Chapter 2

THE GEOLOGICAL ENVIRONMENT AND ECOSYSTEMS

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Judging from the absolute age of the most ancient rocks, the geological cover of the Earth has been developing for about 4 billion years. The processes of origination and evolution of all forms of life on the planet are inseparably connected with two important media – geological and aquatic (oceanic) ones. First, about 1 billion years ago, life in the form of protozoa originated in an aquatic medium and then, with sophistication of the forms and accretion of populations, moved to the land. The geological matrix served always as a substrate for it.

The history of the development of the lithogenic basement and life presents itself as a chain of complicated processes of a tight, multiform and continuous interaction and interconnection between biotic and abiotic matter. After being died, bio-organisms have been and are forming now caustobioliths, organogenic limestones and some of siliceous rocks. The bio-organisms through the physiological activity of some of their biological communities participated in formation of many types of other rocks, accumulations of iron, manganese, copper, and many useful mineral compounds. Simultaneously with this, the biological forms were undertaking an ever growing complexity and improvement; they were becoming more diversified, and more adjustable to the conditions of staying in various thermodynamic zones of the lithosphere, and in all geographical points of the Planet. It was established, for example, that some forms of bacteria and microorganisms are able to exist in the subsurface (in particular, in the conditions of oil- and gas accumulation) at temperature up to +80°C; germinative spores and plant pollens can survive at negative temperatures in permafrost for millions of years.

According to V.I.Vernadsky's evaluations, the total biotic-matter mass of the Earth remained constant during the entire Phanerozoic period, with an

ever growing role for biotic organisms in the lithosphere evolution at the same time. It may be supposed that this process was accompanied by the formation of an abundance of various ecosystems, making its own "contribution" to evolutionary processes in the Earth's geological cover.

So study an ecosystem one should take a functionally unified and mutually dependent totality of vegetative and live organisms, the reproduction and destruction of which is regulated by the internal equilibrium laws of biological communities participating in the building of the this totality. It follows from this that the ecosystem is a basic functional unit of the planetary cycle of life. In essence, the concept "ecosystem" is close (though wider in interpretation) to another concept, " biocenosis", used in the biological literature. In this book we will also mean by the concept "biogeocenosis" a community of functionally interconnected vegetative and animal organisms and their habitats (landscapes, top soils, surface and ground waters, rocks, geophysical and geochemical fields), homogenous by topographical, soil, hydrologic, micro-climatic and other conditions.

The biotic organisms (from microscopic to large forms) through interacting with the basis of their existence (rock minerals, groundwater, gases etc), perform a big geochemical "job" on transformation, accumulation and dispersion of the earth crust's matter, leading to a change in the initial rock properties.

In turn, the evolutionary processes of the geological environment cause changes in the conditions of ecosystems' functioning, helping, thus, their development-adjustment to new P-T and Ph-Eh conditions or, in case of sharp changes in the life activity's conditions, destructively affecting the steady forms of the biological communities' existence. A direct sequence of large changes in the geoenvironmental state may be a deterioration or aggravation (up to the complete decay) in the functioning conditions of the earlier formed ecosystems.

It follows from the above-stated that the litho-mineral matrix of rocks, being at the same time a basis for habitats' formation, "nutrient" material for many biological forms, and, very often, a carrier of "field atmosphere" where biotic organisms are functioning, serves to be the most important factor which determines a direction and intensity of developing life activity's processes.

An impact of geological processes upon the ecosystems is especially acute while catastrophic scenarios of the geoenvironment develop. First of all, most notable is this impact on man and the ecosystems' elements related to him.

In particular, in the long chain of destructive geological processes, the most dangerous (by rapidity, areas of affectedness and scales of human and

material losses) role belongs to earthquakes and tsunami accompanied actually by instant and terribly devastative acts.

According to the data of the Scientific Board of Japan (1989), only in the 20th century were the highest share of catastrophic events of the above-mentioned type of natural disasters and amounted to 50.9 % of their total number.

