Models of Earth's accretion

1. The initial bombardment created a homogeneous Earth. Subsequent heating caused differentiation.

2. Different layers accreted at different times. The core was the first to form and the crust later.

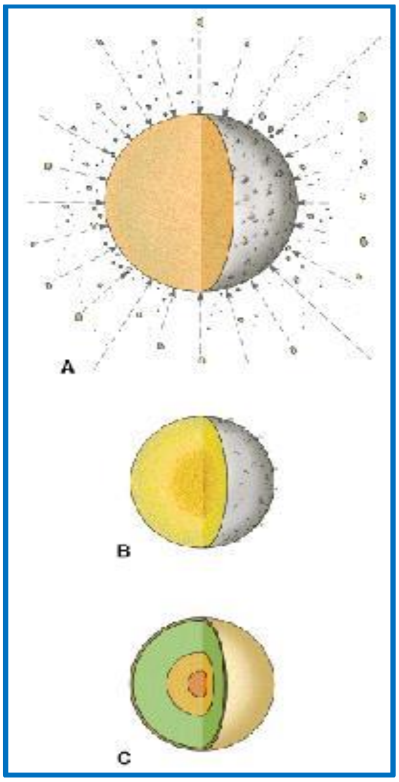


Fig. 47: Earth accretion model 1

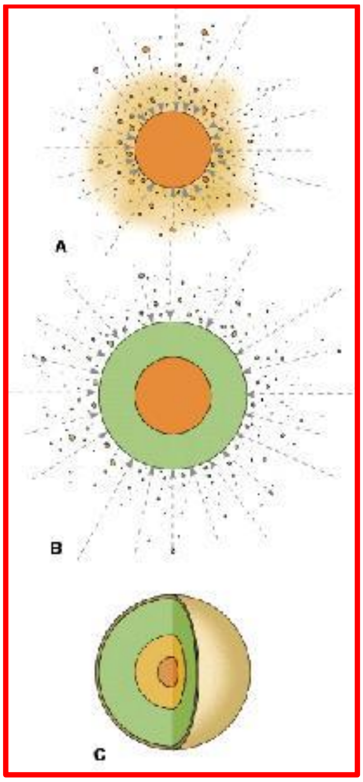


Fig. 48: Earth accretion model 2

b. The Archean Eon

The word comes from ancient Greek (Arkhē), meaning "beginning, origin". The Archean corresponds to the second geological epoch of the Precambrian. It extends from ~-4 to -2.5 Ga. Water filled the depressions and formed oceans; we distinguish the deeper oceanic crust and the lighter continental crust that would form the emergent continents not yet stabilized. Continental nuclei (shields) began to appear.

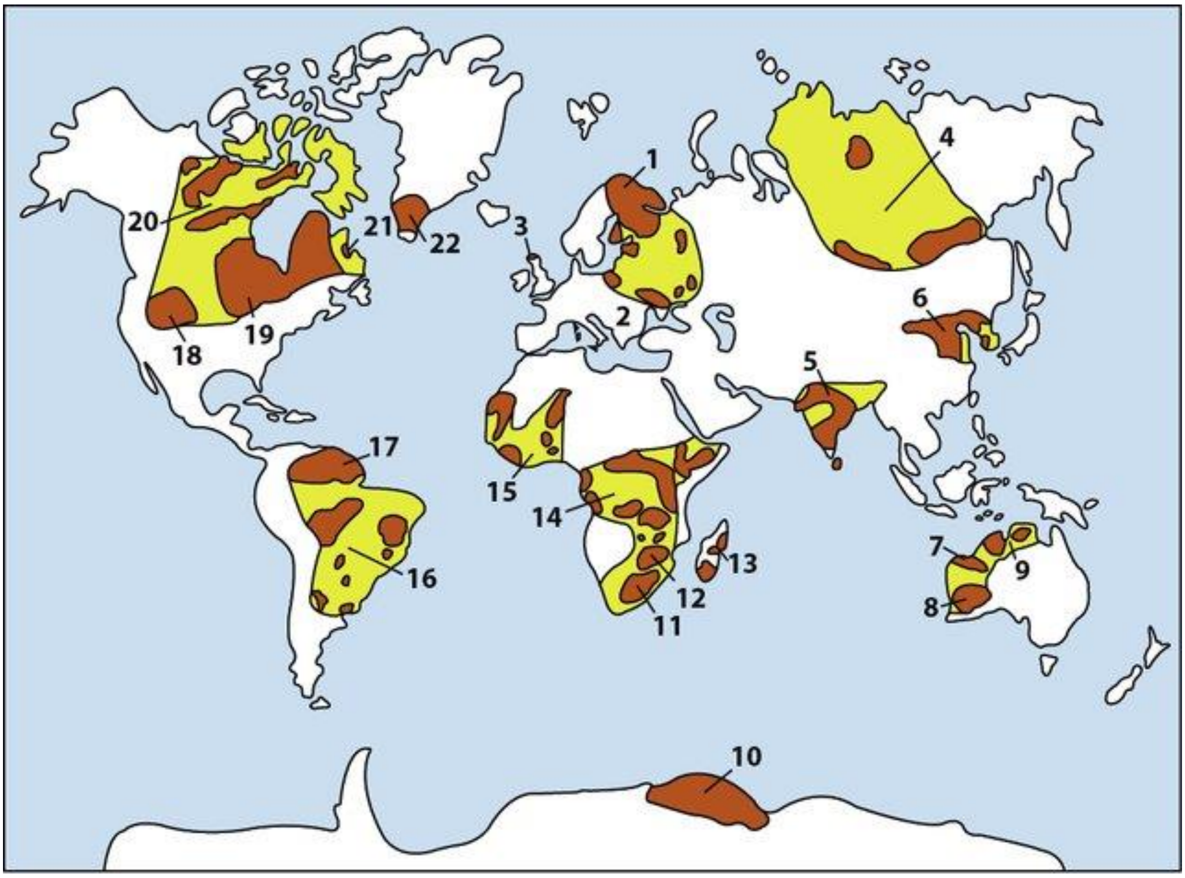


Fig. 49 : The major Archean rock provinces.
Outcropping Archean terrains are in red, while those overlain by volcanic or sedimentary formations are shown in yellow. [33]

(1) Baltic Shield; (2) Ukrainian Shield; (3) Scottish Shield; (4) Siberian Shield; (5) Indian Shield; (6) Sino-Korean Craton; (7) Pilbara Block; (8) Yilgarn Block; (9) North Australian Block; (10) Napier Complex; (11) Kaapvaal Craton; (12) Zimbabwe Craton; (13) Madagascar Craton; (14) Central African Shield; (15) West African Shield; (16) São Francisco Craton; (17) and the Guiana Shield; (18) Wyoming Province; (19) Superior Province; (20) Slave Province; (21) Labrador Shield (22) Greenland Shield

The first terrestrial life forms, prokaryotes (living with cells devoid of a nucleus, e.g., bacteria) would have appeared during this period marked by the occurrence of a rain that lasted several hundred Ma. It was about 3.8 Ga ago. Probable prokaryotic microorganisms are dated to 3.4 Ga in Australia (Pilbara) and South Africa (Barberton) and even to 3.8 Ga in ancient rocks of Greenland (Isua Volcano).

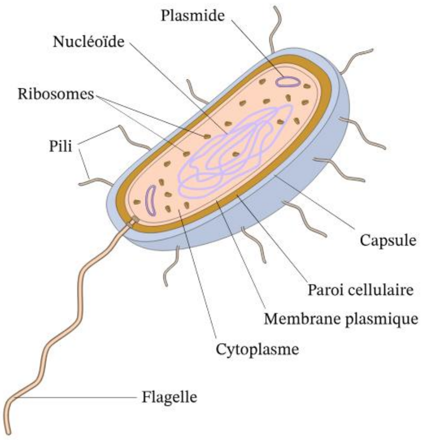


Fig. 50: Illustration of a bacterium, with its plasmids represented.

The region where the chromosomal DNA is located is called the nucleoid.

Cyanobacteria practiced photosynthesis, which means they produced oxygen. They would have strongly contributed to the Great Oxygenation Event, an event that occurred about 2.3 Ga ago (Proterozoic) during which the concentration of oxygen in the atmosphere suddenly increased.

