GEOFIZIK GUNAAN

Introduction

Advantages of Geophysics

In geophysical exploration measurements are made over a geographically restricted area to determine physical properties of subsurface. Similar to geological mapping, but data usually processed in some way after acquisition.

Remote sensing technique

Can infer properties of subsurface from surface measurements. Geological sampling restricted to surface or expensive boreholes.

Rapid and Cost-Effective

Costs from $1,000's to $1,000,000's, but can cover areas up to 100's of km quickly. Can detect targets for drilling too expensive or difficult to locate otherwise.

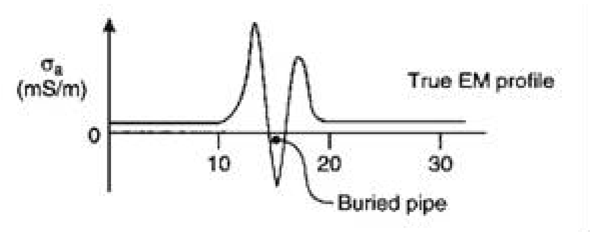
Regular, continuous mapping

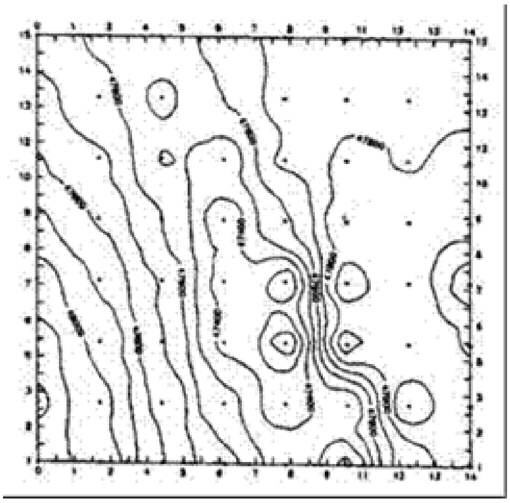
2-D methods measure geophysical properties along a surface line. Produce "cross-section" through subsurface. 3-D methods measure properties over an area. Can generate a volumetric image of subsurface.

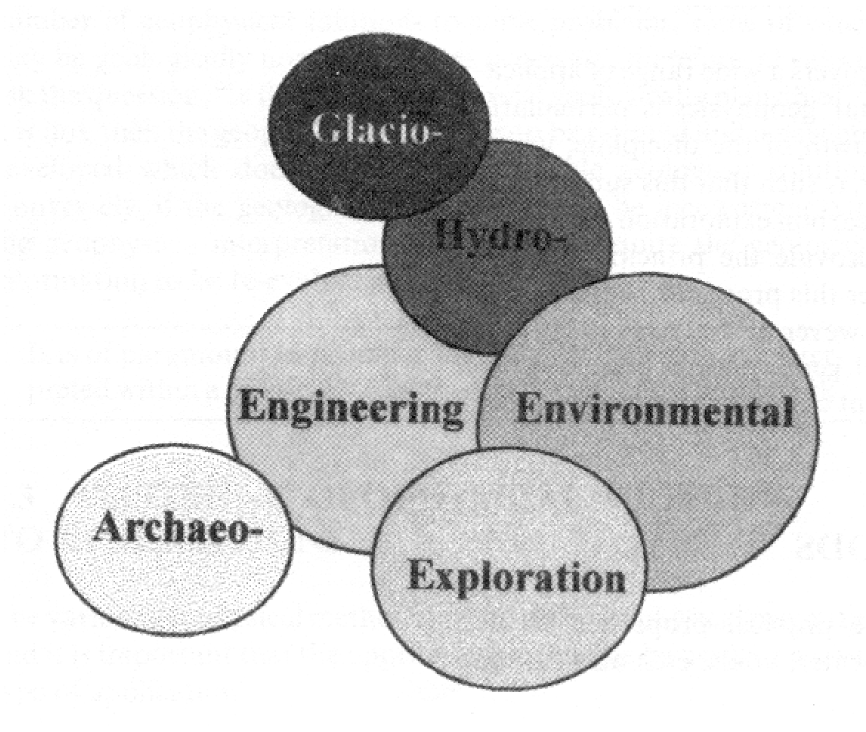
EM profile over pipe Magnetic survey over intrusion

Applied Geophysics

Similar geophysical methods used in many different situations:







Exploration geophysics

Application of geophysics to identification of mineral deposits and hydrocarbon reservoirs.

Engineering geophysics

Application of geophysics to investigation of subsurface materials and structures likely to impact man-made structures.

