GLY 102

Introduction to Geology II

Principles of Historical Geology

Dr. Atunima Jonathan &
Dr. James A. Adeoye
Department of Geosciences
aejonathan@mtu.edu.ng
jaadeoye@mtu.edu.ng

Course Description

This Course makes use of the principles and techniques of geology to reconstruct and understand the geological history of Earth. It focuses on evolution of organism , their distribution, classification, occurrence and uses as fossil for relative dating of rocks.

The course also explains the use of stratigraphy, structural geology and paleontology to tell the sequence of rock formation and the timing of other events observed on rocks during different time periods in the geological timescale. Account of historical geologists will also be thought.

Learning Objectives

By the end of this Course and after answering tutorial questions and assignments, students should be able to understand:

•The historical development of the field of geology

•The development of the basic geologic principles employed by historical geologists.

•The evolution of the geologic time scale

•The history of the Earth from its inception to the present

Course Contents

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7	Global Dating of the Rock Record
8	First Continuous Assessment
9	Unconformity
10	Rock Cycle
11	Rock Cycle
12	Second Continuous Assessment
13	Water Cycle/Hydrologic Cycle
14	Water Cycle/Hydrologic Cycle
15	Revision
16	Examination
17	Examination

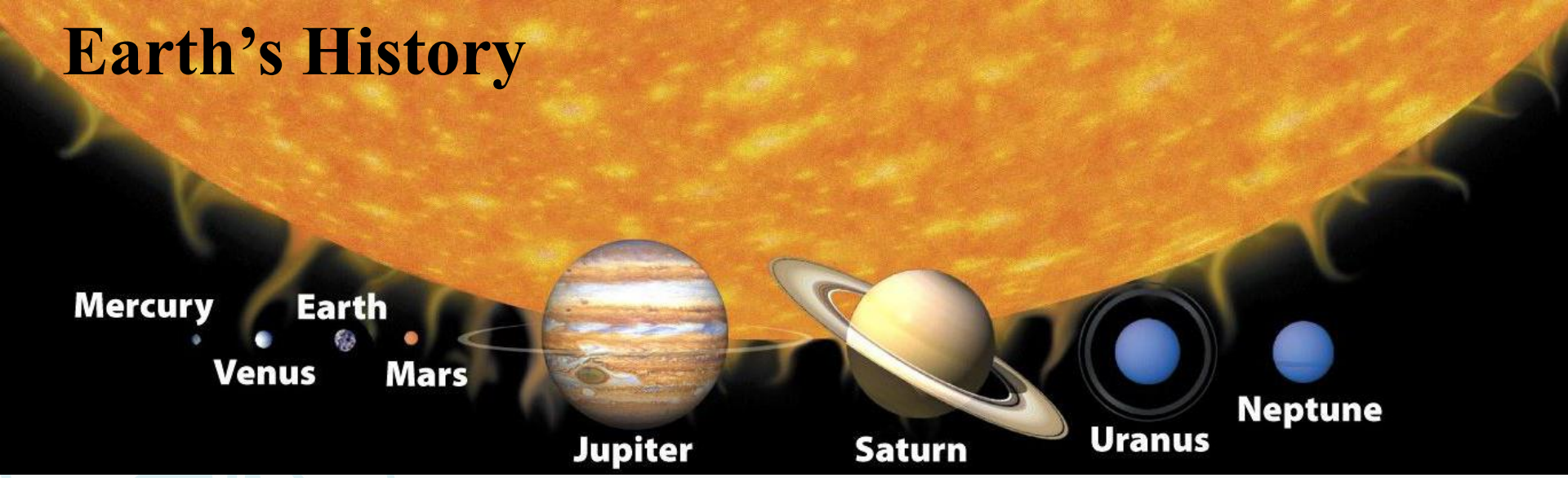
Additional Textbooks

- Understanding Earth Sixth Edition Edition by John Grotzinger (Author), Thomas H. Jordan
- Principles of Geology: (Classic Reprint) Paperback – June 15, 2012 by Charles Lyell.
- System History - Text 3RD EDITION by Steven M. Stanley. W.H. Freeman, 2009

Earth's History

The Earth is a very special and unique planet. It has temperature, composition and atmosphere that favor life. It is dynamic and ever-changing and has a long and complex history.

Earth's History



The vastness of the Universe is almost incomprehensible containing several galaxies. The Milky Way galaxy consist of the solar system and our sun which is one of the 300 billions stars in this galaxy. Andromeda, the next galaxy, is 2,200,000 light years away.

The planet earth is a large solid body orbiting a star (e.g., the Sun) with a nearly spherical shape. The planet Earth is one of eight planets in the solar system.

