

Boris Zvyagin (1921–2002)

On 18 September 2002, **Boris Zvyagin**, brilliant scientist and unique personality, passed away. Zvyagin was one of the leaders in structural mineralogy, crystallography and electron diffraction, widely acknowledged by the international scientific community. It would not be an exaggeration to say that the modern level of our knowledge of crystal structures and crystal chemistry of layer minerals, and primarily of phyllosilicates and clay minerals is, to a significant degree, the result of his fundamental research.

Boris Zvyagin was born on 14 April 1921 in Nevel (Russia), into a poor Jewish family. The extraordinary abilities that he had shown at school allowed him to be admitted to Moscow State University without exams. He graduated from MSU Physics Department in 1944 and then prepared and successfully defended his PhD. From 1949, Zvyagin worked at the All-Union Geological Institute in Leningrad as a senior scientist. In 1963, he became a Doctor of Science and moved to Moscow to work at the Institute of Ore Mineralogy of the Russian Academy of Sciences as the head of the laboratory and then as a principal scientist. In 1977, Zvyagin became a Professor of Crystallography and Mineralogy.

Zvyagin was a pioneer in many theoretical and experimental aspects of structural mineralogy. He developed an original methodological approach to deduce systematically regular polytypes of kaolinite, chlorite, serpentine, mica, talc-pyrophyllite, palygorskite, and other layer silicates. He successfully applied his methodological approach to analyze polytype diversity not only of layer silicates, but also of various other layer and pseudo-layer minerals such as astrophyllite, chain-ribbon silicates and silicates with complex tetrahedral layers, high-temperature superconductors, oxyborates, *etc.*

Zvyagin was a pioneer in the comprehensive structural study of layer minerals by electron diffraction. In fact, he was the first to work out and successfully use oblique texture electron diffraction (OTED) as an independent and powerful tool for structural analysis of layer minerals. Thanks to a deep

understanding of relationships between structural and diffraction features of different polytypes, Boris discovered structural peculiarities of various minerals poorly studied at that time, including halloysite, lizardite-2H₁, *cis*-vacant 1M illite, 2M₂ mica, triclinic cookeite, chapmanite and bismuthoferrite, copper- and zinc-containing clay minerals, iron oxides and hydroxides, as well as layer silicates with complex or unusual structures, that are of special crystal-chemical interest, such as 4M Ti-biotite and six-layer Unst-type serpentine. Zvyagin was the first who successfully refined the crystal structures of the clay minerals using the OTED technique. This was a remarkable result. At that time, most crystallographers believed that electron diffraction could not be used for structural analysis because of dynamic effects, and the only way to refine a crystal structure was by single-crystal X-ray analysis. One of Zvyagin's main activities was the development of electron diffractometry, which allowed a considerable increase in the accuracy of intensity measurements, thus providing a new level in the structural analysis of minerals. From 1981 to 1990, Boris Zvyagin was a member of the Commission on Electron Diffraction of the International Union of Crystallography.

For the last decade, Boris concentrated his attention on developing modular analysis of crystal structures. He proposed analytical means for the consideration, description, and derivation of modular structures, which included as components, polymorphism, polytypism and the theory of OD structures. This is a new scientific domain in modern structural mineralogy, and he was a leader.

Boris Zvyagin was an active and creative scientist. He is an author and co-author of 400 publications concerning theoretical aspects of electron diffraction, polytypism and polymorphism, and modular crystallography, as well as the structure and crystal chemistry of layer and pseudo-layer structures.

For outstanding contributions to crystallography and the structural mineralogy of layer silicates, Boris Zvyagin was awarded the highest honours presented by the Russian Academy of Sciences for Crystallographers, the Fedorov Gold Medal Award,

and by the Clay Minerals Society – the CMS conferred on him the rank of Marilyn and Sturges Bailey Distinguished Member. He was also awarded the Vainshtein Award for Electron Crystallography.

Boris was one of my closest friends, and I always kept admiring his extraordinary and powerful personality. He had a passion for life in all its aspects. Every scientific problem that he tackled, he approached with striking enthusiasm and ardour. He was a fantastic expert in music – he loved all kinds of music but it was classical music in which he was an acknowledged authority among professionals. Boris was a wonderful husband and a unique father and grandfather. He had dozens of friends, and his loyalty to friends and friendship adorned his life and the lives of his friends. To say that his friends and family will miss him is to say nothing. Without Boris, our world will not be as rich and varied as it was before.

Victor A. Drits