Geophysics: Scientific Scope and Future Career Opportunities

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Geophysics: Scientific Scope

- What is Geophysics?
- What is the connection of Geophysics to subsurface & Physics?
- What questions about the subsurface are we trying to answer?

What is Geophysics?

- Geophysics involves the application of physical theories and measurements to discover the properties and processes of the earth.

- The study of the earth by quantitative physical method :
  - Seismic (sound) reflection and refraction
  - gravity, magnetic
  - electrical, electromagnetic
  - radioactivity methods.

From Robert E. Sheriff's *Encyclopedic Dictionary of Applied Geophysics*

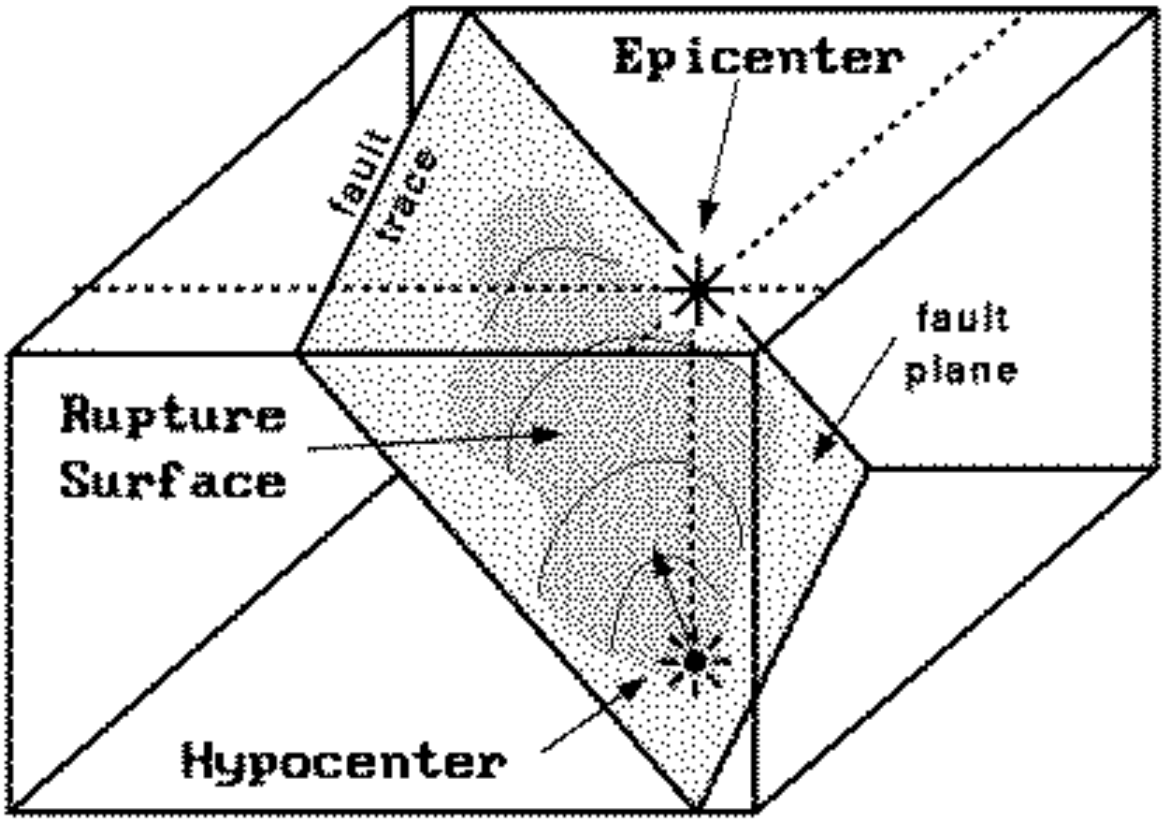
Brief History of Geophysics

- Began with prediction of Earthquakes (still an unsolved problem)
- Major development in 1500 A.D. (Gravity & Magnetics)
- Rapid development in 20th Century (Seismic, Electrical, Electromagnetics, NMR, Radioactivity)
- Geophysics has contributed significantly in the understanding of many physical processes that lead to scientific and economic contribution to our society.

Earthquakes

Earthquake in Northern Kashmir, border of India and Pakistan. More than 150000 people died

Earthquakes



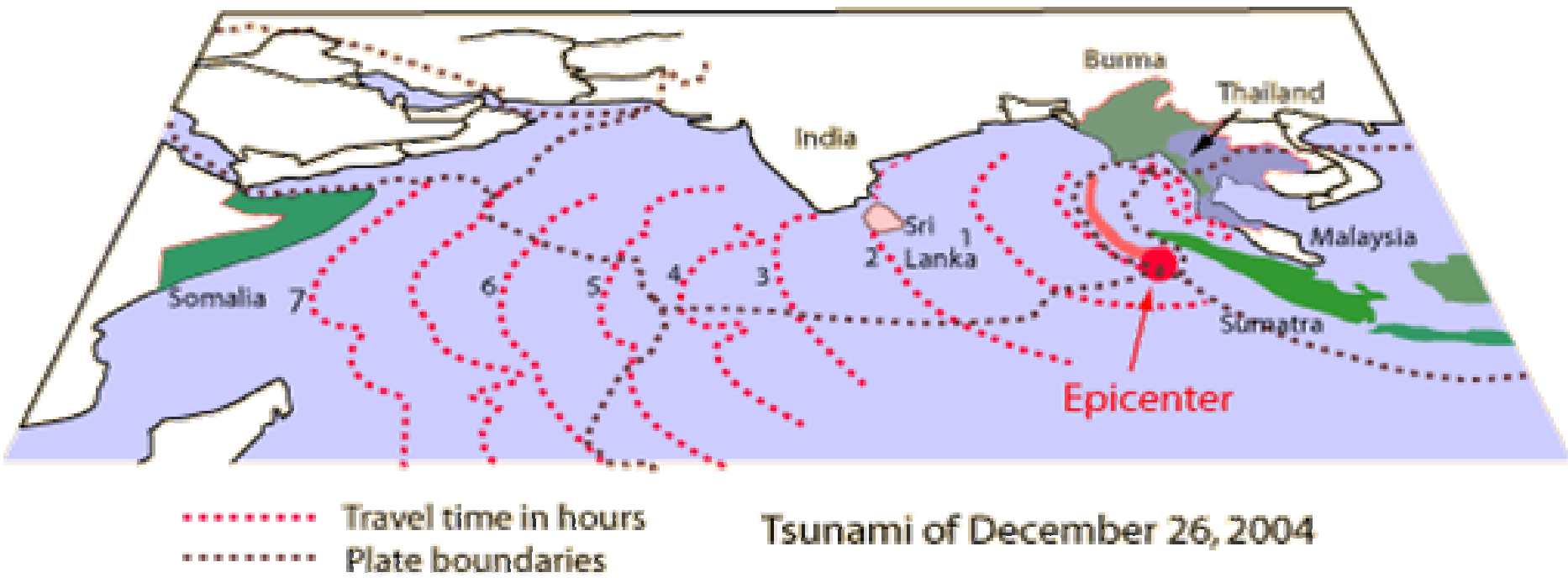
Tsunamis

Tsunami (*tsoo – nah – mee*)

Tsu (harbor) & nami (wave)

