EVOLUTION OF BIOSPHERE AND ITS PHYSICAL AND ECOLOGICAL MODEL

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Abstract*: Paleo biological data is an example of extinction of the whole groups of organisms. These evident events are usually referred to as global ecological crisis or catastrophes. Very frequently, they are described by extraordinary processes of global range, which have actually taken place in the history of Earth and have had a significant role in the development of the biosphere. The problem is how and what they influence. That's why, in order to find out the essence of evolution of life on Earth over a long period of time, it is very important to define which processes are essential and how they are linked to the whole history of the biosphere, generally bio ecological evolution. To answer these questions, we must imagine which evolutionary changes of organisms, ecosystems and, generally, the biosphere are regular, which of them are comparatively random, which are conditioned by external factors and which are defined by inner characteristics of these systems. We should also find out which variations of the features of the systems are important for their perfect functioning, which of them have the least influence on their existence and further evolution.*

The present paper deals with the solution of these issues and problems on conceptual level and presents physical and ecological model of the biosphere.

In physical evolution of the biosphere, a significant role is played by the constant growth of energy current. It should be noted that little is known about the earliest stages of development of life on our planet. Some data about it is presented in different works [1, 2, 3, 4]. But, without doubt, at the end of archaic era, about 2,5 million years ago, life was widely spread on Earth and it was mainly located in hydrosphere. For its existence, prokaryote biosphere of the ancient archaic era used chemical mineral sources, including energy, which were found in the earth geosphere, including hydrosphere and lithosphere. The Sun supported life on planet indirectly. It mainly conditioned chemical cycle and general temperature and climate balance. Approximately 2 billion years ago, after the creation and wide distribution of photosynthetic organisms (first of all, cyanobacteria), biosphere biota in the process of creation of atmospheric oxygen changed, as oxygen was a powerful poison for the majority of anaerobic organisms characteristic for archaic era. Biosphere life and, therefore, its physical evolution became dependent on the electromagnetic radiation of the visible part of the sun specter, which was especially effective in the period of the activity of the sun [4, 5].

At the early stage of evolution of photosynthetic biosphere, physical evolution was adjusted with the improvement of chemical mechanisms of photosynthesis and was revealed in strengthening of chlorophyll efficiency. At the same time, the most effective chlorophylls were created, in fact, the producers of main organics substances of the biosphere. In Phanerozoic epoch (the last 550–570 million years) chemical evolution of photosynthesis finished and the eukaryotic life which began in Proterozoic era started to spread to land [6, 7]. It was supported by the fact that eukaryots themselves had the ability to create such complicated multicellular organisms which were equipped with special tissues and organs necessary to perform different functions. It conditioned the creation of numerous possibilities and ways for the existence of these organisms in the environment. Extracting water from the upper level of soil with roots and moving photosynthetic organisms to the surface, where there were better light conditions, is one of the impossible methods for unicellular organisms. The growth of photosynthetic ability of surface vegetation and the physical evolution of the biosphere connected with this process develop as a result of the creation and development of special adapting factors, which conditioned the growth of the area of photosynthetic surfaces. Thus, Phanerozoic stage of the evolution of the biosphere was significantly linked to the photosynthetic changes of surface vegetation. The data shows that the alteration of the surface vegetation communities in the process of its Phanerozoic evolution was the following: the solar energy current acquired by the biosphere importantly grew during that period of time. Therefore, it is logical to assume that the given tendency, namely, the growth of energy current used by the biosphere in the process of evolution was characteristic for all stages of its development. Such hypothesis is one of the main proofs of physical and ecological conception of the biosphere evolution.

Undoubtedly, the growth of energy current in the biosphere leads to the growth of the number of organic substances which are created and, at the same time, participate in the cycle of the biosphere, to the creation of new life licenses. The increase in the difficulty of biosphere organization is also connected with the increase in the differences between biological forms and to the so-called process of progressive evolution of some of them [8, 9].

The general model of the physical evolution of the biosphere means that each bio system "strives" to achieve such functioning that its energy current won't decrease, that's why each interruption in the process of acquiring energy encourages the bio system to physical evolution [3, 10]. This model can be used to describe physical evolution of the biosphere during Phanerozoic and, in this case, discuss the events which lower the productivity of photosynthesis throughout the planet.

