PREOPERATIONAL AND OPERATIONAL MONITORING OF THE GEOMAGNETIC ACTIVITY IN THE AREA OF CYCLOTRON CENTER OF THE SLOVAK REPUBLIC

J. Vozár [1], I. Túnyi [1]

[1] Geophysical Institute of the Slovak Academy of Sciences, Bratislava, Slovakia, geofjavo@savba.sk, geoftuny@savba.sk

Abstract

Multipurpose project of the preoperational and operational monitoring of the geofactors of environment at area and surrounding of the Cyclotron Centre of the Slovak Republic (CCSR), located in the Slovak Institute if Metrology Campus (SIMC) in Bratislava, includes monitoring of the geomagnetic activity and artificial electromagnetic field. For past six years, the measurements of geomagnetic and electromagnetic field, electromagnetic smog and their modeling have been carried out to prove minimal influence of CCSR on human environment. Contribution presents maps and graphs of spatial and time distribution of geomagnetic field disturbances. For showing an influence of artificial electromagnetic time varying field the schemes of measured electromagnetic smog for several frequency bands were constructed. The time-frequency analyses of measured field and theoretical models of geomagnetic field show likeliest source of the main observed disturbances.

Introduction

Electric and magnetic fields (EMF) refer to fields which are invisible lines of force that surround any electrical device, such as a power line, electrical wiring, or an operating appliance. Electric fields are produced by voltage and these fields are easily shielded by objects (e.g., trees, buildings, and skin). In contrary, magnetic fields are produced by current and pass through more materials. Both electric and magnetic fields weaken with increasing distance from the source. Substantial part of natural geomagnetic field is generated in the Earth's core and its minor part in the magnetosphere and ionosphere. Direct effects of the geomagnetic field on human healthy at the Earth's surface are quite frankly, insignificant. The most important effects on man can be created by the magnetic fields induced by electrically-based technological systems. Most public concern about electromagnetism and a hazard to human health has concentrated on power-frequency, microwave and radiofrequency fields (WHO, 2006; Noble et al. 2005). The scientific evidence does not firmly establish that exposure to 50 Hz electric and magnetic fields, found in the houses, offices or near of the power lines is a hazard to human health. The evidence does not allow health authorities to decide whether there is a specific magnetic field level above which continuous exposure is dangerous or compromises human health (IARC Monographs, 2002). In the Slovak republic there were prepared several studies of magnetic disturbances in city agglomerations (Túnyi, Čajagi 1995; Túnyi 1999).

The project of preoperational and operational monitoring of the geomagnetic activity in the area of the Cyclotron Center of the Slovak Republic includes all types of measurements concerning determination of the geomagnetic field disturbance level and artificial time-varying electromagnetic field (EMF).

Natural geomagnetic field disturbances

The monitoring of the geomagnetic field disturbances consist of the measurements of the actual total magnetic induction **B** of the magnetic field in the area of the planned CCSR and carrying out of the long period records of magnetic variation on several points in the area of SIMC, where will be CCSR situated, and its surroundings.
Generally, the bedrock of planed CCSR site comprises mostly tertiary sediments with dominance of a sandstone and crystalline rocks of Little Carpathians Mts.. Natural rock setting indicate good electric conductivity shallow structures with increased density of artificial scatter currents and related distorted magnetic field. A not inconsiderable influence on disturbed field has existence of ferroconcrete buildings in the monitored area.

The measurements of actual total magnetic induction **B** of the magnetic field was carried out during normal working day with the proton precession magnetometer PPM-OMNI IV with the sensor B-580 produced by EDA INSTRUMENTS. Spatial scheme of the measurement points and the results are presented in Fig 1. Interpolation of the measured values exhibit magnetic inhomogeneities monitored area with increased magnetic induction near laboratory object J.

