A new method for flood reconstruction over the past millennia

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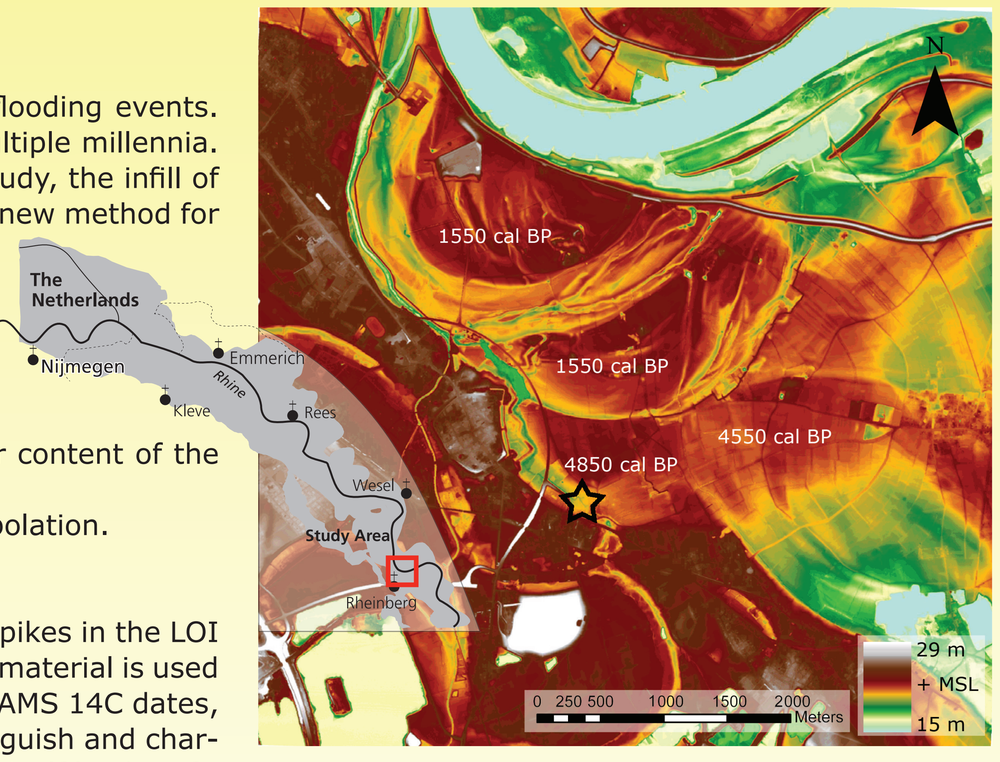
Introduction

Reconstruction of the flooding history of the river Rhine is important for the study of extreme flooding events. Sedimentary sequences from palaeochannel fills and oxbow lakes can hold records that cover multiple millennia. In this case, their sediments provide a good source of information on past river activity. In this study, the infill of a palaeochannel of the Rhine near Rheinberg, Nordrhein-Westfalen, Germany is used to develop a new method for flood reconstruction on decadal timescales.

Methods

The principal method used is Loss-on-ignition (LOI), providing information on the organic matter content of the sequence. A high-resolution LOI analysis is preformed in order to:
1) apply a new age-depth model that translates LOI into aggradation rate for improved age interpolation.
2) investigate the registration and recurrence of extreme floods in the oxbow lake.

Because siliciclastic material has been deposited by flowing water in the palaeochannel, negative spikes in the LOI record, meaning increased clastic material inputs, represent flood events (1A). The influx of clastic material is used to calculate changes in deposition rates and, in combination with a P-sequence age model using 4 AMS 14C dates, construct an age-depth model (1B). Explorative statistical techniques are applied in order to distinguish and characterize significant LOI spikes, thereby defining suspected major flood events on a cal BP timescale (2). The LOI record shows distinct breaks in mean LOI that might reflect shifts in former positions of the river Rhine.

