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Memorial of Charles Meyer
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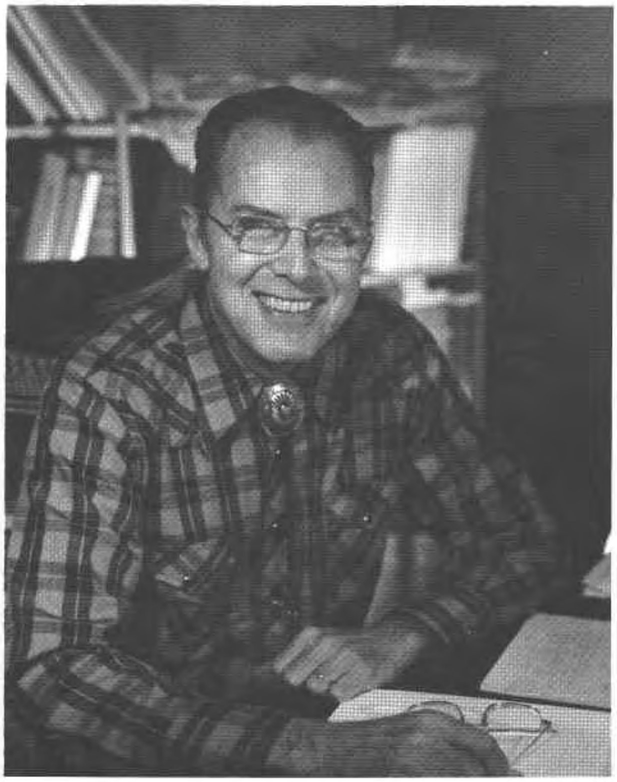

Charles Meyer, through his careful observations of ore deposits, his well-reasoned arguments about ore formation, and his gift for teaching, has advanced our understanding of processes of ore formation immeasurably over the past forty years. He died on November 15, 1987, in Sedona, Arizona. At the time of his death, he was actively at work on new ideas, particularly ideas concerning patterns of ore distribution through geologic time and space. His last papers on this subject, published posthumously, will guide many future generations of scientists in further advancing our understanding of earth history and ore-forming processes.

Charles Meyer was born September 30, 1915, in St. Louis, Missouri. He was the only child of Olinda Hopmann Meyer and Charles F. Meyer. He graduated Phi Beta Kappa from Washington University in St. Louis in 1937 with a bachelor's degree in geology. Meyer completed a master's degree at Washington University in 1939, for which he studied the magnetite deposits of Pilot Knob, Missouri. In the fall of 1939, he began graduate studies at Harvard University where he had earned a fellowship. Early in 1940, he married Virginia Borrenpohl, a student of Latin and classics whom he had known at Washington University. They had two sons, Charles, Jr., and Richard Frederick, both born in Butte, Montana.

Charles Meyer stayed at Harvard, studying under L. C. Graton and Donald McLaughlin, just long enough to earn a second master's degree and complete the coursework for his Ph.D. Then he left for Butte, Montana, where, with Reno Sales, he began his now-famous studies of wall-rock alteration and mineralization in the giant, high-grade Butte vein system. In part, his studies concerned the metasomatically zoned alteration envelopes bordering the Butte veins.

Using detailed petrographic and compositional observations of altered wall rock, combined with an elegant, direct line of reasoning, Meyer established that (in his words) "each mineralogical alteration zone migrated away from the [vein] channel by growing at its outer edge while simultaneously receding at its veinward edge because of encroachment of the next innermost zone." This conclusion established the very important and new concept that the same fluid was responsible for all of the several mineralogical bands in the envelope and that the envelope zoning was a consequence of diffusion of chemical species into and out of the wall rock.

Meyer also developed important concepts about the "zonal growth" not only of individual vein envelopes, but of mineralizing hydrothermal systems as a whole. He made the case in Butte that district-scale concentric mineral and metal zoning developed by progessive outward replacement of outer zone mineralization by inner mineralization. These controversial ideas that Meyer argued so convincingly to establish forty years ago are so well accepted now that we have lost track of their source in the early work of Charles Meyer. Much of this work constituted Meyer's dissertation, for which he was awarded his Ph.D. degree from Harvard in 1950. This early work on Butte was published in a series of papers with Reno Sales.

