- Australia and New Guinea moved northward,
- Antarctica continued its journey toward the South Pole,
- the Atlantic widened, and
- South America connected to North America.

- An increasingly unstable climate set in, reaching its paroxysm in the great glaciations of the Quaternary.

8. Why is the Cenozoic the Age of Mammals?

The current mammalian fauna includes:
- ~4000 species and 114 families of placentals (our main group),
- 270 species and 16 families of marsupials (the kangaroo group),
- and only 3 species and 2 families of monotremes (the platypus group).

At the end of the Cretaceous (Campanian-Maastrichtian, 85-65 Ma), only 150 to 300 species and 27 families of mammals have been identified so far, including about ten families of marsupials and about ten placentals.

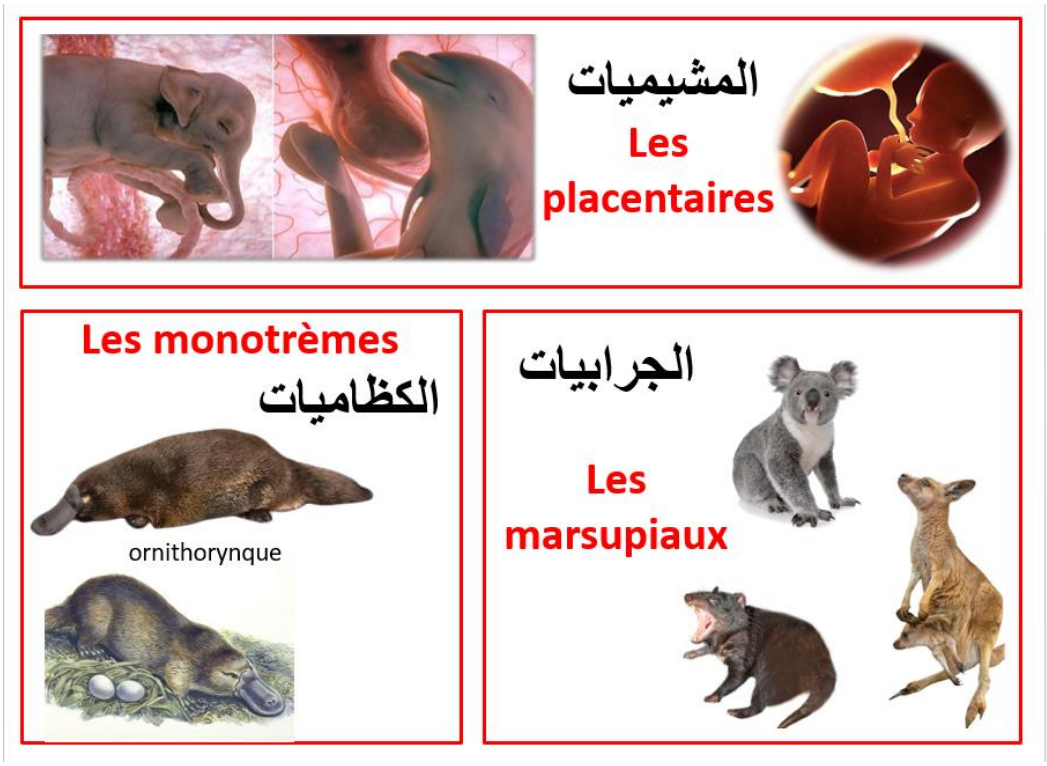


Photo. 25: Mammal's classes

9. Human origin

- Class: "Modern" mammals in the Eocene, around -55/-50 Ma.
- Order: Primates (الرئيسيات) emerged around -55 Ma.
- Family: Hominids (البشرانيات) (approx. 14 Ma)
- Homo Sapiens *sapiens* (modern human) would emerge through:

1. Pre-hominids around -7 Ma (Toumaï),
2. Australopithecines around 3.18 (Lucy),
3. Homo Habilis, 2.5 to 2 Ma,
4. Homo Ergaster, 2.2 Ma, and also
5. Homo Erectus, 2 Ma...
6. Homo neanderthalensis, -30,000 years

Photo. 26: Human at different sizes!

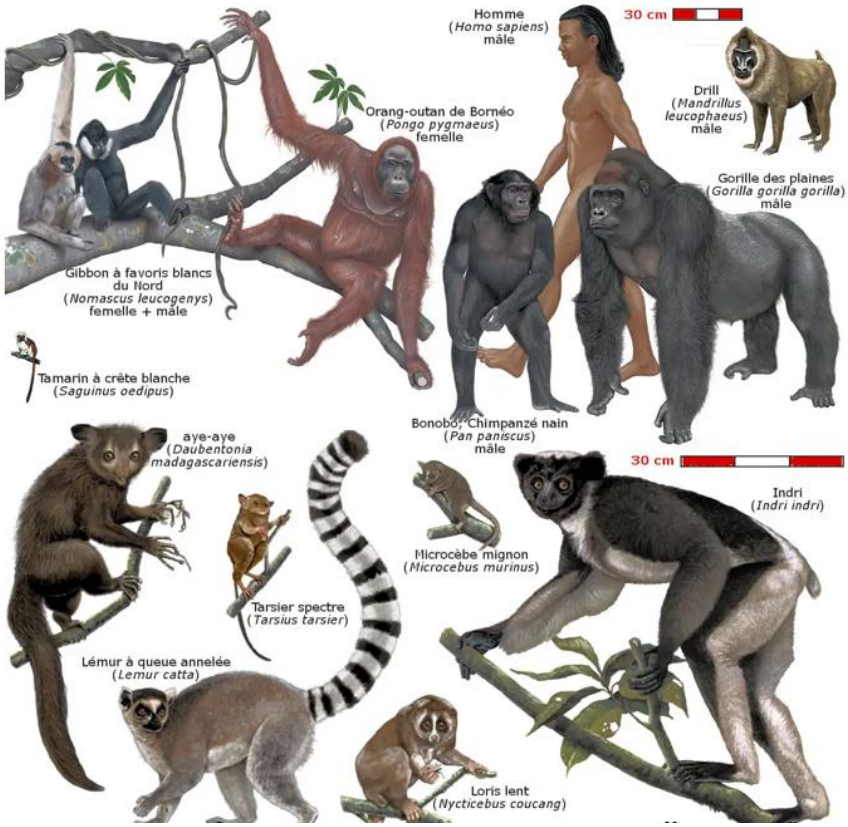


Photo. 26: Primates [49]

