Hatten S. Yoder Jr.

1921–2003

BIOGRAPHICAL *Memoirs*

A Biographical Memoir by
W. G. Ernst,
Robert M. Hazen,
and Bjorn Mysen

NATIONAL ACADEMY OF SCIENCES

HATTEN SCHUYLER **YODER JR.**

March 20, 1921–August 2, 2003

Elected to the NAS, 1958

Courtesy Geophysical Laboratory Archives

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Hatten Yoder was a petrologist who pioneered the study of minerals under high pressure and temperature conditions approximating the Earth's lower crust and upper mantle. He identified five new minerals, wrote petrology textbooks that are still widely used, wrote some of the most commonly cited studies in his field, and was also a widely published historian of the Earth sciences. Hat served as Director of the Geophysical Laboratory at the Carnegie Institution in Washington, D.C., as well as on many National Research Council boards and advisory committees. A scientist of high integrity, Hat conspired to desegregate the whites-only Willard Hotel in the early 1960s, and argued unsuccessfully against the conclusions of a National Research Council study of the health hazards of asbestiform minerals, which became the basis of national health standards.

Early life

Hatten Schuyler Yoder, Jr., known to his friends and colleagues around the world as "Hat," was born in Cleveland, Ohio on March 20, 1921. He received a Bachelors of Science degree from the University of Chicago in 1941, and briefly but intensively continued studies of meteorology at the University of Minnesota.

After the outbreak of hostilities, he joined the U.S. Navy in 1942. Rising to the rank of Lieutenant Commander, Hat saw active duty from 1942-1946, and served an additional twelve years in the U. S. Navy Reserves. A decorated officer, he served on an aircraft carrier in the European theater, then in the Pacific. After 18 months of sea duty, Hat was assigned as meteorologist to the MOKO expedition to Siberia, where he was an integral part of the American-Soviet effort to monitor weather conditions prior to the anticipated Allied invasion of Japan. He described this unique and little known project in a 1997 book entitled *Planned invasion of Japan (1945): The Siberian Weather Advantage.*

Geophysical Laboratory

After the war, Hat returned as a graduate student to MIT, where he was awarded his Ph.D. in 1948. By this time he had already been recruited as an experimental petrologist at the Geophysical Laboratory of the Carnegie Institution in Washington, D. C. With brief visiting professorships at Caltech in 1958, the University of Texas at Austin in 1964, the University of Colorado in 1966, and the University of Cape Town in 1967, Hat spent an entire career, even after retirement, pursuing his evolving research directions at the Geophysical Laboratory. Hat married Elizabeth Marie Bruffey on August 1, 1959. They had two children, Hatten S. Yoder, III, who died in November 1998, and Karen M. Wallace.

Yoder in 1992 actively conducting experiments at high temperatures and pressures under conditions approximating those of submarine hydrothermal vents.
(Courtesy Geophysical Laboratory Archives.)

As a neophyte Johns Hopkins graduate student, I (WGE) visited the Geophysical Laboratory in September 1955, to begin experimental phase equilibrium research at the Carnegie as a predoctoral fellow. What a day! I was given a whirlwind tour of the Lab and staff—half an hour each with Frank Schairer, Joe Boyd, Hans Eugster, Felix Chayes, and Phil Abelson. By noon my eyes were glazed from the scientific overload, but still had the afternoon in prospect. Mercifully, we all went to lunch. At our table sat a young, exuberant, experimental petrologist with an easy, broad smile and infectious laugh, spouting phase equilibria while studying the menu. I was astonished to learn that this man was Hat Yoder. He seemed far too young to have completed the comprehensive, detailed investigations of the system MgO-Al_2O_3-SiO_2-H_2O, the metamorphic facies concept vis a vis the influence of bulk composition, and the role of H_2O in metamorphism, as well as a host of seminal studies on rock-forming minerals such as grossular, analcime, phlogopite, muscovite, jadeite, and even the ternary feldspars. These were classics! But of course, it was Yoder.

Prior to Hat's arrival at the Geophysical Laboratory, high-pressure experiments could only achieve conditions appropriate to the Earth's uppermost crust. In order to rectify this, in the creative environment of the Geophysical Laboratory, Hat designed and constructed high-pressure autoclaves that simultaneously controlled the gas pressures of supercritical fluids as well as temperatures appropriate to the Earth's lower continental crust and uppermost mantle. Such internally-heated pressure vessels remain in use today. With this equipment, Hat was able to duplicate the pressure and temperature conditions of formation (up to 10 kbar of pressure and 1200°C of temperature) of the primary igneous rocks and deep-seated metamorphic rocks of the crust, as well as that of their constituent minerals.

His diverse interests spanned a continuum of topics including experimental phase equilibria, igneous and metamorphic petrogenesis, the properties of minerals at elevated pressures and temperatures, heat transfer in partially molten systems, Earth resources and strategic minerals, the abiotic synthesis of organic compounds, and the origin of biological activity.

Best known as an accomplished and distinguished experimental petrologist, Hat's insightful contributions to a fuller understanding of the origin and petrochemical evolution of the igneous rocks and of the bulk chemical parameters along with pressure and temperature conditions governing metamorphism are some of the most cited references of the last century among those who study rocks.

Asbestos controversy

Hat's scholarly productivity was prodigious, and was sustained even as he served as Director of the Geophysical Laboratory from 1971 to 1986. This productivity continued unabated as he transitioned to the status of Director Emeritus in 1986. Hat was elected to membership in the National Academy of Sciences in 1958 at the age of 37, the youngest geologist ever elected to the NAS. From 1972 until his death, he was an active member of the Geosciences Advisory Committee to the Los Alamos National Laboratory, and chaired this group from 1992-1997. Over his lifetime Hat served the National Academy and its National Research Council on several boards and U.S. national committees with dedication and distinction.