In 1953, after twelve years in Butte, Meyer accepted a tenured full professorship at the University of California, Berkeley, where he stayed for 27 years. At Berkeley, he continued his work on wall-rock alteration. With Julian Hemley, he delved into experimental studies of mineral stabilities in relation to fluid composition, and produced some of the earliest detailed chemical explanations of the

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processes of wall-rock alteration. Through this work, he and a few others pioneered the now-standard application of chemical reaction concepts to understanding processes of hydrothermal alteration and ore formation. Meyer had an intimate knowledge of alteration patterns and petrography, based on his own mapping and microscopic studies, which he combined with an excellent command of experimental and theoretical geochemistry. Meyer and Hemley's papers on wall-rock alteration, published between 1957 and 1970, became classics because, in their lucid, authoritative explanations of alteration phenomena, they tied detailed descriptions of mineral replacement relationships to the chemical reactions that produced them.

Meyer's teaching at Berkeley was characterized by a remarkable, infectious enthusiasm and high expectations of his students. Students regarded his ore-deposits course as one of the best courses in the department, despite (or partly because of) the 1200 pages of reading, two mapping field trips, and three research papers that Meyer required in the ten-week course. Meyer dedicated enormous energy to students: He spent hours beyond class time discussing student questions that he stimulated by his lectures. He spent weeks taking students on field trips where, under his guidance, they learned how to be first-rate observers. He showed students by his example how to constrain the answer to a question, carefully distinguishing between that which was definitely known and that which was conjectural. Starting with his ore-deposits course, Meyer launched many student geologists who described a large variety of major ore deposits in North and South America and Australia. In addition to the observations of ore deposits that Meyer made while working in the field with his students, he visited hundreds of mines and prospects all over the world in the course of his travels, where often he had been invited to give lectures and short courses.

In addition to his studies in Berkeley of the chemistry of alteration and its relationship to ore mineralogy generally, Meyer and several of his students continued investigations of Butte, describing its pre–main stage, porphyry copper mineralization and potassium silicate alteration. This work was published in his 1965 paper in *American Mineralogist* and in the 1968 Graton-Sales volume of the AIME, as well as in papers of more recent students.

Throughout Meyer's Berkeley years and continuing afterwards, he maintained his close association with the Anaconda Company, spanning a total of 44 years. He regularly mapped and logged drill core at Anaconda mines and prospects, often working alongside his current or former students. Through this role with Anaconda, he provided valuable technical guidance to the exploration and mine development efforts of the company, but he is probably best remembered by the many geologists at the prospects and mines as a wonderfully enthusiastic teacher, a tremendous source of encouragement, and an incisive analyst of their geologic data and interpretations.

In more recent years, Meyer combined his broad observational experience with his characteristic careful, logical analysis to understanding metallogenesis through geologic time. Starting in 1972, in his presidential address to the Society of Economic Geologists, and in four subsequent papers, he demonstrated fundamental connections between processes of ore formation and the petrologic and tectonic evolution of the earth's crust and the chemical evolution of the oceans and atmosphere. Among the points that Meyer emphasized in papers published in 1980 and 1988 is that processes of ore formation experienced a major global transition in the mid-Proterozoic, between 2000 and 1600 Ma. Others, too, have pointed this out for certain sediment-hosted ore types, but Meyer documented the significance of this transition period for at least ten other ore types: "Except for chrome cumulates and nickel sulfide segregations in mafic intrusions . . . very few of the major ore types of the first half of earth's history continued directly into the second." Meyer expanded on the significance of this and other transitions in his last paper on this subject, entitled "Ore deposits as guides to geologic history of the Earth," in which he outlined critical relationships of ore deposits to their host rocks and to their place in earth history. With this paper, he began a project that will take decades of research by future geologists to finish.

Charles Meyer was an outstanding human being and one of the great geologists of our time. Through the excellence of his scientific work, his incisive approach to solving geologic problems, his scientific vision, his infectious enthusiasm for his subject, and his caring way of relating to students, colleagues and friends, Charles Meyer was, and will continue to be, an inspiration to hundreds of geologists.

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