

NATIONAL ACADEMY OF SCIENCES

CHARLES KENNETH LEITH

1875—1956

A Biographical Memoir by

D. F. HEWETT

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Biographical Memoir

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C. R. Leith

CHARLES KENNETH LEITH

January 20, 1875-September 13, 1956

BY D. F. HEWETT

CHARLES KENNETH LEITH was an extraordinary person. In four separate but related fields of activity, he achieved outstanding distinction; these were as a teacher (geology and related topics at the University of Wisconsin from 1902 until he was retired in 1945), as a student and worker in the science of geology (especially in the geology of the Lake Superior region, in metamorphic rocks and in ore deposits), as a professional consultant and an operator of mines, through which he made a modest fortune, and finally, as a consultant and adviser to numerous government agencies both in peace and in war. Few men working in a scientific field have achieved such distinction and recognition. The published record of his work is impressive in its scope, quantity, and quality and reveals his versatility, his extraordinary energy, and the clarity and incisiveness of his mental processes.

EARLY LIFE

Leith was born in Trempealeau, a town on the Mississippi River in western Wisconsin, January 20, 1875. Six years later, the family moved to Madison, and he grew up under the influence of the University of Wisconsin with which he was identified most of his life. He attended the public schools of Madison and, after graduating from high school in 1892, attended the local business college. He was undecided about a career but wanted to be sure that he could earn enough money to carry him through the university. This action,

seemingly of minor importance at the time, was to prove decisive in the choice of a career, for it brought him into close contact with the man who was to inspire and guide him as long as he lived, Charles R. Van Hise. Soon after Leith completed the course in the business college, he answered an advertisement in the university newspaper by Van Hise for part-time assistance in stenography and typing. Through this association Leith became private secretary to Van Hise, who had just been appointed professor of geology; Leith soon decided to pursue a career in geology.

It is worth noting that the life of Van Hise went through an interesting cycle. Like Leith he was born in Wisconsin, attended the university, and was graduated in mining in 1879. He was appointed instructor in metallurgy, a position which he held until 1883, when he was promoted to assistant professor; in 1886 he was appointed professor of metallurgy. From 1888 to 1890 he was professor of mineralogy; from 1890 to 1892, professor of Archean and applied geology; from 1892 to 1903 he was professor of geology and head of the department. In 1903 Van Hise became president of the university and held that position until his death in 1918. The published papers of Van Hise show the evolution of his interests from metallurgy to mineralogy, to the minerals found in pre-Cambrian metamorphic rocks and to ore deposits in the pre-Cambrian rocks, especially the iron ore in the Lake Superior region and, finally, to the entire range of problems of pre-Cambrian geology. In his later years he pioneered in the study of conservation not only of minerals but of all resources. What a piece of good fortune it was for Leith that at the age of seventeen he became associated with Van Hise! Actually, the evolution of Leith's own life shows several similarities to that of Van Hise.

The art of stenography was to serve Leith well through his life. Those who saw him in conferences and gatherings in Washington during the two wars will recall that he commonly made stenographic notes in his own peculiar system on scraps of paper. The conference over, he generally crumpled them and threw them away, but there

can be no doubt that merely making the notes kept his mind focused on the discussion and improved his memory of what had passed.

When Leith was a student at Wisconsin, Van Hise was deeply involved with others in the study of the iron districts of Michigan and Minnesota for the U. S. Geological Survey. In the first three monographs on iron districts, Penokee, Marquette and Crystal Falls, the only reference to Leith is in the last, by Clements and Bayley, where it is stated, "I wish to thank C. K. Leith who has been of the greatest clerical assistance." Apparently, Leith made field trips with Van Hise and others during his student days, but he did not begin independent work in the region until 1900, when he began the study of the newly found Mesabi district. He received the degree of Bachelor of Science in 1897 and that of Doctor of Philosophy in 1901.

