جامعة أبو بكر بلقايد

كلية التكنولوجيا

UNIVERSITY OF TLEMCEN

Faculty of Technology

**Department of Civil Engineering**

***L2 Civil Engineering***

***Semester: 3***

***Discovery teaching unit GS471***

***Module 1: Geology***

***VHS: 22H30 (Lecture: 1h30)***

***Credits: 1***

***Coefficient: 1***

**Part 1/5**

**1 Chapter /5**

**xx pages**

**By Prof, Habib TROUZINE**

*This course corresponds to the **Geology** module intended for students in the second year of a degree in civil engineering and public works. Its objectives are to introduce students to the general notions of geology applied to civil engineering and public works. The student will be able to read and interpret a geological map and to better understand geotechnical problems and to know the geophysical methods used.*

*Handout available in pdf version on: http://*

*If you find an error, please report it by email to h_trouzine@yahoo.fr*

*January 2023*

| Subject program | Hourly volume/chapter |
|---|---|
| **Chapter 1:** Introduction to geology | **02 Weeks** |
| **Chapter 2:** Minerals and rocks | **04 Weeks** |
| **Chapter 3:** Action of different elements on rocks | **03 Weeks** |
| **Chapter 4:** Concept of geodynamics | **03 Weeks** |
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5.2 Use of graphic constructions
5.3 Geological survey of discontinuity surfaces
5.4 Use of stereographic projection

**References:**

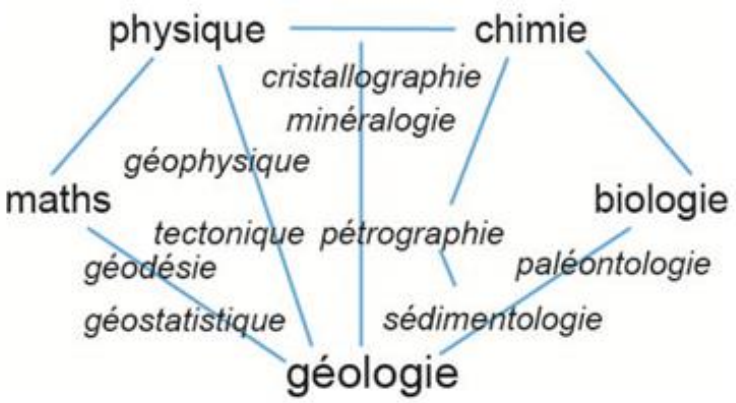
1. G. BOGOMOLOV Hydrogéologie et notions de géologie d'ingénieur,
2. Aurèle Parriaux et Marcel Arnould, 2009 Géologie : Bases pour l'ingénieur,
3. Roger Cojean et Martine Audiguier, 2011 Géologie de l'ingénieur : Engineering geology. Bilingue français/anglais,
4. Hydrogéologie, géologie de l'ingénieur, Éditions du BRGM, 1984.
Faucault A.Raoult J-F (1995) – Dictionnaire de géologie, 4 édition. Editions Masson, 325p
5. Pomerol C., Lagabrielle Y., Renard M. (2005) – Eléments De Géologie, 13e édition. Editions Dunod, 762p

# Chapter 1: Introduction to Geology

## 1.1. Definitions

**Geology** is the **science of the earth**; not only the **description of its current external form**, which, under the name of geography, is in truth only a secondary branch, but the **reconstruction of its history**, or, as they say, of its paleogeography, of its mode of development in the past (comparable to that of a living being) and **the determination of those deep parts** which ordinarily escape our gaze, but which certain works, mine shafts, tunnels, etc., allow, at selected points, to observe or verify[1].

Geology is a science comprising many specialties and calls upon the knowledge of various scientific fields (see figure below).

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|---|
| geodesy |
| geology |
| geophysics |
| geostatistics |
| math |
| mineralogy |
| paleontology |
| petrography |
| physics |
| sedimentology |
| tectonics |

***Fig. 1.1. Relation entre certaines spécialités de la géologie et plusieurs disciplines[2]***

***(Relationship between some geology specialties and several disciplines)***

Geology has two main parts, fundamental geology and applied geology.

