Field Training Report - Day 07 on

Electrical Resistivity Tomography (ERT)

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Content:

OBJECTIVE: **ELECTRICAL RESISTIVITY TOMOGRAPHY(ERT) SURVEY USING DIPOLE-DIPOLE AND WENNER-SCHLUMBERGER ELECTRODE CONFIGURATION.**

Geology of Baliapur and its surrounding:

• Dhanbad's geological composition predominantly consists of the Chotanagpur Gneissic Complex, which underlies the region encompassing IIT (ISM)Dhanbad. The lithology is marked by metamorphicand igneous rocks, including granites and gneisses. Notably, the Khudia Nala section offers a prime view of these rocks, showcasing gneisses with distinct compositional banding. The Khudia Nala traverse also reveals the rock's deformational history, illustrated by reclined folds. Baliapur CD Block is encircled by Dhanbad and Govindpur CD Blocks to the north, Nirsa CD Block to the east, Raghunathpur II CD Block in Purulia district (West Bengal) to the south, and Jharia CD Block to the west.

The lithology and geology structure are shown below figure,

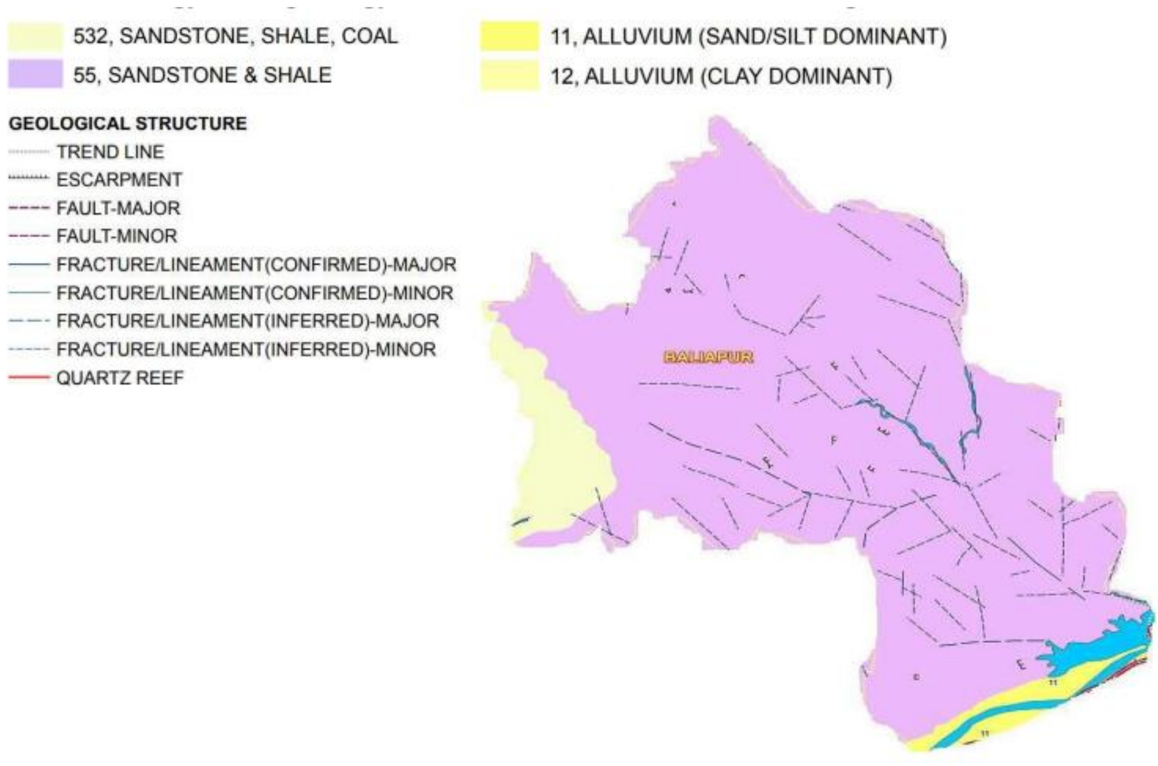


***Figure 1**: Lithological map of Baliapur ,Dhanbad*

THEORY:

Electrical Resistivity Tomography (ERT):

The Resistivity technique is a useful method for characterizing the sub-surface materials in terms of their electrical properties. Variations in electrical resistivity (or conductivity) typically correlate with variations in lithology, water saturation, fluid conductivity, porosity and permeability, which may be used to map stratigraphic units, geological structure, sinkholes, fractures and groundwater. The acquisition of resistivity data involves the injection of current into the ground via 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 via 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 bulk resistivity measurements from greater depths.

