STUDIA UBB GEOGRAPHIA, LIX, 2, 2014, pp. 25-46
(RECOMMENDED CITATION)

SPONTANEOUS POTENTIAL INVESTIGATIONS IN SEMENIC MOUNTAINS

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ABSTRACT.- Spontaneous Potential Investigations in Semenic Mountains. The use of geophysical methods such as that of Spontaneous Potential (***SP***) to investigate areas where the geomorphological processes occur, has the role to identify less visible processes as for example subcutaneous erosion or piping, subsoil water drainage and finding specific spatial differences of these processes. Comparative study of these sites allows correlation between geomorphological factors, soil and climate, but also to observe the evolution of subsurface erosion or underground water infiltration over time. During this investigation a series of mesh grids have been made in areas with different characteristics (lithology, pedology, slope, exposition, etc.) at different time periods in order to spot and analyse the change in data in the chosen sites, various conditions given. Values expressed in millivolts (***mV***) obtained by the Spontaneous Potential method have been put into an algorithm for interpolation looking to yield a pattern of values of what is happening in the soil during that period of time. Thus, in the autumn, the investigation site at the nivation niche Baia Vulturilor, returned values of between -22.6 mV and 65.6 mV, while in spring in the same site, values were within the range of -14.4 mV / 30.1 mV. On the other hand, on the site of the cryopediment under the Semenic peak, in the spring, return values ranged from -40.4 mV and -1.1 mV. A particular case is that of the glacis near Piatra Goznei peak; in this area anthropogenic electricity influences on soil can be found. Based on some models a trend of water movement in the soil could be established, this depending heavily on the amount of precipitation infiltration, local lithology, depth of soil and their structure, and evapotranspiration process. Water movement in the soil may be a correlation with sediment movement in soil horizons and instability manifested on the slopes.

Keywords: *spontaneous potential, piping, subsoil water drainage, nivation niche, cryopediment, Semenic Mountains.*

1. INTRODUCTION

Self potential, or spontaneous potential (SP), is a naturally occurring electric potential difference in the soils and geological substratum and is determined by two processes involving the movement of ions, streaming potential and electrochemical potential. The self-potential (SP) methods are, hovever, among the oldest of all geophysical methods, and they involve the measurement of the electric potential at a set of measurement points called self-potential station (Revil, Jardani, 2013).

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In the literature we find studies of the relations between the geomorphological component and the hydrological characteristics, the latter being the one that is registered by the Spontaneous Potential method, in this case.

The water infiltrated into the soil contributes to the formation of landslides (Naudet, 2008; Chambers *et al*., 2011; Hattori *et al*., 2011; Revil, Jardani, 2013), modeling of the karst relief (Jardani *et al*., 2006), and of the relief partially saturated with water (Jugnot, Linde, 2013). All of these can be monitored through geophysical investigation methods. Another component that can be analyzed is the anthropogenic landforms (Price *et al*., 2011). The structures of earth dams are frequently studied using this type of method (Boleve *et al*., 2011; Minsley *et al*., 2011; Rinehart *et al*., 2012) and the fluvial geomorphology (Onu, Opara, 2012).

These are just some of the aspects of geomorphology that can be monitored by the Spontaneous Potential method, this analysis depends both on the answer of the mechanical action of the water (Straface *et al*., 2011) and on the chemical reactions that can cause electric current into ground (Gu, 2013).

The Self- Potential (SP) method is a non-intrusive method and provides an image of what is happening at a time in the undersoil (Revil, Jardani, 2013). The method itself has been used since 1830 for determining subsoil resources (Fox quoted by Roudsari, Beitollahi, 2013) and relies on recording the values of the movement of the water in porous spaces (Jardani, 2007; Boleve e*t al.,* 2011). It has direct applications of fluid flow in soil mapping, identification of natural or man-made cracks in dams made of earth (Wishart *et al*., 2009; Moore *et al*., 2011; Boleve *et al*., 2011), mineral resources (Guerrero, 2004), analyze characteristics of the hydrothermal areas (Colangelo *et al*., 2006; Singarinbum *et al*., 2012) and other related fields.

Spontaneous Potential method can be approached also in mathematical manner, with studies such as those of Mehanee (2014): "*An efficient regularized inversion approach for self-exploration potential on interpretation of hours using a mix of logarithmic and non-logarithmic model parameters*". Straface, De Biase (2013) or Roudsari and Beitollahi (2013), these are just some of the recent studies on this topic. Physical-chemical approach method was performed by Revil *et al*. (2009) in "*Ionic Contribution to the self-potential signals associated with a redox front*", Peksen *et al*. (2011): "*Application of particle swarm optimization on self-potential data*", Boleve A. (2009) or Linde N. *et al*. (2007) with "*Estimation of the water table throughout the catchment using self-potential and piezometric time in a Bayesian framework*."

All these works have helped to create a solid basis of this method, proving the validity of how it is perceived in the SP geophysical method. Although in Romania there are currently not many such works, the results obtained by external researchers can still be correlated with a local geophysical environment to implement this method optimally. We can therefore use this technique to highlight the fluid mobility processes existing in the landforms and finally reveal some characteristics of geological substratum and geomorphological structures. In the Romanian geomorphology the Spontaneous Potential method was applied for the first time on the periglacial earth hummock of Muntele Mic in October 2011[2].

[2] Urdea, P. (2011), Spontaneous potential in periglacial geomorphology researches, International Scientific Conference „*Geographical research trends in the European space*'', West University of Timişoara,Timişoara 13-15.05.2011.

An important aspect is the quantification of results obtained by this method, so to have a more complete picture of what takes place in the ground, there is a need for continuous structures. This can be achieved by interpolating the values obtained in the field, and as interpolation methods can be used Radial Basis Functions (Buhmann, 2000, 2003; Bullinaria, 2004; Morse, 2005; ArcGIS 10.1 Help), Kriging with its many variants (Kleijnen, 2011; Hengl *et al.*, 2008; ArcGIS 10.1 Help) or Inverse distance Weighted (Lu and Wong, 2008; Miller, 2005; ArcGIS 10.1 Help), can be used as interpolation methods, each presenting some advantages and disadvantages.

The main **purpose** of our study is the analysis and interpretation of data derived from measurements made in different sites. The **objectives** of this study are the evaluation of the values acquired through Spontaneous Potential method in the mountainous landforms and analyze their temporal evolution.

