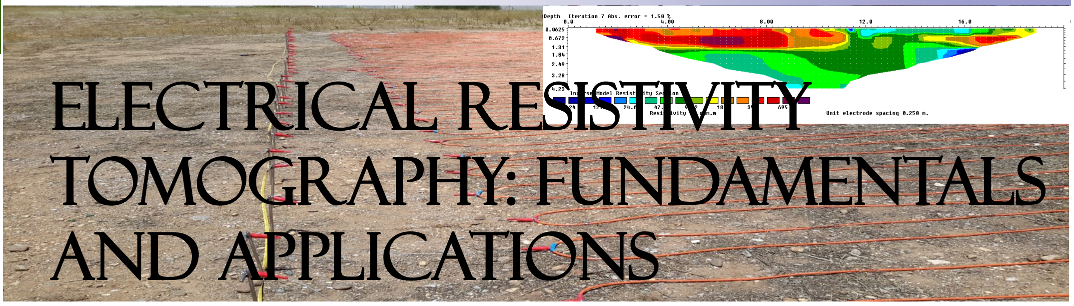


ELECTRICAL RESISTIVITY TOMOGRAPHY: FUNDAMENTALS AND APPLICATIONS

Electrical resistivity tomography

This notebook describes the method of electrical resistivity tomography and its main applications and provides examples of the results obtained in various studies.

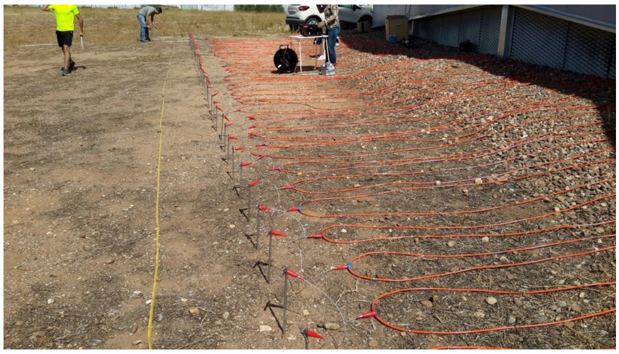
Description of the method

Electrical resistivity tomography is a geophysical prospecting method for obtaining the distribution of electrical resistivity in the subsoil, both laterally and at depth. The resistivity or specific resistance is a measure of the opposition of the material to the passage of an electric current and has units of ohm-metres (Wm). It is an intrinsic characteristic of a material and thus allows the detection of bodies or structures that are buried and that present a resistivity value that is different from that of the surrounding environment.

In general, it consists of introducing into the ground an electric current of known intensity through electrodes implanted along an equidistant profile. From the intensity of this current and the observed potential difference, the instrument provides the value of the apparent resistivity (so called because it is not the true resistivity) at points located along the observation profile and at different depths.

Subsequently, the numerical inversion of the apparent resistivity is carried out to obtain the distribution of the true resistivity.

In addition to studies along a profile (2D), 3D studies can also be performed, in which case the observations are made in parallel equidistant profiles, defining a grid.



Observations along a profile

Instrument

The instrument we have is the 4-channel ABEM Terrameter LS, which operates in line with a total of 64 electrodes. Cables of different lengths are available, along with 21 take-outs and a total of 90 electrodes. The equipment is complemented by other accessories such as 12 V batteries, chargers, clubs, and tape measure. The equipment has several data acquisition protocols, including gradient, dipole-dipole, reverse dipole, Wenner, etc.

Data processing is performed with the inversion programs Res2dinv and Res3dinv of Geotomo Software .

