

# Using Spontaneous Potential (SP) as a Geophysical Method for Karst Terrains Investigation in the Mărghitaş Plateau (Banat Mountains, Romania)

Laurențiu ARTUGYAN, Petru URDEA

**Abstract:** Mărghitaş Plateau is the name of a karstic plateau situated in the karstic area called Anina Mining Area, in Anina Mountains (Banat Mountains). This plateau is located in the North part of Anina Mining Area and it is characterized by sinkholes doline valleys and independent sinkholes, but also by the missing of surface water and springs. Anina Mining Area is defined by Vasile Sencu (1977) as the area that is surrounded Anina town and it may be exploited by mining activities. The studied area presents many landforms specific for karst terrains. These features belong to the exokarst forms (sinkholes, poljies, karrens, gorges, karstic springs), but also to the endokarst forms (caves, shafts). Because of the geomorphology and the absence of surface rivers, this plateau is very interesting to study, both surface and underground. Geophysical methods are an option to study the subsurface in connection with the surface landforms. One of these methods, which is also used in the analysis of the groundwater, especially in karst areas, is spontaneous potential (SP). Spontaneous potential (SP), also called self-potential method, is a passive and an electrical geophysical method, which quantifies natural electrical fields that are passing along the Earth's surface. We developed measurements in 7 sinkholes, during different periods of the year to take in terms of comparability. We chose approaches, naming here profiles and grids. The method involves two non-polarizing electrodes, a fix electrode and a mobile one. Each electrode was introduced in a hole, approximately at 10 cm deep in the soil and after 1 minute we noted the value - measurements were made in mV- showed on the voltmeter and then we move the mobile electrode. In most of the situation the distance between the electrodes was 3 m, or if the field was larger we take 5 m distance between electrodes. The purpose of this work is to present our preliminary results obtained using the spontaneous potential method to characterize the surface and subsurface drainage in a karstic plateau. The results showed in most of the cases negative values, suggesting a direction in the water circulation, but we also obtained positive values during the dry season, most of them being measured in August and September, after large dry periods. Besides, we note that atmospheric conditions and the quantity of precipitations have a significant influence on our outcomes. In our study, we intend to obtain more field data using spontaneous potential to compare with our first results, but we also to validate the SP results with other geophysical methods such as Ground Penetrating Radar and Electrical Resistivity Imaging.

**Keywords:** karst terrain, sinkholes, spontaneous potential, Anina Mountains.

## 1. Introduction

Karst terrain is the meaning of a distinct relief, which is a result of rock masses dissolution, having as consequences an effective underground flow (Waltham *et al.*, 2005). To understand karst topography, we must recognise the nature and that factors that are defining dissolution processes in karst soluble rocks and the drainage resulted from these processes (Ford, Williams, 2011).

Anina Mining Area is defined by Sencu (1977) as the area that is surrounded Anina town and it may be exploited by mining activities and later, in 1978, Sencu included this study area in a tourist guide. He established the limits of this area as a rectangle with the large side oriented North-South (Fig. 1a).

Tacking into account the main marks of the geomorphological landscape, we established the geomorphological limits of the study area, using the topographic maps 1:25000 (Fig. 1b).

Mărghitaş Plateau is the name of a karstic plateau situated in the karstic area called Anina Mining Area, in Anina Mountains (Banat Mountains). This plateau is located in the North part of Anina Mining Area and it is characterized by sinkholes valleys and independent sinkholes, but also by the missing of surface water and springs. The studied area presents many landforms specific for karst terrains, both exokarst forms (sinkholes, poljies, karrens, gorges, karstic springs) and also endokarst forms (caves, shafts).

