

PHYSICAL GEOLOGY

GEOLOGY 1

Instructor: Dr. **Haibo Zou**

T and TH: 11:10-12:35

Office hour: Tuesday, 12:50-2:00

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GOLOGY 1 - Physical Geology - Spring 2006 Syllabus

Geology 1 Physical Geology is an introductory level class designed to provide a broad overview of how the Earth works. The goals of the class are (1) to gain a general understanding of important earth processes (e.g., plate tectonics, Earthquake, volcanism, weathering and erosion, and glaciation) and (2) to learn the knowledge of rocks, minerals, and geologic resources. The course provides a fundamental scientific background for students who are interested in working in the fields of resource (oil and metal) industry, environmental protection and hazard reduction, land-use planning and geological research in the future.

- *I am dedicated to your success in my class.* If you do your part by studying hard, you will succeed in this class.
- I encourage you to ask questions.



WEEK	DAY	DATE	TOPIC	CHAPTER
1	T	2/7	Introduction, <i>Geology</i> and Earth Processes	1
	TH	2/9	Time and <i>Geology</i>	8
2	T	2/14	Minerals 1	9
	TH	2/16	Minerals 2	9
3	T	2/21	Volcanism	10
	TH	2/23	Igneous Rocks 1	11
4	T	2/28	Igneous Rocks 2	11
	TH	3/2	Sedimentary Rocks 1	14
5	T	3/7	Sedimentary Rocks 2	14
	TH	3/9	Metamorphic Rocks 1	15
6	T	3/14	Metamorphic Rocks 2, Review Before Midterm	
	TH	3/16	Midterm Exam 1 (25% of grade)	
7	T	3/21	Earth's Interior	2
	TH	3/23	Sea Floor	3
8	T	3/28	Plate Tectonics 1	4
	TH	3/30	Plate Tectonics 2	4
9	T	4/4	Earthquake 1	7
	TH	4/6	Earthquake 2	7
10	T	4/11	Holiday- Spring Break	
	TH	4/13	Holiday- Spring Break	
11	T	4/18	Mountain Belts	5
	TH	4/20	Geologic Structure 1	6
12	T	4/25	Geologic Structure 2, Review Before Midterm	
	TH	4/27	Midterm Exam 2 (25% of grade)	
13	T	5/2	Weathering and Soil 1	12
	TH	5/4	Weathering and Soil 2	12
14	T	5/9	Groundwater	17
	TH	5/11	Glaciation	19
15	T	5/16	Desert	18
	TH	5/18	Geologic Resources	21
16	T	5/23	Other Planets	
	TH	5/25	Comprehensive Review of the Class	22
17	T	5/30	Final Exam (30% of grade)	

Class Policies

1) Textbook and reading:

The textbook, **Physical Geology Earth Revealed**, is required and there is a reading assignment for every class. Lectures highlight and extend topics presented in the reading.

2) Attendance:

Attendance at lectures is extremely important! Exams are based on materials presented in lectures, including some information not in the textbook. Pop quizzes will be frequently given in lectures and all quizzes will amount to **20%** of your grade.



3) Exams and Grading:

- There are two in-class exams (dates marked in the syllabus) and a cumulative final exam during finals week. The two in-class exams are each worth 25% of your grade for the course, and the final is worth 30%.
 - o In-class quizzes = 20% of grade;
 - o In-class exams 2 X 25% = 50% of grade;
 - o Final exam = 30 % of grade.

4) Courtesy to your fellow students: Please arrive for class on time. Silence your cell phone before class and do not answer in class.

5) Academic Integrity



WHO NEEDS GEOLOGY?

- Supplying things we need (metals, energy resources—petroleum, coal, nuclear power)
- Protecting the environment (lessen or prevent damage to the environment)
- Avoiding geologic hazards (Earthquakes, volcanic eruptions, landslides, floods and tsunamis)
- Understanding our surroundings (gain knowledge and find new truth about the world around them)



What Geologists Do:


- Locate **Geologic Resources** (water, petroleum, natural gas, metal ores, industrial minerals)
- Investigate, forecast and mitigate **natural hazards** (earthquakes, volcanic eruptions, weather hazards, sea-level changes, floods, landslides, environmental degradation)
 - Geological and Mining Engineering
 - Site Study
 - Land-Use Planning
- **Environmental Protection**
 - Environmental Impact
 - Ground Water and Waste Management
- Do **Basic Research** on Earth system processes and the Earth's history, furnishes fundamental knowledge for the applications)

- **Mineralogy:** The examination, classification, and analysis of minerals, gems, and precious stones.
- **Petrology:** The analysis and classification of rocks to learn their origin and history.
- **Structural Geology:** The study of the deformation of rocks and the forces that cause deformation.
- **Sedimentology:** The study of modern and historic depositional environments.