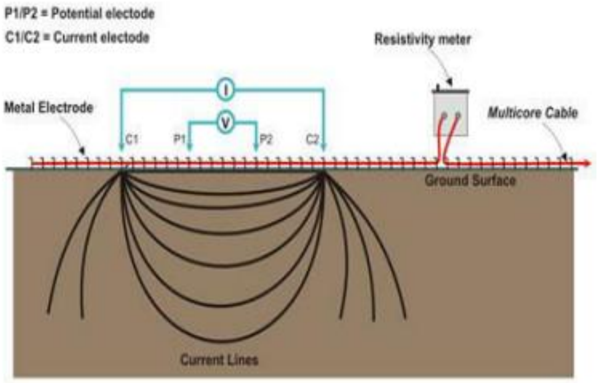


***Figure 2**: General Principle of Resistivity*

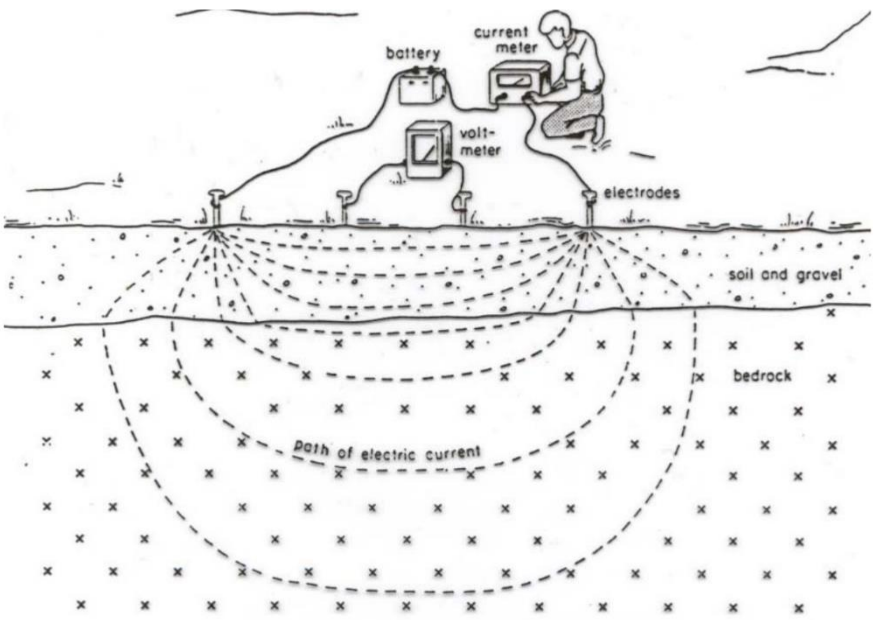


***Figure 3**: Basic Principle of Resistivity*

APPARENT RESISTIVITY & GEOMETRICAL FACTOR:

In a heterogeneous medium, the measured resistivity is an apparent resistivity, which is a function of the form of the inhomogeneity and of the electrode spacing and surface location.

K is named the geometric factor.