The Earth's Components

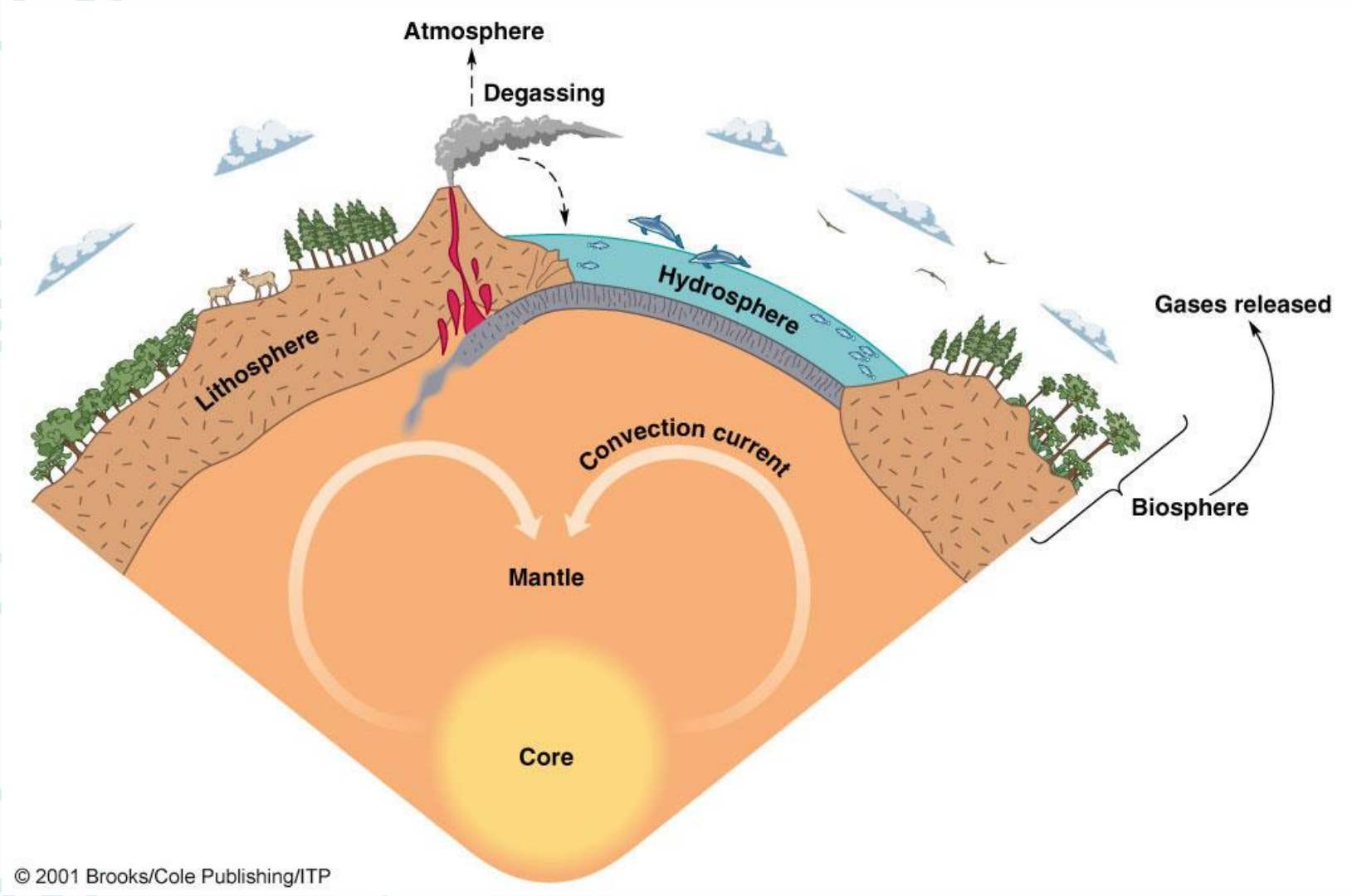
Earth System

The Earth system is a small part of the larger solar system and has its components, which can be thought of as its subsystems.

These systems, or "spheres," are the:

- **Atmosphere** , the gases that envelop the Earth.
- **Hydrosphere** is the water on or near Earth's surface which includes the oceans, rivers, lakes, and glaciers of the world. Earth is unique among the planets in that two-thirds of its surface is covered by oceans.
- **Biosphere** is all of the living or once-living material on Earth.
- **Geosphere**, or solid Earth system , is the rock and other inorganic earth material that make up the bulk of the planet.

