


The Geological Time Scale

Earth is 4.6 billion years old.

James Hutton, 1726-1797
18th Century Scottish Geologist



Title: father of geology

First to provide convincing evidence that the Earth was far older than human civilization, but he could not measure the Earth's age directly.

Hutton - the father of geology

- Hutton made the connection through his observations of the rocky crags of Scotland.
- *Uniformitarianism* – the principle that physical processes we observe today also operated in the past and were responsible for the formation of geologic features we see in outcrops; the present is the key to the past.

THOMAS HENRY HUXLEY, 1825-1895
1868 – GEOLOGY LECTURE
NORWICH, ENGLAND



- Chalk told a story about the Earth
- Chalk contained plankton shells and microscopic fossils of swimming reptiles, fish, and invertebrates – species absent in the seas today.
- *Cretaceous* derives from the Latin word for "chalk"

Terms used to describe Age

- Relative Age –the age of one geologic feature with respect to another.
 - *One example:* when we look at a sequence of sedimentary rock layers, each layer must be younger than the one below it.
- Numerical Age – the age of a feature given in years through radiometric dating

DEEP TIME

- A hike down a trail into the Grand Canyon is a great way to soak in the concept of deep time. A hike becomes a journey to the distant past.
- As we observe each layer of rock, we realize that each happened at a different time period.

Geological Time Scale

- 4.57 billion years is divided into four Eons.
- Eons are divided into Eras
- Eras are divided into Periods
- Periods are divided into Epochs

HADEAN EON

- The time between the birth of the Earth and 3.80 Ga (billion years ago)
- Named after the Greek Hades, the god of the underworld.
- Earth was a molten sea of hot magma, with rising waves pushing up the mantle.

Dante's Inferno

- After differentiation and moon formation, Earth was a molten sea of hot magma, with rising waves pushing up the mantle.
- By 4.4 Ga – at least some solid rock was formed.

Close of the Hadean Eon

- Cooling down occurred, allowing condensation of water, rainfall
- By 4.4 Ga – at least some solid rock was formed.
- Geologists have found marine sediments in rock as old as 3.8 billion years, pointing to the existence of liquid water oceans by this time

Archean Eon, 3.8 – 2.5 Ga

- From the Greek word for “ancient”
- By 2.7 Ga, the first cratons, or large durable blocks of crust, had developed.
- Volcanism supplied gas to the atmosphere during this eon.
- 80% of continental crust had formed by the end of the Archean Eon.

Earliest Life happened in the Archean Eon

- Life has existed on Earth since 3.5 Ga because rocks of this age contain chemical signatures of organisms.
- Earliest life, heat-loving bacteria, probably formed in submarine hot-water vents, so called black smokers in the depths of the sea. (Photosynthesis had not yet evolved.)

Closing of the Archean Eon

- First continents existed
- Life had colonized in shallow marine environments, as well as the depths of the sea
- Mountain belts were forming
- Erosion was taking place
- The atmosphere was accumulating oxygen – as a small percentage.

PROTEROZOIC EON

- Spans about 2 billion years (2 Ga)
 - From 2.5 billion years to the beginning of the Cambrian Period, 542 million years ago.
- From the Greek word, meaning “early life”.
- This Eon covers almost half of Earth’s history.

Proterozoic Eon – Bridge to the Modern World

- Continental crust grew by collisions of chunks hanging around from the Archean Eon. Volcanoes also occurred during this time, and the magma and ash **accreted** onto – or *stuck onto* – the small continents which had already begun to form. These hot continents cooled down to form the large cratons which exist today.

Interior of North America

- The Canadian Shield is the only true exposed CRUST of Earth in North America. It is a broad region of exposed Precambrian rocks.
- In the United States, Phanerozoic strata bury most of the Precambrian rocks

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The first three Eons = Precambrian

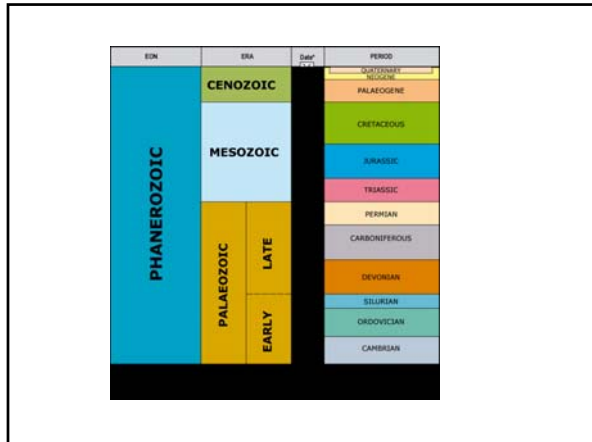
- Hadeon, Archean, and Proterozoic Eons
- Only small organisms with no shells existed, so Precambrian fossils are hard to find.
- Invertebrates with shells constitute the Precambrian/Cambrian boundary.

