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Record and description of the sediments of the flood in June 2013 in the area of the Donau-Auen National Park

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Gisela Wittwer

University of Natural Resources and Life Sciences, Vienna
Department of Civil Engineering and Natural Hazards

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Introduction

Floods appear with varying characteristics as natural phenomena of the hydrological cycle. By means of erosion, transport and sedimentation of eroded material they form the fluvial topography. A number of studies deal with the development of inundation areas in connection with overbank deposits due to floods. For instance Wolman and Leopold (1957) identified the main development processes as laminar deposits, development of lateral deposits in form of sand and gravel banks, as well as lateral erosion together with relocation of the riverbed. Along regulated rivers like the Danube, side erosion is prevented to a large extent and deposited material is hardly remobilized. So far, the progressive increase in elevation of the inundation area for the Donau-Auen National Park was examined by comparison of landscape models based on laser scans with historical records (Klasz et al. 2014) or data from core drilling of different analyses (e.g. Fiebig & Preusser 2007) was used.

The aim of the present paper is to assess the influence of the deposited sediment load due to bigger floods on the development of the elevation of the inundation area Donau-Auen in the context of the extreme flood event in June 2013.

Methods

This paper investigates the national park Donau-Auen. Due to the size of more than 9,300 ha (Donau-Auen 2014) the area was limited to the floodplain next to Orth an der Donau, approximately between river kilometre 1902 and 1907. This region serves as an inflow area with high sedimentation rates during floods (Klasz et al. 2014). In the area of investigation two former branches of the Danube (Reckendorfer 2006) are situated, the 'Kleine Binn' and the 'Große Binn'.

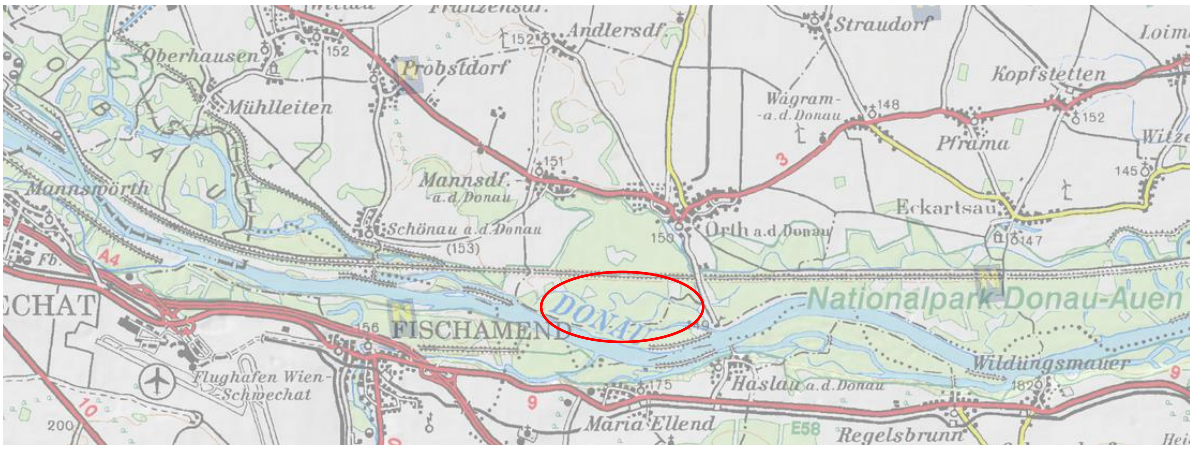

Figure 1: Layout plan of the investigation area next to Orth an der Donau (NÖ-Atlas, 2014).

The basic approach of the analysis was the determination of the layer thickness of the deposits of the 200-year flood in June 2013 in the Danube area with the help of the overlain vegetation horizon before the extreme flood event. In the scope of the fieldwork soil profiles were used to find the former vegetation layer and to assess the newly added sediments. The different layers, their thickness, colour and grain size categories were identified.
All profiles were recorded with their coordinates (WGS84) and processed by means of an ArcGIS elevation model based on laser scans of VIA Donau (2010), orthophotos from Google Earth and maps and orthophotos from NÖ-Atlas. The analysis and presentation of the investigated layer thicknesses as elevation model was carried out with OriginPro 9.1.

