ACCEPTANCE OF THE ROEBLING MEDAL BY ESPER S. LARSEN

The chief and most cherished reward of a scientist is the recognition by his friends and associates. It was with great pleasure, therefore, that I received word that I was to be the fourth recipient of the Roebling Medal. I am truly proud that I have been placed with my three eminent predecessors. I am especially pleased that the presentation is taking place in my own city. I am deeply grateful to you for the pleasure and honor you have given me.

The Roebling Medal has an especial meaning to those who knew Colonel Roebling. I knew him less well than some of the former recipients of the Roebling Medal, but I had the pleasure of several visits with him and was much impressed by his great knowledge and love of minerals. He was most generous with his collections, and while I was accumulating data for my mineral tables he permitted me the free use of many of his rare specimens and the data on 110 rare species were secured from specimens of Colonel Roebling's great collection.

I have had unusual opportunities for my researches. I have always had much time and help for my work. I have been very fortunate in having the help, the counsel and the inspiration of many friends and associates. The inspiration and instruction of Professors Lawson and Eakle, and of Dr. Wood and later the kindly, patient help of our President, Dr. Wright, gave me an unusual start in my beloved work. At the Geological Survey I had the privilege of being associated for many years with Dr. Cross, one of our greatest petrologists. I also had the advantages of the help, counsel and friendship of Doctors Schaller, Foshag, Shannon, Ross, and Steiger. At Harvard I have had the privilege of association with Professor Palache, and from Doctors Berman and Hurlbut I have received much help and inspiration and have thus been enabled to keep somewhat in touch with the newer developments in mineralogy. I have been truly fortunate in my friends and associates.

My chief work in mineralogy has been on the optical properties of minerals and on the minerals in igneous and other rocks. The study of minerals under the microscope is fascinating, and it is remarkable that by this means one can identify a tiny grain and for many isomorphous groups can determine the approximate composition of the mineral. The mathematical interrelation between the various optical properties, their relations to the crystal structure, the density and the chemical composition of the crystal are marvels of natural law. The accuracy with which the properties can be rapidly measured is a tribute to the students of the subject. The three indices of refraction, or the three velocities of light for

Esper S. Larsen, Recipient of the Roebling Medal of the Mineralogical Society of America a biaxial mineral, can ordinarily be measured with an accuracy of a few parts in a thousand in less than an hour, or by Emmons' dispersion method with an accuracy of a few parts in ten thousand. All this can be done on one tiny grain.

The microscope has been used for the study of rocks and minerals for several centuries, but in the early days it was used simply as a magnifying instrument. The discovery and study of Iceland spar in the seventeenth century was the beginning of modern optical crystallography. At first Iceland spar was used as a toy by the ladies of the French Court, but a few scientists of the day studied its properties with great skill and diligence. Huygens worked out the ray velocity surface and many other properties of the mineral. No great contributions to the optical properties of crystals were made for over a hundred years. In the early part of the nineteenth century Fresnel and Arago studied the effects of superimposing plates of Iceland spar, formulated the laws governing interference in polarized light, and explained interference colors. Brewster studied crystals in transmitted polarized light and distinguished between isotropic, uniaxial, and biaxial crystals. The invention of the nicol prism by Nicol in 1829 gave us an easy means of obtaining polarized light.

In 1850 Sorby made thin sections of rocks by a technique not very different from that used today. Some thin sections had been made before Sorby's work. Zirkel became a student of Sorby and began an ardent study of rocks in thin sections. In the early years of this study it was considered a method for the study of texture only, and it was thought that minerals could not be identified in this way. However, within a decade Zirkel was able to identify the minerals of the rocks, and modern optical mineralogy had its beginning. Zirkel's work stimulated the microscopic study of rocks and minerals in Germany. Rosenbusch was one of the great early contributors. Tschermak studied many groups of minerals and gave us much optical data. In France, Foqué, Michel-Levy, and Des Cloizeaux contributed.

In 1870 Rosenbusch developed a polarizing microscope with a rotating stage for the study of rocks and minerals. Most of the instruments used in optical crystallography were invented in the latter half of the nineteenth century, and in that period the theory of optical crystallography was extensively developed. One of the most important of the instruments was the universal stage, described by a Russian, Fedorov, in a number of papers published in the last decade of the nineteenth century.

Up to the early part of the twentieth century minerals were studied under the microscope almost entirely in thin sections. They were recognized largely by sight and by simple tests such as relief, pleochroism, birefringence, extinction angle, and optical character. If a worker could not identify a mineral, he sent the section to his friends, who might have found it in their work. The microscopes of that period would be considered almost useless by an elementary student of this day. Yet the identification of minerals by such men as Iddings, Pirsson, and Cross was remarkably accurate.

Minerals have long been studied by immersing them in liquids. In 1893 Becke proposed the method of central illumination for comparing the indices of refraction of adjoining bodies, and in 1898 Schroeder von der Kolk proposed the method of inclined illumination. These methods for the determination of the indices of refraction led to the systematic use of the immersion method. In 1894 Brun applied this method for the systematic study of minerals, and in 1898 Schroeder von der Kolk published tables for the determination of minerals by the immersion method. Wright was largely responsible for the introduction of the immersion method to America and he proved its great value in the study of minerals and synthetic products. While on the Geological Survey I found that the immersion method, taught me by Wright, was of great value in identifying the many specimens that came to me. At that time the books on optical mineralogy described only the rock minerals. I found so many minerals whose optical properties were not listed in the available books that I undertook to gather together for my own use all of the available data. This still left the data too incomplete for satisfactory use, so I undertook to measure the indices of refraction and other optical properties of the common minerals. With these new data there were fewer gaps than before, but still too many for entirely satisfactory use, and I felt compelled to secure optical data on as many of the recognized species as possible. In 1921 I was able to publish relatively complete tables for the systematic identification of minerals by the immersion method after I, and some of my close associates, had used the method for many years.

The recent development of the dispersion methods by Merwin and Emmons, and Emmons' use of the universal stage and the double dispersion method, have been great advances in the rapid and accurate determination of the optical properties of crystals. Indeed, Emmons' method for rapidly determining with considerable accuracy nearly all the optical properties of a mineral on a single small grain and in a single immersion is one of the great contributions to optical crystallography.

In the field of optical crystallography much has been accomplished in the last hundred years. Much remains to be done. Much more accurate and complete optical data, including such data as dispersion of the indices of refraction, are needed. Such data should be correlated with other mineral data and in particular with accurate chemical analyses. We especially need more data on minerals that show solid solution, as most minerals do, so that we can determine more accurately the composition of a particular specimen. We have several hundred analyses with accompanying data on members of the amphibole group but this is not nearly enough to characterize the group. Few mineral groups or isomorphous series have been studied with sufficient detail and system. We need data on specimens carefully selected so that we can fill in systematically the many gaps that exist.

In conclusion, we can be certain that many very important contributions will be made in the next few decades but their exact character cannot be predicted.