Proceedings of the VI International Geomechanics Conference
24 – 28 June 2014, Varna, Bulgaria

DEFINING THE SLIDING PLANE IN MICRO PLAN ON ROCKY MASSIF USING GEOELECTRICAL METHOD

MSc. Risto Popovski, Prof. Dr. Zoran Panov,
MSc. Radmila Karanakova Stefanovska, MSc. Blagica Doneva
Faculty of natural and technical sciences, University of Goce Delcev, Republic of Macedonia

ABSTRACT
The paper presents data from geoelectrical measurements of micro locations where there is a sliding rock mass. These studies have been conducted on location mountain Plackovica in the Eastern Macedonian zone. The observations were performed with an interval of two years.
Method geoelectrical sounding was conducted. Measurements are performed multiple times on the same profile, in order to define the sliding plane, depending on the weather. From the data obtained from geoelectrical sounding it can be concluded that the specific electrical resistance of the rock masses decreases at a time of increased amount of rainfall. During dry periods of the year occur relatively high values of the specific resistance, especially in the surface layer. This phenomenon is normal to expect.
The analysis of the specific electrical resistance in the investigated profile clearly indicates that the plane of the sliding rock masses characterized by reduced specific resistance in relation to the surrounding rock mass, especially in extremely wet weather. In these conditions comes to the intense activation of the process of sliding rock masses. The results obtained are consistent with the basic theoretical assumptions, i.e. the zone with increased amounts of water has a lower value of the intensity of the specific electrical resistance, although it is the same type of geological environment. The results of these studies indicate that geoelectrical methods can provide useful information when investigating the sliding plane in rock mass.
Keywords: *electrical measurements, sounding, profiles, rock masses*

Introduction

The paper presents part of the measurements and the results from the analyses. Highly sophisticated equipment Terrameter SAS 1000, from the Swedish company ABEM was used.

It was done geoelectrical probing and geoelectrical mapping on micro - area, with aim to define precise measurements of the geoelectrical parameters. These parameters are used for defining the sliding plane.

In the paper are presented geoelectrical profiles and horisontal layers of the explored area.

Geological features of exploration area

The geological composition of investigating area is represented by quartz - chlorite schists, above them is thin proluvial cover with thickness 1-2 m. Clearly are distinguished two fissure systems which are mutually normal. At greater depth there is appearance of blocks of rocks.

During rainfall occurs presence of water along the fissure system and on the contact of proluvial and schistose part of the rocky massif.

Fig. 1. Satelite figure of the investigation area

Used geoelectrical method

In the exploration was used combined method with Schlumberger and Wenner array of the current and potential electrodes, depending of the terrain conditions. Fig. 2 shows the electrode arrays.

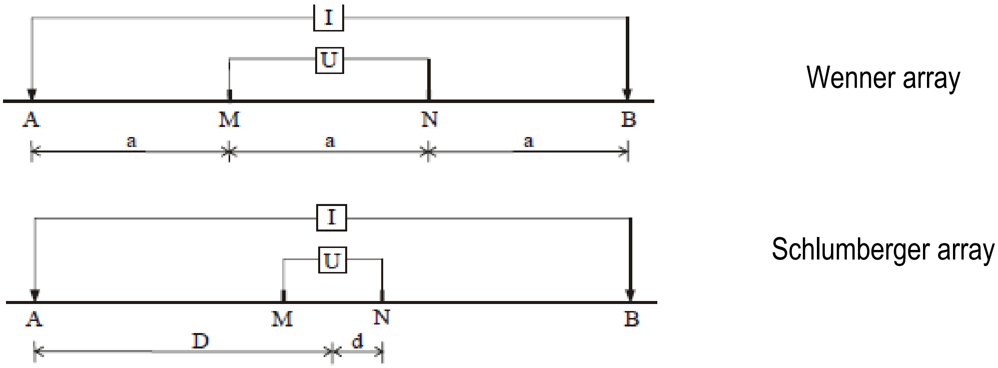

Fig. 2. Electrode arrays (A and B are current, M and N are potential electrodes)

Geoelectrical mapping and probing

Mapping and probing are two basic methods of geoelectrical research of internal structure of the Earth. The method of mapping has greater opportunities to detect vertical changes (faults, vertical contacts etc.), while sounding method has a better chance of detecting the horizontal change (layers, horizontal contacts, faults with a small angle to the horizontal plane, etc.) [1].

