CHAPTER 1 : The principle and limitations of geophysical exploration methods

1.1 Introduction (p. 1)

Def : Geophysics (GP)

The principles of physics applied to the study of the Earth

Geophysics = physics + geology

* Typical situation in a GP-survey :

Measurement ⟶ Analysis results
Processing

↓

Interpretation

↓

Model for the interiour of the Earth

* Two options for "observing" the subsurface

① Geophysical survey
remote observation / sensing

② Drilling
direct method

GP methods are used for :

- hydrocarbon detection/exploration
- finding fresh water
- archiological applicatons
- finding landmines
- finding cole/salt (mineral exploration)
- understanding the structure of Earth
- enviornmental applications

1.2 Survey Methods (p. 1)

Two types of sources :

1. Natural sources
2. Man-made sources (active sources)

Many survey types exist

- depends on what you want to measure

Examples : Table 1.1

GP survey applications : Table 1.2

Geophysical anomaly

A GP-anomaly is an area (or point) of the survey area showing GP-data that are different from surrounding areas (or regions).

Such GP-anomalies can give us clues (or not) to understand the subsurface structure of the Earth.

A case study : salt-dome

- explain how salt domes are formed
- properties of salt
  - low density
  - negative magnetic susceptibility
    $\vec{M} = \chi_m \vec{H}$
  - high seismic wave velocity
  - high electric resistivity

Examples of GP-surveys over salt domes

see Fig 1.1 - 1.4

1.3 Ambiguity in GP interpretation

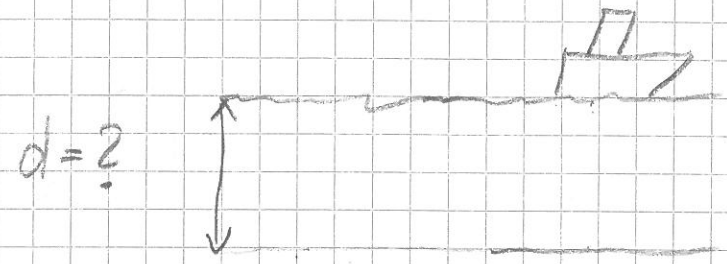
Interpretation of GP data is challenging

Q : Why

A : Inverse problem (no unique sol)
too little data

Examples :

① Echosounding to determine water depth



Measure travle time for "a ping"

$t \longrightarrow d$

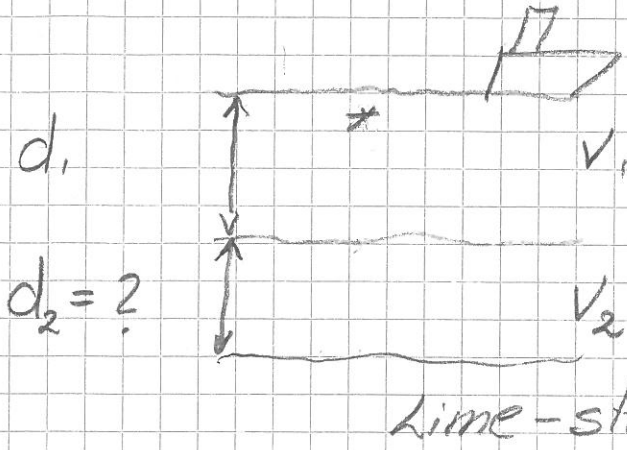
Ex $t = 0.1s$: $2d = vt$

$$\Rightarrow \quad d = \frac{vt}{2} = \underline{75\ m}$$

② Depth of a lime-stone layer (on land)

$$d = d(t, v) = \frac{vt}{2}$$

③ Depth of an off-shore lime-stone layer



$$2(d_1+d_2) = v_1 t_1 + v_2 t_2$$

$$= \underbrace{v_1 t_1}_{2d_1} + v_2 (t - t_1)$$

$$2d_2 = v_2 \left(t - \frac{2d_1}{v_1}\right)$$

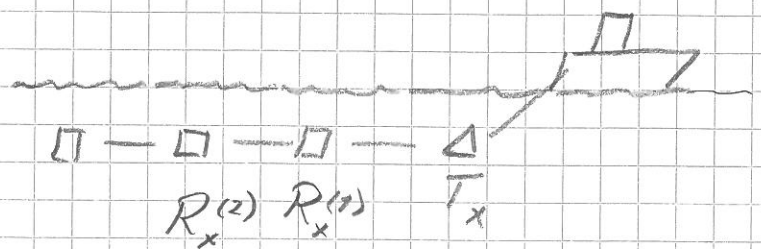
$$d_2(v_2, d_1, t) = \frac{v_2 t}{2} - \frac{v_2}{v_1} d_1$$

Conclusion:

The depth to the lime-stone layer is not uniquely determined.

Q: Can one determine the depth to the lime-stone layer?

A: Yes, for instance by considering different source-receiver offsets.



General problem

Inverse problems do not have a unique solution

Q: How to overcom this situation?

A: - combine several GP methods
- use interpretation (joint)
- data from nearby areas
- "common sense" (experienced geologist/geophys.)