Map of parameters of the current flows in surficial layer-effective tool for proper location and protection of underground mettalic constructions

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Abstract: The paper deals with the Map of parameters of the natural and artificial current flows in surficial layer of the rock medium, constructed in Vranov – Humenné – Strážske region.

The target of this study was determination of presence and parameters of current flows of the natural origin (electrochemical, filtration, diffusion and telluric current fields) and from artificial sources (cathode protection of the burried pipe lines, vagabond flows, etc.).

Following parameters have been determined: density of current flow and its course as well as resistivity of the surficial layer. Depth penetration of the measurements: 3.75-6.25 m below surface. The density of the observations: 1-4 stations per sq.kms. The results obtained have been compared with valid Slovak technical norms. As a result of this comparison, the area in question has been divided accordingly the aggresivity degree of geological medium on various metallic constructions.

Key words: surficial layer, current density, soil resistivity, soil aggresivity for metallic constructions

Intruduction

In the present, huge construction activities are performed in Slovakia and abroad. It is generally known, that underground metal constructions need anticorrosion measures and active cathode protection in case of higher soil aggresivity. The degree of aggresivity depends on current flow density and course as well as on resistivity of the surficial layer. That is why the information on spatial distribution of these parameters of the natural and artificial current flows are very important for proper location and protection of the underground metal constructions and pipe lines.

This paper deals with results of determination of the presence and parameters of the electric current flows in surficial layer of the rock medium in Vranov-Humenné-Strážske region. These observations have been done in frame of the project: „Maps set of geological factors of the environment in Vranov-Humenné-Strážske region", performed in 1998-2003 period.

The subjects of study have been current flows of natural origin (electrochemical, filtration, diffusion and telluric ones) and originating from artificial sources (active cathode protection of burried pipe lines, industrial currents, etc.). These flows posses various density and courses. The resistivity of surficial layer, which is other parameter influencing the soil aggresivity on metal constructions, has been determined too.

The measuring stations have been located with different density. In the area of Vranov, Strážske, Humenné and Snina towns, the density varied in the interval of 2-4 points per sq.km, while in other regions 1 point/km^2 was measured.

Geological setting of the area under study

The area under study is built by Mesozoic, Paleozoic, Paleogene and Neogene formations. The Quaternary is presented by proluvial, fluvial, deluvial, eolic and eolic-deluvial sediments. Following geological units can be distinguished: Čergov-Beskydy flysch, klippen zone and nearklippen area, Central Carpathian Paleogene, Slanské vrchy neovolcanics, Eastern Slovakia basin, Humenné hills and Vihorlatské vrchy neovolcanics.

The substantial part of the area belongs to Čergov-Beskydy flysch, built by sandstones and claystones. The Quaternary evolution has been influenced by surface presence of the various type of Magura nappe rocks. Easy weathering of claystones caused the rise of thick layers of deluvium on the slopes. The typical flysch (alternation of claystones and sandstones) is more resistant to weathering and linear erosion is frequent here.

The narrow strip of the area is built by klippen zone with predominant carbonates and flyschoid sediments. The klippen zone is divided from Central Carpathian Paleogene by rocks of outer flysch zone. Generally, the klippen belt is typical by the smallest thicknesss of the Quaternary sediments.

The Paleogene claystones of sub-Tatras group very easily weather and they create smoothly modelled hilly country. Ocassionally presented conglomerates create steeply cutted valleys with development of outwash cones at their estuary.

The neovolcanics of Slanské vrchy hills create hilly, frequently sharply cutted relief. The positive morphostructure of Slanské vrchy hills has been subject of intensive weathering processes during Pleistocene. The weathering products were transported to lower part of the mountain. This process, togehter with active tectonics, caused the thickest accumulations of Quaternary sediments in the area under study (more than 30 m).

The Eastern Slovakia basin is namely built by Neogene pelites. The relief is in the form of water cut valleys with accumulation of Quaternary sediments in central part and smooth slopes with development of deluvium on their foots.

The southern margin of the area is created by Mesozoic rocks of Humenské vrchy hills and by neovolcanics of Vihorlatské vrchy hills.