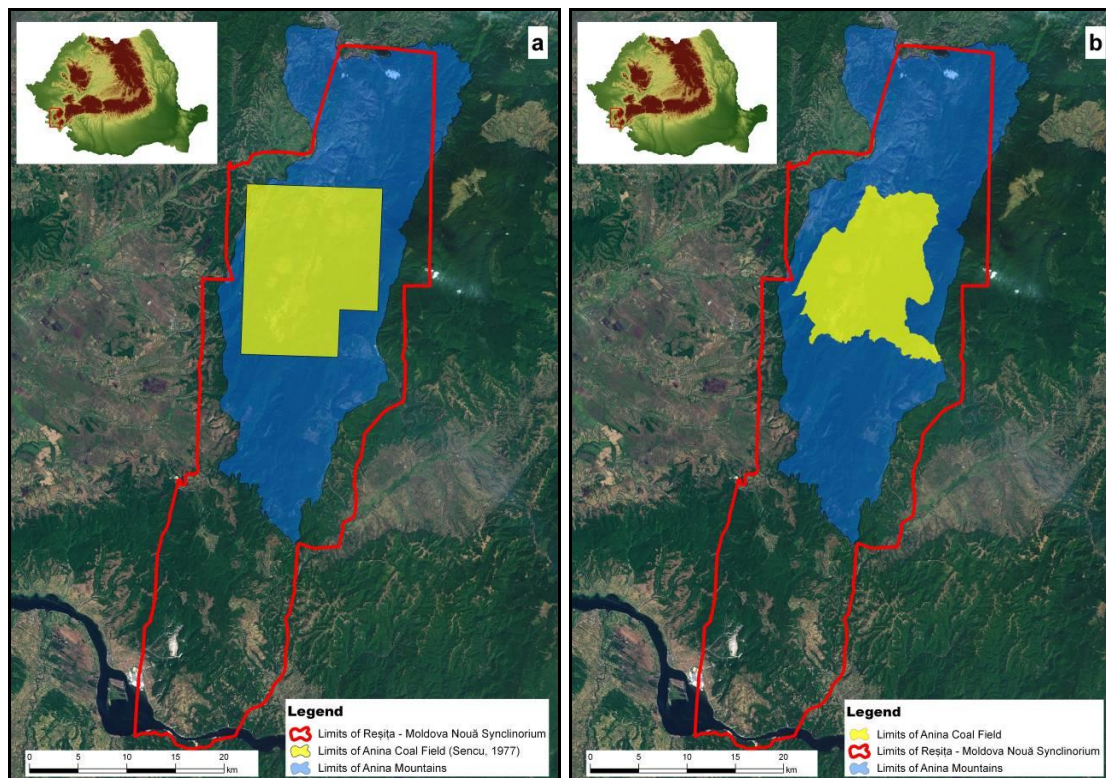


Fig. 1. Location of Anina Mining Area and the limits established by Vasile Sencu, 1977 (a) and in our study (b).

## 2. Study area

Our study area is situated in the largest and most compact area of carbonate rocks in Romania, in a typical structural area, Reșița-Moldova Nouă Synclinorium (Orășeanu, Iurkiewicz, 2010), where the Paleozoico-Mesozoic formations are overlapping fundamental crystalline domain (Bucur, 1997). This overlapping was explained by Oncescu (1965) as a consequence of the fact that the Paleozoic and Mesozoic sedimentary deposits were deposited either before main tectonic meso-Cretaceous phase or in the phase that followed the meso-Cretaceous phase. From tectonic point of view this area is part of Supragetic Unit which consists mainly of crystalline formations, overlain in place by Paleo-Mesozoic sedimentary rocks, affected by the Austrian and Iaramian paroxysmal phases (Năstăseanu et al., 1981).

The Reșița - Moldova Nouă Zone is regarded as the classic area for sedimentary domains, even if sediments that covered a significant part of the sedimentary field were largely removed by erosion. Even so, sediments remained in the area due to the fact that Reșița - Moldova Nouă Zone had the status of sedimentary depression in which succession and erosion of sedimentary cover was complete (Mutihac, Ionesi, 1974).

The study area is representative for the suspended karst plateaus, due to presence of wide

and flat interfluvies separated by deep valleys, and characterized by a high degree of karstification (Onac, 2000).

Mărghitaș Plateau (Fig. 2) is delimited by a ridge and some peaks with altitudes reaching 700 meters in the Western part, and, by the Buhui valley in the Eastern part. The general aspect of this plateau is a flat area (Fig. 3a) with many sinkholes (Fig. 3b), sinkholes valleys, a number of small caves and vertical shafts. Another characteristic for this karstic plateau is that the surface water is missing and also the springs are present only along the Buhui valley.