Primates

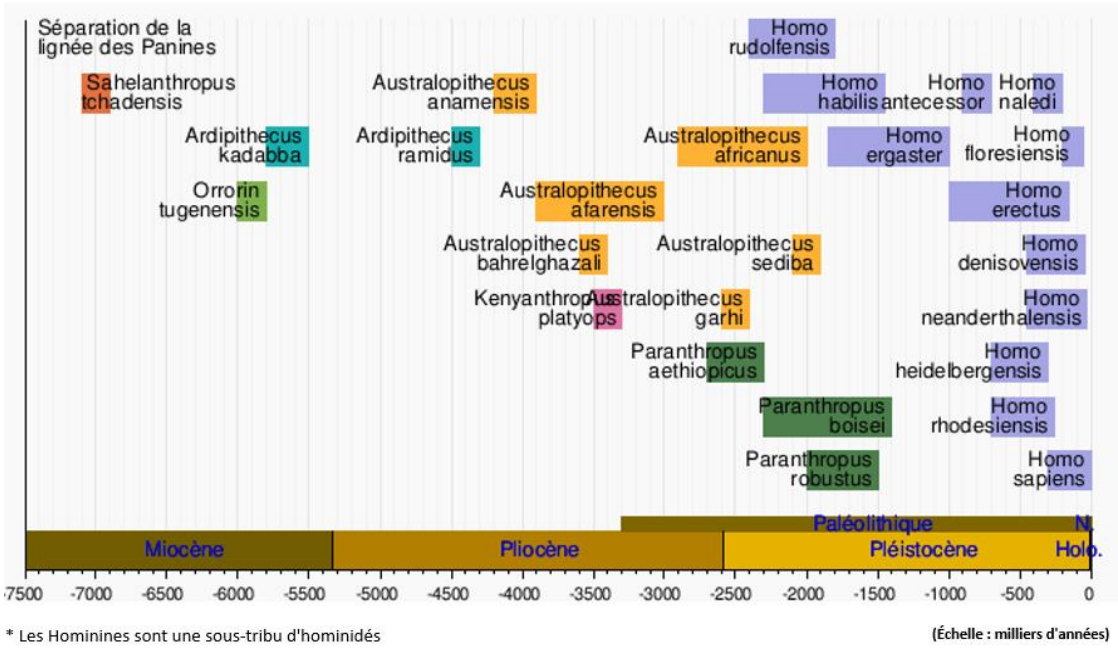


Fig. 110 : Hominins over time

10. Plant Life and Tectonic Evolution Through Geological Epochs

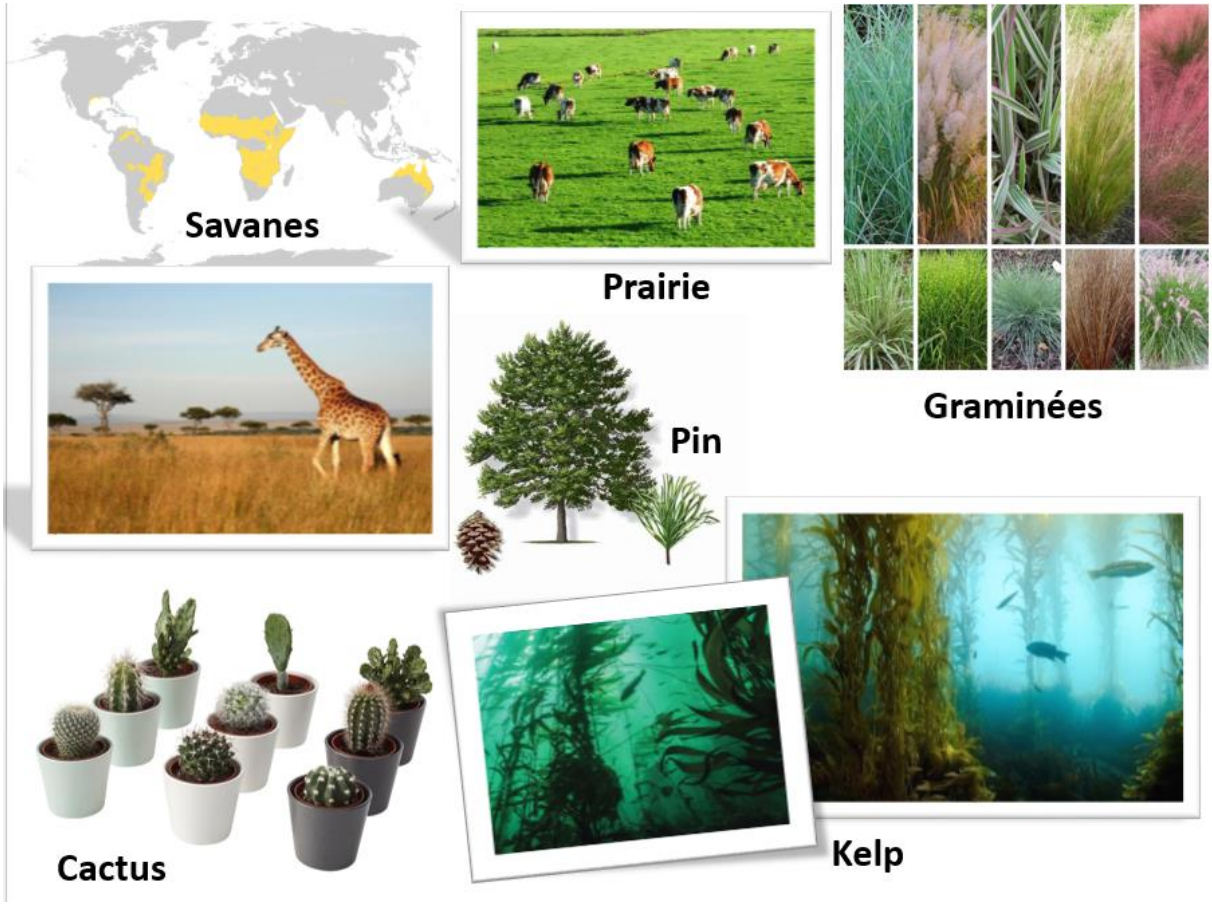
10.1. Plant Life - Paleogene

- **Paleocene**: New plants evolved rapidly and the first pines, cacti, and palm trees appeared. Flowering plants continued to diversify rapidly**.
- **Eocene**: The highly successful flowering plants continued to diversify until they filled most environments on Earth.
- **Oligocene**: The cooler, drier, and more seasonal climate of the Oligocene was ideal for the evolution of many grass species.

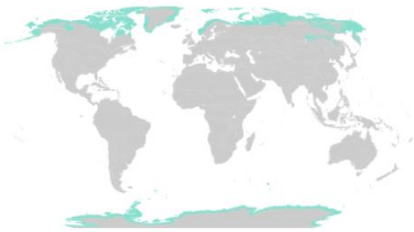
10.2. Plant Life - Neogene/Pleistocene

- **Miocene**: The two major plant changes were the major expansion of grasslands and the appearance of kelp forests in the oceans.
- **Pliocene**: Grasslands and savannas expanded considerably due to the cooler, drier climate. Plant species were very similar to those of today.
