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HOW LIFE CHANGED THE EARTH AND HOW EARTH CHANGED THE LIFE

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Article describes some important points about the history of our planet, and the impact the changes on Earth have had on living things. We first looked at the changes the Earth had gone through since it formed billions of years ago, and then we focused on the patterns of change since life began. The arrangement of continents on Earth is only one aspect of the physical changes the planet has undergone thought its history. Also, atmosphere has changed greatly since the Earth formed, and the climate has fluctuated between icy and steamy extremes. In addition, we tried to find the effect of temperature in different meteorological stations with similar characteristics on the planet's life. It was defined from the obtained data that the global warming has definitively happened in the second half of the 20th century, as in all the vegetation types there has been a wide change in the trend temperatures from the time period 1900 to 2013. Also, it seen that the water vegetation type is the one that shows more accurate results, due to the bigger amount of stations. And also it is one of the vegetation types that has suffered a bigger change in the trend temperature, around 0,10 ºC per decade.

Key words: algae, trilobites, meteorite, club mosses, global warming.

ЯК ЖИТТЯ ЗМІНИЛО ЗЕМЛЮ ТА ЯК ЗЕМЛЯ ЗМІНИЛА ЖИТТЯ

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Описані деякі важливі аспекти історії нашої планети та наслідки впливу змін, що відбуваються на Землі на життя живих організмів. Було розглянуто зміни, через які пройшла планета Земля із часів її утворення, та закономірності змін із часів появи життя. Розташування континентів на Землі є лише одним з аспектів фізичних змін, що планета зазнала за свою історію. Крім того, із часів утворення планети атмосфера також сильно змінилася, змінюючи клімат то в напрямку похолодання, то – потепління. Також спробувано знайти вплив температури, отриманої з різних метеорологічних станцій, з аналогічними характеристиками, на життя планети. Було визначено, що згідно з отриманими даними глобальне потепління однозначно відбулося в другій половині 20-го століття, так як у всіх типах рослинності спостерігалася широка зміна температур в період часу з 1900 по 2013 роки. З отриманих даних видно, що водна рослинність показує найбільш точні результати внаслідок більшої кількості станцій. Також цей тип рослинності зазнає зміни температури приблизно на 0,10 º С за десятиліття.

Ключові слова: водорості, трилобіти, плавуни метеорит, глобальне потепління.

PROBLEM STATEMENT. It is believed that the earth solidified as a planet approximately 4,5 billion years ago. For the first 1,5 billion years of its existence, there was no life on the planet.

The first plant life, algae, probably came into existence about 3,2 billion years ago. Two billion years of plant development passed before the first waterborne animal life came into existence (1,2 billion years ago). Trilobites dominated the seas 600 million years ago, and the first fish came into existence 500 million years ago.

About 440 million years ago the first surface life appeared in the form of plants. Fish began to crawl from the sea 400 million years ago, leading to the development of the first amphibians.

The quick run thru 4,5 billion years process is shown in the fig.1.

This diagram shows us how much existence of planet has been occupied by life. Learning to think about deep time is really important to have a taste of evolution and geology. At the beginning we had a reducing atmosphere and course of O_2 was photosynthetic bacteria. Chemical links that had to be filled first were elements and molecules that combine readily with oxygen, such as iron and sulphur. Until 2,3 billion years the content of O_2 was less than 0,4 %. With this oxygen concentration all people will die in a minute. The evidence that we had a free oxygen in the atmosphere is the age of iron (red iron beds at 2,3 billion years ago). So, there was ferrum oxide. It could dissolve in water flowing around the ocean. And then the oxygen level in the atmosphere got high enough it oxidized to ferric oxide, and the ferric oxide fell out of solution and it made the iron.

