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Reflection seismic investigation of a subrosion area using a combined approach of P- and SH-waves

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Subrosion, the dissolution of soluble rocks, e.g., sulfate, salt, or carbonate, and the resulting structures, such as sinkholes and depressions, are a great geohazard because they can cause damage to buildings and infrastructure, and lead to life-threatening situations. The process requires unsaturated water and fluid pathways that enable the water to flow through the subsurface and generate cavities.

In Germany, sinkholes are a widespread problem, because soluble rocks, such as gypsum and anhydrite, are located close to the surface in many areas. One such area is the federal state of Thuringia, where our study area Bad Frankenhausen is situated.

For a better understanding of the local subrosion processes and structures, a detailed subsurface characterization of sinkholes and small- and large-scale depressions was necessary. Therefore, we used P-wave and SH-wave reflection seismics for high-resolution imaging of the near-surface. We were able to identify covered subrosion structures and –zones, and faults and fractures, which serve as fluid pathways. The seismic investigations were supplemented by geoelectric and gravimetric surveys in order to validate the interpreted fluid pathways and areas of underground mass movement.

We conclude that tectonic movements during the Tertiary, which lead to the uplift of the Kyffhäuser hills north of Bad Frankenhausen and the formation of faults parallel and perpendicular to the low mountain range, were the initial trigger for subrosion. The faults and the fractured Triassic and Lower Tertiary deposits serve as fluid pathways for groundwater to leach the deep Permian Zechstein deposits, and subrosion is more intense near faults. The artesian-confined salt water ascends towards the surface along the faults and fracture networks, which formed an inland salt marsh over time. In the past, subrosion of the soluble Zechstein Formations formed several, now covered, sagging and collapse structures, and, since the entire region is affected by recent sinkhole development subrosion must be still ongoing.

Due to the results of this study, we suggest a combined approach using P- and SH-wave reflection seismics to identify and analyse subrosion structures, and to use additional geophysical methods

like electromagnetic- and gravimetric surveys to develop a more comprehensive model explaining the local subrosion processes.