Abem Terrameter LS equipment

Stages of an electrical resistivity tomography study

When carrying out an electrical resistivity tomography study, it is important to divide the work into a series of stages, as in any geophysical survey method. The quality of the results depends on these stages being carried out correctly (Orellana, 1982). The main stages are as follows:

•Problem statement and data collection

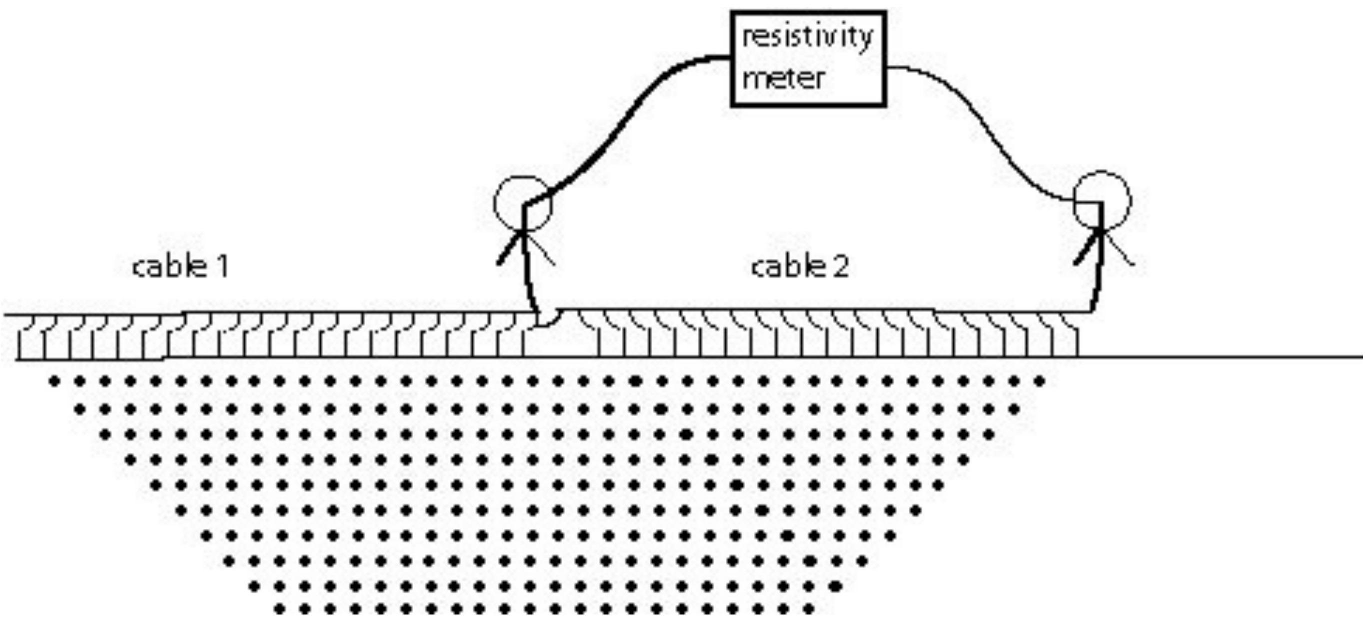
In this stage, the objectives of the study are taken into account and a means of achieving them is proposed. All the information on the study area is collected, such as results from other geophysical studies, cartography, and geological information.

•Detailed scheduling of fieldwork based on the objective and its circumstances

The correct scheduling of fieldwork is of great importance since it can save time and avoid problems. In this stage, for example, we will decide whether a 2D or 3D study will be performed and determine the data acquisition protocol. Additionally, here, we decide the location and length of the profile or profiles on the ground, which determines the number of take-out cable systems to be used and the distance between electrodes. This distance determines both the degree of resolution and the maximum depth to be reached, so that at a lower separation there is greater resolution but less depth. As a rough rule, the maximum depth that is reached using two cables is the distance between electrodes multiplied by 6. If four cables are used, it would be multiplied by 10-12. For example, if we use 2 cables and have an interelectrode distance of 0.5 m, we have the ability to detect bodies with this minimum dimension, up to a depth of approximately 3 m. In 3D studies, the number of profiles that make up the grid and the distance between them will also be chosen depending on the degree of detail allowed by this distance.