2. RESEARCH AREA

Semenic Mountains are the highest unit of the Banat Mountains, reaching 1447 m in Piatra Goznei Peak. One of the features that provide a unique identity to these mountains, even to the highest part of them, is the wide deployment of the peneplains. The upper surface was identified and named Semenic by Emm. de Martonne (de Martonne, 1924). This author believes that the physiognomy of this erosion platform is identical to Borăscu platform, but at a lower altitude („…*la physionomie de la platform du Semenic est bien celle de la platform Boresco à un niveau inférieur*"; de Martonne, 1924, p. 154).

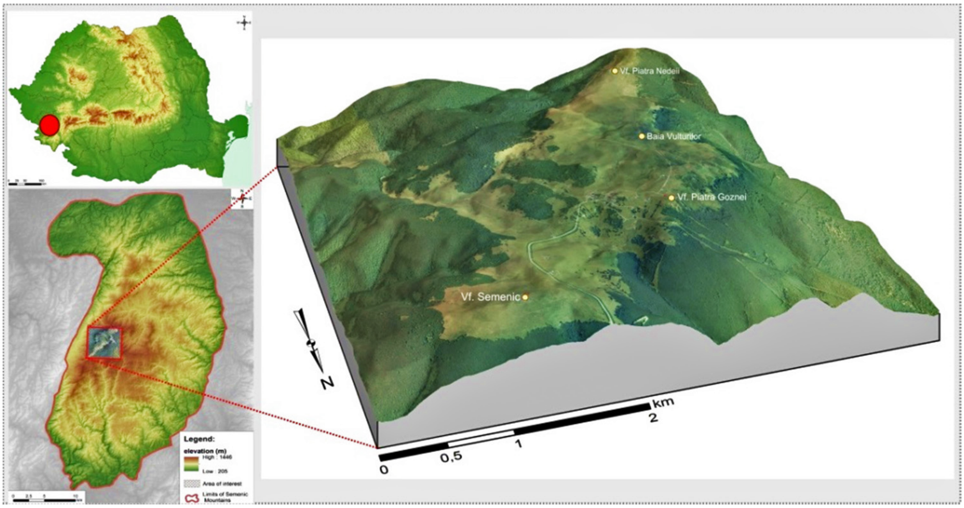

Fig. 1. Location of the research area.

The detailed geomorphological elements are represented by many periglacial landforms, with an evolution connected to the current weather conditions. The long period of time that snow persists contributes to the emergence of specific crionival landforms.

Semenic plateau, above 1400 m a.s.l., is dominated by residual peaks of monadnock type, the most important ones being Semenic peak (1446 m), Piatra Goznei peak (1447 m) and Piatra Nedeii peak (1437 m) (fig. 1).

The Spontaneous Potential investigations were made in Semenic plateau, in the central west side of Semenic Mountains (fig. 1), at altitudes above 1350 m, in three distinct areas: the nivation niche near Baia Vulturilor spring, a section of cryopediment developed under the Semenic peak and a portion of glacis near Piatra Goznei peak, close to the television tower.

Semenic Mountains are made of intensely metamorphosed crystalline schists, predominantly those meso-metamorphosed and the epimetamorphic ones, part of the Lotru Series of the Getic Nappe, which are quite limited to the central region. In Piatra Goznei, Semenic and Piatra Nedeii peak area, sinorogenic granitoides rocks can be observed. Semenic peak consists of micaschists, biotite paragneiss, nodular gneisses and migmatites, while Piatra Goznei peak has in its composition micaschists, granites, granodiorites and lenticular migmatites (Savu, Maier, 1976).

The geomorphologycal landscape is dominated by Semenic leveled peneplain - with low landform energy. Because of this, in the central plateau and beyond, have formed raised bogs, water drainage being reduced. The residual peak Semenic, Piatra Goznei and the Piatra Nedeii peak are surrounded by cryopediments (fig. 2). Also landforms such as glacis and nivation niches are to be found here.

Fig. 2. Cryopediment around Semenic Peak.

On Semenic plateau, one finds many **soil types** grouped into certain categories so that pre-podzols are in the upper part. They are divergently arranged around the higher areas. Flat surfaces are composed of histosols due to the accumulation of liquid and solid precipitation and insignificant runoff. Besides the predominant soil types, there are associations of districam-bosoils, podzols and lithosols having a sandy loam texture[3].

Each type of soil characteristic influences the SP values obtained, and this case is an example of the nival niches pedology.

From the **hydrological** point of view, Semenic plateau is drained by many rivulets, in some areas forming small periglacial lakes during periods of snow melting and significant rainfall. In the center of the plateau bogs are formed due to weather conditions and local morphology.

[3] Romanian soil map 1: 200,000, 1989

The **climatic conditions** are influenced by the western winds. The annual average temperatures is around 1.5°C, rainfall exceeds 1400 mm, with heavy snow[4]. Precipitation has a significant role because the streaming potential study takes into account the movement of particles entrained by water in the soil, but must take into account several other parameters.

The subalpine **vegetation type** is found at altitudes above 1350 m, local conditions (precipitation, temperature, circulation of air masses) contributing to the appearance of the mountain meadows with *Carex curvula, Poa media* and *Festuca* and isolated patches of shrubs (*Vaccinium myrtillus; Vaccinium vitis - idaea*). In the marginal zone of the Semenic plateau there are spruce and beech forest patches, and swamps with peat moss (*Sphagnum*) are characteristic to the areas with poor or difficult drainage. These characteristics influence the Spontaneous Potential values received by water absorption from the soil by the root system and transport to the canopy. The mixed arrangement of these species contributes to the diversification of characteristics exerted on the soil and rock layer in some cases.

As we mention, cryopediments are present around the peaks, the result of erosion occuring due the periglacial conditions on a surface with solifluction and slope drains, transporting the debris fragments resulted outside the area (Iannicelli, 2010). Environmental conditions during glacial periods significantly influence the formation mechanism of the cryopediments, being influenced by the lithological structure, slope, vegetation coverage, the presence of permafrost, type and amount of precipitation (Czudek, Demek, 1971; Vandenberghe, Czudek, 2008). As for other landforms, the glacis are described as concave surfaces of various sizes, whose slope is running from the edges towards the inside (Garcia – Tortosa *et al.,* 2011). There can be found the pedological material erosion in the marginal zone and sedimentation thereof in the central part, a result of the action of water drainage. Although the size is reduced, we can still observe the local trend, but due to anthropogenic influence exerted by the television tower nearby, there were abnormalities of electricity in the soil, imposing filtering the signal (Crespy *et al*., 2008).

