

Curriculum Vitae

ANDREW D. CZAJA

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Professional Appointments

- 2018–present **Associate Professor**, Paleobiology, Biogeochemistry, and Astrobiology.
University of Cincinnati, Dept. of Geology
- 2012–2018 **Assistant Professor**, Paleobiology, Biogeochemistry, and Astrobiology.
University of Cincinnati, Dept. of Geology
- 2008–2012 **Postdoctoral Research Associate**, Geochemistry, Isotope Geochemistry,
Astrobiology. University of Wisconsin, Madison, Dept. of Geoscience.
- 2007 **Lecturer**, University of California, Los Angeles, Dept. of Earth & Space Sciences
- 2006–2007 **Lecturer**, California State University, Fullerton, Dept. of Geological Sciences

Education

- Ph.D., University of California, Los Angeles, 2006, Geology (concentration: Paleobiology)
Thesis title: *Characterization of the geochemical alteration of permineralized fossil plants based on macromolecular structure and composition*
- B.S., University of Connecticut, 1998, Environmental Sciences and Biological Sciences
Summa cum laude, Honors Scholar
Honors thesis title: *Effects of debris-avalanches on surrounding Betula cordifolia in Franconia Notch State Park, New Hampshire*

RESEARCH

Research Interests

I want to know how life originated on Earth, how it evolved, and whether or not life exists elsewhere in the universe. I study Precambrian microfossils with emphasis on those of the Archean and terrestrial/lacustrine and deep marine paleoenvironments. I study the possibility of extraterrestrial life through the search for geochemical and morphological signatures of past terrestrial life that could be applied to past or present extraterrestrial life, particularly on Mars. I am also interested in the evolution of Earth's surface conditions, particularly the transition from anoxic to oxic conditions at the Neoproterozoic–Proterozoic boundary. Finally, I am interested in understanding the processes of fossilization. I approach this topic through studies of geochemical alteration of organic matter and inorganic aspects of such fossilization (e.g., permineralization), as well as geochemical, isotopic, and taphonomic studies of ancient sediments and stromatolites to understand their genesis and evidence of past life preserved within.

Current Projects

- Trace element biosignature for microorganisms preserved in modern and ancient silica (with Prof. Jeff Havig of the University of Minnesota, and Andrew Gangidine of UC)
- Micropaleontological and paleoecological study of 2.5 billion-year-old fossils from across the Kaapvaal Craton of South Africa (with Prof. Nic Beukes of the Univ. of Johannesburg and Andrea Corpolongo of UC)
- Taphonomic study of 2.5-billion-year-old filamentous microfossils from the Kaapvaal Craton of South Africa (with Prof. Nic Beukes of the Univ. of Johannesburg and Kira Lorber of UC)

- Carbon isotope compositions and ecological interpretations of 2.5-billion-year-old coccoidal microfossils from the Kaapvaal Craton, South Africa (with Jeff Osterhout of the University of California, Los Angeles; Dr. Ken Williford of the Jet Propulsion Laboratory; and Prof. John Valley, University of Wisconsin, Madison)
- Thermal alteration of ancient sedimentary rocks as measured by Raman spectroscopy in various lithologies (with several colleagues from the University of Wisconsin, Madison)
- Thermal alteration of phosphatized scale-like objects in Neoproterozoic cherts from Tasmania (with Dr. Leigh Anne Riedman and Prof. Susannah Porter of the UC, Santa Barbara)
- Identifying inclusions in garnets in Paleozoic metamorphic rocks from New England (with Prof. Craig Dietsch, UC Geology)
- Mineral compositions of the carapaces of clam shrimp via UV Raman spectroscopy (with Prof. Thomas Hegna of Western Illinois University and Dr. Christopher Rogers of the Kansas Biological Survey)

Publications

Peer-reviewed articles (* indicates a student led paper)

