The Paleozoic era

The Phanerozoic: The Paleozoic, the Mesozoic, and the Cenozoic compose the second geological eon, called the Phanerozoic**. The latter extends from about -542 million years to the present day. It represents ~12% of Earth's history.

The Paleozoic era occupies a time interval of about 300 million years. It is the longest era of the Phanerozoic. It is subdivided into six periods:

- Cambrian, Ordovician, and Silurian (Lower Paleozoic) or Caledonian times.
- Devonian, Carboniferous, and Permian (Upper Paleozoic) or Hercynian times.

The term Middle Paleozoic is sometimes used to designate the Devonian.

7. Lower limit of the Paleozoic

The Stratotype of the Precambrian-Cambrian boundary is defined at Fortune Head in the Burin Peninsula of Newfoundland (Canada). The base of the Cambrian there has been fixed by the appearance of the ichnofossil Treptichnus pedum.

Photo 6: Fortune Head - Burin in Terre Neuve (Canada).

**Phanerozoic: Phanero- from Greek phanerox = visible, thus "visible life"

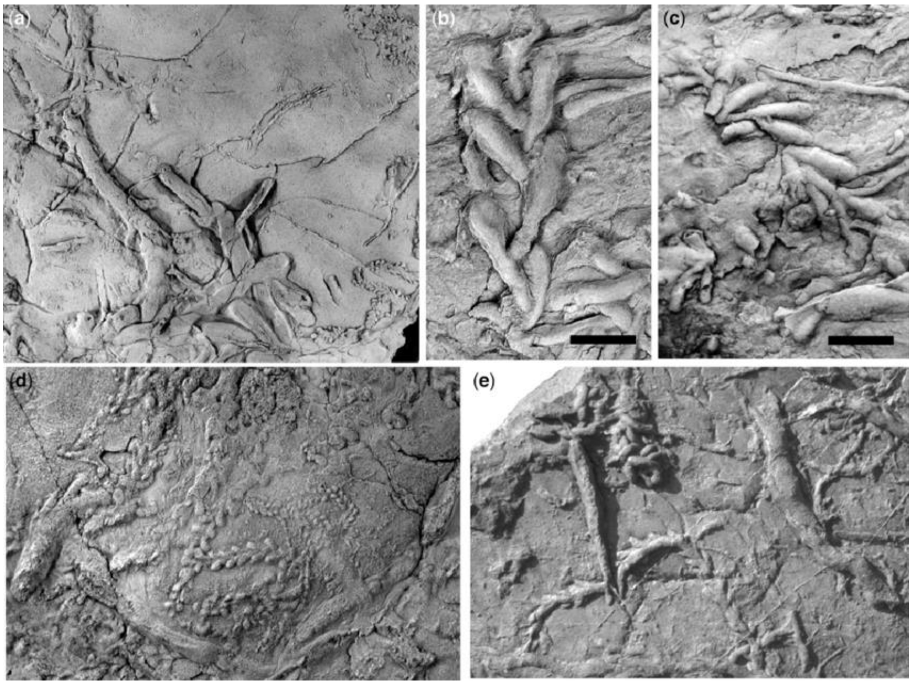


Photo 7: Ichnofossile ***Treptichnus pedum*** Tanafjord, Finnmark, North of Norway

Reminder about Stratotypes

There are two types of stratotypes:

*1. **The unit stratotype** corresponds to an outcrop that is recognized by specialists as the "type" of a geological stage (type-section that serves as a standard).*

Example: The stratotype of the Barremian was designated by Busnardo in 1963. It is located along the road to Angles, in the heart of the Haute Provence Geological Reserve (France).

*2. **The boundary stratotype** corresponds to a continuous set of layers at which the boundary between two stages is identified.*

The Global Boundary Stratotype Section and Point (GSSP) specifies the existing boundaries between two geological stages in work coordinated by the International Commission on Stratigraphy (ICS) and the International Union of Geological Sciences (IUGS). The boundary is marked on the outcrop by a golden spike.

Precambrian stages are defined by absolute ages (GSSA-Global Standard Stratigraphic Ages)

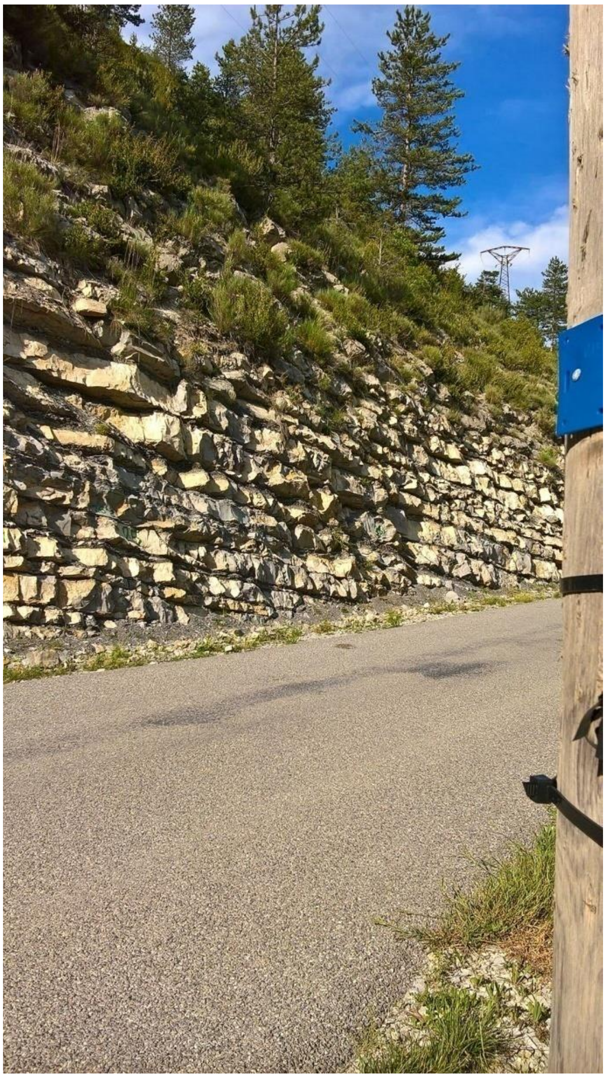


Photo 8: Stratotype of Barremian - *Haute Provence (France)*

Photo 9: This "Golden Spike" ("Golden Nail") represents the physical expression of the boundary between Santonian and Campanian, dated 83.6 million years ago. the Gola del *Bottaccione* (Gubbio) Italy.

Photo 10: Global stratotype point of the Ladinian (Upper Middle Triassic), at the Romanterra geological site in Bagolino, Italy.

