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Content

Introduction

Historical Geology examines how our planet has evolved over geological time, integrating concepts from stratigraphy, sedimentology, paleontology, structural geology, geochronology and plate tectonics.

Throughout this course, you will learn to interpret the rock record to understand ancient environments, biological evolution, and the dynamic processes that have shaped Earth into the planet we know today.

Key Topics We'll Cover

1. **Earth's Formation and Early History**
    - Origin of the solar system
    - The Hadean and Archean Eons
    - Development of the early atmosphere and oceans
2. **The Evolution of Life**
    - Fossil record and preservation
    - Major evolutionary transitions
    - Mass extinctions and their causes
3. **Tectonic History**
    - Continental drift and plate tectonics
    - Supercontinent cycles
    - Mountain building episodes
4. **Brief geological history of Algeria**

What to Expect

This course combines theoretical lectures with practical laboratory work of other courses and field trip experiences. You will develop skills in:

- Identifying and describing rocks and fossils
- Reading and interpreting geological maps
- Constructing stratigraphic columns
- Synthesizing multiple lines of evidence to reconstruct Earth history

Historical Geology

Historical Geology is a discipline that aims to trace the sequence of major geological events that have given the Earth its current appearance.

5. Objectives of historical geology:

Historical geology focuses on understanding Earth's past through its rock record. The primary objectives of this field include:

- Reconstructing Earth's history by determining the sequence of geological events, including the formation and movement of continents, mountain building, and periods of erosion.
- Understanding the evolution of life by studying fossils to trace how organisms have changed over time and responded to environmental changes.
- Interpreting past environments by analyzing sedimentary rocks, their structures, and fossil content to reconstruct ancient landscapes, climates, and ecosystems.
- Establishing a geologic time scale by dating rocks relatively and absolutely, this aims to create a chronological framework for Earth's history.
- Deciphering past climate changes through evidence in the rock record to better understand natural climate cycles and extreme events.
- Exploring natural resource formation by understanding the geological processes that created deposits of oil, gas, coal, and minerals.
- Correlating rock units across different regions to build comprehensive models of Earth's structural and stratigraphic history.
- Applying uniformitarianism - the principle that present-day processes also operated in the past - to interpret ancient geological features.

This field combines elements of stratigraphy, paleontology, sedimentology, and geochronology to piece together Earth's 4.6-billion-year story.

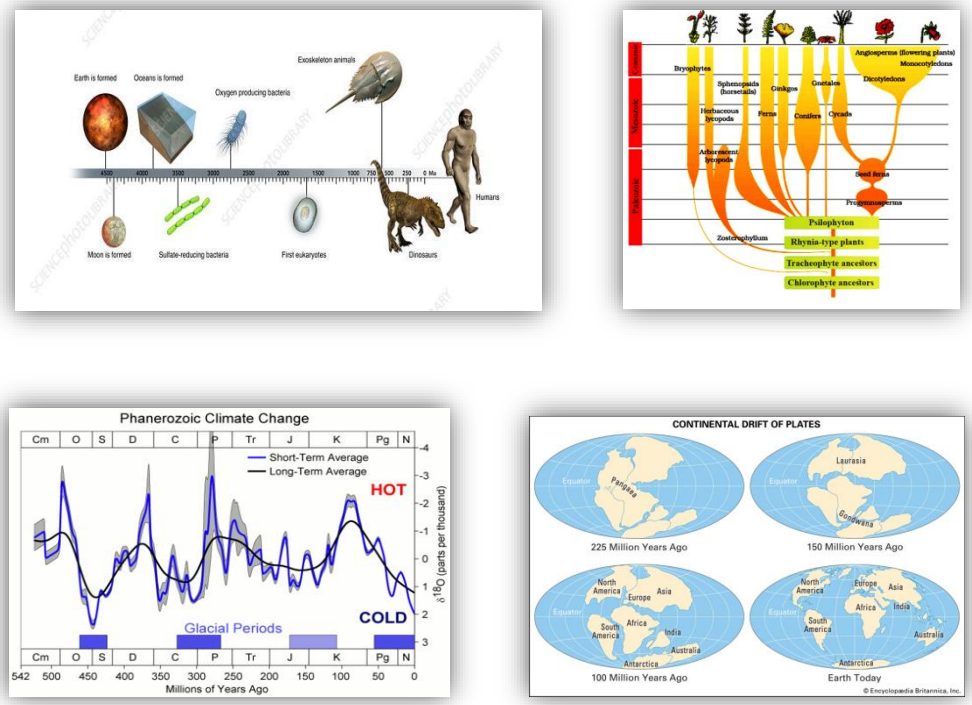

Fig. 1: The four main areas of historical geology:
Animal life, Plant life, Climate change and Plate tectonics.

6. Tools:

Several disciplines are involved, such as stratigraphy, sedimentology, petrography, tectonics, geochemistry, geophysics...

7. Difficulties:

While local correlations appear relatively easy, regional correlations are more difficult, and planet-wide (or global) correlations sometimes seem impossible. The scale of study is among the major difficulties. The limitations of the aforementioned tools represent another obstacle.