- **Pleistocene**: During interglacial periods, forests dominated. When the climate cooled, grasslands expanded and tundra dominated.

** Contrary to what is stated by the theory of evolution.




Taïga

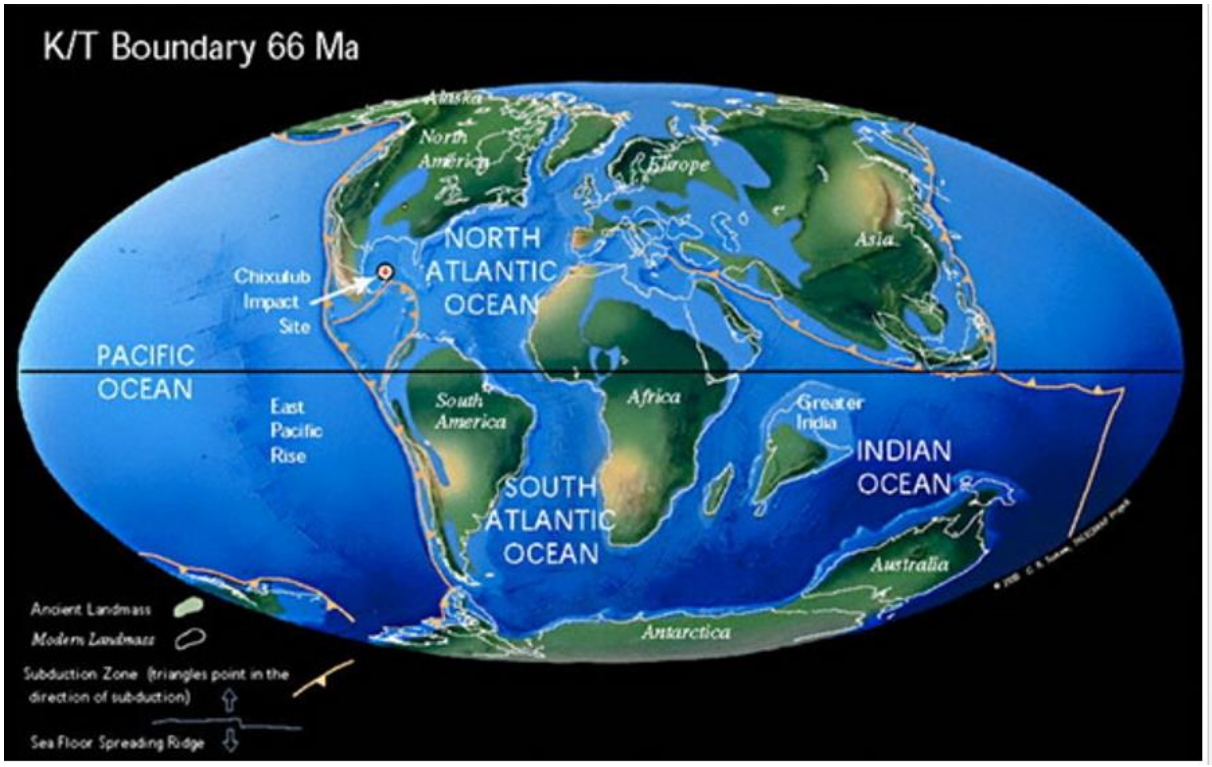

Toundra

11. Cenozoic tectonics and climate evolution

11.1. Paleocene

During the Paleocene, sea levels receded considerably, exposing substantial landmasses globally. North America's last major inland sea disappeared by the period's end. The continents of South America, Antarctica, Australia, India, and Africa existed as separate landmasses. The climate was significantly warmer and more uniform than today's.

The Paleocene concluded with a dramatic warming event, potentially caused by substantial carbon dioxide and methane releases into the atmosphere and oceans. This triggered shifts in oceanic and atmospheric circulation patterns, leading to extinctions among deep-sea organisms and significant turnover in terrestrial mammal species.