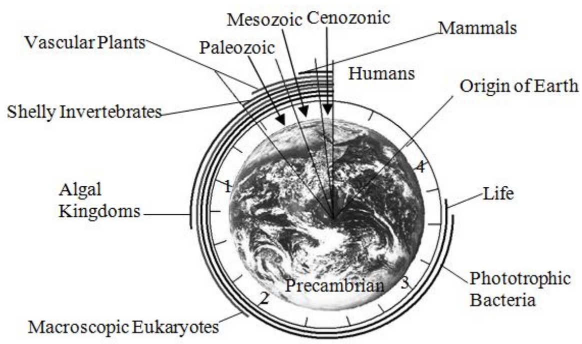


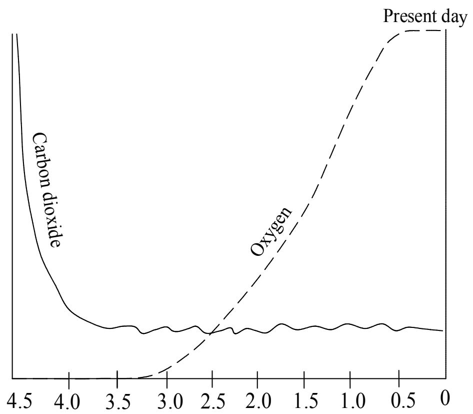
Figure1 – Earth's biological clock in billions years

This kind of process continued with others sorts of element. So, we have copper coming out at 1,7 billions years.

The consequence of free oxygen is that ozone layer forms in atmosphere. Ones we have oxygen in the atmosphere we can start getting nitrates. Nitrates are oxygenated nitrogen. So, you won't really have nitrogen fertilizer until we have free oxygen and it became the key nutrient for algae.

In our early environment the Sun was only 70 % hot then it is now, and about 500 million years ago it was up to 95 %. The early environment of Earth was meteorite bombardment. The heat flows out of the molted mass forming the core of the Earth.

If we look at the history of atmosphere (fig. 2), at the origin the CO_2 level was much higher [1].



Time scale in billions of years
Figure 2 – History of atmosphere in billions years

The atmosphere was more than 100 % CO_2 level, because it was thicker. Oxygen rose and probably rich present level about 5…6 mya. The Earth was much more of greenhouse gas in the past than it used today (table 1).

Table 1 – The fate of the original atmospheric carbon dioxide

Carbon reservoir	Gigatons	Percent, %
Limestone in sedimentary rocks	40,000,000	79,92709
Organic carbon in sedimentary rocks	10,000,000	19,98177
Oceanic bicarbonate ion	37,000	0,07393
Fossil fuels	4,200	0,00839
Organic carbon in sediment and soil	1,600	0,00320
Oceanic carbonate ion	1,300	0,00260
Oceanic dissolved CO_2	740	0,00148
Living biomass	760	000152
Atmospheric CH_4	10	0,00002

Basically, if we look at that we can see, the carbon balance of the planet is extremely dependent upon what happens in rocks. If there is small geological changes in the cycle of how carbon is going out of rocks make much bigger difference to the amount of carbon in the atmosphere than amount of fossil fuel has been burned.

If we look at the way the life structures the planet, one of the very important things is done is soil. The first plants on land were probably liverworts, first fossils were club mosses: Ordovician and Silurian, 510…410 mya. They are fossil soils and those fossil soils have roots in them. First rooted soils suggest first forest: Devonian, 410…355 mya. First modern soils with layering and with evidence of seed plants appear: carboniferous, 355…290 mya.

In the past bacteria were really engineering the planet and they continued to do so. In the carbon cycle they produce and oxygenate methane and fix CO_2 an aerobically. In the nitrogen cycle, they fix nitrogen from the atmosphere as ammonia, oxygenate ammonia to nitrate and denitrify nitrates to ammonia. Sulphur bacteria oxidize hydrogen sulfide to sulfate and reduce sulfate to hydrogen sulfide. Iron bacteria convert ferrous to ferric iron and in coupled reactions influence the formation and degradation of manganese and copper deposits. Also bacteria can be active several kilometers deep. So, they are really key players in structuring the environment in which we live. So, those aspects how life modified the planet.

And how has the planet modified life? There are four main geology's impacts on life: continental drift, glaciation, mass extinctions, and local catastrophes.

