American Mineralogist, Volume 107, pages 985–986, 2022

Presentation of the Dana Medal of the Mineralogical Society of America for 2021 to Sergey Krivovichev

Frank C. Hawthorne[1,*]

[1]Department of Earth Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada

The Dana Medal recognizes continued outstanding original research in the Mineralogical Sciences by a scientist in their mid-career. It gives me great pleasure to introduce Sergey Krivovichev as the 2021 Dana medallist.

Sergey V. Krivovichev received his Ph.D. in 1997 and his Doctor of Science in 2001, both from St. Petersburg State University. He joined the staff there after graduation and has been Chair of the Department of Crystallography from 2005 to 2021, when he resigned as Chair and was succeeded by his former student Andrey Zolotarev. In 2017, he was appointed President of the Kola Science Centre of the Russian Academy of Sciences in Apatity and is a corresponding member of the Russian Academy of Sciences. He has won many national and international honors and has an extremely active editorial career with many journals. Sergey is married to Irina Krivovicheva (neé Staritskaya), a distant relative of famous Russian mineralogist and geochemist Vladimir Vernadsky, and they have seven children. For many years, he was a deacon and is now a priest of the Russian Orthodox Church.

Sergey Krivovichev has 540+ refereed papers published or accepted for publication in scientific journals, has authored five books, edited six others, and written 21 book chapters—an astonishing record for this stage of his career. Many of his book chapters are concerned with the properties of minerals and mineral analogs as advanced materials of interest from an industrial or environmental perspective. On the other hand, his books address fundamental issues in the structure of minerals. They are the first books to deal with Structural Mineralogy from a modern perspective and are the most important books published in this field of Mineralogy since the essays of Nikolay Belov.

Sergey's work may be divided into two broad areas: Experimental Mineralogy and Theoretical Mineralogy.

Experimental Mineralogy. Sergey has built a laboratory of unparalleled productivity at St. Petersburg State University. He has assembled a cadre of technical people to run this facility, catering not only to Mineralogy but also to Inorganic Chemistry and Materials Science. He attracts many students, several of whom are emerging as significant scientists in their own right.

Sergey has a major interest in actinide compounds, particularly uranium, and he and his group have done an immense amount of synthesis and structural work that has greatly improved our knowledge of uranyl structures and their crystal chemistry. In particular, he has done much work on novel synthesis and structural characterization of nano-structured uranyl compounds. Much of this work has focused on the possible application of complex structures to industrial and environmental processes, particularly those involving ion exchange or encapsulation of radiogenic and/or toxic elements/isotopes. He has examined a wide variety of materials in this work, including titanosilicates, layered double hydroxides, zeolites, layered titanates, much of which has led to patents, and some are under consideration for development.

He has also worked on minerals from the Kola Peninsula and from the Tolbachik Eruptions at Kamchatka, and it was the new structures from Kamchatka that led him and his group to develop the idea of anion-centered polyhedra in minerals and to relate the occurrence of these entities in minerals to gas transport in volcanic vapors.

Theoretical Mineralogy. Sergey's theoretical work may be divided into four areas: (1) Complexity; (2) Mineral Evolution; (3) Anion-centered Structures; and (4) Structure Hierarchy and Graph Theory.

Complexity. The idea of complicated crystal structures has been around for a hundred years, but Sergey was the first to quantify this idea using the mathematics of complexity. He has shown how the complexity of a mineral is related to its Shannon entropy and has single-handedly developed this topic into one of the leading areas of research in Structural Mineralogy. He has analyzed *all* minerals in terms of their information content, which allows analysis of paragenetic sequences of minerals in terms of evolving complexity and allows hierarchical organization of minerals in an evolving geochemical system. Moreover, he has shown that the Ostwald Step Rule is related to systematic change in mineral complexity.

Mineral Evolution. The idea of mineral evolution was introduced ~40 years ago by N.P. Yushkin and A.G. Zhabin. In the last few years, this area has undergone rapid development. Sergey has recently become involved in this work and has introduced an increased level of rigor by relating mineral evolution to the changing complexity of minerals.

Anion-centered Structures. Sergey has developed the idea of anion-centered structures and produced an extensive structure hierarchy of both minerals and synthetic inorganic compounds. These minerals tend to crystallize from volcanic gases, and Sergey and his group have done experimental work to show that the metals are transported in the gas phase via anion-centered complexes, providing a direct link between paragenesis, crystallization sequence, and the method of transport of metals in the fluid-gas phase.

Structure Hierarchy and Graph Theory. Our ideas on structure hierarchy have evolved rapidly over the last twenty years, and Sergey has played a major role in this development. He

* E-mail: frank.hawthorne@umanitoba.ca

0003-004X/22/0005–985$05.00/DOI: https://doi.org/10.2138/am-2022-AP10752

has combined ideas on the graph-theoretical representation of crystal structure with ideas on structure hierarchy, and these topics have been a major focus not only of many of his papers but also three of his books. This approach allows a much more quantitative comparison of mineral structures than was hitherto possible, a comparison at the level of bond topology, which allows a better understanding of minerals at the scale of atoms and chemical bonds, and permits quantitative consideration of mineral stability. This work forms the basis for further work in both Theoretical and Experimental Mineralogy, allowing individual results to be placed into a general framework that indicates their more general importance in Earth processes.

In summary, Sergey's theoretical work is truly novel and addresses the fundamental basis of mineral composition and stability. He is more than deserving of the Dana Medal of the Mineralogical Society of America.