## 3. Methods

The characterization of karst regions requires specific knowledge of both surface and those forms of underground, and application of the geophysical methods are an option to study the subsurface in connection with the surface landforms. One of these methods, which is also used in the analysis of the groundwater, especially in karst areas, is spontaneous potential (SP). Spontaneous potential, also called self-potential method, is a passive and an electrical geophysical method, in which detect and quantifies natural electrical fields that are occurring on the Earth's surface. The spontaneous potential method is not a new one, being used before in many



karstic areas (Stevanovic, Dragisic, 1998; Lange, 1999; Rozycki et al., 2006; Guichet et al., 2006; Jardani et al., 2007; Jardani et al., 2009; Jouniaux et al., 2009; Robert et al., 2011).

The spontaneous potential method involves two non-polarizing electrodes, a fix electrode and a mobile one. Each electrode has to be introduced in a

hole, approximately at 10 cm deep in the soil and after the value - in mV- showed on the voltmeter is stable, we note it and then we move the mobile electrode. The length between the electrodes was 3 m, or if the field was larger we take 5 m distance between electrodes.

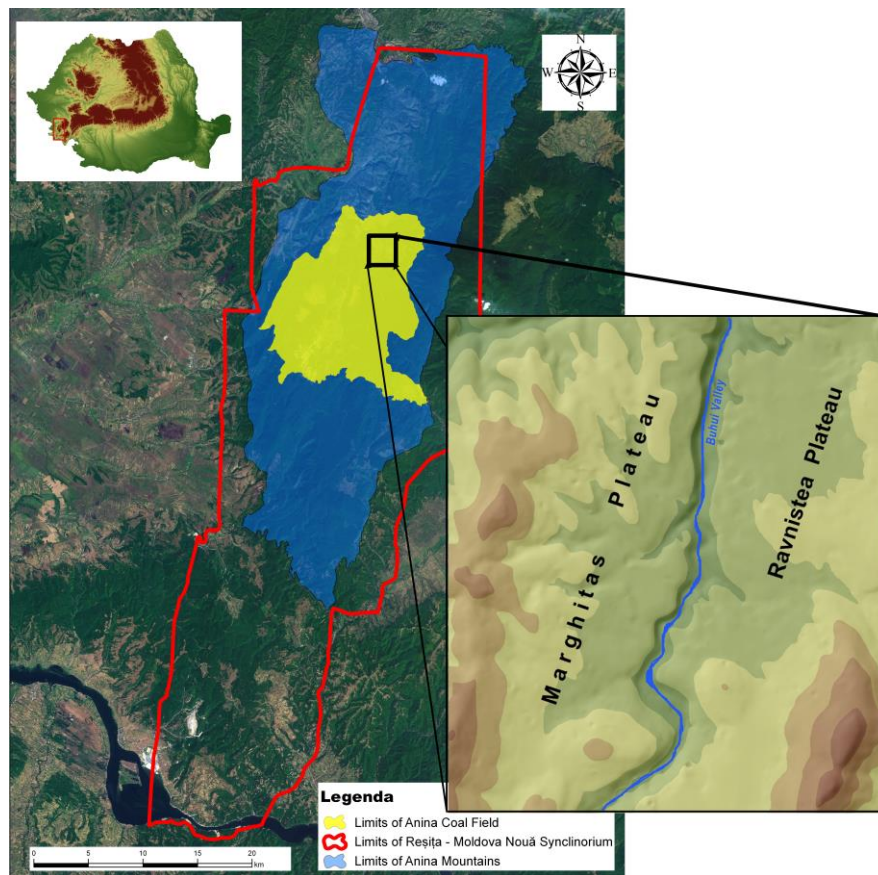


Fig. 2. Location of Mărghitaş Plateau



Fig. 3. General aspect of Mărghitaş Plateau (a) and a large sinkhole (b)

In Mărghițaș Plateau we measured SP in 10 sinkholes. These data campaigns were made during different points of the year to take in terms of comparability. Those measurements were realized as profiles and grids. These measurements give the results of 3 grids (in 2 sinkholes, meaning that in 1 sinkhole we repeated our measurements in a different period) and 28 profiles (2 profiles per each sinkhole measured, N-S and W-E).

