

## 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 electrodes is called “a” spacing . So  $AM=MN=NB=\frac{1}{3} AB = a$ .

$$P_a = 2 \pi a \quad V / I$$

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 .

$$P_a = 4 \pi a \quad V / I$$

This array has been used extensively in the past .

### 3) Schlumberger Arrangement .

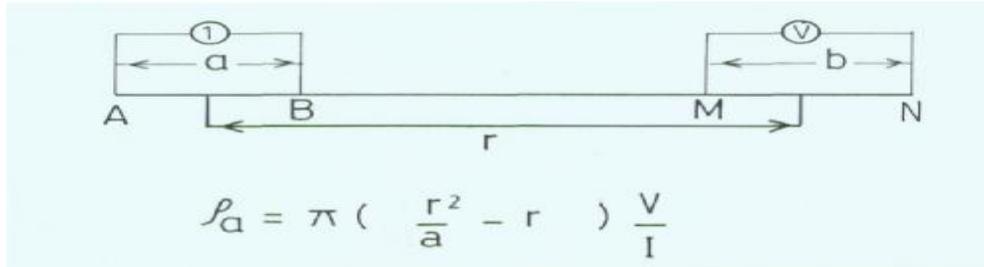
This array is the most widely used in the electrical prospecting . Four electrodes are placed along a straight line in the same order AMNB , but with  $AB \geq 5 MN$

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

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

### 1. Dipole – Dipole Array .

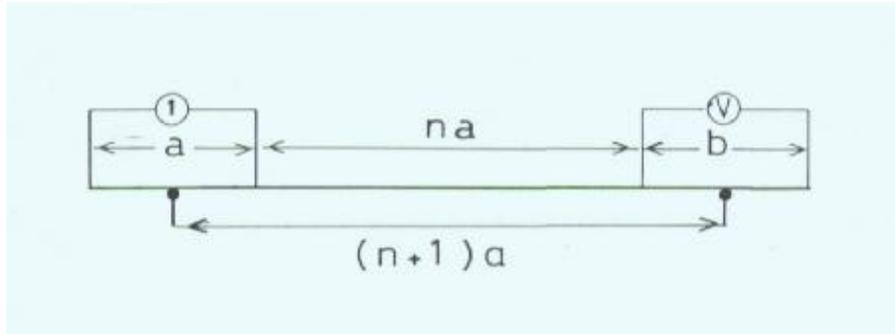
The use of the dipole-dipole arrays has become common since the 1950's , Particularly in Russia. In a dipole-dipole, the distance between the current electrode A and B (current dipole) and the distance between the potential electrodes M and N (measuring dipole) are significantly smaller than the distance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



$$\rho_a = \pi \left[ \left( \frac{r^2}{a} \right) - r \right] \frac{V}{I}$$

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

$$\rho_a = n(n+1)(n+2) \cdot \pi a \cdot \frac{V}{I}$$



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

**Four basic dipole- dipole arrays .**

- 1) Azimuthal
- 2) Radial
- 3) Parallel
- 4) Perpendicular

When the azimuth angle ( $\Theta$ ) formed by the line  $r$  and the current dipole  $\mathbf{AB} = \pi/2$ , The Azimuthal array and parallel array reduce to the equatorial Array.

When  $\Theta = 0$ , the parallel and radial arrays reduce to the polar or axial array .

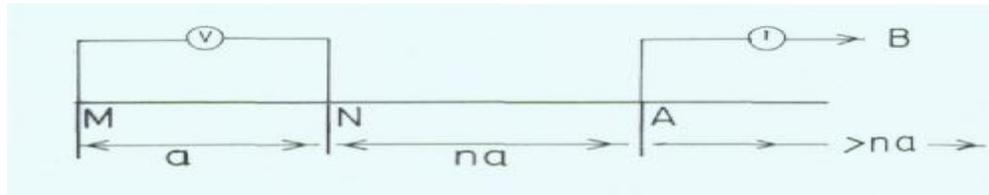
If MN only is small is small with respect to R in the equatorial array, the system is called Bipole-Dipole ( $\mathbf{AB}$  is the bipole and  $\mathbf{MN}$  is the dipole ), where  $\mathbf{AB}$  is large and MN is small.

If AB and MN are both small with respect to R , the system is dipole- dipole

### 5) Pole-Dipole Array .

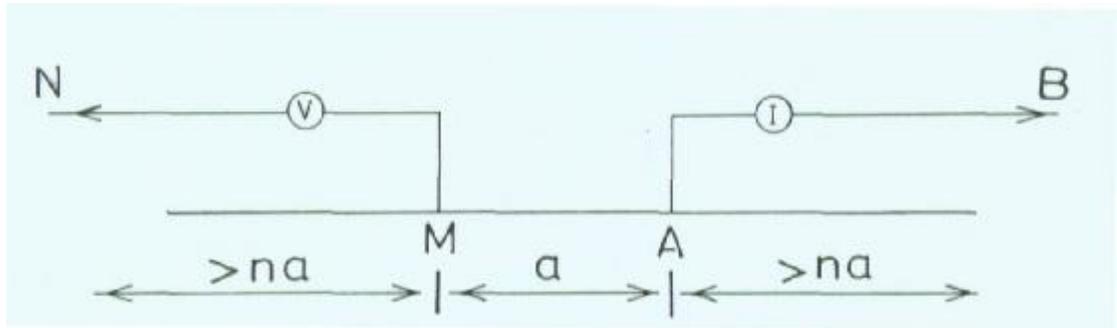
The second current electrode is assumed to be a great distance from the measurement location ( infinite electrode)