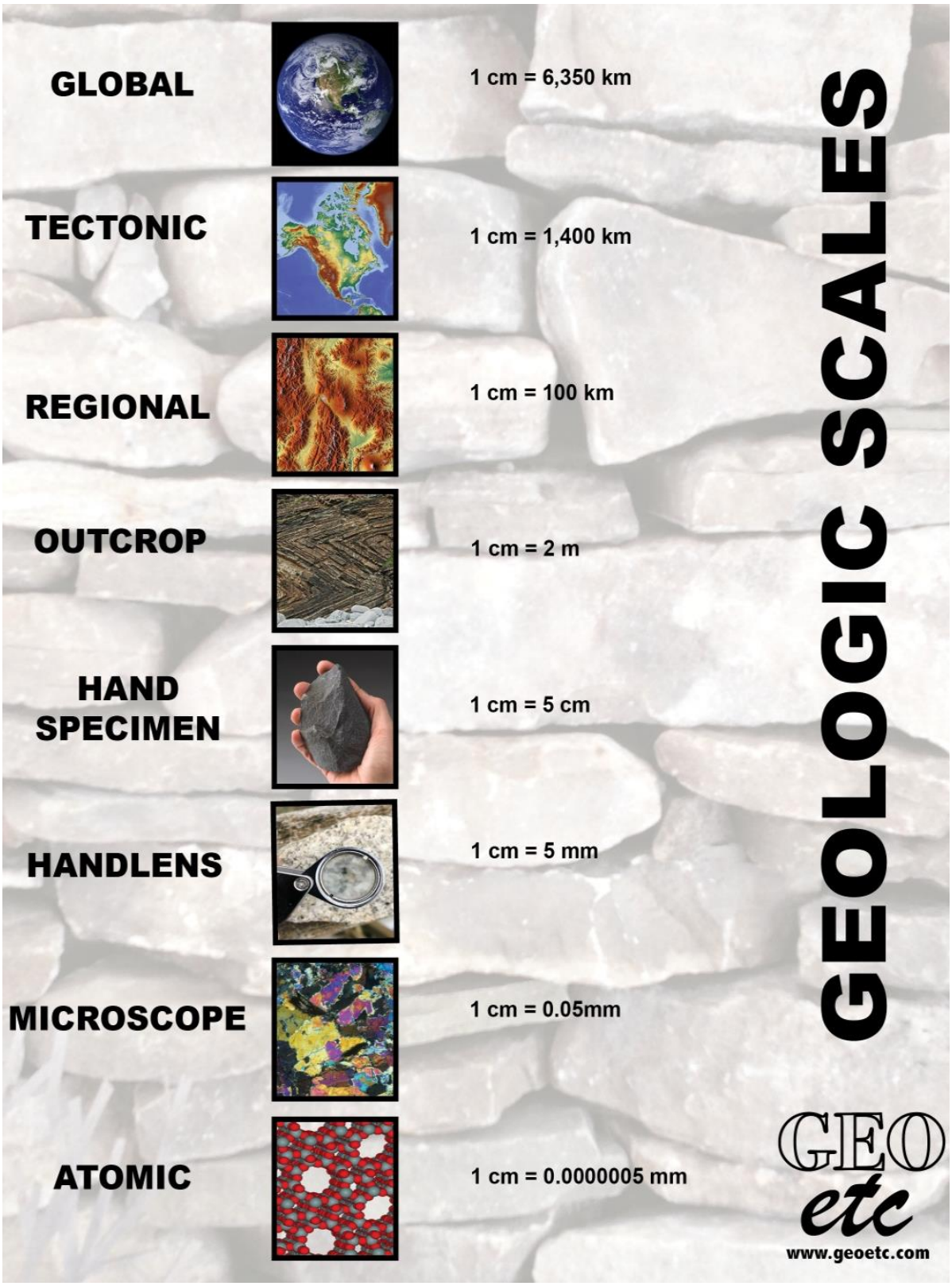

Fig. 2: Geological scales [1]

8. Time since the Big Bang:

1. Cosmological time
2. Geological Time
3. Quaternary Time
4. Historical Time
5. Future Time

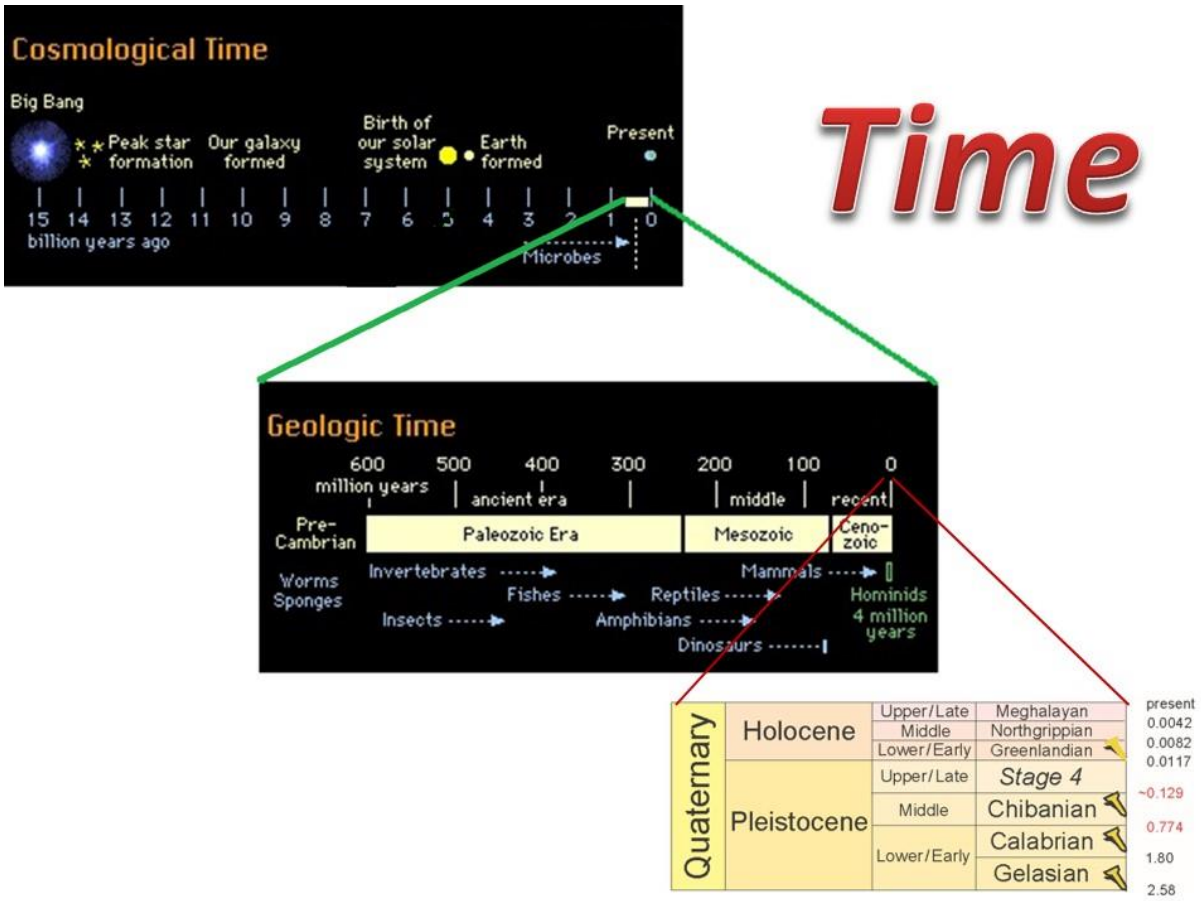

Fig. 3: Time since the Big Bang

Brief overview of Earth's origin

1. Big Bang 13.7 billion years ago.
2. Formation of hydrogen and helium.
3. Formation of our Galaxy (10 billion years ago)
4. Heavy elements are synthesized from Supernovas*.
5. A nebula** begins to contract (4.7 billion years ago).
6. The Proto-sun begins to form as a result of the rotation of nebular material.
7. Accretion of planetesimals*** to form Earth and other planets of the Solar System.
8. Continuous bombardments and disintegration of radioactive elements produce the magma ocean.
9. Chemical differentiation produces the different internal layers of Earth.
10. A celestial object the size of Mars strikes the young Earth (4.6 billion years ago).
11. Debris resulting from the impact orbits Earth and begins to condense.
12. Formation of the Earth-Moon system.
13. Gases released by Earth form the primitive atmosphere.

