GEOPHYSICAL INVESTIGATIONS IN OPEN PIT “ADA TEPE” GOLD MINE IN SOUTHEASTERN BULGARIA

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ABSTRACT

The aim of the research is to provide information about geological features in the area of open pit “Ada Tepe” gold mine part of the “Khan Krum” gold deposit. The mine site is located at Ada Tepe hill, approximately three kilometers south of the town of Krumovgrad in southeastern Bulgaria. The “Ada Tepe” deposit is classified as a low sulphidation type epithermal gold-silver deposit formed in the Early Oligocene. Around the area of the study, there is information from several drillings, according to which the following rocks are observed: clays, breccia conglomerate, breccia conglomerate with quartz inclusions and metamorphic clasts. In this research Electrical Resistivity Tomography (ERT) is used to detect and characterize layers by exploiting resistivity contrasts between different geological features using electrical current. The specific electrical resistance of conglomerates and clays is lower because they are strongly saturated with pore water. The silicified sedimentary rocks on the other hand are among the highest electrical resistance rocks. Thus, the specific electrical resistance of the breccia conglomerate with quartz inclusions is distinctly higher than that of the metamorphic clasts and clays which allows for their differentiation. This information is highly important for drilling blasting works because of the blasting energy distribution.

Keywords: Open pit, Electrical tomography, Geophysical research.

INTRODUCTION

The purpose of this research is to collect information for the geological section up to 15m depth in the area of “Ada Tepe” open pit gold mine in south-eastern Bulgaria. Detailed information for spatial distribution of different lithological characteristics between horizon 445m and horizon 440m is obtained using geophysical electrical tomography method. This method is used for imaging sub-surface structures from electrical resistivity measurements made at the ground surface. Usually this methodology is largely used in media with different electrical resistivity properties because it proved to be effective and also offers non-destructive survey of the investigated area which is a key element in the modern geophysical prospection. Electrical resistivity tomography (ERT) deserves a growingly larger attention since it is a low-cost and high-resolution technique that can rapidly image states and processes [1]. In this research electrical tomography method cope with providing detailed information for spatial distribution of different lithological characteristics in the observed area.

The reported results illustrate the potential of electrical resistivity methods to provide actual information for observed geological section based on electrical resistivity [2], [3]. This information can be useful for rocks differentiation on the terrain, because support drilling blasting works and helps to set up the blasting energy in the areas with hard rocks.

DESCRIPTION OF THE TECHNOLOGY

Electrical Resistivity Tomography (ERT) is easy to use and very productive geophysical method used to determine the subsurface resistivity distribution by making measurements generally on the ground surface [4], [5], [6], [7], [8], [9]. The ERT method is an electrical method where electrical current is induced in the ground using two current electrodes. The electrical potential field is then read using two other electrodes. There are many different electrode array configurations available, but all them are used to gather data that can be used to estimate lateral and vertical variations in ground resistivity values.

ERT data are rapidly collected with an automated multi-electrode resistivity meter Terrameter SAS 1000.

Electrical methods and especially ERT are proved themselves as very effective, but most of them are affected by several factors, which need to be inspect during the study:

- the geochemistry of the subsurface;
- grainsize distribution;
- ground water chemistry;
- the presence of contamination.

ERT profiles consist of a modeled geological cross-sectional (2-D) plot of resistivity versus depth (Ωm). On the field survey, automatic computer-controlled system measures potential differences between pairs of electrodes, creates resistances by dividing by the current passed, and converts these resistances into apparent resistivity using geometrical factors. Geometrical factors are determined by the relative positions of the electrodes [10]. Interpretation process of ERT data is supported by borehole data and usually accurately represent the geometry and lithology of subsurface geologic formations.

In a geophysical survey, we acquire observed data and its estimated uncertainties. Later on, the problem is to find model that inverts the observed geophysical data to adequate subsurface physical properties. The model, along with physical property values of local rock types, is used to interpret geology and structure, and ultimately help for positioning the drill holes that intersect mineralized zones [11].

