

MITCHELL D. SCHULTE

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Education:

Ph.D., Earth & Planetary Sciences, Washington University, 1997
M.S. Program (ABD), Geology & Geological Engineering, University of North Dakota
B.A., Earth & Planetary Sciences, Washington University, 1987

Positions Held:

Assistant Professor, Dept. of Geological Sciences, University of Missouri (since Sept. 2005)
Guest Investigator, Woods Hole Oceanographic Institution (since June 2007)
Staff Research Scientist, Exobiology Branch, NASA Ames Research Center (2000-2006)
Postdoctoral Associate, National Research Council, NASA Ames Research Center (1998-2000)
Research Scientist, Washington University / NASA Ames Research Center (1997-1998)
Graduate Research Assistant, Dept. of Earth & Planetary Sciences, Washington University
Graduate Teaching Assistant, Dept. of Earth & Planetary Sciences, Washington University
Graduate Teaching Assistant, Dept. of Geology & Geological Engineering, Univ. N. Dakota
SEM Technician, Dept. of Geology & Geological Engineering, Univ. of North Dakota (1990)

Awards and Professional Recognition:

Geological Sciences Faculty Scholar, University of Missouri, 2006-2007
Incentive Award for Outstanding Performance, NASA Ames Research Center, August 2005
Incentive Award for Outstanding Performance, NASA Ames Research Center, March 2005
National Research Council Postdoctoral Research Associateship, 1998-2000
NASA Astrobiology Institute postdoctoral scientist, 1997-1998
Wheeler Fellowship, Washington University, 1991
University of North Dakota, Graduate School Research Grant, 1990
Election to Sigma Gamma Epsilon (1989) and Sigma Xi (1989) honorary societies

Teaching Experience:

Assistant Professor, Dept. of Geological Sciences, University of Missouri

- Geomicrobiology (upper undergraduate / lower graduate level, Fall semester 2005, 2007)
- Historical Geology (introductory undergraduate, Winter semester 2006-2009)
- Rocks and Minerals (undergraduate, Fall semester 2007, 2008)
- Principles of Geology (general education, Fall semester 2006)
- Advanced Geomicrobiology (graduate, Winter semester 2007)

Adjunct Faculty, California State University, East Bay (April 1999-June 2005)

- Advanced Topics - Organic Geochemistry (graduate level, Winter quarter 2002)

Lecturer, San Francisco State University:

- Introduction to Oceanography (general education course, Spring semester 1998)

Graduate Teaching Assistant, Washington University:

- Life of the Geologic Past, Environmental Geology, Resources of the Earth (1991-93).

Graduate Teaching Assistant, University of North Dakota:

- Historical Geology, Physical Geology, Planetary Geology, Engineering Geology, Basic Earth Science; I designed and implemented a new lab course in Petrology (1989-90).

Research Experience:

Assistant Professor, Dept. of Geological Sciences, University of Missouri

- Hydrothermal organic geochemistry, geomicrobiology, high temperature calorimetry of aqueous organic compounds

Staff Research Scientist, Exobiology Branch, NASA Ames Research Center

- Chief Scientist, field and analytical studies of ophiolites and associated springs in California, including chemistry, microbiology and mineralogy/petrology.
- Modeling behavior of aqueous organic compounds and minerals during water/rock reactions on meteorite parent bodies and in terrestrial hydrothermal systems.
- Development and refinement of equations of state used to calculate reaction properties of aqueous organic compounds at elevated temperatures and pressures.
- Critical evaluation and estimation thermodynamic properties of aqueous organic sulfur compounds for incorporation into geochemical models of modern and early Earth environments.
- Analyzing chemical composition of meteorites; investigating effects of sample preparation on imaging by high resolution scanning electron microscopy; searching for mineralogical biomarkers in extraterrestrial and terrestrial samples.

Postdoctoral Associate, National Research Council/NASA Ames Research Center (11/98-6/00).

