

Jeff R. Havig

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Professional Preparation:

Arizona State University Geological Sciences (Geochemistry) Ph.D. [2009]
Dissertation title: *Geochemistry of hydrothermal biofilms: Compositions of biofilms in a siliceous sinter-depositing hot spring.*

Washington State University Geology (Groundwater) M.Sc. [2002]
Thesis title: *Effects of perturbation on nutrient pools and loss from an experimental forest mesocosm.*

Washington State University Chemistry (Environmental Chem.) B.Sc. [1999]

Appointments:

University of Minnesota	Contract Assistant Professor	Sept. 2017-present
University of Cincinnati	Adjunct Faculty	Aug. 2015-May 2017
University of Cincinnati	Postdoctoral Researcher	Aug. 2015-Aug. 2016
University of Cincinnati	Visiting Scientist	Mar. 2015-Aug. 2015
Pennsylvania State University	PSARC Postdoctoral Researcher	Jul. 2012-Jan. 2015
Arizona State University	Postdoctoral Research Faculty	Jan.2010-Dec. 2011
Arizona State University	Postdoctoral Research Faculty	Jun.2009-Dec.2009

Publications: (listed in chronological order, *denotes student led paper)

Havig, J. R., Corman, J. R., and Hamilton, T. L. (2018) Potential effects of eutrophication-induced cyanobacterial blooms and invasive mussel species on carbon cycling and burial in Great Lakes Region lakes and reservoirs. **Biogeochemistry** (submitted)

Havig, J. R., and Hamilton, T. L. (2018) Snow algae drive productivity and weathering at volcanic rock-hosted glaciers. **Geochimica et Cosmochimica Acta** (submitted, in review)

Havig, J. R. and Hamilton, T. L. (2018) Hypolith photosynthesis in hydrothermal areas and implications for cryptic oxygen oases on Archean continental surfaces. **Frontiers in Earth Sciences, Biogeoscience** (in revision)

Rutledge, A. M., Horgan, B. H. N., **Havig, J. R.**, Rampe, E. B., Scudder, N. A., and Hamilton, T. L. (2018) Silica Dissolution and Precipitation in Glaciated Volcanic Environments, and Implications for Mars. **Geophysical Research Letters** 45. DOI: 10.1029/2018GL078105

*Milshteyn, D., Damer, B., **Havig, J. R.**, and Deamer, D. (2018) Amphiphilic Compounds Assemble into Membranous Vesicles in Hydrothermal Hot Spring Water but Not in Seawater. **Life** 8(11). DOI: 10.3390/life8020011

Herndon, E. M., **Havig, J. R.**, Singer, D. M., McCormick, M. L., and Kump, L. R. (2018) Manganese and iron geochemistry in sediments underlying a redox-stratified lake. **Geochimica et Cosmochimica Acta** 231: 50-63. DOI: 10.1016/j.gca.2018.04.013

Havig, J. R., McCormick, M. L., Hamilton, T. L., McClure, B. E., Sowers, T., and Kump, L. R. (2018) Water column and sediment carbon stable isotope biogeochemistry of a redox-stratified lake: Fayetteville Green Lake, N.Y. **ASLO Limnology and Oceanography** 63(2), 570-587. DOI: 10.1002/lno.10649

Hamilton, T. L. and **Havig, J. R.** (2018) Inorganic carbon addition stimulates snow algae primary productivity. **The ISME journal**, 1. DOI:10.1038/s41396-018-0048-6

Havig, J. R., Hamilton, T. L., Bachan, A. V., and Kump, L. R. (2017) Sulfur and carbon isotopic evidence for metabolic pathway evolution and a four-stepped Earth system progression across the Archean and Paleoproterozoic. **Earth-Science Reviews** 174: 1 – 21. DOI: 10.1016/j.earscirev.2017.06.014

Havig, J. R., Grettenberger, C. L., and Hamilton, T. L. (2017) Microbial community composition across a range of acid mine drainage impact and implications for the Neoproterozoic-Paleoproterozoic transition. **JGR Biogeosciences** 122(6): 1404-1422. DOI: 10.1002/2016JG003594

