ROCK STARS

Bob Garrels conducting fieldwork in the late 1930s or early 1940s. Photo courtesy Cynthia Garrels.

Robert M. Garrels

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An obvious way to begin this article would have been, "It's hard to imagine a more influential geochemist than Robert Minard Garrels," but one of many pieces of advice Garrels (1916–1988) gave his students was, "If you find yourself saying 'it's hard to imagine …' imagine harder!" Imagining hard is what characterized Garrels' approach to the earth sciences.

Garrels' contributions to the fields of geology and geochemistry are immense, for which he received many honors. With Mary Thompson, he pioneered the use of the ion-pairing model to understand the behavior of the elements in seawater. With William Krumbein (1952) and later Charles Christ, he explained, through many examples, how redox potential (Eh) and acidity (pH) can be used to characterize natural environments and to predict the minerals that occur stably in them. With Fred Mackenzie he proposed that seawater chemistry was strongly affected by equilibria with newly formed silicate minerals (the concept of *reverse weathering*). The collaboration with Mackenzie led to a series of papers and a 1971 textbook, *Evolution of Sedimentary Rocks*, which reinvigorated the concept of global cycling of the elements. Garrels came to imagine that the chemistry of the oceans and atmosphere were in a dynamically steady state rather than in equilibrium, and this led to a series of papers that transformed these ideas into ordinary differential equations (box models), as classically presented in the BLAG model (for Berner, Lasaga, and Garrels; Berner et al., 1983). His textbooks are classics, and his publications impactful, still to be mined for treasured insights.

What made Bob Garrels so uniquely able to see order in the chaos of nature and to present it in a way that was accessible even to less chemically oriented geologists? Like so many of us, his early experiences and great mentors along the way had tremendous influence. His father was a chemical engineer who worked for a chemical company that used local salt and limestone in its processes. Garrels credits his father's interest and the local salt deposits and fossil-rich rocks as factors that set him on the path toward a career in earth science. A neighbor who excelled in astronomy took the time to instill a sense of wonder about the universe in young Garrels and his friends. Bob liked to play with his mother's lye (which she used for making soap) because it felt so slippery, and he learned the hard lesson that bases can be as caustic as acids when his fingernails fell off. At Michigan, where he obtained his undergraduate degree, Garrels was turned off to chemistry by a poor teacher and settled on geology.

Upon graduation in 1937, Garrels found that continuing on for an advanced degree at Northwestern paid almost as well as available jobs and took the offer of a teaching assistantship in the geology department. Having taken all the geology courses offered, he enrolled in chemistry courses, which "to [his] amazement, [were] fascinating and useful" (quoted in Berner, 1992). From a geology professor, John T. Stark, he learned to question tacit assumptions and to adopt the position of devil's advocate, an approach he is said to have used with great pleasure. He learned from a chemistry professor (F.T. Gucker Jr.) not to underestimate students, but rather to challenge them with problems that seemed beyond their abilities, and to "make [them] understand that it was unthinkable for [the students] not to solve them." To Garrels own students' immediate dismay but enduring benefit, they experienced this teaching pedagogy many times in the geochemistry classroom.

Garrels moved many times during his career (Sloss and Berner, 1989). After receiving his Ph.D. in 1941, he remained at Northwestern until 1952, excepting a one-year stint in the military mapping beaches in the Pacific. He left Northwestern for the U.S. Geological Survey to work on the geochemistry of uranium, an element of great interest in the post-war atomic age and Cold War, but longed for a return to academic life and so in 1955 accepted a position at Harvard. In 1965, fleeing the administrative duties of department chairman, he returned to Northwestern. Four years later, he moved to Scripps, then two years later to the University of Hawaii, then two years later back to Northwestern for five years, and finally to the University of South Florida.

