

## What is geophysics?

➤ Application of the principles of physics in the study of Earth to discover what lies beneath

For Example:

- ✓ Newton's Law (gravity)
- ✓ Faraday's Law (electromagnetics)
- ✓ Ohm's Law (electrical resistivity)
- ✓ Snell's Law (seismology)



## Sub-disciplines of geophysics

1. Global geophysics - structure of the Earth
2. Exploration geophysics
  - a. petroleum geophysics – structures that trap oil
  - b. mining geophysics - detection of ore bodies
3. Geotechnical & environmental geophysics
  - a. site investigations - mechanical properties and depth
  - b. groundwater studies - depths, thicknesses
  - c. contaminant studies - detection, flow direction

## What is the objective of geophysics?

- to locate or detect the presence of subsurface structures or bodies and determine their configuration (i.e. size, shape, depth) and physical properties (i.e. physical parameters).

## Physical Properties

Measurements made on the surface of the Earth are controlled by lateral and vertical variations in the physical properties of the subsurface.

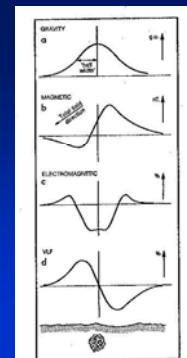
These lateral and vertical variations in physical properties give rise to geophysical anomalies which we use to map out subsurface lithology contrasts and which forms the basis of our interpretation..

## Physical properties of the subsurface

- ✓ elastic parameters - bulk modulus, rigidity modulus, Poisson's ratio
- ✓ density
- ✓ electrical conductivity
- ✓ electrical capacitance
- ✓ electrical inductance
- ✓ magnetic susceptibility and remanence
- ✓ dielectric constant

## What is a geophysical anomaly?

An anomaly is a deviation from the uniform.



## Geophysical methods

- ✓ Passive methods - these involve measuring the spatial variation of static or natural fields of force, e.g. gravity and magnetic fields. Lateral variations in physical properties give rise to spatial variations in the field. It is difficult to separate size from density or susceptibility, and therefore, there is an inherent ambiguity in interpretation.
- ✓ Active methods - these involve measuring the characteristics of a wave field, i.e. travel times of elastic waves, and amplitude and phase of electromagnetic waves. Energy is introduced into the ground and you control the source and detector, therefore there is less ambiguity

## Specific Geophysical Methods Covered in GE 3040

- Gravity
- Magnetics
- Seismic Refraction and Reflection
- Electrical Resistivity
- Electromagnetics
- Ground Penetrating Radar

## Gravity

- ✓ Measures the spatial variations in the strength of the gravitational field of Earth
- ✓ Lateral variations in density give rise to spatial variations in the field

## Gravimeters

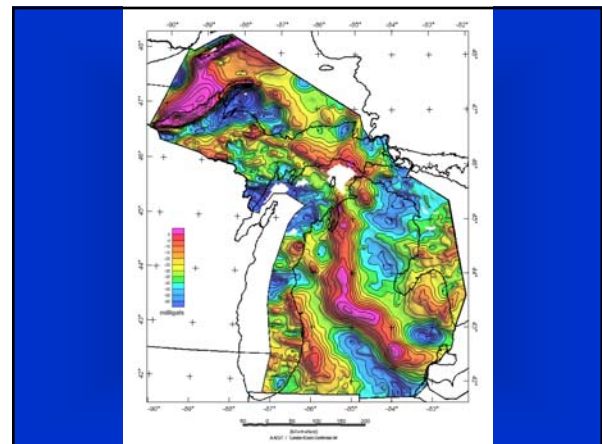
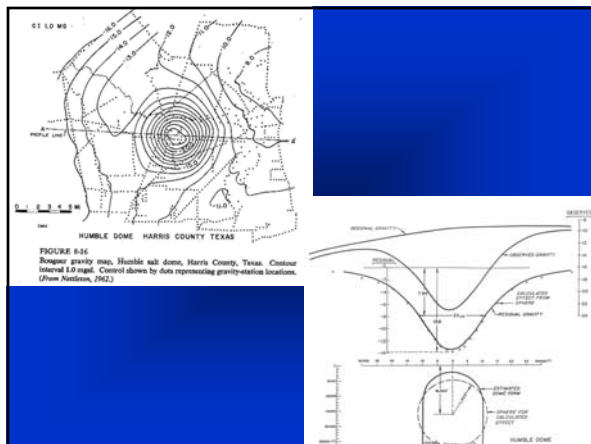