- Designed, tested and implemented experiments for a supercritical water oxidizer (SCWO) at NASA Ames Research Center to study organic compound stability and reactions in near surface environments.
- Performed experiments to test buffering capacity of mineral assemblages and determined stability of organic compounds under hydrothermal conditions; analyzing reaction products using gas chromatography, HPLC, IC and spectrophotometric methods.
- SEM characterization of morphologic forms in terrestrial and extraterrestrial materials as tests for determining biogenicity.
- Evaluated and estimated thermodynamic properties of aqueous organic compounds for incorporation into geochemical models of early Earth environments.

Research Scientist, Washington University/NASA Ames Research Center (11/97-10/98).

- Designed and performed aqueous organic geochemistry experiments to investigate organic compound stability and reactions in hydrothermal environments, using flexible gold cell hydrothermal bombs at the U.S. Geological Survey in Menlo Park.
- Prepared, derivatized and analyzed aqueous organic experimental samples by gas chromatography-mass spectrometry (GC-MS).

Consultant, Carnegie Institution of Washington, Geophysical Laboratory (9/97-10/97).

- Investigated organic reactions in high pressure hydrothermal environments with geochemical models for complementary experimental work.

Graduate Research Assistant, Washington University (1/92-8/97).

- Determined the role of geochemical variables such as oxidation state, pH, composition, mineralogy, temperature and pressure, on the fate of organic compounds in geologic environments such as oilfield brines, hydrothermal systems and groundwater.
- Calculated energy availability for thermophilic microorganisms in modern and ancient hydrothermal systems and investigated relevance to emergence of metabolism in such systems.
- Investigated potential for organic synthesis in hydrothermal systems on Earth, Mars, asteroids, and Europa using geochemical models.
- Compiled data and devised correlations for estimating thermodynamic properties of aqueous organic compounds; performed regression of heat capacity, volume, solubility, and enthalpy of solution data to determine equation of state parameters for aqueous organic and inorganic species; developed an equation of state for calculating properties of neutral aqueous species at elevated temperatures and pressures.

Graduate Research Assistant, Université Blaise Pascal, France (April - July, 1996).

- Measured volumetric properties of aqueous organic compounds to 250°C at elevated pressure with high temperature & pressure densitometer in Laboratoire de Thermodynamique et Génie Chimique under the supervision of Dr. Vladimir Majer; applied group contribution algorithms to develop equations of state for thermodynamic properties of aqueous organic molecules.

SEM/Electron Microprobe Technician, Natural Materials Analytical Laboratory, Energy and Environmental Research Center, University of North Dakota (1990).

- Operated scanning electron microscope and electron microprobe for laboratory and industrial users; trained students in use of microscope/microprobe.

Funding History:

Co-proponent, Integrated Ocean Drilling Program, Santa Barbara Basin, forwarded to Science Planning Committee, November 2008.

Principal Investigator, NASA Astrobiology: Exobiology and Evolutionary Biology Program, “Experimental determination of partial molal heat capacities and volumes of aqueous organic compounds,” \$517,417 over three years, awarded July 2007.

Principal Investigator, University of Missouri – Columbia Research Board, “Experimental and analytical studies of organo-sulfur compounds under hydrothermal conditions,” \$8,500 over two months, awarded March 2007.

Co-Investigator, NASA Astrobiology Institute, “Linking Our Origins to Our Future,” (Principal Investigator – D. Des Marais), awarded June 2003.

Principal Investigator, NASA Exobiology Program, “Ultramafic terranes and associated springs as habitats for ecosystems on Mars and early Earth,” awarded March 2003, \$377,100 over three years.

Principal Investigator, Director’s Discretionary Fund, NASA Ames Research Center, “California’s ophiolites as analogs to early Earth habitats,” awarded December 2002, \$80,000 over 2 years.

Co-Investigator, NASA Mars Fundamental Research Program, “Characterization of volcanic rock alteration for analysis of spectroscopic and chemical data from the surface of Mars,” (Principal Investigator - J. Bishop), awarded August 2002.