Photo 11: Installation of the GSSP golden nail of the Hettangian stage at Kuhjoch (Tyrol, Austria)

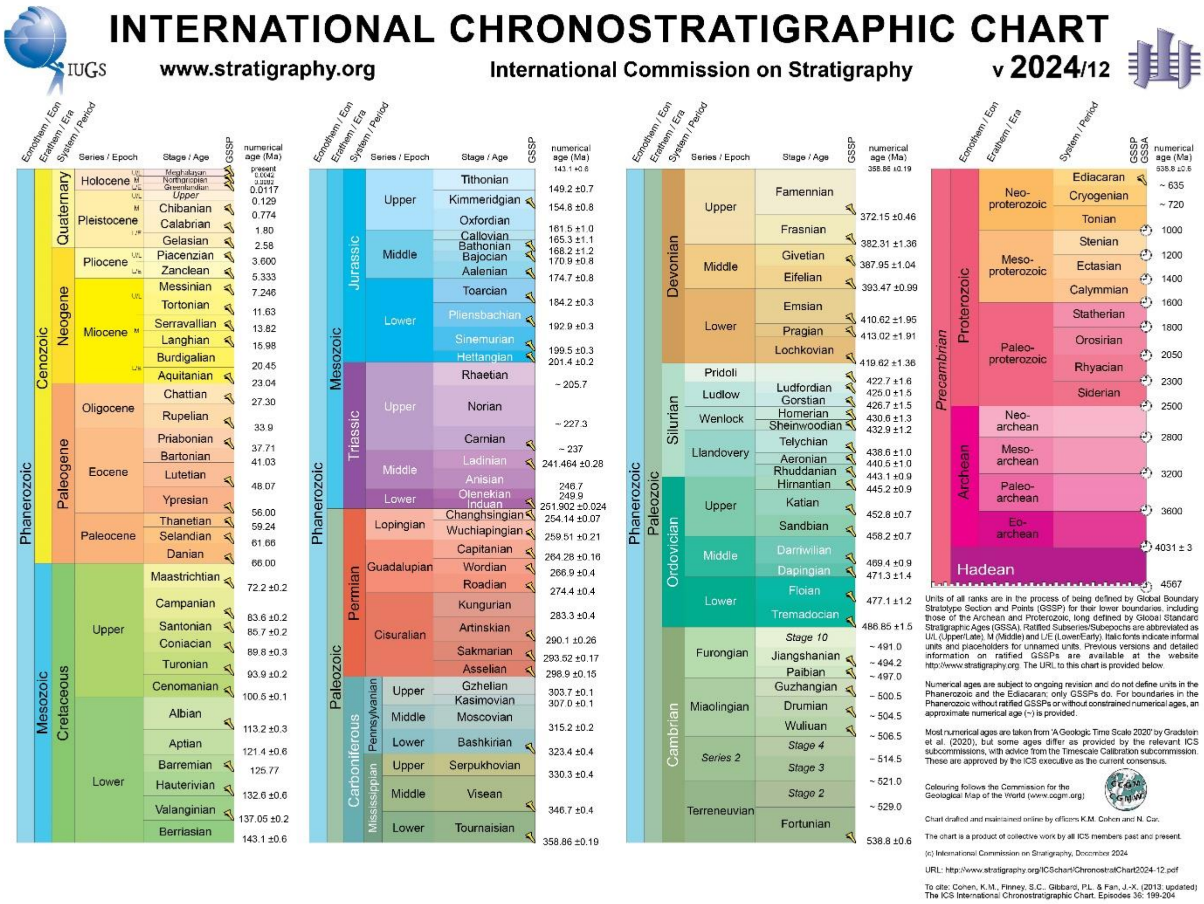


Fig. 75: International Chronostratigraphic Chart (2024/12 version.) [42]

8. Upper limit of the Paleozoic (Permian-Triassic)

The upper limit of the Paleozoic has often been defined by the end of the great Hercynian orogenic cycle. For more precision, the Paleozoic-Mesozoic boundary is marked by a significant renewal of faunas that corresponds to the great global extinction in Phanerozoic history.

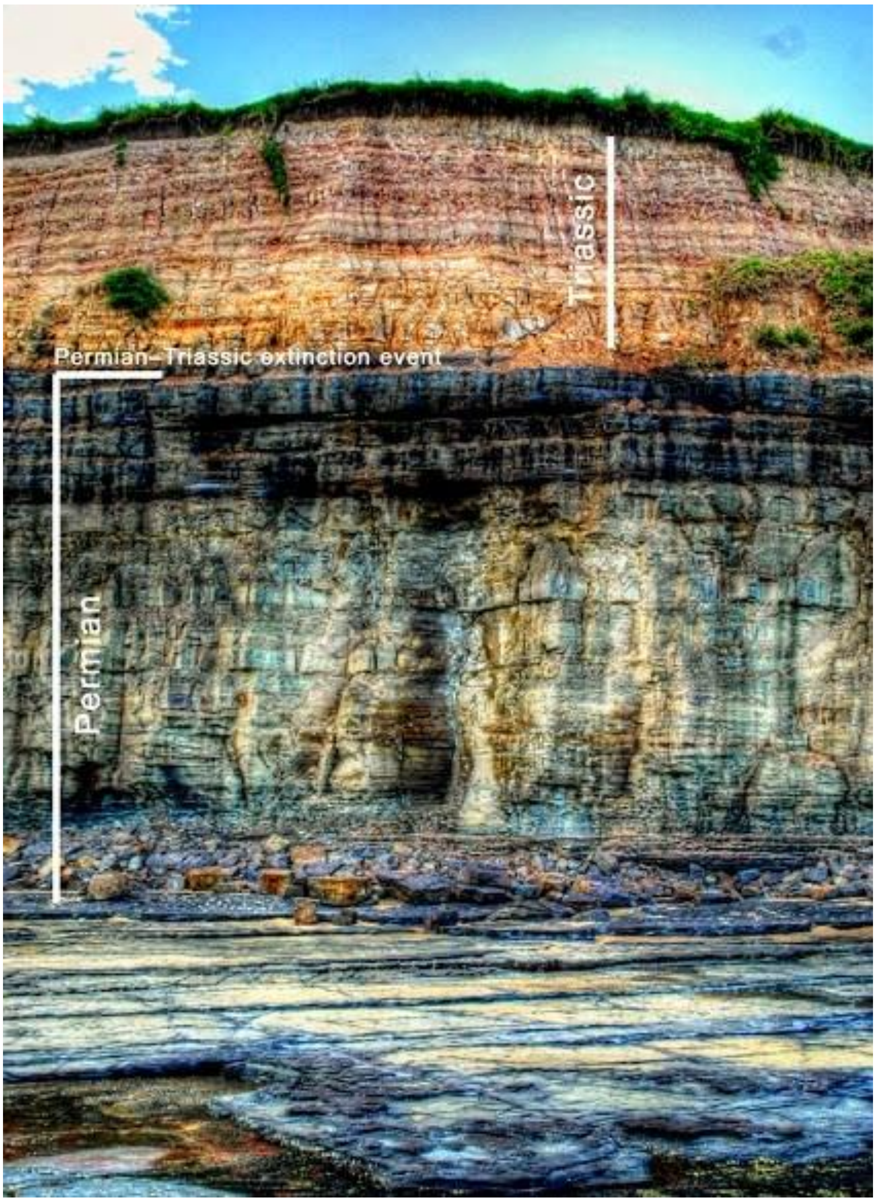


Photo 12 : Permo-Triasic boundary between Sydney and Wollongong.