Worden



Relative g

Lacoste Romberg



## Magnetics

- ✓ Measures the spatial variations in the strength or intensity of Earth's magnetic field
- ✓ Lateral variations in magnetic susceptibility and remanence give rise to spatial variations in the field

## Magnetometers

Proton precession

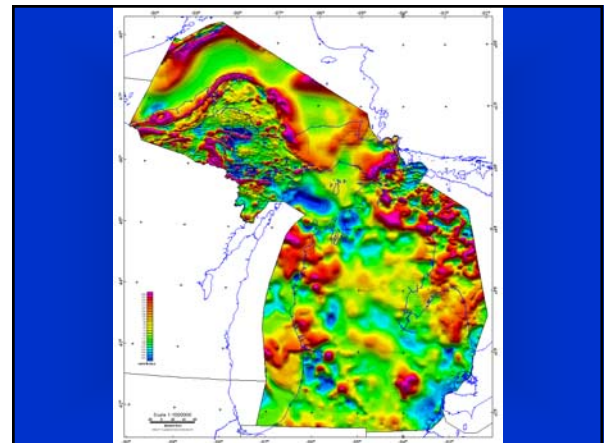
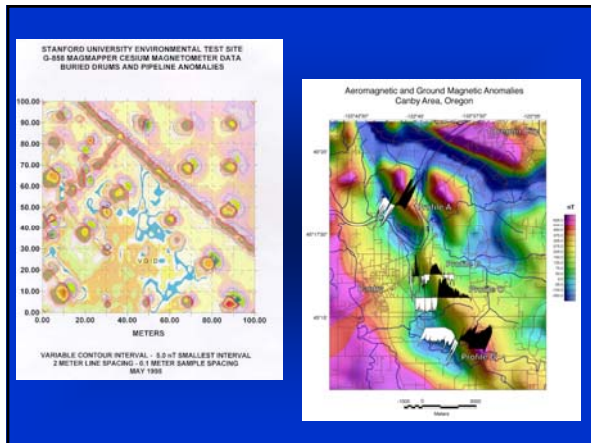


Cesium vapor in gradiometer mode

Cesium Vapor



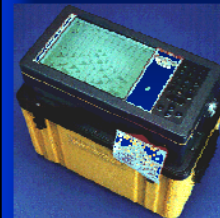
Fluxgate

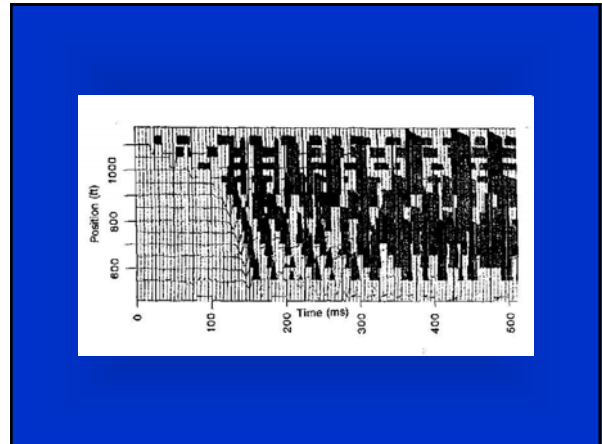
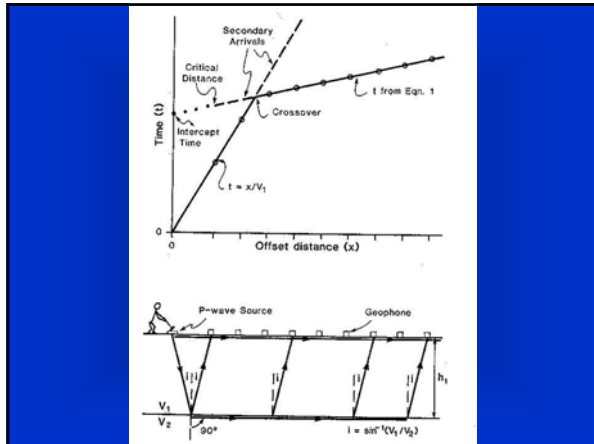


## Seismic Refraction

- ✓ Measures the travel times of refracted waves
- ✓ The propagation velocity and path are controlled by the density and elastic moduli of the material through which the waves pass

