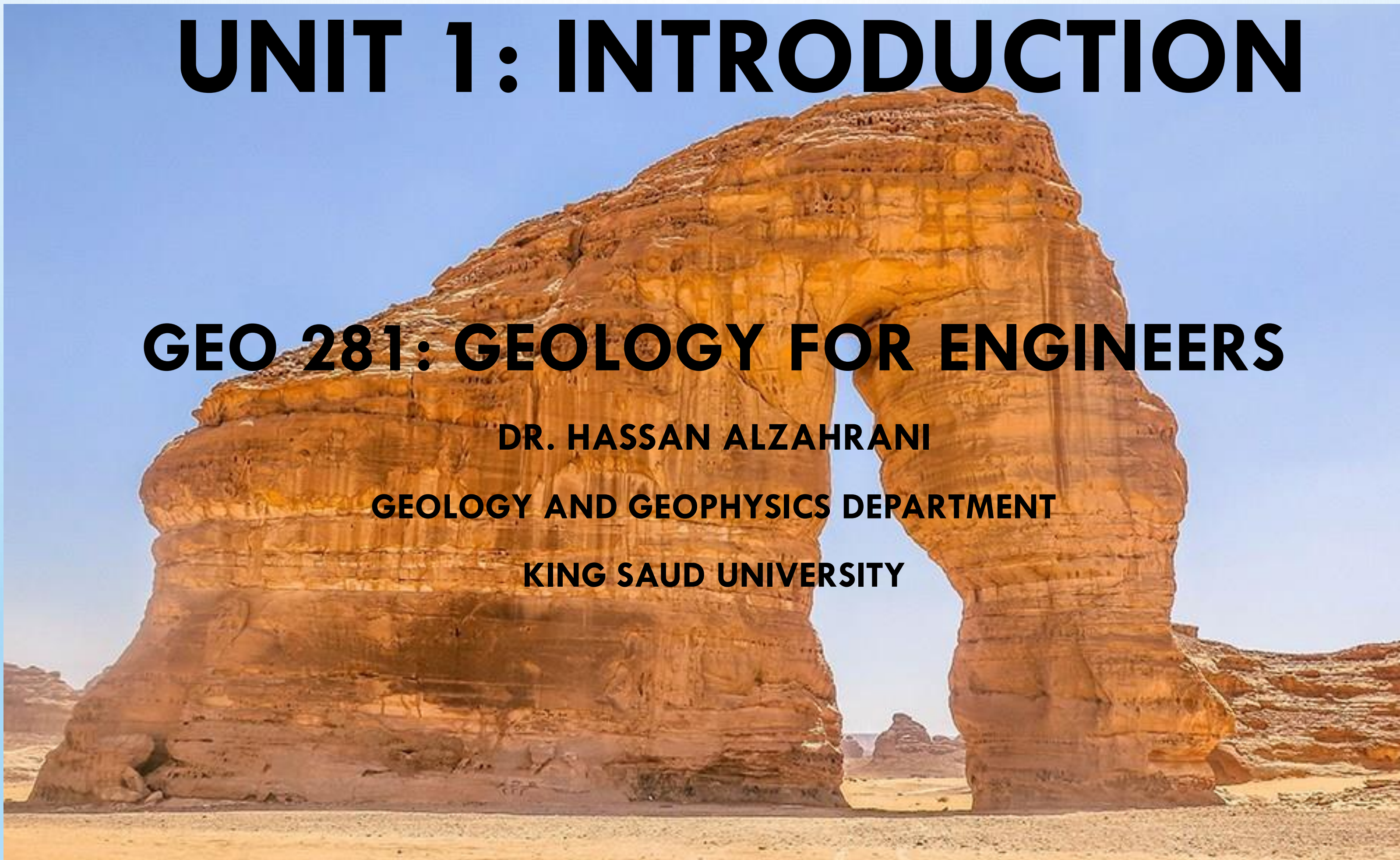

UNIT 1: INTRODUCTION

GEO 281: GEOLOGY FOR ENGINEERS

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IMPORTANCE OF GEOLOGY IN CIVIL ENGINEERING

- **Geology is the study of earth, the materials of which it is made, the structure of those materials and the effects of the natural forces acting upon them** and **is important to civil engineering because all work performed by civil engineers involves earth and its features**.
- Fundamental understanding of geology is so important that it is a requirement in university-level civil engineering programs.
- For a civil engineering project to be successful, the engineers must understand the land upon which the project rests.
- Geologists study the land to determine whether it is stable enough to support the proposed project.
- They also study water patterns to determine if a particular site is prone to flooding.
- Some civil engineers use geologists to examine rocks for important metals, oil, natural gas and ground water.

