THE AMERICAN MINERALOGIST, VOL. 54, MARCH–APRIL, 1969

PRESENTATION OF THE ROEBLING MEDAL OF THE MINERALOGICAL SOCIETY OF AMERICA FOR 1968 TO TEI-ICHI ITO

MARTIN J. BUERGER, *Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.*

When the Roebling Medal is presented, it is customary to state that it is the highest award of the Mineralogical Society of America and is given specifically for outstanding original research as expressed in scientific publications. It is not restricted by nationality, personality, age, or place of employment. It has been presented on 26 former occasions from 1937–1967, although not in every year. Of the 26 recipients, 18 were Americans and 8 were from abroad, including one Austrian, four British, one German, one Norwegian and one Swiss. I now have the honor of introducing to you a Japanese colleague who has been chosen by our Society for this award in 1968, Professor Tei-ichi Ito.

It is a personal pleasure to introduce Professor Ito, for we have long been colleagues and friends. Ito's first paper, entitled "Zonal growth of plagioclase and soda-orthoclase" published in Japanese in 1925, was an item of which I was unaware until many years later. His first paper for international consumption was published in the *Zeitschrift für Kristallographie* in 1927, and entitled "Die Kristallisationsverhältnisse von Arakawaite." My first paper was published in the same year in *Economic Geology*, entitled "Tin Ores of Chocaya, Boliva." So, as young men, we began our careers together in mineralogy.

I actually first became aware of his work when he began a series of three papers on the geometry of the packing of atoms in crystals. These were "Die Diamantgitterkomplex im rhombschen System" published in 1927; "Isogonale Polyeder und Partikelgruppen," published in 1929; and "Radienquotient der Partikelgruppen und Koordinationszahl" published in 1930. To understand the relevance of these papers, you should recall that the relation between coordination numbers and radius ratio had been established by V. M. Goldschmidt only three years earlier. In these papers Ito brought out the relation between Niggli's so-called "lattice-complexes," or sets of equipoints, and coordination numbers, a theme which is still being explored today. By these papers, published while still a young man, Ito foreshadowed the part he would take in contributing to the geometry of crystal structures.

During this period, Ito was a post-doctoral fellow in Niggli's Mineralogical Institute. Although Zurich was his headquarters, he made a visit for about a semester to Bragg's laboratory in Manchester where he learned the techniques of X-ray diffraction under Taylor. He spent

another season there in 1931–1932, when he worked with J. West. This experience began Ito's career as a structural crystallographer; while in Manchester he worked out with West the structures of hemimorphite and bertrandite. On his return to Japan, Ito and his students deluged us with crystal-structure results, adding reports on the structures of epididymite, tellurite, epidote, eudidymite, vivianite, symplesite, warwickite, ludwigite, pinakiolite, boracite, tourmaline, ludlamite, axinite, milarite, realgar, datolite, parasymplesite, boleite, kotoite, lievrite, antigorite, and orpiment.

Unfortunately after he reported the structure of tellurite, World War II temporarily interfered with publication of his results. But this did not stop the flow of research from his laboratory, as we discovered later when his book *X-ray Studies in Polymorphism* was published in English in 1950. This book which, in part, took the place of research papers which might have appeared in the *Zeitschrift für Kristallographie*, had it not ceased publication until 1955, contained the results of the work of Ito and his students Sadanaga, Takéuchi, Sawada, Morimoto and Mori during the straightened period immediately following the war.

The book was unusual in two respects. In addition to reporting just crystal-structure results, Ito made practical use of his own theory of polymorphism—which he also developed in the book and which was responsible for its name—based on intimate twinning within the cell, so to speak. This fertile notion continued to engage the attention of many later investigators.

In a large appendix of the book Ito also described a new method of indexing powder photographs which was to become known as *Ito's method*. This procedure not only proved to be a valuable tool for interpreting powder photographs, but it also threw light on how to deal with this problem generally by treating it in reciprocal space. Ito's work in this field has stimulated interest among many crystallographers, including myself, because it provided a prototype solution to a perplexing crystallographic problem by showing how it could be handled in a rational fashion.

Through both his research papers and his book, Professor Ito has had a strong influence on the development of mineralogy in the recent past. The unravelling by him and his coworkers of the arrangements of atoms in some 25 mineral species gave mineralogists some much-needed information at a time when the relationships between minerals were beginning to be studied on a structural basis. For example, some of this work incidentally lead to a rational classification of the borate minerals, especially in the hands of Ito's student, Takéuchi, and various members of the U. S. Geological Survey.