- *Gangidine A, Havig JR, Fike DA, Jones C, Hamilton TL, and **Czaja AD** (2020) Trace element concentrations in hydrothermal silica deposits as a potential biosignature. *Astrobiology*, 20(3): 1–12.
- *Osterhout JT, **Czaja AD**, Fralick PW, and Bartley JK (2019) Preservation of carbon isotopes in kerogen from thermally altered Mesoproterozoic lacustrine microbialites. *Canadian Journal of Earth Science*, 56: 1017–1026, dx.doi.org/10.1139/cjes-2018-0309
- Manning-Berg AR, Wood RS, Williford KH, **Czaja AD**, and Kah LC (2019) The taphonomy of Proterozoic microbial mats and implications for early diagenetic silicification, *Geosciences*, 9, 40, doi:10.3390/geosciences9010040
- Beaty DW, et al. (70 co-authors) (2019), The potential science and engineering value of samples delivered to Earth by Mars sample return, *Meteoritics & Planetary Science*, 54(S1): S3–S152, doi: 10.1111/maps.13242.
- Czaja AD**, Van Kranendonk MJ, Beard BL, and Johnson CM (2018) A multistage origin for Neoproterozoic layered hematite-magnetite BIF from the Weld Range, Yilgarn Craton, Western Australia. *Chemical Geology*, 488: 125–137.
- Muscente AD, **Czaja AD**, Tuggle J, Winkler C, and Xiao S (2018) Manganese oxides resembling microbial fabrics and their implications for recognizing inorganically preserved microfossils. *Astrobiology*, 18(3): 249–258.
- Guo Z, Peng, X., **Czaja AD**, Chen S, and Ta K (2018) Cellular taphonomy of well-preserved Gaoyuzhuang microfossils: a window into the preservation of ancient cyanobacteria. *Precambrian Research*, 304: 88–98.
- *Vrazo MB, Diefendorf AF, Crowley BE, and **Czaja AD** (2018) Late Cretaceous marine arthropods relied on terrestrial organic matter as a food source: geochemical evidence from the Coon Creek lagerstätte in the Mississippian embayment. *Geobiology*, 16: 160–178.
- Kang J, **Czaja AD**, and Gulians VV (2017) Carbon dioxide as feedstock in selective oxidation of propane. *European Journal of Inorganic Chemistry*, 2017(40): 4757–4762.

