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A GREENHOUSE EFFECT AND LIKELY PROSPECTS: GLOBAL DISASTER OR OPTIMIZATION OF THE BIOSPHERE?*

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Attention is drawn to the polyvariance of the expected sequelae of the greenhouse effect, the evolutionary–biological aspect of the problem and the difficulties of evolutionary prediction. The prospect of the survival of the biosphere and mankind resides in mutual adaptation through the process of co-evolution. The formulation of a mature theory of biological evolution providing the basis for evolutionary prediction and control of the biosphere is becoming ever more pressing.

In his publications, Karnaukhov [1, 2] draws the attention of scientists to the problem of the "greenhouse effect" in which he detects the probability of sequelae dangerous for the existence of the biosphere and the survival of mankind. A different view is taken by Yanshin who, in a newspaper article [3], not only did not share alarmist predictions in relation to global ecological problems but even expressed confidence in the sequelae of the greenhouse effect beneficial for mankind.

Ecological problems caused by human activity in our time are increasingly often assuming global proportions and diverse aspects: from purely scientific to economic, international and political. As shown by the quite instructive example of the "hole in the ozone layer" [4], global ecological problems directly or indirectly affect the interests of extensive sections of the population of the planet including powerful politicians and businessmen, influential government departments and companies. Undoubtedly, the greenhouse effect may affect the interests of mankind to an even greater degree. Therefore, the discussion of this problem is topical and it is desirable that the arguments and conclusions of authors are amenable to understanding not only of narrow specialists but also all who this problem may interest to differing degrees.

SOME REMARKS ON THE POSITION OF KARNAUKHOV

The greenhouse effect has as its main cause not only the presence in the atmosphere of carbon dioxide but also methane and chlorofluorohydrocarbons [4–6]. The assumption that human activity may lead to the extinction of marine species capable of utilizing CO_2 for constructing calcareous skeletons [1, 2] requires factual confirmation. The point is that in the history of the

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Earth, the extinction of any species has always brought its replacement by another species in fulfilment of the ecological role (or the ecological niche). The same ecological replacement is also noted in present day ecosystems when extinction is the fault of man. There are always claimants to substitution in ecosystems (with rare exceptions in insular ecosystems) as manifest in the superfluity of biosystems [8, 38]. It is doubtful whether carbon turnover in marine ecosystems has suffered from the extinction of individual species. There are sufficient grounds for speaking of the contraction of marshes as a result of drying out, although the process of waterlogging of felled sites in boreal forests covering large areas is just as obvious [9].

The rate of extinction in a historical epoch is actually growing [10–12], although there are no grounds for asserting that it "far exceeds that of the species extant at the times of the largest scale ecological disasters of the past" [2]. In the geological history of the Earth extinctions have not once been of a catastrophic character nor of very high rate [13–15]. The unprecedented character of the current situation lies in the anthropogenic nature of the causes of the ecological shocks also triggering the growing pace of extinction.

Looking at the distribution of coal deposits over the Earth's surface, including the near-polar regions, Karnaukhov leaves aside the current versions of the theory of continental drift of Wegener, forfeiting for discussion an important factor in the problem of paleoclimates. It would be desirable to know the view of geologists on the component "due to the processes of convection in the lithosphere" [2], on the impact assumed by Karnaukhov of nuclear tests on the strengthening of tectonics and the process of degassing of the lithosphere. It is obvious that in the theoretical construction of Karnaukhov, one may find contentious points and incompleteness of the factors taken into account. The problem discussed offers possibilities for different versions of the greenhouse effect.

FACTS AND JUDGEMENTS

Evidently, the first scientific judgements on the global phenomena of the greenhouse effect in the history of the Earth were expressed at the end of the 19th century by Arrhenius and Chamberlain [16]. Since then, a great deal of data has been gathered on the content of carbon dioxide in the spheres of the Earth [5–7, 16, 17]. Attention to the greenhouse effect in our time may be judged from the journal *Priroda*, almost every issue of which contains articles or abstracts of new publications on the theme. A growing volume of evidence points to an increase in the concentration in the Earth's atmosphere of CO_2 and a slow rise in the mean temperature values on the surface of the planet [18–21] in the 20th century.

