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Identification and characterization of recent and paleo subsurface collapse structures in the metropolitan region of Hamburg – a hazard potential analysis

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Surface structure differentiation between sinkholes and fluvioglacial kettle holes is very difficult although both structures developed during different geological processes. A kettle hole formed after glaciation as a result of a slowly melting ice block covered by sediments. In contrast sinkholes develop by subrosion processes in the deeper underground. The occurring depression of each structural type is generally filled with sediments or water.

Both structural types arise in the district of Altona (Hamburg). Some of them occur as peat or water filled circular and bowl shaped depressions, whereas most of them are covered by infrastructure in the highly built-up urban area. Their extent in diameter and depth varies between some meters and some tens of meters but does not give any information about their origin. The hazard-potential of kettle holes is low, merely the compaction of commonly occurring peat filling may cause slight down bending of the surface. In contrast sinkhole formation can cause moderate to catastrophic effects. To estimate the hazard-potential that is related to the different structures we developed a concept to detect and to analyze the buried structures in the shallow underground.

As a first step we computed surface models of different sediment layers by interpolating well data down to a depth of about 20 meters. These geo-referenced elevation models indicate the geographical distribution of funnel shaped anomalies in the study area and their differences in shape, dimension and depth. Structures piercing through all layers indicate a roof-collapse. Other structures where only the lower sediment layers are affected can be classified as a collapse event in time prior to the latest

undisturbed layer.

As a next step we analyzed each structure with GPR to clarify its origin: kettle hole or sinkhole. Therefore we recorded GPR-data along measure grids for further 3D-visualization and detailed structural analysis of single structures. A fence like net of long distance GPR-transects is used for extended structural investigation of the whole study area.

A further step is to classify the subsidence structures due to the fact that the whole dimension of a collapse event depends on: the sinkhole-type, the time of its formation, the structural extension, multiple deformations by possibly ongoing subrosion processes in the deeper underground and the affected urban development above the subsiding area. Finally the collapse endangered zones will be locally defined, disclosed in a report and visualized in a hazard map of the working area.