- Smith AJB, Beukes NJ, Gutzmer J, **Czaja AD**, Johnson CM, and Nhleko N (2017) Oncoidal granular iron formation in the Mesoarchaeon Pongola Supergroup, southern Africa: Textural and geochemical evidence for biological activity during iron deposition. *Geobiology*, 15: 731–749.
- Czaja AD**, Beukes NJ, and Osterhout JT (2016) Sulfur-oxidizing bacteria prior to the Great Oxidation Event from the 2.52 Ga Gamohaam Formation of South Africa. *Geology*, 44(12): 983–986.
- d'Abzac F-X, **Czaja AD**, Beard, BL, Schauer JJ, and Johnson CM (2014) Iron distribution in size-resolved aerosols generated by UV-femtosecond laser ablation: Influence of cell geometry and implications for *in situ* isotopic determination by LA-MC-ICP-MS. *Geostandards and Geoanalytical Research*, 38(3): 293–309.
- Wilmeth DT, Dornbos SQ, Isbell JL, and **Czaja AD** (2014) Putative domal microbial structures in fluvial siliciclastic facies of the Mesoproterozoic (1.09 Ga) Copper Harbor Conglomerate, Upper Peninsula of Michigan, USA. *Geobiology*, 12: 99–108.
- d'Abzac F-X, Beard BL, **Czaja AD**, Konishi H, Schauer J, and Johnson CM (2013) Iron isotope composition of particles produced by UV-femtosecond laser ablation of natural oxides, sulfides, and carbonates. *Analytical Chemistry*, 85: 11885–11892.
- Li W, **Czaja AD**, Van Kranendonk MJ, Beard BL, Roden EE, and Johnson CM (2013) An anoxic, Fe(II)-rich, U-poor ocean 3.46 billion years ago. *Geochimica et Cosmochimica Acta*, 120: 65–79.
- Shen-Miller J, Aung LH, Turek J, Schopf JW, Tholandi M, Yang M, and **Czaja AD** (2013) Centuries-old viable fruits of *Nelumbo nucifera* Gaertn var. China Antique. *Tropical Plant Biology*, 6(2-3): 53–68.
- Czaja AD**, Johnson CM, Beard BL, Roden EE, Li W, and Moorbath S (2013) Biological Fe oxidation controlled deposition of banded iron formation in the ca. 3,770 Ma Isua Supracrustal Belt (West Greenland). *Earth and Planetary Science Letters*, 363: 192–203.
- Czaja AD**, Johnson CM, Roden EE, Beard BL, Voegelin AR, Nägler TF, Beukes NJ, and Wille M (2012) Evidence for free oxygen in the Neoproterozoic ocean based on coupled iron–molybdenum isotope fractionation. *Geochimica et Cosmochimica Acta*, 86: 118–137.
- Czaja AD**, Johnson CM, Yamaguchi KE, and Beard BL (2012) Comment on “Abiotic Pyrite Formation Produces a Large Fe Isotope Fractionation” by Guilbaud et al. *Science*, 335: 538.
- Beard BL, Handler RM, Scherer MM, Wu L, **Czaja AD**, Heimann A, and Johnson CM (2010) Iron isotope fractionation between aqueous ferrous iron and goethite. *Earth and Planetary Science Letters*, 295: 241–250.
- Czaja AD**, Johnson CM, Beard BL, Eigenbrode JL, Freeman KH, and Yamaguchi KE (2010) Iron and carbon isotope evidence for ecosystem and environmental diversity in the ~2.7 to 2.5 Ga Hamersley Province, Western Australia. *Earth and Planetary Science Letters*, 292: 170–180.
- Czaja AD**, Kudryavtsev AB, Cody GD, and Schopf JW (2009) Characterization of permineralized kerogen from an Eocene fossil fern. *Organic Geochemistry*, 40(3): 353–364.

- Schopf JW, Kudryavtsev AB, **Czaja AD**, and Tripathi AB (2007) Evidence of Archean life: stromatolites and microfossils. *Precambrian Research*, 158(3–4): 141–155.
- Czaja AD**, Kudryavtsev AB, and Schopf JW (2006) New method for the microscopic, nondestructive acquisition of ultraviolet resonance Raman spectra from plant cell walls. *Applied Spectroscopy*, 60(4): 352–355.
- Schopf JW, Kudryavtsev AB, Agresti DG, **Czaja AD**, and Wdowiak TJ (2005) Raman imagery: a new approach to assess the geochemical maturity and biogenicity of permineralized Precambrian microscopic fossils. *Astrobiology*, 5: 333–371.
- Jones CS, Cardon ZG, and **Czaja AD** (2003) A phylogenetic view of low level CAM in *Pelargonium* (Geraniaceae). *American Journal of Botany*, 90: 135–142.
- Cardon ZG, **Czaja AD**, Funk JL, and Vitt P (2002) Periodic carbon flushing to roots of *Quercus rubra* seedlings affects soil respiration and rhizosphere microbial biomass. *Oecologia*, 133: 215–223.
- Schopf JW, Kudryavtsev AB, Agresti DG, Wdowiak TJ, and **Czaja AD** (2002) Images of Earth's earliest fossils? – Reply. *Nature*, 420: 477.
- Schopf JW, Kudryavtsev AB, Agresti DG, Wdowiak TJ, and **Czaja AD** (2002) Laser-Raman imagery of Earth's earliest fossils. *Nature*, 416: 73–76.
- Manuscripts submitted or in preparation (* indicates a student led paper)*
- Riedman LA, Porter SM, and **Czaja AD** (in prep) Globally distributed phosphatic scale microfossils of the mid-Neoproterozoic. To be submitted to *Nature Geoscience*.
- Czaja AD**, Kudryavtsev AB, Cody GD, and Schopf JW (in prep) Kerogen formation during fossilization: a comparison of fossil and experimentally thermally altered modern plants. To be submitted to *Geochimica et Cosmochimica Acta*.
- Czaja AD**, Osterhout JT, Williford KH, and Valley JW (in prep) Stable isotope geochemistry of a late Archean microbial ecosystem: Diversity in the pre-GOE oceans, to be submitted to *Precambrian Research*.
- Peer-reviewed book chapters/encyclopedia entries*
- Muscente AD, **Czaja AD**, Riedman LA, and Colleary C (2017) Organic Matter in Fossils. In *Encyclopedia of Geochemistry*, White WM, Ed. Springer International Publishing.
- Schopf JW, Kudryavtsev AB, Tripathi AB, and **Czaja AD** (2011) Three-dimensional morphological (CLSM) and chemical (Raman) imagery of permineralized fossils, in *Taphonomy: Process and Bias Through Time*, 2nd edition, PA Allison and DJ Bottjer, Eds., Springer, New York.
- Invited papers*
- Czaja AD** (2010) Microbes and the rise of oxygen. *Nature Geoscience*, 3: 522–523.
- Book reviews*
- Czaja AD** (2010) Astrobiology of Earth: The Emergence, Evolution, and Future of Life on a Planet in Turmoil, by Joseph Gale. *Quarterly Review of Biology*, 85(1): 88.

