

## SELF- POTENTIAL (SP)

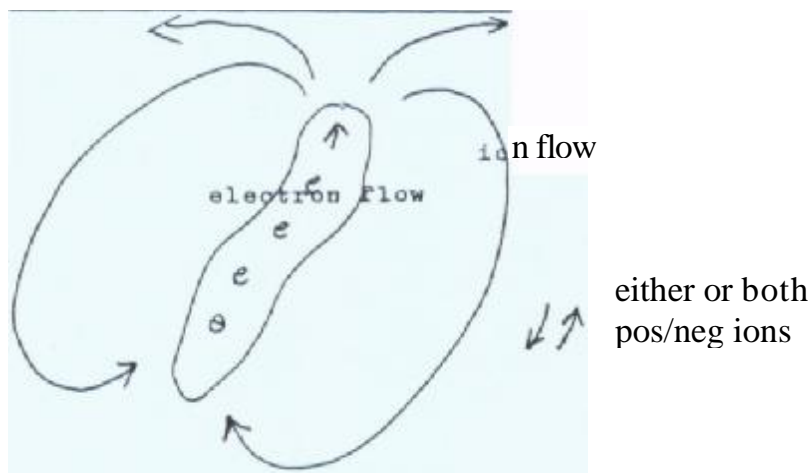
SP is called also spontaneous polarization and is a naturally occurring potential difference between points in the ground. SP depends on small potentials or voltages being naturally produced by some massive ores.

It associate with sulphide and some other types of ores. It works strongly on pyrite, pyrrohotite, chalcopyrite, graphite.

SP is the cheapest of geophysical methods.

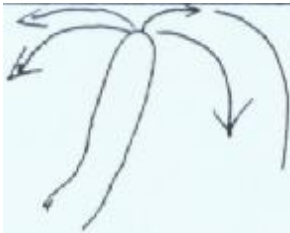
### Conditions for SP anomalies

- 1) Shallow ore body
- 2) Continuous extension from a zone of oxidizing conditions to one of reducing conditions, such as above and below water table.



Note that it is not necessary that an individual ion travel the entire path. Charges can be exchanged.

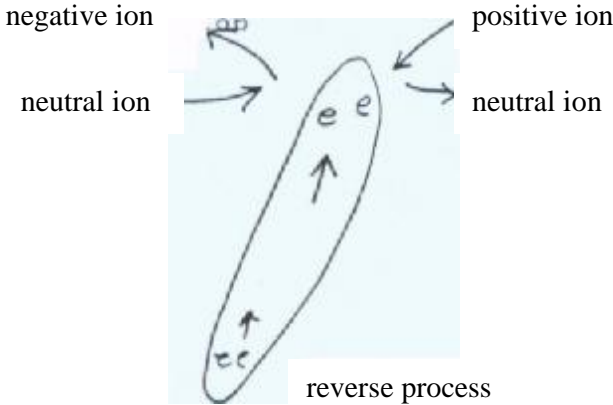
The implications of this for potential distribution would be



When we come to consider more specifically the mechanism, we see that it must be consistent with

- è - electron flow in the ore body
- è - ion flow in surrounding rock
- è - no transfer of ions across ore boundary, although electrons are free to cross

