Fossils and Fossilization

Zurab Kurtsikidze / EPA

Professor David Lordkipanidze of the Georgia National Museum shows a skull of an ape-like man who lived about 1.8 million years ago in Tbilisi, Georgia, October 18, 2013.

Sources: science.time.com

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FOSSILS

- Fossils are the preserved remnant of organisms or traces of geologic past.
- Preserved remnant or traces of organisms that once lived on the Earth and buried in sediments after their death.
- Fossils are biological and geological evidences of past which reveals that the life on earth was once different from today.
- Fossils could be as tiny as a pollen grains or as huge as a skeleton of dinosaur. They could exist microscopic traces or rarely, as a complete organism.
- Fossil is a visible connection to life, landscapes, and climates of the geologic past. They guide us how life, landscapes, and climate have changed over time and how living things responded to those changes.
- Fossils are mostly preserved in sedimentary formations specially in marine environments.

FOSSILIZATION

- The probability of preservation depends on the constituents of hard parts of organism and burial environment.
- Hard, mineralized parts (bones, shells, teeth, etc.) tend to be preserved more easily than the soft parts.
- Immediate burial or cut off from the destructive agents like mechanical weathering, oxidation, hydration, bacterial decomposition are prerequisites.
- Marine organisms with hard parts are most likely to be preserved more favourably.
- Soft parts are subject to rapid microbial decay in the presence of oxygen.
- Hard parts also contain some organic matrix that would impact durability and its preservation.

FOSSILIZATION CONSTITUENTS

- CARBONATES: Variety of organism secretes calcium carbonate($CaCO_3$) such as Calcite or Aragonite.
  - Aragonite is comparably less stable than Calcite.
  - Most marine shells are composed of calcium carbonate (CaCO3)

- PHOSPHATES: Includes calcium phosphate, one form of which is Apatite, $Ca_5(PO_4, CO_3)_3(F, OH, Cl)$.
  - Phosphates are one of key components of hard parts like teeth and bones of organism.

- ORGANIC COMPOUNDS:
  - *Chitin*; a major component of Arthropods' cuticles and Fungi.
  - *Cellulose* and *Polysaccharides*; a components of cell walls in Algae and Plants.
  - *Keratin*; a fibrous structural protein, constituent of horns, claws, bills, and feathers.
  - *Lignin*; a component of tissues in Vesicular Plants.
  - *Collagen*; a component of the connective tissues of animals.

- SILICA: Hydrous Silica or opal(SiO_2*H_2O), is an important constituents of sponges, diatoms and radiolarians.