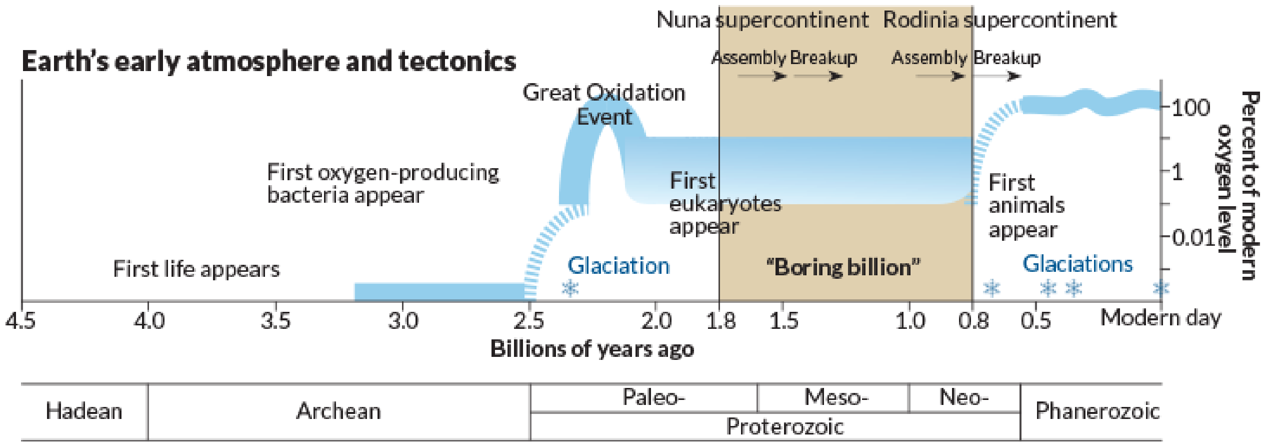


Fig. 51: Great Oxygenation event in the Archean

The lower limit of the Archean is set at the certain appearance of life (-2.5 Ga), but also stromatolites found are dated:

- At 2.8 Ga – Fortescue – Australia
- At 2.7 Ga – Bulawayo – Zimbabwe

Photo. 3: Stromatolithes in plan and in section

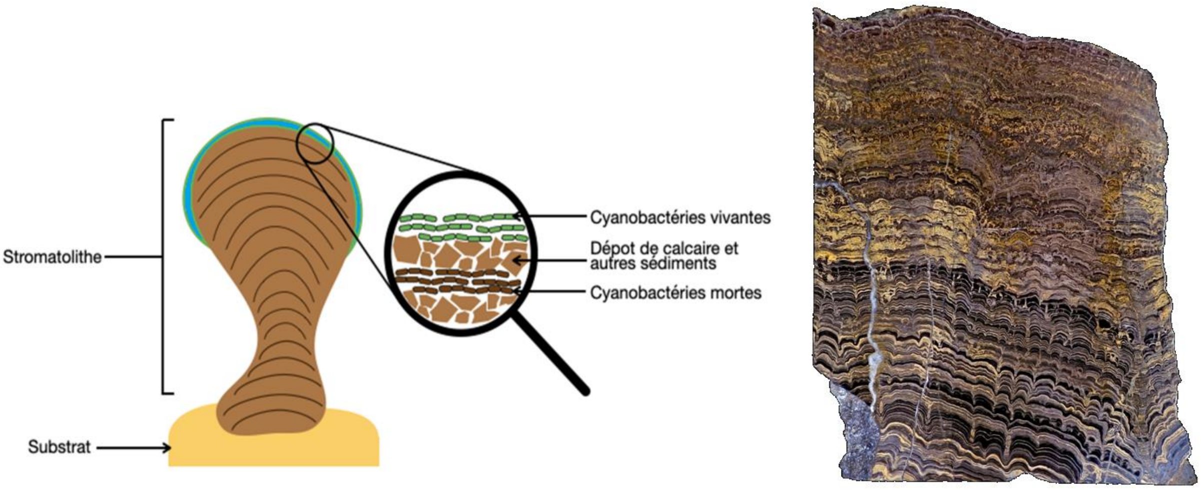


Fig. 512: Section of a rock showing laminations with alternating stromatolites and sediments dating from the Proterozoic (Bolivia)

Photo. 4 : Stromatolithes - Australia

c. The Proterozoic Eon

The term Proterozoic literally means "earliest life. " This eon is split into three distinct periods:

- Paleoproterozoic Era (2,5 – 1,6 billion years ago)
- Mesoproterozoic Era (1,6 to 1,0 billion years ago)
- Neoproterozoic Era (1,0 – 0,542 billion years ago).

The start of the Proterozoic, around 2. 5 billion years ago, signifies the onset of:

- A more advanced form of plate tectonics.
- A more sophisticated method of sediment deposition.
- A new global climate phase marked by ice ages.
- The beginning of an atmosphere rich in oxygen.
- The rise of an aerobic biosphere, known as the Great Oxygenation.
- The development of Eukaryotes, which are organisms with cells that have nuclei containing genes.

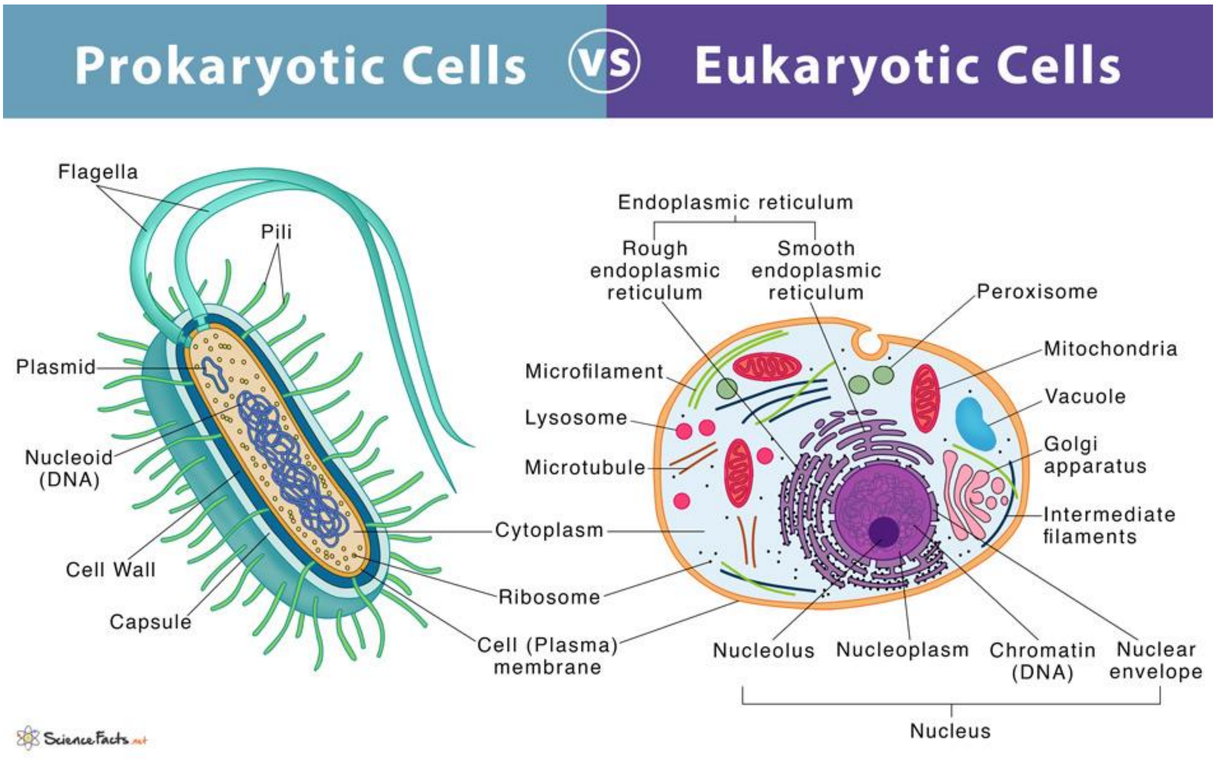


Fig. 53: Prokaryotes vs Eukaryotes [34]

Rocks from the Proterozoic are simpler to investigate than those from the Archean due to their lesser alteration. However, they are harder to study than Phanerozoic rocks since they contain fewer fossils.

