James D. Webster (1955-2019)
Obituary

James D. Webster, a noted geologist and curator at the American Museum of Natural History, died at the age of 64 on 6 July 2019. The cause was glioblastoma, a virulent brain cancer.

Dr. Webster was best-known for his work in experimental petrology (the study of rocks and their formation) and for the application of that research to the mechanisms of volcanic eruption and the formation of certain ore deposits. His experimental research focused on the chemical equilibria among magmas and the various fluids that exsolve, or separate, from them as the magmas rise through the crust, decompress, and erupt, or alternatively as they cool and solidify within the crust.

Dr. Webster's foray into experimental petrology began with his PhD research at Arizona State University, where he studied under the renown experimentalist John Holloway. In his thesis, completed in 1987, Dr. Webster determined the solubilities of chlorine and fluorine in granitic magmas, referring to the silicate liquids that give rise to the granites and rhyolitic lavas common throughout the world. He found that the associated fluids were saline with high concentrations of dissolved metals. The results of his studies implicated fluids in the formation of certain types of ore deposits.

Upon moving to AMNH in 1990 as a new assistant curator in what is now the Department of Earth and Planetary Sciences, Dr. Webster established a laboratory centered around an internally-heated, high-pressure vessel, a device that allowed him to apply extreme temperatures of up to 1,250°C (2,280°F) and pressures as high as 10,000 times that of standard atmospheric pressure to geologic samples about the size of a pea. These temperatures and pressures are sufficient to melt rocks and also mimic conditions throughout Earth's crust.

It was apparent by this time that chlorine has a large influence on the conditions at which fluid separates from magma. In what were perhaps his most important series of papers, published between 1997 and 1999, Dr. Webster, along with several co-authors, determined the complex relations between the solubility of chlorine in silicate melts and composition of their associated fluids. In the process, they also identified conditions under which the fluid itself becomes immiscible, or separates to form coexisting chloride-rich and aqueous fluids, like oil and water separate to form two fluids. Ultimately, the work led to an empirical model relating chlorine solubility to magma temperature, pressure, and composition for magmas ranging from silica-rich rhyolite to silica-poor basalt.

This body of work led naturally to experimental investigations of magmas that crystallize apatite, a common trace mineral in many igneous rocks. Apatite typically contains small quantities of chlorine and fluorine, so in principle it is possible to calculate the abundances of these elements in magmas and associated fluids simply from the composition of the apatite in the present rock. The experiments of Dr. Webster and coworkers provided the necessary calibration for such calculations.

As discerning as this work was, Dr. Webster's early experiments were on synthetic melts with relatively simple compositions, which were therefore not truly representative of more complex, natural magmas. In particular, the synthetic samples did not contain sulfur or carbon, elements that typically constitute a significant proportion of natural magmatic fluids. Nonetheless, in an intellectually daring set of experiments, Dr. Webster and colleagues added these two elements to their experiments. The data, which were reported in a series of papers published in 2011, provided new insights but predictably defied coherent thermodynamic modeling. By the time deteriorating health forced Dr. Webster to stop working, he and the team of collaborators he had assembled had designed yet another set of experiments that they hoped would bring them closer to a predictive model of magma-fluid chemical equilibria relevant to natural systems, a holy grail of experimentalists, and to better understand the physics of magma degassing.

Dr. Webster's experiments were important for another reason, namely that they provided the basis for the understanding of melt inclusions, or blebs now consisting of glass or finely crystalline material entirely included within crystals. One problem in studying the fluid constituents of molten rocks is that upon solidification or eruption those constituents are lost from them. The study of melt inclusions avoids this problem because inclusions generally represent tiny samples of magma trapped in growing crystals prior to loss of the magmatic volatile components.

Because of this, it has long been recognized that melt inclusions have the potential for providing insight into how magmas and their fluids evolve with cooling and crystallization. Thus, in one set of melt inclusion studies, Dr. Webster and coworkers were able to show that the slow crystallization of a basaltic magma at depth eventually produces a residual magma of granitic composition plus saline fluid that can carry significant quantities of copper, tin, tungsten, molybdenum and certain other metals, explaining why ore deposits of these element are largely associated with granitic rocks.

Dr. Webster did not confine himself to the laboratory, but also found time for field investigations of several volcanoes, notably Augustine, in Cook Inlet, Alaska; Mount Mazama, the dormant volcano of Crater Lake, Oregon; and the periodically active Mount Vesuvius that looms over Naples, Italy. Vesuvius represents a significant eruption risk to many of the people that live near it. There Webster and colleagues were able to apply their melt inclusion studies to discover that the magmas associated with explosive Vesuvius eruptions, such as the catastrophic 79 AD one that buried the villages of Pompeii and Herculaneum, contained much higher concentrations of water, chlorine and other volatile compounds than the magmas associated with other, more passive eruptions. This was clear evidence that the separation of fluids from magmas can drive volcanic eruption.