**Fundamental geology:** It includes many scientific disciplines, such as:

- **Crystallography:** This is the study of the properties, in particular geometric, of the crystalline state of matter.
- **Mineralogy:** This is the study of the composition and physicochemical properties of minerals.

[1] L. DE LAUNAY, Géologie pratique et petit dictionnaire technique des termes géologiques les plus usuels. 2Ed. Librairie Armand Colin, Paris 1909.

[2] R. DJERRAB, Cours de GEOLOGIE, 1ère année SNV de l'Université de Chlef, 2016.

- **Petrography:** is the study and classification of rocks. We will distinguish the petrography of sedimentary rocks, the petrography of magmatic and metamorphic rocks.
- **Petrology:** is the study of the genesis of rocks. We will also call exogenous petrology the study of sedimentary rocks, and endogenous petrology the study of magmatic and metamorphic rocks.
- **Volcanology:** it studies the structure, formation and evolution of volcanoes.
- **Sedimentology:** it studies the processes of sediment deposition and the genesis of sedimentary rocks.
- **Pedology:** this discipline studies the characteristics and formation of soils, particularly from a morphological and physicochemical point of view.
- **Stratigraphy**: it studies the succession of deposits and sedimentary layers to arrive at a reconstruction of successive paleogeographies.
- **Geochronology**: allows the determination of the age of a rock by physical methods.
- **Paleontology**: studies animal fossils (paleozoology) or plants (paleobotany): description, classification, evolution, extinction, ecology (paleoecology).
- **Tectonics**: studies the deformations of the Earth's crust and their genesis.
- **Geophysics**: is the study of the physical properties of the globe (magnetic field, gravity field and seismic waves for example) in order to understand its structure and movements.
- **Geochemistry**: studies the distribution of elements and the laws of their chemical behavior in minerals, rocks and the various envelopes of the Earth.
- **Geodynamics**: studies major geological processes, both external (erosion) and internal (earthquakes).

**Applied geology:** This is the use of geological data and methods to study the conditions of deposit, formation and exploitation of various subsoil resources, as well as the carrying out of public works.

It includes:

- **Hydrogeology**: deals with the circulation of water in the subsoil: search for water tables, evaluation of reservoirs, etc.
- **Hydrochemistry**: deals specifically with water chemistry.
- **Petroleum geology**: or more generally hydrocarbons concerns all the disciplines of geology implemented for oil prospecting.

- **Geology** of metalliferous deposits: includes depositology which studies the structure of mineral concentrations and metallogeny, which describes their genesis.
- **Geotechnics**: is the study of the mechanical properties of rocks and rock masses. We speak of geology of development and civil engineering for the study of major works (roads, bridges, tunnels, dams) and the associated risks.
- **Applied geophysics**: allows to obtain a local image of the subsoil by studying physical properties. It is widely used in prospecting for georesources.
- **Applied geochemistry**: allows the chemical characterization of water and soils, particularly in the case of pollution.
- **Cartography**: is the set of techniques and graphic arts leading to the establishment of maps and their printing.
- **Remote sensing**: from aerial photographs or satellite images, brings together all the methods allowing to study remotely (tele) the electromagnetic properties of the earth's surface.

## Fields of Engineering Geology[3, 4]

Engineering geology is the science that is dedicated to the research, study and resolution of engineering and environmental problems resulting from the interaction between geology and human works and activities; it is also dedicated to the prediction of geological risks and the development of preventive and curative measures. Engineering geology includes:

- the definition of the morphology, structure, stratigraphy, lithology of geological formations as well as the geological context of aquifers;
- the characterization of the mineralogical, physico-geomechanical, chemical and hydrological properties of all materials of the earth's crust involved in the construction of works, the extraction of natural resources and the modifications made by man to the environment;
- the evaluation of the mechanical and hydrological behavior of soil and rock assemblies;
- the determination of the parameters to be taken into account for the study of the stability of civil engineering works and that of soil and rock masses;
- the improvement and maintenance of the environment and the properties of the soil surface.