Apparent resistivity for any array of two current (A-B) and two potential (M-N) electrodes placed on the ground (homogenous half - space) is given with expression (1):

$$\rho_P = \frac{2\pi}{\frac{1}{r_1} - \frac{1}{r_2} - \frac{1}{r_3} + \frac{1}{r_4}} \frac{\Delta V}{\Delta I} \qquad (1)$$

Geoelectrical explorations

On the ground, measurement was made on the locations where deformation and sliding on the ground has occurred. The instrument TERAMETER SAS 1000 was used for measuring specific electrical resistance, and a profile of 40 m, using 20 electrodes spaced at a distance of 2 m was done (Figure 3).

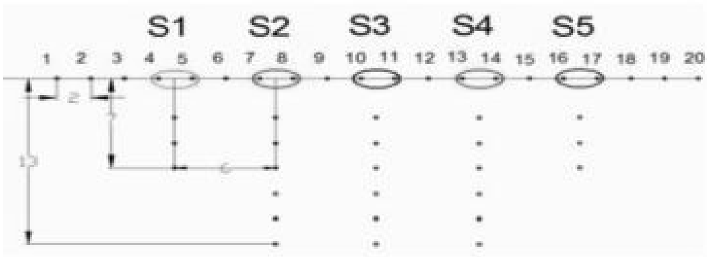

Fig. 3. Array of placed electrodes on the profiles for presentation of 2D tomography

2D-electrical tomography was applied representing surface geoelectrical method that explores the electrical resistivity of the geological environment. It is usually one of the methods of apparent electrical resistance. 2D surveys produce more accurate models of one-dimensional research, because there are taken into account vertical and horizontal changes in electrical resistance.

On the terrain was made profiling with probing on the locations where deformations and sliding occurred. Results are analyzed with the software IPI2win which allows presentation of the results in 2D electrical tomography.

Investigation area on mountain Plackovica

Explored area is placed on the mountain Plackovica, at the distance of about 40 km from the town Stip. The area is limited with several measurement points and covers area of about 1000 m^2.

On the given satelite picture (fig. 1) is given location of the placed geoelectrical profiles.

Measurement of apparent electrical resistance is performed continuously during 2010, 2011 and the beginning of 2012. Profile PR-1 was continuously monitored while using the profile PR-2 was performed mapping of the terrain. Thus get more models, maps of iso - ohms of the apparent electrical resistance of rocks of varying depth.

In the tables 1 and 2 are given measured values of the apparent electric resistance on the profiles PR-1 and PR-2.

Table 1

PR - 1	**Measured apparent electrical resistance, ρ_a, (Ω m)**				
H=AB/2 (m)	S-1	S-2	S-3	S-4	S-5
3	1200	1114	1573	1155	1506
5	1241	988	1227	897	1270
7	1055	942	1153	681	1399
9		902	1089	554	
11		833	1015	500	
13		736	924	496	

Table 2

PR - 2	**Measured apparent electrical resistance, ρ_a, (Ω m)**				
H=AB/2 (m)	S-1	S-2	S-3	S-4	S-5
3	2058	1592	1904	1855	1855
5	2140	1679	1790	1694	1694
7	2037	1585	1771	1538	1538
9		1433	1751	1398	
11		1305	1692	1276	
13		1226	1598	1174	

On the graph on fig. 4 are presented the changes of the average value of the apparent resistivity for the profile PR - 1 on Plackovica.

