Introduction to Environmental Geophysics

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Course Website:

http://www.geophysik.uni-koeln.de/geoscience.html

Recommended Literature:

Reynolds, J. M.: An Introduction to Applied and Environmental Geophysics, Wiley, 1998

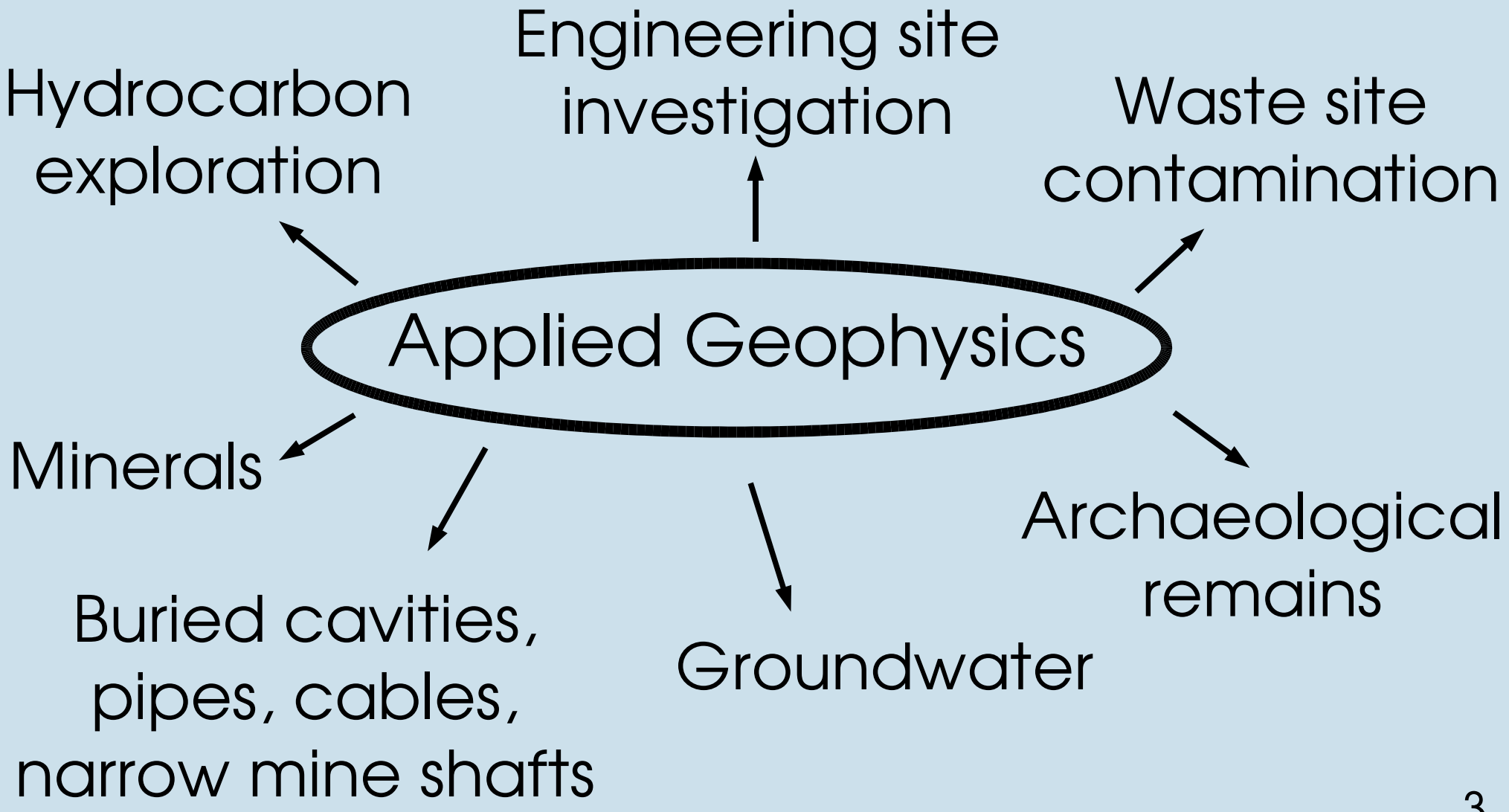
1. What are applied and environmental geophysics?

Geophysics: application of physics to investigations of the earth, moon and planets

Solid Earth Geophysics: use of physics to study the interior of the earth from land surface to the inner core

Applied Geophysics: is concerned with investigating the earth crust and near surface to achieve a practical and **economic** aim.

Applied Geophysics



Applied and environmental geophysics

Applied Geophysics: The total depth of investigation is usually less than 150 m.

