# APPLICATION OF ELECTRICAL RESISTIVITY TOMOGRAPHY FOR SAND UNDERWATER EXTRACTION

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## ABSTRACT

The present research is performed to collect information about the presence, location and characteristics of sand and gravel in “Kriva bara” field and also its possible expansion. For this purpose is used one of the most high-resolution geophysical methods - electrical resistivity tomography (ERT). This is a geophysical technique for imaging sub-surface structures from electrical resistivity measurements made at the ground surface. The results illustrate the potential of electrical resistivity methods to separate different layers and monitor the subsurface based on electrical resistivity. This method proved to be very effective in mediums with comparatively different electrical resistivity properties and also offers non-destructive survey of the investigated area which is a key element in the modern geophysical prospection.

**Keywords:** Electrical resistivity tomography (ERT), underwater extraction, geophysical prospection.

## INTRODUCTION

Within the scope of the study is determination of the location, size and quality of the raw materials in the present “Pet mogili” deposit and also determination of the surrounding area (“Kriva bara” deposit) as its possible expansion.
Considering the terrain and geological conditions of the area was designed electrical geophysical measurement. Electrical resistivity tomography is a useful method for characterising the sub-surface materials in terms of their electrical properties. Variations in electrical resistivity (or conductivity) typically correlate with variations in lithology, porosity and permeability, which may be used to map stratigraphic units, geological structure, fractures and groundwater.

## GEOLOGICAL - GEOGRAPHICAL FEATURE

Area of "Kriva Bara" deposit is located in the left floodplain and the first overflowing terraces of the Iskar River. The terrain of the deposit is slightly hilly. Geographically it falls in the northeastern part of the Sofia valley.
The geological structures of the deposit are presented the following lithostratigraphic units:
- Quaternary - Alluvium;
- Pliocene - Lozen's branch.

The alluvial deposits include mostly clay, sand, with gravel (small and medium grain size). This clay covers the gravel-sand deposits throughout the area. According to the

petrographic composition Iskar's gravel is distinguished by predominant pieces of granite, pegmatite, gneiss, quartz, quartzite, syenite, andesite, sandstone.
Under the alluvial deposits, Pliocene sediments are presented as follow clay, gravel, (small and medium grain size), sand (finely grained). The power of Pliocene deposits from the upper complex - Lozenets, for the region is set at 50-200 m [1].

## DESCRIPTION OF THE TECHNOLOGY

In recent years geophysical methods have been commonly used to study alluvial plains, the depositional mechanisms of river sediments, pollutant infiltration and etc. To characterise the lithology and thickness of near water-bed materials is possible to be used electrical resistivity tomography (ERT). This method has the potential to detect the near-bed layer with significantly good resolution.
Electrical Resistivity Tomography (ERT) is one of the most useful geophysical methods used to determine the subsurface's resistivity distribution by making measurements generally on the ground surface.
Variations in electrical resistivity typically correlate with variations in lithology, water saturation, fluid conductivity, porosity and permeability, which may be used to map stratigraphic units, geological structure, fractures and groundwater.
Two-dimensional electrical tomography surveys are usually carried out using a large number of electrodes, 25 or more, connected to a multi-core cable [2].
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. In this case study one of the most commonly used arrays for 2-D imaging the Wenner array is preferred. Among the characteristics of an array that should be considered are:

- 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 [3].

ERT data are rapidly collected with an automated multi-electrode resistivity meter Advanced Resistivity Scanner (ARS). It allows you to look for metals, minerals, caves, voids and water. This is achieved through resistivity analysis. The ARS send electrical current in the soil using 2 or 4 probes for depth up to 200 meters.
The measurements include inserting two probes half way in the ground. The device is placed in the middle of the probes. The farther the probes are one from another, the deeper the scan goes, so the lenght of the cable is very important. Standard equipment includes 4 cables (probes) of 25m which means that it could be reached depth up to 50 meters with 2 probes and 25 meters with the use of 4 probes. ARS runs with 110V therefore can achieve up to 200m depth below the surface. ARS analyse the soil layers by layers and tell the result on the screen then automatically export data to a PC.