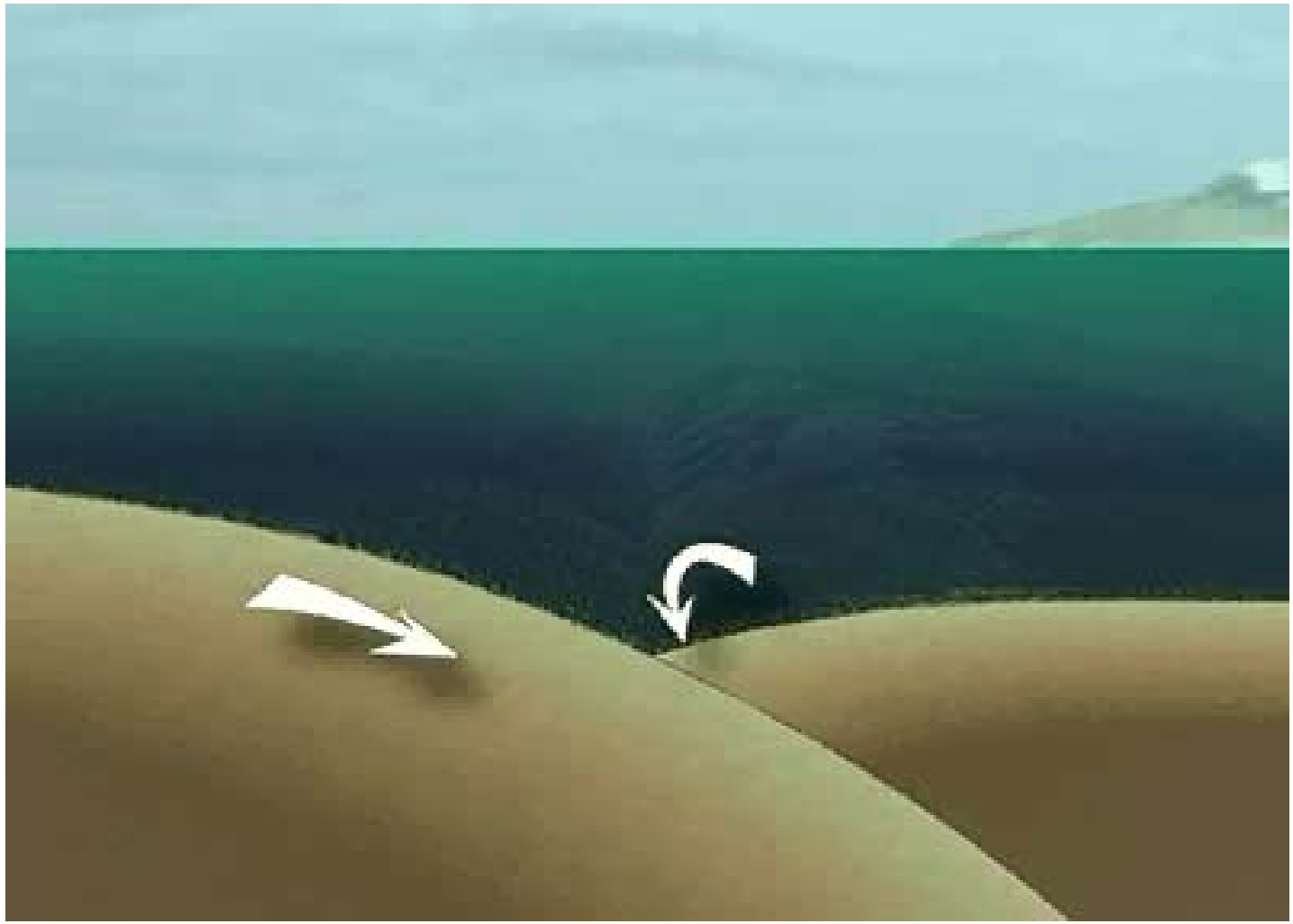
"A natural phenomenon consisting of a series of waves generated when water in a lake or the sea is rapidly displaced on a massive scale" (www.wikipedia.org)

Tsunami



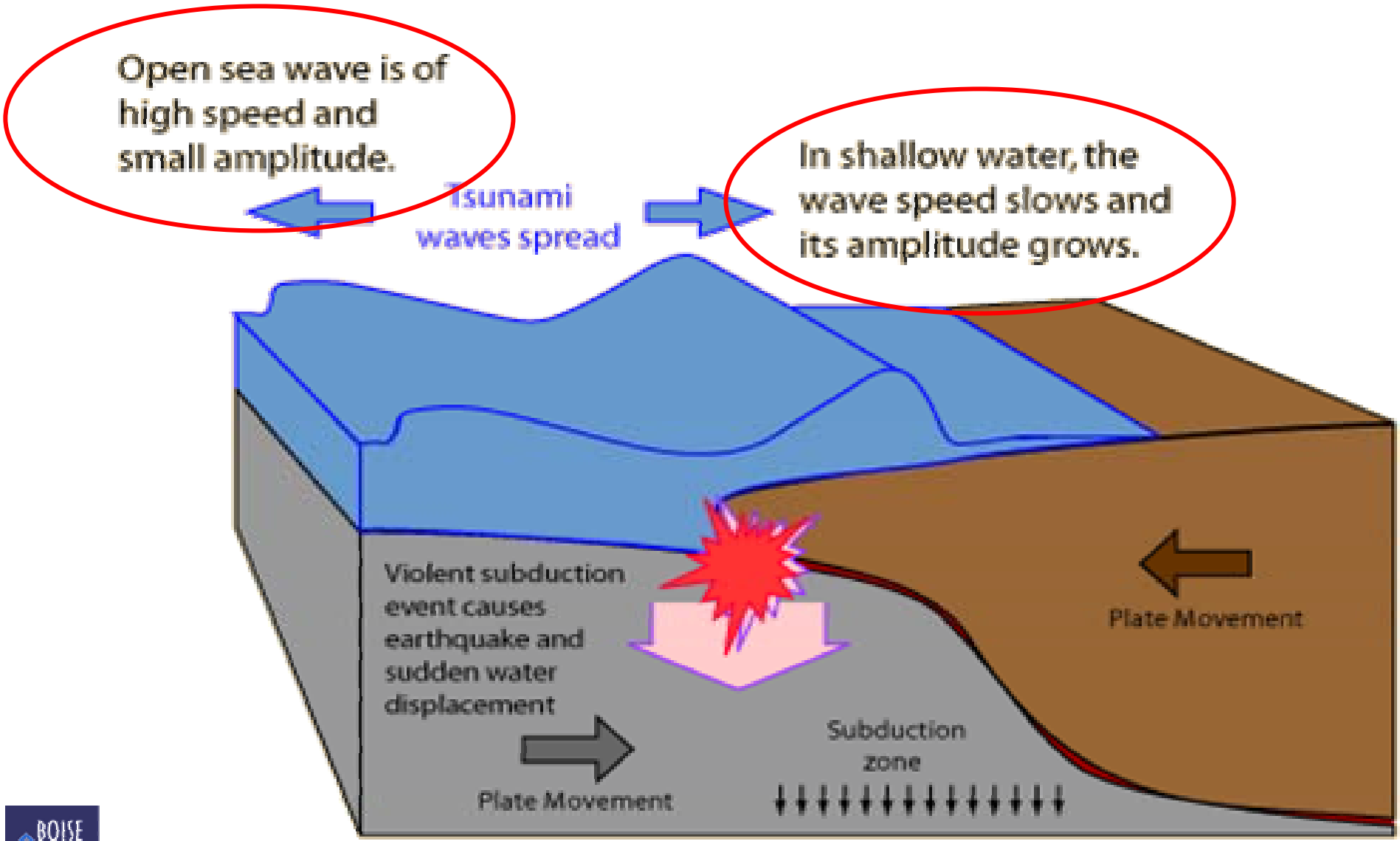
- Magnitude of earthquake = 9.0
- Height of wave reach up to 30 m with speed ~ 800 km/hr
- More than 200K people died

Tsunami



Source: NOAA

Tsunamis


Open sea wave is of high speed and small amplitude.
Tsunami waves spread
In shallow water, the wave speed slows and its amplitude grows.
Violent subduction event causes earthquake and sudden water displacement
Plate Movement
Subduction zone
Plate Movement

Areas that Geophysics have Impacted

- Earthquakes and Tsunamis (Seismology)
- Geothermometry (Heat Flow)
- Physical oceanography (Heat, Waves, Tides)
- Meteorology (Temperature, Pressure)
- Hydrology (Ground and Surface Water)
- Exploration/ Environmental/ Engineering

What is the Broad Picture of Geophysics?

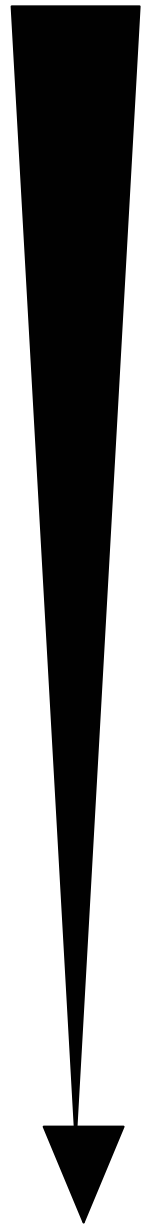
- Application of Physics to various global earth processes/ geological/ hydrological/ environmental/ engineering problems.

- Areas within geophysics evolved with the advancement in methodology and instrumentation.

- Depending the process we are trying to study geophysics can be broadly classified into **three** areas.

