

## CURRICULUM VITAE -- ROBERT MILLER HAZEN – March 2015

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**Place of Birth:** Rockville Centre, NY  
**Citizenship:** USA  
**Date of Birth:** November 1, 1948

**Marital Status:** Married August 9, 1969 to Margaret Joan Hindle  
**Children:** Benjamin Hindle Hazen (b. June 18, 1976)  
Elizabeth Brooke Hazen (b. September 1, 1978)

### Education:

Massachusetts Inst. of Tech.	1966-1970	B.S. Earth Science
Massachusetts Inst. of Tech.	1970-1971	S.M. Earth Science
Indiana University	1969	Summer Field Geology
Harvard University	1971-1975	Ph.D. Mineralogy & Crystallography

### Employment History (Scientific Research and Education):

Executive Director and PI, Deep Carbon Observatory, 2008-  
Clarence Robinson Professor of Earth Science, George Mason University, 1989-  
Senior Staff Scientist, Geophysical Laboratory, 1978-  
President, Robert & Margaret Hazen Foundation, 2008-  
Research Associate, Smithsonian Institution, Department of Paleobiology, 2007-  
President, Hazen Associates, Ltd., 1994-2007  
Professional Trumpeter, 1965-2013  
Visiting Researcher, Univ. California at Santa Barbara, Chemistry Department, 1987.  
Summer Faculty, IBM T. J. Watson Research Center, 1978.  
Research Associate, Geophysical Laboratory, 1976-1978.  
NATO Postdoctoral Fellow, University of Cambridge, Department of Mineralogy and Petrology, Cambridge, England, 1975-1976.  
Research Assistant and Teaching Fellow, Harvard, 1973-1975.  
Field Assistant, U. S. Geological Survey, Summers of 1970 and 1971.  
Curator of Geological Collections, M.I.T., 1967-1970.  
Laboratory Assistant, Isotopes, Inc., Westwood, NJ, Summer, 1967.

### **Professional Experience—Scientific Research and Education:**

From 1971 to 1999 most of Robert Hazen's scientific research focused on the close relations between crystal structure and physical properties. He developed several high-pressure and high-temperature techniques and applied these techniques to understanding effects of temperature and pressure on atomic arrangements, particularly in deep Earth environments – work summarized in *Comparative Crystal Chemistry* (Wiley, 1982) and the edited volume *High-Temperature and High-Pressure Crystal Chemistry* (Mineralogical Society of America, 2000). He studied a wide variety of materials, including lunar minerals, ceramics, ferroelectrics, solidified gases, and organometallics. Hazen led the team of Carnegie scientists who first isolated and identified several new high-temperature superconductor structure types. Some of these studies are summarized in *Breakthrough: The Race for the Superconductor* (1988), *The New Alchemists* (1994), and *The Diamond Makers* (1999).

In January 1989, Hazen joined the faculty of George Mason University as Clarence J. Robinson Professor of Earth Sciences. This opportunity arose from his interest in engaging students of all ages, especially students who are not science majors, in the natural sciences. Science is central to all our lives, and a firm grounding in scientific literacy informs our citizens in a broad range of topics related to health, environment, resources, business and education. Science is also an engine of discovery, and represents a great human adventure. Accordingly, he has developed undergraduate courses in scientific literacy (with Prof. James Trefil), scientific ethics, symmetry in art and science, and the image of the scientist in popular culture, as well as graduate seminars in astrobiology and the origins of life. Their writings include the bestselling *Science Matters: Achieving Scientific Literacy* (Doubleday, 1990; 2<sup>nd</sup> edition, 2010) and *The Sciences: An Integrated Approach* (Wiley, 1993; 8<sup>th</sup> edition, 2015). He has been active in national efforts to reform science education and has presented lectures and workshops on undergraduate science curricula at more than 100 colleges and universities. He contributed as a writer for the *National Science Education Standards*, and served on the Executive Board of the National Research Council's Committee on Science Education, as a member of the American Association for the Advancement of Science's Committee for the Public Understanding of Science and Technology, and on the National Academy of Sciences' committees to write *Teaching About Evolution and the Nature of Science* (1998) and to revise the influential pamphlet, *Science and Creationism* (3<sup>rd</sup> edition, 2007).

In 1996, thanks to a new perspective on science research opportunities fostered by teaching integrated science, Hazen began research on high-pressure organic synthesis and the varied roles of minerals in processes that led to the origins of life. Working with a team of scientists at the Carnegie Institution, he developed a proposal to join NASA's Astrobiology Institute to study physical and chemical environments of high-pressure hydrothermal systems and their possible role in prebiotic organic synthesis and the origin of life. Recent research projects include studies of mineral-mediated organic synthesis, the role of minerals in stabilizing organic compounds, the nature of mineral-molecule interactions in aqueous solutions, and the chiral selectivity of enantiomeric mineral surfaces. He is also active in the development of micro-analytical tools for paleontology. Some of this work is summarized in *Genesis: The Scientific Quest for Life's Origins* (National Academy, 2005) and in *The Story of Earth* (Viking, 2012). The latter book is now serving as the basis of an episode of NOVA (WGBH-TV), to be aired in Fall 2015.

In 2006 Robert Hazen began studies in the changing diversity and distribution of minerals in the near-surface environments of Earth and other terrestrial planets and moons, a field that he called "mineral evolution." Earth's mineralogical history is thereby divided into ten stages, each of which saw significant changes in the surface mineralogy. Principal findings include the realization that different planets and moons achieve different stages of mineral evolution. Furthermore, 2/3rds of known mineral species on Earth probably could not have appeared prior to the origin and evolution of life. Recent mineral evolution studies reveal significant correlations between Earth's near-surface mineralogy and the supercontinent cycle, changes in atmospheric and ocean chemistry, and the emergence of the terrestrial biosphere.

These studies led in the Summer of 2014 to recognition that mineral diversity-distribution data conform to Large Number of Rare Event (LNRE) frequency distributions. LNRE statistical models lead to predictions of the type, age, and localities of Earth's "missing" minerals—species that occur on Earth but have not yet been discovered. These new methods may help to transform aspects of mineralogy from a descriptive to a predictive science. Hazen is also active in the study of emergent systems (especially their relevance to origins of life), the quantification of complex systems (through the formalism of functional information), and the evolution of complex systems under selective pressures.

Hazen is Executive Director of the Deep Carbon Observatory (DCO), a 10-year effort to achieve fundamental advances in understanding the chemical, physical, and biological roles of carbon in Earth

(<http://deepcarbon.net>). The DCO has more than 1,000 collaborators from 45 countries with total funding from governmental, corporate and private sources exceeding \$300 million. In addition to his studies of carbon mineralogy through Earth history, Hazen is responsible for the integration and synthesis of all of DCO's diverse research projects, which collectively address the quantities, movements, forms, and origins of carbon in Earth.

As part of George Mason University and the Carnegie Institution's ongoing educational activities, Robert Hazen has supervised approximately 50 young scientists as Summer Interns, Predoctoral Fellows, and Postdoctoral Fellows. He currently advises Ph.D. students at the University of Arizona, University of Maryland, and Johns Hopkins.

### **Professional Experience—Popular Writing in History and Science**

Hazen, frequently in collaboration with his wife Margaret Hindle Hazen, has written several books and many related articles on aspects of the history of American science and society. Previous works include *American Geological Literature* and *North American Geology* (a bibliography and review, respectively, of early American geological research), *Wealth Inexhaustible* (a history of American mining and other mineral industries), and *The Poetry of Geology* (a collection of geological poetry of the 18<sup>th</sup> and 19<sup>th</sup> centuries). *The Breakthrough: The Race for the Superconductor* (Summit, 1988) is his popular account of the discovery of high-temperature superconductivity. The Hazens also wrote *Keepers of the Flame* (Princeton, 1990), a cultural and technological history of fire in early America, published by Princeton University Press in 1992. Hazen's books, *The New Alchemists: Breaking through the Frontiers of High-Pressure Research* (Times Books, 1994) and *The Diamond Makers* (Cambridge University Press, 1999), explore the history of diamond making and other high-pressure applications.

In 1990 Hazen, with physicist James Trefil, wrote *Science Matters: Achieving Scientific Literacy* (Doubleday, 1991; second edition 2009), which now has more than 200,000 copies in print in a dozen languages. That volume proposes a definition of scientific literacy based on overarching scientific principles. In conjunction with the book Hazen has appeared on NBC's *The Today Show*, CBS's *Nightwatch*, NOVA (WGBH, Boston), and numerous other national and local TV and radio programs. Hazen also contributed articles and editorials to *Newsweek*, *The New York Times Magazine*, *Chronicle of Higher Education*, *The Scientist*, and other periodicals. Hazen and Trefil have also written three undergraduate textbooks that amplify these themes, *The Sciences: An Integrated Approach* (Wiley, 8<sup>th</sup> edition, 2015), *The Physical Sciences* (Wiley, 1996), and *Physics Matters* (Wiley, 2003). *The Sciences* also served as the basis for Hazen's 60-lecture video and audio course, "The Joy of Science," which is distributed nationally by The Teaching Company (Chantilly, Virginia). *Why Aren't Black Holes Black: Unanswered Questions at the Frontiers of Science* (Anchor, 1998), written with Maxine Singer, adopts the style of *Science Matters*, but focuses on the overarching questions that drive today's science. *Genesis: The Scientific Quest for Life's Origin* (Joseph Henry Press, 2005), with a companion 24-lecture series, "The Origins of Life" (The Teaching Company, 2005), surveys the origins-of-life research field.

Hazen's most recent book, *The Story of Earth* (Viking, 2012) examines more than 4.5 billion years of Earth history framed in the context of the coevolving geosphere and biosphere. *The Story of Earth* was named a semi-finalist in the 2013 Royal Society (London) Science Book Prize, a finalist in the 2013 Phi Beta Kappa Science Book Prize, and one of Kirkus Reviews "top 25 non-fiction books" of 2012. The book, and the thematic subject of mineral evolution, will be the basis of an episode of NOVA (WGBH TV, Boston) now in production and to be aired in the Fall of 2015. The book has also been developed as a 48-lecture video/audio course in the Great Courses series, published by The Teaching Company (2013).

### **The Hazen Collection of Trilobites**

From 1968 to 2014 Robert Hazen amassed one of the largest collections in private hands of trilobites (fossil arthropods from the Paleozoic Era). Many of the specimens were collected by Robert and Margaret Hazen in Europe, Africa, and North America. Beginning in 2007 most of this collection was transferred by donation to the Smithsonian Institution's National Museum of Natural History. Approximately 100 specimens of the 2000-piece collection are on display at the Museum, including approximately 50 specimens in the new Hall of Ocean Life, which opened in November of 2008. An additional collection of more than 300 specimens has been donated to the University of Arizona Mineral Museum and forms the core of the new exhibit "Meet the Trilobites: Arizona's First Inhabitants." An illustrated catalog of the collection is in preparation. These specimens also form the basis of recent taphonomic studies of preserved biomolecules that have demonstrated the preservation of chitin byproducts in specimens as old as lower Middle Cambrian (~500 Ma).

### **Employment History (Professional Music):**

Founding Member, Cambridge Symphonic Brass Ensemble, 1967-1975  
Solo Trumpet, Emmanuel Bach Orchestra, Boston, 1973-1975; Guest soloist 2006-2008  
Founding Member, Washington Chamber Symphony, 1977-2003  
Founding Member, Washington Chamber Orchestra, 1980-1988; European tour, 1986  
Member, National Gallery Orchestra, 1977-2010  
Member, Washington Bach Consort, 1977-2010; German tour 2000  
Founding Member, National Chamber Orchestra, 1979-1985  
Founding Member, and Board of Directors, National Philharmonic, 2004-2011  
Alternate Musician, National Symphony Orchestra, 1978-2005; national tour, 2004  
Member, Filene Center (Wolf Trap and Wolf Trap Opera) Orchestra, 1977-2006  
Freelance Union musician, Boston and Washington, 1971-2013

### **Professional Experience—Music:**

Robert Hazen played symphonic trumpet professionally from 1966 until his retirement in June 2012. He was a tenured member of the National Gallery Orchestra (1977-2010), the National Philharmonic (2004-2010), and the Washington Bach Consort (1977-2010). He studied in Boston with Natalo Paella, Andre Come, and Armando Ghitalla, and in Washington with Steven Hendrickson, Adel Sanchez, Emerson Head, and Chris Gekker. He appeared as soloist with the Boston Symphony Esplanade Orchestra, the National Gallery Orchestra, the Washington Handel Festival Orchestra, the Washington Chamber Symphony, the National Gallery Orchestra, the Emmanuel Music Orchestra (Boston), and on BBC TV in England in a live performance of Henry Purcell's *Sonata in D*. Hazen has given many recitals in the United States and Great Britain, including the Busch-Reisinger and Gardner Museums in Boston, the Smithsonian and Corcoran Museums in Washington, and Kings College and St. Johns College in Cambridge England. In 1998 he appeared as soloist at the Kennedy Center with the Washington Chamber Symphony, for which he played 2<sup>nd</sup> trumpet from its founding in 1977 until its demise in 2003.

In 1967 he co-founded the Cambridge Symphonic Brass Ensemble, a brass quintet that thrives to this day. They performed hundreds of concerts and recitals throughout New England, including the first performances of the Christmas Revels at Sanders Theater in Cambridge, the first Ascension Day brass concerts from the Tower of the Busch-Reisinger Museum on the Harvard University campus, and many concerts at the Castle Hill Music Festival.

He has performed as an extra trumpeter with numerous ensembles in Europe and North America, including the Boston and National Symphonies, Orchestre de Paris, the New York, Boston, Washington, and Metropolitan Operas, and the Jeffrey, American, Washington, Baltimore, Kirov, and Royal Ballets. His frequent appearances with National Symphony Orchestra include performances with Mstislav Rostropovich, Erich Leinsdorf, Antal Dorati, and Leonard Slatkin. He performed with the NSO on their 2004 national tour, including performances at Carnegie Hall.

He continued to perform on historic instruments until 2012 with such ensembles as the Washington Bach Consort, the Folger Consort, the Handel Choir of Baltimore, the Cathedral Choral Society, the Wolf Trap Opera, and the Washington Bach Sinfonia. Hazen has recorded on both modern and historic instruments with ensembles on DDG, Pro Arte, New World, Nonesuch, Smithsonian, and AMI records.

Robert and Margaret Hazen are authorities on the history of bands in America. They assembled one of the largest collections of brass band ephemera in the world and they wrote *The Music Men: An Illustrated History of Brass Bands in America* (Smithsonian Institution Press, 1987), which won the 1989 ASCAP Deems Taylor Award. They subsequently wrote the script and appeared in a documentary film on the history of bands, produced by SIRS Inc. and shown on PBS TV. The Hazen Collection of Brass Band Ephemera is now preserved in the archives of the Smithsonian Institution. More than 100 historic brass instruments collected by Robert Hazen are also in the collections of the Smithsonian Institution, the Boston Museum of Fine Arts, and the National Music Museum (Vermillion, South Dakota).

Robert and Margaret Hazen performed as semi-professional Renaissance dancers from 1972 to 1984. They were members of the Cambridge Court Dancers (Boston) and the Dupont Circle Consortium (Washington) in numerous venues, including the Boston Museum of Fine Arts, the Cloisters, Dumbarton Oaks, the Folger Theatre, and the Smithsonian Institution.

Robert Hazen is also an amateur cellist. He plays regularly with Margaret Hazen (a violist) and a growing circle of musical friends. They completed their first Beethoven string quartet cycle in 2012 and are now engaged in a Shostakovitch cycle.

### **Professional and Committee Memberships:**

Mineralogical Society of America (Life Fellow, 1982; Program Committee, 1978-80; MSA Award Committee, 1983; Associate Editor, 1983-87; Councilor, 1987-90; Mineral Physics Representative, 1990-94; Special Editor, 1997-98; Nominating Committee, 2002; Vice President, 2003-04; President, 2004-05; Past President, 2005-06; Chairman Benefactors Committee, 2005-; Distinguished Public Service Award, 2009; Member (2011- ) and Founding Chairman (2011-2013), Data Science Committee

International Society for the Study of the Origins of Life (Elected to the Executive Council, 2011)

American Geophysical Union (Mineral Physics Committee Executive Panel, 1984-88; Macelwane Award Committee, 1986-88; *Journal of Geophysical Research* Associate Editor, 1985-87; Editor of "Mineral Physics News;" History of Geophysics Committee; Sullivan Award Committee, 1999-2002)

National Research Council (Committee on K-12 Science Education and Executive Committee, 1995-2001; *National Science Education Standards*, writing team; Working Group on Teaching Evolution and coauthor *Teaching About Evolution and the Nature of Science*; writing team for 3<sup>rd</sup> edition of *Evolution and Creationism*, 2004-2007; Physics and Chemistry of Earth Materials Steering Committee, 1985-87; Board of Earth Sciences Committee on Education)

National Academy of Sciences, Science and Entertainment Exchange, Advisory Board, 2008-

National Science Foundation, Biosciences Directorate Advisory Board, 2009-2012

American Association for the Advancement of Science (Fellow, 1996; Committee for the Public Understanding of Science, 2001-2008)

Geochemical Society (Fellow, 2013)

American Chemical Society (Ipatief Prize, 1986)

American Institute of Physics (Andrew Gemant Award Committee, 1997-2003)

Geological Society of Washington (Bradley Lecturer, 2011)

Sigma Xi (Distinguished Lecturer, 2008-2010)

History of Earth Science Society

National Committee for the History of Geology (Executive Committee and Secretary, 1978-1983)

International Committee for the History of Geology (Corresponding Member, 1983-1989)

American Musical Instrument Society

International Federation of Musicians (AFL-CIO)

International Trumpet Guild

Historic Brass Society

### **Advisory Board Memberships**

Earth Life Sciences Initiative, Tokyo Tech, Japan, International Advisory Board, 2012-

National Science Foundation, Biosciences Directorate, Advisory Board, 2009-2012

Earth & Sky (National Public Radio), 1999-2013

National Science Resources Center (Smithsonian and NAS), 1992-1996

NOVA (WGBH TV, Boston) Advisory Board, 1993-

California State University-Wide Science and Math Collaborative, 1993-1995

The Carnegie Council (Washington, DC), 1993-

George Mason University, Institute of the Arts, Core Faculty, 1994-2002

Winding Your Way through DNA Project (UCSF), 1994-1996

Idaho State Science Education Project, 1995-1996

Virginia Urban Corridor Science Collaborative, 1995-1997

Advisory Board, *Encyclopedia Americana*, 1995-2011

National Philharmonic, Board of Directors, 2003-2011

Hazen has also served as advisor to state science education groups in Connecticut, Idaho, New York, New Hampshire, North Carolina, Texas, and West Virginia.