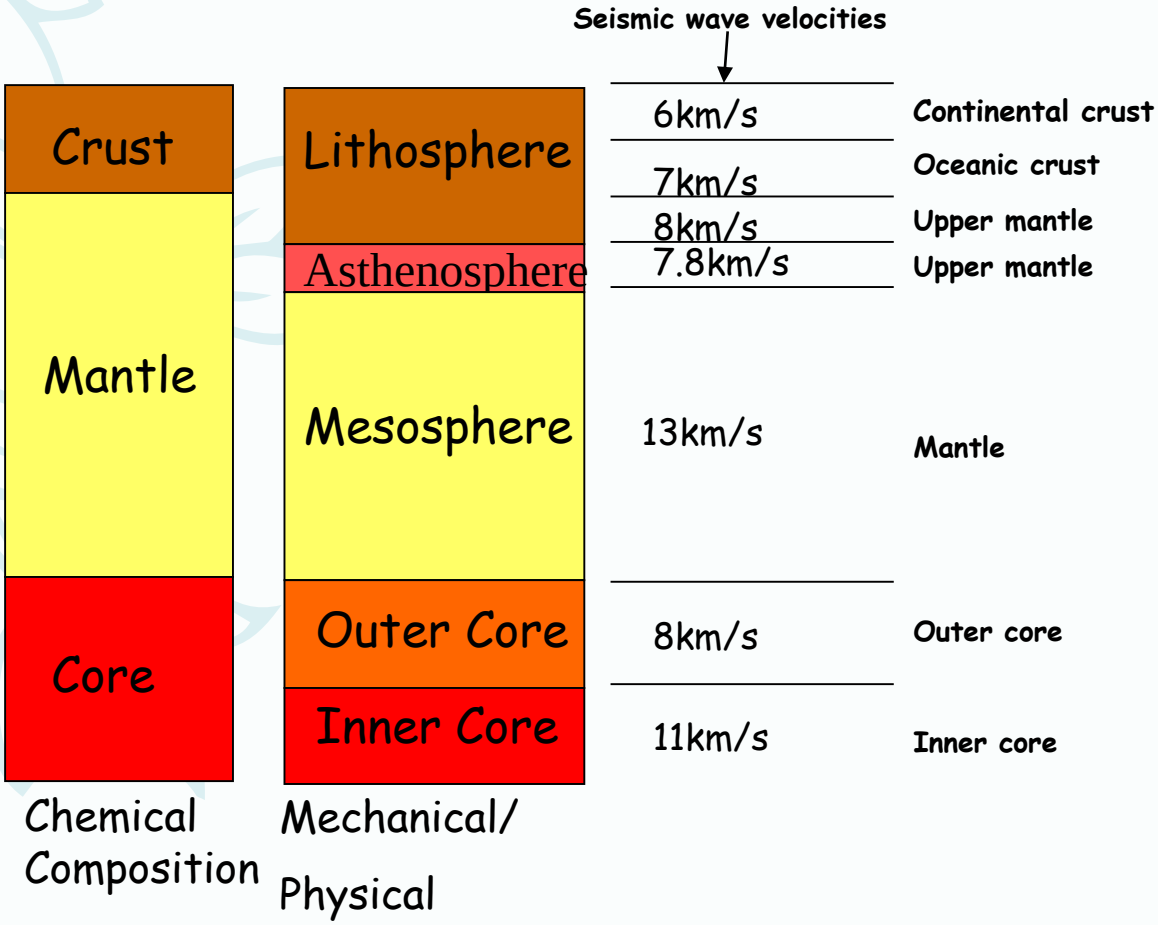
The Earth's Components



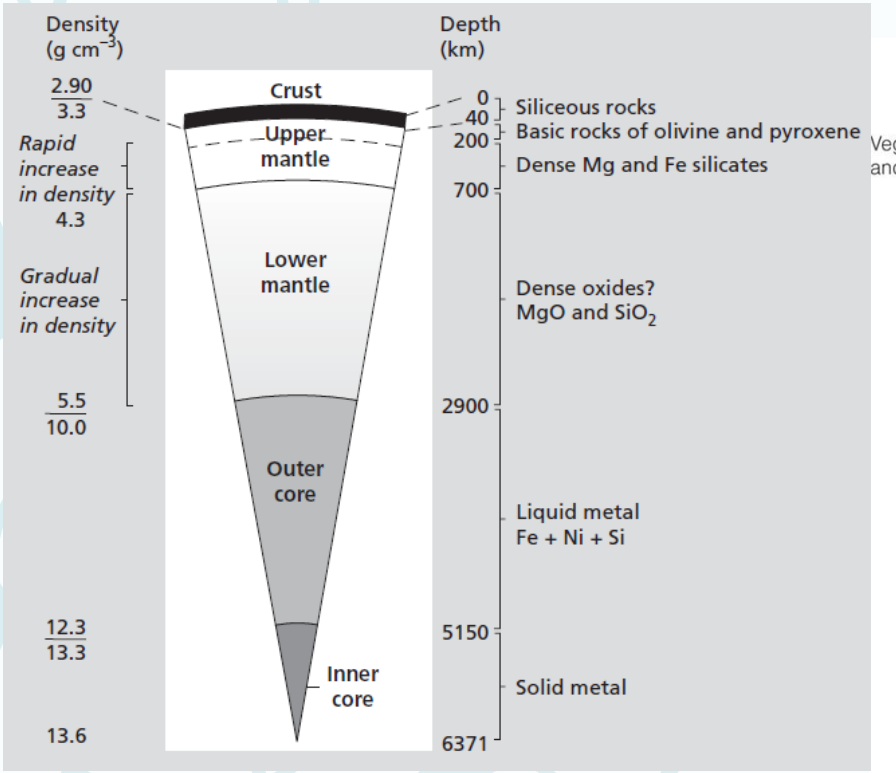
The Earth's Components - Geosphere

What is inside Earth?

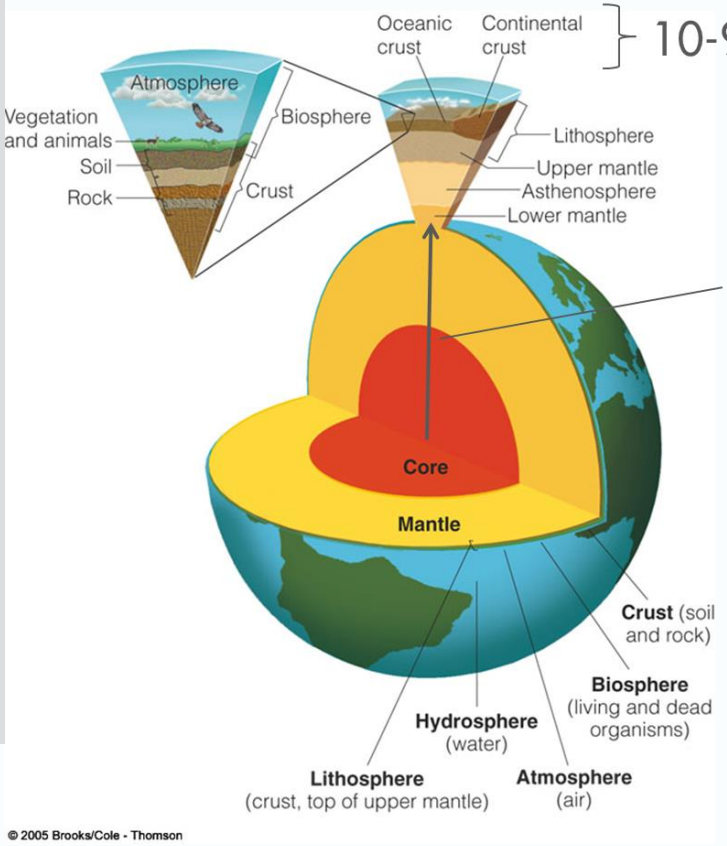
- Earth is made of several layers and each layer has its own characteristic properties. Scientists think about earth's layers in two ways i.e. in terms of chemical composition, and physical properties.



