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Predicting sinkhole collapses at the Dead Sea from above and from within: Results from microseismic monitoring and SAR interferometry

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So far more than 4000 sinkholes occurred along the Dead Sea (DS) coast and the growth rate of number of sinkholes has reached to more than 400 sinkholes per year. The sinkholes are formed by collapses dissolution caverns within a salt layer, buried in several tens of meters deep within the coastal sediments. This dissolution was triggered by the shrinkage of the Dead Sea which in turn causes incursion of fresh groundwater to the salt layer. The hazardous shaft-like sinkholes occur at the alluvial fans and can reach to depth of 20 m, whereas the sinkholes at the mud flats are shallower and wider. The sinkholes at the alluvial fan can emerge to the surface long after (e.g., around 10-20 years) a considerable cavity size was formed by dissolution of the salt layer. The mechanical competency of the fan sediments preserves concealed activity of underground collapses long before the sinkhole occurrence. We conducted an experiment of microseismic monitoring in order to record this early collapse activity. We compared the distribution of the microseismic events to small land subsidence recorded by the SAR interferometry (InSAR).

Five smart tri-axial 14hz geophones were planted within five boreholes located apart by several hundred meters and with variable depths (between 10 to 25 m), around the sinkholes cluster of Mineral Beach resort area. During the monitoring period of 70 days (from 28.06.12 to 07.09.12), a total of 82 seismic events in the magnitude range of -3.6 $\leq$ML $\leq$0.4 were recorded. Most of the events were in magnitude of (-3) to (-2).

Small land subsidence related to sinkhole activity observed by the InSAR (recorded between 27.9-13.10.2012) was around the existing sinkhole lineament. Whereas, the location of the microseismic events shows concealed collapse activity east of the sinkhole line approaching the Mineral Beach resort area, in accordance with the sinkhole development at other parts of this sinkhole site and in other sinkholes sites along the Dead Sea coast. The depth range of these events is also in agreement with the depth of the salt layer inferred from seismic refraction and boreholes. Later InSAR record (19.12.2013-14.1.2014) indicates a broader area of subsidence around the sinkholes which lies above more of the microseismic events.