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Vladimir I. Vernadsky (1863–1945) and his 'descriptive mineralogy'

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ABSTRACT

The Russian geoscientist Vladimir Ivanovich Vernadsky (1863–1945) widely known as the founder of biogeochemistry, the co-founder of geochemistry, and for authoring the concepts of the biosphere and the noosphere, began his scientific career as a mineralogist. His novel chemical–genetic perspective on the formation of minerals changed the objectives of the mineralogical sciences, but these ideas have until now been largely ignored. However, later on in his career, this novel perspective led Vernadsky to the recognition of the significance of the activity of organisms and humankind as important mineralogical and therewith geological force.

1. Introduction — the early history of mineralogy and crystallography of Russia

When the 18 year old Vladimir Ivanovich Vernadsky (1863–1945) became a student at the Department of Natural Physics of the St. Petersburg University and began to study mineralogy and crystallography, these sciences were – not only in Russia – characterized by the qualitative description and classification of minerals and largely confined to the collection and organization of data. The two sciences were then much more closely linked than today, because the objects of crystallographers were always minerals, and the research methods of mineralogists were mainly of the crystallographic character as revealed through chemical analyses.

In the second half of the 19th century, preceding Vernadsky's birth, the development of mineralogy and crystallography in Russia is mainly connected with the name of Nikolai I. Koksharov (1818–1892). Koksharov is considered the 'father' of Russian crystallography and representative of the empirical methods of crystallography in mineralogy. His activity coincided in time with the collection of an enormous amount of data and material from newly discovered ore deposit districts in Russia, which he made available to scientists and the general public through his remarkable publications. His main work 'Material of the mineralogy of Russia' in six volumes (Koksharov, 1852, 1855, 1858, 1862, 1866, 1877) was then the most comprehensive mineralogical encyclopedia of Russia.

Koksharov was the first Russian mineralogist to overcome the school of Abraham Gottlob Werner (1749–1817) by switching from the qualitative description of the minerals to crystallographic investigation and analysis of their exact physical and chemical properties. However, theoretical generalizations and problems of genetic mineralogy did not appear in his works. His administrative successor at the St. Petersburg Mining Institute was Pavel V. Eremeev (1830–1899). Eremeev's accomplishments were mainly in the fields of crystal morphology and topographic (regional) mineralogy.

Evgraf S. Fedorov (1853–1919) is considered as one of the founders of modern crystallography. Modern crystallography owes him and the German mathematician Arthur Schönflies (1853–1928) the mathematical deduction of 230 space groups (Fedorov, 1891; Schönflies, 1891), commonly called Fedorov groups to honor him. With these publications both scientists created the most important theoretical basis for the detailed description of crystal structures. Fedorov's findings were initially underestimated by his contemporaries and by Koksharov and Eremeev as well, probably because of the high degree of abstraction and mathematical skills needed to understand the classification. Fedorov was an active critic of the Tsarist regime and he was, therefore, refused entry to high administrative positions and to the membership of the Russian Academy of Sciences, of which he became finally a member as late as 1919.

2. Vernadsky — the years of mineralogical studies

When Vernadsky registered at the St. Petersburg University he had the good fortune to become a student of the famous chemists Dmitri I. Mendeleev (1834–1907) and Aleksandr N. Butlerov (1828–1886) and of the pedologist Vasili V. Dokuchaev (1846–1903). Dokuchaev had

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been a professor of mineralogy and crystallography since 1879, and when Vernadsky entered the university Dokuchaev studied black soils in Russia and was already on the way to become the founder of modern soil science. Dokuchaev obviously placed great emphasis on a broad education of his students and colleagues and he was the teacher who most influenced Vernadsky. Therefore, it was not surprising that in his 3rd academic year Vernadsky chose Dokuchaev as his mentor and specialized in crystallography and mineralogy.

'Soils,' as Dokuchaev wrote, 'are the result of an extraordinarily complex interaction of local climate, plant and animal organisms, composition and structure of parent rock, relief of locality, and finally the age of the region, therefore, clearly, they require that their researcher have an adequate training in various fields.' (Dokuchaev, 1883; cited after Balandin, 1982). This versatile, complex thoughts and research appealed to the young Vernadsky, and is reflected in his later scientific work. Specifically, Vernadsky:

1. considered minerals as changing matter which are subjected to genetic processes;
2. related mineralogy, previously only inorganic described, to the life sciences;
3. combined scientific questions with economic aspects.