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

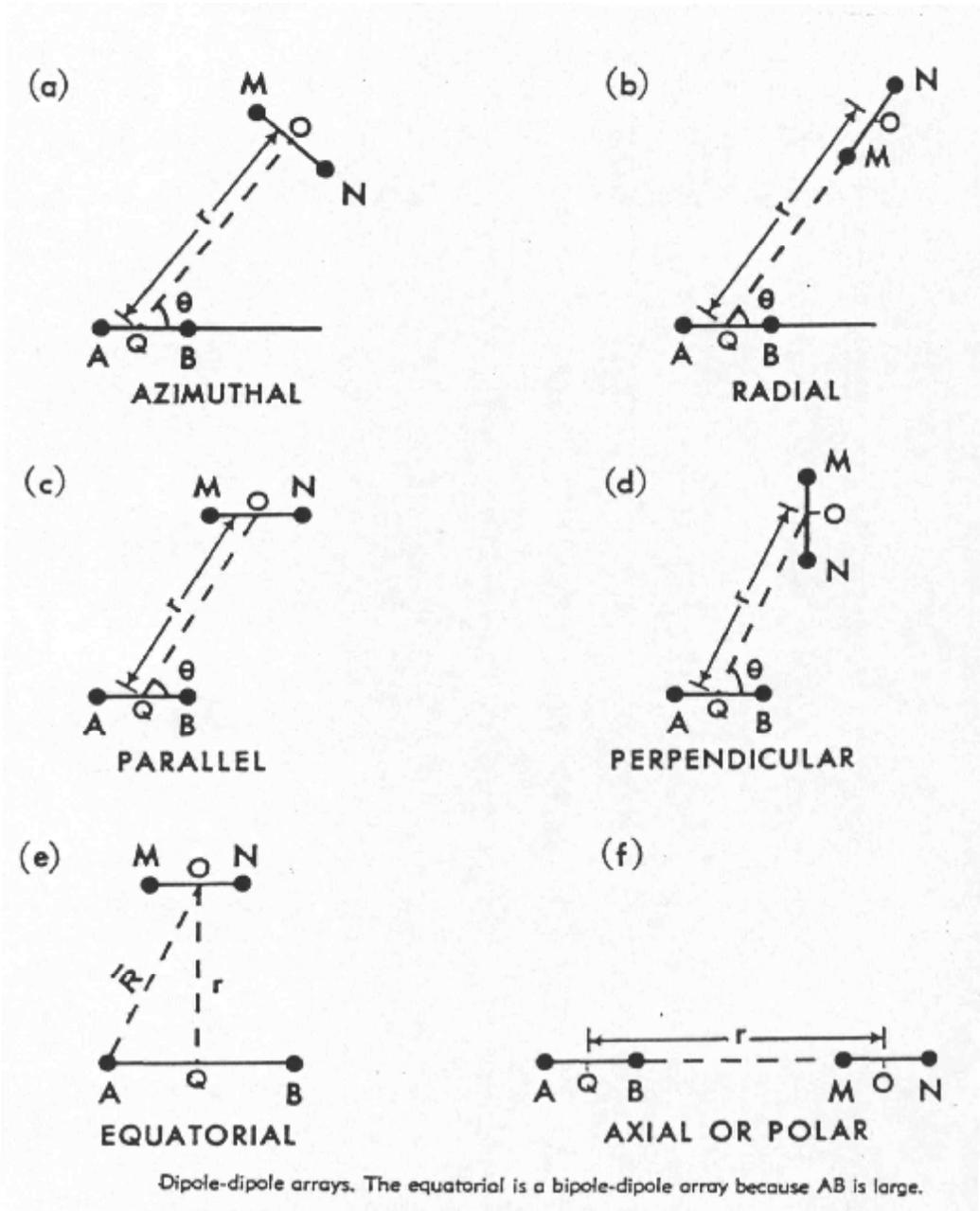


### 6) Pole – Pole.

If one of the potential electrodes , N is also at a great distance.



$$P_a = 2\pi a \quad V / I$$

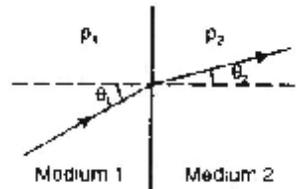


**REFRACTION OF ELECTRICAL RESISTIVITY**

### A. Distortion of Current flow

At the boundary between two media of different resistivities the potential remains continuous and the current lines are refracted according to the law of tangents.