### **Fellowships, Scholarships, Academic Honors:**

The Morgan Lecturer, Appalachian State University (2016)

The Leibnitz Lecturer, University of Pottsdam (2015)

The Ingerson Lecturer of the Geochemical Society (2014)

Foster-Hewitt Lecturer, Lehigh University (2014)

Elected Fellow, Geochemical Society (2014)

Plenary Keynote Lecturer, Society of Economic Geology (2014)

Plenary Keynote Lecturer, American Society of Cell Biology (2014)  
Keynote Lecturer, Gordon Research Conference on Biomineralization (2014)  
Keynote Lecturer (2 sessions), International Mineralogical Association (2014)  
Capital Science Lecturer, Carnegie Institution (2014)  
Arthur Storke Lecturer, Columbia University (2013)  
Finalist, Phi Beta Kappa Science Book Prize (2013)  
Semi-Finalist, Royal Society (London) Science Book Prize (2013)  
Nobel Symposium Lecturer, Royal Academy, Stockholm, Sweden (2013)  
Linus Pauling Lecturer, Portland, Oregon (2013)  
Qualline Lecture, University of Texas (2013)  
Naff Symposium Lecture, University of Kentucky (2013)  
Plenary Lecturer, Goldschmidt Conference (2013)  
Condon Lecture, Oregon State University (2012)  
Moore Lecture, Oregon State University (2012)  
Vetlesen and Fish Lectures, University of Rhode Island (2012)  
Virginia Outstanding Faculty Award (2011)  
Linnaeus Prize and Lecture, Uppsala, Sweden (2011)  
Keynote Lecturer, Deep Carbon Cycle Workshop, Sendai, Japan (2011)  
Keynote Lecturer, American Association for the Advancement of Science, Annual Meeting, Washington DC (2011)  
Distinguished Scientist Lecture, Trinity University, San Antonio, TX (2010)  
Keynote Lecturer, Origins of Life Symposium, Groningen, Netherlands (2010)  
Keynote Lecturer, Synthetic Biology Symposium, Vienna, Austria (2010)  
Pardee Symposium Organizer, Geological Society of America, Denver, CO (2010)  
Keynote Lecturer, International Mineralogical Association, Budapest, Hungary (2010)  
The Bradley Lecture, Geological Society of Washington (2010)  
Mineralogical Society of America, Distinguished Public Service Medal (2009)  
The Baldwin Lecture, Miami University of Ohio (2009)  
The Charter Lecturer, University of Georgia (2009)  
"Mineral evolution" selected by *Science News* as a "science story of the year" (2008)  
Sigma Xi, Distinguished Public Lecturer (2008-2010)  
National Science Foundation, Biosciences Directorate, Distinguished Public Lecturer (2007)  
Elected Chair, Gordon Research Conference on the Origin of Life (2007-2008)  
The Robert Reed Lecturer, The Ohio State University (2007)  
The Elsasser Lecturer, The Johns Hopkins University (2007)  
The Darwin Lecturer, Northwestern University (2007)  
The Sokol Lecturer, Montclair State University (2007)  
Invited Guest Editor of *Elements*: Volume 1, #3, "Genesis" (2005); Volume 6, #1 "Mineral evolution" (2010)  
Mineralogical Society of America, Elected Vice President (2003-2004) and President (2004-2005); Distinguished Lecturer (2003-2004)  
"Life's Rocky Start" selected for *Best Science Writing of 2001*, Natalie Angier, Editor. (2002)  
Smithsonian Institution Senate of Scientists, Distinguished Lecturer (2001)  
Elizabeth Wood Science Writing Award, American Crystallographic Association (1998)  
*Physics Today* 50th Anniversary Essay Contest, Honorable Mention (1998)  
The Dibner Lecturer, Smithsonian Institution (1996)  
Educational Press Association Award, for the *Time* magazine essay "Why my kids hate science" (1992)  
ASCAP Deems Taylor Award, for *The Music Men* (with Margaret Hazen, 1989)  
The Ipatief Prize of the American Chemical Society (1986), "To recognize outstanding chemical experimental work in the field of high pressure."  
The Mineralogical Society of America Award (1982) "For outstanding contributions to the chemistry of crystals at high pressure."  
Geophysical Laboratory Postdoctoral Fellowship (1976-1978)  
NATO Postdoctoral Fellowship in Science (1975-1976)  
The Bowdoin Prize (Harvard University essay award), Honorable mention (1974)  
National Science Foundation Graduate Fellowship (1971-1974)

Ancient and Honorable Artillery Society Prize for history, MIT (1973)  
United States Geological Survey Junior Field Assistant (1970)  
Elected President, MIT Geology Club (1969-1970)  
Phi Lambda Upsilon (National Chemistry Honorary), MIT (1969)  
Baton Society, MIT music honorary (1969)  
Elected President, MIT Symphony Orchestra (1968-1970)  
Outstanding Musician Award, New York State Invitational, Fredonia, NY (1966)  
New Jersey All-State Orchestra and All-State Band (1965-1966)  
The Harvard Prize for the outstanding underclassman, Ridgewood High School (1965)

**Grants for Research (Robert Hazen is PI unless otherwise noted):**

"The Co-evolution of the Geosphere and Biosphere," Keck Foundation, (1/1/2015-12/31/2017), \$1,400,000.  
"The Deep Carbon Observatory Secretariat: Years 6 and 7," Alfred P. Sloan Foundation, (7/1/2014-6/30/2016), \$2,250,000.  
"Integrative and Synthetic Research for the Deep Carbon Observatory" (11/1/2013-10/31/2016), \$400,000.  
"Mineralogical Characterization of Methane Hydrate," Carnegie Canada Foundation, (11/1/2012-10/31/2013), \$8,300.  
"The Deep Carbon Observatory Secretariat: Years 4 and 5," Alfred P. Sloan Foundation, (7/1/2012-6/30/2014), \$2,250,000.  
"Deep Carbon Instrumentation II," Alfred P. Sloan Foundation, (4/1/2012-12/31/2013), \$1,150,000.  
"Collaborative Research: An Interdisciplinary Study of Chiral Adsorption on Mineral Surfaces," NSF (9/15/2010-9/14-2013), with Dimitri Sverjensky (Johns Hopkins) as co-PI, \$610,000.  
"Deep Carbon Instrumentation," Alfred P. Sloan Foundation, (6/1/2010-12/31/2010), \$900,000.  
"The Deep Carbon Observatory," Alfred P. Sloan Foundation. (7/1/2009-6/30/2012). \$4,000,000.  
"Astrobiological Connections," NASA Astrobiology Institute, (2/15/2009-2/14/2015). \$6,414,585. (George Cody, PI).  
"The Deep Carbon Cycle: A Proposal for Interdisciplinary Study." Alfred P. Sloan Foundation, 2007-2009. \$400,000.  
"Proposal to NASA-NAI for Support of the 2008 Origin of Life Gordon Research Conference." NASA Astrobiology Institute, 2007-2008. \$30,000.  
"Investigating the Biosphere's Roots in Deep Earth Geochemistry." Keck Foundation, 2007-2009, with M. Fogel, PI, and 4 others. \$1,200,000.  
"Astrobiological Pathways: From the Interstellar Medium, Through Planetary Systems, to the Emergence and Detection of Life," NASA Astrobiology Institute, Approximately \$6,300,000 for 2003-2008, with Sean Solomon and others.  
"Collaborative Research: An Interdisciplinary Study of Chiral Adsorption on Mineral Surfaces," NASA and NSF co-funded, 2007-2010, with Dimitri Sverjensky (Johns Hopkins) as co-PI, \$570,000  
"Signs of Life: A search for  $\gamma$ -sulfur in Canadian hot springs." Turner Foundation, \$8,000 for 2005-2008.  
"A Multidisciplinary Study of Selective Adsorption of Chiral Molecules on Mineral Surfaces," NSF. \$95,714 for 2003-2004, with Andrew Steele.  
"High-Pressure Crystal Chemistry of Earth Materials," NSF. \$270,000 for 1999-2002, with Charles Prewitt and Hexiong Yang.  
"Hydrothermal systems: Physical, chemical, and biological evolution and cosmic environments," NASA Astrobiology Institute, Approximately \$3,200,000 for 1998-2003, with Sean Solomon and others.  
"High-pressure, hydrothermal organic synthesis," NSF Life in Extreme Environments (LEn) and SGER programs, \$100,000 for 1997-1999, with George Cody and Russell Hemley.  
"Wonderful Life: Isotope micropaleontology of the Burgess Shale," Turner Foundation, \$30,000 for 1997-1999; \$5,000 extension for 2001-2002.  
"Mineral catalyzed biochemical reactions in high-pressure hydrothermal environments," NSF SGER Program, \$10,000 for 1997-1998.  
"Acquisition of a four-circle single-crystal diffractometer with a CCD detector," NSF Division of Earth Sciences, \$161,000 for 1997-2000, with Larry Finger and others.  
"High-Pressure Crystal Chemistry of Earth Materials." National Science Foundation grant awards for 1990-1993 (\$240,000) and 1993-1998 (\$380,000), with Larry Finger.

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“Mineral Energetics: Relationships among structure, bonding, thermochemical properties and elastic properties of minerals in the system  $\text{MgO-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O}$ .” National Science Foundation grant awards for 1986-1987 (\$54,600), for 1988-1990 (\$140,000), with Larry Finger.

“Mineral Energetics: Relationships among structure, bonding, thermochemical properties and elastic properties of minerals in the system  $\text{BeO-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O}$ .” National Science Foundation Grant Awards for 1984-1986 (\$250,000), with Larry Finger.

“Mineral Physics: relationships between physical properties and crystal structure” National Science Foundation Grant Awards for 1978-1979 (\$80,000.00), for 1980-1981 (\$120,000.00), for 1982-1984 (\$158,000.00), and approved for 1985-1988 (\$185,000.00) with Larry W. Finger.

“Mineral Physics Conference” National Science Foundation Grant Award for travel and other expenses associated with this conference, held at Airlie House, VA, October, 1977. (\$13,000.00) with Charles T. Prewitt.

“Origin and history of returned lunar samples and selected meteorites” NASA grant award for 1978-1979 (\$55,000.00) with Peter M. Bell and David Mao.

Robert Hazen was also on the scientific staff of the Center for High-Pressure Research, funded by the National Science Foundation, 1990-2002, Charles T. Prewitt, Principal Investigator.

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**Published Abstracts and Invited Lectures:** Approximately 180 abstracts have been published in proceedings of professional societies since 1971. Invited/plenary/keynote papers have been presented at meetings of the following societies:

AIRAPT (High-pressure research society)  
American Association for the Advancement of Science  
American Chemical Society  
American Crystallographic Society  
American Geophysical Union  
American Physical Society  
American Society of Cell Biology  
Biophysical Society  
Coast Geological Society (Santa Barbara, CA)  
Dallas Mineral Symposium  
Earth-Life Science Institute (Tokyo, Japan)  
Geochemical Society  
Geological Society of America  
Geological Society of Washington  
Gordon Research Conference (High Pressure)  
Gordon Research Conference (Origin of Life)  
Gordon Research Conference (Biomineralization)  
Gordon Research Conference (Geobiology)  
Industrial Diamond Association  
International Mineralogical Association  
Japan Geosciences Union  
Kavli Futures Workshop  
Mineralogical Society (Great Britain)  
Mineralogical Society of America  
Philosophical Society of Washington  
Potomac Geophysical Society  
Society for Economic Geology

Invited lectures have been delivered at numerous colleges, universities and national laboratories, including:

University of Alaska (Anchorage)

University of Arizona (Tucson, AZ)

University of California (Santa Barbara, CA)

University of California (Los Angeles, CA)

California State University (Fresno, CA)

Arizona State University (Tempe, AZ)

University of California (Berkeley, CA)

Stanford University (Stanford, CA)

CalTech (Pasadena, CA)



Jet Propulsion Laboratory (Pasadena, CA)  
NASA Ames Research Lab (Moffett Field, CA)  
Loyola Marymount University (Los Angeles, CA)  
Coast Geological Society (Ventura, CA)  
University of Colorado (Boulder, CO)  
University of Connecticut (Storrs, CT)  
Central Connecticut State Univ. (New Britain, CT)  
University of Delaware (Newark, DL)  
Georgia Tech (Atlanta, GA)  
University of Georgia (Athens, GA)  
University of Idaho (Moscow, ID)  
University of Chicago (Chicago, IL)  
Northwestern University (Evanston, IL)  
Purdue University (Lafayette, IN)  
Iowa State University (Ames, IA)  
Centre College (Danville KY)  
University of Kentucky (Lexington, KY)  
The Johns Hopkins University (Baltimore, MD)  
Salisbury State University (Maryland)  
Carnegie Inst., Dept. Embryology (Baltimore, MD)  
Army Research Lab  
Harvard University (Cambridge, MA)  
Massachusetts General Hospital (Boston, MA)  
Boston College (MA)  
University of Minnesota (St. Paul, MN)  
University of Missouri (Kansas City, MO)  
University of New Hampshire (Durham, NH)  
Princeton University (Princeton, NJ)  
Rutgers University  
St. Johns College (Santa Fe, NM)  
University of New Mexico (Albuquerque)  
State University of New York (Stony Brook, NY)  
Cornell University (Ithaca, NY)  
University of Buffalo (Buffalo, NY)  
Lamont-Doherty (Columbia Univ., Palisades, NY)  
RPI (Troy, NY)  
Simons Foundation (NY, NY)  
Duke (Durham, NC)  
Elon College (Elon College, NC)  
Denison University (Granville, OH)  
Wright State University (Dayton, OH)  
Miami University (Oxford, OH)  
University of Oklahoma (Norman, OK)  
Linfield College (McMinnville, OR)  
Portland State University (OR)  
Pennsylvania State Univ. (University Park, PA)  
Academy of Natural Sciences of Philadelphia

Beckman Center (Irvine, CA)  
University of California (Santa Cruz, CA)  
University of Southern California (Los Angeles)  
Scripps (La Jolla, CA)  
Yale University (New Haven, CT)  
Fairfield University (Bridgeport, CT)  
University of Delaware (Lewes, DL)  
Georgia Southern University (Statesboro, GA)  
Southern Illinois University (Carbondale, IL)  
Argonne National Laboratory (Argonne, IL)  
University of Indiana (Bloomington)  
McPherson College (McPherson, KS)  
Eastern Kentucky University (Richmond, KY)  
University of Maryland (College Park, MD)  
NASA Goddard (Greenbelt, MD)  
NIST (Gaithersburg, MD)  
Space Telescope Science Institute  
University of Massachusetts (Amherst, MA)  
Schlumberger Research (Cambridge, MA)  
MIT (Cambridge, MA)  
Washington University (St. Louis, MO)  
Keene State College (Keene, NH)  
Montclair State University (Montclair, NJ)  
Los Alamos National Lab (Los Alamos, NM)  
IBM Watson Res. Cen. (Yorktown Heights, NY)  
The Century Club (New York, NY)  
State University of New York (Cortland, NY)  
American Museum of Natural History (NY, NY)  
Alfred P. Sloan Foundation (NY, NY)  
East Carolina University (Greenville, NC)  
The Ohio State University (Columbus, OH)  
Case Western Reserve Univ (Cleveland, OH)  
Oregon State University (Corvallis, OR)  
University of Pennsylvania (Philadelphia, PA)  
LaSalle University (Philadelphia, PA)

University of Pittsburgh (Pittsburgh, PA)  
Carnegie-Mellon University (Pittsburgh, PA)  
Villanova University (Villanova, PA)

University of Rhode Island (Providence, RI)

Clemson University (Clemson, SC)  
University of Charleston (Charleston, SC)