RESULTS AND INTERPRETATION

Electrical resistivity surveys were conducted to clarify the location of breccia conglomerate with quartz inclusions and metamorphic clasts and clays at both prospect and detailed scales. Apparent resistivity data were collected with a Wenner array on the ground surface. ERT data processing and modelling were done using the RES2DINV. This computer program automatically determines the 2D resistivity model for the observed data [12].

The ERT field measurements were performed along 13 profiles (red lines) with total length of 1865m. The length of each line is present in the Table № 1.

Table 1. Total length of each line in “Ada Tepe” gold mine deposit

Line	**Line 2**	**Line 3**	**Line 4**	**Line 5**	**Line 6**	**Line 7**	**Line 8**	**Line 9**	**Line 10**	**Line 11**	**Line 12**	**Line 13**	**Line 14**
Length [m]	**150**	**165**	**170**	**170**	**170**	**150**	**150**	**155**	**155**	**110**	**110**	**105**	**105**

The precise location of the geophysical surveying lines in the area of “Ada Tepe” gold mine deposit is illustrated in Figure 1.

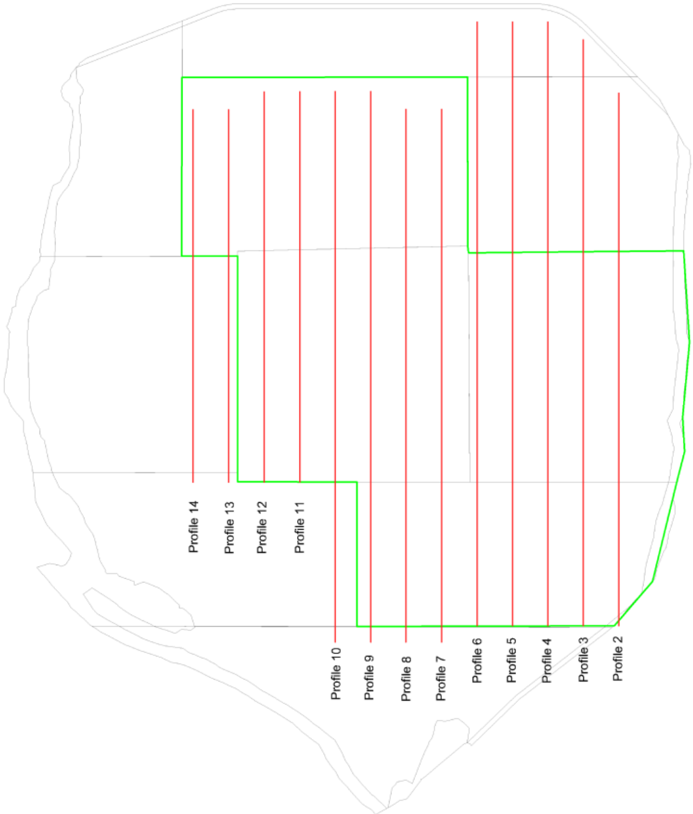

Figure 1. Field measurements situation plan

After careful analysis of conducted geoelectrical research it is considering that average electrical resistivity of the medium is between 100 Ωm and up to 4500 Ωm. Furthermore, clay materials, metallic oxides, and sulphide minerals, which compose Shavar formation are amongst the sedimentary materials that can carry significant electrical current through the material itself. Therefore, it is significantly difficult to determine sulphide mineralized rocks from clay materials and vice versa.
After the interpretation process, researched geoelectrical sections are represented by four 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 geoelectrical section - in the range of 100 Ωm to 550 Ωm. It can be assumed that Zone 1 marks a layer of sediments of Shavar formation presented by metamorphic clasts and clays.
- The second electrical environment (Zone 2) is characterized by relatively higher values of electrical resistivity - from 550 Ωm to 1500 Ωm. This medium is mostly composed from carbonite breccia and breccia conglomerates.
- The third electrical environment (Zone 3) is characterized by almost highest electrical resistivity values ranging from 1200 Ωm to 4000Ωm. This environment is likely to map out siltstones with high content of quartz or muscovite.
- The fourth electrical environment (Zone 4) is also characterized by the highest electrical resistivity values ranging from 2500 Ωm to 4500Ωm. This values of resistivity are considering as a result of decoupling after blasting processes in the research area and therefore anthropogenic activities.