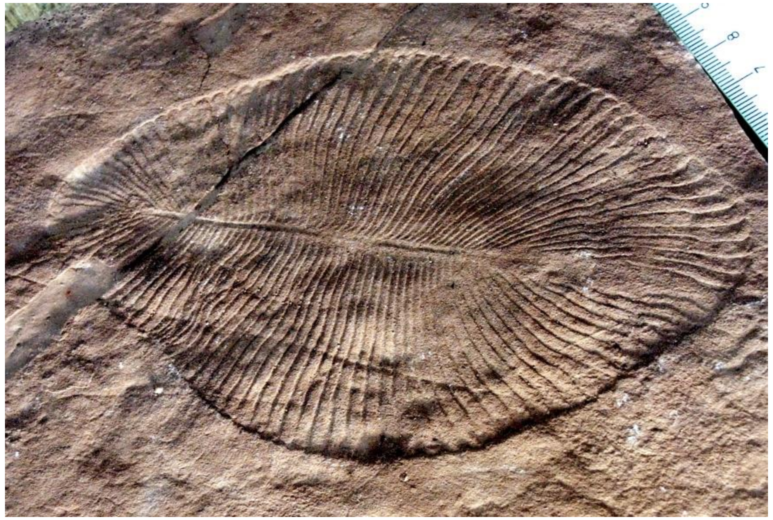
MODES OF FOSSILIZATON

- PERMINERALIZATION: Filling of void spaces of shell or bones by secondary mineral matter in solution, ions in solution that replaces the organic matrix in skeletal materials.
- REPLACEMENT: Filling in (by various minerals) of the void space after dissolution of original skeletal material, replacement processes are so slow that even fine details could get preserved.
- RECRYSTALLIZATION: Recrystallization involves the physical re-arrangement of crystalline structure of skeletal material. The structure keeps its shape but loses its crystal structure; example, aragonite turning into calcite.
- CARBONISATION: Distillation processes of organic matters, basinal black shales, and coal swamps. Most of the volatiles lost with carbon film left behind
- MOLDS: An impression left on the fine grained sediment by skeleton or shell before its dissolution.
- CASTS: Formed by the in-fillings of molds.
- TRAILS, TRACKS AND FOOTPRINTS: Traces left during various activities by organism in their life time such as: burrows, footprints, nutrition, reproduction, dwelling, crawling, grazing, physical behaviour etc.

MODES OF FOSSILIZATION

Part of Dinosaur Freeway at Dinosaur Ridge, Morrison, Colorado, USA Sources: https://commons.wikimedia.org/

Glossopteris plant leaves,
https://science.howstuffworks.com



Dickinsonia costata, an Ediacaran organism, displays the characteristic quilted appearance of Ediacaran enigmata

"Sue" T-rex skeleton: The bones of this Tyrannosaurus rex were preserved through the process of permineralization, which suggests that this organism was covered by sediment soon after death.

Sources: Wikipedia/sue_(Dinosaur).

Encasement in Amber

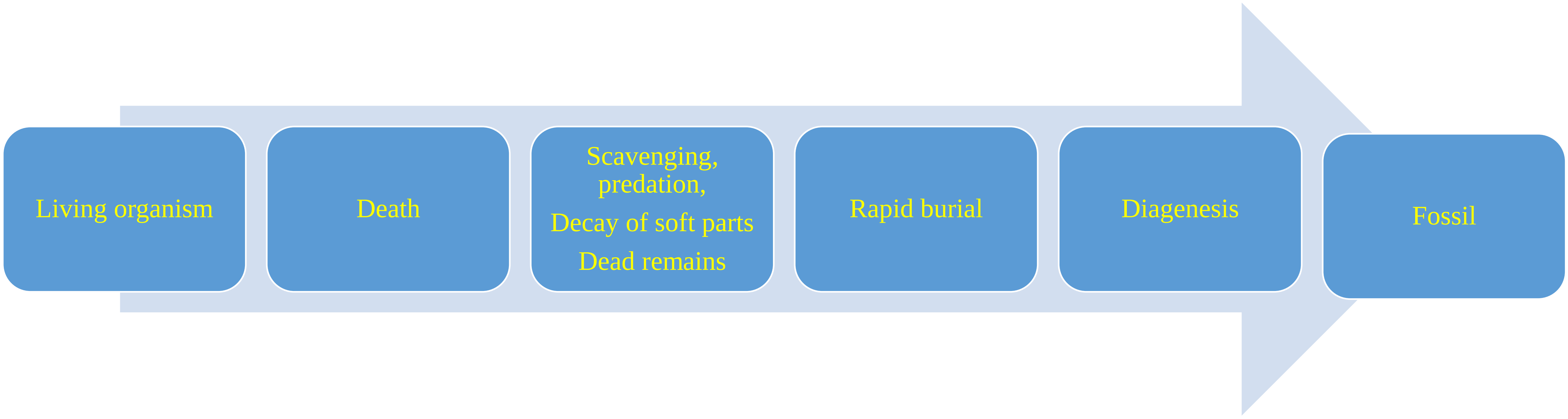
Petrified (permineralized) tree log

Primary Habitat of Major Fossil Groups		
Marine		**Terrestrial**
Benthic	Pelagic	
Brachiopods Corals Foraminifera Mollusks Ostracods	Calcareous nannofossils Conodonts Diatoms Dinoflagellates Foraminifera Radiolaria Vertebrates	Mollusks Spores and Pollen Vertebrates (courtesy of the USGS)