Another landform associated with the periglacial slope processes found in the Semenic plateau and which showed interest was the nivation niche from Baia Vulturilor, identified since 1922 by Emm. de Martonne („*Les depressions tourbeusses où l'on trouve meme de petit lacs à la localité appelée Adlerbad, ont l'apparence de cirques embryonnaires, et indiquent qu'il y a eu là, pendant la periode glaciaire function de névés temporaries*"; de Martonne, 1924, p 153). These landforms are formed at the base of slopes where they accumulate more snow; it is maintained for a longer time period, and due to frost acting on detaching fragments from slopes due to temperature differences (Gerrard, 1990). The rock fragments accumulate where the snow is discontinuous, and between the origin slope and the fragments layer an asymmetrical excavation is formed in the soil retaining water for a longer time.

Because this area of investigation is integrated in the "Semenic–Cheile Caraşului National Park" protected area, for studies on specific aspects of soil, it requires the use of non-invasive methods. Such a method is the Spontaneous Potential with insignificant impact on the ground. Although the literature mentions the complementary use of geophysical methods for higher accuracy, such as the use of electrical and electromagnetic methods, for this study, the Spontaneous Potential method was chosen as the study technique.

[4] Annual Report on the state of the environment in Region 5 West in 2010

2.1. Investigation on the characteristics of the sites

The first set of measurements was conducted on 10.11.2011, investigations being carried out on that date in two sites of the grid type. Grid 1 was conducted in the nivation niche near Baia Vulturilor spring (fig. 3).

At that date soil moisture was lower due to the lack of precipitation during autumn, but due to the high altitude, vegetation moisture content was increased. That day, visibility was low due to dense fog and the temperature was low also. It has sides of 30 m, and the points from which the data were obtained has a frequency of 5 m. The fixed electrode has been set at about 2.5 m from the upper edge of the profile, in the middle of it.

Fig. 3. Baia Vulturilor nivation niche site.

The second grid was conducted on the southeastern slope of the Piatra Goznei peak, close to the TV tower, about 130 m from it (Fig. 4).

Just like in the first place, the edges of the profile were about 30 m, with a frequency of the sampling points of 5 m.

Due to human conditionings that we will present later, in the framework of the second phase of measurements (19.05.2012), we have not made a grid near the TV tower, but only in the nival niche Baia Vulturilor, in the same sample points, and on the cryopediment situated on the SW side of Semenic peak. Within this site, a grid with sides of 30 m in width and 45 m in length was made.

Fig. 4. Piatra Goznei site.

3. SPONTANEOUS POTENTIAL METHOD

Spontaneous Potential method is a method of non-invasive geophysical survey that allows obtaining values of the electric potential of the soil as a result of the interaction between chemical, physical and biological properties of the generator agents (Revil, Jardani, 2013). Knowledge of internal mechanisms that generate this natural electricity leads to a better interpretation of the results obtained, so that the process will be presented in the following.

Spontaneous Potential is defined by Jardani as "*passive measure in the surface or drilling of the natural electrical potential distribution created by polarization mechanisms of the electric cargoes in porous media (streaming potential linked to water flow, consistent with redox phenomena*" (Jardani, 2007, p. 46).

It is accepted that the mechanisms generating a potential difference are:

• electro-diffusion phenomena: in which the difference in mobility of ions in a given environment and the existence of a salinity gradient created by the electrical potential difference is called the diffusion potential (Maineult, 2004; Jardani, 2007);

• oxidation-reduction phenomena: where oxidation reactions and reduction produces electrons that can be mobilized because of the redox potential;

• electrothermal phenomena: this differential ion diffusion under the influence of a thermal gradient of pore water is contributing to power generation;

• streaming potential phenomena: they involve moving of the excess electric charge near the mineral surface under the influence of the fluid movement into the soil pore system.

The fluid movement in the pores of the soil or weathered rocks, contributes to the existence of the mobile ions movement and when the contact between colloids and the mobile part of the mineral layer is free, this detach helping to create a convection current and the other side, called conduction current. The associated potential conduction current is the one that can be measured at ground level (Moore *et al.*, 2011).

Generation of current from streaming potential due to the electric interaction of the fluid and minerals depends largely on the factors existing at a point, but knowledge of their internal mechanisms can lead to a proper correlation between the internal and external environment. Due to the shaping in the soil of the processes through which current generates streaming potential, the pedological material characteristics are influenced by many factors (geology, plant associations, climatic influences, soil moisture, geomorphometry). Spontaneous Potential values obtained have influenced each other by many factors. Besides, streaming potential itself is associated with a range of parameters that influence the positive or negative values recorded. Jardani (2007) identified the following two sources as being responsible for producing noise:

- the magnetotelluric induction: where temporal variations of magnetic field induce electric telluric currents, and the frequency can be identified at the level of the sidereal day; if there are irregular and rapid variations (within one hour), this may be due to thunderstorms; in the case where investigations are to be carried out for a period of time less than a day, it can disregard this noise source;
- the bioelectric potential: may occur due to the transfer of chemicals between biotic factors and may influence the SP by generating an electric current induced in the ground; its effect is well highlighted in forests, meadows and pastures, which drains water through plant roots from the soil and helps to create an additional electric potential. To avoid this source of noise, measurements should be performed away from the root system and use the bentonite for stabilization of the moisture in the sample points.

According to the company producing SDEC electrodes (electrodes used in this study[5]) the ratio temperature /electro-infiltration current is 0.21 mV / °C, so that during

[5] *http://www.sdec-france.com/soil-science-equipment-sensor-pms9000.html*

the day, thermal amplitude should be considered and should offset final values. A difference of 10°C is considered to be responsible for SP amplitude values of about 2 mV, which should be corrected (Jardani *et al.*, 2009).

In addition to the listed sources of noise, changes in the values of SP are also influenced by the effect of the pH with alkaline as it is, the values recorded are larger-scale negative (Ishido, Mizutani, 1981, cited by Guichet 2002). Rock mineralogy also imposes certain issues, depending on their composition yielding electro-infiltration differentiated values. The influence of permeability is equally important, as well as partial saturation of the electrolyte and electrical conductivity of the soil (Darnet, 2003). The knowledge of these parameters allows an objective distinction between power sources themselves and those that are redundant and contribute to a misinterpretation of results.

4. DATA ACQUISITION

Spontaneous Potential investigations were carried out using non-polarized electrodes connected to a voltmeter (fig. 5).