Among the components of the Earth of importance in the greenhouse effect on our planet, many must be named: these are the subsystems and processes of the lithosphere (including vulcanism and degassing), the atmosphere, hydrosphere and biosphere. Of the living components all take part in one way or another in the turnover of carbon but some biosystems play a more crucial role in the greenhouse effect: these are marshes, paddy fields, animals and plants with a calcareous skeleton, photosynthetics and methane-forming organisms. Although the main place in the greenhouse effect is assigned to carbon dioxide, methane accounts for about a quarter of this phenomenon [6]. It has been estimated that one methane molecule retains in the atmosphere 25 times more thermal energy than the CO_2 molecule.

The physicochemical processes, which may be related to the greenhouse effect, are as follows: degassing of the lithosphere, vulcanism, exchange of CO_2 between the atmosphere and ocean, change in the ratio of the areas of dry land and ocean, the development of glaciations and their contraction, rock weathering, etc. On unfreezing of marshes, the latter are brought into the process of exchange of CO_2 and methane. Melting marshy grounds may release into the atmosphere considerable stores of accumulated methane. Fires appearing in nature for natural reasons release CO_2 from the burnt plants, the mortmass and the caustobioliths.

Contemporary man has appreciably intensified the process of accumulation of CO_2 in the atmosphere through anthropogenic fires, burning of fuel and emission into the atmosphere of chlorofluorohydrocarbons. In addition, man has created processes powerful enough to influence natural mechanisms on which depends the balance of greenhouse gases in the spheres of the Earth. As a whole, evaluation of the situation on the planet gives grounds for discussing the processes of anthropogenic reduction of the biosphere reservoirs of carbon on dry land [20] and the incipient reduction of autoregulatory mechanisms of the biosphere [37].

The world community is not remaining indifferent to the prospect of the global greenhouse effect: the content of greenhouse gases in the atmosphere is being monitored, in 1992 in Rio de Janeiro the framework convention on the climate was adopted providing for sanctions for excessive emissions of CO_2, many scientific conferences have been held on the problem of climate and the greenhouse effect and several models have been proposed for long-term global forecasting.

VIEWS ON THE FUTURE

Models predicting the possible perspectives of the greenhouse effect [1, 2, 7, 19–21], provide the bases for discussion on many aspects. I shall turn to the biological part of the problem: it seems that this aspect is being discussed less than others. Yet, among the causes generating the greenhouse effect or of crucial importance in the balance of greenhouse gases, the role of living systems is quite obvious [5–7, 16, 17, 22].

The role of the Earth's biosphere in maintaining a dynamically balanced state (ecological homeostasis) for the biosphere as a whole and its subsystems is known [17, 23–25, 37]. This particularly applies to the gas composition of the atmosphere and ocean, climatic indicators. These characteristics of the spheres of the Earth have undergone considerable changes, which, nevertheless, have not gone beyond the confines of the possible for the preservation of life on the planet. The subsystems of the biosphere (living matter, the ocean, the upper part of the lithosphere) may be regarded as natural regulators of the CO_2 content of the atmosphere and temperature on the surface of the planet. It is considered that in the past history of the Earth, the CO_2 content was far higher than in our time. Thus, at the beginning of the Cambrian the concentration of carbon dioxide exceeded the current level ten times. Cyclic changes in this indicator in the geological history of the Earth are known.

Most present-day terrestrial plants exist quite well on a CO_2 content exceeding almost 60 times the existing concentration [16]. It is natural to suppose that the Earth's phytocenoses are in heavy abundance in relation to the higher concentrations of carbon dioxide and are successfully coping with the task of utilizing and binding carbon.

According to one scenario [1, 2], the greenhouse effect by its far action will convert our planet to one similar to Venus. In biology it is common to classify the evolutionary growth of the similarity of two systems as convergence. Is such a convergence possible in the evolution of planets? For the time being one can say with confidence only that the condition for such a development of events must be the prior destruction of the biosphere.

Like other ecological factors, in the course of biological evolution the greenhouse gases may perform two evolutionary roles: selectogens and catastrophogens [8, 26]. In the first case there will be gradual evolutionary adaptation of living systems of the biosphere to the growing concentration of CO_2 and other greenhouse gases. New adaptations will differ: those aimed at increasing the utilization of these gases and the development in biosystems of the ability to live in a greenhouse atmosphere; in addition, the mechanisms of ecosystems aimed at suppressing the causes enhancing the greenhouse effect will progress. If the concentration of greenhouse gases reaches values destructive for the less stable part of the terrestrial biota, local or regional disasters will probably develop followed by evolutionary transformations in the subsystems of the biosphere more profound than before. In the history of the biosphere there is no doubting the principle that the deeper the signs of ecological disasters, the more significant were the later changes in the organization of terrestrial biosystems. The capacity of living systems for adaptive changes, self-regulation and evolution at all levels of organization is disregarded or not duly considered by the authors of existing models of greenhouse scenarios.