Fundamental geology is one of the bases of the engineer's curriculum in the following branches:



[3] AIGI : Association Internationales de la Géologie de l'Ingénieur et de l'Environnement.

[4] Aurèle Parriaux (2006) Géologie, Bases pour l'ingénieur, 2éme Edition. Presses Polytechniques et Universitaires Romandes, Lausanne.

- civil engineering,
- environmental sciences,
- soil and rock mechanics,
- hydrology,
- hydrogeology,
- pedology[5].

Beyond the scientific bases, the study of earth sciences influences the engineer's way of thinking, both in the exercise of his profession and his culture, and this by::

- a broad sensitivity to the earth context in which the works are installed (work-environment relationships);
- the differences in scales in space and time;
- a broader qualitative view of the problems to be solved; alongside quantitative notions;
- a multidisciplinarity;
- a critical mind regarding the results of specific measurements and simulation models,
- access through geology to modern challenges of our society in terms of the environment affecting the subsoil..

The fields uniting **geology-engineering** are generally presented in the form of four large groups which are: **construction of works; natural risks; geological resources and environmental pollution**.

## 1.2. Role of the geologist in civil engineering[6] :

In any civil engineering project, the geologist intervenes, in consultation with the project manager and in liaison with the various specialists (structural engineer, road technician, rock or soil mechanic, landscaper, etc.), at several stages:

- upstream of the studies, in the choice of sites according to technical requirements (linked to topography or lithological, structural or environmental constraints) or economic, and in the definition of the reconnaissances to be carried out; at this level, it is essential for the geologist to identify the major constraints linked to the nature of the land, the structure, the morphology, active developments;
- during geotechnical studies, in the interpretation of the results, in their interpolation, to refine knowledge and control hypotheses;

[5] Aurèle Parriaux (2006) Géologie, Bases pour l'ingénieur, 2éme Edition. Presses Polytechniques et Universitaires Romandes, Lausanne.

[6] Jean - Louis DURVILLE, Pierre POTHÉRAT (1997) Géologie, Techniques de l'ingénieur Réf : C204 v2 du 18 juin 2015

- during the work, in the possible reorientation of the project due to results not conforming to the initial hypotheses, or if an incident occurs (landslide, water ingress, etc.).

## 1.3. Paleontology:

The Larousse dictionary gives the following definition: "Science that studies living beings (animals, plants or micro-organisms) that have populated the earth over geological time, based mainly on the interpretation of fossils".

