New software for the 2d inversion of dc-resistivity data (applied geoelectric, ageo)

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We present a newly developed software package for the interpretation of DC-geoelectric data in 1D and 2D. The 2D- forward modelling was implemented by using the Finite-Difference method to solve the Poisson equation for the two dimensional case. The obtained equation system was solved using Cholesky decomposition. Different inversion schemes like Marquardt, constraint Marquardt, and Occam were also implemented to get better information about the structure. These equations were then solved using the most commonly equations solvers. Another feature of the program is to derive the best electrode configuration for a given 2D conductivity model prior to a field experiment. The selection of the best electrode configuration is based on 2D forward modelling and a sensitivity analysis for the most commonly used electrode configurations. The program provides various graphical tools for analysing and viewing the results at different stages of computation. The new software was extensively tested with synthetic and field data. The results are in good agreement with other widely used numerical 2D inversion programs and also with analytical solutions. We show field examples of 2D inversion results from multichannel experiments of an archaeological site in Turkey.

Assessment of the deep structure of the El-Qaa plain, Southeast Sinai, Egypt, using MT and TDEM data.

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El-Qaa plain represents a structural depression trending NW-SE parallel to the main clysmic rift and extends for about 150 Km with average width of 15 Km. The main target of this study is to shed more light on the deep-seated basement structure, which might control the accumulation and flow of groundwater in this semi-arid area of Egypt. An electromagnetic survey comprising seven magnetotelluric (MT) stations and twenty five time domain electromagnetic (TDEM) stations was carried out along a profile crossing the plain. In addition, information from a pizometer nearby and dc resistivity sounding was used to constrain the interpretation of EM data. TE and TM modes of MT data were inverted separately and jointly to obtain the geoelectric cross section. TDEM data was used to correct the static-shift effect in MT data and to investigate shallow structures. The joint interpretation of the all available EM data elucidates the basement rock of the El-Qaa plain. There are minor shallow as well as deep faults dissecting the plain which are responsible for the graben structure. The interpreted cross section allows to explain the main structural settings across the study area.

Joint Interpretation of MT and Gravity Data - Case Studies from Polish Outer Carpathians

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Polish Outer Carpathians is a geological zone with unusually high complexity, which is located on the outskirts of Carpathians' major tectonic boundaries. The complex geological structure of the Carpathian orogen and its basement made seismic research very difficult. So, it is necessary to supplement seismic survey with other surface geophysical investigations, e.g. magnetotellurics and gravity method. A new approach of the comprehensive MT and gravity data interpretation was applied in selected areas. Joint interpretation of maximum horizontal gradient of gravity field and gravity deconvolution was analyzed together with maps of resistivity distribution at depth slices to obtain the initial structural model for quantitative interpretation. Next, 1D magnetotelluric and 2D magnetotelluric and gravity modeling and inversion (with different inversion codes) were made and a joint geological model based on seismic and borehole data was obtained. Such way of interpretation allows the authors to show some new presumable hydrocarbon traps located in the Carpathian basement.

Joint Bayesian inversion of self potential, hydraulic and thermal data: basics

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We have developed a Bayesian toolbox for the joint inversion of hydro-geothermal data: hydraulic heads, temperature, and linear combinations (e.g., velocities), with respect to thermal properties, hydraulic properties, and boundary conditions. As expected, this use of different data types often leads to considerably better results than hydraulic or thermal inversion alone. However, depending on the scale of the model, hydraulic heads or related quantities are relatively expensively to determine for deep reservoirs. For this reason the measurement of self potential may be a way to increase the available data for certain systems. Also, the inclusion of SP in comparatively easy within the given inversion framework. We will give the basic physics, present first synthetic results, and discuss possible field setups and the effectivity of the technique.

Study of causal relation between electromagnetic data and geodynamic activity monitorized in geodynamic observatories from Romania

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We obtained same categories of electromagnetic data with different system of acquisitions (ADU 06 METRONIX, ICP-CON, EDAS) for a long time in geodynamic observatories from Romania. Parallel with electromagnetic measurements we study the correlations of the measures done by different types of devices (gravimeters, clinometers, pendulum of different sizes, sensors of vibrations) in some locations (active geodynamic zones) from the Romanian territory (including also the surface and underground observatories which have a specific design, similar to ones of large wide world geodynamic observatories). All the data are processed with MATLAB, looking for a correlation with the major seismic events.

Analysis modalities of magnetotelluric soundings for a very long period in Vrancea seismogenic area.

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The magnetotelluric data were obtained with METRONIX device, set up in three measurement points, the measurements lasting one month each. The measurements were done in HF, LF1, LF2 and LF3 frequency domain. The data files are in ats format and there were exported in txt format through CYGWIN. Based on these data there were done several correlations between electrical, magnetic channels and crossed correlations electric-magnetic. As well, we compared electromagnetic data with of the measures done by different types of devices (gravimeters, clinometers, pendulum of different sizes, sensors of vibrations) situated in the Carpathians zone of Curvature, zone where the geotectonic conditions assure the realization of a natural geodynamic laboratory.

Geoelectric strike and 2-D inversion of a MT profile in the Parecís Basin, Brazil.