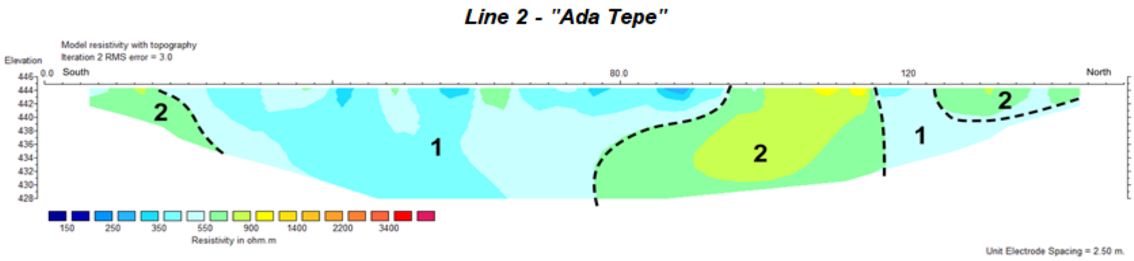

Figure 2. ERT Line 2 – "Ada Tepe" gold mine deposit

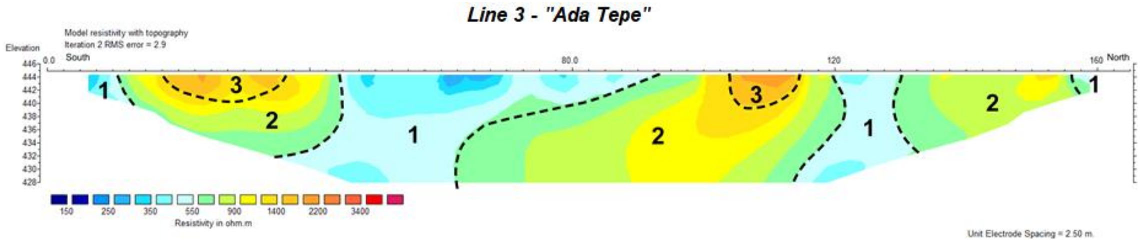

Figure 3. ERT Line 3 – "Ada Tepe" gold mine deposit

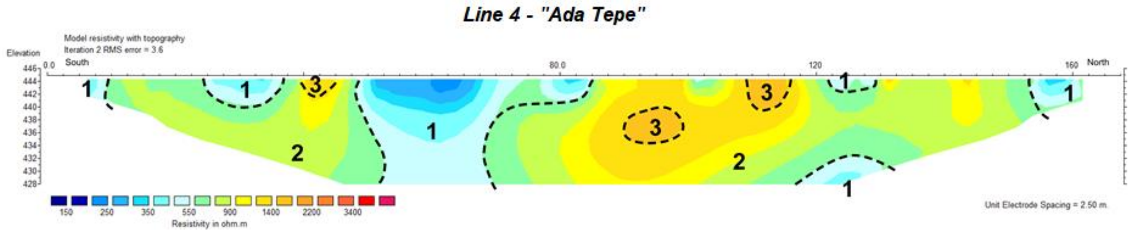

Figure 4. ERT Line 4 – "Ada Tepe" gold mine deposit

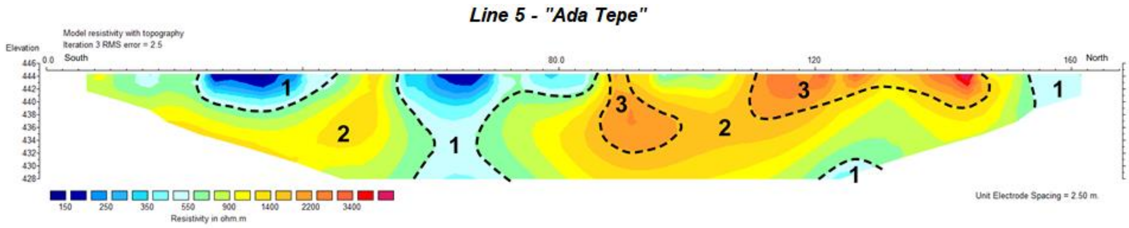

Figure 5. ERT Line 5 – "Ada Tepe" gold mine deposit

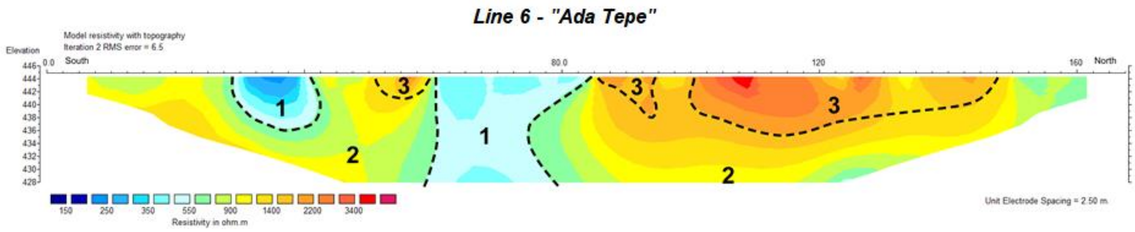

Figure 6. ERT Line 6 – "Ada Tepe" gold mine deposit