The thickness of Quaternary sediments is result of complicated geological-geomorphological processes during the youngest geological period. It is conditioned by lithology of Pre-Quaternary basement, its morphology and by development of individual genetic types of Quaternary sediments, which are expressed by own geomorphological form. The maximum thickness of Quaternary reaches over 30 m (at Soľ village), but predominantly varies in the interval of 0-2.5 m.

Methodology of the field measurements

For location of the measuring stations, the topographical maps of 1:25 000 scale have been used. The values of potential differences, of which knowing is necessary for calculation of the current flow density and determination of its course, have been measured at every station in two directions: N-S and W-E.

The potential differences (ΔV) have been measured between two nonpolarizable electrodes ($Cu/CuSO_4$), distant 20 m. The measurements of ΔV have been performed in both courses simultaneously, by two digital multimeters. The measuring time at one point has been chosen after changes frequency of the ΔV values-from ca 7 minuts to 15 minuts as a maximum in case of intensively disturbed electric current flow. The multimeters registered ΔV changes in one second intervals. By connected portable computers, the average ΔV values with determination of their polarity were obtained.

After finishing ΔV measurements the apparent resistivity (ρ_a) measurements have been carried out at the same courses. The ρ_a observations have been performed utilizing Wenner electrode configuration. The model used: A5M5N5B. The depth penetration of this electrode configuration is ca 3.75-6.25 m below terrain surface (after Slovak Technical norm No. 038 363). The measuring methodology is in accordance with STN 038 363 and STN 038 365.

Processing of the measured data

After termination of the field measurements, following data have been available for each measuring station:

- number of station
- average value of ΔV [mV] and its polarity in 20 m length for N-S and W-E directions
- average value of ρ_a [Ωm], calculated as an arithmetic average from ρ_a values, obtained for N-S and W-E courses.

From ΔV values, measured in both directions, the vector total has been constructed. The length of this vector (1 cm = 1 m) corresponds to ΔV value, originated by electric current flow at measuring station, while course of this vector represents direction of the current flow. The ΔV value, determined from a lenght of vector, corresponds to electrode distance of 20 m. Dividing this ΔV value by 20, the resulting ΔV value in $mV.m^{-1}$ has been obtained.

For determination of current flow density (I_f) in 1 m^2 space, it is necessary to know the ρ_a value of the rock medium, in which flow is passing. For calculation of the I_f [in $\mu A.m^{-2}$], the arithmetic average of both ρ_a values has been used.

Outputs of the observations and major results

The outputs of the above mentioned observations are as follows: Map of parameters of the natural and artificial current flows in surficial layer of the rock medium in 1:50 000 scale, Map of spatial distribution of the soil aggresivity degree on metal constructions after apparent resistivity values (Fig. 1) and Map of spatial distribution of the soil aggresivity degree after current flow density, both in 1:200 000 scale (Fig. 2). All maps have been constructed in accordance with STN 038 372 and STN 038 375.

After above mentioned norms, the relation between I_f, ρ_a and soil aggresivity degree is presented in Table 1.

Table 1.