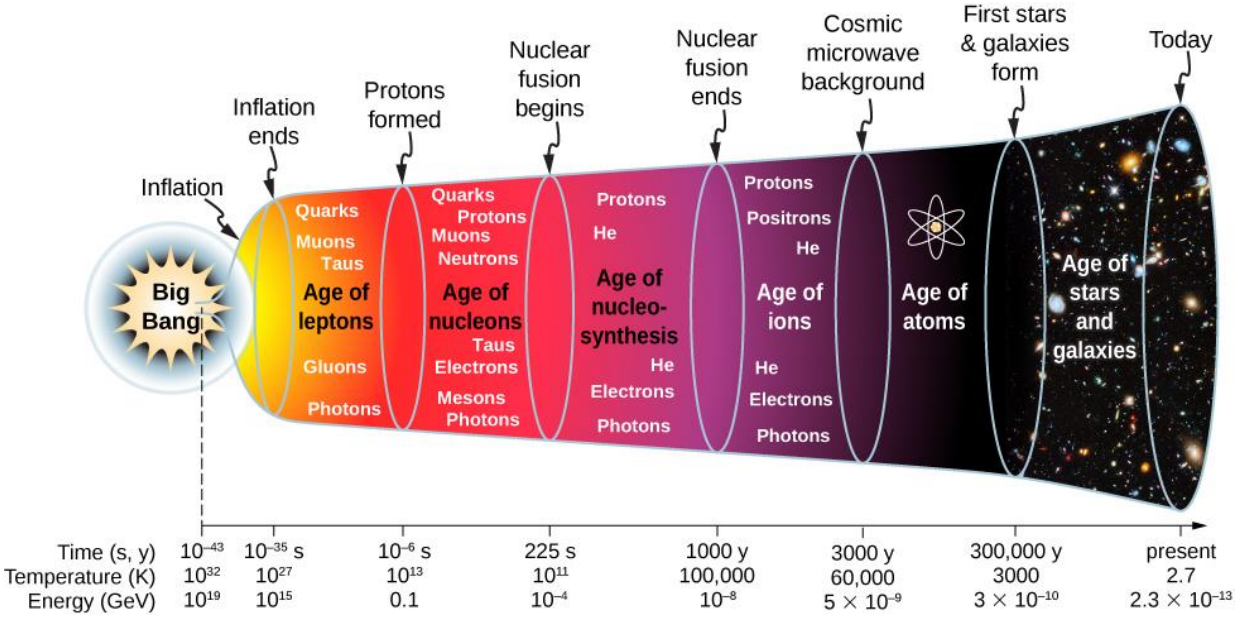

Fig. 4: Evolution of the universe on an approximate timeline [2]

*Supernova: implosion phenomenon of a dying star.

**Nebula: cloud of interstellar dust, hydrogen, helium, and other ionized gases.

***Planetesimals: small bodies (km-sized) formed by the agglutination of dust during the planet formation process.

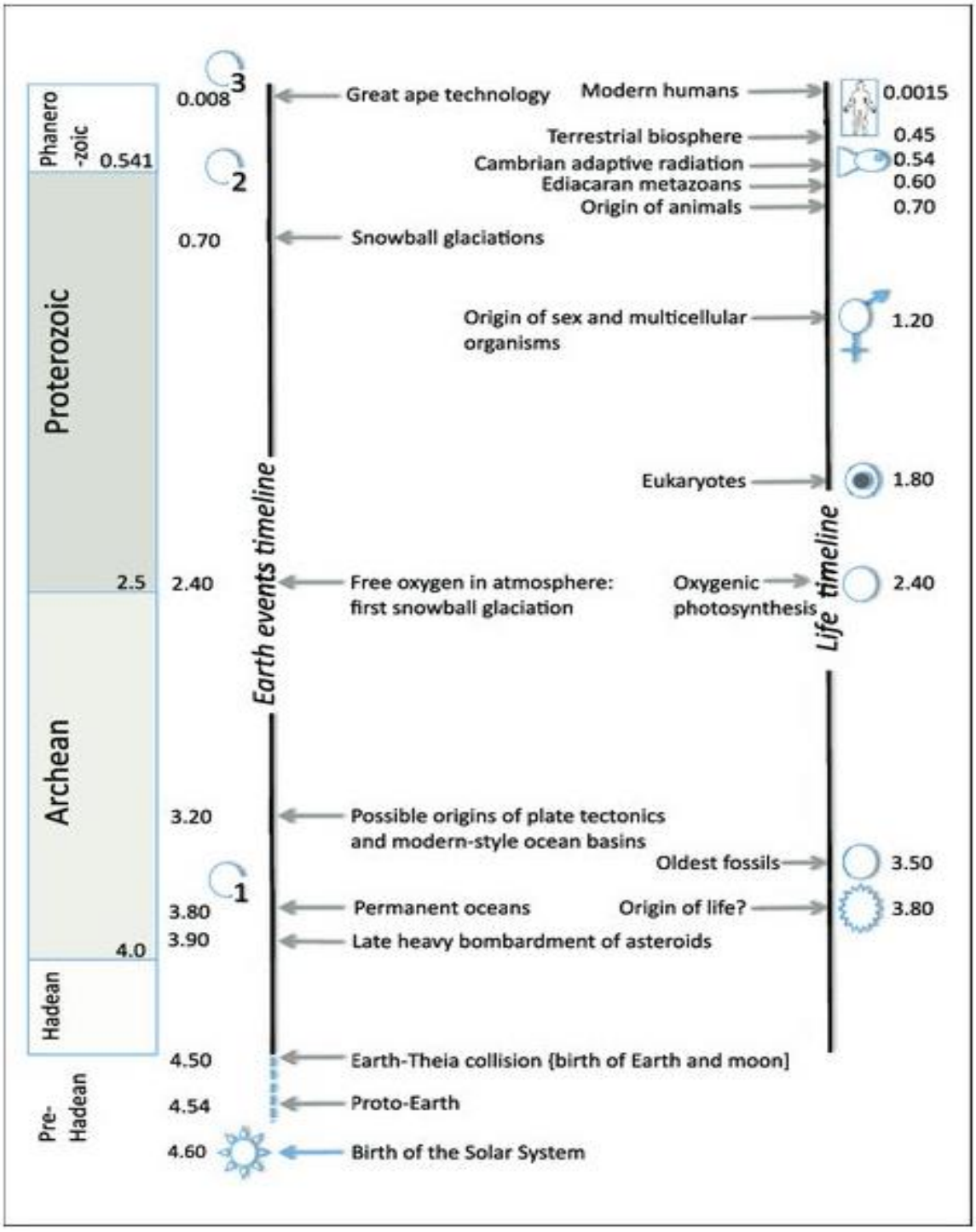

Fig. 5: Earth History stages - Major events in the evolution of life and the planet: circled numbers 1 (microbial), 2 (metazoan), and 3 (Anthropocene) represent the three stages in the evolution of the biosphere discussed here. The origin of plate tectonics is a controversial subject and may have begun much earlier than 3.2 Ga [3]