Our campaigns started on 1<sup>st</sup> of May 2013 in this area and our last campaign of measurements was in 27<sup>th</sup> of October 2013. During this period we could observe the difference in SP values during three different seasons, starting from the spring and finished in the autumn. The results of these

measurements will be presented in the next section of this paper.

#### 4. Results and discussions

A first finding is that the results showed in most of the cases negative values, suggesting a direction in the water circulation, but we also obtained positive values during the dry season, most of them being measured in August and September, after large dry periods. Besides, we note that atmospheric conditions and the quantity of precipitations have a significant influence on our outcomes. Four of our sites measurements are shown in Figure 4.

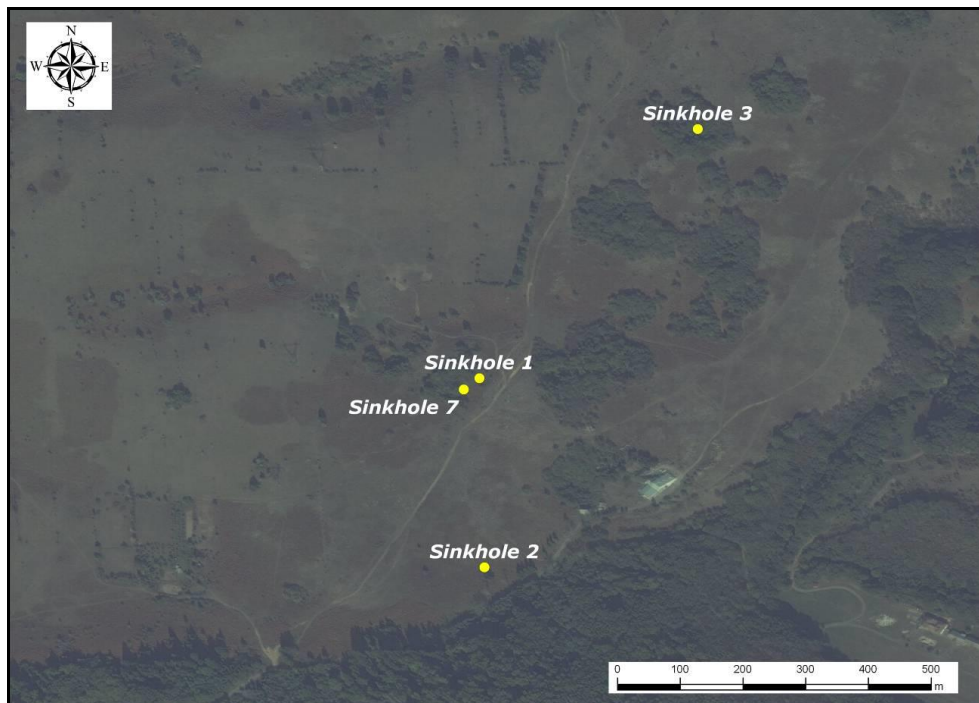


Fig. 4. The localization for Sinkhole 1, 2, 3 and 7

##### 4.1. Grids study case

We developed 3 grid measurements, in 2 sinkholes. The first one is located near other 4 sinkholes, and the other one is located in a plane area bordered by karrens.

The first sinkhole, Sinkhole 1 (Fig. 5a) was measured in 1<sup>st</sup> of May 2013, after a large dry period and during a day with high temperature, from SW to NE direction. Also, measurements of SP show that in the centre of this sinkhole the water is retained more and the ground moisture is higher than on the sinkhole's slopes. The negative values point out that

the water is flowing from SE and from NW toward the bottom of this sinkhole. If we compare the outcomes from this sinkhole with the outcomes of the measurements of the second sinkhole, Sinkhole 2, studied in the same campaign (Fig. 5b), we may observe that the SP values range is similar, with larger values on the boundaries of those two sinkholes, both of them being surrounded by karrens. In both sinkholes our measurements show that in the centre of these landforms, where the aspect is flatter the water is retained more than on the sides of the sinks.