TEACHING AT WISCONSIN

If Leith derived inspiration and knowledge from Van Hise during undergraduate days, it is quite clear, too, that Van Hise was deeply impressed by this serious young man. In 1900, when Leith was doing graduate work at Wisconsin, Van Hise, being in charge of plans and field work in the Lake Superior region for the U. S. Geological Survey, assigned him to make a monographic study of the Mesabi iron range which had only recently been discovered. Then, in 1903, when Van Hise was chosen president of the University of Wisconsin, he picked Leith to succeed him as Professor of Geology and head of the department. Leith was then twenty-eight years old.

Leith was chairman of the department until 1934 (thirty-one years), and a member until he was retired in 1945. In his position as Professor of Geology he conducted classes and held seminars in structural geology, metamorphic geology, pre-Cambrian geology, and ore deposits; also, for many years, he conducted field trips with the students. Generally there was a fall trip to the Baraboo Range to see features in general geology and a spring trip to the iron ranges to see the rocks and ore deposits in their setting. On these trips he re-

vealed the wide range of his interests and knowledge while maintaining an informality that attracted the students and endeared him to them.

As a part of his preparation for the courses in geology he maintained comprehensive files, but generally, when he appeared in the classroom, his only equipment was a slip of paper on which were written brief stenographic notes; when the lecture was concluded, he crumpled the slip of paper and dropped it in the waste basket. Some might have thought that the notes were the only record of his preparation and that much was improvised. Those on the staff knew, however, that there was a long record of preparation. Students who heard the lectures state that they were well-ordered, that he had the subject well in hand, and that he held attention and made a deep impression. Some students recall that the opening sentence of many lectures was, "Now this is the broad, general setup of this problem." Then followed, in orderly manner, the details that fortified the general conclusions. In seminars, a statement by Leith was followed by critical questioning and there was generally a terminal question, "Well, has anyone any questions to ask?" Students agree that he held undivided attention in classes by his obvious command of the subject, by his forceful manner of speaking, and by the prestige of the work he had done.

When Leith was chairman of the department, from 1903 to 1934, staff meetings were very informal; generally the group gathered for a weekly luncheon in the library. Most would agree that during the periods of chairmanship by Van Hise and Leith the department at Wisconsin was outstanding, measured both by the attainments of the members and by the quality of the graduates.

Leith did not maintain intimate social relations with the students, but once a year the graduate students were entertained at his house. He was not readily accessible to the students outside of classrooms. To consult him in his office it was necessary to get permission from his secretary, A. C. Deming, and this was not easy. It should be noted that Leith was very fortunate in the abilities and loyalty of Deming

who, in his early years, performed the usual duties of such a position but who, as the years passed, assumed responsibility for many personal matters, even fiscal, for Leith.

As his life broadened and his activities multiplied, especially following the war of 1917-18, Leith spent more and more time away from Madison; for the last ten years of his chairmanship, he received only one half of his allotted salary from the university.

In addition to instructing young men, colleges have an opportunity and perhaps some responsibility for placing these men after graduation. With the rapid growth of the American iron and steel industry from 1900 onward, there was great need for well-trained young geologists and mining engineers and, with his ties in the Lake Superior iron districts, Leith was able to aid graduates from Wisconsin in getting positions. With his own affairs also, both in the university and outside, Leith was so prolific in ideas and plans that he was in constant need of assistance from his associates and students. In his early life he was both highly industrious and meticulous in details. Later in life he developed the plans for a piece of work and delegated the details to associates and graduate students.

