Nikolai Vasilyevich Belov (on his Eightieth Birthday)

Participants in our crystallographic congresses, delegates to the General Assemblies of the International Union of Crystallography and members of its Executive Committee take it for granted that Professor Nikolai Vasilyevich Belov, Full Member of the Academy of Sciences of the USSR, Honorary Member of the Mineralogical Societies in a number of Western countries, invariably stands as the leader of Soviet crystallographers. Powerful intellect, bubbling energy, wide knowledge in the most various branches of history, culture and science, unusual kindness and true fellowship give his listener or opponent ineffable pleasure.

On December 14, 1971 the Russian crystallographers celebrate Belov's eightieth birthday. While approaching this noteworthy day he is full of energy and lives in the midst of vital scientific problems. His guidance, advice and encouragement as well as his own work developed many sound scientists. The representatives of Belov's school, from postgraduate students to members of the Academy, are actively engaged in scientific work in Moscow, Gorky, Baku, Tashkent, Dushanbe, Ashkhabad, Kishenev, Novosibirsk, Yakutsk, Khabarovsk and some new cities of the Soviet Union, such as the capital of Mordovia–Saransk.

After graduating from the Leningrad (St. Petersburg) Polytechnic Institute N. V. Belov worked for some time at the little Council of People's Economy in a small town of Ovruch (North Ukraine). In the early years of the Soviet Republic (from 1919 to 1923) he was in charge of work on the repair of bridges and various buildings, and was a representative of Gubsovnarkhoz (Provincial Council of People's Economy) and Gubtorg (Soviet commercial organization). All these big names with very modest real meaning were characteristic of the hard first years of the Russian Revolution. Having returned to Leningrad in 1924, N. V. Belov became a chemist-analyst, first at big industrial plants and later in the Laboratory of the Commission on Study of the North – the future Arctic Institute. In the early thirties a close cooperation and friendship developed between N. V. Belov and A. E. Fersman, the creator of Russian geochemistry, who invited Nikolai Vasilyevich to join the research group engaged in the study of the Khibinyi Problem. The lack of appropriate technological solutions impeded the practical use of the greatest deposits of apatites and nephelines of the Kola Peninsula. The theoretical approach of N. V. Belov to the nepheline problem was highly appraised by academician V. I. Vernadskii. N. V. Belov proposed and developed the technology for utilizing nepheline in the tanning, textile, paper and other industries. He was the co-author of the method for extracting the rare earths from apatites.

