

SCIENTIFIC THOUGHT AS A GEOLOGICAL FORCE IN THE BIOSPHERE: -- V.I. Vernadsky (1938)

Chapter 1 (selected excerpts)

Man and mankind in the biosphere as a regular part of its living matter and its organization. Physical chemical and geometrical heterogeneity of the biosphere: the radical difference in organization (with respect to matter and energy as well as to time) between its living and inert matter. Evolution of species and evolution of the biosphere. Manifestation of a new geological force in the biosphere – that of the scientific thought of social humanity. This manifestation is related to the glacial period we are going through with one special geological phenomenon among many phenomenon recurrent in the history of our planet, which, as to their causes, are outside the Earth's crust.

1. Like all living [organisms], man is not a self-sufficing natural object, independent from the environment. However, nowadays, even naturalists do not take this into account while contrasting man, and living organisms in general, to their environment. As for contemporary scientists, the indissolubility of a living organism and its environment is unquestionable. It represents the starting point for the biogeochemist who aims at the understanding, expressing, and fixing of this functional dependence. For the most part, philosophers and modern philosophy do not take into consideration this functional dependence – of man as a natural object, and mankind as a natural phenomenon, upon the environment where they live and think...
2. The concept of life and living is clear to us in our daily round, and never raises a scientifically serious doubt, in terms of its real manifestations a the corresponding natural objects. It is only in our century, after the filterable viruses have been discovered, that science has obtained facts making us for the first time ask seriously, scientifically and not philosophically, whether we deal with a living natural matter of with an inert abiotic one [i.e. is the natural matter we are surrounded with actually inert, abiotic, or might the matter be living? – MLO]. With reference to viruses, the doubt is caused by scientific observation, and not by a philosophical idea. This is wherein the greatest scientific meaning of virology consists. This discipline is today on the right track. The doubt will be solved in the future and will lead to nothing but a more exact concept of *a living organism*...

To avoid any misunderstanding, in the future I shall refrain from using the terms “life”, “living”. For should we proceed from such concepts, we would go far beyond the limits of the life phenomena as studied by science, and into the field of philosophy, or into a new field of new manifestations of matter and energy common to all natural bodies of the biosphere. This new field far exceeds the boundaries of the topic which interests us now, that is of the main problem of the living organism and living matter.

Thus I shall avoid the terms and concepts “life” and “living” and narrow my research area to the ideas of “*the living natural body*” and *living matter*”. Every living organism in *the*

biosphere is a living natural body *The living matter of the biosphere is the totality of the living organisms inhabiting it.*

3. Man, as any other living natural body, is inseparably linked to a certain geological envelope of our planet, with the biosphere noticeable differing from its other envelopes. The structure of the biosphere is defined by its peculiar *state of organization*...

Organization is not a mechanism. It is clearly distinct from a mechanism in its being always in the process of formation; the smallest matter and energy particles involved in it incessantly move. With respect to time (in the generalizations of mechanics and in a simplified model) we may define the organization by that none of its points (either material or energetic) returns regularly: none of them ever returns to the same biosphere point where it once had been. Such return may only occur as a result of contingency of a very small probability...

There is an unceasing exchange of matter and energy between the abiotic, inert part of the biosphere, its inert natural bodies, and the living matter populating it. The matter exchange is implemented through the atomic movement caused by the living matter. In the course of time, this exchange manifests itself by the regularly shifting *equilibrium*, ever striving for stability. It permeates the whole biosphere, and this *biogenic flow of atoms* creates the latter, to a significant degree. In this way, during all geological time, the biosphere remains inseparably and continuously linked to the living matter which populates it...

4. *The organized state* of the biosphere, of the organization of the living matter, must be viewed as a dynamic equilibrium oscillating about an average distinctly expressed in both historical and geological time. Displacements or oscillations of the average itself are continuously manifested in geological time, not in historical. During geological time, in the circular processes characteristic of biogeochemical organization, no point (be that atom or chemical element) ever returns in aeons of centuries identically to its previous position.