Compositional Zonation of the Earth



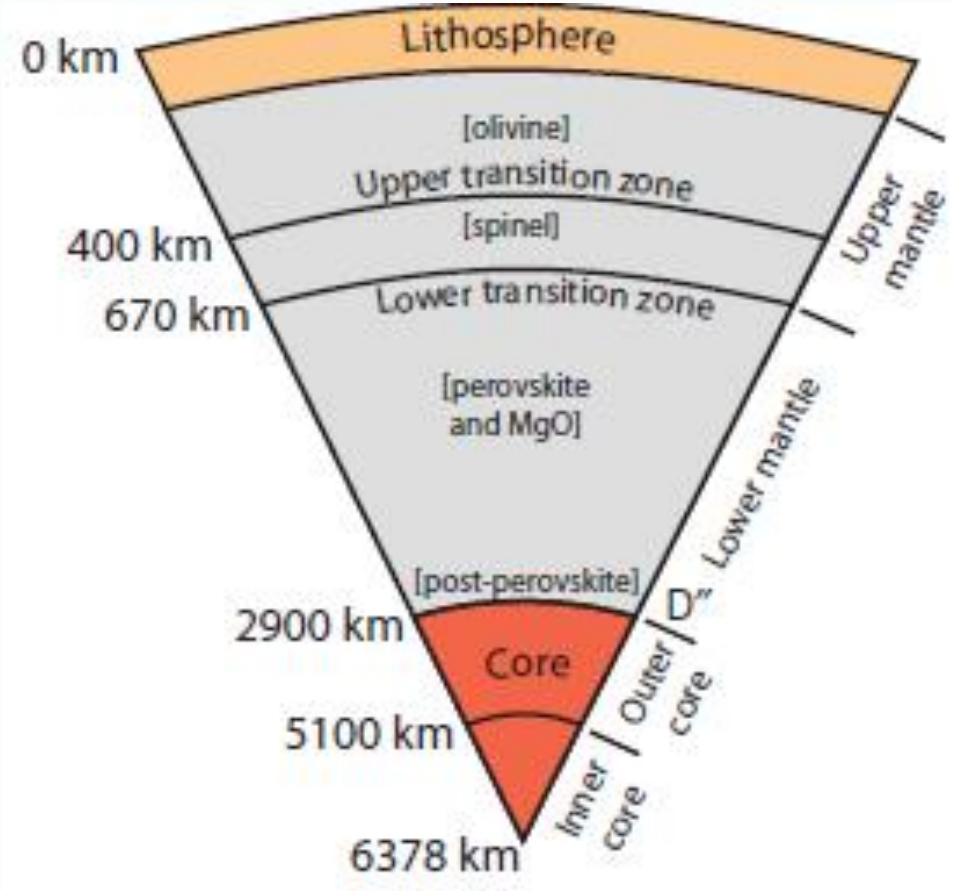
Raiswell et al. (1980)



Moho is a discontinuous layer that separates the crust and the mantle.

Rheological Zonation of the Earth

- Lithosphere
- Asthenosphere



Earth's History

Rocks of the crust provide clues to Earth's past

- *By analyzing these clues we can infer events from the past*
- *Planet Earth is approximately 4.5 X 10^9 years old*

Prior to geologic principles, Archbishop James Ussher calculated the age of the Earth at 6000 years. He noted that calculations were made based on the books of the Bible (namely Genesis) and pinpointed the origin of the Earth to be October 26, 4004 B.C. at 9:00 a.m.

Earth's History

Two conceptions of Earth history

- **Catastrophism**
  - Assumption: great effects require great causes
  - Earth history dominated by violent events

- **Uniformitarianism**
  - **Assumption**: we can use *cause and effect* to determine causes of past events
  - **Finding:** Earth history dominated by small-scale events typical of the present.
  - Catastrophes do happen but are uncommon

Earth's History

Catastrophism

The concept was first popularised by the early 19th-century French scientist Georges Cuvier, who proposed that new life forms had moved in from other areas after local floods, and avoided religious or metaphysical speculation in his scientific writings.

Catastrophism is a theory that state that the Earth had largely been shaped by sudden, short-lived, and violent events which are possibly worldwide in scope.

Catastrophism held that geological epochs had ended with violent and sudden natural catastrophes such as great floods and the rapid formation of major mountain chains.

Earth’s History

Catastrophism

Plants and animals living in the parts of the world where such events occurred were made extinct, being replaced abruptly by the new forms whose fossils defined the geological strata. Some catastrophists attempted to relate at least one such change to the Biblical account of Noah's flood.

This was in contrast to uniformitarianism (sometimes described as gradualism), in which slow incremental changes, such as erosion, created all the Earth's geological features. In part, the geologists' rejection was fostered by their impression that the catastrophists of the early nineteenth century believed that God was directly involved in determining the history of Earth.

Earth's History

Catastrophism

Some of the theories about Catastrophism in the nineteenth and early twentieth centuries were connected with religion and catastrophic origins were sometimes considered miraculous rather than natural events.

Since the early disputes, a more inclusive and integrated view of geologic events has developed, in which the scientific consensus accepts that there were some catastrophic events in the geologic past, but these were explicable as extreme examples of natural processes which can occur.

The rise in uniformitarianism made the introduction of a new catastrophe theory very difficult.

Earth's History

Uniformitarianism

Principle of ***Uniformitarianism:***

James Hutton, late 1700s – (considered to be "Father of Geology")

Hutton realized that most sedimentary layers were deposited from gradual, day-to-day processes. He realized that it took a long time to form these rocks. This was far different from what others believed prior to this time.

"Present is the key to the past" -- whatever processes are occurring today (plate tectonics, volcanism, mountain building, earthquakes, sedimentation) also occurred in the past and probably at the same (or very comparable) rates.

Earth's History

Uniformitarianism

Uniformitarianism held that the present was the key to the past, and that all geological processes (such as erosion) throughout the past were like those that can be observed now.

❖**Uniformitarianism is a cornerstone of geology**

- ❖ present-day processes have operated throughout time
- ❖ physical and chemical laws of nature have remained the same through time
- ❖ to interpret geologic events, we must first understand present-day processes and their results

Earth’s History

Uniformitarianism

Uniformitarian explanations for the formation of sedimentary rock and an understanding of the immense stretch of geological time were found in the writing of James Hutton, sometimes known as the father of geology, in the late 18th century.

Charles Lyell, a geologist built upon Hutton's ideas during the first half of 19th century and amassed observations in support of the uniformitarian idea that the Earth's features had been shaped by same geological processes that could be observed in the present acting gradually over an immense period of time.

Earth's History

Uniformitarianism

❖Lyell presented his ideas in the influential three volume work, Principles of Geology, published in the 1830s, which challenged theories about geological cataclysms proposed by proponents of catastrophism like Cuvier and Buckland

❖From around 1850 to 1980, most geologists endorsed uniformitarianism ("The present is the key to the past") and gradualism (geologic change occurs slowly over long periods of time) and rejected the idea that cataclysmic events such as earthquakes, volcanic eruptions, or floods of vastly greater power than those observed at the present time, played any significant role in the formation of the Earth's surface.

