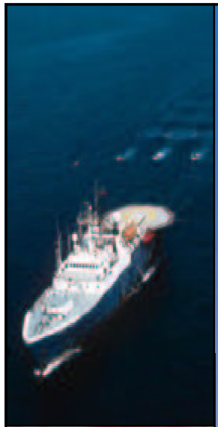
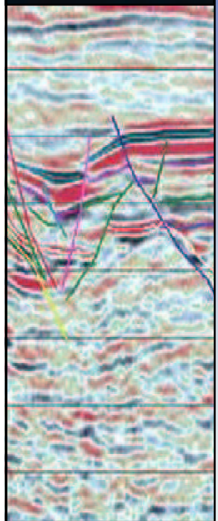
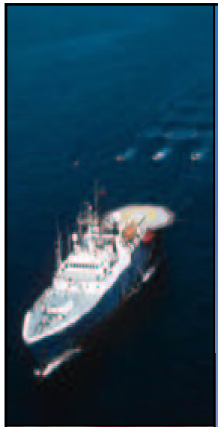
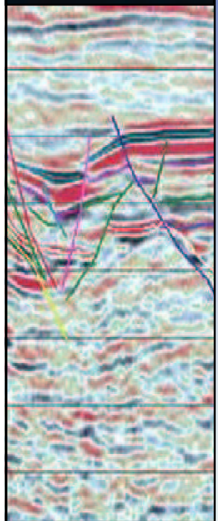




Applied Geophysical Methods

A course on geophysical methods for 2nd year B.Sc. Students of Earth Sciences

Literature

- Keary, P., Brooks B., Hill, I., An introduction to Geophysical Exploration, Blackwell Publishing, 2003.
- Mussett, A.E., Khan, M.A., Lookig into the Earth, Cambridge University Press, 2000
- Shearer, P., Introduction to seismology, 1999.
- Use www-resources (Google „applied environmental geophysics …“)


What is *applied* geophysics?

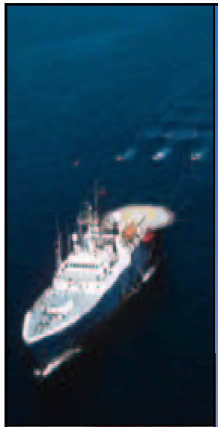
… there is a fuzzy distinction between *applied* and *general* geophysics …

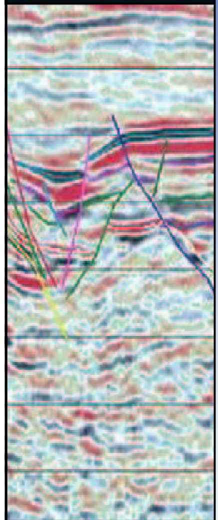
Geophysics is the application of physical principles to problems in Earth Sciences

… let us assume for now that *applied geophysics* are particular applications of geophysical methods in domains where (at least in some cases) you can make money (rather than solving academic questions) …

Examples:

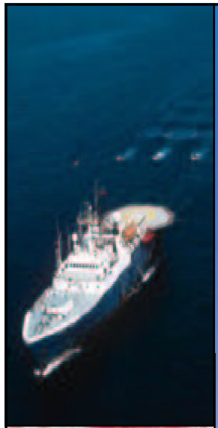
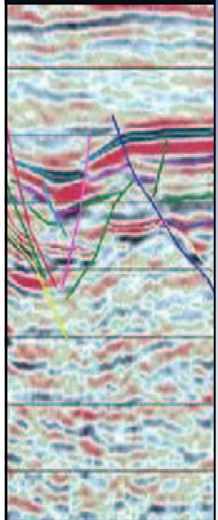
- find oil, gas, minerals, etc.
- monitor fluid flow
- estimate ground properties before constructions (tunnels, tall buldings, etc.)
- Geophysical archeology
- Hazard and risk investigations (volcanoes, earthquakes)





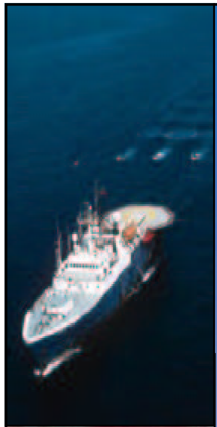
What are the physical methods in *applied* geophysics?