Ito's view that the relation between certain polymorphs can be accounted for on the basis of twinning within the cell has been substantiated in many laboratories, including my own. The original theory has since been reformulated elegantly in terms of the little-known mathematical theory of groupoids and this has led to a better understanding of an important part of symmetry theory, and its relation to the theory of order-disorder.

In a similar manner, Ito's method provided a turning point in both theory and practice in the field of powder diffraction. First, it stimulated a generalization of the original theory in the hands of de Wolff and others. Second, it resurrected some otherwise unused theoretical devices which had lain fallow for some time, specifically Dalaunay's beautiful algorithm for reducing cells, and Niggli's exposition of the distinct reduced-cell types and how these are distributed among the crystal systems. Third, it had the effect of introducing into routine use the Guinier focussing powder camera, whose extreme dispersion and sharp lines turned out to be nearly a requirement when using Ito's method.

Thus, judged by the standard that good research is open-ended and leads to further developments, it is evident that Ito's work is of high order, and fulfills the conditions required of a Roebling medallist. So let us turn to another facet of Ito's career. He has taught mineralogy to some one hundred students. Many of them have become known to us personally because, after leaving Ito's laboratory, they have worked with us in our own laboratories (I refer especially to Morimoto, Takéuchi, Niizeki, Jun Ito, and Takeda) or they are known to us because they are book authors, for example, Imai and Sudo. Professor Ito has thus not only trained mineralogists, but through them he has been fortunate in spreading his philosophy in the mineralogical world.

Ito was born September 27, 1898, in Osaka, Japan. He received his Bachelor of Science in Geology from the Faculty of Science of the University of Tokyo in March 1923, and in May entered the Graduate School of Kyoto University, where he studied petrology for a year with Professor Takuji Ogawa. After an interim with Niggli in 1926 to 1928, and with Bragg and West in 1931 to 1932, he returned to his own country and was awarded the degree of Doctor of Science from Tohoku University for his work on moonstone. Meanwhile he had been appointed Lecturer in Mineralogy in Tokyo in 1924, Assistant Professor of Mineralogy in 1925, and Professor of Mineralogy in 1943. He also acted concurrently as Professor of Mineralogy at Kyoto from 1956, retired from Tokyo in 1959, and from Kyoto in 1961.

In 1945 he received the award of the Japan Academy for his studies on the crystal structures of complex silicate minerals, was elected a mem-

ber of the Academy in 1953, and was offered an honorary membership in the Mineralogical Society of London. His name first appears on the list of Fellows of the Mineralogical Society of America in 1960.

Professor Ito, your colleagues here are happy to acknowledge you as one of the leaders of our science. Mr. President it is my privilege, and personal pleasure, to present to you Professor Tei-ichi Ito.

THE AMERICAN MINERALOGIST, VOL. 54, MARCH–APRIL, 1969

ACCEPTANCE OF THE ROEBLING MEDAL OF THE MINERALOGICAL SOCIETY OF AMERICA FOR 1968

TEI-ICHI ITO, *Mineralogical Institute, Department of Science, University of Tokyo, Tokyo, Japan.*

Mr. President, Professor Buerger, Fellows and Members of the Mineralogical Society of America, and Guests:

I feel indeed very much honored by the award of this coveted medal, and by the inclusion of my unworthy name in the illustrious list of the Roebling medalists that adorn the history of our science. When the fund for the medal was established about thirty years ago and as the first recipient, the late Professor Palache was announced, I could, of course, hardly imagine that I should one day be conferred with the same honor. However, I wouldn't be honest with myself if I denied that a faint aspiration arose in the bottom of my heart for contributing to our science something, however insignificant it might be, as compared with the brilliant works of Palache. For me the dream has turned to reality. It was to my utmost pleasure to be informed by the President that the Mineralogical Society of America was bestowing upon me this unique distinction for a mineralogist. In particular, to be introduced by Professor Buerger, whose works I have admired throughout my life, is the highest honor conceivable for me, although I think I do not at all deserve his utterances concerning me and my works. Actually I used to hand over to him many of my pupils, who had outgrown me, to be trained further by him in his laboratory.

Mr. President, I should like to express my sincere gratitude to the Mineralogical Society of America for the great honor it has done me as well as to my many collaborators without whose painstaking efforts I couldn't arrive anywhere.

Perhaps as usual I may be permitted to say some personal words on this occasion. I was, as Professor Buerger remarked, at first interested