The development of the chemical mineralogy in Russia in the late 18th - early 19th century in the works of V. M. Severgin

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Abstract. The late 18th and early 19th centuries saw a clear differentiation of sciences. First of all, general mineralogy split into oryctognosy (mineralogy-proper), geognosy (geology), and geogeny (geotectonics). Paleontology became a discipline of its own a bit later, as well as crystallography. Fossils and rock formations were excluded from mineralogy. The concept of a ‘mineral’ became clearer. The verbal description of minerals was complemented with their accurate crystallographic measurements, the one-circle reflecting goniometer was invented, and crystallographic methods became crucial for mineral diagnostics. The period between the 1790es and the 1830es is characterized by the rapid development of chemical concepts, the discovery of many chemical elements, and the study of physical and chemical properties of well-known and newly-discovered minerals. V.M. Severgin played a key role in the establishment of chemical mineralogy in Russia. Severgin wrote numerous works in mineralogy and chemistry and published translated works by foreign scientists complemented with his many contributions. As a disciple of M.V. Lomonosov’s ideas, he proved that mineralogy must be based on chemistry in his works. Severgin provided one of the first definitions of chemical mineralogy as a subject that deals with the decomposition of minerals into their components, their compounding, and changes they undergo due to chemical processes. The works of V.M. Severgin are of historical value and they can be seen as a source of learning about the history of mineralogy and chemistry in our country. Some ideas proposed by V.M. Severgin remain relevant to this day. These include the following: 1 the chemical mineralogy; 2 the applied study of paragenetic mineral associations; 3 the use of many mineralogical and chemical terms coined by the scientist.

1. Introduction
The emergence and development of capitalism in Russia at the turn of the 19th century resulted in the upsurge of the mining industry and significant progress in natural sciences including chemistry and mineralogy. The preceding academic expeditions brought descriptions, maps, and rock samples that were valuable for the mineralogy and geology of the country. Besides, new auriferous gravel fields were discovered, as well as native platinum, tin, and other metals and various ornamental stones.

Descriptive mineralogy remained dominant until the 19th century. Many scientists both in Russia and abroad stuck to the descriptive mineral parameters and classifications that lacked the accurate crystallographic measurements and gave little consideration to the chemical formula suggested by A.G. Werner in his work On External Characters of Minerals.

The late 18th century was referred to by M. Berthelot, a French chemist (1827-1907), as the “chemical revolution” due to the shift from the phlogiston theory that was dominant since the late 17th
century and through most of the 18th century to the oxygen combustion theory suggested by A. Lavoisier. By the end of the first third of the 19th century, there were 54 chemical elements, 26 of which were discovered within this 40-year stage (1790-1830): Ti, Sr, Y, Cr, Be, V, Ta, Os, Ir, Rh, Pd, Na, K, Mg, Ca, B, F, I, Si, Se, Li, Cd, Al, Br, Th, Ce. Severgin also noted the rapid development of chemistry and the associated discovery of new chemical elements: “…The pioneering efforts of new chemists increase their numbers almost every year…” [1].

2. Results

V.M. Severgin is a major figure in descriptive mineralogy, and he was a direct successor to M.V. Lomonosov’s ideas and one of the first Russian scientists who unified the key discoveries and achievements in mineralogy, chemistry, and physics of his time. He wrote about 250 papers on various areas of knowledge: mineralogy, geology, chemistry, engineering, physics, agriculture, etc. The diversity of his activities is impressive: he wrote research papers and published them, developed scientific terminology, held public lectures, edited the Tekhnologichesky Zhurnal, prepared guidelines for ore processing, etc. All of these were related to his desire to promote scientific knowledge in Russia and help develop Russian industries. The result of his entire thirty-seven-year academic career (1789-1826) is the motto coined in one of his works: “Labor and diligence”.

