

MAKKO BILLI SCHOOL

Grade 11 student note

UNIT ONE

FORMATION OF THE CONTINENTS

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1.1. FORMATION OF CONTINENTS

The Earth, together with other planets and their moons, form the planetary system. The Sun and the planets together again form the Solar System.

The formation of the Earth is thus attributed similar to the creation of other companion planets and the entire development of the Solar System. Therefore, it is necessary to comprehend the origin of the Solar System to understand the foundation of the Earth

Among the various assumptions and theories proposed about the formation of the Universe and Earth, the “**Big Bang**”

According to this theory, the **Universe originated** sometime 10–20 billion years ago. The expansion of a small volume of matter at an exceedingly **high density and temperature**.

This space explosion was then followed by the formation of numerous space objects like the

Sun, planets, stars, meteors, asteroids, and comets through material **collision, cooling, and gravitational attraction**.

Our Earth was thus created from the mixture of gas and dust particles moving in space around the Sun about 4.5 billion years ago.

The first cosmic rocks solidified and created the first Earth at about 4600 to 3900 Ma. Following that, initial land masses gathered to form the early continent called ‘**Rodinia**’.

During the late Cambrian period (514 Ma) the Gondwana Supercontinent had evolved around the South Pole.

Next to this four major continents (**Gondwana, Baltica, Siberia & Laurasia**) came into being during 458 Ma (in the mid-Ordovician Period). The continual collision had then produced the pre-Pangaea continent during the early Devonian period, at about 390 Ma.

From the preceding section, it is possible to note that the present-day continents were joined together by **forming Pangaea** until about 200 Ma.

At about 160 Ma, Pangaea divided into **two bigger landmasses** called **Gondwanaland** and **Laurasia** by the process of continental drift. **India** moved northwards and separated from the Gondwana continent by the caused the collision **Australia** had separated from Antarctica and this has pronounced the break-up of the Gondwana continent.

The two giant continents (Gondwanaland & Laurasia), then moved apart **east and west** thereby resulting in the opening of the **Atlantic Ocean**. **Gondwanaland** (which consisted of **South America, Africa, the Arabian Peninsula**, the Indian subcontinent, Australia and Antarctica) **Laurasia** which included the **North America** and **Eurasia**.

continental drift refers to the moving apart of continents initiated by Sea-floor Spreading at mid-Ocean ridge locations.

The Origin of Continents and Oceans. Alfred Wegener set forth the basic outline of his radical hypothesis of **continental drift**

1.2 The Geologic Timescale

12.1 Meaning of Geologic Timescale

Geological timescale is the time-frame (timetable) showing the possible age of the Earth and its associated life-forms.

It provides a review of Earth’s history and the major changes that occurred over time.

It is developed by Earth scientists through the study of Earth’s rocks.

The study of rocks, scientists determine the Relative and Absolute ages of rocks.

1.2.2. Relative and Absolute Age of Rocks

❖ Relative age

Its mainly depends on the analysis of the **sequence of geological occurrences** without giving due regard to the **exact time of origin**.

It focuses only on determining the sequence of formation of events (whether the event had occurred before or later than the other related one).

This method principally depends on the study of **sedimentary rocks and often applies to local conditions interpretations**.

➤ **Geologists employ three basic principles (rules) during the study of the relative age of rocks:**

1. **The principle of original horizontality** indicates that layers of sediments are originally placed horizontally under the action of gravity. This means that except for the

disturbed sequences, sedimentary rocks are always deposited in nearly horizontal beds.

2. The principle of superposition

asserts that in an undisturbed sequence of sedimentary rock layers (beds) or lava flows, the overlying bed is younger than the underlying rock.

3. The principle of cross-cutting relationships

indicates that a rock-layer that cross-cuts another rock-layer is said to be younger than the rocks it cross-cuts. This is a condition where older rocks are cut by younger geologic features or igneous intrusions.

❖ Absolute age

Absolute age refers to the actual age of rocks given in numerical values through the analysis of the spontaneous decay of radioactive isotopes.

