ROCK STARS

Robert M. Garrels (1916–1988): Pioneer of Modern-Day Sedimentary Geochemistry and Geochemical Cycling

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SUMMARY

Bob Garrels spent his formative years in the mountainous southwestern part of Saltville, Virginia, USA, passing most of his time outdoors, hunting, exploring, and swimming. This probably laid the foundation for Bob's selection of a scientific career involving the outdoors.

Except for a brief stint (1952–1955) with the U.S. Geological Survey, Garrels' entire 47-year career was as a researcher and teacher in academia. During his career, Garrels was among a handful of persons who truly altered the field of geochemistry and earth science in general, particularly in the disciplines of sedimentary geochemistry and geochemical cycling.

Robert M. Garrels

THE EARLY YEARS

Robert Minard Garrels, the son of John C. Garrels and Margaret Ann Gibney, was born in Detroit, Michigan, USA, on 24 August 1916. His father was a chemical engineering graduate of the University of Michigan, where he excelled in track and field and football. His athletic accomplishments were passed on to his children, and Bob became highly proficient in tennis. He habitually frustrated opponents by lobbing one "where they ain't."

Bob's mother enrolled him in piano lessons at the age of three. He had a natural talent for the piano and continued to play into his college days and thereafter. Although I thought he was a great rag-time player, one of his music teachers told him, "Bob, you play loud and fast, but don't try to make it a profession!"

In 1923, the Garrels' family moved to Saltville, Virginia. Bob's father was an assistant plant manager at a soda ash plant that used local salt and limestone as raw materials. The rural setting in which Bob lived was idyllic for free exploration and the initial development of Garrels' congenial character and warmth. The influence on his career choice by these years in Saltville is clear. In his unpublished autobiography, Garrels wrote:

> There were three factors, I think, that pushed me toward a scientific career. First, of course, my father's interest; second, the richness of the area (southwestern Virginia) in natural lore. The rocks of the hills surrounding the town contain abundant Paleozoic fossils. The third factor was the presence of James Moore, a bachelor who was a first-rate amateur astronomer, and who delighted in teaching me and my friends about the universe.

When Bob was 12, the Garrels family moved to Grosse Ile, Michigan, USA. Grosse Ile then was sparsely populated and Bob continued to flourish in this rural setting with forests and plenty of space for exploration. In high school, he excelled in mathematics and chemistry, continued to be an avid reader, and maintained his interest in athletics. One of his enjoyments was sailing on the Detroit River with his brother, John.

COLLEGE

Garrels entered the School of Liberal Arts at the University of Michigan in 1933. He studied chemistry, geology, and German. His original intention was to become a chemist like his father, or a novelist. However, because of a bad chemistry teacher (he actually failed physical chemistry!) Garrels instead majored in geology.

In 1937, Garrels earned a B.S. with honors from the University of Michigan. Because of the Great Depression, he went straight to work with the Michigan Geological Survey. Garrels soon found, however, that he could attend graduate school with a scholarship at a pay level only slightly less than what he was making at the Michigan Geological Survey. So, in 1937, he enrolled in Northwestern University's department of geology. In his own words:

> I entered the Graduate School at Northwestern University, only because they needed a teaching assistant at $50 per month and the best job (at the Michigan Geological Survey) I could find paid $75. The Department of Geology at Northwestern was small but excellent; my fellow graduate students were compatible, competitive, and capable. I soon ran out of geology courses, and took chemistry courses to fill in my program; to my amazement I found them fascinating and useful.

On his first day at Northwestern, Garrels met John T. Stark, chair of the department of geology. He described his first meeting with Professor Stark:

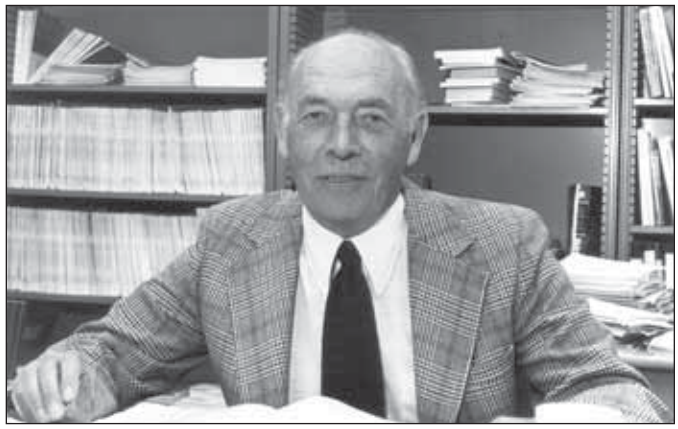
> I walked into the chairman's office and was invited to sit down. The chairman stretched out his hand, which was full of pebbles, and asked me to identify them. I said they looked like stream pebbles to me, and Jack remarked, "Not bad," as he popped one of those candy pebbles into his mouth.

Jack Stark became a close friend and had a tremendous influence on Garrels. Stark's teaching method was that of devil's advocate, and Garrels adopted and employed this method in his own career with great relish.

C.H. Behre Jr. was the chair of Garrels' M.S. thesis committee at Northwestern. Garrels received his M.S. in 1939 for work on iron ores of Newfoundland, and in 1941, he received his Ph.D., primarily for his laboratory work employing electrochemical techniques to study complex ion formation between lead and chloride ions in aqueous solution. This was the beginning of his lifelong interest in natural aqueous solutions and the use of Eh-pH diagrams in interpreting their history and evolution.