Environmental Geophysics: The application of geophysical methods to the investigation of near-surface physico-chemical phenomena

- Waste site exploration
- Location of contamination

1.1 Aims of geophysical investigation

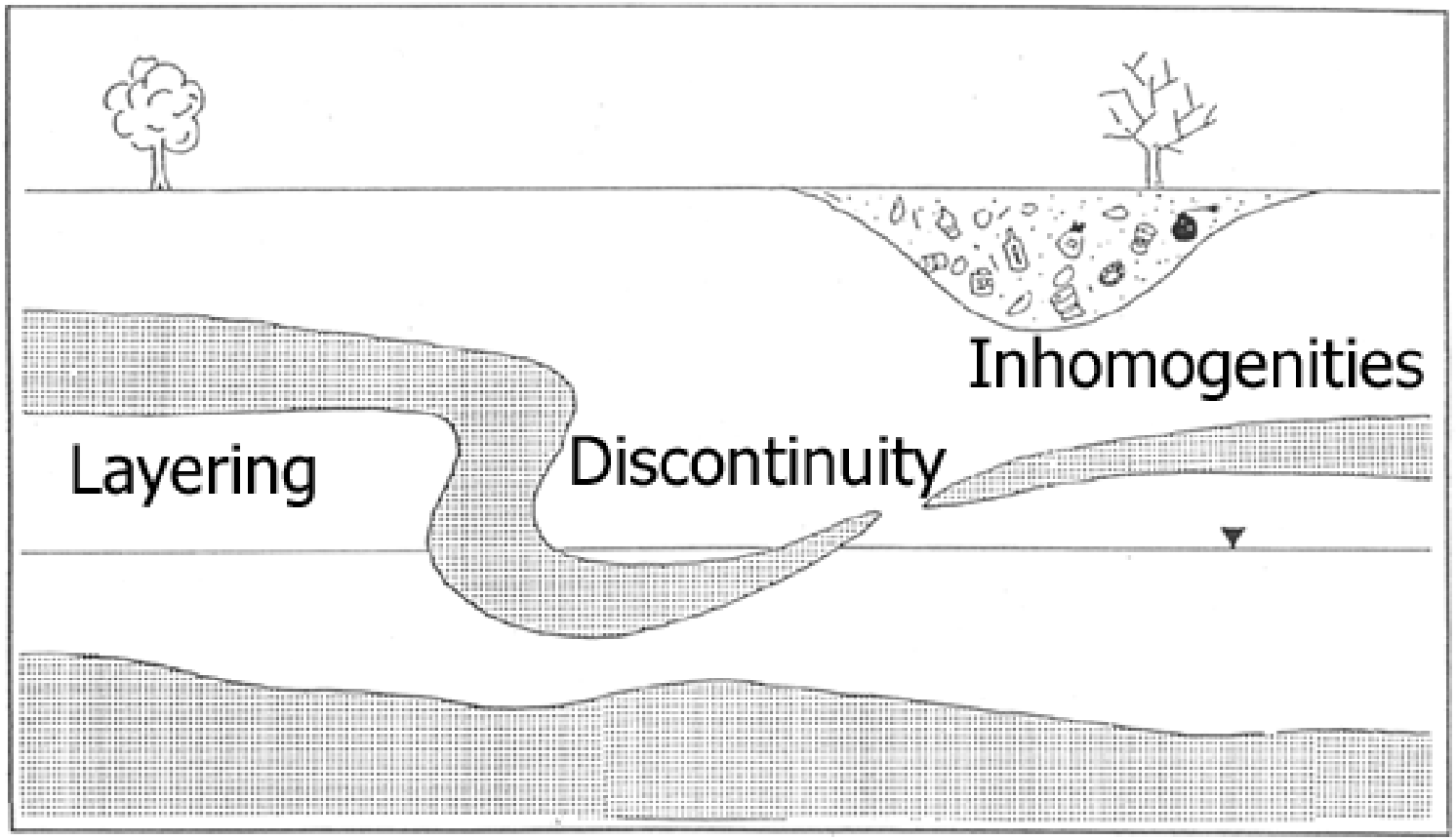


Fig. 1: Aims of geophysical measurements

Aims of geophysical investigations

- Determination of the lithology (e.g. layering)
  - → Groundwater prospection
  - → Sands, gravel, clay
- Detection of faults and discontinuities
  - → Important for the determination of possible contamination paths in the earth
- Exploration of buried waste sites, pipes, tanks, contaminated soil