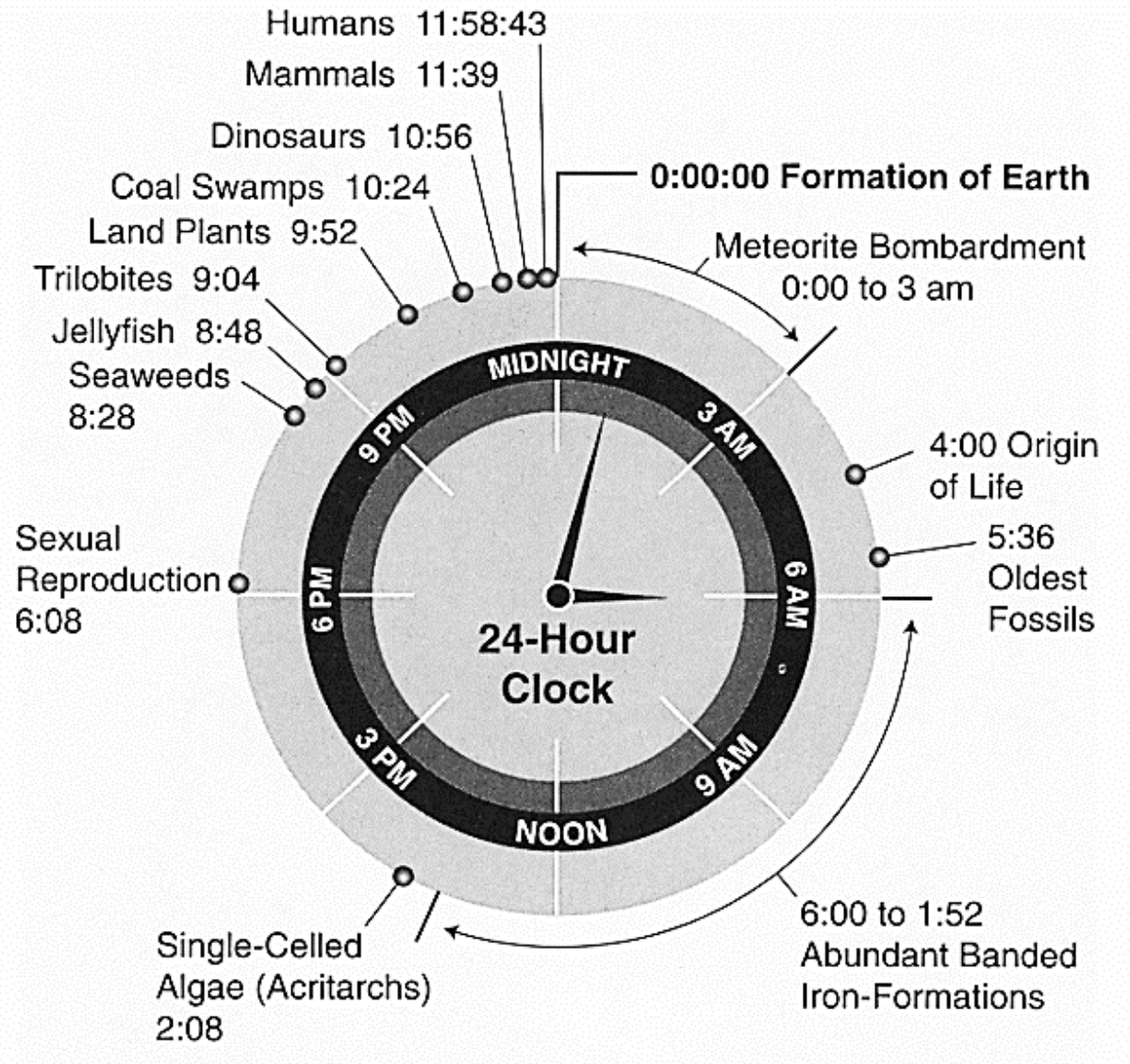

Fig.6: Diagram representing the 4 eons (Hadean, Archean, Proterozoic and Phanerozoic) of the geological time scale reduced to a 24-hour section. [4]

Origin of Life

Some key stations

1. Eukaryotes (organisms with true nuclei), cellular organisms, appeared around 2500 to 2100 million years ago.

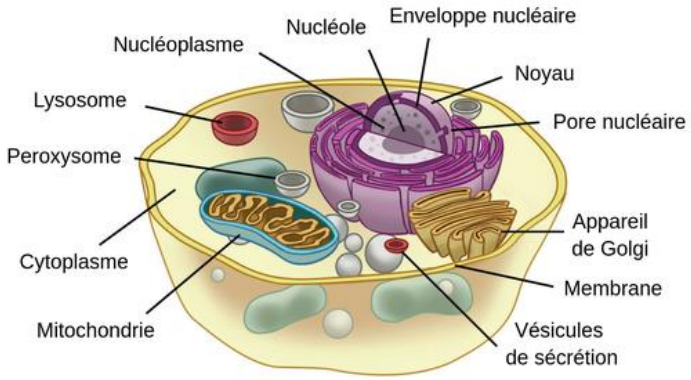

Fig. 7 : Eukaryotic cell

2. First metazoans (group of organisms designating multicellular animals), such as cnidarians (e.g., jellyfish) appeared between 700 to 600 million years ago (Ma).

Fig. 8 : Metazoans Group

3. At the end of the Proterozoic, the development of life accelerated.
4. Appearance of triploblastic* organisms with more than two cell layers 570 million years ago.

*Triploblastic organisms: animals whose embryo is organized into three embryonic layers: the ectoderm, endoderm, and, unique to triploblastics, the mesoderm.

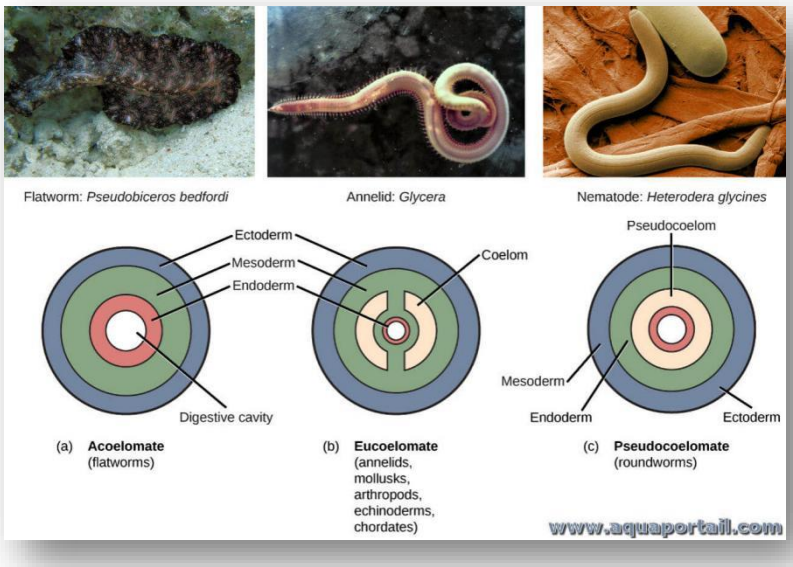

Fig. 9 : Triploblastic organisms

5. At the end of the Proterozoic, the development of life accelerated.
6. Triploblastic organisms: animals whose embryo is organized into three embryonic layers: the ectoderm, endoderm, and, unique to triploblastics, the mesoderm.

