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Abstracts

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Abstracts

Stability monitoring of Bratislava urban area through time series InSAR image analysis

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Abstract: The main purpose of this research is to study the ground displacement characteristics and determine the causes of subsidence and/or uplift in urban area of Bratislava, capital city of Slovakia. This project represents first such academic initiative conducted from Slovakia country. The study area is situated in geologically and tectonically interesting area. The current state of relief and the spatial distribution of individual geological forms is the result of vertical tectonic movements, e.g. subsiding parts of Vienna Basin and Danubian Basin or uplifting mountains.

The work aims to perform a series of differential interferograms and PSInSAR technique, covering the target area with Envisat ASAR images from ascending track No. 229 and descending track No. 265 from years 2002 – 2010. Processing involves two different software solutions for obtaining the differential interferograms and performing the PS methodology: SARscape v4.4 and StaMPS v3.2.1.

By the detailed look on the deformation maps, strong deformation trend increasing from west to east is observable. The reason for this can be occurrence of residual processing errors such as uncompensated orbital errors or low frequency atmospheric effects, as the deformations due to geophysical phenomena and/or anthropogenic impact is not expected in this way of behavior. Process of improving the results is applied by the combination of all radar images to the interferometric pairs in order to eliminate radar images strongly affected by the atmospheric noise.

The preliminary analysis of the results (Fig. 1) shown that the investigated urban area of Bratislava is stable with the deformation rates within the few millimeters around the noise level.

Key words: InSAR, radar interferometry, deformation monitoring

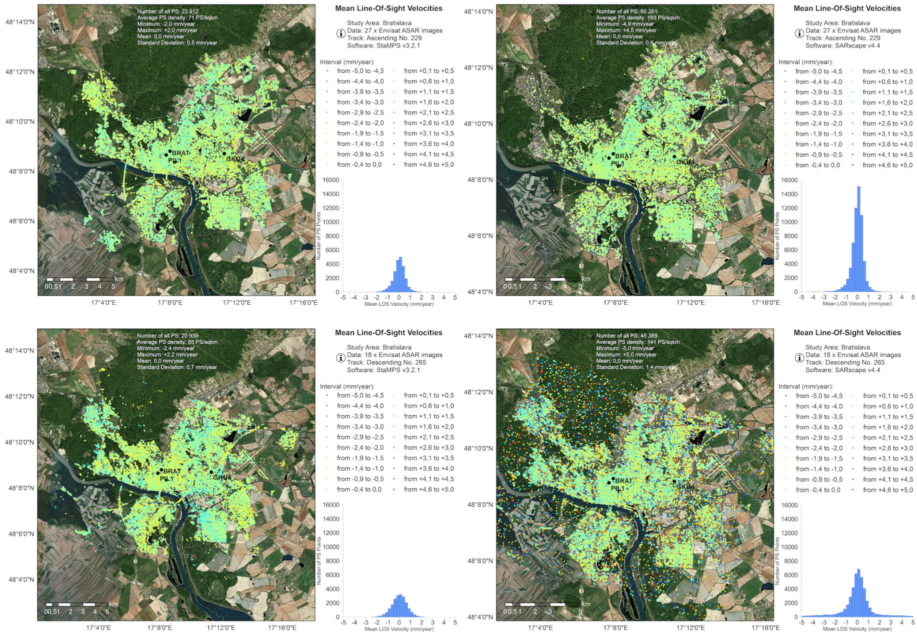

Fig. 1. Deformation maps of the Bratislava and surrounding area.

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Papčo, J., Bakoň, M., 2012: Object Recognition Based on High Resolution Radar Imagery. Deutschen Zentrum furn Luft- und Raumfahrt (DLR) TSX-Archive-2012 Project ID LAN1583.

Colours of stress

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Abstract: Stress tensor at a point cannot be rendered by colour only. Nevertheless, the relationships between the three principal stress values can be efficiently translated into an intuitively-readable colour map of stress. For this purpose we constructed three-dimensional colour functions (*Bednárik and Kohút, 2012*). We tested their performance on a stress field generated by the Brazilian test (Fig. 1). We can only recommend this promising visualization technique for applications in tectonics, geotechnics or seismic wave propagation modelling.

Key words: principal stress values, three-dimensional colour function

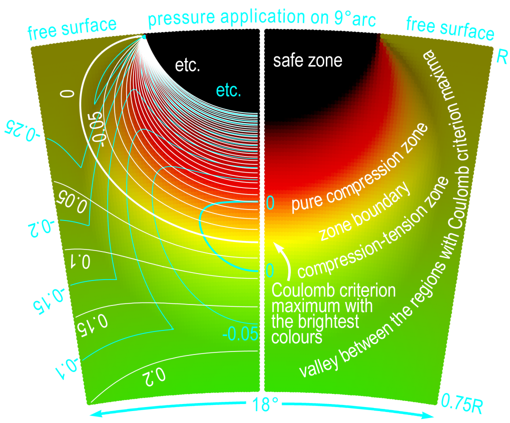

Fig. 1. Detail of the colour map of the stress field near one of the load application regions in Brazilian test.

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Deep-seated magnetic and geoelectric anomalies in the Western Carpathians

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Abstract: Magnetic map of Slovakia (*Kubeš et al., 2008*) shows distribution of rock complexes with higher magnetic properties. A basic division of magnetic anomalies according to geological provenance is as follows:

- The first group contains well identifiable rock complexes situated mostly on the surface, or in the shallow depths, represented by Neogene volcanic rocks developed on the surface and inside of Neogene sedimentary filling. There are also the Early and Late Paleozoic volcanics (mailny in Gemericum and Hronicum), basic and ultrabasic rocks of oceanic crust in Meliaticum and finally magnetic rocks belonging to crystalline basement (amphibolites, tonalites, mica-schists, gneisses) of various tectonic units.
- The second group is represented by large deep-seated (a depth more than 3 – 4 km) magnetic anomalies caused mainly by Cadomian basement or similar type of relatively heavy and magnetic crust. These are occured in the North below overthrusted the Outer Carpahians (Brunia); or in the blocks of the structure of the Inner Western Carpathians – mainly to the South of the Klippen belt and finaly in the South of Slovakia. Another types of deep-seated anomalies are connected with Neogene extension tectonics, that were caused by asthenolite ascent and accompanied of basic intrusions into crust (Danube and Transcarpathian basins). Several deep magnetic anomalies are situated within crystalline basement (tonalites?) bellow Tertiary sedimentary filling.

Deep geoelectic anomalies (high conductivity zones) are connected with deep and steep Neoalpine fault zones. A high condustivity is generated perhaps by crushed rocks containing higher amounts of carbon and fluids. Neoalpine faults are mostly of strike-slip character and separate the Inner Carpathians from the European platforme and individual tectonic blocks within Carpathians. That document “strike-slip type” of final stage of Western Carpathians Neoalpine

orogeny, which ended by “basin and ranges type of structure” connected with volcanic activity. Other types of higher conductive zones are caused by underlying metasedimentary complexes under granitic ones as a remnants of Hercynian tectonic pattern.

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Results of the extensometric measurements in Slovakia

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Abstract: The interpretation of the non-tidal deformations observed at the Vyhne tidal station showed that these deformations could be divided into three parts. The first component is periodical with the period about one year. The second one is not periodic. Moreover the short considerable changes in the rate of the slow deformations were observed. The comparison of the short changes of the slow deformations and the air pressure variations was made. From this comparison we can conclude that this part of the slow deformations is induced by the air pressure changes.

Surface displacements, deformations and gravity changes due to underground heat source

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Abstract: Thermo-elastic strains and stresses play a considerable role in the stress state of the lithosphere and its dynamics, especially at pronounced positive geothermal anomalies. Topography has a significant effect on ground deformation. Two methods for including the topographic effects in the thermo-viscoelastic model are described. First we use an approximate methodology which assumes that the main effect of the topography is due to distance from the source to the free surface and permits to have an analytical solution very attractive for solving the inverse problem. A numerical solution (for 2D plain strain case) is also computed using finite element method (FEM). The numerical method allows include the local shape of the topography in the modeling. In the numerical model the buried magmatic body is represented by a finite volume thermal source. The temperature distribution is computed by the higher-degree FEM. For analytical as well as numerical model solution only the forces of thermal origin are considered. The results show that for the volcanic areas with an important relief the perturbation of the thermo-viscoelastic solution (deformation and total gravity anomaly) due to the topography can be quite significant. In consequence, neglecting topography could give erroneous results in the estimated source parameters.

Keywords: displacements, deformations, gravity changes.

1 Analytical solution

The thermo-visco-elastic model presented in *Hvoždara (1992)* was applied to estimate the volcanic ground deformations. Fundamental equations for the uncoupled thermo-visco-elastic problem for a point heat source located at depth ζ are given in *Nowacki (1962)*. Thermo-visco-elastic gravity anomaly on the surface is given by *Brimich (2000)*.

Charco et al. (2002) propose a simple method for including topographic effects in a 3D thermo-visco-elastic model that allows source depth to vary with the relief. On the Figs 1, 2 and 3 are given horizontal, vertical thermo-viscoelastic displacement (in m) as well as the gravity changes computed for different relaxation times and the static value (thermoelastic case) considering (a) a flat

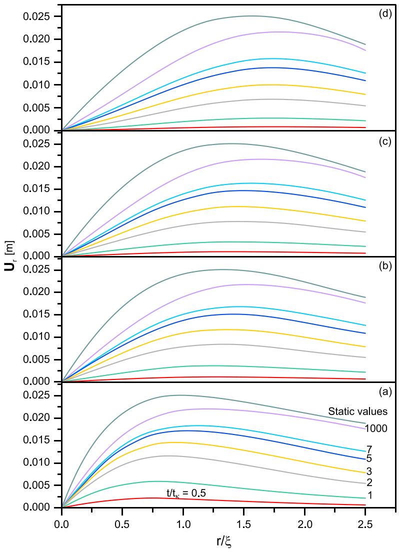

Fig. 1. Radial displacements

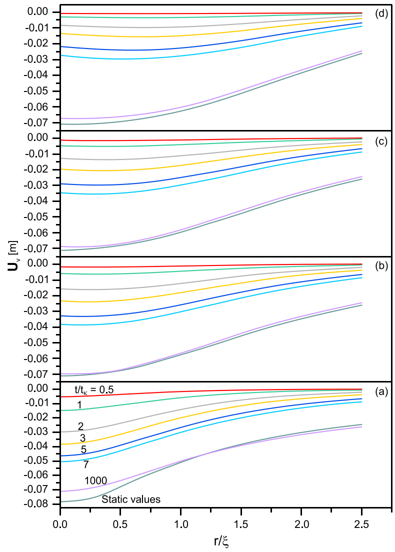

Fig. 2. Vertical displacements

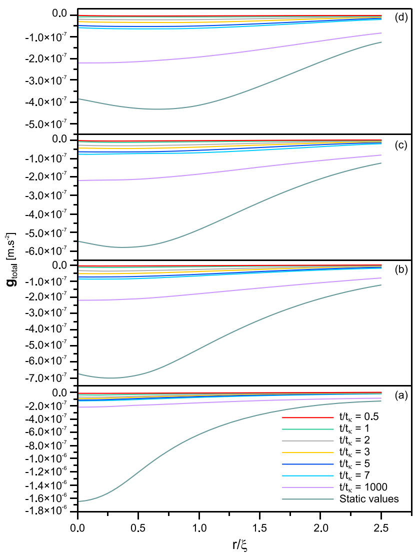

Fig. 3. Gravity changes.

surface, and (b)-(d) axis-symmetric volcanic cone with an average slope of the flanks of 15º, 20º and 30º respectively. The influence of the topography is visible as the horizontal shift of maximal values of the both displacement components and particularly gravity changes.

2 Numerical solution

To include the topography effect in the thermoelastic solution we have used the finite element method computation. The principles and basics of finite-element method are generally known and are described in numerous monographs (e.g. *Irons and Ahmad, 1986; Babuška and Szabo, 1990*). All the computations are obtained by the COMSOL Multiphysics© software. Although numerical methods are time consuming, their results are more precise than the analytical approximate solutions since they allow to include structural characteristics of the medium as the topography.