Aims of geophysical investigation

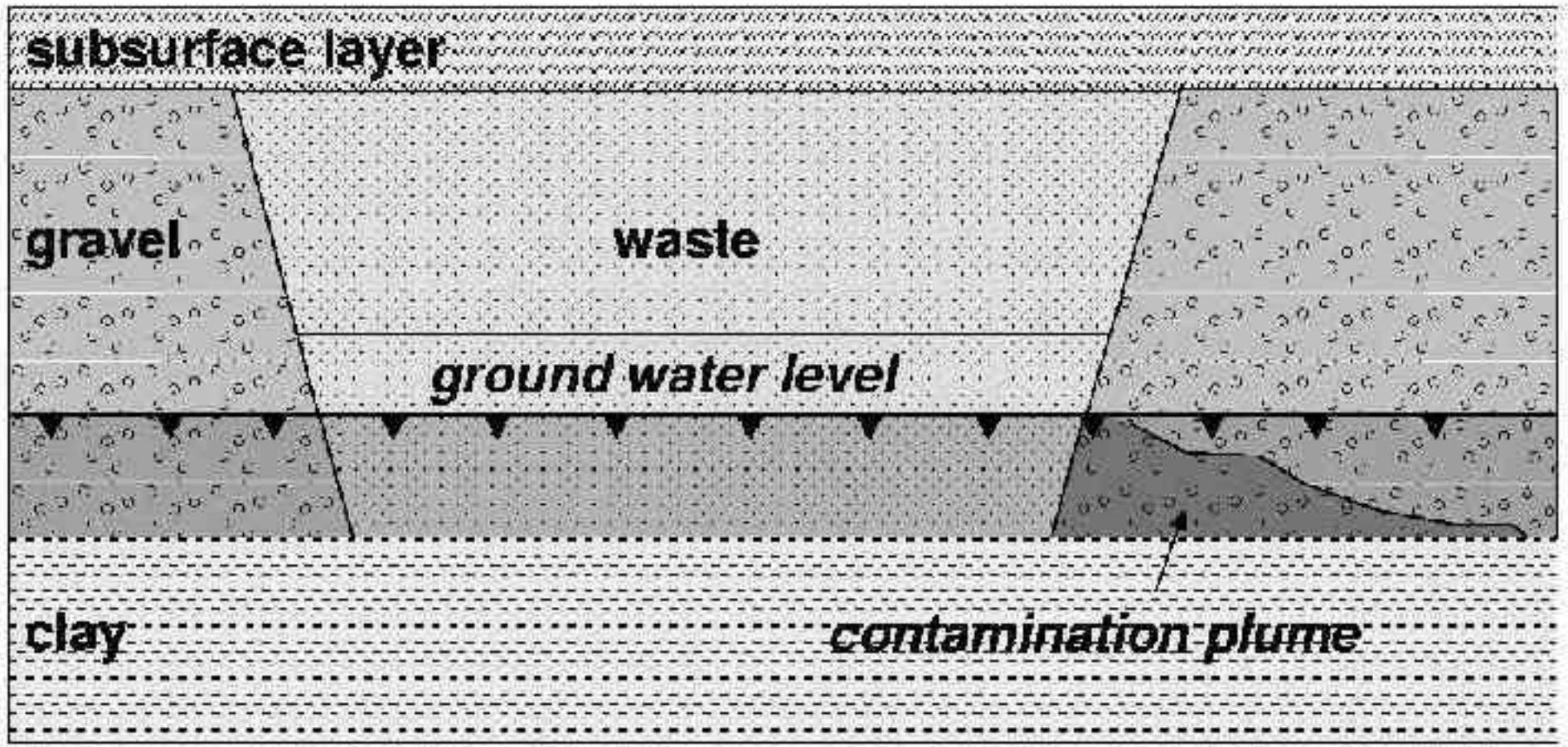


Fig. 2: A common waste situation [1]

Aims of geophysical investigation

- Buried waste deposits represent one of the important and actual environmental problems.
- During the last 50 years small gravel pits have been filled with household refuse, building debris and different kinds of potentially dangerous industrial waste.
- They were often filled up in an uncontrolled manner with little or no documentation.
  - ➔ Huge risk for the environment, main source for groundwater contamination

Waste site situation

Waste sites constitute a serious problem in Europe
– 90000 in Germany !!

Waste site situation in Cologne

Waste disposals

Potential waste disposals	300
Evaluated so far	30
Immediate Action necessary	3

Industrial sites with potential contamination

Evaluated 10% of Cologne area

3000 sites found with environmental relevance

10000 sites expected

1.2 Required physical property contrast for various methods

All geophysical methods depend on physical property contrasts between the target and the background geology.

- The physical property determines the geophysical technique.
- Interpretation of geophysical results together with geologists, hydrogeologists, civil engineers, ...

Basis of geophysical exploration methods

Method	Basic Physical Property
DC-resistivity	resistivity
Electromagnetics	resistivity
Georadar	dielectric constant
Seismics	elastic constants, density
Magnetics	magnetic susceptibility
Gravity	density
Spontaneous Polarization (SP)	oxidation potential, hydrogen concentration
Induced Polarization (IP)	electrochemical properties of electronically conducting particles in rock pores