On the fig. 5 are presented gradient maps of the rock massive at various depth.

Model of the specific electrical resistance on the profiles PR-1 and PR-2 is given on the fig. 6. The layers are separated according the calculated resistance [2].

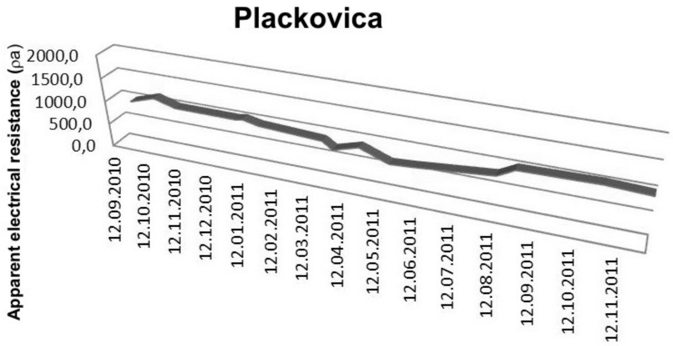

Fig. 4. Annual change of the average value of the apparent resistivity

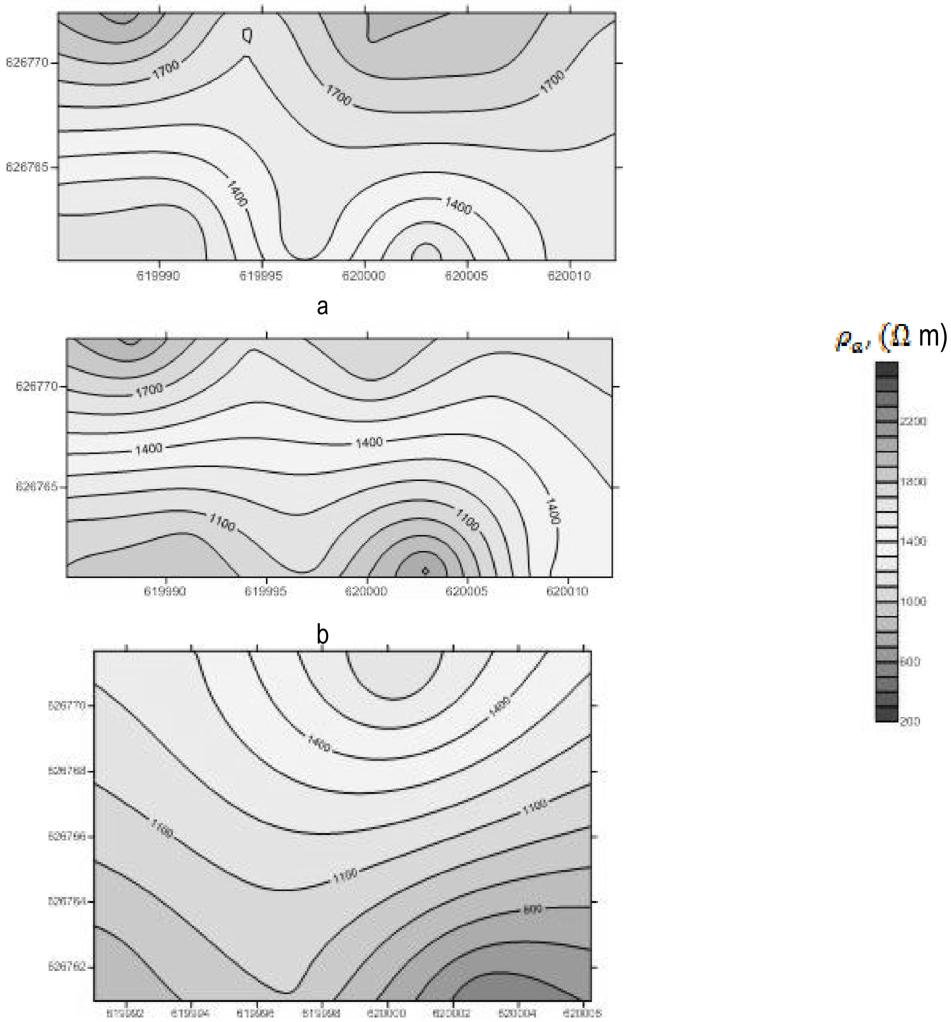

Fig. 5. Gradient maps of iso - ohms after Layer
a) H=3 m, b) H=7 m, c) H=11 m,

On the given calculated model of the specific resistance is made the model (fig. 7) for calculation of the stability of the ground. On it we define sliding plane where they could exist, which is critical place where sliding occurs. Thus assign sliding plane and where groundwater appears if any. The defined parameters are important and play an essential role in the stability of the rock formations [3].

In this case, the calculation according the specified methods and given parameters of the model was analyzed the terrain stability. The results (fig.7) shows that it is unstable terrain where may have been the appearance of water, and with that was reduced the electrical specific resistance of the material. If there is no water, apparent electrical resistance of the medium is higher and the slope is stable, then the stability factor would be greater than 1, F > 1.