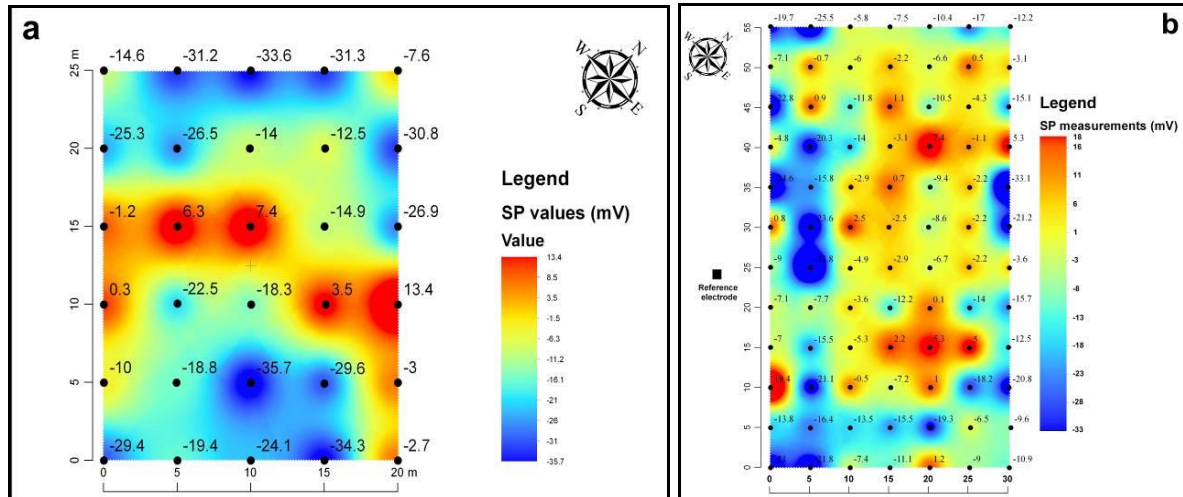


Fig. 5. Sinkhole 1 SP values in 1<sup>st</sup> of May 2013 (a) and Sinkhole 2 SP values in 2<sup>nd</sup> of May 2013 (b-Artugyan & Urdea, 2014)

#### 4.2. Profiles study case

We choose for exemplifying our studies 5 sinkholes for which we realized 10 profiles of spontaneous potential measurements, by two perpendicular profiles, one oriented E-W and one oriented N-S.

##### Sinkhole 3

This sinkhole is a large one, with a diameter of almost 70 meters on E-W orientation and of 60 meters on N-S orientation, having a circular form, with a very flat bottom and very steep slopes sprinkle with large karrens. SP measurements show that on E-W orientation (fig. 6a) the negative values indicate a direction of water flowing to the underground, but the larger values located in the bottom of these sinkholes point out that there the soil moisture is higher as the water stagnation. On the other side, for the N-S orientation (fig. 6b) the profile is more fluctuating, alternating larger values with small values for the entire profile.

The next 3 sinkholes, Sinkhole 4 (fig. 7a), 5 and 6 (fig. 7b), are located in the same area, being as a

chain of 3 sinkholes. The choice of these sinkholes are certainly determined by the fact that these sinks are located in a forested area, and, being late autumn - measurements were created on the 27th of October 2013, leaves retain more humidity even if the measurements were taken in after a large period without precipitations. This is the reason for which nearly all the values measured are negative, with only 2-3 positive anomalies. These sinkholes are not already marked with the GPS.

##### Sinkhole 4

This sinkhole has circular form based on the two diameters, presents greatly forest vegetation and it presents not very steep sides. The N-S orientation (fig. 8a) is relatively homogenous in the profile, but on the E-W orientation (fig. 8b) the values decrease from East to West, as the slope decrease also and at the end of the profile the values are more homogeneous. This suggests that the water flowing direction is from the East to the West, being determined by the slope gradient.