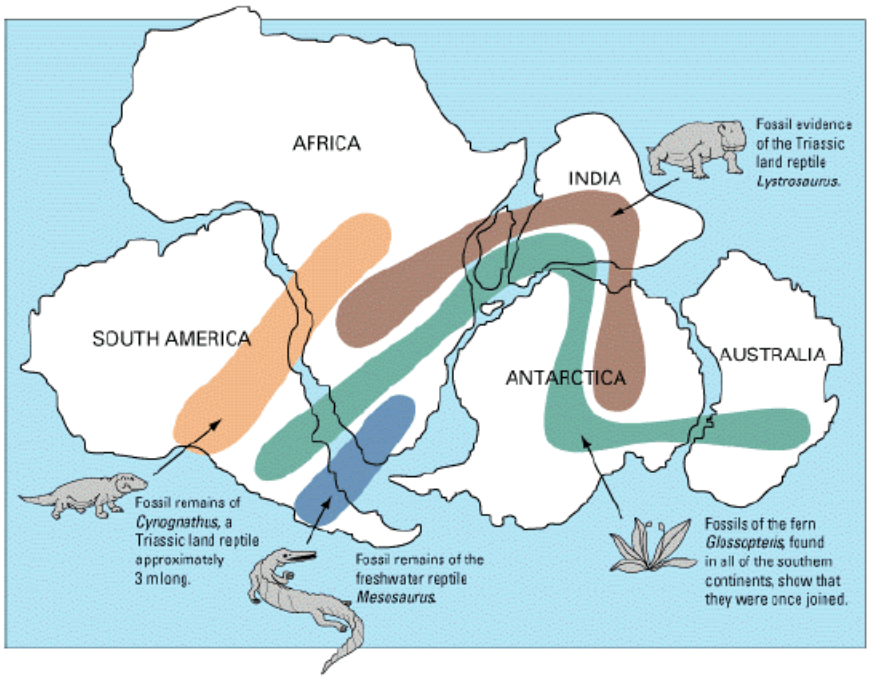



***Fig. 1.2. Structure du globe terrestre _ Théorie des plaques.***[7]

Paleontology has two main objectives:

1. to date the sedimentary layers containing the fossils (biostratigraphy).
2. to reconstruct and characterize ancient living environments (paleoenvironments "temperature, depth, salinity...").

Paleontology is divided into three sub-specialties: animal paleontology (synonymous with paleozoology), human paleontology (synonymous with paleoanthropology), plant paleontology (synonymous with paleobotany).

[7] Martin Cyr "La Géologie Appliquée au Génie Civil", Cours de l'INSA de Toulouse.

## 1.4. Origin of the Earth

The Earth is the third planet in order of distance from the Sun and the fifth largest in the solar system both in terms of mass and diameter. Furthermore, it is the only celestial object known to support life. Located approximately 150 million km from the Sun, the Earth completes a revolution around the Sun in just over 365 days. The Earth rotates on itself around an axis of rotation passing through the poles in 24 hours. This axis is slightly inclined (23°) relative to the plane of the ecliptic (plane of revolution); this inclination is the cause of the existence of seasons.

The Big Bang "Grand Boum" is used by scientists to describe the origin and evolution of the universe[8]. It was initially proposed in 1927 by Georges Lemaitre, who described in broad outline the expansion of the universe.

The age of the Earth is approximately that of the Sun, or 4.6 billion years.

**Overall characteristics:** Its radius is approximately 6371 kilometers. The Earth is slightly flattened at the poles.

The globe is practically spherical with the dimensions[9]: polar radius (Rp ) = 6356.77km; equatorial radius (Re ) = 6378.16 km; mean radius (equal volume sphere) = 6371 km; Surface area S $\approx$ 510 x $10^6$ $km^2$; Volume V $\approx$ 1.083 x $10^{12}$ $km^3$; Mass M $\approx$ 5.975 x $10^{21}$ T; Average density of 5.52 $T/m^3$.

**Geoid:**

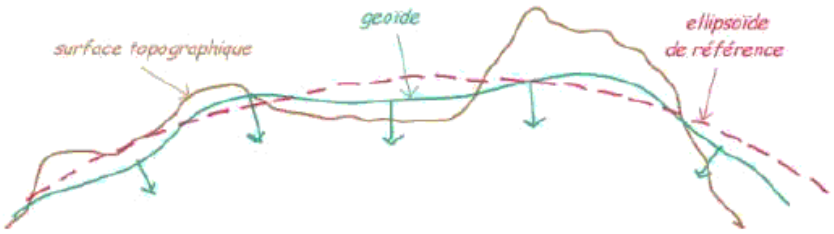
The geoid is defined as the equipotential of the gravitational field (W=Wo) corresponding as closely as possible to the mean sea level. It was mainly used for research on vertical references and mean sea level. Since the advent of space positioning techniques, and more particularly with the rapid development of the GPS system, the situation has changed radically; the geoid has become an indispensable tool for converting heights or differences in heights above the ellipsoid from GPS into altitudes or differences in altitudes for the purpose of leveling[10].



[8] Daniel, J.Y "Sciences de la Terre et de l'Univers", Vuibert, Paris. 2015

[9] Martin Cyr "La Géologie Appliquée au Génie Civil", Cours de l'INSA de Toulouse.