- **Paleontology:** The reconstruction of past environments by studying fossils and other life forms.
- **Geochemistry:** The study of the chemical composition of rocks and minerals for a variety of environmental and economic applications.
- **Geophysics:** The study of gravity, magnetism, and seismic characteristics of the Earth.



- **Seismology**: The study of the location and force of earthquakes to understand their origin and minimize their effects.
 - **Geomorphology**: The study of the shape of the surface of the earth and the processes that create those shapes.
 - **Economic Geology**: The study of economically valuable earth materials such as ore deposits.
 - **Petroleum Geology**: The use of geologic techniques to locate oil reserves and determine methods for profitable extraction.
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- **Hydrogeology**: The study of the location, movement, and chemical composition of groundwater.
- **Oceanography**: The study of the physical aspects of oceans such as their currents and their interaction with the atmosphere.
- **Remote Sensing**: The use of radar, sonar, seismology, and aerial photography to locate and analyze the internal and external formations of the earth.



The Scientific Method

Observation - Evidence that can be measured or observed.

Hypothesis - Formation of an explanation of the observation. An untested idea.

Hypothesis Testing - Designing an experiment that tests your hypothesis. Ideas are continually challenged. Differences in opinions often lead to advances in science.



The Scientific Method

Theory -

- Elevated hypothesis
- Has withstood tests by numerous investigators
- Generally accepted by the scientific community

Law -

- Universally accepted theory
- No deviations have ever been observed.
- Most certain concept in science

- Learn to make observations
- Develop skills to interpret data
- Become a better informed citizen



Some Unique Aspects of Geology

Importance of **Time**

Importance of **Relationships**

- Sequential
- Spatial

Distinctive Problems of Evidence

- Mostly Slow Rates
- Rare Events
- Destruction of Evidence
- Inaccessibility



Some Unique Aspects of Geology (Continued)

Reliance on **Inference and Deduction**

Intrinsically "Unsolvable" Problems

- Ancient Landscapes
- Mass Extinctions
- Ancient Ocean Basins



Time in the Earth Sciences

- Earth system processes take place over different time scales
 - Short (seconds to years - earthquakes, tides, tsunamis, hurricanes, floods, volcanic eruptions)
 - Long (hundreds to billions of years - formation of soil from bare rock, uplift of mountain ranges, movement of the continents)
- For long processes, earth scientists sometimes use the present to infer what happened in the past - uniformitarianism
- Earth scientists must be "detectives" in order to study the Earth's past (and the Earth's interior)

Some Geologic Rates

Cutting of Grand Canyon

- $2 \text{ km}/3 \text{ m.y.} = 1 \text{ cm}/15 \text{ yr}$

Uplift of Alps

- $5 \text{ km}/10 \text{ m.y.} = 1 \text{ cm}/20 \text{ yr.}$

Opening of Atlantic

- $5000 \text{ km}/180 \text{ m.y.} = 2.8 \text{ cm/yr.}$

Uplift of White Mtns. (N.H.) Granites

- $8 \text{ km}/150 \text{ m.y.} = 1 \text{ cm}/190 \text{ yr.}$



Some Geologic Rates

Movement of San Andreas Fault

- $7 \text{ m}/140 \text{ yr} = 5 \text{ cm/yr.}$

Growth of Mt. St. Helens

- $3 \text{ km}/30,000 \text{ yr} = 10 \text{ cm/yr.}$

Deposition of Niagara Dolomite

- $100 \text{ m}/1 \text{ m.y.} = 1 \text{ cm/100 yr.}$



Scientific Principles in Geology

- Parsimony
- Superposition
- Uniformitarianism

Using these principles in geology, plus observations, we establish facts about Earth Processes