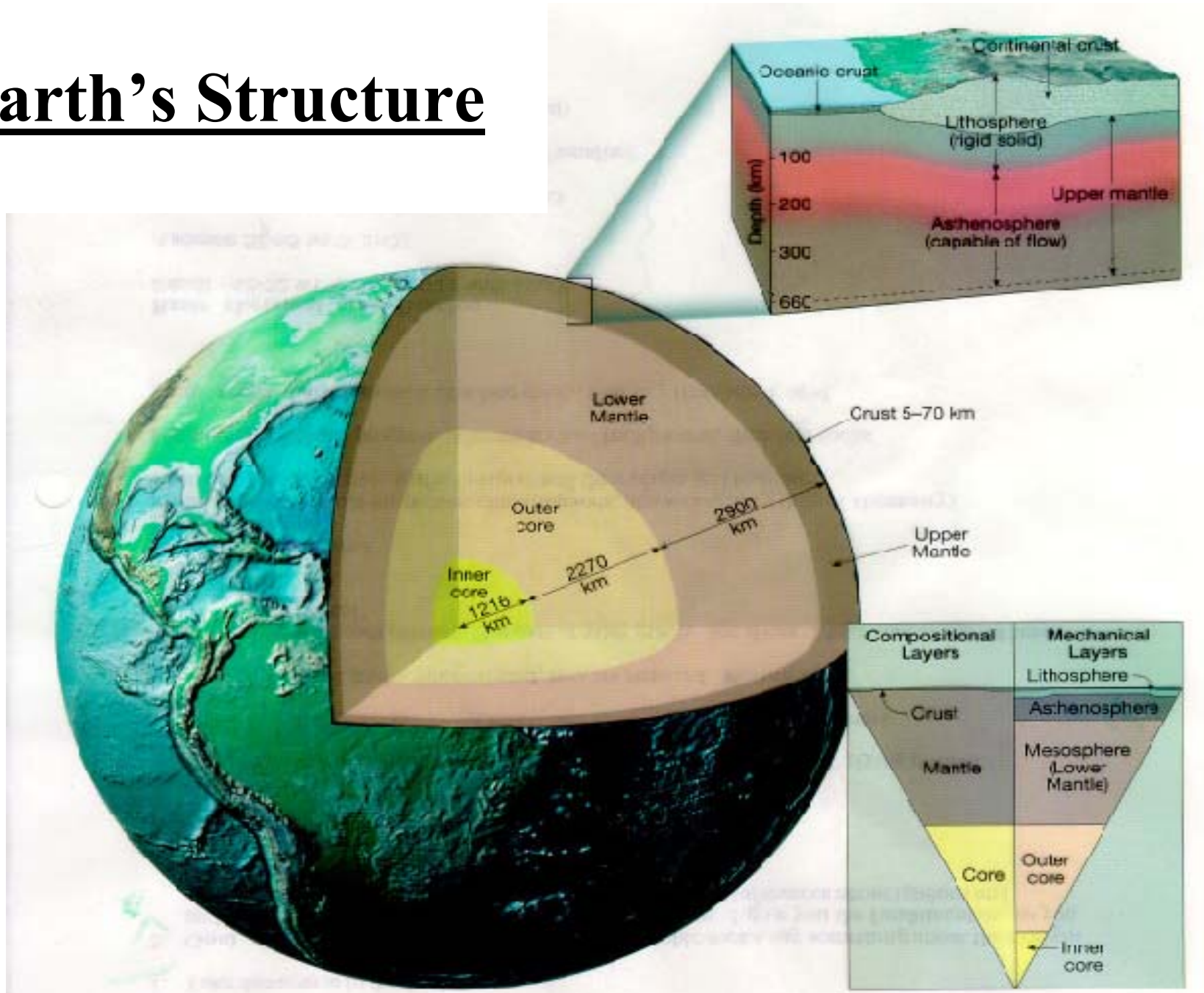
Branches of Geophysics

- Solid Earth Geophysics
  - Earthquakes, Tsunamis, Tectonics
  - Geodynamics
- Exploration Geophysics
  - Oil and Gas exploration
  - Minerals exploration
- Environmental & Engineering Geophysics
  - Groundwater exploration
  - Contaminant delineation
  - Utility or object detection



Scale Decreases

Earth's Structure



Geophysics: As tool to look inside the subsurface

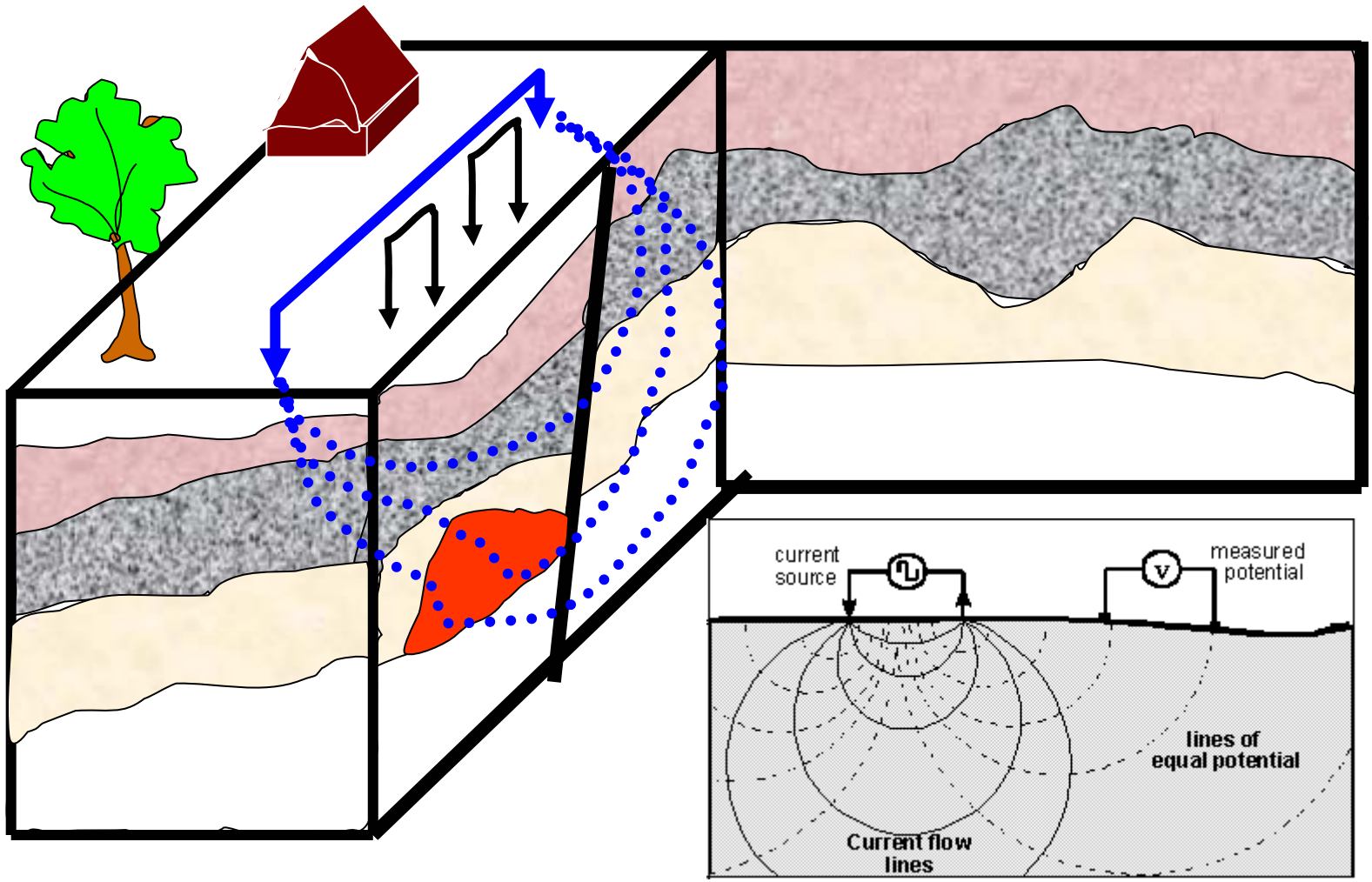
- What is the problem we are trying to solve?

- Decide the “appropriate” physics and “appropriate” scale to probe the Earth.

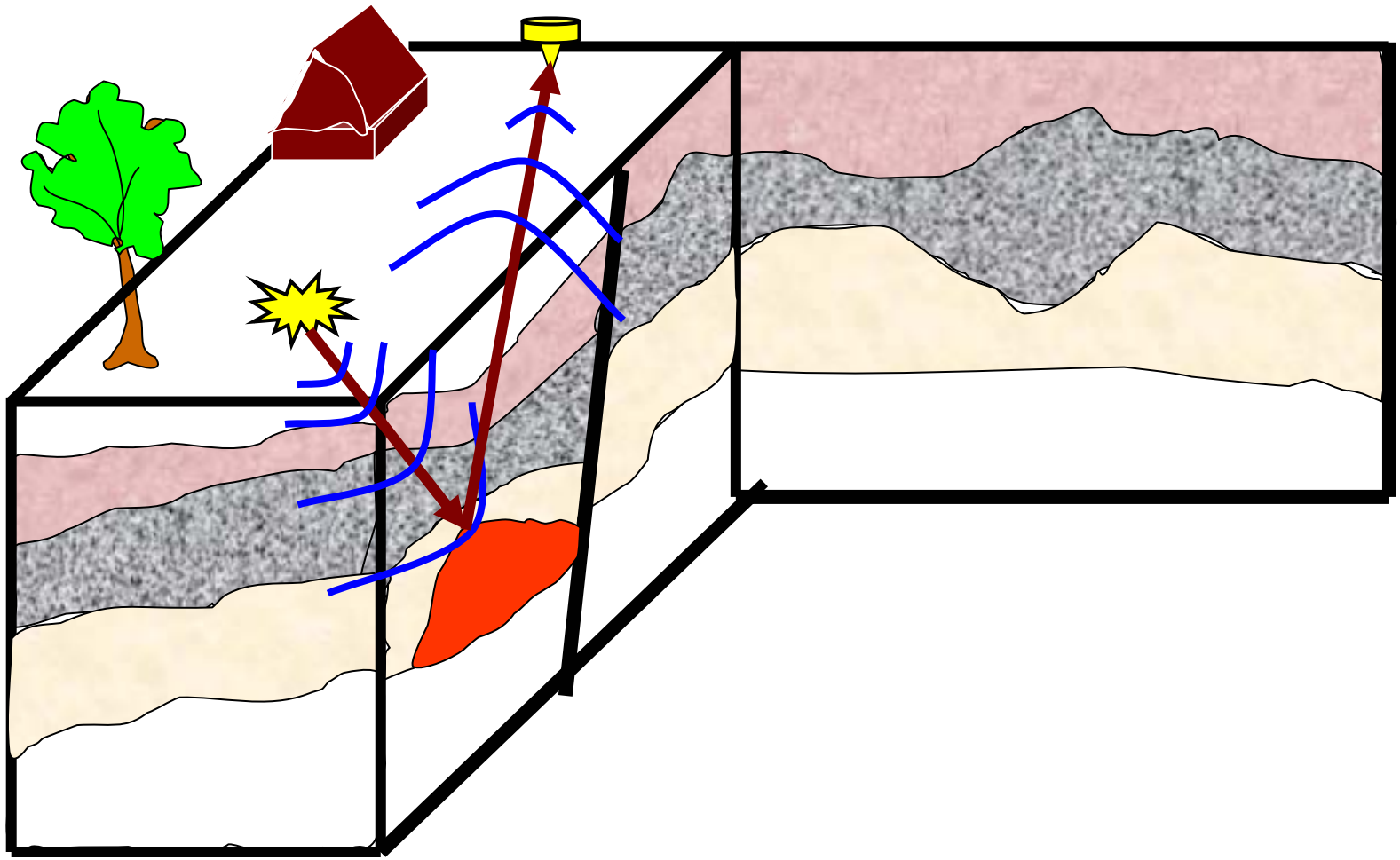
Why Physics?

