GEOPHYSICAL INVESTIGATIONS IN "STARITE KOLIBI" MARBLE DEPOSIT IN CENTRAL SOUTHERN BULGARIA

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ABSTRACT

The scope of the research is to collect information about presence and locations of marbles in the area of "Starite kolibi" deposit. Around the area of the study, there is information from several boreholes, according to which the following rocks are observed: sandstones, clays, marble. Marbles in the area are transformed limestone and dolomite limestone under the conditions of regional metamorphism. In this research is used Electrical Resistivity Tomography (ERT) as a technique that can detect and characterize layers by exploiting resistivity contrasts between different layers using electrical current. The specific electrical resistance of sandstones, conglomerates and clays is lower because they are strongly saturated with pore water. The marbles on the other hand are among the highest electrical resistance rocks. Thus, the specific electrical resistance of the marble is distinctly higher than that of the clays which allows for their differentiation. In the whole investigated area, the top layer is made of clay and sand mix with small marble pieces and soil. The top layer's average thickness is about 0,4m. The electrical resistivity measurements are used to "separate" a hard rock (marble) from clay and sandstone into the horizons.

Keywords: Marbles, Electrical Tomography, Geophysical Research.

INTRODUCTION

The aim of the study is to determine marble occurrence in "Starite kolibi" deposit using geophysical electrical tomography method. Marble is a major mineral raw material for many industries. It is a crystalline, non-foliated metamorphic rock formed from limestone or dolomite due to the action of heat and pressure. The marble deposits are built from low porosity, high resistivity crystalline rocks. Within the scope of this study is to locate the lateral and depth extent of the *marble* deposit as well as size and quality of the marble [1]. For this purpose, is used one of the most high-resolution geophysical methods - electrical resistivity tomography (ERT). This geophysical technique is used for imaging sub-surface structures from electrical resistivity measurements made at the ground surface. Geophysical resistivity methods are very appropriate in this medium because of the resistivity contrast characteristics of marble deposits compared to the immediate host of sandy-clay rocks. This technology is often used in media with different electrical resistivity properties because proved to be effective and also offers non-destructive survey of the investigated area which is a key element in the modern geophysical prospection.

The reported results illustrate the potential of electrical resistivity methods to separate different layers and monitor the subsurface based on electrical resistivity [2], [3], [4].

DESCRIPTION OF THE TECHNOLOGY

Geophysical techniques have been done to delineate the boundary and thickness of the deposits. The electrical tomography method in particular has been employed in this geophysical investigation of marble bodies because the deposit is formed by massive marble without sloping surfaces, with crystalline calcites often seen on the small cracks [5].

Electrical Resistivity Tomography (ERT) is one of the most useful geophysical methods used to determine the subsurface resistivity distribution by making measurements generally on the ground surface. It is a technique that can detect and characterize layers by exploiting resistivity contrasts between different layers using electrical current. The aim of the electrical resistivity tomography (ERT) technique is to scan the subsurface along the survey line using a selected electrode array [6], [7]. The choice of the “best” array for a field survey depends on the type of structure to be mapped, the sensitivity of the resistivity meter and the background noise level. Among the characteristics of an array that should be considered are [8]:

- The depth of investigation;
- The sensitivity of the array to vertical and horizontal changes in the subsurface resistivity;
- The horizontal data coverage and the signal strength.

ERT data are collected with an automated multi-electrode resistivity meter Terrameter SAS 1000. The acquisition of resistivity data involves the injection of current into the ground using a pair of electrodes and then the resulting potential field is measured by a corresponding pair of potential electrodes. The field set-up requires the deployment of an array of regularly spaced electrodes, which are connected to a central control unit via multi-core cables. Resistivity data are then recorded through complex combinations of current and potential electrode pairs to build up a pseudo cross-section of apparent resistivity beneath the survey line. The depth of investigation depends on the electrode separation and geometry, with greater electrode separations yielding resistivity measurements from greater depths [9].