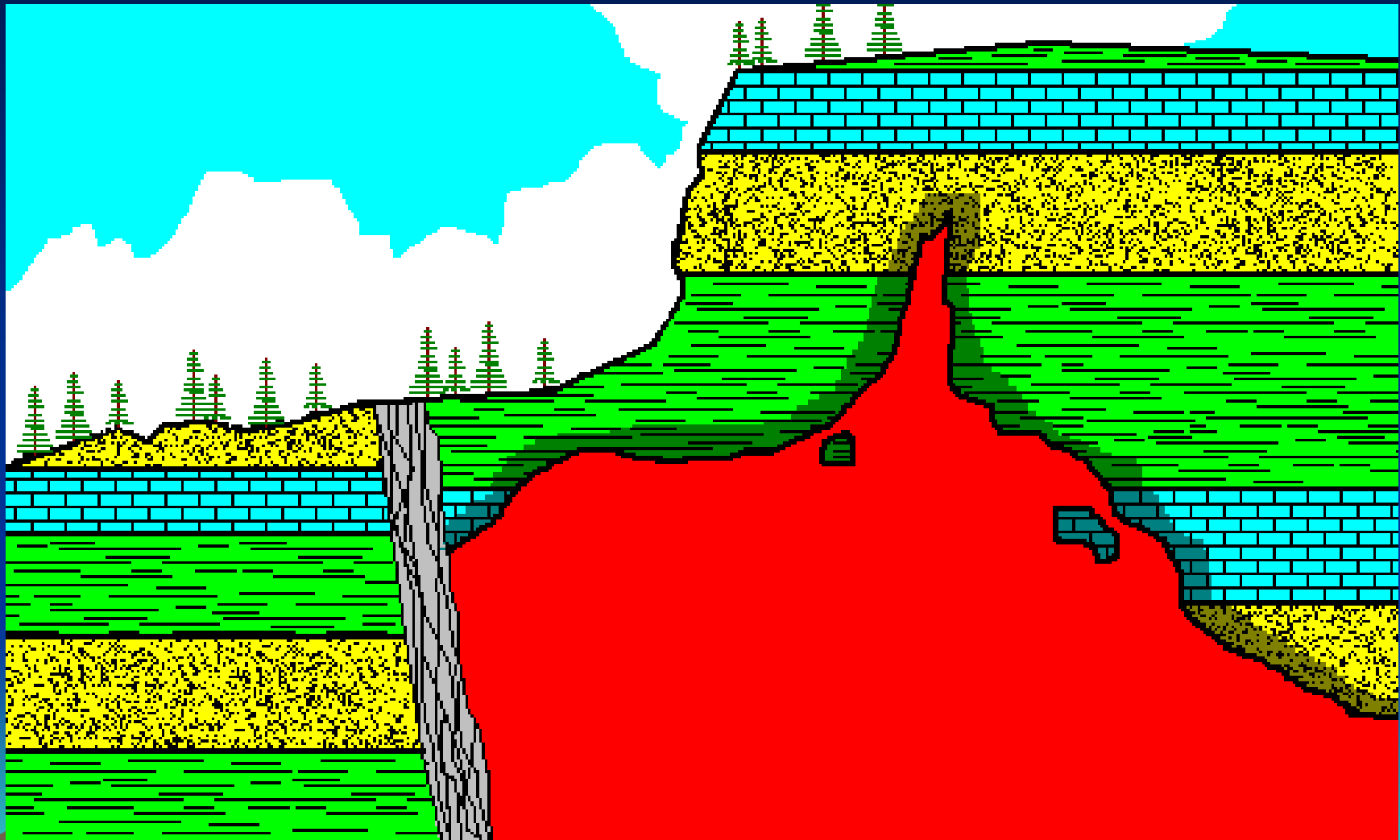


Parsimony

- The simplest explanation that fits all the data is preferred
- Doesn't guarantee that things must be simple!
- Theories with lots of *ad hoc* or unsupported ideas are probably wrong.



Contacts



Uniformitarianism

A geological doctrine that existing processes acting in the same manner as at present are sufficient to account for all geological changes

-The present is the key to the past.