Severgin provided definitions for ‘mineralogy’ and ‘mineral’ in several of his works. In his “Primary grounds of mineralogy…” (1798), he wrote that there are three types of natural bodies: animals, worts, and the mineral realm. The latter included minerals that were divided into the minerals proper (minerals and rocks) and fossils that were “transferred into the mineral realm from other natural realms and transformed”.

Severgin defined mineralogy as follows: “Mineralogy is a part of natural History that teaches us to understand minerals, i.e. Set them apart from any other, as well as their use and all their crucial parameters, know their properties, fields, benefits and their relationships between each other and with other bodies” [2, p. 3]. In other words, the goals and objectives of this science, with a few exceptions, were similar to those of contemporary mineralogy.

Unlike the comprehensive definition of mineralogy, the definition of a mineral is pretty primitive in line with the development level of sciences at the time: “Non-organic natural bodies that lack life and feelings increasing through the external accumulation of tiny particles and located mostly in the earth’s bowels are called Fossils or Minerals” [3, p. 1].

The scientist saw the development of the country’s minerals as the material base for the development of industries, which was supposed to result in ‘the improvement of our factories and the beneficial replacement of products imported from other countries and various local goods that are rare or required somewhere else’ [4, p. 4].

Taking a cue from M.V. Lomonosov, he urged to study the extractable resources available in the country and composed the first detailed report on Russia’s mineralogy entitled The Experiment in the Mineralogical Geography of Russia. Severgin paid a lot of attention to the study and use of mineral properties. He believed that mineralogy became a real science ‘when the true methods of real mineral recognition were gradually discovered... ’ [5, p. 4].

In the big two-volume Detailed Mineralogical Dictionary that ‘contains a detailed explanation for all words and names used in mineralogy (1807), Severgin coined many mineral names in the Russian language by translating them from Latin, French, and German. Besides, he added a lot of Russian mineral names.

During the study of minerals, Severgin used morphological, physical, and chemical methods. The morphological study of well-crystallized minerals involved the measurement of the angle between crystal faces using once-circle contact goniometers by M. Carangeot and Lovides. The physical properties, including the weight, magnetic and electric properties were tested using hardware. All other physical properties (color, cleavability, roughness, taste, etc) were determined subjectively: by sight, feel, and taste. Severgin provided detailed descriptions for 23 “external” or “sensual” parameters: “The color, binding, look, surface, external and internal shine, breaks, types of slivers and
specific parts, clarity levels, marks, crocking, hardness, frangibility levels, density, flexibility, tongue sticking, resonance, palpability, coldness, heaviness, smell and taste” [3, p. 2-3].

The scientist saw the chemical method of mineral identification as the most significant one because ‘chemistry... shed its lights on mineralogy itself’ [5, p. 4], and he viewed the chemical makeup of minerals as the key ‘internal’ parameter for diagnostics that determined the properties of the mineral. Severgin analyzed multiple samples of minerals and ores and developed procedures to obtain natron, saltpeter, and other substances. The chemical properties of minerals were studied either via the “wet” quantitative analysis or via the “dry” qualitative analysis methods. The chemical analysis of minerals using the “wet way” was labor-intensive, while the “dry way” of the qualitative analysis was easy and required little time and small amounts of minerals. Due to the level of chemistry at the time, the quantitative analysis was an ‘incomplete and primitive analysis of complex substances and could just determine the content of acids and bases in salts and minerals” [6, p. 251].

Severgin put a lot of significance on the study of minerals using a soldering pipe that allowed for quick qualitative chemical analysis and helped determine some of the physical properties (changes in color, melting, swelling, etc). However, the scientist believed this research method was incomprehensive and pointed out that it had to be combined with the external parameters of the mineral and the “wet-way” chemical analysis. Severgin improved the soldering pipe by adding bellows. The “bellow-action” soldering pipe was manufactured by P. Dahlgren, a master blacksmith, under the supervision of the scientist, and it was demonstrated to the Free Economic Society [7]. Since the late 18th century, the soldering pipe became an indispensable quick qualitative chemical analysis tool for minerals and ores used by mineralogists, chemists, and metallurgists due to Severgin's work.