Professional Presentations

Invited Talks

- 2018 “Discovering the Mars 2020 Rover”, University of Cincinnati, Alumni Weekend, *Explore UC* program
- 2017 “Geological fieldwork on another world: plans for Mars sample return and the search for extraterrestrial life”, University of Cincinnati, Undergraduate Astronomy Club meeting (upcoming)
- 2017 “Selecting a field work site from 50 million kilometers away: the landing site selection process for the Mars 2020 mission”, University of Cincinnati, Department of Geography Colloquium Series
- 2017 “Mission to Mars: the landing site selection process for the Mars 2020 mission”, University of Cincinnati, College of Arts & Sciences, Dean’s Advisory Board Meeting
- 2017 “Micron-scale organic geochemical and fluorescence imaging of Earth's most ancient life”, University of Cincinnati School of Design, Art, Architecture, and Planning, Architecture colloquium
- 2017 “Sulfur oxidation, biodiversity, and oxygenation in the Archean”, Harvard University, Department of Earth and Planetary Sciences, Geobiology Seminar
- 2016 “Life in the Archean: Increasing the diversity”, Ohio University, Department of Geological Sciences colloquium
- 2016 “Life in the Archean: Increasing the diversity”, Kent State University, Department of Geology, Palmer Lecture Series
- 2015 “Life in the Archean: Increasing the diversity”, University of South Florida, School of Geosciences colloquium
- 2014 “Possible large planktonic fossil microbes preserved in Neoproterozoic deep water sediments”, Virginia Tech, Department of Geosciences colloquium
- 2013 “Geochemical and paleontological evidence for photosynthesis on the early Earth”, Marine Biological Laboratory (MBL) Microbial Diversity Summer Course
- 2013 “Micron-scale organic geochemical and morphological analyses of Earth's ancient biosphere”, Univ. of Cincinnati, School of Energy, Environment, Biological and Medical Engineering
- 2011 “Evidence for significant free oxygen in the ocean prior to the Paleoproterozoic Great Oxidation Event”, University of Illinois, Chicago, Department of Earth and Environmental Sciences colloquium
- 2011 “Evidence for significant free oxygen in the ocean prior to the ~2.4 Ga Great Oxidation Event”, University of Wisconsin, Madison, Department of Geoscience Weeks Lecture
- 2009 “Iron and carbon isotope evidence for ecosystem and environmental diversity in the ~2.7 to 2.5 Ga Hamersley Province, Western Australia”, University of Wisconsin, Milwaukee, Department of Geosciences colloquium
- 2006 “Understanding the paleobiological afterlife: a modern approach to an ancient problem”, California Institute of Technology, Division of Geological and Planetary Sciences Geology Club colloquium

