Field considerations for DC Resistivity

1- Good electrode contact with the earth
  - Wet electrode location.
  - Add Nacl solution or bentonite

2- Surveys should be conducted along a straight line whenever possible .

3- Try to stay away from cultural features whenever possible .
  - Power lines
  - Pipes
  - Ground metal fences
  - Pumps

Sources of Noise

There are a number of sources of noise that can effect our measurements of voltage and current.

1- **Electrode polarization.**
A metallic electrode like a copper or steel rod in contact with an electrolyte groundwater other than a saturated solution of one of its own salt will generate a measurable contact potential. For DC Resistivity, use nonpolarizing electrodes. Copper and copper sulfate solutions are commonly used.

2- **Telluric currents.**
Naturally existing current flow within the earth. By periodically reversing the current from the current electrodes or by employing a slowly varying AC current, the affects of telluric can be cancelled.

3- **Presence of nearby conductors. (Pipes, fences)**
Act as electrical shorts in the system and current will flow along these structures rather than flowing through the earth.

4- **Low resistivity at the near surface.**
If the near surface has a low resistivity, it is difficult to get current to flow more deeply within the earth.

5- **Near- electrode Geology and Topography**
Rugged topography will act to concentrate current flow in valleys and disperse current flow on hills.

6- **Electrical Anisotropy.**
Different resistivity if measured parallel to the bedding plane compared to perpendicular to it .

7- **Instrumental Noise .**

8- **Cultural Feature .**

Current Flow in A Homogeneous Earth

1. Point current Source :

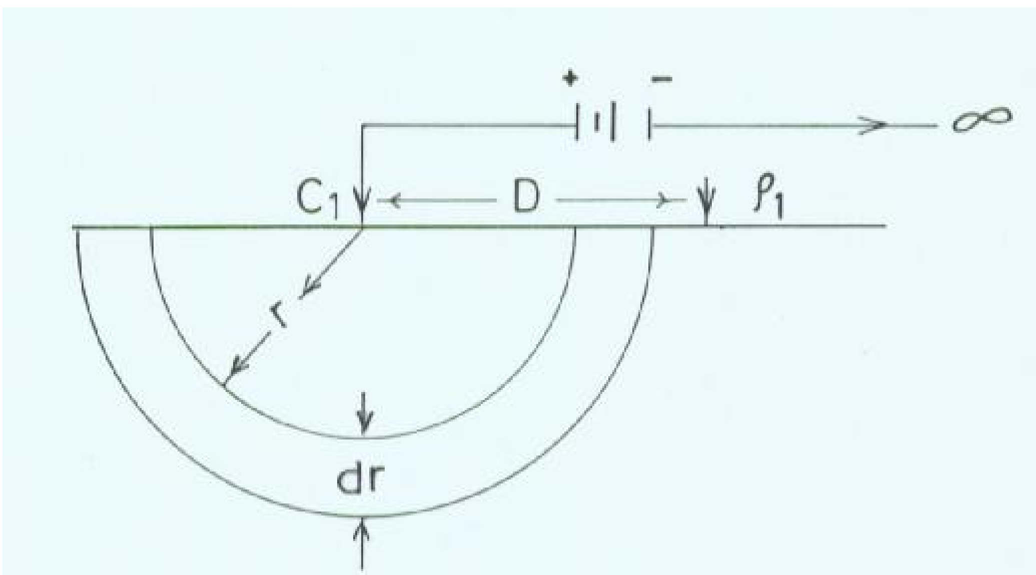
If we define a very thin shell of thickness dr we can define the potential different dv

$$\mathbf{dv = I(R) = I(\rho L / A) = I(\rho\ dr / 2\pi r^2)}$$

To determine V a t a point . We integrate the above eq. over its distance D to to infinity :

$$\mathbf{V = I\rho / 2\pi D}$$

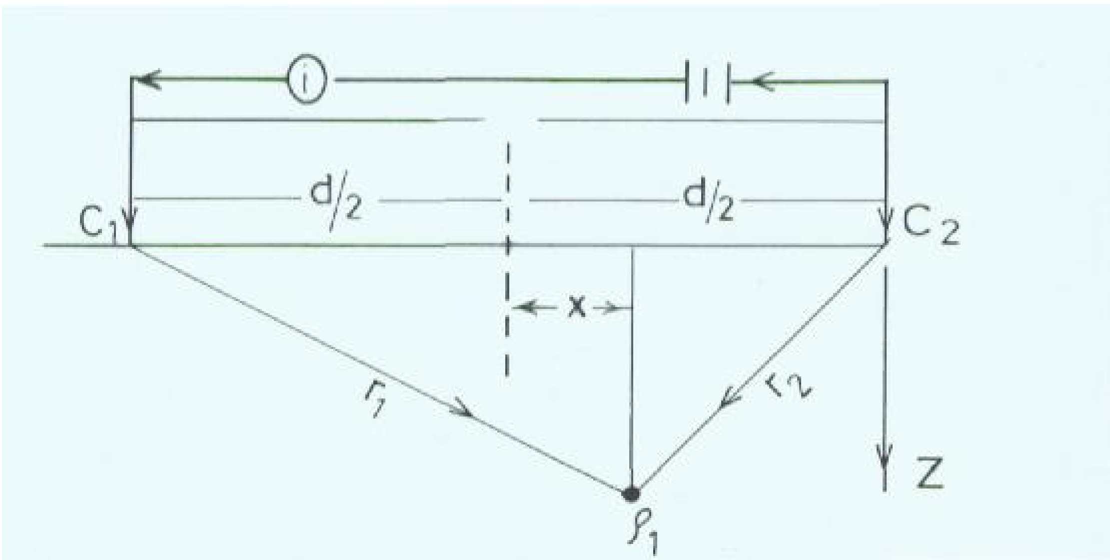
C: current density per unit of cross sectional area :



