

## Vladimir Ivanovich Vernadsky Originator of the Biosphere Concept\*

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Vladimir Ivanovich VERNADSKY (1863-1945) is one of the most eminent investigators of the Earth and Life. The Earth is an object of geology, geography, geophysics, geochemistry and of many other branches of science. Similarly Life is an object of biology with all its branches. V.I.VERNADSKY did not simply sum Earth and Life knowledge, but elaborated very compact integrative concept with **chemical interaction** of Earth and Life, and their **interface** became the central problem.

Before the communistic upheaval he was a professor of mineralogy and crystallography of Moscow University. During the next years his interests shifted to Geochemistry, Radio-geochemistry, Biogeochemistry, History of Natural Science. In 1912 he became a member of the Russian Academy of Sciences, and in 1919 the first President of the Ukrainian Academy of Science. VERNADSKY founded several new scientific laboratories and institutions. However, from 1936 and up to his death he was honoured not so much in official scientific circles, but mostly among freely thinking scientific "dissidents". For many years his name was not mentioned by officials of the Academy of Sciences of USSR; some of his ideas and works., especially in philosophy of science were proclaimed as false and covered by silence.

The reason for ignorance is obvious: V.I. VERNADSKY was an outstanding Thinker so broad, so deep and interdisciplinary minded, so independent in philosophical imagination of the World Ocean, Terra, Wild Life and Life of Mankind in their interaction (while communists sup-



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pose themselves to be the best experts of Mankind and even Life), that he did not correspond to narrow limits posed on science by party ideologists. And on the contrary, his mentality was familiar to many, ignoring traditional scientific boundaries and looking ahead.

Beginning from 1965, long before the GORBACHEV's "Perestroika", when some of ideological dogmas were rejected, the Academy of Sciences of USSR revised former partial ignorance of VERNADSKY, his main works were republished (VERNADSKY, 1965;1988), some of them published for the first time. His treatise "Biosphere" is the most well known and was translated into some languages (VERNADSKY, 1926).

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Vladimir Ivanovich VERNADSKY (1863-1945)

In a short paper it is impossible to give a review of all of VERNADSKY's fundamental ideas. Also I do not wish to present him as a giant of Science History. Much more significant to every working in natural science is that he is really a giant of **Contemporary Science**.

However, not only by communistic ideologists, even by many biologists and ecologists, the main VERNADSKY's ideas were not accepted and used broadly.

Which of V.I. VERNADSKY's ideas, concerning Life on the Land and in the Oceans, may be considered as "the main"? And why was his concept of Life on the Earth not accepted in its fullness (but at the same time was not disproved; a strange situation)?

1. First stumbling block was his central idea of "living matter" (VERNADSKY, 1978). As an Earth scientist he was a geochemist dealing with

chemical transformations and mass transfer mediated by organisms (biogeochemistry). It is the term "living matter", used by him ordinarily, that became a first source of misunderstanding of his ideas by many biologists and (surprising!) even by some ecologists.

For most biologists the main objects to be investigated and described in all details are the definite individuals and biological species, not the indefinite "living matter". The term "living matter" means (biologists suppose) that all the details of species and individuals are ignored by VERNADSKY (biologists: "the details of individuals and species are insignificant? ..... It is impermissible!"). That is why the term "living matter" became odious to many. Being unable to accept the term they did not accept the basis of the biogeochemical approach as such.

However, the meaning of this term did not contradict through and detailed biological

investigations. VERNADSKY holds correctly that the main biogeochemical functions of any group of organisms. i. e., **the flows, the fluxes of matter**, are influence by the organisms ("Living Vortex" according to VERNADSKY and "Tourbillon Vitale" according to CUVIER) may be described without mentioning the many traits of different species and sometime irrespective of species name.

"Irrespective of species name" (?) was unacceptable to many biologists, because they were educated in classical traditions.

Clearly in the first part of the twentieth century the fluxes of matter in natural environments were not so interesting to biologists and did not seem significant for mankind. They only are at the end of this century, when the fluxes of many atoms and complex natural compounds changed dramatically as a result of total human activity in biosphere. And it is just now that biogeochemical thinking became essential for the security of mankind itself.