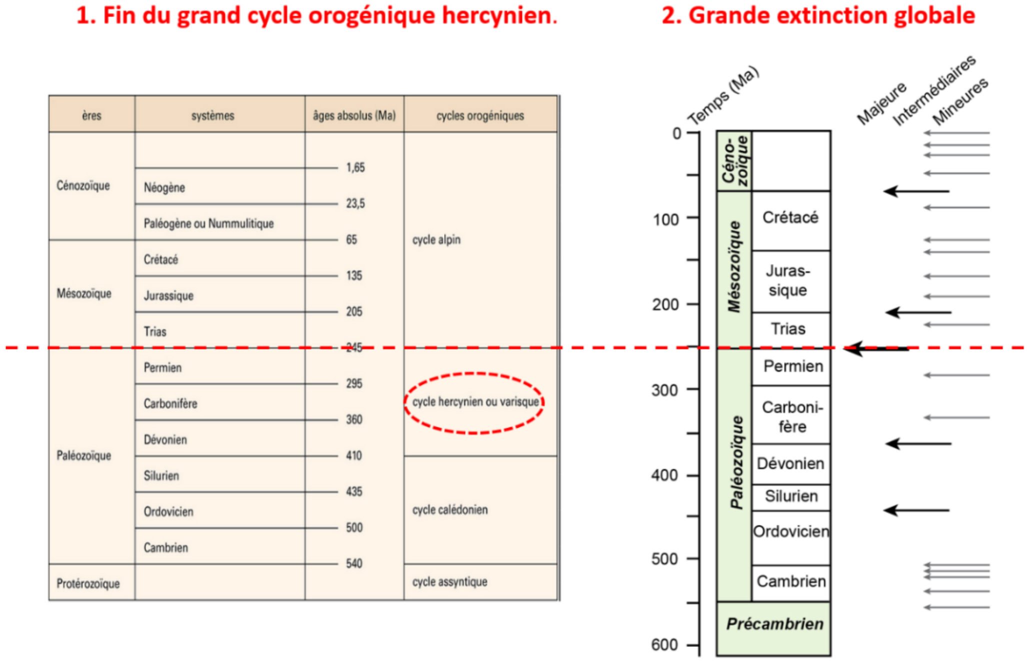


Fig 76: Permian-Triassic boundary
(End of Hercynian cycle and great global extinction)

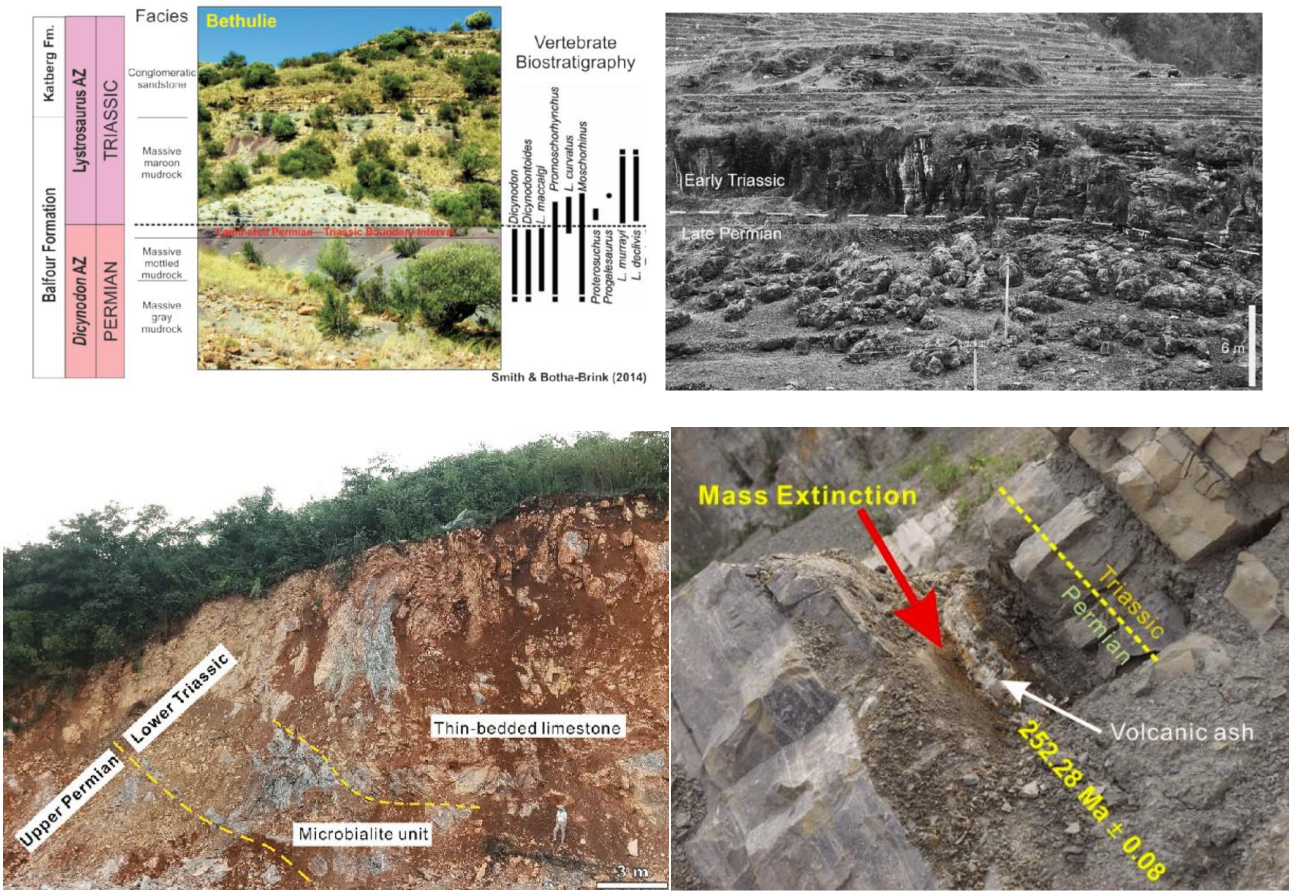


Photo 13 : Permian-Triassic boundary

9. Evolution of life in the Paleozoic

The Paleozoic is bounded by major events in the history of life. It begins with an "explosive" animal appearance in various forms in the marine environment and ends with the most important biological crisis on Earth.

The Paleozoic is characterized, contrary to the Precambrian, by an expansion of fauna and flora.

All animal phyla* appeared at the beginning of the Paleozoic (= Cambrian Explosion):