ROLE OF ENGINEER IN THE SYSTEMATIC EXPLORATION OF A SITE

- The investigation of the suitability and characteristics of sites is an important pre-requisite for any engineering projects as they affect the design and construction of civil engineering works and the security of neighboring structures.
- A professional engineer must have some basic ideas related to geology and site exploration.
- The primary objective of a site investigation is to determine as accurately as may be required-
  - **The nature and sequence of strata;**
  - **The ground water conditions at the site;**
  - **The physical properties of soil and rock underlying the site;**
  - **The mechanical properties, such as strength and compressibility of different soil or rock strata, and**
  - **Other specific information, when needed, such as the chemical composition of the groundwater, and the characteristics of foundations of the adjacent structure.**

ROLE OF ENGINEER IN THE SYSTEMATIC EXPLORATION OF A SITE

- The systematic exploration and investigation of a new site involves five stages of procedure. These stages are:
  - preliminary investigation using published information and other existing data;
  - a detailed geological survey of the site, possibly with a photogeology study;
  - applied geophysical surveys to provide information about the subsurface geology;
  - boring, drilling and excavation to provide confirmation of the previous results, and quantitative detail, at critical points on the site; and
  - testing of soils and rocks to assess their suitability, particularly their mechanical properties (soil mechanics and rock mechanics), either in situ or from samples.

ROLE OF ENGINEER IN THE SYSTEMATIC EXPLORATION OF A SITE

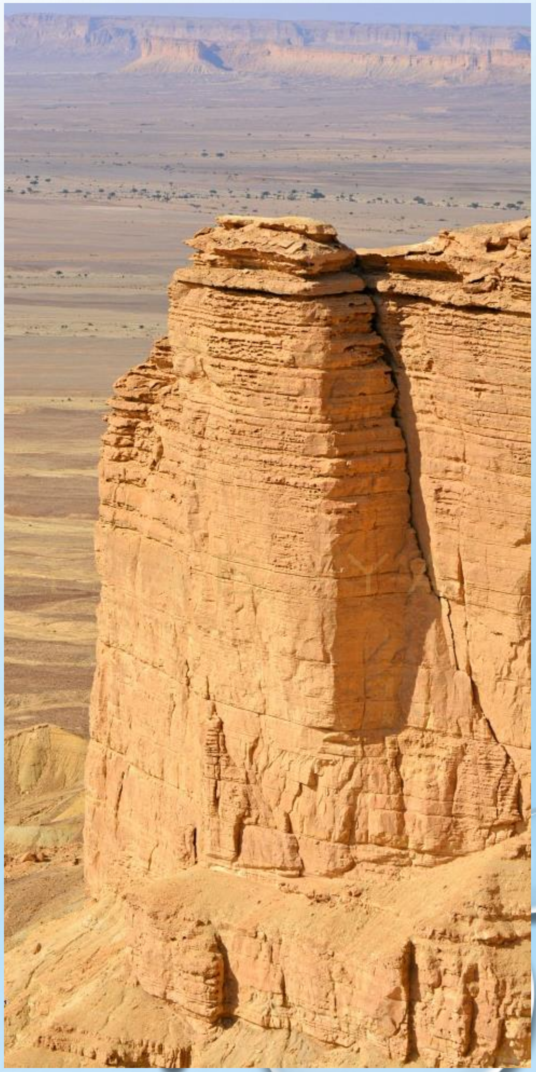
- In a major engineering project, each of these stages might be carried out and reported on by a consultant specializing in geology, geophysics or engineering (with a detailed knowledge of soil or rock mechanics).
- However, even where the services of a specialist consultant are employed, an engineer will have overall supervision and responsibility for the project.
- The engineer must therefore have enough understanding of geology to know how and when to use the expert knowledge of consultants, and to be able to read their reports intelligently, judge their reliability, and appreciate how the conditions described might affect the project.