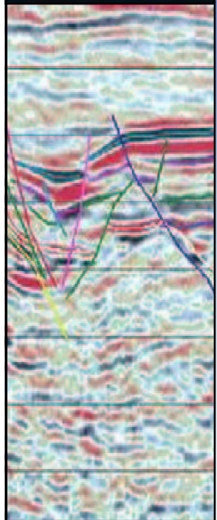
- Seismic methods, *reflection and refraction seismology, earthquake seismology, seismic surveys*
- Gravity, *gravimeters, anomalies, rock density, corrections*
- Electrical surveying, *resistivity, polarization, self potential*
- Magnetic surveying, *rock magnetism, mangnetic surveys, anomalies*
- Electromagnetic surveying, *EM fields, survey methods, ground penetrating radar*
- Borehole geophysics, *well logging, drilling, permeability, porosity*
- Radiometric surveying, geothermal methods


Course structure

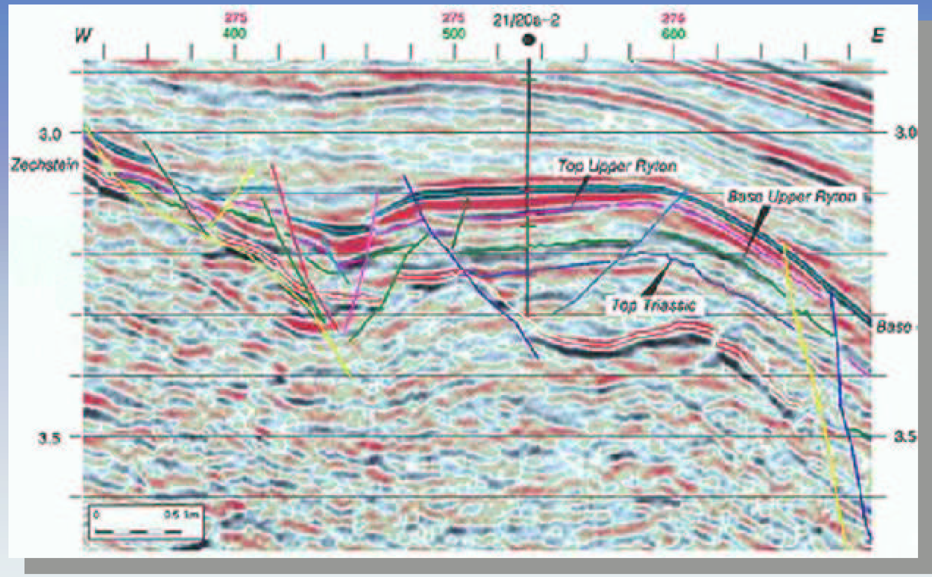
Week	Material	Lecturer
1	Introduction – Data processing	Igel
2-5	Seismic methods and seismology	Igel
6-7	Geoelectrics + georadar	Igel
8-9	Gravity methods	Winklhofer
10	Magnetic methods	Winklhofer
11	Borehole geophysics and rock properties	Winklhofer
12	Case studies	Igel/Winklhofer
13	Revision	Igel/Winklhofer
14	Exam	Igel/Winklhofer





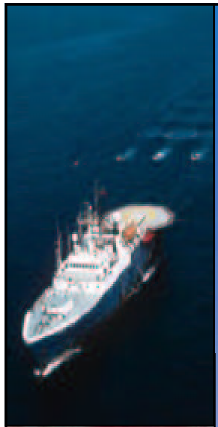
Applied Geophysics: a sample problem
Hydrocarbon exploration