Uniformitarianism

Continuity of Cause and Effect

- Apply Cause and Effect to **Future** - **Prediction**
- Apply Cause and Effect to **Present** - **Technology**
- Apply Cause and Effect to **Past** - **Uniformitarianism**



Uniformitarianism *does* mean:

Using our knowledge of physical laws,
we can test:

- Whether catastrophes have occurred
- Whether physical conditions on earth have changed, and if so, how (ice ages, warm periods, high or low sea level, etc.)
- Whether physical laws themselves have changed in time, or elsewhere in the universe.



Earth Systems

- Atmosphere (the gases that envelop Earth)
- Hydrosphere (water on or near Earth's surface, including oceans, rivers, lakes, glaciers)
- Biosphere (all of the living or once-living material on Earth)
- Geosphere (the rock and other inorganic Earth material that make up the bulk of the planet)
 - Crust
 - Mantle
 - Core



Atmosphere & Hydrosphere



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The outermost layers of the earth:

Atmosphere:

Extends to 480 kilometers, most within 16 kilometers

Composed of gases nitrogen (N_2), oxygen (O_2), argon (Ar), carbon dioxide (CO_2), also water vapor (H_2O)

Hydrosphere

All natural water and ice
Oceans are largest part (97%), depths to 11 kilometers

Also rivers, lakes, groundwater, glacial ice

Solid Earth

Crust (5-70 km)

Most abundant elements are silicon (Si) and oxygen (O)

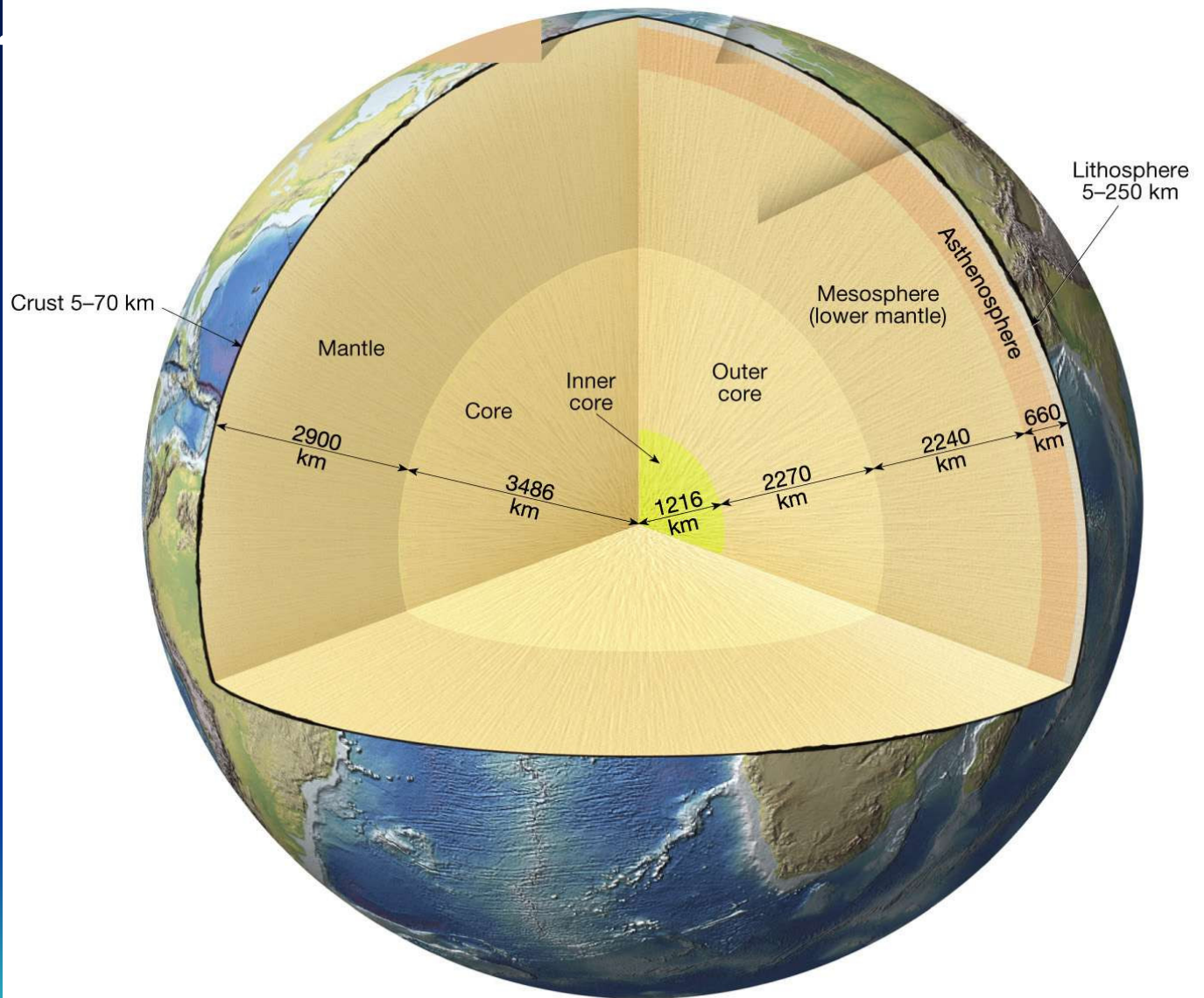
Mantle (2900 km):