Results

In general, sand and fine sand was found next to the bank. With increasing distance to the water the fraction of silt and clay rose, whereas the amount of sand and the layer thickness declined. Next to the Danube sedimentation varied between 50 and 60 cm with a maximum of up to 1 m. In the area of the dam still 3 mm of fine sediments were found.

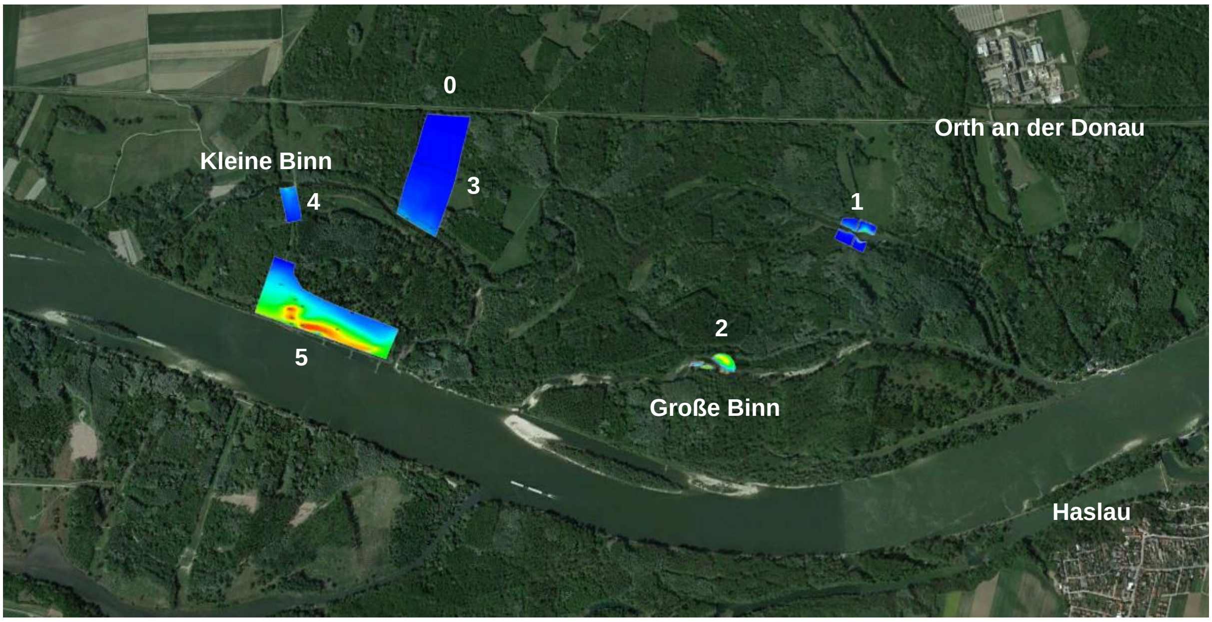

Figure 2: Areas of layer thickness investigation (GOOGLE EARTH, 2014).

Particularly in the first 100 m distance to the Danube as well as in the area of the anabranch 'Große Binn' material with highly varying layer thickness was deposited due to diverse conditions. In areas farther away from the water and in the area of the anabranch 'Kleine Binn' more homogenous layer thicknesses were found.

In addition to the spatial illustration also the change of sedimentation rates was identified as a function of distance to the water. Depending on the fact that sedimentation only starts when the bankfull discharge is exceeded (approx. 4,800-5,000m³/s; KLASZ et al. 2012; LIEDERMANN et al. 2012) and the inundation area is flooded, the bank edge was used for distance measurement.

In general, the sedimentation of the 200-year flood can be well described with an exponential function. In the context of the distance to the water this means an exponential decrease of sedimentation rates with rising distance. This correlation can for instance be identified in the diagram of the deposits at the anabranch 'Kleine Binn' in Fig. 3. The description of sedimentation by means of an exponential function is suitable for bigger observation areas with a high number of soil profiles. Especially for areas farther away from water, the fast decline of layer thickness is estimated accurately. If only bankside areas like area 4 are to be taken into consideration, for instance a power function provides a better description (Fig. 4).