[10] GHOUGALI Mammar (2019) Détermination précise d'un modèle local du géoïde en Algérie à partir des données satellitaires GRACE et SRTM, Thèse de doctorat de l'Université de Ouargla.

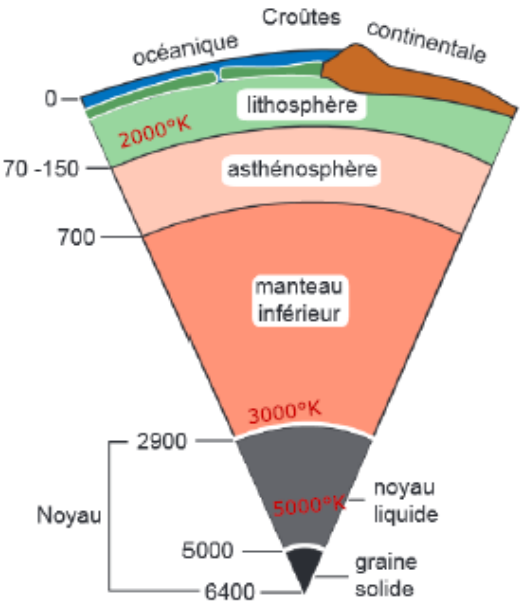



*http://zoumine.free.fr/tt/navigation/ellipsoides.html*

**Internal structure of the Earth**[11]**:** It is made up of a succession of concentric envelopes separated by discontinuities (e.g. crust-mantle = Moho). The envelopes are increasingly dense and increasingly hot towards the center. Their physical and chemical properties are different (liquid outer core).

•Accessible indirectly (study of the propagation of seismic waves; average density 5.5).

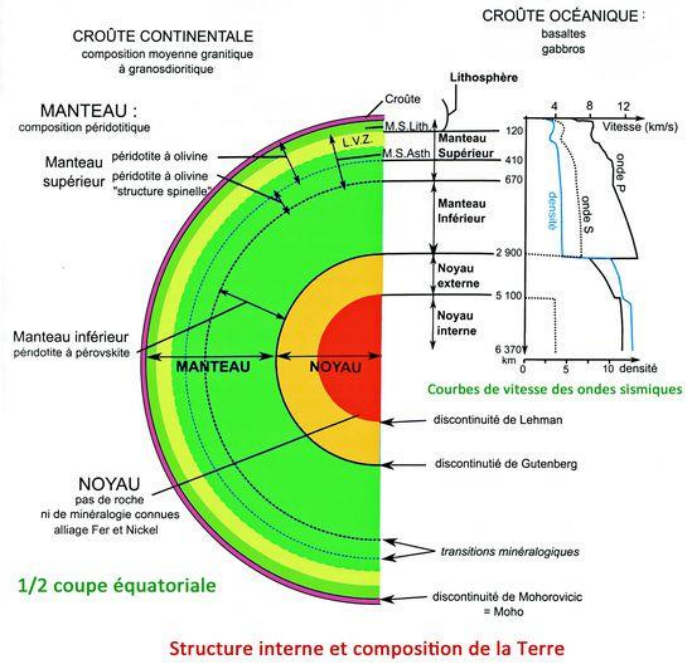
•Liquid outer core at the origin of the Earth's magnetic field.




**Seismological model:**

The model is established by interpreting the data provided by seismographs during earthquake recordings. The model simplifies from the propagation speeds of seismic waves, the modulus of elasticity and density of the crossed media.

[11] Hubert Brill (2016) GÉOLOGIE : LE MINIMUM VITAL. Université de Limoges



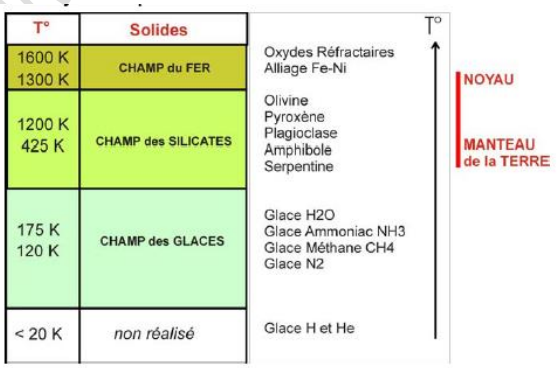

Structure interne et composition de la Terre _ Modèle sismique[12]

