Geophysical Research Abstracts
Vol. 14, EGU2012-11596, 2012
EGU General Assembly 2012

A Lower Rhine flood chronology based on the sedimentary record of an abandoned channel fill

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The Bienener Altrhein is an abandoned channel of the Lower Rhine (Germany). Following a late 16th century abandonment event, the channel was disconnected from the main stream and the oxbow lake gradually filled with 8 meters of flood deposits. This process still continues today. During annual floods, a limited proportion of overbank discharge is routed across the oxbow lake. Large floods produce individual flood layers, which are visually recognized in the sedimentary sequence. Based on the sedimentary characteristics of these event layers, we created a ∼450-year flood chronology for the Lower Rhine.

Laser-diffraction grain size measurements were used to assess relative flood magnitudes for individual flood event layers. Continuous sampling at a ∼2 cm interval provided a high-resolution record, resolving the record at an annual scale. Standard descriptive techniques (e.g., mean grain size, 95th percentile, % sand) and the more advanced 'end member modelling' were applied to zoom in on the coarse particle bins in the grain size distributions, which are indicative of higher flow velocities.

The most recent part of the record was equated to modern discharge measurements. This allows to establish relations between deposited grain size characteristics in the abandoned channel and flood magnitudes in the main river. This relation can also be applied on flood event layers from previous centuries, for which only water level measurements and historical descriptions exist. This makes this method relevant to expand data series used in flood frequency analysis from 100 years to more than 400 years.

To date event-layers in the rapidly accumulated sequence, we created an age-depth model that uses organic content variations to tune sedimentation rates between the known basal and top ages. No suitable identifiable organic material for radiocarbon dating was found in the cores. Instead, palynological results (introduction of agricultural species) and palaeomagnetic secular variation measurements did allow to verify the initial age-depth model. Furthermore, initially modelled ages attributed to the five biggest floods were compared to hazardous events described in historical records. As these reproduce their dates within a decade, the dated flooding events are used as additional age tie-points for further improvement of the age-depth model. The refined model was in turn used to date floods of a medium magnitude, which are more common and thus more difficult to individually relate to a specific historical peak discharge.

This case study demonstrates the suitability of channel fill sediment records for (palaeo)flood characterisation. Based on a network of sites (work in progress), it should be possible to provide an accurate (internally cross-validated) flood chronology for the Lower Rhine and delta. Moreover, given the preservation of filled oxbows from all periods along the Lower Rhine, it is possible to extend relative flood chronologies back to the Early Holocene using channel fill sedimentary data.