*American Mineralogist, Volume 106, pages 1183–1185, 2021*

# Memorial of Alden Bliss Carpenter (1936–2019)

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Alden Bliss Carpenter was born on February 24, 1936, in Newton, Massachusetts. He was the son of Harvard Professor and Curator of Fossil Insects, Frank Morton Carpenter. Alden had a lifelong commitment to sharing his love of minerals and inspiring others in science. As a neighborhood babysitter in Lexington, Massachusetts, Alden would hide mineral specimens in stone walls and crystals in the lawn grass for the children to discover. This novel pedagogical technique helped produce at least two successful geoscientists: Jon Peter B. (Joe) Fletcher (Columbia Ph.D. 1975) and John W. Valley (Michigan Ph.D. 1980). In the summer of 1956, after his junior year at Harvard, Alden worked as a counselor at the former Camp Monadnock near Jaffrey, New Hampshire. In our microscope sessions, Alden enthusiastically nurtured my own love of minerals as a 12-year-old camper, and he treated us boys to exciting collecting at famous mineral localities nearby. I acknowledge my boyhood debt to Alden, and I am thankful that we remained lifelong friends sharing our love of mineralogy.

Alden went on to mentor students in his role as a tenured faculty member at the University of Missouri-Columbia and then left academia in 1981 to work as a geochemist at the renowned Chevron Oil Field Research Laboratory in La Habra, California. In 1998, he returned to Harvard, where he worked as a Teaching Assistant and Museum Associate until 2017, again sharing his love of minerals with students, as long as his failing health permitted. Alden devoted the last two decades of his life to cataloging and curating his magnificent Crestmore Collection as his lasting research legacy to the Mineralogical and Geological Museum, Harvard University (MGMH).

In this memorial, I will focus on Alden's contributions to mineralogy. A companion memorial article in the *AAPG Bulletin* (Grew 2021, in press) features his discoveries in the geochemistry of oilfield brines relevant to petroleum geology.

By good fortune, when Alden graduated from Harvard in 1957, Colonel (Col.) Clarence Marvin Jenni (1896–1973), Director of the Geological Museum at the University of Missouri-Columbia, donated an important collection of minerals to the MGMH from the famous Crestmore contact aureole locality in Riverside, California. Col. Jenni persuaded the Riverside Cement Company, which worked the mine, to give Harvard $8000 "that made possible the work of a graduate student [Alden Carpenter]...to make a significant contribution to the list of minerals" (Burgess 1971). UCLA Professor Joseph Murdoch (President of MSA in 1960), who had devoted much effort to the study of Crestmore minerals, came to work at Harvard as a visitor. Murdoch considered Crestmore to be "on a par with the two other great contact metamorphic assemblages—Franklin, New Jersey, and Långban, Sweden." He reported on the experience in his MSA Presidential Address in 1960: "During the autumn and winter of 1959–1960, I have had the privilege of working in the Harvard laboratory on an extensive collection of Crestmore material made by Col. C.M. Jenni. At the same time, Alden Carpenter, a graduate student, has been working on his own collection of Crestmore specimens at the same place... in the course of routine examination an additional eight named species have been added, including the rare minerals ettringite, szaibelyite, and huntite" (Murdoch 1961). Alden reported the huntite in the first abstract of his career in 1961 at the Geological Society of America annual meeting. In 1963 he reported oriented overgrowths of thaumasite on ettringite, and he published results from his Crestmore thesis in *American Mineralogist* in 1967.