SIGNIFICANCE OF GEOLOGY TO CIVIL ENGINEERING

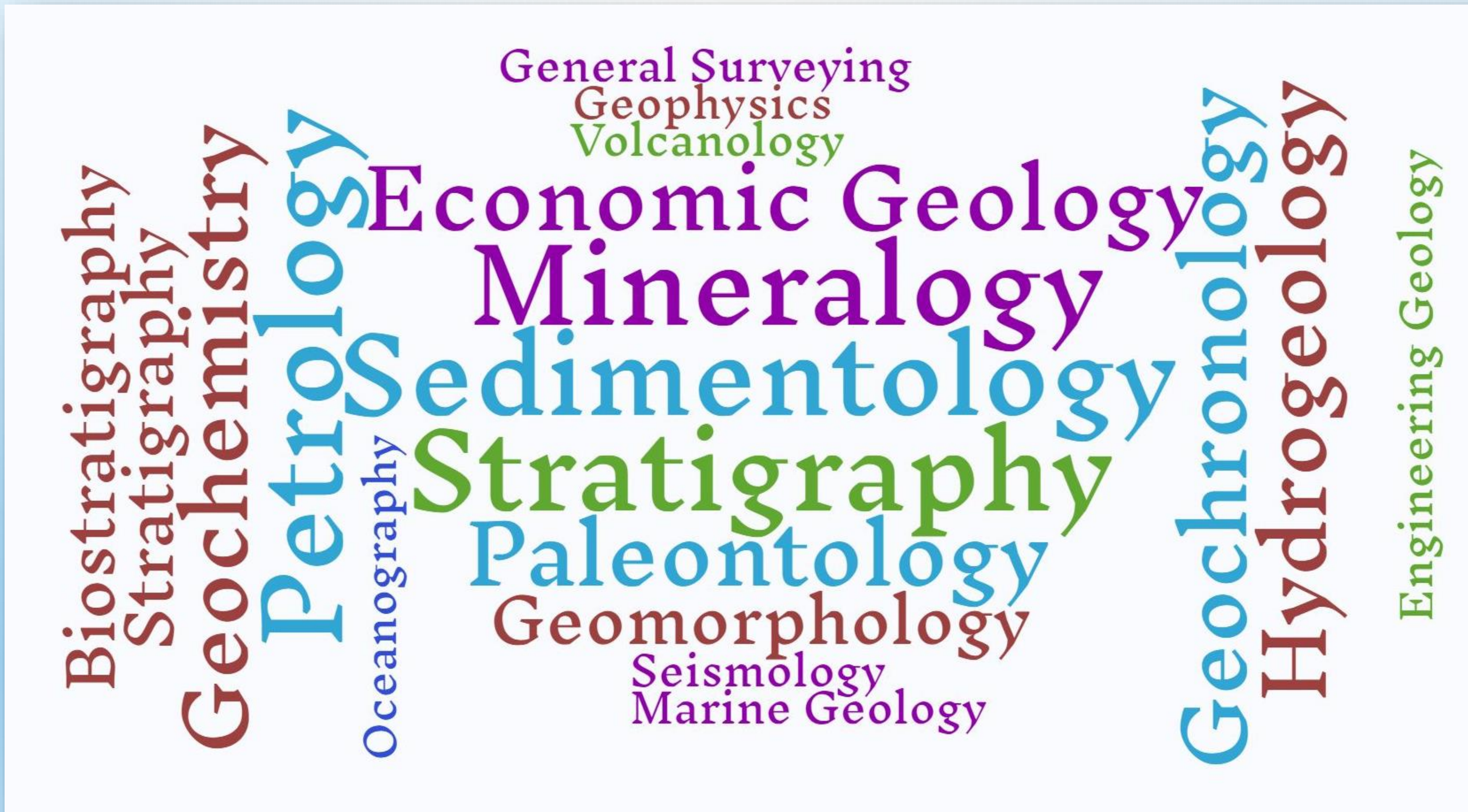
- Most civil engineering projects involve some excavation of soils and rocks, or involve loading the Earth by building on it.
- In some cases, the excavated rocks may be used as constructional material, and in others, rocks may form a major part of the finished product, such as a motorway cutting or the site for a reservoir.
- The feasibility, the planning and design, the construction and costing, and the safety of a project may depend critically on the geological conditions where the construction will take place.

THE SCIENCE OF GEOLOGY

- The term geology is derived from the Greek words **"GEO"** = **Earth** and **"LOGOS"** = **Study or discourse**.
- Therefore **Geology is a branch of science that deals with the study of planet Earth.**
- Geology is traditionally divided into two broad areas— **physical** and **historical**.
- **Physical geology** deals with the material the Earth is composed of and the many processes that operate beneath and on the surface of the Earth.
- **Historical geology** talks about the origin of Earth and its development through time.