Physical property contrasts

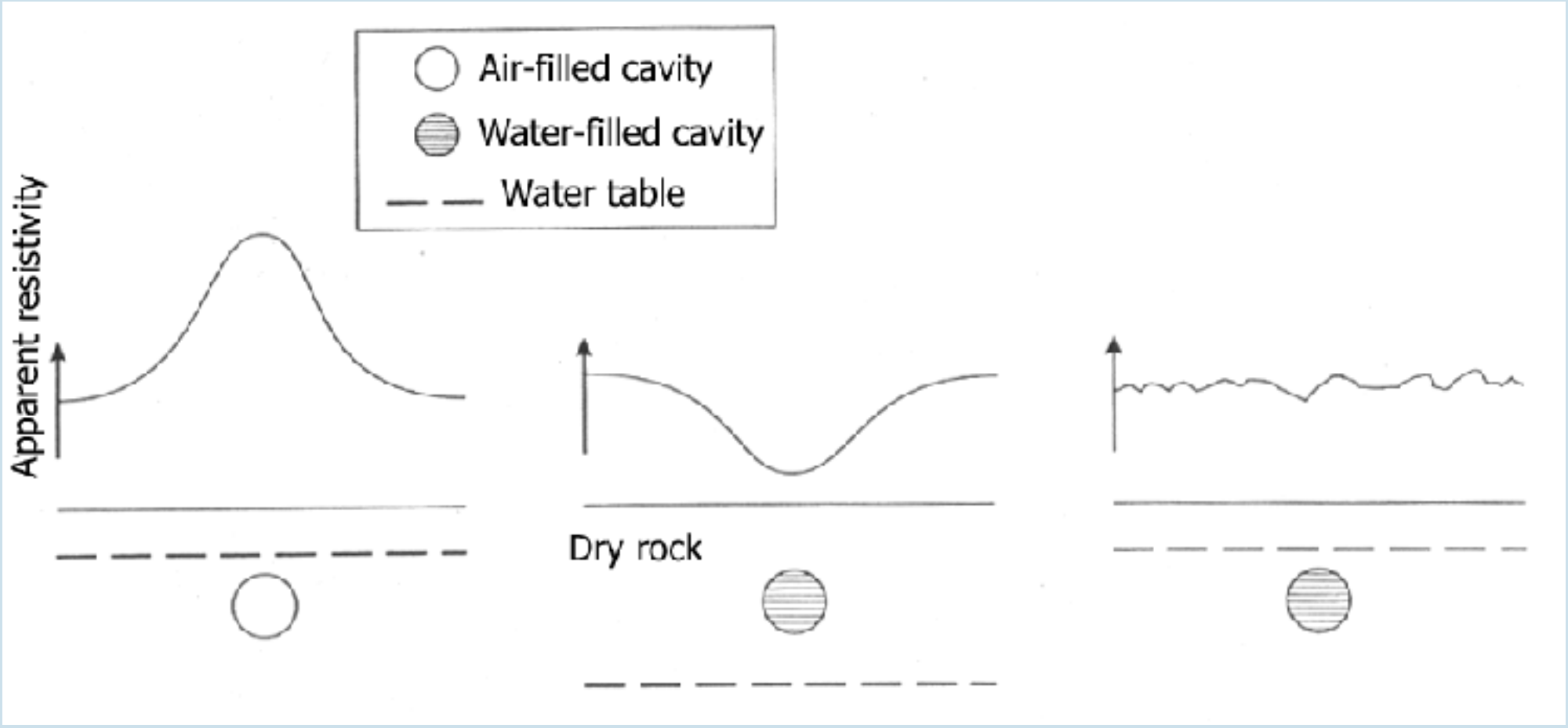


Fig. 3: Contrasts in physical properties from geological targets [2]

Boreholes and geophysical observations

- The geophysical methods (except well-logging) are non-invasive methods

→ Better determination of the location of the boreholes

→ Better interpretation of the structure between the boreholes

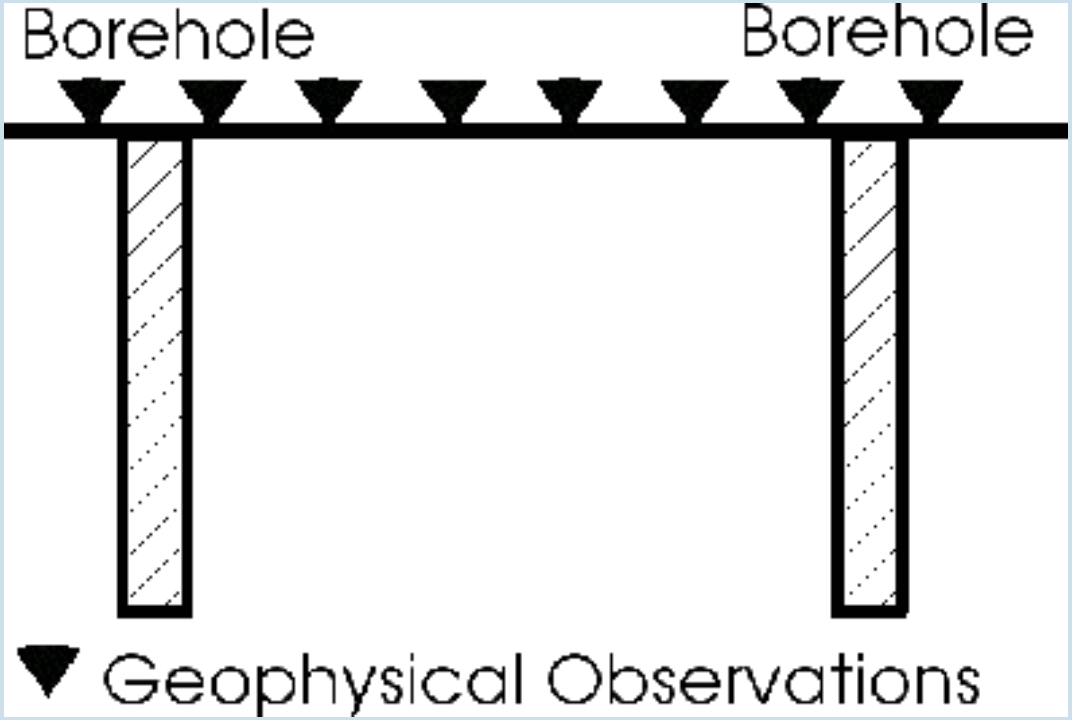


Fig. 4

Cooperation

Difficulties and misunderstandings may arise between geophysicists and engineers due to the lack of mutual understanding

Reason: Different consideration of geophysical results

Engineer: Every figure/result is absolute

Geophysicist: The data must be interpreted, they might be relative though they are based on the exact science of physics and mathematics.