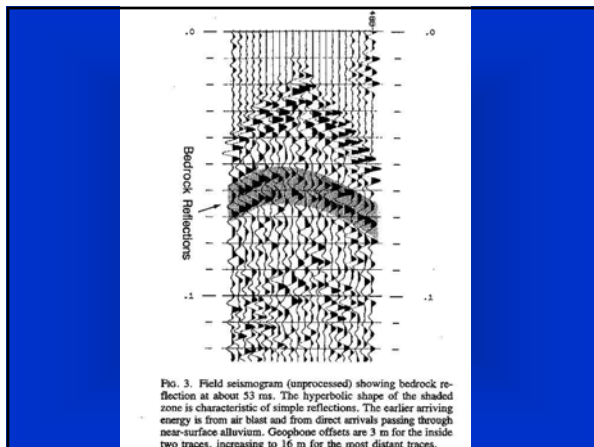
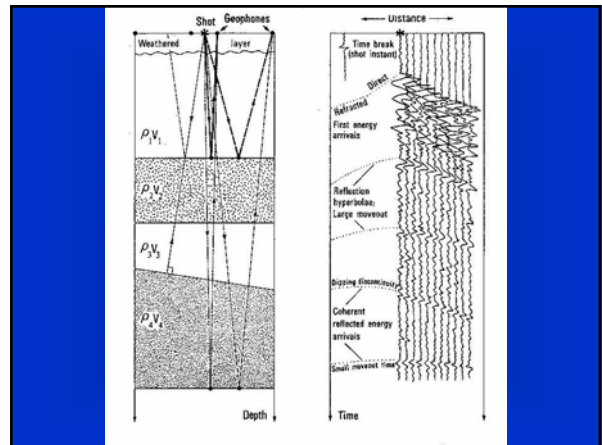
## Multi-channel Seismograph





## Seismic Reflection

- ✓ Measures the travel times of reflected waves
- ✓ The propagation velocity and path are controlled by the density and elastic moduli of the material through which the waves pass



## Electrical Methods

- ✓ Measures the resistance or potential drop of the ground between two electrodes
- ✓ Resistance measured at the ground surface is controlled by lateral and vertical variations of electrical conductivity



## Resistivity Meters

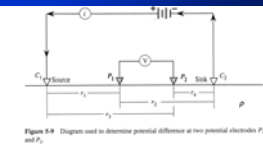



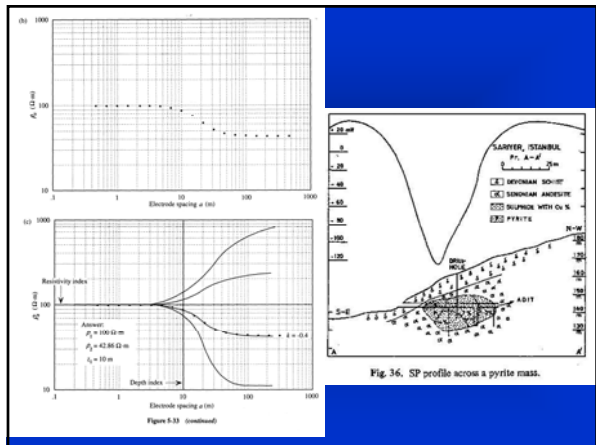
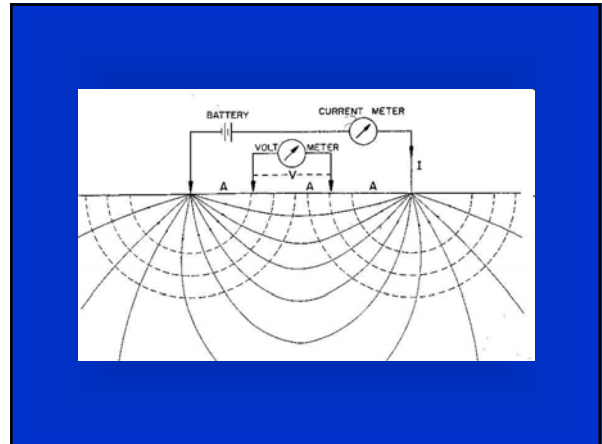
Figure 5.9 Diagram used to determine potential difference at two potential electrodes  $P_1$  and  $P_2$ .