Tennessee Technical University (Cookeville, TN)  
University of Tennessee, Knoxville

Texas Tech (Lubbock, TX)  
Trinity College (San Antonio, TX)

George Mason University (Fairfax, VA)  
Union Theological Seminary (Richmond, VA)  
Virginia Commonwealth University (Richmond, VA)  
National Science Foundation (Ballston, VA)

Norwich University (Northfield, VT)

Howard University (Washington, DC)  
Carnegie Institution (Washington, DC)  
National Academy of Sciences (Washington, DC)  
George Washington University (Washington, DC)

University of Washington (Seattle, WA)

University of West Virginia (Morgantown, WV)

University of Wyoming (Laramie, WY)

University of Melbourne (Australia)

University of Vienna (Austria)

McMaster University (Hamilton, Ontario, Canada)  
Royal Ontario Museum (Toronto, Ontario, Canada)

Institute for Geology and Geophysics (Beijing, China)

University of Cambridge (England)  
University of Oxford (England)

Institute de Physique du Globe (Paris, France)  
Air Liquide Research (Paris, France)

University of Kiel (Germany)  
University of Freiberg (Germany)  
University of Muenster (Germany)  
German Research Institute (Potsdam)  
University of Potsdam

University of Groningen (Holland)

Technical University (Budapest, Hungary)

University of Rome (Italy)  
Campiglia Maritima (Italy)

University of Tokyo (Japan)  
Tokyo Tech (Japan)

University of Bergen (Norway)

Spanish Astrobiology Institute (Madrid)

University of Uppsala (Sweden)  
Swedish Royal Academy of Sciences (Stockholm)

Lafayette University (Easton, PA)  
Franklin and Marshall Univ. (Lancaster, PA)  
Lehigh University (Bethlehem, PA)

Brown University (Providence, RI)

The Citadel (Charleston, SC)

East Tennessee State Univ. (Johnson City, TN)  
University of Tennessee, Martin

University of Texas (Austin, TX)

Mary Washington College (Fredericksburg, VA)  
Virginia Tech (Blacksburg, VA)  
Old Dominion University (Norfolk, VA)  
William and Mary (Williamsburg, VA)

St. Mary's College (Burlington, VT)

Smithsonian Institution (Washington, DC)  
Brookings Institution (Washington, DC)  
Naval Research Laboratory (Washington, DC)

University of Puget Sound (Tacoma, WA)

Marquette University (Milwaukee, WI)

Austrian Academy of Sciences (Vienna)

McGill University (Montreal, Quebec, Canada)  
University of British Columbia (Vancouver)

University of Newcastle (England)  
University of Liverpool (England)

Schlumberger Research (Paris, France)

University of Greifswald (Germany)  
University of Bochum (Germany)  
University of Cologne (Germany)  
University of Bremen (Germany)

Eötvös University (Budapest, Hungary)

University of Florence (Italy)  
University of Milan (Italy)

Tohoku University (Sendai, Japan)

Palace Royale (Santandar, Spain)

University of Stockholm (Sweden)

**Selected Television Appearances:**

CNN, "Sonia Live"  
CBS, "Nightwatch"  
NBC, "The Today Show"  
KDFW (Dallas, TX), "Point of View"  
KHOV (Houston, TX), "AM Houston"  
Maryland Public TV, "The Environment"  
Spanish Public TV, "REDES"  
Discovery Science, "Sci-Fi Science"  
PBS, "Science Journal"  
WGBH (Boston), "NOVA" (several episodes)  
BBC (London), "Horizon"  
IDEA TV (Brazil)  
History Channel, "Modern Marvels"  
Discover Channel, "Naked Science"  
National Geographic, "Origins"  
Japan National Public Television

**Selected Radio Appearances (1-Hour Live Talk Shows):**

NPR, "Science Friday"  
Monthly hour-long appearances on Wisconsin Public Radio  
WAMU (Washington), "Diane Rehm Show" and "Mike Cuthbert Show"  
KPRC (Houston), "Doug Johnson Show"  
KLBK (Austin, TX) "PM Show"  
KING (Seattle), "Jim Altoff Show"  
KABC (Los Angeles), "Michael Jackson Show"  
KXLY (Seattle), "PM Show"  
WNYC (New York), "New York & Company"  
KNBR (San Francisco), "Leo LaPorte Show"  
BBC (London)  
WBZ (Boston), "Lovell Dyett Show"  
KFI (Los Angeles), "Lora Cain Show"  
KMOX (St. Louis), Morning show  
KSDO (San Diego), "Roger Hedgecock Show"  
WAMC (Albany, NY), "The Best of Our Knowledge"  
WJNO (West Palm Beach, FL), "Jack Cole Show"  
WKAR (Michigan Public Radio), "Carey Bernstein Show"  
KNSS (Wichita, KS), "Morning Magazine"  
Virginia Public Radio, "With Good Reason"  
KDKA (Pittsburgh, PA), "Open Mike"

**Selected Taped Radio Spots:**

NPR "All Things Considered," "Weekend Edition"  
CBS "Countdown to Tomorrow"  
ABC "Chuck Taylor"  
WKYS (Washington), "Sunday Morning Magazine"  
KIKK (Houston), "Talkin Country"  
Southern Baptist Radio, "Master Control"  
KPLU (Seattle), "Morning Edition"  
KMPS (Seattle), "Introspect"  
KGW (Portland, OR), "Peter Wiseback Show"  
National Public Radio, "All Things Considered"  
Wisconsin Public Radio, "To the Best of Our Knowledge"  
BBC Radio (London)  
BBC World Service  
Canadian Broadcast System  
PBS, "Earth & Sky"  
Prof. Michio Kaku, "Explorations"

**Selected Articles about R.M.Hazen**

Kirkland, Betty P. (1990) "Musician's science of life" *Potomac Gazette*, February 28, 1990, A29, A43.  
Pool, R. (1990) "Teaching science appreciation" *Science* **248**, 158.  
Yasui, Todd A. (1991) "Scientific principles" *Washington Post Magazine*, January 1991, 10.  
Williams, Hill (1991) "Hey, 'Science Matters,' He Says." *Seattle Times*, January 17, 1991, G6.  
Orndorff, Beverly (1991) "Science illiterates hide even in colleges, two say" *Richmond Times*

- Dispatch*, February 17, 1991, B8.
- Mayer, Maureen (1991) "Course may offer cure for scientific illiteracy" *The Mason Gazette* 7, March 15, 1991, 1, 7.
- Galloucis, Mike (1991) "Making science simple" *The Fairfax Journal, Tempo*, March 28, 1991.
- Pool, Robert (1991) "Science literacy: The enemy is us" *Science* 251, 266-267.
- Culotta, Elizabeth (1991) "Science's 20 greatest hits take their lumps" *Science* 251, 1308-1309.
- Frenck, Janet E. (1991) "Potomac author sticks up for science" *Bethesda Gazette*, April 18, 1991, A20.
- Church, Vernon (1991) "Life among the science impaired" *Discover*, December, 1991.
- Kainan, Beth (1992) "Finding harmony in music, science" *Washington Post*, January 23, 1992, C3.
- McClain, Buzz (1992) "Science and art in tune" *Fairfax Journal*, January 24, 1992.
- Kim, Sunah (1992) "GMU professor claims U.S. science illiteracy." *Harvard Crimson*, March 10, 1992, 1.
- Rayl, A. J. S. (1992) "Popular science writing" *The Scientist*, May 11, 1992, 21-22.
- Rayl, A. J. S. (1992) "Researchers embark on effort to improve image of scientists" *The Scientist*, June 22, 1992, 20-21.
- Miller, Victor (1992) "Teacher says students lack basic knowledge of science" *Chattanooga News*, July 13, 1992, B5.
- Gabel, Mary (1992) "Visiting professor offers tips on teaching science." *Chattanooga News*, July 14, 1992, B4.
- Krehbiel, Ken (1992) "Robert Hazen's historical horn of plenty" *Washington Post*, February 4, 1992, B4.
- Haggin, Joseph (1992) "Efforts to promote public understanding of science continue" *Chemical and Engineering News*, Sept. 14, 1992, 31-32.
- Moffat, Anne Simon (1993) "New meetings tackle the knowledge conundrum" *Science* 259, 1253-54.
- Editor (1994) "Person of the Week" *GMU Broadside*, February 14, 1994, 8.
- Billings, Linda (1996) "Pre-life sciences" *Washington Post Magazine*, August 11, 1996, 3-4.
- Carlowicz, Michael (1996) "Public knows the value of science, but not the meaning" *EOS Transactions of the American Geophysical Union*, August 27, 1996, 339.
- Carlowicz, Michael (1996) "Teachers, administrators look to higher standard" *EOS Transactions of the American Geophysical Union*, September 17, 1996, 365-367.
- Trescott, Jacqueline (1996) "Trumpeters' hallelujah season" *Washington Post*, December 18, 1996, D1 and D8-9.
- Hazen's book *Genesis: The Scientific Quest for Life's Origins* (National Academy, 2005) received national and international notice, including pieces in *Nature*, *National Geographic*, *The Guardian* (London), *The Washington Post*, and *Publisher's Weekly*, as well as an extensive critical review, "Weird Science," by Andrew O'Hehir, at [www.salon.com](http://www.salon.com).
- Joel Achenbach (2006) "The origin of life? All in a day's work. For some scientists it's a race to the start." *Washington Post* (January 8, 2006).
- Dennis O'Brien (2006) "A rocky pathway to life's origins." *Baltimore Sun*, December 29, 2006.
- Michael Bugeja (2007) "Sound science or sound bite?" *American Physical Soc. News* 16, #1, 8.
- Dennis O'Brien (2007) "Backyard search, Prehistoric finds." *Baltimore Sun*, July 9, 2007.
- Davide Castelvecchi (2007) "Alien pizza, anyone?" *Science News*, August 18, 2007, 107-109.
- Karen Akerlof (2008) "Professor searches for the genesis of biological systems in the Earth's depths." *The Mason Gazette*, March 3, 2008.
- Helen Fields (2010) "Before there was life." *Smithsonian Magazine*, v.41, #6, (October 2010), 48-54.
- Pamela Toutant (2011) "Robert Hazen: In work and art, board member strives for "the highest level." *Applause at Strathmore*, May-June 2011, p.17.

#### **Selected Articles on "Mineral Evolution"**

- Minik Rosing (2008) "On the evolution of minerals." *Nature* 456, 456-458.
- Sid Perkins (2008) "As life evolves, minerals do too." *Science News*, December 6, 2008, 10.
- Phil Bernardelli (2008) "Earth's minerals evolved, too." *ScienceNOW Daily News*, Noember 14, 2008. (<http://sciencenow.sciencemag.org>)
- Crisogono Vasconcelos and Judith McKenzie (2009) "The descent of minerals." *Science* 323, 218-219.

Brian Fisher Johnson (2009) "Minerals take on a new life." *Earth*, January 2009, 14-15.  
Harvey Leifert (2009) "Rocky Road." *Natural History*, February 2009, 14.  
*Science News* (2009) News of the Year issue, "Minerals evolve too." January 3, 2009, 26.  
*American Scientist* (2009) "Rocks evolve too." January-February 2009, 25.  
Colin Nickerson (2009) "The blurry line between life, nonlife." *Boston Globe*, January 12, 2009, A9.  
Boris Bellanger (2009) "Mineraux sans la vie, il n'en existerait pas autant!" *Science et Vie*, March 2009, 102-104.  
"Mineral evolution rocks world." *Carnegie Science*, Spring 2009, 10-11.  
Bradley, D.C. (2015) Mineral evolution and Earth history. *American Mineralogist* 100, 4-5.

### **Selected Web Links on "Mineral Evolution"**

Astrobiology Magazine (11/14/08):

<http://www.astrobio.net/news/modules.php?op=modload&name=News&file=article&sid=2934&mode=thread&order=0&thold=0>

BBC Radio (11/14/08): [http://www.bbc.co.uk/worldservice/programmes/science\\_in\\_action.shtml](http://www.bbc.co.uk/worldservice/programmes/science_in_action.shtml)

Centauri Dreams (11/14/08): <http://www.centauri-dreams.org/?p=4302>

Discover Magazine Blogs (11/17/08): <http://blogs.discovermagazine.com/80beats/2008/11/17/mineral-evolution/>

The Economist (11/13/08): [http://www.economist.com/science/displaystory.cfm?story\\_id=12592248](http://www.economist.com/science/displaystory.cfm?story_id=12592248)

e! Science News (11/13/08): <http://esciencenews.com/articles/2008/11/13/mineral.kingdom.has.co.evolved.with.life>

Live Science (11/13/08): <http://www.livescience.com/strangenews/081113-mineral-evolution.html>

New Scientist (11/19/08):

<http://www.newscientist.com/article/mg20026834.500-earths-mineral-kingdom-evolved-hand-in-hand-with-life.html>

Science Daily (11/14/08): <http://www.sciencedaily.com/releases/2008/11/081113181035.htm>

Science News (12/06/08): [http://www.sciencenews.org/view/generic/id/38485/title/Minerals\\_evolved\\_along\\_with\\_life](http://www.sciencenews.org/view/generic/id/38485/title/Minerals_evolved_along_with_life)

Science Now (11/14/08): <http://sciencenow.sciencemag.org/cgi/content/full/2008/1114/2>

Scientific Frontline (11/14/08): [http://www.sflorg.com/earthnews/en111408\\_01.html](http://www.sflorg.com/earthnews/en111408_01.html)

Wired blog (11/15/08): <http://blog.wired.com/sterling/2008/11/earths-minerals.html>

La Opinion (11/13/08) Spanish

[http://www.laopinion.es/secciones/noticia.jsp?pRef=2008111300\\_18\\_181685\\_Ciencia-y-Tecnologia-minerales-coevolucionado-organismos-vivos](http://www.laopinion.es/secciones/noticia.jsp?pRef=2008111300_18_181685_Ciencia-y-Tecnologia-minerales-coevolucionado-organismos-vivos)

Faz net (11/19/08) German

[http://www.faz.net/s/Rub2542FB5D98194DA3A1F14B5B01EDB3FB/Doc~E99B42A8CCDD54B78900B41684DC9A78B~ATpl~Ecommon~Scontent.html?rss\\_googlefeed](http://www.faz.net/s/Rub2542FB5D98194DA3A1F14B5B01EDB3FB/Doc~E99B42A8CCDD54B78900B41684DC9A78B~ATpl~Ecommon~Scontent.html?rss_googlefeed)

Science Ticker (11/14/08) German: <http://www.scienceticker.info/2008/11/14/mineralische-evolution/>

Tyden.cz (11/21/08) Czech:

[http://www.tyden.cz/rubriky/veda-a-technika/veda/vetsina-mineralu-by-neexistovala-nebyt-zivota\\_90581.html](http://www.tyden.cz/rubriky/veda-a-technika/veda/vetsina-mineralu-by-neexistovala-nebyt-zivota_90581.html)

Deutschlandfunk (11/19/08) German: <http://www.dradio.de/dlf/sendungen/forschak/878261/>

Brig Klyce (2008) "Life has a role in the origin of minerals." (<http://www.panspermia.org>)

## BIBLIOGRAPHY

### 1971

Hazen, R.M. (1971) *Effects of cation substitution on the physical properties of trioctahedral micas*. Master's Thesis, M.I.T., Department of Earth and Planetary Sciences, 88 p.

### 1972

Hazen, R.M. and D.R.Wones (1972) The effect of cation substitution on the physical properties of trioctahedral micas. *American Mineralogist* **57**, 103-129.

### 1973

Smyth, J.R. and R.M.Hazen (1973) The crystal structures of forsterite and hortonolite at several temperatures up to 900°C. *American Mineralogist* **58**, 588-593.

Hazen, R.M. and Burnham, C.W. (1973) The crystal structures of one-layer phlogopite and annite. *American Mineralogist* **58**, 889-900.

### 1974

Hazen, R.M. and C.W.Burnham (1974) The crystal structures of gillespite I and II: a structure determination at high pressure. *American Mineralogist* **59**, 1166-1176.

Grove, T.L. and R.M.Hazen (1974) Alkali feldspar unit-cell parameters at liquid-nitrogen temperature: low-temperature limits of the displacive transformation. *American Mineralogist* **59**, 1327-1329.

### 1975

Hazen, R.M. (1975) *Effects of temperature and pressure on the crystal physics of olivine*. Ph.D. Thesis, Harvard University, Department of Geological Sciences, 264 p.

Hazen, R.M. (1975) The founding of geology in America: 1771 to 1818. *Geological Society of America Bulletin* **85**, 1827-1834.

### 1976

Hazen, R.M. (1976) Effects of temperature and pressure on the cell dimensions and isotropic temperature factors of periclase. *American Mineralogist* **61**, 266-271.

Hazen, R.M. (1976) Effects of temperature and pressure on the crystal structure of forsterite. *American Mineralogist* **61**, 1280-1293.

Hazen, R.M. (1976) Effects of temperature and pressure on the crystal structures of silicate minerals. *Mineralogical Society of London Bulletin* **20**, 8.

Hazen, R.M. (1976) Sanidine: predicted and observed monoclinic-to-triclinic reversible phase transition at high pressure. *Science* **194**, 105-107.