Co-Investigator, NASA Exobiology Grant, “Minerals and Submicrometer forms as Biomarkers,” (Principal Investigator - Dr. David Blake), awarded December 1999

NASA Ames Research Center/Washington University Joint Research Interchange Grant
(Principal Investigator - Prof. Everett Shock), awarded October 1997

Invited Talks:

University of Western Ontario, Dept. of Earth Sciences, January 2009
Woods Hole Oceanographic Institution, Biogeochemistry Group, June 2007
University of Missouri, Saturday Morning Science Series, December 2006
University of Missouri, Dept. of Chemistry, December 2006
University of Missouri, Dept. of Biochemistry, April 2006
AGU Fall Meeting 2005, Serpentinization and Life, Session V43C, December 2005
Ridge 2000 Progress and Planning Workshop, November 2005
San Jose State University, Dept. of Geological Sciences, April 2005
University of Missouri, Dept. of Geological Sciences, March 2005
University of California, Davis, Dept. of Geology, December 2002
University of Washington, Astrobiology Program, February 2001
Arizona State University, Dept. of Geology, May 2000
University of California at Los Angeles, Dept. of Earth & Space Sciences, March 2000
University of Puerto Rico, Mayagüez, Dept. of Geology, March 2000
University of South Florida, Dept. of Geology, February 2000
California State University, Hayward, Dept. of Geological Sciences, November 1999
Stanford University, Dept. of Geological & Environmental Sciences, November 1997
Shell Oil Company, Houston, TX, August 1997
NASA Ames Research Center, Exobiology Branch, July 1997
V. M. Goldschmidt Conference, Symposium in Honor of Prof. Bart Nagy, June 1997
Carnegie Institution of Washington, Geophysical Laboratory, March 1997
Université Blaise Pascal, Laboratoire de Thermodynamique et Génie Chimique, June 1996

Professional Activities and Development:

Steering Committee, Workshop on Drilling Mid-Ocean Ridges, Aug. 2009. Co-convenor of workshop approved for funding by the Consortium for Ocean Leadership, to be held in Austin, TX in August 2009.

Steering Committee, CHART Workshop for the Consortium for Ocean Leadership, 2008-2009. Developing U.S. program statement for INVEST meeting to define future of the Integrated Ocean Drilling Program.

Advisory Committee, Dark Energy Biosphere Institute, Research Coordinated Network

Guest Investigator, Woods Hole Oceanographic Institution, June 2007 – May 2008.

Ridge 2000 Progress and Planning Workshop, 30 Oct. – 2 Nov. 2005, Invited speaker on Ridge program-related activities and research, participated in planning future Ridge activities.

New England Biolabs Workshop in Molecular Biology and PCR, Smith College (22 June - 05 July 2003). Learned techniques and methods for molecular biology and polymerase chain reaction, including classroom and laboratory instruction.

Ridge 2000 Community Meeting and Workshop, 6-8 Nov. 2003, Review of time-critical and integrated site studies and development of future directions.

Member, NASA Center for Computational Astrobiology, NASA Ames Research Center.

Colloquium Committee, Space Science Division, NASA Ames Research Center (2001-2005).

RIDGE 2000 Exploratory Studies Workshop, 5-7 Oct. 2000: Defining new directions and assisting with summary of science planning for new RIDGE directive from NSF.
Volunteer Gallery Assistant, St. Louis Science Center: Assisted visitors with explanation and interpretation of displays of Earth science, including geology, environmental science, space sciences and paleontology (4 years).
Elementary School Group Tour Guide, University of North Dakota: Gave elementary school children tours of geology department facilities and collections (2 years).

Service

Professional Service:

Editorial Board Member, Astrobiology: Reviewing and handling manuscripts for publication (2002-present).

Associate Editor, The Geochemical News: Soliciting, editing, and writing articles and news items for the newsletter of the Geochemical Society; conducted and edited interviews with H. Helgeson, C. Chyba, A. Navrotsky and D. Des Marais (1999-present).

Co-Convener, Session B16, AGU Fall Meeting, San Francisco, CA, Dec. 2008, Organizing and co-chairing session on the deep biosphere (with Beth Orcutt and Peter Gurguis).

IODP - SSEP Review Panel, 10-13 November 2008, San Francisco, CA.

Mentor, MS-PHD's Program, 19-22 May 2008. Mentored Fabian Batista during IODP Panel Review meeting.

IODP - SSEP Review Panel, 19-22 May 2008, Busan, S. Korea.

NASA Astrobiology: Exobiology and Evolutionary Biology Review Panel, 28 Jan.-1 Feb. 2008, Washington, DC.