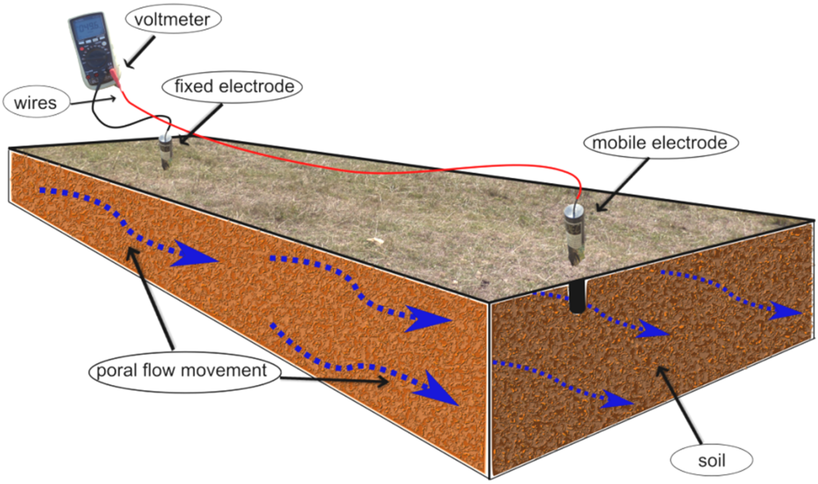

Fig. 5. Spontaneous potential acquisition values.

A non-polarized electrode is made of a metal in contact with a saline solution (Revil, Jardani, 2013). In this case electrodes Petiau Pb/Cl_2 are used: one used as a fixed electrode, placed outside the investigation site, and a second electrode as a mobile electrode, moved at different sample points in the field.

At the point where the fixed electrode is placed, for better conductivity, bentonite mixed with water is inserted, and to avoid reducing the salinity of the pore water due to evapotranspiration results by the analyst soil ripped to break up, a saline solution is applied (Revil, Jardani, 2013).

A VoltcraftVC850 digitalmultimeter was used, which allows the recording of the voltage of the electric current in the range of 0.1 mV– 1000V, thereby providing very accurate values. In addition to recording Spontaneous Potential values expressed here in millivolts (mV), the instruments may be used for the acquisition of soil temperature values or the intensity and frequency of the electric current in the ground.

4.1. The interpolation of values obtained using Self Potential method

The next step of the data acquisition has been to use them in such a way as to allow continuous analysis of the values obtained in the grids made. The objective was to obtain patterns of subcutaneous erosion and penetration of water into the soil. This operation was performed by integrating these values in the interpolation methods implemented in the software ArcMap 10.1, allowing the realization of the whole process of preprocessing, and exporting the resulting data. For this purpose, one can use other programs such as Surfer or SAGA. In ArcMap 10.1 several methods of interpolation were implemented, as deterministic, such as Inverse Distance Weighting, Global Polynomial Interpolation, Radial Basis Functions and Local Polynomial interpolation as well as stochastic called geostatistical methods[6].

However, in both types of interpolation methods, they are interpolations that return results that take into account the values previously entered, there is a crossover between the output and the sample values, called exact methods, and interpolation simulating results based on baseline applying a smoothing over them, called inexact methods. However, we briefly introduce most interpolation methods that are implemented in ArcMap program.

The interpolation method that was suitable for this study was ***Radial Basis Function***. In this method, the resulting surface must pass through every sample, the spaces between the points are constructed based on variables chosen by the analyst as: Thin-plate spline, Spline with tension, Multiquadric function, Completely regularized spline and Inverse multiquadric function. The latter function returning in a much smaller prediction error as compared with the other[7], and, on the other hand, the advantage of this method of interpolation is that it shows to be more flexible and more automatic than Kriging functions. The variables available are much fewer, but still provide a measure of accuracy.

When the number of samples is higher, the results are more in line with reality, making it a relative smoothing compared with Inverse Distance Weighted interpolation method. Low quality outcomes are returned if the differences between inserted points are high, favoring a high degree of uncertainty. The method was used in this study because of the favorable response to all data sets compared to other models that returning the artifacts for some integrated datasets.

Another interpolation method that has the potential to use is ***Inverse Distance Weighted***, being a deterministic method, accurate, relying on the idea that the more things are close, then they should be similar. This method generates values around the sample

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[6] A quick tour of Geostatistical Analyst ArcMap 10.1

[7] ArcGis 10.1 Help

point, giving high weight areas in the immediate vicinity, and low weights to those distant, thus helping to create a map composed of concentric circles. Within a dataset, weights corresponding to sample values will decrease in importance as they are farther from the point of origin. The weight is set so as to yield a reduced root mean squared prediction error (RMSPE), statistically calculated in the module at the stage of cross validation. The result is sensitive to the presence of clusters and outliers and it does not appear as a viable model due to the lack of integration standard error of prediction.

A third ***Kriging*** method is used as part of geostatistical interpolation methods. It is an interpolator that can be exact or inexact by measurement error models and exploratory tendency (local or global). It is flexible and helps graphically investigate the autocorrelation and cross correlation. Kriging method uses statistical models to return a variety of surfaces including predictions of surface result, predictions of standard errors, probability and quantile. The flexibility of the models requires an active involvement of the analyst, which reduces the objectivity of the final results. There are several types of Kriging interpolation - Ordinary Kriging is the most common, others are Simple Kriging and Universal Kriging. Ordinary Kriging is characterized by flexibility and means that using a constant average is acceptable and this is used for data showing trends.

A fourth method of interpolation that can return satisfactory results is ***Empirical Bayesian Kriging***. This works by automating some parameters in their calculation segmentation processes, the input data set and the integration of simulations. These parameters must be set manually in other Kriging models. It is based on the Kriging interpolation method, reducing uncertainty estimation of these mivariogram by additional semivariogram of simulated input data.

Empirical Bayesian Kriging performs local models based on a subset of data originally inserted. Due to non-integration of uncertainty in the algorithm, other methods of this class underestimate the standard errors of prediction. Among the advantages of this method, one can include the need for a minimum contribution of the analyst in setting the model variables, the standard errors of prediction are more accurate as the other Kriging methods and lends itself much better than normal Kriging models for the analysis of small data sets. Simultaneously, the disadvantages faced are related to high processing time simulations and return a raster, and that log transformation Empirical (based only on positive values) is sensitive to isolated values.

4.2. Definition of parameters used in the interpolation

Radial Basis Functions is a method in which there are some parameters that must be defined to obtain a mean square error (RMS) as low (table 1). However, it must set the same parameters for all data sets to reduce the influence of the human factor, although in some cases custom settings are imposed. These parameters were determined by testing multiple combinations.