2. Dealing with "living matter", VERNADSKY looks first of all as a physicist not in the term of organisms, species and societies (as biologists do), but in the term of "particles", biological "dispersion", "patches of particles", and "layeres". As a biogeochemist he realized that in all, especially in lower organisms, nutrients penetrate the body via their surface area. And the less their body size, the more their relative surface area ( $S/V$ , where  $S$  is the surface area,  $V$  is the volume of the body). And the most intensive is chemical exchange between the smallest organisms and surrounding water.

That is why VERNADSKY is interested first of all in size distribution in aquatic life, especially in oceans: "biological particles" there were the smallest in size, the greatest in numbers and, as we know now, organized in patches and layers. It is not surprising, therefore, that oceanographers were the first who began to use size spectra for the description of marine biota. Really, they follow VERNADSKY's ideology without any mentioning of his name and often are even unfamiliar with his work. By means of size spectra, interesting comparison of destructive biogeochemical functions in Earth's biota, including mankind, was given (GORSHKOV, 1990)

as soon as comparison of different marine and freshwater basins (for instance, Black Sea, Ribinsk reservoir and some man-made aquatic systems [KAMENIR, 1993]).

3. Dealing with organized life on the Earth, VERNADSKY asked himself: What is the main object of early Life from the biogeochemical point of view? The answer given by biologists (organisms and species are the main) did not satisfy VERNADSKY. For the biogeochemist the interaction between living (biotic) and dead (abiotic) matter was the basic event, the main process in Life. That is why "bio-abiotic bodies" ("bio-abiotic systems" in recent terms) became the central objects in VERNADSKY's concept of Life on the Earth. Any ocean with all its biota, any sea or lake with all its biota, and even any living body (the most of which is abiotic matter—the water) are "bio-abiotic systems". Quantitative comparison of these systems, so different in external appearance, supports the idea of fundamental biogeochemical similarity in them (KHAILOV and SILKIN, 1986).

Interestingly, recently limnologists and oceanographers describe living and dead particles and even the lakes and seas in their series in form of size spectra (KHAILOV and SILKIN, 1986; SCHWINGHAMMER, 1981), or with allometries. By these means they follow behind VERNADSKY, exactly as do biologists, when they use allometries for the description of size series of organisms. The same methodology was used recently for the description of phytoplankton patch size series (SUZUKI and SEKI, 1988). Such broad comparison corresponds exactly to the idea of "living matter". Size spectra and allometric analysis did not contradict obvious external differences between dead suspended particles, living organisms, lakes and oceans. Even more: the numerical quotients of allometric equations for the above mentioned objects reflect clearly all their specificity as well as general similarity.

4. If Life on the Earth is organized in bio-abiotic systems of different levels of organization from the living cell to the biosphere, then all these systems have their specific ("private")

**living space.** And this space must be organized by life and as life itself. Strangely, biologists investigate external and internal structure of the organisms, but do not investigate in term of living space (volume and subvolumes). Space and time in natural systems—one more problem posed V.I. VERNADSKY—did not affect the minds of his contemporaries. The problem is open for future Science.

VERNADSKY's ideas mentioned above are part of scientific paradigms other than the classical one. Classical, species-centric image of Life on the Earth puts Life ahead of abiotic parts, emphasizing the "living". The species-centric concept corresponds to that state of mankind and biosphere, when environments were relatively clean and safe. Then organisms and species may be regarded as the main natural objects. The recent state of mankind and biosphere is extremely polluted and unsafe. Therefore another image of Life has become valuable. VERNADSKY did not put Life ahead of the abiotic parts of the Earth; he regarded both as of equal significance in the biosphere. In recent times, whole land regions, whole seas, oceans, big ecosystems became the main objects in science and in other human activities. My deep conviction is that the main ideas of V.I. VERNADSKY will be accepted broadly in the world and used for biosphere management, right at the beginning of the twenty first century.

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