Garrels always welcomed new ideas, and because of this he struck up a deep friendship with James Lovelock, originator of the controversial "Gaia Hypothesis" that imagines Earth as a living organism, able to regulate important state variables such as temperature and ocean composition. Lovelock wanted to test his

Gaia concept on a geochemist, and Garrels was one of the few willing to listen. Lovelock considered the global geochemical cycling models “sterile,” without adequate accommodation for the interactions with living organisms. Garrels argued that the biota were implicit in aspects of the model (e.g., in the burial of organic matter that created a net flux of oxygen to the atmosphere). But Lovelock was looking for more, for regulatory mechanisms (feedbacks) that recognized the importance of organisms in controlling what the geochemists were treating as largely inorganic processes (e.g., chemical weathering). The ensuing decades have witnessed an explosion of research on biotic influences on “geologic” processes.

Garrels’ understanding of and concern for the environment was expressed in a seminal publication with Mackenzie and Garrels’ second wife, Cynthia A. Hunt (Garrels et al., 1975) that presaged our current realization that we live in the “Anthropocene,” an era of geological relevance in which humans have modified the environment at a global scale. He pondered the “world without us,” wondering how long it would take to erase the presence of mankind on the planet. Among other unpublished observations he made in his later years were the correspondence between the age of sidewalks and the extent of their re-carbonation through reaction with carbonic acid in rainwater, and of the variety of minerals precipitated on copper roofs and how they reflected the regional deposition of various pollutants. Mason jar experiments aimed at determining siderite solubility and copper-sulfate-chloride solution interactions with biogenic calcite moved with his last student, Terri Woods, to East Carolina University, where they served as the basis for student research.

Garrels had diverse interests. He was an athlete who briefly held the world masters records in the high jump and triple jump; he was an avid tennis player; and he favored ping-pong over extended discussions of science with his students if forced to choose (although both could be conducted simultaneously, on Fridays with beer in hand). He developed an algorithm to calculate how many gin and tonics one deserved after a swim in the ocean, depending on the strength and direction of the tide (it turned out to be an exponential function; Berner, 1992). And he was a poet. His “Cycle of P” has been reprinted often (see https://en.wikipedia.org/wiki/Robert_Garrels), but less well known is a shorter poem:

The P Song
Pollutia
Cycle me, cycle me, you know where
Into the oceans and through the air
And if you don’t cycle me in the right place
I’ll weed up your rivers and eutroph your lakes.

Bob Garrels enjoyed life. He valued collaboration and companionship, and he was curious and imaginative. He had a great sense of humor, he was fair and humble, and he was surprisingly approachable for a scientist of his stature. I recall a group of us as graduate students approaching him at the beginning of TGIF and timidly alerting him to the fact that we had discovered an error in a classic paper. Garrels response was “oh, that’s too bad—anyone want to play ping-pong?”

Garrels was truly a rock star, and his legacy exists in the creative way we view the operation of Earth as a system today.

REFERENCES CITED

Berner, R.A., 1992, Robert Minard Garrels: A biographical memoir: Washington, D.C., The National Academies Press, p. 195–212, http://www.nap.edu/read/2037/chapter/11#206.

Berner, R.A., Lasaga, A.C., and Garrels, R.M., 1983, The carbonate-silicate geochemical cycle and its effect on atmospheric carbon dioxide over the past 100 million years: American Journal of Science, v. 253, p. 641–683.

Garrels, R.M., and Mackenzie, F.T., 1971, Evolution of Sedimentary Rocks: New York, W.W. Norton, 397 p.

Garrels, R.M., Mackenzie, F.T., and Hunt, C., 1975, Chemical Cycles and the Global Environment: Assessing Human Influences: Los Altos, California, William Kaufmann Inc., 206 p.

Krumbein, W.C., and Garrels, R.M., 1952, Origin and classification of chemical sediments in terms of pH and oxidation-reduction potentials: The Journal of Geology, v. 60, no. 1, p. 1–33.

Sloss, L.L., and Berner, R.A., 1989, Memorial to Robert M. Garrels, 1916–1988: Boulder, Colorado, Geological Society of America Memorials, v. 20, p. 5–10.

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