Colman, D. R., Poudel, S., Hamilton, T. L., **Havig, J. R.**, Selensky, M. J., Shock, E. L., and Boyd, E. S. (2017) Oxygen and the Evolution of Thermoacidophiles. **ISME** DOI: 10.1038/ismej.2017.162

Hamilton, T. L., and **Havig, J. R.** (2017) Primary productivity of snow algae communities on stratovolcanoes of the Pacific Northwest. **Geobiology** DOI:10.1111/gbi.12219

Havig, J. R., McCormick, M. L., Hamilton, T. L., and Kump, L. R. (2015) The behavior of biologically important trace elements across the oxic/euxinic transition of meromictic Fayetteville Green Lake, New York, USA. **Geochimica et Cosmochimica Acta** 165, 389-406. DOI: 10.1016/j.gca.2015.06.024

Boyd, E.S., Hamilton, T.L., **Havig, J. R.**, Skidmore, M., Shock, E.S. (2014) Chemolithotrophic primary production in a subglacial ecosystem. **Applied and Environ. Microb.** 80: 6146-6132. DOI:10.1128/AEM.01956-14

Hamilton, T. L., Koonce, E., Howells, A., **Havig, J. R.**, Jewell, T., de la Torre, J. R., Peters, J. P., and Boyd, E. S. (2014) Competition for ammonia influences the structure of chemotrophic communities in geothermal springs. **Applied and Environ. Microb.** 80(2), 653-661. DOI: 10.1128/AEM.02577-13

*Paukert, A. N., Matter, J. M., Kelemen, P. B., Shock, E. L., and **Havig, J. R.** (2012) Reaction path modeling of enhanced in situ CO₂ mineralization for carbon sequestration in the peridotite of the Samail Ophiolite, Sultanate of Oman. **Chemical Geology** 330-331:86-100. DOI: 10.1016/j.chemgeo.2012.08.013

Boyd, E. S., Fecteau, K. M., **Havig, J. R.**, Shock, E. L., and Peters, J. W. (2012) Modeling the Habitat Range of Phototrophs in Yellowstone National Park: Toward the Development of a Comprehensive Fitness Landscape. **Front. Microbio.** 3:221. DOI: 10.3389/fmicb.2012.00221

Miller-Coleman, R. L., Dodsworth, J. A., Ross, C. A., Shock, E. L., Williams, A. J., Hartnett, H. H., McDonald, A. I., **Havig, J. R.**, and Hedlund, B. P. (2012) Korarchaeota Diversity, Biogeography, and Abundance in Yellowstone and Great Basin Hot Springs and Ecological Niche Modeling Based on Machine Learning. **PLoS ONE** 7(5): e35964. DOI:10.1371/journal.pone.0035964

Swingley, W. D., Meyer-Dombard, D. R., Shock, E. L., Alsop, E. B., Falenski, H. D., **Havig, J. R.**, and Raymond, J. (2012) Coordinating Environmental Genomics and Geochemistry Reveals Metabolic Transitions in a Hot Spring Ecosystem. **PLoS ONE** 7(6): e38108. DOI:10.1371/journal.pone.0038108

*Loiacono, S. T., Meyer-Dombard, D. R., **Havig, J. R.**, Poret-Peterson, A. T., Hartnett, H. E. and Shock, E. L. (2012), Evidence for High-Temperature *in situ nifH* Transcription in an Alkaline Hot Spring of Lower Geyser Basin, Yellowstone National Park. **Environmental Microbiology**, 14: 1272–1283. DOI: 10.1111/j.1462-2920.2012.02710.x

Havig, J. R., Meyer-Dombard, D. R., Raymond, J., and Shock, E. L. (2011) Merging Isotopes and Metagenomics: Coupling Biofilm C and N Isotopes and Metagenomics in a Siliceous Sinter-Depositing Hot Spring. **JGR-Biogeosciences** 116: G01005. DOI: 10.1029/2010JG001415

*Cox, A., Shock, E. L., and **Havig, J. R.** (2011) The Transition to Microbial Photosynthesis in Hot Spring Ecosystems. **Chemical Geology** 280(3-4): 344-351. DOI: 10.1016/j.chemgeo.2010.11.022