1.3 Basic concepts of geophysical measurements

- Geophysical methods respond to the physical properties of the subsurface media (rocks, sediments, water, voids, etc.)

Geophysical Methods

Passive Methods → Observation of natural fields (e.g. Gravitational and magnetic fields)

Active Methods → Artificially generated signal transmission into the ground (e.g. Exploration seismics)

Basic concepts of geophysical measurements

Passive Methods

Active Methods

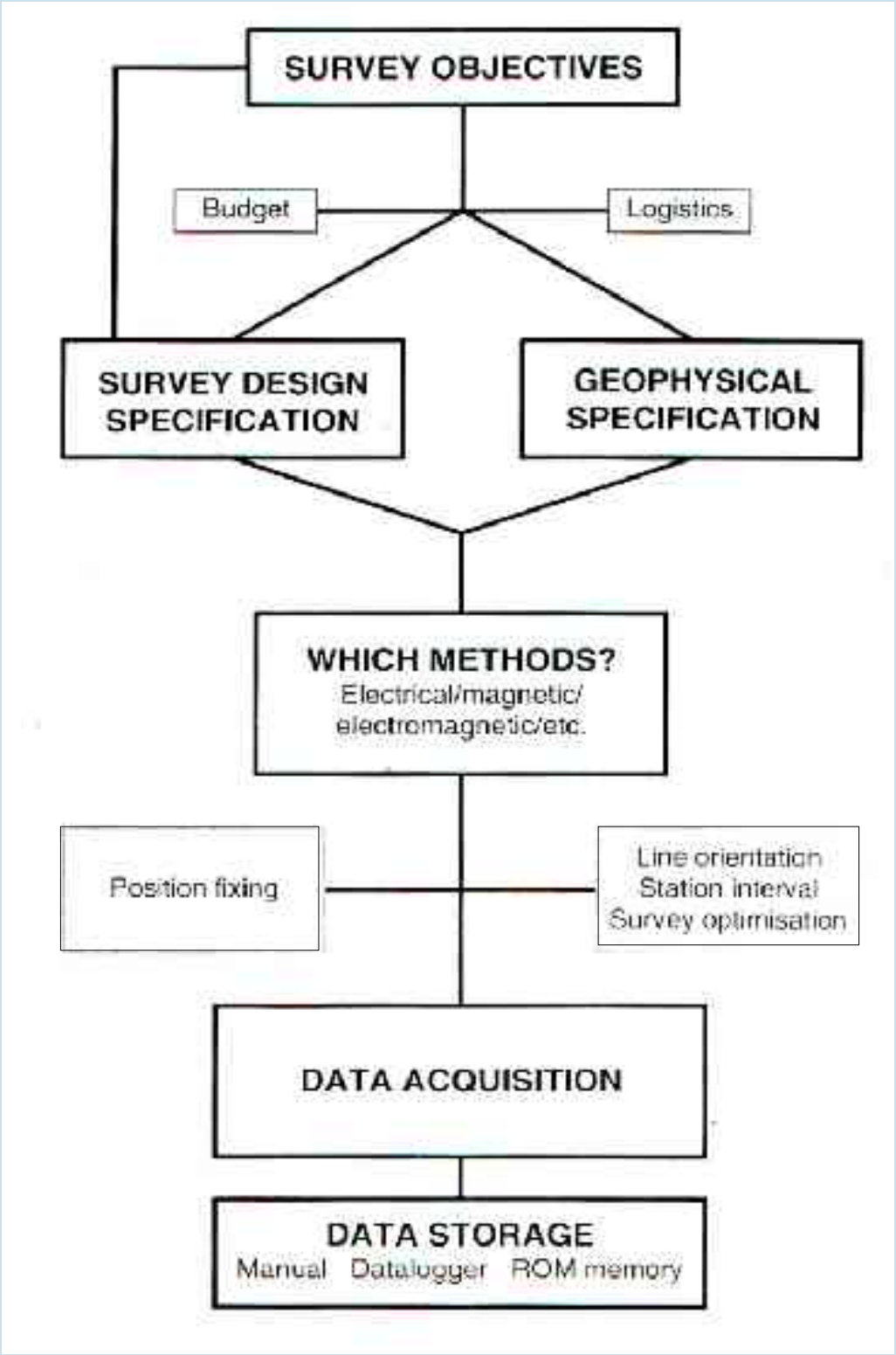
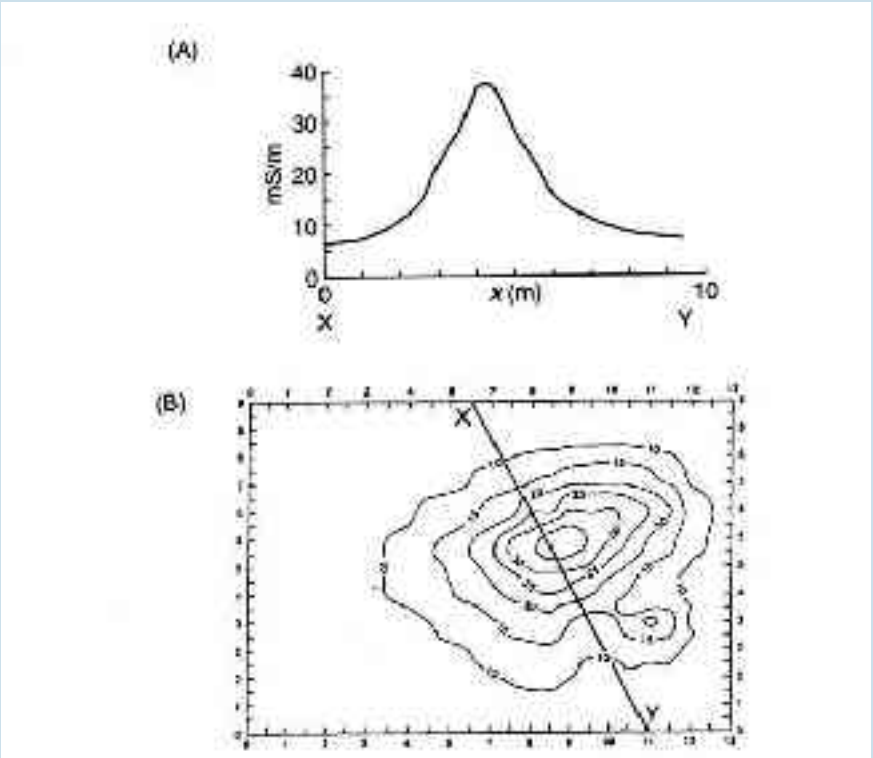