SCIENTIFIC WORK

For the twenty years following his graduation Leith's research work was devoted to the problems of the Lake Superior region, especially those concerned with the rocks, their correlation, deformation, metamorphism, and the ore deposits. With regard to the Lake Superior region, it may fairly be stated that, even though there were earlier reconnaissance examinations of the resources and geology of the area, systematic studies did not begin until about 1840. Since then many eminent geologists have devoted their lives to geologic studies in the region. Van Hise, who devoted most of his life to these problems, pays high tribute to his predecessors, especially R. D. Irving. Leith was introduced to these problems by Van Hise, and in many places expresses great appreciation for the association, and for the

guidance and help received from Van Hise. A review of the published papers by Van Hise shows the evolution of his interests from mineralogy to the minerals in the rocks of the Lake Superior region, to the larger problems of the rocks, their correlation, structural features, and their ore deposits over the entire Lake Superior region. Leith's own record shows a similar evolution and it seems that he took over many of the problems where Van Hise left off when he became president of Wisconsin in 1903. Thereafter, Van Hise's chief interests centered on the nationwide problems of conservation of resources and of corporate monopolies. On the other hand, from 1920 on, Leith's principal field of interest covered national resources of minerals in peace and war and the policies of the United States and all nations toward mineral supplies and trade.

In the summer of 1900, Van Hise, while in charge of the Division of Pre-Cambrian and Metamorphic Geology of the U. S. Geological Survey, assigned Leith, then twenty-five years old, to the study of the Mesabi iron district, Minnesota. The text of Monograph 43 on the Mesabi district was transmitted by Van Hise for publication in June, 1902. Earlier there had been monographic reports on the Penokee Series of Michigan by R. D. Irving and C. R. Van Hise, on the Marquette district of Michigan by Van Hise and W. S. Bayley, and on the Crystal Falls district of Michigan by J. M. Clements and H. L. Smythe. The Mesabi report by Leith was followed by one on the Vermilion district of Minnesota by Clements and one on the Menominee district of Michigan by W. S. Bayley. Monograph 52, *The Geology of the Lake Superior region* by Van Hise and Leith, published in 1911, completed this program of study of the region and its resources. In 1935 there was published Professional Paper 184 by C. K. Leith, Andrew Leith, and Richard J. Lund, which presented a revised geologic map of the Lake Superior region and the new data accumulated since 1911. This program of study and mapping of a large area with many complex problems, largely planned by Van Hise, was about the most ambitious ever undertaken by the Geological Survey.

Leith's work in the Mesabi district and field studies in the rest of the region laid the foundation for topical studies of rock cleavage (Bulletin 239, 1905), *Structural Geology* (1913, revised in 1923), *Metamorphic Geology* (with W. J. Mead, 1915). The first of these studies, Bulletin 239, assembled much data and interpreted the features that arise out of various stresses in rocks. The second and third books were modern interpretations and served as standard textbooks for many years.

Though the Mesabi Range is only a part of the Lake Superior region, Leith's work gave him a grasp on the geology of the entire region and he became the foremost authority on it. Only in the matter of the mode of origin of the Mesabi iron ores, the "soft ores," was his authority challenged. The theory arose in later years that the soft hematites may have been derived from the iron formation by hydrothermal processes instead of surface circulations, but in recent years the consensus of opinion favors Leith's interpretation.

CONSULTATION AND MINING WORK

As long as Leith held appointment on the U. S. Geological Survey he could do no consulting geologic work in the United States. From 1905 onward, however, he was much in demand as a consultant in geologic work and as a witness in litigation. He was one of the first Americans to examine the Cobalt district in Canada (1905) and in 1909 he conducted an investigation of reported iron ore on the east shore of Hudson's Bay; this episode led to the preparation of a book, *A Summer and Winter on Hudson Bay*, with the aid of his brother, A. T. Leith. In 1910 he made investigations of the iron ore deposits in central Brazil and a company, Brazilian Iron and Steel Company, was formed to exploit them. Work continued in the area for ten years but the company finally withdrew.

In 1910, with W. J. Mead, he made an examination of the extensive laterite iron ores of eastern Cuba. At this time Leith was without doubt the best informed geologist in the United States con-

cerning iron ore deposits in North and South America. It was natural, therefore, that he should be sought for guidance by some of the larger iron- and steel-producing companies of the United States. From time to time he was engaged as a witness in mining litigation but this activity was a small part of his consulting work.