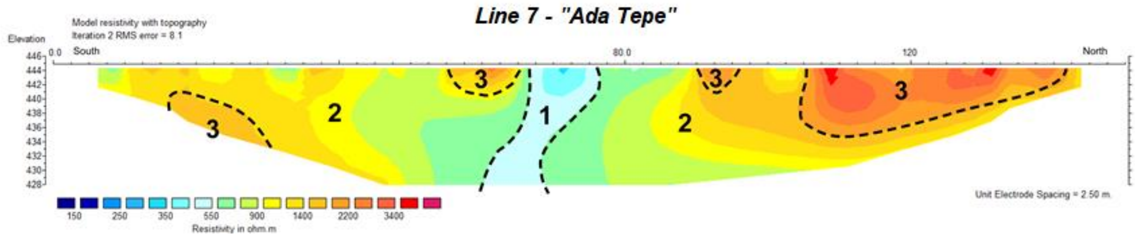

Figure 7. ERT Line 7 – "Ada Tepe" gold mine deposit

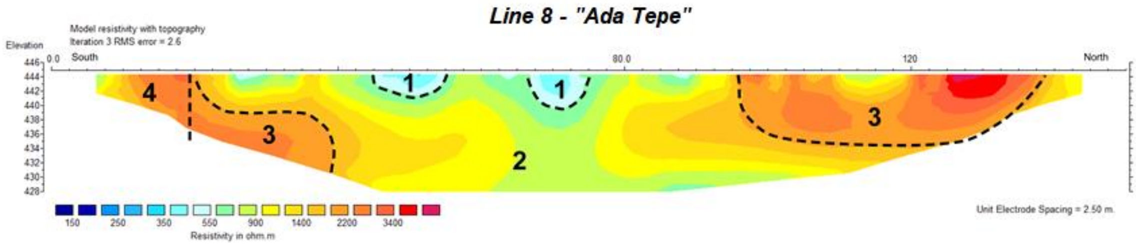

Figure 8. ERT Line 8 – “Ada Tepe” gold mine deposit

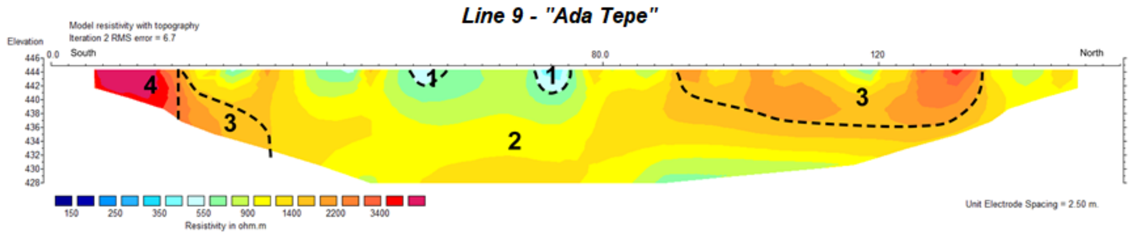

Figure 9. ERT Line 9 – “Ada Tepe” gold mine deposit

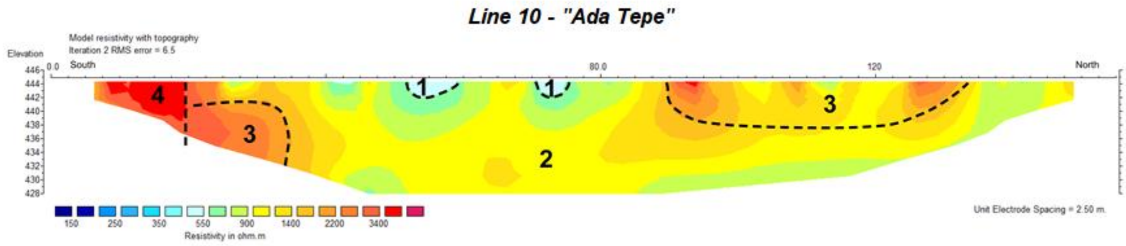

Figure 10. ERT Line 10 – “Ada Tepe” gold mine deposit

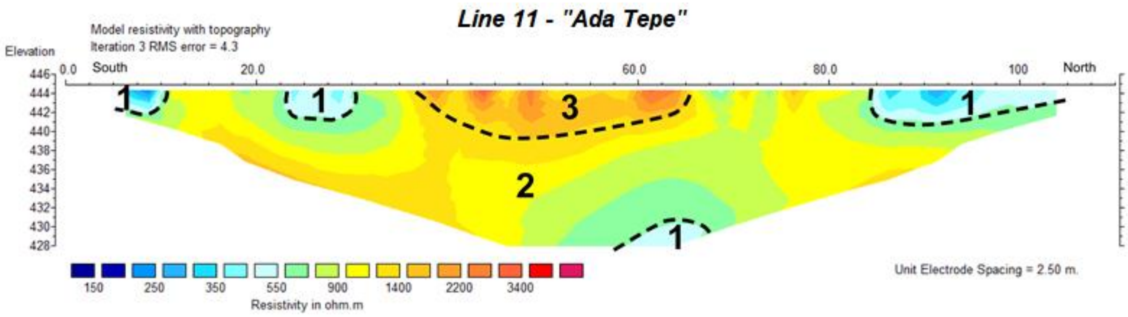