The term isotope refers to the presence of an element in different forms. Radioactive decay stands for the conversion of unstable (Parent) elements into daughter (Stable) elements through the gaining or losing of particles in their nucleus. For instance, Potassium-40 (⁴⁰K) decays into Argon-40 (⁴⁰Ar). Similarly, Carbon-14 (¹⁴C) changes to Nitrogen (¹⁴N). Rubidium-87 (⁸⁷Rb) converts also to Strontium-87 (⁸⁷St). Likewise, Uranium-235 (²³⁵U) change to and Lead-207(²⁰⁷Pb)

No	Parent isotope	Daughter isotope	Half-life
1	Uranium - 238 (²³⁸ U)	Lead – 206 (²⁰⁶ Pb)	4.5 bill years
2	Rubidium – 87 (⁸⁷ Rb)	Strontium – 87 (⁸⁷ Sr)	48.8 bill years
3	Potassium-40 (⁴⁰ K)	Argon – 40 (⁴⁰ Ar)	1.25 bill years
4	Uranium - 235 (²³⁵ U)	Lead – 207 (²⁰⁷ Pb)	704 mill years

	Carbon-14 (¹⁴ C)	Nitrogen– 14(¹⁴ N)	5,730 years
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The time taken to convert from parent element to Daughter element is commonly measured in half-lives. The half-life of an isotope is the time taken for half of the parent isotope to change to its product atoms. The relative proportions of the Parent and Daughter isotopes are used to determine the number of half-lives. Before conversion, 100% of the Parent prevails and no daughter product is formed. After one half-life, 50% of the Parent remains while 50% of the atoms are changed to Daughter atoms. After two half-lives, the number of Parent isotopes is again halved (25%) whilst the number of Daughter atoms increases by the same amount (to 75%).

Proportion of Parent and Daughter isotopes during radioactive decay

No	No of half-lives	Proportion (% of total isotopes)	
		Parent isotope	Daughter isotope
1	0	100	0
2	1	50	50
3	2	25	75
4	3	12.5	87.5

📌 Note

Radioactive decay occurs when elements recombine to form new minerals during the processes of metamorphism or when magma cools. Radioactive elements found in igneous and metamorphic rocks are commonly used in rock-dating studies.

As mentioned earlier, the geological timescale forms a division of geological processes and life-forms based on standard time units through the

study of fossil remains imprinted in rock layers.

The scale divides the age of the Earth into

Eons, Eras, Periods, and Epochs

When the geological timescale was initially developed, the earliest fossils were found not exceeding 600 million years (Ma) from the present (the Cambrian Period) in age. Based on that, the part of the geological history of the earth before the Cambrian Period (the time from 600-4500 Ma) is classified as **Precambrian**.

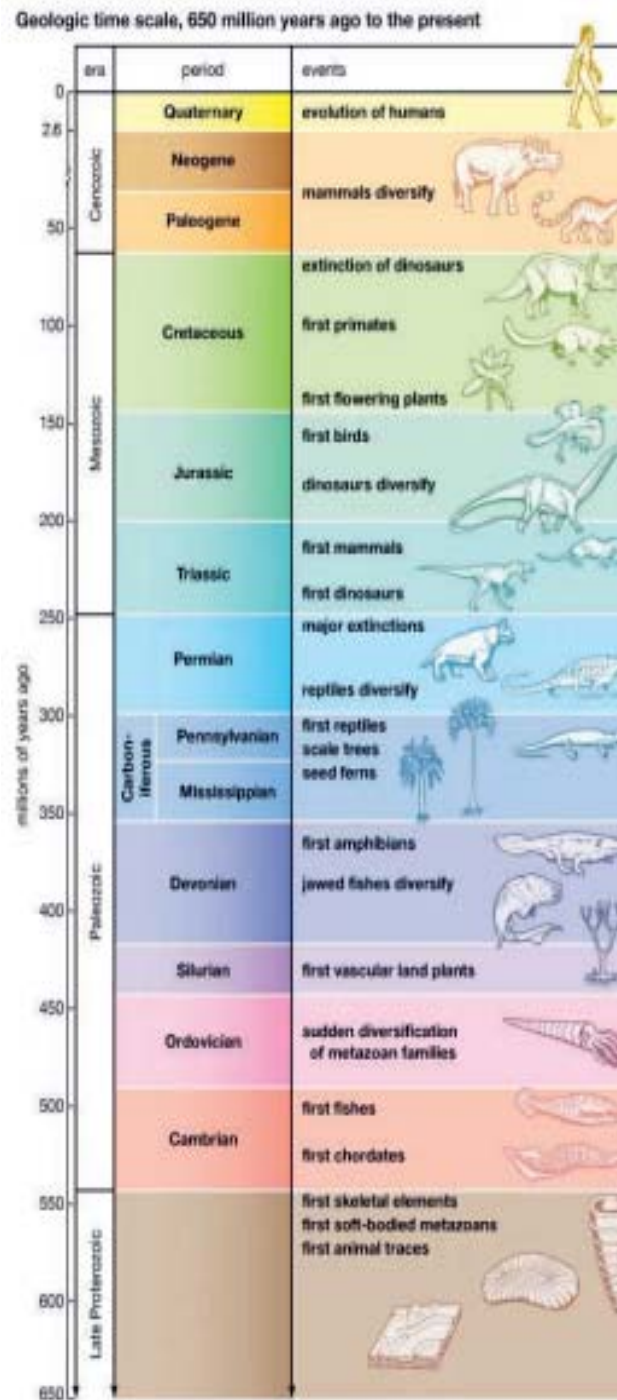
Precambrian, thus, means the time before Cambrian