Vernadsky completed his studies in 1885 and remained at the University to prepare for a professorship. First he became curator of the mineral collection of the St. Petersburg University. One might assume that he was on the safe way to follow the classical principles of empirical mineralogy. However, Vernadsky decided to follow his own inspiration. As a young scientist he was already very imaginative, tending to broad generalizations and setting himself ambitious scientific and personal goals. At the age of 23 he wrote:

> 'I feel that the path of my life is already now largely predestined. It will be a scientific but also a social and journalistic career. What is the duty of a man? The duty is doing the best for society and the nation. The first step is to develop ideas which are of maximum benefit to society. There is a general lack of self awareness in society and, consequently, one has first to work on one's own character, striving to perform all duties honestly, with self-reliance and self-confidence and never to be afraid or ashamed to state an opinion and to complete your work once started. However, that is not enough. It is also necessary to have a wide ranging knowledge, continuously educating your mind, and familiarizing yourself with philosophy, mathematics, music and art. In order to achieve significant benefits a scientist should not be a narrow-minded expert and specialist.'
>
> [Vernadsky diaries (1886); cited in Mochalov (1970)]

In 1887, in connection with the revelation of an attempt on Tsar Alexander III's life, Vernadsky encountered political difficulties. Through the intercession of influential relatives and his teacher Dokuchaev his threatened termination was averted. In 1888 he was allowed to take his previously-deferred three years of study abroad. The first year he spent in Munich with the 'king of crystallography' Paul von Groth (1843–1927). He spent his remaining two years in Paris in the laboratories of Ferdinand Fouqué (1828–1904), and Henry Le Chatelier (1850–1936). According to the work schedule elaborated together with Dokuchaev, Vernadsky devoted himself to the synthesis of minerals and experimental studies on the polymorphism of minerals.

In the summer of 1890 Vernadsky returned to Russia and was appointed as assistant professor of mineralogy at the Moscow University. A year later he successfully defended his master's thesis 'On the sillimanite group and the role of alumina in silicates' (Vernadsky, 1891a). He lectured on mineralogy and crystallography for students of geosciences and medicine. From the lecture notes Vernadsky's first publications in Russia emerged (e.g., Vernadsky, 1891b).

In 1897 he defended his doctoral thesis 'The phenomena of gliding in crystalline substance' (Vernadsky, 1897). In the same year he decided to leave behind crystallographic studies in order to 'deepen increasingly the studies in chemical mineralogy under consideration of geological aspects'. At that time the prevailing view on the subject of mineralogy was essentially only the description of mineral species, their chemical composition, crystal morphology, physical properties, varieties, aggregates and associations, the recording of their occurrence as well as classification of the mineral systems. Already in his 'History of the minerals of the earth's crust' (Vernadsky, 1923, 1927, 1933, 1934, 1936) which he started to write in 1898 but remained unfinished, Vernadsky vehemently criticized this state: 'The mineralogy is a dynamic science and it is necessary to examine the history of the minerals. The compilation of mineralogical facts dominates everything. But what is the task? Only to describe and systematize? No, in the ocean of facts it is no longer possible to orientate without evolutionary ideas. I am not exaggerating: all that I am telling contradicts the well-known ideas about minerals. Nevertheless, the future subject of the mineralogy will be the chemical–genetic one' (cited after Krüger, 1981).

In 1898 he became extraordinary professor at the Moscow University (Fig. 1).

3. Formulation of the new concept of the genetic mineralogy

Vernadsky read the work of Swedish chemist Jöns Jacob Berzelius (1779–1848) with "colossal pleasure." He liked Berzelius' idea that the mineralogy should be considered part of chemistry and represents the science of the inorganic constituents of the earth. Vernadsky taught his lectures in that way, explaining minerals mainly as chemical objects and interpreting the earth's crust as a gigantic and complicated chemical laboratory: 'The mineralogy is the chemistry of the Earth's crust. It examines the products of natural chemical processes, the processes themselves and the changes of products and processes with time' (Vernadsky, 1891b).

In 1908 the first volume of Vernadsky's 'An attempt at a descriptive mineralogy' was published (Vernadsky, 1908) (Fig. 2). In the introduction he wrote: 'The main objective is the revision of natural chemical constituents of the Earth considering the chemical processes taking place. This is the main task of mineralogy, which – similar to the

Fig. 1. Vernadsky as professor at the Moscow University, 1905.