Leith acquired a modest fortune from private mining ventures which began as an association with two former students, William N. Smith and Sidney H. Davis, for the operation of zinc mines in southwestern Wisconsin. Later it became the Ozark Chemical Company, operating zinc mines in the Miami area, Oklahoma, to produce zinc and sulphuric acid. Still later the Mahoning Mining Company was formed and then these were merged to become the Ozark-Mahoning Company, the principal holdings of which were fluorite properties in southern Illinois.

PUBLIC ACTIVITIES

The movement for conservation of natural resources in the United States began about 1900. Conservation of water resources in the arid regions was advocated about 1870; conservation of timber resources followed, and conservation of mineral resources began to attract wide interest about 1900. An early advocate of conservation was President Theodore Roosevelt, who initiated a national conference on conservation in 1905. Van Hise at Wisconsin was an early advocate, and in 1910 he wrote a book entitled *Conservation of Natural Resources in the United States*. From about 1900 to 1920 the United States was more than self-sufficient in most minerals and metals, and exported large quantities to Europe. The war in 1914 soon created a crisis in our shipping and made many persons in the United States aware of the dependence of Europe upon mineral supplies from the United States, and also of the dependence of the United States upon foreign sources of several mineral supplies, especially manganese, chrome, tungsten, and sulphur.

Early in the war the U. S. Shipping Board was formed to control

both exports and imports, and with the entrance of the United States into the war in 1917 there was created the Committee on Mineral Imports and Exports. E. F. Gay of the Harvard School of Business Administration was chairman of the Division of Planning and Statistics of the Shipping Board and asked his friend Leith to become chairman of the Mineral Committee. After several months of inquiry, early in 1918, the Committee devised a program of imports and exports in minerals which was placed in operation. This work completed, Leith became an adviser to the Chairman of the War Industries Board, Bernard Baruch. Through this association Leith became an adviser of the Peace Commission and spent most of 1919 in Europe. This early history is presented because it indicates the expansion of Leith's interest in national and international mineral problems that were to absorb more and more of his interest and time until his death.

Soon after the end of the war in 1918, two national engineering societies gave attention to the problems of mineral supplies in the event of war, and committees were formed to study the problems and recommend policy and action. These were the Committee on Industrial Preparedness of the American Institute of Mining Engineers, of which Leith was a member, and the Committee on Foreign and Domestic Mining Policy of the Mining and Metallurgical Society of America, of which Leith was chairman. The reports of both committees were published in 1925 in the form of a pamphlet entitled *International Control of Minerals*. In the report of the first committee a program of creating stockpiles of several of the deficient minerals was first proposed. During the next fifteen years the proposal was discussed at many meetings of groups interested in mineral supplies, and in Congress. It did not get sympathetic consideration from Congress until 1938, and the act authorizing stockpiles was not passed until 1939 (Public Law No. 117).

In 1925 and 1926 Leith was invited to lead a round-table discussion on the topic "Mineral Resources in their Political Relations," at the Sixth Conference of Institute of Politics at Williamstown,

Massachusetts. These conferences attracted eminent contemporary historians and economists from Europe as well as from the United States, and they did much to arouse general interest in mineral supply problems throughout the world. One result of Leith's activities and interests during this decade was the book, *World Minerals and World Politics*, the first to emphasize the place and influence of minerals in world affairs.

The next episode in the study of mineral problems was the formation of "The Mineral Inquiry" in 1933, sponsored by the American Institute of Mining Engineers and financed privately; Leith was chairman. During eight evening sessions in New York, eighteen speakers, largely specialists in some aspect of the mineral industries, discussed numerous problems. The papers were published in a volume entitled *The Elements of a National Mineral Policy*.

The appearance of this volume was timely, for the new administration in Washington early in 1933 created the National Planning Board, which was superseded by the National Resources Board, and a Committee on Mineral Policy held prolonged hearings and discussions in Washington. Out of this review a comprehensive report of the Planning Committee for Mineral Policy was published (1934); Leith was vice-chairman of this committee.