Hazen, R.M. (1976) *Bibliography of American-Published Geology: 1669 to 1850*. Geological Society of America Microform Publication 4, 979 p.

Bassett, W.A., R.M.Hazen and L. Merrill (1976) New applications of the miniature diamond pressure cell: III. High-pressure single crystal x-ray diffraction. In R.G.Strens (ed.) *The Physics and Chemistry of Minerals and Rocks*. New York: Wiley, 459-468.

## 1977

Hazen, R.M. (1977) Temperature, pressure, and composition: structurally analogous variables. *Physics and Chemistry of Minerals* 1, 83-94.

Hazen, R.M. (1977) Effects of temperature and pressure on the crystal structure of ferro-magnesian olivines. *American Mineralogist* 63, 286-295.

Hazen, R.M. and C.T.Prewitt (1977) Linear compressibilities of low albite: High-pressure structural implications. *American Mineralogist* 62, 309-315.

Hazen, R.M. (1977) Mechanisms of transformation and twinning in gillespite at high pressure. *American Mineralogist* 63, 528-533.

Hazen, R.M. and C.T.Prewitt (1977) Effects of temperature and pressure on interatomic distances in oxygen-based minerals. *American Mineralogist* 62, 554-558.

Hazen, R.M. and L.W.Finger (1977) Crystal structure and compositional variation of Angra dos Reis fassaite. *Earth and Planetary Science Letters* 35, 357-362.

Hazen, R.M., H.K.Mao and P.M.Bell (1977) Effects of compositional variation on absorption spectra of lunar olivines. *Proceedings of the Lunar Science Conference* 8, 1081-1090.

Finger, L.W. and R.M.Hazen (1977) High-pressure crystal structures of the spinel polymorphs of  $\text{Fe}_2\text{SiO}_4$  and  $\text{Ni}_2\text{SiO}_4$ . *Carnegie Institution of Washington Year Book* 76, 504-505.

Hazen, R.M., H.K.Mao and P.M.Bell (1977) Comparison of absorption spectra of lunar and terrestrial olivines. *Carnegie Institution of Washington Year Book* 76, 508-512.

Hazen, R.M. and L.W.Finger (1977) Compressibility and crystal structure of Angra dos Reis fassaite to 52 kbar. *Carnegie Institution of Washington Year Book* 76, 512-515.

Hazen, R.M., P.M.Bell and H.K.Mao (1977) Polarized absorption spectra of Angra dos Reis fassaite to 50 kbar. *Carnegie Institution of Washington Year Book* 76, 515-516.

Finger, L.W. and R.M.Hazen (1977) Crystal structure and compressibility of ruby to 80 kbar. *Carnegie Institution of Washington Year Book* 76, 525-528.

Hazen, R.M. and L.W.Finger (1977) Linear compressibilities of layer minerals. *Carnegie Institution of Washington Year Book* 76, 529-531.

Hazen, R.M. and L.W.Finger (1977) Modification in high-pressure single-crystal diamond cell techniques. *Carnegie Institution of Washington Year Book* 76, 655-656.

## 1978

Hazen, R.M. and L.W.Finger (1978) Crystal structures and compressibilities of layer minerals at high pressure. I.

BN and SnS<sub>2</sub>. *American Mineralogist* **63**, 289-292.

Hazen, R.M. and L.W.Finger (1978) Crystal structures and compressibilities of layer minerals at high pressure. II. phlogopite and chlorite. *American Mineralogist* **63**, 293-296.

Hazen, R.M. and L.W.Finger (1978) Crystal structures and compressibilities of pyrope and grossularite to 60 kilobars. *American Mineralogist* **63**, 297-303.

Hazen, R.M. and D.R.Wones (1978) Predicted and observed compositional limits of trioctahedral micas. *American Mineralogist* **63**, 885-892.

Hazen, R.M. and L.W.Finger (1978) Crystal chemistry of silicon-oxygen bonds at high pressure: implications for the earth's mantle mineralogy. *Science* **201**, 1122-1123.

Finger, L.W. and R.M.Hazen (1978) Crystal structure and compressibility of ruby to 46 kbar. *Journal of Applied Physics* **49**, 5823-5826.

Hazen, R.M., H.K.Mao and P.M.Bell (1978) Effects of compositional variation on absorption spectra of lunar pyroxene. *Proceedings of the Lunar Science Conference* **9**, 2919-2934.

Bell, P.M., H.K.Mao and R.M.Hazen (1978) The Luna 24 sample from Mare Crisium: New structural features in lunar glasses deduced from a study of crystal-field spectra. *Proceedings of the Conference on Luna 24*, 265-280.

Spear, F.S. and R.M.Hazen (1978) Sodium trioctahedral mica: a possible new rock-forming silicate from the Post Pond Volcanics, Vermont. *Carnegie Institution of Washington Year Book* **77**, 808-812.

Hazen, R.M., L.W.Finger and T.Yagi (1978) Crystal structure and compressibility of MnF<sub>2</sub> to 15 kbar. *Carnegie Institution of Washington Year Book* **77**, 841-842.

Hazen, R.M. and L.W.Finger (1978) Relationships between crystal structure and compressibility in ionic crystals. *Carnegie Institution of Washington Year Book* **77**, 848-850.

Finger, L.W. and R.M.Hazen (1978) Refined occupancy factors for synthetic Mn-Mg pyroxmangite and rhodonite. *Carnegie Institution of Washington Year Book* **77**, 850-851.

Hazen, R.M. P.M.Bell and H.K.Mao (1978) Systematic variation of pyroxene absorption spectra with composition. *Carnegie Institution of Washington Year Book* **77**, 851-855.

Bell, P.M., H.K.Mao and R.M.Hazen (1978) Luna 24 glass fragments: a study of soil samples recovered from the Russian Luna 24 mission to Mare Crisium. *Carnegie Institution of Washington Year Book* **77**, 855-856.

Hazen, R.M. (1978) Curve fitting. *Science* **202**, 823. (Also reprinted in several anthologies of science humor.)

## 1979

Hazen, R.M. and L.W.Finger (1979) Polyhedral tilting: a common type of phase transition and its relationship to analcite at high pressure. *Phase Transitions* **1**, 1-22.

Hazen, R.M. and L.W.Finger (1979) Crystal structure and compressibility of zircon at high pressure. *American Mineralogist* **64**, 196-201.

Finger, L.W., R.M.Hazen and T.Yagi (1979) Crystal structures and electron density studies of nickel and iron silicate spinels at elevated temperature or pressure. *American Mineralogist* **64**, 1002-1009.



- Hazen, R.M. (ed.) (1979). *North American Geology: Early Writings*. Stroudsburg, PA: Dowden, Hutchinson and Ross, 384 p.
- Hazen, R.M. and L.W.Finger (1979) Linear compressibilities of NaNO<sub>2</sub> and NaNO<sub>3</sub>. *Journal of Applied Physics* **50**, 6826-6828.
- Finger, L.W. and R.M.Hazen (1979) Response of oxygen-based structures to changes in temperature, pressure and composition. *Transactions of the American Crystallographic Association* **15**, 93-105.
- Hazen, R.M. and L.W.Finger (1979) Bulk modulus-volume relationship for cation-anion polyhedra. *Journal of Geophysical Research* **84**, 6723-6728.
- Hazen, R.M. and M.H.Hazen (1979) Neglected geological literature: an introduction to a bibliography of American-published geology, 1669 to 1850. In C.J.Schneer (ed.) *Two-Hundred Years of American Geology*. Hanover, NH: University Press of New England, 33-36.
- Hazen, R.M. and L.W.Finger (1979) Studies in high-pressure crystallography. *Carnegie Institution of Washington Year Book* **78**, 632-636.
- Hazen, R.M. and L.W.Finger (1979) A high-temperature diamond pressure cell for single-crystal studies. *Carnegie Institution of Washington Year Book* **78**, 658-659.
- Hazen, R.M. (1979) Workshop on heating the diamond-anvil, high-pressure cell. *Carnegie Institution of Washington Year Book* **78**, 683-684.
- Hazen, R.M., M.H.Hazen and L.W.Finger (1979) Speleological writings in early America. *Journal of Spelean History* **13**, 58-65.

## 1980

- Hazen, R.M. and M.H.Hazen (1980) *American Geological Literature, 1669 to 1850*. Stroudsburg, PA: Dowden, Hutchinson and Ross, 431 p.
- Finger, L.W. and R.M.Hazen (1980) Crystal structures and isothermal compression of Fe<sub>2</sub>O<sub>3</sub>, Cr<sub>2</sub>O<sub>3</sub> and V<sub>2</sub>O<sub>3</sub> to 50 kbar. *Journal of Applied Physics* **51**, 5362-5367.
- Hazen, R.M., H.K.Mao, L.W.Finger and P.M.Bell (1980) Structure and compression of crystalline methane at high pressure and room temperature. *Applied Physics Letters* **37**, 288-289.
- Hazen, R.M. (1980) Publications in American geology to 1850. *Journal of Geological Education* **28**, 249-255.
- Hazen, R.M. (1980) Essay book review of *Minerals, Lands, and Geology for the Common Defense and General Welfare* by Mary Rabbitt. *Geological Magazine* **117**, 397-398.
- Hazen, R.M., H.K.Mao, L.W.Finger and P.M.Bell (1980) Crystal structures and compression of Ar, Ne, and CH<sub>4</sub> at 20°C to 90 kbar. *Carnegie Institution of Washington Year Book* **79**, 348-351.
- Hazen, R.M. and L.W.Finger (1980) Crystal structure of forsterite to 40 kbar. *Carnegie Institution of Washington Year Book* **79**, 364-367.
- Mao, H.K., R.M.Hazen, P.M.Bell and J.Wittig (1980) Evidence for a localized 4f-shell breakdown in praseodymium under pressure. *Carnegie Institution of Washington Year Book* **79**, 380-384.
- Hazen, R.M. and L.W.Finger (1980) High-temperature diamond anvil cell for single-crystal studies. *Carnegie Institution of Washington Year Book* **79**, 406-409.

## 1981

- Hazen, R.M. and L.W.Finger (1981) Bulk moduli and high-pressure crystal structures of rutile-type compounds. *Journal of the Physics and Chemistry of Solids* **42**, 143-151.
- Hazen, R.M. and L.W.Finger (1981) Module structure variation with temperature, pressure and composition: a key to the stability of modular structures? In: A.Navrotsky and M.O'Keefe (eds.) *Structure and Bonding in Crystals*. NY: Academic Press, volume 2, 109-116.
- Hazen, R.M. and L.W.Finger (1981) High-temperature diamond anvil pressure cell for single-crystal studies. *Review of Scientific Instruments* **52**, 75-79.
- Spear, F., R.M.Hazen and D.Rumble (1981) Wonesite: a new rock-forming silicate from the Post Pond Volcanics, Vermont. *American Mineralogist* **66**, 100-105.
- Hazen, R.M., L.W.Finger and D.Velde (1981) Crystal structure of silica-rich trioctahedral mica. *American Mineralogist* **66**, 586-591.
- Finger, L.W., R.M.Hazen, G.Zou, H.K.Mao and P.M.Bell (1981) Structure and compression of crystalline argon and neon at high pressure and room temperature. *Applied Physics Letters* **39**, 892-894.
- Hazen, R.M. and L.W.Finger (1981) Calcium fluoride as an internal pressure standard in high-pressure/high-temperature crystallography. *Journal of Applied Crystallography* **14**, 234-236.
- Hazen, R.M. (1981) A bibliography for historians of geology. An essay review of *Geologists and the History of Geology* by W.A.S.Sarjeant. *Geological Magazine* **118**, 425-428.
- Finger, L.W. and R.M.Hazen (1981) X-ray crystallographic studies at high pressure and high temperature. In: *High Pressure as a Reagent and an Environment*. Washington: American Chemical Society, 77-81.
- Mao, H.K., R.M.Hazen, P.M.Bell and J.Wittig (1981) Evidence for a localized 4f-shell breakdown in praseodymium under pressure. *Journal of Applied Physics* **52**, 4572-4574.
- Zou, G., H.K.Mao, L.W.Finger, P.M.Bell and R.M.Hazen (1981) Interatomic potentials for solid argon and neon at high pressures. In: J.S.Schilling and R.N.Skelton (eds.) *Physics of Solids under High Pressure*. Amsterdam: North-Holland Publishing Co., 137-140.
- Hazen, R.M., H.K.Mao, L.W.Finger and P.M.Bell (1981) Irreversible unit-cell volume changes of wustite single crystals quenched from high pressure. *Carnegie Institution of Washington Year Book* **80**, 274-277.
- Hazen, R.M. (1981) Systematic variation of bulk modulus of wustite with stoichiometry. *Carnegie Institution of Washington Year Book* **80**, 277-280.
- Zou, G., L.W.Finger, R.M.Hazen, P.M.Bell and H.K.Mao (1981) Isothermal equations of state for neon and argon. *Carnegie Institution of Washington Year Book* **80**, 295-299.
- Finger, L.W. and R.M.Hazen (1981) Refinement of the crystal structure of an iron-rich kornepurine. *Carnegie Institution of Washington Year Book* **80**, 370-373.
- Hazen, R.M. and L.W.Finger (1981) Crystal structure of diopside at high temperature and pressure. *Carnegie Institution of Washington Year Book* **80**, 373-376.
- Hazen, R.M. and M.H.Hazen, compilers (1981) *Indices of the Annual Reports of the Director, Geophysical Laboratory, 1905-1980*. Washington: Carnegie Institution of Washington, 143 p.

Hughes, J.M., L.W.Finger and R.M.Hazen (1981) The crystal structure of bannermanite. *Carnegie Institution of Washington Year Book* **80**, 379-380.

Ralph, R.L., R.M.Hazen and L.W.Finger (1981) Cell parameters of orthoenstatite at high temperature and pressure. *Carnegie Institution of Washington Year Book* **80**, 376-379.

Pinckney, L.R., L.W.Finger, R.M.Hazen and C.W.Burnham (1981) Crystal structure of pyroxmangite at high temperature. *Carnegie Institution of Washington Year Book* **80**, 380-384.

## 1982

Hazen, R.M. and L.W.Finger (1982) *Comparative Crystal Chemistry: Temperature, Pressure, Composition and the Variation of Crystal Structure*. London: J. Wiley & Sons, xv, 231 p.

Hazen, R.M., editor (1982) *The Poetry of Geology*. London: George Allen and Unwin, 98 p.

Hazen, R.M. and J.W.Mariathasan (1982) Bismuth vanadate: a high-pressure, high-temperature crystallographic study of the ferroelastic-paraelastic transition. *Science* **216**, 991-993.

Hazen, R.M. and L.W.Finger (1982) High-temperature and high-pressure crystal chemistry. In: W.Schreyer (ed.) *High-Pressure Researches in Geosciences*. Stuttgart: Schweizerbart'sche Verlagsbuch Handlung, 151-176.

Hazen, M.H. and R.M.Hazen (1982) The emergence of geology in eighteenth-century America. *Journal of Geological Education* **30**, 144-148.

Hazen, R.M. (1982) PT crystallographic study of the gillespite I-II phase transition. *Carnegie Institution of Washington Year Book* **81**, 380-384.

Hazen, R.M. and L.W.Finger (1982) A reversible phase transition in sodium tungstate perovskite at 12 kbar. *Carnegie Institution of Washington Year Book* **81**, 384-386.

Hazen, R.M. (1982) Book review of *The New Madrid Earthquakes* by J.L.Penick. *Isis* **73**, 454.

Finger, L.W., R.M.Hazen and J.Hughes (1982) Crystal structure of monoclinic ilvaite. *Carnegie Institution of Washington Year Book* **81**, 386-388.

Hazen, R.M. (1982) Curve fitting. In: R.L.Walker (ed.) *More Random Walks in Science*. Bristol, England: The Institute of Physics, 184-185.

Hazen, R.M. (1982) Book review of *Grove Karl Gilbert, a Great Engine of Research*, by S.J.Pyne. *Annals of Science* **39**, 110-111.

## 1983

Hazen, R.M. (1983) Zeolite molecular sieve 4A: anomalous compressibility and volume discontinuities at high pressure. *Science* **219**, 1065-1067.

Hazen, R.M. and L.W.Finger (1983) High-pressure and high-temperature crystallographic study of the gillespite I-II phase transition. *American Mineralogist* **68**, 595-603.

Jeanloz, R.L. and R.M.Hazen (1983) Compression, nonstoichiometry and bulk viscosity of wustite. *Nature* **304**, 620-622.

Hazen, R.M. (1983) Acceptance of the Mineralogical Society of America Award for 1982. *American Mineralogist* **68**, 655-656.

Hazen, R.M. and M.H.Hazen (1983) Compiling *American Geological Literature, 1669 to 1850*: A systematic approach to natural history bibliography. In: N.J.Root (ed.) *Contributions to the History of North American Natural History*. London: Society for the Bibliography of Natural History, 91-97.

Hazen, R.M. (1983) Rock-forming silicates. *Reviews of Geophysics and Space Physics* **21**, 1399-1407.

Sharpe, M.R., T.N.Irvine, B.O.Mysen and R.M.Hazen (1983) Density and viscosity characteristics of melts of Bushveld chilled margin rocks. *Carnegie Institution of Washington Year Book* **82**, 300-305.