BRANCHES OF GEOLOGY



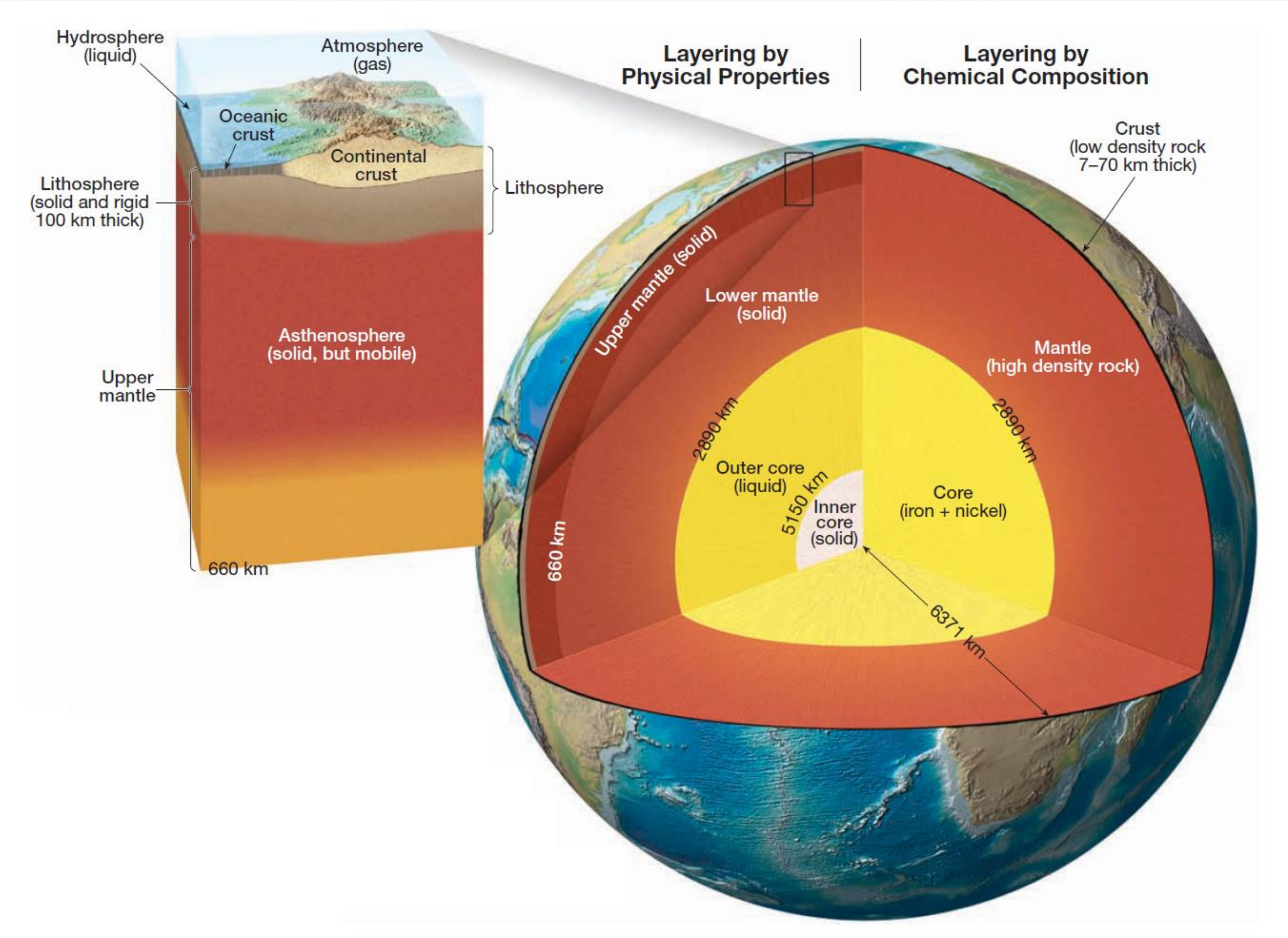
SOME BRANCHES OF GEOLOGY RELEVANT TO ENGINEERS

- **PETROLOGY** – Study of rocks (igneous, metamorphic, and sedimentary petrology) and how they form in their specific environment.
- **MINERALOGY** – Study of minerals, their crystalline and chemical structures, and their properties
- **CRYSTALLOGRAPHY** – Study of the arrangement and bonding of atoms in crystalline solids and with the geometric structure of crystal
- **HYDROGEOLOGY** – Area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust.
- **LITHOLOGY** – Study of the classification of rocks based on their physical and chemical properties.

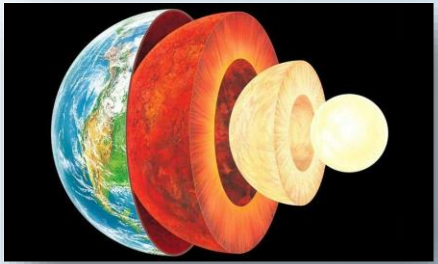
SOME BRANCHES OF GEOLOGY RELEVANT TO ENGINEERS

- **GEOPHYSICS** – Branch of geology that uses physics to examine the earth's structure, climate, and oceans.
- **BEDROCK GEOLOGY** – How the intact, solid rock beneath surficial sediments formed including age (stratigraphic sequences), morphology and rock properties (folds, faults, fractures).
- **STRATIGRAPHY** – How layering of rocks and strata are analyzed to measure geologic time.
- **SOIL SCIENCES** – How soils relate as a natural resource including their formation factor classification, physical, chemical and fertility properties.

STRUCTURE OF THE EARTH

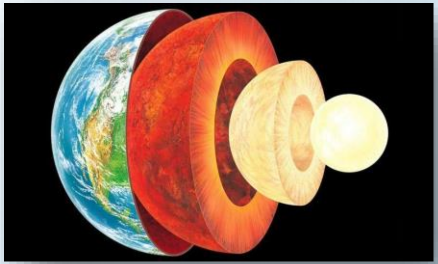


STRUCTURE OF THE EARTH



- The age of Earth is put at about 4.6 billion years.
- Segregation of material that began early in Earth's history resulted in the formation of **three layers** defined by their **chemical composition** — the **crust, mantle, and core**.
- Earth can be divided into layers based on **physical properties**.
- The physical properties used to define such zones include whether the layer is solid or liquid and how weak or strong it is.
- Knowledge of both types of layered structures is essential to our understanding of basic geologic processes, such as volcanism, earthquakes, and mountain building.