- Geophysics is an indirect way of obtaining information about subsurface.
- First associate what change in subsurface will give rise to the understanding of the problem.
- Changes or **Anomaly** are crucial:
  - density of material, electrical conductivity, magnetic susceptibility, dielectric property, rigidity, bulk modulus
- Based on the property choose the governing physics.

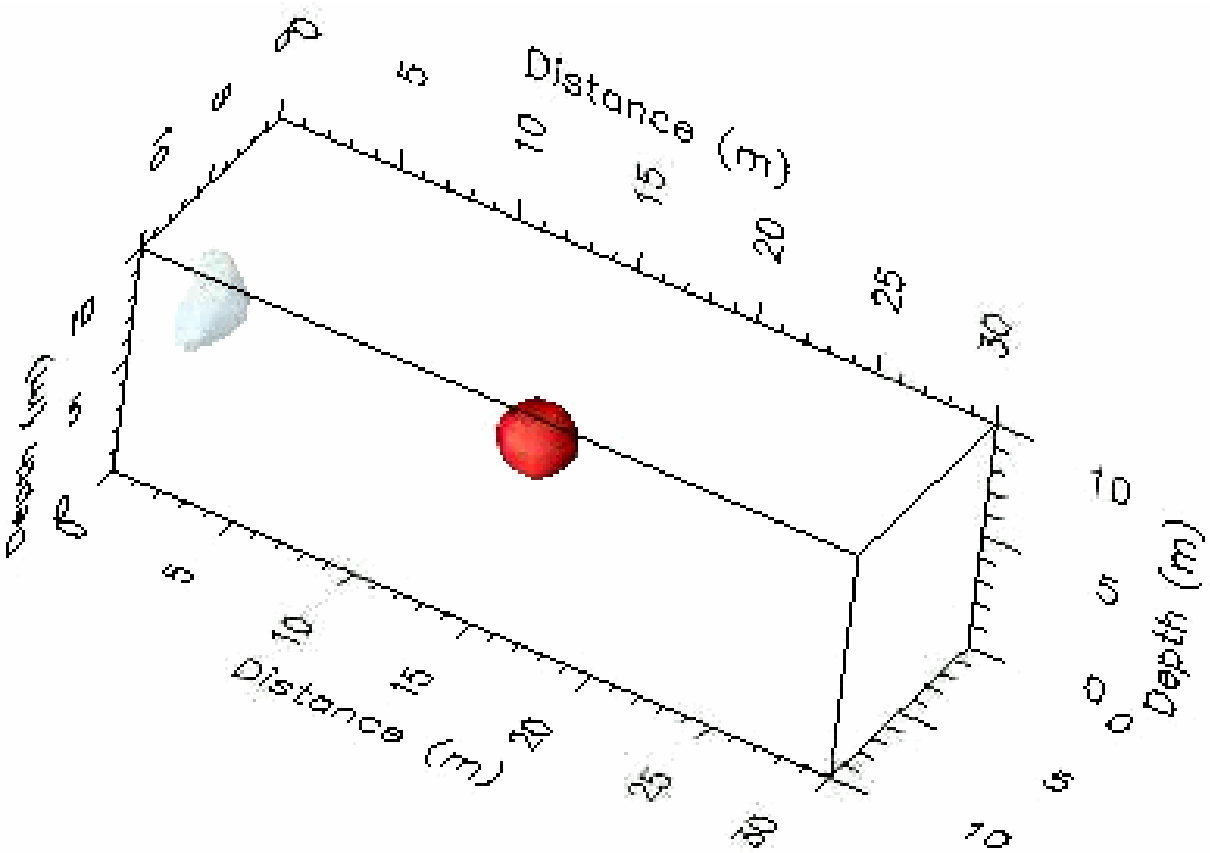
Looking inside the Subsurface: Electrical