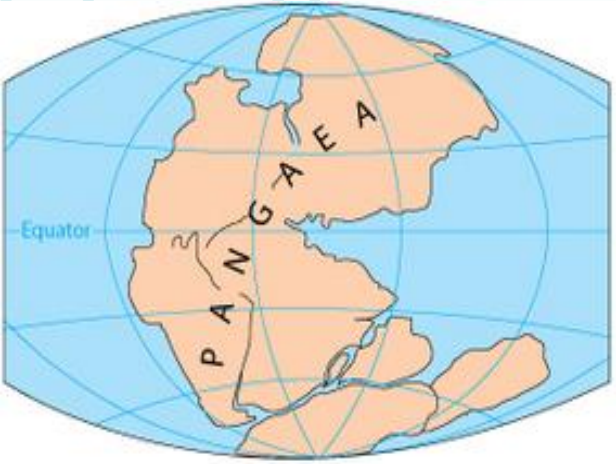
❖Instead they believed that the earth had been shaped by the long term action of forces such as volcanism, earthquakes, erosion, and sedimentation, that could still be observed in action today.

Earth's History Through Geologic Time

Pangaea

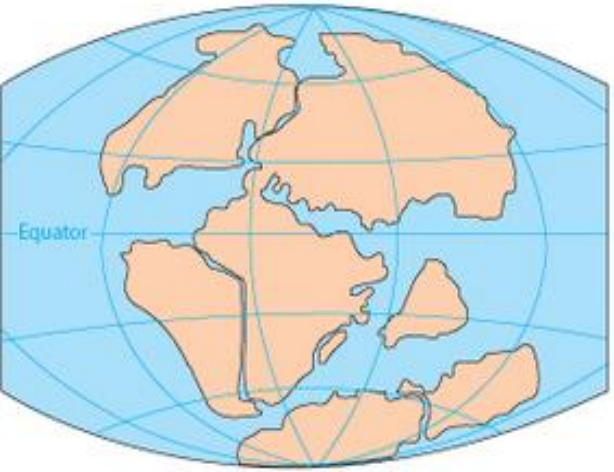
- Supercontinent that existed 250 million years ago
- All the land made up 1 continent until its split into the modern day configuration of the continents.
- Discovered by Alfred Wegner in 1912, but not accepted by the public until after his death in the 1950's.

