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Evidence of spring formation and subrosion-induced sinkhole development at Ghor Al-Haditha, Jordan, from repeated close-range photogrammetry

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The widespread development of sinkholes and land subsidence poses a major geological hazard to infrastructure, local population, agriculture and industry in the Dead Sea area. For assessment of the key physical factors in this development, repeated photogrammetric and field surveys at Ghor Al-Haditha in Jordan have been undertaken.

Recent results provide evidence for subrosion based on strong periodic water flows, as the basic underlying physical process of such land subsidence phenomena. From combined Helikite- and Quatrocopter-based photogrammetric surveys, high resolution Digital Surface Models from October 2014 and October 2015 are compared. Change detection reveals: (1) active subsidence in a hundred metre-scale depression zone, (2) a highly-dynamic spring and canyon system connected with recent sinkhole collapses and (3) the rapid formation of new sinkholes both in alluvium and mud cover sediments.

The formation of new sinkholes has been documented locally by means of aerial and field observations during a storm with strong rainfall. A new artesian spring formed in the former Dead Sea bed (mud-flat) at this event. The alluvial sediment load of the stream, a periodic location change of the spring and a connected uphill sinkhole cluster formation provide strong evidence for subrosion of weak material with subsequent underground void collapse.

Additionally a documented lake and its' subsequent drainage forming a new canyon reveals the local penetration of the aquiclude behavior of the mud-flat in the major depression area, which can be explained by an under-saturated groundwater flow at a strong hydrostatic gradient.

Furthermore an enlargement of the investigated area in the 2015 survey indicates a continuation of subsidence and sinkhole activity towards the North. It reveals several points of emanation of water streams in the mud-flat beneath the alluvial cover and vegetation as an indicator of relatively fresh groundwater inflow.

This repeated photogrammetry and field survey confirms the hypothesis of a large-scale, channelized subterranean water flow in a 3d network of interconnected tubes. This subsurface karstic channel network is hence responsible for sinkhole formation and rapid land subsidence at the Ghor Al-Haditha sinkhole area and perhaps elsewhere around the Dead Sea.