V.M. Severgin paid a lot of attention to the formation of rocks and minerals in many of his works. In his Initial Bases of Natural History, the scientist lists and describes ten mineral formation processes that largely correspond to today's views: ‘The key ways of mineral formation are binding, dissolution, agglutination, crystal formation, settlement, sublimation, melting, and fermentation that can be complemented by weathering and dehydration’ [8, p. 96]. Severgin had a practical approach to the assessment of ore body settings, their quality composition, and mineral reserves for extraction and mining facility construction. The combined occurrence of minerals was deemed significant for both the prospecting of minerals and ores because ‘it would simplify the finding of ores and gemstones’ [8, p. 86] and the identification of minerals as he often mentioned typical associated or “complementary” minerals in his descriptions.

Being one of the pioneers in the establishment of mineralogical systems in the Russian scientific literature and an ardent supporter of the chemistry-based grouping of minerals, Severgin developed his own mineral classifications in the Oryctognostic System of Mineral Bodies of 1798; the New System of Minerals based on their external features of 1816, as well as the classifications based on those suggested by well-known foreign peers (R. Kirwan, L.J.-M. D’Aubenton, A.G. Werner, R.J. Haüy), which he modified significantly.

In the late 18th century, the chemical neptunism hypothesis was very popular, yet at the same time, rare opponents of this theory were also appearing. The latter were plutonists who theorized about the plutonic-vulcanic origin of magmatic rocks and minerals. The first provisions of the mineral paragenesis theory were formulated. Mineral classifications combined the chemical approach to grouping along with the analysis of their crystallographic and physical properties.

In his works, Severgin paid great attention to the conditions under which minerals and rocks formed. He supported the plutonism hypothesis and advocated the “fiery” origin of basalt. He also pointed out that water solutions played a big role in weathering and mineral formation on the earth's surface. He laid the foundation of the mineral paragenesis theory, which he called “cooccurrence”. Severgin understood “cooccurrence” as a set of minerals formed simultaneously during the same mineral forming process or successfully during different processes.

The chronological analysis of Severgin's imperfect chemical mineral classifications shows that they changed significantly over the thirty years (1791-1824). The improvements of mineral classifications include the following: 1 the use of chemical parameters for mineral grouping within classes along with
their physical and crystallographic properties (the systems of 1807-1824); 2 the exclusion of fossils (the systems of 1791-1824) and rocks (the systems of 1791-1824) present as additions; 3 the exclusion of some rocks (clays, jaspers, etc.) from minerals; 4 the increase in mineral species from 191 (the system of 1791) to 319 (the system of 1824)

3. Conclusions
In 1790-1830, general mineralogy split into geology, mineralogy, crystallography, petrography, and paleontology.

During these years, chemistry developed very fast. The phlogiston theory shifted to the oxygen theory of combustion, isomorphism was discovered, key provisions of the molecular theory were published, the atomic weights of most of the 54 known chemical elements were determined, and the study of the chemical makeup of minerals began taking into account the laws of constant composition and chemical atomism.

The quantitative chemical analysis was performed using the “wet” way, and the qualitative using the soldering pipe. Severgin’s works promoted the popular use of the soldering pipe in Russia for mineral and ore diagnostics. He also applied the oxygen and the Lavoisier theories to the chemical identification of minerals. The scientist fully adopted the crystallographic system of R.J. Haüy and began supporting and promoting his theory of the internal “molecular” structure of crystals using the accurate crystal structure of minerals for both their identification and classification.

The contemporaries had high regard for Severgin’s works that could ‘be used by readers of any condition’ and ‘because this learned and hardworking man promoted the taste and achievements of the science in our Fatherland” [9, p. 29]. Speaking about Severgin's advances in the science of minerals, G.P. Barsanov called him ‘the creator of the bases of mineralogy as a discipline of its own with clearly defined goals and further development prospects’ [10, p. 9].

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