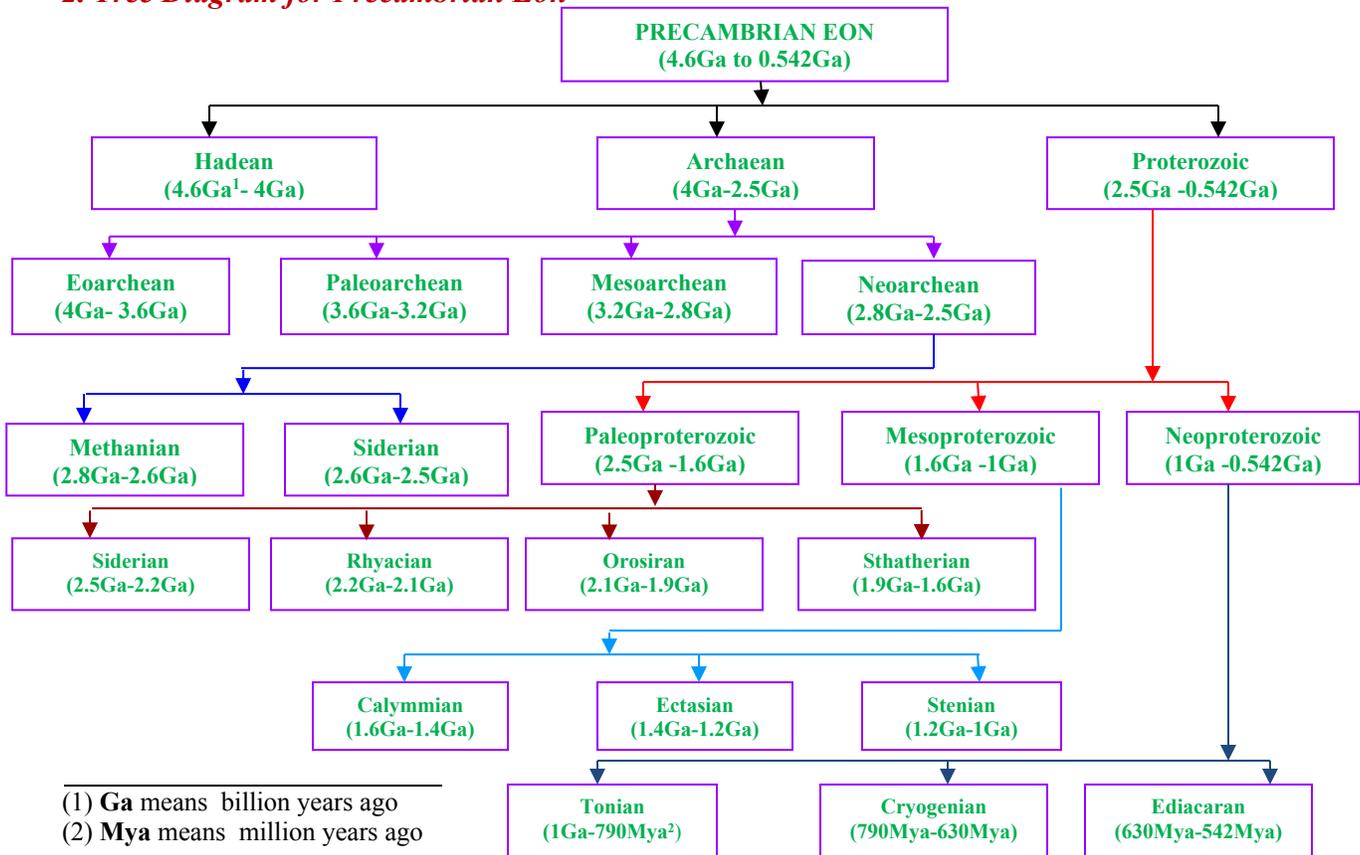


Climate Change, Transformation and Beginning of Life

1. Introduction

The Earth began its journey about 4.6 billion years ago. The journey was neither smooth in its initial period nor is it smooth now. The Earth, what we see today with blue sky, oceans, forests, mountains and meadows was not so when it was born. Like our biological mother, our mother Earth had also given birth to our life despite passing through turbulent times. The magma ocean lasted for about 200 million years from its birth. Giant impacts occurred intermittently for millions of years. The largest one crushed the surface, causing oceans' water to evaporate and shattered the composition of atmosphere which was building up slowly. Our mother Earth would have broken into pieces and vanished in the inner solar system like many other short lived and unlucky worlds. Various other impacts erratically altered the climate from time to time. Temperature sometime fell below the freezing point of water and sometime became very hot making it inhabitable. Notwithstanding these adverse situations, our mother Earth created a situation, presumably in such a systematic manner that has helped giving the source of life which has gone through various evolution and created us, the human beings. It took many years for its transformation. The transformation process passed through various stages. They are called *Eras or Eons*. Two main Eons are *Precambrian* and *Phanerozoic*. In this issue of *Anuranan*, transformation of Earth and the associated climate changes upto Neoproterozoic Eon (2.5 Ga) have been described. Happenings and climate changes during the subsequent period shall be written in our next volumes – June and July.

2. Tree Diagram for Precambrian Eon



3. Hadean Eon (4.6 Ga – 4 Ga)

During **Hadean** eon, the most break point was formation of our Lovely **Moon**. Around 4.5 Ga, a few million years after formation of Earth, a large asteroid crashed on the Earth. As a result, hot rocks splashed off from the earth's surface. These rocks started orbiting around the Earth and subsequently, when cooled, joined together forming the **Moon** as a spherical body under the influence of gravity. Initially, Earth consisted of magma held together by gravity.



Moon

