Flood-related variations in provenance of fine-grained palaeochannel sediments in the Rhine river basin **Universiteit Utrecht**



MARCEL VAN DER PERK¹, WILLEM H.J. TOONEN¹, JOCHEM YPMA¹, PAUL A. BREWER², MAARTEN A. PRINS², MARK G. MACKLIN², HANS MIDDELKOOP¹

¹Utrecht University, Department of Physical Geography, P.O. Box 80115, 3508 TC Utrecht, The Netherlands; e-mail: m.vanderperk@uu.nl, ²Aberystwyth University, Centre for Catchment & Coastal Research, Aberystwyth, United Kingdom, ³Vrije Universiteit Amsterdam, Faculty of Earth and Life Sciences, Amsterdam, The Netherlands

1. Introduction

Rhine river delta.



Fig. 1 Sampling locations in the Bienener Altrhein palaeochannel and in the Rhine tributaries.

2. Methods

Geochemical and grain size analyses were conducted on channel-fill sediments from multiple core sections, ranging from 1.00 m to 8.48 m depth, which represents pre-industrial sediment deposited from approximately 1550 AD to 1860 AD. In addition, four sediment cores of ~ 1 m length were retrieved from channel-fills or overbank deposits along the Upper Rhine and the three main tributaries of the Rhine in Germany (Neckar River, Main River and Moselle River). Sediment geochemistry was analysed using an Itrax X-Ray Fluorescence (XRF) core scanner.

Four elements were selected for further analysis. The XRF counts for four selected elements (Ti, Co, Rb, W) were standardised to z-scores and were subsequently corrected for the variation clay content (< $2 \mu m$) by means of linear regression. The Mahalanobis distance was adopted as a measure of dissimilarity between the BAR sediment increments and the sediment from the upstream tributary source areas. The similarities (-log Mahalanobis distance) were correlated to the sand content (> 150 μ m). The occurrence of peaks in similarity during floods (as derived from historical flood records) compared to no-flood periods was examined using Chi-squared tests. The agreement between the occurrence of positive peaks in the similarity and the occurrence of historical floods in the tributaries was examined using the kappa-statistic.



tributaries in the Bienener Altrhein

3. Results and discussion

	Upper Rhine River	Neckar River	Main River	Moselle River
Correlation sand content - similarity between BAR sediment and sediment from tributaries	r = 0.143**	r = 0.101*	r = -0.119**	r = 0.064 (n.s.)
Occurrence of peaks in similarity during historical floods	more positive peaks*** more negative peaks**	more positive peaks*	more negative peaks***	no relation
Agreement between the occurrence of positive peaks and historical floods	no agreement $(\kappa = -0.163)$	no agreement $(\kappa = -0.034)$	no agreement $(\kappa = 0.030)$	no agreement $(\kappa = 0.119)$

The Mahalanobis distances are larger than 1 for most increments (Fig. 2), which indicates that the four sampled upstream sites do not entirely cover all sources of sediment deposited in the BAR palaeochannel. The positive relations between sand content and the similarities with sediment from the Upper Rhine and Neckar Rivers (Table 1, Fig. 2) imply that the proportion of fine sediment that originates from the upper parts of the river basin increases with flood magnitude. The occurrence of significantly more positive peaks in the similarities with those upstream source tributaries during historical flood events is in line with this result. The lack of agreement between the occurrence of positive peaks in the

similarities and the occurrence of historical floods (Table 1) could be due to gaps in the historical record of floods in the tributary source areas or uncertainties in the dating of early floods. Although the BAR captured relatively more sediment derived from the upstream source areas during flood events, this lack of agreement could also indicate that during flood events sediment is not transported at once from the tributary rivers to the delta apex.

4. Conclusions

• The proportion of fine sediment deposited in the BAR palaeochannel, which originates from the upper parts of the Rhine River basin increases with flood magnitude.

• This indicates that the sediment transport distance increases with flood magnitude

• Nevertheless, the lack of agreement between the occurrence of positive peaks in the similarities and the occurrence of historical floods suggests that the sediment derived from the upstream tributaries does not reach delta apex during one flood event.