It is worth noting that under the Natural Resources Board there was prepared by Kenneth Leith (older son of C. K. Leith) and Donald M. Liddell, a report entitled *The Mineral Reserves of the United States and its Capacity for Production* (1936). This report was the first attempt to assemble in one volume the known mineral reserve data for thirty-one minerals and metals in the United States and to estimate the probable amount and duration of their production. Earlier such data had been assembled for petroleum, iron ore, etc. This study was inspired by Leith, as it was essential background in any efforts to form policies concerning minerals in war or in peace.

Even though there was peace among the major powers from 1919 to 1939, the rise of militant Germany during these twenty years

caused steadily growing concern among the other nations. In 1937 the Army and Navy Munitions Board appointed a Minerals Advisory Committee and requested a review of potential supplies of sixteen minerals; Leith was chairman of this committee. During 1937 comprehensive reports on sixteen deficient minerals were prepared. These reports were considered confidential and have never been published, but they were the basis of hearings in Congress, out of which came the first bill that authorized the accumulation of stockpiles of deficient minerals. This bill died in the Mining Committees of Congress in 1938 but was reintroduced in 1939 and became Public Law No. 117. Under it stockpiling of some minerals was authorized and in August, 1939, money was appropriated to purchase the minerals. War came in Europe in the late summer of 1939. Under the act, in addition to authorizing the creation of stockpiles, the Department of the Interior, through the Geological Survey and Bureau of Mines, initiated a program to search for deposits of the deficient minerals and carry on exploration.

With the abrupt collapse of France in June, 1940, new measures to control and allocate production of many materials used in the industries of the United States were needed. The President used the authority conferred on him by the Council of National Defense Act of 1916 to form the Advisory Committee to the Council. This Committee requested the National Academy of Sciences to form an Advisory Committee on Manganese, which later became the Advisory Committee on Metals and Minerals, of which Leith was chairman. During the next three years, many reports on sources of supply of metals and mineral production, substitution, and use were prepared, first for the Office of Production Management and, after the attack on Pearl Harbor in December, 1941, for the War Production Board. The scope and high quality of these reports is a tribute to the guidance of its chairman, as well as to the members of the several committees who prepared them. It is fair to say that the guidance of the chairman was most needed early in the war in the creation of procedures to handle the conflicting interests of the producers of raw

materials, the fabricators, and the consumers. Late in the war, say from 1943 to 1945, with procedures established, concern was largely directed toward maintaining maximum production and efficient distribution.

The dependence of industry on minerals, especially during a war, is indicated by the steady growth in the number of minerals that were regarded as strategic or critical. During the First World War, only four were regarded as vital and deficient in the United States: manganese, chrome, tungsten, and sulphur. As of 1939 when war in Europe began, the Army and Navy Munitions Board list included nine: seven metals and quartz and mica. Late in the Second World War, fifty-two minerals and metals were either strategic or critical.

With the termination of the war late in 1945, the war agencies were quickly dissolved and the personnel dispersed. Anticipating the problems of the peace, Leith with an intimate associate, J. W. Furness of the U. S. Bureau of Mines, and Miss Cleona Lewis of the Brookings Institution, had devoted considerable time to the preparation of a book, *World Minerals and World Peace* (1943).

This memorial is not the place to discuss the origin and evolution of the many problems that surround the discovery, exploitation, marketing, and consumption of minerals throughout a nation or the world. It is interesting, however, to trace the contributions of C. K. Leith to some of these problems. When the First World War broke, he was probably the best-informed person concerning the ferrous metal resources of North and South America, and he was familiar with these resources throughout the rest of the world. A review of his writings on these topics, beginning with the close of this war and continuing through the Second World War, reveals some of his conclusions and recommendations:

1. Important sources of minerals are distributed sporadically throughout the world, without any relation to the political boundaries of the nations; a few nations are endowed with diversity and abundance of minerals; a few have one or more minerals in great abundance and become dominant sources; most nations have modest

resources of some minerals and are deficient in many minerals; no industrial nation is completely self-sufficient in all of the minerals that it needs.