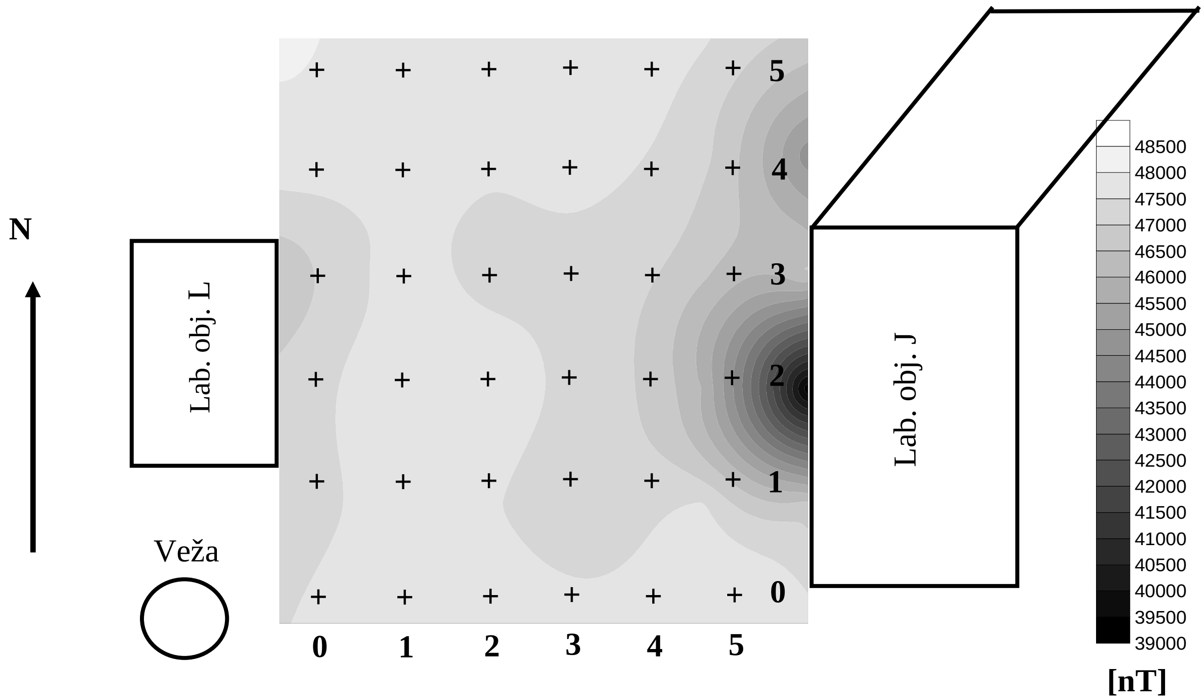

Figure 1: Total magnetic induction **B** in the CC SR area.

The measurements of disturbances in three magnetic component variations were carried out in the five points inside SIMC and five points outside SIMC. The registration of magnetic field was measured by the polish optoelectronic equipment PSM. The spatial distribution of monitored points is showed in Fig. 4. Daily variation of geomagnetic north-south component X, east-west component Y and vertical magnetic component Z are presented in Fig. 3. Time-frequency analyses of the vertical magnetic component Z is showed in Fig. 2.