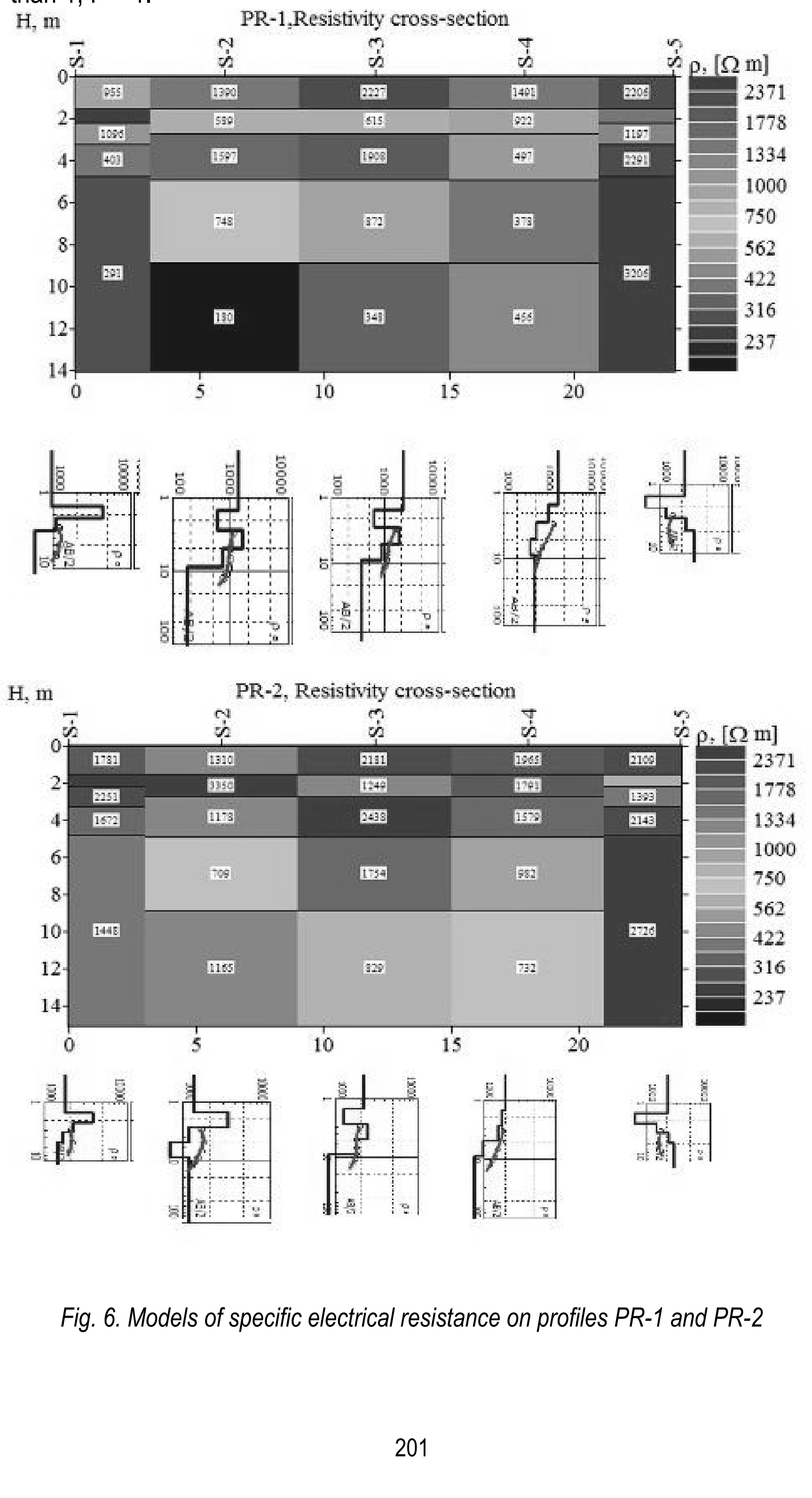

Fig. 6. Models of specific electrical resistance on profiles PR-1 and PR-2

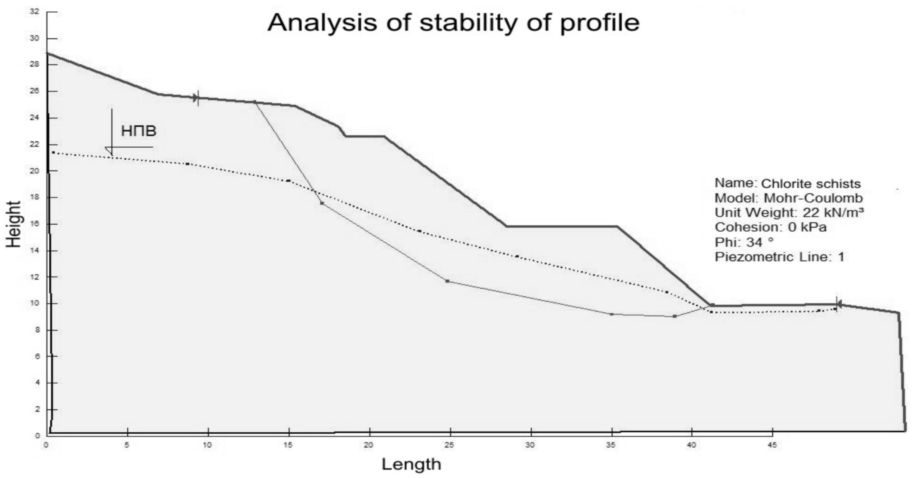

Fig. 7. Calculation of model stability

SAFETY FACTOR	Ru=0		Ru=0.2	
	F	M	F	M
Bishop	1,405		1,075	
Janbu		1,306		0,955
Spencer	1,339	1,337	1,034	0,974
Minimal value (Fs)	1,306		0,955	
Average value	1,347		1,026	
Stability condition (Fs>1.3)	YES		NO	

Conclusion

Conducted research yielded good correlation between geoelectrical parameters and the plane of sliding.

It is normal to expect on the contact between schistose rocky mass which is low permeable and proluvium which is high permeable, have the appearance of reduced electrical resistance.

This phenomenon is due to the increasing presence of water. Two years of observation and geoelectrical measurements accurately define the plane of sliding.

References

1. Delipetrov T. Basics of geophysics. University of Sts. Cyril and Methodius - Skopje, Faculty of mining and geology - Stip. 2003
2. Manual for using the software IPI2win.
3. Panov Z. Rock mechanics. University of Goce Delcev, Faculty of natural and technical sciences - Stip. 2011