Looking inside the Subsurface: Seismic/Radar

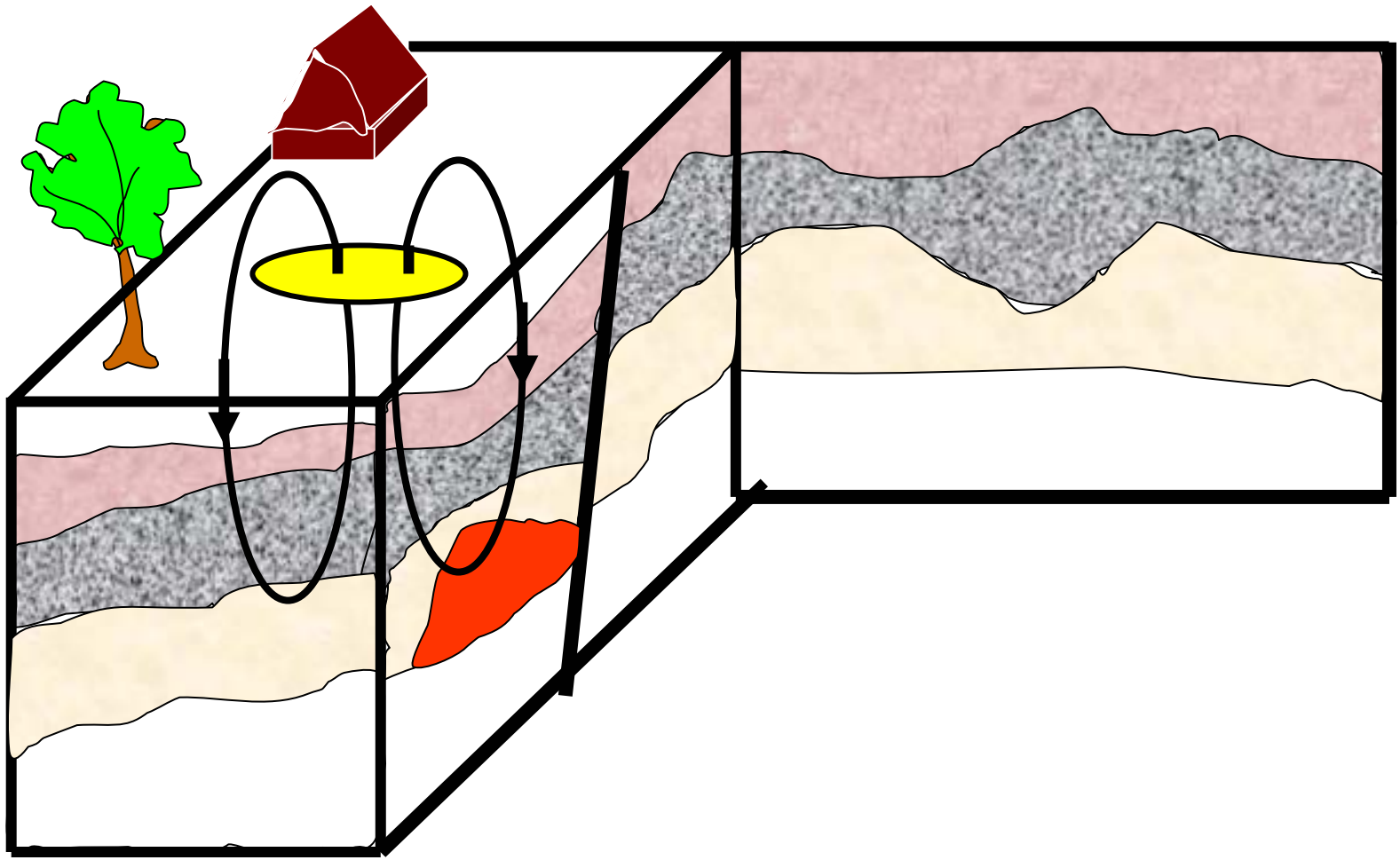


Wave Propagation Example

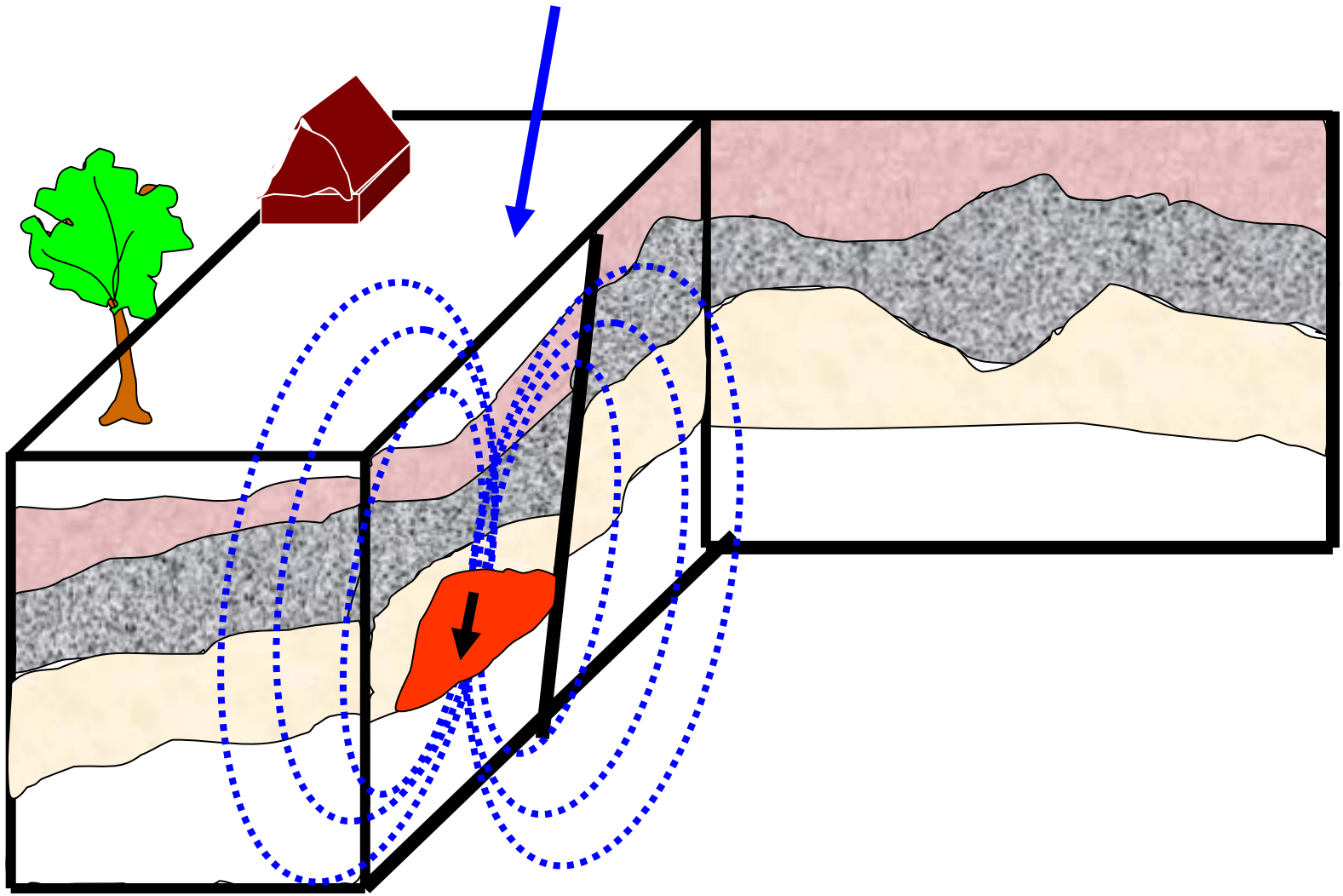


- Radar Wave Propagation
- Background = 0.001S/m Scatterer = 0.1 S/m

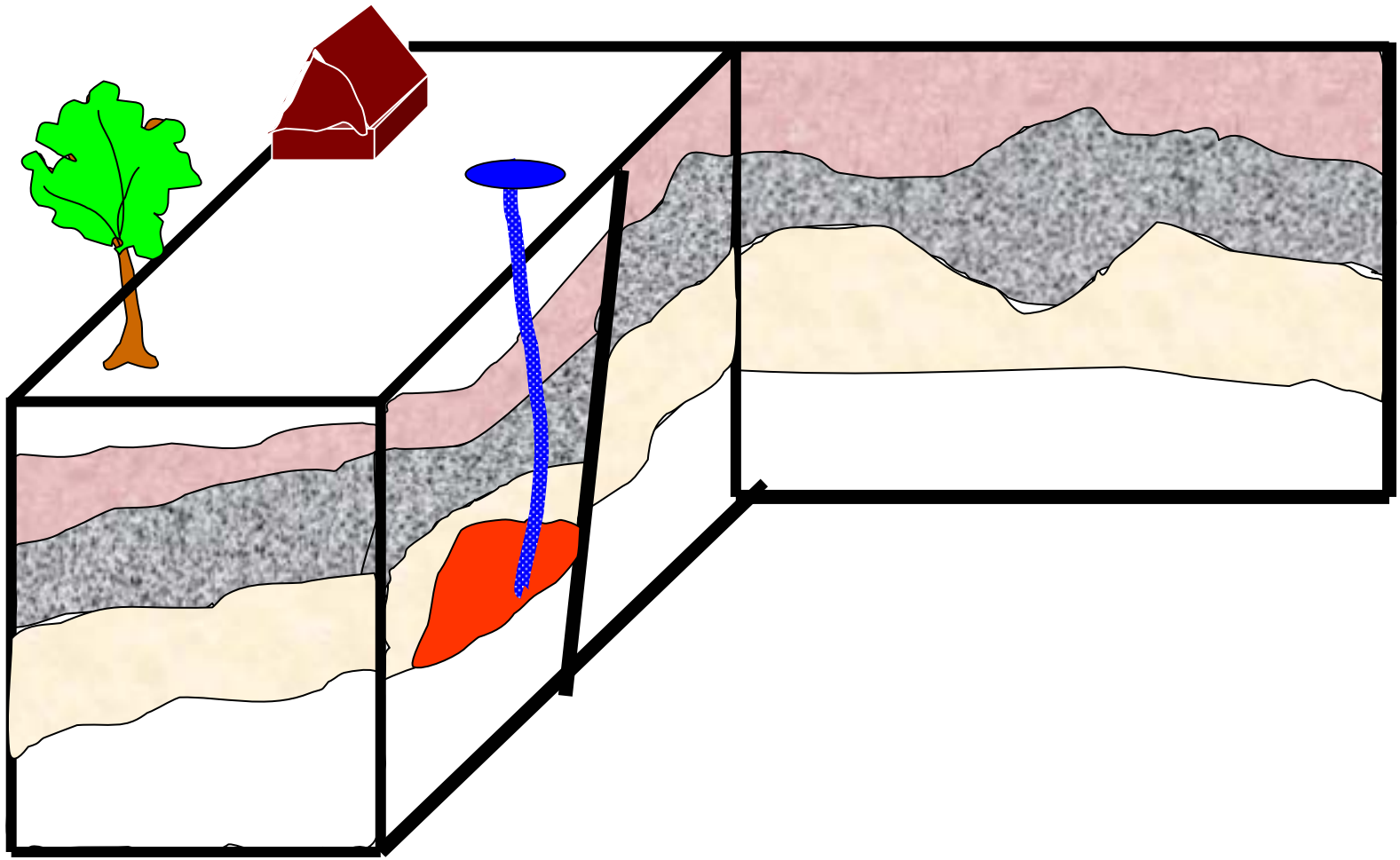
Looking inside the Subsurface: Electromagnetics



Looking inside the Subsurface: Magnetics



Looking inside the Subsurface: Borehole Methods



Summary of Geophysical Methods

- Gravity
- Magnetics

Potential Fields

- Electrical
- Heat Flow
- Electromagnetics (EM)

Diffusive Fields

- Seismic (Sound Waves)
- Radar (EM Waves)