In order to prove the proportion of the magnitude of the existing changes acquired by the given Phanerozoic biosphere during the interruption of the energy current and the current of general biosphere, it is necessary to prove the proximity between the biosphere and the ideal bio system. It means that energy interruptions are the situations when the productivity of photosynthesis is decreased according to external reasons which create the conditions for producing new, more effective producents. In case of unchanged conditions, the process of evolution of the biosphere and ecosystems stops [10].

The latter is easier to prove if we consider that the biosphere, ecosystems and their representative fragments are presented as eco biotic bio systems, which deter evolution in different ways and directions, if the external conditions remain unchanged. Indeed, the permanence of the internal environment in the established bio systems and also morphogenetic and morphofunctional restrictions, which narrow the specter of possible changes of organisms in the process of evolution, usually condition only ecological and neutral or, in other words, non-directional, non-final evolution. In this case the ecological features of populations don't change, which supports the stability of ecosystem's inner environment, i.e. establishes ecological homeostasis.

In case of interruption of planetary range which decreases the productivity of photosynthesis the balance between different trophic levels of bio systems is disturbed, the demand for organic substances exceeds their production by producents, which causes critical situation. The number of traditional producents and their consumers reduces, while more effective among the producents acquire the skill of selection. This means the creation of specific conditions during which evolution becomes directed. All these events lead to the predicted structural changes in the vegetation communities. The appearance of new producents is followed by the creation of new groups of producents and consumers and, finally, there are irreversible changes in composition of species, the number of populations, energetics and the characteristic features of successive cycle, which is surrounded by crisis processes of ecosystems. Such changes in ecosystem result in the creation of ecosystems filled with more effective producents and new consumers [4]. It is clear that in respect of biosphere energetics, the most important among these ecosystems are massive, i.e. new biogeocenoses.

Thus, if, as a result of the influence of external factors on the biosphere of the planet, conditions change so significantly that the biosphere is unable to use the solar energy current acquired earlier, then we have the ecological crisis of ecosystems which later includes the whole biosphere. This may cause the establishment of biosphere systems carrying new, more effective producents. If, after this, the earlier conditions restore, then on completion of the interruption, the new system of the biosphere will use more energy current than it used before the interruption. This mechanism is discussed in the physical and ecological model of the biosphere evolution.

It should be noted that insignificant changes in external conditions are not interruptions and don't cause ecosystem to reassemble, as in a certain diapason ecosystems can adapt to the altered external conditions. Besides, powerful and rapid changes in planetary conditions must cause not the physical evolution of the biosphere but its catastrophe, during which a lot of biological forms become extinct and the energy current used by the biosphere decreases sharply. That's why, while discussing the mechanism of physical and ecological evolution of the biosphere, we should take into consideration that it can "work" in a limited diapason of changes in external factors.

In some respects, the above given mechanism resembles the mechanisms presented by Eldridge and Gould [11] and also Krasilov [12], within the so-called interrupted balance, which establishes between critical epochs. This hypothesis also discusses the selection mechanisms of new biological forms which are found at some stages of biosphere evolution. According to the data presented by different authors [13, 14, 15], the most critical epochs are late Dokembrian, Permian, Upper Cretaceous and Upper Silurian periods. Sometimes, critical epochs in the history of the biosphere are referred to as *revolutionary epochs*.

Of course, none of the scientific information about the history of the Earth is complete. Despite this, there is quite enough data about the past of our planet. Based on astrophysical, paleomagnetic, geological, paleoclimatic, paleoecological and many other data [4, 15], we can assume that the change in the parameters of the Earth orbit as well as the periodical decrease in emission of carbon dioxide from fossils, are the most important reasons which cause interruptions in the whole biosphere.

Let's discuss this evidence separately.

The fluctuations of the parameters of the Earth orbit are tens of thousands of years old, which cause the changes in the duration of seasons as well as ice age on the planet's high longitude. According to M. Milankovich and some others [4, 16, 17, 18], these fluctuations are caused by the gravitational interdependency created on the Earth by other objects of the solar system. As a result, there are periodical movements of the Earth orbit to ellipsis. There is also axis precession of the earth orbit (period 23–25 thousand years). The change in the orbit eccentricity causes periodical changes in the general current of the sun radiation by approximately 0.3 %. At the same time, other changes of the planet do not influence general insolation, though, in high longitude, they influence the length of the seasons and the climate of non-equator zones. According to some specialists [19], the change of eccentricity conditions physical evolution during Phanerozoic, while other variations of the orbit's parameters cause periodical changes in climatic zones.