Figure 11. ERT Line 11 – “Ada Tepe” gold mine deposit

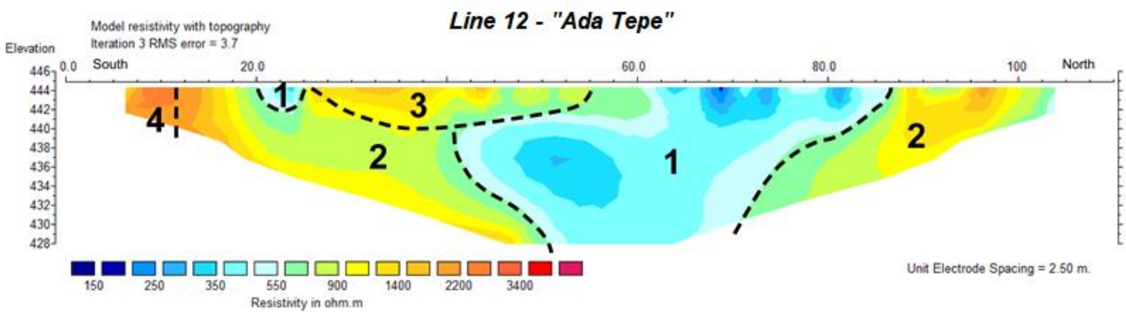

Figure 12. ERT Line 12 – “Ada Tepe” gold mine deposit

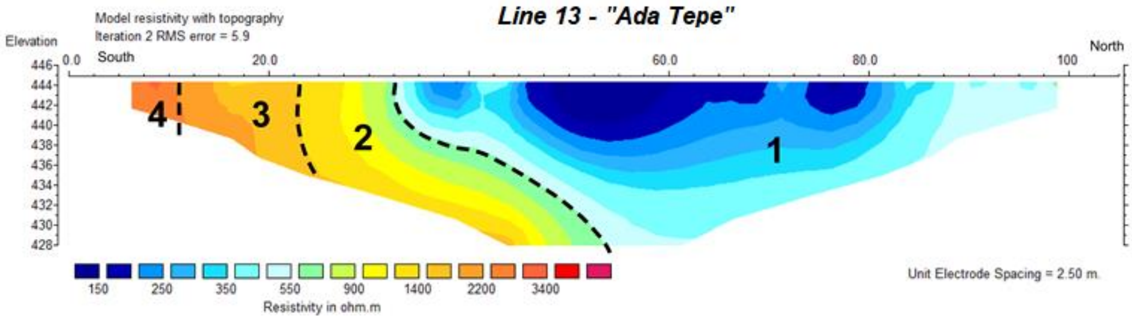

Figure 13. ERT Line 13 – "Ada Tepe" gold mine deposit

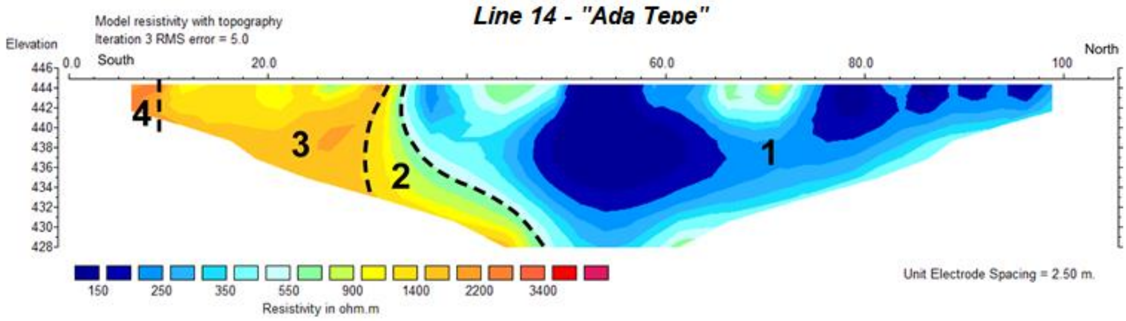

Figure 14. ERT Line 14 – "Ada Tepe" gold mine deposit

Based on the results of the interpretation of ERT lines is created schematic illustration of spatial distribution of Zone 1 and Zone 3 between horizon 445m and horizon 440m (Figure 15). From this picture can be drown a conclusion that relatively high resistivity Zone 3, containing siltstones with high content of quartz or muscovite, is located from West to North-East. In comparison lower values of resistivity, due to the presence of clay component, are presented from West-to-East and are crossed by Zone 3 almost in the middle of the working area diagonally.