Plate tectonics:

In the early Proterozoic era, continental fragments from the Precambrian came together to create large landmasses such as Laurentia (the North American craton), as well as Australia, Antarctica, Amazonia, Baltica, and Siberia. The merging of these landmasses occurred along mountain-building zones. This assembly formed a supercontinent called RODINIA, a term derived from the Russian word for "motherland. " About 750 million years ago, towards the end of the Proterozoic, Rodinia broke apart into eight continents, leading to their subsequent movement.

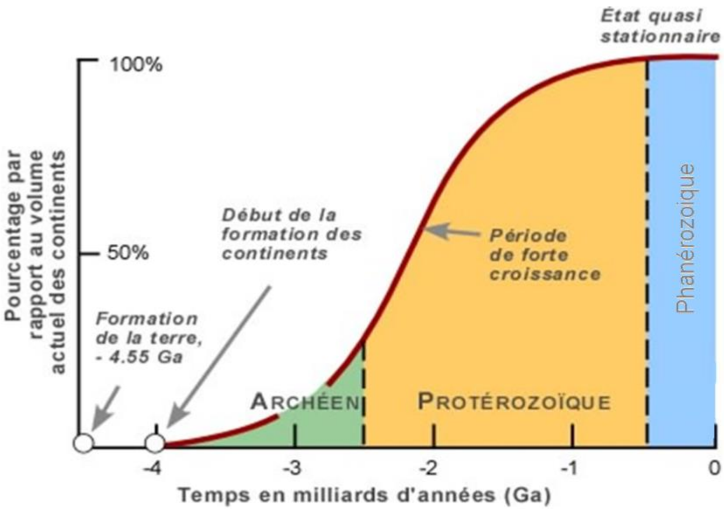


Fig. 54: Evolution of the volume of continents [35]

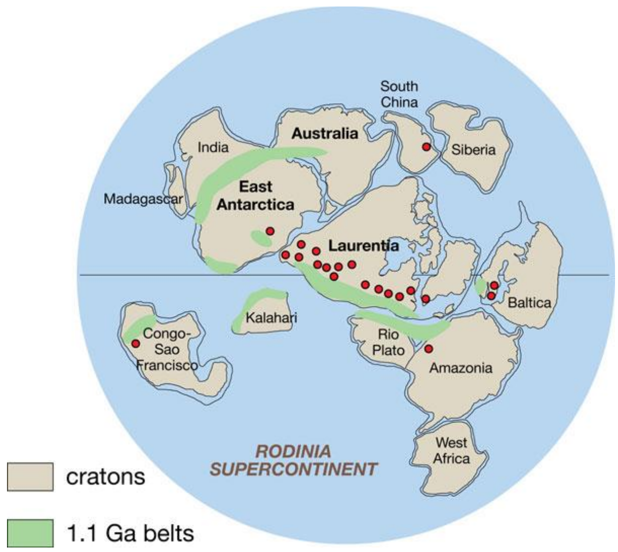


Fig. 55: A possible reconstruction of Rodinia around 750 Ma.
The red dots represent granites dated to 1.3–1.5 Ga. [36]

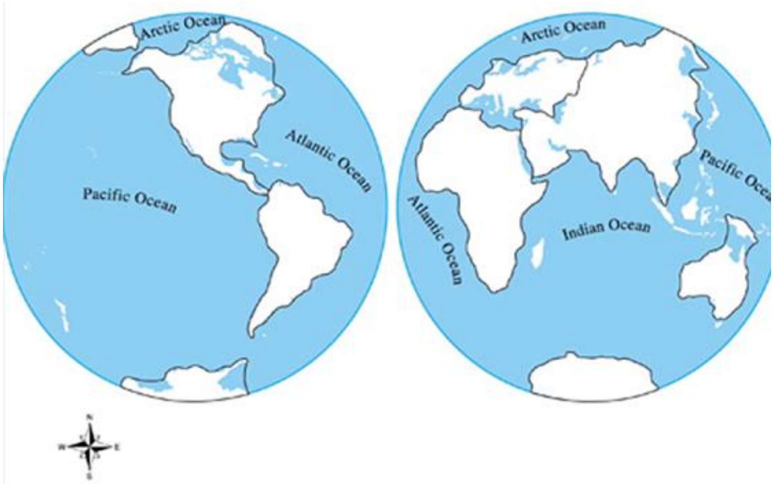


Fig. 56: Current position of the continents

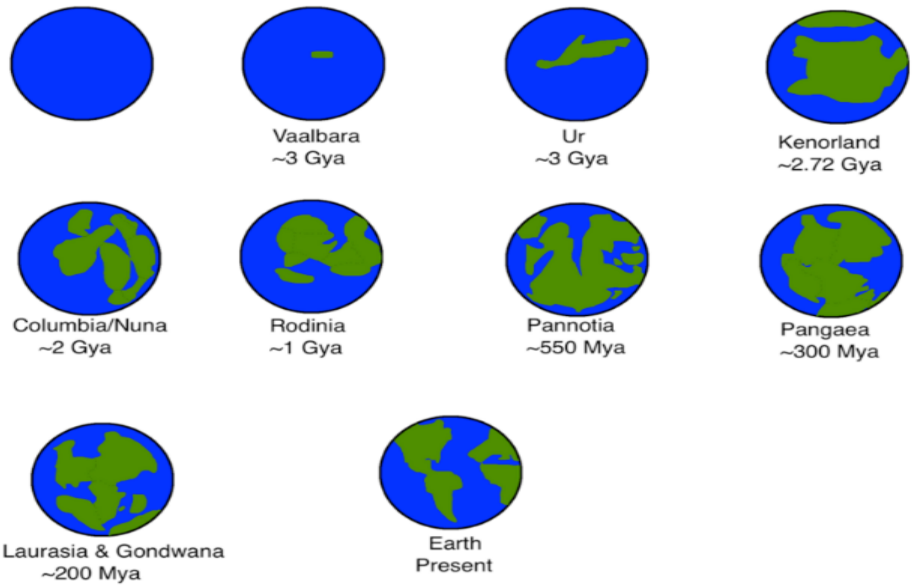


Fig. 57: Supercontinents through time [37]

The sedimentation on and near the craton was composed of shallow clastic and carbonate materials settled on wide continental shelves and in shallow seas. Weathering, erosion, and deposit of the earliest rocks that led to the formation of the first sedimentary rocks can be traced back to approximately 3,8 billion years ago. The banded iron formations, or BIFs, from the Lower Proterozoic, represent significant deposits; these layers extend across extensive regions and are crucial for economic purposes. Their origins have been debated for many years, dating between 2,5 and 1,9 billion years ago.

Climate: Proterozoic glaciations occurred during:

- Paleoproterozoic, 2.4-2.1 Ga (Huronian Glaciation).
- Neoproterozoic, 850-600 Ma (Varengian Glaciation).

