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# 3D magnetic resonance imaging as a non-invasive tool for investigating water-filled karst formations

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Magnetic Resonance Sounding (MRS) is a geophysical technique developed for groundwater exploration. MRS can be used for reliable identification of karst aquifers because of the relaxation time of the magnetic resonance signal (T1) is longer for bulk water in karst caverns and channels (about 2 s) than for water in porous rock (few tens of ms). MRS is sensitive primary to groundwater volume but electrically conductive layers modify electromagnetic fields in the subsurface and thus may have an effect on MRS performance. Generally, the study of a karst requires a 3D field set-up and we developed a measuring procedure and interpretation software that makes it possible to image heterogeneous water-bearing geological formations down to about 80 m (3D-SNMR method). Numerical modeling results show that limited resolution of the method allows only identification of large karst formations. For example detectable karst should be larger than a few hundred cubic meters when karst is located close to the surface and a few thousand cubic meters when it is located at 60 m. Time Domain Electromagnetic method (TDEM) is known as an efficient tool for investigating electrical conductivity of rocks. TDEM results allow more accurate computing of the EM field in the subsurface and thus contribute for improving accuracy of MRS results.

TDEM and 3D-SNMR methods were applied jointly in the Dead Sea coast of Israel (Nahal Hever South). The subsurface in this area is heterogeneous and composed of intercalated sand and clay layers over a salt rock, which is partly karstified. Groundwater is very saline, with a chloride concentration of 100-225 g/l thus rendering the resistivity of geological formations less than 1 ohm-m. We have shown numerically that under Dead Sea coast conditions, 3D-SNMR is able to detect and to locate the target within an error of a few tens of meters. In the investigated area (500×500 m2) our results reveal a very heterogeneous shallow aquifer that could be divided into two parts. In the northern part, the aquifer allows intensive circulation of groundwater. It was identified as a karst aquifer. In the southern part, the subsurface is composed of compact clay-type material with low hydraulic conductivity. Development of the karst was not observed.