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Geophysical imaging of subsurface groundwater conduits controlling sinkhole and stream channel evolution at the regressing Dead Sea shoreline

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The rapid regression of the Dead Sea by currently more than 1m/yr leads to a dynamic reaction of the hydrogeological system. During the last decades, new springs, stream channels, depressions, and sinkholes have evolved on both sides of the lake in alluvium, mud and salt deposits. The connection between surface and subsurface development presents methodological challenges that are here addressed by a novel combination of methods. Focusing on the eastern shoreline, near Ghor Al-Haditha in Jordan, we use satellite image analysis, near-field photogrammetry, electric resistivity tomography (ERT), self-potential (SP) and hydrogeological modelling to reveal the dynamic formation of a system of stream channels carved into the former lake bed and their relationship to nearby karstic geomorphic features.

Satellite imagery and photogrammetric surveys reveal that the development of the stream channel system in space and time is closely linked to that of the nearby karstic features. Moreover, the stream channel system has localised from several small channels to one ‘main channel’ over time. This main channel formed late in the system evolution and, unusually, it developed by rapid retrogressive (upslope, headward) erosion. ERT data from near the still-evolving head of the ‘main channel’ reveal an extremely low resistivity layer (interpreted as salty mud) beneath resistive alluvial gravel and sand cover. These data also highlight low resistivity areas of possible groundwater flow connected to the spring system. Complementary results are achieved in a 2D SP array with local, strong negative potentials indicating sub-horizontal groundwater flow.

ERT data from another of the stream channels is interpreted to reveal the existence of a subsurface relatively fresh water conduit that intruded into the mud-flat deposits. This is the first geophysically-imaged evidence of $>$100 m deep groundwater flow in this area of the Dead Sea. A simple 2D hydrogeological model is developed to investigate the possible origin of this water. Finally, from combination of all methods, we can connect observations of the surface development of the stream channel system with hydrogeological conditions and dynamic flow patterns in the subsurface and enhance our understanding of the evolution and hazard potential of the related subsidence and sinkhole phenomena.