The models are homogeneous, isotropic, axi-symmetric with respect to vertical axis. In this way, the 3D rock massif has been modeled by an axi-symmetric section with respect to vertical axis passing through the heat source with 2 versions – with and without topographical feature modeling the volcano cone (of 2 km height). The summit of the volcano is located over the thermal source. The domain horizontal length is 120 km and the vertical span is from +2 to –38 km in order to minimize the influence of the external boundaries. The heat source is modeled by the spherical body in the 5 km depth. In the computation only the forces of thermal origin are considered.

At first step, the domain was divided into finite elements. The mesh corresponding to each plane section is formed by 19568 triangular elements. In the neighborhood of the thermal source, the mesh is refined into smaller elements due to the large gradients of computed fields in this area (see Fig. 4). On the Figs 5 and 6 are given radial and vertical displacements obtained using FEM.

3 Discussion

The methods described in this work can be very suitable to more complex models that consider sources of different geometries and allow elastic properties of the medium to vary with depth. While the analytical approximate methodology can be very attractive for solving the inverse problem, the numerical method described above may be used to include the topography when accurate solution is desired since it permits the consideration of non-uniform elastic and thermal properties of the medium and the local shape of the Earth's surface.

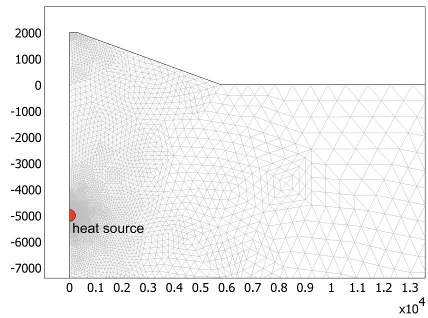

Fig. 4. Mesh with the position of the heat source.

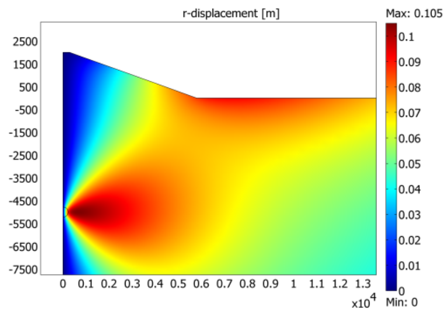

Fig. 5. Radial displacements

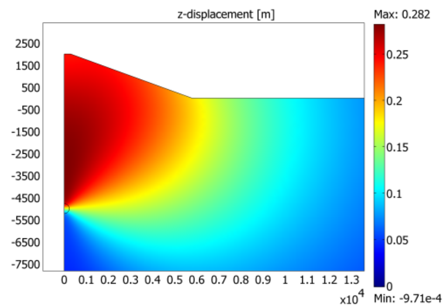

Fig. 6. Vertical displacements

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Detailed Profile Gravity Measurements in the Pieniny Klippen Belt (Middle Váh Valley, Western Slovakia)

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Abstract: The examined area is situated in the Púchov section of the Pieniny Klippen Belt (PKB) in western Slovakia, on the territory of municipalities Tuchyňa, Mikušovce, Červený Kameň and Kvašov (Fig.1). The main aim of our research was to broaden the present knowledge on geological structure of the PKB and on its tectonic connection to the surrounding regional units using the geophysical methods.

The profile gravity measurements consist of two parallel profiles named *prof_1* and *prof_2* of roughly NNW-SSE direction. The eastern section *prof_1* has a length of 6.36 km; the western profile *prof_2* is about 3.84 km long (Fig.1B). Measurements were carried out at intervals of 20 meters (overall 506 points were gauged) by gravimeters Scintrex CG3 and CG5. The acquire data were processed into the Bouguer gravity anomalies. The software package GM-SYS (Geosoft) was applied for the gravity modelling and the final geological-geophysical sections represent distribution of the lithological members with their specific density parameters (density values were determined by the own laboratory measurements of rock samples collected along the profiles). The density modelling was also based on the results obtained by the geoelectrical exploration (vertical electric sounding and resistivity profiling), new surface geological mapping and borehole interpretation (continuously cored bores MIK-1 and

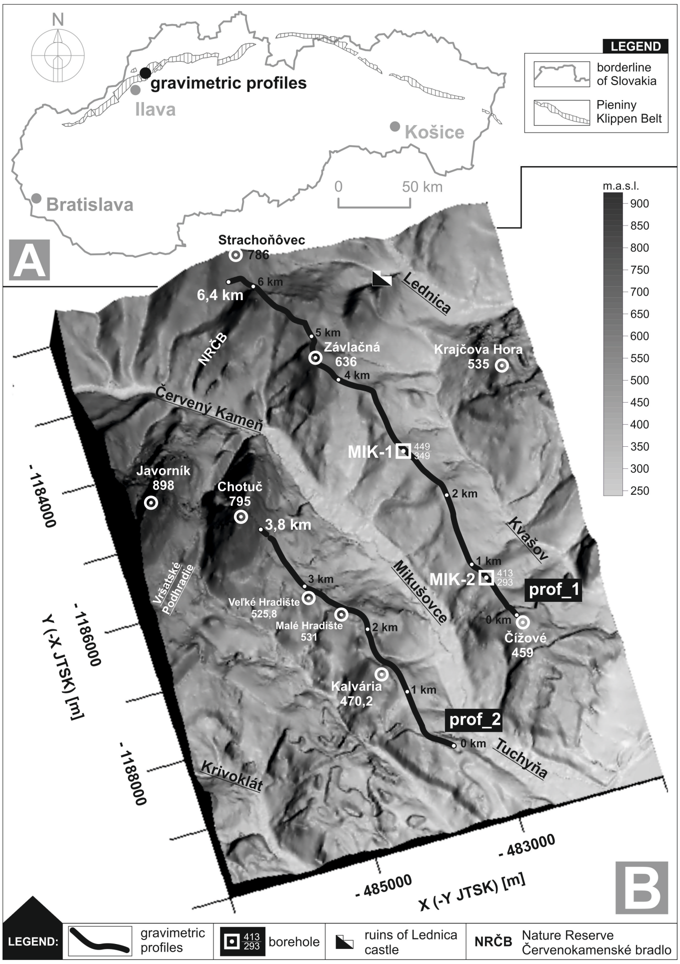

Fig. 1. Location of the gravimetric profiles (prof_1 and prof_2). A: General position of the profiles in Slovakia. B: Detail 3D topographic map of the studied profiles (black lines).

MIK-2).

Presented detailed gravity measurements reflect density differences between klippen (rigid limestone blocks) and their mantle (predominant marlstone) and they demonstrate that the primary fold-nappe system of the PKB was destructed by the subsequent deformation, resulting in the formation of the positive flower structure and backthrusting. Summing up, the new density modelling confirmed complex geological structure of the studied area and helped us to better interpret the tectonic evolution of the PKB.

Key words: applied geophysics, gravity measurements, Bouguer gravity anomalies, Pieniny Klippen Belt, Western Carpathians

Acknowledgements: The authors are thankful to the Slovak Research and Development Agency (grants APVV-0465-06 and LPP-0225-06) and the Slovak Grant Agency VEGA (grant No. 1/0095/12) for the financial support.

Near real-time web based automatic processing of macroseismic questionnaires – testing, verification and validation

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Abstract: Slovak macroseismic questionnaire and its processing were updated to the EMS-98 scale in 1999 (*Labák et al., 1999*). However, the macroseismic survey had to be conducted in a manual manner. The approach required significant effort connected with questionnaires distribution and consequent processing. It prevented fast estimate of macroseismic impacts of an earthquake.

Semi-automatic procedure was developed and tested in 2002 (*Labák and Kováčová, 2002*). It provided semi-automatic estimate of intensity values, but still it was necessary to conduct the survey manually (and to collect questionnaires by ordinary post service) and to load input data from the questionnaires manually into the software. Later, the web interface enabling to electronically fill in macroseismic questionnaires directly on the institutional web page was created and the new software tool for automatic extraction of input information into semi-automatic processing of macroseismic data was developed at Geophysical institute of Slovak Academy of Sciences. This recently implemented electronic dissemination and acquisition of the questionnaires significantly reduced the time necessary for conducting a macroseismic survey. However, the near real-time (NRT) automatic processing and producing of outputs (intensity maps, tables) would be the very useful next improvement of the current macroseismic processing scheme.

Therefore, the new approach based on the web forms connected to the seismic database has been developed as a part of the new seismic database development. The new environment will integrate the earthquake information based on the instrumental measurements with the macroseismic information and it will provide NRT automatic processing of the macroseismic data with corresponding outputs.

The new XML model of the questionnaire and automatic processing techniques have some inherent limitations and hence prevent the exact implementation of the currently used questionnaire into the one suitable for NRT automatic processing. Therefore, the new version of questionnaire and its processing is carefully tested and verified by reprocessing of sets of questionnaires for several earthquakes for which the results of previous manual processing are available. Influence of differences between the two questionnaire versions and of their processing on the estimated macroseismic intensity values is investigated and discussed.

Key words: macroseismic questionnaire, EMS-98, near real-time (NRT), automatic processing, seismic database

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Earthquakes in Slovakia

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Abstract: The monitoring of seismic activity of the territory of Slovakia is one of the main tasks of the Geophysical Institute of the Slovak Academy of Sciences. The Department of Seismology operates the National Network of Seismic Stations that consists of 12 seismic stations. The Iža seismic station is temporary out of operation due to security reasons and considerable increase of seismic noise level. Replacement of this seismic station to new and more appropriate location is considered. Data from seismic stations are transmitted to the data center in Bratislava in real-time and processed in two steps – an automatic processing with real-time first localizations, and a detailed manual interpretation on daily basis. In addition to data from the national network, the center also collects data from the Virtual Network of Seismic Stations comprising seismic stations of the cooperating institutions from the Central and East-Western Europe.

The Department of Astronomy, Physics of the Earth and Meteorology of the Faculty of Mathematics, Physics and Informatics, Comenius University operates the Local Seismic Network of Eastern Slovakia. The local network consists of 6 seismic stations with real-time data transmission to the data center in Bratislava. Data processing and analysis is similar to that in the national network. There is a close cooperation between both research institutions.

The Department of Seismology of the Slovak Academy of Sciences also cooperates with the Progseis company that operates the local networks of seismic stations deployed around nuclear power plants Mochovce and Jaslovské Bohunice. These data are particularly usefull for studying the Dobrá Voda source zone. Monitoring of the northern part of this source zone was improved by three additional temporal seismic stations built in cooperation between Geophysical institute of Slovak Academy of Sciences, the Progseis company and the Institute of Rock Structure and Mechanics of the Academy of Sciences of the Czech Republic, Prague. The three new stations started their operation at the end of 2011/beginning of 2012.

Using seismic data from the National Network of Seismic Stations and the Local Seismic Network of Eastern Slovakia about 155 earthquakes with epicenters on the territory of Slovakia were seismometrically localized in the period 2011-2012. In the same period, 8 earthquakes with macroseismic effects were observed on the territory of Slovakia - 1 of them with epicenter in northern Hungary (near Tatabánya), 7 with epicenters in Slovakia. The highest reported macroseismic intensity on the territory of Slovakia was 4° EMS-98 for the March 5, 2012 Záhorie area earthquake and the May 2, 2012 Vihorlat area earthquake. We experienced quite large amount of macroseismic questionnaires submitted through web interface (more than 1800 questionnaires for the January 29, 2011 northern Hungary earthquake and more then 800 questionnaires for the May 31, 2012 Vernár area earthquake). The new software tool for automatic extraction of input information for the processing of macroseismic data was developed in 2011.

Key words: seismic stationc, monitoring, earthquakes in Slovakia

Calculation of temperature distribution and rheological properties of the lithosphere along transect I in the Western Carpathians

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Abstract: Using the 2D integrated modelling method, we calculated the temperature model of the lithosphere along transect I passing through the Western Carpathians. Based on the extrapolation of failure criteria, lithology and calculated temperature distribution, we derived the rheology model of the lithosphere in the area. Our results indicate clearly that the strength decreases from the Bohemian Massif via the Western Carpathians to the Pannonian Basin. The largest strength can be observed within the upper crust on the boundary between the upper and lower crust. This phenomenon is typical for all studied tectonic units: the Bohemian Massif, the Western Carpathians and the Pannonian Basin. These results suggest mostly rigid deformation in the upper crust of the units. By contrast, the lower crust in the Bohemian Massif and the Western Carpathians reflects significantly lower strength, while in the Pannonian Basin the strength is the smallest. In all tectonic units the strength within the uppermost mantle (lower lithosphere) disappears. It can be suggested that the ductile deformation dominates in this part of the lithosphere.