This salient feature of the biosphere has been strikingly and dramatically expressed by Leibnitz (1646-1716) in one of his philosophical discourses, his *Theodicy*. He recollects there how, in the late 17th century, he was taking a walk in a large garden, in the company of high society persons. Having spoken about the infinite diversity of nature and about the infinite efficiency of mind, Leibnitz indicated that one never finds two leaves of a tree of herd that would be fully identical with one another. Of course, all attempts of this numerous company to find identical leaves remained futile...

In everyday life, one may see the same nonidentity phenomenon in *personality*: there cannot exist two identical individualities indistinguishable from one another. In biology, the same phenomenon may be derived from the *chemical distinction* of any average *individual* of living matter from other ones. Both in its chemical combinations, and,

evidently, in its chemical elements each individual possesses certain peculiar features of its own.

5. *Physical-chemical and geometrical heterogeneity* is extremely characteristic of the structure of the *biosphere*. The latter consists of living and inert matter, which, in the course of geological time, remain clearly distinct in the genesis and structure. Living organisms, i.e. the whole of living matter, originate from living matter, and in the course of time form generations that never emerge directly from any abiotic matter of the planet outside another similar living organism. Still, there is an incessant, never interrupted connections between the inert and living matter. This connection is characterized as a continuous biogenic flow of atoms from the living matter into the inert matter of the biosphere, and back again. This biogenic flow of atoms is called forth by the living matter and evidenced by the never ceasing processes of breath, nutrition, reproduction, etc.

In the biosphere, this continuous heterogeneity of its structure, lasting throughout the entirety of geological time, is the main prevailing factor sharply distinguishing it from all other envelopes of the planet.

The heterogeneity penetrates, deeper than the phenomena studied by the natural sciences, into such properties of space and time to which scientific thought approaches only in our times, in the 20th century.

Living matter embraces all the biosphere, creates and changes it, while with respect to weight and volume, makes up but a small portion of it. The abiotic inert matter prevails. With respect to volume, the rarified gasses predominate; with respect to weight, the solid rocks, and to a lesser degree, the saline water of the world ocean.

Living matter, even in its greatest concentrations in exceptional cases, and in minor parts of the biosphere, does not constitute more than several tens percent of the volume of matter in the biosphere. As to weight, living matter averages from one to two hundredth of one percent. However, geologically, it is the greatest force in the biosphere, and determines, as we shall see all processes in the biosphere, developing huge free energy and generating the main geologically evident force in the biosphere. We cannot yet measure this force quantitatively, but, perhaps, it exceeds the force of any other geological phenomena in the biosphere...

6. In the biosphere, apart from living and abiotic natural bodies, a great part is played by their regular structures, by heterogeneous natural bodies, for example, soils, silt, surface water, the biosphere itself, etc.; they are constituted by living and abiotic natural bodies forming complicated living/abiotic structures. I shall call these complicated natural bodies "*living-abiotic natural bodies*". The biosphere itself is a complex planetary living-abiotic natural body. As we shall see, the distinction between living and abiotic natural bodies is so great that in the Earth processes one never observes a transition of one of these categories into another...

7. In living matter, processes take place at a *historical time* scale; in abiotic matter, at a *geological time* scale, whose "second is some amount less than a decamiriade (100 thousand years of historical time)...

Up until recently, geology was dominated by an idea that geologists cannot recognize the manifestations of slow geological changes that had taken place during the epoch of man's existence, one learned and thought that, as a rule, the climate, mountain structures, the species of organisms do not change in the course of a geological study, are not *current affairs* for a geologist. Now this ideological situation has changed abruptly, and we see the action of geological forces more clearly and intensely. It is hardly and accident that this change coincided with the growth in scientific consciousness of the belief in the geological significance of *Homo sapiens*: the discovery of a new biospheric state, the noosphere, one of the forms in which this state expresses itself.

The sharply distinct manifestations of the living and inert features in the biosphere, in their temporal aspect, though important, serve a peculiar expression of a much more general phenomenon which is reflected in the biosphere at every step.