$$\rho_a = \frac{\Delta V_{MN}}{I} K$$

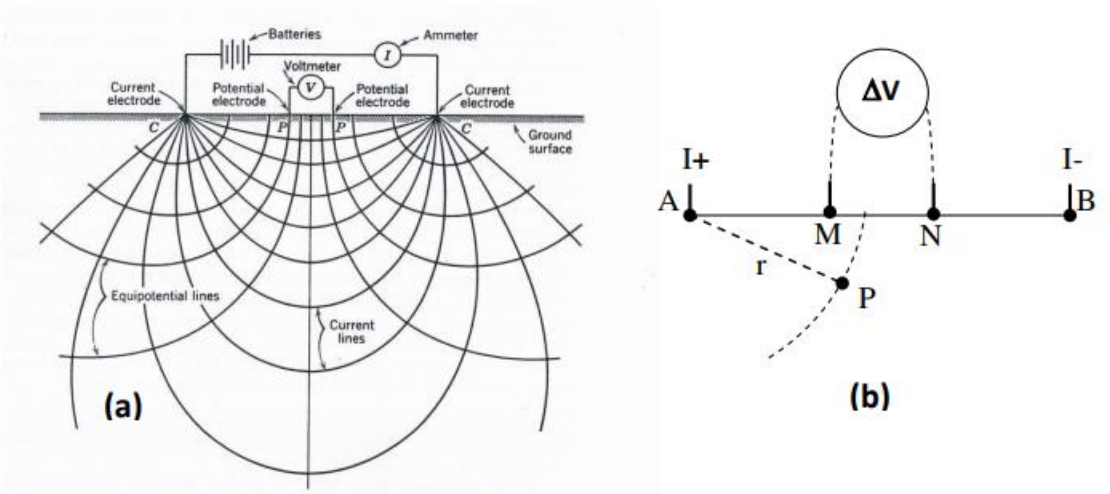


Figure 4: The geometry of current distribution within homogeneous and isotropic subsurface media

$$\Delta V_{MN}^{AB} = \frac{\rho I}{2\pi} \left(\frac{1}{AM} - \frac{1}{AN} - \frac{1}{BM} + \frac{1}{BN}\right)$$

$$\text{Geometrical Factor } (K) = (2 * \pi)/\left(\frac{1}{AM} - \frac{1}{AN} - \frac{1}{BM} + \frac{1}{BN}\right)$$

ELECTRODE SPREADS & APPARENT RESISTIVITY:

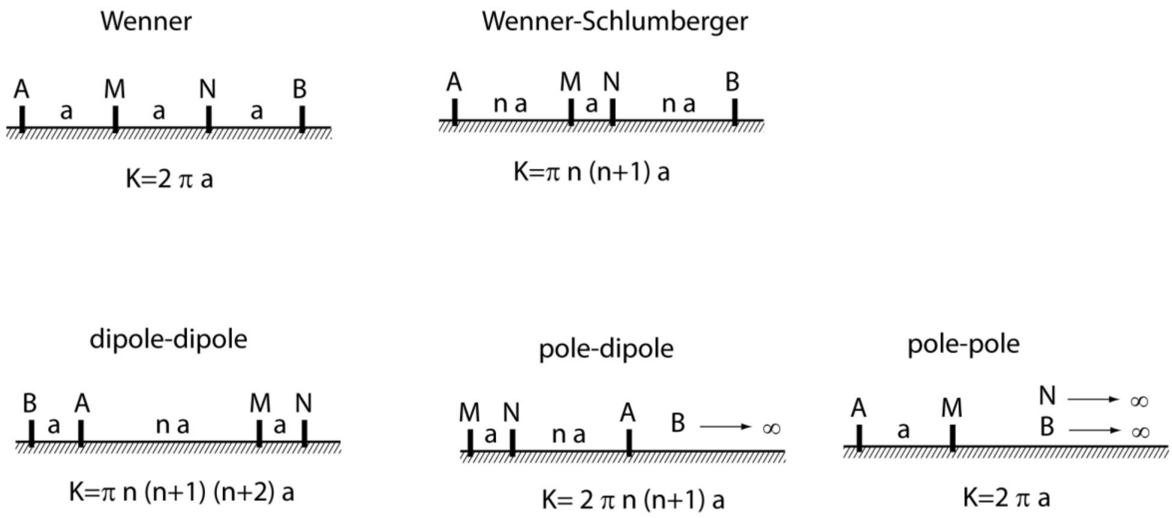


Figure 5: *Electrode spreads and associated Geometrical Factor*

$$\rho_a = 2\pi a \frac{\Delta V}{I}$$ Wenner array

$$\rho_a = \pi n(n+1)a \frac{\Delta V}{I}$$ Schlumberger array

$$\rho_a = \pi n(n+1)(n+2)a \frac{\Delta V}{I}$$ dipole-dipole array

METHODOLOGY:

❖ SURVEY DESIGN:

- We need to define our survey area.
- We need to design our survey profile (we did in a linear fashion)
- What should be our electrode array, we chose “DIPOLE – DIPOLE” and “WENNR-SCHLUMBERGER” configuration.
- We need to defining the spacing between electrodes depending upon objectives (we take it 10m)
- What should be the number of electrode (multiple of 12). We did our survey using 72 electrodes.
- We need to define magnitude of current in mA unit.
- We need to define ‘Q’ factor value (we set for our survey is 0.5).
- What should be the number of pulse using for stacking (we took 4 to 8)

❖ Instrumentation:

- Syscal pro
- Electrodes (72).
- Generator and battery.
- Multi colour cable.
- Wire.
- Field computer.
- Connecting box.
- Ranging rod.
- Measuring tape.
- Hammer.
- Connecting clip.