*Phyla = Superfamily

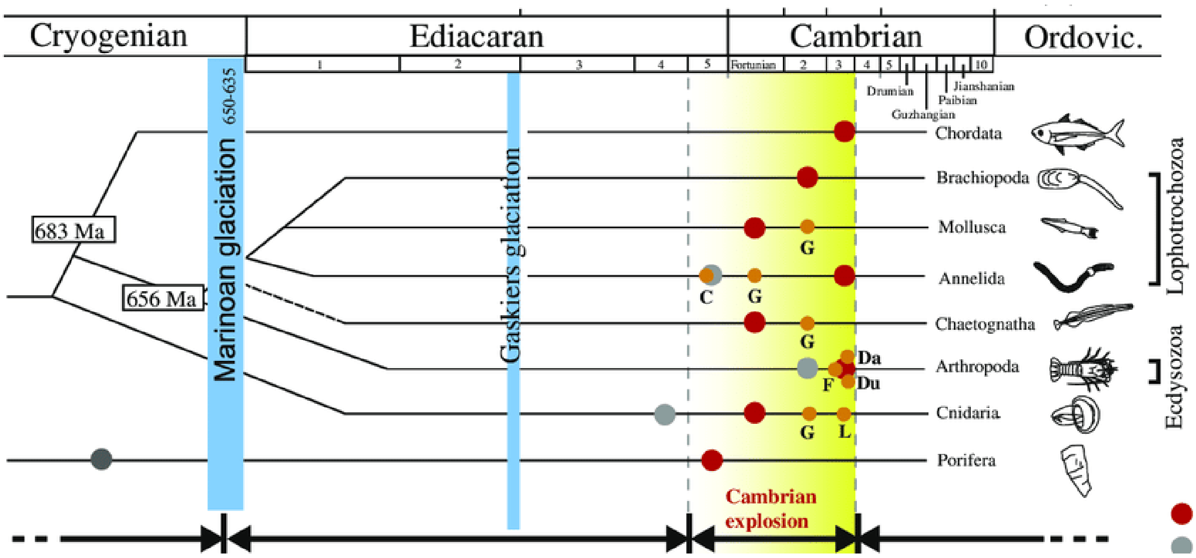


Fig 77a: Cambrian Explosion

10. Current location of Lower Cambrian fossil sites

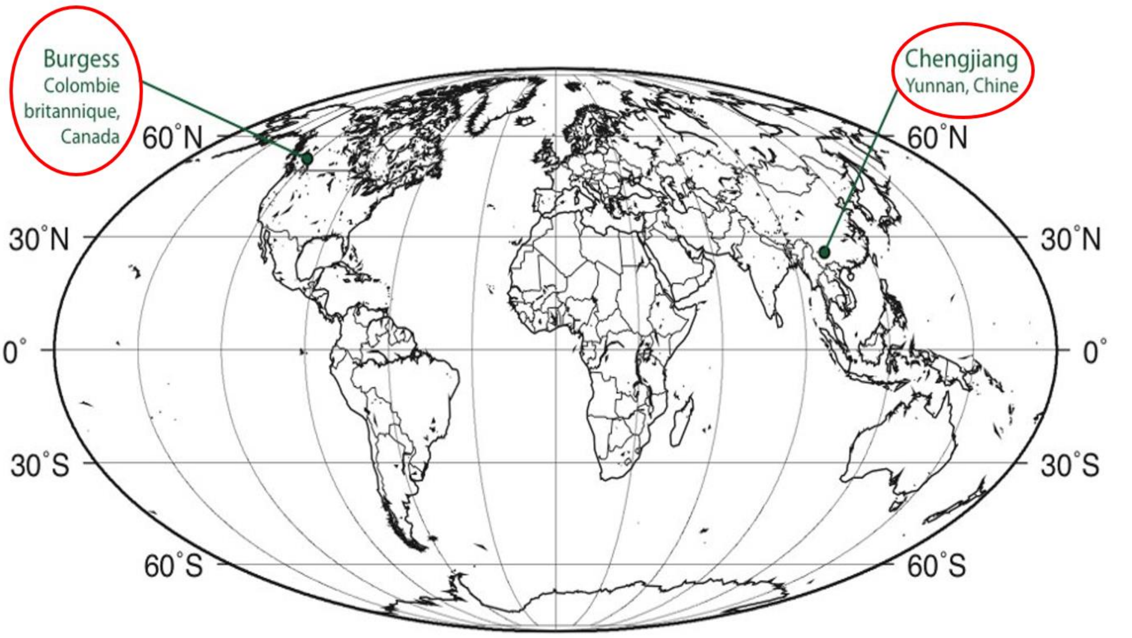
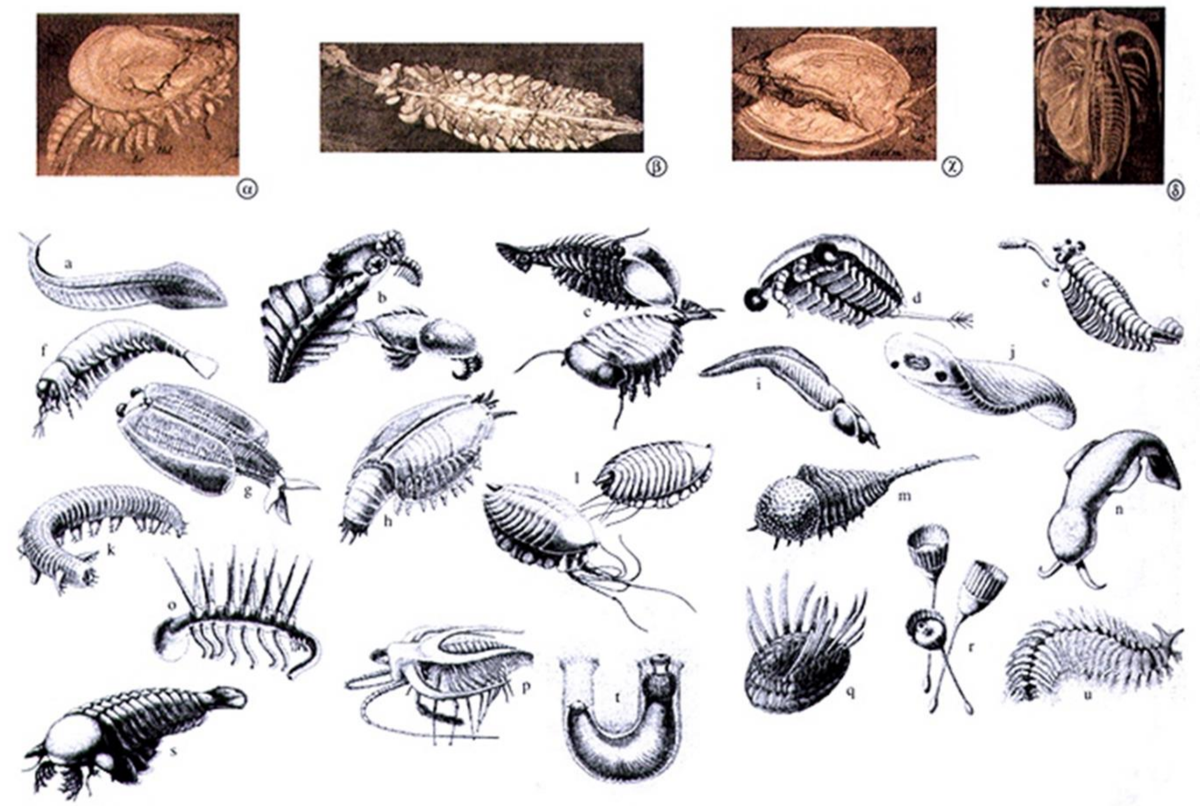


Fig 77b: Current Cambrian explosion sites [43]

Photo 14 : Burgess Shale quarries viewed from Emerald Lake



La faune cambrienne de Burgess Pass (Colombie britannique).
α. *Canadaspis*. β. *Opabinia*. χ. *Leanchoilia*. δ. *Marella splendens*.

CARON J.-M. et coll., *Comprendre et enseigner la planète Terre*. Ophrys, 2003.

Représentations *(d'après Collins)* :
a. *Pikaia* (chordé). b. *Anomalocaris*. c. *Sidneyia*. d. *Sarotrocercus*. e. *Opabinia*. f. *Yohoia*. g. *Odaraia*. h. *Canadaspis* (malacostracé).
i. *Nectocaris*. j. *Odontogriphus*. k. *Aysheaia* (onychophore ?). l. *Leanchoilia*. m. *Habelia*. n. *Amiskwia*. o. *Hallucigenia*. p. *Marella*. q. *Wiwaxia*.
r. *Dinomischus*. s. *Sanctacaris* (arthropode chélicérate). t. *Ottoia*. u. *Canadia*.

