

Geochemistry and the Biosphere / Essays by Vladimir I. Vernadsky

First English Translation from the 1967 Russian Edition of Selected Works
Santa Fe, NM: Synergetic Press, 2007

Book review by Ralph Abraham

1. INTRODUCTION

Since 1960 I have been lecturing and giving courses on dynamical systems theory and its applications in the sciences, with an emphasis on simulation of complex dynamical systems since 1974. Over these years I have built up a compendium of historical data on the many branches of whole systems mathematics as a matrix of websites for my students, and in support of my own writings. [Ref. 1]

So, when I accepted the task of writing a review of the Synergetic Press edition of Vernadsky essays, I turned to my websites for support, and was shocked to find that I had nothing on Vernadsky, and little on biospherics, in the matrix. This was particularly embarrassing as I regard the IE (Institute of Ecotechnics) group as part of my family, since meeting them in 1983 at their "Cosmos Conference" in France where (I believe) their famous Biosphere Two project was born. [Ref. 2] Of eight or so conferences on biospherics the IE has hosted since 1978 I had attended two, in 1984 and 1985. [Ref. 3] Furthermore, they had published "The Biosphere Catalogue" in 1985, which has been on my bookshelf every since. [Ref. 4] So I resolved to try to correct the situation by including in this review all that I can collect regarding the history of biospherics and Vernadsky, and how this history diffused into our cohort. Then I will conclude with a brief review of the Biosphere Essay. Throughout I have benefited from input from the IE, especially, from Mark Nelson.

2. THE HISTORY OF BIOSPHERICS

The best known nodes of the matrix of whole systems studies --- to which biospherics belongs --- are general systems theory and cybernetics. Here is a chronology of all the nodes I know, according to their dates of creation, as found in my website noted above, in which I have now inserted the events of biospherics in their proper places. [Ref. 5]

1785, Hutton (1726-1979), geophysiology [Ref. 6]

1802, Lamarck (1744-1829), Paris, the biosphere concept (realm of life) [V. p. 402]

1875, Suess (1831-1914), Vienna, the biosphere concept and word

1911, Vernadsky met Suess in Austria

1925, Lotka, physical biology

1926, Vernadsky, biosphere book
 1928, Von Bertalanffy, general systems theory
 1930s, Gestalt theory, berlin
 1948, Rashevsky, mathematical biology
 1942, Wiener, cybernetics
 1942-63, Macy conferences, cybernetics
 1950, Forrester, system dynamics
 1957, Waddington, theoretical biology
 1966-70, Serbelloni conferences, theoretical biology
 1968, Lovelock, Gaia hypothesis
 1976-80, IE Conference Series on the major Earth biomes
 1983, IE, Cosmos Conference
 1984, IE First Biosphere Conference, Oracle AZ
 (where I first saw Lovelock's simulation of Daisyworld)
 1985, Laszlo, general evolution theory
 1986, 1st closed system experiment at Space Biospheres Ventures
 1987, 1st Intl. Conference of Biospherics, Royal Society and October Gallery, London.
 Publication of Space Biospheres
 1989, 2nd Intl. Conference on Biospherics in Krasnoyarsk, Siberia
 (the name "biospherics" agreed)
 1991-93, Biosphere 2 experiment with Vernadsky's theory

Among the various whole systems theories, the one closest to biospherics is Gaia theory, which was not introduced until some twenty years or so after Vernadsky's death. Balandin (Vernadsky's biographer) gives some credit for the biosphere idea to Vernadsky's uncle, Yevgraf Korolenko. [Ref. 7]

Vernadsky visited Western Europe on several occasions, and even wrote Biosfera in Paris while teaching at the Sorbonne. He came to be known in the United States through the Introduction by G. E. Hutchinson to a special edition of Scientific American in 1969, and through the Man and the Biosphere (MAB) Programme of UNESCO. This program, launched in 1970, now manages a number of ecosystem or biosphere reserves. The IE was founded in 1973, held its first conference in 1974, and embraced biospherics early on. It started a series of conferences on major Earth biomes in 1976 which culminated in the Planet Earth conference in 1980 in France. The biomes covered including oceans, deserts, mountain (the conference in Kathmandu, Nepal in 1978), the jungle (rainforest) conference in Penang in 1979, and the Eco-transition Zones conference in Perth, Australia in 1980. Both the Kathmandu and Penang conferences were co-sponsored by the U.N. Man and the MAB Program.

