Analysis of Salt Intrusion Shape by Forward and Inverse Gravity Modelling Based on Real, Analog and Synthetic Data

Jan Mrlina, Roman Beranek

Institute of Geophysics CAS

Investigating salt structures in oil exploration still represents a difficult task due to loss of seismic signal and poor imaging. Even the contact of salt diapirs with surrounding basin formations cannot often be described by seismic in detail, needed for trap exploration. Magnetotellurics (MT) can provide a rough contour of salt structures, but without enough details. Then, gravity survey is a good choise to investigate these salt features. We performed numerous tests based on synthetic and analog gravity data, but also on real survey data. We started with forward gravity/density modeling of various shapes of salt diapirs (intrusions), using not only usual measured gravity data, but also gravity gradients. Resulting data mixed with ceretain level of noise were then used for gravity inversion process. We found some limits of sensitivity to selected starting models and extreme significance of realistic definition of starting models for sucessfull inversion result. We applied achieved experience to real data - we digitized published gravity maps with negative anomalies related to salt structures. Contrary to the publication, we developped more accurate and complex 3D model of the principal salt structure. Currently we follow analogue modelling of a simulated salt intrusion process in a laboratory, and perform gravity modelling according to digitized shape of salt (special silicon) intruding a homogenous sedimentary (sand) formations. Beside other methods, we apply 3D inversion using Tikhonov's deterministic inversion method implemented by the open-source python library SimPEG. The problem can be defined on a tensor or octree mesh with the possibility of mesh refinement to increase or decrease the resolution in certain parts of the model. The results provide a detailed density model of the diapir allowing the determination of the spatial extent of salt sheet. Our aim is also to achieve a suitable geometrical correlation with MT, as such twin gravity-MT response for various types of salt structures may encourage application of such twin geophysical methodology.