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THE PROBLEM OF BIODIVERSITY: THE GEOHISTORICAL APPROACH

This article tackles the problems of the biodiversity parameter evolution from the geo-historical perspective. The authors come to a conclusion about the prevalence of global terrestrial and cosmic factors in the development of biosphere processes. On the basis of the biogeochemical approach to the biosphere evolution, the authors could identify the principal stages of its development from the ancient times to the modern epoch and refute the postulate of Leibniz ('nature makes no leaps').

Key words: biodiversity, geo-historical approach, geo-ecological factors, evolution periodicity.

Biodiversity and its evolution in the unique conditions of the Earth draw the attention of scholars, first of all, as a complex geo-historical process of the appearance, distribution and complication of the types and forms of organisation of the "living matter" (according to V. I. Vernadsky) from the ancient times to the present. These types and forms (taxonomic, biocenotic, ecosystems, and bio-geochemical), which emerged at the early pre-Cambrian stage of biosphere development, continue to evolve in the modern age, when some species and communities become extinct and are replaced by others. The biogenic process on the Earth was periodically disturbed by events taking place within the environment and the biota itself [7].

Global biosphere processes, developing in the conditions of climate change and rising sea level, are analysed, as a rule, in view of one or two factors (increase in atmospheric CO2, expanding or shrinking of the Earth, environmental pollution, etc). At the same time, the cosmic-planetary character of global process, the bio-geospheric and ecospheric transitions are often ignored. However, as early as 1926, V. I. Vernadsky [1] discovered the bio-geochemical approach, on which he pinned his hopes for a deeper cognition of the essence of global processes — from atom and molecular to biosphere ones. V. A. Zubkov suggested considering the crises and catastrophes, which shake the Earth every now and then, in the framework of historical geoecology, to a great extent, on the basis of bio-geochemical ideas of Vernadsky. Following his appeal, the authors of the article analyse the key biosphere events in the history of the Earth from the geo-historical and biogeochemical perspective.

Today, it is a general belief that the formation of the planet and the emergence of its biosphere took place almost simultaneously in geological terms (4—4.5 Ga). The early pre-Cambrian biosphere was limited to primitive carbonate-siliceous associations of stromatolites and oncolites in the shelf areas of ancient continents (the Baltic shield and others). There is more information on the period of development stretching from 3.76 to 1.9 Ga. The communities of akaryote cyanobacteriae were represented by autotrophs, heterotrophs, and saprophytes, which could survive without atmospheric oxygen and nitrogen in the soil. Later (1.9 Ga — 0.9Ga), the biosphere developed through the emergence of eukaryotes, which had a karyon and chromosomes. It was the age of the complication of inra-cellular processes and the appearance of the first colonial organisms. Autotrophic plants (photoautotrophs) synthesised organic matter forming the basis of the trophic pyramid of biosphere. The biogeochemical function of fungi consisted in the decomposition of organic matter and its preparation for digesting by other organisms. The function of unicellular animals was to redistribute the components of bio-inanimate systems (soils, silts) containing a sufficient amount of water.

Approximately 0.9 Ga, the evolution of the multicellular Metazoa commenced causing a steep increase in biodiversity. As early as the Vendian period, some groups of still existing organisms (for instance, sponges, siboglinidae, cnidarians) appeared. A significant increase in the level of organisation, physiological and biogeochemical mechanisms of ancient invertebrates led to a greater ability to expand in space and time. A qualitatively higher degree of biota development accounted for the higher level of biosphere interdependences. By the end of the pre-Cambrian, the trophic and metabolic chains in ecosystems had extended and complicated.

By the beginning of the Phanerozoic, there the two principal groups of organisms comprising a unified bio-energetic system had diverged considerably. Plants found at the basis of the trophic pyramid, provided animals with organic food and atmosphere with oxygen, in their turn, plants received carbon dioxide and other metabolites from animals. As organisms became more active, the rate of their evolution sped up and the divergence of phylogenetic branches and biogeochemical connection increased. The dramatic morphogenetic changes in the pre-Cambrian led to the mass development of skeletal colonial forms of invertebrates. Starting with the early Palaeozoic, Calcium, silicon, phosphate, strontium and other organisms determined the spectrum of targeted biogeochemical processes that finally shaped the diversity in invertebrates in the modern biosphere.

