
بسم الله الرحمن الرحيم

GPH 201

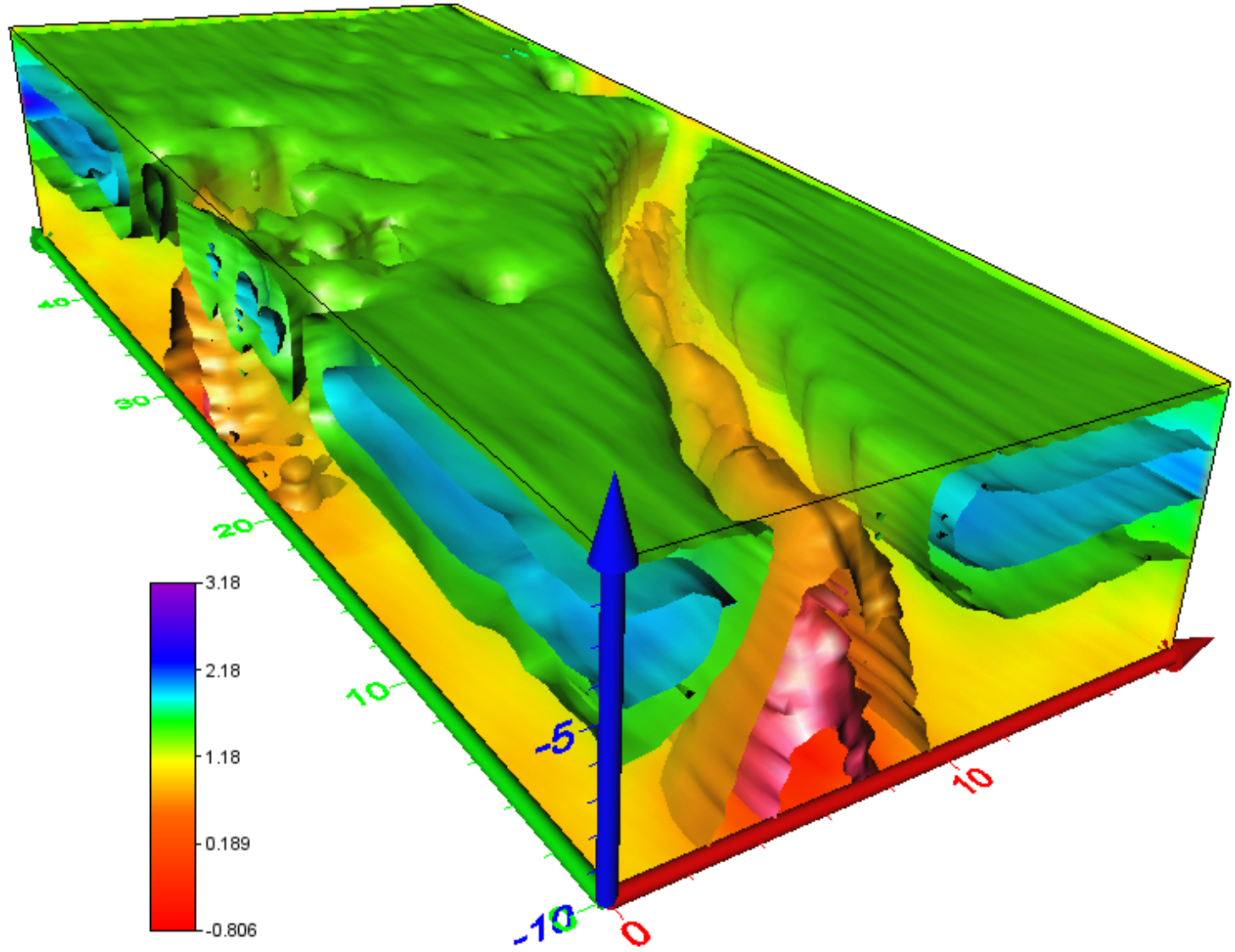
Principles of Geophysics

Dr. Sattam Abdulkareem Almadani

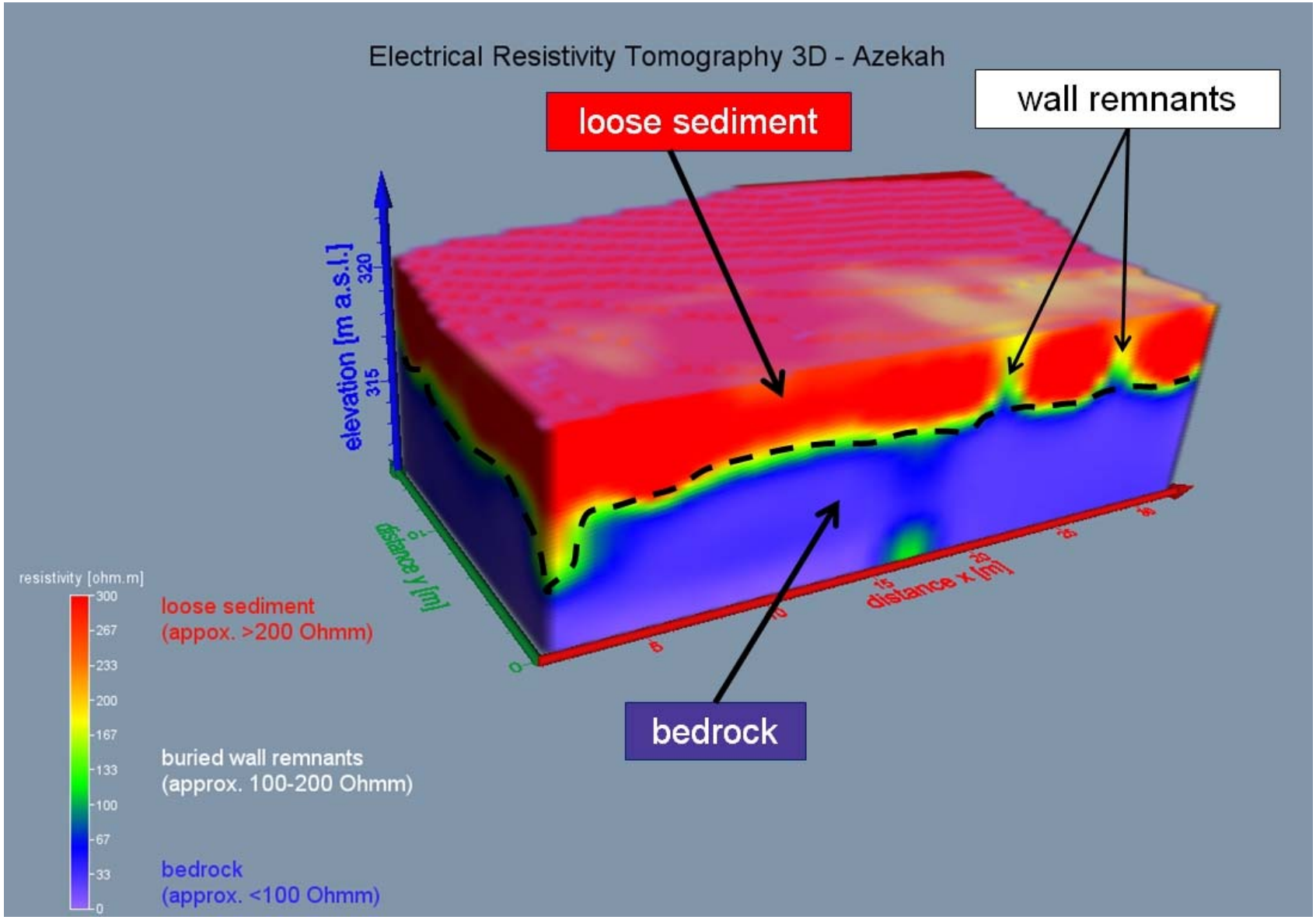
Outline

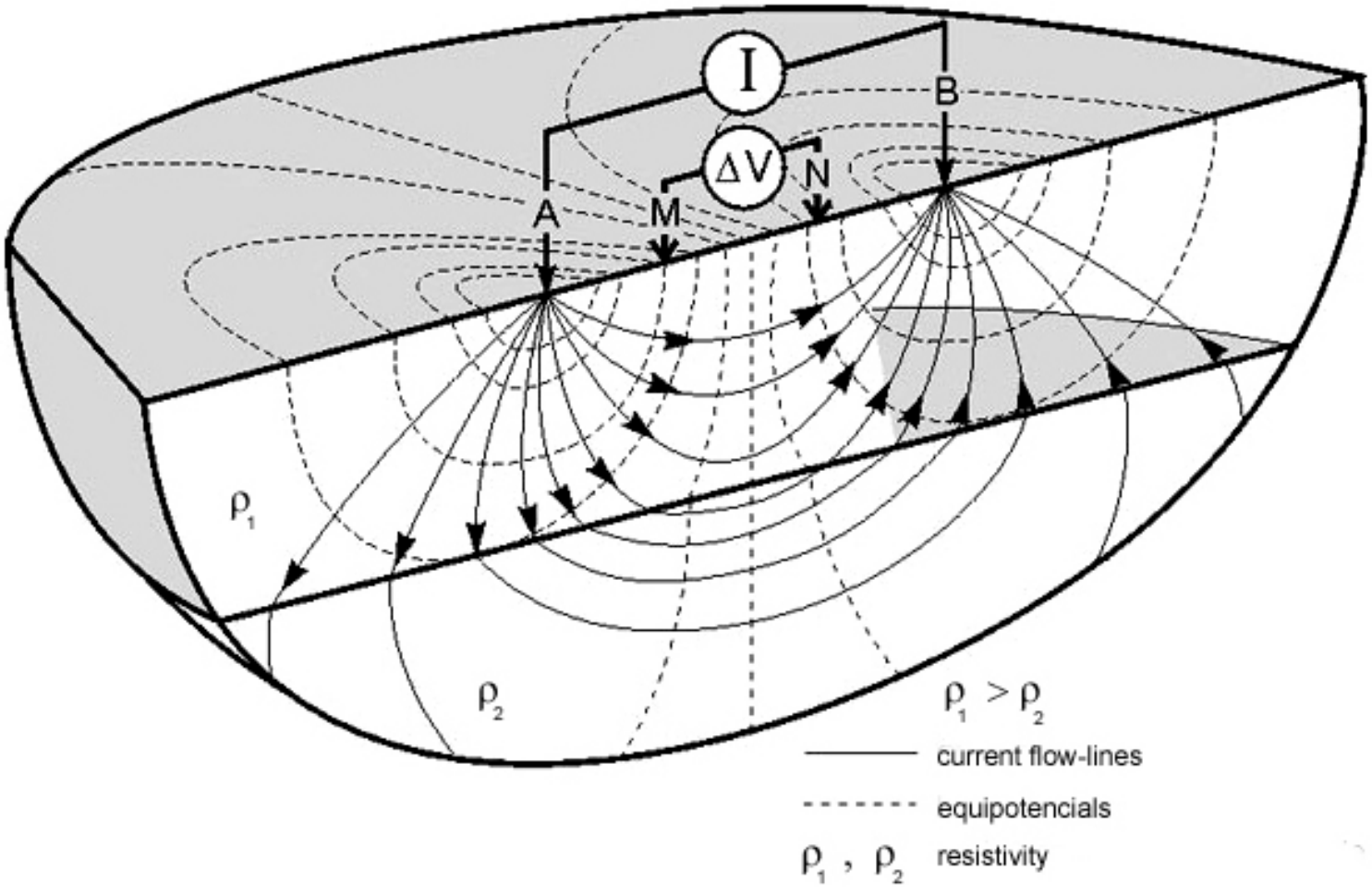
- What is geoelectrical exploration
- Types of electrical exploration
- Electrical properties of rocks
- Electrical methods
- Electrical applications
- Definition of resistivity
- Resistivity's law
- Factors that affect resistivity
- Archie's law
- Types of resistivity survey
- Calculations