Meyer-Dombard, D. R., Swingley, W., Raymond, J., **Havig, J.**, Shock, E. L., and Summons, R. E. (2011) Hydrothermal Ecotones and Streamer Biofilm Communities in

the Lower Geyser Basin, Yellowstone National Park. **Environmental Microbiology** 13(5): 1-16. DOI: 10.1111/j.1462-2920.2011.02476.x

Boyd, E. S., Lange, R. K., Mitchell, A. C., **Havig, J. R.**, Hamilton, T. L., Shock E. L., Peters, J. W., Skidmore, M. (2011) Diversity, Abundance, and Potential Activity of Nitrifying and Denitrifying Microbial Assemblages in a Subglacial Ecosystem. **Appl. Environ. Microbiol.** July 2011 vol. 77 no. 14 4778-4787. DOI: 10.1128/AEM.00376-11

Keller, C. K., O'Brien, R., **Havig, J. R.**, Smith, J. L., Bormann, B. T., and Wang, D. (2006) Tree Harvest in an Experimental Sand Ecosystem: Plant Effects on Nutrient Dynamics and Solute Generation. **Ecosystems** 9(4): 634-646. DOI: 10.1007/s10021-006-0162-6

Mount, G. H., Rumburg, B., **Havig, J.**, Lamb, B., Westberg, H., Yonge, D., Johnson, K., and Kincaid, R. (2002) Measurement of Atmospheric Ammonia at a Dairy Using Differential Optical Absorption Spectroscopy in the Mid-Ultraviolet. **Atmospheric Environment** 36(11): 1799-1810.

Manuscripts (Pending submissions, manuscripts available upon request):

Havig, J. R., Meyer, K., Bachan, A. V., Rybacki, K., Boyer, A., Saltzman, M., House, C., Bekker, A., and Kump, L. R. (est. Oct., 2018) Coming down after a breakup: The Nash Formation, extremely positive $\delta^{13}\text{C}$ carbonate values, the end of the Lomagundi positive C-isotope excursion, and supercontinent rifting. (Target: Nature Geosciences)

Havig, J. R., Kuether, J., Gangidine, A., and Hamilton, T. L. (est. Oct., 2018) Hot spring microbial community elemental composition: Hot spring and soil inputs, and the transition from biocumulus to sinter. (Target: Astrobiology, invited paper)

Havig, J. R. and Hamilton, T. L. (est. Nov., 2018) Biofilms on the edge: Carbon uptake and community composition of low biomass silica precipitating hot springs. (Target: Life, invited paper)

Meeting Abstracts: (last three years in chronological order, *denotes student led)

Havig, J. R. and Hamilton, T. L. (2018) Snow algae drive surface productivity and subglacial weathering at volcanic rock-hosted glaciers in the Pacific Northwest. Abstract, presented at 2018 Snow Algae Meeting, Potsdam, Germany, 15-16 Nov.

*Bennett, A. C., Murugapiran, S., **Havig, J. R.**, and Hamilton, T. L. (2018) Phototrophic community distribution and morphology along a geothermal stream: Insights into both modern and ancient microbial ecology. Abstract, presented at 2018 Geological Society of America Annual Meeting, Indianapolis, IN, 4-7 Nov.

Havig, J. R. and Hamilton, T. L. (2018) Cryptic Oxygen Oases: Hypolithic oxygenic photosynthesis in hydrothermal areas as a model for continental oxidation before the GOE. Abstract, presented at 2018 Goldschmidt Conference, Boston, MA, 13-17 Aug.

*Chen, X., Romaniello, S., McCormick, M., Sherry, A., **Havig, J.**, and Anbar, A. (2018) Do Manganese Oxides Dominate Transport of Mo Across the Chemocline of Redox-Stratified Lakes? Abstract, presented at 2018 Goldschmidt Conference, Boston, MA, 13-17 Aug.

Hamilton, T. L., Bennet, A., Murugapiran, S., and **Havig, J. R.** (2018) Anoxygenic photosynthesis across temperature and pH space. Abstract, presented at 2018 Goldschmidt Conference, Boston, MA, 13-17 Aug.