$$\frac{\tan \theta_1}{\tan \theta_2} = \frac{\rho_1}{\rho_2}$$

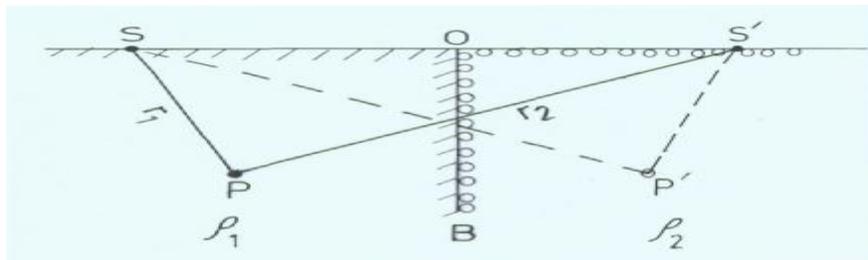


$$\rho_1 \tan \theta_1 = \rho_2 \tan \theta_2$$

If  $\rho_2 < \rho_1$ , The current lines will be refracted away from the Normal. The line of flow are moved downward because the lower resistivity below the interface results in an easier path for the current within the deeper zone.

### B. Distortion of Potential

Consider a source of current  $I$  at the point  $S$  in the first layers  $\rho_1$  of Semi infinite extent. The potential at any point  $P$  would be that from  $S$  plus the amount reflected by the layer  $\rho_2$  as if the reflected amount were coming from the image  $S'$



$$V_1(P) = i \rho_1 / 2\pi [ (1 / r_1) + (K / r_2) ]$$

$$K = \text{Reflection coefficient} = \rho_2 - \rho_1 / \rho_2 + \rho_1$$

In the case where  $P$  lies in the second medium  $\rho_2$ , Then transmitting light coming from  $S$ . Since only  $1 - K$  is transmitted through the boundary.

The Potential in the second medium is

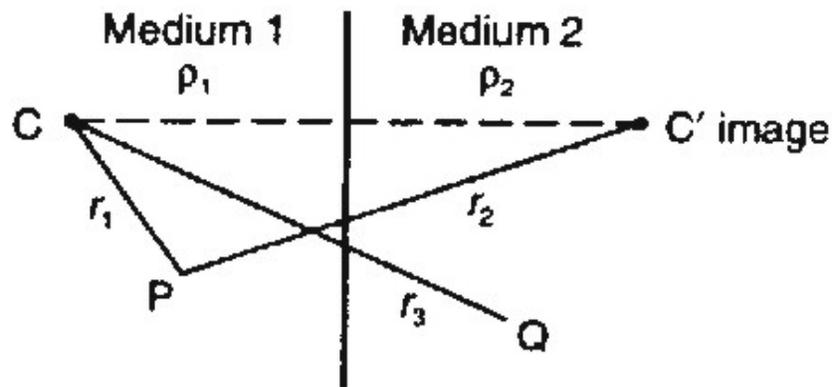
$$V_2(\mathbf{P}) = I \rho_2 / 2\pi [ (1 / r_1) - (K / r_2) ]$$

Continuity of the potential requires that the boundary where  $r_1 = r_2$ ,  $V_1(p)$  must be equal to  $V_2 ( P)$ .

At the interface  $r_1 = r_2$ ,  $V_1 = V_2$

### Method of Images

Potential at point close to a boundary can be found using "Method of Images" from optics.



### In optics:

Two media separated by semi transparent mirror of reflection and transmission coefficients  $k$  and  $1-k$ , with light source in medium 1. Intensity at a point in medium 1 is due to source and its reflection, considered as image source in second medium, i.e source scaled by reflection coefficient  $k$ . Intensity at point in medium 2 is due only to source scaled by transmission coefficient  $1-k$  as light passed through boundary.

## Electrical Reflection Coefficient

Consider point current source and find expression for current potentials in medium 1 and medium 2: Use potential from point source, but  $4\pi$  as shell is spherical:

Potential at point  $P$  in medium 1:

$$V_p = \frac{I, \rho_1}{4 \pi} \left[ \frac{1}{r_1} + \frac{k}{r_2} \right]$$

Potential at point Q in medium2:

$$V_Q = \frac{I, \rho_2}{4 \pi} \frac{[1 - k]}{r_3}$$

At point on boundary mid-way between source and its image:

$r_1=r_2=r_3=r$  say. Setting  $V_p = V_q$ , and cancelling we get:

$$\frac{\rho_1}{\rho_2} = \frac{1 - k}{1 + k}$$

$$k = \frac{\rho_2 - \rho_1}{\rho_2 + \rho_1}$$

k is electrical reflection coefficient and used in interpretation

The value of the dimming factor , K always lies between  $\pm 1$

If the second layer is a pure insulator

(  $\rho_2 = \infty$  ) then  $K = + 1$

If The second layer is a perfect conductor

(  $\rho_2 = 0$  ) then  $K = - 1$

When  $\rho_1 = \rho_2$  then No electrical boundary Exists and  $K = 0$  .