Fig. 78: Fossils of Burgess site

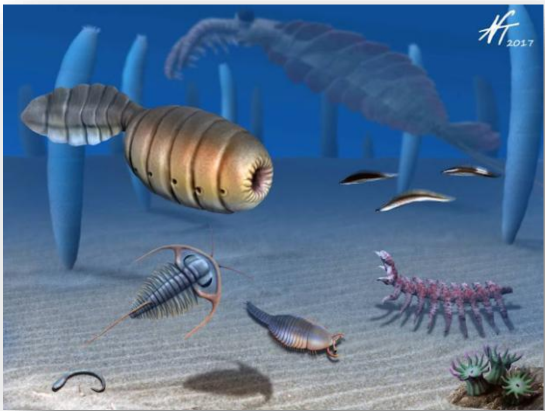


Photo 15 : Outcrop of the Maotianshan Shale, site of the discovery of the Chengjiang Biota, now preserved as part of a UNESCO world heritage site

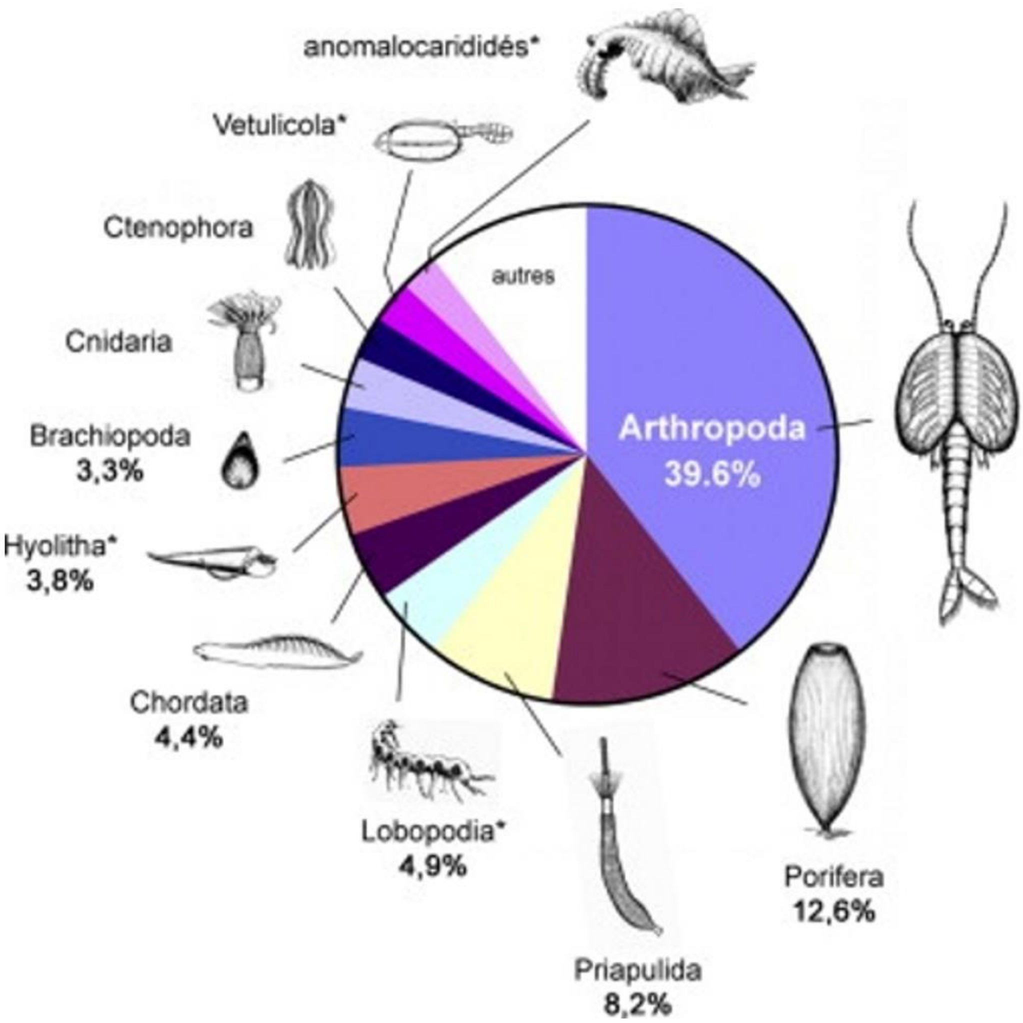


Fig. 79: Faunal biodiversity in Chengjiang [43]

Some characteristic features of the evolution of animal life in the Paleozoic are:

- Distribution of trilobites throughout the Paleozoic

- Development of tetracorals from the Silurian to the end of the Paleozoic

- Evolution of cephalopods:

  - Nautiloids in the Ordovician
  - Ammonoids in the Devonian

- Evolution of fish in the Silurian,

- Global distribution of amphibians in the Carboniferous

- Distribution of reptiles in the Permian.

It should be noted that the first appearance of these groups precedes their period of global propagation. For example, the first trilobites date from the early Cambrian, but their real development did not occur until the Cambro-Ordovician boundary.