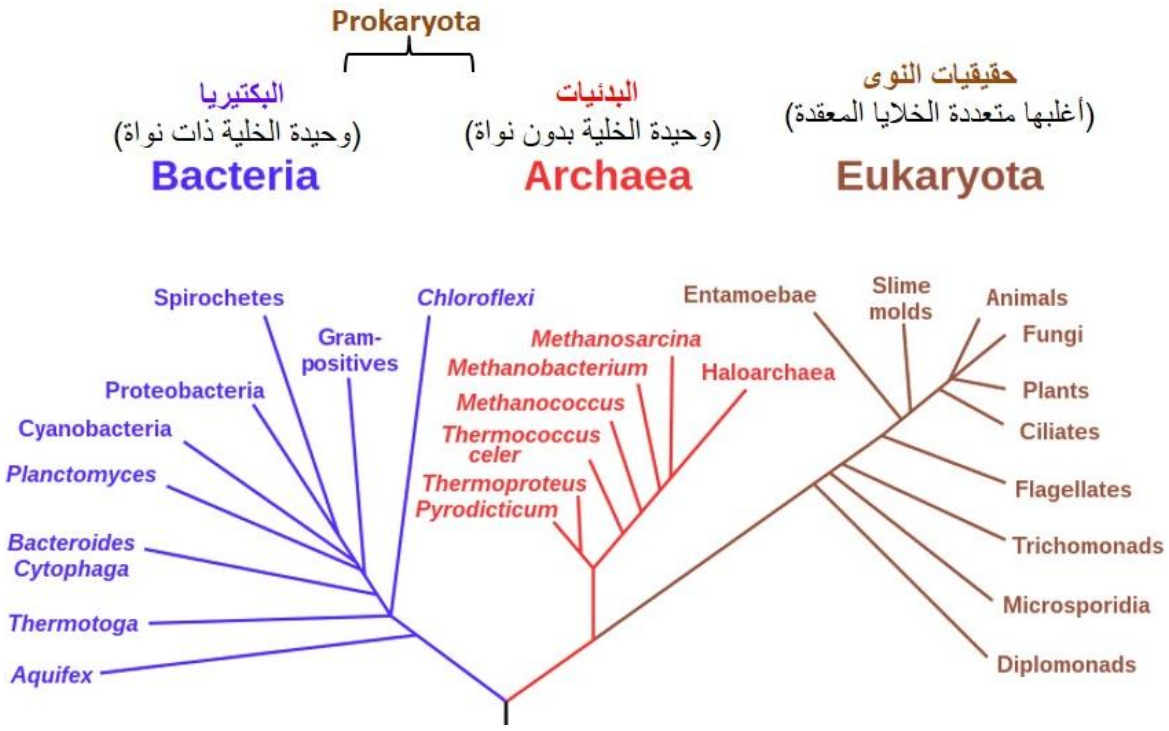

Fig. 10: The three domains of life [5]

7. Around -542/-530 Ma, the "Cambrian explosion" occurred, a very important diversification of life forms.

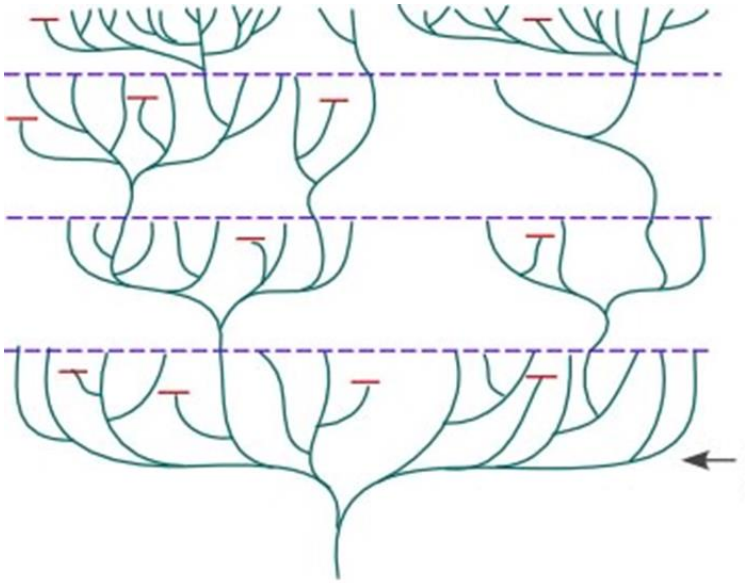

Fig. 11 : Cambrian explosion

8. The Ordovician begins with an extinction episode of some species. It ends with a mass extinction. The geological layers of the Ordovician contained abundant life and today contain vast oil and gas reservoirs around the world.

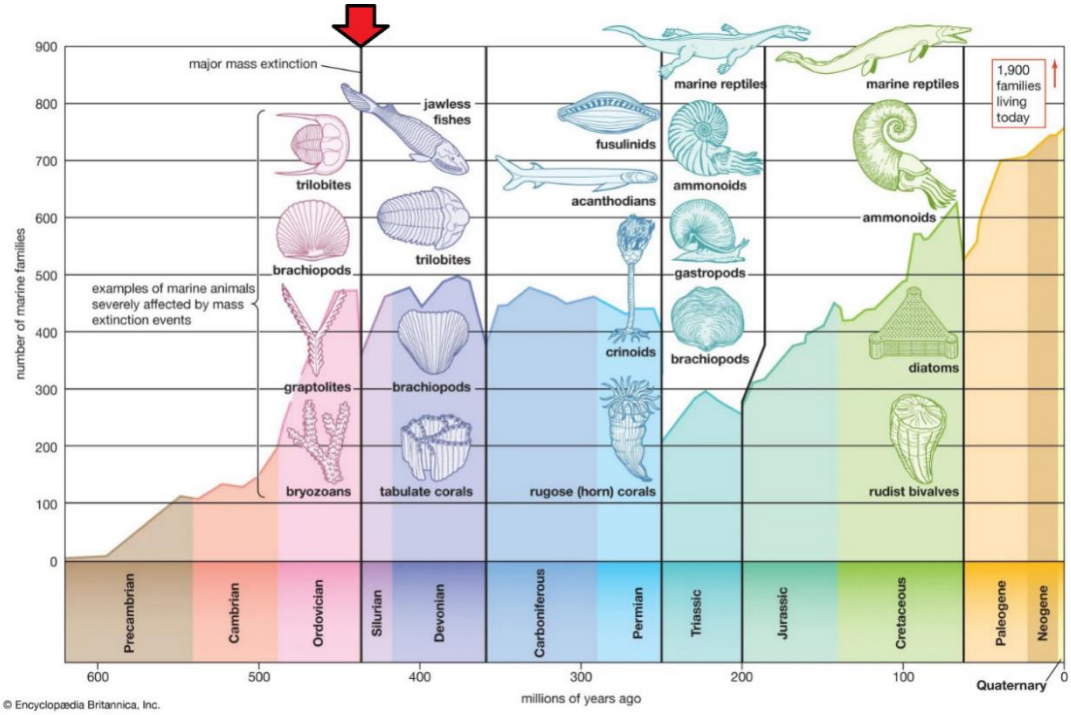

Fig. 12: End of Ordovician extinction [6]

9. In the Silurian (-444/-416 Ma), the first vertebrates with jaws appeared and vascular plants (higher plants with stems, roots, and leaves) began to colonize the land.