The atmosphere comprised mainly of carbon dioxide with little hydrogen and water vapour. Over a period of time, the Earth started cooling down. Heavier molten iron atoms descended below the surface and formed the core. Lighter atoms like silicon and hydrogen rose to the surface, cooled and formed the outer crust. Earth's crust was very unstable at that time. As the Earth's magnetic field was not strong enough to resist rocky bodies orbiting around the Sun falling on it, they crashed on the earth almost continuously making the initial crust formed on the surface more uneven. Water brought to earth by these bodies evaporated creating steam atmosphere around the earth. The atmosphere at that stage was hot and acidic with no oxygen at all. With passage of time, when bombardment of outside bodies slowed down, the Earth became cool and its crust started hardening. Formation of various sizes of thin and fragile rocks on its surface started. Water vapour in the atmosphere began to condense causing rainfall. Large water bodies were formed. These are today's oceans. May be at that time, Sun, Moon and stars were noticed. **The Earth experienced the first sunrise and sunset.** Surface temperature of the ocean was around 450 degree Fahrenheit. Gradually, when surface temperature cooled down, composition of atmosphere changed. Hydrogen, carbon dioxide, methane, ammonia and nitrogen floated high up. The ocean was chemically rich containing hot smelly soup of ammonia, formaldehyde, formic acid, cyanide, methane, hydrogen sulfide and organic hydrocarbon. With combination of these elements, amino acid was formed and joined together. These amino acids gradually got mixed with ocean's water and created a kind of protein having no life. These may be the beginning of Ribonucleic Acid (RNA) molecules. There was, however, no existence of life in them. **Formation of these RNA molecules were the first step in the evolution of life.**

4. Archean Eon (4 Ga – 2.5 Ga)

The Archean eon which covered a period of about 1.5 billion years consists of four sub eons, namely, *Eoarchean*, *Paleoarchean*, *Mesoarchean* and *Neoarchean*. During this eon, important events that took place are as follows: Occasional heavy asteroid bombardment; Earth's crust was transformed from unstable state to stable state; Super continental and continental blocks were formed besides creation of Banded Iron Formation. *The most important event was the appearance of the first life on the Earth in the form of unicellular bacteria.*

4.1 Heavy Bombardments

Late Heavy Bombardment by a massive asteroid took place about 3.8Ga. Again, during the end of Paleoarchean eon, about 3.26Ga, a large asteroid collided with the Earth creating a belt known as Barberton Greenstone Belt which is still found in South Africa.