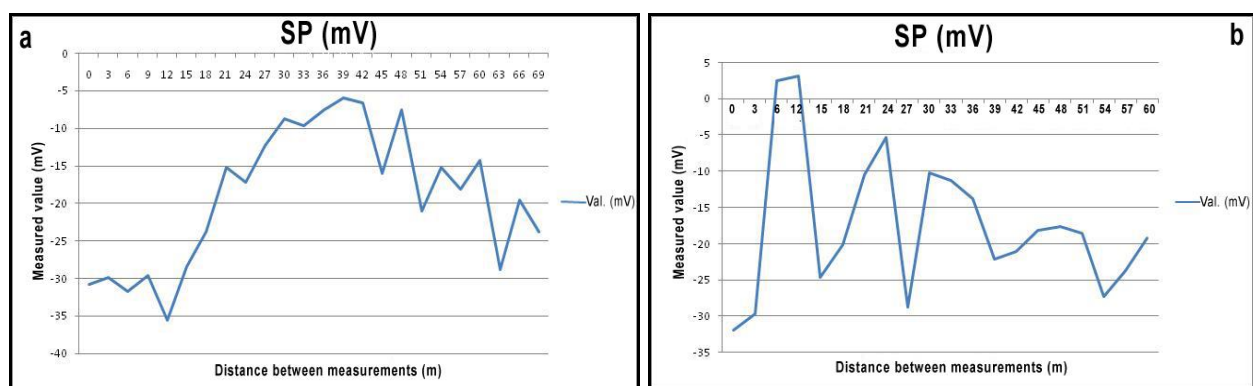


Fig. 6. Two profiles of Sinkhole 3 (26<sup>th</sup> of October 2013) on E-W orientation (a) and N-S orientation (b)



Fig. 7. Sinkhole 4 (a) and Sinkhole 6 (b) located in the wooded area of Mărghițaș Plateau

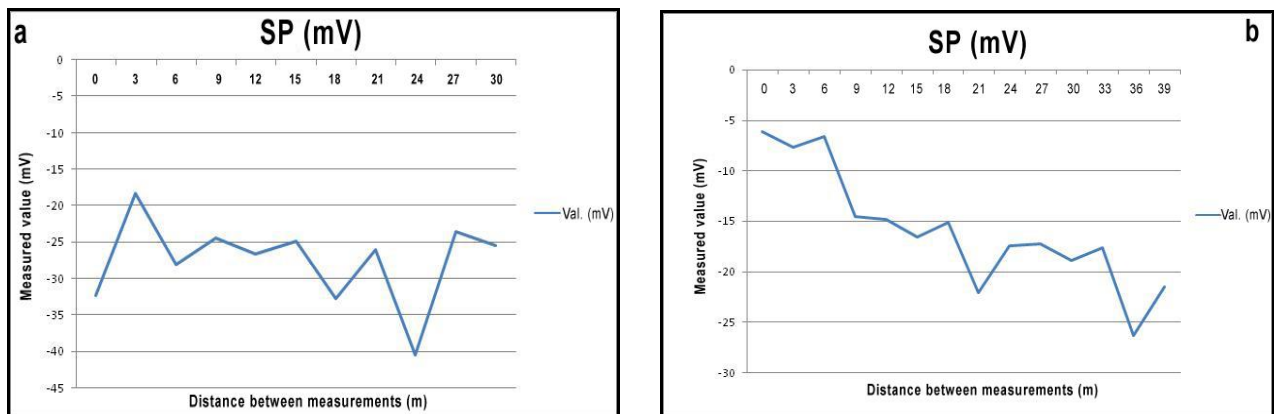


Fig. 8. Two profiles of Sinkhole 4 (27<sup>th</sup> of October 2013): North-South orientation (a) and East-West orientation (b)

#### Sinkhole 5

Along the North-South orientation (fig. 9a) presents a sinuosity at the bottom of the sinkhole, with larger negative values in the North side and positive values to the Southern part, as a result of the steepest slopes located in the Northern part. On

the other hand, the E-W orientation (fig. 9b) presents a large negative anomaly right in the middle of this sinkhole, meaning that at that point may be important cracks network drainage to underground.