- 2006 “Understanding the paleobiological afterlife: a spectroscopic comparison of modern and permineralized plant axes”, Carnegie Institute of Washington, Washington, DC, Geophysical Laboratory
- 2004 “Illuminating the black box that is fossil kerogen”, NASA Astrobiology Institute, Forum for Astrobiological Research seminar series

First-author oral presentations at conferences

- 2019 **Czaja AD**. Variable morphological and geochemical preservation of Neoproterozoic organic-walled microfossils: Implications for biosignature detection on Mars and in returned samples. NASA Astrobiology Science Conference, Seattle, WA.
- 2018 **Czaja AD**, Gangidine A, Lorber KN, and Osterhout JT. Diagenesis of organic microfossils and their mineral matrices: Implications for biosignature preservation on Earth and Mars. American Geophysical Union Fall Meeting, Washington, DC. (**Invited**)
- 2018 **Czaja AD**. Searching for signs of life: Morphological and geochemical biosignatures on Earth (and Mars?). Gordon Research Conference on Geobiology, Galveston, TX. (**Invited**)
- 2016 **Czaja AD** and Riedman LA. Mineralogical control on apparent thermal alteration of ancient organic matter as measured by Raman spectroscopy. Geological Society of America Annual Meeting, Denver, CO. *Abstracts with Programs*, Vol. 48, 7.
- 2015 **Czaja AD**, Osterhout JT, and Beukes NJ. Exceptionally large Neoproterozoic spheroidal microfossils from South Africa: possible contributors to the GOE. Geological Society of America Annual Meeting, Baltimore, MD. *Abstracts with Programs*. Vol. 47, No. 7.
- 2014 **Czaja AD**, and Lorber KN. *In situ* Raman spectroscopy and confocal microscopy of 2.5 billion-year-old fossil microorganisms: viable nondestructive techniques for the study of returned Martian samples. American Geophysical Union Fall Meeting, San Francisco, CA. (**Invited**)
- 2013 **Czaja AD**, Johnson CM, Beard BL, Roden EE, Li W, and Moorbath S. Anoxygenic photosynthesis recorded in 3.8 Ga BIFs of the Isua Supracrustal Belt. NASA Astrobiology Institute Early Earth Focus Group, Workshop without Walls.
- 2012 **Czaja AD**, Johnson CM, Beard BL, and Moorbath S. Early Archean Fe oxidation revealed by meso- and micron-scale Fe isotope analyses of the 3.7–3.8 Ga Isua BIFs. *Mineralogical Magazine*, 76(6): 1612. Abstracts of the 22nd Annual V.M. Goldschmidt Conference Montreal, Quebec Canada.
- 2012 **Czaja AD**, Johnson CM, and Beard BL. Meso- and micron-scale Fe isotope analyses of the 3.7–3.8 Ga Isua BIFs reveal Early Archean Fe oxidation. NASA Astrobiology Science Conference, Atlanta, GA.
- 2011 **Czaja AD**, Johnson CM, Roden EE, Beard BL, Voegelin AR, Nägler TF, Beukes NJ, and Wille M. Evidence for free oxygen in the Neoproterozoic ocean based on coupled iron–molybdenum isotope fractionation. American Geophysical Union Fall Meeting, San Francisco, CA.

