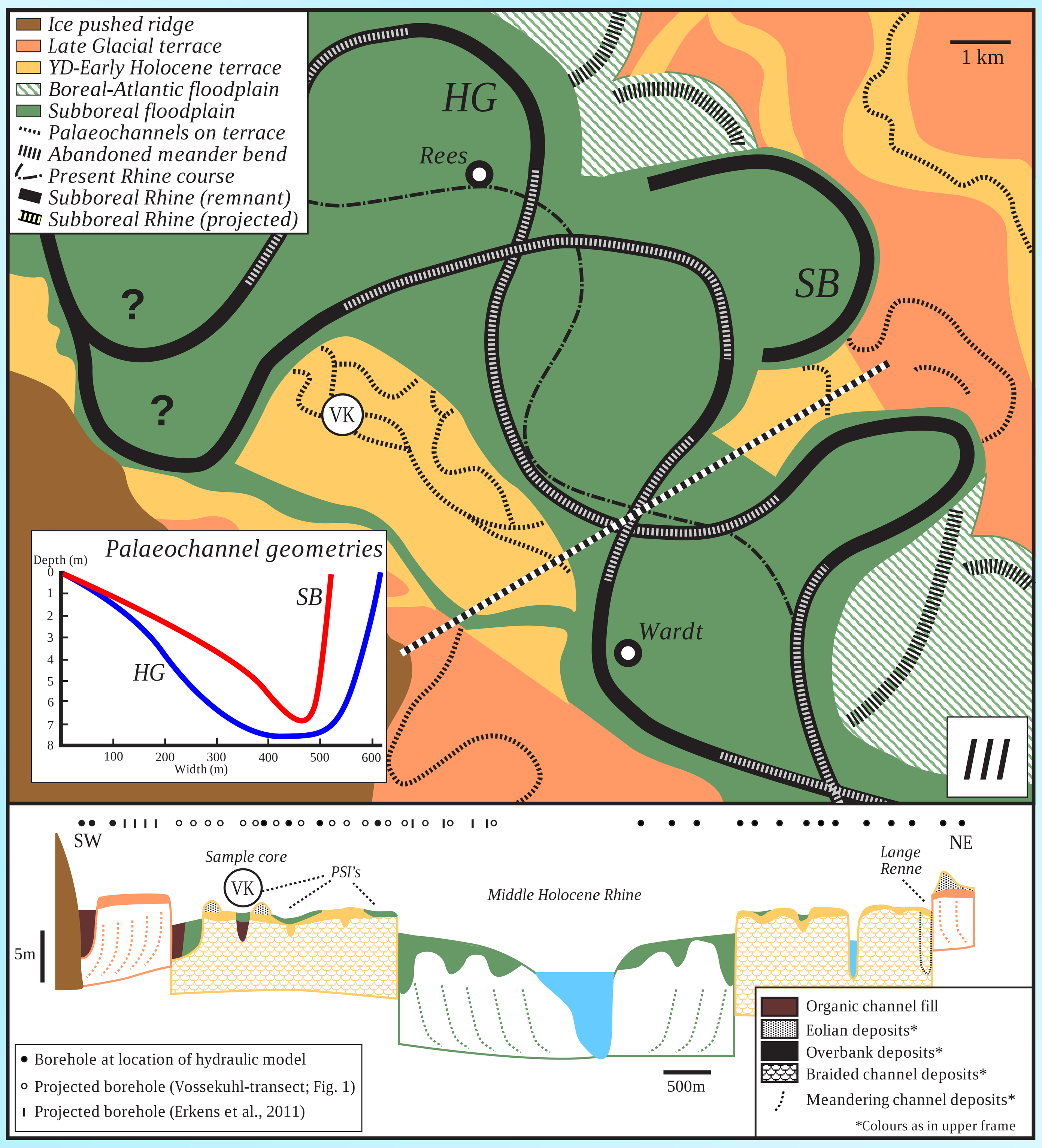
II) Modelled valley cross-section with classication per floodplain compartment with general vegetation composition, the projected location of the Vossekuhl (VK) sample core, upper and lower estimated flood water levels, and zone-averaged Chézy roughness values for the best guess estimate scenario.

METHODS

A Chézy-based hydraulic model was used to calculate the palaeoflood discharge out of carefully selected geological input data (palaeochannel dimensions (*III*), reconstructed palaeofloodplain topography, surface and river bed roughness, and palaeostage indicators). To account for uncertainty, we considered 10 sets of input variables, which represent a realistic range of model inputs and results.



IV) The Vossekuhl sample core with general lithology, organic content, pollen assemblages and estimated ages (CP = culture crop pollen, NAP = non-arboreal pollen, AP = arboreal pollen). Arrows indicate the location of extreme floods (clay laminations in peaty matrix), squares represent AMS dates in radiocarbon ages, and black circles mark the location of samples for palynological analyses.