PHANEROZOIC EON
The last 542 million years of Earth history

We sub-divide this eon into eras:

Paleozoic Era ("ancient life")
Mesozoic Era ("middle life")
Cenozoic Era ("recent life")

**We divide eras into periods.
Periods are divided into epochs.**



Phanerozoic means **visible life**.

- Organisms with hard shells appear early in this eon. Later, skeletons developed - both became widespread, so fossils are abundant in this eon.
- Trilobites, brachiopods, ammonites, corals, gastropods (snails), graptolites, crinoids, bivalves (clams and oysters), cephalopods, bryzoans.

The Phanerozoic Eon, Part 1

The Early Paleozoic Era
 (Cambrian-Ordovician Periods, 542-444 Ma)
Smaller continents:
Laurentia (North America and Greenland)
Gondwana (South America, Africa, Antarctica, India and Australia)
Baltica (Europe)
Siberia

Early Paleozoic Era

- Sea levels rose. Most continents were flooded with shallow seas called **epicontinental** seas. The only dry land on Laurentia was a region centered on Hudson's Bay. Most of what is now the United States was under water.

**Paleozoic Era includes
The Cambrian Explosion**

- This event refers to the sudden diversification of life which exploded over a relatively short interval of time.
- This lasted about 20 million years.
- Seas were shallow and regressions and transgressions occurred. Water levels were only a few meters and well-lit, ideal conditions for Life to develop.

Ordovician Period

- In this period, crinoids appeared.
- First vertebrate animals
- Jawless fish
- At the end of the Ordovician period, mass extinction occurred, possibly due to the brief glaciation and sea-level lowering of this time.

Middle Paleozoic Era
(Silurian – Devonian Periods, 444 – 359 Ma)

- Global climate warmed
- Sea levels rose
- Continents flooded again.
- Orogeny took place – mountain-building
 - The Appalachian Mountains formed
 - Eastern North America was hit by small continental masses drifting in from the east

Middle Paleozoic – late Devonian

- By the end of the Devonian Period, there were swampy forests with tree-sized plants related to club mosses and ferns.
- **Insects:** spiders, scorpions, insects, and crustaceans inhabited dry-land and fresh water. Jawed fish like sharks and bony fish began to swim in the oceans. The first amphibians breathed with lungs on land.

Late Paleozoic Era
(Carboniferous – Permian Periods, 359-251 Ma)

- The global climate had cooled and Earth entered ice-house conditions. Gondwana & Siberia lay at high altitudes, covered by ice sheets.
 - Seas retreated and we had coastal swamps and river deltas in which sand, shale, and organic debris accumulated.
- During this period, Laurentia (including the United States) lay near the equator, where tropical conditions created lush growth in swamps, leaving thick piles of woody debris which were buried and transformed into coal.

Pangea
by mid-Permian Period, 299-251 Ma

- Finally, in the late Paleozoic, continual continental collisions formed one solid continent, Pangea.
- Laurentia joined with Gondwana.
- Appalachians were complete
- Allegheny Orogeny – forces were so strong that faults across North America moved, uplifting the Rocky Mountain region, known as the Ancestral Rockies.

Mesozoic Era: early & mid
Age of Dinosaurs, Triassic–Jurassic Periods, 251-145 Ma

- **Paleogeography**
- Pangaea lasted about 100 million years, through the late Triassic/early Jurassic Periods, when the continent had begun to break up.
- The Atlantic Ocean formed; North America grew in land mass through collisions of microcontinents and volcanic activity.

Mesozoic Era

- **Early Mesozoic:** Pangaea was a nonmarine environment, allowing the erosion of red sandstones and shales to be deposited in what we see in the beautiful cliffs of Zion National Park.
- **Middle Jurassic Period:** The Sea level rose. The Rock Mountains were under shallow seawater.