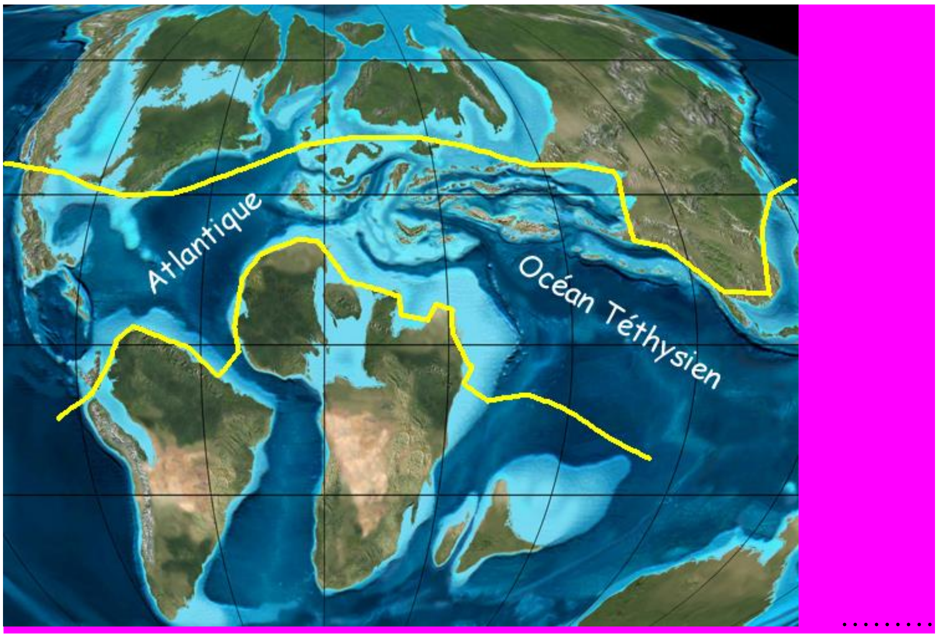


Fig. 58: Marine sedimentation areas (Light blue)

The map does not represent Proterozoic even it shows shelves and epireic or shallow seas (It must be changed)

Photo 5b: Banded Iron Formation (BIF) sample, South of Barberton (South Africa)
The gray beds, more or less shiny, with a more or less metallic luster, consist of virtually pure hematite (Fe2O3). When altered or hydrated, these ferric oxide layers can turn a dark reddish-brown. The pink or "brick red" beds consist of silica, more or less colored pink or red by traces of hematite. [38]

Photo 5b: Banded Iron Formation (South Africa)

Precambrian events and atmospheric changes:

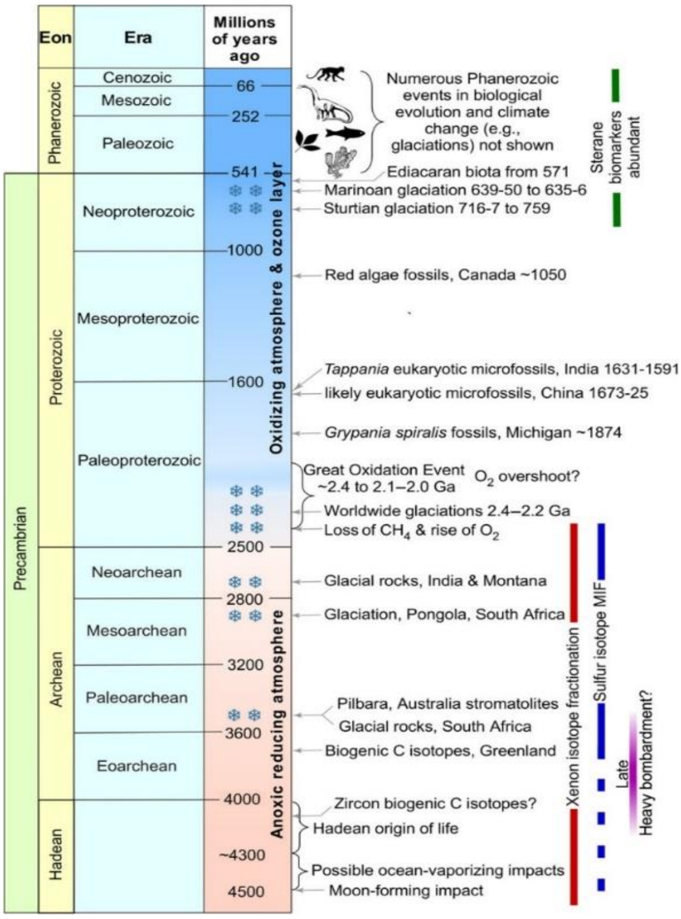
+-+**1.** During the Hadean and Archean, the atmosphere was anoxic and reducing.

2. The origin of life occurred in the late Hadean. A zircon crystal dated to 4.1 Ga has a carbon inclusion that may be biogenic. Organic carbon dated to 3.77 Ga has been found in Greenland.

3. 3.5 Ga ago, stromatolites were built by microbial colonies on the Pilbara craton in Australia and glacial sediments were deposited on the Kaapvaal craton in South Africa.

4. New glacial sediments appear 2.94 Ga ago in South Africa, then around 2.7 Ga in India and Montana.

5. Throughout this period, the isotopic fractionation of xenon indicates the presence of methane in the atmosphere.



6. The Proterozoic begins with the rise of oxygen and the loss of methane (approximately in 10,000 years) and major glaciations.

7. Ozone is therefore present.

8. Macroscopic fossils of Grypania spiralis appear.

9. The first eukaryotes (cells with nuclei) are attested a little more than 1.6 Ga ago and red algae fossils date from the Mesoproterozoic.
10. The Neoproterozoic is marked by two global Sturtian and Marinoan glaciations, which led to the birth of sponges, the first animals.
11. The Ediacara fauna emerged 571 Ma ago, then the current animal world.

Fig. 59: Precambrian atmospheres and related events

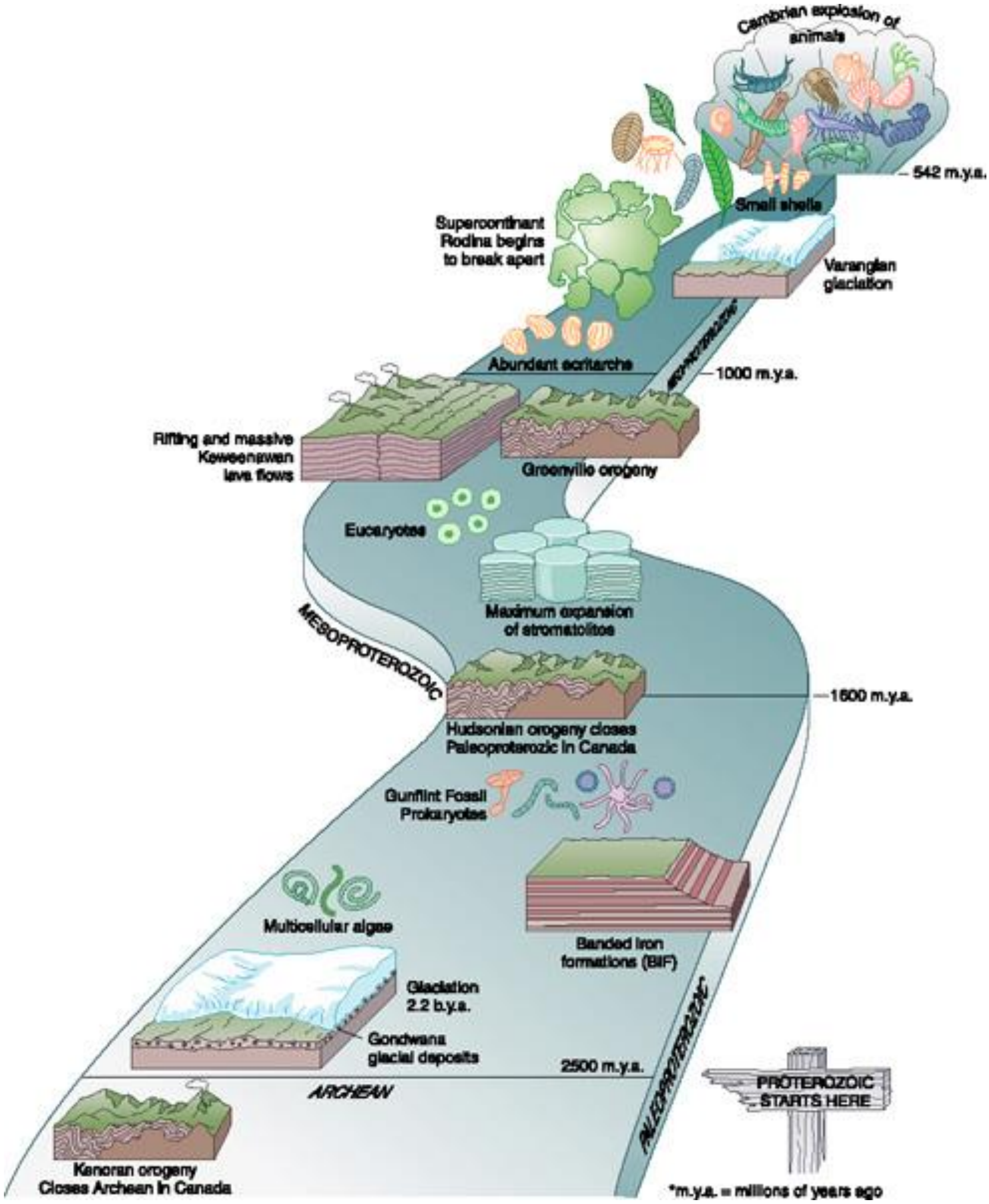


Fig. 60: Overview of events of the Proterozoic.