Continents suddenly started to drift about 300 million years ago [2]. Until that time, the continents formed one land mass, named Pangea (Greek *pan, pas* = the whole; *geo* = earth). The first split between the northern half, now named Laurasia (Europe, North America and Asia), and the southern half, named Gondwanaland (South America, Africa, India, Antarctica, Australia and New Zealand), began 300 million years ago. It is possible that the gap between the two continents was sufficiently large to form the first circumglobal sea, allowing ocean currents to travel around the world, resulting in a warm equitable climate everywhere. In any case, the seas that formed between the splitting continents were warm and rich in nutrients and marine life, laying down all the mineral oil we now mine. These changes must have been accompanied with severe climate changes and changes in vegetation, accompanied by massive erosion.

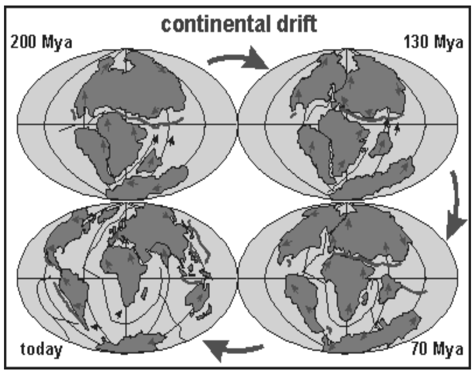


Figure 3 – The model of the continental drift

Major glaciations were happened during Pleistocene, Permian and Late Proterozoic. The Pleistocene Epoch (a.k.a. the Great Ice Age), started about 2 million years ago and has been characterized by several periods in which glaciers advanced from the north to blanket large portions of North America and Eurasia [3]. Up to a mile (5,280 feet) thick, these glaciers scoured the land and flattened the hills which they covered. The climate since then has actually been warm. Last glacial maximum was about 20,000 ya and peak melting about 12,500 ya. The glaciers have left behind numerous small lakes (kettles) and erratically meandering (or lost) rivers.

What about mass extinction? There have been two biggest: end-Permian; end-Cretaceous [4]. At the end of Permian were disappeared trilobites (250 mya), 83 % of marine invertebrate genera, 97 % of marine invertebrate species. At the end of Cretaceous were disappeared ammonites (65 mya), dinosaurs, most terrestrial species >5 kg, 70 % of marine invertebrate species.

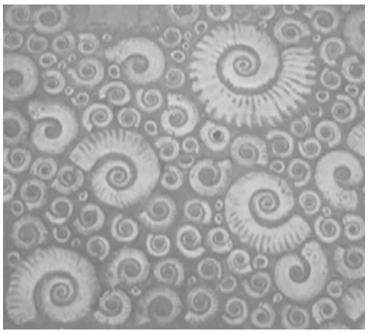


Figure 4 – Ammonites

This was a big one but the Permian extinction was much bigger. The main phase of extinction appears to have lasted less than ten thousand years. It happened both on land and in the oceans. In the ocean organisms that had passive gas exchange were particularly susceptible. This suggests very high CO_2 level. Possible causal chain: massive volcanism in Siberia causes global warming, triggering the release of huge amount of methane stored in the oceans. The methane is oxidized to CO_2, and extinctions occur by poisoning and asphyxiation. The amount of carbon oxidized was equivalent to several times the current live biomass of the planet. The percentage of oxygen in Earth’s atmosphere at that time was about 7 %.

The Cretaceous extinction happen about 65 mya. There was a large meteorite impact right at the end of the Cretaceous in the Yucatan (fig. 5) [5].