Wave Propagation

Exploration Geophysics: Geothermal Energy

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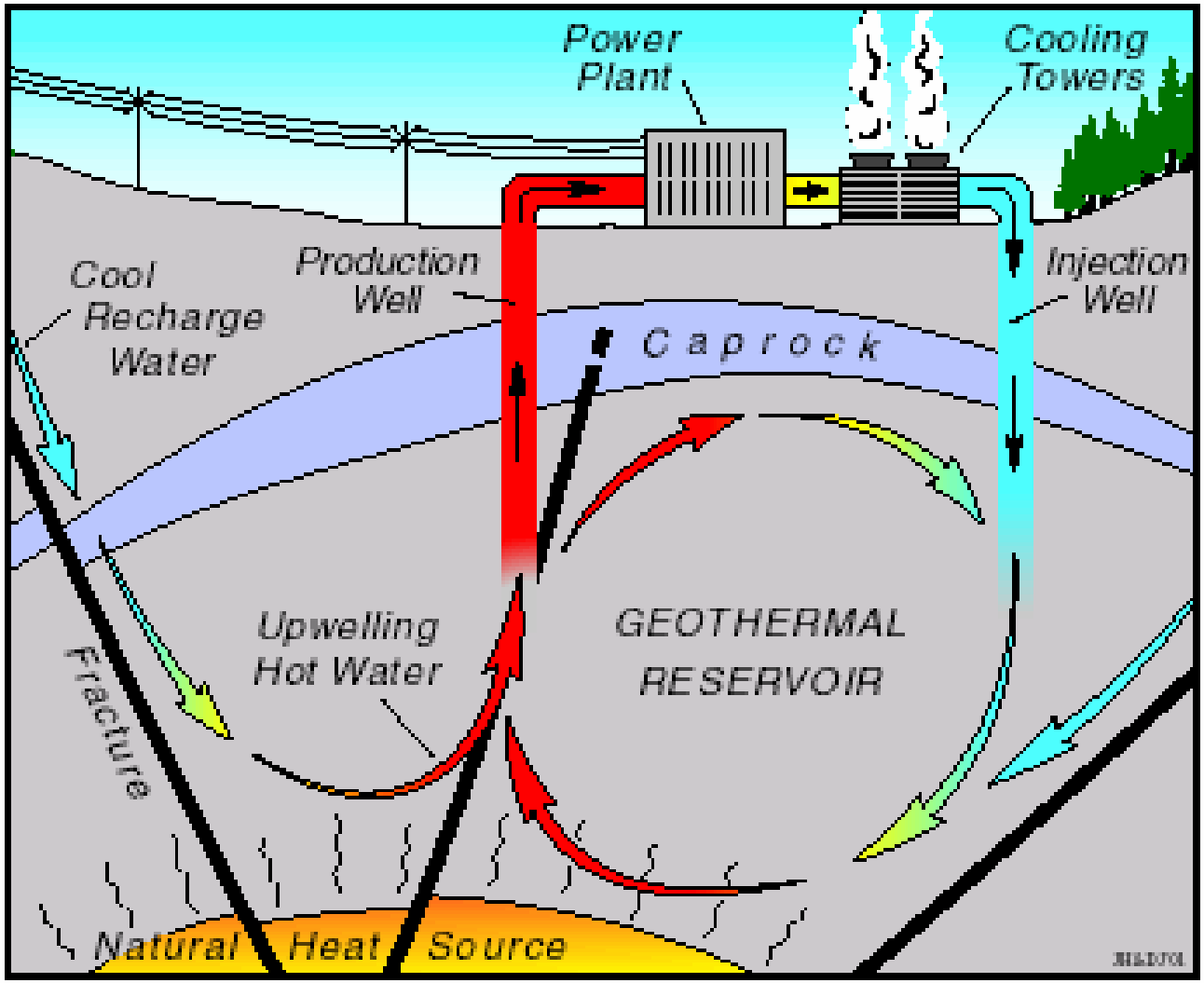
Exploration Geophysics: Geothermal Energy

