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Contribution of Magnetic Resonance Sounding to karst aquifer characterization and sinkhole hazard evaluation on the Jordanian coast of the Dead Sea

M. Boucher (1), A. Legchenko (1), M. Ezersky (2), C. Camerlynck (3), and A. Al-Zoubi (4)

(1) IRD/ UJF-Grenoble 1/CNRS/G-INP, UMR 5564 LTHE, Grenoble, France (marie.boucher@ird.fr), (2) Geophysical Institute of Israel, Lod, Israel, (3) Université Pierre et Marie Curie – Paris 6, UMR 7619 Sisyphe, Paris, France, (4) Al-Balqa' Applied University, Engineering Faculty, Salt, Jordan

Since the 1970s, the water level of the Dead Sea has highly dropped causing the appearance of sinkholes along the shoreline both in Jordan and Israel. In South Jordan, the consequences are dramatic for farmers who exploit the land. The subsurface in this area is heterogeneous and composed of intercalated sand and clay layers over a salt rock, which is partly karstified. The appearance of sinkholes is known to be initiated by the emptying of karst cavities in depth. In order to identify the risk of collapse it is necessary to better understand the relations between the Dead Sea and the coastal aquifer. In this framework, the Ghor Al Haditha site was prospected by Magnetic Resonance Sounding (MRS). The MRS method is a non-invasive geophysical method that allows estimating the geometry, the porosity and the transmissivity of aquifers.

On Ghor Al Haditha site, 3 MR soundings were performed in 2005 and repeated in 2007 and 12 additional soundings were carried out in 2007. The conductivity of the field (to 0.3-0.5 ohm.m in this context) was measured by TDEM on the same locations and was taken into account in the inversion of MRS data.

We detected water saturated and permeable sediments (water content of 10-15% and permeability of 2.10^{-4}-2.10^{-3} m/s) that is located at the salt formation ($\sim$40 m) deep. MRS results revealed also a hydraulic gradient towards the Dead Sea, indicating a flow of water from the sediment aquifer to the Dead Sea that rounds the salt (and karstic cavities). The hydraulic gradient is particularly high ($\sim$3%) in the area where sinkholes had appeared. This higher gradient can be explained by slightly lower MRS transmissivity (0.01-0.02 m/s^2) in comparison with the part of the site without sinkhole (0.03-0.05m/s^2). We suggest that the low transmissivities are probably due to the refilling of karst cavities by fine materials after sinkholes formations. Indeed, the MR sounding repeated 2 times and located in the close vicinity of an area that collapsed between the 2 measurements showed lower transmissivity in 2007 than in 2005. All MRS parameters including porosity could be used to build a numerical groundwater model for quantifying the water fluxes from costal aquifer to the Dead Sea.