Hazen, R.M., L.W.Finger and M.Barton (1983) High-pressure crystal structures and compressibilities of bertrandite, beryl and euclase. *Carnegie Institution of Washington Year Book* **82**, 357-359.

Hazen, R.M. (1983) Compressibility and high-pressure pleochroism of  $\text{CaCr}^{2+}\text{Si}_4\text{O}_{10}$ . *Carnegie Institution of Washington Year Book* **82**, 359-361.

Hazen, R.M. and M.R.Sharpe (1983) Radiographic determination of the positions of platinum spheres in density-viscosity studies of silicate melts. *Carnegie Institution of Washington Year Book* **82**, 428-430.

Hazen, R.M. and L.W.Finger (1983) Anomalous compressibility of zeolite 4A in several pressure media. *Carnegie Institution of Washington Year Book* **82**, 361-363.

Hazen, R.M. (1983) Review of *High-pressure research in Geophysics* by S.Akimoto and M.Manghnani (eds.). *American Scientist* **71**, 582.

#### **1984**

Hazen, R.M. and L.W. Finger (1984) Comparative crystal chemistry. *American Scientist* **72**, 143-150.

Hazen, R.M. and R.L. Jeanloz (1984) Wüstite ( $\text{Fe}_{1-x}\text{O}$ ): a review of its defect structure and physical properties. *Review of Geophysics and Space Physics* **22**, 37-46.

Hazen, R.M. (1984) Mineralogy: A historical review: *Journal of Geological Education* **32**, 288-298.

Hazen, R.M. and L.W. Finger (1984) Anomalous compressibility of zeolite 4A in several hydrostatic pressure media: *Journal of Applied Physics* **56**, 1838-1840.

Hazen, R.M. and L.W. Finger (1984) Compressibilities and high-pressure phase transitions of sodium tungstate perovskites ( $\text{Na}_x\text{WO}_3$ ): *Journal of Applied Physics* **56**, 311-313.

Mendes Filho, J., V. Lemnos, F. Cerdeira, R.S. Katiyar, R.M. Hazen and L.W. Finger (1984) Raman and x-ray studies of a high-pressure phase transition in b- $\text{LiIO}_3$  and the study of anharmonic effects. *Physical Review* **B30**, 7212-7218.

Hazen, Margaret H., and R.M. Hazen (1984) *Wealth Inexhaustible: An Introduction to the History of American Mineral Industries to 1850*. Stroudsburg, PA: Van-Nostrand Reinhold, 459 p.

Ralph, R.L., L.W. Finger, R.M. Hazen and S. Ghose (1984) Compressibility and crystal structure of andalusite at high pressure. *American Mineralogist* **59**, 513-519.

Hazen, R.M. [Editor] (1984) Mineral Physics News. *EOS Transactions of the American Geophysical Union* **65**, 746.

#### **1985**

- Hazen, R.M. and L.W. Finger (1985) Crystal compression. *Scientific American* **252**, 110-117.
- Hazen, R.M. (1985) Comparative crystal chemistry and the polyhedral approach. *Reviews in Mineralogy* **14**, 317-346.
- Mariathasan, J.W.E., L. W. Finger and R.M. Hazen (1985) High-pressure behavior of LaNbO<sub>4</sub>. *Acta Crystallographica* **B41**, 179-184.
- Hazen, R.M., L.W. Finger and J.W.E. Mariathasan (1985) High-pressure crystal chemistry of scheelite-type tungstates and molybdates. *International Journal of the Physics and Chemistry of Solids* **46**, 253-263.
- Hazen, R.M. (1985) Review of *Geometrical and Structural Crystallography* by J. V. Smith. *American Journal of Science* **285**, 192.
- Hazen, R.M. (1985) Review of *Materials Science of the Earth's Interior* by I. Sunagawa (ed.). *American Scientist* **73**, 291.
- Hazen, R. M. (1985) Review of *Landprints* by Walter Sullivan. *Nature* **314**, 693.
- Au, A. Y. and R. M. Hazen (1985) Polyhedral modeling of the elastic properties of corundum (a-Al<sub>2</sub>O<sub>3</sub>) and chrysoberyl (Al<sub>2</sub>BeO<sub>4</sub>). *Geophysical Research Letters* **12**, 725-728.

#### 1986

- Hazen, R. M. and A. Y. Au (1986) High-pressure crystal chemistry of phenakite (Be<sub>2</sub>SiO<sub>4</sub>) and bertrandite (Be<sub>4</sub>Si<sub>2</sub>O<sub>7</sub>(OH)<sub>2</sub>). *Physics and Chemistry of Minerals* **13**, 69-78.
- Mariathasan, J. W. E., R. M. Hazen and L. W. Finger (1986) Crystal structure of the high-pressure form of BiVO<sub>4</sub>. *Phase Transitions* **6**, 165-174.
- Hazen, R. M., A. Y. Au, and L. W. Finger (1986) High-pressure crystal chemistry of beryl (Be<sub>3</sub>Al<sub>2</sub>Si<sub>6</sub>O<sub>18</sub>) and euclase (BeAlSiO<sub>4</sub>OH). *American Mineralogist* **71**, 977-984.
- Finger, L. W., R. M. Hazen, and A. M. Hofmeister (1986) High-pressure crystal chemistry of spinel (MgAl<sub>2</sub>O<sub>4</sub>) and magnetite (Fe<sub>3</sub>O<sub>4</sub>): Comparisons with silicate spinels. *Physics and Chemistry of Minerals* **13**, 215-220.
- Hazen, R. M. and L. W. Finger (1986) High-pressure and high-temperature crystal chemistry of beryllium oxide. *Journal of Applied Physics* **59**, 3728-3733.

#### 1987

- Finger, L. W. and R. M. Hazen (1987) The crystal structure of monoclinic ilvaite and the nature of the monoclinic--orthorhombic transition at high pressure. *Zeitschrift fur Kristallographie* **179**, 415-430.
- Hazen, R. M., L. W. Finger, D. K. Agrawal, H. A. McKinstry and A. J. Perrotta (1987) High-temperature crystal chemistry of sodium zirconium phosphate. *Materials Research Bulletin* **2**, 329-337.
- Hazen, R.M. (1987) High-pressure crystal chemistry of chrysoberyl, Al<sub>2</sub>BeO<sub>4</sub>: Insights on the origin of olivine elastic anisotropy. *Physics and Chemistry of Minerals* **14**, 13-20.
- Hazen, R.M. and L. W. Finger (1987) High-temperature crystal chemistry of phenakite (Be<sub>2</sub>SiO<sub>4</sub>) and chrysoberyl (BeAl<sub>2</sub>O<sub>4</sub>). *Physics and Chemistry of Minerals* **14**, 426-434.

- Sharp, Z. D., R. M. Hazen and L. W. Finger (1987) High-pressure crystal chemistry of monticellite,  $\text{CaMgSiO}_4$ . *American Mineralogist* **72**, 748-755.
- Hazen, R. M., H. K. Mao and L. W. Finger (1987) Single-crystal x-ray diffraction of solid  $\text{n-H}_2$  at 5.40 GPa and 300 K. *Physical Review* **B36**, 3944-3947.
- Hazen, R. M., T. C. Hoering and A. M. Hofmeister (1987) Compressibility and high-pressure phase transition of a metalloporphyrin: 5,10,15,20 Tetraphenyl 21H,23H Porphine Cobalt (II). *Journal of Physical Chemistry* **91**, 5042-5045.
- Hazen, R. M., L. W. Finger, R. J. Angel, C. T. Prewitt, N. L. Ross, H. K. Mao, C. G. Hadidiacos, P. H. Hor, R. L. Meng and C. W. Chu (1987) Crystallographic description of phases in the Y-Ba-Cu-O superconductor. *Physical Review* **B35**, 7238-7241.
- Hazen, M. H. and R. M. Hazen (1987) *The Music Men: An Illustrated History of American Brass Bands, 1880-1920*. Washington: Smithsonian Institution Press, xxiv, 225 p.
- Hazen, R. M. and M. H. Hazen (1987) Brass bands in stereo. *Stereo World*, May-June, 14-22.
- Ross, N. L., R. J. Angel, L. W. Finger, R. M. Hazen and C. T. Prewitt (1987) Oxygen-defect perovskites and the 93-K superconductor. In D. L. Nelson, M. S. Whittingham and T. F. George (editors), *Chemistry of High-Temperature Superconductors*, American Chem. Soc. Symposium Series 351, 164-172.
- Hazen, R. M. and M. H. Hazen (1987) Museum collects band ephemera. *Paper and Advertising Collector*, Issue for August, 1988.

## 1988

- Hazen, R. M. (1988) *The Breakthrough: The Race for the Superconductor*. New York: Summit Books, 271 p. Paperback edition by Ballantine/Science, New York, 1989. Foreign editions: *Superconductors: The Breakthrough*, Unwin Hyman Ltd., London, 1988; *La Course Aux Supraconducteurs*, Librairie Plon, Paris, 1989; *De Dag Dat de Wetenschap Wild Werd*, Uitgeverij Lannoo, Tiel, The Netherlands, 1989. Also Japanese, Italian, Greek, and Chinese editions.
- Hazen, R. M. (1988) A useful fiction: Polyhedral modeling of mineral properties. *American Journal of Science* **288A**, (Wones Volume), 242-269.
- Hazen, R.M. (1988) Perovskites. *Scientific American* **258**, #6 for June, 74-81.
- Veblen, D. R., P. J. Heaney, R. J. Angel, L. W. Finger, R. M. Hazen, C. T. Prewitt, N. L. Ross, C. W. Chu, P. H. Hor, and R. L. Meng (1988) Crystallography, chemistry, and structural disorder in the new high-Tc Bi-Ca-Sr-Cu-O superconductor. *Nature* **332**, 334-337.
- Hazen, R. M., C. T. Prewitt, R. J. Angel, N. L. Ross, L. W. Finger, C. G. Hadidiacos, D. R. Veblen, P. J. Heaney, P. H. Hor, R. L. Meng, Y. Y. Sun, Y. Q. Wang, Y. Y. Xue, Z. J. Huang, L. Gao, J. Bechtold, and C. W. Chu (1988) Superconductivity in the high-Tc Bi-Ca-Sr-Cu-O system: Phase identification. *Physical Review Letters* **60**, 1174-1177.
- Angel, R. J., R. M. Hazen, T. C. McCormick, C. T. Prewitt and J. R. Smyth (1988) Comparative compressibility of end-member feldspars. *Physics and Chemistry of Minerals* **15**, 313-318.
- Mao, H. K., A. P. Jephcoat, R. J. Hemley, L. W. Finger, C. S. Zha, R. M. Hazen, and D. E. Cox (1988) Synchrotron x-ray diffraction measurements of single-crystal hydrogen to 26.5 Gigapascals. *Science* **239**, 1131-1134.

Hazen, R. M., L. W. Finger, R. J. Angel, C. T. Prewitt, N. L. Ross, C. G. Hadidiacos, P. J. Heaney, D. R. Veblen, Z. Z. Sheng, A. El Ali, and A. M. Hermann (1988) 100 K superconducting phases in the TI-Ca-Ba-Cu-O system. *Physical Review Letters* **60**, 1657-1659.

Meng, R. L., P. H. Hor, Y. Y. Sun, Z. J. Huang, L. Gao, Y. Y. Xue, Y. Q. Wang, J. Bechtold, C. W. Chu, R. M. Hazen, C. T. Prewitt, R. J. Angel, N. L. Ross, L. W. Finger, C. G. Hadidiacos (1988) The 120K-superconducting phase in Bi-Ca-Sr-Cu-O. *Modern Physics Letters B2* (Singapore), 543-549.

Hazen, R.M. (1988) Understanding perovskites of benefit to science and industry--an interdisciplinary approach, *Earth in Space* **1**, #3, 8-10.

Hazen, R. M. and Z. D. Sharp (1988) Compressibility of sodalite and scapolite. *American Mineralogist* **73**, 1120-1122.

Angel, R. J., T. Gasparik, N. L. Ross, L. W. Finger, C. T. Prewitt and R. M. Hazen (1988) The structure of silica-rich sodium pyroxene; a new phase with six-coordinated silicon. *Nature* **335**, 156-158.

Hazen, R. M. (1988) High- $T_c$  Newsletters: Hot from the laboratory. *Nature* **335**, 677-678.

Sheng, Z. Z., A. M. Hermann, D. C. Vier, S. Schultz, S. B. Oseroff, D. J. George and R. M. Hazen (1988) Superconductivity in the TI-Sr-Ca-Cu-O system. *Physical Review* **B38**, 7074-7076.

Hazen, R. M., L. W. Finger, R. J. Angel, N. L. Ross, C. T. Prewitt, H. K. Mao, C. G. Hadidiacos, D. J. George, D. R. Veblen and P. J. Heaney (1988) Superconductivity in new high- $T_c$  systems: phase identification. *Annual Report of the Director, Geophysical Laboratory, Carnegie Institution*, 99-105.

## 1989

Finger, L. W., J. Ko, R. M. Hazen, T. Gasparik, R. J. Hemley, C. T. Prewitt, and D. J. Weidner (1989) Crystal chemistry of phase B and an anhydrous analogue: implications for water storage in the upper mantle, *Nature* **341**, 140-142.

Hazen, R. M., L. W. Finger, H. K. Mao and R. J. Hemley (1989) High-pressure crystal chemistry and amorphization of alpha-quartz, *Solid State Communications* **72**, 507-511.

Hazen, R. M., L. W. Finger and D. E. Morris (1989) Crystal structure of DyBa<sub>2</sub>Cu<sub>4</sub>O<sub>8</sub>: A new 77 K bulk superconductor. *Applied Physics Letters* **54**, 1057-1059.

Hazen, R. M. and L. W. Finger (1989) High-pressure crystal chemistry of andradite and pyrope: revised procedures for high-pressure diffraction experiments. *American Mineralogist* **74**, 352-359.

Angel, R. J., L. W. Finger, R. M. Hazen, M. Kanzaki, D. J. Weidner, R. C. Liebermann, and D. R. Veblen (1989) Structure and twinning of single-crystal MgSiO<sub>3</sub> garnet synthesized at 17 GPa and 1800°C. *American Mineralogist* **74**, 509-512.

Finger, L. W., R. M. Hazen, and R. J. Hemley (1989) BaCuSi<sub>2</sub>O<sub>6</sub>: A new cyclosilicate with four-membered rings, *American Mineralogist* **74**, 952-955.

McCormick, C. T., R. M. Hazen, and N. L. Ross (1989) Compressibility of omphacite to 60 kbar: Role of vacancies, *American Mineralogist* **74**, 1287-1292.

Ross, N. L. and R. M. Hazen (1989) Single-crystal diffraction study of MgSiO<sub>3</sub> perovskite from 77 to 400 K. *Physics and Chemistry Minerals* **16**, 415-420.

Morris, D. E., J. H. Nickel, J. Y. T. Wei, N. G. Asmar, J. S. Scott, U. M. Scheven, C. T. Hultgren, A. G. Markelz, R.

M. Hazen, J. E. Post, P. J. Heaney and D. R. Veblen (1989) Eight new high temperature superconductors. *Physical Review* **B39**, 7347-7350.

Hazen, R. M. (1989) A farewell to obsolete pyroxenes. *The Lattice* **5**, 6-7.

Hazen, R.M. (1989) The billion dollar formula. *The Weekend Guardian* **April 15-16, 1989**, 1-4.

## 1990

Hazen, R. M. (1990) Crystal structures of high-temperature superconductors. In *Physical Properties of High-Temperature Superconductors II*, D. M. Ginsberg, ed., Chapter 3, pp. 121-198, World Scientific, New Jersey.

Ross, N. L., and R. M. Hazen (1990) High-pressure crystal chemistry of  $\text{MgSiO}_3$  perovskite. *Physics and Chemistry of Minerals* **17**, 228-237.

Hazen, R. M., J. Zhang, and J. Ko (1990) Effects of Fe/Mg on the compressibility of synthetic wadsleyite:  $\beta\text{-}(\text{Mg}_{1-x}\text{Fe}_x)_2\text{SiO}_4(x \neq 0.25)$ . *Physics and Chemistry of Minerals* **17**, 416-419.

Hemley, R. J., H. K. Mao, L. W. Finger, A. P. Jephcoat, R. M. Hazen, and C. S. Zha (1990) Equation of state of solid hydrogen and deuterium from single-crystal X-ray diffraction to 26.5 Gpa. *Physical Review* **B42**, 6458-6470.

Ross, N. L., J. F. Shu, R. M. Hazen, and T. Gasparik (1990) High-pressure crystal chemistry of stishovite. *American Mineralogist* **75**, 739-747.

Angel, R. J., N. L. Ross, L. W. Finger, and R. M. Hazen (1990)  $\text{Ba}_3\text{CaCuSi}_6\text{O}_{17}$ : A new  $\{\text{B}, 1_4^1\} \{\text{Si}_6\text{O}_{17}\}$  chain silicate. *Acta Crystallographica* **C46**, 2028-2030.

## 1991

Hazen, R. M., and J. S. Trefil (1991) *Science Matters: Achieving Scientific Literacy*. NY: Doubleday. Paperback edition, NY: Anchor (1992). Numerous foreign editions, including French, Italian, Spanish, Portuguese, Greek, Korean, Chinese, and Japanese.