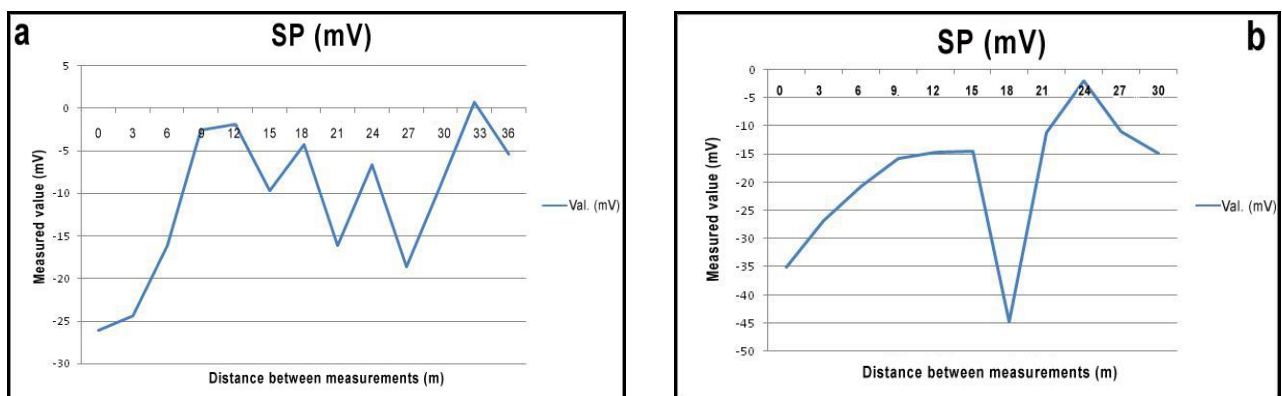


Fig. 9. Two profiles of Sinkhole 5 (27<sup>th</sup> of October 2013): North-South orientation (a) and East-West orientation (b)

### Sinkhole 6

This sinkhole is the last one situated in the continuation of the two previous sinkholes, deepen in the forest. Again, the North-South orientation (fig. 10a) is relatively sinuous, but without large anomaly values. On the other side, on East-West orientation (fig. 10b) our measurements indicate 2

large anomalies at the West end of the profile, a negative and a positive one. But, besides these anomalies, this profile indicates that at the bottom of the sinkhole the water is retained more (higher values of SP measurements) and again the slope configuration determine the drainage to the bottom of the sinkhole.

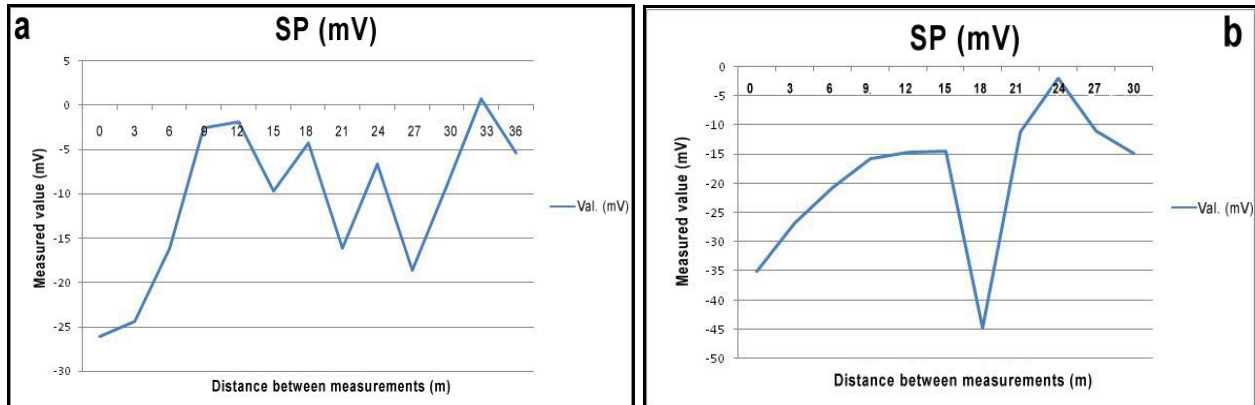


Fig. 10. Two profiles of Sinkhole 6 (27<sup>th</sup> of October 2013): North-South orientation (a) and East-West orientation (b)

### Sinkhole 7

This sinkhole is the only one located on this karstic plateau for which we managed to obtain results in two different campaigns. The results presented in fig. 11 shows that even if the two campaigns were made in different seasons (first one during the spring and the second one during the autumn), the general aspects of these profiles are

almost the same. In May the results indicate well de bowl-shaped as a doline, but reversed, because the larger values indicate the water stagnation more in the bottom of the sinkhole, while in October, the values are more homogeneous, as the consequence of a large period without precipitations that preceded this measurements (Artugyan & Urdea, 2014).

