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Atmospheric variation and future climate change: based on Paleoclimate studies

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Abstract

Global Warming and climate change is major problem for everyone. We are taking various precautions to avoid the global climate change. After the industrial revolution in 18th century, Carbon dioxide (CO_2) concentration has been increases rapidly and predicted the impact of global warming. During the Paleo-climatic studies it was observed that climate change happened several times in geological past. Atmospheric concentration varies due to various natural reasons. The CO_2 concentration was much higher and oxygen was very low during early atmospheric condition. Later on due to various climatic changes, concentration of CO_2 in the atmosphere varies from 7000 part per million (PPM) to 350PPM, Oxygen (O_2) varies between 1% to 35% in atmosphere, sea level 450m high to (-)50m low from present sea level and Earth average temperature varies between 29°C to 11°C. Sun brightness was also varying 95% to 100% compared to present. In this paper, trying to discuss Paleo-climatic variation throughout the Geological time, it's affecting factors and observed that average atmospheric concentration of CO_2, O_2, Earth's average temperature and sea level was much higher than present level. Based on observed data, prepared the impact of CO_2 and O_2 on flora, fauna and natural disaster. Also prepared line bar chart and predicted that atmospheric concentration of CO_2, O_2, Earth's average temperature and sea level would be increased naturally in future and affect the ecosystem by various way.

Keywords: Climate change, paleo-climate, geological time, atmospheric variation, greenhouse effect.

Introduction

Human life evolved only in 315000 years back and development of human society is still going on. Human have natural tendency to know everything in details, accordingly exploring the ecosystem. Every life species has been surviving in a specific weather condition and change according to climatic condition called evolution.

Earth was originated approximate 4600 million years (Ma)/ 4.6 billion years (Ga) ago and were very hot with no or little oxygen in the atmosphere. Later on, due to specific location of Earth in solar system and geological activities, atmosphere and organic activities started. Life evolution is very complex and time taken process also depends on atmospheric composition, Earth mean temperature, sea level, vegetation and greenhouse effect of Earth.

From beginning of industrial evolution in mid-18th century, Carbon dioxide (CO_2) concentration were 280 part per million (PPM) in atmosphere, but due to use of fossil fuel as source of energy and weapons, atomic bomb, air conditions, refrigerator and other machineries, now it is reaching 400PPM. Climatologist had observed this increasing phenomena in mid-19th centuries and raised voice against Global warming and climate Change; accordingly taken various precautionary measures for decrease the impact of global warming. In this paper, trying to discuss the variation in atmospheric composition, Earth temperature, sea level variation compared to present temp and level, sun luminosity throughout the Earth history for better understand the Paleoclimate variation and tried to predict the future climatic condition.

Discussion

Evolution of life and temperature of Earth have been depending on atmospheric composition, its greenhouse effect, vegetation, CO_2 and Oxygen (O_2) percentage. Carbon is basic component of life. It provides food and energy in the Ecosystem. It is the sole source of carbon in the Protein, Carbohydrate, fats and other organic molecules which the living things are formed. Variation in Carbon concentration may affect the living species. Earth life have divided into Geological time scale, which shows variation in Flora and Fauna in different climatic condition. Paleo-climatic data have received through study of glacier, deep sea sediments, fossils, geochemical studies of geological strata, paleomagnatic studies etc. Based on Paleo-climatic data, prepared one table which shows variation in CO_2, O_2, Earth temperature, variation in Sea level and Sun Luminosity compared to present have given in below Table-1.

As refer in Table-1, it shows that Archean period (2.5-2.3 Ga ago) atmosphere were rich with Method and Nitrogen with little or no oxygen. Larger part of CO_2 was dissolved in the Ocean

and Blue green algae started the Photosynthesis about 3.5 Ga ago[1]. That time sun brightness was only 77% of today's brightness and at the end of Archean, reached 83%. Two major ice age were observed during the 2.4-2.1 Ga and 0.9-0.6 Ga ago. Reason behind the ice age was not firm fixed but it is believed that there may be 250 million year (Ma) long break in volcanic activities and CO_2 level were drop down in atmosphere. Due to drop down in CO_2 in atmosphere, greenhouse effect was reduced and Earth temperature drop down. At the end of Proterozoic, O_2 concentration reached 1-2% in atmosphere, sun brightness was 95% of present level.

