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# Migration of sinkhole development along the eastern shore of the Dead Sea

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Over 5,500 sinkholes have formed around the shores of the Dead Sea since the 1980s. This prolific sinkhole development is associated with an ongoing, largely anthropogenically-forced decline of the Dead Sea level. Previous studies have predicted that the fall in this hydrological base level should cause a lateral (seaward) migration of the interface between under-saturated groundwater and the hypersaline Dead Sea brine. This interface migration is suspected to enable under-saturated groundwater to dissolve subsurface salt deposits that were previously in equilibrium with Dead Sea brine, ultimately leading to cavity development underground and to sinkhole collapse at the surface.

As part of the recent Dead Sea Research Venue (DESERVE) initiative, we investigated the spatio-temporal evolution of the main sinkhole-affected site on the eastern shore of the Dead Sea, at Ghor Al-Haditha in Jordan. Our data set includes high resolution optical satellite imagery, aerial survey photographs and drone-based photogrammetric surveys covering the period from 1970-2017. Our analysis shows that sinkholes initiated as spatially distinct clusters, with the locations of newly formed clusters migrating progressively from southwest to north east, roughly parallel to the coastline. Furthermore, we observe an uneven but consistent seaward migration of sinkhole development once clusters are initiated. The largest observed seaward migration is >750 m in 10 years. Our observations are therefore generally consistent with predictions of previously-published hydrogeological theory regarding the lateral migration of a saturated/under-saturated groundwater interface, albeit with two refinements. Firstly, the coastline-parallel migration is suggestive of an oblique intersection of the interface with sub-surface salt deposits. Secondly, the unevenness in migration may be spatially linked with focussed groundwater inflow near active wadi systems in the Ghor Haditha area. Our results therefore suggest that sinkhole migration patterns result from a complex interaction of geological and hydrological factors. Furthermore, these findings could potentially enable identification of areas of future sinkhole-related hazard on the eastern shore of the Dead Sea.