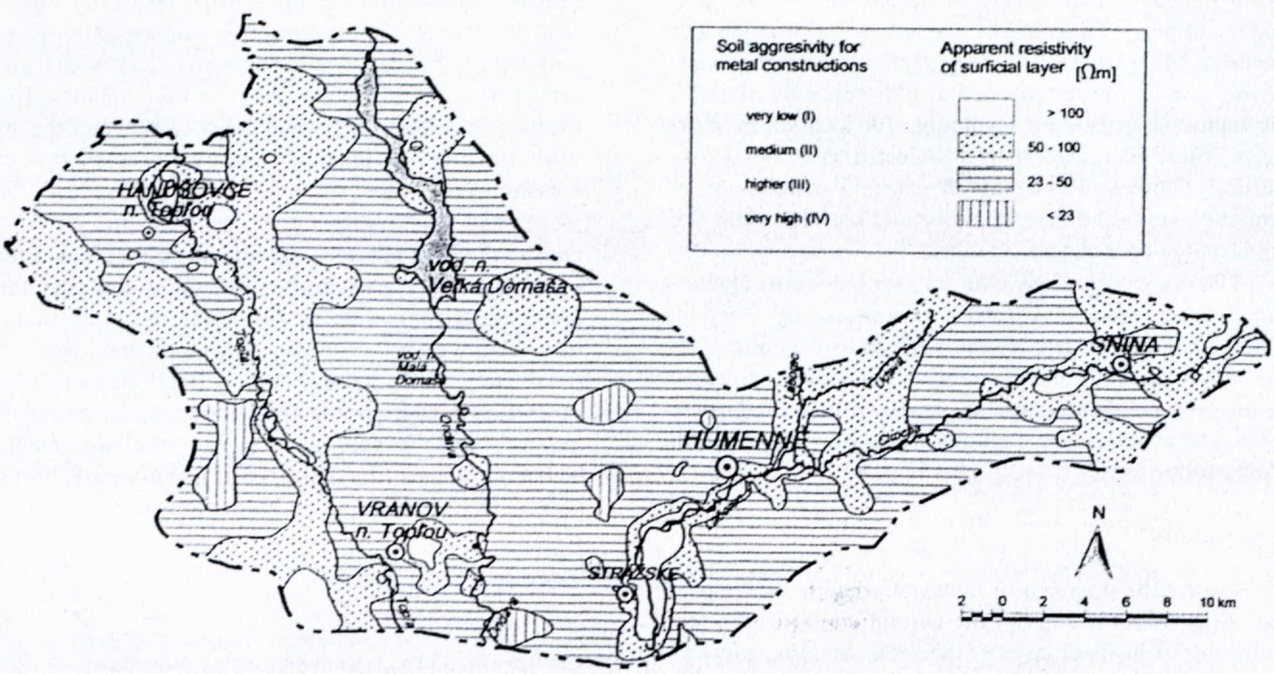
Soil aggresivity degree	ρ_a [Ωm]	I_f [$\mu A.m^{-2}$]
very low (I)	> 100	< 0.1
medium (I	50 – 100	0.1 – 3.0
higher (III)	23 – 50	3.0 – 100.0
very high (IV)	< 23	> 100

The results of the observations are as follows:

The Vranov-Humenné-Strážske region posseses-according to the spatial distribution of ρ_a values – all four degrees of the soil aggresivity. The medium and higher degrees prevail.

In case of presence of higher and very high aggesivity, it is necessary to protect metal underground constructions by anticorrosive measures and in case of metal pipe lines (for transport of gas and crude oil) by active cathode protection. The ρ_a values lower than 23 Ωm (very high soil aggresivity) have been detected in the area of Hlinné village (sw. part), north of Zámutov village (extremely sw. part), north of Lieskovec, at Topoľovka and at Nižný Hrabovec villages (s. margin of the region).

After values of current flow density (I_f) the medium aggresivity degree prevails in the area under study. This soil aggresivity does not need special anticorrosion and