2. Two current electrodes

To determine the current flow in a homogeneous, isotropic earth
When we have two current electrodes. The current must flow from the positive (source) to the resistive (sink).
The effect of the source at C1 (+) and the sink at C2 (-)

$$V p_1 = i\,\rho / 2\pi\, r_1 + (- i\rho / 2\pi\, r_2)$$



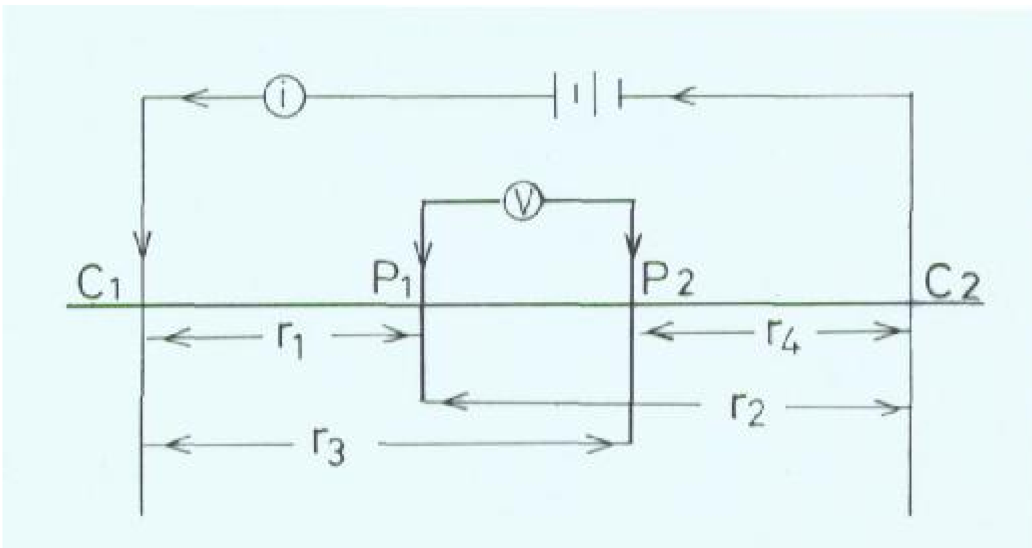
$$V p_1 = i\rho / 2\pi \{ 1/ [(d/2 + x)^2 + Z^2]^{0.5} - 1 / [(d/2 - x)^2 + Z^2]^{0.5} \}$$

3. Two potential Electrodes

$$Vp_1 = i\,\rho / 2\pi\, r_1 \quad - i\rho / 2\pi\, r_2$$

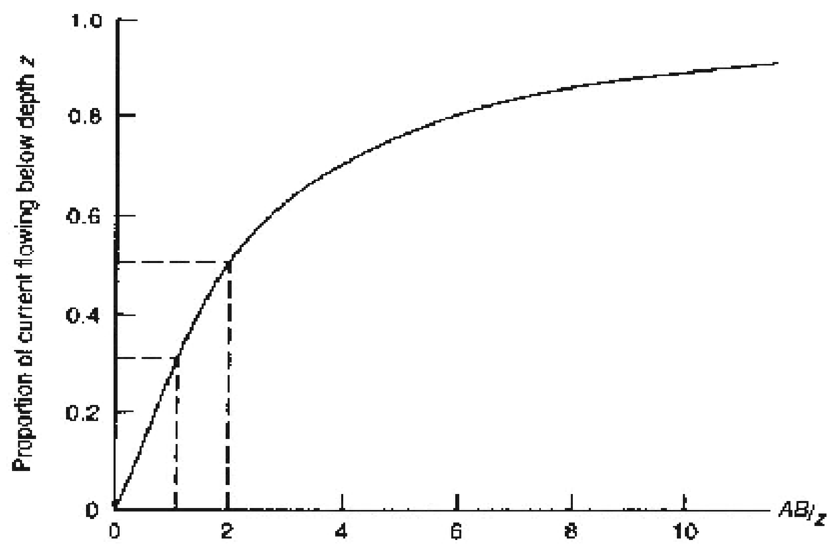
$$Vp_2 = i\,\rho / 2\pi\, r_3 \quad - i\rho / 2\pi\, r_4$$

$$\Delta V = Vp_1 - Vp_2 = i\,\rho / 2\pi\, (1/r_1 - 1 / r_2 - 1 / r_3 + 1 / r_4)$$