Havig, J. R. and Hamilton, T. L. (2018) Cryptic Photosynthesis: Hypolith phototrophic communities as analogs for early Earth and Mars. Abstract, presented at 2018 Australasia Astrobiology Meeting, Rotorua, New Zealand, 25-26 Jun.

Havig, J. R. and Hamilton, T. L. (2017) Cryptic oxygen oases: Hypolith photosynthesis in hydrothermal areas and implications for Archean surface oxidation. Abstract, presented at 2017 Fall Meeting, AGU, New Orleans, LA, 11-15 Dec.

Rutledge, A. M., Horgan, B., **Havig, J. R.**, Rampe, E. B., Scudder, N. A., and Hamilton, T. L. (2017) Glacial chemical alteration of Mars-like bedrock. Abstract, presented at 2017 Fall Meeting, AGU, New Orleans, LA, 11-15 Dec.

Hamilton, T. L. and **Havig, J. R.** (2017) Inorganic carbon stimulates snow algae primary productivity. Abstract, presented at 2017 Fall Meeting, AGU, New Orleans, LA, 11-15 Dec.

Havig, J. R. and Hamilton, T. L. (2017) Cryptic Photosynthesis: A possible terrestrial analog for early Earth and Mars. NASA Astrobiology Science Conference, Mesa, AZ, April 24-28, 2017.

Rutledge, A. M., Scudder, N. A., **Havig, J. R.**, Horgan, B., Rampe, E. B., and Hamilton, T. L. (2017) Does Melt-driven Silica Cycling Dominate Weathering in Glaciated Volcanic Terrains? Lunar and Planetary Science Conference, Houston, TX, March 20-24, 2017.

Havig, J. R., Hamilton, T. L., McCormick, M., McClure, B., Sowers, T., Wegter, B., and Kump, L.R. (2017) Water Column and Sediment Carbon Isotope Geochemistry of Permanently Redox-Stratified Fayetteville Green Lake, New York, USA. Geological Society of America Joint 52nd Northeastern Annual Section/51st North-Central Annual Section Meeting, Pittsburgh, PA, March 19-21, 2017.

Havig, J. R., Hamilton, T. L., and Grettenberger, C. (2016) Zombie Mines and Brain Biofilms: Acid Mine Drainage Impact and Implications for the Archean-Paleoproterozoic Transition. Geological Society of America Annual Meeting, Denver CO, Sept. 25-28, 2016.

Herndon, E., **Havig, J. R.**, Singer, D. M., McCormick, M., and Kump, L. R. (2016) Investigating Fe and Mn Geochemistry in Sediments of a Redox-Stratified Lake. Geological Society of America Annual Meeting, Denver CO, Sept. 25-28, 2016.

*Paton, T., Howard, L., Osterhout, J., **Havig, J. R.**, and Huff, W. (2016) Mineralogy and Geochemistry of Hot Spring Deposits in Yellowstone National Park. (Student Poster) Geological Society of America Annual Meeting, Denver CO, Sept. 25-28, 2016.

*Scudder, N. A., Horgan, B., **Havig, J. R.**, Rutledge, A., Rampe, E. B., and Hamilton, T. (2016) Differentiating hydrothermal, pedogenic, and glacial weathering in a cold volcanic Mars-analog environment. Lunar and Planetary Science Conference, Houston, TX, March 21-25, 2016.

Havig, J. R., Propaipong, P., Moore, G., Zolotova, N., Fecteau, K., Robinson, K., St. Clair, B., Boyer, G., and Shock, E.L. (2015) Hot Spring Microbial Community Elemental Composition: Hot Spring and Soil Inputs, and the Transition from Biocumulus to Sinter. Abstract, presented at 2015 Fall Meeting, AGU, San Francisco, Calif., 14-18 Dec.

Havig, J. R., Hamilton, T. L., Boyd, E. S., Zolotova, N., and Shock, E. L. (2015) Datapocalypse Now: Availability and Use of Fixed Nitrogen for Microbial Metabolism Across the Yellowstone Hot Spring Landscape. Midwest Geobiology Conference, Indiana University, IN, Oct. 12, 2015.

Research Grants/Awards:

Some Liked it Hot: Searching for Early Life in Terrestrial Hot Springs. Royal Society Te Apārangi Marsden Fund. Invited Collaborator: J. Havig, PI: K. Campbell. \$958,000NZD. 01-10-2018 to 12-31-2020.