4.2 Formation of Supercontinent and continental blocks

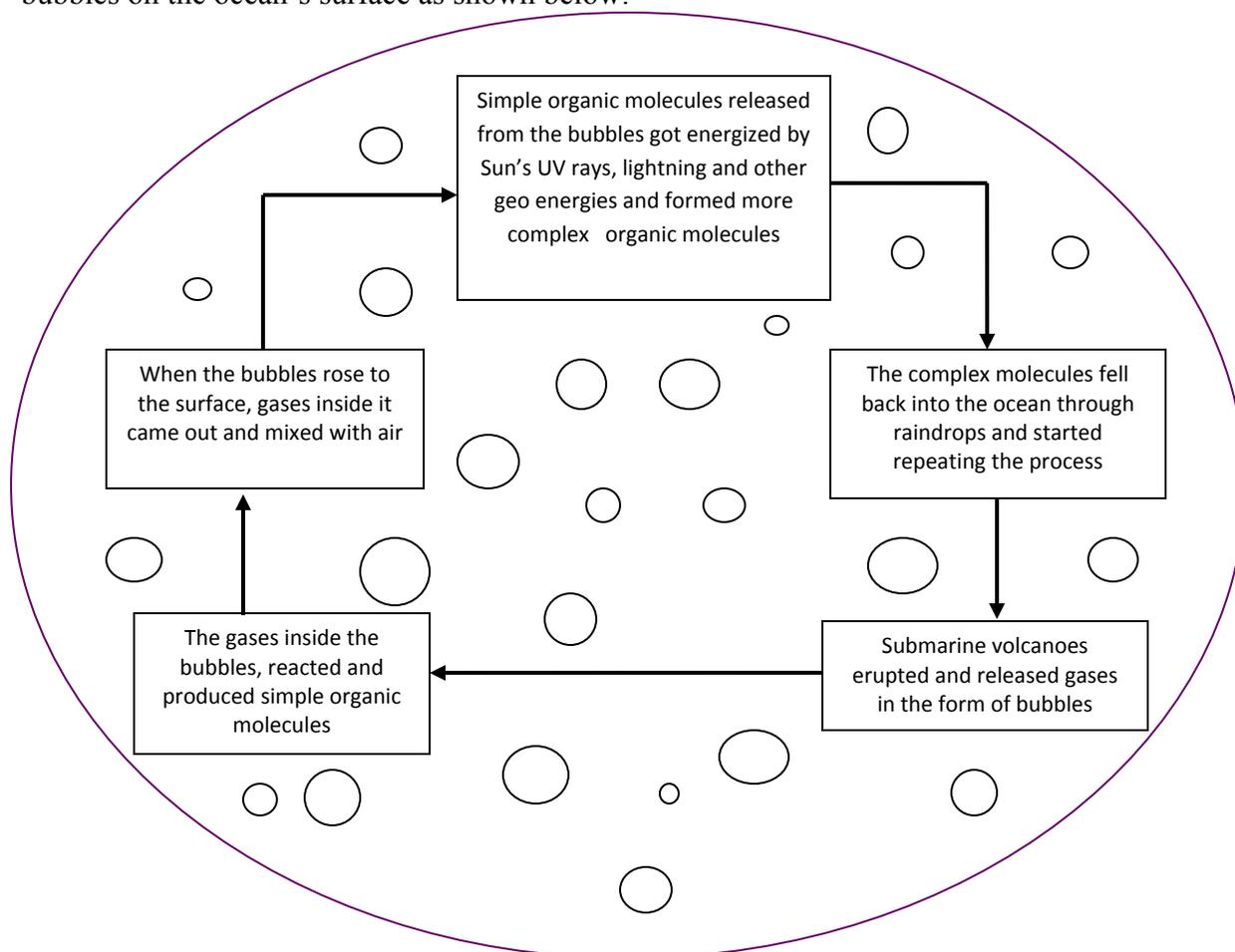
Earth's crust gradually cooled down. The frequency of bombardment of asteroids and meteors almost stopped due to the change in the gravitational force of the Earth. As a result, Earth's crust was gradually transformed from unstable to stable state. Solid rocks also started forming. At one time, during the Paleoarchean eon, *the first Supercontinent Vaalbara* was formed around 3.1 Ga. This Vaalbara Supercontinent comprised of two cratons namely *Pilbara and Kaapvaal* which combined to form this supercontinent. These continental blocks were being formed under the ocean's surface at that time. During the Mesoarchean Eon, *Vaalbara* broke up into separate landmasses forming a continent called *Ur*. After about 500 million years, Vaalbara began to separate further and a new landmass known as *Kenorland* was formed (2.7 Ga). The Pilbara craton is now found in Western Australia and Kaapvaal craton is now found in South Africa. The continent of *Atlantica* was then formed around 2.5 Ga.