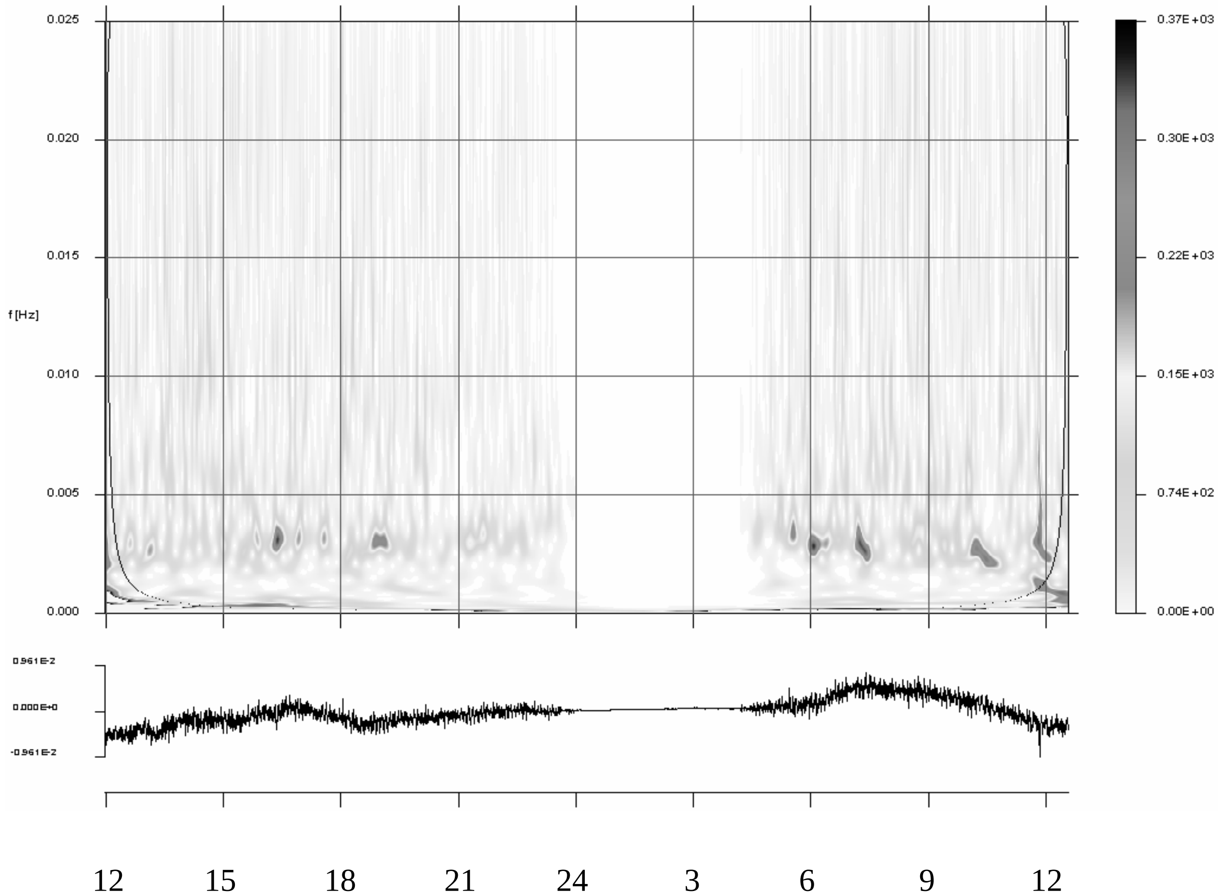

Figure 2: Time-frequency analyze: a) Z component of magnetic field

For the point with longest registration time were determined so called geomagnetic activity index K. From Fig. 2 be clear that most disturbed is Z component of magnetic field. For this reason all disturbance analyses were studied from short period variations of the vertical magnetic component Z. Short-period variations are strongest for vertical component Z of disturbed magnetic field and they are generated by city electric traffic system (trams, trolleybus, electrical network etc.). Influences of these sources are visible from records, where night changes in components variations are much lower than day changes and are similar to normal natural geomagnetic variations. This anomalous magnetic field generates horizontal vagabonds currents, which have origin in tram contact line and rail with the Earth. This kind of disturbances are interpreted by parameter Z_D (D - disturbances) and was evaluated in each point as middle amplitude of disturbed magnetic field variation of the vertical component Z above normal natural variation. Parameter Z_D has dimension [nT]. The final results inside of SIMC are presented in Fig 4 and outside of SIMC in Fig. 5.