Environmental geophysics

Application of geophysical methods to investigation of near-surface physico-chemical phenomena likely to impact the local environment.

Archeo-geophysics

Application of geophysics to investigation of archeological sites.

Hydro-geophysics

Application of geophysics to ground water investigation.

Geophysical Surveys

Survey Types

In general, geophysical surveys fall into two classes:

- Natural field methods: measure physical properties of the Earth, e.g. measurement of gravity field.
- Artificial source methods: require input of signal into Earth and measurement of its effect, e.g seismic refraction.

Natural field surveys easier to acquire as no need to provide equipment for source.

Natural field methods usually provide greater depth of investigation, but lower resolution than artificial source surveys.

Artificial source surveys allow survey to be designed to image objective in optimal fashion.

Survey Locations

Geophysical surveys are carried out in all environments:

- On land, e.g. electromagnetic for contaminant mapping
- At sea, e.g. seismic reflection for oil exploration
- In air, e.g. aeromagnetics for regional geology mapping

Geophysical surveys carried out at all scales:

- Reconnaissance over 10 to >100 km
- Focussed mapping 1 to 10 km
- High resolution mapping of fine detail at <1 km

Geophysical Survey Methods

Gravity

Measurement of the magnitude of Earth's gravitational field (e.g. for location of salt domes or buried mine workings).

Magnetics

Measurement of the magnitude and direction of Earth's magnetic field (e.g. for mapping of buried metal pipes).

Resistivity

Measurement of differences in electrical potential at Earth's surface in response to injection of electric current (e.g. for exploration for conductive ore bodies).

Seismic refraction

Measurement of travel times of seismic waves at various distance from a seismic source (e.g. for estimation of depth to bedrock).

Ground Penetrating Radar

Measurement of lateral variation in arrival time and amplitude of radio waves reflected from the subsurface after transmision of a radio pulse into ground (e.g. for mapping near-surface stratigraphy).

Electromagnetic Surveying

Measurement of effect of current flow in the Earth induced by a surface source (e.g. for mapping salt water contamination).

Seismic Reflection

Measurement of lateral variation in arrival time and amplitude of seismic waves reflected from the subsurface after firing a seismic source (e.g. for locating prospective hydrocarbon reservoirs).

Physical Properties: Basis of Geophysical Surveying

Each geophysical technique measures a specific parameter, which depends on one, or perhaps more, physical properties of the Earth.

Which geophysical method to use for a particular problem depends on whether the relevant physical property varies.

Examples:

- Magnetic field measurements can be used to detect ores that contain magnetic minerals such as magnetite, because magnetite has a high magnetic susceptibility compared with most rocks.
- Seismic refraction can be used to locate the water table, because water saturated rocks have a higher seismic P wave velocity than rocks where the pore space is filled with air.

Survey method	**Physical Property**
Gravity	Density
Magnetics	Magnetic Susceptibility and Remanance
Electrical Resistivity or Induced Polarisation	Electrical Conductivity or Electrical Capacitance
Seismic Refraction	P wave velocity, S wave velocity

Applications of Different Geophysical Methods

Because not all physical properties will vary in a particular situation, certain techniques are not suitable for all problems.

Application	Appropriate Method	Inappropriate Method
Hydrocarbon Exploration	SRFL G, M, SRFR	
Mineral Exploration	M, R, EM G	
Engineering Site Invesigation	SRFR, R, EM, GPR SRFL, G, M	
Hydrogeological Invesigation	R, EM, GPR G, SRFL, SRFR	M
Detection of Cavities	R, EM, GPR G, SRFR	
Leachate Contaminant Mapping	R, EM GPR	G, M, SRFR, SRFL
Buried Metallic Objects	M, EM, GPR R	G, SRFR, SRFL
Archeogeophysics	M, R, EM, GPR G	SRFR, SRFL
Forensic Investigation	GPR	G, M, SRFR, SRFL
Regional Geological Mapping	G, M, SRFR, SRFL EM	