4.3 Banded Iron Formation

Eruption of volcanoes was almost a regular phenomenon that time. Iron (Fe^{+2}) released from outgassing of submarine volcanoes reacted with oxygen and formed hematite (Fe_2O_3) which then precipitated creating *Banded Iron Formation* (2.5 Ga).

4.4 Beginning of life

With temperature cooling down, there was further change in the climate. Atmosphere contained abundant amount of nitrogen and methane with less amount of ammonia and carbon dioxide. There was no oxygen in the atmosphere. Further drop in temperature caused a change in the atmospheric content of water vapor, carbon dioxide and methane. This, in turn, lowered the temperature even more causing a decrease in absolute humidity in the atmosphere. With condensation of water, the coverage of Earth's ocean increased. At this stage, the simple molecules of RNA which existed in the Earth's atmosphere combined to form more complex and larger molecules by means of the energy coming from lightning and geothermal energy. Over a period of time, continuous interactions with chemically rich ocean water changed their composition and increased their stability enabling them to persist longer. Finally, these molecules might have spontaneously organized themselves into formation of living cells. Some scientists believe that the chemical process leading to the evolution of life took place within bubbles on the ocean's surface as shown below:



Others say that right combination of physical events and chemical processes at the right place and time might have created the first living cells on the Earth. Whatever may be the reasons, first life appeared about 3.6 Ga on the Earth in the form of unicellular *prokaryote* named as *Cyanobacteria*. It looks like a kind of blue green algae. Immediately on its evolution, it started eating Carbon from Carbon dioxide decreasing the Carbon dioxide content in the atmosphere. Gradually, Cyanobacteria and other microorganisms mutually interacted with each other and they took the shape of moss-like cushions with a thick calcareous crust known as *stromatolites* (3.5 Ga). These stromatolites became the longest living organism on the Earth. They grew through sediment and sand, binding the sedimentary particles together, resulting in successive layers which, over a long period of time, hardened to form rock. Cyanobacteria within these stromatolites, over a period of time, harnessed energy from sunlight and used this energy to split water molecules and carbon dioxide to form complex carbon molecules, giving off gaseous oxygen molecules in the atmosphere as a metabolic byproduct by a process known as *photosynthesis* (3.2 Ga). During this eon, other prokaryotes such as Archaeobacteria and Eubacteria also evolved. They along with Cyanobacteria increased their populations and generated greater levels of oxygen. Thus, Cyanobacteria became the first organism which formed the basis of all life on the Earth.

4.5 Conclusion

We now understand why Earth is not only our home but also our mother. One kind of life arose and evolved here. It began to generate its own food through photosynthesis and release oxygen in the atmosphere. Photosynthesis transformed the atmosphere paving the evolution process to continue further creating present day's human beings. We are the child of mother Earth. Her love to us is without limit. She bears with our misdeeds and defects. We should try to be the true child of the mother Earth. This is possible only when we take a vow to protect her from environmental pollution.