STRUCTURE OF THE EARTH



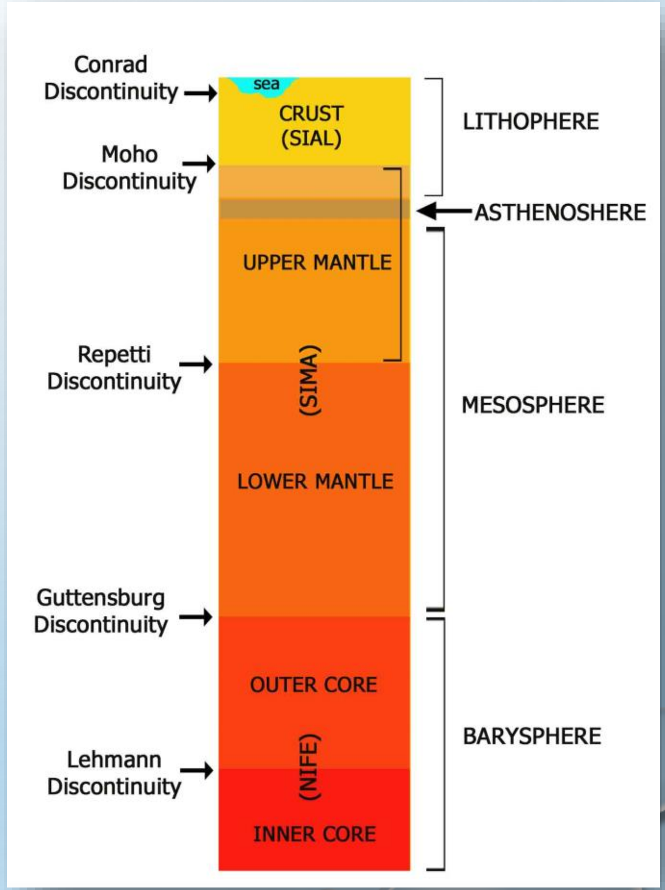
EARTH'S CRUST

- The crust, Earth's relatively thin, rocky outer skin, is of two different types — **continental crust** and **oceanic crust**. Both share the word "crust," but the similarity ends there.
- The **oceanic crust** is roughly **7 kilometers thick** and composed of the dark igneous rock **basalt**.
- By contrast, the **continental crust** averages about **35 kilometers** thick but may exceed 70 kilometers in some mountainous regions such as the Rockies and Himalayas.
- Unlike the **oceanic crust**, which has a **relatively homogeneous chemical composition**, the **continental crust** consists of **many rock types**.
- **Continental rocks** have an **average density** of about **2.7 g/cm3**, and some have been discovered that are **4 billion years old**.
- The rocks of the **oceanic crust** are **younger (180 million years or less)** and **denser** (**about 3.0 g/cm3**) than continental rocks.*

STRUCTURE OF THE EARTH

EARTH'S MANTLE

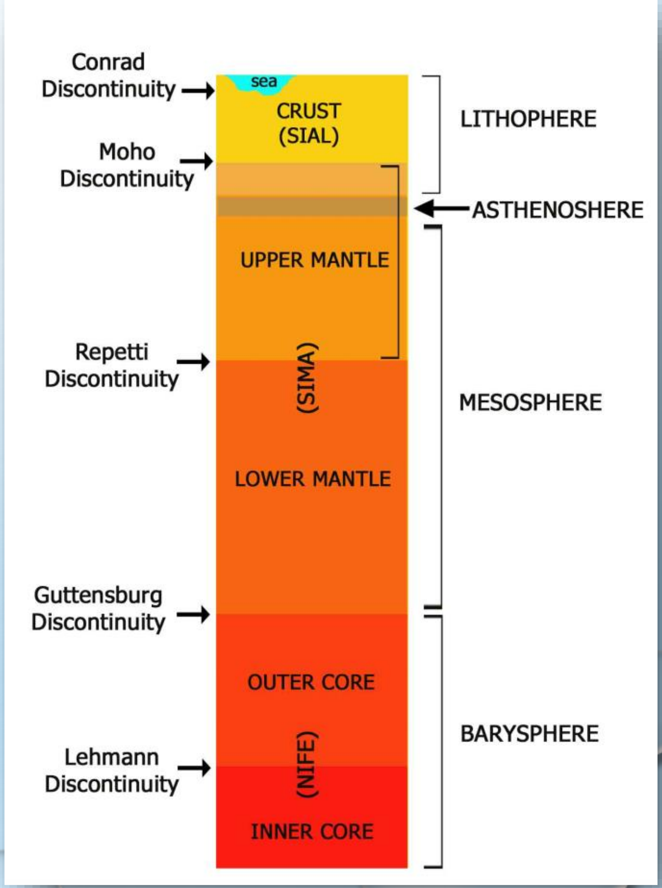
- More than 82 percent of Earth's volume is contained in the mantle, a solid, rocky shell that extends to a depth of nearly 2900 kilometers .
- The boundary between the crust and mantle represents a significant change in chemical composition.
- The dominant rock type in the uppermost mantle is **peridotite**, which is richer in the metals magnesium and iron than the minerals found in either the continental or oceanic crust.