In order to calculate this data and theory and prove the possibility of using the model of physical evolution of the biosphere, it is necessary to find the method which will help to estimate the acquired energy current. In case of Phanerozoic biosphere, we can use the data about photosynthetic ability at a certain stage of the evolution of vegetation communities. Namely, this is the data according to photosynthetic index of the main biogeocenosis.

The concept of *photosynthetic index* is the generalization of the concept of leaf bearing index [20] and spreads to all forms of photo synthesizers. It is clear that in the late vegetation communities the number of these indices can be more than one. In this respect, modern rainforests are leading, as their index reaches thirty.

If we consider that surface multicellular producents of Phanerozoic era use the same chlorophylls to produce organic substances, then we can conclude that the energy current obtained at a certain stage of Phanerozoic evolution is proportional to the average photosynthetic index of land. Unfortunately, it is impossible to make more or less accurate calculations about the length of Phanerozoic period but the usage of the data of maximum photosynthetic index of vegetation communities in different periods of the biosphere evolution is quite enough for approximate calculation.

If we take the interval of time between Devonian and Neogene periods, then, according to calculations [19], the change in maximum photosynthetic index was dozens in number. In the same period, i.e. for 400 million years, there were 4000 interruptions as a result of periodical change in the orbit's eccentricity. Generally, the number of interruptions must have been more because the ideal movements on land are not ideal, that's why other kinds of changes in the orbit's parameters also played their role (leave alone other factors). If we consider interruptions nearly identical, the average quantity of the interruptions will be approximately 0,25 %. This value is close to the fluctuations in solar insolation created as a result of eccentricity changes (~ 30 %) [4, 21]. If we consider that the quantity used in these calculations is approximate, that these are some other factors which influence the growth of photosynthetic index and that this growth is a nonlinear event in time, then this kind of coincidence is very important and this proves the accuracy of physical and ecological model of the biosphere evolution.

In the biosphere, other important interruptions are the changes of the amount of carbon dioxide used in photosynthesis: carbon dioxide is a limiting factor and its lack causes the degradation of the efficiency of producing organic substances by vegetation communities, the same happens during the reduction of solar insolation. Geological data shows that the emission of gases from the earth changes significantly and lasts approximately 200 million years, which is close to the period of time necessary for the solar system to rotate around the center of galaxy, i.e. one galactic year [21]. All this enables us to express different hypothesis about the connection between the biosphere evolution and galactic processes [22].

The supposition about 200-million-year period is proved by paleontological data which shows that the beginning of wide distribution of macrotaxons of important surface vegetation coincides with the end of the epoch of the reduction of gas emission. At this time, the wide distribution of new macrotaxons of surface animals develops in twice as short period, and the origin of new forms of progressive life is dated 100 and more million years before compared to their wide distribution [13].

Thus, the decrease of carbon dioxide current can also be discussed as an interruption, which must be taken into account in the physical and ecological model of the biosphere. It makes nearly the same contribution in the biosphere evolution as the changes in the parameters of the earth orbit.

Some works [23] mention the galactic period of 25–30 million years, which corresponds to the change in the position of the solar system to its galactic orbit, though there is still no data to prove that these variations are important in the evolution of the biosphere.

Besides, a lot of geological and, namely, paleontological data reveals that in the history of the development of earth, there are periods which are characterized by different planetary conditions. During Phanerozoic period there was an important change in the gas contents of the atmosphere, the earth's climatic systems altered, the climate in different parts of the planet changed. At the beginning of Mesozoic era, the united supercontinent *Pangaea* started to separate, creating separate continents. It is beyond doubt that these processes also had certain influence on the evolution of the biosphere [24].

The evolution of the biosphere must have been influenced by such extraordinary processes which are connected with the earth's collision with the gigantic meteor, or the fall of small meteorites, catastrophic volcanic eruptions and earthquakes, rapid changes in the flowing of seas and oceans, the reductions of sun radiation necessary for vegetation (which must be linked to the passage of the solar system through galaxy dust clouds [21]) and other less exotic events. These global cataclysms must have occurred in the history of earth and must have speeded up the evolutionary process of its biosphere. Despite the importance of any of these cataclysms in the history of our planet, their influence on the physical and ecological evolution of the biosphere was single and relatively short compared to the systematic and multiple influences which are connected with the variations of parameters characteristic for the earth orbit.

The influence of these factors conditions the growth of biosphere energy current which is caused by the origin of new producents which use the sun energy current more effectively. For example, in the surface vegetation communities, the energy current in Phanerozoic epoch increased, new ecosystems and biogeocenosis were created, which made a significant influence on the evolution of the biosphere.

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