Table-1: Atmospheric Variation during the geological time[2-4].

Atmospheric Variation during Geological Time																		
Eon	ERA	Period	Epoch	Age before present (million year)	Time duration (million year)	C O_2 PPM	O_2 PPM	Earth average Temp °C	Sea Level in m (compared to present level)	Era Average				Earth life time average				Sun Luminousity refer to present luminosity
										CO2 in PPM	O2 in PPM	Earth average Temp °C	Sea Level (refer to present level)	CO_2 PPM	O_2 PPM	Earth average Temp °C	Sea Level (refer to present level)	
Phane-rerozoic	Cenozoic	Quaternary	Holocene	0.01- 0	0.01	280	21	15	0	570.83	25.76	19.39	91	3385.55	23.67	22.25	230.6	100
			Pleistocene	1.8-0.01	1.79			11	20									
		Tertiary Neogene	Pliocene	5-1.8	3.2	500	23	17										
			Miocene	24-5	19			11	60									
		Tertiary Paleogene	Oligocene	34-24	10	700	24	20	30									
			Eocene	55-34	21		26	27	150									
			Paleocene	65-55	10		34	21										99
	Mesozoic	Cretaceous		144-65	79	2250	27	23	300	2730.87	22.55	22.7	196					
		Jurassic		205-144	61	2600	20	20	170									
		Triassic		248-205	43	3800	18	26	50* m & (-50 m)									97.98
	Paleozoic	Permian		295-248	47	950	30	21	270*	5365.77	28.41	26.86	336					
		Carboniferous		354-295	59	933	35	18	350									
		Devonian		416-354	62	5700	18	23										95.96
		Silurian		442-416	26	7600	17	18	430									
		Ordovician		495-442	53	6460	20	25	500									95
		Cambrian		544-495	49	7000	20	29	350									
Pre-Cambrian	Proterozoic			2400-544	1856													
	Archean			3800-2400	1400													
Origin of Earth				4600-3800	800													

Note: 1) Considering present Carbon dioxide concentration is 380ppm and Average earth temp 15°C. 2) CO_2 Concentration in Early, middle & late Carboniferous were 1500ppm, 350ppm and 950ppm respectively. Due to decreasing trend upto middle carbaniferous and later on increasing treand, mean CO_2 concentration taken 933ppm. *50 m high (for 30 my) and (-50 m low) for 15 my in which 7 my from Triassic & 6 my from Permian

Paleozoic Era: Paleozoic Era period was 544 Ma to 248 Ma ago. CO_2 concentration was high in early Paleozoic. Detail atmospheric variation are given below:

In Cambrian, CO_2 concentration was 9500-7600PPM, O_2 reached about 20% and Earths average temperature was 29°C. At the beginning of Ordovician climate was mild, and temperature about 25°C. But at the end of the Ordovician Earth was wiped out 85% of all species and passed one cold phase, called the Andean-Saharan ice age but CO_2 concentration were still high i.e. 6400PPM and temperature 18°C.

During the Silurian, after the ice age temperature raised again and at beginning of Devonian it reached 23°C. O_2 reached at 16-17% and CO_2 was 7600PPM. The sea level was 450m higher than the present level. Again in the Devonian period, climate was warm and humid with high CO_2 concentration 5700PPM and the surface land were covered with Tracheophytes (vascular) plants with new fast growing plants. The sun was 96% bright then present and sea level was 350 m higher.

During the Carboniferous, sun was 97% bright, temperature was 18-21°C, CO_2 concentration varies from 1500PPM in early Carboniferous to as low as 350PPM in mid carboniferous and again raised and reached 950PPM in late carboniferous; O_2 concentration was highest in geological time that was 35%. Earth was covered with dense forest. Worlds good quality coal are formed in this time only.

In the Permian, sun was 97-98% bright and O_2 concentration decreases and reached 30% and end of Permian huge mass extinction happened and about 90% of all species were extended (Figure-1). Major Volcanic activities started and again CO_2 concentration increased in the atmosphere.

Mesozoic Era: Mesozoic (248-65 Ma ago) have comprised of three periods i.e. Triassic, Jurassic and Cretaceous.