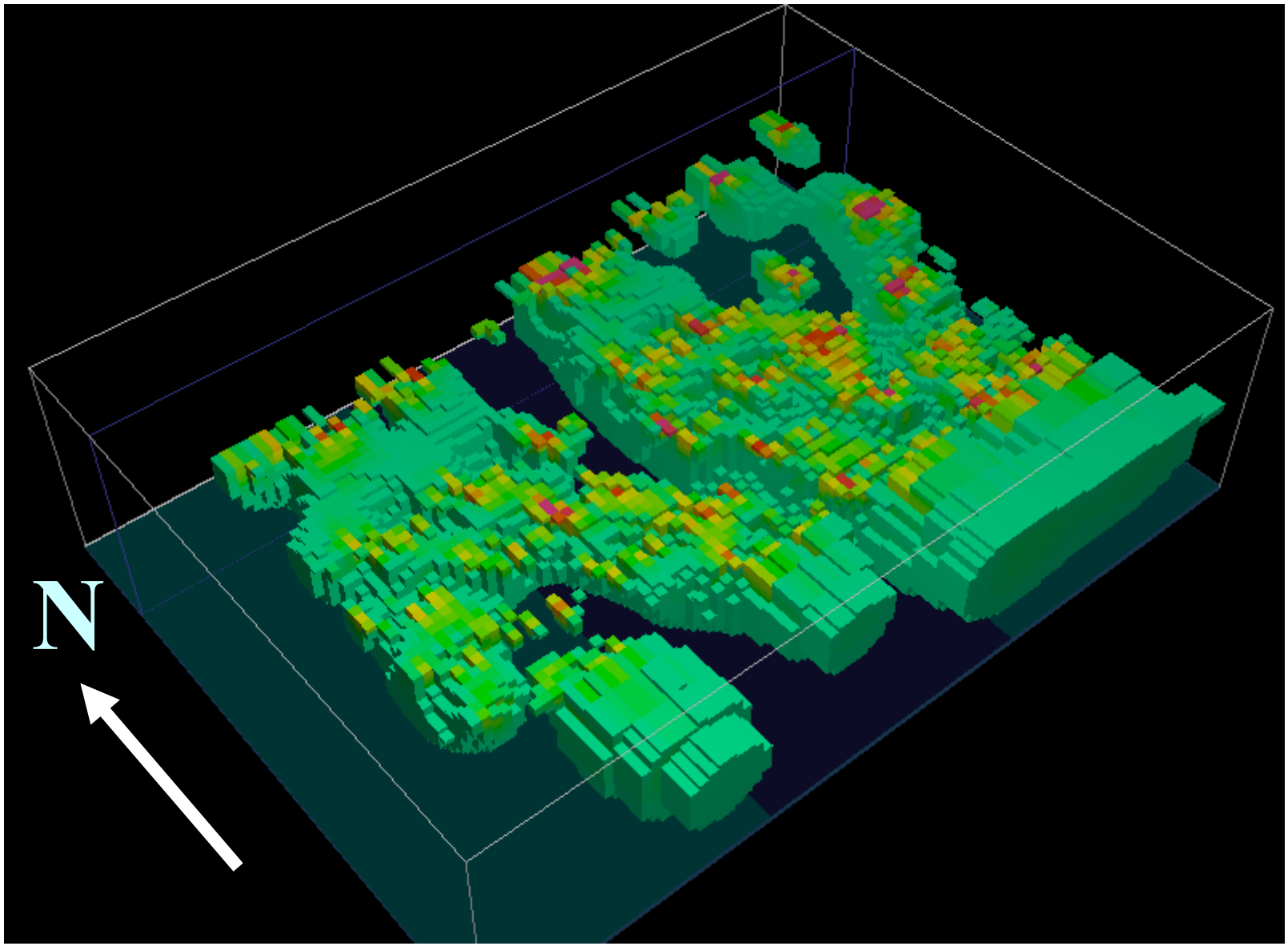


Electromagnetic

Seismic

Magnetic

Imaging Geothermal Targets using Electromagnetics



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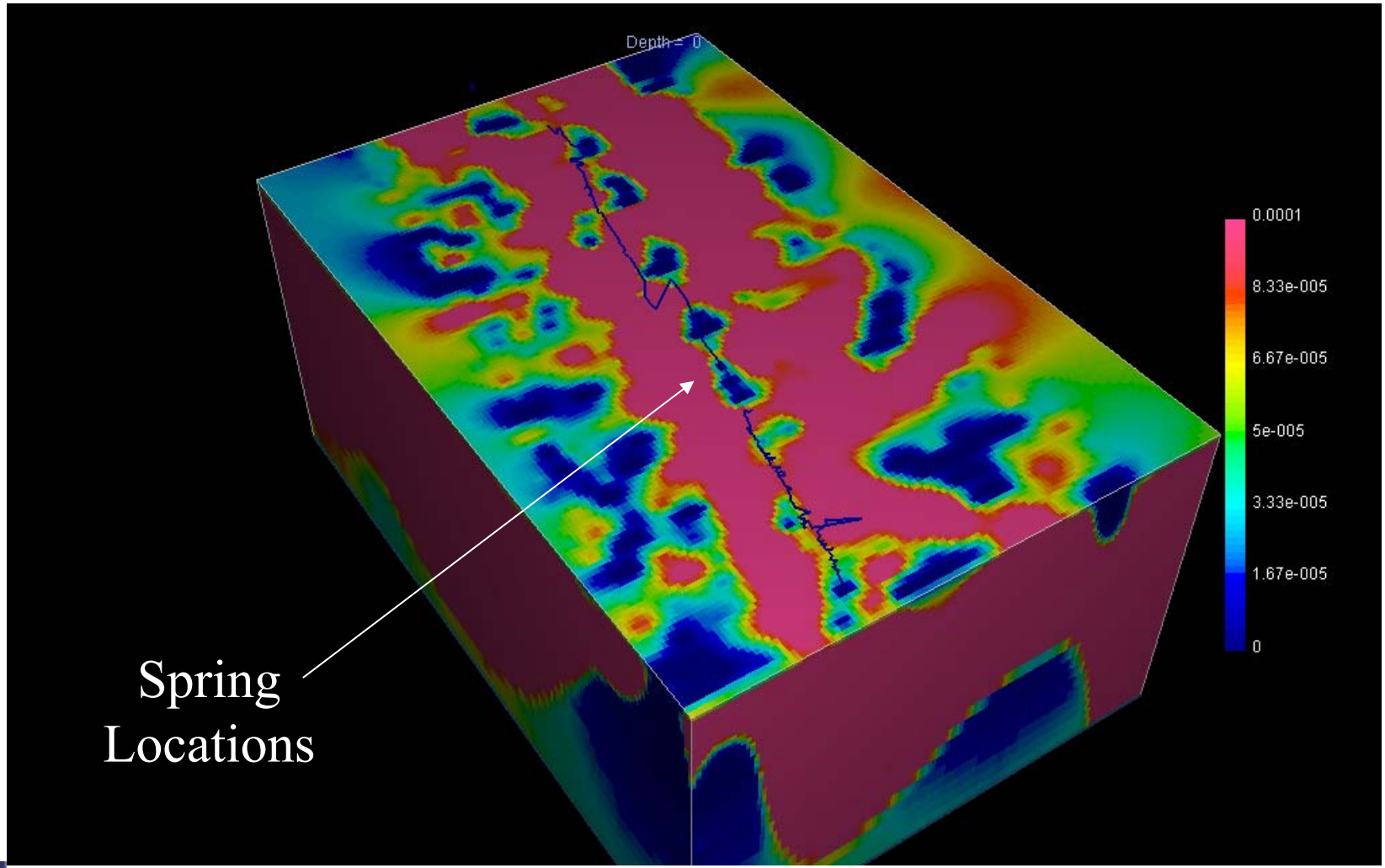
Imaging Hot Springs Using Magnetics



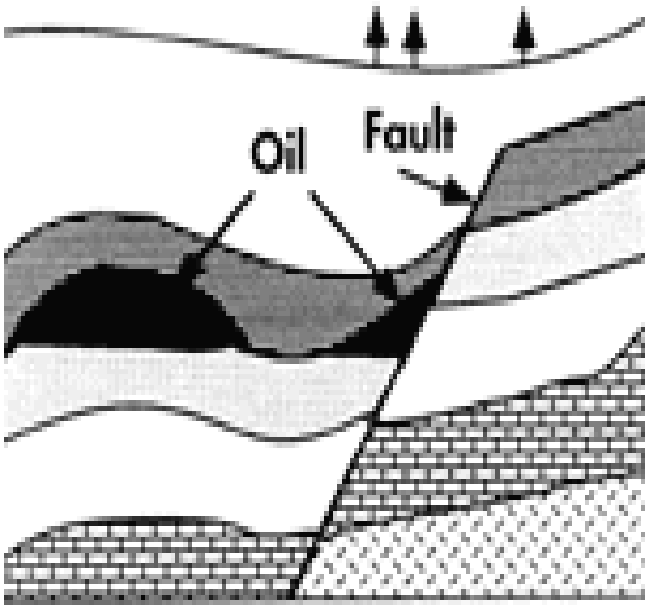
Exploration Geophysics: Oil and Gas

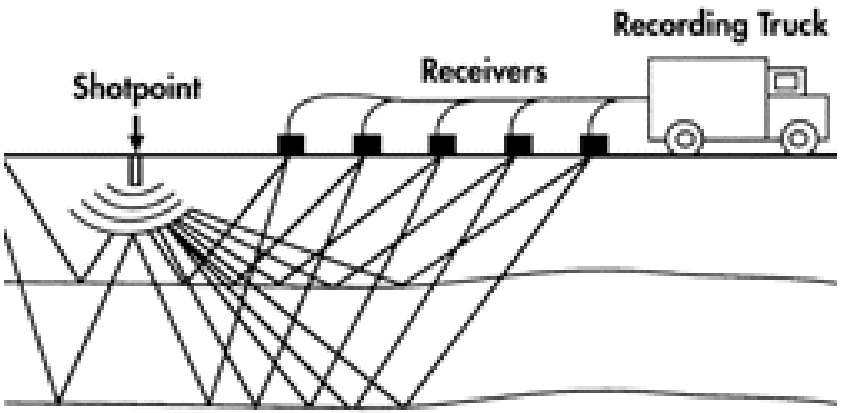
Gravity

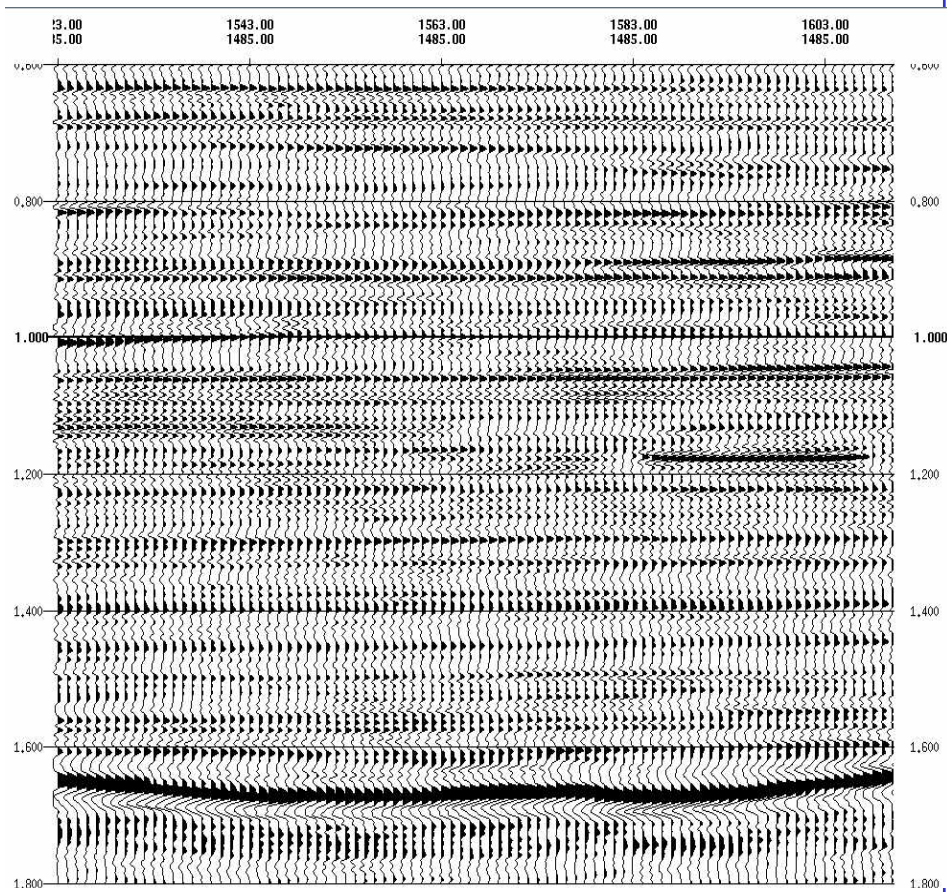
Seismic

Electromagnetic

Exploration Geophysics: Oil and Gas







Seismic Data

Recent News: Oil and Gas

Chevron says Gulf drilling a success

Well could become the nation's biggest new domestic source of oil, according to newspaper report.

September 5 2006: 12:36 PM EDT

NEW YORK (Reuters) -- Chevron Corp. said Tuesday it had successfully drilled for oil in the Gulf of Mexico's deep waters, in what could be one of the most significant finds for the domestic oil industry in a generation.

The successful well, known as Jack 2, reached a record total depth of 28,175 feet, coming in 7,000 feet of water and more than 20,000 feet under the sea floor. Analysts said the find suggested the success of that drilling may mean more oil than previously believed is available under the Gulf of Mexico, a region that already provides a quarter of U.S. output.

Geophysics/Physics/Engg. is Crucial for these discoveries!