RESULTS AND INTERPRETATION

ERT data processing and modelling were done using the RES2DINV. This is a computer program that automatically determines the 2D resistivity model for the data obtained [10]. The program makes inversion by dividing the original data into rectangular bocks. The results from are plotted in the form of a pseudo section which gives a picture of the subsurface geology.

The precise location of the geophysical surveying lines in the area of “Starite kolibi” deposit is illustrated in Figure 1. The ERT field measurements were performed along 4 profiles (red lines) with total length of 800m.

Figure 1. Field measurements situation plan

The electrical resistivity of the different rock types in the quarry was determined empirically on the basis of a comparison between the electro resistivity tomography sections (ERT) and geological boreholes provided.

The true resistivity models are presented as colour contour sections revealing spatial variation in subsurface resistivity. On Figure 2 is shown ERT Line 1 with length 70m. The profile crosses the entire working field for this stage of opencast works. It reveals areas with the highest electrical resistivity (over 6500 Ωm) which is considered as massive marble layers.

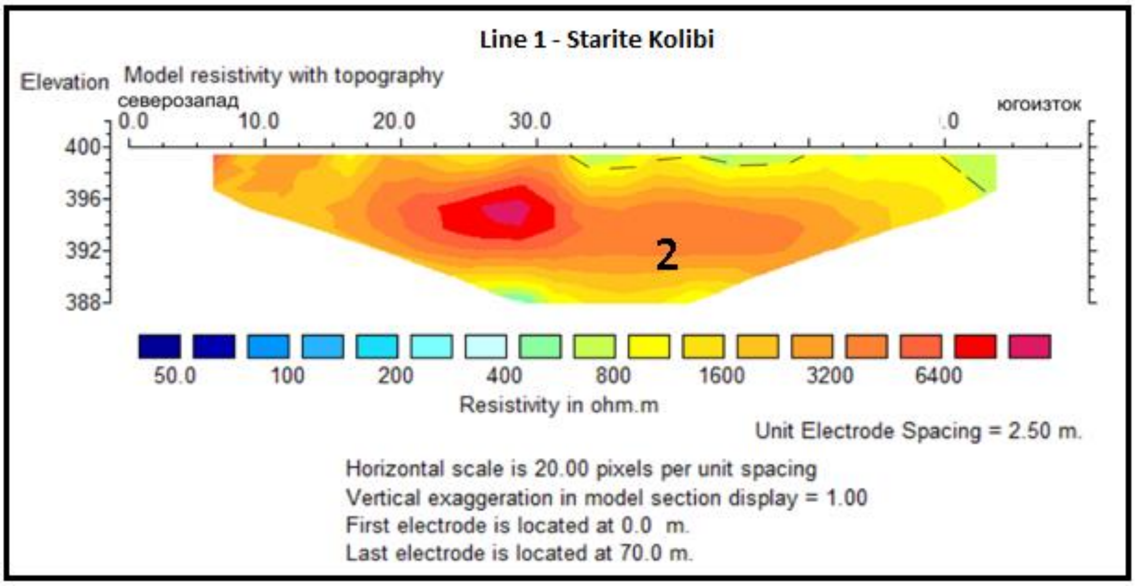

Figure 2. ERT Line 1 – “Starite Kolibi” deposit

Under the surface zone, the electrical resistivity values vary a lot between 400 and 6500 Ωm. This part is considered as electrical environment called Zone 2. This medium is likely to be composed of layers of marble and carbonized sand.
On Figure 3 is shown ERT Line 2. The line is situated on the most northern part of the research area with almost east-west direction. The line is 175m long and reveals electrical environment from Zone 1 to Zone 3. Deeper parts of the section represent higher electrical resistivity zones, probably due to some marble occurrence. In the upper parts of the line electrical resistivity values marked a layer of sandy clay with single marble inclusions or thin marble layers at the top of the section.