Triassic period was 248 Ma to 205 Ma years. Triassic was warmer than today and average temperature was 26°C. The atmospheric concentration of CO_2 was 3800PPM and O_2 concentration were very low about 18%. In early Triassic period sea level was 50 m less than present level for 15 my (7 Ma in Triassic and 8 Ma from Permian) after that sea level raised about 100 m and reached 50m higher than present level. Volcanic activities again started in late Triassic and breaking up of Pangea continents started. It was continuing through Jurassic time. After the broken of Pangea continent, climate was belonging to temperate zone and warm-humid tropical winds flowed through the continents. The vegetation belongs to ferns, cycads, ginkgo trees and various conifers trees. Earth Albedo were decreases that time due to water and vegetation cover on continents and more sun radiation were absorbed as atmospheric heat that was major reason for increasing Earth temperature. During Jurassic time, the atmospheric CO_2 level was 2600PPM, with had dense forest. Earth was ruled by big Dinosaurs and they were highest stage of life development and food cycle fulfilled by dense forest. Earth's average temperature was 20°C and O_2 were about 20% of the atmosphere[5,6].

The Cretaceous period began 144 Ma ago and lasted until the dinosaur extinction 65 Ma ago (Figure-1). In the Cretaceous period, CO_2 concentration was 2250PPM, O_2 was about 27% of atmosphere and sealevel were about 300m higher than present sea level.

Cenozoic Era: The Cenozoic Erais divided into the Tertiary (65 Ma–1.8 Ma) and Quaternary (1.8 Ma - present) periods. Tertiary divided into Paleocene, Eocene, Oligocene, Miocene and Pliocene and Quaternary divided into Pleistocene and Recent.

Paleocene is the earliest period in Tertiary. It began with the Cretaceous-Tertiary (K/T) catastrophe 65 million years ago, which destroyed all dinosaur species atone time, and ended with the strange Paleocene-Eocene Thermal Maximum. Paleocene atmosphere was as high as 2000PPM CO_2 level and some believes that it was well twice as high as today, about 700PPM. The oxygen content of the atmosphere was close to 25%. Most of the Earth had tropical climate and very little difference between summer and winter. Nearly entire Earth was covered with dense impenetrable virgin forests. There was not any ice at the poles, and Polar Regions were covered with conifers and deciduous trees. The prior Paleocene climate was hot, but in the early Eocene, it was even more unbearably hot and humid. Eocene optimum about 25°C in global annual average temperature and O_2 concentration was 26%.

After that again O_2 concentration and Earth temperature started down and reached 24% and 20°C in Oligocene and sea level was 30m higher[7]. During Mid Miocene again temperature drop down and reached 11°C with average 23% O_2 and CO_2 was about 500 PPM. Pliocene is the most recent and shortest period of Tertiary (5 Ma to 1.8 Ma) and climate was warmer than today (17°C).

Pleistocene is the period in Earth's history that we commonly known as the Ice Age. Through much of this period, thick ice was present at North and south pole region. Thereby Earth's albedo increased dramatically and a very high proportion of solar radiation was reflected back to space, which intensified further cooling. There were at least 20 cycles of such advances and retreat soft he ice masses. During the ice ages global average annual temperature was 5-6 degrees colder than today.

Present Holocene time is known as warm period/phase because it started after the Weichsel ice age about 11700 years ago. At the starting of Holocene time, Northern Hemisphere was very cold and later on temperature increased gradually and reached about 3-4°C above the present temperature. Frequent fluctuation in temperature (Warm and cold temp. compared to present) were continue. As Climate was cold and wet before 2,000-3,000 years and again 1600-1700 BC year, climate was very cold and known as Little Ice Age[8].