The data acquisition protocol will determine the electrodes that will be used in succession and which will act as current (through which the electric current is introduced) or as potential (between which the potential difference will be measured). According to the chosen protocol, the instrument uses greater gaps between the electrodes that will act as current. The greater the distance between these electrodes, the deeper the point to which the apparent resistivity value is assigned.

In the case of profiles in which a large length is desired, it is common to use the technique known as roll-along, which allows greater distances to be surveyed while maintaining coverage.



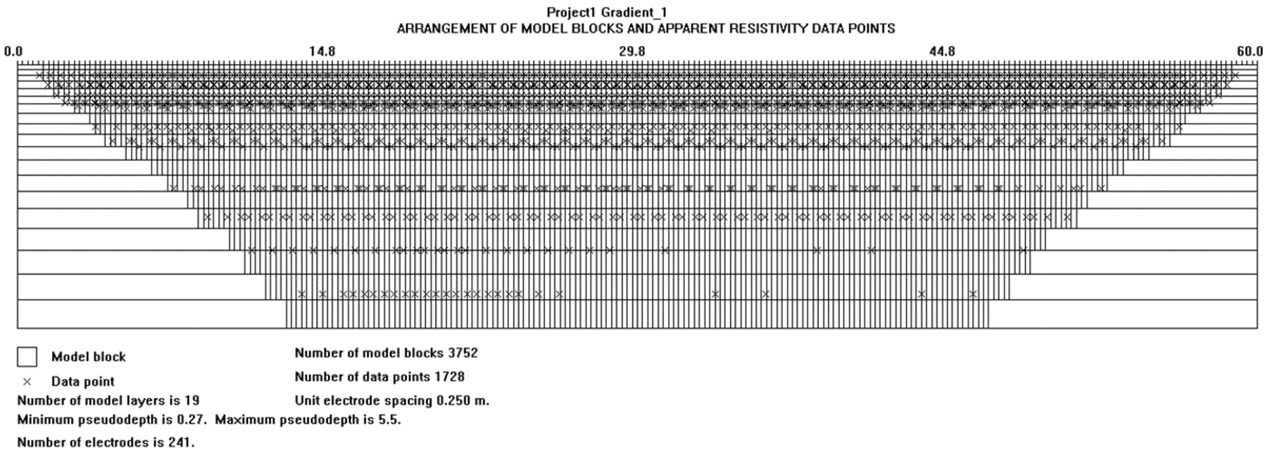
Example of acquisition protocol

•Implementation of field work

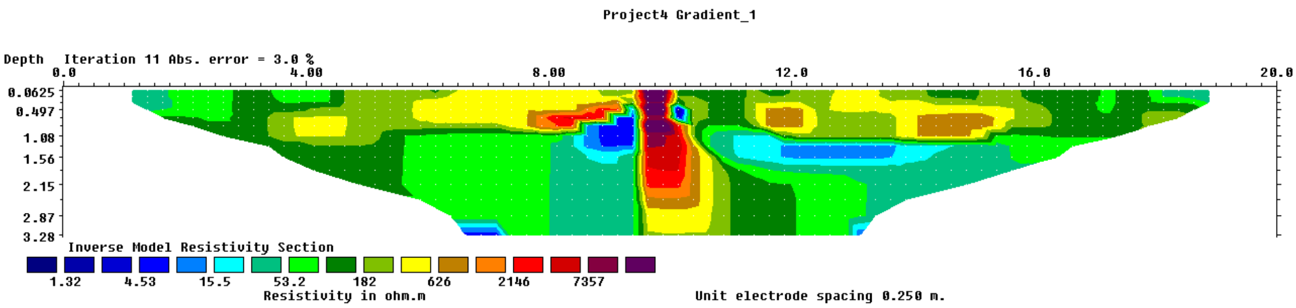
On the ground, the profile is laid out by a tape measure and the electrodes are implanted according to the chosen distance. The electrodes are connected to the take-outs on all electrode cables and the external power supply is also connected. Then, data collection can begin. The unit of measurement will automatically execute all the observation sequences according to the chosen protocol. In addition, it is important to assign coordinates to a series of profile points, usually using GPS observations. Moreover, during the measurement process, photos and notes are taken on the area to be studied, noting any possible incidents.