IODP - SSEP Review Panel, 12-15 November 2007, Arcachon, France.

IODP – Science Steering and Evaluation Panel, Member, 1 October 2007-30 September 2010

Mentor, MS-PHD's Program, 28 May - 1 June 2007. Mentored Adrienne Smith during IODP Panel Review meeting.

IODP-SSEP Review Panel, 28 May – 1 June 2007, Houston, Texas.

IODP-SSEP Review Panel, 12-16 November 2006, Sapporo, Japan.

Reviewer, Peer Reviewed Journals (Geochimica et Cosmochimica Acta, CALPHAD, Astrobiology, International Journal of Astrobiology, American Journal of Science, Biogeosciences, Earth and Planetary Science Letters, Geochemical Transactions, Environmental Chemistry, Deep Sea Research)

Reviewer, Grant Funding Agencies (NASA, NSF, DOE, IODP, Swiss National Science Foundation)

Co-Convener, Session B16, AGU Fall Meeting, San Francisco, CA, Dec. 2005, Organized and co-chaired session on organic compounds in volcanic hydrothermal systems (with Florian Schwandner, Jenny Cox and Terry Seward).

Co-Convener, Session P19, AGU Fall Meeting, San Francisco, CA, Dec. 2005, Organized and chaired session on the hydrothermal solar system (with Everett Shock).

Invited Panelist, Evening Session, “An Ecologist’s Guide to the Galaxy,” 90th Annual Ecological Society of America Meeting, Montreal, Québec, Canada, August 2005.

Chair, Student Travel Support Committee, Eighth Triennial Exobiology PI Meeting, NASA Ames Research Center, Moffett Field, CA, 15-19 August 2005.

Organizing Committee, Eighth Triennial Exobiology PI Meeting, NASA Ames Research Center, Moffett Field, CA, 15-19 August 2005.

International Program Committee, Origin of Life/Life in Extreme Environment Theme, Goldschmidt 2005 Conference, Moscow, Idaho, 20-25 May 2005.

Symposium Organizer and Chair (with Tori Hoehler and Tom McCollom), Energetic considerations for the emergence and proliferation of life in extreme environments, Goldschmidt 2005 Conference, Moscow, Idaho, 20-25 May 2004.

Organizing Committee, Seventh Triennial Exobiology PI Meeting, NASA Ames Research Center, Moffett Field, CA, 25-29 August 2003.

University Service:

University of Missouri

University of Missouri Doctoral Faculty (present)

Department of Geological Sciences

Graduate Admissions Committee, Dept. of Geological Sciences, University of Missouri (present)

Colloquium Committee, Dept. of Geological Sciences, University of Missouri (present)
Faculty Advisor, MU Geology Club (present)

Graduate Students:

Ariel Bennett, Ph.D., Dept. of Geological Sciences, University of Missouri (present)

Steven Pagan, M.S., Dept. of Geological Sciences, University of Missouri (12/08)

Graduate Student Committees:

Damon Bassett, Ph.D., Dept. of Geological Sciences, University of Missouri (present)

Gouri Chavan, Ph.D., Dept. of Chemistry, University of Missouri (present)

Carolina Isaza, Ph.D., Dept. of Geological Sciences, University of Missouri (present)

Scott Lepley, Ph. D., Dept. of Geological Sciences, University of Missouri (present)

Chad Magee, Ph.D., Dept. of Chemistry, University of Missouri (05/08)

Elyn Potter, M.S., Dept. of Geological Sciences, University of Missouri (05/07)

Mary Schubert, M.A., Dept. of Geological Sciences, University of Missouri (05/07)

Field Experience:

Field Assistant for Cynthia Schultz, Coast Range Volcanics (January 2008): Survey of geology and collection of basaltic glasses for study of biosignatures in volcanic rocks.

Science Party, R/V Atlantis Leg 15-9 (Aug.-Sep. 2006): Collection of hydrothermal fluid samples; CTD casts; starboard observer on DSV Alvin Dive 4233 to Mothra Hydrothermal Field and Geology Transect, Endeavour Segment, Juan de Fuca Ridge.