**SuperSting Multi-channel**



**ABEM Terrameter SAS 300**





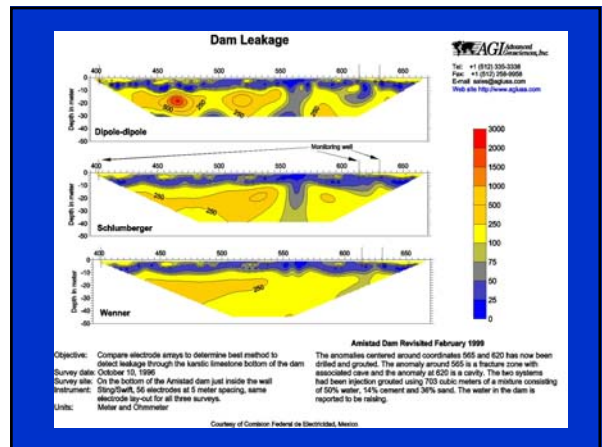
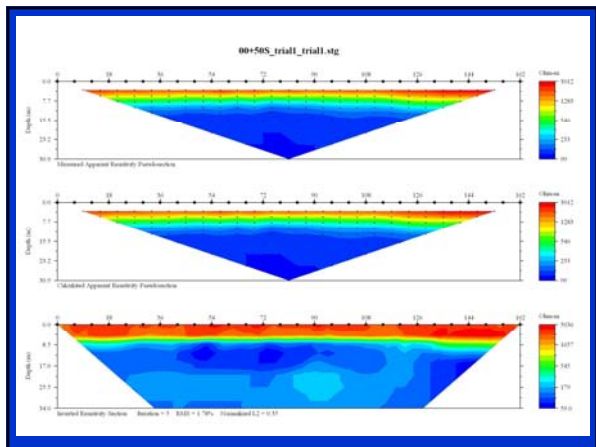
## Multi-channel Resistivity Meters



Acquisition control



2D (profile)



## Electromagnetics

- ✓ Measures the components of a secondary electromagnetic field resulting from the induction of a primary electromagnetic field
- ✓ Secondary electromagnetic fields are a function of the subsurface electrical conductivity and inductance

## Electromagnetics in Action



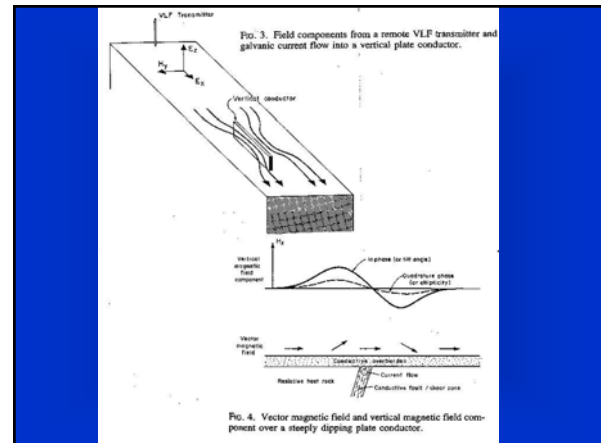
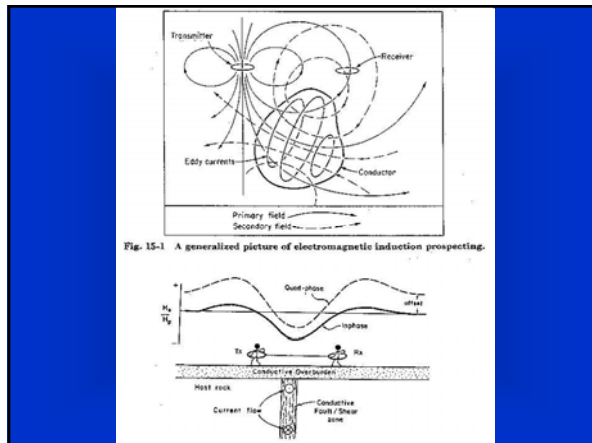
Geonics EM16



GEM2



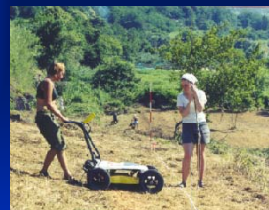
APEX MaxMin I



## Ground Penetrating Radar

- ✓ Measures the travel time of reflected radar waves
- ✓ Velocity of the radar wave is controlled by the dielectric constant of the subsurface materials
- ✓ Dielectric constant - a measure of the capacity of a material to store a charge when an electric field is applied

## GPR in Action



Noggin

Pulse Echo IV



