Geophysical Research Abstracts,
Vol. 10, EGU2008-A-10717, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-10717
EGU General Assembly 2008


# Estimation of the dissolution karst volume based on 3D microgravity modeling in the Dead Sea sinkhole hazards problem

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***Introduction***. Sinkholes developed during two last decades along the Dead Sea western and eastern shorelines in Israel and Jordan are the main concern of the region. The salt dissolution model is accepted today as being the main mechanism of sinkhole formation (Yechieli et al., 2002). For sinkholes recognition in complicated geophysical fields is suggested to use a special method for distinguishing concentric structures based on summing up of horizontal gradients (Khesin et al., 1996; Eppelbaum, 2007a). The possibilities of potential and quasi-potential geophysical fields quantitative analysis for karst terranes localization are shown in Eppelbaum (2007b). In the framework of NATO *Science for Peace* (*SfP*) project No. 981128 a multidisciplinary geophysical study has been performed. Scientifically, the goal of the study is *to develop an integrated approach for prediction of natural hazards caused by the development of sinkholes in the Dead Sea region of Israel and Jordan through the joint application of hydrogeological and geophysical studies* (Ezersky et al., 2005). One of the problems studied in the framework of this project is an improvement of the microgravity method for detection of the buried salt dissolution caverns. In this presentation we consider the results of 3D microgravity modeling aimed to estimate a volume of the buried cave in the Nahal Hever South area revealed by Rybakov (2001).

***Site geology***. A group of sinkholes about 20-50m apart appeared in July 1998. These sinkholes (2.0-3.0 m deep and up to 3m in diameter) did not change their appearance over approximately 8-9 months, but then their sizes began to vary over some time and, at present, there are sinkholes clusters up to 50-100 m in diameter. The geological section is composed of alluvial fan sediments down to 18 m deep, a marl layer of 5 m thick and a salt layer of 11 m thick. A 5 m thick clay and gravel underlies the salt layer. The elevation of the area is approximately –393 m. The top of the salt layer is located at the depth of 24 m. In one of boreholes, a cavity filled by dense mud was detected at the depth of 2329 m, which is assumed to be the result of the salt layer dissolution. The visible section of sinkholes consists of sand-gravel intercalating clay-sand layers; iron oxide mineralization is also visible.

***Problem formulation***. Recent and previous surveys enable us to reach a complete understanding of the physical-geological model of the area and create the necessary precursors to mapping the salt layer (Ezersky et al., 2006). Microgravity mapping of 200 x 200 $m^2$ area was carried out in 1999 after the first sinkholes appeared (Rybakov et al., 2001). The residual microgravity anomaly of –(80÷130) microGal, extending in the north-south direction, was revealed in the area. The anomaly consists of three sections with sizes from about 20 x 20 $m^2$ to 50 x 50 $m^2$. About 5000 gravity stations were observed in this area. Gravity readings were corrected for the instrument drift, tidal drift, elevation and latitude to obtain the simple Bouguer gravity values. These data were completely terrain corrected (Rybakov et al., 2001). The recent studies have shown that the major limitation of the microgravity method is the disturbing effect caused by bodies underlying the studied targets. The method could be very effectively applied when the structure below the desired objects is known. It is especially important in zones of the salt layer existence. In our case gravity effect from salt layer distorts the observed gravity anomaly because salt density exceeds the surrounding medium density. Modeling of all factors participating in the formation of the gravitational field in the sinkhole development sites permits to exclude an influence of these factors and detect anomaly associated with the void existence (Rybakov, 2007).

***Results.*** We applied the Emigma 7.8 software (PetRos EiKOn Inc) to estimate the volume of the buried caverns and create the 3D physical-geological models of the sinkholes area development. The densities of bodies composing these models were obtained using known relationships from the seismic velocities and from the analysis of continuous vertical electric sounding (CVES). It should be noted that application of the *GSFC* program, developed specially for 3D combined gravity-magnetic modeling in complicated environments (Khesin et al., 1996; Eppelbaum and Khesin, 2004), gave the similar results.

***Conclusion.*** Results of the modeling clearly show potential of the microgravity method for the large buried cavern detection at the depths of 25-50 m. The microgravity study should be combined with other geophysical methods (seismic refraction and CVES) permitting specifying the geological structure of the site (salt layer borders and its surface topography, decompaction of the uppermost part of section, etc.).

***Acknowledgements***. Our study is sponsored by the NATO *Science for Peace* (*SfP*) program (*SfP* project No. 981128). We are also grateful to the Ministry of Infrastructure of Israel for supporting this investigation. We thank Dr. M. Rybakov for cooperation in framework of this project.

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