Most abundant elements are magnesium (Mg), oxygen (O) and silicon (Si)

Core:

Composed mainly of iron (Fe), with some nickel (Ni), lighter elements

Inner core is solid, outer core is liquid



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Some observations about Solid Earth

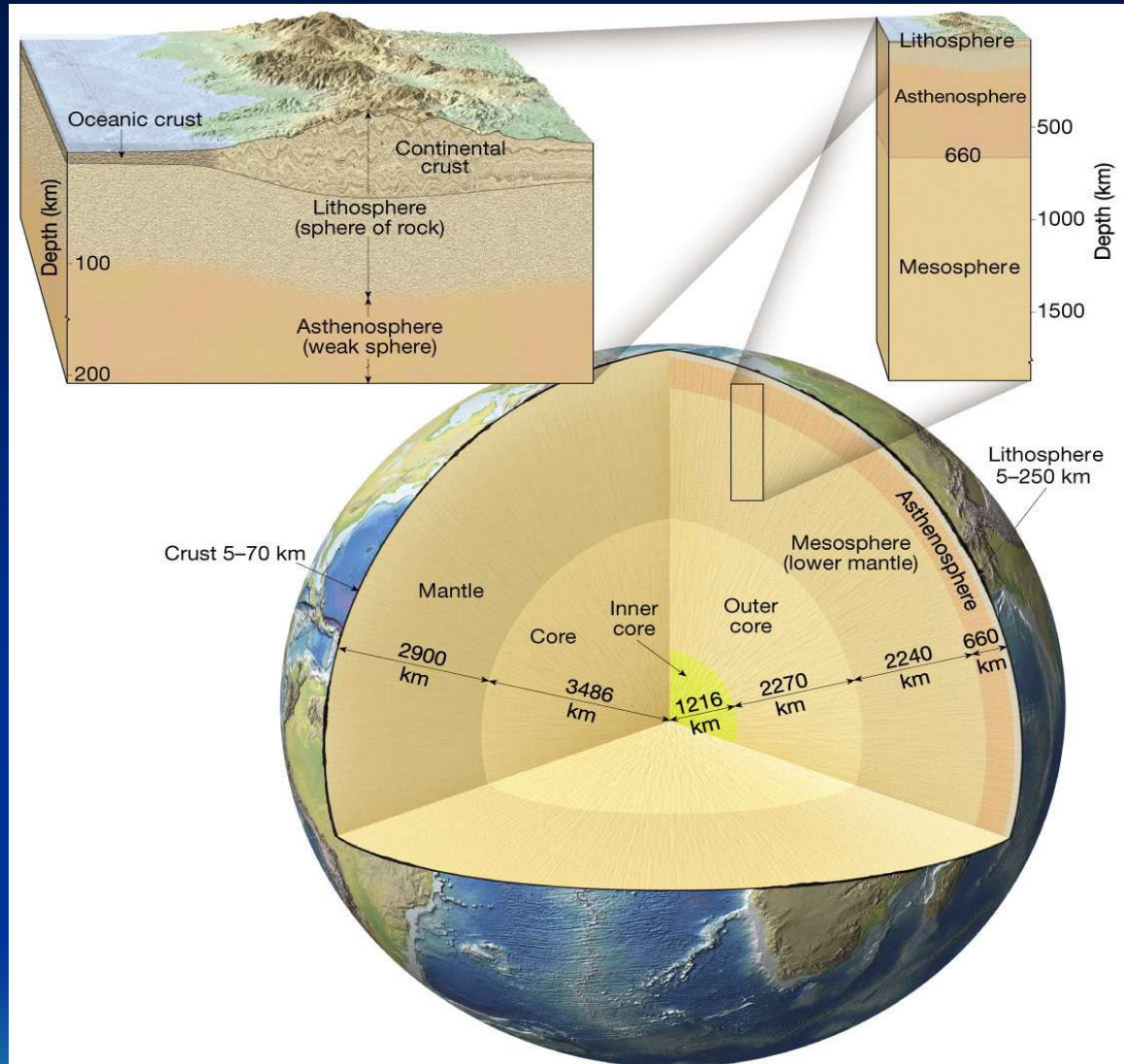
- Densest material is in the interior, volatile (gaseous compounds) on the outside
- Core is metal (denser) and overlying mantle and crust are silicate rock (less dense)
- Part of core is molten metal and metal has a lower melting point than silicate rock