The Precambrian in Algeria

1. Hoggar & Eglab:

In the Hoggar, the basement is of Pan-African age (approx. 600Ma) and associated with the Pan-African chain. This is interpreted as a collision chain between a stable and rigid craton to the west, the West African Craton (WAC), and a mobile zone, a true active margin to the east. The suture between these two blocks is represented by a clear contact between the metasediments of the West African Craton, of Upper Proterozoic age, and the Pan-African gneisses (Hoggar). These were formed from pluto-volcanic rocks and reworked basement. These metasediments rest on an older Eburnean basement (approx. 2 Ga) [39].

Fig. 61: Western Gondwana with the major cratons in brown
and the Pan-African orogeny in gray.

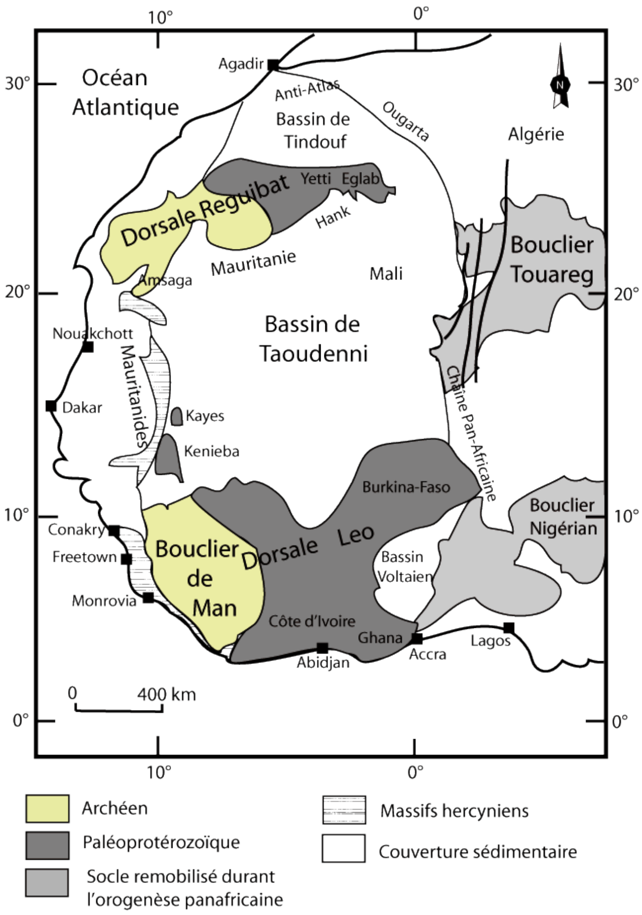


Fig. 62: West African structures

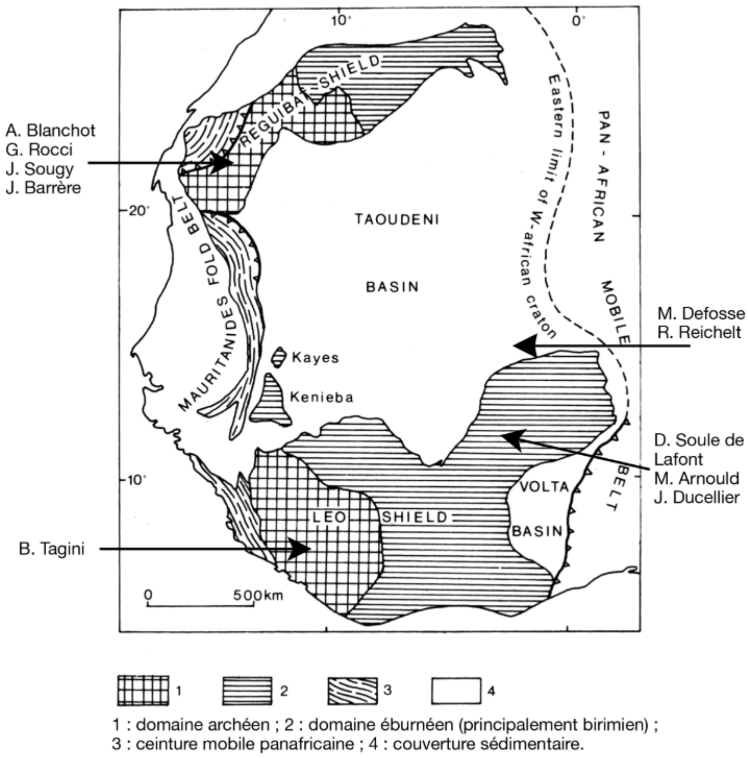


Fig. 63: Reguibat shield

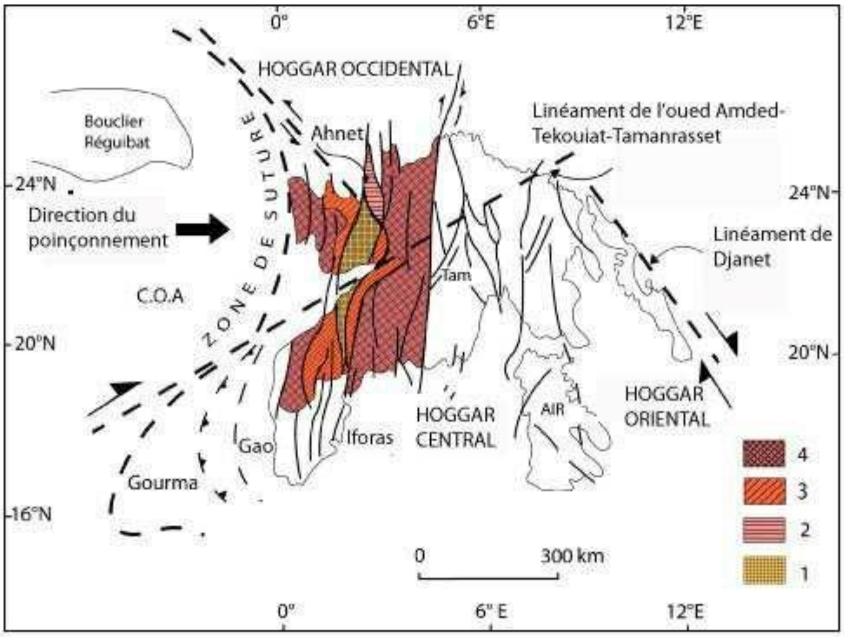


Fig. 64: Hoggar shield

1. Gneiss granulitiques du terrane de l'In Ouzzal (Archéen et Protérozoïque inférieur) ;
2. Quartzites de l'Adrar Ahnet (Protérozoïque moyen) ;
3. Gneiss-amphibolites-quartzites et granites du Protérozoïque moyen ;
4. Protérozoïque supérieur et terminal (Pharusien) ;

COA : Craton Ouest Africain

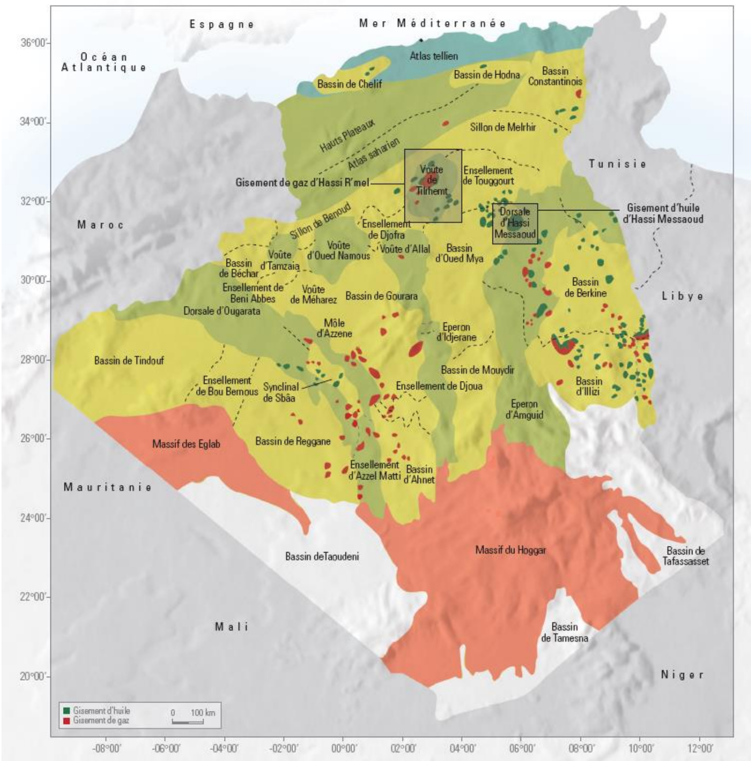


Fig. 65: Main Algerian Geological structures [39].