Science Party, R/V Atlantis Leg 11-31 (August 2005): Collection of hydrothermal fluid samples; compilation of DSV Alvin dive videos; starboard observer on DSV Alvin Dive 4145 to Main Endeavour Field, Juan de Fuca Ridge.

Science Party, Lost City Jason Project (July 2005): Assisted Chief Scientist Deborah Kelley with science operations for research cruise to Lost City Hydrothermal Vent Field from remote control center at the University of Washington, Seattle.

Science Party, R/V Atlantis Leg 11-20 (November 2004): Collection of hydrothermal fluid samples; compilation of Alvin dive videos; starboard observer on DSV Alvin Dive 4051 at 9°N on the East Pacific Rise.

Chief Scientist, ophiolite terrane project in N. California (2001-present): Determination of site selection, sample design and sampling protocol for *in situ* water analysis of water chemistry, collection of petrologic, water, sediment, and biologic samples.

Field Assistant for Prof. Everett Shock, Yellowstone National Park (1998-2000): *In situ* analysis of water chemistry, mapping, evaluation of sampling sites of hot spring locations, collection of petrologic, water and biologic samples.

Field Assistant for graduate student project in Iceland (1995): Collection of petrologic, sediment and water samples, mapping, evaluation of hot spring sampling locations.

Affiliations:

American Geophysical Union, Geochemical Society, Geological Society of America, International Society for the Study of the Origin of Life, Meteoritical Society, RIDGE2000

Foreign Languages:

Swedish, French, Mandarin Chinese and Russian

Publications:

Professional Journals

- 2009 **Schulte M.** Organic geochemistry of hydrothermal systems on Europa, submitted to JGR.
- 2009 **Schulte, M.** Organic sulfides in hydrothermal solution: Standard partial molal properties and role in the organic geochemistry of hydrothermal environments, submitted to *Aquatic Geochemistry*.
- 2009 Dalla-Betta, P. and **Schulte M.** Calculation of the aqueous thermodynamic properties of citric acid cycle intermediates and precursors and the estimation of high temperature and pressure equation of state parameters, invited to Special Issue on Origin of Life, *International Journal of Molecular Sciences*, v. 10, 2809-2837.
- 2006 **Schulte, M.**, Blake, D., Hoehler, T. and McCollom, T. Serpentinization and its implications for life on the early Earth and Mars. *Astrobiology* v. 6, 364-376.
- 2004 **Schulte M.** and Shock E. Coupled organic synthesis and mineral alteration on meteorite parent bodies, *Meteoritics & Planetary Science*, v. 39, 1577-1590.
- 2004 **Schulte M. D.** and Rogers K. L. Thiols in hydrothermal solution: Standard partial molal properties and their role in the organic geochemistry of hydrothermal environments, *Geochimica et Cosmochimica Acta*, v. 68, 1087-1097.
- 2001 **Schulte M.**, Shock E. and Wood R. The temperature dependence of the standard state thermodynamic properties of aqueous nonelectrolytes, *Geochimica et Cosmochimica Acta* v. 65, 3919-3930.
- 1999 **Schulte M. D.**, Shock E. L., Obsil M. and Majer, V. Volumes of aqueous alcohols, ethers and ketones to T=523K and p=28 MPa, *J. Chem. Thermodynam.* v. 31, 1195-1229.
- 1998 Shock E. L. and **Schulte M. D.** Organic synthesis during fluid mixing in hydrothermal systems, *J. Geophys. Res.* v. 103, 28,513-28,527.
- 1995 **Schulte M.** and Shock E. L. Thermodynamics of Strecker synthesis in hydrothermal systems, *Orig. Life Evol. Biosphere* v. 25, 161-173.

