Geophysics 224 - Geophysical exploration techniques

A: Introduction

What is geophysical exploration?

- imaging underground structures from surface measurements of artificial or natural signals that travel through, or are generated by, the Earth.

Why?

- oil and gas exploration
- mineral exploration
- hydrogeology
- monitoring contamination and remediation
- tectonic studies
- earthquake hazard studies

Some basic principles

- All geophysical methods remotely sense a **material property** of the Earth (*e.g.* seismic velocity, rock density, electrical resistivity, magnetization etc)

- Knowledge of these material properties must then be **interpreted** to determine what rock type is present. Well log information is very important in this task.

- 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 reflection surveying, sound waves are generated with an explosion).

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

- 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).

- Geophysical imaging does not always give a unique answer! Additional information is often needed to discriminate between possible solutions (*e.g.* other geophysical surveys, knowledge of local geology, well log information in the study area).

- Please do not be intimidated by equations! 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.

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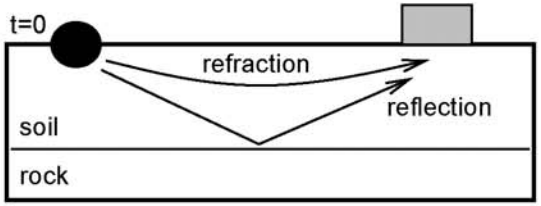
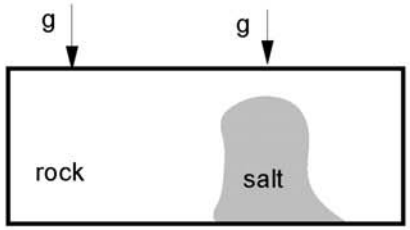
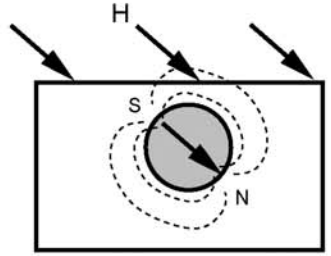
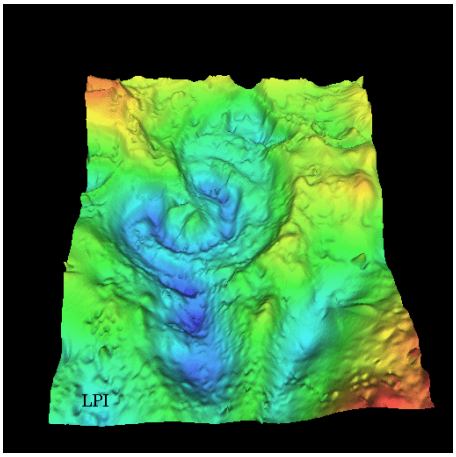
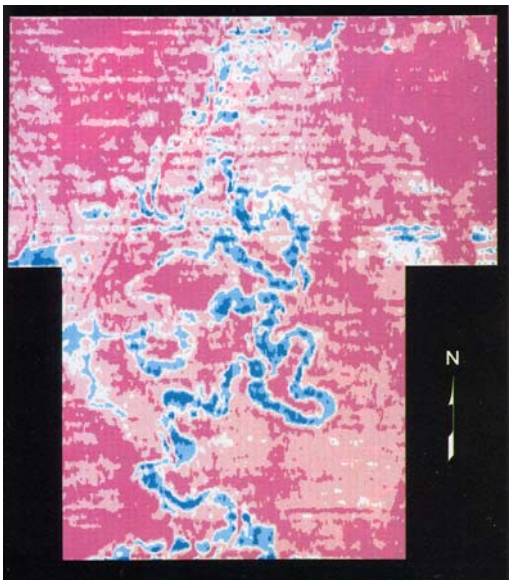
A: INTRODUCTION
SUMMARY OF GEOPHYSICAL EXPLORATION TECHNIQUES

	Seismic exploration	**Gravity exploration**	**Magnetic exploration**
Quantity measured in field survey	Travel times (t) and amplitude of seismic waves	Gravitational force on known mass (g)	Magnetic field (H)
Property calculated in data analysis	Seismic velocity (v)	Density (ρ)	Magnetic susceptibility (k) Remnant magnetization (M)
Survey layout			
Common applications	Depth to bedrock, geotechnical studies Oil and gas exploration Tectonic studies	Depth to bedrock Mapping salt domes Locating caves Mapping landfill geometry Tectonic studies	Locating metal drums and pipes Mineral exploration Depth to igneous basement Archaeology Tectonic studies



200 km diameter impact crater in the Yucatan Peninsula of Mexico, imaged with gravity data



Paleo-meanders imaged in 3-D seismic data, Gulf of Thailand (AAPG memoir 42)

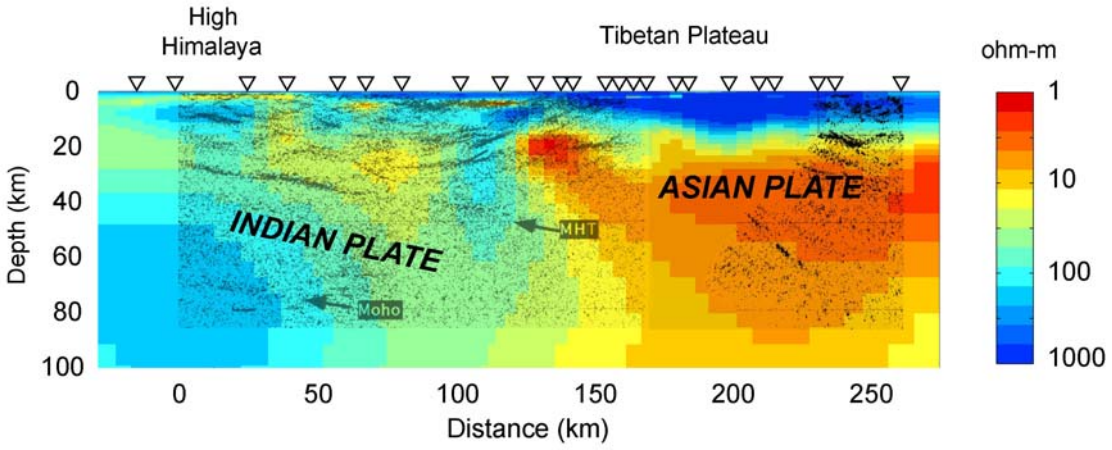


Plate tectonics in action. Seismic reflection and electromagnetic images of India underthusting the southern edge of the Tibetan Plateau (Unsworth et al., 2005)

Unsworth, M.J. A.G. Jones, W. Wei, G Marquis, S. Gokarn, J. Spratt, Crustal rheology of the Himalaya and Southern Tibet inferred from magnetotelluric data, **438**, 78-81, doi:10.1038/nature04154, *Nature* 2005.