CAREER HIGHLIGHTS

Garrels stayed at Northwestern as a replacement for Charles Behre and worked with a distinguished faculty, including Larry Sloss, Bill Krumbein, Ed Dapples, and Art Howland. In 1944, he joined a team of scientists working with the military geology unit of the U.S. Geological Survey (USGS). He was based in Hawaii with the Corps of Engineers' beach erosion board, studying maps and photographs for the planned invasion of Japan.



Robert M. Garrels

After the war, in 1945, Garrels returned to Northwestern and remained until 1952. At Northwestern, he produced the first of several books, *A Textbook of Geology*, an undergraduate text far ahead of its time because of a heavy dose of physics and chemistry and innovative thought.

In 1952, Garrels joined the USGS as head of the solid state group, geochemistry and petrology branch. He did not remain there long because the personnel-related duties were not to his liking. Thus, in 1955, he accepted the position of associate professor of geology at Harvard and in 1957 was promoted to professor. At Harvard, Garrels' research talents flourished and he attracted an excellent group of graduate students. His laboratory was a hub of intellectual activity with individuals like Paul Hosteler, Owen Bricker, and Don Langmuir doing Eh-pH experiments in mineral-aqueous solutions; Hal Helgeson and Al Truesdell doing theoretical calculations; Bruce Hanshaw studying the flow of water through clay packs; and M. Sato, along with Garrels' laboratory assistant, Mary Thompson, making electrodes out of such materials as sulfide minerals. Bob Berner, presently a professor at Yale University, feels himself fortunate to have been trained by Garrels in the theoretical and experimental aspects of geochemistry, which at that time were not commonly taught elsewhere.

Garrels published a book in 1960 titled *Mineral Equilibria at Low Temperatures and Pressure*, which changed completely the field of low-temperature geochemistry. This book and its successor, *Solutions, Minerals, and Equilibria* (1965), co-authored with long-time friend, Charles L. Christ, were ahead of the field and the first of their kind to demonstrate to earth scientists how to rigorously apply chemical thermodynamics, particularly in the form of Eh-pH diagrams, to the solution of geochemical and geological problems involving minerals and aqueous solutions. Garrels also wrote several classic papers while at Harvard. One of these, "A Chemical Model for Sea Water at 25 °C and One Atmosphere Total Pressure" (1960, with co-author Mary Thompson), attests to Garrels' diverse interests in the natural sciences. This paper was a *tour de force* in chemical oceanography but encountered resistance from the ocean-scientist community and was turned down three times before being published.

Garrels chaired the geology department at Harvard from 1963 to 1965, but because of his continuous dislike for administrative duties returned to Northwestern in 1965. Hal Helgeson and Fred Mackenzie joined Garrels on the Northwestern faculty at about the same time. The early 1960s also saw the beginning of Garrels' association with the Bermuda Biological Station for Research (now the Bermuda Institute of Ocean Sciences), at which Fred Mackenzie was then staff geochemist. Garrels spent many summers at the station writing and conducting research with several colleagues, including his close friend, Roland Wollast. This intellectual setting not only led to a great deal of scientific output but also to the formation of the Bermuda Biological Station Athletic Club (BBSAC), with Garrels as president. This unusual organization sponsored athletic events at the station for students, staff, and scientists. It also had a strong code of ethics, which included rules for how many gin and tonics one might be entitled to for swimming 200 yards between a raft and the research vessel *Panuliris*.

In 1969, Garrels left Evanston for the Scripps Institution of Oceanography, and in 1972 he became the Captain James Cook Professor of Oceanography at the University of Hawaii. In 1974, he once more returned to Northwestern, leaving there in 1980 to join the faculty in the department of marine science at the University of South Florida, where he held the St. Petersburg Endowed Chair of Marine Science until the time of his death in 1988.

During all these moves, Garrels continued to produce a number of innovative and insightful papers and books and was largely responsible (with Bryan Gregor) for the GSA symposium on geochemical cycles that ran for 11 years. The 1971 book *Evolution of Sedimentary Rocks* (with co-author Fred

Mackenzie) had a major influence on scientists interested in the chemical recycling of sediments. During this time, Garrels also wrote two books with his second wife, Cynthia Garrels (Hunt): *Water: the Web of Life* (1972) and *Chemical Cycles and the Global Environment* (1975, with a third co-author, Fred Mackenzie). The latter book was one of the first in geochemistry to demonstrate the strong influence of human activities, including fossil-fuel burning, on the natural biogeochemical cycles of life-essential elements such as carbon. Garrels' final book, written shortly before his death, was a compilation of thermodynamic data for minerals at low temperature (1987, with co-author Teri Woods). Important papers, usually written with friends and co-authors, dealt with topics such as irreversible reactions in geochemical processes; the diffusion coefficient of silica; the concept of reverse weathering; carbon, sulfur, and oxygen cycling through geologic time; the BLAG model of the carbonate-silicate cycle; and modeling oxygen in the global sedimentary redox cycle.

HONORS AND AWARDS

Garrels received many awards during his lifetime, including election to the U.S. National Academy of Sciences, the Arthur L. Day and Penrose Medals of the Geological Society of America, the V.M. Goldschmidt Medal of the Geochemical Society, the Roebling Medal of the Mineralogical Society of America, and the Wollaston Medal of the Geological Society of London.

FINAL NOTE

Robert M. Garrels was one of the giants in the field of geochemistry but always felt himself to be a geologist at heart. He certainly is the recognized "father" of modern sedimentary geochemistry. His one overriding goal was to understand the origin and evolution of the surface environment of Earth from a geologist's point of view.

ACKNOWLEDGMENTS

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FURTHER READING

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