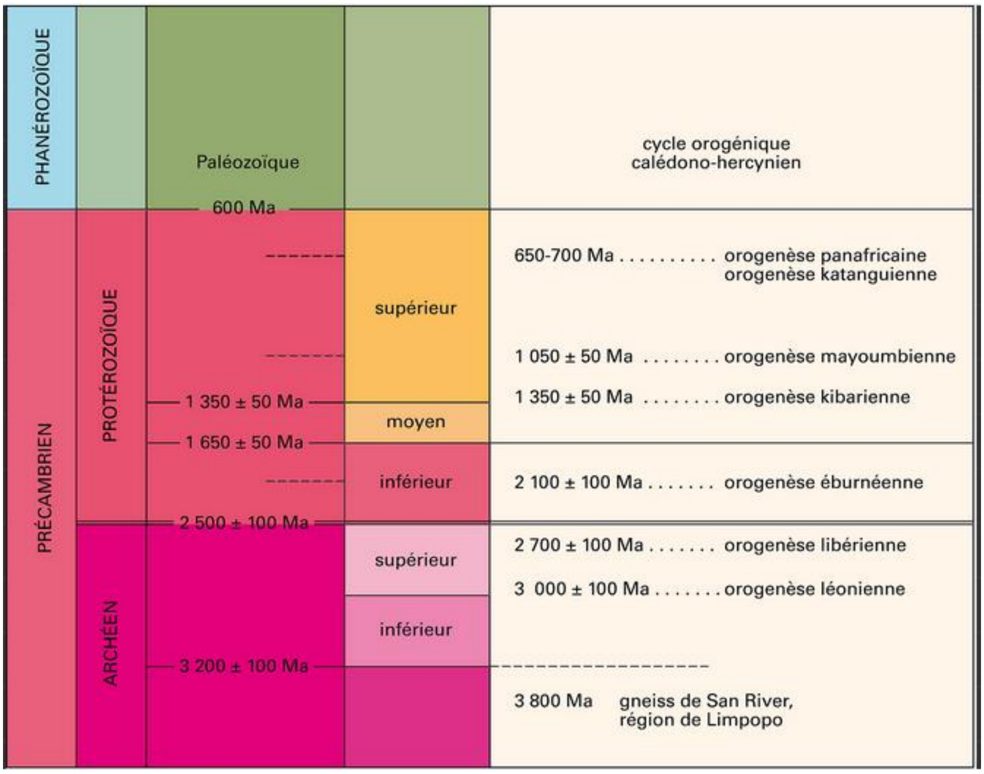


Fig. 66 : Precambrian orogenies in Africa

This suture, defined by gravimetry, would pass under the axis of the Reggane basin and at the NW limit of the Tindouf basin. Further south, the presence of deep material such as basalts, gabbros, harzburgites, etc., would testify to the existence of a pre-collision oceanic domain (= before the collision) [39].

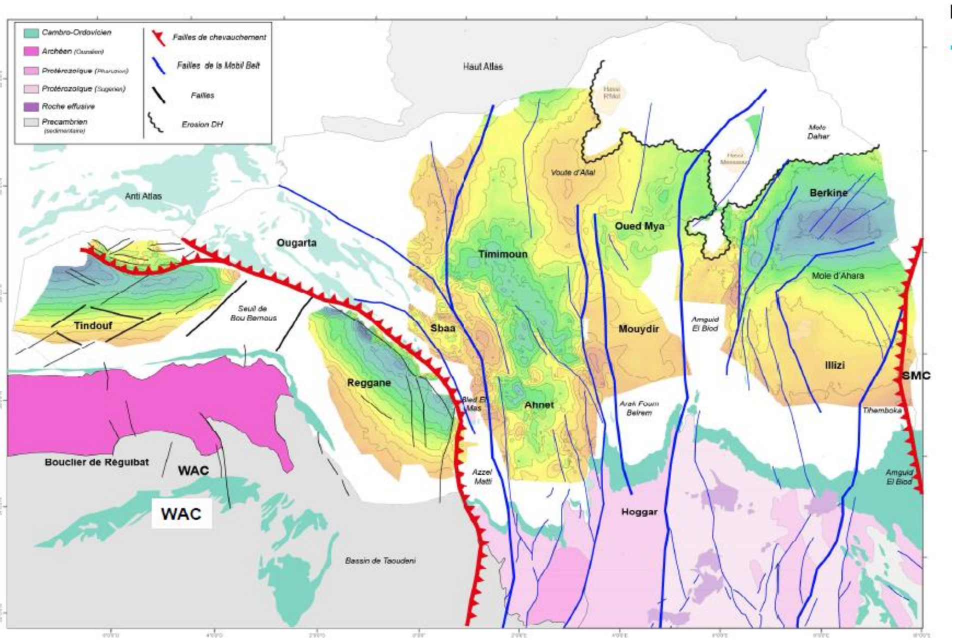


Fig. 67: SW Algerian suture (between Reguibat shield and Hoggar shield)

2. Saharan Platform

In the Saharan basins, with sedimentary cover of Paleozoic age or more recent, the substratum is recognized by drilling, especially in the regions of Illizi and Ahnet. It seems to be of the same nature and age as that outcropping in the Hoggar.

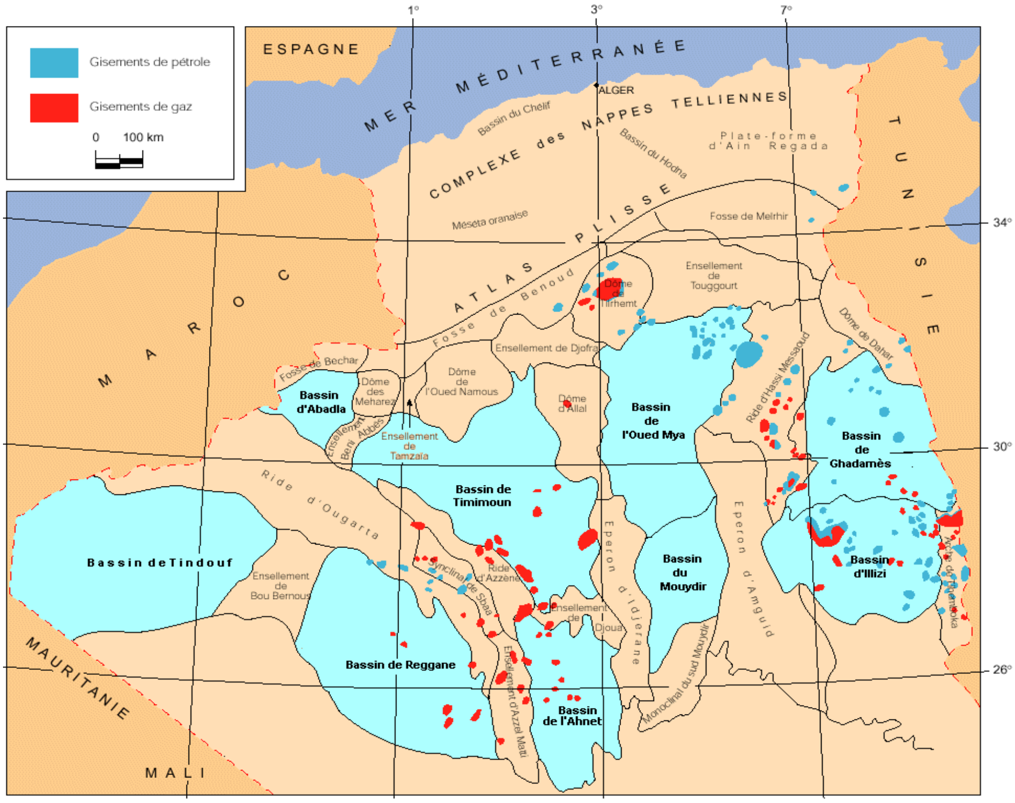


Fig. 68: Sedimentary basins of the Saharan platform [40].