The Cambrian "transformation" of the biogeochemical processes was prepared by the dramatic changes in the architectonics of certain groups of invertebrates (molluscs, brachiopods, corals, etc). The Silurian saw another transformation relating to cephalization — the development of brain in chordates. The diversity of physicochemical conditions on land caused the differentiation of biogeochemical processes adapted to the local conditions. The intensity of substance, energy and information exchange between the components of biogeochemical systems increased sharply [5].

The development of terrestrial biosphere commenced as plants "came ashore" 420 Ma. The processes of soil formation were affected biotic and abiotic factors. An important event was the development of angiosperms 130 Ma. Since late Cretaceous and throughout the Cenozoic, angiosperms have been the prevalent component of terrestrial flora, which created the conditions for the development of many groups of animals, including birds, mammals, and the human being.

In the course of evolution, biogeochemical processes manifested themselves (according to Vernadsky's principles) as the functions of living matter — the energy, concentration, destructive, environmental, and transport functions, which account for the development of the oxygen atmosphere (as a result of photosynthesis and the deposition of large amounts of CO_2 in biogenic rocks). Most rocks, ores, and minerals (silicates, carbonates, and even granites) in the Earth's stratosphere stem from ancient biospheres. Thanks to them, the process of interaction between the living and inanimate matter can be traced back to the earliest geological periods (high-carbon compositions like shungite in Karelia, ferruginous quartzites, silicates, and carbonates in many regions of the world).

Mineral matter has been transformed by living organisms numerous times. The crucial for the modern biosphere CO_2-O_2 system was changing in the geological past due to the increase in the diversity of photosynthesising plants in the World Ocean and the continents. Primitive anoxic cycles of the early stages of biosphere evolution were substantially transformed as a result of the emergence of more complex biogeochemical chains and links in the Phanerozoic. The direction of biosphere evolution and its periodical changes can be easily traced with the help of integral biogeochemical markers — the correlation between oxygen, carbon, sulphur, calcium, magnesium, strontium, and other isotopes [6].

Global changes in the evolution of organic world can be explained by the space radiation impact. The great milestones in the history of organic world development (the extinction of faunas and floras) are of a truly planetary scale; they embrace diverse biotopes and, thus, cannot be set off by local circumstances. The evolution of organic world in the Phanerozoic covers four gigantism eras: the Ordovician — the Ludlow, the Carboniferous — the early Permian, the middle Jurassic — the Maastrichtian and the Quaternary marked by greatest number, taxonomic diversity, biological productivity, and the largest sizes of individuals in most taxonomic groups. The gigantism ages lasted 80—90 Ma alternating with the periods of the same or a shorter duration, when all these properties were manifested less strongly.

The alteration of periods brings us to the rejection of Leibnitz's postulate "nature make no leaps". Crises and catastrophes in the biosphere evolution can be connected with the well-known cases of extinction of faunas and floras at the turns of geological periods, ages, and epochs, while the latter can be related to the rotation of the Solar system around the centre of the Milky Way, in view of the fact that, in different periods of its development, the Earth received different doses of space radiation. The rotation of the Solar system around the galaxy centre was established by astronomers, although the duration of each revolution was calculated only approximately. According to some data it equals 200 Ma, according to other — 250 Ma. If we link the periodical alteration of geological processes to the rotation of the Solar system, in terms of absolute chronology, the duration of one revolution will be 160 Ma.

The evolution of biogeochemical processes (coal accumulation, carbonate accumulation, silicon accumulation) was accompanied by crisis phenomena and even catastrophic system transformations of biogeochemical connection. Such disruptions in otherwise continuous development manifested vigorously in the periods of: intense volcanism, continental glaciation, dramatic changes in the solar activity and the electromagentic field, the expansion and shrinking of the Earth, etc.

The discovery of transitional forms between anthropoid apes and the human being — the Australopithecus, who lived from 4—5 to 1 Ma — opened a new stage in research on biosphere evolution. It is usually linked to the fall of temperature and the following glaciation. The modern human being has increasing influence on the biosphere processes. The impact of anthropogenic activity is such that it can not only disturb the balance of global biogeochemical relations, but also reverse them. The human being, having become a "geological force" (according to Vernadsky), is now close to self-destruction as a result of unprecedented concentration of military radioactive waste, atmospheric and hydrospheric chemical pollution, deforestation and damage to other geo-systems. All of it changes the course of geochemical processes dramatically. We are witnessing the transformation of the human being themselves (from replacement of organs and tissues to artificial impregnation, surrogate motherhood, cloning), their nutrition (through the genetic modification of plants and animals, the use of preservatives, etc), medicine and so on. The process of transformation of the human being as a biosocial creature is related by some researcher to industrial development, urbanization and the scientific and technological revolution.