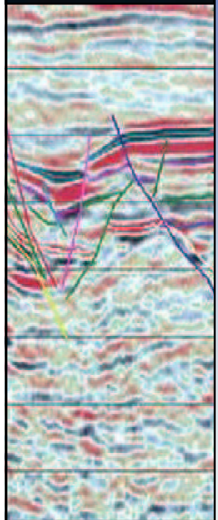
Data acquisition



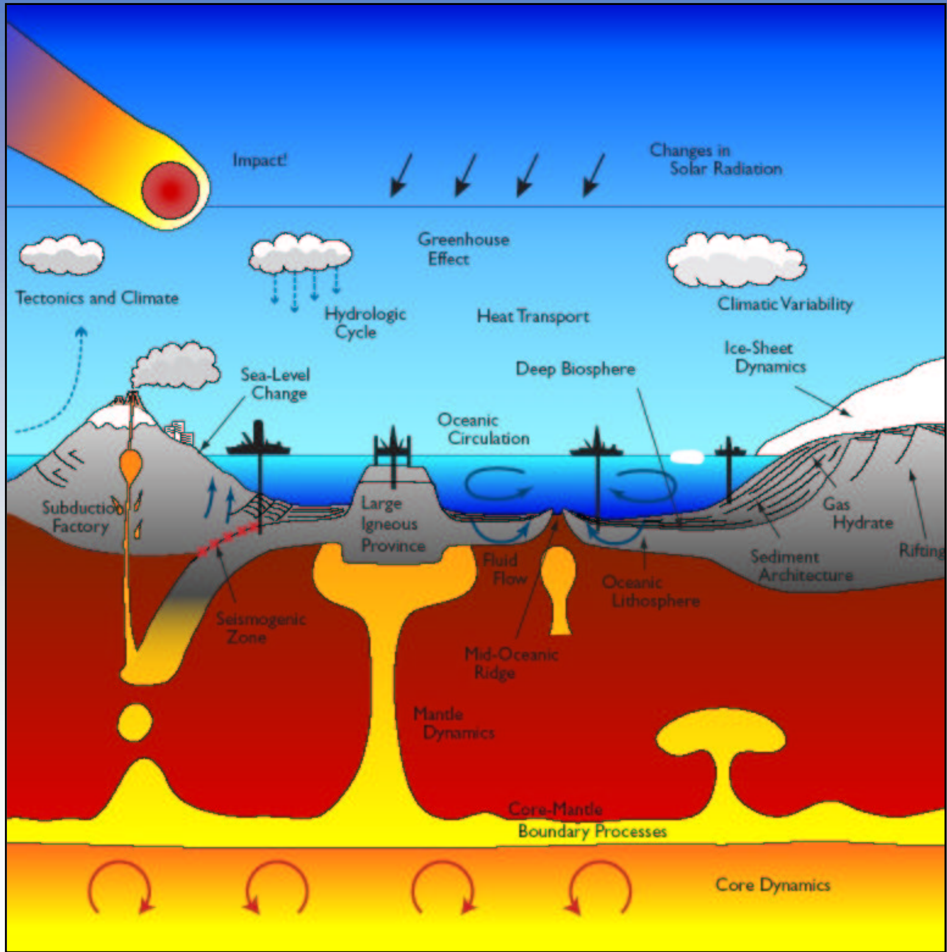
Data processing and interpretation

seismic methods – gravity methods – borehole geophysics – radiometric methods – magnetic methods – rock physics – 4D surveys





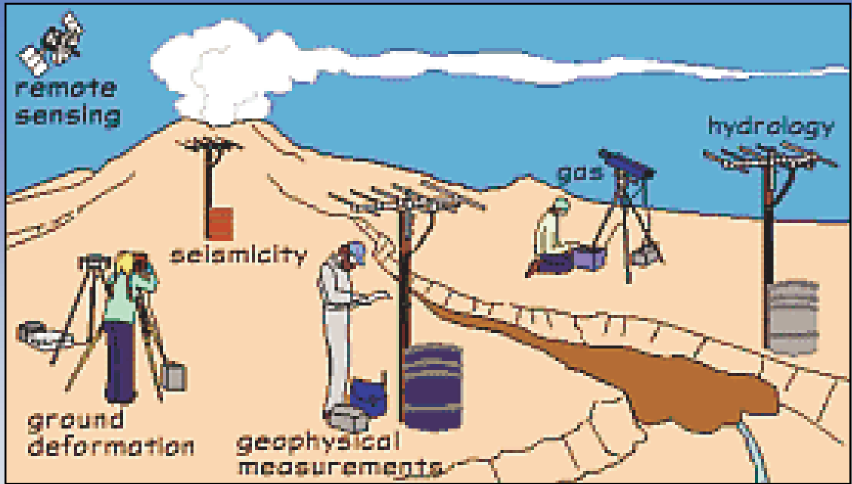
Applied Geophysics:
IODP: Integrated Ocean Drilling Program