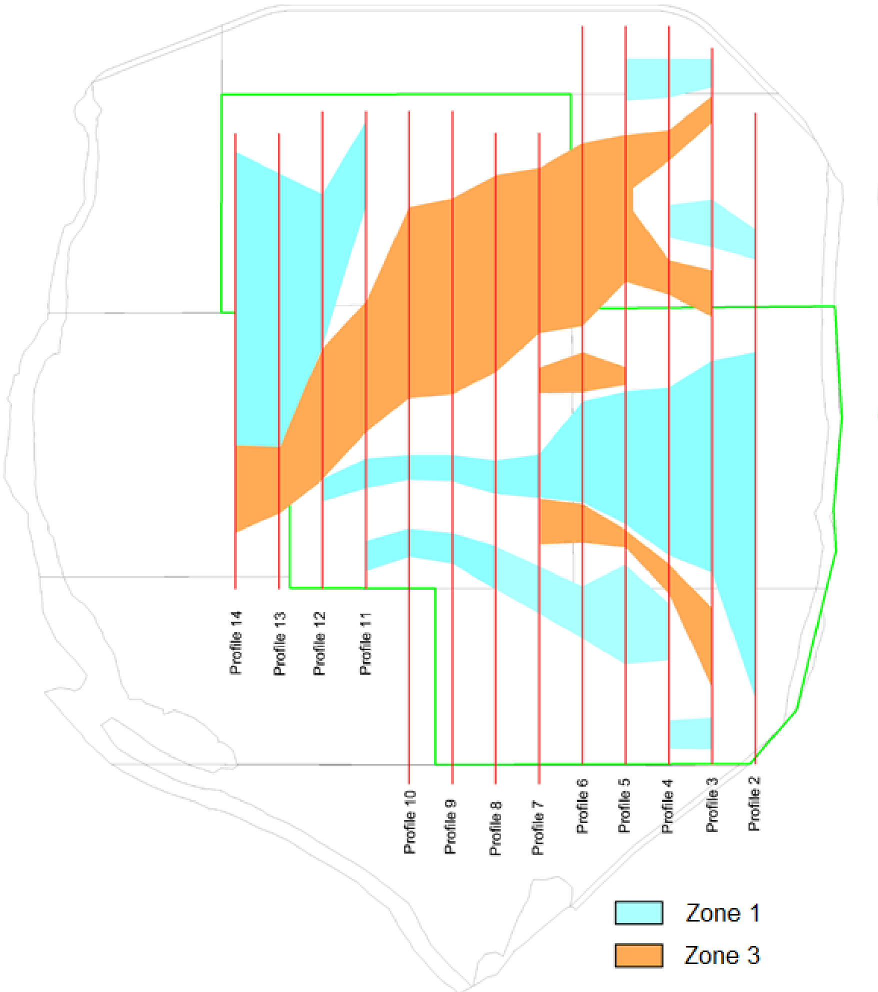

Figure 15. Schematic illustration of spatial distribution of Zone 1 and Zone 3 between horizon 445m and horizon 440m

CONCLUSION

Almost a century geophysicists have been use ERT successfully for solving different kind of problems. Additionally, field equipment and data processing procedures have been developing very rapidly and made 2D surveys routine and even more 3D surveys possible. According to the measurement results and the interpretation of the ERT lines is considered that the specific electrical resistance of the observed rock types varies from 100 Ωm to more than 4500 Ωm. Therefore, it is distinctively different to separate the clay components (Zone 1) from the breccia conglomerate with quartz inclusions (Zone 3). This information can be of use for planning drilling blasting works in the way that clay components do not absorb the blasting energy. In term, blasting energy distribution can be managed to pass through the hard rocks and so that to be reduced the number of oversized particles after the blasting works. In this way ERT as non-destructive technique prove to be very effective and can be used as a routine before planning drilling blasting works in the area of open pit “Ada Tepe” gold mine.

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