- 2011 **Czaja AD**, Johnson CM, Roden EE, Beard BL, Voegelin AR, Nägler TF, Beukes NJ, and Wille M. Evidence for free oxygen in the Neoproterozoic ocean. Gordon Research Conference, Geobiology, Ventura, CA. **(Invited)**
- 2010 **Czaja AD**, Johnson CM, Beard BL, and Van Kranendonk MJ. Iron isotopes reveal an abiogenic origin for a 2.75 Ga BIF from the Yilgarn Craton, Western Australia. *Geochimica et Cosmochimica Acta*, 74 (12, S1): A201. Abstracts of the 20th Annual V.M. Goldschmidt Conference Knoxville, TN.
- 2010 **Czaja AD**, Johnson CM, Beard BL, Eigenbrode JL, Freeman KH, and Yamaguchi KE. Iron and carbon isotope evidence for ecosystem and environmental diversity in the ~2.7 to 2.5 Ga Hamersley Province, Western Australia. NASA Astrobiology Science Conference, League City, TX.
- 2009 **Czaja AD**, Johnson CM, Beard BL, Eigenbrode JL, Freeman KH, and Yamaguchi KE. Iron and carbon isotope evidence for ecosystem and environmental diversity in the ~2.7 to 2.5 Ga Hamersley Province, Western Australia. Geological Society of America Annual Meeting, Portland, OR.
- 2008 **Czaja AD**, Kudryavtsev AB, Cody GD, and Schopf JW. Similar fossil ferns having dissimilar organic geochemical preservation, *Geochimica et Cosmochimica Acta*, 72 (12, S1): A193. Abstracts of the 18th Annual Goldschmidt Conference Vancouver, Canada.
- 2007 **Czaja AD**, Kudryavtsev AB, Cody GD, and Schopf JW. Comparison of fossil fern kerogen from two Eocene cherts. Geological Society of America Annual Meeting, Denver, CO.
- 2007 **Czaja AD**, Kudryavtsev AB, Cody GD, and Schopf JW. Fine-scale analysis of permineralized kerogen. 3rd Astrobiology Graduate Conference, San Juan, Puerto Rico.
- 2006 **Czaja AD**. Raman spectroscopic analysis of permineralized organic-walled fossils, Eocene to Archean. 3rd Annual Southern California Geobiology Symposium, University of California, Riverside. Riverside, CA.
- 2005 **Czaja AD**, Kudryavtsev AB, and Cody GD. Toward a better understanding of the paleontological afterlife: a spectroscopic comparison of modern and permineralized plant axes. Geological Society of America Annual Meeting, Salt Lake City, UT.
- 2005 **Czaja AD**. Fossil organic matter: a better understanding of its history. Astrobiology Graduate Conference, Scripps Institution of Oceanography, La Jolla, CA.
- 2004 **Czaja AD**, Cody GD, Kudryavtsev AB, and Schopf JW. Turning ferns into fossils: biogeochemical alchemy. Geological Society of America Annual Meeting, Denver, CO.

First author poster presentations at conferences

- 2018 **Czaja AD**, Osterhout JT, and Gangidine AJ. Mineralogical control of organic matter thermal alteration: Implications for biosignature preservation in returned martian samples, 2nd International Mars Sample Return Conference, Berlin, Germany.
- 2015 **Czaja AD**, Osterhout JT, and Beukes NJ. Fossil evidence of possible contributors to the Great Oxidation Event: Exceptionally large Neoproterozoic microfossils from South Africa. Fourth Annual Midwest Geobiology Symposium, Bloomington, IN.