EON	PERIOD	EPOCH	AGE [Ma]	MAJOR EVENTS
CENOZOIC	QUATERNARY	Holocene	Present – 0.01	Modern Humans
		Pleistocene	0.01 – 1.6	Ice Age
	NEOGENE	Pliocene	1.6 – 5.3	Early Hominids
		Miocene	5.3 – 23.7	
	PALEOGENE	Oligocene	23.7 – 34.4	
		Eocene	34.4 – 57.8	Extinction of Dinosaurs
		Paleocene	57.8 – 70	
	CRETACEOUS		70 – 144	First birds
		JURASSIC		144 – 208
		TRIASSIC		208 – 250
PALAEOZOIC	PERMIAN			250 – 284
		Carboniferous		284 – 320
		MISSISSIPPIAN		320 – 340
	DEVONIAN			340 – 408
	SILURIAN			408 – 438
	ORDOVICIAN			438 – 505
	CAMBRIAN			505 – 600
	PROTEROZOIC			600 – 2500
ARCHEAN	HABEAN			2500 – 3900
HADEAN	IAN			3900 – 4500

Based on the geological timescale, the history of the formation of the Earth is classified into four longer geological periods named Eons. Hadean, Archean, Proterozoic, and Phanerozoic are four major sub-divisions of the known Eons. The Hadean, Archean and Proterozoic Eons are often called Precambrian by scientists to refer to the geological time before the emergence of life on Earth. The Phanerozoic is the most recent Eon. It is further sub-broken into three Geological Eras named Paleozoic, Mesozoic, and Cenozoic

1.2.3. Geologic Eras

They are the Precambrian, Paleozoic, Mesozoic, and Cenozoic. The Precambrian is the oldest of all the geological eras. It covers the time from 600 million to 4.5 billion years (about 85% of the geological time of the Earth). It was the time of solidification of the Earth and the formation of the oldest rocks. Rocks created during that time are rich in base metallic minerals and are often called crystalline basement complex rocks.



The Paleozoic era covered the time from 600 to 250 Ma from the present. It is believed that it marked the beginning of life and is commonly referred to as the age of **ancient life**. **Trilobites** and **shelled** animals were the **common species** of the time. The Devonian, the fourth period of the Paleozoic, was rich in fish species and referred to as the age of fish. **By the end of the Paleozoic, all continents of the Earth had joined together and created the Supercontinent named Pangaea**. The creation of Pangaea led to extreme seasonal weather changes that caused the great extinction of Earth species. Due to that, around 75% of the Amphibian species have perished



The **Mesozoic era** marked the time from 250-70 Ma. It is often referred to as the era of middle life and the age of **Dinosaurs** owing to their relative dominance. Turtles, snakes, crocodiles, and lizards were among the life forms of the time. Low-lying areas were occasionally flooded by shallow marine transgressions followed by depositions of red sandstones and mudstones. Tropical areas were dominated by extensive swamps which later became rich coal deposits.

The mid-Mesozoic era was experiencing the splitting of Pangaea into Laurasia and Gondwanaland.

Igneous activities had initiated also the development of volcanic mountain ranges in western North America.

The end of the Mesozoic era saw the emergence of land mammals but marked the **mass extinction of Dinosaurs**).

The Cenozoic era is the recent one covering the time since 70 Ma. As it forms the recent geologic time, it is well known compared to the other Geological eras. Birds, mammals, and flowering plants dominate succeeded on Earth. It is commonly named an era of recent life and the age of mammals.

During the beginning of the Cenozoic era the rifting of Pangaea has been fully achieved and the continents retained their present form. Great volcanism and orogenic folding caused the formation of numerous volcanic, fault-block, and fold mountains in the different parts of the Earth's continents. Glaciations were experienced in some high-latitude areas while heavy rainfall occurred in other localities. Extinction of some mammals happened in some localities.

NOTE:



Orogenic is the formation of mountains, especially through the folding of the earth's crust

1.3. DISTRIBUTION OF THE CONTINENTS AND OCEANS

The surface area of the Earth is estimated to be 510,072,000 km² and the area of the Oceans is about 363, 000,000 km². All water (hydrosphere) in total covers greater than 71% of Earth's surface. The largest of these are the Oceans, which account for over 97% of all the water on Earth. Glaciers and polar ice caps contain just greater than 2% of the Earth's water in the form of solid ice. Only about 0.6% is found under the surface as groundwater. Nevertheless, groundwater is 36 times more plentiful than water found in lakes, inland Seas, rivers, and in the atmosphere as water vapor.