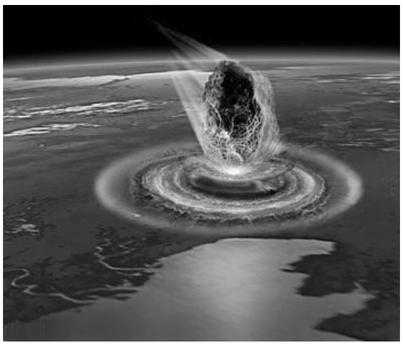


Figure 5 – Chicxulub impact in Mexico

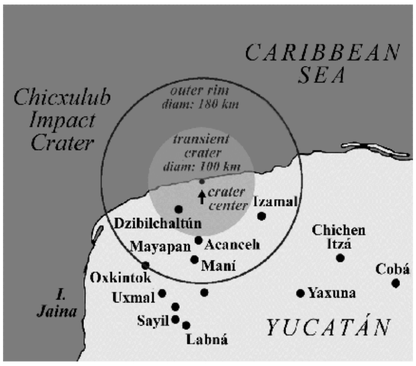


Figure 6 – Location of Chicxulub crater in Northern Yucatan

The center of the Yucatan crater at latitude 21º30' N, longitude 89º50' W lies at the village of Chicxulub, near Progreso on the Caribbean coast. The impact basin is buried by several hundred meters of sediment, hiding it from view. NASA scientists believe that an asteroid 10 to 20 kilometers (6 to 12 miles) in diameter produced this impact basin. The asteroid hit a geologically unique, sulfur-rich region of the Yucatan Peninsula and kicked up billions of tons of sulfur and other materials into the atmosphere. Darkness prevailed for about half a year after the collision. This caused global temperatures to plunge near freezing. Half of the species on Earth became extinct including the dinosaurs. The reconstruction that has happened is shown in the table 2. But the mechanisms are not yet completely clear.

Table 2 – The end-Cretaceous extinction: 10 km meteorite hits the Yucatan

Time	Effect
1 s	Annihilation around impact site
1 min	Earthquakes, Richter Scale 10
10 min	Spontaneous ignition of North American forests
60 min	Impact eject across North America
10 h	Tsunamis ca.1 km high swamp coastal margins
1 week	First extinctions
9 months	Dust clouds begin to clear
10 years	Severe cooling ends
1000 years	Continental vegetation recovers, end of “fern spike”
1500 years	Deep-water benthic systems begin to recover
7000 years	Complete recovery of deep-water systems
70,000 years	Ocean anoxia diminishes
100,000 years	Final extinction of dinosaurs
300,000 years	Final extinction of ammonites
500,000 years	Ocean ecosystems start to stabilize
1,000,000 years	Open ocean ecosystems partly recovered

The meteorite was not necessarily the sole cause: the Deccan Traps - unusually active volcanoes in what is now India-led to global cooling and acid rain, and were the major cause of mass extinction too.

Also, many others local catastrophes had impact on life:

1. Major earthquakes (mountain building and tsunami, 1755 Lisbon, 1960 Chile, 1964 Alaska, 1976 China, 2005 Indonesia, 2010 Chile, 2011 Japan).

2. Major eruptions (1600 BC Santorini, Tambora 1815, Krakatao 1883. These things caused tsunamis and global cooling).

3. Gigantic eruptions (Crater Lake, Oregon, The Phlegrean Fields, Naples. About 1 every 10000 to 100000 years).

4. Undersea landslides (Hawaiian rifts luffing, huge tsunamis. One or two every 100000 years).

Super floods (Siberia, Manitoba. They happened at the end of Ice ages).

EXPERIMENTAL PART AND RESULTS OBTAINED. Global warming also makes impact on life and it could threaten one-fourth of the world's plant and vertebrate animal species with extinction by 2050 [6].

We tried to compare it's effect in different meteorological stations with similar characteristics but that present different vegetation types.

The set of stations selected are the ones situated at latitude of 40-50N and an altitude over the sea level of 0–100 m. This makes reduce the total number of stations suitable from the Time Series Browser from 7169 to 459. Among these stations there are over 20 vegetation types.

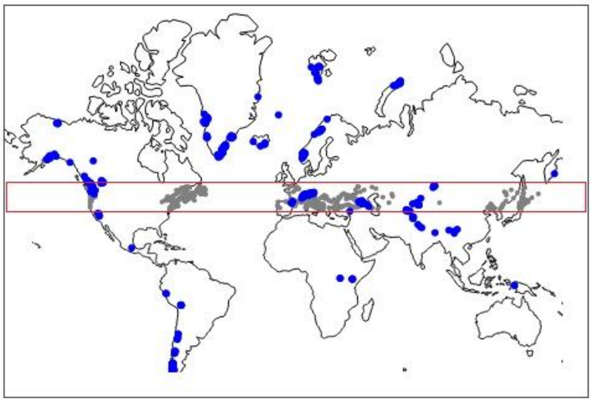


Figure 7 – Region studied and stations analysed (grey points)

It is going to be analysed only the subset of vegetation types that have enough number of stations with data between 1900–1950, to be able to normalize the data. This makes reduce the total number of stations analysed to less than 400 and the number of vegetations types to 7.