•Data processing

Data processing consists of solving the inverse problem. This means obtaining a distribution model of the true resistivities of the subsoil from the values of apparent resistivity. For this, we have the Res2dinv and Res3dinv programs of Geotomo Software for 2D and 3D studies, respectively. These programmes are based on least-squares optimization method, with the subsoil being divided into cells with an initial value of the true resistivity. The programme then obtains an apparent resistivity value for each cell and compares it with the observed values. The resistivity values of each cell are adjusted iteratively until a minimum error is achieved. The inversion can be performed by adding the topography. .



Example of division into cells for numerical inversion.



Distribution of true resistivities after inversion .

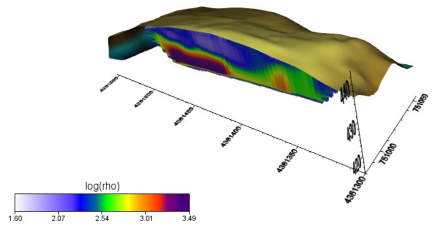
•Physical interpretation of the results obtained

To carry out an interpretation from the physical point of view, the resistivity values showing the greatest discrepancy with the medium are selected. These are known as anomalies. It is advisable to make different graphic representations, especially in 3D studies, where representations of horizontal sections at different depths are also made, as well as 3D representations of specific resistivity values.

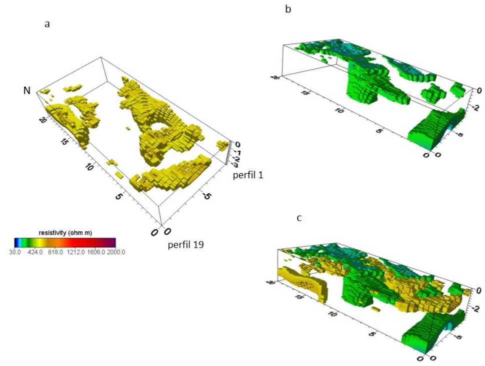
To perform a complete interpretation, it is very important to collaborate with experts in other disciplines such as geology or archaeology, depending on the objective of the study .

Applications

Geological, geotechnical and hydrogeological studies often use the electrical resistivity tomography method. As it is a non-destructive method, it is very appropriate in archaeological studies, offering results with a high degree of detail. As an example, the figure shows some results obtained in geological and archaeological studies carried out at the site of Villasviejas del Tamuja in Botija (Cáceres) within the framework of the project "Desarrollo de métodos de mínima invasión para la revalorización socio-cultural de zonas arqueológicas" ("Development of minimally invasive methods for socio–cultural revaluation of archaeological zones") (PRI IB116150) funded by the Government of Extremadura.



3D representation of a profile and the topography (De Tena et al., 2020).



3D representation of resistivity selection (Pro et al., 2020).

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CMPLab is the acronym for Data Capture, Virtual Modelling and Production/Prototyping Laboratory. CMPLab arose from a project entitled Aid to Infrastructures and Scientific-Technical Equipment of the Secretariat of State for Research and began its journey in 2016. This laboratory works in research areas related to the construction of 3D models of archaeological objects, very high resolution photography, geophysical prospecting and applications of geomatics to cultural heritage.
Its physical headquarters is on the first floor of the research building of the **University Centre of Merida**.

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The Kraken research group is made up of people from different areas of knowledge: geomatic engineering, earth physics, biology, telematics, agronomy, etc. The link between its members is the capture and processing of spatial data both at a detailed scale (3D models and graphic documentation of objects) as well as at the territorial level (geographic information systems, remote sensing, geophysics, etc.).

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