Collapse of the Ancient Maya: Microbiome and Geochemical Analyses of Reservoir Sediments from Tikal Source of Support. NSF High-Risk Research in Biological Anthropology and Archaeology. Co-I: J. Havig, PI: D. Lentz. \$34,937. 01-01-2017 to 12-31-2018.

Midwest Geobiology Conference, 2016. Ohio Space Grant Consortium: SICHOP Grant. PI: J. Havig. \$2,000. Summer, 2016

Midwest Geobiology Conference, 2016. Agouron Institute Award. PI: J. Havig. \$8,000. Spring, 2016

Geochemical alteration and biological colonization of volcanic substrates: Utilizing the Penn State Steam Plant. Pennsylvania Space Grant Consortium Seed Grant Award. PI: J. Havig. \$3,400. Spring, 2013.

Development of an in-lab hydrothermal artificial mesocosm. Arizona State University Astrobiology Minigrant Award. PI: J. Havig. \$5,172.94. Spring, 2010

Pending (submitted) Grants:

Trace element biosignature for microbial life in modern and ancient ecosystems: implications for the search for evidence of extraterrestrial life. NASA Exobiology. Co-PI: J. Havig, A. Czaja. \$895,184. Submitted: May 24th, 2018.

Cryptic photosynthesis oases: Hypolithic hydrothermal environments as analogs for Archean Earth and Mars terrestrial surfaces. NASA Exobiology. PI: J. Havig. \$409,000. Submitted: May 24th, 2018.

Planned (to be submitted) Grants:

Hydrothermal silica deposits as Mars analogs: Characterizing geochemistry, mineralogy, and spectral variation. (resubmission) NASA Solar System Workings. Co-I: J. Havig, PI: A. Rutledge. \$750,000. NOI: Nov. 15th, 2018, Due: Jan. 31st, 2018.

Interpreting 3.5 billion-year-old hot spring deposits using modern Yellowstone analogs. NASA Habitable Worlds. PI: J. Havig, Science PI: T. Djokic. \$600,000. NOI: Nov. 15th, 2018, Due: Jan. 17th, 2018.

Interpreting S isotope fractionations across pH space: Hot spring water and biofilms from pH 2 to 9 in Yellowstone National Park. NSF Geobiology/Low Temperature Geochemistry. PI: J. Havig, Science PI: A. Bosco. \$450,000. Submission target: Nov. 2018.

Special Activities and Service:

Book proposal: **Havig, J. R.** *The first scientific expedition to Yellowstone: Notes and reflections on the 150th anniversary of the Hayden Expedition of 1871.*

Washington State University Press, Pullman, WA. (accepted proposal, anticipated publication: 2021)

Undergraduate Studies Committee, Dept. of Earth Sciences, UMN (Fall, 2018-present)
Soft Rock Lunch Seminar Organizer, Dept. of Earth Sciences, UMN, Fall 2018 and Spring 2019.

Participant: Astrobiology Grand Tour, Pilbara region of Western Australia, July 02-11, 2018. Run by the Australian Centre for Astrobiology. Hosted by Professor Martin Van Kranendonk, University of New South Wales, Australia.

Co-author, Astrobiology Science Strategy White Paper: *Terrestrial Hot Springs and the Origin of Life: Implications for the Search for Life Beyond Earth.* (Primary author: M. Van Kranendonk). National Academy of Sciences, Engineering, and Medicine, January 8th, 2018.

National Science Foundation Spring Grants Conference, Louisville, KY, June 5-6, 2017.
Primary Editor: *Frontiers in Geosciences Special Research Issue: Redox stratified systems: a special issue related to Fayetteville Green Lake, New York.*

Meeting Co-convenor: Midwest Geobiology Conference (5th annual), October 15, 2016. Hosted by Dept. of Geology and Dept. of Biological Sciences at UC. Co-convenors: Dr. Aaron Diefendorf, Dr. Andrew Czaja, & Dr. Trinity Hamilton.