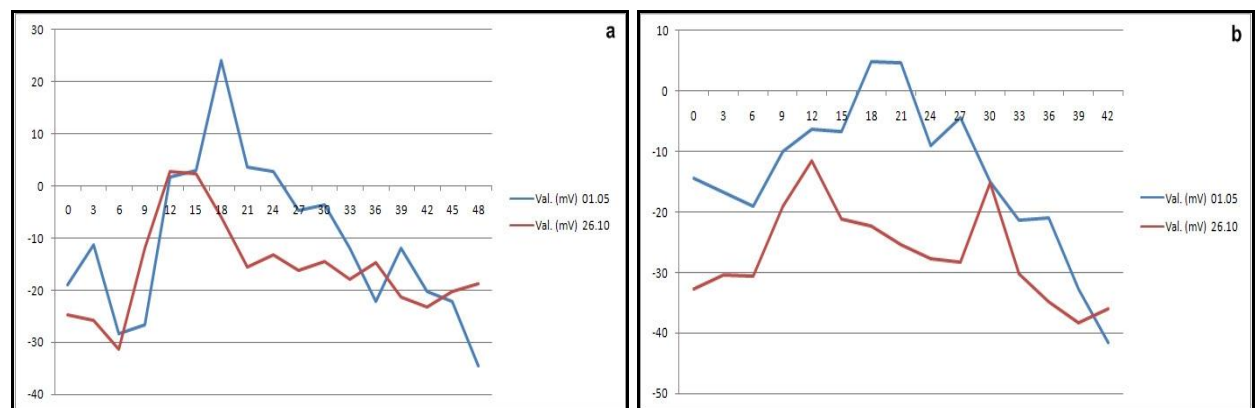


Fig. 11. Comparison for Sinkhole 7 self-potential measurements in 1<sup>st</sup> of May 2013, North-South orientation (a) and in 26<sup>th</sup> of October 2013, East-West orientation (b) (by Artugyan & Urdea, 2014)

## 5. Conclusions

Spontaneous potential measurements helped us to obtain data regarding water drainage at the surface in a karstic plateau situated at altitudes between 580 and 740 meters. Our approaches involved grids measurements and profiles measurements. Grids measurements are more representative because it

reveals values for the entire area, both boundaries and the bottom of these sinkholes. But, profiles are also useful because they show relatively well if there is a certain direction in water drainage and if the bottom of studied sinkholes presents a higher level of moisture.

SP measurements show that the temperature and the precipitations are factors that are really

important values, interpretations because the SP values are strongly correlated with those atmospheric conditions. Another factor that influences our results is the vegetation. Most of our results are obtained in forested areas, or even if the sinkhole were not situated in a forest, almost all the sinkholes located in these karstic plateaus present many trees and shrubs because these landforms are the places with the highest moisture degree, so are the sites where vegetation may find more humidity due to the characteristic of these features to retain water in karstic areas.

From this self-potential measurements we may point out that in most of the sites where we developed measurements the characteristics are similar, meaning that most of the sinkholes presents a water flowing direction from the boundaries toward the bottom, and, also the bottom presents the property of retaining water and humidity for a longer period due to the soil thickness which is larger in the middle of the doline.

Based on our study, we may conclude that sinkholes are those features which are the last point where water is retained on the surface of this karstic plateau. Besides, these sinks may be the link between water percolation surface drainage into the underground. This hypothesis must be determined using other geophysical methods, as Electrical Resistivity Tomography (ERT) which will offer the image for the bedrock and soil thickness, and, also

will help us to identify if there are some voids where the water is flowing to the secret.

In the following months we aim to repeat SP measurements in those sinkholes presented above, to get more data to compare and to point out certain charges of water drainage in Mărghitaș Plateau. Besides, our approach involves other sinkholes that were placed near those already presented to be included in our geophysical measurements.

In our study, we intend to obtain more field data using spontaneous potential to compare with our first results, but also to validate the SP results with other geophysical methods such as Ground Penetrating Radar and Electrical Resistivity Imaging.

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<sup>1</sup>West University of Timișoara,  
Department of Geography,  
V. Pârvan Bvd., 4, 300223, Timișoara, România  
lau\_artugyan@yahoo.com