Earth's History Through Geologic Time

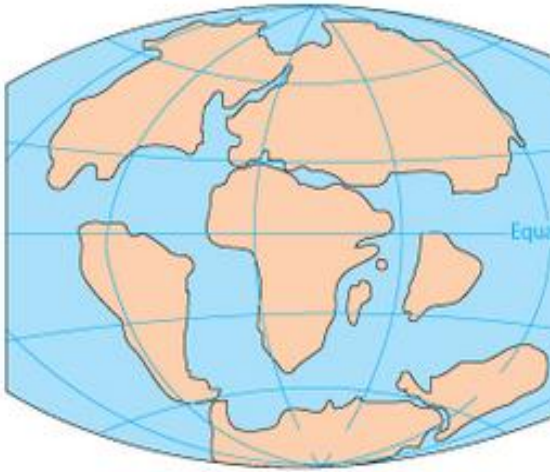


PERMIAN
250 million years ago

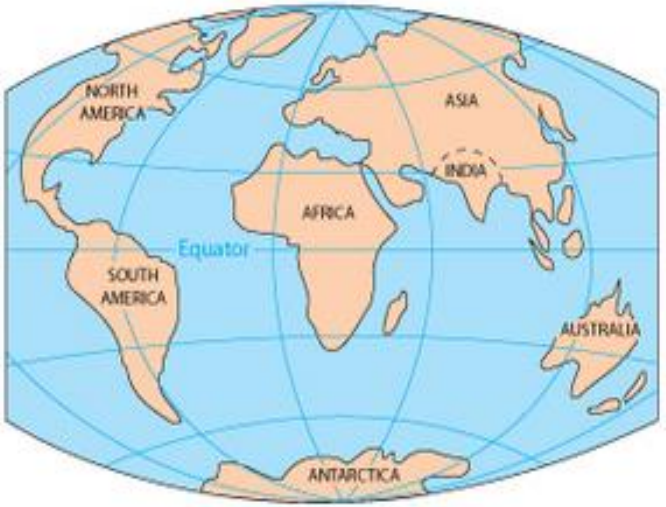
TRIASSIC
200 million years ago



JURASSIC
145 million years ago



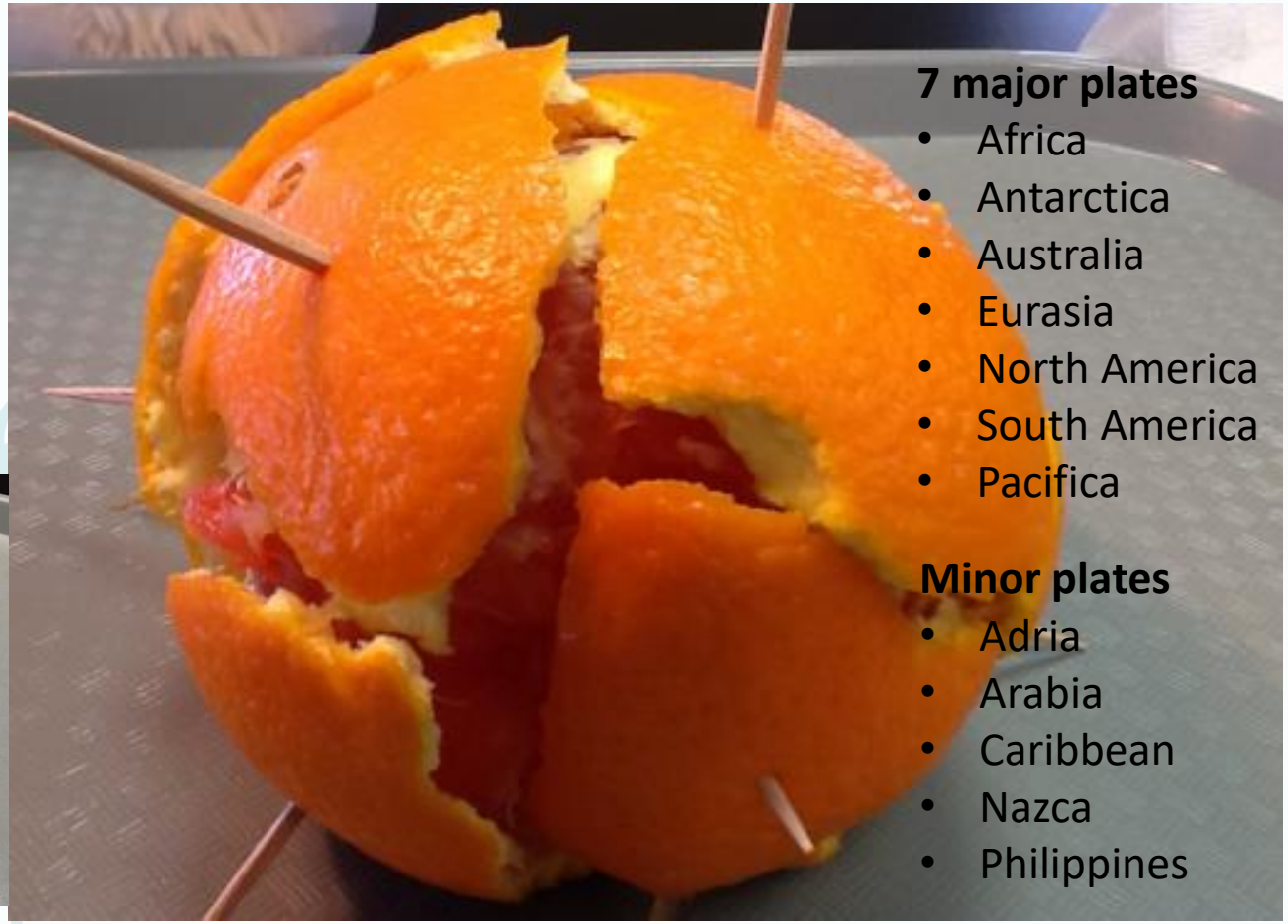
CRETACEOUS
65 million years ago



PRESENT DAY

Plate Tectonics - Introduction

- Continents drift; sea floor spread;
- The lithosphere is broken into a number of plates;
- The study of plate relative motions and their consequences (large-scale deformation)



7 major plates

- Africa
- Antarctica
- Australia
- Eurasia
- North America
- South America
- Pacifica

