5th JUBILEE BALKAN MINING CONGRESS

PROCEEDINGS

18th-21st September 2013 Ohrid, Macedonia

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BALKANMINE 2013

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APPLICATION OF GEOPHYSICAL METHODS IN EXPLORATION AND EXPLOITATION OF MINERAL RAW MATERIALS

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A B S T R A C T

Opening of a mine is complex procedure dependent on more parameters, but as the most important are: deposit with sufficient concentration of useful material which can be extract with appropriate technological process and economic working. Anyway, for possible opening of a mine, first and necessary factor is determination of deposit area and defining the space distribution and concentration of mineral raw material.

Intense exploitation of mineral raw materials which were base for future development of the industry, especially in 20-th century, caused many mines to finish their life. Deposits which were easy detectible and near to the surface, for a short time were depleted. The need for metals and non-metals, and especially energetic mineral raw materials increases, so the investigation from the Earth's surface went deeper in its interior.

If geological explorations were carriers of the discovery of sub - surface deposits of mineral raw materials, today there is a wide range of geophysical methods that gives possibility to expand the our knowledge deeper under the Earth's surface. Importance of geophysics should be underlined in exploration of seas and oceans which covered 3/4 from the Earth's area.

Geophysical methods are divided into: gravity, geomagnetic, geoelectrical, seismic, geothermal, radioactivity and radar methods with wide range of radiation.The paper, briefly presents the basic physical parameters characteristic for given methods.

Keywords

Gravity, Geomagnetic, Geoelectrical, Seismic, Geothermal, Radioactivity, Radar Methods

1. INTRODUCTION

Geoelctrical methods are used for exploration of horizontal and vertical changes of the electrical resistance of the rocks, from which it can be obtained data for geological composition, structure of the rocks, their layers and possibility for fracture from self - loading or coercive effect of load. The result is a clearer picture of the rocky massif and its position in space.

Electric measurement of specific resistivity of rocks is used to identify existing or potential sliding plane. Sliding plane that occurs often can't be accurately defined and possible errors in the calculation of stability on the ground are present. Using shallow geo-electrical and 2D profiling can successfully make models that can be used to determine the site of the sliding plane.

In time the development of geotechnical models are made with geomechanical and geophysical methods in order based on certain physical characteristics of the soil to determine the stability of rock slopes in each case separated.

Stability of slopes (natural or artificial) in the solid rock massifs is very complex process and depends of many factors. The most important are the following:

- the strength of unchanged rocks is much larger than the strength of shearing along the discontinuity,

- problems often occurs in three - dimensional static system for which only simplest calculation schemes are appropriate,
- water affection is manifested in the discontinuities and can have size and direction of the influence that depends on situation and direction of the discontinuity striking.

Knowing these specific characteristics of static behavior of the rock masses, classical methods for stability that were developed on the problem of soil mechanic will be limited. Because of that limitation, it is important to see the main difference between the methods in rock mechanics and soil mechanics, because on some parts that difference could not be expressed.

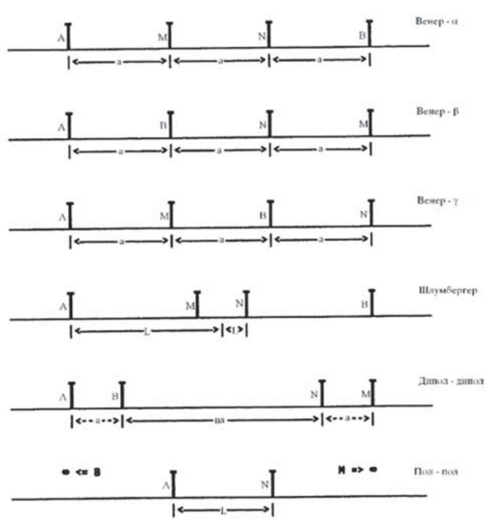
2. USED GEOELECTRICAL RESEARCHES

On the terrain, is conducted profiling and sounding of places where occurred deformations and sliding on the ground. For the measuring is used geoelectrical instrument for measuring specific electrical resistance TERAMETER SAS 1000s.