- 1995 Shock E. L., McCollom T. M. and **Schulte M. D.** Geochemical constraints on chemolithoautotrophic reactions in hydrothermal systems, *Orig. Life Evol. Biosphere* v. 25, 141-159.
- 1993 **Schulte M. D.** and Shock E. L. Aldehydes in hydrothermal solution: Standard partial molal properties and relative stabilities in geological environments, *Geochim.Cosmochim. Acta* v. 57, 3853-3846.
- 1993 Shock E. L. and **Schulte M. D.** Reply to the comment by Miller S. and Bada J. on "Summary and implications of reported amino acid concentrations in the Murchison meteorite," *Geochim. Cosmochim. Acta* v. 57, 3475-3477.
- 1991 Shock E. L. and **Schulte M. D.** Reply to scientific correspondence of Miller S. and Bada J., *Nature* v. 350, 388.
- 1990 Shock E. L. and **Schulte M. D.** Summary and implications of reported amino acid concentrations in the Murchison meteorite, *Geochim. Cosmochim. Acta* v. 54, 3159-3173.
- 1990 Shock E. L. and **Schulte M. D.** Amino acid synthesis in carbonaceous meteorites by aqueous alteration of polycyclic aromatic hydrocarbons, *Nature* v. 343, 728-731.
- 1988 Arvidson R. E., **Schulte M.**, Kwok R., Curlander J., Elachi C., Ford J. P., and Saunders R. S. Construction and analysis of simulated Venera and Magellan images of Venus, *Icarus* v. 27, 163-181.

Manuscripts in preparation

- Schulte M.** and Rogers K. Thermodynamics of sulfur metabolism.
- Blake, D., **Schulte M.** and Bunch T. Submicroscopic morphological features and mineralogies as biomarkers.
- Schulte M.** and Shock E. Organic compounds in geologic fluids: Predicting thermodynamic properties of aqueous organic compounds at high temperatures and pressures.

Articles and Book Chapters

- 2008 Schulte, M. Modeling the organic geochemistry of hydrothermal systems, RIDGE 2000 Events, Summer 2008, v. 3, pp. 20-22.
- 2007 **Schulte, M.** The Emergence of Life. *Oceanography*, v. 20, issue 1, pp. 42-49.
- 1999 **Schulte, M.** Thermochemistry, in *The Encyclopedia of Geochemistry* (C. P. Marshall and R. W. Fairbridge, eds.), Kluwer Academic Publishers, pp. 626-627.
- 1998 Shock E. L., McCollom T. and **Schulte M. D.** The Emergence of Metabolism from within Hydrothermal Systems, in *Thermophiles: The Keys to Molecular Evolution and the Origin of Life?* (J. Wiegel and M. Adams, eds.), Taylor & Francis, London, pp. 59-76.

Abstracts and Conference Presentations

- 2008 **Schulte, M.**, Orcutt B. and Girguis P. Earth's deep biosphere and life in the solar system. Fall Meeting of the American Geophysical Union, San Francisco, CA, 14-19 Dec 2008.