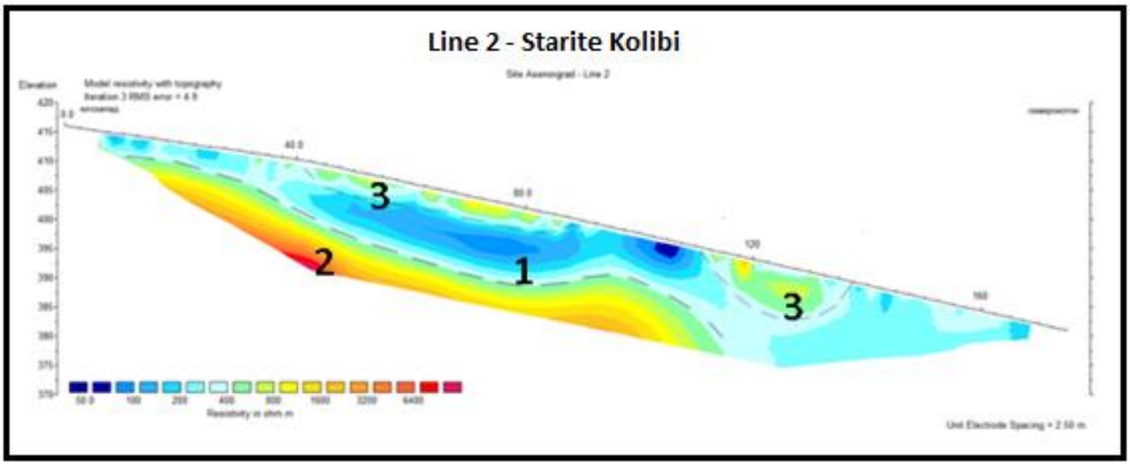

Figure 3. ERT Line 2 – "Starite Kolibi" deposit

On Figure 4 is shown ERT Line 3. The line is situated parallel to the Line 2. Its length is also 175m and it is present of the same electrical zones from 1 to 3, but as it is shown on the picture here Zone 2 is much thicker than it is on Line 2. This means that on the same depth moving from north to south marble layers become thicker and sandy clays predominant.

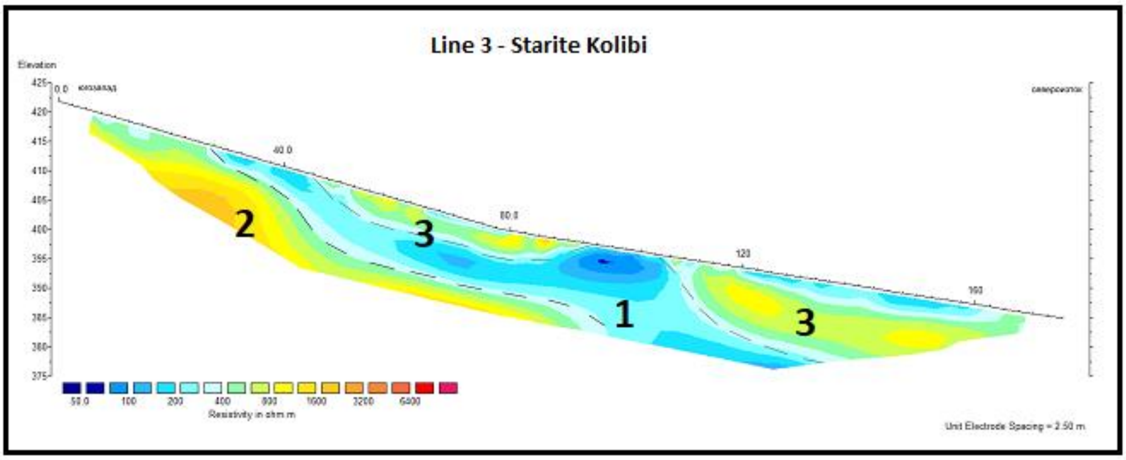

Figure 4. ERT Line 3 – "Starite Kolibi" deposit

On Figure 4 is shown ERT Line 4. The line is 175m long and is presented by electrical Zones 1 and 3. It reveals electrical environment (Zone 3) characterized by relatively high electrical resistivity values ranging from 800 Ωm to 1000-1200 Ωm. This environment is likely to map out thin marble layers at the top of the section.