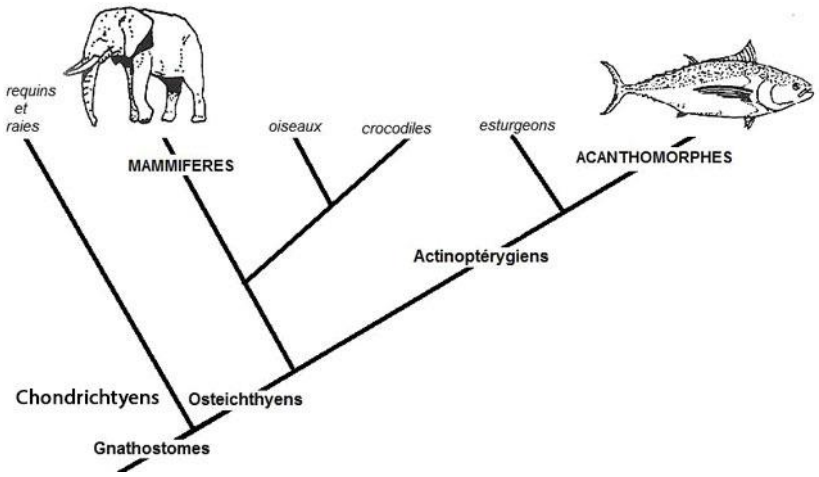

Fig. 13: The Gnathostome Tree: Jawed Vertebrates.

10. End of the Devonian, around -365 Ma, a very important mass extinction occurred. In total, about 70% of marine taxa died.

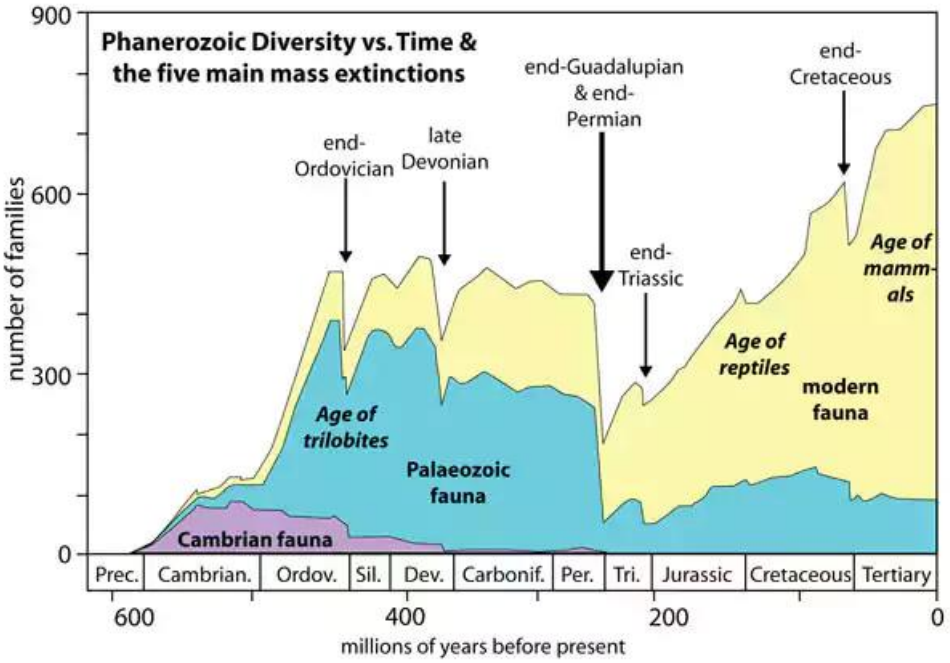

Fig. 14: Late Devonian extinction [7]

11. The Carboniferous (-359/-299 Ma) saw a rapid development of plants.

12. In the Triassic, the first dinosaurs appeared.

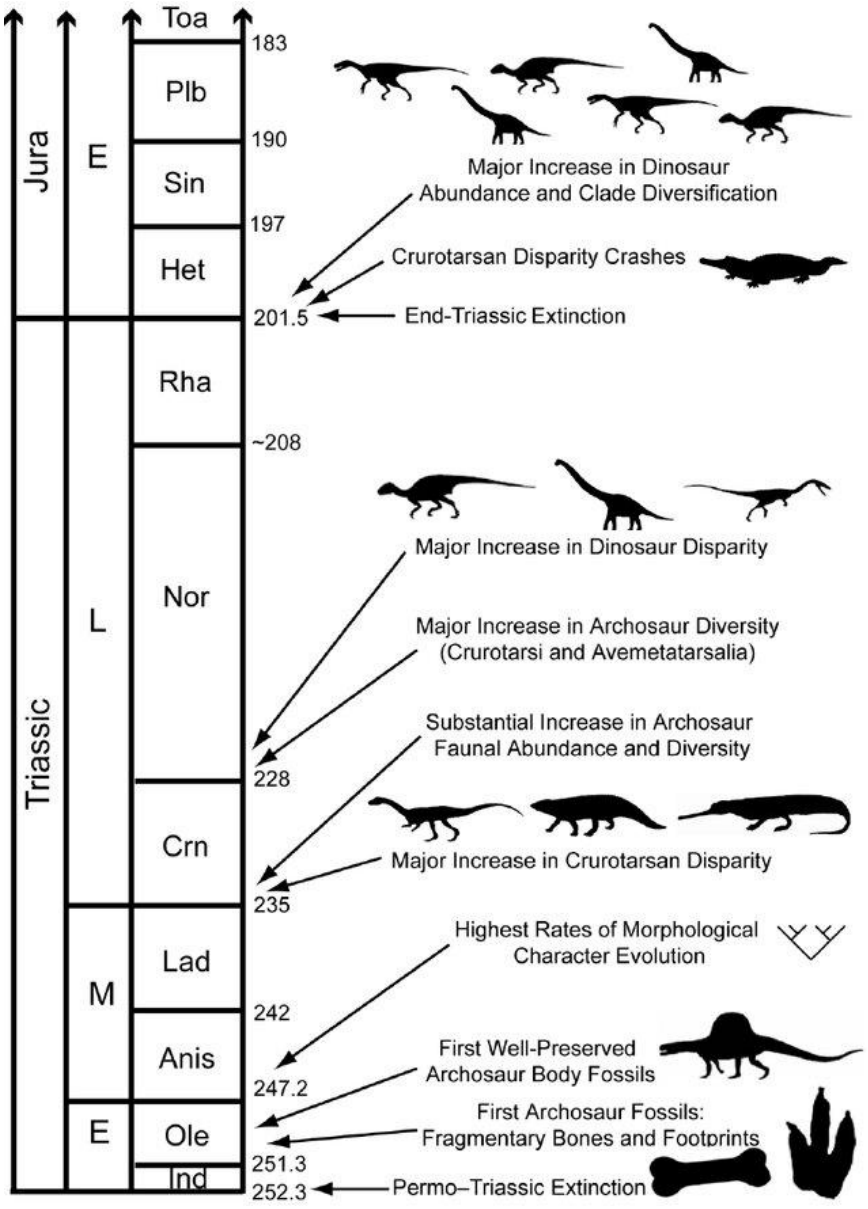

Fig. 15: A generalised timeline of important events in Triassic–Early Jurassic archosaur evolution. [8]

13. Birds: evolved from archosaurs (group including crocodilians and birds), appeared around -150 Ma, in the Jurassic.

14. The Jurassic, and the Cretaceous that follows, would be "the time of dinosaurs"...

15. A little later, around -135 Ma, "plants with fruits" began to develop, as did marsupial mammals. Snakes started crawling around -100 Ma...