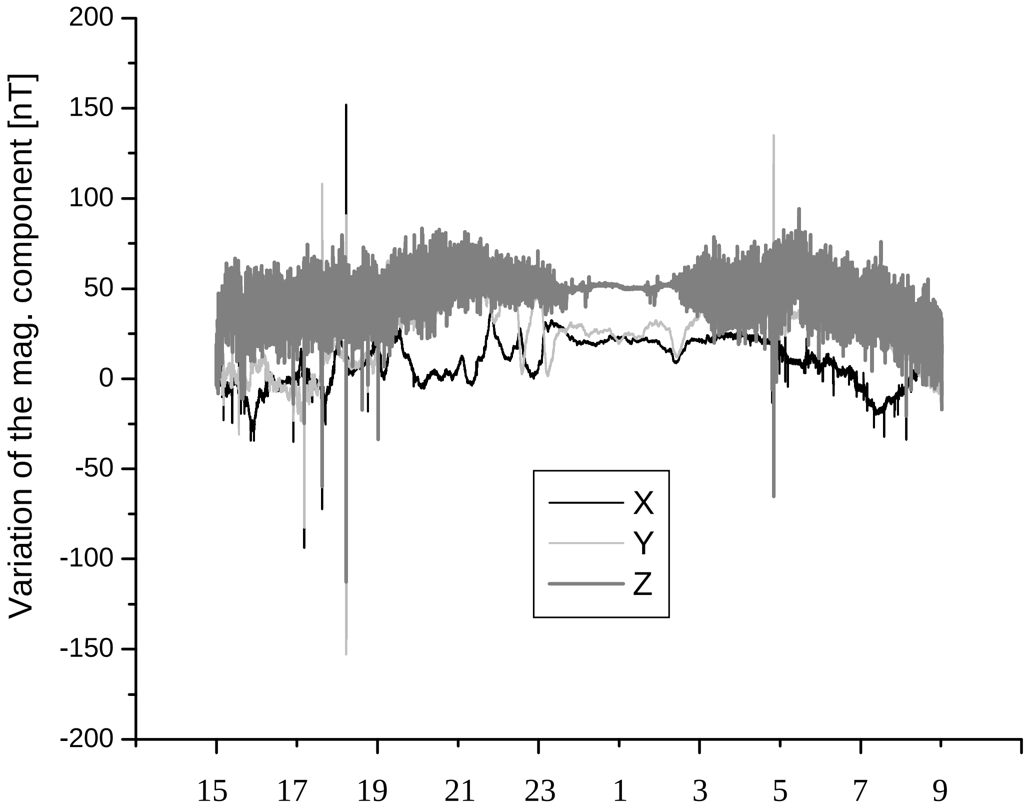

Figure 3: Daily variation of three component magnetic field (we have to take into account base values of each geomagnetic component: X_B = 20 860 nT; Y_B = 223 nT; Z_B = 42 653 nT).

The most usual method for determination of geomagnetic activity is international geomagnetic K-index. It is dimensionless parameter useful in determining the state of the geomagnetic field, the quality of radio signal propagation and the condition of the ionosphere. Each day is divided into 8 three-hour intervals, where K-index is determined for each of them. The K-index ranges from 0 to 9. It is assigned to the end of the 3 hour period. K-index requires very long measurements and was evaluated only for measured point. Determined K-indexes were compared with geomagnetic standard for the Slovakia, it means with Geomagnetic Observatory GPI SAS Hurbanovo. Averaged differences (ozn. δK) was taken as representative divergence from standard. We calculated 62 K-indexes for one point in the SIMC area. Representative divergence from standard is δK = **0.86**. This result confirms assumption, that the geomagnetic activity is higher than in GPI SAS Hurbanovo and is cased by the industrial noise.

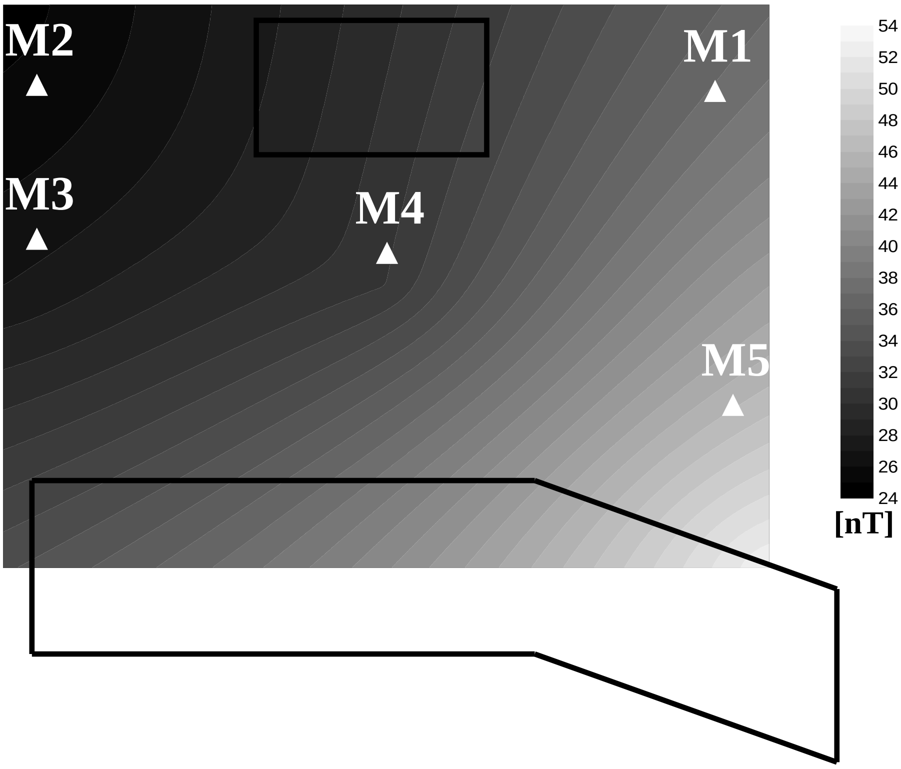

Figure 4: Values of Z_D parameter for magnetic disturbances in the CC SR area.