Figure 6: Syscal Pro

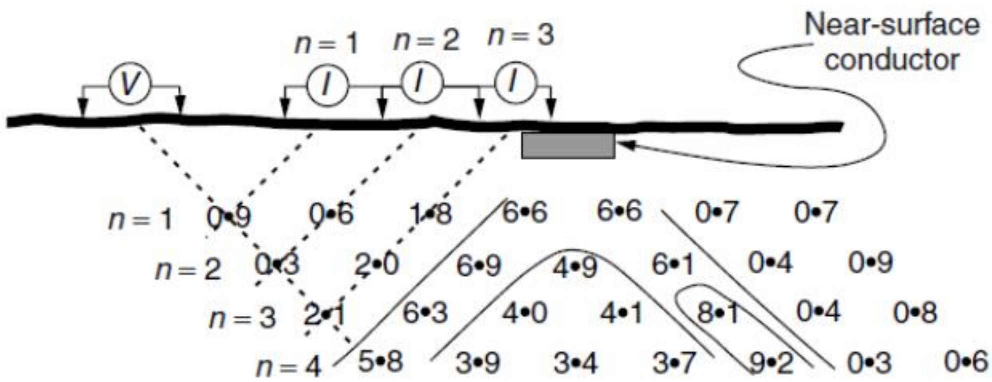
Figure 7*: Typical field survey design*

❖ Field Procedure:

- First, we need to complete a profile of 710m for 72 electrodes.
- Then we need to place each electrode with 10m spacing between each.
- Then we need to connect each and every electrode with the wire using connecting clips.
- Then we need to fix all the parameter in the instrument like Q value, electrode spacing, type of electrode spacing, no. of pulse and mode etc.
- Before starting survey, we need check the resistance and if resistance in between any electrodes cross 1kohm then we need to and salt water.
- When resistance between every electrode is below the 1kohm then we need to start.
- Make sure that generated pulse should be in squared form for the change in polarity.
- Then it will be taking value for n=6 and keep on going.

Dipole–dipole data:

Dipole–dipole traverses at a single n value can be used to construct profiles but multispaced results are almost always displayed as pseudo-sections.



The figure above showing the Pseudo-section construction. The three different positions of the current dipole correspond to three different multiples of the basic spacing. Measured values (of IP or resistivity) are plotted at the intersections of lines sloping at 45◦ from the dipole centres.

Data Inversion and Interpretation:

The recorded data are transferred to a PC for processing. In order to derive a cross-sectional model of true ground resistivity, the measured data are subject to a finite-difference inversion process via RES2DINV software.

Data processing is based on an iterative routine involving determination of a two-dimensional (2D) simulated model of the subsurface, which is then compared to the observed data and revised. Convergence between theoretical and observed data is achieved by non-linear least squares optimization. The extent to which the observed and calculated theoretical models agree is an indication of the validity of the true resistivity model (indicated by the final root-mean-squared (RMS) error).