Depth of Current Penetration

Current flow tends to occur close to the surface. Current penetration can be increased by increasing separation of current electrodes. Proportion of current flowing beneath depth z as a function of current electrode separation AB:



Example

If target depth equals electrode separation, only 30% of current flows beneath that level.

- To energize a target, electrode separation typically needs to be 2-3 times its depth.
- High electrode separations limited by practicality of working with long cable lengths. Separations usually less than 1 km.

  The fraction of the total current (if) penetrating to depth Z for an electrode separation of d is given by :

$$\mathbf{if = 2/\pi \; \tan^{-1} (2 Z / d)}$$

ELECTRODE CONFIGURATIONS

The value of the apparent resistivity depends on the geometry of the electrode array used (K factor)

1- Wenner Arrangement

Named after wenner (1916) .

The four electrodes A , M , N , B are equally spaced along a straight line. The distance between adjacent electrode is called “a” spacing . So AM=MN=NB= ⅓ AB = a.

$\mathbf{P_{a=}\ 2\pi\ a\quad V\ /\ I}$

The wenner array is widely used in the western Hemisphere. This array is sensitive to horizontal variations.

2- **Lee- Partitioning Array** .

This array is the same as the wenner array, except that an additional potential electrode O is placed at the center of the array between the Potential electrodes M and N. Measurements of the potential difference are made between O and M and between O and N .

$\mathbf{P_{a=}\ 4\pi\ a\quad V\ /\ I}$

This array has been used extensively in the past .

3) **Schlumberger Arrangement** .

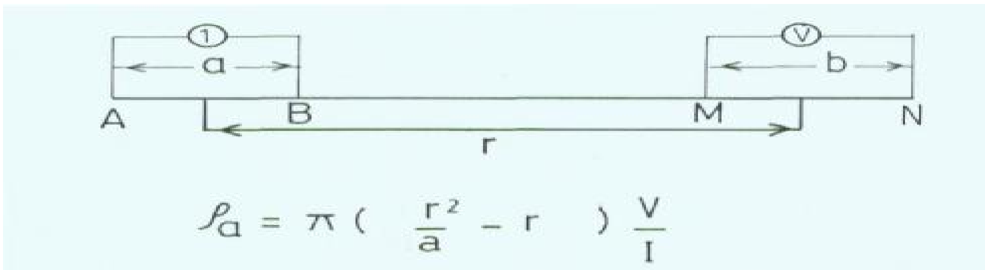
This array is the most widely used in the electrical prospecting. Four electrodes are placed along a straight line in the same order AMNB , but with AB ≥ 5 MN

$$ra = p \times \frac{V}{I} \times \left[\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN} \right]$$

This array is less sensitive to lateral variations and faster to use as only the current electrodes are moved.

4. Dipole – Dipole Array .

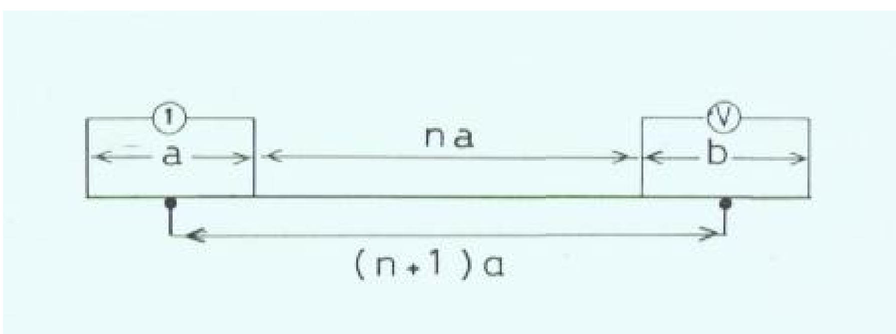
The use of the dipole-dipole arrays has become common since the 1950's , Particularly in Russia. In a dipole-dipole, the distance between the current electrode A and B (current dipole) and the distance between the potential electrodes M and N (measuring dipole) are significantly smaller than the distance r , between the centers of the two dipoles.



$$\rho_a = \pi [(r^2 / a) - r] \, v/i$$

Or . if the separations a and b are equal and the distance between the centers is **(n+1) a** then

$$\rho_a = n (n+1) (n+2) . \pi \, a. v/i$$



This array is used for deep penetration $\approx$ 1 km.