Melt inclusions also led Dr. Webster to the study of certain ore-bearing pegmatites. These are rare and unusually coarse-grained rocks representing the tiny fraction of magma remaining after nearly complete solidification of granite bodies. From study of the melt inclusions in the pegmatites, Dr. Webster and coworkers hypothesized that pegmatitic liquids sometimes separated into two silicate liquids, immiscible with each other, and that the ore-forming elements were preferentially concentrated in one of these liquids. While their observations supplied new insight into ore formation, they upset conventional wisdom and ignited controversy.

In recognition of his contributions to science, Webster was elected a Fellow of the Mineralogical Society of America and of the Society of Economic Geologists.

At AMNH Dr. Webster embraced his role as a curator, which, in addition to academic research, carries with it an array of other responsibilities. He mentored numerous postdoctoral researchers and graduate and undergraduate students; he oversaw the growth of AMNH's ore deposit collection; he administered a *Research Experiences for Undergraduate Student* program, which was supported by the National Science Foundation to provide undergraduate students the opportunity to become direct involved in research; he taught in the museum's *Master of Arts in Teaching* program, an urban teacher residency program for prospective teachers of Earth science; and he co-taught an annual short-course for graduate students organized by Benedetto De Vivo of the University of Naples, Italy, entitled *Fluids in the Earth.* Patricia Nadeau, a former AMNH postdoctoral researcher and now volcanologist with the United States Geological Survey, stated, "Aside from the science, and in spite of the fact that he didn't go into the traditional academic teaching route, Jim was such a gifted communicator and educator."

Dr. Webster also served as curator for the museum's 2006 traveling exhibit entitled *Gold* and as co-curator for the museum's permanent *Gottesman Hall of Planet Earth*, for which he shared the prestigious 2002 American Geophysical Union Excellence in Geophysical Education Award. From 1999 to 2007 he served as Chair of the Division of Physical Sciences.

During his career, Dr. Webster accumulated numerous collaborators, reflecting the simple facts that he was easy to work with and always the gentleman. Don Baker, a colleague at McGill University wrote, "Jim always made me feel that his and our work was complementary and that we were working together, not competing, to better understand the importance of halogens in igneous systems, even though in my case our only official collaborations were on review papers." He added, "I once saw Jim…going over a manuscript with one of my students…He quietly and gently pointed out many problems with the experimental work and gave the student his honest opinion of the work, without criticizing or belittling the student. Indeed, the student later remarked on the usefulness of Jim's comments and appreciated his candor and demeanor." Another colleague, David London of the University of Oklahoma, commented, "He and I have had disagreements in our understanding of magmatic-hydrothermal process, but those arguments, sometimes heated but always together face-to-face, have only made our friendship and mutual respect grow stronger…Jim [is] someone who listens attentively, ponders pensively, and quickly retorts with an 'ah, but…' response."

James Dale Webster was born on May 2, 1955 in Cartersville, Georgia, the oldest of three children born to James and Emma Webster. The elder Webster was in the United States Air Force at the time and then went to work for RCA and later IBM, in the process moving the family to Pennsylvania, Florida (where he worked on the space program), New York, and finally North Carolina, while Emma worked as the traditional homemaker. In 1974, the younger James found himself working at the local pizza house, and there he met his future wife, Marie Nagle.

They married in 1975. In 1974 James also enrolled at North Carolina State University, from which he graduated in 1978 with a degree in geology.

As for many students of geology raised in the eastern United States, James found inspiration from exposure to field work and to the natural wonders of the American west. Thus, his mecca became the Grand Canyon, where the shear scenic magnificence and exquisite display of the last billion years of planetary history drew him to visit again and again throughout the rest of his life. Drawn to the west, the couple moved to Denver, where James attended to the Colorado School of Mines, earning a Master of Science degree in geology in 1981. In 1983, after brief assignments in mineral exploration, James moved to Tempe, Arizona, to attend Arizona State University, with a family in tow that by then included a young son, and where the couple's second son was born a year later.

Dr. Webster is survived by his wife Marie, with whom he had been married for 44 years; their sons Brian and Paul Webster; a brother Michael Webster and sister Kathy Webster; grandchildren Hope Simmons-Webster, Thomas Webster and Sylvianne Crowley; and his mother Emma.