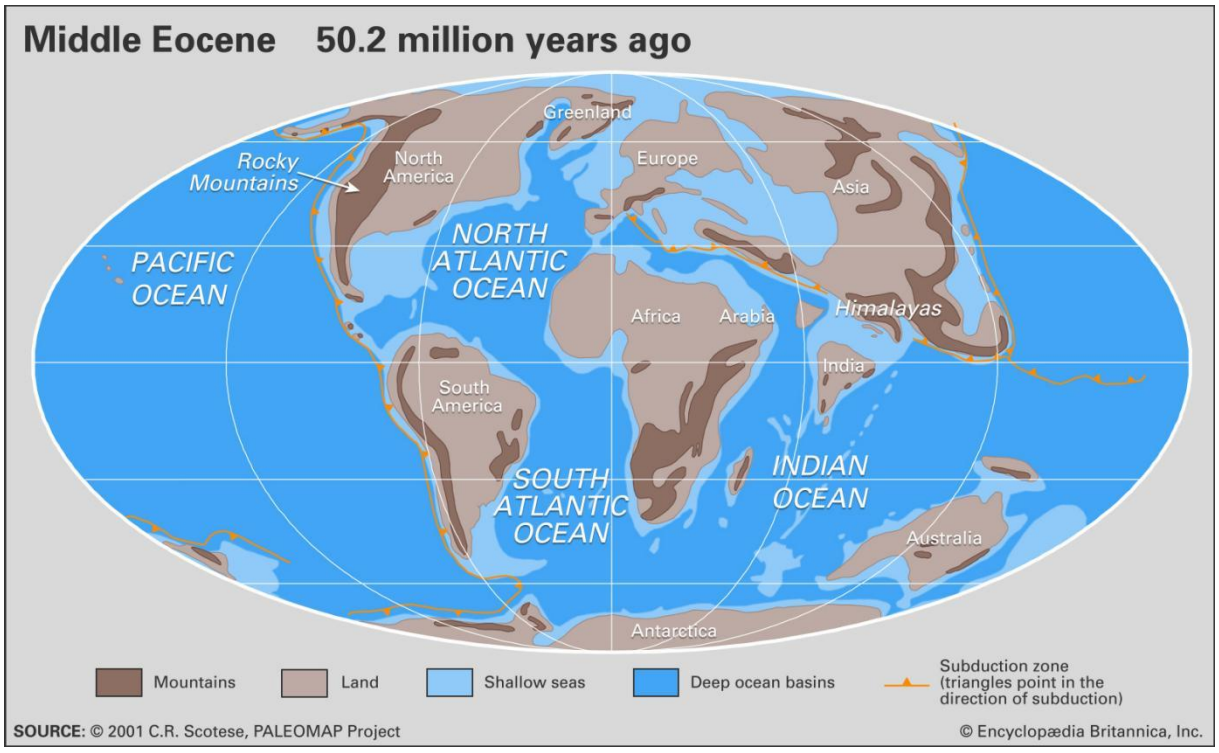


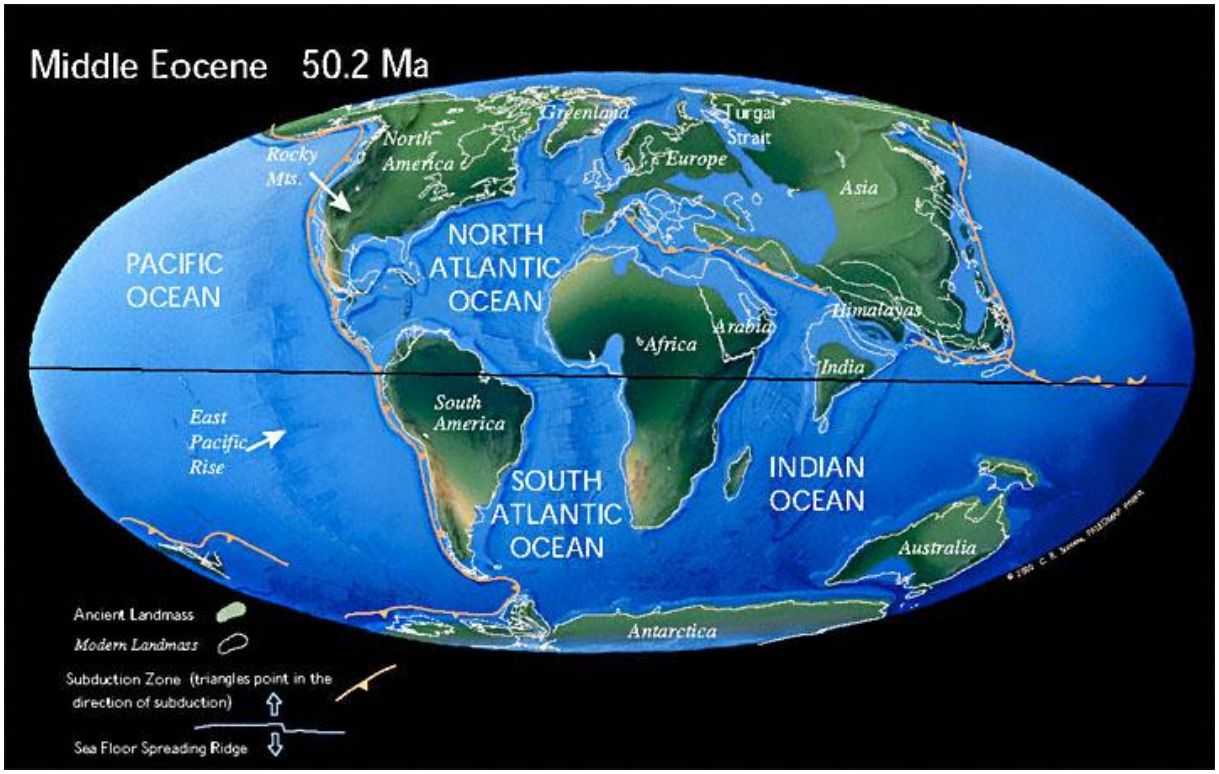
11.2. Eocene

The Eocene began with the collision of the Indian and Eurasian plates, initiating the formation of the Himalayan mountains. Simultaneously, Australia separated from Antarctica and drifted northward. This period experienced the warmest temperatures of the entire Cenozoic era, characterized by abundant rainfall, absence of seasons and glaciers, and relatively uniform temperatures globally—even allowing palms and alligators to thrive within the Arctic Circle.