TAPHONOMY

- It is the study of what happens to an organism after death to the time lastly found as fossil. It is an incorporation of living things into the sedimentary record.
- This includes death, decomposition, predation, transportation, burial, compaction and diagenesis at various stages of fossilization.
- To prevent physical and chemical destructions, rapid burial in a relatively low energy depositional environment required.
- Preservation very much depends on Eh-pH of burial environment.
- Plants often preserved within acidic and reducing environments whereas calcareous shells and bones typically preserved in non-acidic environments.
- Taphonomic processes that have taken place can often lead to better understanding of fossilization environments, pre-burial chemistry and sedimentology of the dead remains.
- It reflects the palaeochemical sedimentary environment, preservation potential of sediment, basinal or tectonic history of the place.

TAPHONOMIC PROCESSESS



- NECROLYSIS: Break up of organisms after death.
- BIOSTRATINOMY: Processes between the death of an organism to burial in sediment.
- DIAGENESIS: The post burial physico-chemical transformation of organic materials.

TYPES OF FOSSILS

1. BODY FOSSILS: Parts of the actual living organism such as shell, bone, teeth, whole insect body, feathers, leaves, etc.

a) Altered Hard Part: simple burial with some weathering.

b) Unaltered Remains- well preserved entire body of organism, preservation due to freezing, mummification, encasement in tar and amber.

c) Preserved Soft Tissue: Soft tissues of various animals and plants.

2. TRACE FOSSILS or ICHNOFOSILS: Preserved traces of biological activities and interactions with environment during life time by organism

- Trace are without any body parts of actual organism.
- burrows, trails, footprints, nutrition, reproduction, coprolites, dwelling, crawling, swim traces, root traces, behavioural activities etc. are examples of trace fossils.

3. CHEMICAL FOSSILS: Chemicals found in rocks that provide an organic signature for ancient life such as bio-signatures, palaeoprotines, amino acids, isotope ratios.

INDEX FOSSILS

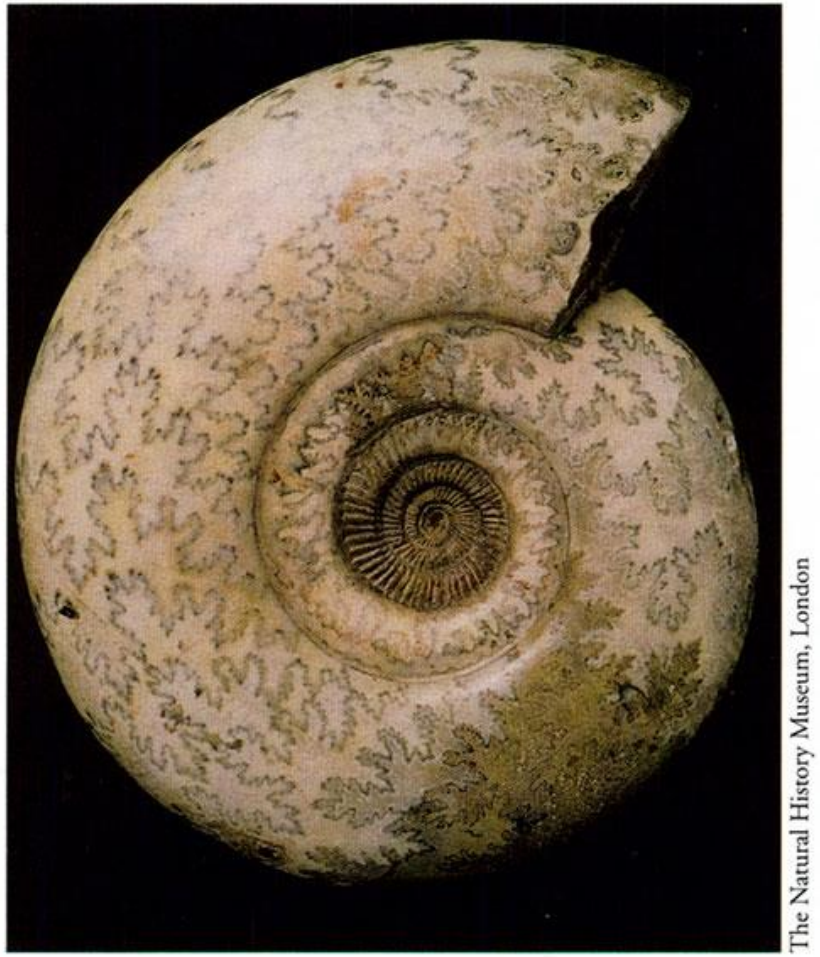
- ❖ An index fossil is the remains of an organism that lived and died during a particular geologic time frame in Earth’s history.
- ❖ Index fossils are used to delineate periods of geological time, age determination of rock formations, and also help to date other fossils found around them.