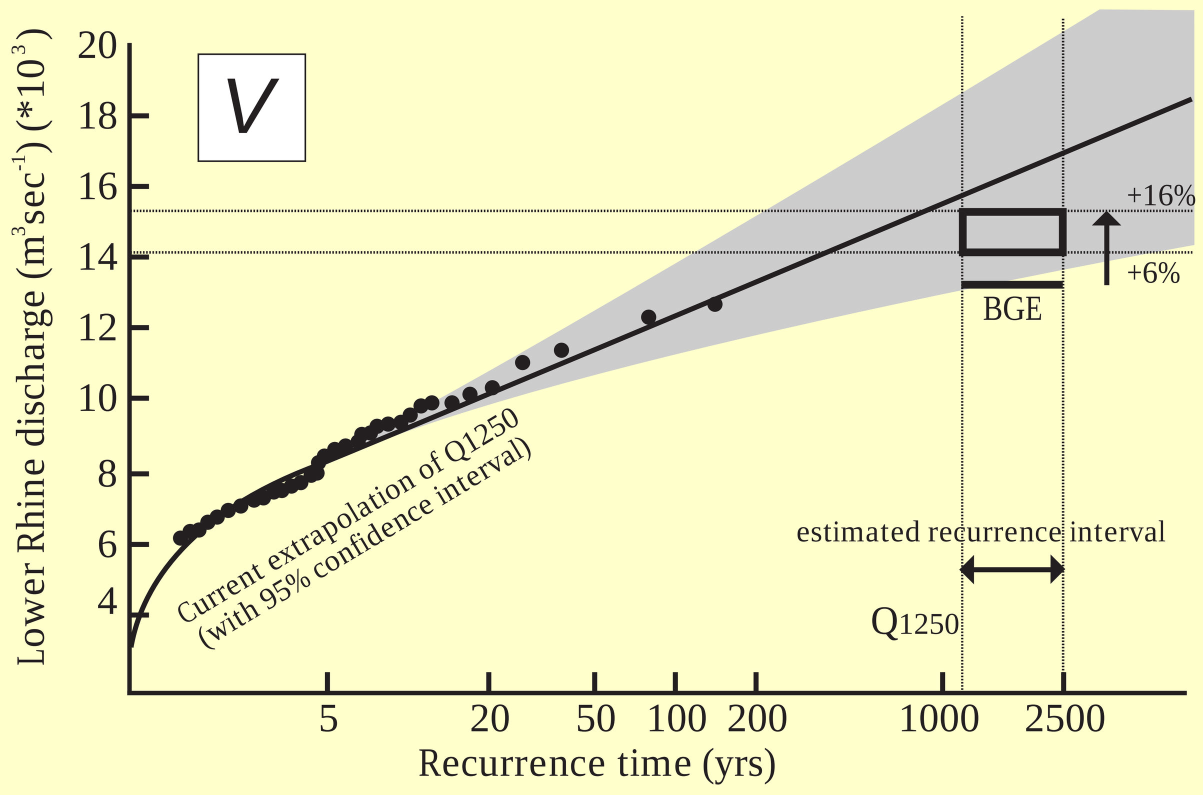


III) Reconstruction of the Middle Holocene Lower Rhine Valley with Subboreal Rhine courses and older morphology (YD = Younger Dryas). The inset shows palaeochannel dimensions of the SB and HG palaeochannels, which have been used as variables in the model scenarios. A schematized geological cross section is shown in the lower frame.

CONCLUSIONS

Geological-based discharge reconstructions provide unique information to bracket magnitudes of extreme flooding events.

Reconstructed Middle-Holocene palaeoflood magnitudes correspond well with previously estimated design discharges for Dutch dikes (*V*).



V) Current flood-frequency extrapolation (redrawn after Chbab et al., 2006) with our calculated range in recurrence interval and the best guess estimate (BGE) for the lower limit of Middle Holocene palaeoflood extremes. The BGE is corrected with +6-16% 'deforestation and engineering'.

RESULTS

A best guess estimate of 13,250 cumecs was calculated for the *minimum* magnitude of floods that left the highest slackwater deposits in our cross section.

The associated recurrence time was estimated to 1,250-2,500 years, based on AMS dating and palynological analysis of the organic palaeochannel fill (*IV*).

At present, discharge waves are steeper than millennia ago, due to deforestation and river management. Correcting for these human impacts (which add ~6-16%), the investigated palaeoflood would correspond to ~15,000 cumecs, which is slightly lower than the present design discharge (*V*).

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References:

Chbab et al., 2006. Estimating exceedance frequencies of extreme river discharge using statistical methods and physically based approach. Osterreichische Wasser- und Abfallwirtschaft 58, p 35-43.
Erkens et al., 2011. Complex fluvial response to Lateglacial and Holocene allogenic forcing in the Lower Rhine Valley (Germany). Quaternary Science Reviews 30:5-6, p 611-627. doi: 10.1016/j.quascirev.2010.11.019.