In Geostatistical Analyst module, after selecting the data set and the values that were to be used in the "Method Properties", the parameters to be presented were introduced.

Table 1.

Comparison of mean square error interpolation models for data used for interpolation in the Baia Vulturilor site 19/05/2012

Function	RMS
Completely Regularized Spline	8.513
Spline with Tension	8.510
Multiquadric	8.694
Inverse Multiquadric	8.450
Thin Plate Spline	9.070

Among the features used, Inverse Multiquadric returned the lowest mean square error. When the tool is selected, the tool of choice of a parameter appears acting as a weight and is directly influenced by the selected function and the characteristics of the data set.

Then follows the method of searching of the neighbors and it returns intermediate values. We chose standard type of neighbors, in order not to influence their search, with a choice of minimum and maximum number of neighbors considered. The maximum number of neighbors is the total number of values that are taken into account in the application position. In this case, there is a total of 10 points selected distance to be used at a time, while the minimum was set to 5 (fig. 6).

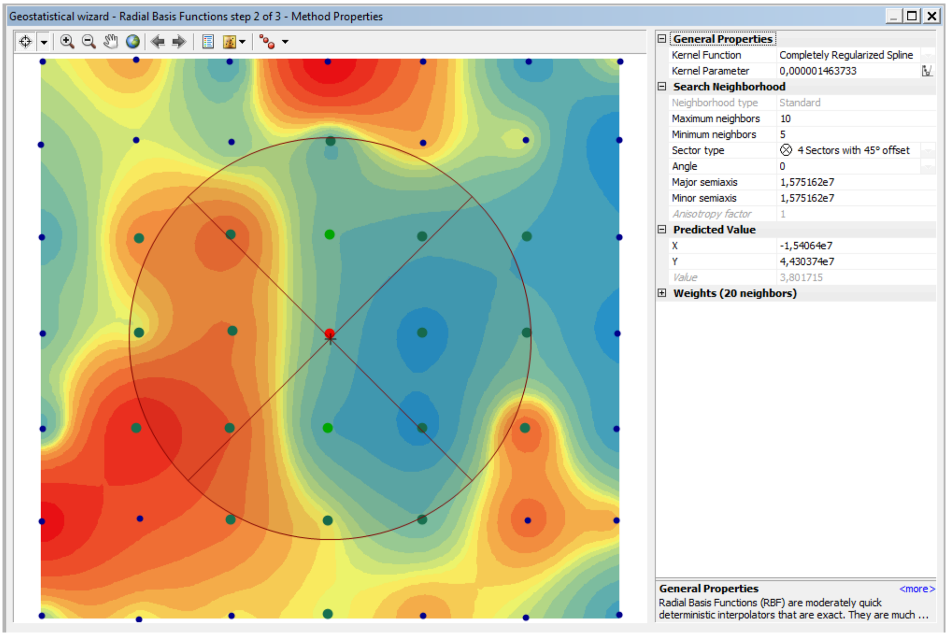

Fig. 6. The implementation of interpolation method in ArcMap 10.1 program

The next step is to choose the type of search of the sector. The amounts can be taken out in a simple circle or one segmented into four sectors, four sectors with an angle of 45° or eight sectors. Each of these different settings affects the final result, but should be kept in mind that these settings should be implemented in each of the data sets, so by their own choice have obtained maximum value for each set.

These are the parameters that could be influenced by this method of interpolation, other features: semi-axis major and minor semi-axis is influenced by the dataset, and the anisotropy could not intervene, conventionally the assigned value is set to 1.

4.3. Comparison of raster types of grading results

After obtaining raster representations of Spontaneous Potential values resulting from the application of interpolation methods, the question is how this structure is classified. Each classification method is implemented in the software ArcMap 10.1. Methods found in other programs have certain characteristics that may influence the graphical representation obtained. Adopting a classification of the raster structure to the detriment of representation unclassified has the advantage of emphasizing certain features that exist in the resulting model but one must carefully choose the method used.

A classification method is implemented using intervals: "***Equal Interval***" and, as known, it involves splitting the value interval in an equal number of classes, number defined by the analyst and is easy to analyze[8]. Disadvantages of this method occur when values are grouped and several elements can appear in a class and very little in another.

Another method exists and has been used in the graphical representation of the results of this study; this is the classification of geometric intervals "***Geometrical Interval***" called "smart quantile". It is a method used for continuous data visualization and data representation folds well, while not having a normal distribution. The method was designed for use in asymmetric histogram data where similar values may appear. The algorithm creates these geometric intervals by reducing the square of an element of a class. The Spontaneous Potential values are similar and they do not necessarily have to be next to each other and smoothing of these values is not necessarily relevant, as these singular values can transmit distinct characteristics of the situation in the ground. The method is used to view the predictions of surface, the distribution of the values but its role is not to identify the values of the isolated space.

A third method used is that of classification through ***quantiles***, where it is assumed that each class contains the same number of elements. This fits in situations where data are distributed. Elements are grouped in a predefined number of classes.

The classification method "***Natural Breaks***" is based on the integration of values in natural groups by combining similar values into different classes or features classes. It is used to represent values that do not normally occur on the histogram; however the method is limited to a single set of data whilst putting the problem of choosing the number of classes due to a wide distribution[9].

[8] *http://individual.utoronto.ca/lackner/ggr272/DataClassificationMethods.pdf*
[9] *http://individual.utoronto.ca/lackner/ggr272/DataClassificationMethods.pdf*

A final method of classification is the ***standard deviation***, and is used to see the variation from the mean data. For this purpose, it calculates the average and standard deviation and class division is based on the values obtained. If one uses only standard deviation the number of classes resulted is 6, and when using only half the standard deviation, the number of classes increases to 12.

At last we will integrate specific elements of a map and its export.

5. RESULTS

Within the investigation sites, spontaneous electrical potential of an area at a time was analyzed when the frequency of rainfall was lower as well as after a period with significant amounts of precipitation both solid and liquid. In winter 2011 and spring 2012, the snow cover on Semenic plateau persisted until May with a significant thickness, so that the amount of meltwater in the soil was considerable in the second stage of investigation.

5.1. Baia Vulturilor nivation niche

The areas with low values (shades of green areas) are areas with a fluid mobility in the soil layer (fig. 7), while the southern part of the grid is characterized by the slope decrease. The existence of concave relief microforms covered with a significant layer of soil and peat material over time are probable, but still directing water flow. The evolution of the current values depended on the local morphology of the soil and climatic situation at a given time. Thus, one can see significant changes between the two periods in which measurements were made. The SP values were amplified in this case by increasing the movement of water caused by increased rainfall and local topography that allows drainage to the SW grid.