STRUCTURE OF THE EARTH

THE UPPER MANTLE

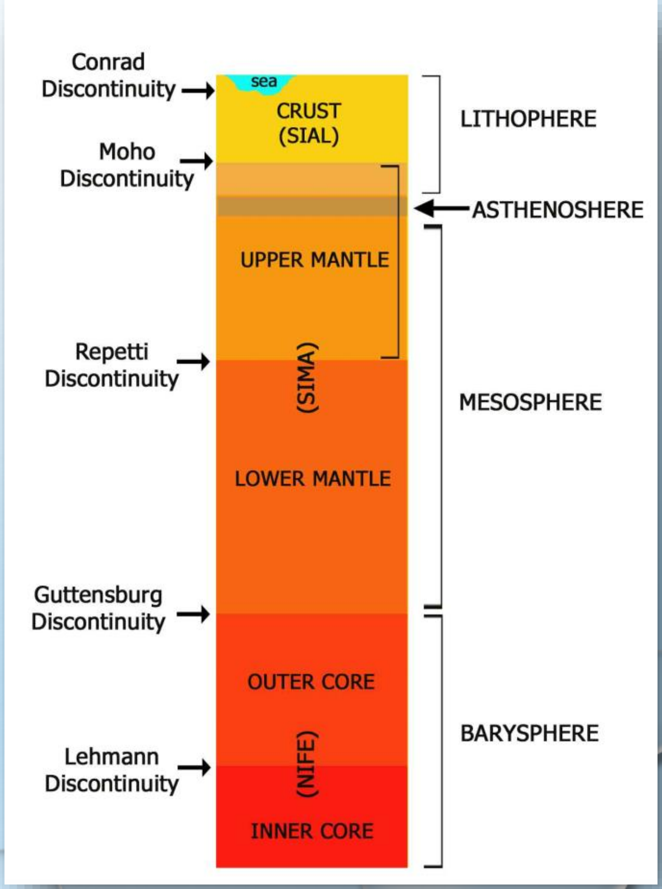
- The upper mantle extends from the crust-mantle boundary down to a depth of about 660 kilometers. **The upper mantle can be divided into two different parts.**
- The top portion of the upper mantle is part of the stiff **lithosphere**, and beneath that is the weaker **asthenosphere**.
- The lithosphere (sphere of rock) consists of the entire crust and uppermost mantle and forms Earth's relatively cool, rigid outer shell.
- Averaging about **100 kilometers** in thickness, the lithosphere is more than 250 kilometers thick below the oldest portions of the continents.
- Beneath this stiff layer to a depth of about 350 kilometers lies a soft, comparatively weak layer known as the **asthenosphere.**



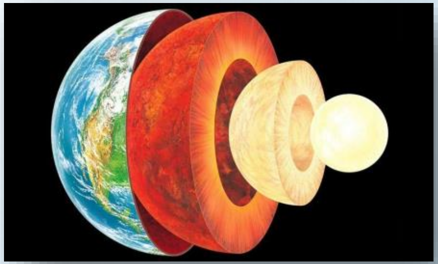
STRUCTURE OF THE EARTH

THE LOWER MANTLE

- From a depth of 660 kilometers to the top of the core, at a depth of 2900 kilometers, is the lower mantle.
- Because of an increase in pressure (caused by the weight of the rock above) the mantle gradually strengthens with depth.
- Despite their strength however, the rocks within the lower mantle are very hot and capable of very gradual flow.



STRUCTURE OF THE EARTH



EARTH'S CORE

- The composition of the core is thought to be an iron-nickel alloy.
- At the extreme pressure found in the core, this iron-rich material has an average density of nearly 11 g/cm3 and approaches 14 times the density of water at Earth's center.
- The core is divided into two regions that exhibit very different mechanical strengths.
- The **outer core is a liquid layer** 2270 kilometers thick. It is the movement of metallic iron within this zone that generates Earth's magnetic field.
- The **inner core is a solid** sphere having a radius of 1216 kilometers.
- Despite its higher temperature, the iron in the inner core is solid due to the immense pressures that exist in the center of the planet.