(http://avg85.fr/le-modele-sismique-de-la-structure-du-globe-terrestre/)

Le modèle de référence est le PREM (Adam M. Dziewonski & Don L. Anderson, ***Preliminary Reference Earth Model*, Physics of the Earth and Planetary Interiors**, Volume 25, Issue 4, June 1981, Pages 297-356)[13]

## Mineralogical model[14]:

This model is based on the principle of variation of minerals with depth (due to the increase in temperature and pressure). It is based on the experiments of condensation of gas mixtures and thermodynamic calculations.




Principe du modèle minéralogique[14].

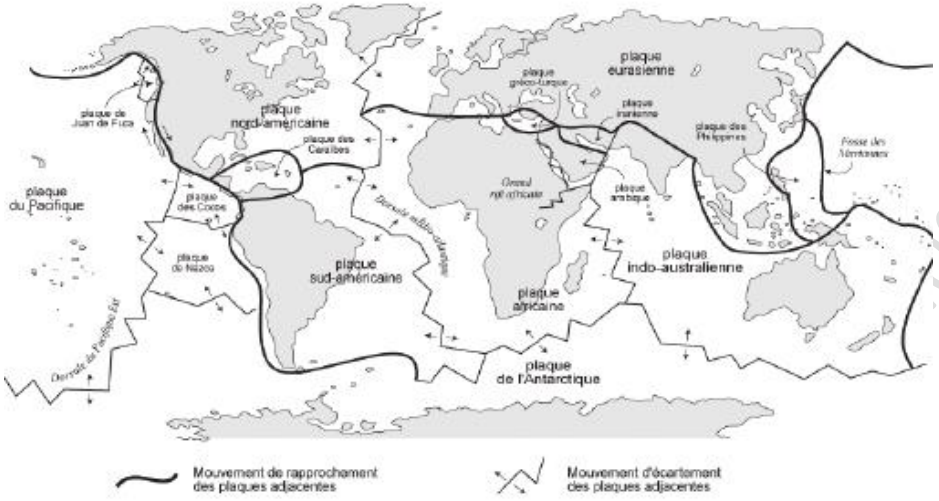
[12] http://avg85.fr/ Site de l'association Vendéenne de Géologie. **Le modèle sismique de la structure du globe terrestre.** Consulté le 22/01/2023

[13] Adam M. Dziewonski, Don L. Anderson. Preliminary reference Earth model. Physics of the Earth and Planetary Interiors. Volume 25, Issue 4, June 1981, Pages 297-356

[14]

### Dynamic model: plate theory (1968):

The surface of the globe is formed of plates that move relative to each other at a speed of the order of cm/year. The boundaries between these plates represent seismic zones.




Ensemble des plaques tectoniques formant la lithosphère[15]

## 1.5. Geological divisions of the Earth:

The geological time scale divides the history of the Earth into shorter units based on the appearance and disappearance of different forms of life. It begins 4.55 billion years ago (4550 million years ago) and continues to the present day.
The eras are the four major divisions of the geological time scale:

**1- Precambrian**: *Living organisms present in the Precambrian are very simple. Single-celled organisms with a nucleus (eukaryotes) appeared 2000 Ma ago, while multicellular organisms appeared 1000 Ma ago.*

**2- Paleozoic**, *This era begins with the appearance of invertebrates with a shell. It is divided into six periods: Cambrian, Ordovician, Silurian, Devonian, Carboniferous and Permian. The Paleozoic era includes three mass extinctions as well as the appearance of the first vertebrates, the first plants and the first terrestrial organisms.*

**3- the Mesozoic** *This era is commonly called "the era of the dinosaurs" since they were the ones who dominated the planet at that time. It is divided into three periods: the Triassic, the Jurassic and the Cretaceous.*

