Geophysics 210 - Physics of the Earth

A1: What is geophysics

Geophysics: Application of physics to understand the structure and working of the Earth.

Geophysics can be divided into exploration geophysics and geodynamics.

Exploration geophysics is the process of imaging what is inside the Earth.

Direct sampling in the Earth with drilling can only reach depths around 10 km so indirect methods are needed.

Often used to describe commercial exploration, but includes investigations to depths of the mantle and core.

All geophysical methods can be divided into **active** and **passive** techniques.

In an **active technique**, **it is necessary to generate a signal** (*e.g.* in seismic studies sound waves are generated with an explosion or an earthquake).

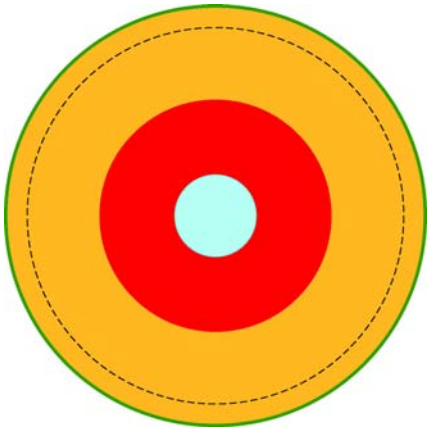
In a **passive technique a naturally occurring signal is detected** (*e.g.* the pull of gravity of a buried object).

Geodynamics is the study of how the Earth works, and considers questions such as:
-what drives plate motion?
-what triggers earthquakes?
-how is the Earth's magnetic field generated?
-how do continent-continent collisions build mountains?

This field depends heavily on information derived from geophysical imaging. Advances in computer power now allow simulations of these processes in ever increasing detail and realism.

A2 : Basic structure of the Earth

- Radially symmetric to first order.
- Crust – mainly silicate minerals, enriched in lighter elements (Na, Al)
- Mantle – silicate minerals with more heavy elements (Fe and Mg) magnesium. Divided into upper and lower mantle (dashed line)
- Outer core - liquid iron that convects rapidly.
- Inner core – Lump of solid iron roughly the size of the moon



- Crust and mantle are defined in terms of their distinct **chemical** compositions.

Lithosphere and asthensophere

- Lithosphere is the rigid outer part of the Earth, typically 100-200 km thick and includes the crust and uppermost mantle.
- Below that is the weaker asthenosphere that can flow on geological timescales.
- Lithosphere and asthenosphere are defined in terms of **mechanical** properties.
- Transition from lithosphere to asthenosphere usually occurs in the upper mantle.

A3 : How do we know what is inside the Earth?

- Drilling can only sample a very limited part of the Earth

  KSDB Kola Superdeep Borehole, Russia : 12,261 m
  KTB Kontinentales Tiefbohrprogramm, Germany 9,000 m

- Quantities measured at the surface can be used to infer what is happening inside the Earth. We will study different aspects of the Earth's structure by focussing on different methods of imaging inside the Earth.

  B: Gravity and geodesy
  C: Seismology
  D: Geomagnetism
  E: Geothermal studies.

- In the last part of the course we will synthesize information from these areas and consider plate tectonics and compare the Earth to other planets in the Solar system.

A4 : General notes

- This class is mostly focussed on the **Solid Earth**. However, other geophysicists study the atmosphere, hydrosphere and space. Each of these areas interacts and this will be stressed where possible in this class.

- More emphasis on **exploration geophysics** is presented in Geophysics 224. Notes from when I taught Geophysics 224 in Winter 2006 are available online: http://www-geo.phys.ualberta.ca/~unsworth/UA-classes/224/index.html

- Geophysical and geological studies complement one another. Geologists are more effective with a basic knowledge of what geophysics can and cannot resolve. Similarly, many geophysicists would benefit from a basic knowledge of geology.

- Mathematics will be used in this class where needed, and I hope that this will provide a review of math classes you have taken in the recent past. I do not expect students to memorize equations. My expectation is that students will be able to perform simple rearrangement of equations, and use a calculator to evaluate an equation for a given set of values.

  I will appreciate feedback to keep the mathematics at an appropriate level.