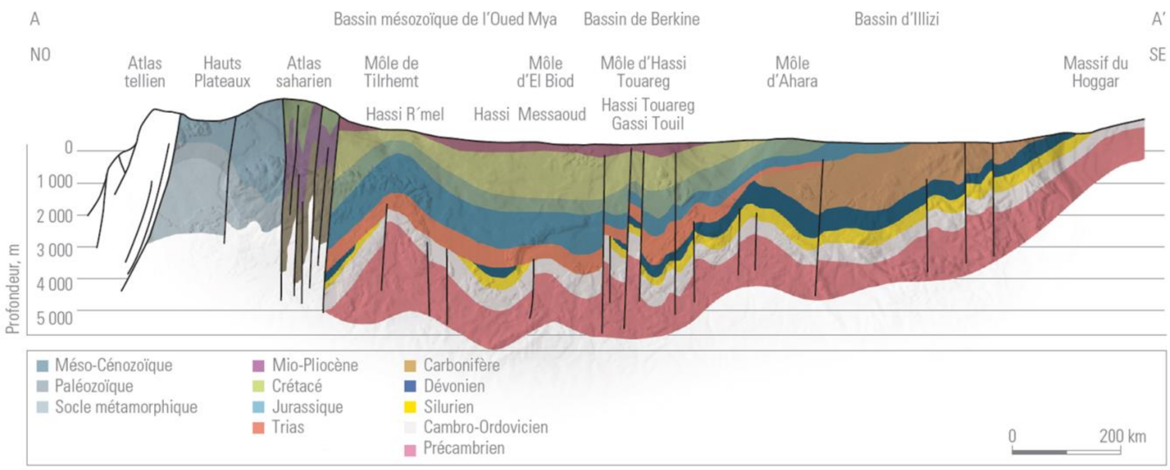


Fig. 69: Algerian NO-SE geological schematic cross-section [39].

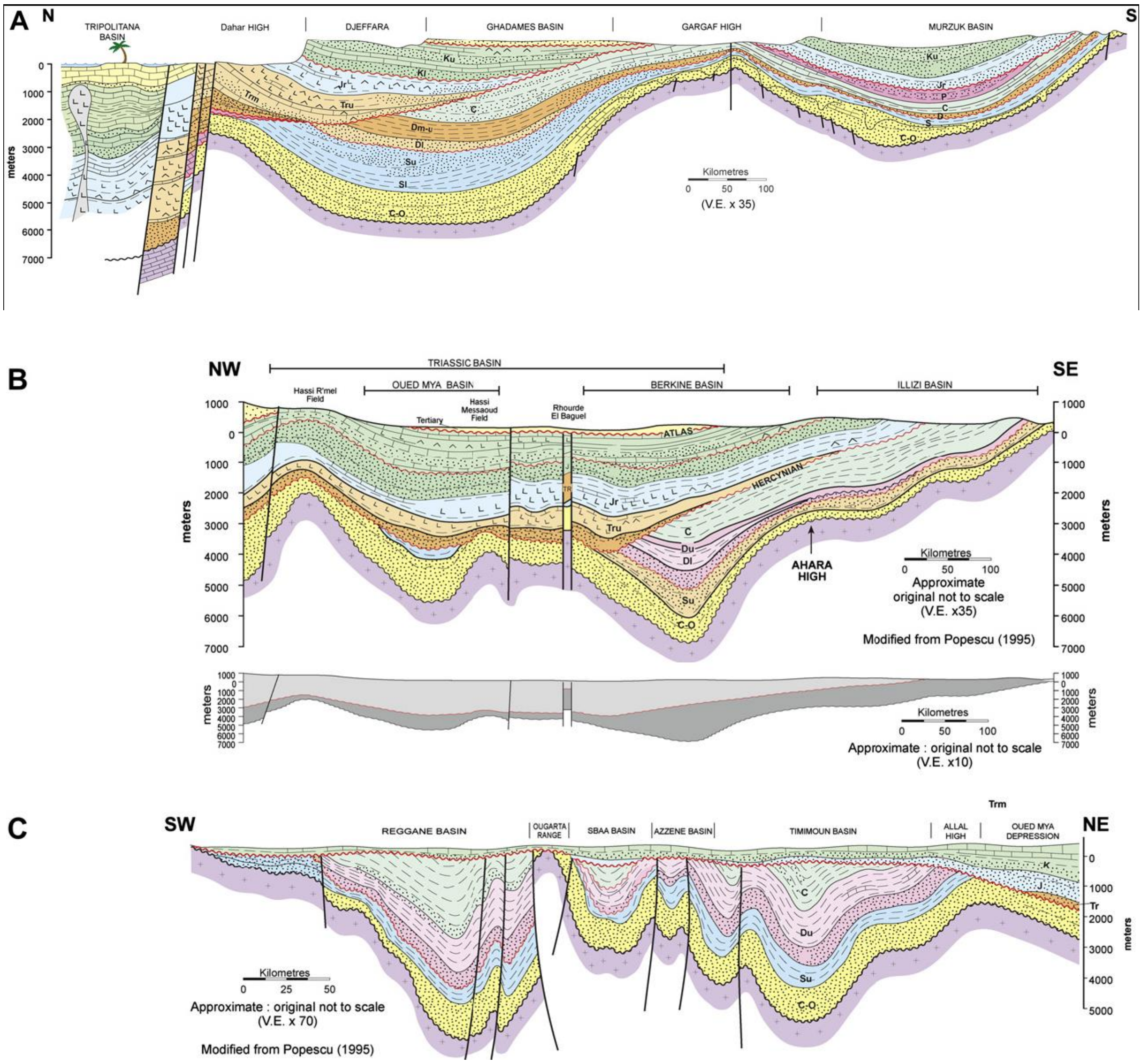


Fig. 70: Geological schematic cross-sections in some Algerian basins [21].

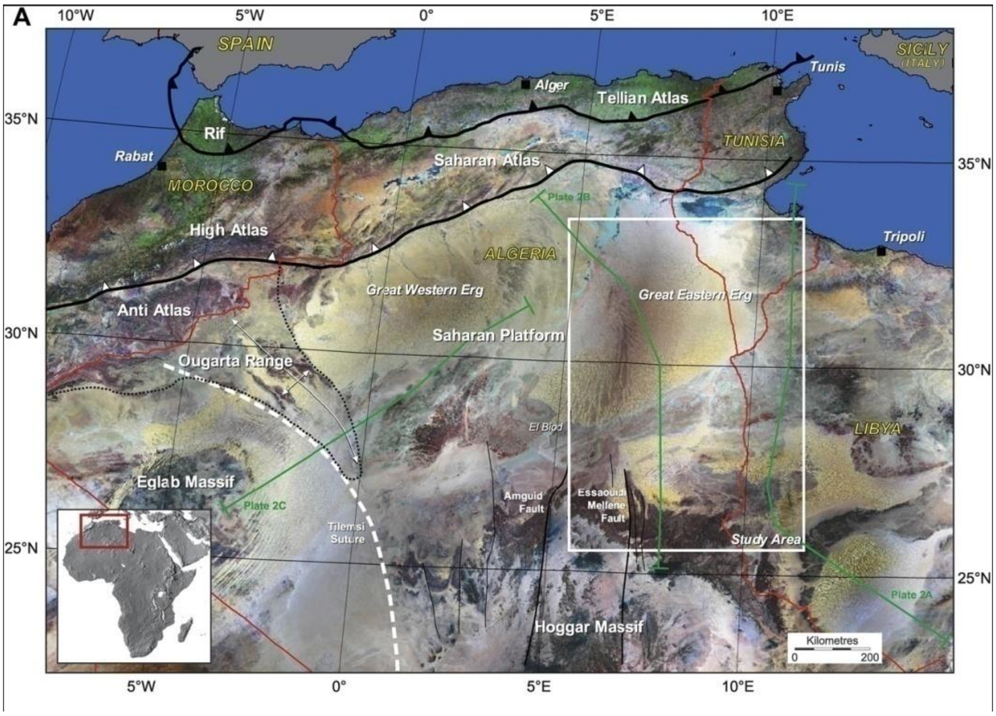


Fig. 71: Cross-sections lines of the figure (70) [21].