By the Eocene's conclusion, the widening gap between Australia and Antarctica enabled the circum-Antarctic current to develop, altering global ocean circulation and triggering worldwide

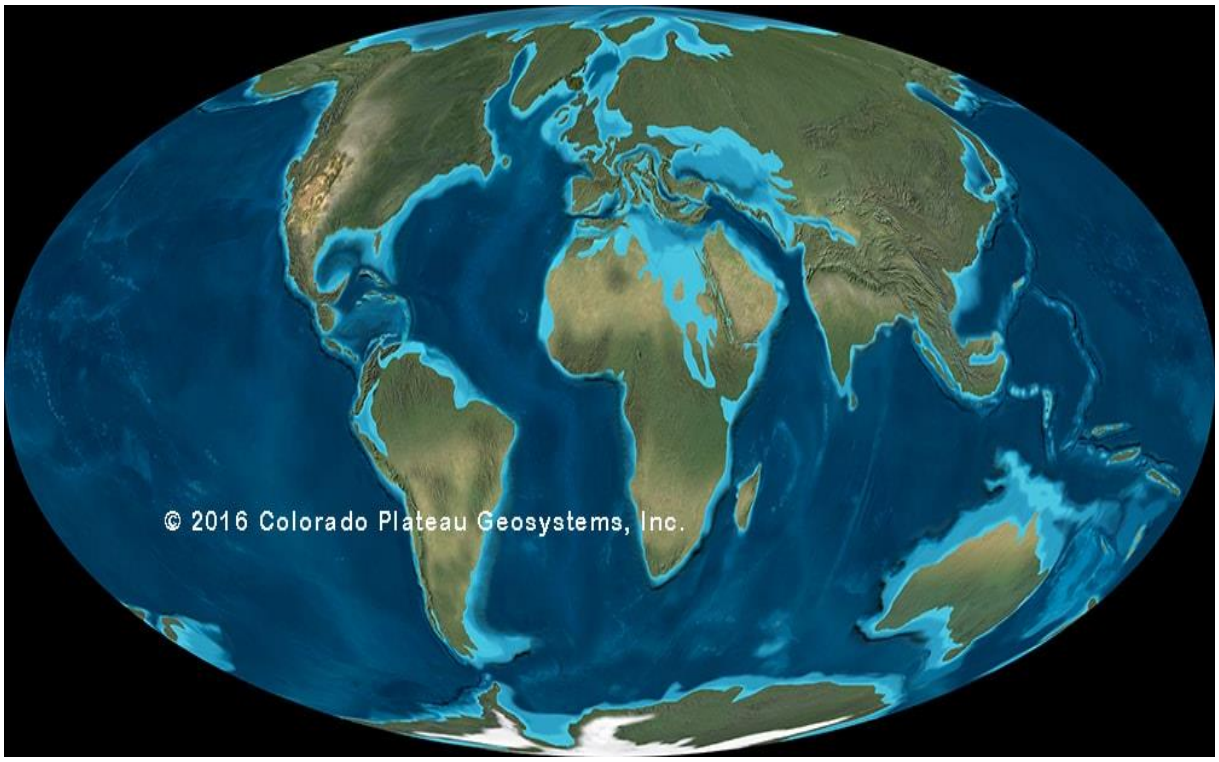
cooling. High sea levels submerged significant portions of most continents during much of this period. The Eocene's end also shows evidence of multiple extraterrestrial impacts on Earth, with crater remnants found across Russia, Belarus, Canada, and the United States, though their timing and environmental impacts remain uncertain.





11.3. Oligocene

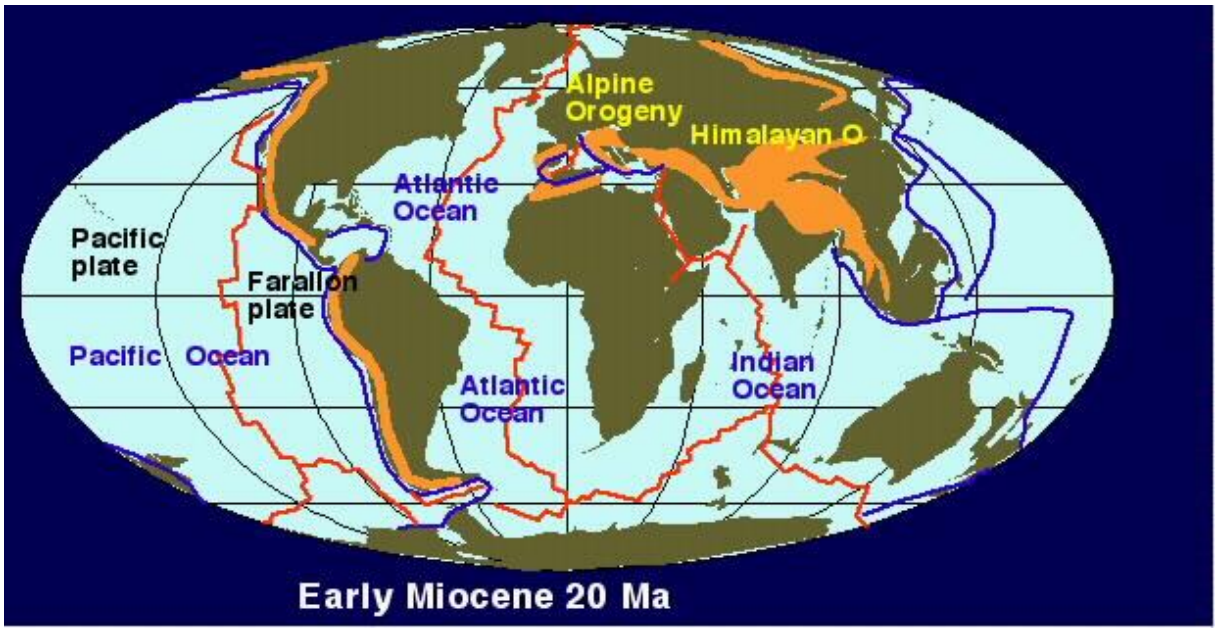
The Oligocene saw India continuing its northward push into Asia, South America fully separating from Antarctica, and Australia's ongoing northward movement. Volcanic activity increased substantially across Europe and North America. The formerly warm, humid Eocene climate transitioned to cooler, drier conditions with more pronounced seasonality. Antarctica developed substantial glaciation for the first time in the Cenozoic, resulting in lowered sea levels.



