

4.4 DC resistivity and IP surveys

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Electrode arrays

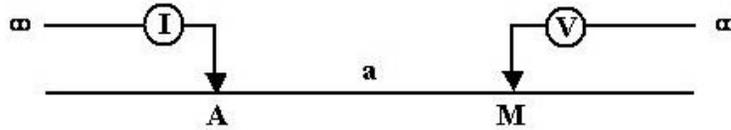
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All the arrays of electrodes used to obtain the apparent resistivity are variants of the four-electrode scheme that was introduced in section 4.2. All the arrays are basically superpositions of the fundamental equation for the potential from a current source with appropriate sign for the current. The formulas for apparent resistivity are a product of the impedance V/I (Ohms) and a geometric factor with the units of length (meters). To investigate the resistivity distribution with depth, called a sounding, the arrays are expanded about a center point and the apparent resistivities are plotted vs. spacing usually on a log-log plot. In the more general case the apparent resistivities are plotted as a function of array spacing and lateral position using plotting conventions that have become accepted for each type of array.



Pole-Pole

The simplest array is one in which one of the current electrodes and one of the potential electrodes are placed so far away that they can be considered at infinity. This configuration with its formula for apparent resistivity is shown below.



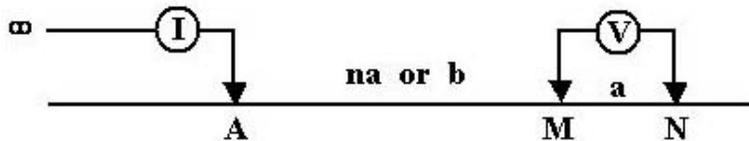
$$\rho_A = \frac{V}{I} 2\pi a$$

This array can actually be achieved for surveys of small overall dimension when it is possible to put the distant electrodes some practical distance away. For a survey in an area of a few square meters “infinity” can be on the order of a hundred meters. Pole-pole sounding data is plotted as apparent resistivity vs. a.



Pole-Dipole

If only one of the current electrodes is placed at “infinity” the configuration and the apparent resistivity are as shown:



$$\rho_A = 2\pi \frac{b(a+b)}{a} \frac{V}{I}$$

This array is used frequently in resistivity surveying and the spacings are usually described, and taken, in integer multiples of the voltage electrode spacing b. The standard nomenclature is to call the potential electrode spacing a so the configuration and apparent resistivity become:

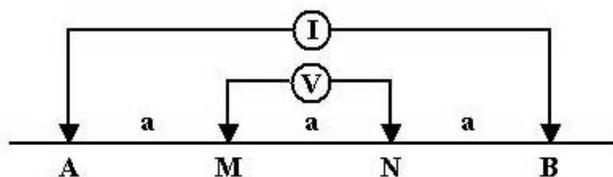
$$\rho_A = 2\pi a n(n+1) \frac{V}{I}$$

pole-dipole sounding data sounding data is plotted as apparent resistivity vs. a.



Wenner

The Wenner array is now seen to be a simple variant of the pole-dipole in which the distant pole at infinity is brought in and all the electrodes are given the same spacing, a , as seen in the following configuration



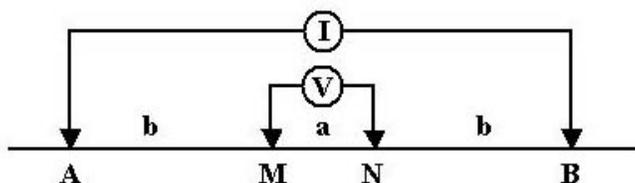
$$\rho_A = 2\pi a \frac{V}{I}$$

The Wenner array is normally used for sounding and the apparent resistivities are plotted vs. a on a log-log plot such as is shown in Figure 4.4.1.



Schlumberger

One of the first arrays used in the 1920's and still popular today is the Schlumberger array shown below with its formula for apparent resistivity. It is another variant of the pole-dipole, again with the second current electrode placed symmetrically opposite the first. The voltage difference is consequently doubled and so the apparent resistivity is the same as that for the general pole-dipole with a factor of $1/2$ in the geometric factor. In a Schlumberger sounding the voltage electrodes are usually kept small and fixed while only the b spacing is changed.



$$\rho_A = \frac{V}{I} \pi \frac{b(b+a)}{a} \approx \frac{V}{I} \pi \frac{b^2}{a} \quad \text{if } a \ll b$$

[Note that if a is small compared to b , $V/a \sim E$ the electric field. The electric field from an electrode is $-\partial\Phi/\partial r = I\rho/2\pi r^2$ and since there are two electrodes the total electric field becomes $= I\rho/\pi r^2$ and so $\rho_A = \frac{E}{I} \pi b^2$.]

Further, it is conventional to consider the spacing to be the distance from the center of the array to the outermost electrodes, i.e. $AB/2$. In this case b in the above expressions becomes $AB/2 - a/2$. If $a \ll AB/2$ the above formulas for ρ_A are unchanged.

Data from a Schlumberger sounding is plotted vs. spacing in the same manner as the Wenner data of Figure 4.4.2.



Dipole-Dipole

The dipole-dipole array is logistically the most convenient in the field, especially for large spacings. All the other arrays require significant lengths of wire to connect the power supply and voltmeter to their respective electrodes and these wires must be moved for every change in spacing as the array is either expanded for a sounding or moved along a line. The convention for the dipole-dipole array shown below is that current and voltage spacing is the same, a , and the spacing between them is an integer multiple of a .



The apparent resistivity is given by:

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



Data plotting for the pole-pole, pole-dipole and dipole-dipole arrays

The pole-pole, pole-dipole and dipole-dipole arrays are normally used in profiling mode to map lateral as well as depth variations in resistivity. The plotting convention is to plot the values of apparent resistivity at the intersection point of two 45° lines descending from the current pole or dipole and from the voltage pole or dipole. This convention is illustrated for each of the arrays in [Figure 4.4.3](#). The resulting “maps” of apparent resistivity are contoured at constant (usually logarithmic) intervals. The contoured sections are called “pseudo sections” because they look somewhat like resistivity cross-sections of the ground but they are not – they are simply a graphical representation of the data. The vertical scale is not depth but some function of the array spacing. For some geological models the pseudo sections do have an intuitive relationship to the actual section but mostly they do not. For a layered earth the contours are horizontal and rise and fall in value in the same sense as the actual resistivity, but for the case of a vertical contact between dissimilar resistivities the pseudo section is a complex map with no direct relationship to the actual model. The example of Figure 4.4.4 in a later section shows a dipole-dipole pseudo section for such a contact.