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A magnetotelluric profile crossing the Parecis Basin (Brazil) in a direction almost perpendicular to the regional geological strike has been made. In the 2-D inversion procedures of MT data, the impedance tensors were rotated by an angle of 140°(+- 10°) measured clockwise from the geographic north using the regional geological lineaments suggested by the main aeromagnetic data trend. An accurate interpretation of MT data requires an understanding of the dimensionality and directionality conditions that must be satisfied by the properties of impedance tensor. However, due to the usual presence of shallow, small-scale galvanic bodies which distort the responses, the regional scale structures can be masked. In order to verify if the geoelectric strike is concordant with the previous choice for the geological strike, a tensor decomposition of MT data procedure was applied for a set of 36 MT soundings in the profile. The results show that the distribution of strike angles is not uniform as expected, but that the bulk strike direction assumed a priori is compatible with the average strike angle. The observed departures from an average angle value can be explained in terms of the geotectonic structure of Parecis Basin and this influence in the geoelectric anisotropy. From a three-dimensional model of the basement topography obtained from the downward continuation of gravity field constrained by spectral estimates of depth to magnetic sources, it can be shown that the most regular strike angle distributions corresponds to the deepest sedimentary structures: Caiabís, Pimenta Bueno and Colorado Grabens. In the interface regions it can be expected that anisotropy is distorting the regional impedance tensor.

Joint inversion of gravity and geoelectric data

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A method to jointly invert gravity and resistivity data in order to obtain the geometry of the density/resistivity interfaces and subsurface electrical resistivity distribution is presented. The results obtained from synthetic data shows that the method significantly improves the solution decreasing the ambiguity of the models. The method was applied to gravity and resistivity data carried out in Sinai (northwestern of Egypt) and in NE Portugal.

Basement depths of 3D basins, estimated from 1D magnetotelluric inversion

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Detailed magnetotelluric soundings along the Hungarian section of the CEL07 seismic profile (SW Hungary, where a series of very deep 3D sedimentary basins is known from various geophysical-geological investigations) enabled us to produce magnetotellurics-based estimations for the topography of the high-resistivity basement. Both TM and TE modes were used for 1D inversion, and the resulting depth values were compared to the depths, taken from the "Pre-Tertiary Basement Countour Map of the Carpathian Basin" by Kilényi and Sefara (1990), called as K-S depths.

The first conclusion is that the observed depth differences do not depend significantly on the sediment resistivity. At the same time, three is a significant difference between the magnetotelluric- and the K-S depths over the Balaton line (the most important tectonic (fracture) line crossing the MT profile). The TE mode-based inverted depth values are smaller, the TM mode-based depth values are larger than the K-S depth values. The adjustment distance in case of the TE mode is of course larger than in case of the TM mode.

Apart from this distortion, the magnetotelluric depth values, especially the TM mode-based ones, are surprisingly very well approximate the K-S depth values. In case of the TM mode 75 p.c. of the differences are less than 500 m. (The average depth is nearly 4000 m). In case of the TE mode such a small deviation is obtained only in 40 percents of the total sounding sites, due to the significant TE effect of the Balaton line (a deep high-conductivity tectonic line).

Comparison of Borehole Resistivity, Deep-Towed CSEM and Seafloor Compliance Imaging of Marine Gas Hydrate Deposits and Cold Vent Structures

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Despite extensive studies, the nature of seismically-identified cold vents offshore Vancouver Island, including Bullseye vent drilled by the IODP Expedition 311, is still subject to debate. These vents may be filled with free gas or conduits of solid gas hydrate (both an energy resource and potential geohazard) since both can scatter seismic energy and cause 'blanking'. By combining techniques sensitive to physical properties affected by hydrate we distinguish between competing models. High resolution IODP data show significant resistivity anomalies in the uppermost 40 m, but these data are not representative of an extended region laterally. CSEM data gathered with the Toronto system show resistive anomalies more than five times background values. Seafloor compliance, the transfer function between pressure induced by surface gravity waves and the associated deformation, indicate increased shear moduli as expected only for gas hydrate, not free gas. Together these data are used to model the vent as a whole.

Deep crustal structure of the Granada Basin from MT soundings

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The Granada Depression is the largest Neogene-Quaternary basin of the central Betic Cordillera. In the Internal Zones, extensional detachments, with a top-to-the SW kinematics, separate metamorphic complexes. Gravity, magnetic, seismic tomography and refraction seismic data evidence the presence of deep crustal detachments. Preliminary 2D inversion of six new MT soundings along a profile crossing the southern part of the basin, from Internal to External Zones, provides the first deep resistivity image of the region. A crustal detachment, with related seismicity, probably separates the heterogeneous upper crust, which includes large normal faults, from the homogeneous lower crust.

MT sounding along the Almanzora Corridor synform

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The Almanzora Corridor is an E-W elongated synformal structure, deformed by different sets of extensional and compressional faults. MT soundings are located along N-S oriented profiles, that show the deep structure across the basin, and an E-W longitudinal profile. These new data contribute to determine the crustal structure of this sector of the Betic Cordillera, where a wide MT grid was already done. Preliminary 2D MT inversion shows the geometry of the low resistive Neogene-Quaternary sedimentary basin infill related to the synformal structure. A more homogeneous crust is evidenced at depth.