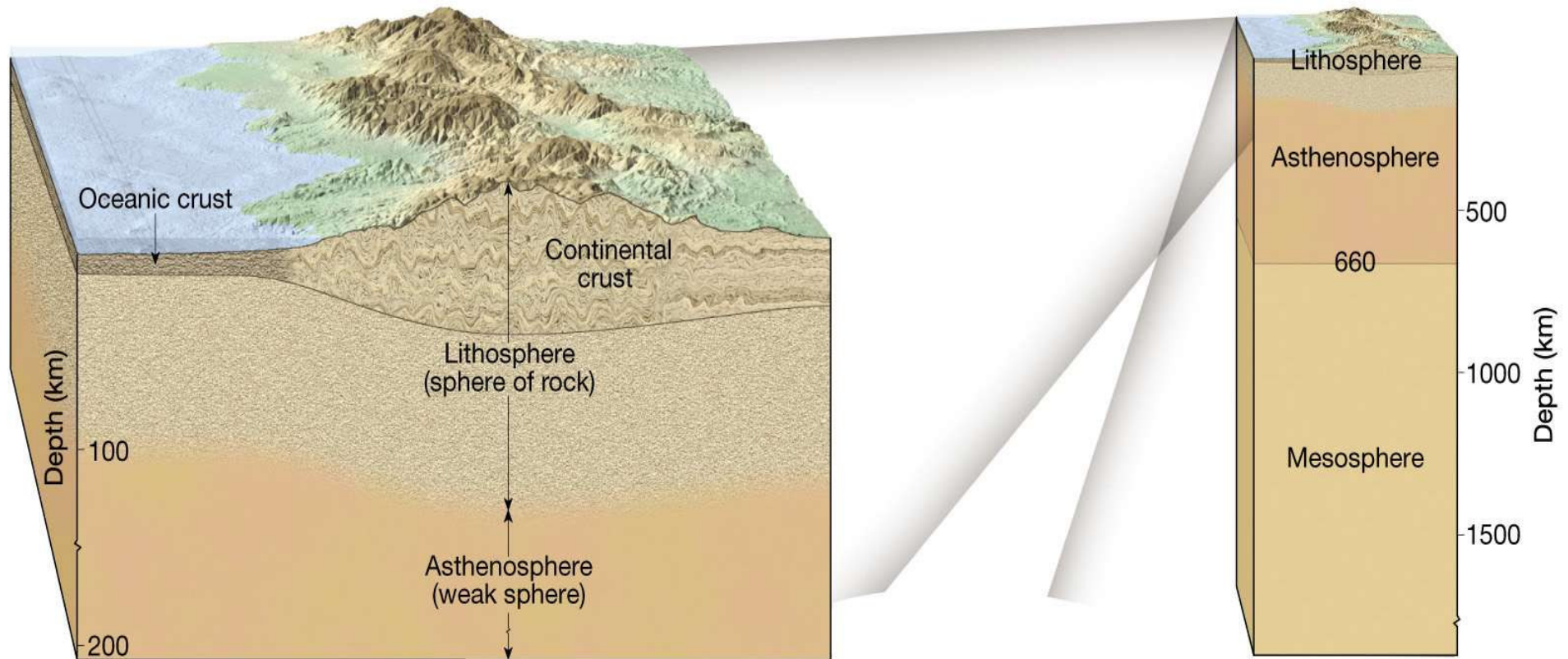
CRUST AND MANTLE

1. Crust
2. Lithospheric mantle
Asthenosphere
Mesosphere
(lower mantle)

Note:
Lithosphere =
crust
+