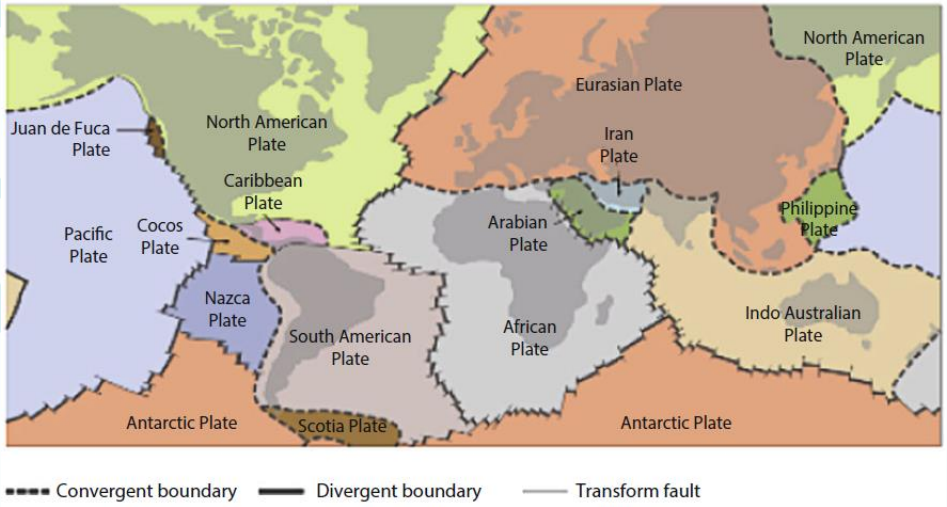
Minor plates

- Adria
- Arabia
- Caribbean
- Nazca
- Philippines

Plate Tectonics – Plate Boundaries

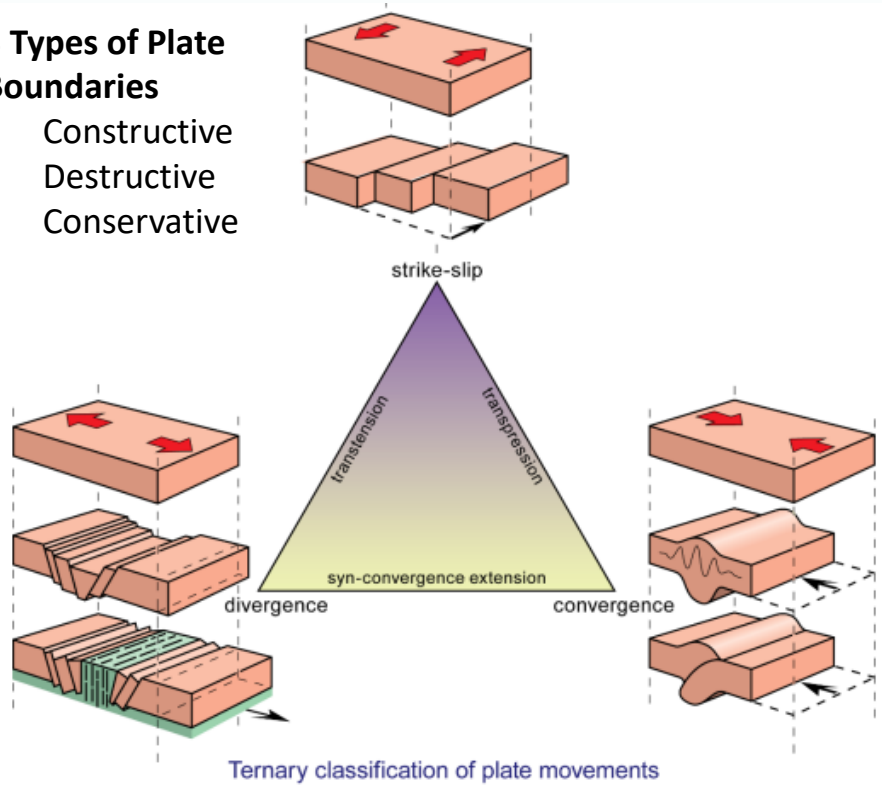
2 Types of Lithosphere

- Continental
- Oceanic



3 Types of Plate Boundaries

- Constructive
- Destructive
- Conservative



Ternary classification of plate movements

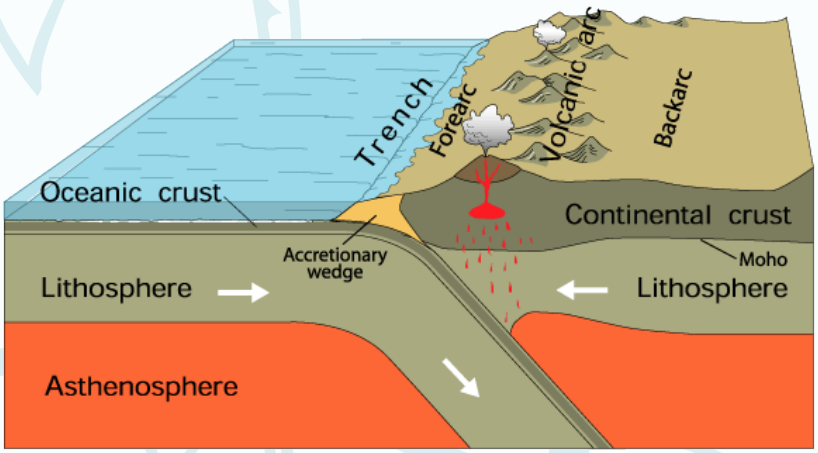
Continental and Oceanic Lithosphere

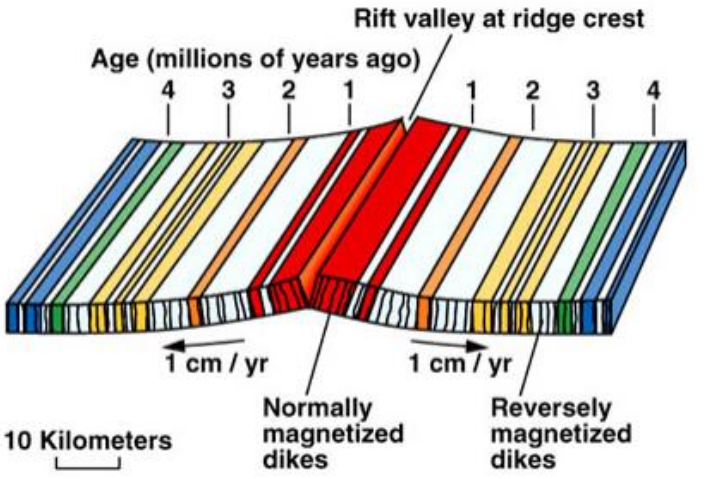
2 Types of Lithosphere

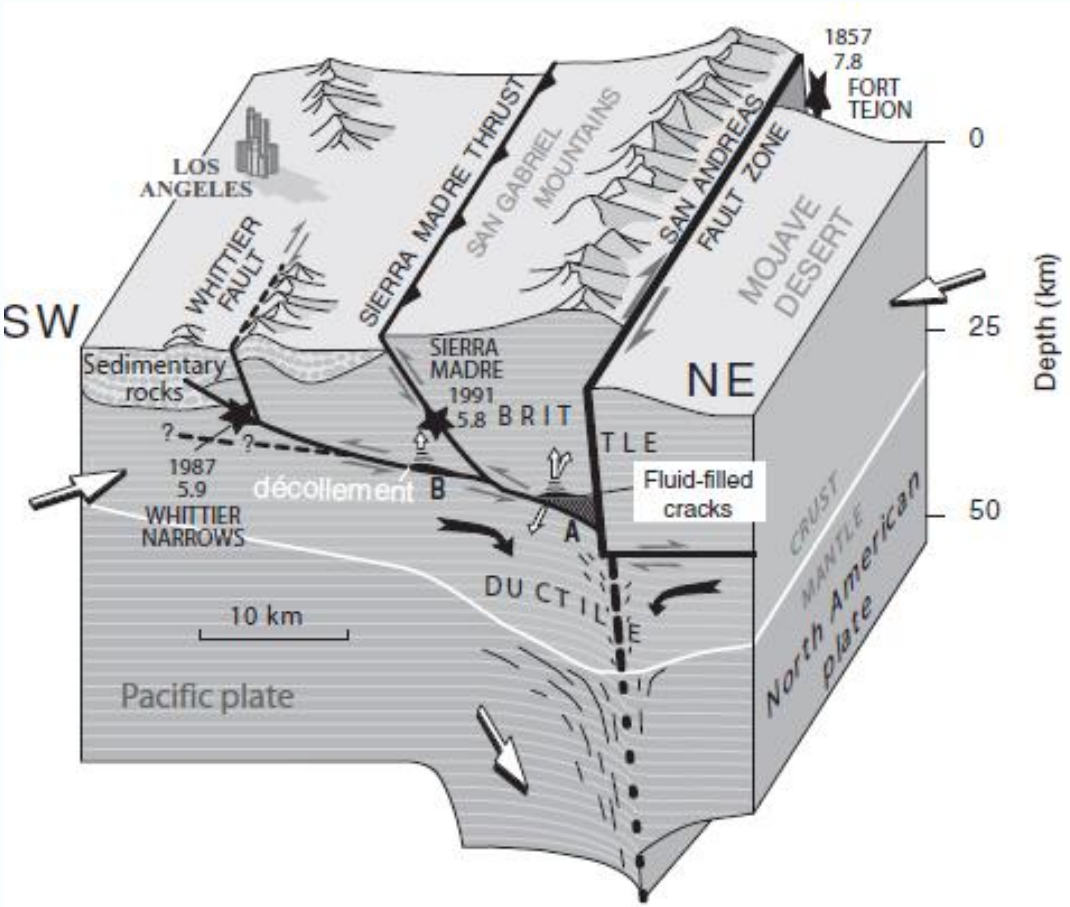
- Continental
- Oceanic

s/n	Oceanic Plate	Continental Plate
1	Denser than continental	Less dense than oceanic
2	Releases strain quickly	Stores strain over an extended period of time
3	Less complex than continental plate	Far more complex than oceanic plate
4	Earthquakes occur only at plate boundaries	Earthquakes are more widely distributed
5	Thin (about 10km)	Thick (20 – 90km, average 35km)
6	Relatively uniform stratigraphy (basalt & gabbro)	Highly variable composition