The distribution of Ocean basins and Continents is unevenly arranged over the Earth's surface

The Continents

A continent is a huge area of land mostly separate by a water body. There are seven known continents on the earth today. They are: Africa, Antarctica, Asia, Australia, Europe, North America, and South America. A brief description of the continents is presented as follows:

Africa

Africa is the second largest continent in the world next to Asia. The equator divides Africa into two parts. But the largest part of the continent is found north of the equator. Africa is the only continent in the world crossed by the equator, Tropic of Cancer, and Tropic of Capricorn. The world's largest hot desert (Sahara), and the world's longest river (River Nile), are found in Africa. Africa has 54 countries.

Antarctica

Antarctica is a permanently ice covered continent located around the South-Pole. The climate is very cold and there are no permanent human

settlements in Antarctica. But, many countries have research stations in Antarctica. It is the third smallest continent on the earth.

Asia

Asia is the largest continent in the world. It lies in the eastern hemisphere covering one-third of the total land area of the earth. It is crossed by the Tropic of Cancer and separated by the Ural Mountains from Europe. It is part of the Eurasia and crossed by the Arctic Circle at its northern margin. It is bounded by water bodies on three sides and by the Pacific Ocean in the east and southern part. Asia has 48 countries and accommodates two-third of the world population. It has the highest mountains (Himalayas), the deepest depressions (Dead Sea), the driest desert (Lut desert), highest precipitation (Assam) and long tradition of civilization (Mesopotamia).

Australia

Australia is the smallest continent in the world. It is surrounded by water in all of its sides and often called an Island continent or Oceania; and has the largest area of ocean jurisdiction of any country on Earth. It is the driest inhabited continent in the world with 70 percent of it either arid or semi-arid. The vast majority of its population is concentrated along the eastern and south-eastern coasts. Australia entirely lies in the southern hemisphere.

Europe

Europe is the second smallest continent in the world, and home of the industrial revolution. It has 44 countries. It lies to the west of Asia and north of Africa. Europe is crossed by the Arctic Circle. It is bounded by the Atlantic and Arctic oceans and by the Mediterranean Sea in the south.

North America

North America is located to the west of the Atlantic Ocean and linked to South America by the narrow strip of land called the Isthmus of Panama. It is the third largest continent of the earth. It lies north of the equator in the western hemisphere and surrounded by the Atlantic, Pacific and Arctic Oceans. The main countries are three (USA, Canada & Mexico).

South America

South America is also located in the western hemisphere, but most of its area lies south of the equator. It is bounded in the east by the Atlantic Ocean and in the west by the Pacific Ocean. The world's largest River (Amazon River), largest and most bio-diverse rainforest, tallest uninterrupted waterfall (Angel Falls) and the north-south extending longest mountain (Andes Mt.) are found in South America. South America has 12 countries.

Geographers have divided and named the interconnected Oceans of the world into five groups. They are:

- The Arctic Ocean,
- The Atlantic Ocean,
- The Indian Ocean,
- The Pacific Ocean, and
- The Southern Ocean.

Arctic Ocean

The Arctic Ocean is the world's smallest Ocean with an area of 14,056,000 km². It lies in the area between Europe, Asia, and North America. Most of its waters are north of the Arctic Circle. Its average depth is 1,205 m. The deepest point lies at the Nansen Basin or Central Basin and it is -4,665 m deep. Throughout most of the year, much of the Arctic Ocean is covered by a drifting polar icepack that is an average of 3 m thick. However,

as the Earth's climate changes, the Polar Regions are warming and much of the icepack melts during the summer months. The Northwest Passage and the Northern Sea route have historically been important areas of trade and exploration.

Atlantic Ocean

The Atlantic Ocean is the world's second-largest Ocean with an area of 76,762,000 km². It is located between Africa, Europe, and the Southern Ocean in the Western Hemisphere. It contains the majority of the Earth's shallow Seas, but relatively few islands. The shallow Seas found in the Atlantic Ocean basin are the: Baltic Sea, Black Sea, Caribbean Sea, Gulf of Mexico, North Sea, and the Mediterranean Sea. The average depth of the Atlantic Ocean is 3,926 m. Its deepest point is the Puerto Rico Trench which is some 8,605 m deep.