Key words: integrated modelling, temperature, rheology, strength, compression, extension, the Western Carpathians

Effect of artificial disturbances from magnetic dipole sources in the geomagnetic field at the GO Hurbanovo

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Abstract: Geomagnetic Observatory at Hurbanovo is one of the few observatories in the world, which from beginning of their existence – although with interruptions – register the changes of the geomagnetic field at the same place. This also entails problems: more and more artificial disturbances appear. The observatory is located in the built-up area of the city, 200 meters from the main road. In this work we try to calculate the possible effects of external sources which have dipole character and appear mainly in the registration of the Z component of the geomagnetic field.

Key words: geomagnetic observatory, artificial disturbances

ERT reciprocal measurements

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Abstract: In recent years, the reciprocal measurements are often carried out to estimate data quality for resistivity methods (*Slater et al., 2000*). The reciprocal resistance measure is obtained by exchanging the current electrodes with the potential electrodes of the normal resistance measure (Fig. 1). The reciprocity theory was described by *Frank Wenner (1912 and 1915)* for homogeneous environments. Theoretically, without any noise the normal and reciprocal measurements should give same observed values, so the difference between the two measurements will give an estimate of the measurement errors.

This principle was tested by the synthetic models of vertical stratification environment and prism in a homogeneous environment, which are represented heterogeneous environment. The apparent resistivity values for synthetic models were calculated using an algorithm based on the method of finite differences by *Dey and Morrison (1979)* for Wenner-alpha and dipole-dipole electrode arrays. The common differences were found in terms of the apparent resistivity due to heterogenity of environment. The largest differences occur in the areas of the vertical contacts resistivity bodies. The differences observed by reciprocal measurements are influenced by the type of electrode array and value of resistivity contrast at the boundary of the model bodies.

Reciprocal measurements are applied in real measurements at several locations. To detect noise in the measured apparent resistivity values we used repeated measurements of the same electrode position. Observed differences reached values up to 10%. Comparing the normal and reciprocal measurements, we found significantly higher differences. The position of differences was detected in the areas around the resistivity of lithological units, in cases with relatively simple geological structures. In cases with complicated geological structure, the differences characterize the overall heterogeneity of the environment.

The principle of reciprocal measurements therefore can not strictly be used to assess the quality of the measured data in heterogeneous environments. On the other hand, reciprocal measurement allows locating the position of anomalous structures.

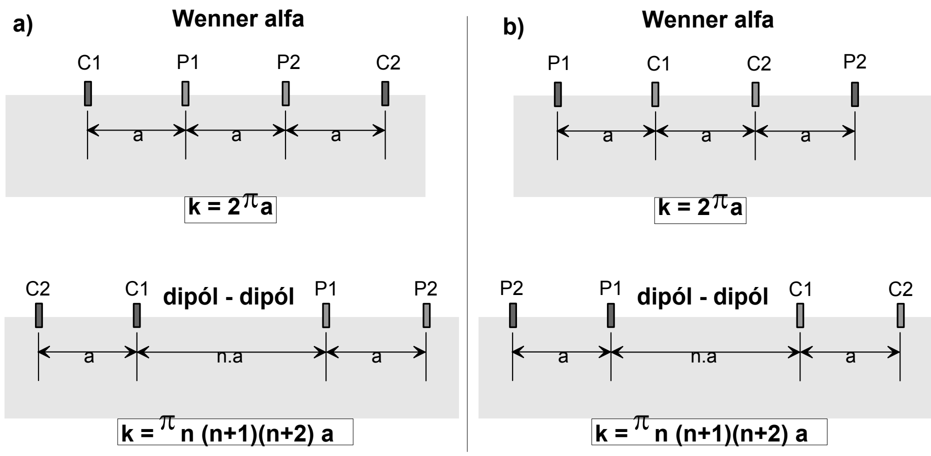

Fig. 1. a) normal position of elektrodes, b) reciprocal position of elektrodes, C1and C2 – current electrodes, P1and P2 – potential electrodes.

Key words: electrical resistivity tomography, reciprocal measurements

Acknowledgments. The authors are grateful to the Slovak Research and Development Agency APVV (Grant Nos. APVV-0194-10, APVV0625-11) and the Slovak Grant Agency VEGA (Grant Nos. 1/0095/12, 2/0067/12, 1/0747/11, 1/0712/11) for the support of their research.

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Geodetic monitoring of earthquake-related displacements

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Abstract: The method of Precise Point Positioning (PPP) is based on simultaneous processing of code and carrier phase measurements of satellites of the Global navigation satellite systems (GNSS) in un-differenced mode. Application of PPP algorithms requires consistent modeling of all relevant disturbing effects (relativity, troposphere and ionosphere delays, etc.) as well as use of precise satellite orbits and satellite clock parameters. The data processing by PPP allow to determine geocentric coordinates of points on the Earth's surface with sub-centimeter accuracy without requiring the reference to terrestrial coordinate frame.

The modern geodetic GNSS receivers enable to record satellite observations with 1 Hz or higher (up to 100 Hz) sampling frequency. Application of PPP then offers continuous monitoring of short-term coordinate variations of individual site during specified time interval without relation to other GNSS observing sites. Such possibility can be used for evaluation of short-term displacements related to seismic activity.

In this paper we show the possibility of detection and monitoring of earthquake-related horizontal and vertical displacements. The changes of position due to seismic events of various magnitudes and with various distances from epicenter will be presented. Our analyses are based on 1 s sampled GPS observations on selected permanent stations, with data available before, during and after the earthquake. The GPS data processing was realized with ABSOLUTE software package designed for the analysis of satellite observations using PPP method, developed at the Department of Theoretical Geodesy, Slovak University of Technology.

For study of earthquake related displacements the software ABSOLUTE was modified to determine the instantaneous site coordinates for each epoch as a new independent parameter. We use the iono-free ranges obtained from combination of code and phase measurements. Troposphere is eliminated with the standard model in combination with stochastic modeling. The estimated parameters are the updated real valued ambiguities, station coordinates and receiver clocks for each observing epoch. For the estimation procedure the Kalman filtering ap-

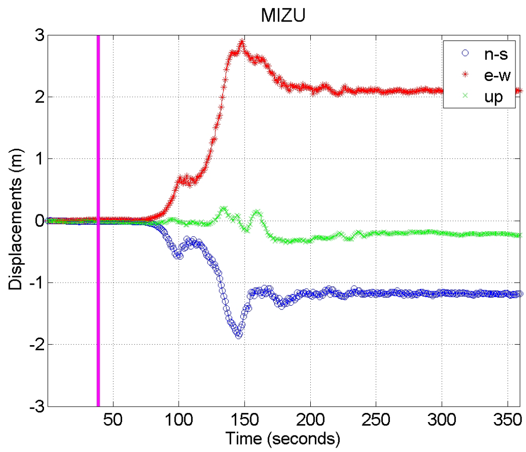

Fig. 1. Coordinate displacements in north-south, east-west and up components on IGS permanent station MIZU during Honshu earthquake 2011, Japan.

proach is applied. For detection and description of the earthquake related displacements we propose two modifications of data processing: PPP in kinematic mode at stations with significant changes in the position and PPP residuals from static mode to detect small positional changes.

Results of application of the software ABSOLUTE are demonstrated on earthquakes with magnitudes from 4.3 to 9.0 on permanent GNSS stations with distances from 5 km up to 2700 km from the epicenter.

Key words: GPS seismology, geo-kinematics, Precise Point Positioning

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Integrated modelling of the lithosphere in the Carpathian – Pannonian Region

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Abstract: We applied 3D inversion (*Motavalli et al., 2013*) to obtain 3D model of the lithosphere in the Carpathian – Pannonian region. The algorithm used is a very fast method based on a Bayesian approach with Gaussian probability density functions. We used a 3D algorithm (GT_3D_INV) to obtain the density structure of the lithosphere from joint inversion of free air gravity, geoid and topography data. The algorithm delivers the crustal and lithospheric thicknesses and the average crustal density in vertical columns. The inversion process may be stabilised by using damping and smoothing parameter as well as use of a priori information like crustal thicknesses from seismic profile. In this work we used a new Moho map of the Carpathian – Pannonian region (*Csicsay, 2010*) as a priori input data file.

The Moho thickness is therefore very similar to the input file with maximum crustal thickness under the Eastern Carpathians Foredeep and minimum crustal thickness of 23 km under the Pannonian Basin. In general, the thickness of the lithosphere decreases from the older and colder Platforms to the younger and hotter Pannonian Basin. The resulting lithospheric thickness varies from a maximum depth of 240 km under the Eastern Carpathians to 180 km under the Southern Carpathians, 100 km under the Transylvanian basin, 100 km under the Aegean Sea and more than 70 km under the whole Panonnian Basin region with some local higher values. Values of less than 40 km can be found in the Southern Carpathians. However, we do not interpret this as real lithospheric thickness. Extremely high values of average crustal density of about 2950 kg/m^3 were obtained in the East European Platform with its Precambrian basement. Up to 2900 kg/m^3 were obtained in the Southern Carpathians, in the western part of the Moesian Platform, in the southern part of Pannonian Basin and in the Transylva-

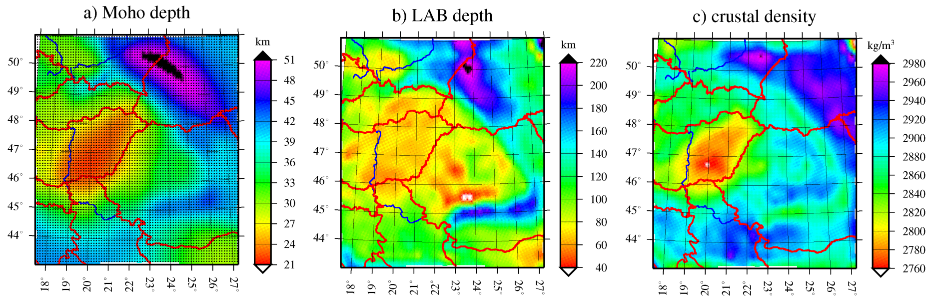

Fig. 1. Result of the 3D inversion using *a priori* data (*Csicsay, 2010*). Black dots in the first image indicate the location of *a priori* data points.

nian Basin, minimum values of about 2770 kg/m^3 were found in the Pannonian Basin. The previous studies in the Pannonian Basin show lower crustal densities (*Dérerová et al., 2006*) which can be a consequence of thinner, younger crust and also considerable thicknesses of sedimentary cover. On the other hand in the Foredeep such low values of the densities are caused by the thick Neogene sediments which decrease the average density.

Key words: 3D inversion, crust, lithosphere, density, Carpathian – Pannonian region

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Pre-Tertiary basement structure of the Turiec Basin using 3D density modelling

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Abstract: New results related to the thickness and density of the sedimentary fill of the Turiec Basin allowed us to construct the first stripped gravity map for this typical intramontane Neogene depression of the Western Carpathians (*Krajňák et al., 2012*). The stripped gravity map of the Turiec Basin reflects the gravity effects of the density inhomogeneities which are located beneath the sedimentary basin fill. This map is therefore suitable for the interpretation of the structure and composition of the pre-Tertiary basement. The 3D density modelling was used to calculate the gravity effect of two density models. The stripped gravity maps were produced by subtracting the density model gravity effects from Bouguer anomalies. Regional trend was removed from the stripped gravity maps also. The residual stripped gravity maps were consequently used for geological interpretation of the pre-Tertiary basement of the Turiec Basin. The pre-Tertiary basement of the Turiec Basin can be divided into northern and southern parts due to its gravity characteristics. Furthermore the northern part can be split into two domains: western and eastern. The crystalline basement of the western domain is likely built by the Hercynian crystalline basement of the Tatric Unit. In the eastern domain the basement consist mostly of the Mesozoic complexes of the Fatric unit. The southern part of the pre-Tertiary basement of the Turiec Basin is built predominantly by Mesozoic complexes of the Hronic unit. It is suggested that the Hronic unit also forms the bedrock of the volcano-sedimentary complex of the Kremnické vrchy Mts. Total horizontal gradients using the

regularized derivatives in the Fourier domain, selecting the optimum regularization (low-pass filter) parameter by means of the C-norm functions analysis (*Pašteka et al., 2009, 2012*) we calculated for the resultant stripped gravity maps and have also proven to be very useful for the interpretation of faults or fault systems in the study area. Various faults, particularly of NNE-SSW and NW-SE directions were discovered. The analysis of the faults indicates clearly that the contact of the Turiec Basin with the Malá Fatra Mts and the Veľká Fatra Mts is tectonic.