**4- the Cenozoic**. *This is the era we are currently in. It is during this era that most of the species of birds, mammals and flowering plants that we know today appeared. It is divided into three periods: the Paleogene, the Neogene and the Quaternary.*



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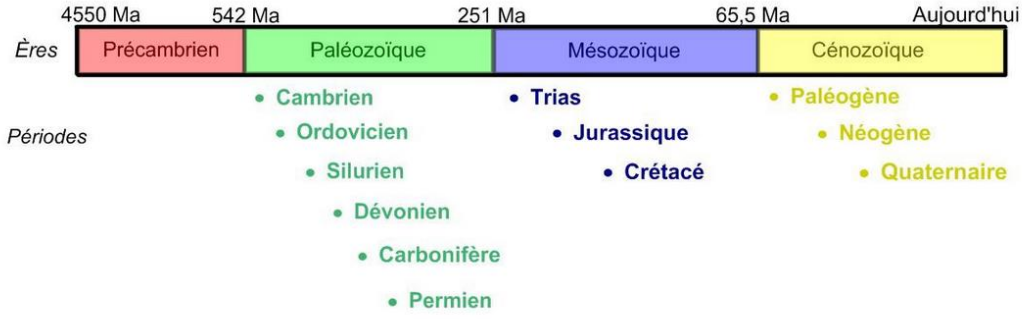
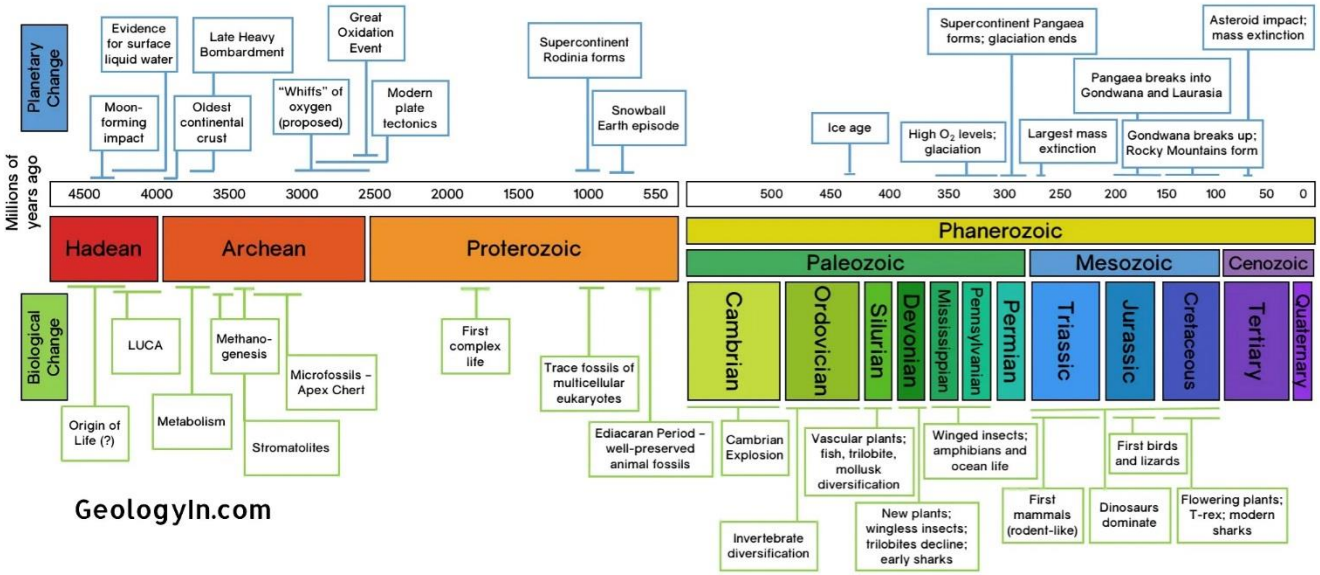



Les ères et périodes géologiques[16].



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