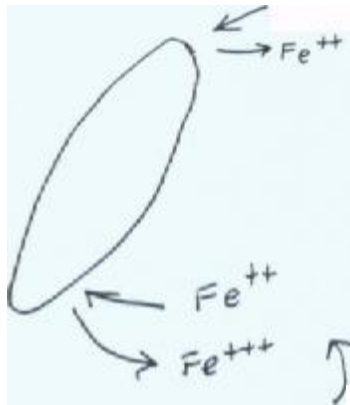
That is we must have



When we consider the possible ion species, the criteria would be

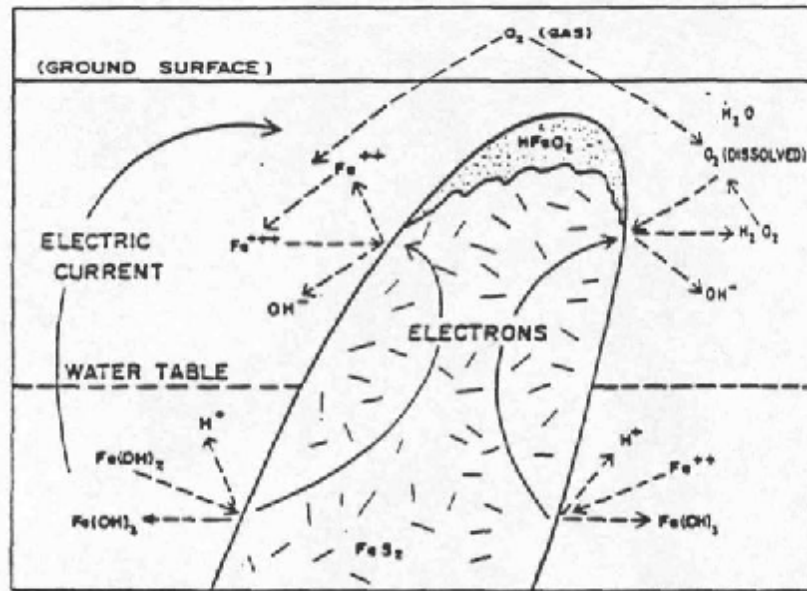
- common enough
- reversible couple under normal ground conditions
- mobile enough

Sato and Mooney proposed ferric/ferrous couples to satisfy these criteria.



made continuous by  $O_2 - H_2O_2$   
reaction with  $O_2$  supplied  
from atmosphere

made continuous by reactions  
involving ferrous and ferric  
hydroxide with presence of  $H^+$



### Proposed electrochemical mechanism for self-potentials

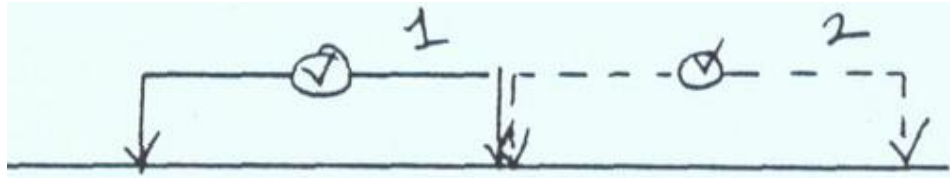
**This proposed mechanism have two geologic implications:**

- 1) The ore body must be an electronic conductor with high conductivity. This would seem to eliminate sphalerite (zinc sulfide) which has low conductivity.
- 2) The ore body must be electrically continuous between a region of oxidizing conditions and a region of reducing conditions. While water table contact would not be the only possibility have, it would seem to be a favorable one.

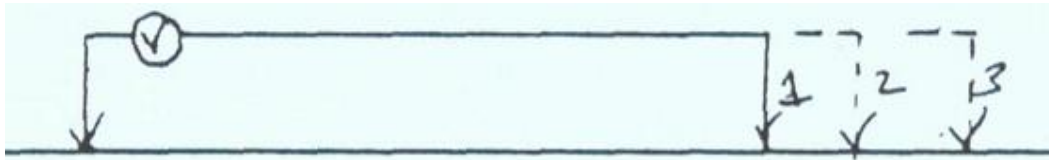
## Instrumentation and Field Procedure

Since we wish to detect currents, a natural approach is to measure current. However, the process of measurement alters the current. Therefore, we arrive at it though measuring potentials.

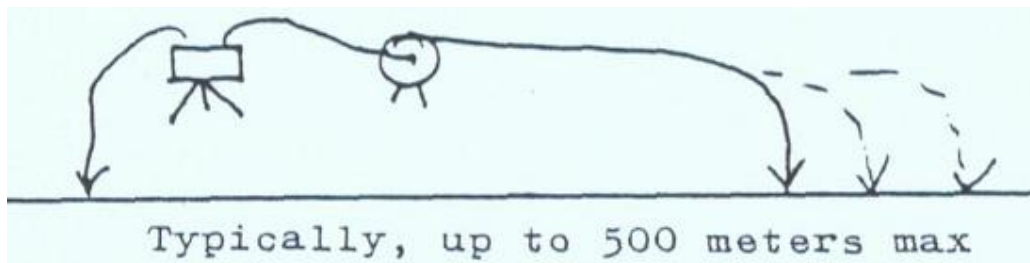
Principle, and occasional practice:



More usual practice



Instruments



### **Equipment:**

- potentiometer or high impedance voltmeter
- 2 non-polarizing electrodes
- wire and reel

Non-polarizing electrodes were described in connection with resistivity exploration although they are not usually required there. Here, they are essential. The use of simple metal electrodes would generate huge contact or corrosion potentials which would mask the desired effect. non-polarizing electrodes consist of a metal in contact with a saturated solution of a salt of the metal . Contact with the earth can be made through a porous ceramic pot.

The instrument which measures potential difference between the electrodes must have the following characteristics:

- a) capable of measuring +0.1 millivolt,
- b) capable of measuring up to  $\pm 1000$  millivolts ( $\pm 1$  volt)
- c) input impedance greater than 10 megaohms, preferably more.

The high input impedance is required in order to avoid drawing current through the electrodes, whose resistance is usually less than 100 kilohms. In very dry conditions (dry rock, ice, snow, frozen soil), the electrode resistance may exceed 100 kilohms, in which case the instrument input impedance should also be increased.

**SP are produced by a number of mechanisms :**

- 1) **Mineral potential** (ores that conduct electronically ) such as most sulphide ores ,Not sphalerite (zinc sulphide) magnetite, graphite. Potential anomaly over sulfide or graphite body is negative The ore body being a good conductor. Carries current from oxidizing electrolytes above water – table to reducing one below it .

2) **Diffusion potential**

$$E_d = \frac{RT(I_a - I_c)}{nF(I_a + I_c)} \quad \text{Ln} (C_1 / C_2)$$

Where

$I_a$  ,  $I_c$  Mobilities of the anions (+ve) and cations( -ve )

R= universal Gas constant (  $8.314 \text{ JK}^{-1} \text{ mol}^{-1}$  )

T : absolute temperature ( K)

N : is ionic valence

F: Farady's constant  $96487 \text{ C mol}^{-1}$  )

$C_1$  ,  $C_2$  Solution concentrations .

3) **Nernst Potential**

$$E_N = - ( RT / nF ) \text{Ln} ( C_1 / C_2 )$$

Where  $I_a = I_c$  in the diffusion potential Equation .

4. **Streaming potentials** due to subsurface water flow are the source of many SP anomalies. The potential E per unit of pressure drop P (The streaming potentials coupling coefficient) is given by :

$$E_K = - \frac{\epsilon \rho C_E \delta P}{4 \pi \eta}$$

$\rho$  Electrical Resistivity of the pore Fluid.

$E_k$  Electro-kinetic potential as a result from an electrolyte flowing through a porous media.

$\epsilon$  Dielectric constant of the pore fluid.

$\eta$  Viscosity of the pore fluid

$\delta P$  pressure difference

$C_E$  electro filtration coupling coefficient.

## **Interpretation**

Usually, interpretation consists of looking for anomalies.

The order of magnitude of anomalies is

0-20 mv	normal variation
20-50 mv	possibly of interest, especially if observed over a fairly large area
over 50 mv	definite anomaly
400-1000 mv	very large anomalies

## **Applications**

Groundwater applications rely principally upon potential differences produced by pressure gradients in the groundwater. Applications have included detection of leaks in dams and reservoirs location of faults, voids, and rubble zones which affect groundwater flow delineation of water flow patterns around landslides, wells, drainage structures, and springs, studies of regional groundwater flow

Other groundwater applications rely upon potential differences produced by gradients in chemical concentration, Applications have included outline hazardous waste contaminant plumes

Thermal applications rely upon potential differences produced by temperature gradients.

Applications have included

geothermal prospecting

map burn zones for coal mine fires

monitor high-temperature areas of in-situ coal gasification processes and oil field steam and fire floods.