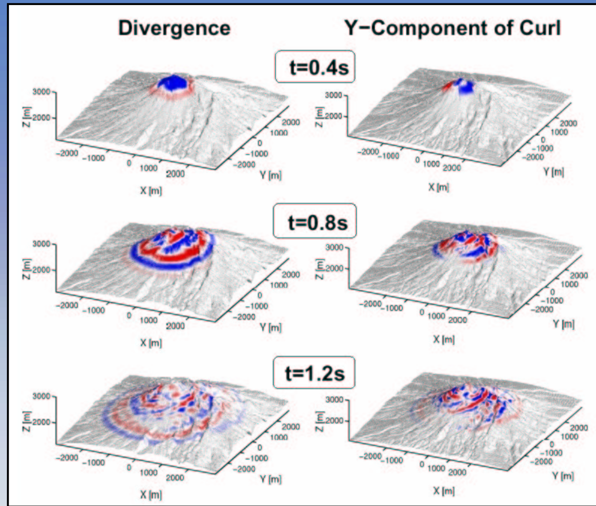
seismic methods – borehole geophysics – radiometric methods – rock physics – gravity methods – electromagnetic methods – magnetic methods

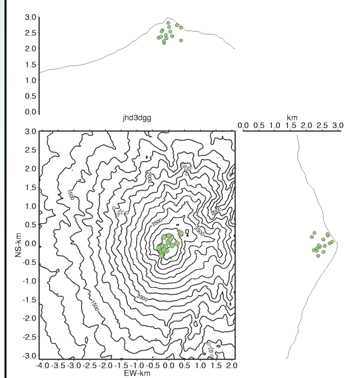
Graphics: IODP www.iodp.org

Applied Geophysics: a sample problem
Monitoring volcanoes



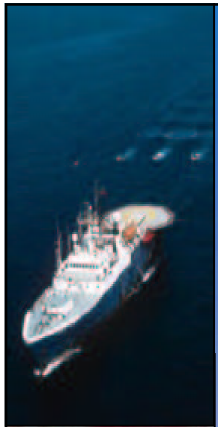
Graphics: USGS

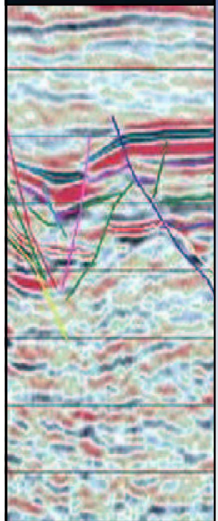




From: Wassermann

seismic methods – borehole geophysics – radiometric methods – rock physics – gravity methods – electromagnetic methods – magnetic methods – deformation – hydrological methods





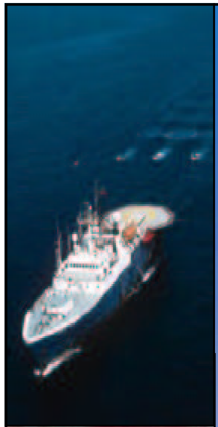
Applied Geophysics: a sample problem
Environmental Geophysics

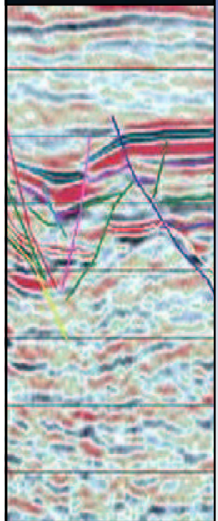
Monitoring waste deposits:

- How do fluids migrate?
- Any danger for ground water quality?
- What is the lithology of the ground?
- Permeability, porosity?
- Any faults?

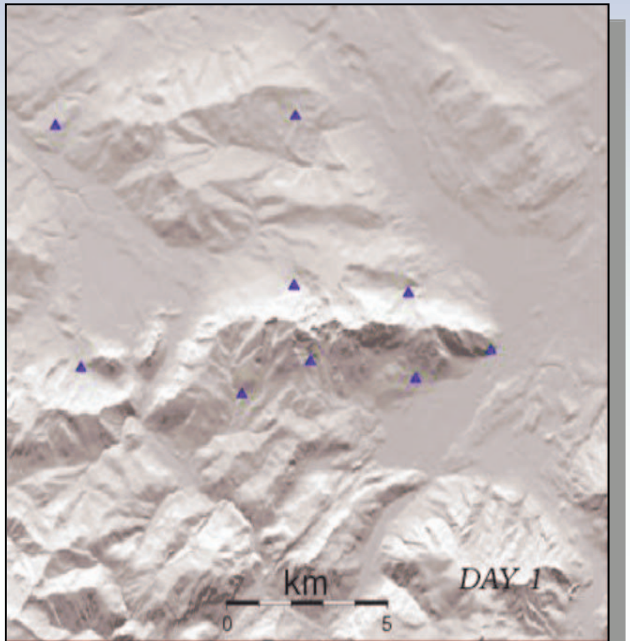
Methods: Electromagnetics, seismics, georadar, magnetics, gravity, etc.

