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ECOLOGO-GEOPHYSICAL FUNCTION OF THE LITHOSPHERE

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The geophysical constituent of the ecologic function of the lithosphere is discussed with an emphasis of its great role in maintaining energy necessary for life on the Earth.

The ecologic functions of the lithosphere such as its mineral resources, geodynamics, and geophysico-geochemical behavior are still poorly known. Until recently, the lithosphere was treated merely as the "lithogenic base of the landscape". Its role as a space inhabited by living organisms and as a source of minerals participating in the trophic cycle of life on the Earth was neglected. Still more obscure was the problem of an energy interaction between the lithosphere and the biosphere.

At the same time, experience shows that a substantial amount of energy required to maintain the processes that regulate life on our planet is provided by the lithosphere. In this context, the study of the ecologo-geophysical function of the lithosphere seems to be an important and promising field of research.

It should be noted that, as a branch of geoscience, geophysics was oriented conventionally to study the Earth as a planet or to investigate the mineral resources and study the geodynamic behavior of the lithosphere. In the latter case, geophysical methods were used to locate and evaluate mineral and fuel deposits, to explore the conditions of their mining and production, and, recently, to assess an ecologic risk involved in their production, as well as in ore concentration and crude oil processing. A popular field of geophysical applications is to derive information on geologic processes that are responsible for the dynamics of the upper crust.

These geophysical applications call for the solution of fundamental and applied geophysical problems using a great variety of methods ranging from regional crustal investigations to local detailed engineering-geological surveys and methods of ecological geophysics for deriving information on the spatial and temporal characteristics of ecologically harmful processes.

Nevertheless, whatever the level of geophysical applications, all of them generally have an obvious "geological" character and are almost unconcerned with biophysical aspects, namely, with the problem of the energy-related association of the Earth as a planet with its living organisms. Geophysicists have never been charged with this task. For this reason any attempts to study the geophysical function of the lithosphere are inevitably confronted with a necessity to deal with problems that are comparatively new for conventional geophysics.

As a matter of fact, the geophysical function of the lithosphere consists in providing energy-related conditions favorable for life. In this context, one can understand the keen and ever increasing interest of geophysicists in problems such as man-made physical pollution of the environment, the ecological problem of the effect of physical fields of the Earth upon natural and man-made ecosystems, geopathogenesis, and living organisms—biocoenoses, phytocoenoses, and man.

The best elaborated is the problem of the hazardous effects of man-made physical contamination of the environment on man [1]. Modern technologies involve the use of huge amounts of energy and raw materials

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causing chemical and physical (energy-related) pollution of the environment. This requires the assessment of the admissible effects (also known as technologic or technogenic impacts) of man-made physical fields on man as he handles modern industrial devices and equipment in the course of the production processes.

The formation mechanism of physical contamination is displayed schematically in Fig. 1. The diagram shows that industrial facilities, farms, and municipal services, that involve the production and accumulation of huge energy resources and large amounts of chemical and biological materials, lead to immense contamination, the level of which exceeds the adaptation capabilities of living organisms and is hazardous for the biota. It has definitely been established that man-made physical fields are harmful.

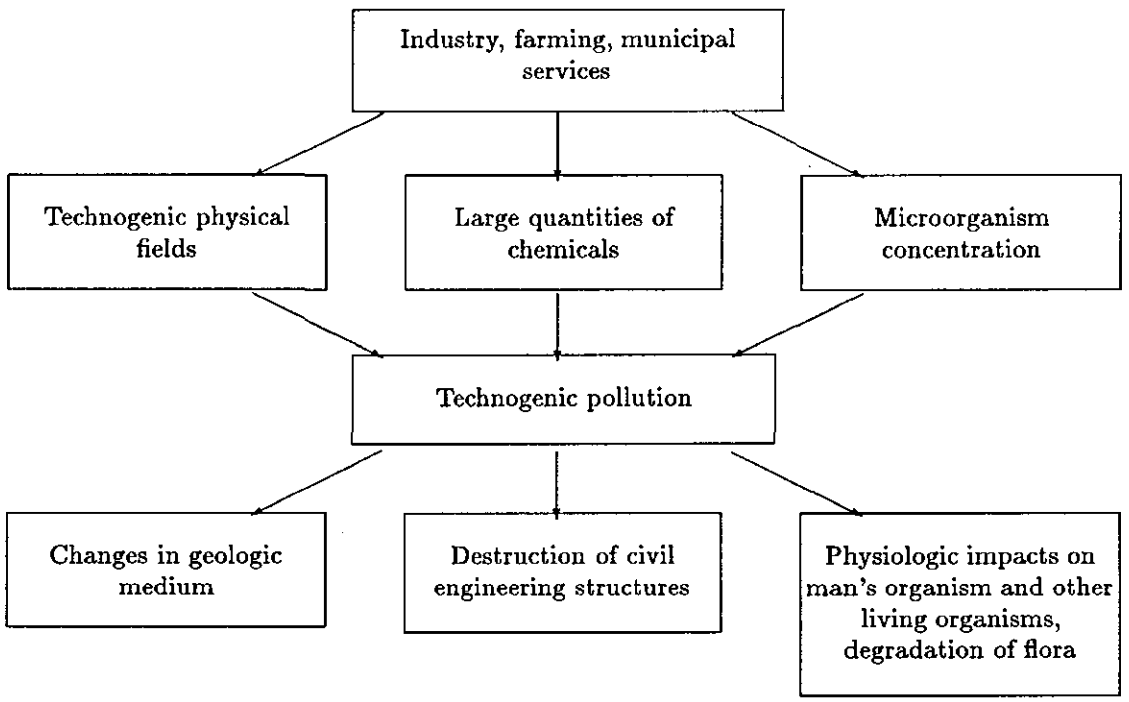

Fig. 1

Schematic diagram of the formation and ecologic impact of man-made physical pollution of the environment

The energy levels of man-made hazardous physical effects were measured instrumentally (Table 1). The technogenic physical fields produced by various industrial facilities, transportation means, and civil-engineering machines and mechanisms surpass manifold the natural background and exceed the admissible (physiological and engineering) limits. And still the solution of this problem is not hopeless.