Applied is a 2D-electrical tomography representing surface geo-electrical method that explores the specific electrical resistance of the geological environment. It is usually one of the methods of apparent electrical resistance. 2D surveys produce more precision models from one dimensional research, because there are taken vertical and horizontal changes of the electrical resistance.

On fig. 1 are shows examples of different collinear configurations of electrodes in use: Wenner (α, β, γ), Schlumberger, dipole-dipole and pole-pole.

You may have noticed that Wenner configuration is a special case where four electrodes are placed at equal distance a.



For Schlumberger ratio l / L will vary during normal measurement, and similarly the factor k will vary in the measurements dipole-dipole.Different configurations of electrodes provide advantages and disadvantages compared to each other in terms of logistics and resolution. In measuring the apparent resistance and collection of data, combinations of connecting two methods for setting the electrodes were used: Schlumberger and Wenner array of electrodes. Profiling and mapping of the terrain was made where it was assumed that deformation and shearing on the ground has occurred. The results are calculated by the program IPI2win which allows presentation of the results in 2D electrical tomography. The profiles are made according to the needs and conditions of the terrain. This program performs the interpolation of sounding of each profile so you can see the measured value of the apparent specific resistance and calculated, ie modeled value of specific resistance ρ_S.

Figure 1. Examples of different schedules of electrodes (A и B are electrical electrodes, M и N are potential electrodes)

3. EXPERIMENTAL RESEARCH

The experimental measurements were performed at three locations in eastern parts of the Republic of Macedonia. Specific areas were selected on the ground where it was assumed that there is a change in the stability of rocks.

Due to the limited ability to present, in this paper are presented the results of only one measuring point located on mountain Plackovica. For the purpose of modifying the stability of the ground special attention is paid to the change in apparent electric resistance which was monitored continuously by the end of 2010 up and early 2013.

Here are just a preview of 3 measurements.

Table 1. Data: 21.09.2010

	Measured apparent geo-electrical resistance, ρ_a, (Ω m)				
H=AB/2 (m)	S-1	S-2	S-3	S-4	S-5
3	87,9	73,1	90,5	78,8	70
5	85,1	85	76,2	86,4	80
7	90,4	95,9	85,2	101	89
9		102	93,3	123	
11		174	100	130	
13		95,8	110	141	

Table 2. Data: 14.09.2011

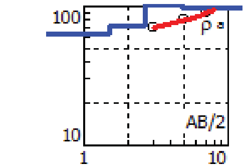
	Measured apparent geo-electrical resistance, ρ_a, (Ω m)				
H=AB/2 (m)	S-1	S-2	S-3	S-4	S-5
3	68,84	87,96	76,48	75,2	30,5
5	84,99	78,31	82,19	84,8	30,1
7	89,92	86,5	88,86	88,9	31,7
9		95,29	103,1	103	
11		102,2	112,6	99,5	
13		103,6	118,4	109	

Table 3 . Data: 18.03.2012

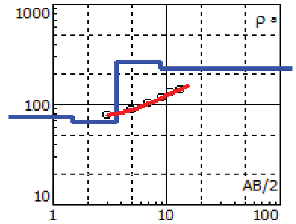
	Measured apparent geo-electrical resistance, ρ_a, (Ω m)				
H=AB/2 (m)	S-1	S-2	S-3	S-4	S-5
3	74,68	76,86	67,02	65,75	53,91
5	88,25	82,23	72,82	72,74	70,42
7	100.2	87,89	78,97	77,64	81,76
9		92,57	84,12	81,51	
11		96,16	88,12	85,02	
13		98,82	91,13	88,43	

Table 4 . Displacement (deformation of the terrain)