Fig. 5: Flow diagram illustrating the decision-making process [2]

1.4 Arrangements of measurements

A) Profiling and mapping: Measurements are carried out along a profile or in an area)

→ f(x) f(x,y) → Detection of lateral variation of the physical parameter at a certain depth



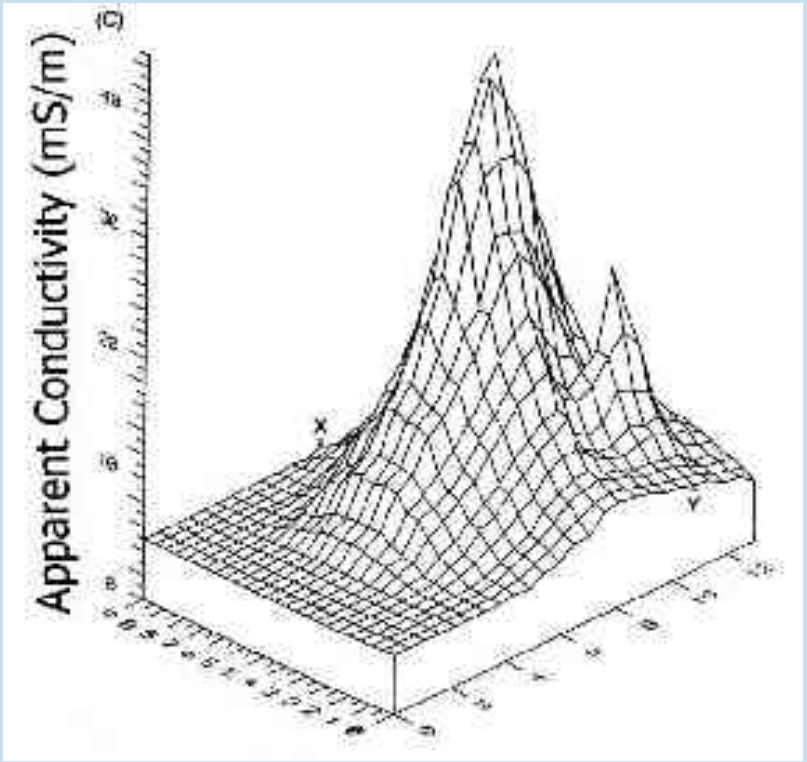


Fig. 6 [2]

1.4 Arrangements of measurements

B) Sounding: Measurements are carried out along a profile. Several data per location are measured

→ f(x,z) → Determination of the variation of the physical parameter as a function of depth