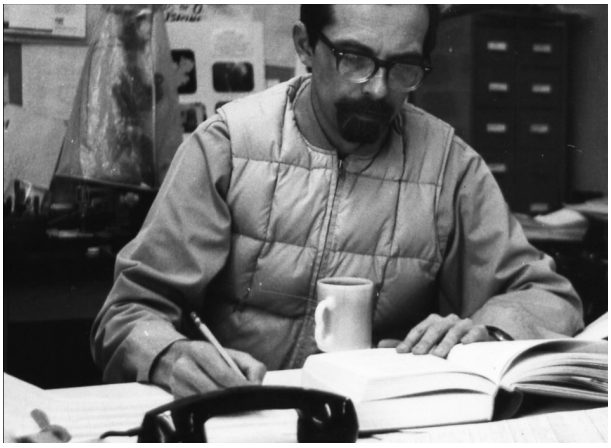

**Figure 1.** Alden avoiding telephone interruptions at his desk at the University of Missouri-Columbia in the 1970s. Photo credit: Courtesy of Laurel Carpenter

Alden's major contribution to Crestmore mineralogy concerned dolomite, which at the time he started his thesis work, was thought to be very rare in the metamorphic aureole. Alden quickly discovered that, to the contrary, dolomite was abundant in the metamorphosed carbonate rocks, and eventually he concluded that it was largely a product of exsolution from magnesian calcite (≥14 mol% $MgCO_3$) formed at the peak of contact metamorphism (760–800 °C).

In the course of his work on the Crestmore material, Alden discovered a new mineral that he named jennite [$Ca_9(Si_3O_9)_2(OH)_6{\cdot}8H_2O$] after Col. Jenni. Alden also helped to identify and characterize a Crestmore unknown that became the new mineral oyelite [now $Ca_5BSi_4O_{13}(OH)_3{\cdot}4H_2O$], a boron mineral related to tobermorite that also occurs in similar contact

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0003-004X/21/0007–1183$05.00/DOI: https://doi.org/10.2138/am-2021-1009

rocks in Japan. The successful proposal to the International Mineralogical Association (IMA) was not submitted until years later when Alden was one of six co-authors of the proposal for oyelite (IMA 1980-103), which was approved as a new mineral by the IMA Commission in 1982 (R. Miyawaki 2021 personal communication).

In 1962, thanks to his long-term friendship with Col. Jenni, Alden was offered and accepted research funding at the University of Missouri (MU), where Colonel Jenni had retired to curate the mineral collection. A year later, Alden joined the faculty at MU, where he served until 1981. With his move to the midcontinent, Alden's interests shifted, and he began to work on scientific questions such as the origin of saline subsurface waters in Missouri.

While the most important factor in prompting this shift in research emphasis was undoubtedly the availability of funding, the seeds for Alden's interest in saline waters and Mississippi Valley-type ore deposits could have been sown by Alden's association with the prominent geochemist Robert Garrels, who was on the Harvard faculty from 1955 to 1965 while Alden was a student. Many consider these years to have been Garrels' most productive in terms of writing and of mentoring students for their careers. Garrels wrote his own thesis on the sulfides of the Mississippi Valley lead-zinc deposits, published in *Economic Geology* in 1941. Although Garrels was not on Alden's official thesis committee, which comprised Cornelius Hurlbut, Clifford Frondel, and Raymond Siever, Alden did acknowledge him as a reader of his doctoral thesis. Alden met Mecca Reitman when they were graduate students auditing a Garrels undergraduate class at Harvard. Mecca's father had died when she was a child, and so it was Garrels who escorted Mecca down the aisle when Alden married her in Harvard Memorial Church in 1961.

While at MU, Alden extended his research on dolomite to include sedimentary rocks. His review paper on dolomitization (Carpenter 1980) continues to serve as a source of data on dolomite stability.

In the mid-1960s at Missouri, Alden embarked on the research for which he is now best known: the geochemistry of brines and saline solutions, beginning with a paper on the origin of saline waters in Missouri (Carpenter and Miller 1969) and including his most cited paper, Carpenter et al. (1974). In the early 1970s, the question of whether lead and sulfur could be carried together in subsurface brines was highly controversial. Through Roger Burtner, a former fellow Harvard graduate student later working at the Chevron Oil Field Research Company, Alden learned that lead was fouling equipment at the Pisgah oil field in central Mississippi, evidence for waters sufficiently high in lead and zinc to produce Mississippi Valley Type ore deposits. Alden presented this hypothesis with his Missouri colleague Tom Freeman at the AAPG-SEPM Annual Convention in 1977. Alden's work on these deposits led to the discovery of a new mineral, fletcherite, a thiospinel from the Fletcher mine in the Viburnum Trend, southeastern Missouri.