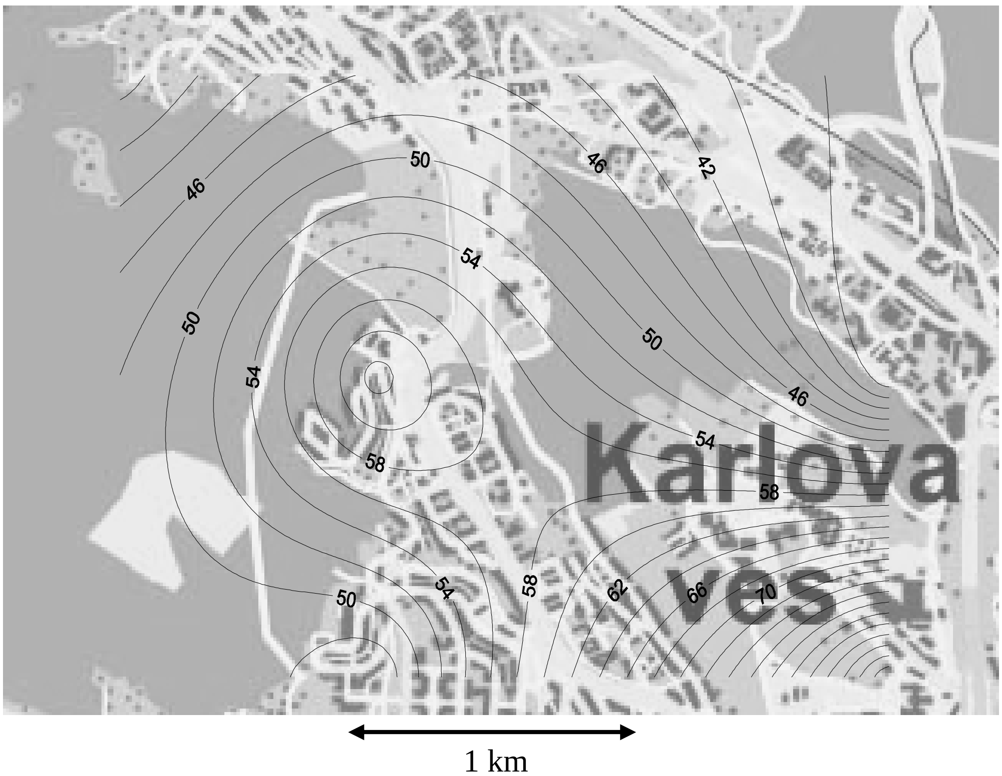

Figure 5: Values of Z_D parameter for magnetic disturbances outside the CC SR area.

The electromagnetic smog

The electromagnetic field was measured in 12 points of monitored area. Narrow-band frequency measurements were carried out by selective transistor voltmeters STV 301, STV 401 and a device for measuring of noise APM320H. Measured values of the EMF are presented in dB/1μV/m and dB/1μA/m. The schemes of the electromagnetic smog for 5 frequency bands were calculated. In this paper are presented only results for 50 Hz and 10MHz (Fig. 6 and 7). This final results of exposure by EMF in certain band confirmed position of the EMF smog source such a 50Hz power lines and another electric devices.