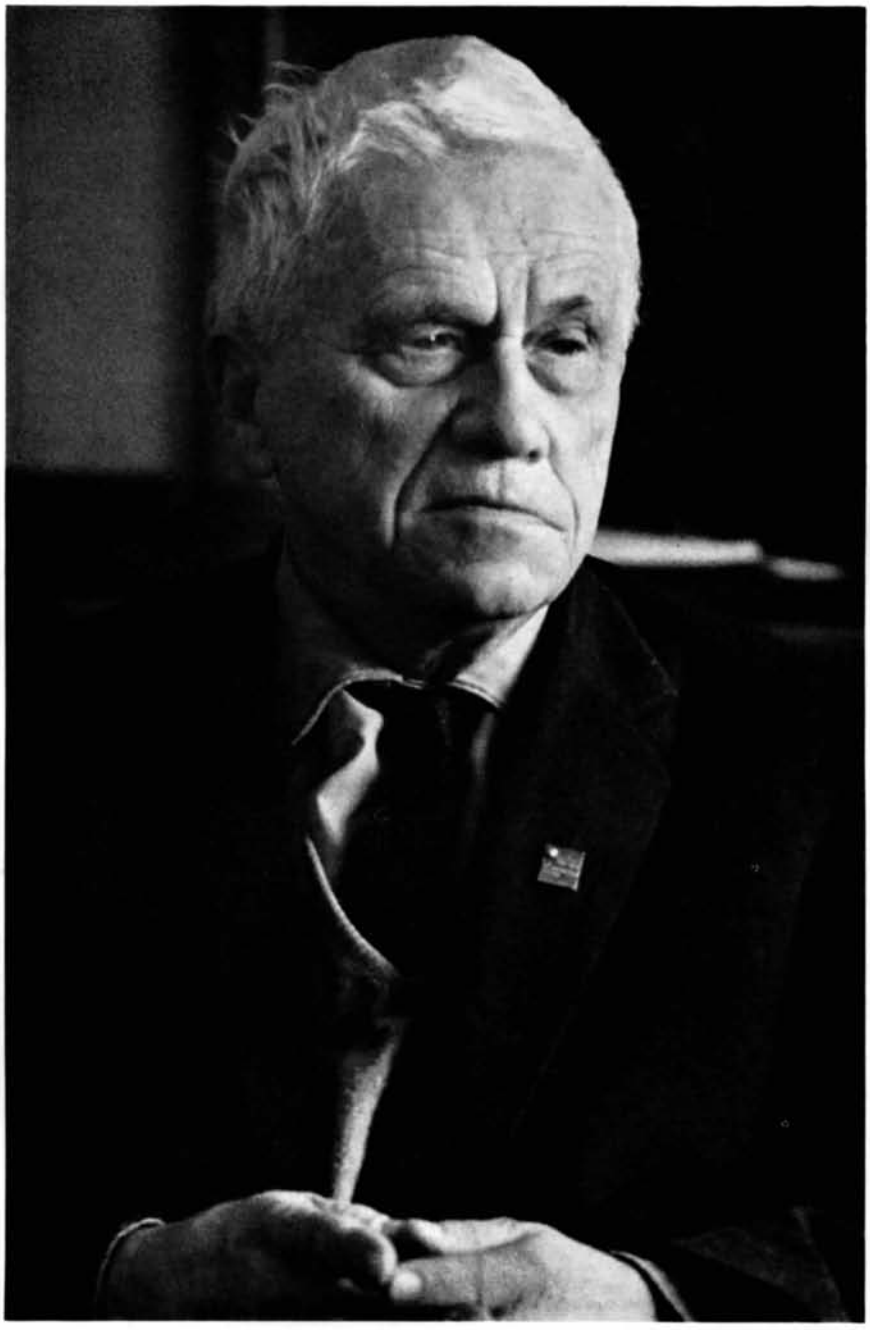
In 1933 N. V. Belov went to the Academy of Sciences as a geochemist. In 1934 the Academy moved to Moscow, and a few years later Nikolai Vasilyevich, following Fersman's suggestion, chose crystallography and geochemistry as his main lines. Outwardly, it manifested itself in his transfer from the Geochemical Department of the Fersman Institute to its Crystallographic Department – now the Academic Institute of Crystallography, run for many years by the late Professor A. V. Shubnikov.

It was during this period that N. V. Belov set himself the goal of elaborating the problems of the crystal chemistry of inorganic structures, and as his immediate task the development of the science of atomic structure of minerals, especially silicates which so obstinately resisted ordinary stereochemical analysis. N. V. Belov found his real vocation: geochemical crystallography and crystal chemistry became the chief fields of his scientific interest. The first structure determined by N. V. Belov was that of dioptase – the formal orthosilicate – which turned out to be copper metasilicate, and this result was followed by the discovery of the same metafactor in the formal orthotitanosilicate ramsayite.

Those who consider well developed space representation as the basis of the crystallographic line of thought are apparently right. In other words, the memory of a crystallographer must store and manipulate three-dimensional images, in contrast to the 'one-dimensional' (in time) memory for music and verses. The specific feature of the crystallographic approach to various phenomena and objects is consideration of their symmetry relationships. Not only did N. V. Belov present the simplest 'visual' (suitable for the student audience) derivation of the 230 Fedorov space groups and, together with his pupils, derive 1651 Shubnikov black–white symmetry groups, but he also introduced into crystallography the more mathematical concept of polychromatic symmetry, the important starting point for some modern branches of crystal science.

N. V. Belov elaborated the strict quantitative theory of the closest packing of spheres, and not only extended this theory to systematization of a large class of atomic structures, but more important still, converted it into a powerful tool for atomic structure determination. At this stage the packings of spheres of various diameters were considered and Pauling's bridge between the sphere and polyhedral representations was firmly established. This made it possible to use Fedorov's works on stereohedra for solving some concrete structural problems.

More complicated objects of investigation and new ideas in the field of Patterson and direct methods of determining the atomic structure of crystals pushed trial-and-error into the background. N. V. Belov became an enthusiast for the new methods, an advocate of these and one (among his pupils) of their active creators. His school's special love is the problem of



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separating the structure from the atomic vector distribution, using such novelties as rhombuses of peaks which characterize every different element of symmetry, not excluding the translational ones.