CHARACTERISTIC FEATURES OF INDEX FOSSILS:

- ✓ Wide spatial or geographical distribution, intercontinental distribution should be most desirable.
- ✓ Narrow vertical geologic time range to delineate particular geologic column.
- ✓ Sufficient morphological features to support easy identification and differentiations.
- ✓ High fossilization potential of body parts, such as hard shell, bone.
- ✓ Independence of Facies.

INDEX FOSSILS

Archaeopteryx lithographica.
The Berlin specimen by Hwa ja gotz. museum für naturkunde Berlin.



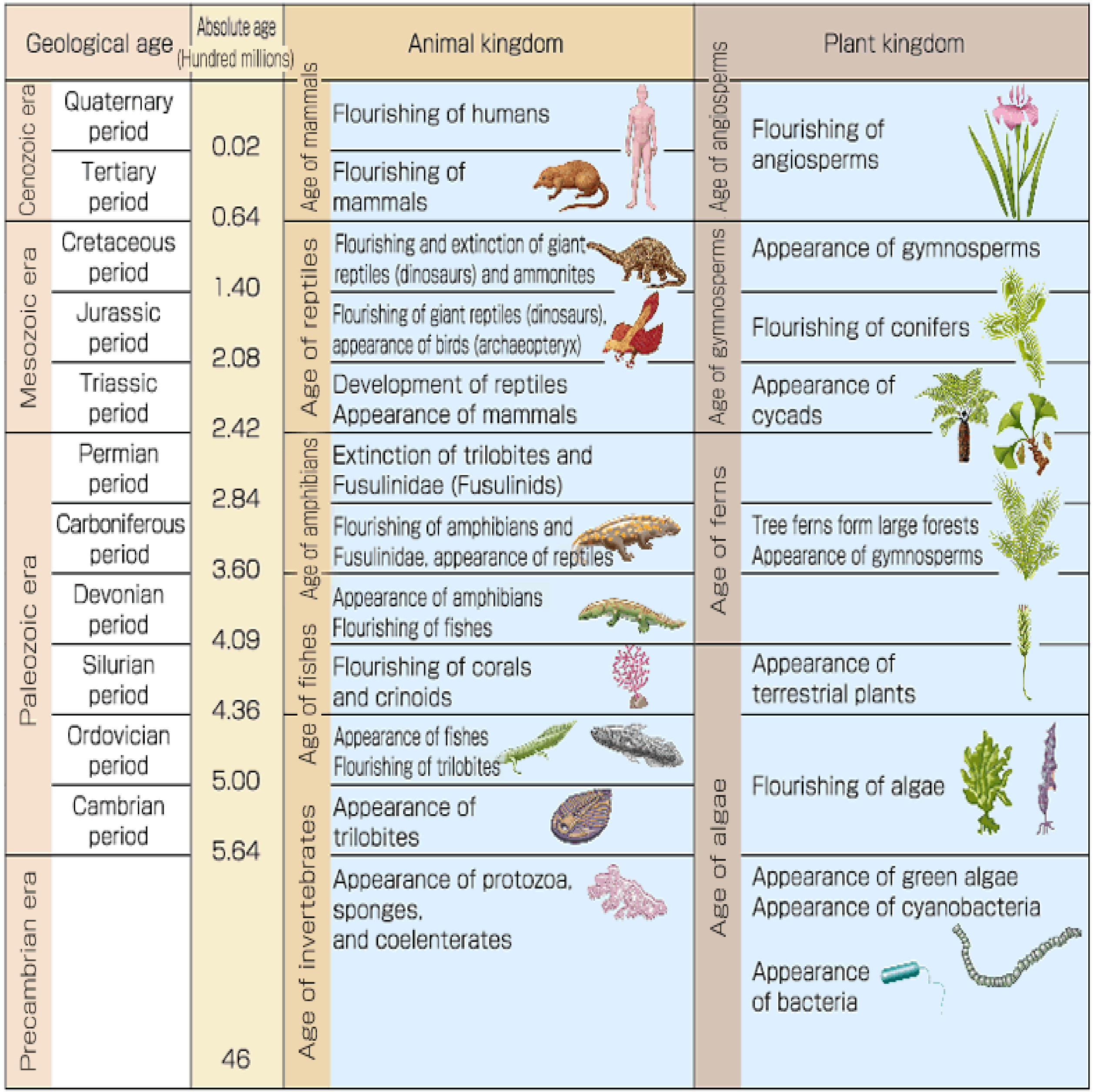
Jurassic ammonite showing sutures.
Sources:https://www.bgs.ac.uk/discoveringGeology/time/Fossilfocus/ammonite.html