- 2008 **Schulte M.** and Rogers K. L. Formation and metabolism of organic sulfur compounds in serpentinizing fluids. *18th Annual Goldschmidt Conference on Geochemistry*, Vancouver, British Columbia, Canada, 13-18 July 2008.
- 2008 Rogers K. L. and **Schulte M. D.** Organic sulfur compounds as potential metabolic energy sources for mesophilic and thermophilic microbial communities. *RIDGE 2000 Mantle to Microbe: Integrated Studies at Oceanic Spreading Centers*, Portland, OR, 25-26 March 2008.
- 2006 **Schulte M.** and Rogers K. L. Evaluating potential metabolic reactions involving organic sulfur compounds. *RIDGE 2000 Theoretical Institute 2006: Modeling Oceanic Spreading Center Hydrothermal Processes: Magma to Microbe*, Mammoth Lakes, CA, 25-28 June 2006.
- 2005 **Schulte M.** Serpentinization and life on Mars. *EOS Trans. AGU*, 86(52), Fall Meet. Suppl., Abstract V43C-08 (invited).
- 2005 **Schulte M.** Organic geochemistry of hydrothermal systems on Europa, *EOS Trans. AGU*, 86(52), Fall Meet. Suppl., Abstract P51D-0968.
- 2005 **Schulte M.** and Rogers K. Organic sulfur compounds in extremophile metabolisms, *Geochim. Cosmochim. Acta* v. 69, No. 10S, A201.
- 2004 Blake D. F., **Schulte M.** and Hoehler T. Ultramafic terranes as habitats on Mars and early Earth, *Astrobiology Science Conference*, NASA Ames Research Center, Moffett Field, CA 28 March – 1 April, *Int. J. Astrobiology*, Supplement 2004, p. 84.
- 2003 **Schulte M.** The habitability of Mars: Lessons from ophiolites on Earth. *AGU Fall Meeting*, 8-12 December 2003, San Francisco, CA.
- 2003 **Schulte M.** Autotrophic ecosystems on the early Earth. *Seventh Triennial Exobiology PI Meeting*, 25-29 August, Moffett Field, CA.
- 2003 **Schulte M.** and Blake D. Ophiolites as analogs to habitats on Mars. *Sixth International Conference on Mars*, 20-25 July, Pasadena, CA.
- 2002 **Schulte M.**, Blake D. and Cullings K. Ultramafic terranes and associated springs as analogs to a Martian biosphere, *AGU Fall Meeting*, San Francisco, CA, 6-11 December 2002.
- 2001 **Schulte M.** and Rogers K. L. The biogeochemistry of sulfur in hydrothermal systems, *Earth System Processes*, 24-28 June 2001, Edinburgh, Scotland.
- 2000 **Schulte M.** and Rogers K. L. The role of aqueous organic sulfur compounds in hydrothermal systems, Geological Society of America Annual Meeting, Reno, NV. *Abstracts with Programs* v.32.
- 2000 **Schulte M.** and Rogers K. L. Thermodynamics of aqueous organic sulfur compounds: A key to the organic geochemistry in hydrothermal systems? *5th RIDGE Theoretical Institute*, Big Sky, Montana, 28 July-1 August 2000.
- 2000 Blake D., **Schulte M.** and Bunch T. Submicroscopic morphological features as biomarkers, *Astrobiology Science Conference*, NASA Ames Research Center, Moffett Field, CA, 3-5 April 2000.
- 1999 Blake D., **Schulte M.**, Bunch T. and Cady S. Submicroscopic morphological features and mineralogies as biomarkers, *Geological Society of America Annual Meeting*, Denver, CO. *Abstracts with Programs* v.31.
- 1999 **Schulte M.** Experimental investigation of organic compound stability under hydrothermal conditions. *217th American Chemical Society National Meeting*, Anaheim, CA, 21-25 March 1999 (Invited).

- 1998 **Schulte M.** Experimental investigation of organic compound stability at hydrothermal conditions. *1st General Meeting of the NASA Astrobiology Institute*, Moffett Field, CA, 5-7 November 1998.
- 1998 **Schulte M.** Organic synthesis during aqueous alteration of carbonaceous chondrites: Comparison of CM and CI groups. *61st Meteoritical Society Meeting*, Dublin, Ireland, 27-31 July 1998.
- 1998 **Schulte M.** and Shock E. Coupled organic synthesis and mineral alteration on meteorite parent bodies. *29th Lunar and Planetary Science Conference*, Houston, TX 16-20 March 1998.
- 1997 Majer V., Degrange S., **Schulte M.** and Obsil M. Volumetric data for aqueous solutions of organic compounds at superambient conditions. Measurements and the data correlation. *52nd Annual Calorimetry Conference (CALCON '97)*, Pacific Grove, CA, 3-8 August 1997.
- 1997 **Schulte M.** and Shock E. Hydrothermal organic synthesis on the early Earth. *Gordon Research Conference on the Origin of Life*, Henniker, NH, July 1997.
- 1997 **Schulte M.** and Shock E. Synthesis of organic compounds during aqueous alteration of the Murchison meteorite parent body, *7th Annual V. M. Goldschmidt Conference, Symposium in Honor of Prof. Bart Nagy*, Tucson, AZ, 2-6 June 1997 (Invited).
- 1997 **Schulte M.** and Shock E. Hydrothermal organic synthesis on the early Earth. *RIDGE Subsurface Biosphere Workshop*, Washington D. C., March 1997.
- 1996 Shock E. L., **Schulte M. D.** and McKinnon, W. B. Coupled organic synthesis and mineral alteration in hydrothermal systems on Europa, *Europa Ocean - An International Conference*, San Juan Capistrano, CA, Nov. 12-14, 1996.
- 1996 **Schulte M.**, Shock E., Obsil M. and Mayer V. Experimental and theoretical study of high-temperature thermodynamic properties of aqueous alcohols, ketones and ethers, Geological Society of America Annual Meeting, Denver, CO. *Abstracts with Programs* v.28, A28.
- 1996 Shock E. L., McCollom T. M. and **Schulte M. D.** The emergence of metabolism from within hydrothermal systems, *Thermophiles '96*, University of Georgia, Athens, GA, September 1996.
- 1996 **Schulte M.**, Obsil M., Majer V. and Shock E. L. Determination of partial molar volumes at infinite dilution for a group of aqueous organic compounds, *12th International Congress of Chemical and Process Engineering (CHISA '96)*, Praha, Czech Republic, 25-30 August, 1996.
- 1996 **Schulte M.** and Shock E. Fluid-mixing and organic synthesis on early Mars, *Orig. Life Evol. Biosphere* **26**, 513-514.
- 1996 Shock E., **Schulte M.** and McCollom T. Hyperthermophiles and the geochemical origin of metabolism, *Orig. Life Evol. Biosphere* **26**, 464-465.
- 1996 **Schulte M. D.** and Shock E. L. Metastable equilibrium among alkenes, alcohols and alkanes in geologic fluids. *211th American Chemical Society National Meeting*, March 24-28, 1996, New Orleans, LA.
- 1995 Shock E. L. and **Schulte M. D.** Hydrothermal systems as locations of organic synthesis on the early Earth and Mars. *Eos Transactions* v. 76, F335.
- 1995 **Schulte M. D.** and Shock E. L. Organic compounds in geologic fluids: predicting molal volumes and heat capacities at high temperatures. Geological Society of America Annual Meeting, New Orleans, LA. *Abstracts with Programs* v.27, A312.