The presently available statistical information does not give sufficiently unambiguous estimates of the impact of seismic catastrophes upon ecosystems and human society. However, it follows from comparing the estimates reported (World Conference on Mitigation of Natural Disasters Hazard, 1994; Despande, 1987; Zschau, 1996) that the human victims of all the earthquakes that happened in the world in the 20th century amounted to about 3.5 mln.persons.

It is enough to mention only some of the strongest earthquakes of the 20th century, which turned large areas into fully ruined zones and killed thousands of people: Tan-Shan, 1923 (200,000 persons): Ashkhabad, 1948 (100,000); Spitak, 1988 (25,000); Rudbar-Tarom, 1990 (45,000). The scales of material losses and total economic damage from some particular seismic events are depressive. Thus, the economic losses from the earthquakes in Managua (23.12.1972) were twice higher than the value of the national gross output in this country; the earthquakes in Honduras (04.02.1976) and Salvador (10.10.1986) have brought economic damages in these countries equal to 32 % and 27 % of their national gross outputs, respectively (Energy and mineral potential of the Central American-Caribean region, 1989).

Environmentally severe consequences accompany various catastrophic phenomena of volcanic origin.

Not speaking about such historically known catastrophes of the above type as Pompeya and Herculanum, one should mention relatively recent events (August,1986) on the crater Lake Nyos located within the so-called "Cameroun volcanic zone" when as the result of a sudden outburst of huge amounts of carbon dioxide, 1746 persons and many wild and domestic animals died from asphyxia. A similar catastrophe but with a lower level of victimization (37 persons) happened near another crater, lake Monoun in 1984 in Cameroun (G.W.Kling, M.Kusakabe et al., 1990; Sigurdsson et al, 1987).

It is quite obvious that such extreme manifestations of the geoenvironmental evolutions are followed also by a rather considerable change in the ecosystem's balance in a region subjected to a natural cataclysm.

While not so notable no such dramatic events, nevertheless, mass impacts on the ecosystems are exerted by the phenomena that follow from the normal

activity of geophysical and geochemical processes in the geological environment.

In particular, with geodynamic processes' activization, seismic events are usually preceded by anomalous changes or an increase in the concentrations of different chemical compounds penetrating from the subsurface in liquid or gaseous state. Besides, prior to seismic events, one observes considerable variations of different geophysical fields exerting an adverse influence both on some individual persons and whole groups of population. The joint impact of all these factors on society can cause psycho-biochemical (biophysical) pre-conditions for formation of a collective reaction of aggression, apathy, fear, etc., leading, in turn, to destructive social acts.

The most dangerous types of such natural "poisoning" of man are those among the naturally existing impacts which, though not manifesting themselves openly, at the same time through a long micro-influence on the human organism, lead to impalpable, but socially hazardous modifications in the behaviour of large groups of people.

That is, in some cases, phases of the social agitation (or non-standard behaviour) can turn out to be derivative elements of the geobiophysical anomalies being periodically generated in nature (Vartanyan, 1997).

Taking into consideration the above-listed statements, Caesar Voute, after having fulfilled the multi-year historical-archeological and ethnographic investigations in the area of the religious construction Borobadur (Central Java) spoke his opinion on a possible influence of geophysical (atmo-geochemical) anomalies upon society during the preparatory periods of the catastrophic earthquakes of 925-1006 (Society and Culture of Southeast Asia. Continuities and Changes, 2000).

It was established by researchers that during the period prior to a series of destructive earthquakes on Java Island, sudden and logically unexplainable (by all other reasons) exodus of the political and religious circles of the Hindu Buddhist Java State happened from the highly habitable and comfortable part of Central Java. The circumstances, established by the investigations, gave grounds to suppose that the motivation of such mass departure could be initiated and governed by tiny mechanisms of psycho-geophysical-geochemical links between "abiotic" (geological) and biotic matter, that have a new impulse due to activization of geodynamic life in the Earth's interior.

It follows from the above-stated that the investigations of fine mechanisms and intensity of an impact upon society from different deformation-geodynamic, physico-chemical anomalies and the related geophysical field effects is becoming an important problem.