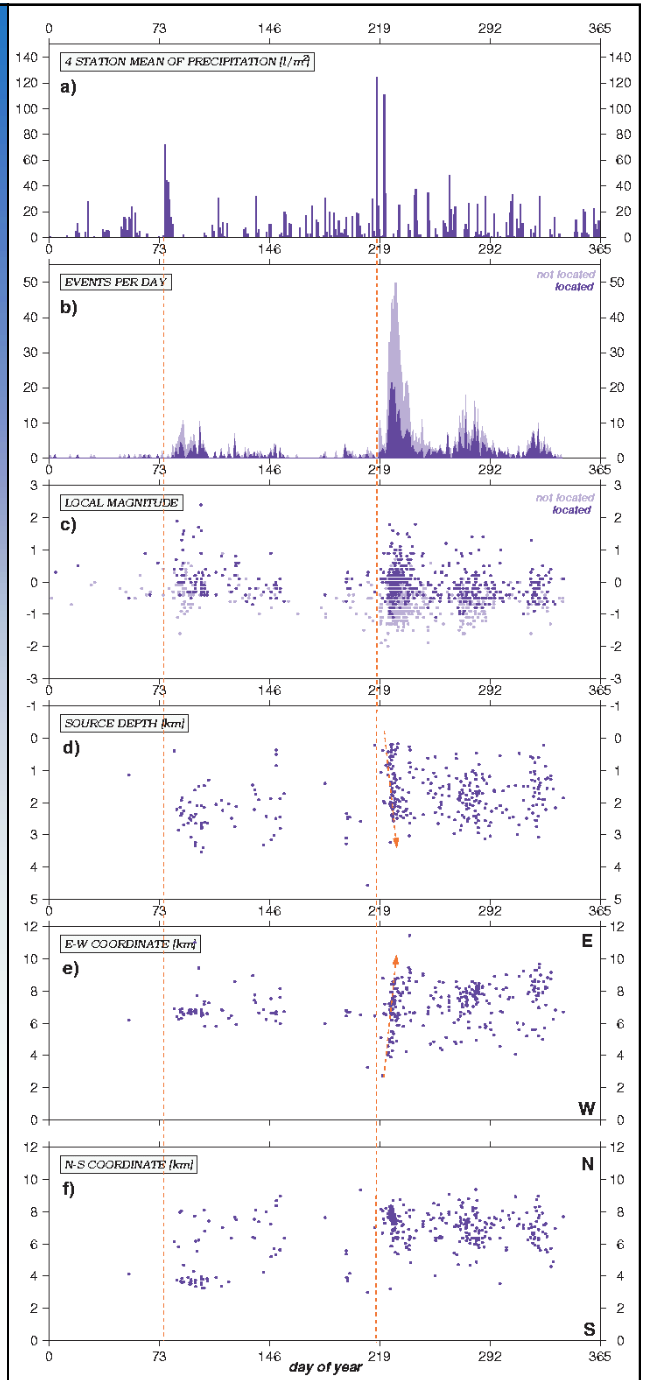
Figure: earthobservatory.nasa.gov

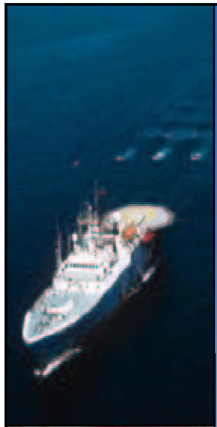


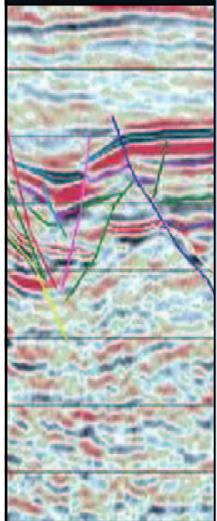


Earthquake monitoring
swarmquakes









General aspects:
Passive versus active methods

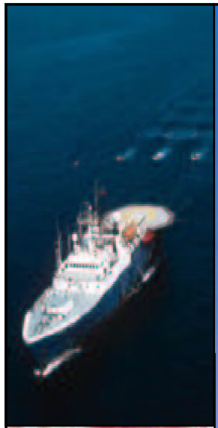
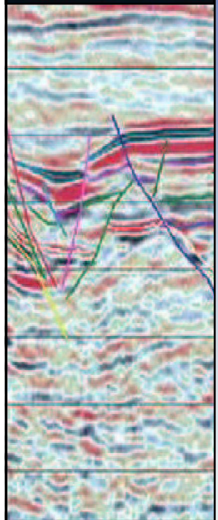
Passive:
Use natural fields, sources to investigate properties of ground

Examples:
- Gravity
- Earthquakes
- EM field
- Etc.

Active:
Use man-made source to image ground properties

Examples:
- Explosions, air guns
- EM waves
- Polarization methods
- Etc.

What are direct and indirect methods?

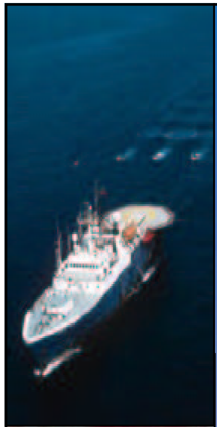

Deciding which method to take …

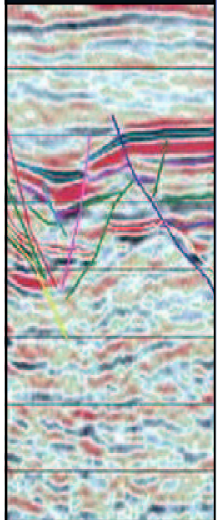
Real life problem: You are given the task to investigate the ground properties for structural stability (tall building), flow properties (waste deposit), archeological tasks, etc.

To decide what **techniques** are approriate we have to consider the following:

- What **physical properties** are relevant (e.g. permeability, poroosity, seismic velocity, anisotroy, conductivity, density)?
- What **spatial scales** are relevant for my problem?
- What **experimental geometries** are optimal?
- How will I **process** and **analyse** the data?
- What „**prior information**“ is known and could be used?
- How do various **physical properties relate** to each other?