16. At the end of the Cretaceous, around -65 Ma, the most well-known biological crisis to the general public occurred as it ended the reign of dinosaurs, flying reptiles, and many marine reptiles.

17. "Modern" mammals appeared in the Eocene, around -55/-50 Ma.

18. Homo Sapiens sapiens (wise man) will emerge through pre-hominins around -7 Ma (Toumaï).

19. Australopithecines (without tails) around -3.18 Ma.

20. Homo Habilis (skillful), around -2.5 to 2 Ma.

21. Homo Ergaster (worker), -2.2 Ma.

22. and also Homo Erectus (upright, standing), -2 Ma...

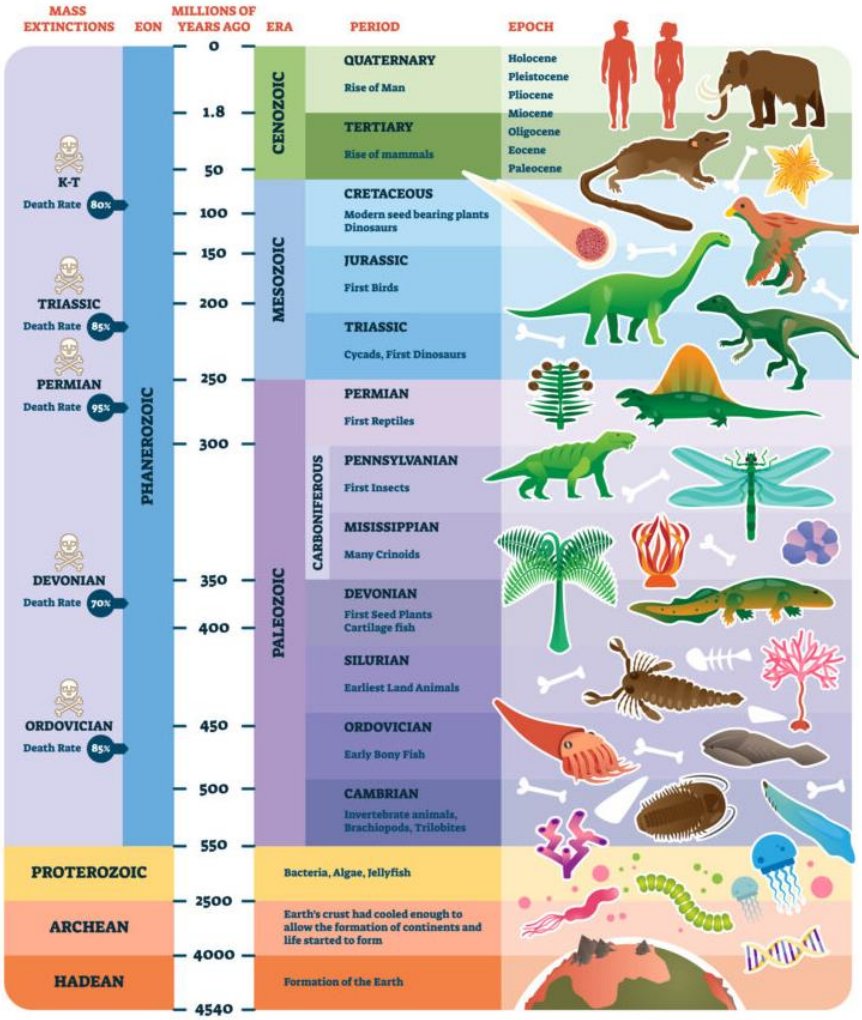

Fig. 16: Life History stages [9]

Orogenic cycles

4. Introduction

Orogenic cycles, also known as tectonic cycles or Wilson cycles, represent the recurring sequence of geological processes that build and destroy mountain ranges through the assembly and breakup of continents. These fundamental Earth processes operate over hundreds of millions of years and form the backbone of our understanding of the planet's tectonic evolution.

5. Definitions

• **Cycle**: A sequence of events concluding with a situation presenting the same characteristics as those of the initial state.

• **Orogenesis**: [from Gr. oros, mountain, and gennan, to engender] (Syn. Orogeny, Adj. orogenic). An orogenesis is the set of "convergent, divergent, or strike-slip" processes leading to the formation of an orogen.

• **Orogen**: is the set of structures and continental or submarine reliefs resulting from different possible stages:

- of plate convergence,
- from regional uplifts,
- to the emplacement of thrust sheets,
- to subduction and collision mountain chains,
- but also everything that results from erosion, from subsidence and peneplanation of reliefs.

6. Orogenic cycle

It's a succession of events that see a mountain chain form and then be destroyed. Typically, an orogenic cycle includes three phases:

1. sedimentation.
2. orogenesis.
3. peneplanation.

The base of each cycle is thus marked by a major unconformity on material affected by the previous cycle. The relationship between these tectonic cycles and plate tectonics is not yet clear, but one can think that a cycle corresponds to the opening followed by the closing of an oceanic domain (Wilson Cycles).

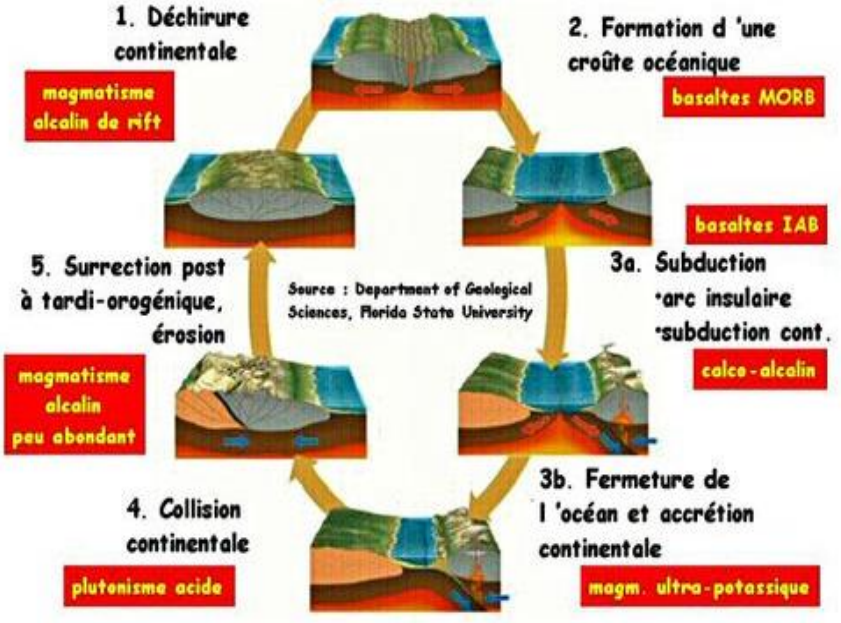

Fig. 17: Wilson Cycle [10]