8. The living matter of the biosphere is sharply distinct from its abiotic matter in two main processes of great geological importance which give a very peculiar appearance to the biosphere, non-existing in any other planetary envelope. Both processes solely manifest themselves against the background of geological time. They may cease sometimes but they never take a reverse course.

First of all, with geological time *the power of the revelation of living matter in the biosphere increases*. The importance of living matter in the biosphere and its influence on other living matter become more significant. This process has still received but little attention. Further, I shall deal with it all the time.

Much more attention was paid to another process, which was much more studied, widely known and most deeply imprinted of the entirety of scientific thought of the 19th and 20th centuries. This is the process of *species evolution* in the course of geological time: the process of radical changes of the living natural bodies themselves.

It is only in living matter that we observe a sharp change of the natural bodies themselves in the course of geological time...

Living nature is plastic. It alters, gets adjusted to environmental changes, but has its own evolutionary process as well, manifesting itself in changes happening on the geological time scale. This is evidenced by an incessant and intermittent growth of the central nervous system of animals in the course of biological time...

We observe a phenomenon common for all living matter: the *plastic evolutionary* process which is completely absent in the inert natural bodies. For the latter, we see *now* the same minerals, the same processes of their formation, the same rocks, etc, that were *two billion years ago...*

Owing to the species evolution which proceeds incessantly and never stops, the reflection of living matter into the environment changes abruptly. Because of it, the process of evolution (alteration) is transferred over the natural bio-inert and biogenic bodies playing the most important part in the biosphere; among them are such bodies as soils, surface and ground water (seas, lakes, rivers, etc.) coal, bitumens, limestones, organogenic ores etc... This is an area of new phenomena hardly taken into account by scientific thought. *The evolution of species turns into the evolution of the biosphere.*

The evolutionary process acquires a special geological significance because **it has created a new geological force: the scientific thought of social humanity.** Now we witness its manifest entering the geological history of our planet. During the recent millennia, one observes the intense growth of influence of the living matter of one species (civilized humanity) upon the shifting the biosphere condition. Under the action of scientific thought and human labor, the biosphere goes over to a new state - to *the Noosphere.*

Due to regular movement which has lasted from one- to two- million years (at a rate constantly accelerating in its manifestations), humanity has embraced the whole planet and becomes separated from the other living organisms as a new and unprecedented geological force. In this way, at a rate comparable to that of reproduction, which is expressed by a geometric progression with time, an incessantly growing set of new (for the biosphere) inert natural bodies and new great natural phenomena is created in the biosphere.

Before our eyes, the biosphere changes sharply. And there can hardly be any doubt that its reconstruction (which is being manifested in this way by scientific thought, through organized human labor) is not an occasional phenomenon depending upon the will of man, but an elementary *natural process* whose roots are deep and were prepared by an evolutionary process which has lasted for hundreds of millions of years.

When man is guided by a scientific concept of the world, he ought to understand that *he is not as incidental* freely acting natural phenomenon, *independent from the surrounding world*, the biosphere or the Noosphere. He is an inevitable manifestation of a great natural process having lasted in a regular way for at least two billion years...

9. This process is tied up with the origin of the human brain. In science history, this process was discovered (in the form of an empiric generalization) by the profound American naturalist, eminent geologist, paleontologist, and mineralogist, J.D. Dana (1813-1895), in New Haven. He published his conclusions as long as 80 years ago. Strangely enough, this

generalization still remains unrealized and rather forgotten. It was not appropriately developed...

Putting it in the current scientific language, Dana has notes that in the course of geological time, a certain part of the planet's inhabitants acquire more and more perfect (as compared to the earlier stages) central nervous apparatus – the brain. Dana called this process *encephelosis*. It never turns back, though repeatedly stops, sometimes for millions of years. Therefore, this process manifests itself through the polar time vector whose direction never changes. We shall see that the geometrical state of the space occupied by living matter is characterized just by the polar vectors, and there is no place for straight lines...