11.4. Miocene

New mountain ranges emerged across North America, South America, Europe, and Africa during the Miocene. The Himalayas continued their uplift, and the Appalachians experienced renewed elevation. Antarctica maintained its polar ice cap, while land bridges connected Africa with Asia and North America with Siberia.

The early Miocene featured warmer conditions, but the latter half saw mountain formation combined with evolving ocean currents and Antarctic ice expansion leading to reduced rainfall, increased seasonality, and cooler temperatures. These climate changes caused forests to contract while grasslands expanded significantly.



11.5. Pliocene

By the Pliocene's onset, continental positions closely resembled their current configuration. The Caribbean plate shifted to connect North and South America at the Isthmus of Panama, creating a land bridge for mammal migration. The Mediterranean Sea temporarily dried up, becoming grassland for an extended period, while the Himalayan mountains continued rising.

The early Pliocene was warmer than present-day Earth with higher sea levels. However, the latter half experienced temperature drops and precipitation decreases. The Antarctic ice sheet expanded, and a new ice cap formed at the North Pole. The precise causes of these climate shifts that ultimately led to the Pleistocene ice ages remain unclear.

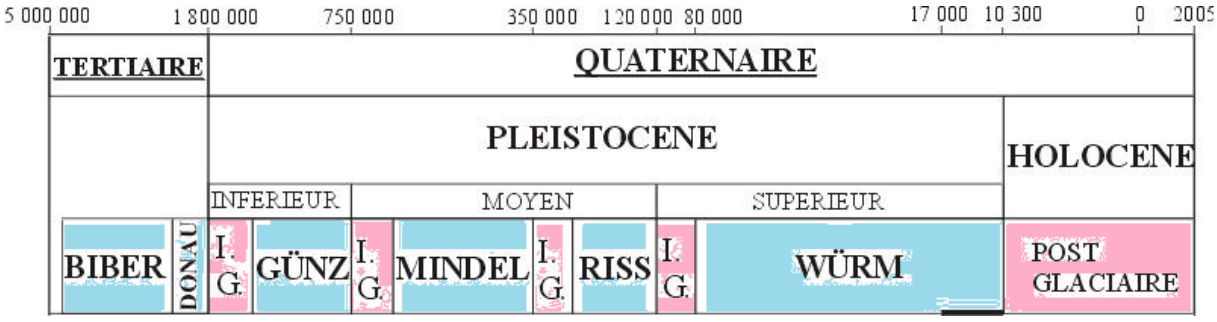
11.6. Pleistocene

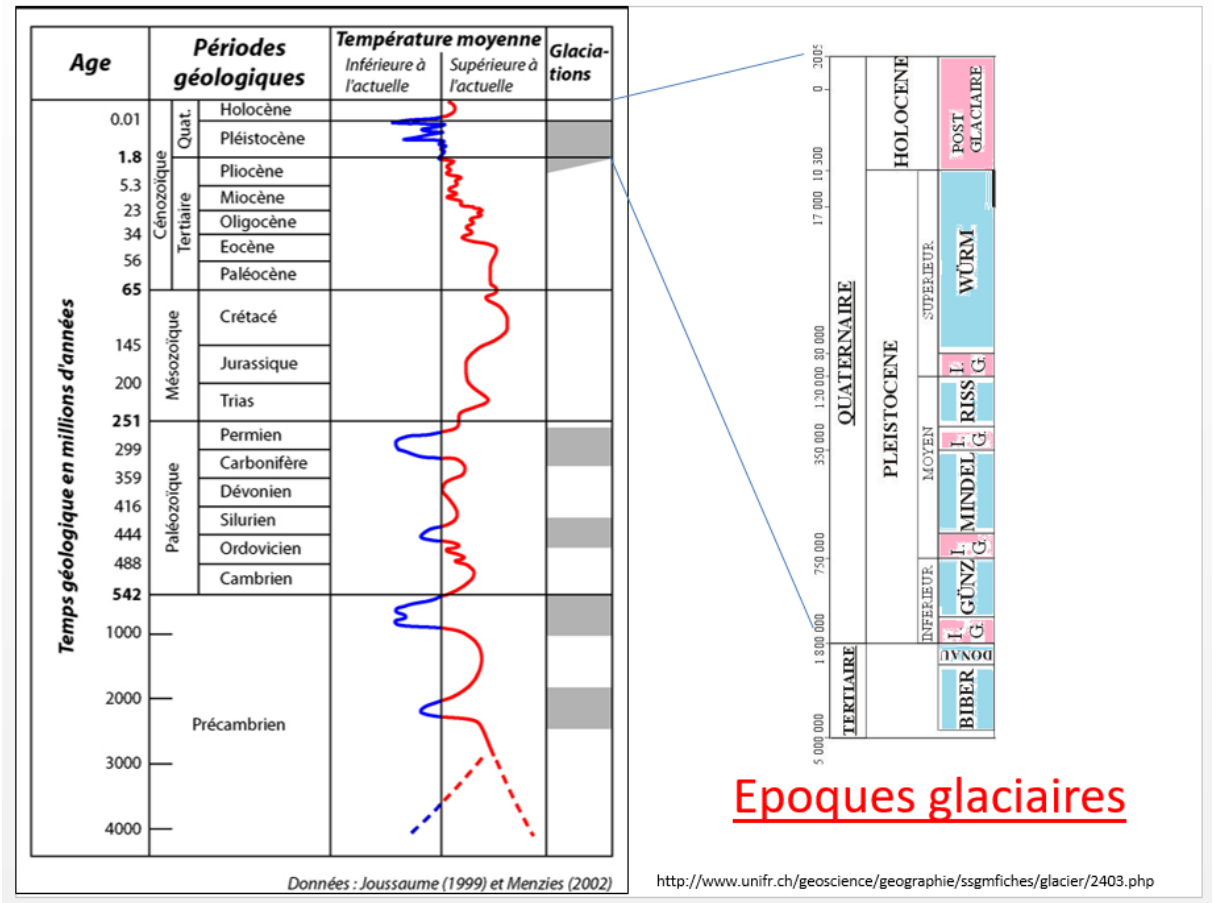
Continental positions during the Pleistocene were essentially identical to today's, though their outlines fluctuated with the ice ages. During glacial periods, sea levels dropped as water became trapped in ice sheets; during interglacial periods, melting ice caused sea levels to rise.