As E. S. Demidenko [2] emphasises, humanity is changing as a result of environmental pollution taking no notice of the parallel processes of bioconcentration of radionuclides, heavy metals, and other toxic substances in the cells, organs and tissues of most groups of organisms. However, humanity does not become independent of the biosphere — it is just impossible.

Does the "mass transformation of biosphere" result from the domestication of wild animals or even the genetic transformation of some of them? There is not a trace of biosphere diversity being replaced by post-biospehre, techno- or noosphere diversity. New varieties of cereals and flowering plants enrich the fund of cultivated crops, but they cannot supplant the millions of wild species. The speculations regarding the total replacement of biosphere with techno-sphere belong to the sci-fi rather than scientific scenario of further development of biosphere.

The human being rose above the herd world as a biosocial creature; however their basic biological functions (nourishment, breathing, and reproduction) did not change. The recent discoveries of medical genetics, immunology and other sciences put an end to the spread of earlier incurable diseases, while the development of general and physical culture of humanity contributes to a lower morbidity rate and, hence, a greater life expectancy.

The ubiquitous disruption of continuity and a distorted trajectory of development are the key features of global catastrophic and crisis transformations of the composition, structure and conditions of the functioning of biosphere and its components. A vivid proof is the paleontological evidence of the global extinction of ancient groups of organisms, the changes in the composition of atmosphere and hydrosphere, volcanism, sedimentation conditions, etc. When analysed in more detail, the pre-Palaeozoic, pre-Mesozoic, and pre-Cenozoic extinctions prove to be not cyclic or synchronized, but caused by multiple factors.

Similar events are usually characterised as a fast short-term change of faunas, floras, and different groups of ancient organisms. At critical boundaries, they are replaced much faster than before and after them. The cyclicity and periodicity of global catastrophic transformations formulated by many researchers [3] are "blurred" in the course of a more thorough data analysis. The statements regarding the periodicity of critical boundaries and catastrophic global transformations are obviously statistical.

The acceleration and retardation of post-catastrophic events in relation to the boundary of biosphere transformation point to the actual meaning of arbitrary factors. In the context of concrete studies, the approximate estimation of such events is conducted with the help of the decomposition method with lagging gradation, which is admissible in case of particular empirical dependencies. However, the characteristic of more general laws of natural system development requires the analysis of relations of stable states and the identification of the causes of their distortion, the search for determining factors and the ways of delivering bio-systems from the catastrophe phase to the new level of targeted development.

George Cuvier admitted the actuality of terrestrial fauna catastrophes alongside the targeted progressive development of hydrobionts. In our understanding, catastrophism is nothing more than an addition to the evolutionism of J-B Lamarck and Ch. Darwin, one of the facets of assessments of a complicated development process. In this case, the arbitrary nature of catastrophes is just a form of necessity. Within the integral structure of a globally developing living system, a catastrophe is a complicating episode, which does not change the general direction, the development vector until the next critical stage. All in all, a catastrophe is a reflection of the final state of biosystem at the disintegration phase.

The increase in complexity of modern interrelation between nature and society (in the conditions of anthropogenic development) is accompanied by the catastrophic decline in biosphere sustainability due to the rapid extinction of many species and their communities (tropical forests, coral reefs, etc.) [2]. The anti-environmental character of political decision of the highest level is a direct threat to biosphere sustainability (the ozone layer depletion, chemical and radioactive contamination of organisms and nutrients, etc). The analysis of biosphere transformations as precursors of geo-ecological catastrophes requires taking into account the characteristics of relevant entropic and anti-entropic processes. The transition from chaotic development to a new structured condition has been analysed only in the form of a comparative description of gradual changes from one allegedly independent state of the bio-system to another, and requires the recognition of interdependence and independence of catastrophism and evolutionarism, as well as their interrelation. The way towards the implementation of this idea lies through the exologisation of science, education and social reproduction of biodiversity.

Through tackling the problem of evolution of biodiversity on the basis of the geo-historical approach, the authors come to the conclusion that this process is periodically disrupted by global events of both terrestrial and cosmic origin. The ages of volcanism and seismicity, the alteration of glacial and interglacial periods, the changes in the World Ocean levels, solar radiation, and many other factors should be taken into account when characterising the biodiversity parameters — the taxonomic, geo-ecological, biogeochemical and others.

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