Key words: applied geophysics, gravity, 3D density modelling, stripped gravity map, Turiec Basin, Western Carpathians.

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Comparison of discrete representations of heterogeneous medium using canonical models of the Mygdonian basin (near Thessaloniki, Greece)

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Abstract: The Mygdonian basin, an elongated tectonic graben located approximately 30 km ENE of the city of Thessaloniki, is one of the major threats for the city, as witnessed by the 1978 Stivos earthquake which occurred on one of the fault branches shaping the graben. A realistic 3D seismic model of the Mygdonian sedimentary basin has been developed with more than one decade of focused seismological, geophysical and geotechnical investigations by Greek seismologists and their international collaborators zones. The model is characterized by complicated geometry of the internal interfaces in sediments and sediment-bedrock interface, relatively low S wave speed in the uppermost sediment layer, large velocity contrast between sediments and bedrock ranging from 4 to 13, large P wave to S wave speed ratio in the uppermost sediment layer (7.5). The verification phase of the international E2VP project (Euroseistest Verification and Validation Project organized by the CEA – Commissariat à l'énergie atomique et aux énergies alternatives in France) led to decision to compare the most advance numerical-modelling methods using canonical modifications of the realistic 3D model of the basin. The canonical models include 3 homogeneous layers over halfspace, 3 gradient layers over halfspace, simplified 2D vertical North-South cross-section of the basin with the wedge-type northern margin and vertical southern margin of sediments. We simulated seismic wave propagation in the models using our finite-difference methodology and compared four alternative discrete representations of continuous and discontinuous heterogeneities of material properties - LOC – local (point) values of the elastic moduli and density, ARI – volume arithmetic averages of the elastic moduli and volume arithmetic averages of density evaluated using numerical integration over a grid cell centred at the grid position of the elastic modulus or density,

HAR – volume harmonic averages of the elastic moduli and volume arithmetic averages of density evaluated using numerical integration over a grid cell centred at the grid position of the elastic modulus or density, ORT – volume effective coefficients corresponding to the orthorhombic averaged medium. The LOC and ARI are still used by some modellers despite the fact that they violate traction continuity condition at material interfaces. The HAR and ORT approximate the boundary condition. We demonstrate that the two latter representations yield considerably more accurate results. The difference is significant in presence of clear material interfaces in the model.

Key words: finite-difference modelling, Mygdonian basin, material parameterization, verification and validation

Data processing in archeomagnetism

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Abstract: Archeomagnetism is the study of the record of the Earth´s magnetic field in the burning archeological objects (clay bricks, furnaces). It is possible because the iron-bearing minerals may record past directions of the Earth´s magnetic field (*Krs, 1969*).

When a thermally altered archeological object cools, it acquires a thermoremanent magnetization from the actual Earth´s field. For the laboratory results processing of thermally altered archelogical material the Thellier method is used (*Thellier and Thellier, 1959*).

Five processing programs, working only for older version of operating systems, have been used up to now. Now we are testing new program based on Thellier method. It was written in Fortran 90. Two ways of data processing are compared on the samples from locality *Starý Plášť*. It turns out that both treatments give similar results.

Key words: archeomagnetism, Thellier method, data processing

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Matlab based ERT forward modeling and inversion by means of 3D finite differences approach

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Abstract: The main aim of the work is to develop stable, robust and reliable algorithm, based on the minimal structure inversion, producing minimal structure and sharp boundaries models. Preliminary results of ERT inversion and forward modeling Matlab package are presented. The main core of the forward modeling code is based on the 3D finite differences modeling code adopted from *Dey and Morrisson (1979)*, where several improvements has been made. Singularity removal technique seems to be most significant improvement to the final results. An up to date numerical techniques, like parallelization and modified preconditioning speed up the solution. These techniques enables us to employ 3D geometry concept to calculate very accurate 2D and 2.5D structures as well with comparable time requirements to the 2D algorithms, which makes the forward modeling code very versatile.

The inverse problem in ERT method is non-linear, so it has to be solved iteratively, where a sensitivity matrix is needed to make a linearized approximation. Presented algorithm is based on the IRLS method (*Farquharson, 2008*), which adaptively adjusts data weights during the inversion on the most non-fitting data during each iteration. The objective function to be minimized in our case follows:

$$\Phi = \phi_d + \lambda \phi_m ,$$

where index d and m represent data and model misfits respectively and λ is dumping factor, which is decreasing during the inversion. For minimum structure and sharp models the l_1 norm is mostly used to evaluate the misfit function.

A series of synthetic models has been computed to test the forward modeling code and the inversion code as well with very satisfactory results. An example is shown in Fig. 1.

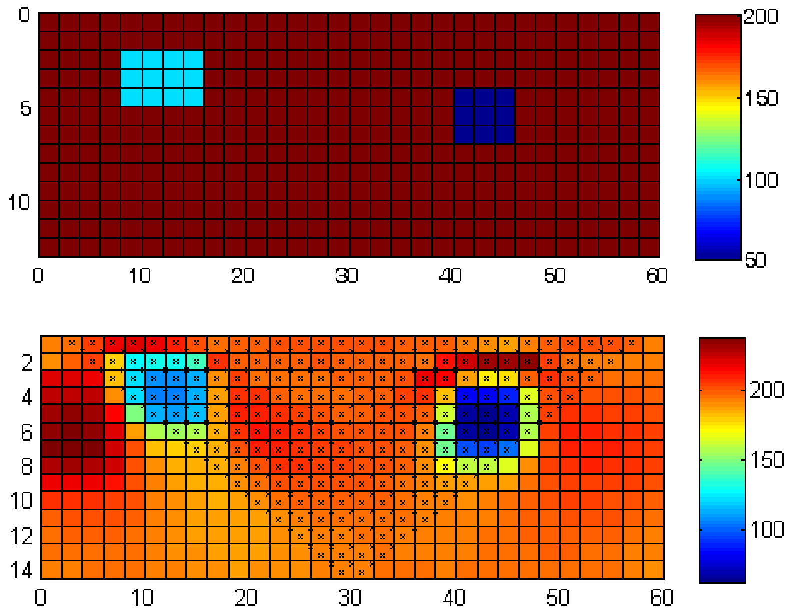

Fig. 1. Comparisson between the model data (a) and the inverse image (b) obtained for dipole-dipole electrode configuration in iteration 8 with relative RMS error 2%.

Key words: inversion, forward modeling, ERT, Matlab

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Compilation, processing and analysis of earthquake catalogue for the NNPP region

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Abstract: The NNPP region is a symmetric geographic area of a circular shape with a radius of 305 km centred at the site of the potential New Nuclear Power Plant near Jaslovské Bohunice. The NNPP region includes parts of the territories of Slovakia, Hungary, Austria, the Czech Republic and Poland, and it partly extends up to Germany, Slovenia, Croatia and Serbia. We elaborated a new earthquake catalogue relevant for the probabilistic seismic hazard assessment for the NNPP site. Preparation of the catalogue consisted in the following steps: A. Compilation. 1. Merging of the so-called national catalogues, bulletins (yearbooks) of national seismological agencies, regional catalogues and global databases of earthquakes (e.g., ISC catalogue); the total number of the used primary catalogues is 10, selected articles were also used. 2. Identification of multiple entries. 3. Selection of primary entries. The resulting database consists of 9142 entries (one entry corresponding to one earthquake). B. Processing. 1. Homogenization of database for a single quantity determining the earthquake size – the moment magnitude Mw. 2. The subset of the database including only earthquakes with Mw >= 1.5 was defined as the earthquake catalogue for the NNPP region. It includes 2652 earthquakes. C. Analysis. 1. Catalogue declustering – identification of foreshocks, main shocks and aftershocks. 2. Analysis of spatial and temporal completeness of the catalogue.

The declustered catalogue served as the basis for determination of magnitude-frequency relationships and maximum magnitudes for identified seismic source zones.

Key words: earthquake database, earthquake catalogue, catalogue declustering, analysis of completeness, probabilistic seismic hazard assessment

Thermal state of the Trancarpathian depression lithosphere

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Abstract: The contribution deals with the interpretation of the geothermal data measured and determined in the region of the Transcarpathian depression and surrounding units, modelling results along profiles crossing this region and of additional local heat flow refraction and/or source-type models. For qualitative and quantitative analysis of the thermal field we used also the modelling results of other authors (stationary and transient models, integrated approaches,...), other geophysical/geological data and the tectonic development of the region under study that influences the temperature and heat flow density distributions.

The mathematical tasks arising from the heat transfer equation solution were fulfilled mainly by the means of the finite difference methods, finite element methods, boundary integral technique or by application of various exact solutions.

Presented results have a great importance both for interpretation of measured geothermal data, modelling of thermal fields, geothermal maps constructions etc. The results are also applicable by prospection of the geothermal energy resources in the most perspective region both for Slovakia and Ukraine.

The works were accomplished within the bilateral project between Slovak and Ukrainian geophysical institutions and with partial support of grants APVV-0724-11, VEGA 2/0067/12 and VEGA 1/0095/12.

Key words: geothermal models, heat flow density, tectonics, Transcarpathian depression

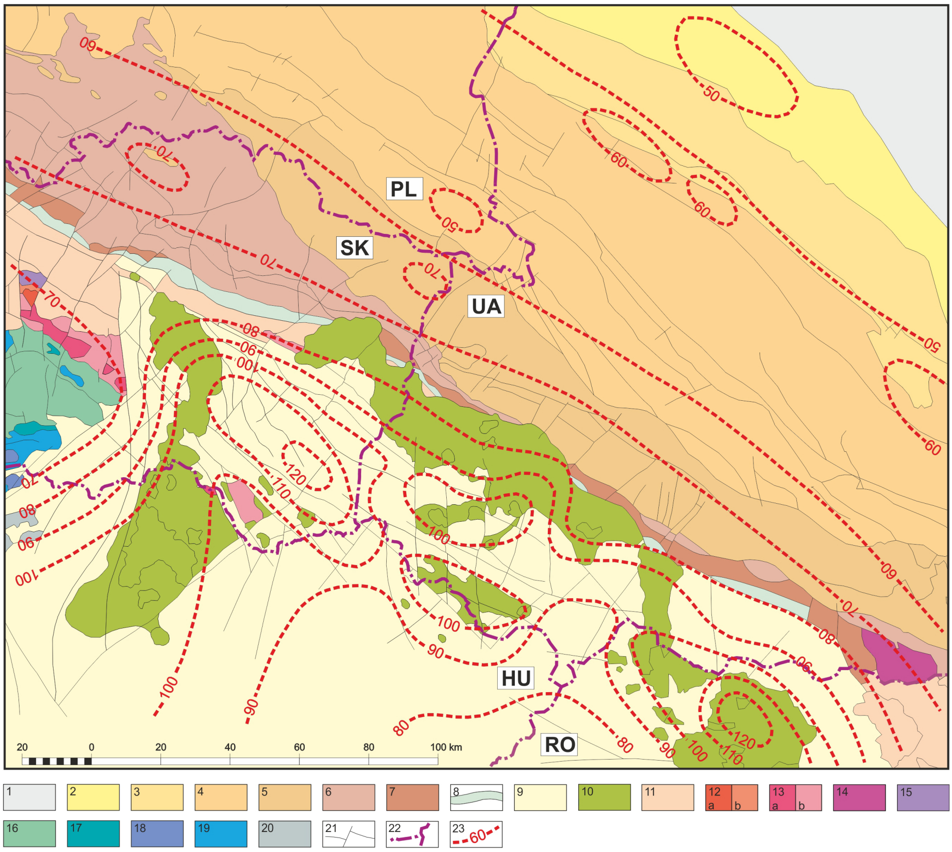

Fig. 1. Terrestrial heat flow density distribution in Transcarpathian depression and surrounding units. 1 – East European platform, 2 – Carpathian Foredeep, 3 – Outer Carpathian Flysch, folded molasse units, 4 – Krosno Nappes group of the Flysh Belt, 5 – Foremagurian units of the Flysch Belt,6 – Outer Magura Nappes of the Flysch Belt, 7 – Inner Magura nappes of the Flysch Belt, 8 – Pieniny Klippen Belt, 9 – Neogene and Quaternary sediments of the Inner Carpathians, 10 – Neogene volcanic rocks (andesites, rhyolites), 11 – Paleogene sediments of the Inner Carpathians, 12 – Tatricum: a. basement, b. sedimentary cover, 13 – Veporicum, Zemplinicum: a. basement, b. sedimentary cover and Krížna Nappe, 14 – Marmarosh Massif, 15 – Hronicum, 16 – Gemericum, 17 – Meliaticum, 18 – Turnaicum, 19 – Silicicum, 20 – Paleozoic of the Uppony-Szendrő, 21 – Faults, Alpine overthrust lines and geological boundaries, 22 – State borders, 23 – Isolines of heat flow density distribution in mW/m².