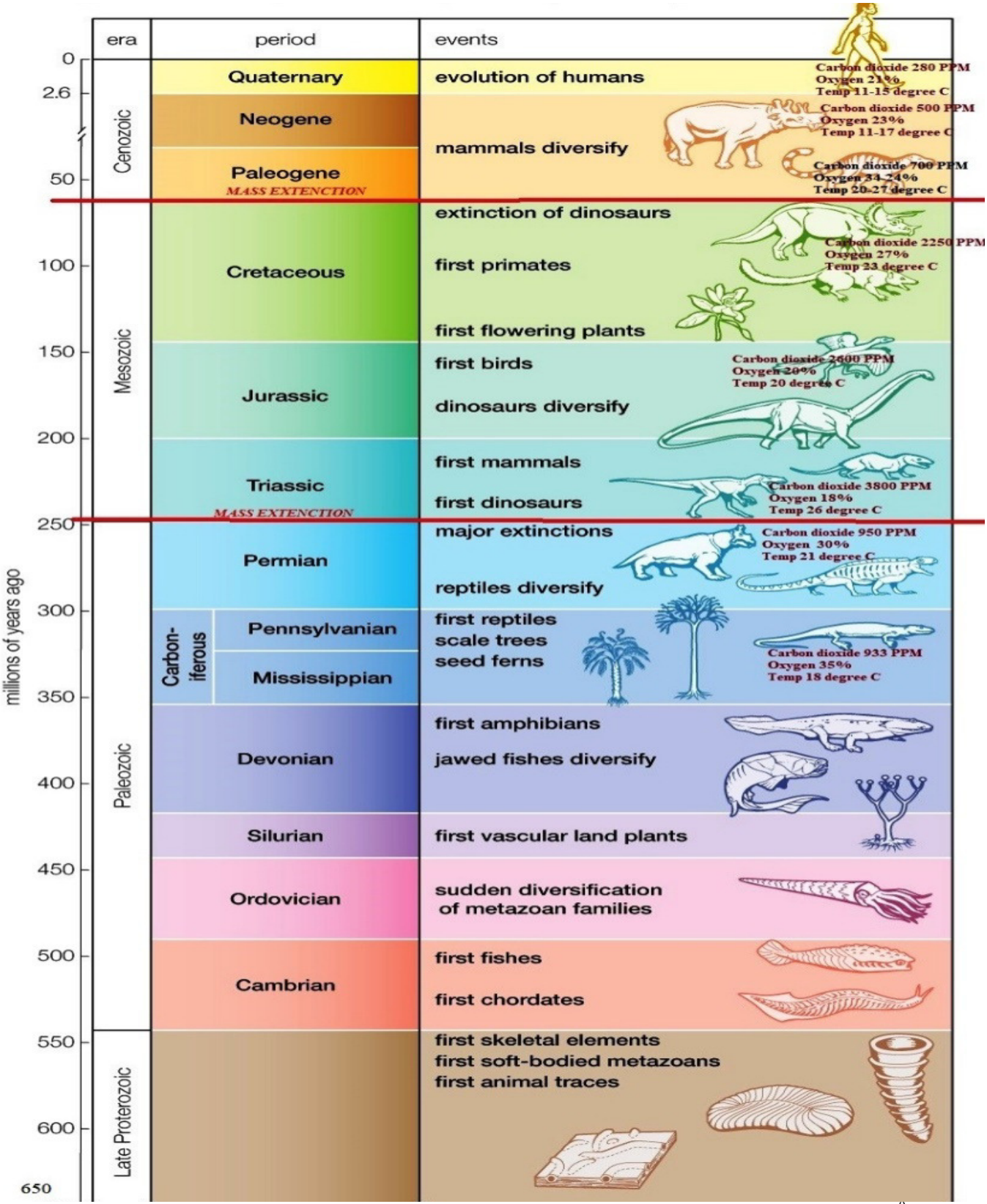

Figure-1: Evolution of life throughout Geological time with atmospheric concentration, Earth temp and Mass Extinction[9].

On the basis of Table-1 and Paleo-climatic studies, prepared the impact of variation of CO_2 and O_2 on flora, Fauna and on natural disaster; shown in Table-2.

Future Climatic Prediction: Based on Paleo-climatic studies (Table-1), we got the average concentration of CO_2, O_2, Earth temperature, sea level for each Era time and Earth life time, excluding Pre-Cambrian time and shown in Figure-2 and Figure-3. It also observed that CO_2 and O_2 are always in indirectly proportional in atmosphere means when CO_2 concentration high in atmosphere, O_2 decreases and when CO_2 concentration lower, then O_2 becomes higher.

Earth's present average CO_2 concentration i.e. 380PPM, is much lower than Earth's average CO_2 concentration in Phanerozoic (3385.55PPM) and average concentration of Mesozoic and Cenozoic i.e. 2730.8PPM and 570.83PPM respectively; O_2 present concentration (21%) is lower than average O_2 concentration in Phanerozoic (23.67%). Earth's today average temperature (15°C), is lower than temperature of Mesozoic and Cenozoic i.e. 22.70°C and 19.39°C respectively. Present average sea level is also much lower than average sea level in Phanerozoic 230.6m and average sea level of Mesozoic and Cenozoic i.e. 196m and 91m high respectively. Sun luminosity was lower than present luminosity and will increase in future.

