Geophysical Research Abstracts
Vol. 17, EGU2015-11324, 2015
EGU General Assembly 2015

Potential Geophysical Field Transformations and Combined 3D Modelling for Estimation the Seismic Site Effects on Example of Israel

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It is well-known that the local seismic site effects may have a significant contribution to the intensity of damage and destruction (e.g., Hough et al., 1990; Regnier et al., 2000; Bonnefoy-Claudet et al., 2006; Haase et al., 2010).

The thicknesses of sediments, which play a large role in amplification, usually are derived from seismic velocities. At the same time, thickness of sediments may be determined (or defined) on the basis of 3D combined gravity-magnetic modeling joined with available geological materials, seismic data and borehole section examination. Final result of such investigation is a 3D physical-geological model (***PGM***) reflecting main geological peculiarities of the area under study. Such a combined study needs in application of a reliable 3D mathematical algorithm of computation together with advanced methodology of 3D modeling. For this analysis the developed *GSFC* software was selected.

The *GSFC* (Geological Space Field Calculation) program was developed for solving a direct 3-D gravity and magnetic prospecting problem under complex geological conditions (Khesin et al., 1996; Eppelbaum and Khesin, 2004). This program has been designed for computing the field of Δg (Bouguer, free-air or observed value anomalies), ΔZ, ΔX, ΔY, ΔT, as well as second derivatives of the gravitational potential under conditions of rugged relief and inclined magnetization. The geological space can be approximated by (1) three-dimensional, (2) semi-infinite bodies and (3) those infinite along the strike closed, L.H. non-closed, R.H. on-closed and open). Geological bodies are approximated by horizontal polygonal prisms.

The program has the following main advantages (besides abovementioned ones): (1) Simultaneous computing of gravity and magnetic fields; (2) Description of the terrain relief by irregularly placed characteristic points; (3) Computation of the effect of the earth-air boundary by the method of selection directly in the process of interpretation; (4) Modeling of the selected profiles flowing over rugged relief or at various arbitrary levels (using characteristic points); (5) Simultaneous modeling of several profiles; (6) Description of a large number of geological bodies and fragments. The basic algorithm realized in the *GSFC* program is the solution of the direct 3-D problem of gravity and magnetic prospecting for horizontal polygonal prism limited in the strike direction. In the developed algorithm integration over a volume is realized on the surface limiting the anomalous body.

It is necessary to note that when we apply a series of interpreting profiles, we can compile several detailed maps of thicknesses of sedimentary or intrusive associations for the area under study. Such an experience was obtained for Carmel and Maanit areas (Eppelbaum and Katz, 2012a).

Taking into account that seismic site effects must have an obvious correlation with tectonic pattern (in regional, middle and detailed scales), satellite (gravity), airborne (magnetic measurements at 1 and 5 km levels) and land (both gravity and magnetic) data were processed by the use of different methodologies.

For instance, it was shown that magnetic gradient computations from airborne magnetic observations (1 km level) enable to classify the region under study to areas with thick sedimentary cover and areas with shallow intrusive rock location. Self-adjusting and adaptive filtering of gravity satellite obtained and magnetic airborne (1 and 5 km) data enabled to reveal the areas with quasi-homogeneous characteristics.

Satellite derived gravity data were processed by the use of numerous algorithms: entropy, adaptive filtering, wavelet, and information approach (Eppelbaum and Katz, 2015a, 2015b, Eppelbaum et al., 2014), and strike angle and virtual deformations (Klokočník et al., 2014). Application of these methods was effective not only for tectono-geological setting sharpening, but also for calculation of such parameters as ‘dominant location of subsurface masses’, areas of ‘compression’ and ‘dilatation’.

Land gravity and magnetic data were processed by the use of abovementioned algorithms including procedures of downward continuation and computation of third derivatives of gravitational potential.

For this investigation was utilized the recently constructed map of the Neogene-Quaternary structural stage (indicating thicknesses of these deposits) of Israel and the eastern Mediterranean (Eppelbaum and Katz, 2014b). Results of other map compilation (Palaeogene, Late and Early Cretaceous, Jurassic and Triassic structural stages, hypsometric map of the base of the newest (Post-Jurassic) tectonic complex as well as map of Lower Mesozoic wells and outcrop locations) (Eppelbaum and Katz, 2011, 2012a, 2012b, 2014a, 2014b, 2015a, 2015b) were taken into consideration for 3D ***PGMs*** construction.

Acknowledgements

This research was carried out under grant No. 214-17-016 from the Ministry of Infrastructure, Energy and Water Resources of Israel.

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