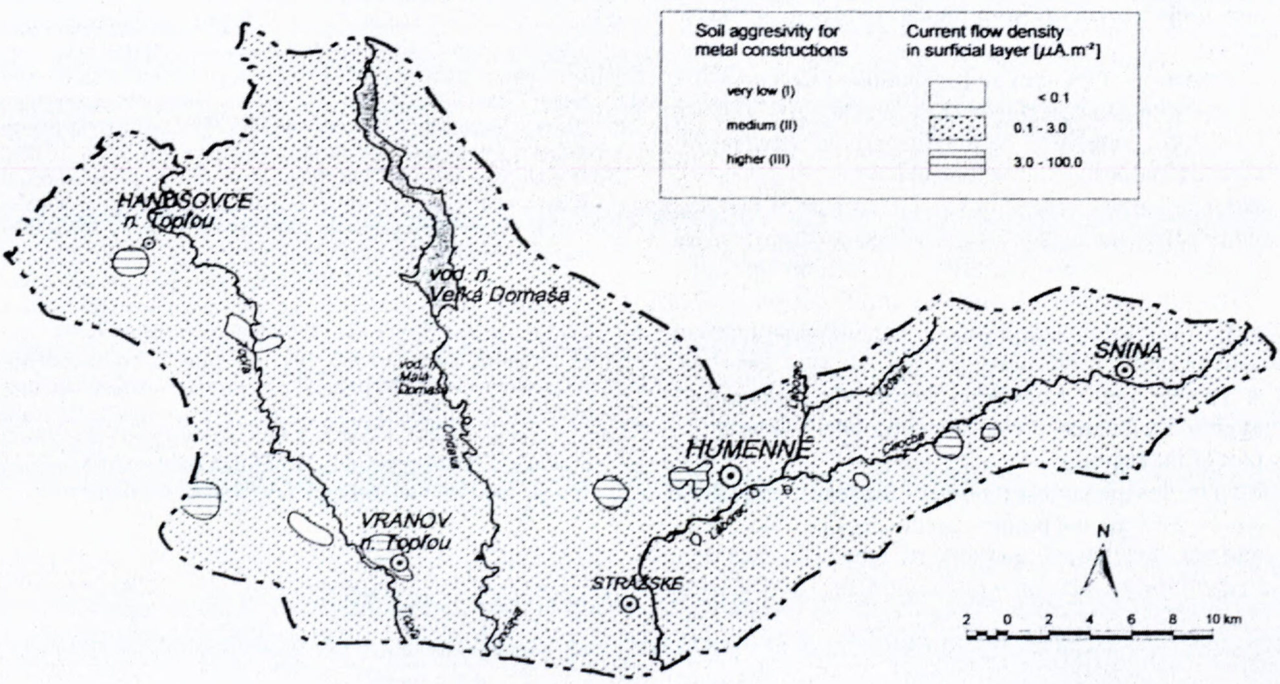


Fig. 2 *Fig. 1 Distribution of the soil aggresivity degree after current flowdensity values in Vranov – Humenné – Strážske region*

cathode protections of the metal constructions. The highest values of I_f have been observed along interrupted line of ca W-E direction, running through Zámutov-Vranov-Topoľovka-Humenné-Dlhé above Cirocha settlements. These high I_f values reflect a presence of the artificial electric current flows, caused by active cathode protection of the gas-pipe line.

Besides assessment of the soil aggresivity distribution, the schematic ρ_a map (Fig. 1) can be also utilized for other purposes. The places with ρ_a values higher than 100 Ωm represent occurrence of thicker layers of sands, gravely sands and gravels of the Quaternary as well as surficial layer of the sandstones, carbonates and solid neovolcanics in case of Quaternary cover absence. (The

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depth penetration of our observations was 3.75-6.25 m under surface.) These rocks are good construction raw materials. In places of terrain depressions along water flows, built by Quaternary permeable sediments (possessing high resistivity), are favourable for location of water wells. These places have been detected in following localities: Ďurďoš, Remeniny, Vechec, Vranov, east of Strážske, south and east of Humenné, between Belá and Snina and in area of Stakčín town.

The resistivities less than 23 Ωm belong to Quaternary loesses and clays with various sandy content, which increases resistivity, as well as to claystones interbedded by flysh and Paleogene sandstones, volcanic pelites and Neogene clays in places withou Quaternary cover.These rocks are favourable as raw material for brick production.

Conclusions

The results obtained in frame of solution of the project „Map of parameters of the natural and artificial current flows in surficial layer of the rock medium„ allow us to state following conclusions:

- Spatial presentation of the soil aggresity degree in the region under study can be used as a basis for planning the location of the underground metallic pipelines and other constructions and after site location for performing corrosion survey with higher density of measurements.
- Comparison of the spatial distribution of the resistivity values with geological map (Karoli et al., 2003) shows very good correlation between measured apparent resistivity and mapped lithological units.
- After resistivity values, in substantial part of the area under study the higher and very high soil aggressivity degree for various metallic constructions prevails. That is why these constructions need the protection against corrosion and in case of metallic pipe lines an active cathode protection.
- After values of current flows density, the medium soil aggresivity degree prevails in absolutely substantial part of the region.
- Map of the spatial distribution of the resistivity values can be utilized for proper location of the water wells and for location of quarries for gravely sands and gravels exploitation (in areas with resistivity higher than 100 Ωm). This statement is confirmed by comparison of the location of known water wells and gravel deposits in various parts of the Vranov – Humenné – Strážske region and the occurrence of the areas with highest resistivity values, observed by our measurements. Most of wells and deposits lie in the places with resistivities higher than 100 Ωm.

Due to the high value of the information obtained for planning the infrastructure and underground metallic constructions as well as for other purposes, mentioned above, we propose to compile the „Map of parameters of the natural and artificial current flows in surficial layer of the rock medium„ in frame of „Maps set of the geological factors of environment„ projects, financed by Ministry of Environment of the Slovak Republic, also in other regions of Slovakia.

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