Bold -- primary method

G – gravity M – magnetics

SRFR – seismic refraction SRFL – seismic reflection

R – resistivity

EM – electromagnetic methods

GPR – ground penetrating radar

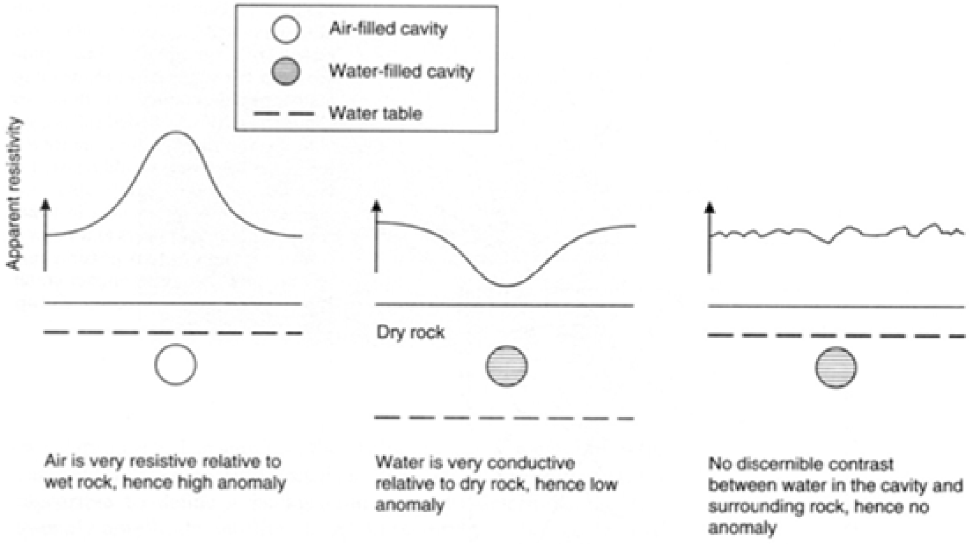
Selection of Geophysical Method

For a geophysical method to be useful, there must be a variation in the physical property that produces a detectable change in the geophysical measurement.

Example: Detection of a buried cavity

Air is electrically resistive relative to water and wet rock, so it stands out as a high in apparent resistivity when an air-filled cavity is below the water table.

When cavity is fluid filled above the water table, the surrounding rock is air-filled and will be more resistive, so there is a low in resistivity.



When fluid-filled cavity below water table, there is no noticeable change in resistivity, because both cavity and fluid-saturated rock have similar resistivities.

Use of resistivity method depends on specific nature of problem.

Geophysical Anomalies

Frequently interested in the local variation of a measured parameter relative to some "normal" background value.

- This local change is called a geophysical anomaly.

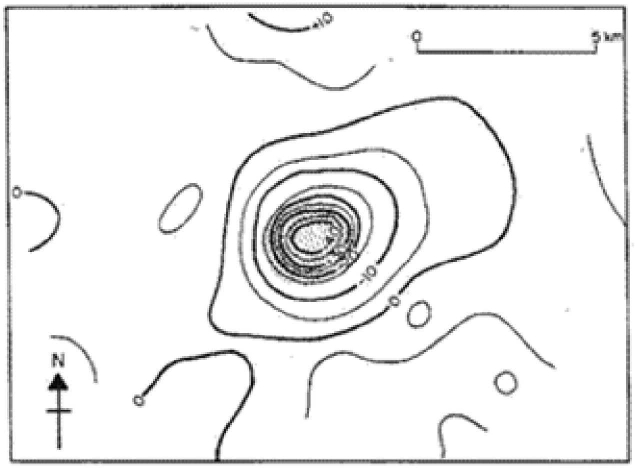
Example: Salt Dome

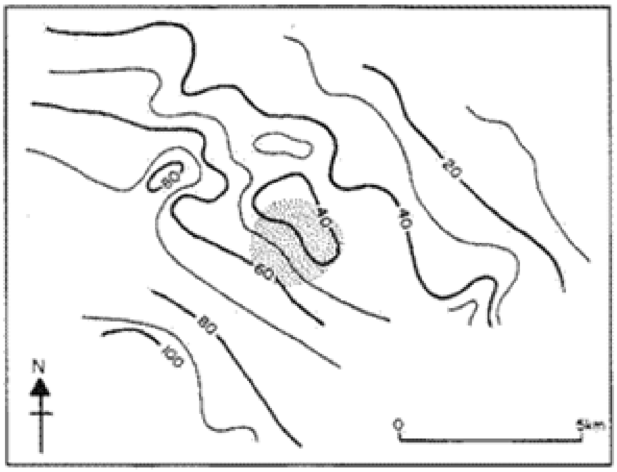
Salt layers formed in many areas by evaporation of inland sea.

Salt has lower density, magnetic susceptibility, and higher seismic velocity and resistivity than surrounding sediments.

Low density causes salt to rise in a diaper over time, piercing overlying strata, and forming a dome-like shape.

- Low relative density ➢negative gravity anomaly
- Negative magnetic susceptibility ➢small negative magnetic anomaly





- High seismic P wave velocity ➢ early seismic arrivals through salt
- High electrical resistivity ➢distortion of electric field