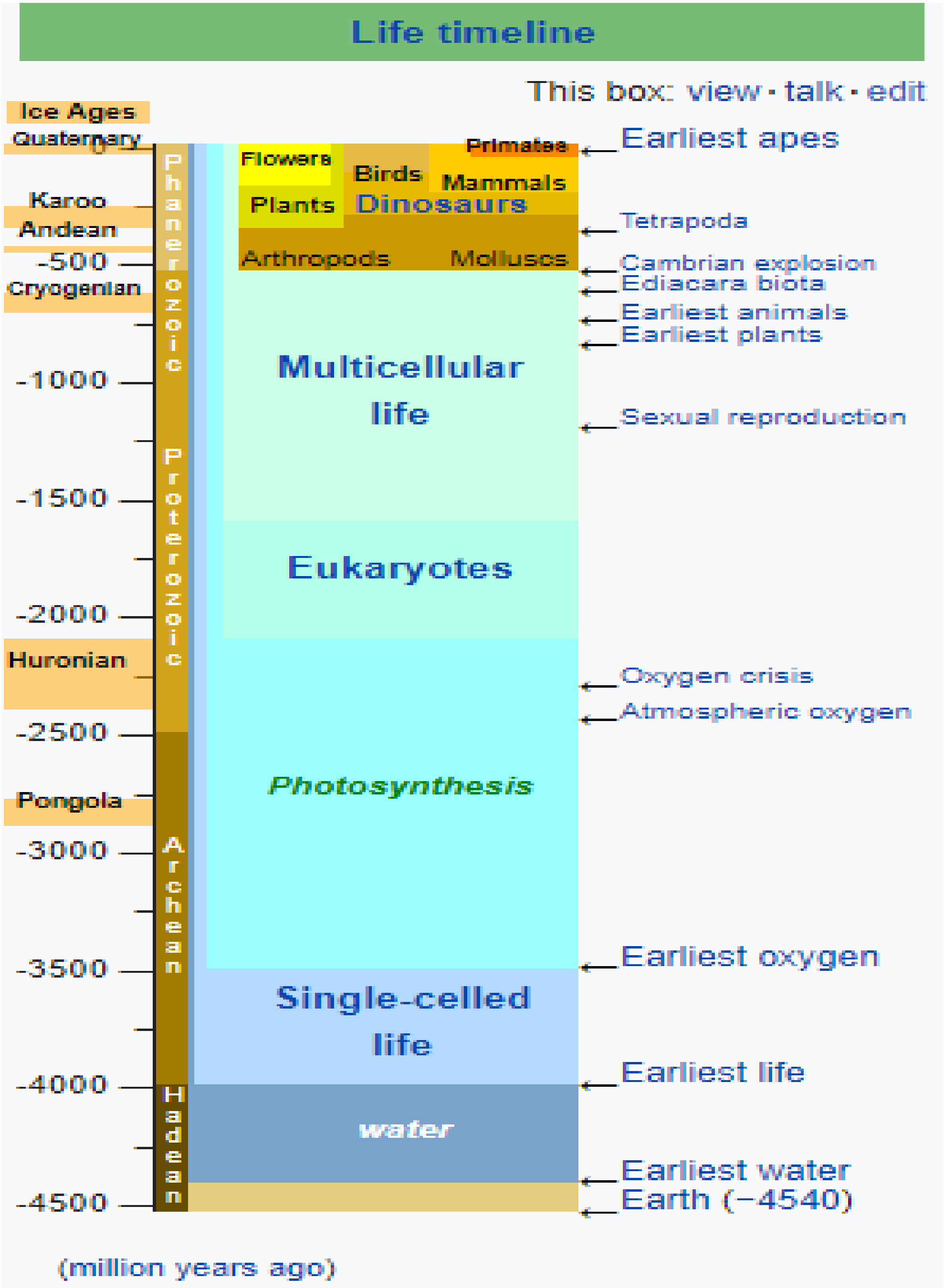
TRILOBITE FOSSIL Fossilized trilobites found in rocks dating to the Cambrian Period in Russia.*age fotostock/SuperStock*