10. We must note and take into account that the process of the evolution of the biosphere and its transformation into the *Noosphere*, clearly reveals the acceleration of the rate of geological processes. The earlier history of the biosphere did not know such changes as those having taken place in the biosphere during the past few *thousand years* in connection with the growth of scientific thought and social activities of humanity...
11. One may give a picture of the evolution of the biosphere beginning from the Algonkian, more clearly from the Cambrian, during 500-800 million years. More than once has the biosphere turned into a new evolutionary state; new geological manifestations, never having existed before, emerged. For example, in the Cambrian, when large organisms with calcareous skeletons originated, or in the Tertiary (or perhaps the Late Cretaceous), 15-18 million years ago, when our forests and steppes were formed and when big mammals came into existence. We are living now (during the past 10-20 thousand years) in an analogous period, when man, having elaborated scientific thought in his social environment, creates a new geological force in the biosphere, previously absent there. The biosphere has turned (or rather is turning) into *a new evolutionary state – the Noosphere*—is being converted by the scientific thought of social mankind.
12. [This is a section on the discoveries by P. Curie and Louis Pasteur respecting the phenomenon of so-called “dissymmetry” in living organisms, in which Vernadsky begins to discuss his hypothesis of the “special *space state*” occupied by the bodies of living organisms, a space which he states “does not correspond to Euclidean space, but corresponds to one form of Riemannian space”, in his words. He also includes two very interesting footnotes, one which refers to Gauss, and one which refers to Einstein.]
13. ...The progress of scientific thought, for example, in the creation of machines, is completely analogous to the course of the reproduction of organisms... The growth of scientific thought, closely tied up with the growth of the peopling of the biosphere by man, through his reproduction and his breeding of living matter in the biosphere, is necessarily restricted by the environment, alien to the living matter, and exert a stress upon it. For this growth is tied

up in with the quantity of the rapidly growing mass of the living matter [who are] participating (directly or indirectly) in scientific work.

This growth and the involved stresses constantly increase because this work includes the action of many man-created machines, whose multiplication in the Noosphere is governed by the same laws and the reproductions of living matter itself, i.e. this growth may be described by a geometrical progression.

Like the reproduction of organisms manifests itself through the pressure of the living matter on the biosphere, the geological manifestations of scientific thought exert (by the tools it creates) a pressure upon the inert and restrictive (for thought) biosphere environment. Thus the Noosphere, the realm of reason, is created.

The history of scientific thought, scientific knowledge, and its historic development reveals itself in a new aspect, previously not recognized. This history ought not to be considered solely as a history of a humanitarian science, at the same time it is the *history of the creation of a new geological force in the biosphere – the force of scientific thought*, something not available earlier in the biosphere. This is the history of the manifestation of a new geological factor, a new expression of the organized state of the biosphere. This factor has formed spontaneously, as a natural phenomenon, during the past several tens of thousand of years. This history is not fortuitous, like any natural phenomenon, it is regular, like the course of the time-dependent paleontological process, which has created the brain of *Homo sapiens* and the social environment where, consequently, scientific thought, this new geological and consciously directed force is being created.

SOME WORDS ABOUT THE NOÖSPHERE (excerpts) –V. I Vernadsky (1943)

...Man, under our very eyes, is becoming a mighty and ever-growing geological force. This geological force was formed quite imperceptibly over a long period of time. A change in man's position on our planet (his material position first of all) coincided with it. In the 20th Century, man, for the first time in the history of the Earth, knew and embraced the whole biosphere, completed the geographic map of the planet Earth, and colonized its whole surface. *Mankind became a single totality in the life of the Earth.* There is no spot on Earth where man can not live if he so desires. Our people's sojourn on the floating ice of the North Pole in 1937-1938 has proved this clearly. At the same time, owing to the mighty techniques and successes of scientific thought, radio and television, man is able to speak instantly to anyone he wishes at any point on our planet. Transportation by air has reached a speed of several hundred kilometers per hour, and has not reached its maximum. All this is the result of "cephalization," the growth of man's brain and the work directed by his brain.