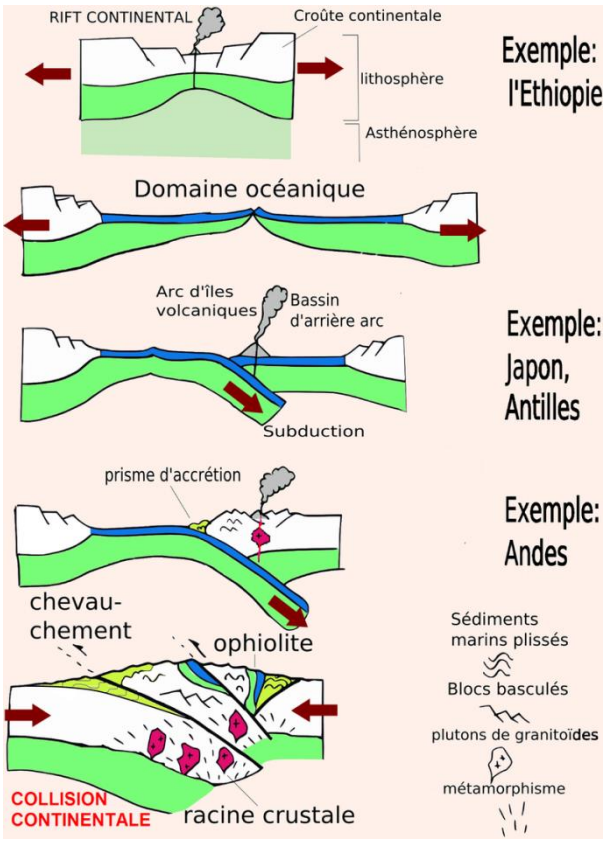

Fig. 18: Examples of Wilson Cycle stages [11]

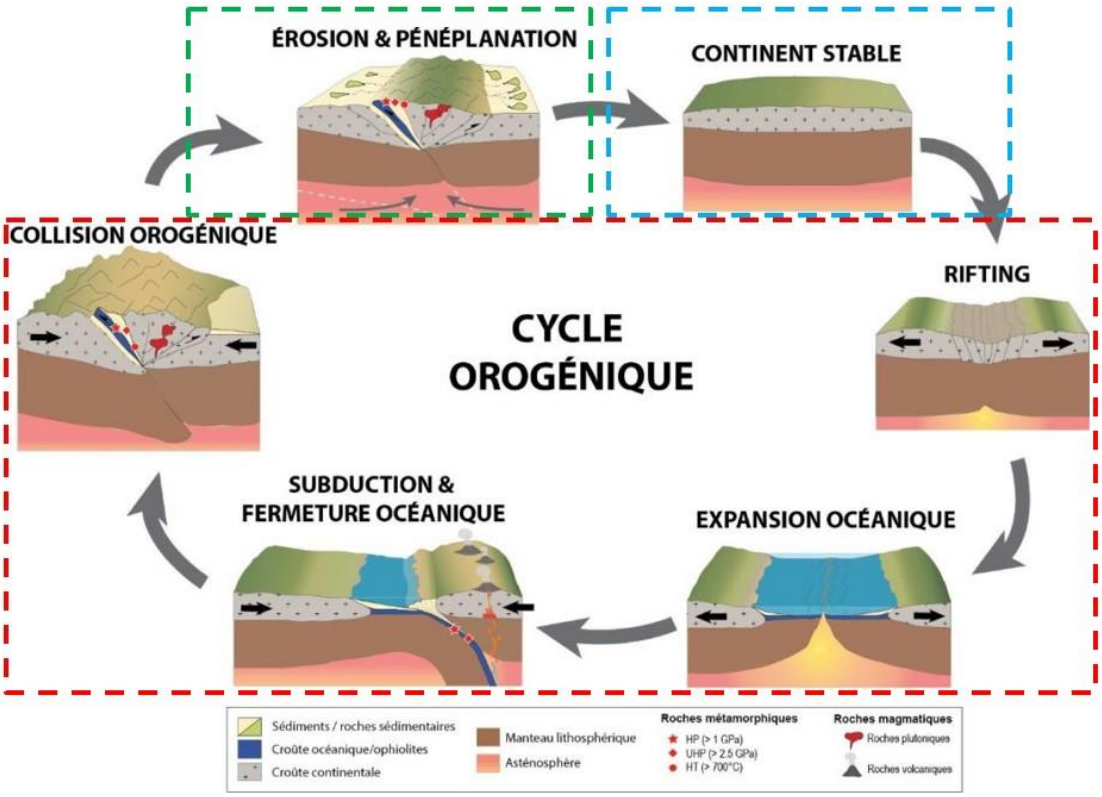

Fig. 19: Wilson Cycle – Another presentation [12]

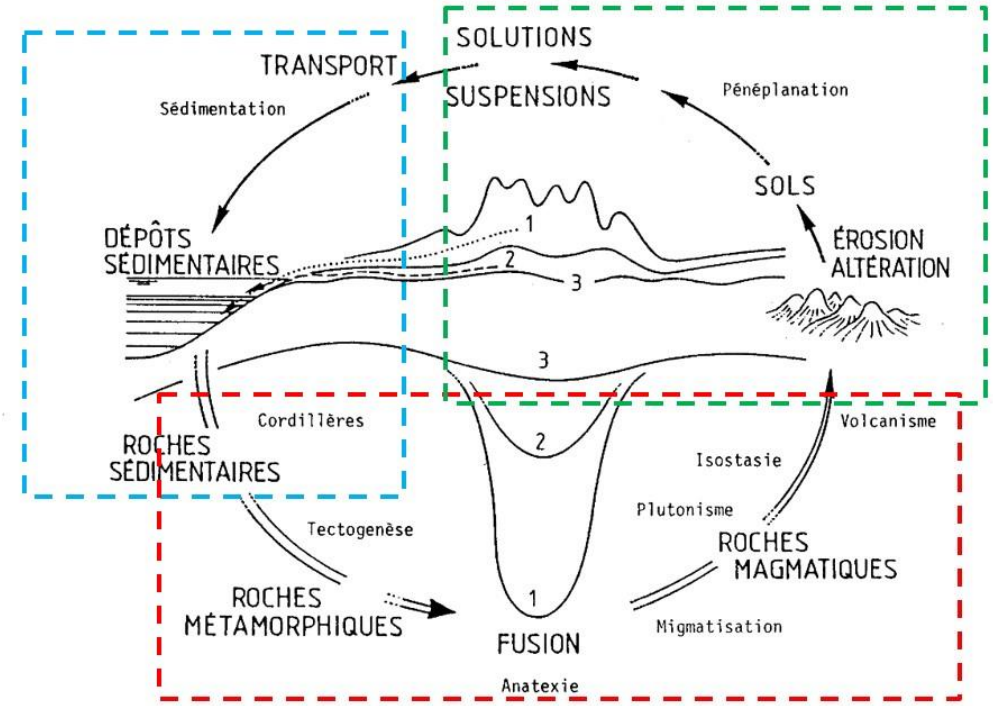

Fig. 20: Wilson Cycle with cycle of rocks [13]