FOSSILS ARE USED IN THE STUDY OF:

- Organic evolution, phylogenetic relationship and establishing ancestors of modern species.
- Migration, dispersal and distribution of plants and animals through geologic time and space.
- Biosratigraphy, chronostratigraphy, stratigraphic correlation and ascertaining order of superposition.
- Palaeoclimatology, Palaeoecology, Palaeoautecology and Palaeosynecology as it explain how organism have adapted to the particular ecological niche and suggest possible causes of mass extinctions.
- Past distribution of plants and animals can provide important clues about the latitudinal-longitudinal location of the continents as well as their relative position.
- Paleogeography and Palaeotectonics, as Earth's geography is constantly changing and to reconstruct the ancient continent-ocean distribution.
- Paleogeographic maps can explain how continents have drifted and how past settings of mountains, lowlands, shallow seas, and deep ocean basins have changed globally with geologic time.
- Sea levels changes and its influence on the evolution, abundance and distribution of organisms.
- Mineral exploration such as coal, fossil fuels etc.
- Marine geochemistry, palaeobathymetry, salinity, ocean circulations, Isotopic studies and changes in ocean chemistry due to actions of organism through the geologic time and space.
- Reconstruction of depositional environments, marine palaeoenvironmental analysis, positions of ancient shorelines, degree of oxygenation at the ocean bottom water and sediment, palynofacies, kerogen analysis.

LIFE THROUGH GEOLOGIC AGES





References and for the further study

- ✓ Clarkson E.N.K. (1986) Invertebrate Palaeontology and Evolution, ELBS
- ✓ Shrock R. R. (1987) Principles of Invertebrate Palaeontology, CBS
- ✓ Ray Anis kumar (2008) Fossils in Earth Sciences, PHI
- ✓ https://commons.wikimedia.org/wiki/File:Neuropteris_flexuosa_fossil_plant
- ✓ https://en.wikipedia.org/wiki/Sue_(dinosaur)
- ✓ https://science.time.com/2013/10/17/rethinking-your-ancestors-the-fossilized-ones/
- ✓ https://en.wikipedia.org/wiki/Geologic_time_scale
- ✓ https://commons.wikimedia.org/wiki/File:Petrified_Forest_National_Park_5.jpg
- ✓ https://www.forbes.com/pictures/55ccadf1e4b0ffa7afe3daa8/fluffy-dinosaur-feathers/#522862014def
- ✓ https://www.bgs.ac.uk/discoveringGeology/time/Fossilfocus/ammonite.html
- ✓ https://www.britannica.com/animal/trilobite