The answer to these questions will strongly depend on the particular target and problem.



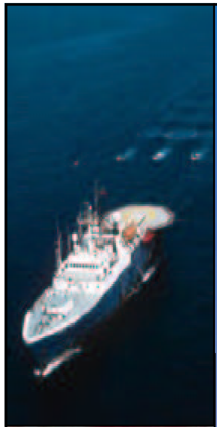
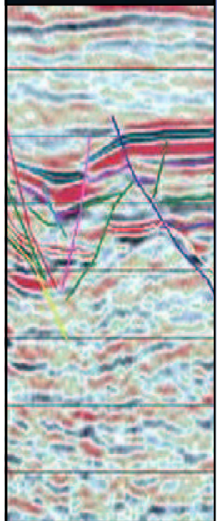


Imaging and Uncertainties

Indirect methods (imaging) usually are „underdetermined mathematical problems“ and/or do not have mathematically unique answers. This has tremendous implications for the interpretation of observed data.

Consequences:

- More than one (often an infinite number) of solutions may explain the observations
- Such kind of information is very difficult to describe in 2-D form (i.e., on paper)
- In practice results are often driven by „wishful thinking“ … beware!
- Good practice: Be crystal clear about the amount of information your observations contain about your physical systen!
  (this usually involves the use of probabilistic methods)


Summary

The geophysical methods touched in this course have a tremendously wide spectrum of applications in research as well as environment, exploration, geo-technical engineering, etc.

The key applications are seismic, geo-electrial, magnetic, gravity, geothermal, radiometric, rheological methods.

Much of the processing tools applied to the observations are identical to all these various fields. The key topics are digitization, spectral analysis, filtering. Therefore these fundamental topics are covered at the beginning of the course.