A kinematic model of vertical geomagnetic field variation resulting from a steady convective flow

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Abstract: A kinematic hydromagnetic problem is investigated in order to follow effects of a prescribed three-dimensional convection on an initially given magnetic field. The vertical velocity profile is *z*-dependent, *z* being the vertical coordinate, and consists of two parts in a manner to define the diffusionless region of the main volume of the fluid and the resistive boundary layer at the rigid wall. The induction equation for the vertical component of the magnetic field is solved analytically in Cartesian geometry in these two distinct regions. Besides of horizontal transport of the field in the main volume, there is also field's distortion due to the vertical velocity gradient causing its weakening at the upwelling and intensifying at the downwelling flow. The resultant solution at the surface of the main volume is a time-varying magnetic field which then penetrates into the boundary layer. This thin region where the velocity rapidly tends to zero, behaves like a solid conductor thanks to the assumption of a steady flow in the main volume and generally attenuates the magnetic field. Depending on the given velocity field configuration, it may also cause its sinusoidal alternation in *z*. At appropriate conditions a reversed field on the surface is obtained. In the context of the geomagnetic secular variation this may be an explanation of the westwardly drifting reversed magnetic flux patches.

Key words: magnetohydrodynamics, induction equation, geomagnetic secular variation, reversed flux patches

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Different geophysical methods applied to investigation of burial mound, Mohyla, Most pri Bratislave

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Abstract: The application of geophysical methods to archaeology grew rapidly over the last decade and become an important part of archaeological prospection. Applied geophysics as non-destructive and fast survey technique becomes very useful with increased land development. It helps archaeologist save the time and labor by identifying and targeting potential archaeological structures and revealing additional information about archaeological sites.

The aim of this project is to test different geophysical methods on selected archaeological sites and evaluate their success and suitability for their further use in investigation of burial mounds. The site of geophysical survey, burial mound,

Fig. 1. Mohyla, Most pri Bratislave

is situated south of village Most pri Bratislave. Up to this time there have been applied geophysical methods as electrical resistivity tomography (ERT), ground penetrating radar (GPR) and magnetic method. The results from these surveys reveal some information about the structure, construction and later use of the burial mound.

Key words: Applied geophysics, non-destructive, ERT, GPR, magnetic method

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Schumann resonances during a solar proton event

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Abstract: The cavity between the conductive Earth and the conductive ionosphere is a global spherical waveguide for electromagnetic waves, which are permanently excited by the lightning activity. The existence of the resonant modes, called Schumann resonances (SchR), due to interference of the electromagnetic waves within the Earth-ionosphere waveguide was theoretically predicted by *Schumann (1952)*. These resonance modes are in the extremely low frequency (ELF) range and they are close to 8, 14, 20, 26 Hz, etc. The electric field SR component is recorded with a capacitive (ball) antenna mounted on a 5 m insulator mast at the Astronomical and Geophysical Observatory (AGO) of Comenius University near Modra. Details are given in *Kostecký et al. (2000)* and in *Ondrášková et al. (2007)*. Since October 2001 up to August 4, 2009 there were only short interruptions when hardware or software was being updated or repaired, which lasted about a month, or shorter interruptions due to power outages or unfavourable weather situation (in some cases days). The raw time series data were collected every half hour for 327.68 seconds (which is 65536 samples taken with 200 Hz sampling frequency). Since July 2006 data of the same length were collected more frequently: every 6 minutes, i.e. 240 files were stored per day.

During some strong eruptive processes on the Sun, energetic protons are emitted from the active regions besides increased X-ray fluxes. Arriving to the Earth they penetrate to the atmosphere where they interact with the molecules. They cause a number of effects, called solar proton events. Increased ionization, changes of ion chemistry, changes of the electric conductivity itself and also the profile of the conductivity are only some of them. The two latter play a decisive role in the electromagnetic wave reflectivity and thus in propagation and eigenfrequecies of ELF waves in the Earth-ionosphere wave guide.

Using our code, we obtaine the SchR mode frequencies from our measured electric field component. During the well-pronounced SPE of December 2006, the X-ray induced increase and subsequent proton-induced decrease of the first SchR mode frequency are clearly observed.

Key words: Schumann resonance, solar proton events

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Polyhedral appoximation of buildings in microgravity data processing: a case study from the St Catherine's church, Little Carpathians

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Abstract: The use of the microgravity technique for cavity detection in the exploration of historical buildings requires the calculation of additional corrections that take into account the gravitational effects of surrounding man-made structures (buildings, known underground spaces, e.g. cellars, tunnels). The capability of digital photogrammetry to improve microgravity data processing was introduced by *Pánisová et al. (2012)*, where a new method for calculating building corrections based on photogrammetric reconstruction was used. This case study demonstrates the application of this method with a microgravity survey undertaken at the Slovak archaeological site (*Pánisová et al., 2013*).

The traditional approach to the calculation of building correction is based on an approximation of the walls by a set of prisms (Fig. 1a, Potent, Geophysical Software Solutions). The polyhedral model (Fig. 1b) described by a TIN (Triangular Irregular Network) was reconstructed in PhotoModeler software (Eos Systems, www.photomodeler.com). The attraction effect of this detailed model was calculated in program Polygrav as the summation of the integrations along the line elements of its individual faces using the equation of *Götze and Lahmeyer (1988)*. The differences between building corrections attain up to 45 μGals in the northern part of the map (Fig. 1c). These high values are caused by an inaccurate modelling of the tower in the Potent software. In general, it may influence the identification of probable subsurface features (in our case, medieval crypt excavated in 2001).

We have shown that digital models of the historical buildings created from photographs with a special photogrammetric software can be directly utilized for the calculation of their gravitational effects in microgravity method. A novel ap-

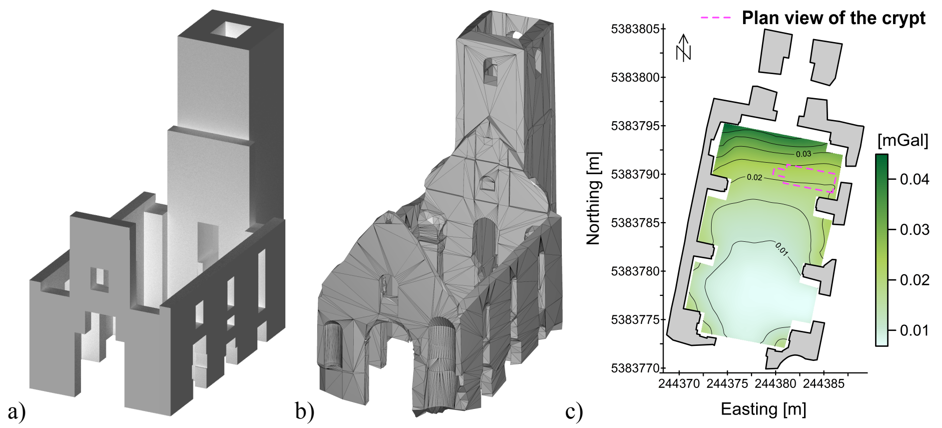

Fig. 1. 3D models of St. Catherine's church ruin (Dechtice) approximated by a set of rectangular prisms – Potent software **(a)** and one polyhedron – PhotoModeler software **(b)**. **(c)** Difference map of corresponding building corrections (model **a** – model **b**).

proach of microgravity data processing designed particularly for archaeological applications provides for high accuracy of calculated building corrections.

Key words: microgravity method, digital photogrammetry, historical buildings, polyhedral body, cavity detection

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Modern methods for determinations of physical heights

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Abstract: The contribution deals with the precise determination of normal heights according to Molodensky in the selected part of the Slovak national leveling network. Introduction to the theory of physical heights and methods for their numerical evaluation is supported by the practical experiment. It was performed the central part of Slovakia around the reference point Pitelova, where four different methods were applied: classical method, method using geopotential numbers, method using GNSS leveling and method using combination of Earth gravity model (EGM) with residual terrain effect. In the solution, different approaches for computing the gravity value (using Bouguer anomalies or EGM) at the points in which it is not directly measured were applied. Values of gravity were determined on the basis of two digital elevation models, DMR-3 (*DTM3, 2013*) and DTM2006.0 (*Pavlis et al, 2007*). Our tests point out to the quality of the regional gravimetric database of Slovakia in respect of geodetic applications. The experiment showed the highest precision of the method using geopotential numbers, which are based on measured gravity and leveled elevations. The classical method is very similar by the results, but nowadays it is practically obsolete. Combination of gravity, obtained from EGM2008 (*Pavlis et al., 2012*) and residual terrain effect computed from residual terrain model is promising, especially in the area with sparse distribution of gravity data. Despite of worse results in comparison with the previous methods, GNSS leveling verified reliability of the used quasigeoid model.

Key words: physical heights, geopotential number, GNSS leveling, Bouguer anomaly, free-air anomaly, Earth gravity model, Residual terrain effect

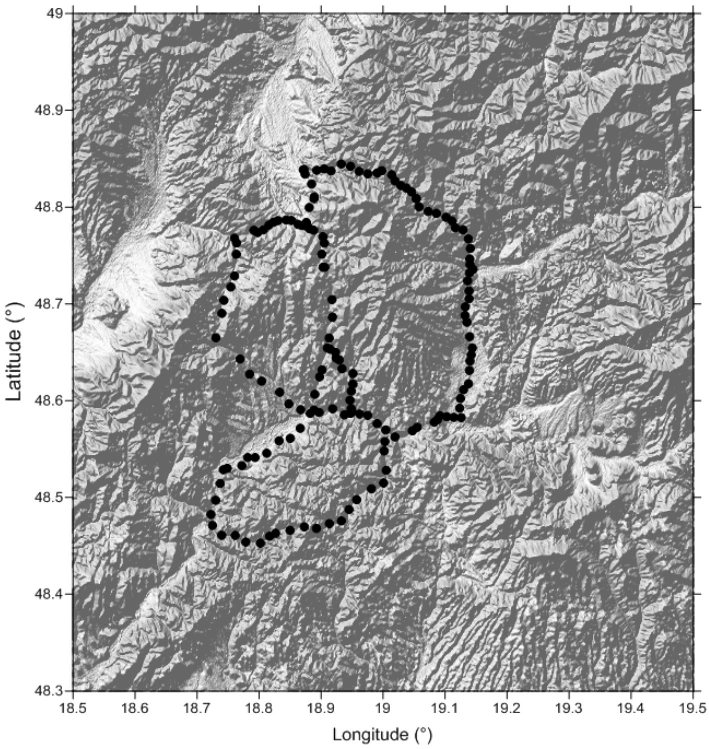

Fig. 1. Points distribution in the central part of the Slovakia.

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Geophysical image of sedimentary structure along the Dunajská Streda – Veľký Meder profile: reinterpretation of geoelectrical data of vertical electrical sounding (VES) method

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Abstract: The central part of the Danube Basin is filled in the near-surface parts of the aquifers, the Danube gravel and sand. Geophysical information originating mainly from geoelectrical measurements are used for better understanding of the structure and development of the sedimentation environment of the central part of this basin. The aim of this study was to compile a detailed geoelectrical cross-section (section A – A') through the gravel-sand horizons based on the reinterpretation of the geophysical measurements (vertical electrical sounding method – VES) and by the use of all available wells of the study area, which were taken from the archive of Geofond division in Bratislava.

Performed qualitative and quantitative interpretation was completed by the statistical-empirical interpretation. On the observed profile was determined the approximate thickness of the youngest Quaternary coarse-grained fluvial sediments and also were indicated possible significant tectonic lines. Lithofacial changes of the sedimentary fill within the three allocated geoelectrical horizons were analyzed. In the gravel-sand sediments was confirmed gradual reduction trend of the grain size towards the SE. On the contrary, in the lowest-lying clay-sandy horizon was demonstrated the opposite trend, gradually more frequent sandy fraction towards the SE.