2. Some nations, possessing large resources of some minerals, sufficient to become dominant world sources, have established national controls of production and, therefore, price, solely to benefit themselves.

3. The United States, uncommonly well-endowed with resources of most minerals that are essential to an industrial nation but deficient in some essential materials, has encouraged free access to discovery and exploitation and has avoided national controls. The First World War brought out the dependency of its industries on some foreign sources and brought it into contact with the controls of some other nations.

4. The importance of (a), the so-called open-door policy with regard to minerals, or equal privileges of access by all nationals to mineral sources throughout the entire world, and (b), international control of international trade in minerals (repeatedly recommended). These policies, controlled by some sort of league of nations, would, over the years, lead to more vigorous and intelligent search for undiscovered sources of minerals throughout the world and maintain conditions of competition in exploitation that would ensure the cheapest supplies of all minerals to all nations.

5. International control of distribution of minerals, by allotting proper supplies to small and weak nations as well as to large and strong nations, would be a deterrent to war.

The rise of the spirit of nationalism throughout the world, and the creation of new nations that followed the First World War, helped to defeat the League of Nations. Also, since the end of the Second World War, more new nations have been created and the spirit of nationalism seems to dominate the world. Little that Leith and his associates recommended during the twenty years between

the wars has been accepted. It seems fair to say, however, that there is so much of idealism and practical economy in these recommendations that sooner or later the world will adopt many of them.

At least one recommendation that took form in 1921 and was emphasized in numerous reports sponsored by Leith was enacted into law in 1939. It is known as the stockpiling act, Public Law No. 117, and in recent years the policy is supported by annual appropriations. Under the present Defense Minerals Exploration Administration large stockpiles of many essential minerals and metals have been accumulated.

In a larger way, however, the activities of numerous committees and conferences of which Leith was either chairman or a member, and books of which he was the author, have finally impressed Congress, the executive departments, and especially the military units, with the vital importance of many minerals in modern industries, not only in times of peace but also, and even more so, in war, where strength is largely industrial power.

Leith's retirement from Wisconsin in 1945 coincided with the coming of peace. From then on he spent the winters in Washington and the summer months in Madison. The formal peace of 1945 did not, however, bring peace and good will among the nations, for a new type of war, the "Cold War," has divided the world and necessitated preparation for possible future conflict. From 1945 to the present, chief concern has been with the minerals uranium and thorium, the sources of nuclear energy. It was natural that Leith, even in retirement, should be called upon for consultation and advice. From 1944 until mid-1956 he was a member of the Combined Development Agency of the U. S. Atomic Energy Commission, and in 1956 he received a citation for outstanding service. He also served with the National Security Resources Board, the Research and Development Board of the Department of Defense, and the Minerals and Metals Advisory Board of the National Research Council.

THE MAN

As a casual review will show, the printed record of Leith's work is impressive in quantity, scope, and quality. This record, however, does not reveal his influence on his associates, students, and faculty at Wisconsin; on his professional associates in the mineral industries, largely in iron and steel; on groups in educational fields; on the government, and on his friends. What peculiar qualities did he possess that made him so influential in such a wide range of activities?

It seems to the writer that Leith possessed an unusual interest in life and people, a very retentive memory, and a physical and mental energy that made him work intensely over a wide range. These qualities made him interested not only in the details of a problem, but also in the broad grasp and larger picture. Until the late years of his life his horizon was steadily expanding. Few professional men have so enlarged their activities through the middle years that they continually needed and wanted help from those that surrounded them, as did Leith. In their interest in details, most professional men find it irksome if not very difficult to use assistance effectively. It seems that Leith was constantly aware of the need for help from his associates in the details of his plans and was able to make use of such help. The opening remark of many of his lectures seems very revealing: "Now, let's get the broad general picture."

