MEMORIAL OF WALDEMAR LINDGREN

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On November 3, Dr. Waldemar Lindgren succumbed to an illness which had made him an invalid for about a year. His death will be regretted not only by mineralogists but by all workers in the several fields of geological knowledge. Lindgren's breadth of geological attainment was equalled by few men. He not only appreciated the many facets of the science of geology, but he contributed to their advancement, and his publications ranged in subject matter from physiography to crystallography.

Waldemar Lindgren was born February 14, 1860, at Kalmar, Sweden, the son of Johan and Emma Lindgren. At a very early age he evinced an interest in mineralogy and geology, and particularly in mineral deposits. Indeed when only fourteen, he started his mineralogical excursions and visited the mining regions of central Sweden, and in the immediately following years, visited the mines of Norway and Germany.

When he graduated from the Kalmar Gymnasium in 1878, Lindgren entered the famous Royal Mining Academy at Freiberg, Saxony, where he studied under Richter, Winkler, Weisbach, and Stelzner. Lindgren took his opportunities seriously; he told me that he often took his mineralogy and petrography text books to bed with him, and read from them till he fell asleep. He graduated with the degree of Mining Engineer in 1882, but stayed for an additional year of graduate work.

In 1883, Lindgren quit Europe for the geological opportunities of America, and was fortunate enough to receive an appointment as assistant to Professor W. M. Davis, who was engaged in the Northern Transcontinental Survey under the general direction of Pumpelly. At the termination of this work, Lindgren showed his versatility by doing assaying, and by designing smelters.

Late in 1884, Lindgren entered the service of an organization with which he was to be identified for many years to come—the United States Geological Survey. This connection afforded him the opportunity for the extensive field work which was to lay the foundation for his subsequent generalizations. During this period of observation, he brought out masterpieces of description on mineral deposits; indeed his publications are still patterns used as guides by men training in this field. Moreover, he supplemented these descriptions by such keen analyses and correlations that he soon established himself as a leading theorist on the origin of ore deposits. Meanwhile, Lindgren slowly rose in rank to Chief of the Division of Metalliferous Geology of the United States

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Geological Survey, and eventually headed the organization as Chief Geologist.

In 1912, Lindgren resigned his post on the Geological Survey to assume the chair of William Barton Rogers Professor of Economic Geology and to become Head of the Department of Geology of the Massachusetts Institute of Technology, at that time located in Boston. He continued to hold this post until the usual retiring age of 70, but, by request of the staff, he consented to continue in this capacity until 1933. He was finally permitted to retire, at the age of 74, with the title of Professor Emeritus.

Shortly following the let-up of active academic duty, Lindgren's health began a gradual decline, and this general illness finally resulted in his death at the age of 79.

Many will think of Lindgren as a mining geologist or economic geologist, because his major contributions were in this field, but he was a great mineralogist as well. Indeed his knowledge of mineralogy, and his consistent mineralogical approach to many problems in ore genesis were important factors in his ability to make such telling contributions to that branch of science, and his stature as a mining geologist was in no small measure due to his habit of being, fundamentally, a mineralogist.

Lindgren put great emphasis on the mineralogical attainments of his students. They received intensive training in both the identification and the paragenesis of the minerals of selected suites of ores. When he received a new graduate student, it was with keen interest that Lindgren first discussed with him the results of the preliminary study of the mineralogy of the suite. I can recall several occasions, following such conferences, when Lindgren would saunter into my office, and, with an air of satisfaction, exclaim, "Well, ———— certainly knows his minerals!" This was always a priceless compliment.

Lindgren was a research worker of the first order, and he tried to inoculate his students with the spirit of research and self-reliance. Naturally, he attracted to himself, because of his prestige in economic geology, many students whose main aim was to become practicing mining geologists. Some of these men occasionally found Lindgren's instruction not specific enough for their needs, and attempted to get him to disclose just how to find ore and just how to proceed when examining a mine. To such men, Lindgren emphasized that it was his aim to teach the fundamentals of the science, in which he hoped they would become so steeped, that they would be able to apply the general principles to any problem with which they were presented.