Key words: applied geophysics, vertical electrical sounding, qualitative interpretation, quantitative interpretation, the Western Carpathians, Danube Basin

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Radiometric measurements in the Bridlicová štôlňa Gallery (Marianka) and its surroundings

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Abstract: Several types of radiometric measurements were carried out in the Bridlicová štôlňa Gallery in the Marianske údolie Valley in Marianka Village near Bratislava as well as in its surroundings at the surface (Malé Karpaty Mts.). The target was to find out the character and quantity of radioactivity of rocks (Jurassic black clayey and marly shales of the Marianka Formation), soil cover and geological structures respectively.

There were realized in situ dosimetry measurements of dose equivalent rate ($\mu Sv \cdot h^{-1}$) of gamma rays at height approx. 1 m above ground by portable Geiger-Müller dosimeter and gamma-ray spectrometry measurements of ^{40}K (%), ^{238}U (ppm eU) and ^{232}Th (ppm eTh) concentrations at ground level by portable scintillation NaI(Tl) gamma-ray spectrometer. Both measurements of gamma-ray field of rocks were done both in the underground mine adit (Fig. 1) and at the surface in surrounding area. Except of this, the soil emanometry measurements were performed at the surface above gallery body for the purpose to determine the content of ^{222}Rn radioactive gas in soil air.

The results show the homogeneity of studied, formerly mined, black shales block from the point of radioactivity with relatively low values of natural K, U and Th radioisotopes concentration as well as its tectonic integrity from the soil emanometry measurements.

Key words: Marianka Formation, Malé Karpaty Mts., concentration of ^{40}K, ^{238}U and ^{232}Th in rock, volume activity of ^{222}Rn in soil air, dose equivalent rate of gamma rays

Acknowledgements: This work was supported by the State Geological Institute of Dionýz Štúr under the contract No. 10 11 "Sandberg – Pajštún Geopark (SAPAG)", by the Slovak Research and Development Agency under contracts No. APVV-0194-10 and by the VEGA grant agency under projects No. 1/0095/12 and 1/0067/12.

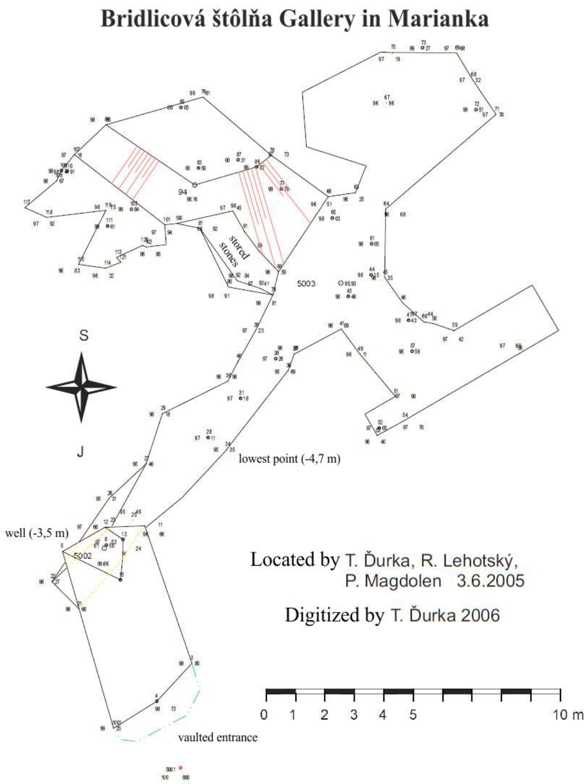

Fig. 1. Detailed plan view of the gallery.

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Results of the archaeogeophysical research of the site Katarínka realized during the years 2011 – 2012

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Abstract: In the frame of a long-year collaboration among universities and non-government organizations (focused on the research and salvation of the monastery complex Katarínka close to Dechtice) several stages of geophysical research have been realized. It was concentrated on the detection of crypts in the main church aisle and covered walls remains in the territory of the monastery (and its close surroundings). Thanks to state of the art geophysical equipment of the German university in Kiel we have been able to perform the widest complex of geophysical methods, which have been ever realized on an archaeological site in Slovakia. It was based on GPR measurements (GSSI SIR-20 with 200 and 400 MHz antennas), microgravimetric measurements (Scintrex CG-5), electrical tomography (RESECS system with 48 electrodes), high definition magnetometric measurements (Bartington Grad 601 with 4 sensors Sensys CON650), electro-

magnetic method (EM38) and as additional ones seismic and radiometric methods have been applied. Results brought several very interesting information. Next two until unknown crypts have been detected in the main church aisle (by means of GPR and microgravimetry). Further side chapels of the church, external and internal walls in the western and northern part of the monastery and foundations of a large building. In the northern part (in the front of the complex) foundations of several chapels have been delineated (GPR, ERT and magnetometry). All these results have confirmed the need of a complex geophysical approach in the utilization of non-invasive prospection methods in archaeology and have brought new insights into the architectonic and functional features analysis of this unique baroque monastery complex.

Key words: GPR, magnetometry, ERT, non-invasive archaeological prospection methods

Local gravity field model from GOCE and terrestrial measurements

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Abstract: Our contribution deals with determination of local or regional gravity field model solving geodetic boundary-value problem by Finite Element Method. We combine two different types of data sources, terrestrial and satellite data sets. On the upper boundary, represented by a part of a sphere, we used gravity anomalies obtained from downward continuation of GOCE gravity gradiometry measurements. Two regularization methods and several methods for regularization parameter estimation are tested. On the bottom boundary, represented by a part of the real Earth surface, we use the gravity anomalies obtained from real measurements. The final local gravity field model is compared with the global gravity field model.

Key words: GOCE, downward continuation, geodetic boundary-value problem, regularization

Waterborne GPR survey for riverbed-sediment mapping

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Abstract: We performed the Ground Penetrating Radar (GPR) survey on a stretch of the Morava River in order to check the GPR ability to discriminate the riverbed sediments through an analysis of the bottom reflection amplitudes. We used GSSI SIR3000 system with 400 MHz central-frequency antenna, which was placed on the flat bottom of an inflatable boat. For boat positioning and tracking have been use the global positioning system (GPS), connected directly to the GPR unit.

Data processing has been done using Reflexw software package (*Sandmeier, 2012*) with a series of simple processing steps (filtering operations).

Processing followed these steps:

1. GPS data have been imported into the traceheaders,
2. subtract-mean (dewow) – remove the very-low-frequency components from all traces, present in the signal because the acquisitions were performed without a filter,
3. make equidististant traces – the option allows to interpolate non-equidistant data in such a way that the resulting data are equidistant. The precondition is that the true position of each trace is stored in the parameter distance within the individual trace header,
4. move starttime – the processing step move starttime facilitates a static correction in time direction by a given value,
5. background removal – apply a high-pass horizontal filter to the profiles to remove a horizontally coherent component to suppress unwanted reverberations,
6. bandpassfrequency – is specified by the setting of the two frequency values lower cutoff and upper cutoff,
7. stack traces – the option allows the temporal simultaneous stacking of a selectable number of traces,
8. subtract traces – the option allows the temporal simultaneous subtraction of a selectable number of traces.

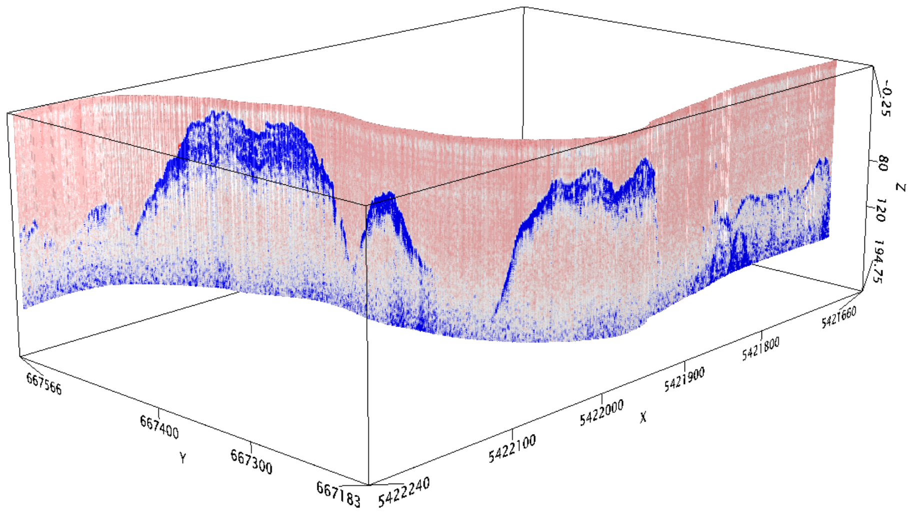

Fig. 1. 3D radargram visualization of the waterborne GPR survey on the Morava River.

Applying the processing flow to the raw data improved the radargram. The processed radargram shows sharp contrasts in the bottom reflections (Fig. 1). This high reflectivity prevents an unambiguous identification of the reflections within the sediments.

Key words: Ground Penetrating Radar (GPR), riverbed-sediment mapping

Acknowledgments: The authors are grateful to the Slovak Research and Development Agency APVV (Grant Nos. APVV-0194-10, APVV0625-11), the Slovak Grant Agency VEGA (Grant Nos. 1/0095/12, 2/0067/12, 1/0747/11, 1/0712/11, 1/0937/11) and Visegrad fund, Strategic project n. 31210058 for the support of their research.

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Modeling of intense geomagnetic storms by using an empirical model and artificial neural networks

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Abstract: An empirical model of the solar wind-magnetosphere interaction together with the approach based on artificial neural networks are considered. We set up a more comprehensive model and employ it to selected intense geomagnetic storms of the 23-rd solar activity cycle. The input of the model consists of the set of solar wind data obtained from the ACE satellite operating at the libration point L1. The output of the model is related to geomagnetic activity in terms of the *Dst* index. This kind of index can serve as a good measure of the overall strength of the near-Earth currents, especially the ring current, thereby providing the proper characteristics for geomagnetic storm intensity. Here, we prove the model for production of the *Dst* index to be a forecasting scheme for geomagnetic storms with one-hour lead time.

Keywords: magnetosphere, geomagnetic storms, artificial neural networks

Analysis of Schumann resonance frequencies determined by two different methods – Lorentz functions fitting and complex demodulation

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Abstract: Schumann resonances (SR) are electromagnetic oscillations in extremely low frequency range (ELF, 3-300 Hz) generated in the Earth-ionosphere cavity by the lightning strokes randomly distributed over the Earth's globe in given time. Despite the fact that lightning discharges radiate the most of power in tens kHz range, the low energy radiated part in ELF-band is very useful due to its weak damping. Measuring the signal in ELF this aspect gives opportunity to catch an instant integrated state of the global lightning activity.

The vertical electric component of the SR was measured at AGO FMPHI CU by a capacitive antenna since October 2001 up to August 2009. Duration of one measured sequence was 327,675 sec., sampling frequency of A/D converter was 200 Hz. Applying FFT, spectral peaks close to 8, 14, 20, 26,... Hz can be found. They reveal a daily, seasonal and inter-annual variations as a consequence of changes of the conductivity of the upper boundary of the cavity. To detect these variations it is important to determine the central frequency of the peaks. Each resonance peak in the forced system with damping (like a cavity with lightning) has the shape of the known Lorentz function. Fitting of four spectral peaks by Lorentz functions using least squares method was applied on the long-term measurement series at AGO, and details of the analysis made in the past were given in *Ondrášková et al. (2007, 2011)*.

Complex demodulation (CD) is a different method of the assessment of central peak frequency. It is often used for narrow-band signals in many applications. The aim of CD is to find approximations of the amplitude A(t) and phase φ(t) of a central frequency component fd (demodulation frequency) from the time series as a function of time, and to obtain a shifted and filtered (low pass filter) version of the signal around fd. Frequency fd is a priori estimated. After determination of phase function φ(t) for given fd, the so-called instant frequency can be computed. Its mean value can be used as new guess of fd and CD is repeated. It was found that after 5-10 iteration steps fd converges to central peak

frequency.