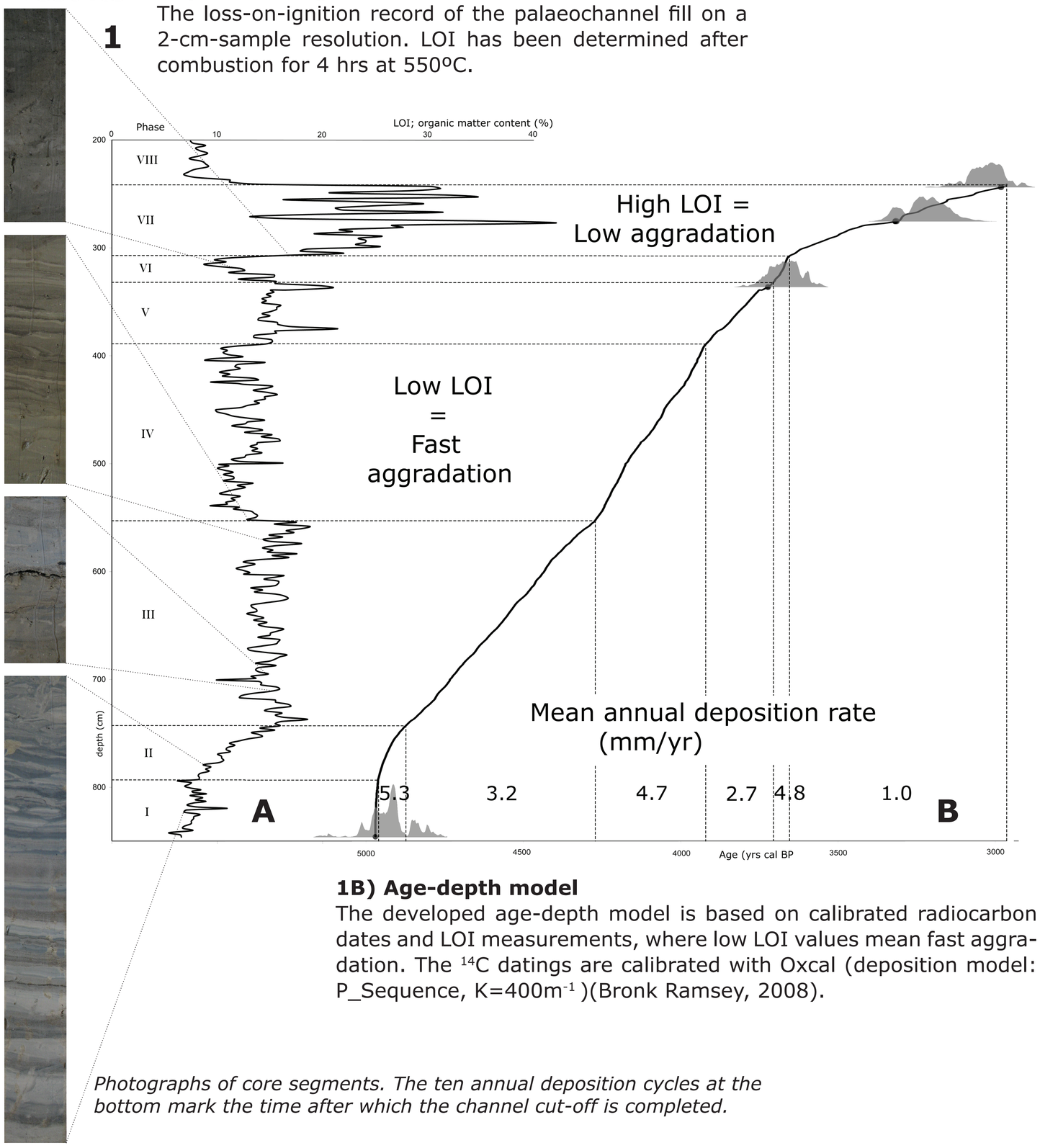


Location of the palaeochannel near Rheinberg, Germany. Channel abandonment datings by Erkens (2009).