We especially remember a meticulous and exhaustive report review of a National Research Council manuscript dealing with the health hazards of asbestiform minerals. Along with colleagues at the U. S. Geological Survey, he waged an intellectually sound

but losing battle to correct the one-sided NRC report. The mineralogical reviewers went down with guns blazing, but America was the real loser, for the nation is now saddled with mineralogically unrealistic OSHA-mandated regulations.

Natural basalts and new minerals

With Gunnar Kullerud, he conducted pioneering research on stability relations of the sulfides in work that is still quoted today. Hat's landmark experimental studies on natural basalts with Cecil Tilley of Cambridge University quantified the classical metamorphic facies concept in terms of state variables, pressure, and temperature. This study proposed the very widely utilized graphical concept of the basalt tetrahedron, and placed new constraints on fractional crystallization of the igneous rocks. According to *Current Contents*, the Hat and Tilley paper was the most cited paper in the geological sciences during the period 1961-1980.

Yoder in 1955 with his internally heated autoclave. Hat and his colleagues employed his pressure vessel during decades of experiments investigating the origins of basalts and other deep-seated rocks. (Courtesy Mrs. Karen Wallace.)

Synthetic system studies at low and high pressures with Frank Schairer and Ikuo Kushiro, respectively, vastly extended our knowledge of the formation, or petrogenesis, of igneous rocks, both within the Earth's crust and the upper mantle. Hat's petrology books, *Evolution of the Igneous Rocks: Fiftieth Anniversary Perspectives, and Generation of Basaltic Magma*, are leading reference volumes today for the study of magmatic processes and the diversity of the igneous rocks.

Hat's research provided the scientific foundation for later experimental studies on heat transfer during the crystallization of heterogeneous silicate melt systems. These latter have shed new light on energy transfer in the outer portions of the planet. In later life, Hat collaborated with Geophysical Laboratory biochemist and astrobiologist colleagues in investigations of the origin and early evolution of life through the synthesis of organic compounds at high pressures and temperatures. In the process, the research group closely approximated the physicochemical conditions characteristic of deep-sea hydrothermal vents, also known as "black smokers."

Early in his career, Hat meticulously identified five new minerals—aluminous serpentine, ferri-diopside, magnesian chamosite, yttrogarnet, and yttroalumite. A hydrous magnesium + iron aluminosilicate phase he synthesized experimentally was subsequently found occurring naturally in Tanzania, and was named yoderite by D. McKie of Cambridge University.

History books

In addition to his world-class petrochemical contributions, Hat was also an accomplished and widely published historian of the Earth sciences. He compiled the biographies of more than twenty famous geologists and petrologists for the *Dictionary of Scientific Biography*, the *Dictionary of American Biography*, the *Biographical Memoirs* series of the National Academy of Sciences, and the *American National Biography*. His historical writings include engrossing accounts of experimental petrology, and a remarkable, insightful timetable of petrology. He was fascinated by the historical development of the sciences of petrology and geochemistry. Hat also wrote more than a dozen papers chronicling the scientific evolution of the Geophysical Laboratory.

Hat displayed an unswerving honesty, integrity, kindness, and dedication to fairness. In the early 1960s, he was one of a group of four men who conspired to desegregate the whites-only restaurant in the historic Willard Hotel in the center of Washington, D. C. Along with colleagues—one a lawyer—he escorted an African-American scientist conducting research at the National Bureau of Standards to the hotel restaurant. When they were refused service, the quartet threatened legal action, and the group was subsequently seated. Later, as Director of the Geophysical Laboratory, Hat championed scientific opportunities for women and under-represented minorities.

Hat was a giant among research mineralogists, petrologists, and geochemists, but his influence has been much magnified through the training, mainly by example, of several

generations of graduate students and postdoctoral fellows. Hat's impact on the course of experimental petrology and geochemistry may be gauged even more by the stable of eminently successful students he inspired than by his own remarkable scientific accomplishments.

As testified by his exemplary service to many scientific societies, and to the nation through his participation in numerous National Research Council studies, in chronicling the progress of the geological sciences and some of its world-class scientists, as well as his legendary devotion to research thrusts and colleagues senior and junior at the Geophysical Laboratory, he was an inordinately generous, selfless man. A gentleman above all else, Hatten S. Yoder, Jr., was kind in the way few great scientists are. He was a towering leader at the Carnegie and is deeply missed.

Awards and honors

Hat was the recipient of numerous awards from a wide range of scientific societies. The Mineralogical Society of America presented him with the MSA Award in 1954, and its highest honor, the Roebling Medal in 1992; he served as President of the Mineralogical Society of America in 1972. Other honors include: the Columbia University Bicentennial Medal, 1954; the Geological Society of America Arthur L. Day Medal, 1962, and the History of Geology Award, 1998; the National Academy of Sciences Arthur L. Day Prize and Lectureship, 1972; the A. G. Werner Medal of the German Mineralogical Society, 1973; the American Academy of Achievement Golden Plate Award, 1973; the Wollaston Medal of the Geological Society of London, 1979; and International Scientist of the Year, 2001 and 2002. He received honorary doctorates from the University of Paris VI in 1981, and the Colorado School of Mines in 1995. However, we suspect that Hat considered his scientific staff membership in the Geophysical Laboratory since 1948 as his greatest honor.

Hat was a member, fellow, or officer of 22 scientific societies, among them the National Academy of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society, the America Geophysical Union, the Mineralogical Society of America, the Geochemical Society, and the Geological Society of America. Some other international group memberships included the geological and/or mineralogical societies of London, France, Finland, Canada, and South Africa.

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