Navajo Sandstone
Zion National Park



CRETACEOUS PERIOD

146 – 65 Million years ago (Ma)

- This period is within the Mesozoic Era, which is within the Phanerozoic Eon.
- Earth's climate was warmer and sea levels rose highest in 200 million years. Seaways flooded most continents depositing thick loads of chalk in Europe and layers of limestone and sandstone in the western interior of North America.
- Later Cretaceous – a shark could have swum from the Gulf of Mexico to the Arctic Ocean.

Late Mesozoic Era
Cretaceous Period

- Breakup of Pangea continued.
- (show pg.321)
- Along western North America, the Sierran arc of volcanoes were very active forming the eventual Sierra Nevada Mtns.
- Converging boundaries caused large thrust faults east of the arc, which geologists call the **Sevier Orogeny**. (pg.320)

Where do the names of periods come from?

- The names often refer to the **locality** where a pretty complete stratigraphic column representing that time interval is very distinctly identified.
- Ex: Devonian Period rocks crop out fully near Devon, England.

Names also derive from a **characteristic** of the time

- For example, rocks from the Carboniferous Period contain high levels of coal.
- There is no set pattern to the terms, which is why it is difficult to learn their order. Names grew in a random fashion between 1760 – 1845.

Cretaceous Period

- Continued pressure from converging boundaries in western North America resulted in large faults in the region of Wyoming, Colorado, eastern Utah, and northern Arizona to slip.
- These faults dropped deep into the Precambrian rocks, as if a basement was uplifting.
- Geologists refer to this as the **Laramide Orogeny**. – like folds of a carpet over a step – forming the structure of the Rocky Mountains.

End of Cretaceous

- KT Boundary - most geologists agree that this period came to a close due to a huge meteor that hit the Yucatan Peninsula in Mexico. 100-km-wide by 16 km-deep scar called the Chicxulub Crater lies buried by younger sidentment.
- The impact caused a 2-m-high tsunamis that inundated the shores. Acid rain fell. Debris blasted into the sky and blocked out sunlight for months, causing a stoppage in photosythesis, leading to a breakdown of the food chain and extinctions.
- Dinosaurs, which had ruled the planet for 150 million years, simply vanished, along with 90% of plankton, and 75% of plant species.

REGIONAL FORMATIONS



Mississippian Epoch, within the Carboniferous Period, 318-359 Ma

- Plant fossil found at 5-mile Quarry in Lindon. Stigmaraia, the scientific name for the roots of the Giant Club Lepidodendron.
- Found in a former estuary channel in the Big Blue Formation.

COLORADO PLATEAU

- The [Colorado Plateau](#) is made of mostly flat-lying layers of [sedimentary rock](#) made up of uplifted [Dakota Sandstone](#) deposited during the [Cretaceous](#) Period (approximately 66-138 million years ago).


The Cockscomb

- The Cockscomb in Grand Staircase-Escalante National Monument. The candy-striped layers of sedimentary rock along the Cockscomb are part of a sharp fold, the East Kaibab monocline, that interrupts the flat-lying sedimentary rock sequence.
- The Cockscomb runs 60-miles congruent to Hwy 89 from Bryce Canyon to the Grand Canyon.

The Cockscomb – Mesozoic Era




Morrison Formation
155 to 147 million years before
present)



**LOWER CRETACEOUS CEDAR MOUNTAIN FORMATION
IN EAST-CENTRAL UTAH**

- Utah is justifiably famous for its dinosaurs from the Upper Jurassic Morrison Formation. However, Lower Cretaceous strata that overlie the Morrison Formation preserve an even greater number of dinosaur species spanning a much larger time interval. Only over the past decade have new discoveries revealed the importance of dinosaurs preserved in Utah's Lower Cretaceous Cedar Mountain Formation. (Jim Kirkland/Scott Madsen, Utah Geological Assoc. Pub. 35)

Cedar Mountain/Morrison Formation



Colorado Plateau

- KODACHROME STATE PARK
- Jurassic & Upper Cretaceous Periods
- Entrada Formation – top layer of red slick rock which sits on top the Carmel Formation – the oldest layer deposited in an inland sea that covered the area – red and white cliffs.

Kodachrome State Park