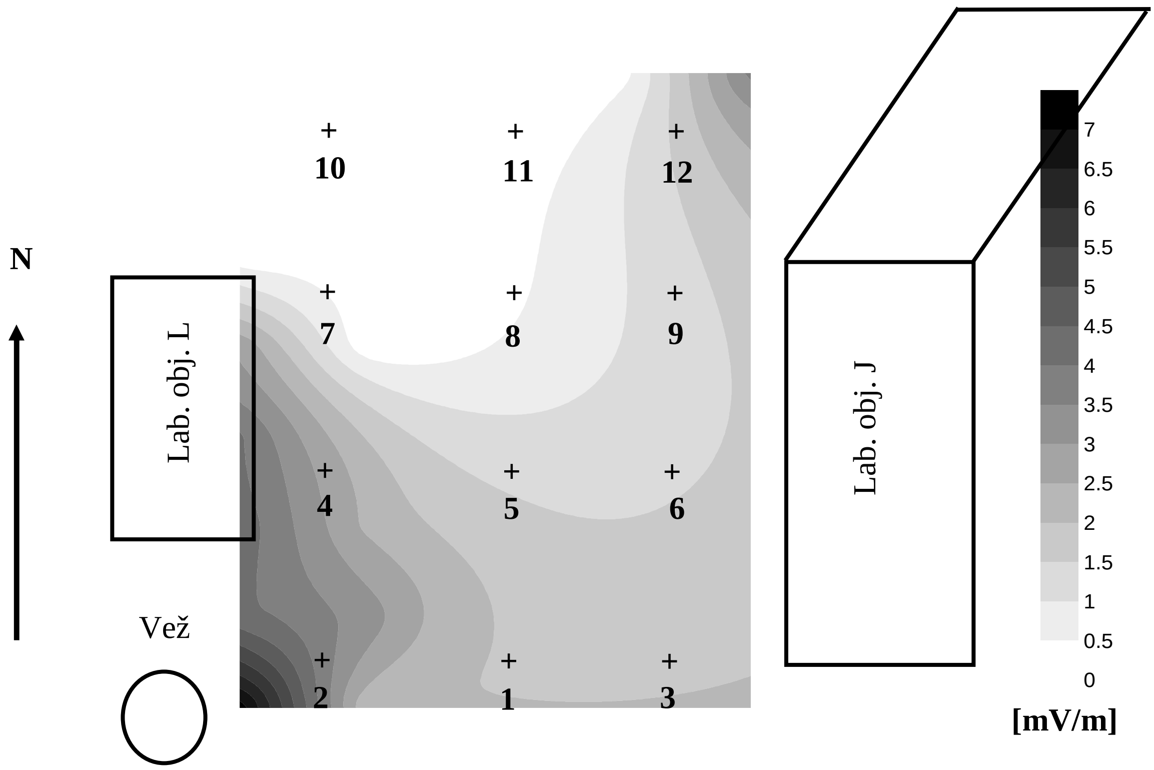

Figure 6: The magnetic field 50 Hz

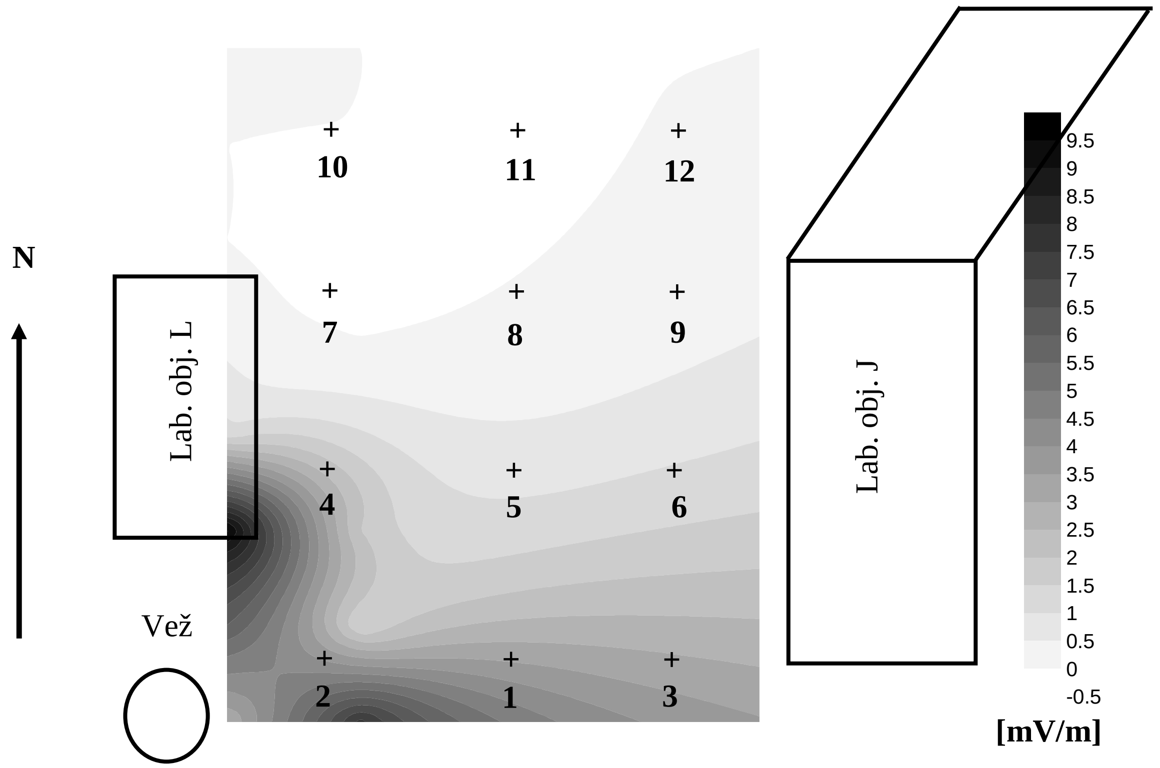

Figure 7: The electric field 10 MHz

The theoretical attempt to explain origin of the artificial noise

Presented monitoring results in the area of planned CCSR and also outside of SIMC prove that the strongest disturbances are caused by the city electrical trafic. We can approximate the influence of the artificial noises in each magnetic components by solving of the geoelectric direct problem (Hvoždara and Kaikonen, 1994; Hvoždara 1995). We determine anomaly changes of the natural geomagnetic field with specific magnetic declination and inclination above two-layered Earth with anomaly body in the first layer (Fig. 8). Power electrode simulated source of the stray current I_1 (e.g. the tram lines oriented in x-axis direction). In the next, we assume magnetic field contribution from two current carriers. The first wire with current I_2 characterizes power tram traction and the second wire with current I_3 presents discharge tram rail. The perturbing body characterizes inhomogeneities of geological units in observed area. The several models for different input conditions (spread of the electrodes, resistivity of units) were computed. Presented modeling result is prepared for:

- electrode position: A (-50 m, 0 m) – positive current, B (50 m, 0 m) – negative current;
- power electrode I_1 = 5 A;
- traction current I_2 = 400 A;
- rail current I_3 = 100 A
- conductivity of the first layer 0.005 S
- conductivity of the second layer and of the anomaly body 0.0001 S;
- thickness of the first layer is 50 m;
- dimension of perturbing body is 100 m, 200 m, 20 m.

Solved results are presented in Fig. 9.

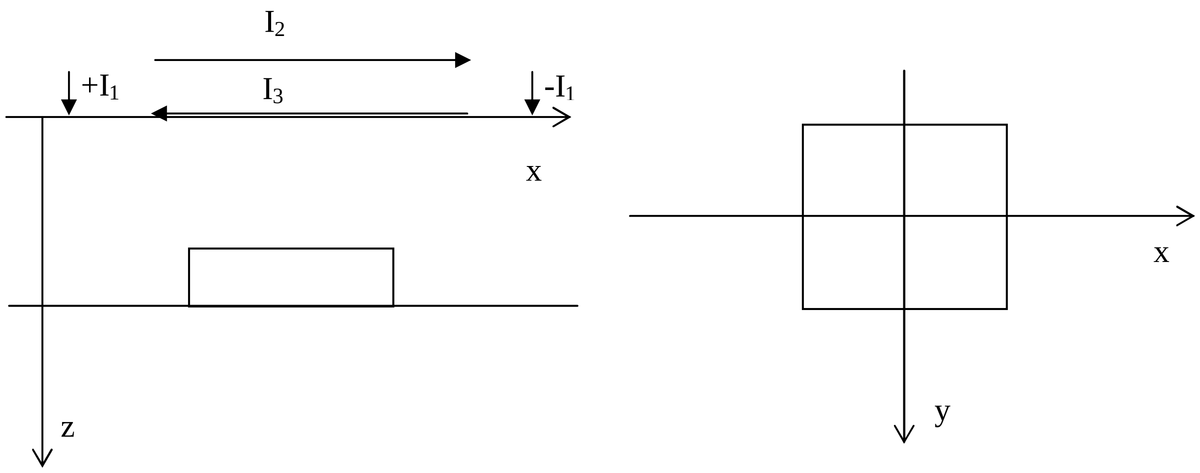

Figure 8: Scheme of solved problem. a) lateral; b) top view

If the orientation of the electric railway is identical with axis x. The lowest influence of artificial noises is visible in the X component of the magnetic field. The Y component of the magnetic field reach maximal values directly above tram railway. The observed area is situated several hundreds meters away from railway and there is several times stronger Z component of magnetic field then remaining two components. However this theoretical model is rough estimation of the perturbing field. For better estimation we need more accurate information about geological structures and their resistivities.