... If a square meter were assigned to each man, and if all men were put close to one another, they would not occupy the area of even the small Lake of Constance between the borders of Bavaria and Switzerland. The remainder of the Earth's surface would remain empty of man. Thus the whole of mankind put together represents an insignificant mass of the planet's matter. Its strength is derived not from its matter, but from its brain. If man understands this, and does not use his brain and his work for self-destruction, an immense future is open before him in the geological history of the biosphere

The geological evolutionary process shows the biological unity and equality of all men, *Homo sapiens* and his ancestors, *Sinanthropus* and others; their progeny in the mixed white, red, yellow, and black races evolves ceaselessly in innumerable generations.¹⁷ This is a *law of nature*. All the races are able to interbreed and produce fertile offspring. In a historical contest, as for instance in a war of such magnitude as the present one, he finally wins who follows that law. One cannot oppose with impunity the principle of the unity of all men as a law of nature. I use here the phrase "law of nature" as this term is used more and more in the physical and chemical sciences, in the sense of an empirical generalization established with precision.

The historical process is being radically changed under our very eyes. For the first time in the history of mankind the interests of the masses on the one hand, and the free thought of individuals on the other, determine the course of life of mankind and provide standards for mere ideas of justice. Mankind taken as a whole is becoming a mighty geological force. There arises the problem of the *reconstruction of the biosphere in the interests of freely thinking humanity as a single totality*. This new state of the biosphere, which we approach without our noticing, is the *Noösphere*...

The Noösphere is a new geological phenomenon on our planet. In it, for the first time, man becomes a *large-scale geological force*. He can, and must, rebuild the province of his life by his work and thought, rebuild it radically in comparison with the past. Wider and

wider creative possibilities open before him. It may be that the generation of our grandchildren will approach their blossoming.

Here a new riddle has arisen before us. *Thought is not a form of energy*. How then can it change material processes? That question has not as yet been solved. As far as I know, it was first posed by an American scientist born in Lvov, the mathematician and biophysicist Alfred Lotka. But he was unable to solve it...

As for the coming of the Noösphere, we see around us at every step the empirical results of that “incomprehensible” process. That mineralogical rarity, native iron, is now being produced by the billions of tons. Native aluminum, which never before existed on our planet, is now produced in any quantity. The same is true with regard to the countless number of artificial chemical combinations (biogenic “cultural” minerals) newly created on our planet. The number of such artificial minerals is constantly increasing. All of the *strategic raw materials* belong here. Chemically, the face of our planet, the biosphere, is being sharply changed by man, consciously, and even more so, unconsciously. The aerial envelope of the land as well as all its natural waters are changed both physically and chemically by man. In the 20th Century, as a result of the growth of human civilization, the seas and the parts of the oceans closest to shore become changed more and more markedly... Besides this, new species and races of animals and plants are being created by man. Fairy tale dreams appear possible in the future; man is striving to emerge beyond the boundaries of his planet into cosmic space. And he probably will do so....

The Noösphere is the last of many stages in the evolution of the biosphere in geological history. The course of this evolution only begins to become clear to us through a study of some of the aspects of the biosphere’s geological past. Let me cite a few examples, Five hundred million years ago, in the Cambrian geological era, skeletal formations of animals, rich in calcium, appeared for the first time in the biosphere; those of plants appeared over 2 billion years ago. That calcium function of living matter, now powerfully developed, was one of the most important evolutionary factors in the geological change of the biosphere.²² A no less important change in the biosphere occurred from 70 to 110 million years ago, at the time of the Cretaceous system, and especially during the Tertiary. It was in that epoch that our green forests, which we cherish so much, were formed for the first time. This is another great evolutionary stadium, analogous to the Noösphere. It was probably in these forests that man appeared around 15 or 20 million years ago.

Now we live in the period of a new geological evolutionary change in the biosphere. We are entering the Noösphere. This new elemental geological process is taking place at a stormy time, in the epoch of a destructive world war. But the important fact is that our democratic ideals are in tune with the elemental geological processes, with the law of nature, and with the Noösphere. Therefore we may face the future with confidence. It is in our hands. We will not let it go.