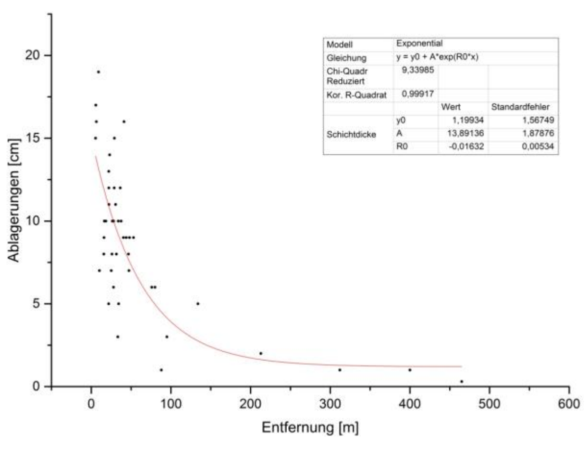

Figure 3: Description of deposited material as an exponential function of the distance to the water, area 3.

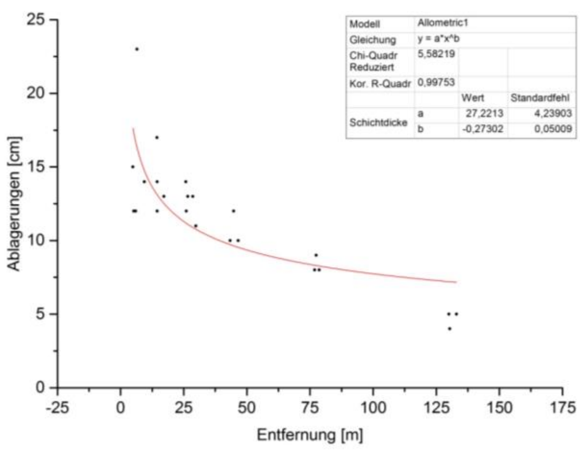

Figure 4: Description of deposited material as a power function of the distance to the water, area 4.

Discussion

KLASZ et al. (2014) estimate the average sedimentation rates of the last 120 years (since the regulation of the Danube in the national park area) to approx. 11 mm p.a. for areas next to the Danube and approx. 0.3 mm p.a. for zones in the floodplain farther away. Thus, the deposited material of the 200-year flood event significantly exceeds the estimated yearly sedimentation rates.

According to the author the investigation area is situated in a zone of increased inflow. Flood events flow into the widening inundation area and due to a reduction of flow speed more sediment load is deposited there than in other areas. Zones where the flood leaves the inundation area show lower sedimentation rates and less ground level elevation in the ArcGis model. Therefore, the observed sediment layer thicknesses of the flood event in 2013 are probably only valid for similar inflow areas and cannot be generalized for the whole national park.

WALLING AND SIMM (1998) describe in their observations that the highest sedimentation rates can be found next to the river, with high variation within individual values. This also applies to the investigation area of the Danube: the biggest variability was observed in the bankside areas of region 5. Furthermore, the authors emphasize the direct relationship between distance to the river and sediment thickness: the greater the distance, the lesser the sediment deposits. Also the exponential connection, described by a number of authors (e.g. WALLING & SIMM 1998; WALLING & HE 1998) largely applies to the area under investigation. The actual sedimentation of bankside areas can be better described by power functions, similar results were found by FILGUEIRA-RIVERA et al. (2007).

Coarser material is sedimented in bankside areas, whereupon especially the sand fraction declines relatively rapidly and fine material as silt and clay are transported far into the inundation area according to TÖRNQVIST & BRIDGE (2002). This leads to a progressive increase in elevation of the banks of the Danube due to levee formation.

Conclusion

Sand and fine sand was found in bankside areas, next to the Danube sedimentation varied between 50 and 60 cm. With increasing distance the fraction of silt and clay rose, whereas the amount of sand and layer thickness declined (3 mm in dam area). This implies that the deposited material of the 200-year flood event significantly exceeds the estimated yearly average sedimentation rates of other studies.

The highest sedimentation rates and the coarsest material could be found next to the river, this leads to a progressive increase in elevation of the banks of the Danube due to levee formation.

The Analysis showed that for bigger observation areas farther away from water, an exponential function estimates the fast decline of layer thickness with rising distance accurately. For bankside areas power functions are more suitable.

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Contact

Gisela Wittwer
gisela@wittwer.co.at