Alden's work on brines led to his realizing that bromine is an inert constituent during the evaporation of seawater and that the ratios of other constituents to bromine are sensitive indicators of the precipitation of evaporite minerals. He thus proposed that this situation can be taken into account through the relationship between $MCl2 = Ca + Mg + Sr - SO_4 - HCO_3$ (in meq/liter) and bromide (in mg/liter) (Carpenter 1978; Carpenter and Trout 1978). Available data often yielded a linear relationship, indicating that most brines are derived from evaporation of average seawater, while contributions from meteoric waters are subordinate. Subsequent studies have vindicated Alden's application of this relationship for identifying the origin of deep basin brines, most notably Knauth (1988), who conferred the name "Carpenter Function" to Alden's "MCl2" formula.

Alden was a dedicated mentor to his graduate students at Missouri. One of those students, Jim Darr (M.A. Missouri 1978), became a lifelong friend who phoned each year on Alden's birthday. Halfway through his graduate program, Darr was devastated by the unexpected loss of his 55-year-old father to a heart attack. He recalls that "Alden quietly took me under his wing. Without his firm and caring intervention, I would have likely dropped out of the program. Alden's legacy goes beyond his contributions to science, as significant and impressive as they are. Alden's legacy continues on in the many people he encouraged and challenged to be and to give their very best."

Alden's most celebrated graduate student is David L. Leach (M.S. and Ph.D. Missouri 1973), who received the R.A.F. Penrose Gold Medal from the Society of Economic Geologists in 2010 for his work on sediment-hosted base metal deposits. Leach says that Alden's "major contributions on the origin of oil field brines that formed in paleo-seawater brine factories... resulted in a paradigm shift in understanding the links between oil field brines and regional metallogeny. Today, Alden's consequential work underlies countless scientific papers on these subjects. Personally, I owe much of my career success to Alden Carpenter...He was a quiet, kind, and dedicated scientist that influenced a lot of people. I always thought he did not receive the acknowledgments he deserved."

In 1981, Alden accepted a position as Senior Research Associate at the Chevron Oil Field Research Company in California, where he remained until his retirement in 1998. At Chevron, Alden further broadened his mineralogical research interests to examine questions such as the relatively high boron contents of pore waters in the Monterey formation, California, which he attributed to the release of boron from diatoms during diagenetic alteration of opal-A to opal-CT. He produced a mineralogical classification of Monterey lithologies and studied the relationship of the timing of siliciclastic diagenesis to hydrocarbon migration.

In the fall of 1998, Alden moved back to Lexington. Carl Francis, then curator at MGMH, invited Alden to become a Museum Associate and worked with him in curating the Crestmore collections, which consist of over 900 cataloged specimens comprising 81 verified species, including multiple examples of all 9 IMA-recognized species for which Crestmore is the type locality. In addition, the collection contains over 1000 samples representing the rock types in the contact aureole.

Alden was predeceased by his wife Mecca B. Carpenter in 2013. He is survived by daughters Laurel Carpenter and Holly Carpenter and by sisters Ellen C. Church of Bass Harbor, Maine, and Cynthia C. Harvey of Acton, Massachusetts.

I am indebted to Raquel Alonso-Perez, Curatrix of MGMH; to Carl Francis, Curator of the Maine Mineral & Gem Museum;

and to Laurel Carpenter and Holly Carpenter for their assistance in preparing this memorial. A bibliography of Alden's works is posted online as Supplementary Material[1].

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[1]Deposit item AM-21-71009, Supplemental Materials. Deposit items are free to all readers and found on the MSA website, via the specific issue's Table of Contents (go to http://www.minsocam.org/MSA/AmMin/TOC/2021/Jul2021_data/Jul2021_data.html).