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Erosion of arable land during the July 2021 flood event in Erftstadt-Blessem, Germany: understanding groundwater sapping

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Although fluvial erosion is predominantly governed by surface driven fluvial incision, more exotic erosional processes can significantly contribute to the fluvial shaping of landscapes. To this group belongs sapping caused by concentrated groundwater discharge, which can form a very distinct type of topography (characterised e.g. by the development of theatre-shaped channel heads). Fluvial erosion through sapping occurs where groundwater encounters a rapid change in elevation (i.e. across scarps, cliffs), and it is highly modulated by the physical properties of the solid. Groundwater sapping is, for example, promoted by inhomogeneities of permeability and/or lithological composition of the subsurface, which is often prevalent in sedimentary deposits and along contact boundaries between different lithological units. Consequently, topography shaped by groundwater sapping can be found in many places on Earth and even on Mars, and the formation of these landscapes can integrate over thousands to millions of years. However, in some regions, such as coastal areas, groundwater sapping has been reported to be associated with severe soil loss and high erosion rates on the order of tens of metres per day.

A similar magnitude of soil loss could be observed close to the village of Erftstadt-Blessem, Germany, as caused by severe flooding, peaking the 15th of July 2021. Here, intense rain events caused the formation of local drainage networks towards a gravel pit located to the north of the village. As a consequence, adjacent arable land was subject to intense backward incision, thereby eroding the underlying Quaternary sediments. The erosion formed drainage networks that appear to resemble characteristic groundwater sapping. This fluvial topography was largely preserved after the flooding, thus providing the opportunity to decipher the processes involved in the formation of these features. We use Structure-from-Motion Multi-View Stereo (SfM-MVS) photogrammetry to reconstruct the drainage geometry based on drone imagery (provided by the Kreisverbindungskommando Köln, M. Wiese; additional SfM-MVS photogrammetry data provided by ESRI Deutschland GmbH, T. Gersthofer) and photographs taken in the field using a handheld camera. The data is subsequently used to characterise the drainage networks and to compare the topography to other groundwater sapping landscapes on Earth and on Mars. Additionally, we intend to perform grain size analyses of the different sediment layers and to quantify fallout $^{239+240}$Pu in selected samples to asses the physical properties of the substratum and to trace the fate of the radionuclides during the flood event. Our aim is that our data will contribute to a better understanding of how groundwater sapping processes operate over time and to assess the importance of individual factors (e.g. substrate properties, vegetation cover and -type) on the

severity of erosion. The outcome could thus not only be important for modelling terrestrial and extra-terrestrial processes but has also practical applications to the loss of arable land and the effects of outburst flooding.