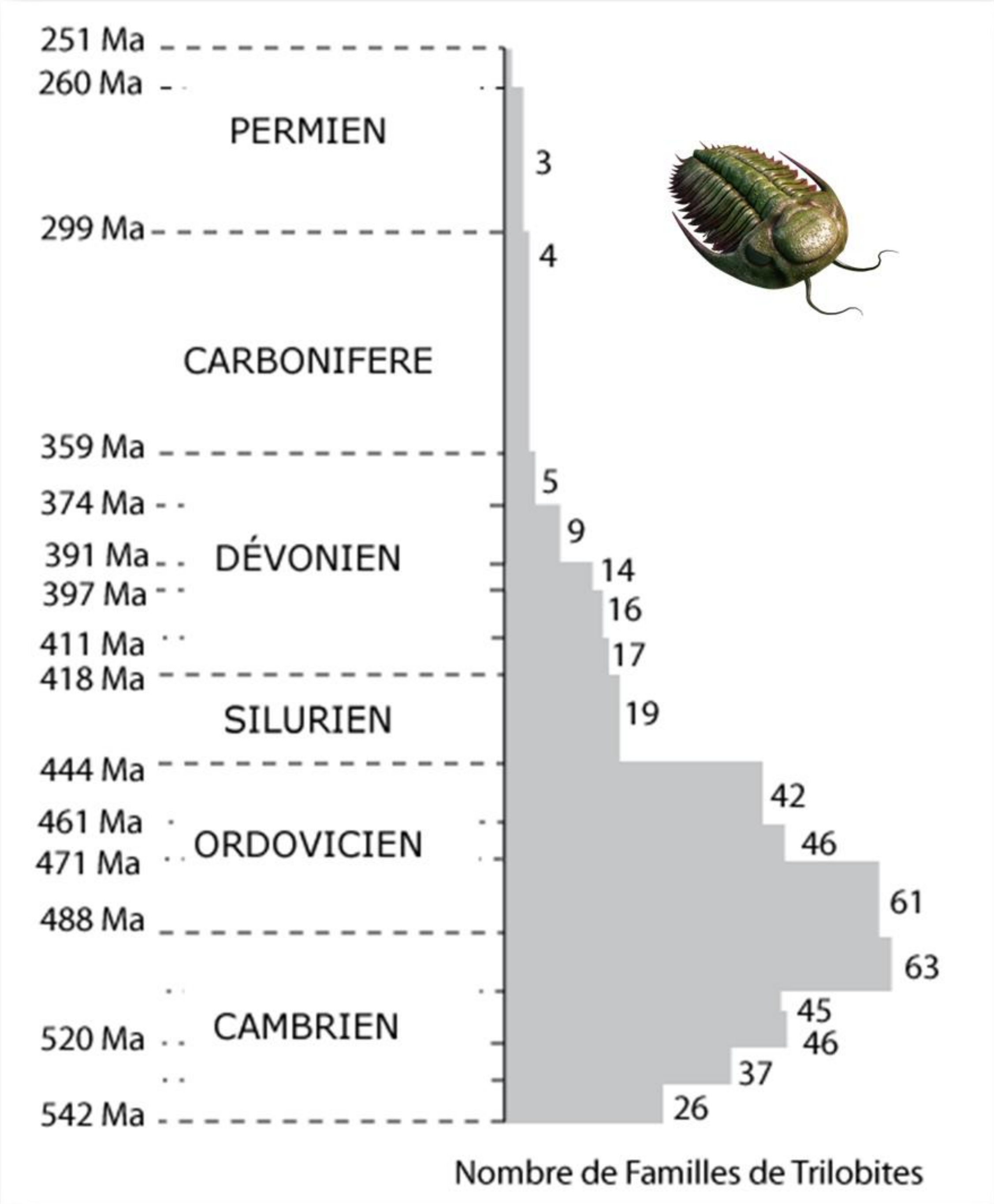


Fig. 80: Trilobites over time

Photo. 16: Trilobites at different scales

11. Plant life in the Paleozoic

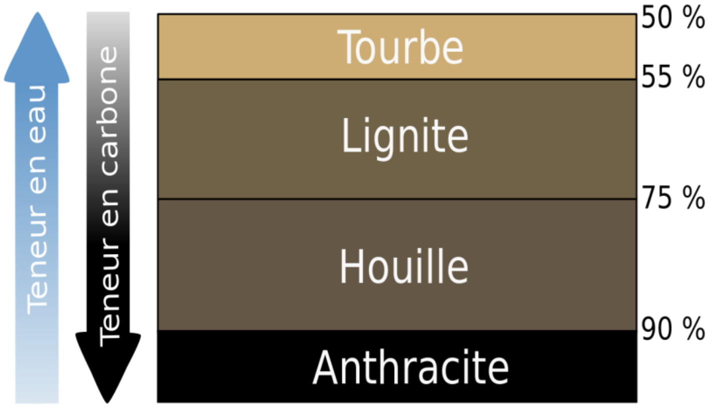
- In the Silurian, vascular plants* set out to conquer the Earth.
- The Carboniferous saw a rapid development of plants.
- It is characterized by the first large trees.
- Carboniferous coal deposits have provided a large part of the energy resources currently used by humans.

The large coal deposits are due to:

- The appearance of bark trees
- The sea level, low, which allowed the extension of vast swamps and forests in North America and Eurasia.
- The first modern trees (conifers) appeared during the Permian.

Fig. 81: Conifers

*A vascular plant is a plant that has vessels used for water circulation. Organized into: root system (Root) + aerial system (Stem and leaves)



Graphite is pure carbon (100% C)

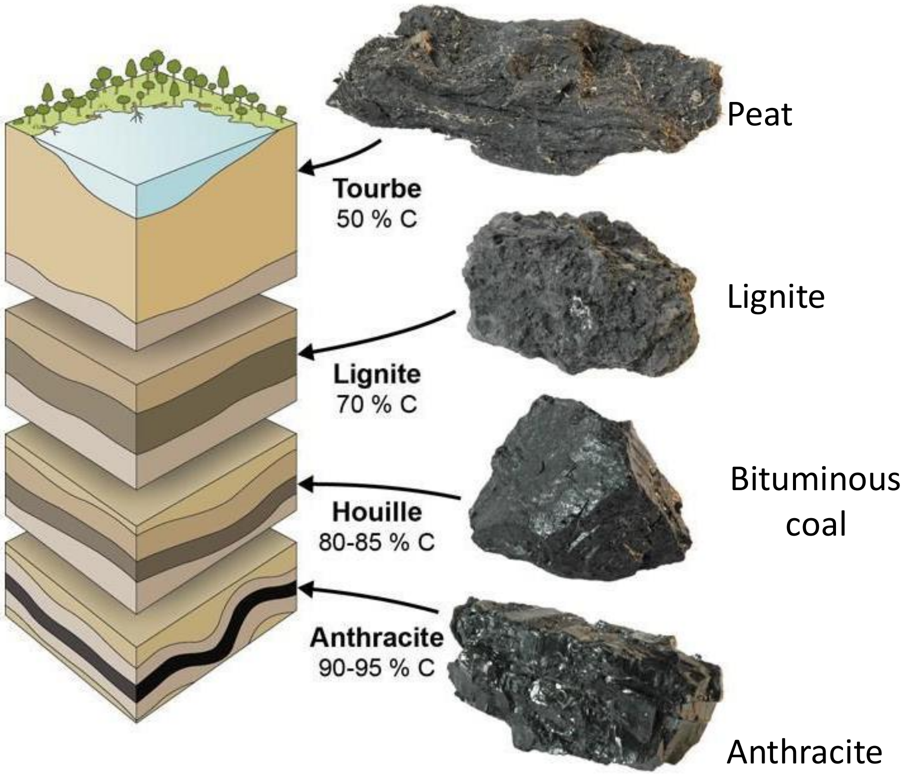


Fig. 82: Main types of coal

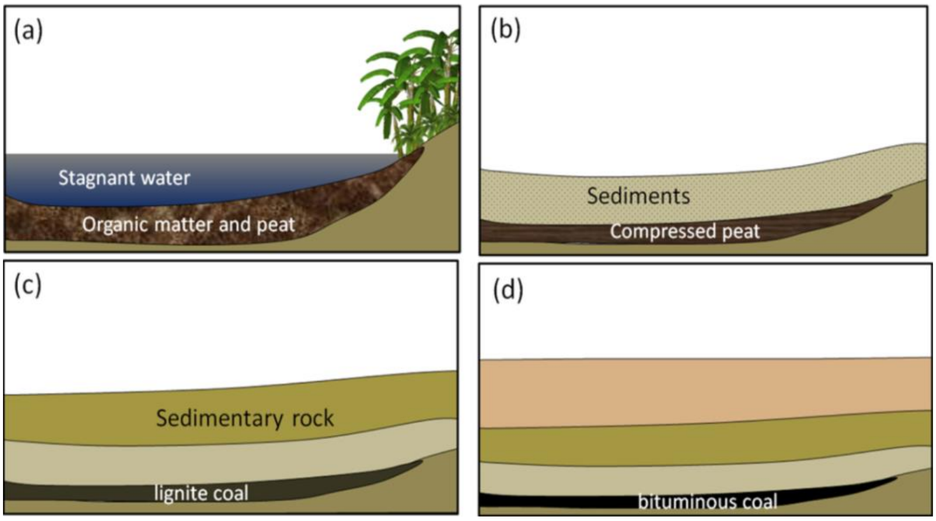


Fig. 83: Formation of coal

(a) accumulation of organic matter within a swampy area;

(b) the organic matter is covered and compressed by deposition of a new layer of clastic sediments;

(c) with greater burial, lignite coal forms;