Q. What is geoelectrical exploration?



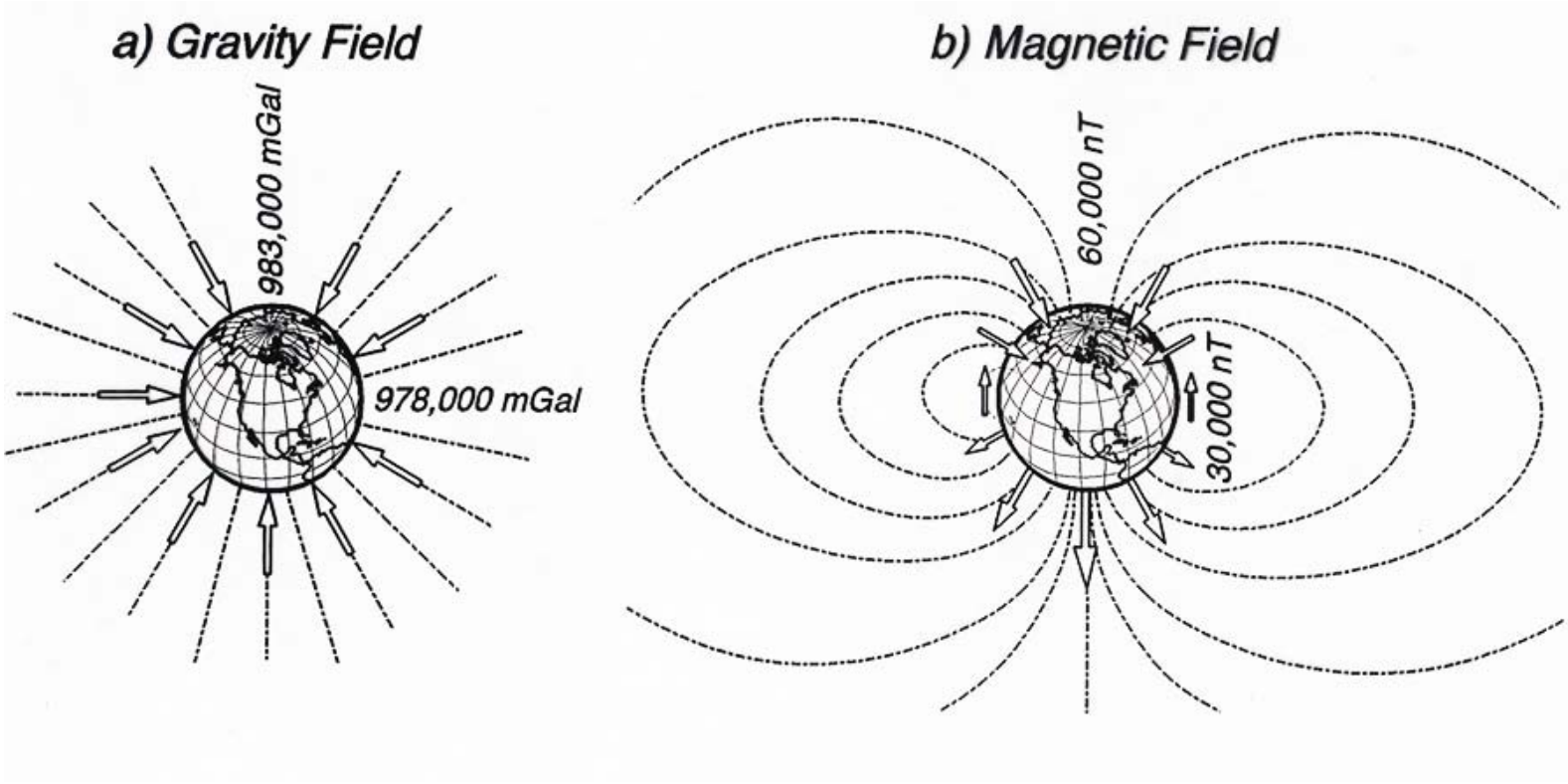
GPH 201 - Electrical Methods


Electrical Resistivity Tomography 3D - Azekah
loose sediment
wall remnants
bedrock
elevation [m a.s.l.]
320
315
distance y [m]
distance x [m]
resistivity [ohm.m]
300
267
233
200
167
133
100
67
33
0
loose sediment
(appox. >200 Ohmm)
buried wall remnants
(approx. 100-200 Ohmm)
bedrock
(approx. <100 Ohmm)