Leith was a very friendly man. Even though he achieved distinction and high place in several fields, he met all kinds of people easily and his conversations and discussions were quite informal. In important conferences he was intense, but even after hours of discussion and argument he never lost his temper. As a measure of his integrity it is recalled that each of two firms involved in a legal controversy engaged him as an adviser, a rare tribute.

Leith was highly esteemed by associates, intimate and formal, and many honors came to him. To mention only a few, he was elected to high office in several professional societies, being president of the Geological Society of America (1933), and of the Society of Eco-

conomic Geologists (1925). Both of these societies awarded him their Penrose Medal (G.S.A., 1942, S.E.G., 1935). Four colleges and universities awarded honorary degrees to Leith: Kenyon College, LL.D., 1926; Lawrence College, D.Sc., 1930; Columbia University, D.Sc., 1940; Stevens Institute of Technology, D.Sc., 1943. In June, 1956, the University of Wisconsin awarded him an honorary degree, Doctor of Science. He was elected to numerous societies, several of them honorary, including the National Academy of Sciences (1920), and the American Academy of Arts and Sciences (1916).

In January, 1898, Leith married Mary E. Mayers, the daughter of a Madison merchant. To them were born two sons, Kenneth, who died in 1940, and Andrew, now associated with the E. J. Lavino Company of Philadelphia.

Charles Kenneth Leith died on September 13, 1956, at the age of eighty-one.

KEY TO ABBREVIATIONS

- Ann. Am. Acad. Polit. Soc. Sci. = Annals of the American Academy of Political and Social Science
- A.I.M.E. = American Institute of Mining Engineers
- Bull. Am. Inst. Min. Eng. = Bulletin of the American Institute of Mining Engineers
- Bull. Geol. Soc. Am. = Bulletin of the Geological Society of America
- Bull. Min. Met. Soc. Am. = Bulletin of the Mining and Metallurgical Society of America
- Econ. Geol. = Economic Geology
- Eng. Min. Jour. = Engineering and Mining Journal
- Geol. Soc. Am. = Geological Society of America
- Jour. Am. Zinc Inst. = Journal of the American Zinc Institute
- Jour. Canadian Min. Inst. = Journal of the Canadian Mining Institute
- Jour. Geol. = Journal of Geology
- Jour. Western Soc. Eng. = Journal of the Western Society of Engineers
- Min. Cong. Jour. = The Mining Congress Journal
- Min. Met. = Mining and Metallurgy
- Ont. Bur. Mines Rept. = Ontario Bureau of Mines Report
- Pan Am. Sci. Cong. = Pan American Scientific Congress
- Proc. Am. Sci. Cong. = Proceedings of the American Scientific Congress
- Proc. Geol. Soc. Am. = Proceedings of the Geological Society of America
- Proc. Int. Geol. Cong. = Proceedings of the International Geological Congress
- Proc. Int. Student Assembly Am. Univ. = Proceedings of the International Student Assembly, American University
- Proc. Nat. Tax Conf. = Proceedings of the National Tax Conference
- Trans. Am. Inst. Min. Eng. = Transactions of the American Institute of Mining Engineers
- Trans. Am. Inst. Min. Met. Eng. = Transactions of the American Institute of Mining and Metallurgical Engineers
- Trans. Can. Min. Inst. = Transactions of the Canadian Mining Institute
- U.S. Geol. Surv. Ann. Rept. = United States Geological Survey Annual Report
- U.S. Geol. Surv. Bull. = United States Geological Survey Bulletin
- U.S. Geol. Surv. Mon. = United States Geological Survey Monographs
- U.S. Geol. Surv. Min. Res. U.S. = United States Geological Survey, Mineral Resources of the United States
- U.S. Geol. Surv. Prof. Pa. = United States Geological Survey Professional Papers
- Univ. Wis. Bull. = University of Wisconsin Bulletin
- Wis. Eng. = Wisconsin Engineer

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