lithospheric mantle



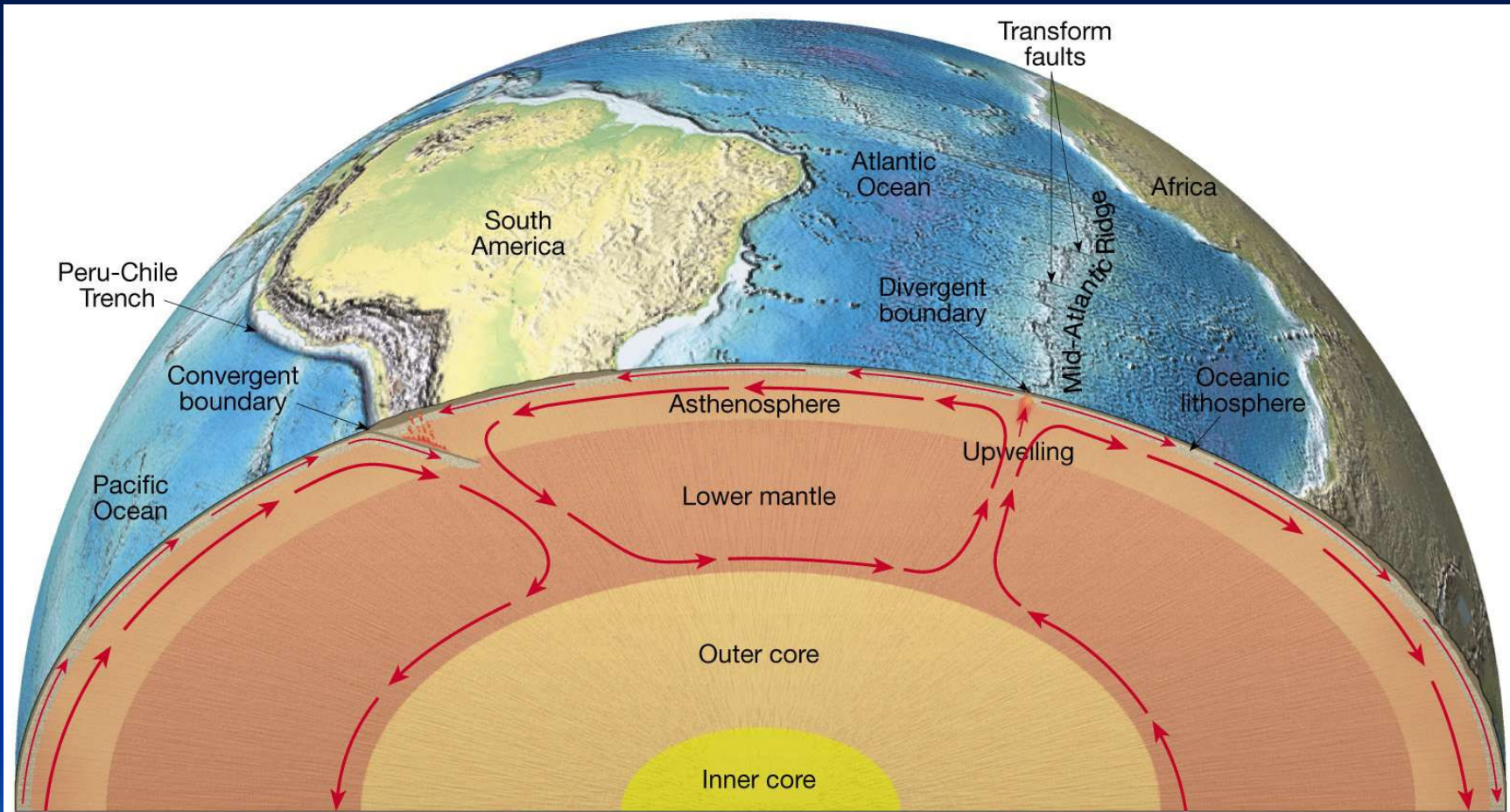
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Three mechanical layers of the crust and mantle:

- **Lithosphere** (crust and upper mantle, about 100 km thick) is strong and brittle
- **Asthenosphere** (mantle, 100-660 km) is plastic and deformable - it contains a small amount of molten rock or magma.
- **Mesosphere** (>660 km) is strong, but not brittle



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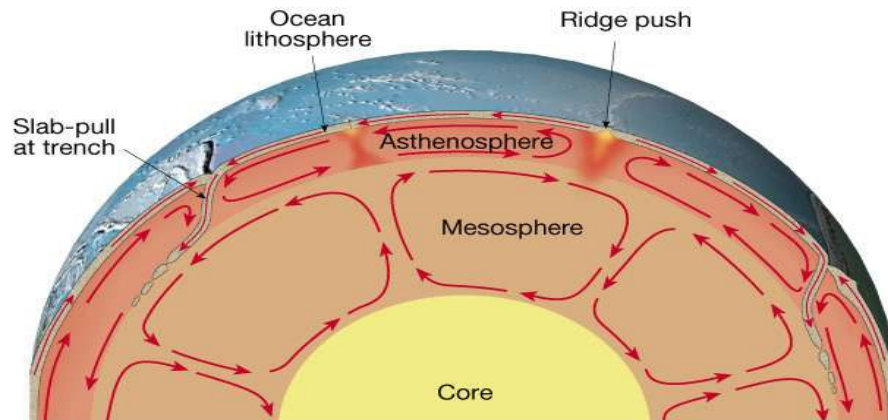
This shows the simplest possible convection pattern, with rising beneath ridges and sinking in subduction zones

Other possible convection patterns are more complex

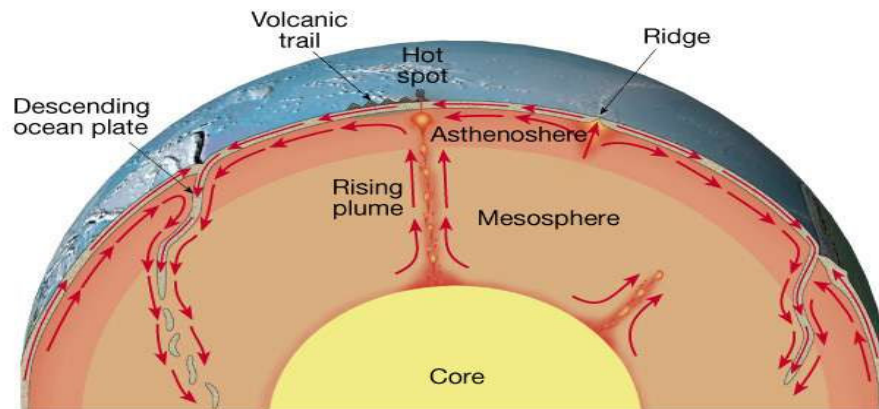
Two layers of convection

Rising beneath hotspots or plumes

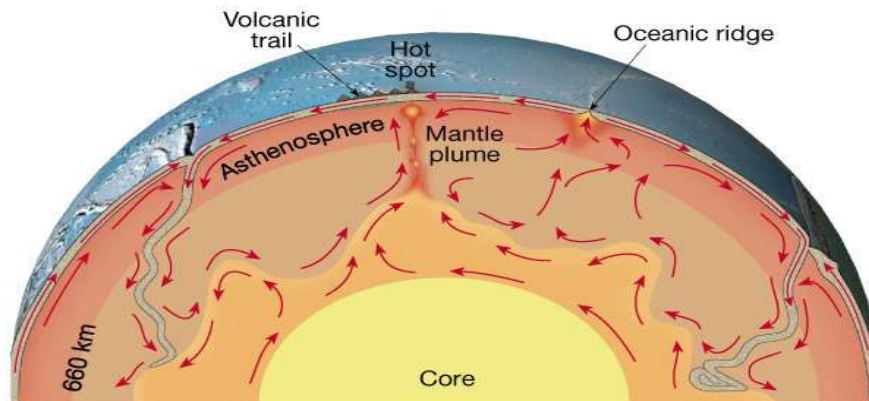
“Lava lamp” model



A. Layering at 660 kilometers



B. Whole-mantle convection



C. Deep-layer model

- End of 1st lecture