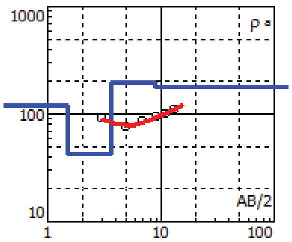
Coordinates				Displacement (m)		
	X-1	Y-1	H-1	DX-1	DY-1	DH-1
T-0	7604364,760	4622920,760	610.57	0	0	0
T-1	7604457,802	4622831,192	611,91	0	0,001	0
T-2	7604454,379	4622849,972	608,56	-0,008	-0,011	0
T-3	7604439,113	4622856,581	604,539	-0,013	-0,021	-0,009
T-4	7604461,784	4622876,634	604,682	-0,015	-0,026	-0,012
T-5	0	0	0	-0,007	-0,005	-0,003
T-6	7604483,801	4622851,667	613,81	0	0	0
T-7	7604495,251	4622868,29	613,77	-0,001	0	0
T-8	0	0	0	0	0	0
T-9	7604478,137	4622891,134	604,823	-0,022	-0,024	-0,003



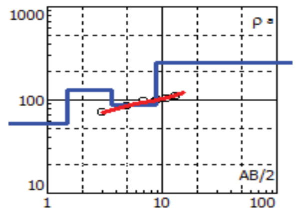
N	1	2	3	4
ρ	63.1	74.4	104	148
h	1.5	1.17	2.09	
d	1.5	2.67	4.76	
Alt	-1.5	-2.672	-4.76	



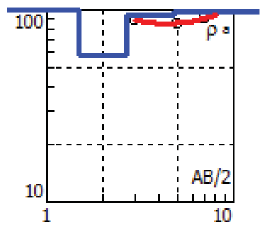
N	1	2	3	4
ρ	76.2	67.4	268	232
h	1.5	2.14	5.2	
d	1.5	3.64	8.84	
Alt	-1.5	-3.641	-8.84	



N	1	2	3	4
ρ	121	42.4	196	181
h	1.5	2.14	5.2	
d	1.5	3.64	8.84	
Alt	-1.5	-3.641	-8.84	



N	1	2	3	4
ρ	58.1	116	103	195
h	1.5	2.14	5.2	
d	1.5	3.64	8.84	
Alt	-1.5	-3.641	-8.84	



N	1	2	3	4
ρ	99.6	58.1	94.2	138
h	1.5	1.17	2.09	
d	1.5	2.67	4.76	
Alt	-1.5	-2.672	-4.76	

Figure 2 . Geoelectric profile

4. DISCUSION

Model of the specific elecrical resistance on the profiles PR-1 and PR-2 is given on fig. 3 layers are separated according the calculated resistance.

On the given calculated model of the specific resistance is made the model for calculation of the stability of the ground. On the profiles is defined sliding plane where it 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. The calculation of this case is made using a part of the package program Geostudio, Geo Slope (student version).

Table 5. Factor of stability

Safety factors	Ru=0		Ru=0.2	
	F	M	F	M
Bishop	1,378		1,019	
Janbu		1,253		0,920
Spencer	1,289	1,253	0,971	0,974
Minimum value (Fs)	1,253		0,920	
Mean value	1,293		0,971	
Condition for stablity (Fs>1.3)	NO		NO	