It is also observed that Earth always tried to maintain an average temperature and CO_2 level, so both may be increase in future by naturally, as happened in geologically past. When Earth average temperature will be increased then sea level will also be increased and more O_2 will be absorbed by the sea water and O_2 percentage will be decreases. Present CO_2 concentration is lowest in Phanerozoic Eon and probably increase naturally by volcanic activities and other natural sources, which emit the CO_2 and greenhouse gases. Human development activities are playing as 'Catalyst' in this process.

Conclusion

Earth's overall CO_2 and O_2 concentration are remain constant but it varies by various geological and natural factors such as photosynthesis, volcanic activities, glacier precipitation and melting, organic materials, sea water absorption, fossil fuel etc. Earth had faced various Ice age even the presence of high CO_2 concentration and again warm age, even O_2 concentration was much higher than present level. During the Mesozoic time when average CO_2 concentration was 2730PPM, very big size species (Dinosaurs) were present. High concentration of Carbon in atmosphere is beneficial for flora and fauna and those species adopted the changes, always be survived.

Present atmospheric concentration is much less than its average concentration. According to Paleoclimatic data it is confirmed that presently Earth is in cold phase and in future Earth will be tried to maintain its average temperature means warn phase. However, it is predicted that CO_2, O_2 concentration, Earth average temp, sea level will be increased and definitely, affect the present precipitation pattern, flora, fauna, glacier melting, sea level rise, increase in Hydro-meteorological disaster, hydrological cycle, rate of decay of organic components, weathering pattern of rock. But these affect will be at slow rate than expected by us.

Table-2: Impact of variation in CO_2, O_2 and green house gases in the atmosphere.

Gasses	Trend	Impact			
		Plant/ Flora	Human and animals/ Fauna	Climate	Frequency of Natural disaster
CO_2	Increase	Positive	Positive	Warm Climate. Increase Evaporation. Decrease Precipitation at lower latitude and increase precipitation in higher latitude. Chemical weathering high.	Increase. Volcanic activity will be low.
	Decrease	Negative	Negative	Cold Climate. Decrease Evaporation. Increase Precipitation at lower latitude and decrease precipitation in higher latitude.	Decrease. Volcanic activity will be high.
O_2	Increase	Positive	Positive	Cold Climate. Decrease Evaporation.	Decrease. Volcanic activity will be high.
	Decrease	Negative	Negative	Warm Climate. Increase Evaporation.	Increase. Volcanic activity will be Low.
Greenhouse Gases	Increase	Negative	Negative	Warm Climate. Increase Evaporation.	Increase. Volcanic activity will be Low.
	Decrease	Positive	Positive	Cold Climate. Decrease Evaporation.	Decrease. Volcanic activity will be high.