Special Research Permit – Active sampling permit allowing collection of samples from

hot springs in Yellowstone National Park, Yellowstone Permit Office (#7020). PI.
Reviewer: Chemical Geology, Sedimentary Geology, Frontiers in Terrestrial
Microbiology, JGR Biogeosciences

Shake, Rattle, and Rocks (Jan., 2013) – Outreach program through the Department of
Geosciences for 5th graders in all schools in the greater State College area.

- Co-instructor and curriculum developer, ‘Geochemistry – Life in Extreme Environments’

Meeting Session Chair

Co-Chair, NASA Astrobiology Science Conference (2017)

- Session Title: Modern and ancient biosignatures and the search for life on Mars.
- Co-chairs: Andrew D. Czaja (Univ. of Cincinnati), Andrew Gangidine (Univ. of Cincinnati), and Scott Perl (NASA-JPL)

Co-Chair, AGU 2015, 2016, 2017 Fall Meetings

- Session Title: (Bio-isotopic) message in a (rock record) bottle: who wrote it, how did it get here, & what does it tell us?
- Co-chairs: Andrew D. Czaja (Univ. of Cincinnati), William Leavitt (Wash. Univ.), and Alexandra Turchin (Univ. of Cambridge)

Co-Chair, AGU 2012 Fall Meeting

- Session Title: Integrating Geochemical and Biological Datasets to Predict the Response of Microbial Communities to a Changing Environment
- Co-chair: Eric S. Boyd (MSU)

Co-Chair, AGU 2011 Fall Meeting

- Session Title: Fun with Isotopes: A lighthearted look at a powerful tool.
- Co-chairs: Laura Wasylenki (IU) and Lynda Williams (ASU)

Invited Talks

Geological Society of Minnesota, University of Minnesota, Minneapolis, MN,
October 15, 2018

- Biosignatures: Yellowstone hot springs, 3.5-billion-year-old rocks in Australia, and the search for evidence of past life on Mars.

Department of Geoscience, University of Nevada, Las Vegas, Las Vegas, NV,
September 19, 2018.

- Snow algae drive surface productivity and subglacial weathering at volcanic rock-hosted glaciers in the Pacific Northwest.

Past Global Changes Symposium – Continental archives of Past Global Changes from Quaternary to Anthropocene, University of Minnesota, Minneapolis, MN, May 24, 2018

- Yellowstone hot spring biofilms: Nitrogen isotopes, nitrogenase, and linking geochemistry to geobiology.

Department of Department of Geological and Atmospheric Sciences Iowa State University, Ames, IA, March 30, 2018

- Ancient mysteries and modern analogs: Exploring the Paleoproterozoic through the geochemistry of meromictic Fayetteville Green Lake, N.Y.

Large Lake Observatory, University of Minnesota, Duluth, Duluth, MN,
February 12, 2018

- Fayetteville Green Lake and a potential mechanism for precipitating the largest Mn ore body on Earth following the Great Oxidation Event.

Department of Earth Sciences, University of Minnesota, Minneapolis, MN
October 5, 2017.

- Ancient mysteries and modern analogs: Exploring the Archean and Proterozoic through the geochemistry of present-day sites.

Department of Geology, University of Cincinnati, Cincinnati, OH,
November 18, 2016.

- Zombie Mines and Brain Biofilms: Acid Mine Drainage Impact and Implications for the Archean-Paleoproterozoic Transition.

Department of Earth Sciences, IUPUI, Indianapolis, IN, April 18, 2016

- Yellowstone hot springs and my hunt for a trace element biosignature.

School for the Environment, University of Massachusetts, Boston, March
27, 2014

- A tale of two hot springs: Exploring geochemical change and biological response in dynamic systems.