The period from 1926 to 1931 was one in which new ground was broken in the field of the crystal chemistry of silicates. Its first steps forward were most intimately connected with the world-famous school of W. L. (later Sir Lawrence) Bragg. Based on a number of early structure determinations Bragg's classification of silicates had been slowly evolving during more than 20 years. Dioptase and ramsayite were among its successes. In the post-war period the structural school of Nikolai Vasilyevich Belov proclaimed its existence at the top of its voice by investigations of a large number of atomic structures among the most complex naturally occurring silicates. This firm foundation laid down by the vast masses of experimental data on such structures led N. V. Belov to modify the generally accepted architectural framework of the crystal chemistry of silicates. The main idea of this reconstruction is that the leading part in the silicate structure is assigned to cations in a given mineral, and not to a silicon–oxygen radical which only accommodates itself in a more passive way to the crystal chemical environments produced by cations. The earlier idea about the dominating role of the silicon–oxygen radical summarized the results of the deciphering of the crystal structures of minerals in which the cations with a mean ionic radius predominated, Fe, Mg and Al being the first to be mentioned. In these silicates the tetrahedron $[SiO_4]$ stands out as a fundamental building unit of the silicon–oxygen radical. In minerals containing large cations, first of all Ca and Na, and then K, it is the diortho-group $[Si_2O_7]$ that functions as the basic silicate block. It is precisely the size of cations that N. V. Belov assumed as a basis for the division of the crystal chemistry of silicates into the first and second chapters. But Nikolai Vasilyevich does not forget that the first structures of the second chapter were displayed by Bragg's school in the course of their investigation of the structure of feldspars. Both in the first and second cases the elementary building units ('Bausteine') $[SiO_4]$ and $[Si_2O_7]$ can appear in more complicated (but still their own) forms of chains, ribbons, rings (one-storied *versus* two-storied), tubes, nets and framework elements.

N. V. Belov not only formulated some new principles and concepts of crystal chemistry, but, together with his pupils, carried out the overwhelming majority of determinations of the atomic structures of silicates under investigation in recent years.

The Ca silicates and hydrosilicates, which play the major part in the cement hardening processes, occupy his school's particular attention. New ideas have produced direct influence on the development of cement-based building materials with significant economic results. The theoretical works of N. V. Belov on crystal chemistry have found their way directly into the glass industry and the production of synthetic zeolites – molecular sieves.

The range of the scientific interests of N. V. Belov is very wide and varied, and extends far beyond the field of silicates. Very important are the results of his school in the field of (hydro)borates. In recent years he has developed the crystal chemistry of sulphides and sulphosalts, which play the most important role in the study of ore deposits. Nikolai Vasilyevich is proud to call the 'kindred' ideas of crystal chemistry of sulphides the second chapter in the science of the Mendeleev periodic system connected with the number 18. Of great importance are Belov's works on isomorphism which interest economic geologists too. Entry of one or another minor element into a given mineral is conditioned by the atomic structure of the host-mineral and its crystal chemistry. N. V. Belov revealed the mechanism for the isomorphous entry of different atoms into Zr, Ti-containing minerals: the strange apparition of Li and Cs instead of Be in beryl. In recent years N. V. Belov and his pupils have elucidated the dual (by analogy with Al) role of titanium in silicates, and worked out the crystallographic approach to the problem of magmatic differentiation.

N. V. Belov has devoted much effort and time to the education of young engineers and scientists. He is a professor in the Moscow and Gorky Universities, both of which produce first-class Soviet specialists in structural crystallography, crystal geochemistry and crystal growth.

N. V. Belov has an excellent knowledge of several languages, especially French, English, Polish and German, which enables him to take an active part in scientific conferences in various countries. Nikolai Vasilyevich is a permanent Chairman of the USSR National Committee of Crystallography. For many years he has been a member of the Executive Committee of the International Union of Crystallography; he was Vice-President, and then President of this forum of crystallographers from all parts of the world.

For his scientific achievements N. V. Belov has been awarded the Lomonosov Gold Medal – the highest Honour within the patronage of the Academy of Sciences of the USSR – as well as other orders and medals. His research work was recognized by the state prize. In 1969 N. V. Belov was honoured with the title of Hero of Socialist Labour.

The International Union of Crystallography and the Editorial Board of Acta Crystallographica congratulate Nikolai Vasilyevich Belov on his 80th Birthday and wish for him ever-vigorous health and great creative success for the welfare of our science and the mutual understanding and friendship between crystallographers from various countries.