3. In northern Algeria?

Northern Algeria is a segment of the alpine chain of the Maghrebides, whose nature and structure of the substratum are poorly known due to the complexity of its geology. The substratum has not been recognized anywhere in the Saharan Atlas. The Atlasic chain was built on a very subsiding Mesozoic basin (5000 to 10,000 m), structured in tilted blocks.

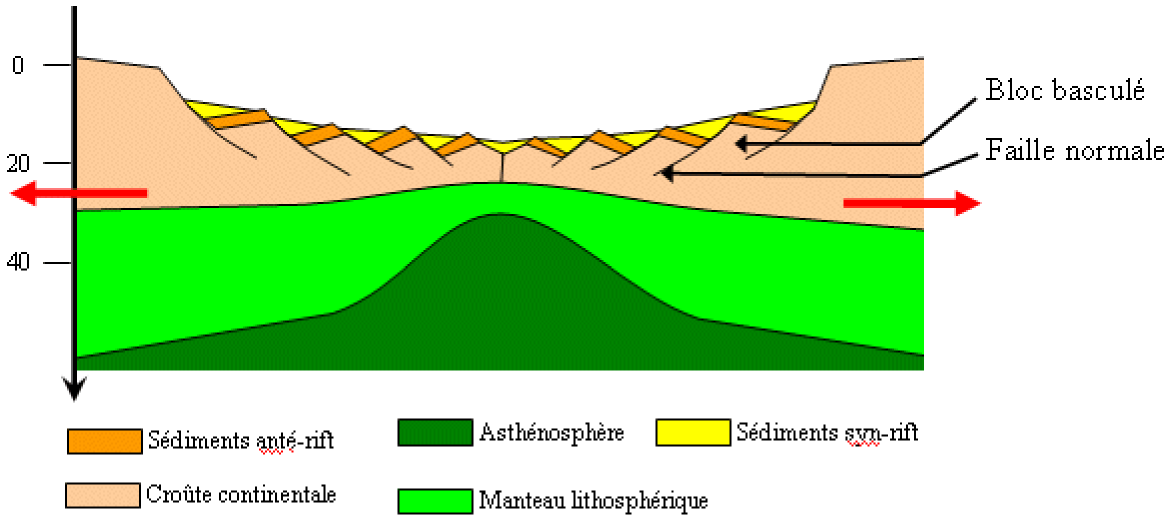


Fig. 72: Tilted blocks

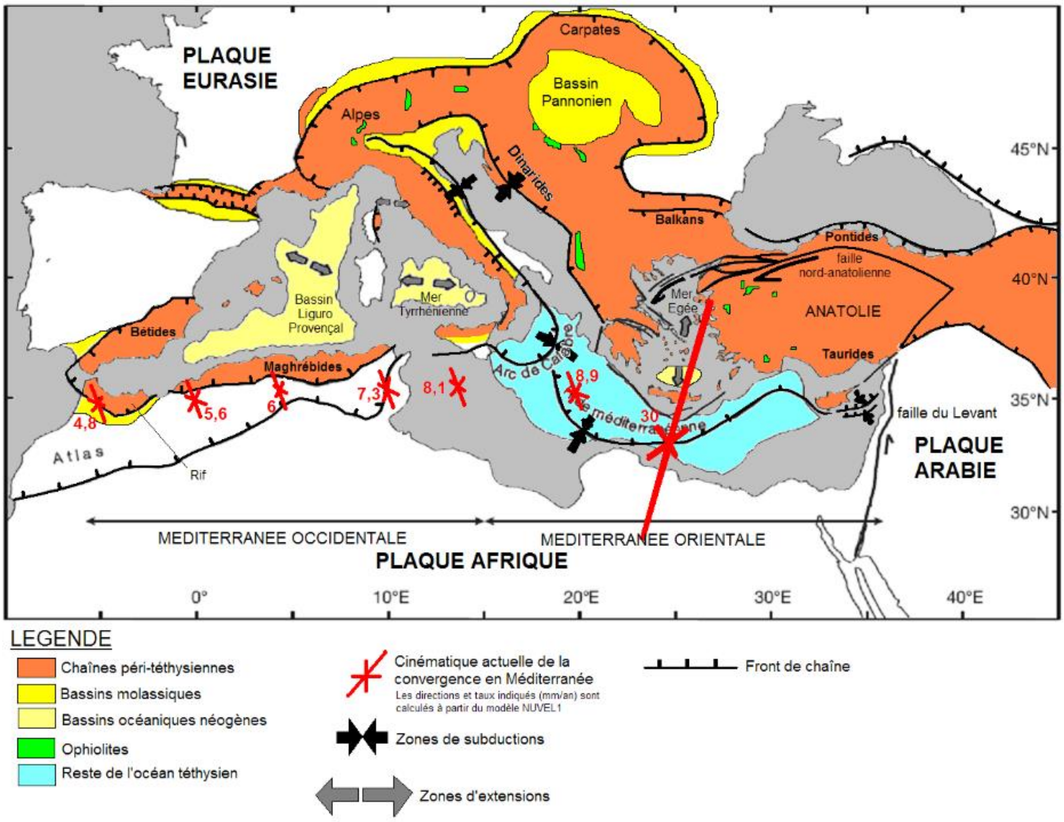


Fig. 73: Magrebides in their regional context [41]

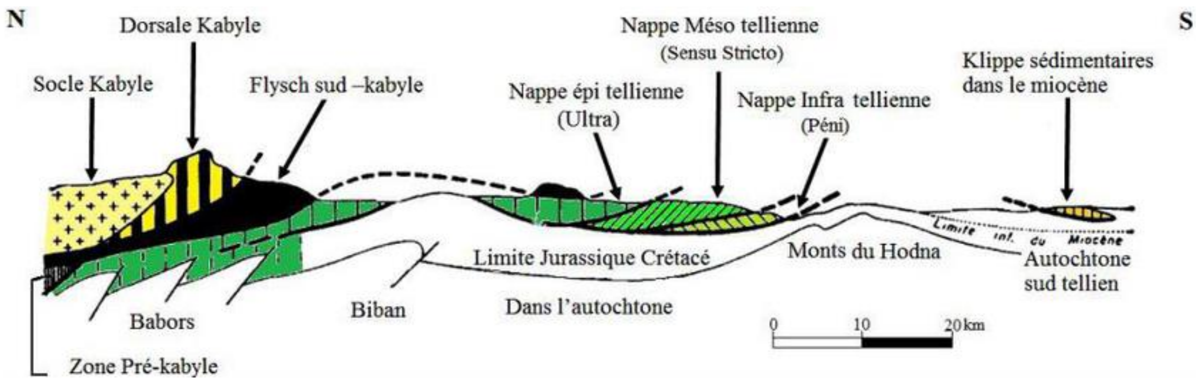


Fig. 74 : N-S detailed geological cross-section in Northern Algeria

According to aeromagnetism and gravimetry, it would be a substratum located under the Mesozoic, structured in longitudinal strips ENE-WSW and cut by transverse accidents.

This implies either the absence of Paleozoic, or a metamorphic nature of it. In the latter case, it would be similar to the European Hercynian basement.

In the far north, in the Tellian domain, particularly in the most internal zones of the Kabyle dorsal and the Jijel-Skikda massif, an undifferentiated basement, including very little metamorphic to metamorphic Paleozoic, schistosed and injected with cross-cutting granites, has been recognized. Its structural relationship with the rest of the series is poorly defined.

Conclusion: Generally, the substratum of sedimentary basins in Algeria would be:

- of Eburnean nature in the SW (Tindouf-Reggane),
- Pan-African on the majority of the Saharan Platform
- and probably Hercynian in the north.