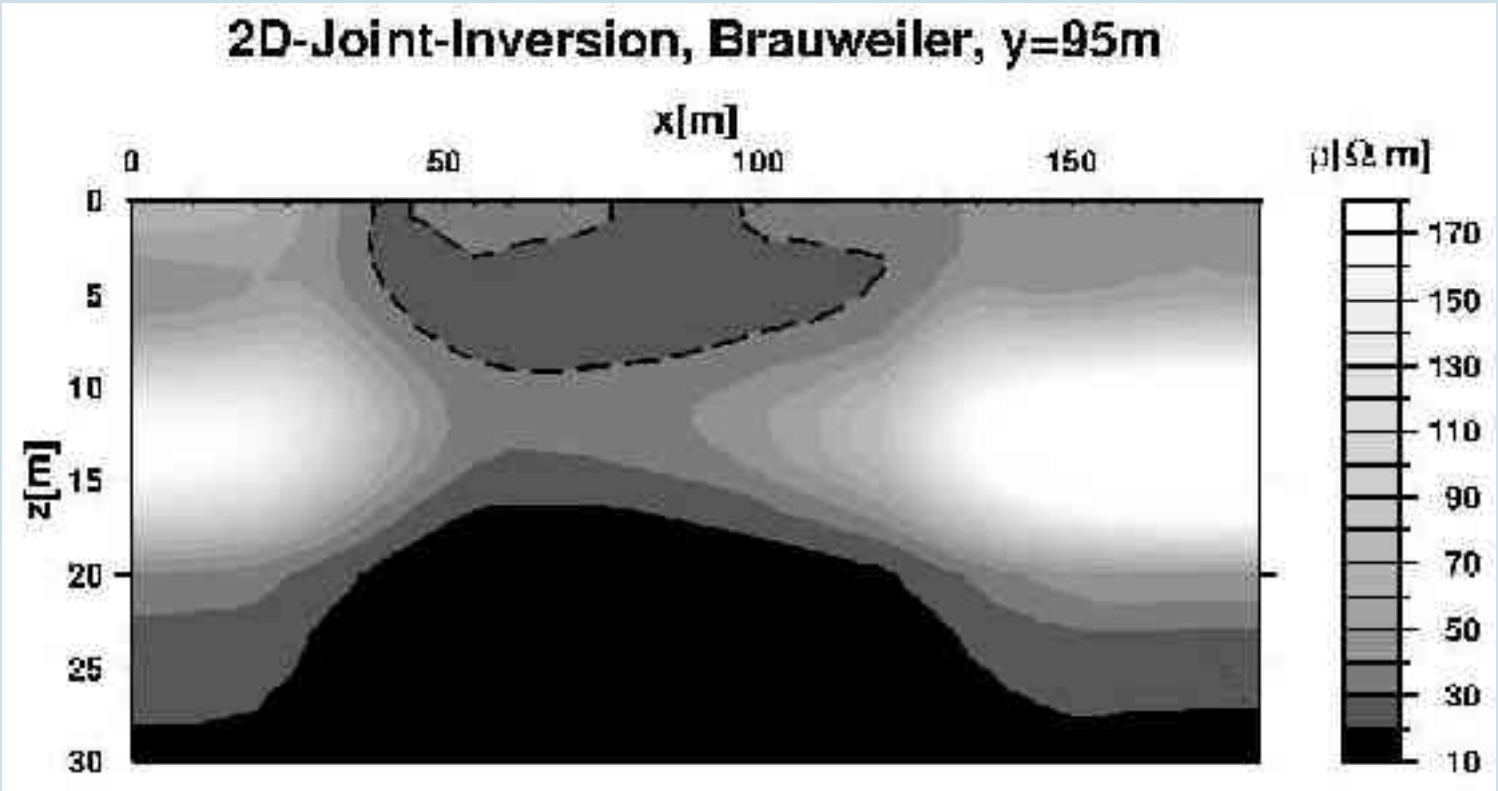


Fig. 7: 2D-RMT resistivity model [1]