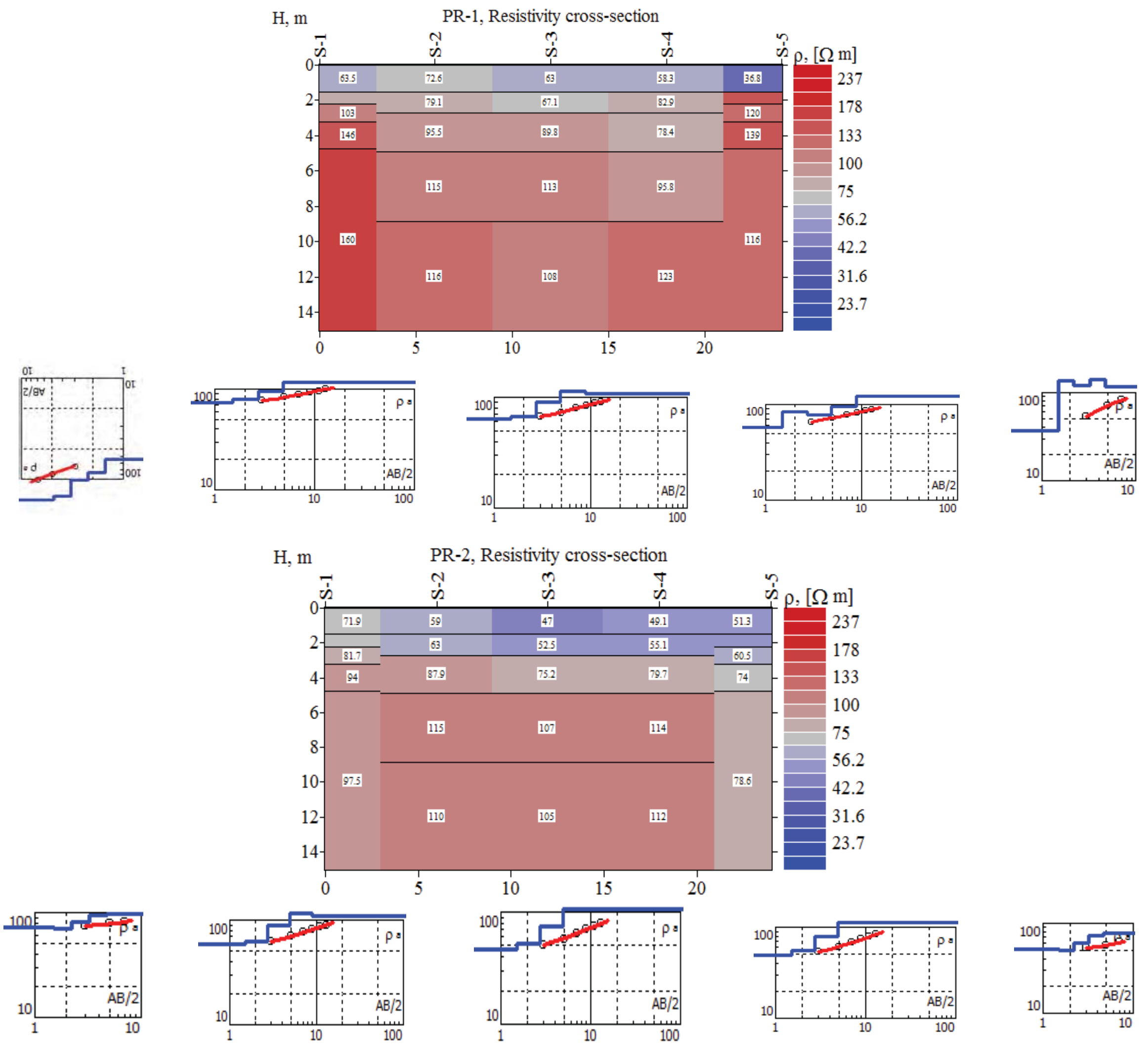


Figure 3. Models of the specific electrical resistance

The results 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.

5. CONCLUSION

From the exploration for the stability of rock masses, performed on three micro locations in Eastern Macedonia, it was made a multiyear research and measurements in places where there is an appearance of sliding rock mass.

Method of geo-electrical sounding with 2D profiling was conducted. Measurements were made many times on the same profile with aim to define sliding plane depending on the weather changing.

From the obtained data of geo-electrical sounding can be concluded that specific electrical resistance of the rock masses decreases in the period of increased amount of rainfalls, and in dry periods appear relatively high values of specific resistance, especially in the surface layer.

We recommend placing a measuring instrument for continuous monitoring of deformations (displacement), pore pressure, complete voltage condition on the ground, specific electrical resistance, etc. If there is more information about the condition of rocks there will be more reliable models for the calculation of stability and determination of the safety factor. The places which are of capital importance (mines, dams, hydropower and other geotechnical structures), which threatened the stability of the ground it is recommended continuous monitoring of multiple parameters.

We recommend placing a measuring instrument for continuous monitoring of deformations (displacement), pore pressure, complete voltage condition on the ground, specific electrical resistance, etc. If there is more information about the condition of rocks there will be more reliable models for the calculation of stability and determination of the safety factor.

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