ROCKS

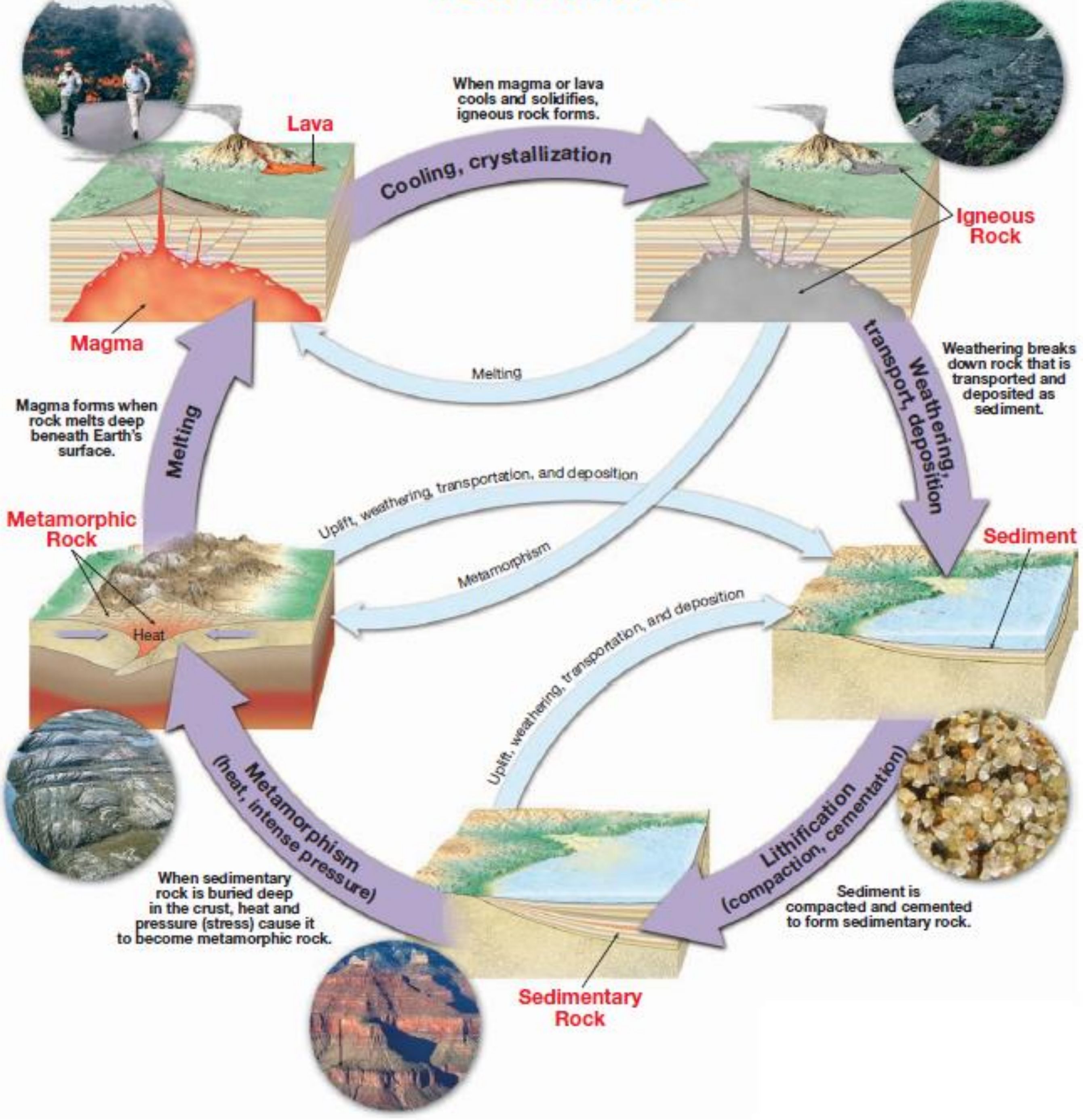
- **Rock is the most common and abundant material on Earth**.
- To a curious traveler, the variety seems nearly endless.
- When a rock is examined closely, we find that it consists of smaller crystals or grains called minerals.
- Minerals are chemical compounds (or sometimes single elements), each with its own composition and physical properties.
- The grains or crystals may be microscopically small or easily seen with the unaided eye.
- The nature and appearance of a rock is strongly influenced by the minerals that compose it.
- In addition, a rock's texture—the size, shape, and/or arrangement of its constituent minerals—also has a significant effect on its appearance.
- A rock's mineral composition and texture, in turn, are a reflection of the geologic processes that created it

ROCKS

- Geologists divide rocks into three major groups: **igneous**, **sedimentary**, and **metamorphic**.



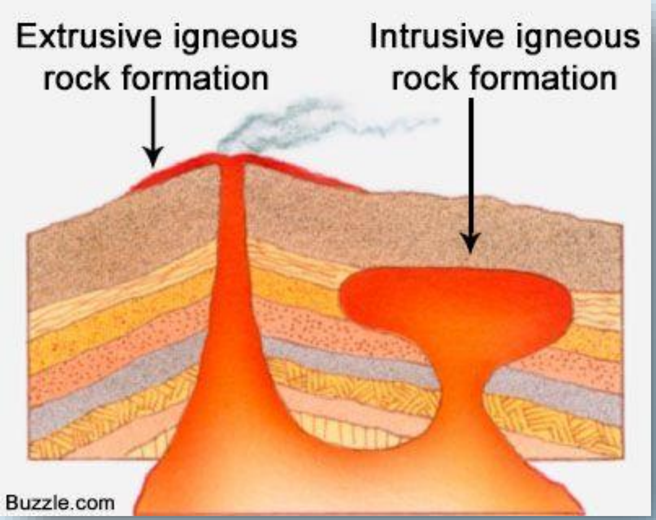
ROCK CYCLE



Lava
When magma or lava cools and solidifies, igneous rock forms.
Cooling, crystallization
Igneous Rock
Magma
Melting
Magma forms when rock melts deep beneath Earth's surface.
Melting
Weathering, transport, deposition
Weathering breaks down rock that is transported and deposited as sediment.
Uplift, weathering, transportation, and deposition
Metamorphic Rock
Metamorphism
Sediment
Heat
Uplift, weathering, transportation, and deposition
Metamorphism (heat, intense pressure)
Lithification (compaction, cementation)
When sedimentary rock is buried deep in the crust, heat and pressure (stress) cause it to become metamorphic rock.
Sediment is compacted and cemented to form sedimentary rock.
Sedimentary Rock