Two independent codes for CD were used. In the first code (author Pavel Kostecký) a measured sequence was divided to 16 equal parts. CD was iteratively applied on each part and their mean value of fd's was accepted as the central peak frequency. In the second code, a set of the subroutines for CD from STARPAC-package was used and applied on the whole sequence again by iterative approach as mentioned above. It is advantageous firstly to cut the analysed peak by band-pass filter, especially in case of the first peak which can be influenced by low frequency noise (e.g. under 5 Hz) caused by local meteorological conditions in the vicinity of the antenna (strong wind and swinging of the trees).

Tests of both codes were performed on 7440 sequences measured in January 2007. Mean daily frequency variations of the three modes are given and compared with previous results obtained by Lorentz function fitting.

Key words: Schumann resonances, Lorentz function, complex demodulation

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Integration measurements of indoor radon and thoron activity concentration in family houses in Ružomberok town (Northern Slovakia)

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Abstract: Exposure to radon gas in the home accounts for about half of all non-medical exposure to ionizing radiation. The building materials of houses and the design and ventilation systems strongly influence indoor levels of the radioactive gas radon and its decay products, which contribute significantly to doses through inhalation (*UNSCEAR, 2000*). Radon in the home accounts for about 9% of deaths from lung cancer and about 2% of all deaths from cancer in Europe (*Darby et al., 2005*).

Intergrational measurements of indoor radon and thoron in family houses were performed in the framework of the project “Harmonization of determining the radiation dose of the population originating from radon in V4 countries”. The objective of the project was to elaborate a common measurement protocol of the Visegrad countries for measuring of indoor radon and thoron concentration (placement of detectors, type of detectors, questionnaires).

In Slovakia, the survey was performed in three localities: Záhorská Bystrica (high Rn risk area), Mochovce and Ružomberok (medium and low Rn risk areas). Monitoring started in March 2012 and lasted for one year. Passive alpha track detectors Raduet were used, for discriminatively determining radon and

thoron concentrations. Fours sets of detectors were used, sets were changed after three months of an exposure to compare the changes of radon and thoron activities during the year.

In Ružomberok ten family houses were selected for the monitoring purposes. Measurements were performed in two rooms situated on the ground floor of a house, detectors were placed 15-20 cm from the wall. The houses built before 1990 were predominantly chosen for the investigation. Information about the building material, window tightness, intensity of the ventilation, year of the construction and reconstruction, number of inhabitants and time spent in monitored room were obtained by the questionnaire.

According to the Regulation of the Ministry of Health SR No. 528/2007, so-called action level 400 Bq/m^3 is recommended for nexisting residential buildings and 200 Bq/m^3 for new residential buildings for annual average radon activity concentration. In selected houses in Ružomberok, radon activity concentration rarely exceeded 400 Bq/m^3 in a three month period, in that case the inhabitants were advised how to lower radon exposure. No house with annual radon activity concentration more than 400 Bq/m^3 was found.

Key words: radon, thoron, activity concentration, intergation monitoring, family house

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Imaging subsurface cavities using geoelectric tomography, ground-penetrating radar and microgravity

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Abstract: In the past few years, construction extended extraordinarily to the southeast of Cairo, Egypt, where limestone caves occur. The existence of caves and sinkholes represents a hazard for such new urban areas. Therefore, it is important to know the size, position, and depth of natural voids and cavities before building or reconstruction. Recently, cavity imaging using geophysical surveys has become common. In this paper, geoelectric-resistivity tomography using a dipole-dipole array, ground-penetrating radar (GPR) and microgravity have been applied to the east of Kattamya at Al-Amal Town, Cairo, to image shallow subsurface cavities. Micro gravity measurement was done to detect density variations in rock strata at Kattamiaa city to delineate the shallow subsurface cavities. Several gravity anomalies were found in the residual Bouguer anomaly map. Semi-automated interpretation techniques including the Euler deconvolution, analytic signal and AN-EUL have been used to investigate the depth and size of anomalous sources. Following this the resistivity survey was conducted along three profiles over an exposed cave with unknown extensions. Results from 27 GPR profiles obtained by a SIR-2000 instrument equipped with a 200 MHz antenna were visualized in the form of horizontal time slices and vertical time sections, and both sets of data were processed and interpreted integrally to image the cave as well as the shallow subsurface structure of the site. As a result, the cave at a depth of about 2 m and a width of about 4 m was detected using the geophysical data, which correlates with the known cave system. Moreover, an extension of the detected cave has been inferred. The survey revealed that the area is also affected by vertical and nearly vertical linear fractures. Additionally, zones of marl and fractured limestone and some karstic features were mapped.

Earth's core rotating magnetoconvection models in the plane layer; two different orientations of rotation axis

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Abstract: The models of planar layer allow to solve geodynamo paradox consisting in the fact that since 1995 computer simulations of geodynamo in spherical geometry simulate the geomagnetic field with its secular variations unbelievably well despite of unrealistic values of some key parameters. The geodynamo related to the problem of planetary dynamos best exhibits known facts among all astrophysical dynamos. The facts are bond to the nature of generated magnetic fields (of Earth, planets or moons, Sun, stars, galaxies, ...) as well as domains of dynamo operation (Earth's liquid core, the shell of metalic hydrogen in Jupiter or Saturn,...).

In this contribution we present our models (*Šoltis and Brestenský, 2010*) of anisotropic diffusion coefficients influence on the basic dynamics in the Earth's core determined by Coriolis, buoyancy and magnetic force (*Roberts and Jones, 2000*).

A linear stability analysis of convection arising in a horizontal plane layer is performed. The layer is rotating about the horizontal axis like in *Eltayeb and Rahman (2013)* (in the case H) and about the vertical axis like in *Roberts and Jones (2000)* and *Šoltis and Brestenský (2010)* (in the case V), and is permeated by a homogeneous horizontal magnetic field perpendicular to the rotation axis. Resulting horizontal convective rolls are inclined to the magnetic field at an angle (*Roberts and Jones, 2000*) dependent on the dimensionless numbers – the Elsasser, Ekman and Roberts numbers, and moreover on the anisotropy parameter, the ratio of horizontal and vertical diffusion coefficients. The investigated cases H and V are analysed in the sense how linear convection properties correspond to dynamo scaling laws by Christensen et al (see e.g. *King et al. (2010)* and *Soderlund et al. (2012)*).

Key words: anisotropic diffusive coefficients, rotating magnetoconvection, Earth's core, geomagnetic field

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Magnetic field and velocity structures in rotating uniformly and non-uniformly stratified spherical fluid shells in dependence on the Prandtl number and electromagnetic boundary conditions

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Abstract: It is assumed that the upper part of the outer liquid Earth's core (close to the core-mantle boundary, CMB) is stably stratified (subadiabatic radial temperature gradient) and the lower part (towards the inner core boundary, ICB) unstably (superadiabatic radial temperature gradient). The stably stratified sublayer is probably very thin, thus, the outer Earth's core is almost unstably stratified. The models of the non-uniformly stratified fluid shell are an acceptable simplification of the real Earth-like conditions.

Non-uniform stratification can be simulated thermodynamically also in the Boussinesq models by means of internal heat sources. A systematical parameter study is presented, i.e. we investigated the dependence of hydromagnetic dynamos in uniformly and non-uniformly stratified spherical shells on the Prandtl number and various electrical conductivity of ICB. Results indicate a significant dependence of dynamos on stratification.

Keywords: numerical simulations of gedynamo, Earth's core, geomagnetic field

Neogene flexural down bending of the lower plate under the West Carpathians, deep seismic evidence and problems in gravity interpretation

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Abstract: Results of six seismic lines crossing the west Carpathian arc in territory between the Vienna basin and the Tatra Mts. will be presented. Four of them are deep seismic lines shot to 14 s of TWT. Numerous wells are also used to quantify the flexural curvature of the lithosphere. Good seismic evidence of the lower plate is generally obtained to depth of 10 to 14 km. Fortunately, extremely good reflector was obtained in unmigrated section 6HR on TWT of 12 to 14 s beneath the northern Inovec Mts. This was mostly due to very low attenuation of P-waves generated by dynamite in strong crystalline rocks of the Inovec Mts. and nearly not existing weathered layer beneath geophone spread. Reliable migration is difficult to reach using standard migration algorithms for such a reflection, so ray tracing depth migration has been used. Deep reflection migrated in NW direction to the area of the Pieniny Klippen belt N of Nové Mesto nad Váhom. Migrated reflection dips about 40° SE in the depth between 20 and 28 km. This reflection matches excellently with flexural curvature of the European basement in the NW continuation of seismic section. Our newly migrated evidence shows that European basement reaches nearly 30 km depth some 70 km from the surface outcrop of the Bohemian Massif beneath Pliocene depression near to Kojetín, NW of Kroměříž. This speaks for very severe bend of the lower plate and its extremely low value of effective elastic thickness – some 4 km. European lithosphere was very weak during lower Miocene subduction of this part of the Carpathian arc. There is not corresponding gravity signal of subducted lithosphere. Bouguer gravity anomaly is narrow with axis above 15 km depth isoline, therefore NW of the reflection. This Bouguer gravity curve might be fully explained by buried continental basement and porous sediments of the upper part of the Rača flysch nappe.

Other profiles show 15 km depth isoline of the European plate beneath the Kúty trough of the Vienna basin E of Kúty, beneath the Lysá Pass on the Czech – Slovak frontier, benath the Pieniny Klippen belt 5 km N of Žilina, beneath the Pieniny belt in Oravský Podzámok and finally beneath the Skorušina Mts. W of

Tatra Mts. It is evident that the 15 km depth isoline does not correspond to boundaries of Carpathian geological units but very well correspond to the axis of the Carpathian gravity low.

European basement dipping 40°SE N of Nové Mesto nad Váhom is probably represented only by very thin buried passive continental margin. Oceanic lithosphere breakoff occurred during Early Badenian very near to the end of this reflector. It is probably the only way how to explain missing gravity anomaly response. Slab breakoff during early Badenian caused sudden uplift of the Carpathian foredeep of several hundreds meters. This is well documented by extremely fast shallowing of the foredeep sea from pelagic dark clays to shelf limestones (Leithakalk) sedimentation. Very short trench–arc distance (100 – 130 km) of the Neogene Carpathians might be explained also by extreme bending of the Carpathian lithosphere. Original passive margin was created during Late Jurassic rifting which was oblique with lot of transtension and, therefore, this margin was very narrow. Evidence for it we see in very fast changed Late Jurassic (Malmian) sediments from platform facies to pelagic facies found beneath the Ždánice nappe in Moravia by numerous boreholes drilled by MND.

Joint 3D interpretation of Kolárovo gravity and magnetic anomalies by the inversion method of local corrections

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Abstract: We present a new interpretation of both the Kolárovo gravity and magnetic anomalies in the Danube Basin based on inverting these data by the so called method of local corrections. First a regional trend is removed from both the gravity and magnetic data in the study area. Two classes of sources are sought by the inversion: contact surfaces (interfaces) and star-convex compact homogenous bodies (*Prutkin et al., 2011*). When searching for compact bodies, inversion is performed first in terms of 3D line segments approximation (ibid). These line segments, as initial representation of the sources, facilitate the inversion by local corrections. The inversion results in several admissible solutions.

Inversion solution A (fig. 1) represents a combination of an intrusive body in the upper crust (density contrast of 300 kg/m^3) and an uplift of the basement above the intrusion. Solution B (fig. 2) is a contact surface (interface with density contrast of 300 kg/m^3) between the upper and lower crusts. Solution C (fig. 3) is an intrusive body in the upper crust. Compared to solution A its shape is more complex since in this case all the gravity signal is attributed to the intrusion. Solution D represents a combination of an uplift of the lower crust with an intrusive body above it (both density contrasts are 300 kg/m^3). These solutions are in fair agreement with several previous interpretations of the Kolárovo gravity anomaly.

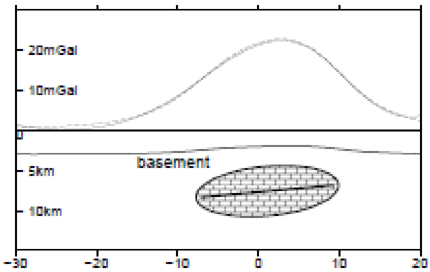

Fig. 1a. Solution A: W-E cross-section.

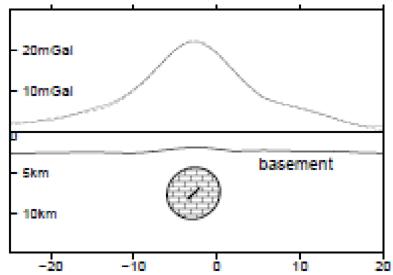

Fig. 1b. Solution A: S-N cross-section.