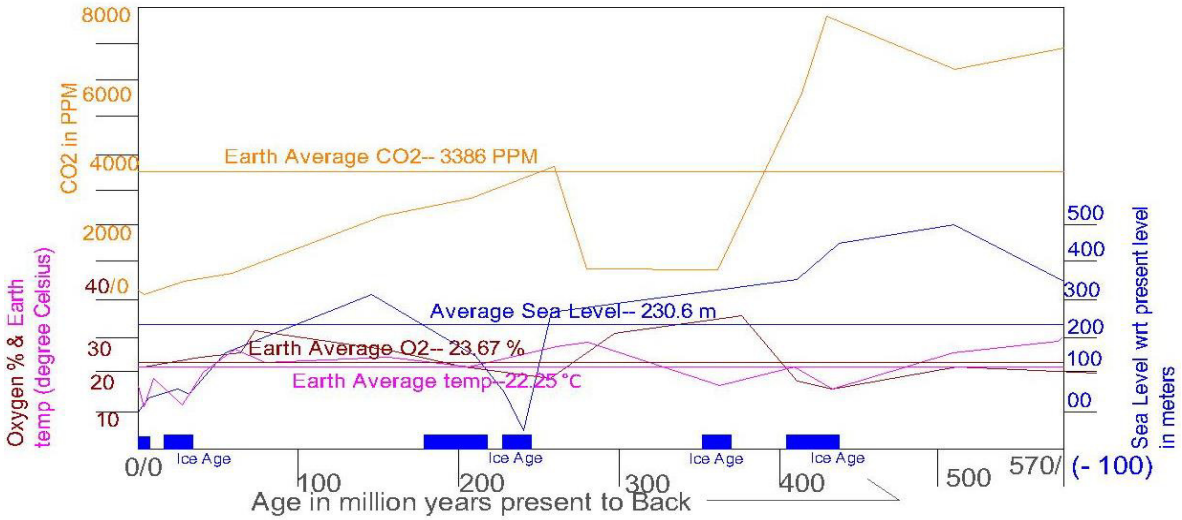

Figure-2: Variation in CO_2, O_2, Earth temperature and sea level during Geological time.

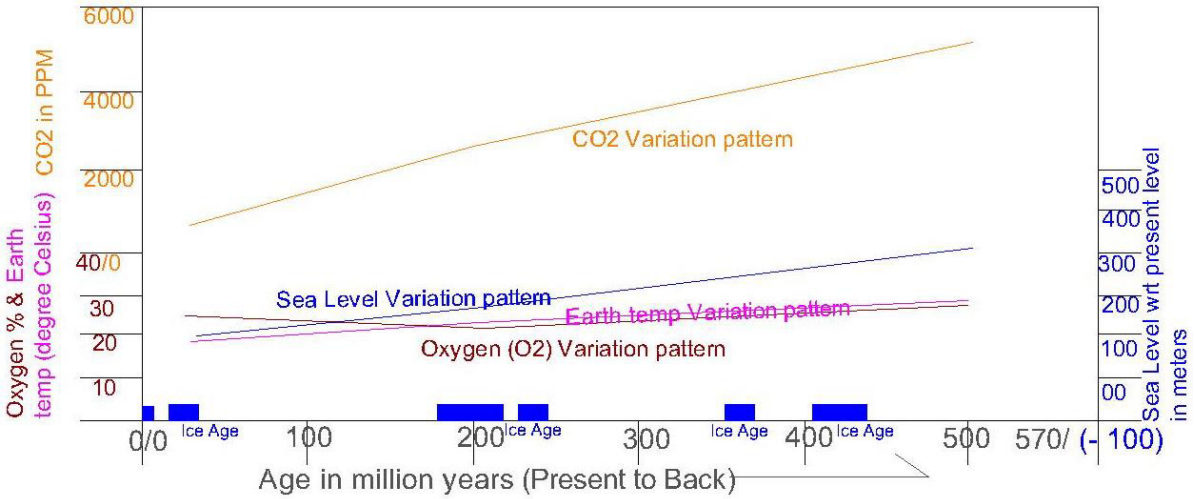

Figure-3: Average CO_2, O_2, Earth temperature and sea level variation during Geological time.

References

1. Garwood Russell J. (2012). Patterns In Palaeontology: The first 3 billion years of evolution. *Palaeontology Online.* 2(11), 1-14.
2. Report (2019). Climate and Carboniferous Climate. http://geocraft.com/WVFossils/Carboniferousclimate.html. Retrieved 25 Jan 2019.
3. Berner Robert A. (1999). Atmospheric oxygen over Phanerozoic time. *Proc. Natl. Acad. Sci.USA*. 96, 10955-10957.
4. Hallam A. (1992). Phanerozoic Sea-Level Changes. *Columbia University Press, New York*. ISBN 0231 074247
5. Berner R.A. (2006). Geocarbsulf: a combined model for Phanerozoic atmospheric O_2 and CO_2. *Geochim. Cosmochim. Acta.,* 70(23), 5653-5664.
6. Berner R.A. (2007). Vanden Brooks. JM, Ward, PD Oxygen and evolution. *Science*, 316, 557-558.
7. Zanazzi A. (2007). Large Temperature Drop across the Eocene Oligocene in central North America. *Nature.,* 445(7128), 639-642.
8. Lamb HH (1972). The Cold Little Ice Age climate of about 1550 to 1800. *Climate: present, past and future. London: Methuen*. 107. ISBN 978-0-416-11530-7.
9. Report (2019). Geological time scale 650 million year to the present. https://www.britannica.com/science/geologic-time/media/229694/1650 (Accessed 2019-02-15).