3. ABOUT VERNADSKY

This chronology is an extract from the internet. [Ref. 8]

1863, born, Saint Petersburg

1885, graduated. Saint Petersburg University
 1890, moved to Moscow
 1897, PhD, Saint Petersburg University
 1911, met Suess, moved back to Saint Petersburg
 1918, moved to Kiev
 1919, moved to Simferopol
 1921, moved to Petrograd
 1922, moved to Paris, wrote *Biosfera*
 1924, Geochemistry published
 1926, moved to Leningrad
 1927, *Features of Geochemistry* published
 1933, wrote *Essays on Geochemistry*
 1935, moved to Moscow
 1941, moved to Kazakhstan
 1943, moved to Moscow
 1944, wrote the 3rd edn of *Biosfera*, *Some Words about the Noosphere* published
 1945, died, Moscow
 1967, 3rd edn *Biosfera* published, including *A Few Words about the Noosphere*

4. THE BIOSPHERE ESSAY

The book published in 2007 by Synergetic Press includes the *Essays on Geochemistry* and *The Biosphere*, both in the English translation by Olga Barash of the 1967 Russian edition of *Selected Works*. The *Essays on Geochemistry*, regarding the chemical elements in the Earth's crust, is a technical work outside my bailiwick -- and there is an excellent review [9] -- so I will confine my review to *The Biosphere*.

The Biosphere has three parts:

1. The biosphere in the cosmos (82 pages),
2. The domain of life (96 pages), and
3. A few words about the noosphere (13 pages).

The first two parts are divided into sections numbered consecutively from 1 to 160: the first part has sections 1 to 67, and the second part, sections 68 to 160. The third part has 13 sections, numbered 1 to 13. I proceed now in this section to give a little flavor of the content of the first two parts.

1. Biosphere [V. 1-67]

In the first part, Vernadsky discusses the biosphere as an interface between the physical planet and its cosmic environment. The emphasis is on the radiations arriving from space, their transformation by the living biosphere, and the role of the biosphere in determining the complex chemical composition of the Earth's crust. He proposes six hypotheses, called empirical generalizations [sec. 17], which I paraphrase as follows:

1. Living matter is not created from inert matter.
2. There are no lifeless geological eras.

3. Living matter of all eras has been similar to contemporary living matter.
4. Throughout all eras, there have been no sharp changes in the influence of living matter on its surroundings, and in all, the average chemical compositions of living matter and crust have been similar to ours.
5. There have been no great changes in the quantity of living matter.
6. All the energy produced by living matter derive from the Sun.

In the Foreword to the volume, the editor, Frank. B. Salisbury, points out:

Vernadsky's thoughts might have been radically changed if he had known about the oxygen revolution that is now thought to have occurred about two billion years ago in the Precambrian.

Vernadsky credits the biosphere as the greatest chemical force on Earth [19]. If life ended, Earth changes would slow to the geological time scale [20]. The essential part of the biosphere is its green living matter [22] which is primarily adapted to the transformation of solar energy [23]. The characteristic feature of living matter is its diffusion through propagation [24] which occurs with mathematical regularity [26]. Animal living matter propagates in a peculiar way, eg, termite swarming [28], bacteria circulating in water [30], all following mathematical laws [32] and limits [33-45]. Green living matter dominates life on the land but to lesser degree in the sea [46]. The main mass of living matter is concentrated in the sea [55]. One of the most important manifestations of life in the biosphere is gas exchange with the surroundings [64].

2. Domain of life [68-160]

In the second part, V. begins by giving credit to E. Seuss for the biosphere idea in 1975. V. describes the biosphere as the upper envelope of the Earth's crust. And here he even states one of the key ideas that appear later in Lovelock's Gaia theory: the biosphere acts as a thermostat [69]. The core of the planet is chemically distinct from the crust [70]. The next concentric shell within the biosphere is the *sima*. It is thick, heavy in silicon, magnesium, and oxygen [72], and low in free energy [74]. The atmosphere, the biosphere, and the crust comprise the field of changes; the *sima* and core comprise the field of stable equilibria [75]. These two fields are separated by the isostatic surface [77]. The deepest part of the crust may be described in three geospheres [80, 81]. The thermodynamics and chemistry of the crust and the biosphere are different [82, 83]. In the crust there are four different forms of existence [86].