Ross, N.L. and R.M.Hazen (1991) High-pressure crystal chemistry of  $\text{MgSiO}_3$  perovskite. *Physics and Chemistry of Minerals* **17**, 228-237.

Finger, L. W., R. M. Hazen, and C. T. Prewitt (1991) Crystal structures of  $\text{Mg}_{12}\text{Si}_4\text{O}_{19}(\text{OH})_2$  (Phase B) and  $\text{Mg}_{14}\text{Si}_5\text{O}_{24}$  (Phase AnhB). *American Mineralogist* **76**, 1-7.

Finger, L.W. and R.M.Hazen (1991) Crystal chemistry of six-coordinated silicon: A key to understanding the earth's deep interior. *Acta Crystallographica* **B47**, 561-580.

Sheng, Z.Z., D.X.Gu, Y.Xin, D.O.Pederson, L.W.Finger, C.G.Hadidiacos, and R.M.Hazen (1991) A new 1212-type phase: Cr-substituted  $\text{TlSr}_2\text{CaCu}_2\text{O}_7$  with  $T_c$  up to about 110 K. *Modern Physics Letters* **B5**, 635-642.

Jeanloz, R., and R.M.Hazen (1991) Finite strain analysis of relative compressibilities: Application to the high-pressure wadsleyite phase as an illustration. *American Mineralogist* **76**, 1765-1768.

Hazen, R.M., and J.S.Trefil (1991) Achieving geological literacy, *Journal of Geological Education* **39**, 28-30.

Hazen, R.M. and J.S.Trefil (1991) Astronomical Literacy. *Sky and Telescope* **84**, 348.



- James, C.C. and R.M.Hazen (1991) *Curiosity is the Frontier*. Washington: National Science Foundation. (Projects for National Science and Technology Week, April 21-27, 1991.)
- Hazen, R.M. and J.S.Trefil (1991) Educators must accept the difference between 'doing' and 'using' science. *The Scientist* **5**, #6, 11-13.
- Hazen, R.M. (1991) Why my kids hate science. *Newsweek*, Feb. 25, 1991, 7.
- Hazen, R.M. and J.S.Trefil (1991) Quick, what's a quark? *The New York Times Magazine*, Jan. 13, 1991, 24-26.
- Hazen, R.M. and J.S.Trefil (1991) Achieving scientific literacy. *Chronicle of Higher Education*, April 10, 1991, A44.
- Hazen, R.M. and J.S.Trefil (1991) Achieving chemical literacy. *Journal of Chemical Education* **68**, 392-394.
- Hazen, R.M. and J.S.Trefil (1991) General science: the key to scientific literacy. *Education Digest* **57**, 64-66.
- Hazen, R.M. and L.W.Finger (1991) Predicted high-pressure mineral structures with octahedral silicon. *Carnegie Institution of Washington Year Book 1990-91*, 101-107.
- Zhang, J.M., R.M.Hazen and J.Ko (1991) High-pressure crystal chemistry of iron-free wadsleyite, beta-Mg<sub>2</sub>SiO<sub>4</sub>. *Carnegie Institution of Washington Year Book 1990-91*, 115-120.
- Hazen, R.M. and J.S.Trefil (1991) Scientific literacy. *Carnegie Magazine* **60**, 14-17.
- Hazen, R.M. (1991) Albert Koch. *Smithsonian Magazine* **22**, #7, 28-31.

## 1992

- Hazen, M.H. and R.M.Hazen (1992) *Keepers of the Flame: The Role of Fire in American Culture, 1775-1925*. Princeton, NJ: Princeton University Press, 281 p.
- Hazen, R.M., L.W.Finger, and J.Ko (1992) Crystal chemistry of Fe-bearing anhydrous phase B: Implications for transition zone mineralogy. *American Mineralogist* **77**, 217-220.
- McCammon, C., J.M.Zhang, R.M.Hazen, and L.W.Finger (1992) High-pressure crystal chemistry of cubanite, CuFe<sub>2</sub>S<sub>3</sub>. *American Mineralogist* **77**, 937-944.
- Hazen, R.M. (1992) Scientific literacy: The enemy is us. In *Agriculture and the Undergraduate*. (Washington: National Research Council), 95-103.
- Hazen, R.M. (1992) The discovery. In W.H.Shore (ed.) *Mysteries of Life and the Universe*. New York: Harcourt-Brace-Jovanovich, 304-311.

## 1993

- Hazen, R.M. (1993) *The New Alchemists: Breaking through the barriers of high-pressure research*. New York, Doubleday, 286 p.
- Hazen, R.M. (1993) Comparative compressibility of silicate spinels: anomalous behavior of (Mg,Fe)<sub>2</sub>SiO<sub>4</sub>. *Science* **259**, 206-209 and cover.
- Jeanloz, R., and R.M.Hazen (1993) Composition limits of FeO and the Earth's lower mantle. *Science* **261**, 923-924.

- Kudoh, Y., L.W.Finger, R.M.Hazen, C.T.Prewitt, M.Kanzaki, and D.R.Veblen (1993) Phase E: A high-pressure hydrous silicate with unique crystal chemistry. *Physics and Chemistry of Minerals* **19**, 357-360.
- Zhang, J.M., J.Ko, R.M.Hazen, and C.T.Prewitt (1993) High-pressure crystal chemistry of  $\text{KAlSi}_3\text{O}_8$  hollandite. *American Mineralogist* **78**, 493-499.
- Schultz, A.J., U.Geiser, H.H.Wang, A.M.Kini, J.M.Williams, L.W.Finger, and R.M.Hazen (1993) Single-crystal x-ray diffraction evidence for a high-pressure structural phase transition in the organic superconductor  $\text{k}-(\text{ET})_2\text{Cu}[\text{N}(\text{CN})_2]\text{Cl}$ . *Physica* **C208**, 277-285.
- Finger, L.W., R.M.Hazen, J.M.Zhang, J.Ko, and A. Navrotsky (1993) The effect of Fe on the crystal structure of wadsleyite  $\beta\text{-(Mg}_{1-x}\text{Fe}_x)_2\text{SiO}_4$ ,  $0.00 < x < 0.40$ . *Physics and Chemistry of Minerals* **19**, 361-368.
- Trefil, J.S., and R.M.Hazen (1993) *The Sciences: An Integrated Approach, Preliminary edition*. New York: Wiley, 546 p.
- Hazen, R.M., L.W.Finger, and J.Ko (1993) Effects of pressure on Mg-Fe ordering in an orthopyroxene synthesized at 11.3 GPa and 1600°C. *American Mineralogist* **78**, 1337-1340.
- Hazen, R.M., R.T.Downs, L.W.Finger, and J.Ko (1993) Crystal chemistry of ferromagnesian silicate spinels: Evidence for Mg-Si disorder. *American Mineralogist* **78**, 1320-1323.

#### 1994

- Hazen, R. M. (1994) Matter; high-pressure phenomena. *Encyclopedia Britannica*, 1994 edition, Vol.23, pp.683-688. Also in subsequent editions.
- Hazen, R.M. (1994) The new alchemy. *Technology Review* **97** (no.8), 24-32.
- Hazen, R.M., D.C.Palmer, L.W.Finger, G.D.Stuckey, W.T.A.Harrison, and T.E.Gier (1994) High-pressure crystal chemistry and phase transition of  $\text{RbTi}_2(\text{PO}_4)_3$ . *Journal of Physics of Condensed Matter* **6**, 1333-1334.
- Finger, L.W., R.M.Hazen, R.L.Meng, and C.W.Chu (1994) Crystal chemistry of  $\text{HgBa}_2\text{CaCu}_2\text{O}_{6+d}$  and  $\text{HgBa}_2\text{Ca}_2\text{Cu}_3\text{O}_{8+d}$ : single crystal x-ray results. *Physica* **C226**, 216-221.
- Hazen, R.M., R.T.Downs, L.W.Finger, P.G.Conrad, and T.Gasparik (1994) Crystal chemistry of Ca-bearing majorite. *American Mineralogist* **79**, 581-584.
- Hazen, R.M., R.T.Downs, P.G.Conrad, L.W.Finger, and T.Gasparik (1994) Comparative compressibilities of majorite-type garnets. *Physics and Chemistry of Minerals* **21**, 344-349.
- Filatov, S.K., and R.M.Hazen (1994) High-temperature and high-pressure crystal chemistry. In *Advanced Mineralogy*, A.S. Marfunin, editor. Vol.1, Ch.2.1.8, pp.76-89. New York: Springer-Verlag.
- Downs, R.T., R.M.Hazen, and L.W.Finger (1994) The high-pressure crystal chemistry of low albite and the origin of the pressure dependency of Al/Si ordering. *American Mineralogist* **79**, 1042-1052.
- Schultz, A.J., H.H.Wang, J.M.Williams, L.W.Finger, R.M.Hazen, C.Rovira, and M.H.Whangbo (1994) X-ray diffraction and electronic band structure study of organic superconductor  $\text{k}-(\text{ET})_2\text{Cu}[\text{N}(\text{CN})_2]\text{Cl}$  at pressures up to 28 kbar. *Physica* **C234**, 300-306.

#### 1995

Finger, L.W., R.M.Hazen, and B.A.Fursenko (1995) Refinement of the crystal structure of BaSi<sub>4</sub>O<sub>9</sub> in the benitoite form. *Journal of the Physical Chemistry of Solids* **56**, 1389-1393.

Downs, R.T., R.M.Hazen, L.W.Finger, and T.Gasparik (1995) Crystal chemistry of lead aluminosilicate hollandite: a new high-pressure synthetic phase with octahedral Si. *American Mineralogist* **80**, 937-940.

Trefil, J.S., and R.M.Hazen (1995) *The Sciences: An Integrated Approach, 1st edition*. New York: Wiley, 634 p.

Hazen, R. M. (1995) Parisian cornet solos of the 1830s and 1840s: The earliest solo literature for valved brass and piano. *International Trumpet Guild Journal* May 1995, 34-38.

## 1996

Hazen, R.M., R.T.Downs, and L.W.Finger (1996) High-pressure crystal chemistry of LiScSiO<sub>4</sub>, an olivine with nearly isotropic compression. *American Mineralogist* **81**, 937-940.

Hazen, R.M., and J.S.Trefil (1996) *The Physical Sciences: An Integrated Approach*. New York: Wiley, 672 pp.

Hazen, R.M., R.T.Downs, and L.W.Finger (1996) High-pressure framework silicates. *Science* **272**, 1769-1771.

Hazen, R.M., and A. Navrotsky (1996) Effects of pressure on order-disorder reactions. *American Mineralogist* **81**, 1021-1035.

## 1997

Hazen, R.M., and M. Singer (1997) *Why Aren't Black Holes Black: The Unanswered Questions at the Frontiers of Science*. NY: Doubleday. Also German Edition: *Warum schwarze Locher nicht schwarz sind* (Vienna and Munich: Franz Deuticke Verlagsgesellschaft m.b.H., 1998). Also Swedish edition: *Varfor ar svarta hal inte svarta?* (Falun: Richters, 1997). Also Portugese edition: *Por Que Nao Sao Negros os Buracos Negros?* (Lisbon: Dinalivro, 1998). Also Polish and Korean editions.

Trefil, J.S., and R.M.Hazen (1997) *The Sciences: An Integrated Approach. Second edition* (extensively revised). NY: Wiley, 614 p.

Yang, H., R.M.Hazen, R.T.Downs, and L.W.Finger (1997) Structural change associated with the incommensurate-normal phase transition in akermanite, Ca<sub>2</sub>MgSi<sub>2</sub>O<sub>7</sub>, at high pressure. *Physics and Chemistry of Minerals* **24**, 510-519.

Hazen, R.M., H.Yang, C.T.Prewitt, and T.Gasparik (1997) Crystal chemistry of superfluorous phase B (Mg<sub>10</sub>Si<sub>3</sub>O<sub>14</sub>F<sub>4</sub>): Implications for fluorine in the mantle. *American Mineralogist* **82**, 647-650.

Hazen, R.M. (1997) What we don't know: the unanswered questions of science. *Technology Review* **100** (no.5), 22-30 and cover. Also French translation: Finie, la science? Tu parles, Charles! *Le Temps Strategique* **Nov-Dec 98**, 80-95 (1998).

Hazen, R.M. (1997) The great unknown. *Technology Review* **100** (no. 8), 38-45.

Yang, H., R.T.Downs, L.W.Finger, R.M.Hazen, and C.T.Prewitt (1997) Compressibility and crystal structure of kyanite, Al<sub>2</sub>SiO<sub>5</sub>, at high pressure. *American Mineralogist* **82**, 467-474.

Yang, H., R.M.Hazen, L.W.Finger, C.T.Prewitt, and R.T.Downs (1997) Compressibility and crystal structure of sillimanite, Al<sub>2</sub>SiO<sub>5</sub>, at high pressure. *Physics and Chemistry of Minerals* **25**, 39-47.

Hazen, M.H., and R.M.Hazen (1998-1999) Biographies of 45 earth scientists for *Encyclopedia Americana* (Mary Anning, Norman Bowen, Edward Bullard, Parker Cleveland, William Conybeare, Reginald Daly, Clarence Dutton, Amos Eaton, Ebenezer Emmons, Victor Goldschmidt, Stephen Jay Gould, Jean Etienne Guettard, Beno Guttenberg, Bruce Heezen, Harry Hess, Douglass Houghton, Richard Kirwan, Johann Lehmann, Waldemar Lindgren, William Maclure, Gideon Mantell, Nevil Maskelyne, Friedrich Mohs, John S. Newberry, Denison Olmsted, David Dale Owen, Frank Press, Raphael Pumpelly, Henry D. Rogers, William B. Rogers, Harry Rosenbusch, S. Keith Runcorn, Johann Scheuchzer, James Sowerby, Eduard Suess, Frank B. Taylor, Gerard Troost, Charles Van Hise, Lardner Vanuxem, Frederick Vine, George Wheeler, John T. Wilson, John Woodward, Fredinand Zirkel). Various volumes.

Hazen, R.M. (1997) Books to grow on: Literature of science. In S.Dodson, *The Mother-Daughter Book Club*, New York: HarperPerennial, p.204.

Hazen, R.M., and H.Yang (1997) Increased compressibility of pseudobrookite-type  $MgTi_2O_5$  caused by cation disorder. *Science* **277**, 1965-1967.

### 1998

Working Group on Teaching Evolution [13 authors including R.M.Hazen] (1998) *Teaching About Evolution and the Nature of Science*. Washington: National Academy of Sciences Press, 140 p.

Brandes, J.A., N.Z.Boctor, G.D.Cody, B.A.Cooper, R.M.Hazen, and H.S.Yoder, Jr. (1998) Abiotic nitrogen reduction in the early earth. *Nature* **395**, 365-367.

Yang, H., R.M.Hazen, C.T.Prewitt, L.W.Finger, R.Lu, and R.J.Hemley (1998) High-pressure single-crystal x-ray diffraction and infrared spectroscopic studies of the  $C2/m-P2_1/m$  phase transition in cummingtonite. *American Mineralogist* **83**, 288-299.

Hazen, R.M. (1998) The stuff of life: What was life's first energy source? *The Planetary Report* **18**, 16-17.

Hazen, R.M. (1998) Plate Tectonics. *Encyclopedia Americana* **22**, 223-226.

Yang, H., and R.M.Hazen (1998) Crystal chemistry of cation order-disorder in pseudobrookite-type  $MgTi_2O_5$ . *Journal of Solid State Chemistry* **138**, 238-244.

### 1999

Hazen, R.M. (1999) *The Diamond Makers*. Cambridge: Cambridge University Press, 236 p.

Yang, H., and R.M.Hazen (1999) Comparative high-pressure crystal chemistry of karrooite,  $MgTi_2O_5$ , with different ordering states. *American Mineralogist* **84**, 130-137.

Yang, H., L.W.Finger, P.G.Conrad, C.T.Prewitt, and R.M.Hazen (1999) A new pyroxene structure at high pressure: Single-crystal X-ray and Raman study of the  $Pbcn-P2_1$  phase transition in protopyroxene. *American Mineralogist* **84**, 245-256.

Downs, R.T., H. Yang, R.M. Hazen, L.W.Finger, and C.T.Prewitt (1999) Compressibility mechanisms of alkali feldspars: New data from reedmergnerite. *American Mineralogist* **84**, 333-340.

Ghiorso, M.S., H.Yang, and R.M.Hazen (1999) Thermodynamics of cation ordering in karrooite ( $MgTi_2O_5$ ). *American Mineralogist* **84**, 1370-1374.

Hazen, R.M., H.Yang, L.W.Finger, and B.A.Fursenko (1999) Crystal chemistry of high-pressure  $BaSi_4O_9$  in the trigonal (P3) barium tetragermanate structure. *American Mineralogist* **84**, 987-989.

Hazen, R.M. and H.Yang (1999) Effects of cation substitution and order-disorder on P-V-T equations of state of cubic spinels. *American Mineralogist* **84**, 1956-1960.

Hazen, R.M. (1999) Citation for History of Geology Award presented to Hatten S.Yoder, Jr. *GSA Today*, 26.