Changes in the geological environment exert the most influence upon the biological component during an intensive anthropogenic impact on rocks and

fluids contained in them. In particular, hydrotechnical construction, connected, as a rule, with a change in the groundwater natural regime, causes either draining and actually complete dewatering of earlier fertile lands with degradation of soils and vegetation or, vice versa, a rise of water level to the earth surface and swamping of large territories.

Thus, for example, the works on regional draining of the swamped territories in Belorussia (including withdrawal of large groundwater amounts), where has existed a stable ecosystem, containing sphagnum moss and the related vegetative and biological communities, led to destruction of a considerable number of swamps and their biological components, degradation of vegetation, top soil. As a result, it brought and harm to natatorial birds' breeding sites, beavers' colonies, and forced other larger animals to migrate out of those areas. That is, the above mentioned engineering actions affecting the geological objects have destroyed the natural chain in the ecosystem formed there.

In turn, the disturbance in the thermal and moisture balance of the atmosphere over these rock massifs has led to appearance of an earlier unknown (in these regions) phenomenon of "black storms" – a factor deteriorating considerably the human habitat conditions.

The cascade of water storage reservoirs constructed on the Don and Dnepr rivers and the system of navigable canals connecting them have sharply changed the basis of groundwater draining within a large territory and led to a water level rise to the earth surface. Due to this, basement spaces in the buildings, outdoor washrooms and other sanitary engineering constructions turned out to be flooded actually over the entire southern part of Russia and in Ukraine (namely, in Rostov and Dnepropetrovsk Regions). In many cases the basement spaces had high concentrations of dangerous gases, including radon.

It is important to note that the above-mentioned adverse effect has manifested itself 20-25 years later after completion of the water storage reservoirs construction. This period was needed for the system of held-up aquifers to get adjusted to the anthropogenically formed draining conditions and therewith induced rise of the groundwater level everywhere in the region. In the practice of large-scaled constructive works accompanied by creation of mine working-outs, there are known cases of a disturbance in the natural regime of groundwater aquifers supplying large water intakes or municipal and resort establishments.

Thus, in Tbilisi – the Capital of Georgia – which is famous for its therms (in Georgian language, "tbili" means warm; "isi" – a lake), the thermal hydrogen-sulphide groundwaters, since long served as a hydro-mineral basis first for public baths in the city and since the 1930s – for resort-curative purposes), were drained for construction of the subway.

The consequent hydrogeological works, carried out to restore the curative thermal water resources in the city, have solved the problem only partially: the yields and especially qualitative characteristics of the groundwater (i.e. temperature, H_2S content) became lower than the earlier ones. At the same time, some of the subway stations have, in spite of intensive ventilation, a persistent smell of hydrogen sulphide, which points to serious, though not yet reaching toxic levels, H_2S concentrations in the air. It is quite obvious that one should speak in the given case about the uncomfortable conditions for passengers and, especially, for the subway employees who have to be in the hydrogen sulphide-polluted atmosphere for a long time.

The above-listed examples are far from covering all the possible variants of an interaction between biotic and abiotic matter (i.e. ecosystems and the geological environment) and are discussed in this chapter to demonstrate a rather wide variety of forms and scales of reaction of live matter to an action of the surrounding medium: from mass psycho-physical consequences in a scale of the socium to discomfortable habitat conditions in concrete geometric spaces; from destruction of the earlier-formed ecosystems to their modifications and so on.

It should be outlined as a result of the above short discussion of the problem that the world practice of the recent 40-50 years enabled us to collect a great amount of information on the high dependence of biological communities on the processes occurring in the Earth's interior. At the same time, this information needs a thorough analysis in order to assess the role of particular geological factors and a degree of their influence upon the life cycles by obtaining reliable qualitative characteristics and the related subsequent ecologo-geological conclusions.

Due to the above-stated, the necessity appears to create a special apparatus of scientific research using both the methods and technology of modern geological science, physics, chemistry, and the techniques of solving the problems of the medical-biological cycle.

It is obvious that in this case it will be required to form teams consisting of specialists of different disciplines, but working on the same scientific problem "Regularities of the interaction between ecosystems and the geological environment – mechanisms of modifications and evolution, intensities, rates".