Oil Reserves

Rank	Country	Proved reserves (billion barrels)
1.	Saudi Arabia	264.3
2.	**Canada**	**178.8**
3.	Iran	132.5
4.	Iraq	115.0
5.	Kuwait	101.5
6.	United Arab E	97.8
7.	Venezuela	79.7
8.	Russia	60.0
9.	Libya	39.1
10.	Nigeria	35.9
11.	**United States**	**21.4**
12.	China	18.3

Rank	Country	Proved reserves (billion barrels)
13.	Qatar	15.2
14.	Mexico	12.9
15.	Algeria	11.4
16.	Brazil	11.2
17.	Kazakhs.	9.0
18.	Norway	7.7
19.	Azerbaijan	7.0
20.	India	5.8
Top 20 countries		90.2
Rest of world		68.1
World total		**1,292.5**

Source: oil & gas

Exploration Geophysics: Mining

Magnetics

Electromagntic

Seismic

Gravity

Exploration Geophysics: Mining

Electromagnetic Survey in Australia

Environmental Geophysics: Contaminants/Objects

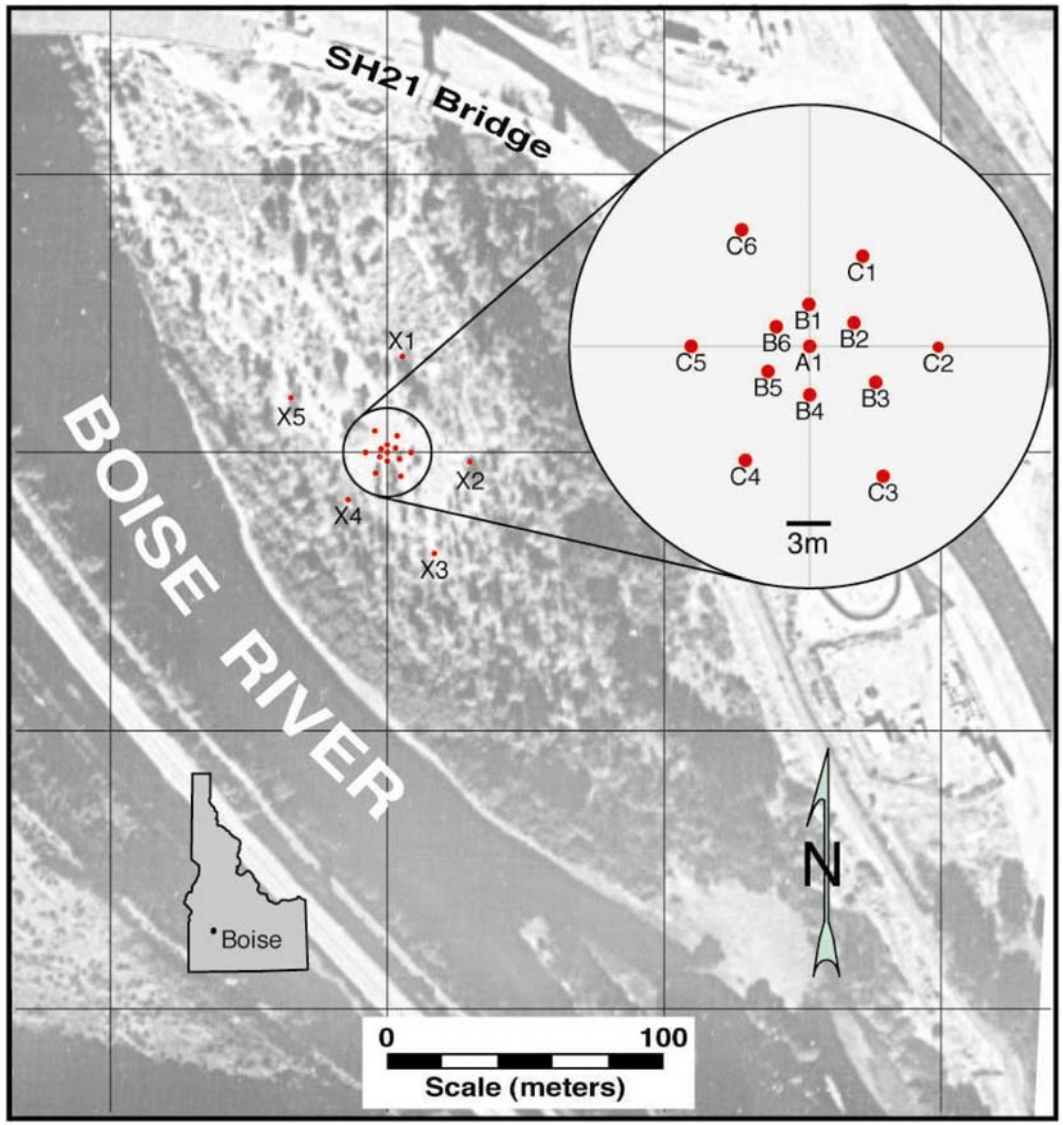
Magnetics

Electromagnetic

Seismic

Gravity

Environmental Geophysics: Ground Water



Electromagnetic

Electrical

Seismic

Geophysics: Career Opportunity

- **Solid Earth:** Earthquakes, Tsunamis, Geodynamics

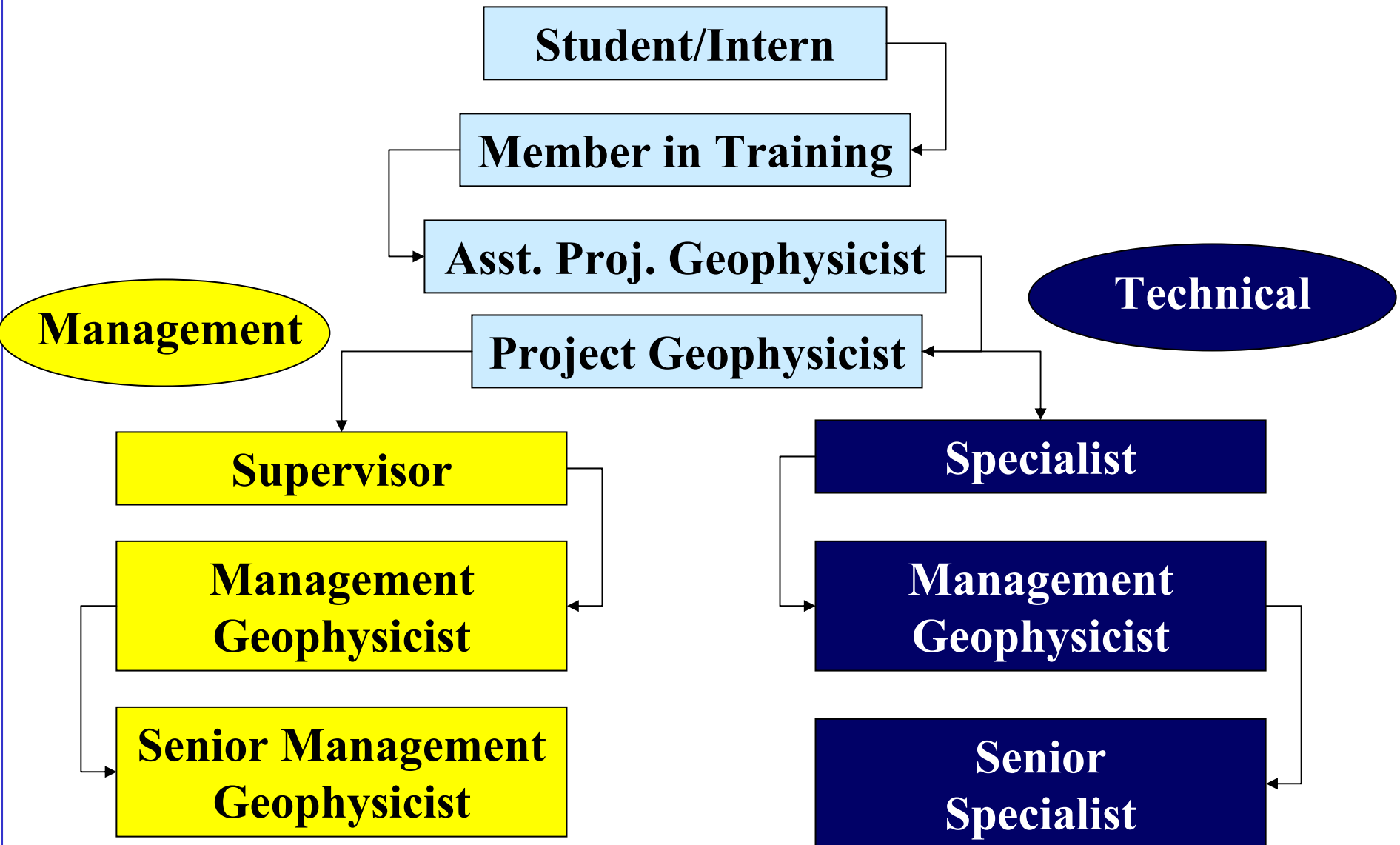
- **Places to Look for jobs:** Academia, USGS, National Labs, Government Agencies, Defense Labs

Geophysics: Career Opportunity

- **Exploration Geophysics:** Oil and Gas

- **Places to Look for jobs:** Academia, Oil and Gas Industry (ExxonMobil, Shell, ConocoPhillips, BP, Chevron,…), Service Industry (Schlumberger, Halliburton, CGG, Veritas,…..)

Example of Industry Career Growth



Source: oil & gas

Geophysics: Career Opportunity

- **Exploration Geophysics:** Mining

- **Places to Look for jobs:** Government agencies, Newmont Gold Exploration, Placer Dome, BHP, INCO, Various consulting firms…

Geophysics: Career Opportunity

- **Environmental Geophysics:** Environmental/Groundwater

- **Places to Look for jobs:** Academia, Government agencies such as National Labs, Defense, Numerous consulting firms, USGS,…