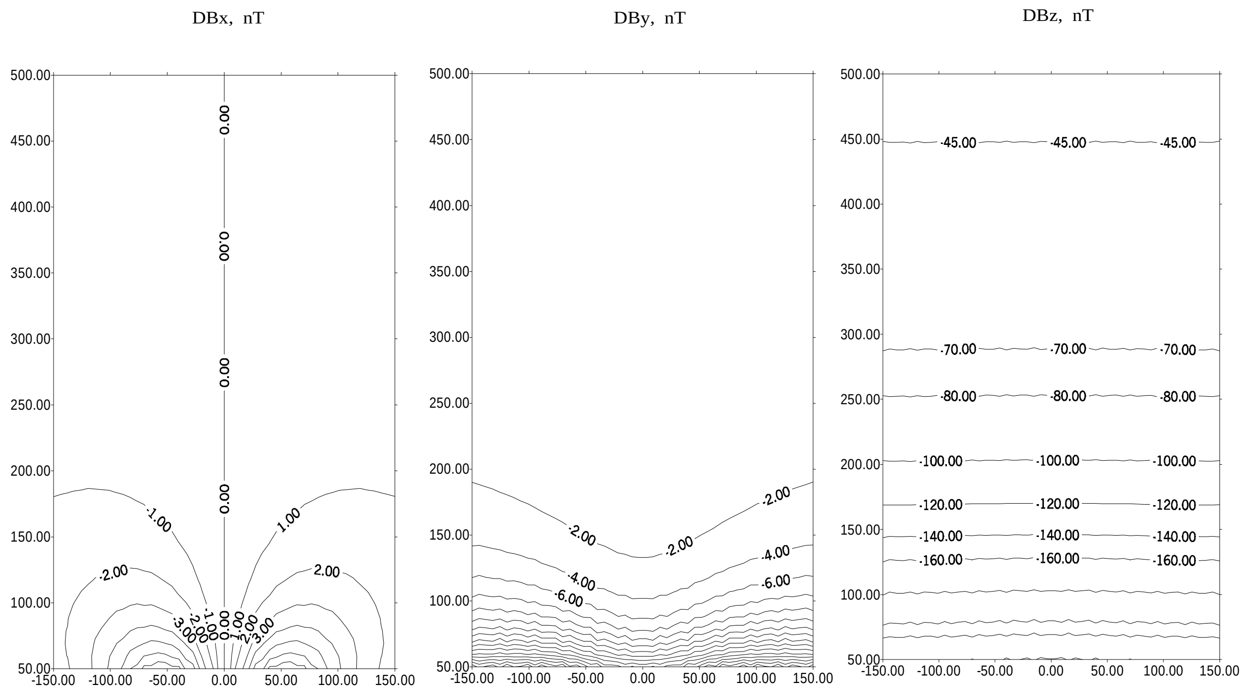

Figure 9: The theoretical modeling of the magnetic field components for two-layered with perturbing body in the first layer. Resistivities: $\rho_{first\ layer}$ = 200 Ohm.m, $\rho_{second\ layer} = \rho_{body}$ = 1000 Ohm.m. Dimension of the perturbing body: 100x200x20 m. Power current I_1 = +5 A for the electrode in the point (-50 m, 0 m), power current I_1 = -5 A for the electrode in the point (50 m, 0 m). Current in tram traction I_2 = 400 A and current in the rail I_3 = 100 A.

Conclusion

The several kinds of the monitoring of electromagnetic field were performed. The monitoring confirm strong disturbances from tram and electric installation in the SIMC area.
The geomagnetic field is strongly disturbed by the artificial sources of EMF. Most disturbed is vertical Z component of magnetic field due to stray currents from nearby tram transport system. Other time-varying sources of disturbances measured like EM smog are electric devices. All measured frequency band of EMF were in the interval of actual pollution standard for exposure of a human body, standardized by order 123/93 Summa of laws.

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