## RESULTS AND INTERPRETATION

Data processing is based on an iterative routine involving determination of a two-dimensional (2D) model of the subsurface, which is then compared to the observed data and revised. 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 [4]. The program makes inversion by dividing the original data into rectangular bocks. The program uses the forward modelling to calculate the apparent resistivity value [5]. The results from such surveys are plotted in the form of a pseudosection which gives an approximate picture of the subsurface geology [6].

The precise location of the geophysical surveying lines in the area of "Kriva bara" deposit is illustrated in Figure 2. The ERT field measurements were performed along 6 profiles (red lines).

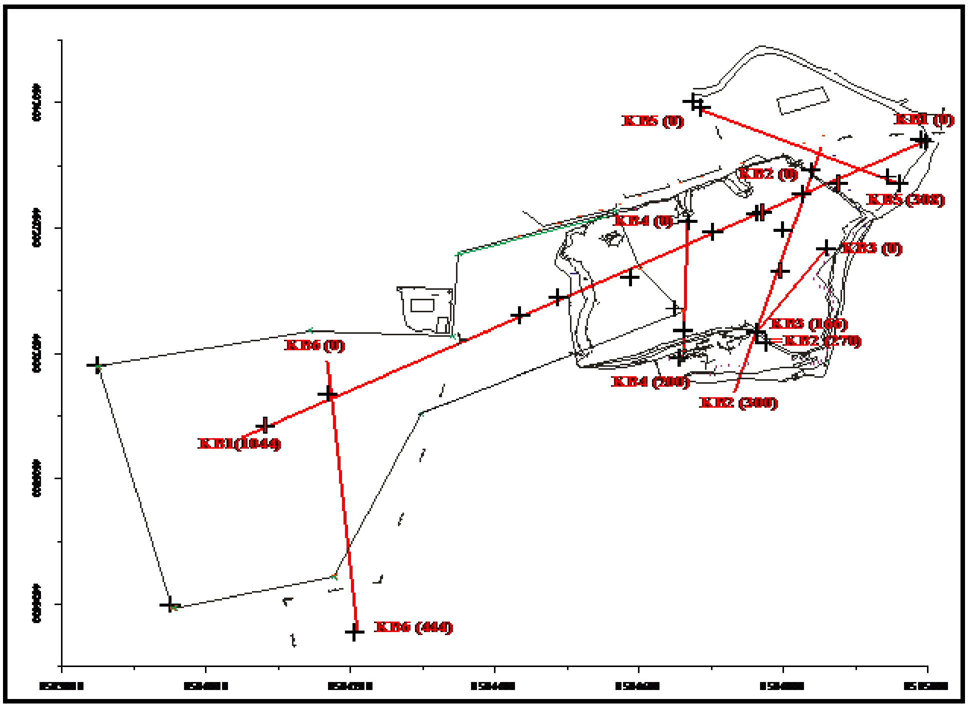

**Figure 2.** Field measurements situation plan

The true resistivity models are presented as colour contour sections revealing spatial variation in subsurface resistivity. On Figure 3 is shown ERT Line 1 with length 1044m. The profile crosses the entire terrain east-west.

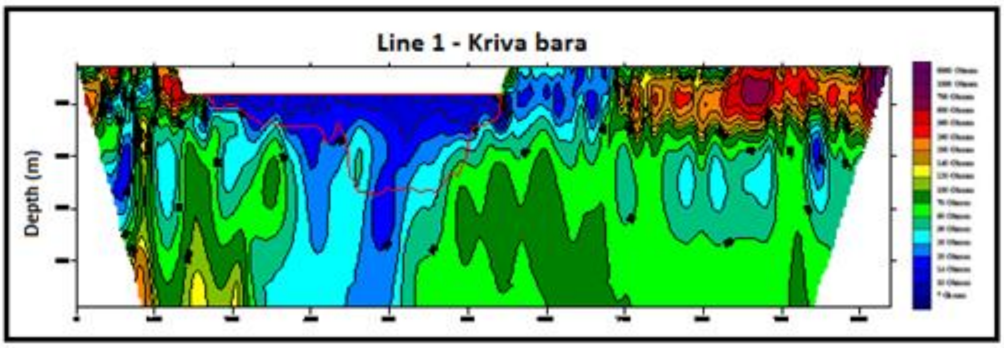


**Figure 3.** ERT Line 1 – Kriva bara

Under the surface zone, the electrical resistivity values vary a lot between 40 and 120 Ωm. This part is considered as composed of mostly clayey gravel where lens of high quality gravel is mixed with clay gravel. On greater depths predominates highly clayey gravel and clay.