Plate Tectonics - consequences







Earth's History Through Geologic Time

ERA	PERIOD	START OF EACH PERIOD (in millions of years)	FLORA & FAUNA
Paleozoic	Permian	245	Radiation of reptiles, which displace amphibians as dominant group; widespread glaciation
	Carboniferous	286	Ferns as dominant plant group; sharks and crinoids abundant; radiation of amphibians; first reptiles
	Devonian	360	Age of fishes (mostly freshwater); first trees and first amphibians
	Silurian	408	Invasion of the land by plants and arthropods; braciopods; primitive jawless vertebrates
	Ordovician	438	Appearance of vertebrates (armoured fishes); brachiopods and cephalopods dominant
	Cambrian	505	Appeamce of all invertebrate phyla and many classes; dominance of trilobites and brachiopods;

Earth's History Through Geologic Time

ERA	PERIOD	START OF EACH PERIOD (in millions of years)	FLORA & FAUNA
Mesozoic	Cretaceous	65	Dominance of flowering plants; extinction of large reptiles and ammonites by end of period
	Jurassic	145	Reptiles dominant on land, sea and in air; first birds; archaic mammals
	Triassic	208	First dinosaurs, turtles, ichthyosaurs, plesiosaurs; cycads and conifers dominant

Earth's History Through Geologic Time

ERA	PERIOD	START OF EACH PERIOD (in millions of years)	FLORA & FAUNA
Cenzoic	Quarternary	1	Modern species of mammals, extinction of large forms, such as mammoth; dominance of human
	Tertiary	54	Rise of birds and placental mammals

Earth's History Through Geologic Time

Paleozoic Era (Ancient Life)

- The Cambrian period is the 1st period of the Paleozoic Era. "Age of the Trilobites"
- Explosion of life in the oceans began during this era.
- Most of the continents were covered in warm, shallow seas.
  - Invertebrates were dominate - Trilobites
  - Fish emerged during this time
  - Fish led to the arrival of amphibians
    - The end of the Paleozoic era is called the "Age of Amphibians"
  - Early land plants including mosses, ferns and cone-bearing plants.
  - The early coal forming forests were also formed during this time.

Earth's History Through Geologic Time

Paleozoic Era

- Much of the **limestone** quarried for building and industrial purposes, as well as the **coal** deposits of western Europe and the eastern United States, were formed during the Paleozoic.

- The Cambrian (beginning) opened with the breakup of the world-continent **Rodinia** and closed with the formation of **Pangaea**, as the Earth's continents came together once again.
  - This event is thought to have caused the climate changes that led to mass extinction event.
- The Appalachian mountains were formed during this time.

Earth's History Through Geologic Time

Paleozoic Era

- At the end of the Paleozoic, the ***largest mass extinction in history*** wiped out approximately 90% of all marine animal species and 70% of land animals.
  - Possible causes of this Mass Extinction Event
    - Lowering of sea levels when the continents were rejoined as Pangaea (convergent boundary)
    - Increased volcanic activity (ash and dust)
    - Climate changes – cooler climate

Earth's History Through Geologic Time

Trilobites

- Lived in Earth's ancient seas
- Extinct before the dinosaurs came into existence
- **Cambrian Period is know as the "Age of the Trilobites"**

***Sphaerocoryphe robusta* Walcott 1875**
M. Ordovician, Trenton Grp., Rust Fm.
Trenton Falls, New York, USA
image courtesy Sam Stubbs & Neal Immega

Earth's History Through Geologic Time

Brachiopods

- Marine animals that resemble clams.

Earth's History Through Geologic Time

Early Land Plants

Cone bearing plants

Mosses

Ferns

Earth's History Through Geologic Time

Mesozoic Era – Middle Life

- At the beginning of this era the continents were joined as Pangaea.
- Pangaea broke up around the middle of this era.
- Reptiles became the most abundant animals because of their ability to adapt to the drier climate of the Mesozoic Era.
  - Skin maintains body fluids
  - Embryos live in shells

Earth's History Through Geologic Time

Mesozoic Era

- Dinosaurs were also very active in this era.
  - First small dinosaurs appeared in the Triassic Period.
  - Larger and more abundant dinosaurs appeared in the Jurassic Period.
- **Small mammals and birds** also appeared during this era.
  - The mammals were small, warm-blooded animals. Hair covering their bodies.
    - These characteristics help them survive in changing environments.

Earth's History Through Geologic Time

Earth's History Through Geologic Time

Mesozoic Era

- The main plant life of this time were Gymnosperms or plants that produce seeds, but no flowers.
  - Pine Trees

- Flowering plants appeared during the **END** of this era.

Mesozoic Era

- This era ended with a mass extinction event about 65 million years ago.
  - Many groups of animals, including the dinosaurs disappeared suddenly at this time.

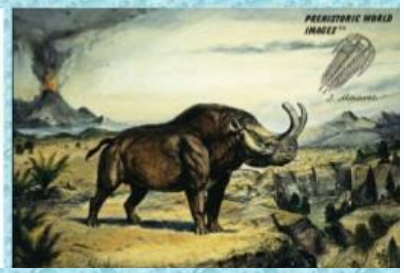
- Many scientists believe that this event was caused by a comet or asteroid colliding with the Earth.

Mesozoic Era – Mass Extinction Event

- Asteroid or Comet collides with Earth.
  - Huge cloud of smoke and dust fills the air
  - Blocks out sunlight
  - Plants die
  - Animals that eat plants die
  - Animals that eat plant-eaters die.
- However, not all forms of life died during this event. Many animals that you see today are descendants from the survivors of this extinction event.

Earth's History Through Geologic Time

Cenozoic Mammals



Flowering Plants were common during the Cenozoic Era