1.4.1 Optimum station interval

- Profile should be oriented at right angles to the strike of the target

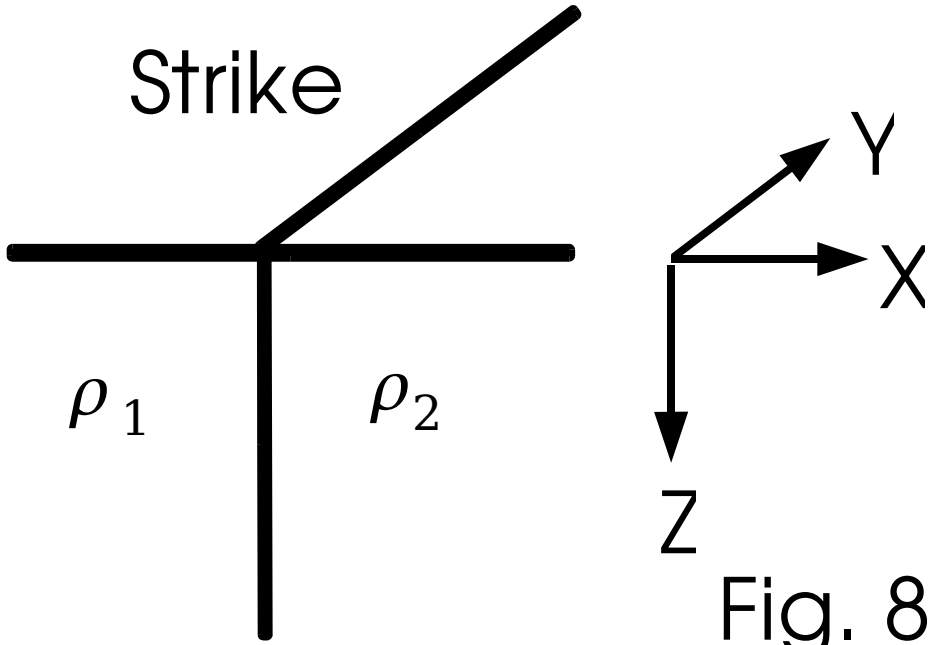


Fig. 8

- Correct choice of station interval is necessary
  - ➔ Waste of time and money to record too many data
  - ➔ Also wasteful if too few are collected

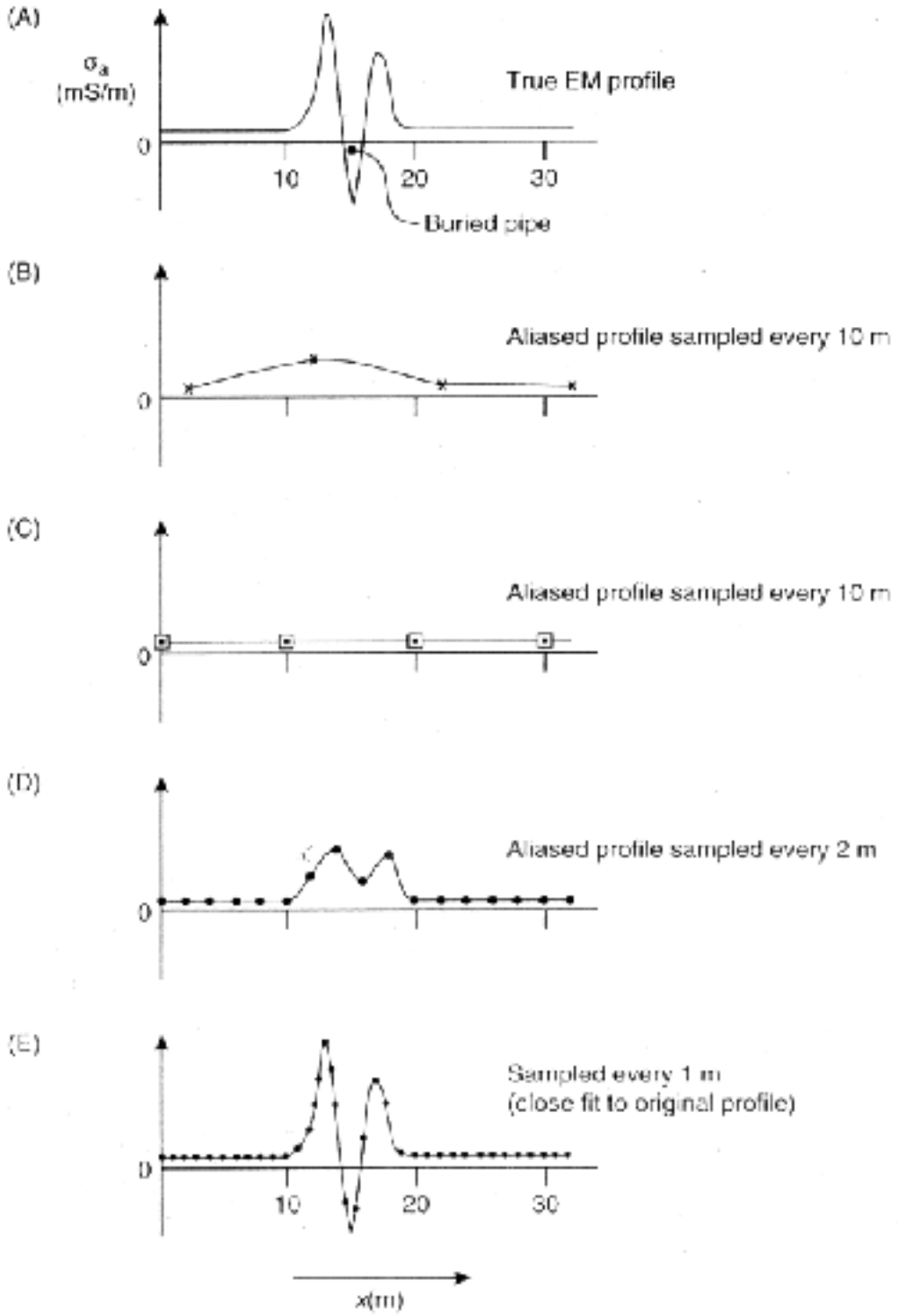


Fig. 9: Examples of various degrees of spatial aliasing using different sampling interval [2]

References

1) Tezkan, B.: A review of environmental applications of quasi-stationary electromagnetic techniques, Surveys in Geophysics, 1999, 20, 279-308

2) Reynolds, J. M.: An Introduction to Applied and Environmental Geophysics, Wiley, 1998