On Figure 4 is shown ERT Line 2. The line is situated in the eastern side of the river in the north-south direction. The line is 150m long and reveals deeply clayey gravel, locally covered with clay in the deeper parts of the line.

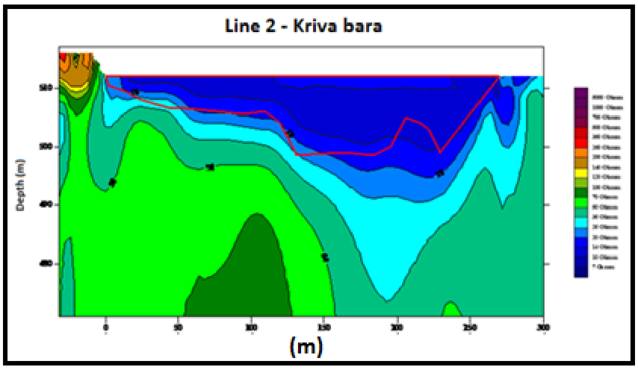


**Figure 4**. ERT Line 2 – Kriva bara

On Figure 5 is shown ERT Line 3. The profile is 170 meters long and crosses the river in its southern part. The line shows gravel like materials only in the vicinity of 50 meters, at a depth of less than 490 meters. The rest of the measurement interval is formed only with clay sediment.

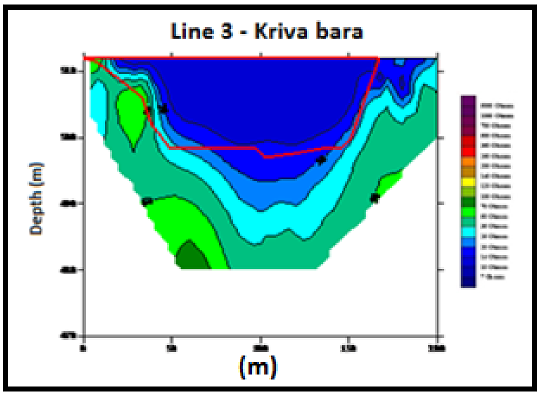


**Figure 5**. ERT Line 3 – Kriva bara

On Figure 6 is shown ERT Line 4. The length of the profile is 200 m. The line passes through the river in its western part in the north-south direction. On the northern shore there are indications of better gravels.

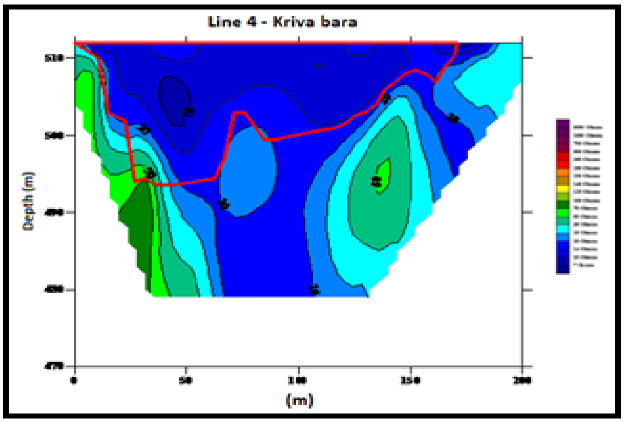


**Figure 6**. ERT Line 4 – Kriva bara

On Figure 7 is shown ERT Line 5. The surface part of the line from 0 to 230 meters (depth of 510 meters) is made of gravel-like materials. The rest of the line (from 230 to 308m) is formed of clay material, which is also found in the whole line to a depth of 490 m.