Thermal Biology Institute, Montana State University, April 5, 2011

- The Geochemical Composition of Hydrothermal Microbial Biofilms

Professional Associations:

Geochemical Society of America/European Geochemical Society

Association of Applied Geochemists

American Geophysical Union

Courses Taught (T)/Teaching Assistant (TA), Developed (D), Semesters (#):

University of Minnesota

Earth Surface Dynamics (T, 1), Astrobiology Freshman Seminar (T, D, 1)

University of Cincinnati

Environmental Studies Capstone (T, D, 4)

Arizona State University

Introductory Geology Lecture (TA, 1), Introductory Geology Lab (TA, 4+),
Geochemistry (TA, 1), Geological Hazards Lab (T, D, 2), Astrobiology (TA, 1),
Historical Geology (TA, 1), Colloquium (TA, 1)

Washington State University

Introductory Geology Lab (TA, D, 3), Organic Chemistry Lab (TA, 1)

Research Field Sites:

Modern hot spring/hydrothermal systems. Primary focus is on Yellowstone National Park, WY to study the geochemistry and microbiology of hydrothermal systems across a wide range of temperature (up to boiling), pH (from less than 2 to almost 10), and element concentrations (as much as over six orders of magnitude). Sampling trips have been at least once a year since 2003, providing a powerful time-series dataset for several dozen hot springs. Chemical analyses conducted in situ on water samples for redox and temperature sensitive chemical compounds. Samples collected for later laboratory analysis include water, biofilm, sediment, rock, and other contextual samples for determining major elements, trace elements, carbon and nitrogen content and isotopes, oxygen and hydrogen isotopes (water only), as well as molecular analysis of biofilm samples. Work has also been done at multiple hydrothermal areas across western Iceland,

and a collaborative effort is being developed to work in multiple hydrothermal areas across the north island of New Zealand. Collaborators include researchers from University of Minnesota, University of Minnesota Duluth, University of Cincinnati, University of New South Wales (Australia), University of Auckland (New Zealand), University of Iceland, University of California Santa Cruz, Massachusetts Institute of Technology, Indiana University Purdue University at Indianapolis (IUPUI), and Arizona State University. Currently maintain an active research permit (#7020) through the Yellowstone Research Permitting Office.

Fayetteville Green Lake, New York. Research conducted on a meromictic lake in coordination with collaborators from Hamilton College on the effects of distinct geochemical gradients formed between the oxygenated upper 20 m, the lower anoxic/euxinic 30 m, and the boundary layer between the two that is inhabited by a photosynthetic purple-sulfur bacterial community. Collaborators include researchers from University of Minnesota, Hamilton College, Pennsylvania State University, Kent State University, and Indiana University Purdue University at Indianapolis (IUPUI).

Cyanobacterial bloom impacts on Midwestern US lakes and reservoirs. Research conducted across Western Ohio from the Cincinnati area through to Lake Erie, and from eastern Indiana through to the Columbus, OH area. Research sites include reservoirs and lakes impacted by cyanobacterial blooms (with a special focus on those with production of the toxin microcystin), and invasive mussel species. Sites sampled include Brookville Reservoir, Crystal Lake, Kaiser Lake, Buckeye Lake, Grand Lake St. Mary's, East Lake, the Maumee River, the Auglaize River, the Sandusky River, Sandusky Bay, and Lake Erie. Currently developing new sites in Minnesota. Collaborators include researchers from University of Minnesota and University of Nebraska.

Glacial systems of the Pacific Northwest and Western USA. Geochemical and microbiological research conducted on the ice-liquid water-sediment/rock interface with the goal of better understanding the geochemical environment and inhabitant microbial communities of these actively changing systems. Sample sites include Mt. Adams in Washington, Mt. Hood and North Sister in Oregon, the Beartooth Mountains in Montana, and the Medicine Bow Mountains and Wind River Range in Wyoming. Collaborators include researchers at the University of Minnesota and Purdue University.

Acid Mine Drainage impacted sites. Geochemical and microbiological research conducted on springs and streams in the Daniel Boone National Forest that are impacted by historical and recent coal mining activities. Sample sites include the Co-Op mining area, Cabin Branch drainage, and the Wildcat Branch Area. Collaborators include researchers from University of Minnesota and University of California Davis.

Ancient terrains of the Pilbara, Western Australia. Archean terrains of the Pilbara including terrestrial hot spring, lacustrine, and marine deposits of the 3.48 Ga Dresser Formation hosting putative microbialites/stromatolites/geyserite. Research focus is on making connections between modern systems in Yellowstone National Park with textures and geochemical signatures found in Dresser Fm. samples. Collaborators include

researchers from University of Minnesota, University of New South Wales (Australia), University of Auckland (New Zealand), and University of Cincinnati.

Professional Contacts:

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