- 1994 **Schulte M. D.** and Shock E. L. Aqueous alteration of the Murchison carbonaceous chondrite parent body. Geological Society of America Annual Meeting, Seattle, WA. *Abstracts with Programs* v. 26, A-359.
- 1994 Shock E. L., **Schulte M. D.** and McCollom T. Are there environmental and industrial applications of metastable equilibria among aqueous organic compounds identified in geochemical processes? *13th IUPAC Conference on Chemical Thermodynamics*, Clermont-Ferrand, France, 17-22 July, 1994.
- 1994 Shock E. L., **Schulte M. D.** and McKinnon W. Coupled aqueous alteration of minerals and organic compounds on meteorite parent bodies and icy satellites. *NASA Fifth Exobiology Symposium and Mars Workshop*, Moffett Field, CA, 25-29 April 1994.
- 1993 **Schulte M. D.** and Shock E. L. From contaminated groundwater to hydrothermal petroleum: The theoretical geochemistry of PAH. *Eos Transactions* v.74, 668-669.
- 1993 Shock E. L. and **Schulte M. D.** The influence of minerals on the distribution of hydrocarbons in hydrothermal petroleum. *Eos Transactions* v. 74, 669.
- 1993 **Schulte M. D.** and Shock E. L. Thermodynamics of Strecker synthesis reactions in hydrothermal systems, *7th ISSOL meeting*, Barcelona, Catalonia, Spain.
- 1992 **Schulte M. D.** and Shock E. L. Thermodynamics of Strecker synthesis reactions during aqueous alteration of carbonaceous chondrite parent bodies, *Meteoritics* v. 27, 286.
- 1990 Shock E. L. and **Schulte M. D.** Implications of the reported amino acid concentrations in the Murchison meteorite, *Lunar and Planetary Science Conference XXI*, 1150-1151.
- 1988 Shock E. L. and **Schulte M. D.** Relative abundances of amino acids in the Murchison meteorite: Clues to synthesis pathways or sampling bias? *Eos Transactions* v. 69, 1286.
- 1988 Shock E. L. and **Schulte M. D.** The role of aqueous solutions in the origin of organic compounds on the Earth, presented at the *Lunar and Planetary Institute Origin of the Earth Conference*, Berkeley, CA, 1-3 Dec. 1988.
- 1988 Arvidson R. E., **Schulte M.**, Kwok R., Curlander J., Elachi C., Ford J. P., and Saunders R.S. Analysis of simulated Venera and Magellan images over terrestrial regions and implications for characterizing surficial processes on Venus, *NASA Technical Memorandum 4041*, 235-236.