Hazen, R.M. and J. Parise (1999) Dedication to Charles T. Prewitt. *American Mineralogist* **84**, 213.

Hazen, R.M. (1999) A new perspective on the origin of life. In Sandra Hackman, Editor: *The NOVA Reader: Science at the Turn of the Millennium*. NY: TV Books, pp.48-54.

Hazen, R.M. (1999) *The Great Principles of Science*. (A 60-lecture videotape and audiotape course, with accompanying booklets). Springfield, VA: The Teaching Company.

Trefil, J.S. and R.M.Hazen (1999) *The Sciences: An Integrated Approach. Updated Second Edition*. NY: Wiley, 614 p.

Hazen, R. M. (1999) Book review of *Cradle of Life: The Discovery of Earth's Earliest Fossils* by J. William Schopf. *Physics Today* **52** (#10), 75-76.

## 2000

Hazen, R.M., M.B.Weinberger, H.Yang, and C.T.Prewitt (2000) Comparative high-pressure crystal chemistry of wadsleyite,  $\exists$ -(Mg<sub>1-x</sub>Fe<sub>x</sub>)<sub>2</sub>SiO<sub>4</sub>, with x = 0 and 0.25. *American Mineralogist* **85**, 770-777.

Hazen, R.M., H.Yang, and C.T.Prewitt (2000) High-pressure crystal chemistry of Fe<sup>3+</sup>-wadsleyite,  $\exists$ -Fe<sub>2.33</sub>Si<sub>0.67</sub>O<sub>4</sub>. *American Mineralogist* **85**, 778-783.

Hazen, R.M. (2000) Isostructural versus equilibrium equations of state. *High-Pressure Science and Technology* **17**, 591-594.

Hazen, R.M. and R.T.Downs [Editors] (2000) *Comparative Crystal Chemistry*. Washington: Mineralogical Society of America, *Reviews in Mineralogy and Geochemistry* Volume 41, viii, 596 p.

Smyth, J.R., Jacobsen, S.D and Hazen, R.M. (2000) Comparative crystal chemistry of dense oxide minerals. *Reviews in Mineralogy and Geochemistry* **41**, 157-186.

Smyth, J.R., Jacobsen, S.D and Hazen, R.M. (2000) Comparative crystal chemistry of orthosilicates. *Reviews in Mineralogy and Geochemistry* **41**, 187-210.

Hazen, R.M. and Finger, L.W. (2000) Systematics of high-pressure silicate structures. *Reviews in Mineralogy and Geochemistry* **41**, 123-156.

Hazen, R.M. and Prewitt, C.T. (2000) Principles of comparative crystal chemistry. *Reviews in Mineralogy and Geochemistry* **41**, 1-34.

Hazen, R.M. and Trefil, J.S. (2000) *The Sciences: An Integrated Approach*. 3<sup>rd</sup> edition. NY, Wiley. 576 p. + CD ROM.

Hazen, M.H. and Hazen, R.M. (2000) Short biographies of N.L.Bowen, E.C.Bullard, W.D.Conybeare, C.E.Dutton, S.J.Gould, Beno Gutenberg, B.C.Heezen, Richard Kirwan, J.G.Lehmann, S.K.Runcorn, Eduard Suess, Lardner Vanuxem, F.J.Vine, G.M.Wheeler, John Woodward and Ferdinand Zirkel. *Encyclopedia Americana*, various volumes.

Cody, G.D., N.Z.Doctor, T.R.Filley, R.M.Hazen, J.H.Scott, H.S.Yoder, Jr. (2000) Primordial carbonylated iron-sulfur compounds and the synthesis of pyruvate. *Science* **289**, 1337-1340.

Brandes, J.A., R.M.Hazen, H.S.Yoder, Jr., and G.D.Cody (2000) Early pre- and post-biotic synthesis of alanine: an alternative to the Strecker synthesis. In: *Perspectives in Amino Acid and Protein Geochemistry*. (G. A. Goodfriend, M. J. Collins, M. L. Fogel, S. A. Macko, and J. F. Wehmler, eds.). Oxford University Press, NY. pp. 41-59.

## 2001

Hazen, R.M. (2001) Hazen, R.M. (2001) Emergence and the origin of life. In: G.Pályi (Editor) *Fundamentals of Life*. New York: Elsevier, pp.41-50.

Cody, G.D., R.M.Hazen, J.A.Brandes, H.J.Morowitz, H.S.Yoder, Jr. (2001) Geochemical roots of autotrophic carbon fixation: Hydrothermal experiments in the system citric acid, H<sub>2</sub>O-(±FeS)-(±NiS). *Geochim. Cosmochim. Acta*, **65**, 3557-3576.

Hazen, R.M. (2001) Life's rocky start. *Scientific American*, **284**, #4, 76-85. Also included in *Best Science Writing of 2001*, Natalie Angier (Editor).

Hazen, R.M., T.R.Filley and G.A.Goodfriend (2001) Selective adsorption of L- and D-amino acids on calcite: implications for biochemical homochirality. *Proceedings of the National Academy of Sciences (US)*, **98**: 5487-5490.

Boyce, C.K., R.M.Hazen and A.H.Knoll (2001) Nondestructive, *in situ*, cellular-scale mapping of elemental abundances including organic carbon in permineralized fossils. *Proceedings of the National Academy of Sciences (US)*, **98**: 5970-5974.

Hazen, R.M. and E.Roedder (2001) How old are bacteria from the Permian age? *Nature*, **411**: 155.

## 2002

Sharma, A., J. H. Scott, G.D.Cody, M.L.Fogel, R.M.Hazen, R.Hemley and W.T.Huntress (2002) Microbial activity at gigapascal pressures. *Science* **295**, 1514-1516.

Hazen, R.M. (2002) Why should you be scientifically literate? [peer-reviewed web publication] <http://www.actionbioscience.org/newfrontiers/hazen.html>

Hazen, R. M. (2002) Curtains for freelancers. *The Washington Post* Sunday, October 20, p.B8.

Hazen, R.M., N. Boctor, J. A. Brandes, G. D. Cody, R. J. Hemley, A. Sharma and H. S. Yoder, Jr. (2002) High pressure and the origin of life. *J. Phys. Condensed Matter* **14**, 11489-11494.

## 2003

Hazen, R.M. and D. S. Sholl. Chiral selection on inorganic crystalline surfaces. *Nature Materials* **2**, 367-374.

Noffke, N., N. Nhleko and R. M. Hazen (2003) Earth's earliest microbial mats in a siliciclastic marine environment (2.9 Ga Mozaan Group, South Africa). *Geology* **31**, 673-677.

Hazen, R. M. (2003) Factors that influence the emergence of complexity in prebiotic geochemical systems. *Astrobiology* **2**, 599.

Hazen, R. M. and D. S. Sholl (2003b) Origins of biomolecular homochirality: selective molecular adsorption on crystalline surfaces. *Astrobiology* **2**, 598-599.

Hazen, R.M., A. Steele, G. D. Cody, M. L. Fogel and W. T. Huntress, Jr. (2003) Biosignatures and abiosignatures. *Astrobiology* **2**, 512-513.

Boyce, C.K., G.D.Cody, M.L.Fogel, R.M.Hazen, C. M. O'D. Alexander and A. H. Knoll (2003) Chemical evidence for cell wall lignifications and the evolution of tracheids in early Devonian plants. *International Journal of Plant Science* **164**, 691-702.

Hazen, R.M. (2003) Éloge: Hatten Schuyler Yoder, Jr. March 20, 1921-August 2, 2003. *Earth Sciences History* **22**, 142-145.

Hazen, M.H. and R.M.Hazen (2003) "In God We Trust:" Motto come lately. *The Washington Post*, September 1, 2003, p.A24.

Trefil, J.S. and R.M.Hazen (2003) *The Sciences: An Integrated Approach*, 4<sup>th</sup> edition. New York: John Wiley & Sons, xxiii, 640 p.

## 2004

Hazen, R.M. (2004) Chiral crystal faces of common rock-forming minerals. In G. Palyi, C. Zucchi and L Caglioti, Eds. *Progress in Biological Chirality*. New York: Elsevier, Chapter 11, pp.137-151.

Churchill, H., H. Teng and R.M.Hazen (2004) Measurements of pH-dependent surface charge with atomic force microscopy: Implications for amino acid adsorption and the origin of life. *American Mineralogist* **89**, 1048-1055.

Cody, G.D., N.Z.Doctor, J.A.Brandes, T.R.Filley, R.M.Hazen and H.S.Yoder, Jr. (2004) Assaying the catalytic potential of transition metal sulfides for prebiotic carbon fixation. *Geochimica et Cosmochimica Acta* **68**, 2185-2196.

Downs, R.T. and R.M.Hazen (2004) Chiral indices of crystalline surfaces as a measure of enantioselective potential. *Journal of Molecular Catalysis* **216**, 273-285.

Trefil, J.S. and R.M.Hazen (2004) *Physics Matters: An Introduction to Conceptual Physics*. New York: John Wiley & Sons, xxviii, 691 p.

Hazen, R. M. (2004) Mineralogy I: Bones to Mars. *Geotimes* **49**, #7, 24-26.

## 2005

Hazen, R. M. (2005) *Genesis: The Scientific Quest for Life's Origin*. Washington, DC: Joseph Henry Press, 339 p. (Softcover edition, 2007). Also Korean edition.

Hazen, R. M. (2005) The plate tectonics revolution. *The Great Courses Magazine* **1** (#6), 36-41.

Hazen, R. M. (2005) *The Origins of Life*. A 24-lecture video/audio course with companion script volumes. Chantilly, VA: The Teaching Company.

Hazen, R. M. (2005) The discovery of DNA. *The Great Courses Magazine* **1** (#12), 6-13.

Hazen, R. M. (2005) Genesis: Rocks, minerals and the geochemical origin of life. *Elements* **1**, #3 (June, 2005), 135-137.

Hazen, R. M. (2005) Science under attack. *Elements* **1**, #5, 255.

Morowitz, H., R. M. Hazen and J. S. Trefil (2005) Intelligent design has no place in the science curriculum. *The Chronicle of Higher Education* **52**, #2 (September 2, 2005), B6-B8.

## 2006

- Hazen, R. M. (2006) Mineral surfaces and the prebiotic selection and organization of biomolecules (Presidential Address to the Mineralogical Society of America). *American Mineralogist* **91**, 1715-1729.
- Hazen, R. M. (2006) Creation myths: What scientists don't – and can't – know about the world. *In Character* **2**, #2, 56-67.
- Hazen, R. M. (2006) Testing the limits on the small scale. *Geotimes* **June 2006**, 22-25.
- Noffke, N., N. Beukes, J. Gutzmer and R. M. Hazen (2006) Spatial and temporal distribution of microbially induced sedimentary structures: a case study from siliciclastic storm deposits of the 2.9 Ga Witwatersrand Supergroup, South Africa, *Precambrian Research* **146**, 35-44.
- Noffke, N., K. A. Eriksson, R. M. Hazen and E. L. Simpson (2006) A new window into Early Archean life: microbial mats in Earth's oldest siliciclastic tidal deposits (3.2 Ga Moodies Group, South Africa). *Geology* **34**, 253-256.
- Trefil, J. S. and R. M. Hazen (2006) *Física Viva: uma Introdução à Física Conceitual [Physics Matters: An Introduction to Conceptual Physics]* (in Portuguese), Livros Técnicos e Científicos Editora, Rio de Janeiro.
- Hazen, R. (2006) What is life? *New Scientist* **192** (no. 2578), 46-51, 2006.
- Hazen, R. (2006) Foreword. In P. C. Gekker, *Fifteen Etudes for Piccolo Trumpet*, NY: Collins Music, p.2.

## 2007

- Trefil, J. S. and R. M. Hazen (2007) *The Sciences: An Integrated Approach*, 5<sup>th</sup> edition. Hoboken, NJ: John Wiley & Sons, xxviii+531+40+12 p.
- Asthaigiri, A. and R. M. Hazen (2007) An *ab initio* study of adsorption of alanine on the chiral calcite (2131) surface. *Molecular Simulation* **33**, 343-351.
- Hazen, R. M., P. Griffin, J. M. Carothers and J. W. Szostak (2007) Functional information and the emergence of biocomplexity. *Proceedings of the National Academy of Sciences USA* **104**, 8574-8581.
- Hazen, R. M. (2007) The emergence of chemical complexity: An Introduction. In L. Zaikowski and J. M. Friedrich [editors], *Chemical Evolution I: Chemical Change across Space and Time*. American Chemical Society Symposium 981, pp.2-14.
- Ertem, G, R. M. Hazen and J. P. Dworkin (2007) Sequence analysis of trimer isomers formed by montmorillonite catalysis in the reaction of binary monomer mixtures. *Astrobiology* **7**, 715-724.
- Bada, J., B. Fegley Jr., S. L. Miller, A. Lazcano, H. J. Cleaves, R. M. Hazen and J. Chalmers (2007) Debating evidence for the origin of life on Earth. *Science* **315**, 937-938.
- Boyce, C. K., C. L. Hotton, M. L. Fogel, G. D. Cody, R. M. Hazen and A. H. Knoll (2007) Devonian landscape heterogeneity recorded by a giant fungus. *Geology* **35**, 399-402.
- Hazen, R. M. and D. Deamer (2007) Hydrothermal reactions of pyruvic acid: synthesis, selection, and self-assembly of amphiphilic molecules, *Origins of Life and Evolution of the Biosphere* **37**, 143-152.
- Hazen, R. M. (2007) Emergence and the origin of life: Presentation, questions and responses. In C. Bertka, N. Roth and M. Shindell (Editors), *Workshop Report: Philosophical, Ethical, and Theological Implications of Astrobiology*. Washington, DC: American Association for the Advancement of Science. pp. 30-40.



## 2008

- Hazen, R. M., D.Papineau, W. Bleeker, R.T.Downs, J.Ferry, T.McCoy, D. Sverjensky and H. Yang (2008) Mineral evolution. *American Mineralogist* 93, 1693-1720.
- Ertem, G., R. M. Hazen, A. M. Snellinger, J. P. Dworkin and M. V. Johnston (2008) Sequence- and region-selective formation of RNA-like oligomers by montmorillonite catalysis. *International Journal of Astrobiology* 7, 1-7.
- Sverjensky, D.M., C.M. Jonsson, C.L. Jonsson, H.J. Cleaves and R.M. Hazen (2008) Glutamate surface speciation on amorphous titanium dioxide and hydrous ferric oxide. *Environmental Science & Technology* 42, 6034-6039.
- Castro-Puyana, M., A. Salgado, R. M. Hazen, A. L. Crego and M. L. Marina (2008) Investigation of the enantioselective adsorption of 3-carboxy adipic acid on minerals by capillary electrophoresis. *Electrophoresis* 29, 1548-1555.
- Brandes, J.A., R.M.Hazen and H.S.Yoder Jr. (2008) Inorganic nitrogen reduction and stability under hydrothermal conditions. *Astrobiology* 8, 1113-1126.
- Noffke, N., N. Beukes, D. Bower, R.M.Hazen, D.J.P. Swift (2008) An actualistic perspective into Archean worlds - (cyano-)bacterially induced sedimentary structures in the siliciclastic Nhlazatse Section, 2.9 Ga Pongola Supergroup, South Africa. *Geobiology* 6 (1), 5-20

## 2009

- Hazen, R.M. and J.S. Trefil (2009) *Science Matters, 2<sup>nd</sup> Edition*. New York: Doubleday, 360 p.
- Trefil, J.S. and R.M. Hazen (2009) *The Sciences: An Integrated Approach*, 6<sup>th</sup> edition. Hoboken, NJ: John Wiley & Sons, 555 p.
- Hazen, R.M. and J.S. Trefil (2009) *Great Ideas of Science: A Reader*. San Diego, CA: Cognella, 256 p.
- Hazen, R.M. (2009) The emergence of patterning in life's origin and evolution. *International Journal of Developmental Biology*, 53, 683-692.
- Hazen, R.M. (2009) Emergence and the experimental pursuit of the origin of life. In C. M. Bertka, editor, *Exploring the Origins, Extent, and Future of Life: Philosophical, Ethical, and Theological Perspectives*. New York: Cambridge University Press, pp. 21-46.
- Hazen, R.M., Ewing, R.J and Sverjensky, D.A. (2009) Evolution of uranium and thorium minerals. *American Mineralogist* 94. 1293-1311.
- Jonsson, C.M, C.L. Jonsson, D.A. Sverjensky, H.J. Cleaves II, R.M. Hazen (2009) Attachment of L-glutamate to rutile ( $\alpha$ -TiO<sub>2</sub>): A potentiometric, adsorption and surface complexation study. *Langmuir* 25, 12127-12135.
- Hazen, R.M. (2009) Chemical evolution: An introduction. In L. Zaikowski, J.M. Friedrich & S.R. Seidel [editors], *Chemical Evolution II: From Origins of Life to Modern Society*. American Chemical Society Symposium Series 1025, 3-13.
- Hazen, R.M. (2009) Les minéraux évoluent aussi. *La Recherche* 430 (May 2009), 60-63.
- Hazen, R.M. (2009) The descent of minerals [in Korean]. *Science Donga*, 282, 54-59.