I
B
ΔV
N
A
M
ρ1
ρ2
ρ1 > ρ2
current flow-lines
equipotencials
ρ1 , ρ2 resistivity

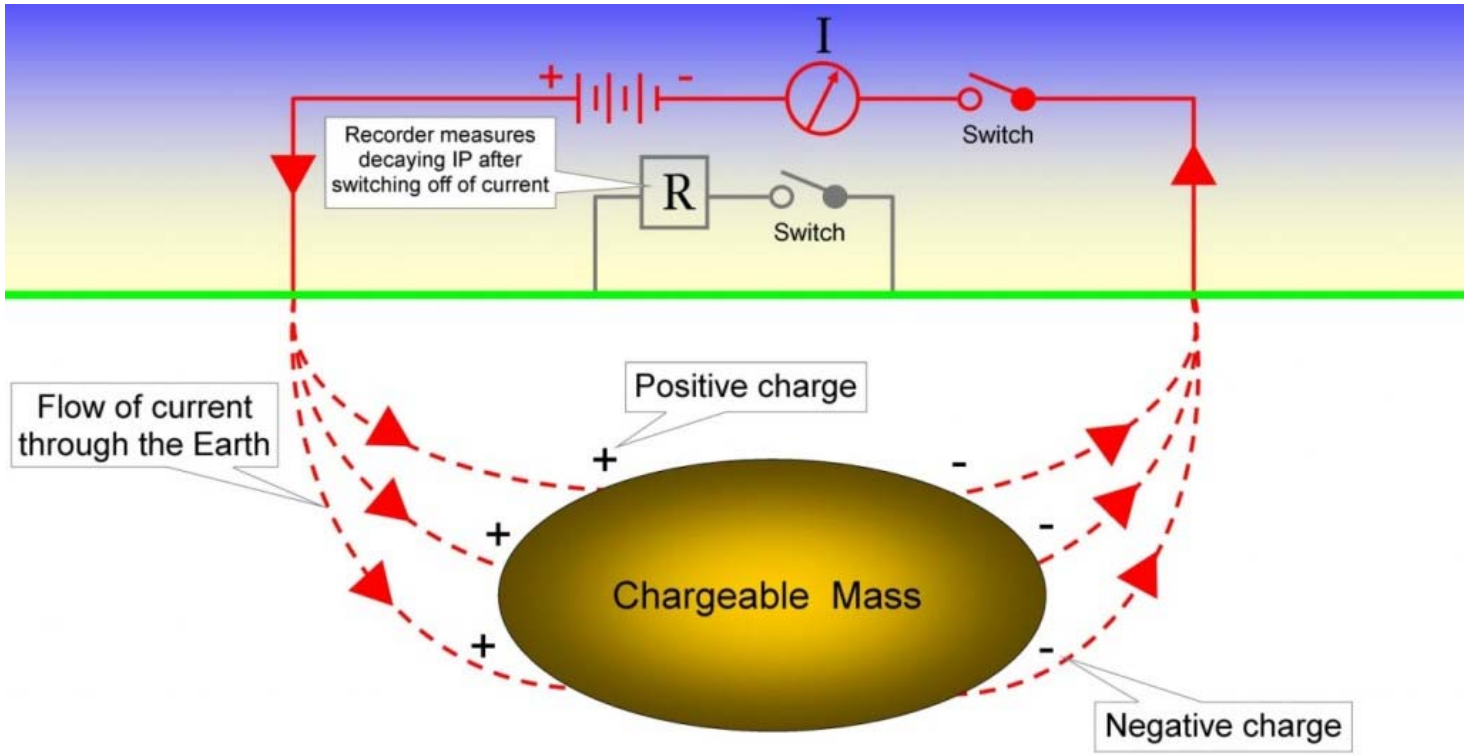
Types of electrical exploration:

1. Self-Potential



Types of electrical exploration:

2. Induced Polarization

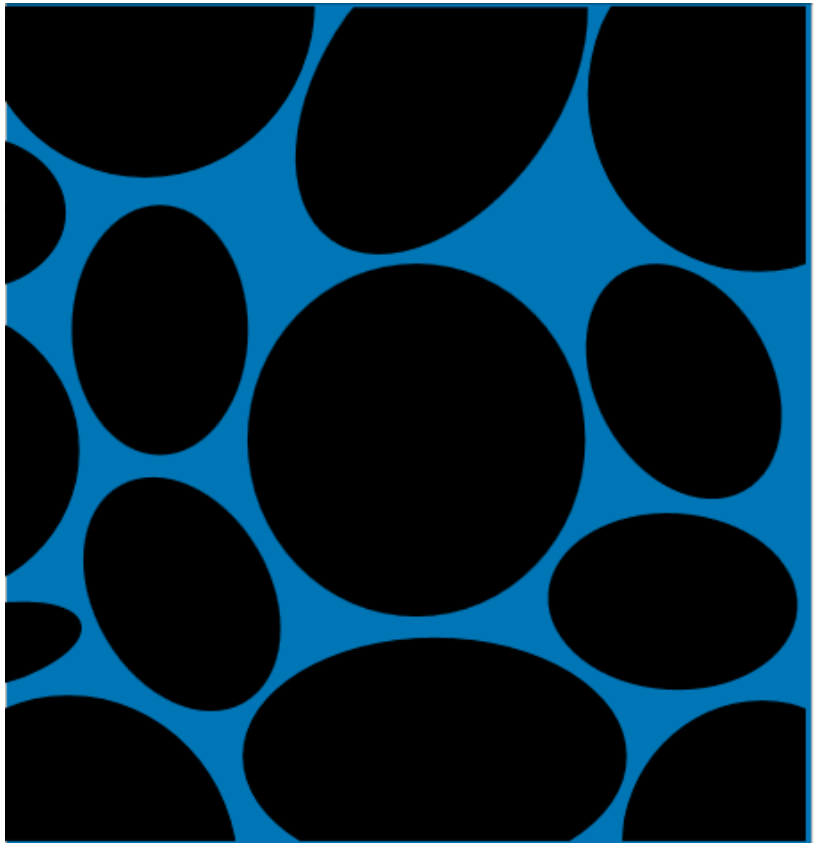


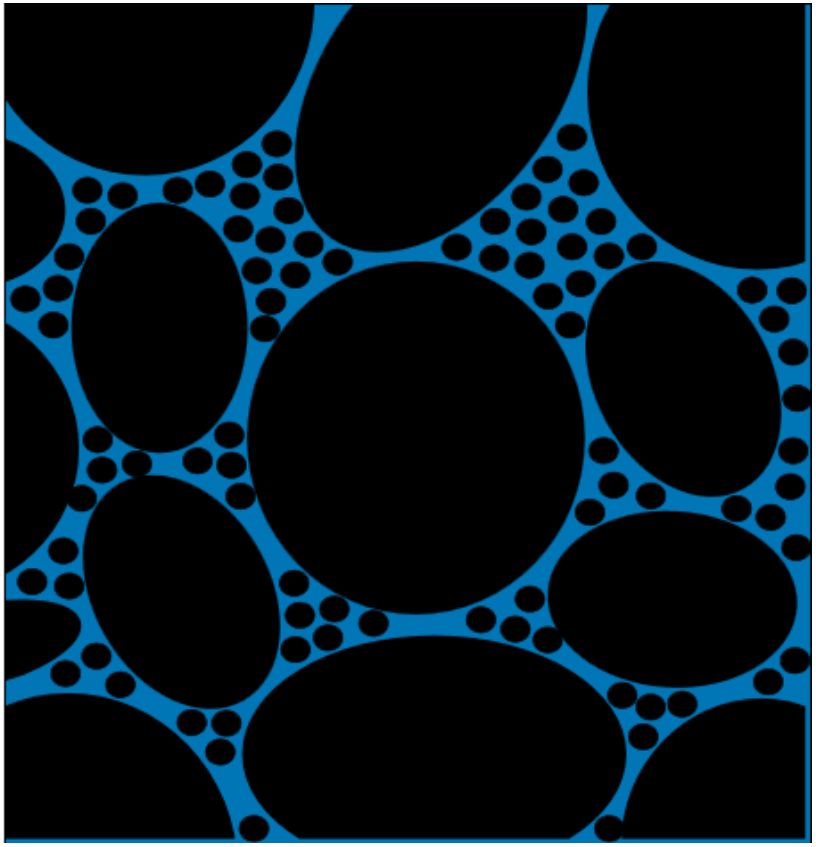
Induced Polarisation

Adapted from: Bleil, D. F., 1953, Induced polarisation: A method of geophysical prospecting: *Geophysics*, 18, 636–661.

Electrical properties of rocks depend on:

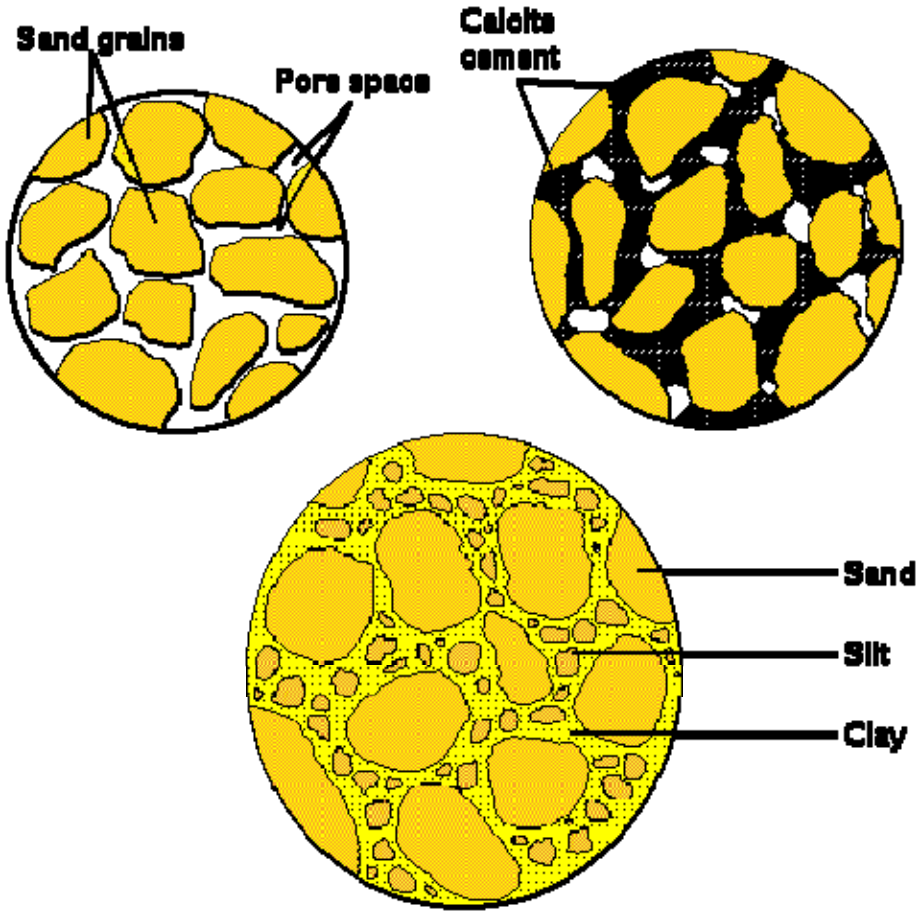
1. Porosity





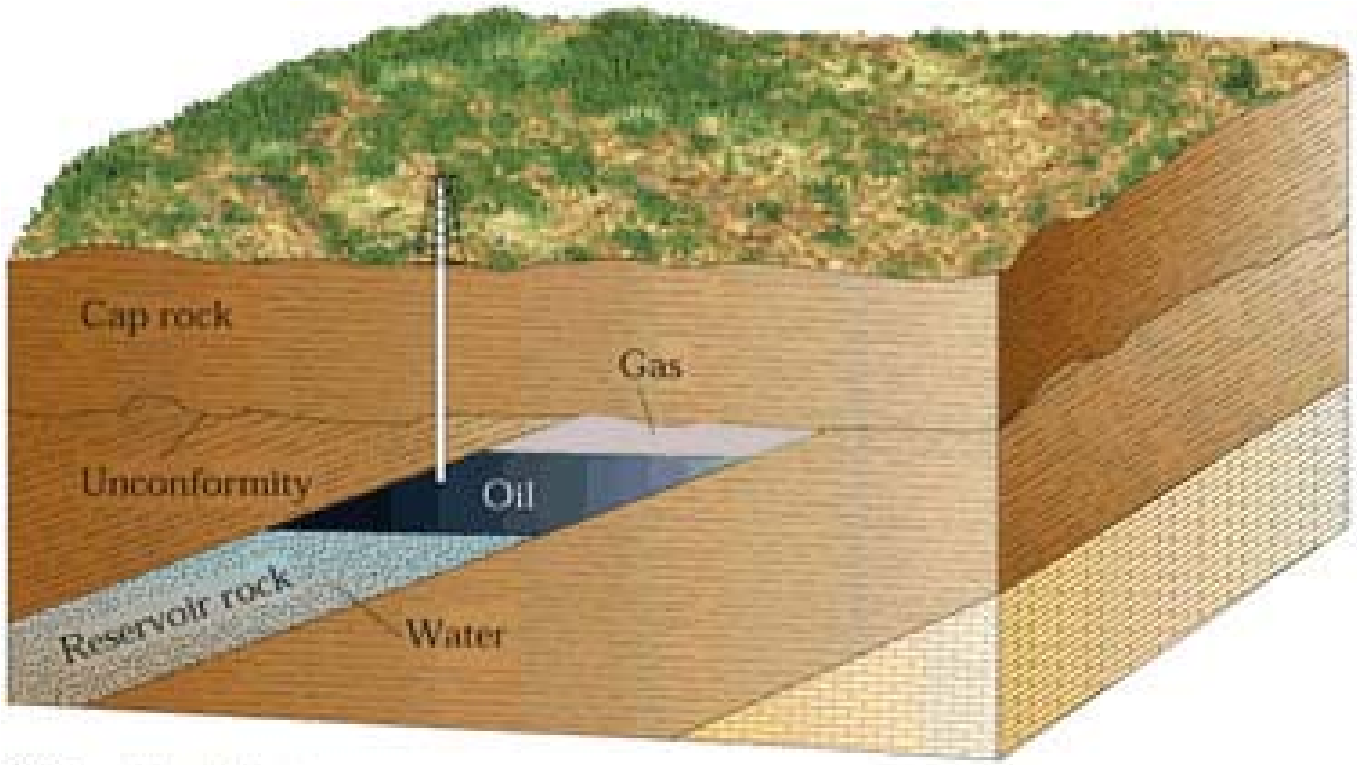
Electrical properties of rocks depend on:

2. Interconnection of the pore spaces



Electrical properties of rocks depend on:

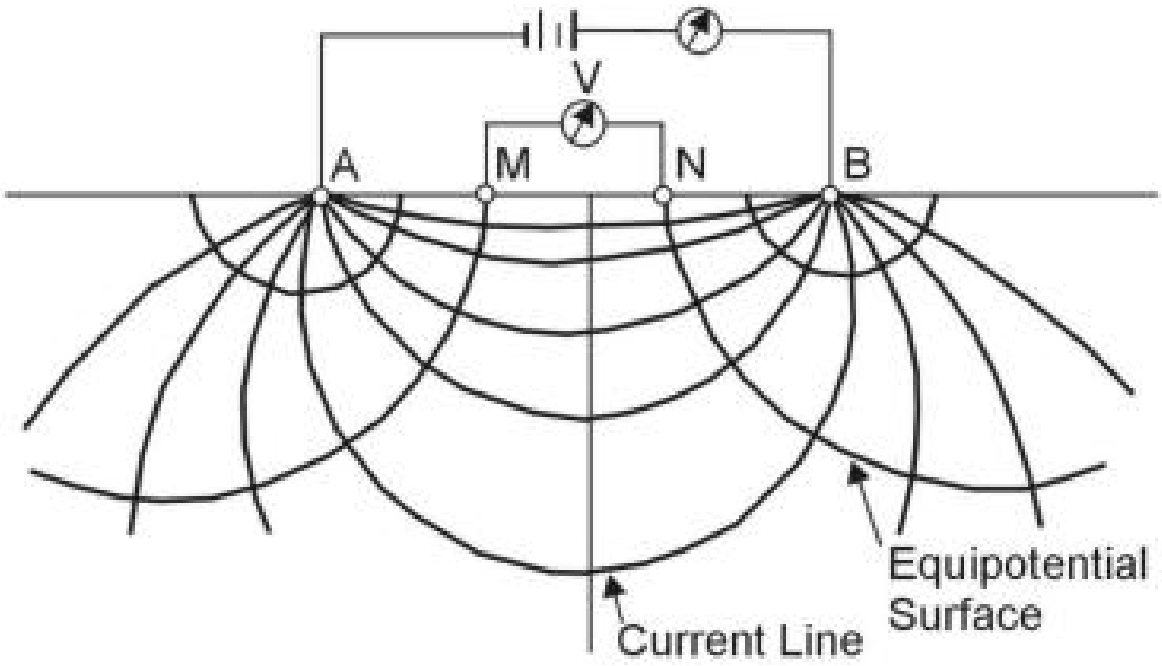
3. Fluid type



C. Stratigraphic trap

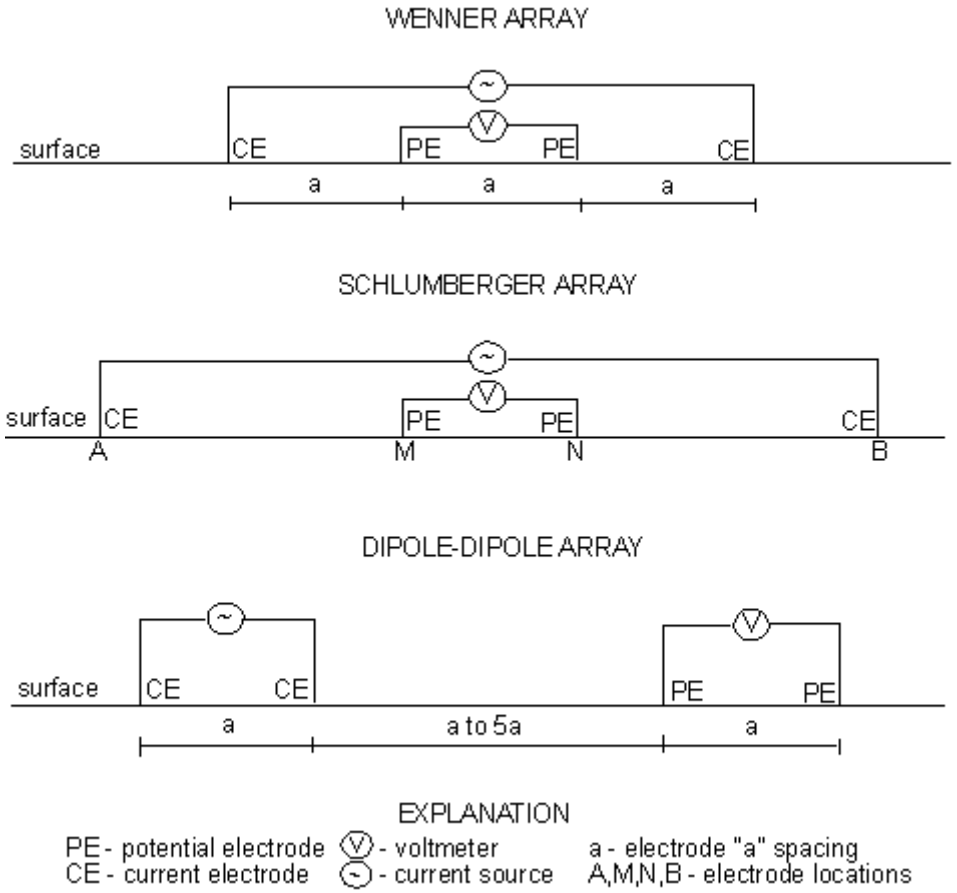
Electrical methods:

1. Equipotential method



Electrical methods:

2. Resistivity method

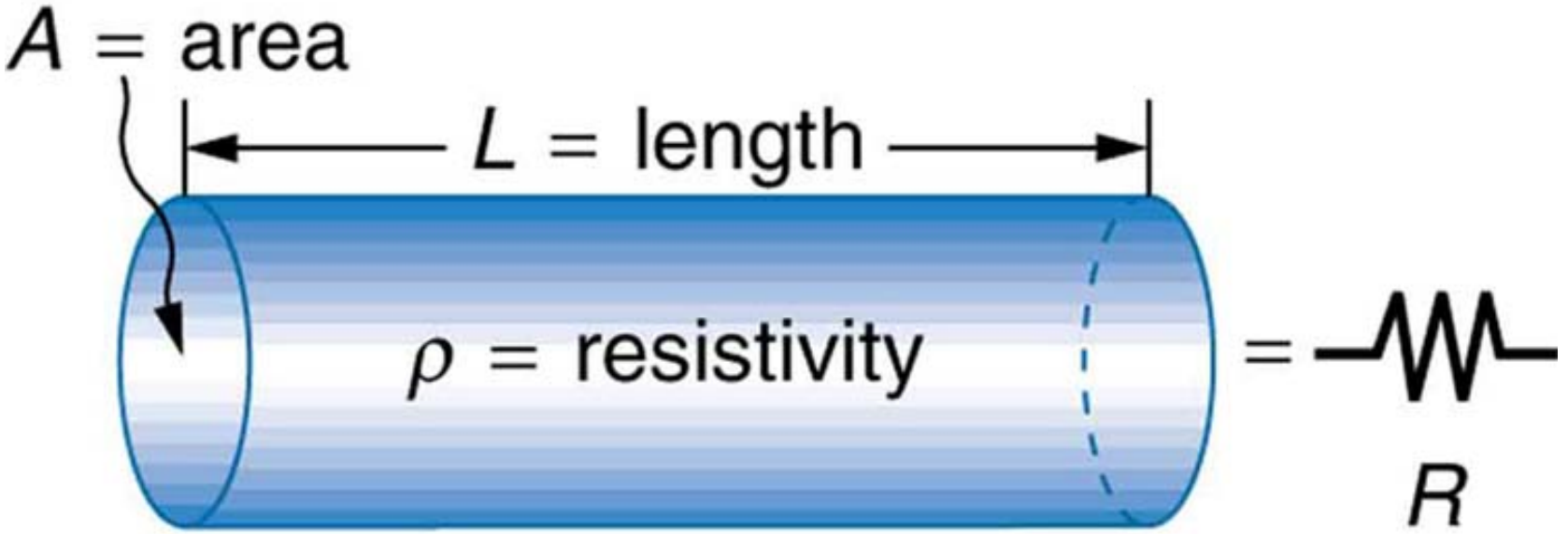


Applications of electrical methods:

1. Minerals exploration
2. Groundwater exploration
3. Geothermal exploration
4. Bed rocks
5. Archaeology

Electrical properties of the rocks:

1. Resistivity
2. Electrochemical
3. Dielectric constant or permittivity



$$R = \rho \frac{L}{A}$$

$$R = \frac{\rho l}{a}$$

R = Resistance (Ohms)
P = Resistivity (Rho)
l = length of conductor (metres)
a = Area (m2)

Factors that affect resistivity of the rocks:

1. Water
2. Salinity
3. Porosity
4. Temperature
5. Minerals
6. Fractures

Archie's Law

The minerals comprising a rock are almost always electrical insulators. Thus, electrical conduction occurs because of the moisture contained within the pores of the rock or soil. The resistivity of soil or rocks depends on several parameters. These include the clay content, moisture salinity, degree of saturation of the pores, and the number, size, and shape of the interconnecting pores. For soils, the degree of compaction (influencing porosity) is also an important factor. Archie (1942) developed an empirical formulae relating resistivity to porosity, degree of saturation and resistivity of the saturating moisture, shown below.

$$\rho_e = a\phi^{-m}s^{-n}\rho_w,$$

where ϕ is the fractional pore volume (porosity), s is the fraction of the pores containing water, ρ_w is the resistivity of the water, n is approximately 2, a and m are constants with a varying between 0.5 and 2.5 and m varying between 1.3 and 2.5.

$$\frac{\rho_r}{\rho_f} = a\phi^{-m} \qquad (3)$$

where

ρ_r is the rock resistivity in the fracture zones, ohm-meters,

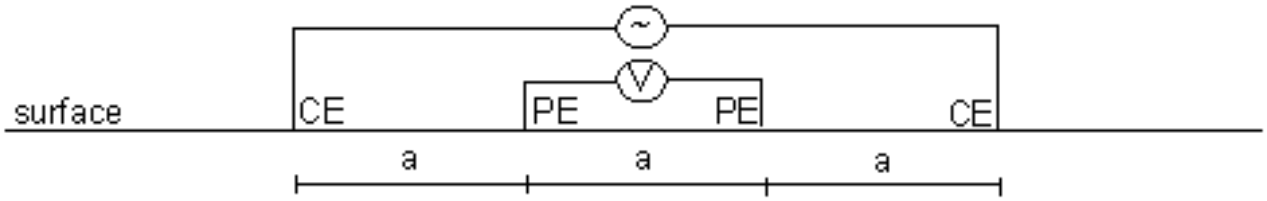
ρ_f is the resistivity of the pore fluid,

a is the coefficient of saturation (1 for complete saturation),

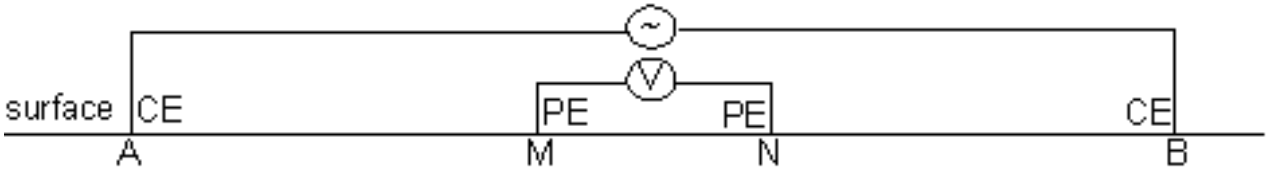
ϕ is the porosity, and

m is the cementation factor.

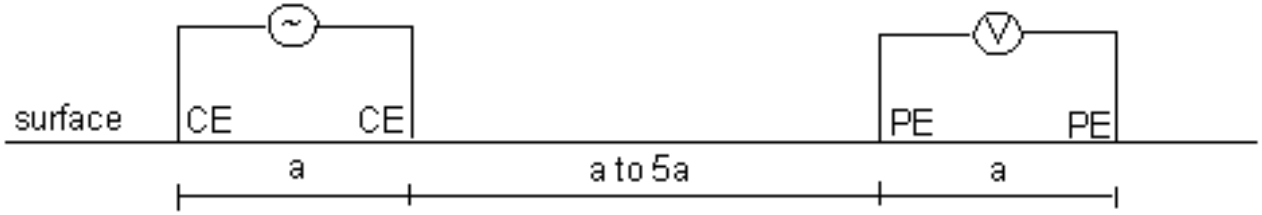
WENNER ARRAY



SCHLUMBERGER ARRAY



DIPOLE-DIPOLE ARRAY



EXPLANATION

PE - potential electrode
CE - current electrode
V - voltmeter
~ - current source
a - electrode "a" spacing
A,M,N,B - electrode locations