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High-resolution imaging of sinkhole structures in the city of Hamburg by urban shear-wave reflection seismics

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The investigated roof region of a salt diapir in Hamburg, northern Germany, suffers sinkhole activity that was accompanied lately by microseismic events in the Gross Flottbek quarter. Thus, a high geohazard potential is present which can only be evaluated if highly resolved structural data are available. The urban environment and high building density required adapted and new, non-invasive geophysical methods for shallow applications (e.g., urban geophysics).

Our shear-wave seismic system, under development at LIAG, consists of a small, horizontal vibrator source (ELVIS, v. 5.0) and a 120 m long, mobile land streamer equipped with 120 SH-geophones. Thereby, a cost-effective, complete shear-wave seismic survey is possible, which is dedicated to urban applications and accounts for sealed surfaces. This high-resolution system is especially useful on sealed terrain because of the absence of surface waves, and it provides a higher resolution than a compressional-wave survey.

Across the Wobbe See sinkhole in Gross Flottbek we acquired 500 profile m of high-resolution shear-wave seismics that enabled urban subsurface imaging with 1 m vertical and 5-10 m horizontal resolution. Small-scale structures in the sediments and salt are resolved down to 100 m depth. We show that it is possible (1) to classify a sinkhole type structurally -collapse depth is found here at ca. 60-80 m depth below surface- and (2) to map subrosion areas by the physical property of lowered shear-wave velocities and a chaotic reflection character. The fault structures found coincide well with the focal depth and mechanism of the 2009 microseismic events. Aditionally, the diapir model is refined locally in terms of rock salt depth suggested here lying as shallow as 60-80 m below surface.