Evolution of SP values (mV) and amplitude for the nivation niche Baia Vulturilor differ from one climate period to another period, in the sense that, for example, the first column of the grid, on 10.11.2011, oscillations are strongly amplified with a maximum of 56.7 mV and a minimum of -0.5 mV, compared to the same line, but on 19.05.2012 with a maximum of 30.1 mV and 10.8 mV minimum. The lack of precipitation contributed to significant fluctuations in the soil layer by decreasing the mobility of chemical elements and forcing them as their movement depends on kinetic energy. High values suggest immobility of the soil colloids in terms of slope and low fluid mobility.

In general, there is a difference between the two periods, at least at the top of the grid, meaning that values of the East-West axis present oscillations that vary from one period to another. This can be explained by reference to the slope which was established as the area of investigation, the first registration point being on the side with higher altitude than the last point of the column. Fluid mobility will therefore be more active on this orientation, SP values retaining a certain uniformity.

In the nivation niche, from row 3 and column 5, graphs of values obtained in two separate periods begin to have relatively similar trends. From this cyclical evolution, it may emerge that non saturated surface (topsoil) of the median - lower grid-like values keep the SP in different climatic periods. Natural drainage in this area remains constant, influencing compliance and particle mobility.

The values presented, in addition to a similar evolution chart, form a similarity between the values obtained, as their amplitude varies only minimally from one case to another with a maximum of 20.9 mV in 10.11.2011 and 27.1 mV in 19.05.2012 for point 3 in both cases and a minimum of -15.9 mV on 10.11.2011 for point 5 and -14.4 mV on 19.05.2012 to section 6 of the row 4.

One notices that in the case of the column 7 values are quite small the first time and now there are two positive peaks in the second period. This last set of values is totally negative marking there is a constant fluid flow that involves chemicals continuous systems. It should be mentioned that there is a small creek in the neighborhood, which can provide a constant wetting of the soil, or at least wet periods, the remaining time can operate in the lower vegetation layer even at low levels.

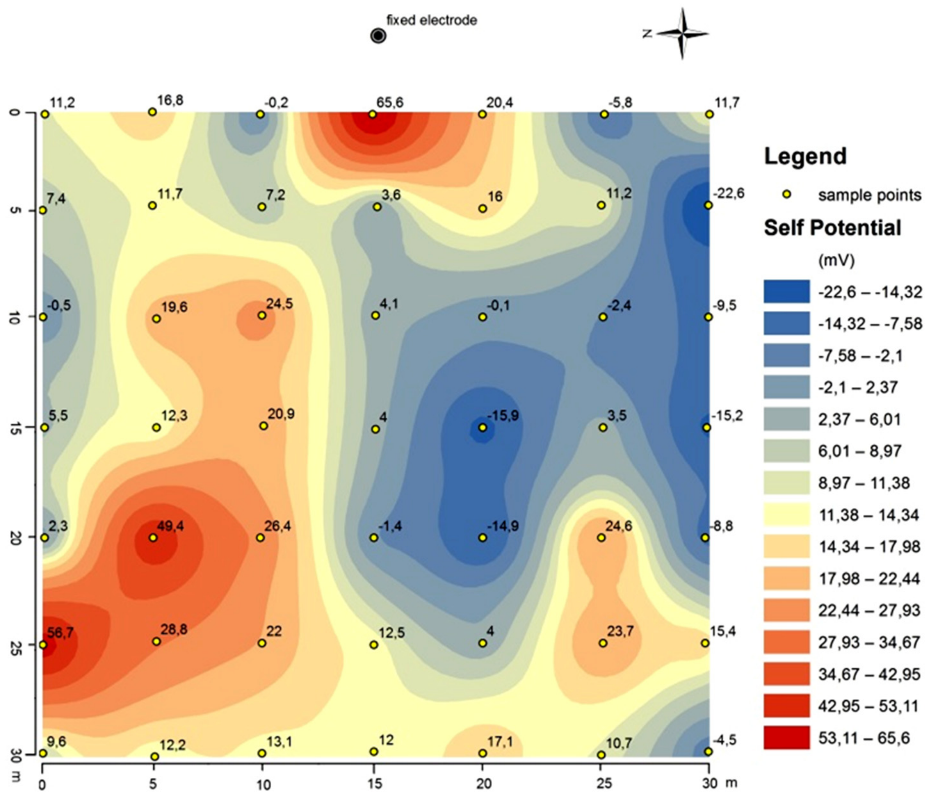

Fig. 7. SP pattern – 10.11.2011 on Baia Vulturilor nivation niche.

Although the difference in height between the North and South side of the grid is reduced to the level of the second period of investigation (fig. 8), leveling values, between 10 mV and 30 mV of Spontaneous Potential in the northern part of the grid are noticeable. If on 10.11.2011 in this part of the grid, there are two values of more than 45 mV, with a maximum of 65.6 mV on the upper side of the investigation site, this time the resulting values are more homogeneous. This is due to the large volume of water in the soil that contributes to its saturation and reduces the water movement in the soil in the northeastern section, forcing it to move to the lower area, this area being the closest to Baia Vulturilor spring. The north-west retains similar characteristics which assert the existence of a concave geological irregularity covered by soil layer that stops water moving to areas with lower slope, while the soil might be deeper to the South, encouraging water circulation.