The forecasting of biological evolution is difficult and some authors write about its ineffectiveness [27–29]. There are definite reasons capable of explaining the real difficulties of evolutionary biological forecasting; the incompleteness of the theory of biological evolution [8, 30–32] is one of the most important reasons. In addition, the organization and evolution of living systems together with the adaptive element, amenable to forecasting, contain a non-adaptive element, the forecasting of which, calls for special procedures. The non-adaptive (excessive) element greatly reduces the accuracy of the evolutionary biological prediction. Finally, phylogenesis of biosystems is a self-regulating process, which increases the number of possible states of the evolving biosystem being predicted. The conclusion is obvious: further development of the theory of biological evolution is necessary with refinement of prognostics and elaboration of a technique of biological evolutionary forecasting.

Evidently, the most serious potential danger may be presented by the release of CO_2 from the sedimentary rocks of the lithosphere as a result of which the greenhouse effect, as is expected, assumes the character of a uni-directed self-enhancing process in the course of which there will be inevitable destruction of the biosphere [1, 2, 37]. The task of scientists is to determine the boundary, reaching of which brings into play the destructive mechanism of the greenhouse disaster and to work out measures, the implementation of which will reliably save the biosphere from a catastrophe. In the final analysis, subject to quantitative comparison will be such processes as: (1) the effectiveness of the regulating reactions of the biosphere; (2) the rate of destruction by man of the regulating mechanisms of the biosphere; (3) the rate of growth of the power of factors taking the biosphere out of the state of dynamic equilibrium; (4) the rate of progressive evolution of the regulating mechanisms of the biosphere; and (5) the effectiveness of anthropogenic regulation of the factors of the greenhouse effect. Each of these processes is in itself complex and demands a developed system of monitoring.

TEMPTATION TO RULE NATURE

Contemporary man has acquired the habit of fearing the genie from the "ecological bottle". However, the impressive growth of the possibilities of man, which have widespread and enormous power, gives grounds for constructing the plans for transforming nature, as is done by Yanshin. To some degree, the principle "every cloud has a silver lining" works: if the greenhouse effect is inescapable, then why not make use of its positive after-effects? Predicting the state of the future biosphere, Budyko [18] considers as probable its rejuvenation: establishment of a warmer climate, rise in productivity similar to the biosphere of the Tertiary. However, here new problems arise. It is curious that in the more distant future (after millions of years), Budyko forecasts complete glaciation of the planet, which greatly differs from the future of the Earth in Karnaukhov's version.

Possibly, the strategy of mankind in his relations with the biosphere must be more flexible and adaptive, and the main trends in it are not to prevent the biosphere from adapting to changes in the physicochemical habitat; not hinder mankind from adapting to changes in the biosphere; the prospect of survival of the biosphere and mankind in mutual adaptation through co-evolution [33]. In planning the considerable expenditure of resources on countering the greenhouse effect, mankind must have a scientifically grounded confidence that he will not be prepared to tilt at windmills [34] and not lose perspectives for optimizing the biosphere. It is important to bear in mind that in the state of catastrophe, the biosystems (including the biosphere, the biomes, ecosystems) have a future of manifold significance; they may, depending on the degree of disturbance, regain the former state, be eliminated or survive with renewal of organization [8]. In the catastrophic state, biosystems are most susceptible to controlling influences.

The possibilities of mankind influencing the future are quite high and now this is the main factor in the evolution of the biosphere. The destructive impact of anthropogenic factors on the biosphere is unquestionable [37] but the possibility of creative accomplishments on such a scale still needs to be demonstrated, which calls for a branched monitoring network, alternative models of the evolutionary shifts, the cooperation of scientific communities and the interaction of States. Possibly, the problem of the greenhouse effect will become an example of the realization of the scientific potential of the world community, of a fully rational approach to estimation of the possibilities of the biosphere and of mankind and to the framing of optimal decisions aimed at genuine co-evolution, the result of which will be the genesis of the noosphere. Whatever bold predictions and decisions controlling the biosystems are adopted by mankind, they must be based on the mature theory of evolution of the biosphere and its subsystems. The time when the theory of biological evolution must acquire practical significance [8, 35, 36] is approaching.

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