(d) at even greater depths, bituminous and eventually anthracite coal form

Photo. 17: Lignite layers

Photo. 18: Open-pit lignite mining

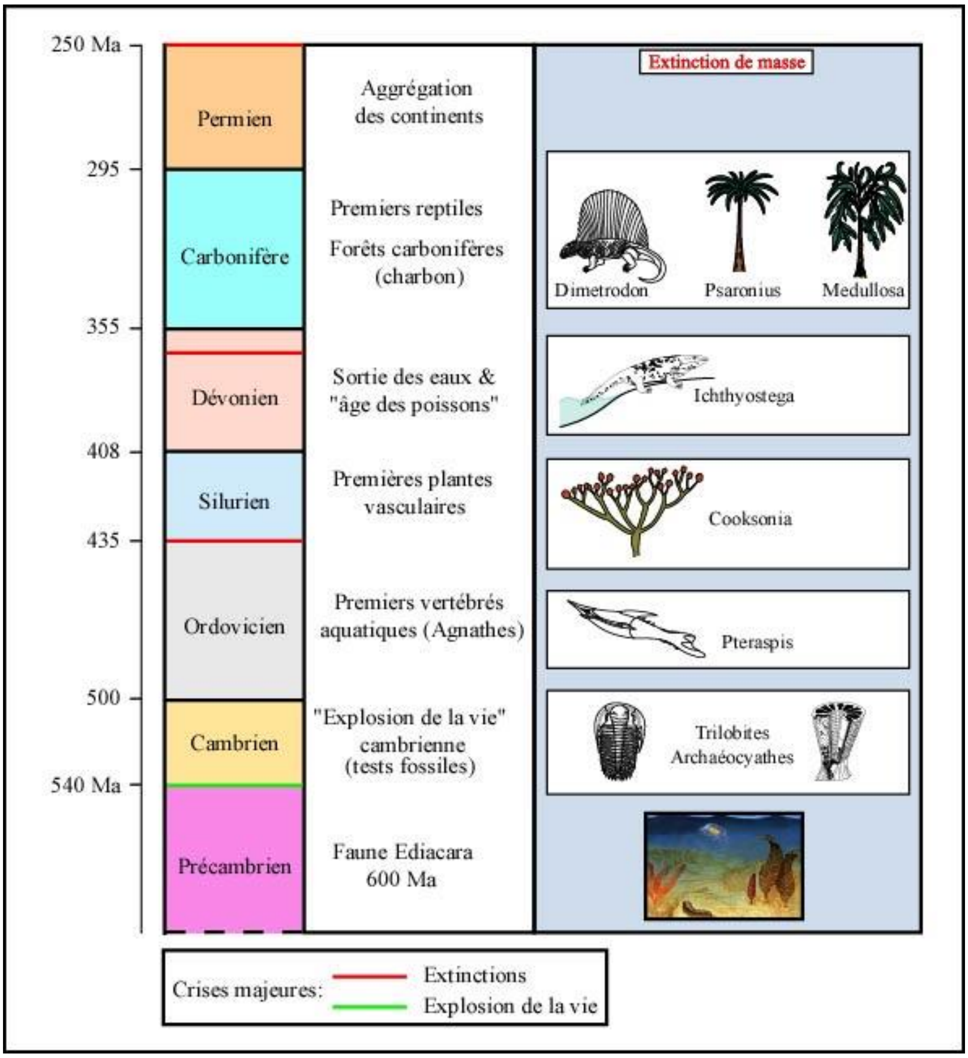


Fig. 84: Main Paleozoic events

12. Biological crises of the Paleozoic

- 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 in certain regions of the world.
- End of the Devonian, around -365 Ma, a very important mass extinction occurs. In total, about 70% of marine taxa died.
- At the end of the Permian (-299/-251 Ma), the greatest mass extinction on Earth occurs.
- It is currently estimated that nearly 90% of species disappeared during this crisis.
- More than half of the families of marine organisms (57%) present in the Permian are no longer found in the Triassic. 70 to 77% of terrestrial vertebrate families disappear.

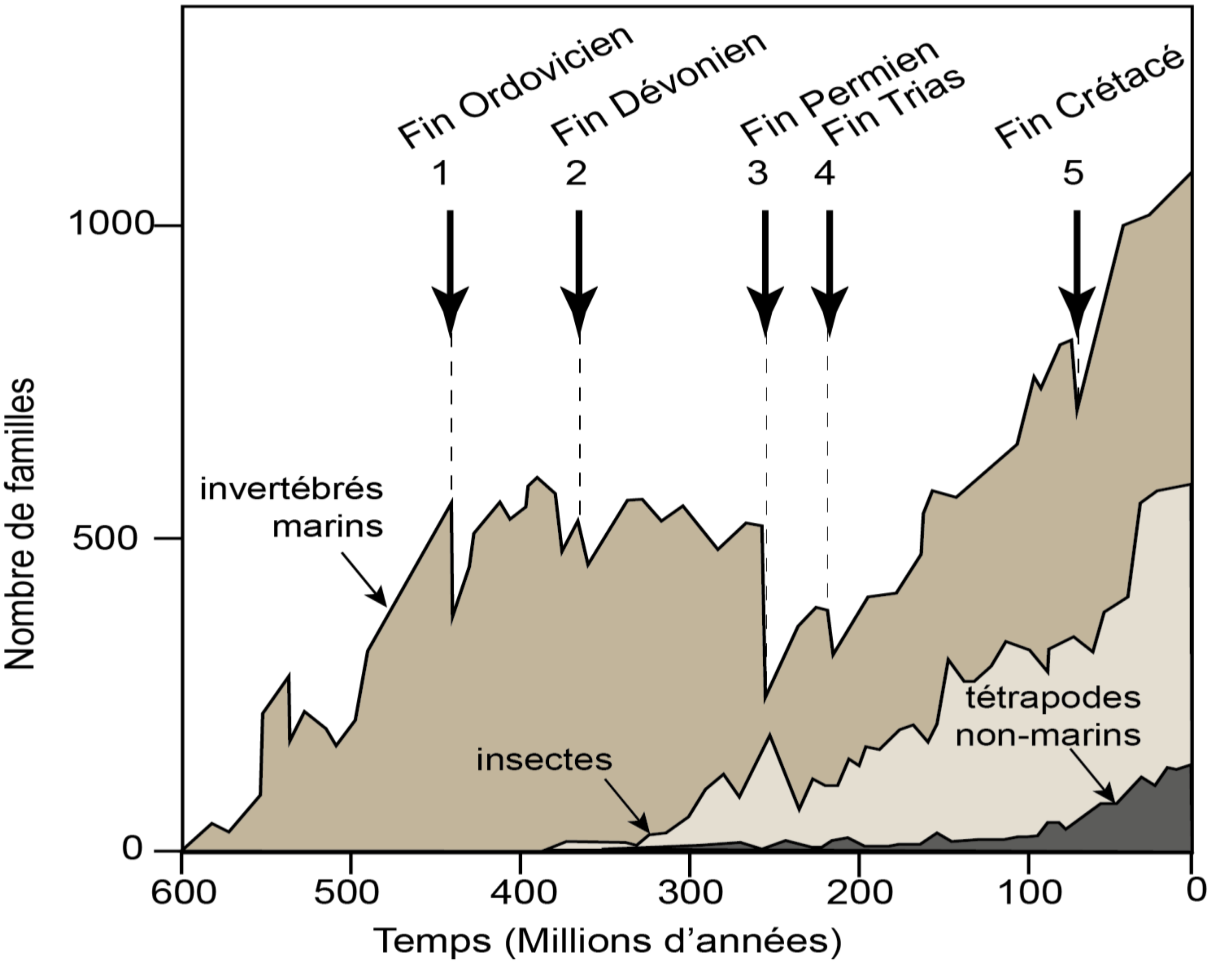


Fig. 85: Biological crises of the Paleozoic

12.1. **Probable causes of the Permian-Triassic crisis**

Several events converge at the end of the Permian that will deal a serious blow to life:

12.1.1. **An intense volcanic eruption**: continental volcanism of the Siberian Traps*.
Dated to approx. 250 million years (Permo-Triassic), volcanic flows lasted about 500,000 years, cover a territory the size of Europe, and ejected 3 million km3 of lavas.
The enrichment in CO2 of the atmosphere, a consequence of continental volcanism (dust ejection), is a possible cause of climate disturbances (greenhouse effect).