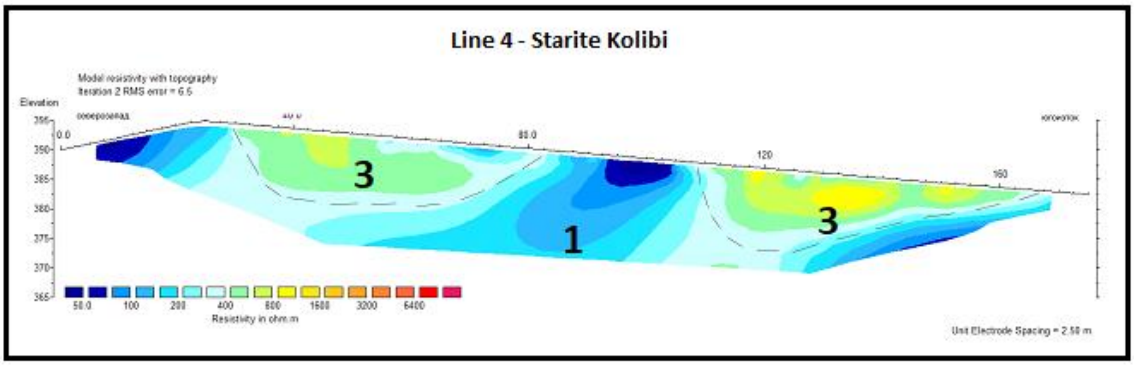

Figure 5. ERT Line 4 – “Starite Kolibi” deposit

The analysis of the conducted geoelectric research allows to be made the following important conclusions:

- Average electrical resistivity of the medium is between 50 – 6500 Ωm;
- Generally, researched geoelectric section is represented by three electric environments with different lithological characteristics:
- The first electrical environment (Zone 1) is characterized by the lowest values of the electrical resistivity for the investigated geoelectric section - in the range of 50 Ωm to 400 Ωm. It can be assumed that Zone 1 marks a layer of sandy clay with single marble inclusions. In areas with low electrical resistivity values (about 50 Ωm) it is due to the clay component.
- The second electrical environment (Zone 2) is characterized by relatively higher values of electrical resistivity - from 500 Ωm to 6500 Ωm. This medium is likely to present layers of marble and carbonized sand. In areas with high electrical resistivity (over 6500 Ωm) it is more likely to be due to the presence of marble inclusions.
- The third electrical environment (Zone 3) is characterized by relatively high electrical resistivity values ranging from 800 Ωm to 1000-1200 Ωm. This environment is likely to map out thin marble layers at the top of the section.

CONCLUSION

According to the measurement results and the interpretation of the ERT lines is considered that the best quality raw material is located in the electrical zone 2 presented mostly by Line 1 and Line 2. The results of Zone 2 in the quarry area make it possible to extract roughly 170,000 t of marbles for crushed fractions when properly mining works are carried out. In Zone 2, the material above the marble layer (outlined on Line 2 and Line 3) is around 7m thick. After that follows a productive layer of marbles with a capacity of 20 meters and a length of 50 meters. So, in this part of the section, in the southwest of the profiles, gives reason to expect about 150,000 tons of marbles for crushed fractions. From correlation made between Line 2 and Line 3 is obvious that on the same depth from north to south marble layers become thicker and sandy clays predominant. This information has great importance for the drilling-blasting works so as to be maximally bound to the actual geological situation in the quarry. This could provide an accurate calculation of the required amount of explosive and the location of the blasting boreholes in a manner consistent with the location of the marble layers. As a result of this optimization of the blasting works, a better fragmentation of the rock mass after the blasting will be achieved.

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