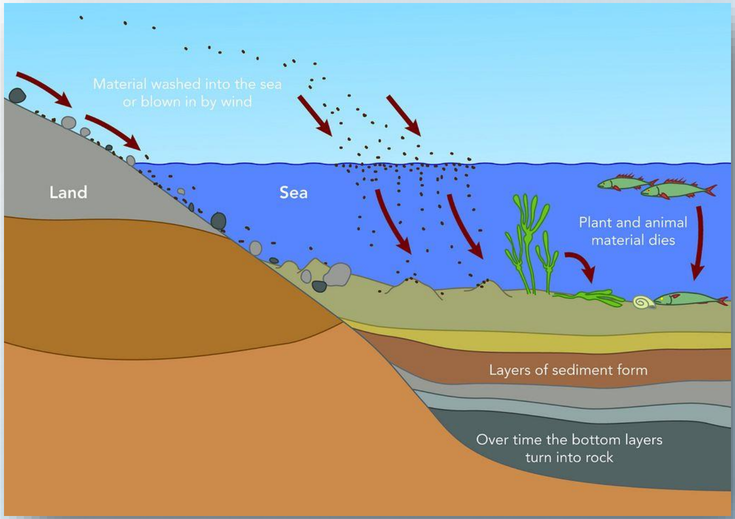
THE ROCK CYCLE: IGNEOUS ROCKS

- **The rock cycle is a basic concept in geology that describes transitions through geologic time among the three main rock types: sedimentary, metamorphic, and igneous.**
- Each rock type is altered when it is forced out of its equilibrium conditions.
- Magma is molten material that forms inside Earth.
- Eventually magma cools and solidifies.
- This process, called crystallization, may occur either beneath the surface or, following a volcanic eruption, at the surface.
- In either situation, the resulting rocks are called **igneous rocks** (ignis = fire).



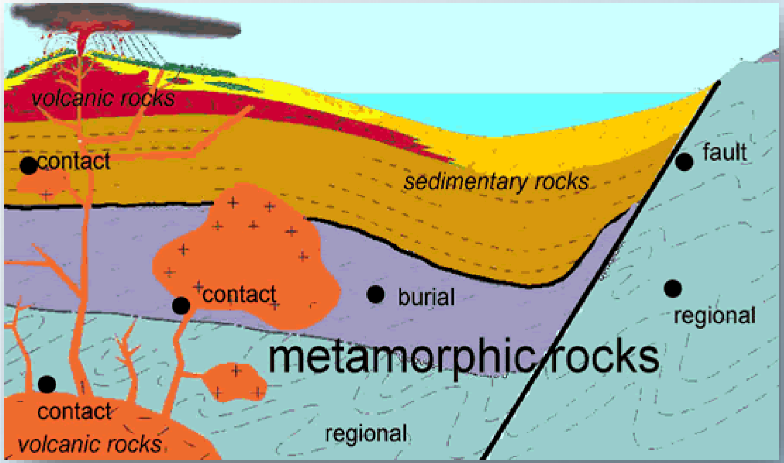
THE ROCK CYCLE: SEDIMENTARY ROCKS

- If igneous rocks are exposed at the surface, they will undergo weathering and form sediments
- The sediments move downslope by gravity before being picked up and transported by any of a number of erosional agents, such as running water, glaciers, wind, or waves.
- Eventually these particles and dissolved substances are deposited (In ocean basins, desert basin etc)
- Next the sediments undergo lithification and change to **sedimentary rock** due to compaction by the weight of overlying layers or when cemented as percolating groundwater fills the pores with mineral matter.



THE ROCK CYCLE: METAMORPHIC ROCKS

- If the resulting sedimentary rock is buried deep within Earth and involved in the dynamics of mountain building or intruded by a mass of magma, it will be subjected to great pressures and/or intense heat.
- The sedimentary rock will react to the changing environment and turn into the third rock type, **metamorphic rock**.



THE ROCK CYCLE

- When metamorphic rock is subjected to additional pressure changes or to still higher temperatures, it will melt, creating magma, which will eventually crystallize into igneous rock, starting the cycle all over again.
- Although rocks may seem to be unchanging masses, the rock cycle shows that they are not.
- **The changes, however, take time—great amounts of time.**
- The rock cycle is operating all over the world, but in different stages.
- **Processes driven by heat from Earth's interior are responsible for forming igneous and metamorphic rocks.**
- **Weathering and the movement of weathered material are external processes powered by energy from the Sun. External processes produce sedimentary rocks.**