Lindgren's greatest contribution to mineralogy was that he supplied that science with a well-authenticated theory of mineral origin, genesis,

and formation. This theory acts as a general framework upon which the various branches of mineralogy hang. Without it, vein mineralogy appears to be a field unconnected with ore mineralogy, and without it, mineralogy degenerates into the shallow fields of mineral collection and mineral description. Lindgren developed this theory by recognizing the merits of a number of scattered suggestions bearing on mineral genesis which had already been made, giving them his own particular emphasis, and adding to them original contributions. He integrated these many theoretical bits together into a general theory, and so thoroughly substantiated the entire theory and its parts, that it has come to be recognized as *the* theory of mineral deposition.

Among the several things which Lindgren emphasized are: the ultimate magmatic origin of mineralization; the classification of mineral deposits into temperature groups; the use of geological thermometers; mineral zoning both radially and in depth; metallogenetic provinces; the idea of replacement, especially volume-by-volume replacement; and the role of colloids in mineral formation. Lindgren's general theory of mineral deposition has been spread and become generally accepted, partly through his students, but largely through his book, "Mineral Deposits," which has passed through four editions and which is found in every mining camp.

By originating the abstracting journal which he named, "Annotated Bibliography of Economic Geology," Lindgren has put mineralogists deeply in his debt. In this innovation, Lindgren has not only contributed to his science by making it possible for the various investigators in the field to keep in touch with one another's progress and the progress in the border sciences, but he has also erected a lasting monument to his perspective and energy.

Among Lindgren's minor contributions to mineralogy, it should be recalled that he perceived the distinct natures of, and gave names to, the two minerals *coronadite*[1,2] ($PbMn_2O_5$), and *violarite*[3] (now known to be Ni_2FeS_4).

Lindgren has received several tokens of recognition of his mineralogical attainment. The mineral *lindgrenite* ($2CuMoO_4 \cdot Cu(OH)_2$) was named in his honor by Palache,[4] because of "His great contributions to

[1] Lindgren, Waldemar (with Hildebrand, W. F.), The copper deposits of the Clifton-Morenci district, Arizona: *Prof. Paper* **43**, *U. S .Geol. Survey*, 103–106 (1905).

[2] Lindgren, Waldemar, Coronadite "Redivivus": *Am. Mineral.*, **18**, 548–550 (1933).

[3] Lindgren, Waldemar, and Davy, W. Myron, Nickel ores from Key West Mine, Nevada: *Econ. Geol.*, **19**, 313–314, 315–319 (1924).

[4] Palache, Charles, Lindgrenite, a new mineral: *Am. Mineral.*, **20**, 484–491 (1935).

the knowledge of the mineralogy of the ore deposits and their paragenesis. . . . " In 1937, the Geological Society of London honored him with the Wollaston Medal, which is given, "to promote researches concerning the mineral structure of the Earth. . . . " He was the recipient of honorary doctor's degrees from both Princeton and Harvard. In 1928 he received the third award of the Penrose Gold Medal from the Society of Economic Geologists, and in 1933 he received the Penrose medal of the Geological Society of America.

Lindgren was a fellow of the Mineralogical Society of America as well as a member or fellow of numerous geological societies, mining societies, and general science societies. He has served as President of the Geological Society of America, the Society of Economic Geologists, the Mining and Metallurgy Society of America, the Boston Geological Society, and as Vice-President of the American Institute of Mining and Metallurgical Engineers.

Lindgren was one of the most widely read men I have ever met. He read everything which came to hand, including the newspapers, but he had the knack of culling the high points rapidly, and without being detained by the embellishments of an article. He was a cultivated linguist. I have a personal knowledge that he spoke English, Swedish, German, French, Spanish and Italian, and was at home with classical Greek and Latin. I also am sure he could read many other languages without, perhaps, being sufficiently well acquainted with them to speak them. Moreover, he was not narrowly a scientist, but he was interested in, and was willing to converse on, any topic which was brought up in the course of a friendly conversation. His wide reading made him an astounding source of information on such occasions, and I was often surprised at the odd realms of knowledge which he had found sufficiently curious to warrant delving into.

For all his attainments, Lindgren was modest and friendly. He invariably carried himself with a quiet dignity, yet was easily approached. His students not only regarded him with a respect reserved for few, but also considered him a good fellow, in token of which they always invited him to their stag affairs.

With the passing of Waldemar Lindgren, the science loses one of those rare individuals who has been able to set up its mileposts, and those who knew him have lost a friend.