## 2010

- Hazen, R.M. and J. M. Ferry (2010) Mineral evolution: Mineralogy in the fourth dimension. *Elements* 6, #1, 9-12.
- Hazen, R.M. and N. Eldredge (2010) Themes and variations in complex systems. *Elements* 6, #1, 43-46.
- Hazen, R.M. (2010) The evolution of minerals. *Scientific American* 303, #3, 58-65.
- Cleaves, H.J. II, C.M. Jonsson, C.L. Jonsson, D.A. Sverjensky, R.M. Hazen (2010) Adsorption of nucleic acid components on rutile (TiO<sub>2</sub>) surfaces. *Astrobiology*, 10, 311-323.
- Hazen, R.M. and D.A.Sverjensky (2010) Mineral Surfaces, Geochemical Complexities, and the Origins of Life. In D.W. Deamer & J.W. Szostak (Editors), *The Origins of Life*, Cold Springs Harbor Perspectives in Biology, 157-177.
- Jonsson, C.M., C.L. Jonsson, D.A. Sverjensky, H.J. Cleaves II, R.M. Hazen (2010) Adsorption of L-aspartate to rutile (α-TiO<sub>2</sub>): Experimental and theoretical surface complexation studies. *Geochimica et Cosmochimica Acta* 74, 2356-2367.
- Hazen, R.M. (2010) How old is Earth, and how do we know? *Evolution: Education and Outreach* 3, 198-205.
- K. Marshall-Bowman, S. Ohara, D. A. Sverjensky, R. M. Hazen, and H. J. Cleaves (2010) Catalytic peptide hydrolysis by mineral surface: Implications for prebiotic chemistry. *Geochimica et Cosmochimica Acta* 74, 5852-5861.
- Hazen, R.M. and J.S.Trefil (2010) Scientific literacy: A modest proposal. In J. Meinwald and J.G.Hildebrand (editors), *Science and the Educated American: A Core Component of Liberal Education*. Cambridge, Massachusetts: American Academy of Arts and Sciences volume, pp.57-69.

## 2011

- Bahri, S., C.M. Jonsson, C.L. Jonsson, D. Azzolini, D.A. Sverjensky, R.M. Hazen (2011) Adsorption and surface complexation study of L-DOPA on rutile (TiO<sub>2</sub>) in NaCl solutions. *Environmental Science and Technology*, 45, 3959-3966.
- Grew ES, Bada JL, Hazen RM (2011) Borate minerals and the origin of the RNA world, *Origins of Life and Evolution of the Biosphere*, 41, 307-316.
- Hazen RM, Bekker A, Bish DL, Bleeker W, Downs RT, Farquhar J, Ferry JM, Grew ES, Knoll AH, Papineau D, Ralph JP, Sverjensky DA, Valley JW (2011) Needs and opportunities in mineral evolution research. *American Mineralogist*, 96, 953-963.
- Parikh, SJ, JD Kubicki, CM Jonsson, CL Jonsson, RM Hazen, DA Sverjensky, DL Sparks (2011) Evaluating glutamate and aspartate binding mechanisms to rutile (α-TiO<sub>2</sub>) via ATR-FTIR spectroscopy and quantum chemical calculations. *Langmuir*, 27, 1778-1787.
- Hazen, R.M. (2011) Exciting frontiers await at scientific boundaries: An example from the Deep Carbon Observatory. *Earth* 56, #7, 71.
- Cleaves, H.J.II, E. Crapster-Pregont, C.M. Jonsson, C.L. Jonsson, D.A. Sverjensky, R.M. Hazen (2011) The adsorption of short single-stranded DNA oligomers to mineral surfaces. *Chemosphere*, 83, 1560-1567.
- Hazen, R.M. (2011) What's new in mineral evolution. Italy Symposium publication

Schaffer, B., K.J.T. Livi, D. Azzolini, C.R. Seabourne, K. Sader, M. Shannon, D. Sverjensky, R. Hazen and R. Brydson (2011) "Imaging the surface of Rutile by STEM and its implication for organic molecule bonding." *Proceedings of the 10th Multinational Congress on Microscopy 2011 (MCM2011)*, September 4 - 9, Urbino/Italy, pp. 591-592.

## 2012

Hazen, R.M. (2012) *The Story of Earth: The First 4.5 Billion Years, from Stardust to Living Planet*. New York: Viking, 306 p. Softcover edition (2013). Foreign language: Spanish, Japanese, Korean, Russian, Polish, and Czech editions.

Hazen, R.M., J.Golden, R.T.Downs, G.Hysted, E.S.Grew, D.Azzolini, D.A.Sverjensky (2012) Mercury (Hg) mineral evolution: A mineralogical record of supercontinent assembly, changing ocean geochemistry, and the emerging terrestrial biosphere. *American Mineralogist*, 97, 1013-1042.

Hazen, R.M. and D.Papineau (2012) Mineralogical co-evolution of the geosphere and biosphere. In A. H. Knoll, D. E. Canfield and K. O. Konhauser (Editors), *Fundamentals of Geobiology*. Oxford UK: Wiley-Blackwell, pp.333-350.

Hazen, R.M., Hemley, R.J., and Mangum, A.J. (2012) Carbon in Earth's interior: storage, cycling, and life. *EoS Transactions of the American Geophysical Union* 93, 17-28.

Hazen, R.M. (2012) Geochemical origins of life. In A. H. Knoll, D. E. Canfield and K. O. Konhauser (Editors), *Fundamentals of Geobiology*. Oxford UK: Wiley-Blackwell, pp.315-332.

Hazen, R.M. (2012) An accident waiting to happen (That's Life). *Eureka, The Times*, #33 (June 2012), 14-19.

Livi, K.J.T., B. Schaffer, D. Azzolini, C.R. Seabourne, K. Sader, M. Shannon, D. Sverjensky, R. Hazen and R. Brydson (2011) Imaging the surface of Rutile by STEM and its implication for organic molecule bonding. *Proceedings of the Microscopy Conference 2011 (MC2011)*, August 28-September 02, Kiel/Germany, page M6\_P621.

Cleaves, H.J.II, A.M.Scott, F.C.Hill, J.Leszczynski, N.Sahai, and R.M.Hazen (2012) Mineral-organic interfacial processes: potential roles in the origins of life. *Chemical Society Reviews*, 41, 5502-5525. DOI: 10.1039/c2cs35112a

Lee, N., Hummer, D.R., Sverjensky, D.S., Rajh, T., Hazen, R.M., Steele, A., and Cody, G.D. (2012) Speciation of L-DOPA on nanorutile as a function of pH and surface coverage using surface-enhance Raman spectroscopy (SERS). *Langmuir*, 28, 17322-17330. doi: 10.1021/la303607a.

## 2013

Hazen, R.M. (2013) Paleomineralogy of the Hadean Eon: A preliminary list. *American Journal of Science*, 313, 807-843.

Hazen, R.M. (2013) *The Story of Earth: The First 4.5 Billion Years, from Stardust to Living Planet*. New York: Penguin, softcover edition, 306 p.

Hazen, R.M., A.P.Jones, and J.A.Baross [Editors] (2013) *Carbon in Earth*. Reviews in Mineralogy and Geochemistry volume 75. Washington, DC: Mineralogical Society of America, 698 p.

Hazen, R.M. and C.Schiffries, C. (2013) Why carbon? In Hazen, R.M., A.Jones, and J.Baross [Editors]. *Carbon in Earth*. Washington, DC: Mineralogical Society of America, pp. 1-6.

- Hazen, R.M., R.T.Downs, A.Jones, and L.Kah (2013) The mineralogy and crystal chemistry of carbon. In Hazen, R.M., A. Jones, and J.Baross [Editors]. *Carbon in Earth*. Washington, DC: Mineralogical Society of America, pp. 7-46.
- Oganov, A., R.Hemley, R.M.Hazen, and A.Jones (2013) Deep carbon mineralogy. In Hazen, R.M., A. Jones, and J.Baross [Editors]. *Carbon in Earth*. Washington, DC: Mineralogical Society of America, pp. 47-77.
- Hazen, R.M., A.Jones, L.Kah, D.A.Sverjensky (2013) Carbon mineral evolution. In Hazen, R.M., A. Jones, and J.Baross [Editors]. *Carbon in Earth*. Washington, DC: Mineralogical Society of America, pp. 79-107.
- Sephton, M. and R.M.Hazen (2013) On the origins of deep hydrocarbons. In Hazen, R.M., A.Jones, and J.Baross [Editors]. *Carbon in Earth*. Washington, DC: Mineralogical Society of America, pp. 449-465.
- Golden, J., M.McMillan, R.T.Downs, G.Hystad, H.J.Stein, A.Zimmerman, D.A.Sverjensky, J.Armstrong, R.M.Hazen (2013) Rhenium variations in molybdenite (MoS<sub>2</sub>): Evidence for progressive subsurface oxidation. *Earth and Planetary Science Letters*, 366, 1-5.
- Hazen, R.M. (2013) Mineral evolution. In *McGraw-Hill Yearbook of Science & Technology 2013*. New York: McGraw-Hill, pp.247-249.
- Hazen, R.M., Sverjensky, D.A., Azzolini, D., Bish, D.L., Elmore, S., Hinnov, L., and Milliken, R.E. (2013) Clay mineral evolution. *American Mineralogist*, 98, 2007-2029.
- Grew, E.S., and Hazen, R.M. (2013) Evolution of the minerals of beryllium. *Stein*, 2013, 4-19. Also Norwegian language version (translated by Roy Kristiansen), "Evolusjon av Berylliummineraler, Stein 3, 2014, 4-20.
- Livi, K.J.T., Schaffer, B., Azzolini, D., Seabourne, C.R., Hardcastle, T.P., Scott, A.J., Hazen, R.M., Erlebacher, J.D., Brydson, R., and Sverjensky, D.A. (2013) Atomic scale roughness of rutile and implications for molecular surface adsorption. *Langmuir*, 29, 6876-6883.
- Noffke, N., D.Christian, D.Wacey, and R.M.Hazen (2013) Microbially induced sedimentary structures recording an ancient ecosystem in the ca. 3.48 billion-year-old Dresser Formation, Pilbara, Western Australia. *Astrobiology Journal*, 13, #12, 1103-1124.
- Bolukbasi, B., et al. (2013) Open data: Creating a culture of cooperation. *Science*, 342, 1041-1042.

## 2014

- Grew, E.S. and R.M.Hazen (2014) Beryllium mineral evolution. *American Mineralogist*, 99, 999-1021.
- Hazen, R.M. (2014) Enantioselective adsorption on rock-forming minerals: A thought experiment. *Surface Science*, 629, 11-14.
- Lee, N., D.I.Foustoukos, D.A.Sverjensky, G.D.Cody, and R.M.Hazen (2014) The effects of temperature, pH and redox state on the stability of glutamic acid in hydrothermal fluids. *Geochimica et Cosmochimica Acta*, 135, 66-86.
- Hazen, R.M. (2014) Data-driven abductive discovery in mineralogy. *American Mineralogist*, 99, 2165-2170.
- Hazen, R.M., Liu, X.-M., Downs, R.T., Golden, J., Pires, A.J., Grew, E.S., Hystad, G., Estrada, C., and Sverjensky, D.A. (2014) Mineral evolution: Episodic metallogenesis, the supercontinent cycle, and the co-evolving geosphere and biosphere. *Economic Geology, Special Publication 18*, 1-15.
- Hazen, R.M. (2014) Mineral fodder. *Aeon Magazine*, published online June 24, 2014, 7 pp.

Trefil, J.S., and Hazen, R.M. (2015) *The Sciences: An Integrated Approach*. 8<sup>th</sup> edition. Hoboken, NJ: Wiley.

Hazen, R.M. (2014) Deep carbon and false dichotomies. *Elements*, 10, 407-409.

Lee, N., D.A.Sverjensky, and R.M.Hazen (2014) Cooperative and competitive adsorption of amino acids with Ca<sup>2+</sup> on rutile (α-TiO<sub>2</sub>). *Environmental Science and Technology*, 48, 9358-9365.

Lee, N., D.I.Foustoukos, D.A.Sverjensky, G.D.Cody, and R.M.Hazen (2013) Hydrogen enhances the stability of amino acids in hydrothermal environments. *Chemical Geology*, 386, 184-189.

## 2015

Hazen, R.M., Grew, E.S., Downs, R.T., Golden, J., and Hystad, G. (2015) Mineral ecology: Chance and necessity in the mineral diversity of terrestrial planets. *Canadian Mineralogist*, *in press*.

Nance, J.R., J.T.Armstrong, G.D.Cody, M.L.Fogel, and R.M.Hazen (2015) Preserved shell-binding protein and associated pigment in the Middle Miocene (8 to 18 Ma) gastropod *Ecphora*. *Geochemical Perspectives Letters* 1, 1-8.

Pober, S., R.M. Hazen and M.H.Hazen (2014+) *American Geological Literature: 1669-1850*. 5 volumes. New York: Pober Publishing, Volume 1 (of 6), *in press*.

Estrada, C., D.A.Sverjensky, M.Pelletier, A.Razafitianamharavo, and R.M.Hazen (2014) interaction between L-aspartate and the brucite [Mg(OH)<sub>2</sub>]-water interface. *Geochimica et Cosmochimica Acta*, *in press*.

Hysted, G., Downs, R.T., and Hazen, R.M. (2015) Mineral frequency distribution data conform to a LNRE model: Prediction of Earth's "missing" minerals. *Mathematical Geosciences*, *in press*.

## Papers in Review/Revision:

Liu, X.-M., Kah, L.C., Knoll, A.H., Cui, H., Kaufman, A.J., Shahar, A., and Hazen, R.M. (2015) Tracing Earth's CO<sub>2</sub> evolution using Zn/Fe ratios in marine carbonate. *Nature*, *in review*.

Grew, E.S., Dymek, R.F., De Hoog, J.C.M., Harley, S.L., Boak, J.M., Hazen, R.M., and Yates, M.G. (2015) Boron isotopes in tourmaline from the 3.7-3.8 Ga Isua Belt, Greenland: Sources for boron in Eoarchean continental crust and seawater. *Geochimica et Cosmochimica Acta*, *in revision*.

Klochko, K., D.S.Sverjensky, G.D.Cody, and R.M.Hazen (2015) Why ribose? Competitive adsorption of pentose sugars on rutile. *Origins of Life and Evolution of the Biosphere*, *in revision*.

Villegas-Jimenez, A., J.F.Anker, M.Hong, R.M.Hazen, D.A.Sverjensky, H.H.Teng, and Y.Kebukawa (2015) Carbon dioxide nanobubble nucleation at the calcite-water interface. *Nature*, *in review*.

Estrada, C., Sverjensky, D.A., and Hazen, R.M. (2015) Enhanced and inhibited adsorption of D-ribose with Ca<sup>2+</sup> and Mg<sup>2+</sup> onto brucite [Mg(OH)<sub>2</sub>]. *Geochimica et Cosmochimica Acta*, *in review*.

Estrada, C., Sverjensky, D.A., and Hazen, R.M. (2015) Selective adsorption of calcium-aspartate ligands onto [Mg(OH)<sub>2</sub>]-brucite: Implications for calcium in prebiotic chemistry. *Astrobiology*, *in review*.

Grosch, E.G., Mcloughlin, N., and Hazen, R.M. (2015) Microbes, mineral evolution, and the rise of microcontinents. *Astrobiology*, *in review*.

Hystad, G., Downs, R.T., and Hazen, R.M. (2015) Earth's mineralogy is unique. *Science*, *in review*.

Villegas-Jimenez, A., Anker, J.F., Hong, M., Sverjensky, D.A., Teng, H.H., Kebukawa, Y., and Hazen, R.M. (2015) Carbon dioxide nanobubble nucleation at the calcite-water interface. *Nature*, in review.

Grosch, E.G., Mcloughlin, N., and Hazen, R.M. (2015) Microbes, mineral evolution, and the rise of microcontinents: Origin and co-evolution of life with early Earth. *Astrobiology*, in revision.

Wenge, J., Pacella, M.S., Athanasiadou, D., Nelea, V., Vali, H., Hazen, R.M., Gray, J.J., and McKee, M.D. (2015) Chiral acidic amino acids induce chiral hierarchical structure in calcium carbonate. *Nature*, in review.

### **Book in Preparation**

Hazen, R.M., *Deep Carbon: The Story of Element 6*

### **Papers in Preparation**

Hazen, R.M., Downs, R.T., and Yang, H., The crystal chemistry of abelsonite and its relationship to bio-porphyrins.

Hazen, R.M., Hystad, G., Downs, R.T., Golden, J., and Grew, E., Comparative mineral ecology of carbon, phosphorus, and sulfur.

Grew, E.S., and Hazen, R.H., Boron mineral evolution.

Grew, E.S., Hystad, G., Downs, R.T., Golden, J., and Hazen, R.M., The “missing” minerals of beryllium and boron: A mineral ecology study.

Krivovichev, S.V., Grew, E.S., and Hazen, R.M., The Relationship between structural and chemical complexity of boron minerals with geological time.

Hao, J., Sverjensky, D.A., and Hazen, R.M., Limits on the partial pressure of H<sub>2</sub> in the Archaean atmosphere during weathering of basaltic minerals.