The Pleistocene featured cycles of planetary cooling and warming, with ice ages and interglacial periods occurring approximately every 100,000 years. At peak glaciation, ice up to 4,000 meters thick covered the northern quarter of the globe, lowering sea levels by about 131 meters. During interglacial periods, northern ice melted substantially and glaciers retreated, while Antarctic ice—which melted less during warm periods—gradually increased in size over time.

12. Ice Ages

- Currently, 10% of the Earth's surface is covered by ice.
- If all the Earth's ice melted, sea levels worldwide would rise by approximately 70 meters.
- During the Quaternary glaciation, a maximum of 32% ice coverage was reached.





Summary: From the Big Bang to Today

- 14 billion years (Ga): formation of the Universe (Big Bang)
- 4.6 billion years: formation of planet Earth
- 4 billion years: appearance of prokaryotic cells
- 3 billion years: appearance of photosynthesis
- 2 billion years: appearance of eukaryotic cells
- 1 billion years: appearance of multicellular life
- 600 million years (Ma): appearance of "simple" animals (Ediacaran fauna)
- 550 million years: appearance of first "complex" animals (Cambrian Explosion)
- 500 million years: appearance of fish and proto-amphibians
- 475 million years: appearance of land plants
- 400 million years: appearance of insects and seeds
- 360 million years: appearance of amphibians
- 300 million years: appearance of reptiles
- 200 million years: appearance of mammals
- 150 million years: appearance of birds
- 100 million years: appearance of flowers
- 66 million years: extinction of non-avian dinosaurs
- 7 million years: appearance of the human lineage (*Sahelanthropus tchadensis*)
- 4 million years: appearance of australopithecines (*Australopithecus anamensis*)
- 2.4 million years: appearance of the genus Homo (*Homo rudolfensis*)
- 250,000 years: appearance of Neanderthal man (*Homo neanderthalensis*)
- 200,000 years: appearance of modern humans (*Homo sapiens*)

History of the Universe, Earth and Life Compressed into One Year

- January 1: Beginning of the Universe's expansion, the Big Bang
- April 1: Our galaxy is formed
- September 9: Birth of our solar system
- September 14: Earth is formed
- October 1: Life appears
- October 9: Bacteria appear
- November 12: Appearance of fossil plants and photosynthesis
- November 15: The first cells with nuclei begin to thrive
- December 1: The atmosphere becomes rich in oxygen
- December 16: The first worms emerge
- December 17: Invertebrates appear
- December 18: Ocean plankton is established
- December 19: Appearance of first fish and first vertebrates
- December 20: Plants colonize land
- December 21: The first insects
- December 22: The first amphibians
- December 23: The first reptiles
- December 24: The first dinosaurs
- December 26: The first mammals
- December 27: The first birds
- December 28: Extinction of dinosaurs
- December 29: The first cetaceans (infraorder of aquatic mammals) and the first primates (Monkeys, Humans, ...) appear
- December 30: Large mammals are on Earth

December 31:

- 10:30 PM: Appearance of the first humans
- 11:46 PM: Humans domesticate fire
- 11:59 PM: They need to communicate and paint on cave walls
- 11:59 PM and 20 seconds: Invention of agriculture
- 11:59 PM and 50 seconds: Astronomy, the oldest science develops, the first dynasties are established
- 11:59 PM and 51 seconds: Invention of the alphabet
- 11:59 PM and 54 seconds: Invention of iron metallurgy, the Assyrian Empire and the founding of Carthage
- 11:59 PM and 56 seconds: The Roman Empire, Euclid's geometry, Archimedes' physics, Ptolemy's astronomy
- 11:59 PM and 58 seconds: Maya civilization, Byzantine Empire, Mongol invasions and the Crusades
- 11:59 PM and 59 seconds: Renaissance in Europe (1300 - present)

References:

[1] https://geoetc.com/scale-fields-of-view-in-geoscience/
[2] https://libretexts.org/
[3] Williams M. (2015). The Anthropocene biosphere DOI: 10.1177/2053019615591020
[4] https://flowingdata.com/2012/10/09/history-of-earth-in-24-hour-clock/
[5] Woese, Carl R.; Kandler, O; Wheelis, M (1990). "Towards a natural system of organisms: proposal for the domains Archaea, Bacteria, and Eucarya". Proc Natl Acad Sci USA. 87 (12): 4576–9.
[6] https://www.britannica.com/science/Ordovician-Silurian-extinction
[7] https://communities.springernature.com/posts/lessons-from-the-deep-past
[8] Stephen L. Brusatte , Michael J. Benton , Graeme T. Lloyd , Marcello Ruta and Steve C. Wang (2011). Macroevolutionary patterns in the evolutionary radiation of archosaurs (Tetrapoda: Diapsida) Cambridge University Press. DOI 10.1017/S1755691011020056
[9] https://www.earth.com/earthpedia-articles/the-history-of-earth-in-exactly-2000-words/
[10] https://avg85.fr/les-variations-du-niveau-des-oceans-les-cycles-transgression-regression
[11] https://fr.wikipedia.org/wiki/Cycle_orog%C3%A9nique
[12] https://ccgm.org/picg-667/
[13] Michot (1989). Les grilles d'interpretation des unites continentales. . Ann. Soc. géol. Belg., 100: 147-156.
[14] Michel Faure (2020). La chaine varisque en France, un édifice multi-collisionnel et poly-cyclique. Institut des Sciences de la Terre d'Orléans, Université d'Orléans
[15] Foucault and Raoult (1980). Dictionnaire de géologie
[16] Michard, André (2011) Nouveaux guides géologiques et miniers du Maroc/New Geological and Mining Guidebooks of Morocco, volume 1: Présentation des circuits - Introduction à la géologie du Maroc. Service Géologique du Maroc. Ministère de l'Energie et des Mines, Rabat
[17] Michard, A., 1976. Elément de la géologie du Maroc. Notes et Mémoires du Service géologique du Maroc, 252, 422p.
[18] Michel Ballèvre, J.R. Martínez Catalán, Alicia López-Carmona, Sonia Sanchez Martinez (2014). Correlation of the nappe stack in the Ibero-Armorican arc across the Bay of Biscay: a joint French–Spanish project. Geological Society London Special Publications
[19]https://www.lithotheque.ac-aix-marseille.fr/liste_grands_evenements/images_grands_evenements/varisque/gerbault_etal_2016b_v2.jpg
[20] https://commons.wikimedia.org/wiki/File:Distribution_of_varisican_orogenies.png?uselang=fr
[21] Galeazzi, S., Point, O., Haddadi, N., Mather, J., Druesne, D., 2010. Regional geology and petroleum systems of the Illizi-Berkine area of the Algerian Saharan Platform: An overview. Marine and Petroleum Geology. Vol. 27, p. 143-178.
[22] https://www.studocu.com/fr/document/universite-cadi-ayyad/geologie-du-maroc-ii/rif-partie-1/46720712
[23] https://fr.wikipedia.org/wiki/Molasse
[24] https://www.sac-cas.ch/fr/cabanes-et-courses/portail-des-courses-du-cas/zones-geologiques/les-roches-de-la-molasse-2
[25] Mikesclark (wikimedia.org)
[26] https://geologyistheway.com/sedimentary/turbidity-currents/
[27] https://en.wikipedia.org/wiki/Orogenic_belt#/media/File:Pacific_Ring_of_Fire.png
[28] https://blogs.univ-poitiers.fr/abderrazzak-el-albani/
[29] https://blogs.univ-poitiers.fr/abderrazzak-el-albani/
[30] https://www.researchgate.net/publication/280954735_Contribution_a_l%27etude_des_grenats_merovingiens_Basilique_de_Saint-Denis_et_autres_collections_du_musee_d%27Archeologie_nationale_diverses_collections_publiques_et_objets_de_fouilles_recentes_Nouvelles_/figures?lo=1
[31] http://www.largeigneousprovinces.org/11may
[32]https://www.semanticscholar.org/paper/The-continental-record-and-the-generation-of-crust-Cawood-Cawood/fed06a5e7247cfcbb1e0c58772091d1b75d82692/figure/3
[33] Martin, H. (1986) Effect of Steeper *Archean* Geothermal Gradient on Geochemistry of Subduction-Zone Magmas. Geology, 14, 753-756.
[34] https://www.sciencefacts.net/prokaryotes-vs-eukaryotes.html
[35] http://www2.ggl.ulaval.ca/personnel/bourque/s4/precambrien.html
[36] https://fr.wikipedia.org/wiki/Rodinia
[37] https://encyclopedia.pub/entry/32673
[38] https://planet-terre.ens-lyon.fr/ressource/Img364-2011-10-10.xml

[39] Zeroug, S., Bounoua, N. Lounissi, R., Zeghouani, R., Djellas, N., Kartobl, K., Tchambaz, M., Abadir, S, Simon, P. and Fuller, J., 2007. Well Evaluation Conference, Algiers, Sonatrach & Schlumberger. [40] Askri, H., Belmeheri, A., Benrabah, B., Boudjema, A., Boumendjel, K., Daoudi, M., Drid, M., Ghalem, T., Docca, A.M., Ghandriche, H., Ghomari, A., Guellati, N., Khennous, M., Lounici, R., Naili, H., Takherist, D. and Terkmani, M., 1995. Geology of Algeria, Well Evaluation Conference (WEC) Sonatrach & Schlumberger, Algiers, pp.1-93.
[41] Philippe Agard, Marcel Lemoine. (2003) *Visage des Alpes : Structure et évolution géodynamique*. Commission de la Carte Géologique du Monde, pp.50,.
[42] www.stratigraphy.org
[43] https://planet-terre.ens-lyon.fr/article/fossiles-pluricellulaires.xml
[44] http://www.jpb-imagine.com/Sharjah/3/32histbioter/doc32/Chap3/Chap232.html
[45] Source : modifié de « Parlons science (2020) »
[46] https://geologie.mnhn.fr/periodespal.html
[47] Omrane Ben Abdelkader, Habib Ben Salem, Pierre Donze, Anne-Louise Maamouri, Henriette Méon, Éric Robin, Robert Rocchia, Laurence Froget (1997). The K/T stratotype section of El Kef (Tunisia): Events and biotic turnovers. Geobios, Volume 30, Issue SUPPL. 2, Year 1997
[48] Oussaid, épse Metsana Fariza (2021). Etude de la limite crétacé-paléogène en Algérie. Thèse de doctorat Université des Sciences et Technologie Houari Boumediene (USTHB)
[49] www.aquaportail.fr