Results

1A) Loss-on-Ignition record

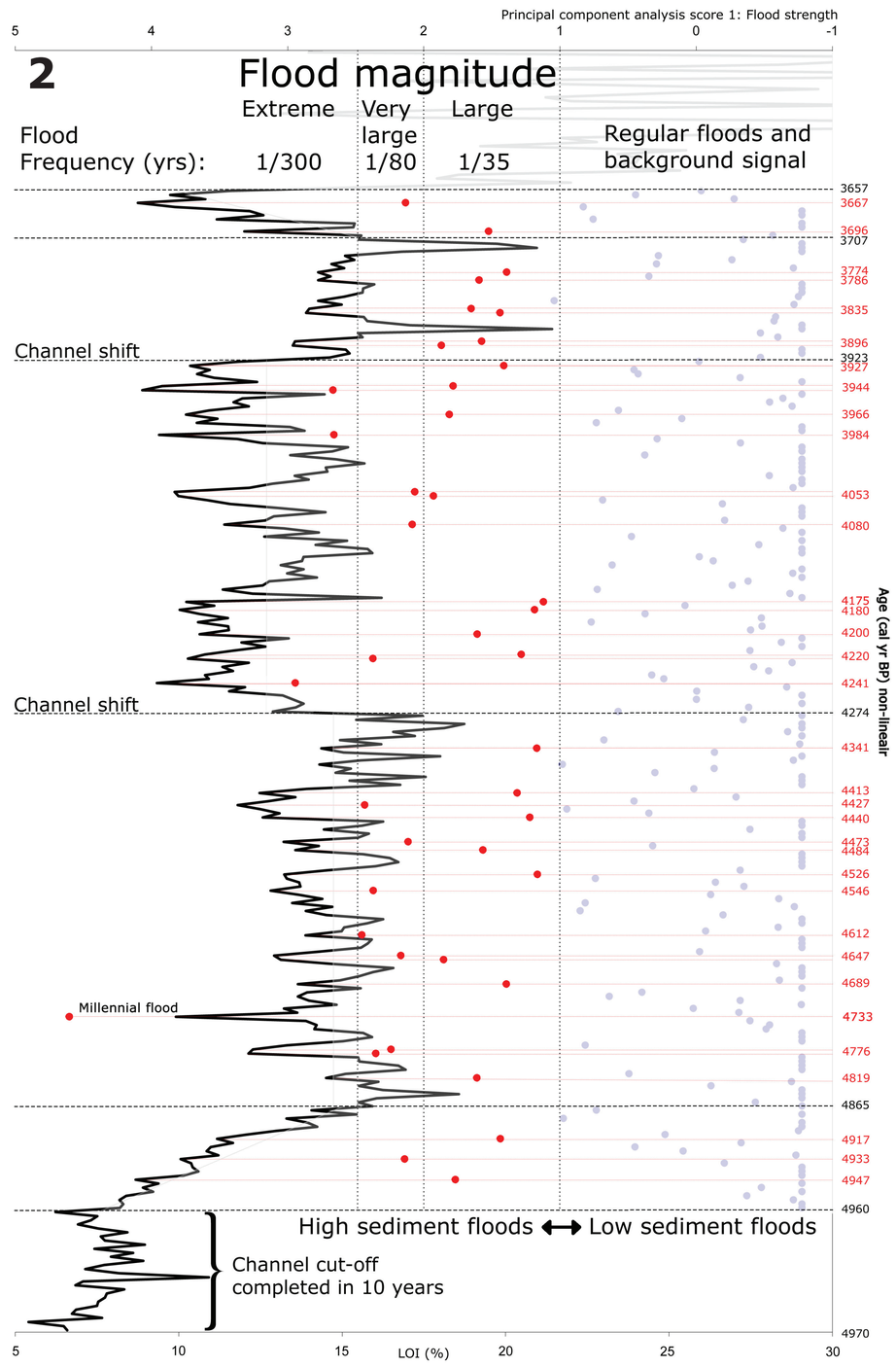
The loss-on-ignition record of the palaeochannel fill on a 2-cm-sample resolution. LOI has been determined after combustion for 4 hrs at 550ºC.



Photographs of core segments. The ten annual deposition cycles at the bottom mark the time after which the channel cut-off is completed.

1B) Age-depth model

The developed age-depth model is based on calibrated radiocarbon dates and LOI measurements, where low LOI values mean fast aggradation. The ^{14}C datings are calibrated with Oxcal (deposition model: P_Sequence, K=400m^{-1})(Bronk Ramsey, 2008).



2) Flood Frequency

Flood reconstruction of the Rhine near Rheinberg. Significant, negative LOI spikes are plotted with their PCA-1 score, which is translated into flood frequency and magnitude. The distinct jumps in the LOI curve reflect former channel shifts.

Conclusions and recommendations

- High resolution loss-on-ignition analysis proves to be a valid and cheap method for flood reconstruction. Increasing the resolution by decreasing the sample size will enhance the results.
- Applying an age-depth model that incorporates LOI as a proxy for aggradation rate performs well and improves the age interpolation results.
- Information on former positions and shifts of the Rhine, which can no longer be derived from today's morphology, since all corresponding river deposits are reworked, is stored in the palaeochannel record.
- The statistical labelling and characterizing of significant LOI spikes worked well and created reproducible results.
- Applying more advance analyses like grain-size, Magnetic Susceptibility or XRF-core logging will add useful information.

By performing similar analyses on multiple palaeochannel cores and correlating the results, locally induced floods can be filtered out, leaving the real, extreme, deltaic wide floods that correspond with extreme river discharge. With these results we are one step closer in defining the corresponding discharge belonging to these extreme flooding events of the Rhine. The method will be applied in the research by Willem Toonen (see poster nearby), so watch this space!

References:
Bronk Ramsey, C., 2008. Deposition models for chronological records. Quaternary Science Reviews, Volume 27, Issue 1, Pages 42-60. Oxcal v4.1.5 http://c14.arch.ox.ac.uk/oxcal.html
Erkens, G. 2009. Sediment dynamics of the Rhine catchment: Quantification of fluvial response to climate change and human impact. http://igitur-archive.library.uu.nl/dissertations/2009-1119-200148/UUindex.html