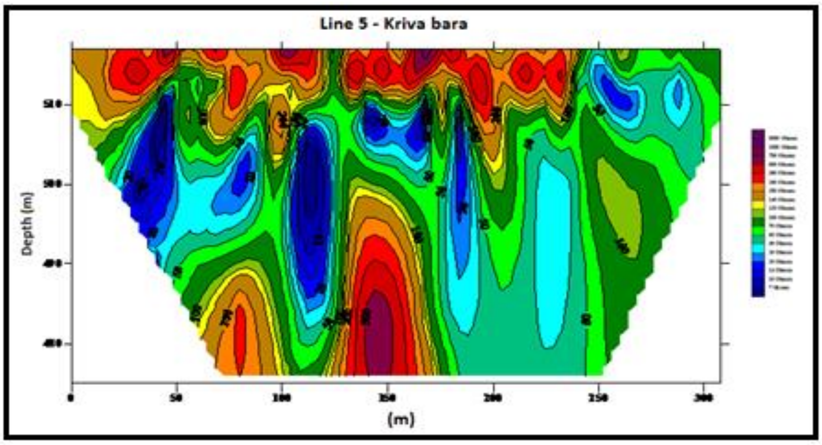


**Figure 7**. ERT Line 5 – Kriva bara

The last Line 6 is shown on Figure 8.

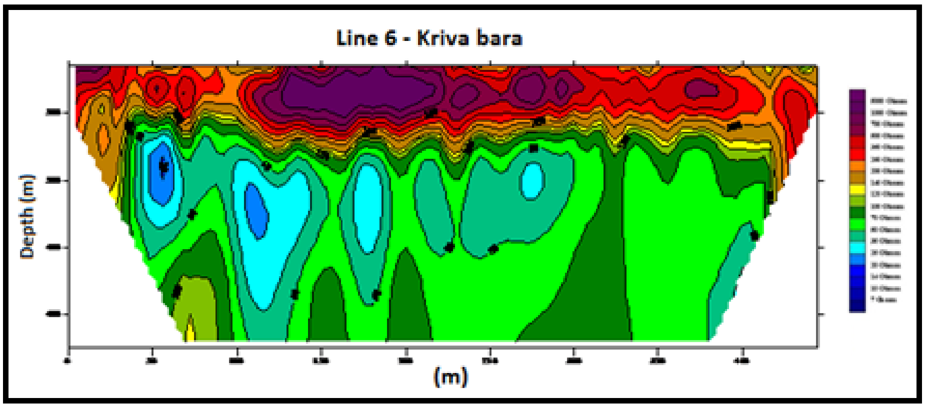


**Figure 8**. ERT Line 6 – Kriva bara

The profile crosses through the central part of the Kriva Bara zone in the north-south direction. Joint review of Line 1 and Line 6 shows that quality gravel is located near surface to a depth of about 508m. The layer consists mainly of highly clayey gravel to a depth of 490 m and at a depth of 490-470m, mainly slightly clayey gravel.

**Table 1.** Apparent resistivity of different type of rocks found in the research area

| **Apparent resistivity (Ohmm)** | | **Geological description for the depth interval (m)** | |
|---|---|---|---|
| **from** | **to** | **517 - 512** | **512 - 470** |
| **-** | **14** | - | Water |
| **14** | **20** | Unbound material | Clay |
| **20** | **50** | clay | Highly clayey gravel |
| **50** | **120** | Highly clayey gravel | Slightly clayey gravel |
| **120** | **260** | Slightly clayey gravel | Gravel and sand |
| **260** | **-** | Gravel and sand | - |

The electrical resistivity of the different types of rocks on the terrain was determined empirically on the basis of a comparison between the geological profiles and geological boreholes provided. Geological boundaries are defined for two depth intervals - a block above the groundwater level of 517 to 512 m and a block below the groundwater level. Apparent resistivity of different type of rocks for these intervals is described in Table 1.

## CONCLUSION

The "Kriva Bara" deposit is made up of the alluvial deposits of the Iskar river, represented by sand, gravel and clay. According to the measurement results and the interpretation of the ERT lines is considered that the useful component is very variable. The best quality raw material is located in the surface area (517 m). In the eastern part of the terrain at a depth of about 505 m, the raw material is of varying quality. The depth interval of 505 to 490 m is mainly formed by the alternation of clayey sandstones and clays. The results obtained from the geophysical investigation allow proceeding with inventory calculation and subsequent development of the deposit.

## REFERENCES

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