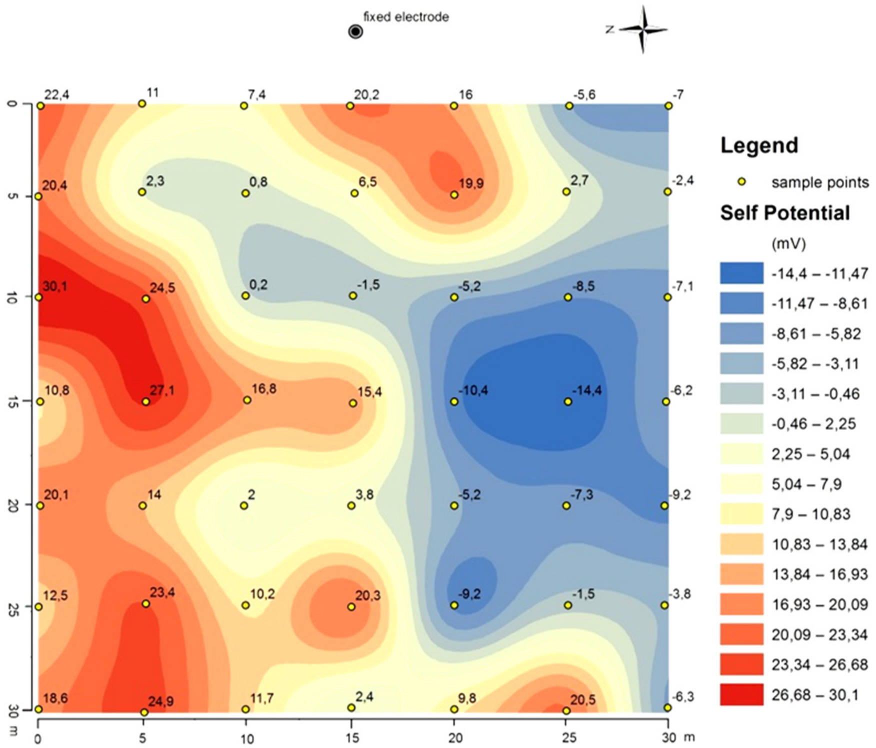

Fig. 8. SP pattern – 19.05.2012 on Baia Vulturilor nivation niche.

It is also possible to monitor the development of Spontaneous Potential values on graphs made by both rows and columns. These graphs allow observing the changes that occur in a single column or row allowing detailed assessment of how the current distribution in the soil evolve, caused by infiltration and evaporation. One notices the existence of the features that can outline a specific way of evolving in different periods and their behaviour.

5.2. The glacis of the Piatra Goznei peak

Another area examined was the glacis near the TV tower on Piatra Goznei peak, but because of electrical interference emitted by the tower, the returned values were strongly influenced. The values resulting from the measurements were very high (fig. 9) compared to those derived from measurements of Baia Vulturilor on the same day. The distortion of SP values obtained obstruct the formation of an image on this area, but even so, we can still deduce general electric character of the area concerned. Higher values are located in the center of the grid while lower intensity values are located peripherally. From this analysis, it may result that there is a radial fluid movement from the center to the periphery.

To demonstrate the influence of electric current emitted by TV tower at other area measurement, we conducted a profile in the same area where we made previous measurements. This time we have not considered the recorded electric voltage, but the frequency of electricity found in soil. Thus we obtained a value of 50 Hz, a frequency that is used throughout Europe. This demonstrates the existence of a power of artificial origin within this site. For this reason we gave up the second set of measurements, which are not conclusive. Data columns are more uneven, but in almost all cases you can view a fall in the south - west grid graphs and convexity in the middle. Even if they try to correct the values by eliminating the electricity mathematically, its action has influenced not only receiving incorrect values , but amplified its power.

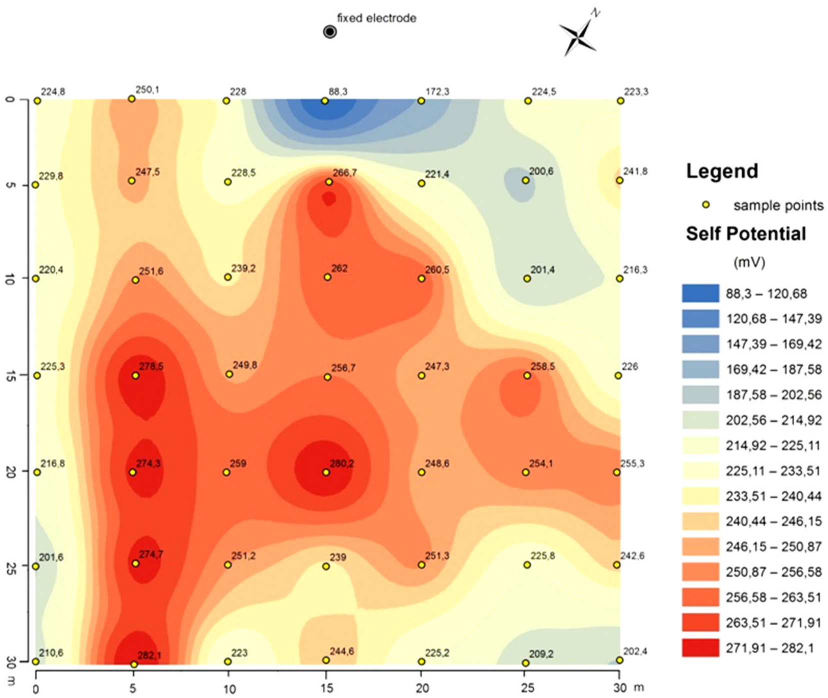

Fig. 9. SP pattern – 10.11.2011on the Piatra Goznei Glacis.

However, the distorted values can be recorded overlapping a compact lithologic body, analyzing the layout of the respective SP values, knowing that certain minerals such as pyrite or quartzite contributes in the return of the high SP values.

Because of the influence of anthropogenic environment, in order not to receive a set of wrong values, we decided to move the study site near Semenic peak.

5.3. The cryopediment developed close to Semenic peak

If the electric anthropogenic influences are reduced or even nonexistent, the SP values may be associated to real situation in the field. With this site, although no comparative investigations of other climatic periods were made, in this set of measurements we found only negative values (minimum is -40.28 mV), which is associated with particularly southern slope gradient and geologic substrate, which can confirm some theories.

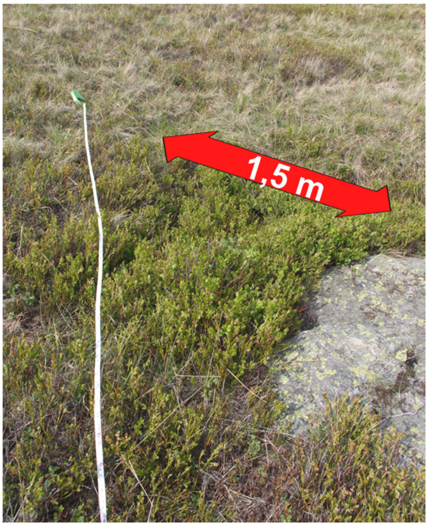

Fig. 10. Ploughingblock in the cryopediment under Semenic peak.

In this case (fig. 10), it can be generally seen that values increase from the upper portion (NE) to the bottom (SW) which means that once the slope decreases and the fluid flow rate in the soil decreases, this is associated with the increase or decrease of the current values in the soil.

The problem is that things are not so simple; the lithology of this area was affected, though on a smaller scale, the presence of cryopedimentation processes, which was visible on the low inclined surfaces surrounding the peaks of Semenic plateau, and the existence of rock fragments radially arranged around the peaks, making part of their structure at some point.