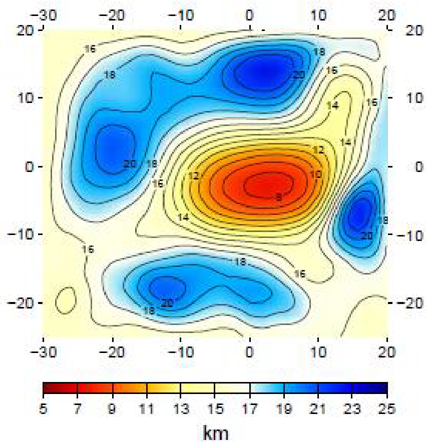

Fig. 2a. Solution B: Depth isolines.

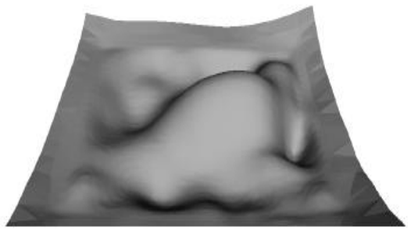

Fig. 2b. Solution B: 3D surface.

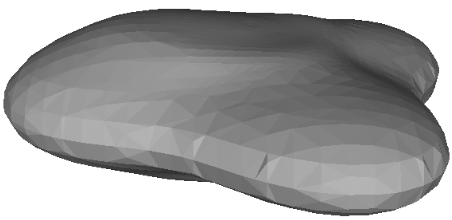

Fig. 3a. Solution C: Intrusion.

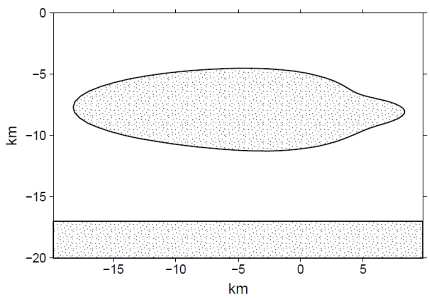

Fig. 3b. Solution C: W-E cross-section.

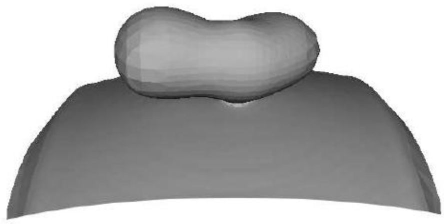

Fig. 4a. Solution D: Intrusion with elevation of lower crust.

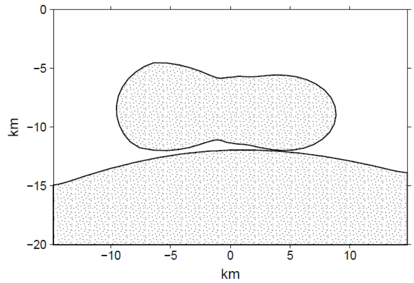

Fig. 4b. Solution D: W-E cross-section.

Next we interpret the magnetic data. The residual magnetic anomaly is transformed into pseudo-gravity. This procedure is described in detail in (*Prutkin et al., 2012, pp 112–127*). Pseudogravity is then approximated by line segments. They are located at depths between 5 and 10 km, just like those in the case of the Kolárovo residual gravity anomaly. This coincidence gives a strong case for the notion that both the gravity and the magnetic fields are caused by the same source. Finally the method of local corrections is applied to invert the pseudo-gravity to obtain a magnetic contact surface. Depths to the contact surface are between 7.7 and 23.5 km, which approximately matches solution B, i.e., contact surface obtained by inverting gravity data. The shapes of the magnetic and density contact surfaces are similar, but do not coincide entirely. A possible explanation is that the up-thrusted lower crustal mafic material is magnetically heterogenous, or not entirely magnetic.

The inversion methodology presented here represents a versatile approach to interpreting potential field data in tectono-geological studies. Its flexibility dwells in separation of multiple source signals. Its merit is in producing several admissible solutions that can be from the viewpoint of geological or tectonic interpretation studied, compared and evaluated in terms of their feasibility in the context of the tectono-geological situation and evolution in the studied area. The four solutions presented above equally well match the observed gravity anomaly. They cannot be discriminated based on observed surface potential field data. The discrimination among these solutions must be carried out based on additional geophysical or earth science constraining information and tectonic and geological considerations. In the light of the tectonic evolution of the Carpatho-Pannonian area we consider solution D as the most realistic, though not unique. The joint interpretation of magnetic and gravity data in the area of the Kolárovo anomaly has confirmed that the higher density basic intrusive body is to a great extent also magnetic.

Key words: Kolárovo anomaly, inverse problem, interpretation, intrusion, applied geophysics

Acknowledgements: This work was supported by the Slovak Research and Development Agency (contracts No. APVV-0194-10 and No. APVV-0724-11) and by Vega grant agency (projects No. 2/0067/12 and 1/0095/12).

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Gravimetric search for magmatic sources during the 2004–2005 Teide (Tenerife) hybrid unrest

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Abstract: During the seismic unrest at the central volcanic complex (CVC) on Tenerife bulk gravity increase was recorded between May 2004 and July 2005 (*Gottsmann et al., 2006*). Here we interpret the gravity signal in terms of multiple sources using a non-linear inversion method based on line segments approximation. Residual gravity changes were decomposed into shallow (Fig. 1) and deep (Fig. 2) constituents (fields) using a triple upward-downward-upward harmonic continuation (*Prutkin et al., 2011*). Each field was inverted based on best-fitting the attraction of line segments, yielding a set of 3 shallow near-surface segments and one deep short bent line segment at 5.7 km b.s.l. (Fig. 3).

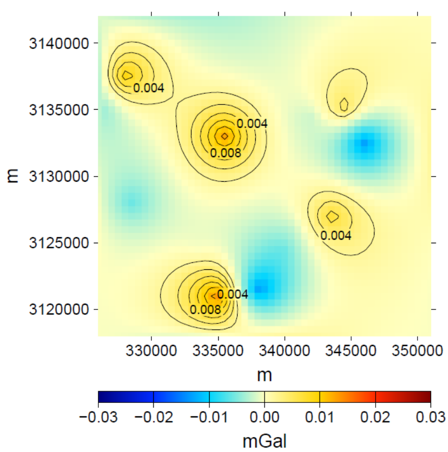

Fig. 1. Shallow field (mGal)

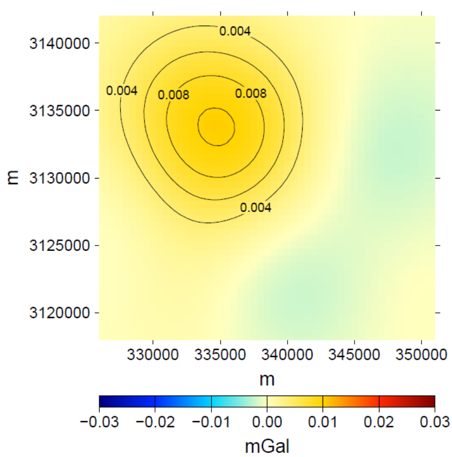

Fig. 2. Deep field (mGal)

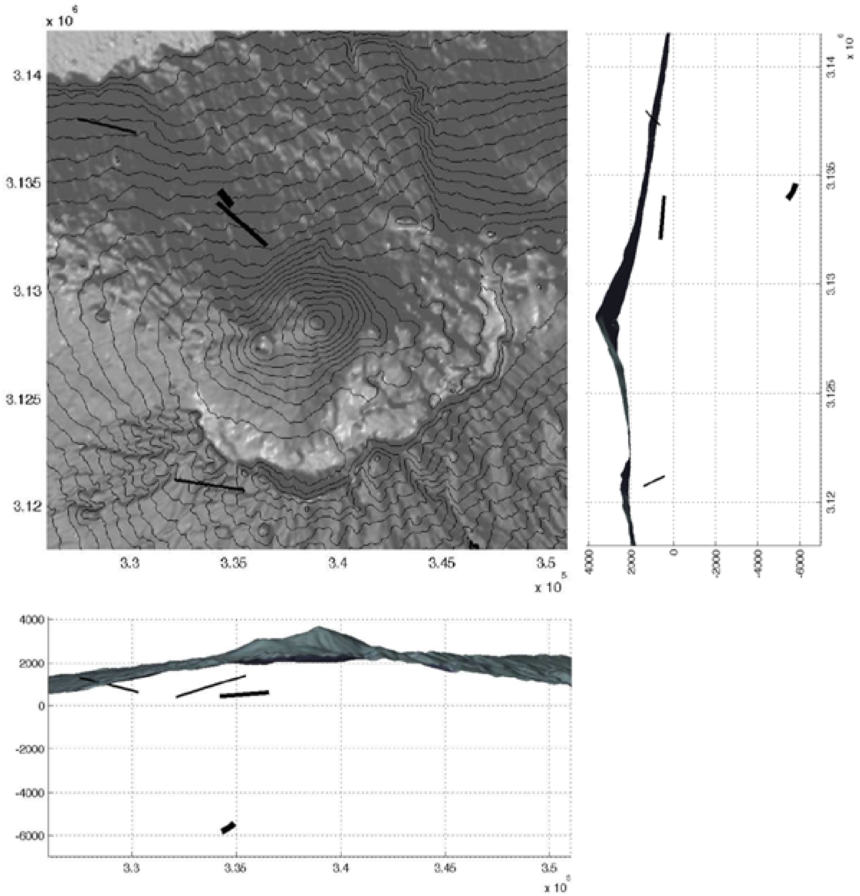

Fig. 3. Inversion results: Shallow and deep sources represented by line segments.

The two NW and one SW shallow segments correlate with the NW and SW seismogenic zones of (*Cerdeña et al., 2011*). We interpret them as risen hydrothermal fluids initiated by deeper magma injection. We interpret the short deep segment as a magma injection at a depth of about 6 km, within the NW zone of VT events swarm identified by [Cerdeña et al., 2011]. This hybrid nature of the observed unrest is best explained by the migration of hydrothermal fluids as a result of magma injection. Our inversion results and interpretation appear to be in fair agreement with the model of the tree-like magma intrusion proposed by (*Cerdeña et al., 2011*).

Key words: gravity change interpretation, volcano reactivation, hybrid unrest

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The historical data of the Hurbanovo Geomagnetic Observatory reconstructed by means of neural networks

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Abstract: The time series of the Hurbanovo Geomagnetic Observatory have been registered since 1893. Up to date, the data represent 120 years of magnetic records. However, there are many magnetograms in the observatory archive for which the baselines and the scales are unknown. Such magnetograms were found for some periods in the first half of the 20th century. Unfortunately, relevant information about the absolute measurements or the corresponding one-hour data, which could be used to determine both the baselines and the scales, are not available. We employed artificial neural networks in order to substitute for the missing one-hour data at the Hurbanovo Observatory. The data of observatories Potsdam, Seddin and Niemegk served as input to our model. In this paper we present the results of our neural-network model for geomagnetic elements *D*, *H* and *Z* (magnetic declination, horizontal and vertical components, respectively).

Key words: Geomagnetic field, geomagnetic elements, artificial neural network

Compilation of detailed gravimetric data from whole area of Slovakia

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Abstract: The results of the first phase of running project *Bouguer anomalies of new generation and the gravimetrical model of Western Carpathians (APVV-0194–10)* are presented. The total number of approximately 106 000 archive measurements was collected, Fig. 1. These data were measured since the year 1976 to the present, therefore they need to be unified and reprocessed. The improved positions of more than 8500 measured points were acquired by digitizing of archive maps (we recognized some local errors within particular data sets).

Besides the local errors (due to the wrong positions, heights or gravity of measured points) we have found some areas of systematic errors probably due to the gravity measurement or processing errors. Some of them were confirmed and consequently corrected by field measurements within the frame of current project.

Special attention is paid to the recalculation of the terrain corrections. We use a new developed software as well as the latest version of digital terrain model of Slovakia DMR-3 (DTM3, 2013).

Fig. 1. Detailed gravity data of Slovakia, approx. 106 000 points.

A new interesting regional structure was recognized in the map of complete Bouguer anomalies of Slovakia. It was confirmed by new detailed field measurements.

Key words: detailed gravity measurements, Bouguer anomaly, digital terrain model

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Digital Terrain Model version 3, 2012: http://www.topu.mil.sk/14971/.

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