Grade 12 Earth and Space Science

SES4U

Qinghao Hu

January 7, 2026

Contents

§1: Earth's Geological History

§1.1 Cosmos Episode 7

1. What year for the beginning of the Earth did James Ussher give based on his study of the Bible?

- 23, October 4004 BC

2. What stable element does Uranium break down into after about 10 transformations?

- Lead

3. What happened to the rocks that were around at the birth of the Earth?

- Crushed, melted, and remade

4. What did Clare Patterson need to build before he could completely rule out lead contaminatoni in his sample?

- a new lab

5. What was the true age of the Earth found to be?

- 4.5 Billion Years old.

6. How did Clare Patterson conclude the oceans were being contaminated by lead gasoline?

- Lead is concentrated at surface not great depth = recent deposition.
- Amount of lead in ice and snow is much lower few hundred years ago. Before industrial revolution.

§1.2 The Impossible Hugeness of Deep Time

§1.2.1 Age of Earth

4.54×10^9 years old / 4.54 Billion years old

§1.2.2 Order of the Event

1. Formation of the Earth
2. Formation of Moon
3. Liquid water
4. Formation of Earth's atmosphere
5. First living organisms
6. Buildup of oxygen in atmosphere
7. First Eukaryotes
8. Formatoin of supercontinent Rodinia
9. Breakup of Rodinia
10. Early multicellular organisms
11. Cambrian explosion
12. First land plants
13. First amphibian, insect, tree, and shark fossils
14. First reptiles
15. Earliest flowering plants
16. Earliest birds and mammals
17. Early primates
18. Present day

§1.3 Relative Age Dating

§1.3.1 Principles

There are five principles can be used to identify rock's relative age.

Principle of superposition: In a sequence of undeformed sedimentary rocks, the oldest beds are on the bottom and the youngest are on top.

Principle of original horizontality: Sedimentary layers are horizontal, or nearly so, when originally deposited. Strata that are not horizontal have been deformed by movements of the Earth's crust.

Principle of faunal succession: Groups of fossil plants and animals occur in the geologic record in a definite and determinable order. A period of geologic time can be recognized by its respective fossils.

Principle of crosscutting relations: Geologic features, such as faults, and igenous intrusions are younger than the rocks they cut.

Principle of inclusion: a rock body that contains inclusions of preexisting rocks is younger that the rocks from which the inclusions came from.

$$N = N_0(\frac{1}{2})^{\frac{t}{t_{half}}} \tag{1.1}$$

§1.4 Seminar Testable Question

§1.4.1 Formation of crust and continents

1. What is planetary differentiation and explain how it contributed to the creation of the Earth's layers?

- Planetary differentiation is a process by which a planet organizes itself based on density.
- Denser materials sank to the core while lighter materials floated upward, forming the different layers of the Earth.

What are two important characteristics of a craton?

- It's the oldest and most stable part of a continent
- Makes up around 10% of Earth's landmass

§1.4.2 Relative and absolute age dating

1.4.2.1 Define Absolute age dating

It determines the exact age of a rock or fossil in years, often using radioactive decay.

1.4.2.2 State the name of any three of five principles of relative age dating and explain

- **Original Horizontality**: Sedimentary rocks are generally deposited in horizontal layers.
- **Cross Cutting Relationship**: An intrusion or fault line is younger than the rock it cuts across.
- **Inclusions**: Inclusions in a rock layer must be older than the rock layer that contains them.

§1.4.3 Fossil Dating

1.4.3.1 How are fossils found on mountaintops, where there are few sediments available?

Tectonic plates push areas of rock together to expose fossils.

1.4.3.2 For a fossil to be considered an index fossil, it must fulfill five criteria. What are three of those criteria

- Unique
- Globally widespread
- Abundant

1.4.3.3 Difference between a mould and cast fossil

- **Mould**: The space left by an organism after it decays.
- **Cast**: when a mould is filled with sediments.

§1.4.4 The Geologic Time Scale

1.4.4.1 What is the relationship between Eons and eras?

Eons are the longest divisions of geological time, and are divided into eons.

1.4.4.2 How are eons divided?

Eons are divided by major global changes

1.4.4.3 How do rock layers act as a "Ruler" for Earth's history?

- Older rock layers usually lie beneath younger layers, creating a time order
- Earth rock layer can provide evidence of Earth's previous environment.

§1.4.5 Famous Geologists

1.4.5.1 What is the principle of Uniformitarianism

Present-day geological processess explain past geological features.

1.4.5.2 Alfred Wegener's theory of Continental Drift was initially rejected by the scientific community because

: HIs maps showing continental fit were geographically inaccurate

1.4.5.3 Explain how Mary Anning's fossil discoveries provided critical evidence that supported Charies Lyell's concept of Deep Time

- He discoveries of complete skeletons of creatures which had no living equivalents provided proof of extinction
- This evidence of extinction required vast periods of time.

§1.4.6 Formation of the atmosphere and oceans

1.4.6.1 Explain how banded iron formations form

- Oxygen reacts with dissolved iron in water, and settles on the ocean floor.

§1.4.7 Early Life on Earth

1.4.7.1 What were the three main gases thought have been involved in the Primordial Soup?

- Methane, Hydrogen, Ammonia

1.4.7.2 Introductoin of amino acids on Earth

Space

- amino acids found in asteroids and comets that survived crash on Earth
- Asteroids and comets have been found on Earth with amino acids
- Difficult to test due to technical limitations

§1.4.8 Paleozoic era

1.4.8.1 Which factor best explains why many animals appear to "suddenly" appear in the fossil record during the Cambrian Period

- Many animals evolved hard body parts the fosslize easily.

1.4.8.2 Three main differences between pre-cambrian life and life during the cambrian period.

Pre-Cambrian life:

- Unicellular organisms
- Organisms were mostly disc/bolb shaped

Cambrian life:

- Developed new body-plans that allowed for increased movement
- More diversity of organisms
- Predator-prey relationships.

§1.4.9 The Mesozoic Era

1.4.9.1 How did seaways form as a result of Pangea breaking apart?

- The heat beneath Pangaea caused the continent to expand, and its brittle lithosphere began to crack.
- Some of the large cracks, called rifts, gradually widened and the landmass began spreading apart.
- Ocean flooded the rift valleys to form seaways, and large blocks of crust collapsed to form deep valleys.

1.4.9.2 What are the names of the two major landmasses that supercontinent Pangea broke into?

Laurasia and Gondwana

§1.4.10 Constructing dinosaurs from fossils

1.4.10.1 Why is it so difficult to accurately reconstruct a dinosaur?

- Most of a dinosaur was composed of soft tissues and fats, which do not fossilize
- Scientists can only predict how they looked baesd on the fossilzed skeleton and related present-day animals

1.4.10.2 What are the desscendants of dinosaurs?

- Birds

1.4.10.3 What is the rarest form of fossils

- Soft Tissues

§1.4.11 The Cenozoic Era

1.4.11.1 What did the Cenozoic Era begin?

- 66 Milion Years ago

1.4.11.2 Which factor played the most important rule in maintaining the extreme warmth of the Early Cenozoic Era?

High levels of atmospheric carbon dioxide caused by intense volcanic activity

1.4.11.3 What kind of habitat became more common as forests shrank

Grasslands and open plains

1.4.11.4 Why is the Paleocene-Eocene Thermal Maximum important?

Because it shows how adding greenhouse gases can quickly warm Earth's climate.