From the representation made, one may see that the areas with shades of blue have lower values of SP, which may correspond to areas with rock fragments, a ploughing block, that are carried along with the soil layer to the edge of the slope.

In the cavities behind these blocks (fig. 11) that moved parallel to the slope, the water infiltration acts simultaneously with the gravity and the slope gradient in the process of that rock slide, and snow accumulates in them in winter. In larger spaces, blueberry bushes grow; the advantage of high humidity, the slope being oriented SW, solar radiation reception is significant, contributing to the evaporation of water from soil.

If the connection between the elements presented and those of the ground is viable, through this method of investigation, differences in the constitution of the cryopediments by a relatively simple and cheap method could be detected.

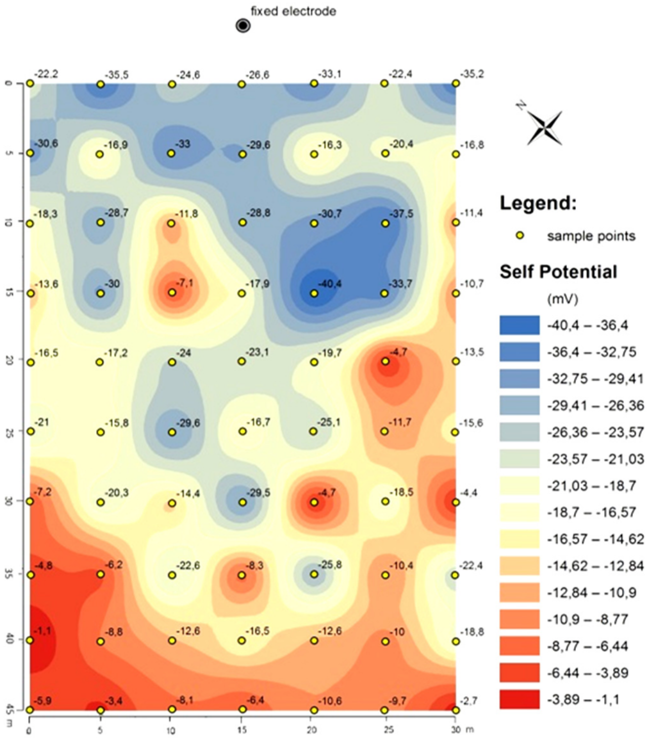

Fig. 11. SP pattern – 19.05.2012. Cryopediment near the Semenic peak.

From the evolution of current values in the soil one can view the increase of SP values from point 1 to point 10 of the columns, suggesting a more pronounced movement of ions combined with higher slope and a drop to the bottom of this report. In general, the values of rows vary according to the geological substrate characteristics which conditions the movement of fragments to the bottom of the slope.

Their variation shows a minimum in the center, but may have more negative peaks in those areas where there is a strong underground infiltration of fluid flow, an infiltration conditioned by the rock layer. Taking into account the not too sharp slope, 16-20°, with a movement towards the bottom of the soil layer, in a long period of time, the movement influenced by rock fragments in place, it can result that the soil layer cannot be very deep.

Examination of figure 10 can punctually identify areas where water can infiltrate in the underground, which may be associated with voids formed behind rocks sliding, enclosing a significant amount of rainfall, which will eventually enter in the basement.

The lower part of the grid returned higher SP values (-12.6 mV / -1.1 mV) compared to the upper zone (-40.4 mV / -33 mV) because this area have a lower slope which contributes to the fluid stability and reduces fluid flow mobility and not involving particles leads to the generation of electro-infiltration potential.

The South-East grid presents a band made up of high values , which climbs to the top of the grid, the draining fluid flow of movement within the grid, and can be associated with a concave rock layer in the portion of soil layer with a lower depth. Instead, the first row of the grid is formed only by low values (between -35.2 mV /-22.2 mV) of Spontaneous Potential, being the part that takes most of the fluid flow recorded.

The values were negative, suggesting fluid dynamics. It must be taken into account that the profile has been achieved after a period with significant precipitation, but in this way, the values highlighted aspects of soil layer. For a better understanding, however, a comparison between two different climatic episodes is required.

5. CONCLUSIONS

The evolution of the current values depended on the local morphology of the soil and climatic situation at a given time. Thus, significant changes between the two periods in which measurements were made can be seen. The values of SP are amplified in the case of increasing the circulation of water generated by increasing the amount of precipitation and local topography that allow water drainage.

For an overview, it is important to use geophysical methods of investigation simultaneously, allowing detailed knowledge of variables that contribute to influencing the values returned.

In these investigations through Spontaneous Potential method, we have emphasized on how water infiltration and movement of water on the geometry of gridsmade in relief developed on crystalline schists, there being some individualized microform specific of this landscape. In fact this is a subcutaneous geomorphological process defined as pipping.

One should consider also the rainfall infiltrated into the soil because Semenic plateau investigations were conducted in the first phase in a period without precipitation and afterwards these investigations resumed after the snow melted. On the Semenic plateau grids were made in nivation niches, glacises or cryopediments surfaces. The general area was characterized by a sustained fluid movement but have a linear distribution character field.

The anthropogenic influence of the natural electric flux puts some problems because its intensity increases, as was the case in the area near the Piatra Goznei peak TV tower. To avoid this problem, in case of investigations of this kind in areas with metal poles or underground power network, before the start of the study one must check the existence of a stable frequency of the electric current.

Although the method itself is quite simple, it can provide valuable information for solving certain environmental problems not only in terms of low cost and high efficiency. It is a noninvasive method, which is important since Semenic plateau investigations were conducted in an area that is part of a national park.

Using this method has the advantage of using a low budget and in less time outlining the characteristics of the subsoil, but for a true validation a second investigation is recommended.

Comparative studies using this method require knowledge of soil moisture in an accurate measurement, soil characteristics and climate issues for a correlation as close to the real situation in the field.

Many factors causing influences of any kind imposed a detail of their knowledge, but also the technique used in some circumstances contributed to the generation of artifacts, especially related cables which convey electricity between electrodes and voltmeter. Therefore, noise (natural or anthropogenic sources) can cause problems, so it must be removed both by mathematical methods and by avoiding certain aspects of the natural environment, not least through the proper use of equipment. However, these problems have been corrected, some influences such as those caused by the thermal amplitude of the day or those induced by vegetation can be deduced and corrected.

Further different geographical environments can be approached, each with its peculiarities and for their detailed analysis, they should be investigated in real time by using multiple electrodes so that they will return values from prescribed intervals revealing some features in detail.

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