Holocene Rhine reoccupation of the IJssel valley by divide dissection north of Zutphen

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ABSTRACT

The Gelderse IJssel is the youngest natural distributary of the Rhine delta. When it came into existence between 300 and 700 AD, it annexed a valley that had not previously been part of the Holocene delta plain before. Underlying the drainage configuration of the valley and the position of the main divide, which separated ‘Rhine tributaries’ from ‘drainage going north’ prior to the formation of the IJssel, is key when reconstructing the timing and mechanics of the annexation process. The initiation of the IJssel was of arc-tectonic/historical interest, and the features from the initial stage - preserved some meters above deposits from later stages - offer a great opportunity to quantify a major flood of the Rhine.

During 5 years of field campaign covering the full river valley length and width, we mapped and dated landscape features related to the IJssel diversion and the area’s many dissected older elements. This allowed us to position the paleodivide between Zutphen and Deventer, and to explain how it formed. The outcomes of this research falsify former paleodrainage reconstructions that assume the divide lay further south and that showed the rivers Berkel and Oude IJssel draining northward, instead of heading west towards the Rhine.

DIVIDE CONTROL ON REOCUPATION

The channel deposits of the Gelderse IJssel show a two-stage division. The oldest stage (‘initial stage’) saw multiple shallow channels and occupied a relatively wide belt within the valley. The younger stage (‘mature stage’) occupies a relatively narrow channel trace, which is characterized by a thick channel fill, and showed all the phenomena of a meandering river. The river was embanked in the 14th century, continued to meander for another two centuries (still ‘mature stage’), and then lost most of its discharge due to discharge redistribution events at the upstream divide apex.

GEOLGY OF DIVIDE FORMATION

Since ~40,000 years ago - after the Rhine abandoned its IJssel valley course between 60,000 and 40,000 years ago - local periglacial depositional systems buried the valley floor. Originated former Rhine tributaries built out low gradient alluvial fans from both sides of the valley. The fans were fed from catchments draining the Veluwe ice-pushed ridge complex and the eastern Netherlands uplands, respectively.

Through deposition the fans raised the local surface elevation. Around 20,000 years ago, the largest two fans grew so large that they met in the axis of the abandoned valley. At this time loe avulsions of the Berkel fan redirected this river to a position south of the most extensive Veluwe-sourced fan. As a result, the originated Berkel tributary once again became a Rhine tributary. Counsardridges formed on top of the abandoned part of the fans, sourced from the ephemeral streams on the active parts. This caused further raising of the surface at a local level.

In sequence, these periglacial developments (from ~40,000 to ~11,000 years ago) created the saddle topography that became the divide-dissolved. The associated drainage network stayed active until late in the Holocene, until the Gelderse IJssel branch reoccupied the area as part of a deltaic-sedimentation by-annexation event (in early medieval times).

DATING THE GELDERSE IJssel

An apparent gap exists in the dated age of the IJssel ‘upstream’ and ‘downstream’ of the divide area. This is due to the (i) the static presence of the divide until ca. 550 AD and (ii) the centuries necessary for the IJssel breach to mature.

Reach upstream of the divide were gradually flooded by Rhine waters from 2500 yr ago onward. Rhine-flood sandwash deposits accumulated up the tributary valleys of the rivers Oude IJssel and Berkel, between 2000 and 1550 AD in the Zutphen vicinity. The reach downstream of the divide record hydrological changes from 350 AD and 650 AD onwards. Rhine clay deposition began later, around 750 AD (event 14C results: Cohen, in prep.) and expanded around 900 AD (Makaleka et al, 2008; 14C dating, historic sources and archaeological evidence imply that the IJssel existed through the divide region since at least 650 AD e.g. Fritjof & Groothedde, ZAP, GJ, Zutphen).

Combined sedimentary and dating evidence constrains the stages as follows:

1) The ‘Initial Stage’ occurred between ca. 500 and 950 AD, with 550 AD as a best guess age for an initial rise-magnitude fixed triggering divide breach to commence, based on lithochronology and palaeohydrology from a former oak mean age at Zeekle (Baut-Raassen & Ameloot NRG 2002).

2) The ‘Mature Stage’ occurred between 900 and 1550 AD, based on increased clay deposition in the lower IJssel, increased sedimentation of the IJssel delta since that time, and historical information on measures mitigating ongoing channel migration near the meadow classes of Zutphen, Deventer, and Doornspijk.

METHOD

The reconstruction is based on systematic lithostratigraphic mapping, coring to 5 meters below surface depth (and occasionally deeper), 10-20 borehole/oriented cores per site, and detailed fieldwork based on high resolution digital elevation data (AHK 1:5cm; RWS/AGI, 2005). The geomorphological analysis and dating methods include the following methods: 1) Stratigraphic mapping of the Rhine floodplain deposits, including a detailed study of its latest Holocene deposits. 2) Detailed bathymetric studies of the Rhine floodplain deposits, including a detailed study of its latest Holocene deposits. 3) Detailed bathymetric studies of the Rhine floodplain deposits, including a detailed study of its latest Holocene deposits. 4) Detailed bathymetric studies of the Rhine floodplain deposits, including a detailed study of its latest Holocene deposits. 5) Detailed bathymetric studies of the Rhine floodplain deposits, including a detailed study of its latest Holocene deposits.

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