It has also been analysed the information obtained from the AR5 models. In this case it has been used the CSM4 model made by the National Center for Atmospheric Research (NCAR) and the historical model scenario that takes into account humans and radiative forcings.

In order to assess the possible anthropogenic global warming happened in the last part of the 20th century, there have been analyzed two different time frames. The first is the one from 1900 to 1950 and the second from 1950 to present time.

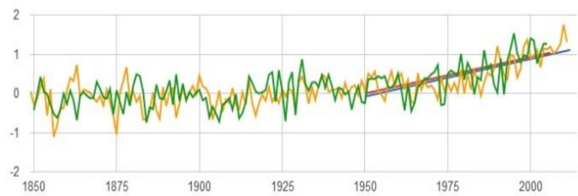


Figure 8 – Example of comparison between station data and CSM4 model results

In the next table are shown the results of the analysis of trend temperatures (ΔT) in ºC per decade for each vegetation type analyzed. The second column shows the number of stations for each vegetation type that satisfy the condition of 0–100 m and 40–50N. The next columns show the trend temperatures for the period from 1900 to 1950 and the second for the period from 1950 to 2013. For each period there are two columns showing trend temperatures obtained by data composite and trend temperatures from the CSM4 climate model.

Table 3 – Results of the analysis of trend temperatures (ΔT) in ºC per decade for each vegetation type

Vegetation type	Stations	ΔT	ΔT CSM4	ΔT	ΔT CSM4
		1900–1950		1950–2013	
Water	118	0,08	0,10	0,19	0,19
Warm Croops	77	0,12	0,11	0,21	0,23
Cool For/Field	63	0,17	0,14	0,16	0,22
Cool conifer	36	0,10	0,10	0,15	0,22
Cool Crops	31	0,18	0,14	0,21	0,23
Cool Mixed	30	0,15	0,09	0,17	0,24
Coastal Edges	18	0,08	0,07	0,24	0,14

The first conclusion that can be obtained from the data of the table is that the global warming has definitively happened in the second half of the 20th century, as in all the vegetation types there has been a wide change in the trend temperatures from the first time period (1900–1950) to the second (1950–2013).

Secondly comparing the trend temperature from the data composite and the climate models it can be seen that the bigger the number of stations is, the more accurate is the result of the climate model.

Finally it can be seen in the data that the Water vegetation type is the one that shows more accurate results, due to the bigger amount of stations. And also it is one of the vegetation types that has suffered a bigger change in the trend temperature, around 0,10 ºC/decade.

CONCLSIONS. So, from the material that has been discussed above, we may safely draw the conclusion that: life engineered the atmosphere, soil, and parts of rocks and ores; the planet and extraterrestrial environment have major impacts on life on the planet at long time intervals, smaller ones more locally at short time intervals.

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КАК ЖИЗНЬ ИЗМЕНИЛА ЗЕМЛЮ И КАК ЗЕМЛЯ ИЗМЕНИЛА ЖИЗНЬ

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Описаны некоторые важные аспекты истории нашей планеты и последствия влияния изменений, происходящих на Земле, на жизнь живых организмов. Рассмотрены изменения, через которые прошла планета Земля со времен ее образования, и закономерности изменений со времен появления жизни. Расположение континентов на Земле является лишь одним из аспектов физических изменений, которые планета претерпела за свою историю. Кроме того, со времен основания планеты атмосфера также сильно изменилась, меняя климат то в направлении похолодания, то потепления. Предпринята попытка найти влияние температуры, полученной с различных метеорологических станций с аналогичными характеристиками, на жизнь планеты. Было определено, что согласно полученным данным глобальное потепление однозначно произошло во второй половине 20-го века, т.к. для всех типах растительности наблюдалась широкая смена температур в период времени с 1900 по 2013 года. Полученные данные показывают, что водная растительность дает наиболее точные результаты благодаря большему количеству станций. Также этот тип растительности подвергается изменениям температуры приблизительно 0,10 ºС за десятилетие.

Ключевые слова: водоросли, трилобиты, плауны метеорит, глобальное потепление.

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