Many streams and rivers discharge their water into the Atlantic Ocean. This basin also drains some of the world's largest rivers including the Amazon, Mississippi, St. Lawrence, and Congo. It receives more freshwater from continental runoff than any other Ocean basin. The Atlantic Ocean is important to the world's weather (as are all oceans) because strong Atlantic hurricanes often develop off the coast of Cape Verde, Africa, and move toward the Caribbean Sea from August to November.

Indian Ocean

The Indian Ocean is the world's third-largest ocean and it has an area of 68,566,000 Km². It is located in the area between Africa, the Southern Ocean, Asia, and Australia. The Indian Ocean has an average depth of 3,963 m. Its deepest point is at the Java Trench or Sunda Double Trench.

The maximum depth reaches some 7,258 m. The waters of the Indian Ocean also include parts of the adjacent water bodies such as the Andaman, Arabian, Flores, Java, and the Red Sea as well as the Bay of Bengal, Great Australian Bight, Gulf of Aden, Gulf of Oman, Mozambique Channel and the Persian Gulf. The Indian Ocean is known for causing the monsoon weather patterns that dominate much of Southeast Asia and for having waters that have been historical checkpoints (narrow international waterways). Because of its proximity to the equator, this basin has the warmest surface Ocean temperatures.

Pacific Ocean

The Pacific Ocean is by far the world's largest ocean basin with about 155,557,000 km². It covers 28% of the Earth and is equal in size to nearly all of the land area on the Earth combined. It is located between the Southern Ocean, Asia, and Australia in the Western Hemisphere. It has an average depth of 4,028 meters, but its deepest point is the Challenger Deep within the Mariana Trench, about 10,924 m deep. This area is also the deepest point in the world. The Pacific Ocean has few marginal Seas but many islands. It is an important Ocean basin from the geographers' perspective not only because of its size but also because it has been a major historical route of exploration and migration.

Southern Ocean

The Southern Ocean is the world's newest and fourth-largest Ocean. In the spring of 2000, the International Hydrographic Organization decided to delimit it as the fifth Ocean. In doing so, boundaries were taken from the Pacific, Atlantic, and Indian Oceans. The Southern Ocean extends from the coast of Antarctica to 60 degrees' south latitude. It has a total area of 20,327,000 km² and

an average depth ranging from 4,000 to 5,000 m. The deepest point in the Southern Ocean is unnamed, but it is in the south end of the South Sandwich Trench and has a depth of 7,235m

1.4. CHANGING POSITION OF CONTINENTS AND OCEANS OVER GEOLOGICAL TIMES

the location of the continents and oceans was not fixed. Due to plate movement (tectonics) the position of continents and oceans has been changing several times.

For instance, during the Triassic period of the Mesozoic era (210 Ma), the earth's continents were joined together forming one big continent called **Pangaea** (meaning the whole of the earth). Pangaea during this time was surrounded by on big water body named **Panthalasu**.

During this time, Laurasia was located around the equator whereas Gondawana was located around the South-Pole.

During the second stage, in the late Triassic period (180Ma), Pangaea started cracking because of continental drift. Following the rifting of Pangaea, Laurasia moved to the north. Africa, South America, India and Arabia started moving to the north too. Antarctica and Australia positioned around the South-Pole. Following the cracking of Pangaea, the oceans flooded the rifted area between the continents.

During the late cretaceous (65 Ma), the separation between Eurasia and North America increased. These two big continents positioned almost north of the tropic of cancer. Africa, South America, Arabia and India separated and positioned around the equator. Antarctica still placed at the South-Pole. Since the cracks between the separating continents widened, all the free areas were

occupied by the Pacific, Atlantic, Arctic and southern oceans.

After the separation of the Pangaea, North America and Eurasia are positioned in the northern hemisphere while India and Arabia joined Eurasia. Africa, South America, and Australia are positioned around the equator; but Antarctica is still placed at the South-Pole. The Atlantic Ocean covered the area between Africa, Eurasia and the two America's. The Pacific Ocean occupied the area between the America's, Eurasia and Australia. The Arctic Ocean covers areas north of the Arctic Circle and areas between North America, Europe and Asia. The Indian Ocean covers the area between Africa, the Southern Ocean, Asia, and Australia. The Southern Ocean covered areas south of the Pacific, Atlantic and Indian Oceans and the coastal lands of Antarctica.

Today, seven continents and five Oceans makes-up the Earth. Most Continents occupy areas north of the equator while oceans dominate the southern hemisphere. The Pacific Ocean is located between Eurasia and the Americas while the Atlantic divides Africa and Eurasia from the Americas. The Indian Ocean also covered the area between Africa, Asia and Australia. The Arctic and Southern Oceans are centered at the North and South-Poles, respectively.