Fig. 86: Continental surface volcanism of the Siberian Traps

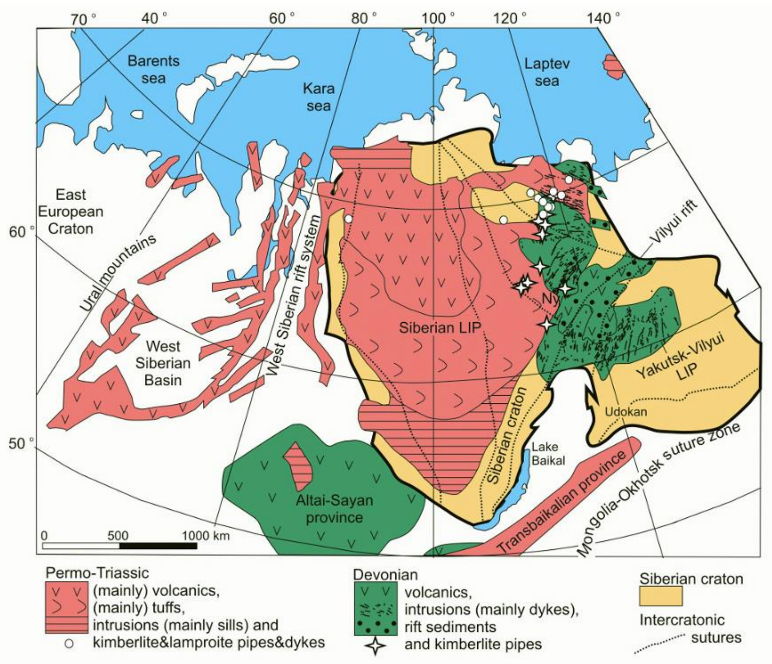


Fig. 87: Geological map of the Siberian Traps

* A trap is a pile of lava flows forming stepped cliffs.

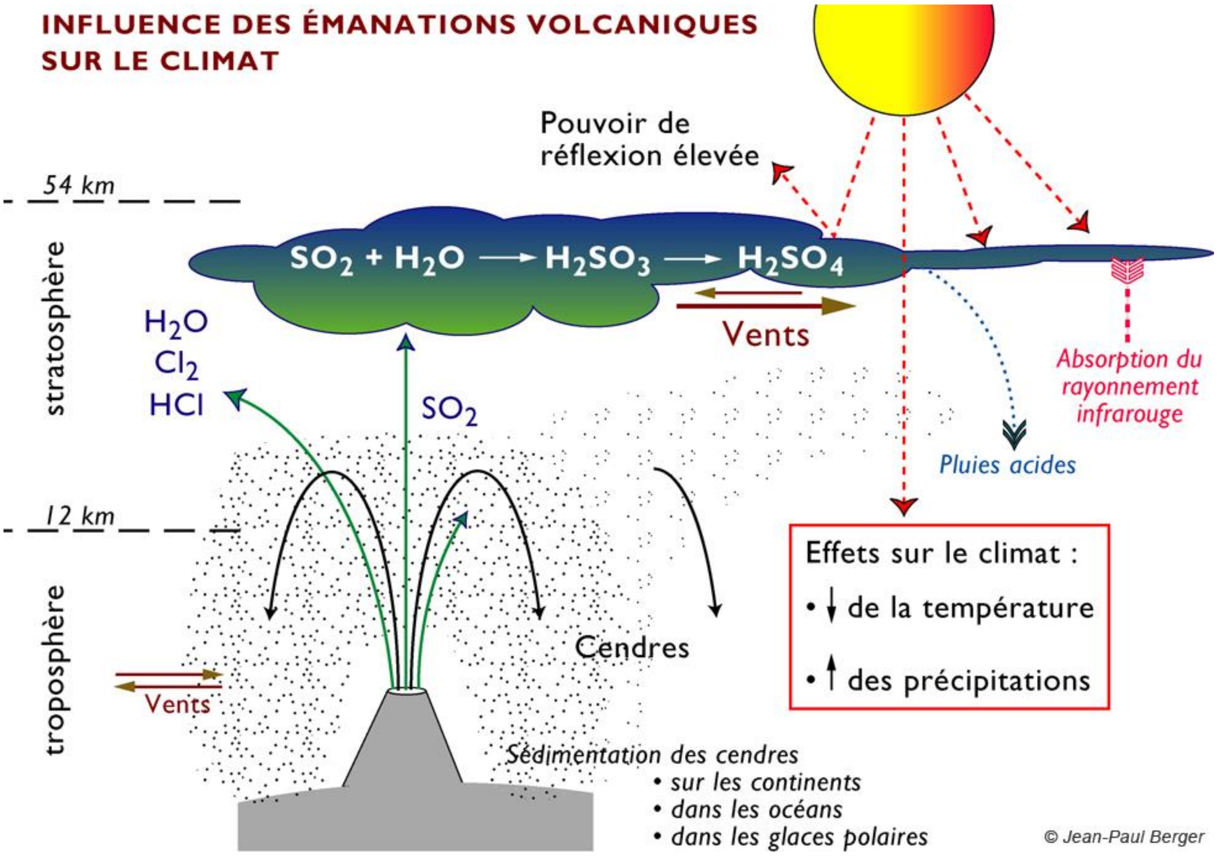


Fig.88: Influence of volcanic gases on climate [44]

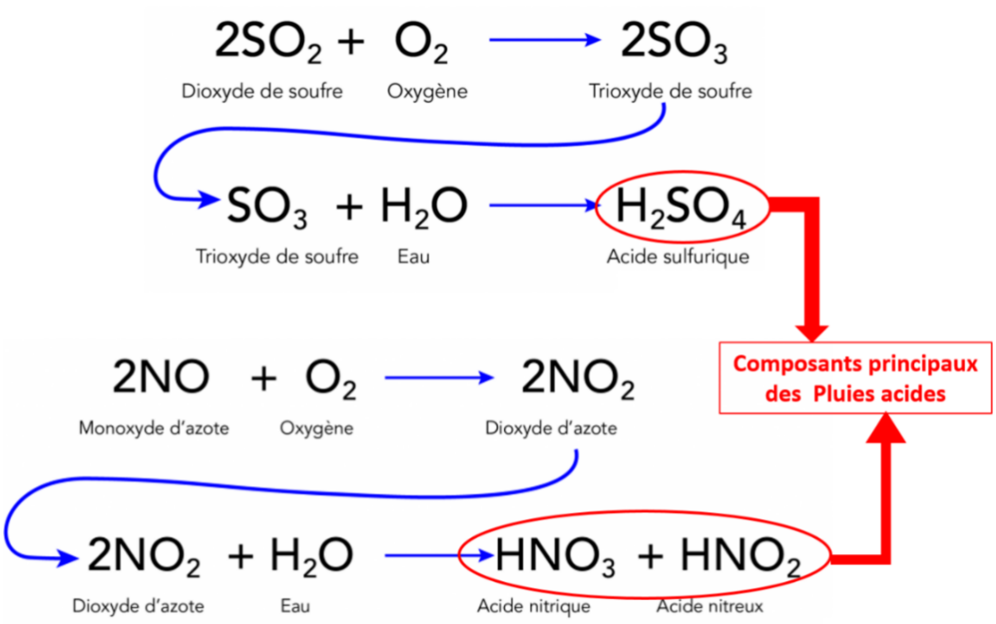


Fig.89: Volcanic gases reactions [45]