Domain of life denotes the environment in which living matter is supported. The pressure of life expands the domain of life within the biosphere [90]. Living matter may be divided into two orders, autotrophic and heterotrophic [91]. Essential gases are produced by the biosphere [92]. Water is created by the green autotrophs [93]. The field of existence of the heterotrophs is wider than that of the autotrophs, which is determined by solar radiation [95]. Autotrophic bacteria are always hungry [99]. The regions free of green autotrophs, including the vital bottom film of the hydrosphere, are slowly expanding [101].

The heterotrophic domain is limited by temperature, pressure, phase, chemistry, and radiant energy [103-108], water [109], gases [110], by the ozone layer of the atmosphere [120], and the high temperatures at a depth of 3-3.5 km below the Earth's surface [121]. The greatest solar energy transformation in the hydrosphere is by vital films and aggregations [125]. The surface of the ocean is covered by green plankton [126]. Other than these films and aggregations, life is sparse in seawater [128-129]. The life in the bottom film -- comprising the pelogen or benthos (upper part) and the layer of bottom mud -- is more massive than that on the surface [130]. Aggregations include the benthos (bottom zone), coastal aggregations, and sargassos (floating masses) [10]. The surface plankton are vitally connected to the coastal aggregations [131] and sargassos [132]. Only 2% of the ocean mass is occupied by aggregations of life [133]. propagation of the plankton films is seasonal, blooming in the spring [137].

The plankton film is the principal domain of isolation of free oxygen, concentration of nitrogen, and precipitation of calcium and silicon [138]. The sargassos and coastal aggregations are similar [139]. But in the coastal aggregations, more chemical elements leave the life cycle than in the plankton film [140]. The bottom film has a great concentration of bacteria and life products which absorb free oxygen [141], create inert matter [142], support both oxidation and reduction [143], and influence the distribution of elements in the Earth's crust [144-148]. The distribution of life in the hydrosphere and its geochemical manifestation has been the same through all geological periods [149].

Life covers the land in a continuous film [150]. It is thin [151] and contains us and green plants [152]. The geochemistry differs from that of the hydrosphere, chemicals are caught and held by living matter [153, 154]. Organic remains are concentrated in soils [155]. Water comprises two thirds of living matter on land [156]. All life, and all inert matter surrounding the biosphere, comprise an indivisible unity [159].

5. THE NOOSPHERE ESSAY

The concept of the noosphere, as the sphere of human thought encircling the Earth, was greatly popularized by Teilhard de Chardin (1881-1955) in *The Phenomena of Man* (1955). Teilhard had heard of this idea of Vernadsky in 1922. Here is a compressed paraphrase of the Vernadsky essay written in 1943.

The idea of indivisible unity of living and inert matter was stimulated by World War II [1]. Since World War I there has emerged an emphasis on "living matter", as distinct from "life" [2]. The whole of mankind is related to the biosphere [3]. Mankind cannot exist without the biosphere [4]. Huygens' (1629-1695) principle (1698): life is a cosmic phenomenon [5]. The evolution of the form of living matter leads to change in its chemistry [5]. Living matter created rocks [6]. Dana (1813-1895) and Le Comte (1823-1901) showed that evolution of living matter had a direction [7]. This direction -- cephalization, which evolved the brain or central nervous system -- never reverses [8]. Man embraced the biosphere for the first time, and became a single entity, mankind, in the 20th century [9]. Mankind is becoming a powerful geological force and is

reconstructing the biosphere. The new state of the biosphere is the noosphere [10]. Proceeding from V.'s Sorbonne lectures in Paris in 1922-23, Eduard Le Roy lecturing at the College de France in 1927 introduced the noosphere as a present-day stage that is developing within the biosphere. He acknowledged this as joint work with Teilhard [11]. In the noosphere Man becomes a great geological force for the first time, using thought, not energy [12]. We are entering the noosphere at a terrible time, but our ideals of democracy correspond to a spontaneous geological process, the creation of the noosphere [13].

6. CONCLUSION

The Biosphere puts forward a number of "empirical generalizations" or hypotheses [12] which beg to be empirically proved. Biosphere 2 aimed to test many of these hypotheses, and had the full cooperation of the Russian scientists who follow Vernadsky. Many of the hypotheses have been resolved since Vernadsky wrote his essay, but by 1944 he had marshaled a great deal of detailed technical support for his biospheric proposals from the scientific findings of his generation. His way of thinking is decidedly materialistic, or rather, biogeochemical. But looking from a distance, we may see emerging in his work a new level of holism in the science of the biosphere.

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