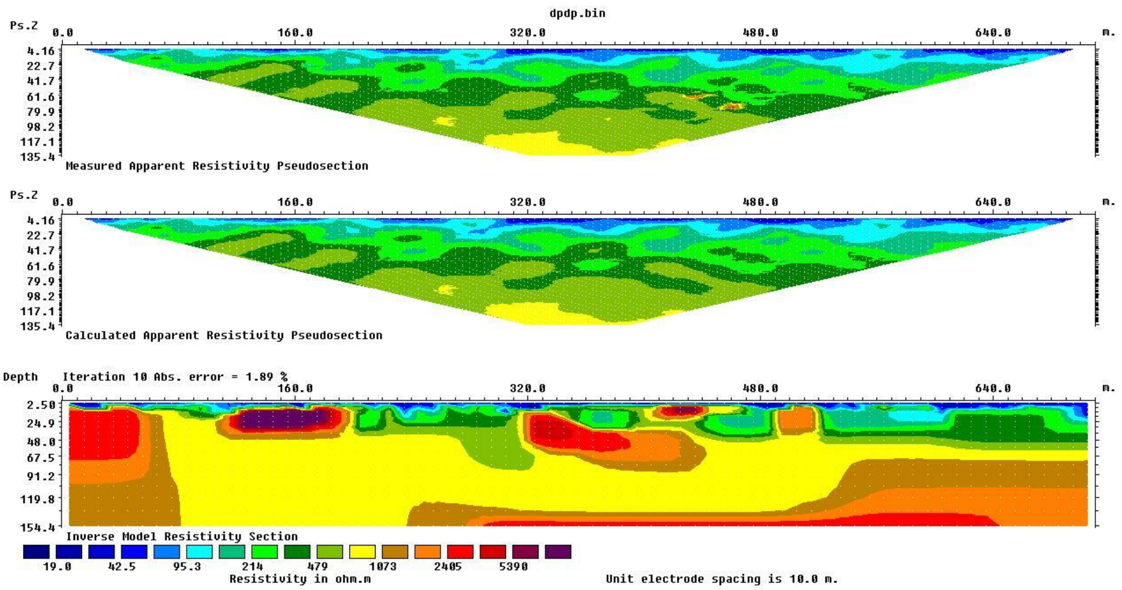


__Figure 8:__ Pseudo section of acquired apparent resistivity data using dipole-dipole configuration

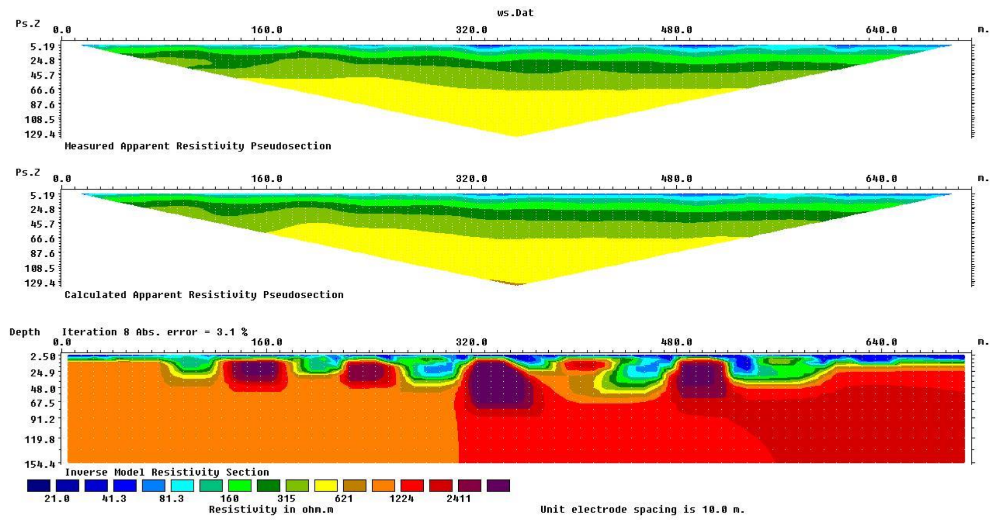


__Figure 9:__ Pseudo section of acquired apparent resistivity data using Wenner-Schlumberger configuration

From the figure of dipole-dipole (72 channel), we can get a crude model of Earth's subsurface. By applying 10 iterations this inversion model is established which clearly depicts the change in resistivity value with respect to depth. Violet colour corresponds to a higher resistivity approximately greater than 5400 ohm-m. At around 160 m away from the initial survey point (0,0) we find a high resistive body in the optimized inversion model which may indicate some kind of highly resistive non-conductive body. The uniform yellow colour continues below 20m to 154.4 m. Thus, this indicates the starting position of the basement at about depth 20m.

From the figure of Wenner-Schlumberger, we made an inversion model of Earth's subsurface by using 72 channels of Werner- Schlumberger array. In the 3rd figure of the resistivity section, we can interpret a clear starting of the basement as well as prominent high resistive structures. From the colour-bar of resistivity, violet colour presents high resistivity. In this last figure, there are many accumulations of high resistive materials at about 160m, 250m, 320m, and 490m distances from the origin point (0,0). The approximate depth of the basement is coming from this figure in the depth of 20m from the Earth's surface in the inversion model which has been created from 8 iterations. Though the number of data points are very much higher in the case of Dipole-dipole configuration, it gives a crude idea of resistivity of the surveyed region.