Less known, and even enigmatic, is the problem of geopathogenesis, the pathogenic effect of the lithospheric physical fields on living organisms.

In accordance with our definition in [2], geopathogenesis is understood as the development of steady pathologic changes in living organisms in response to specific geological, geochemical, geophysical, and other natural processes. Accordingly, geopathogenic zones can be interpreted as the Earth's surface areas and localities, where there exists a danger of geopathogenesis on the strength of some geologo-geophysical and geologo-geochemical conditions.

The lithosphere is on the one hand a generator and, on the other hand, a medium-carrier of geophysical fields. Of great interest in this context are geophysical anomalies that are investigated conventionally to derive information on the Earth's internal structure and natural resources. Geophysical anomalies are especially pronounced in the regions of geologic and tectonic inhomogeneities of the lithosphere.

Until recently the mechanism whereby geophysical fields act upon living organisms remained unknown.

Table 1

Comparative Characteristics of Natural and Technogenic Physical Fields

Type of field	Field level			
	background	produced	sanitary limit	technical limit
Acoustic [dB(A)]	25–30	80–120	45–60	
Vibration [mm/s]	0.02–0.50	0.02–16.0	0.12	0.20–0.40
Thermal [°C]	(−2)–(+10) (*in soil at 1.5–2 m depth*)	(−160)–(+1500) (*in soil, at heat source contact*)	16–24 (*in office and home*)	
Electric [mV/m] (*in soil*)	5–10	10–300		3–5
Electromagnetic [kV/m]	10^{-6}	2.5–10.0	5.0	
Radiation [mSv/yr*]	0.3–2.2	1.6	2.1	

* 1 mSv = 100 mr.

The first step toward the solution of this problem is to evaluate the relative magnitudes of various geophysical anomalies existing on the planet and investigate their impacts on the state of the biota. In fact, geophysicists are challenged to look at the conventional subject of their research from a different, ecological, standpoint.

Insofar as the processes occurring in living organisms and controlling their vital functions belong to a class of electrochemical or electrophysical processes, main attention should be given to electric, electromagnetic, and magnetic fields.

Anomalies that are observed in the geomagnetic field (Table 2), which is dominated by a component that originates in the lithosphere at the expense of the existence of magnetic rock masses, may be as much as three times higher than the background, as is, for example, the case of the Kursk magnetic anomaly. Electromagnetic fields observed in the vicinity of metalliferous ore deposits or tectonic elements of the crust may also exceed the background by a factor of two and even more.

Of great interest is the impact of atmospheric electricity upon the biota. In his fundamental works, A. L. Chizhevskii [3, 4] showed that there was a fairly close correlation between electric atmospheric activities and the states of living organisms and the general conditions of people, including various kinds of pathologies. A. L. Chizhevskii did not go into the origin of atmospheric electricity and dealt only with its biophysical qualities. The data presented in Table 2 demonstrate a significant variation in the values of the parameters that characterize this kind of a geophysical field as a function of various types of the country. It can be assumed that at the general background of atmospheric electricity, perceptible effects may be caused by air ionization at the expense of radioactive emanations from the Earth's crust and the concentration of positive aeroions near metallic and graphite-bearing deposits. Atmospheric electricity can therefore be classed with the category of lithospheric "products" that control the ecologic function of the lithosphere.

It is believed that man is "blind" with respect to the gravity field, that is, he does not react to it in the same perceptible manner as he does to magnetic and electromagnetic disturbances or to changes in the amounts and ratios between aeroions in the near-earth atmospheric layer. It should be noted however that the magnitudes of the observed anomalies of the gravitational field (which is known to be universally penetrating) may be two or three orders higher than the total tidal anomaly caused by a combined effect of the sun and moon on the surface of our planet. A rapid travel of man in a meridional direction causes an abrupt change in the influence of the gravitational field on him (see Table 2).

It can thus be concluded that a new line of research has originated, geophysical ecology, which is entitled to combine the efforts of geologists, geophysicists, biologists, and medical people. For this reason this paper can be taken as an invitation to discussion and to a close cooperation in the common ecologic field of research.

Table 2

Observed geophysical anomalies

Type of field	Magnitude
Magnetic [mOe*]	
Background	500–618
Anomalies	200–1300
Gravitational [gal**]	
Background	978–983
Anomalies	$(30–300) \times 10^{-3}$
Tidal anomaly	0.345×10^{-3}
Saratov–Yamal flight	1.4
Electromagnetic [mV/km]	
Background	0.1–10
Anomalies	30–40
Atmospheric electricity [ion/cm^3]	
Background	$(1–1.4) \times 10^3$
Air in large cities	$(1.1–1.5) \times 10^3$
Air in "electroresorts"	$(1.8–3.7) \times 10^3$
Air near waterfalls and surf	$(100–200) \times 10^3$
Radiation [mSv/yr]	
Background	0.3–2.2
Anomalies	20–90
Permissible limit	50

* 1 mOe $\cong$ 0.08 A/m.
** 1 gal = 0.01 m/s^2.

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