- 2015 **Czaja AD**, Osterhout JT, and Beukes NJ. Large planktonic microfossils preserved in a deep water facies of the 2.52-Ga-old Gamohaana Formation, South Africa. NASA Astrobiology Science Conference, Chicago, IL.
- 2014 **Czaja AD**, Lorber KN, and Beukes NJ. Filamentous microfossils from the Neoproterozoic Gamohaana Formation of South Africa: Implications for the history of photoautotrophy. Origins2014 Meeting, Nara, Japan.
- 2010 **Czaja AD**, Johnson CM, Beard BL, and Van Kranendonk MJ. Iron isotope evidence for an abiogenic origin of a BIF from the Yilgarn Craton, Western Australia. 5th International Archean Symposium, Perth, WA, Australia.
- 2008 **Czaja AD**, Kudryavtsev AB, Cody GD, and Schopf JW. Geochemical characterization of permineralized kerogen: similar fossils having dissimilar degrees of preservation. NASA Astrobiology Science Conference, San Jose, CA.
- 2006 **Czaja AD** and Kudryavtsev AB. Raman spectroscopic characterization of the thermal history of permineralized fossils. NASA Astrobiology Science Conference, Washington, DC.
- 2006 **Czaja AD**. Spectroscopic analysis of the thermal alteration of permineralized organic matter. *Origins of Life and Evolution of the Biosphere*, 36(3): 311. Abstracts of the 14th International Conference on the Origin of Life and 11th International Society for the Study of the Origin of Life (ISSOL) Meeting, Tsinghua University. Beijing, PRC.
- 2005 **Czaja AD**, Kudryavtsev AB, and Cody GD. Raman spectroscopic analysis of the thermal alteration of permineralized organic matter. NASA Astrobiology Institute Conference, University of Colorado at Boulder, Boulder, CO.
- 2004 **Czaja AD**, Cody GD, and Schopf JW. Turning ferns into fossils: biogeochemical alchemy. *International Journal of Astrobiology*, 3(Suppl. S1): 27. Abstracts of the Astrobiology Science Conference, NASA Ames Research Center, Moffett Field, CA
- 2003 **Czaja AD**, Schopf JW, Storrie-Lombardi MC, and Cody GD. Multi-spectra analysis of geochemical alteration through natural and artificial fossilization. NASA Astrobiology Institute Conference, Arizona State University. Tempe, AZ.
- 2002 **Czaja AD**, Schopf JW, Storrie-Lombardi MC, Kudryavtsev AB, and Bhartiya R. Laser Raman spectroscopic analysis of chemical changes caused by fossilization. 13th International Conference on the Origin of Life and 10th International Society for the Study of the Origin of Life (ISSOL) Meeting, Oaxaca, Mexico.
- 2002 **Czaja AD**, Schopf JW, Storrie-Lombardi MC, Kudryavtsev AB, and Bhartiya R. Laser Raman spectroscopic analysis of biochemical changes caused by fossilization. Astrobiology Science Conference, NASA Ames Research Center, Moffett Field, CA.

Student presentations at conferences (* – graduate; † – undergraduate)

- 2019 *Copolongo A, and **Czaja AD**. Extra-large and morphologically unique microfossils of the 2.52 Ga Gamohaana Formation, South Africa. NASA Astrobiology Science Conference, Seattle, WA.

- 2019 *Gangidine AJ, **Czaja AD**, and Havig JR. A trace element biosignature for life on early Earth and Mars. NASA Astrobiology Science Conference, Seattle, WA.
- 2019 *Gangidine AJ, Walter M, Havig JR, and **Czaja AD**. Living on the edge: Searching for life in the Jezero crater rim. Impacts and Their Role in the Evolution of Life Conference, Tällberg, Sweden.
- 2018 *Gangidine AJ, **Czaja AD**, and Havig JR. The preservation of trace elements in hydrothermal deposits. American Geophysical Union Conference, Washington DC, USA.
- 2018 *Gangidine AJ, **Czaja AD**, and Havig J. Developing a trace element biosignature for early Earth and Mars. 2nd International Mars Sample Return Conference, Berlin, Germany.
- 2017 *Osterhout JT and **Czaja AD**. Stable isotope geochemistry of a late Archean microbial ecosystem: Diversity in the pre-GOE oceans, Geological Society of America Annual Meeting, Seattle, WA.
- 2017 †Perfetta C, **Czaja AD**, and Lentz D. Contaminated water and the collapse of the ancient Maya: Microbiome analyses of reservoir sediments from Tikal. Undergraduate Research Forum, University of Cincinnati, OH.
- 2017 *Gangidine AJ, **Czaja AD**, and Havig J. A novel trace element biosignature for life on early Earth and Mars. NASA Astrobiology Science Conference, Mesa, AZ.
- 2017 *Manning-Berg AR, Tuite M, Williford K, **Czaja AD**, and Kah LC. Exceptional preservation of biomarkers in the 1.2 Ga Angmaat Formation chert, Bylot Supergroup, Baffin Island. NASA Astrobiology Science Conference, Mesa, AZ.
- 2016 *Gangidine AJ, **Czaja AD**, and Havig J. Developing a trace element biosignature in modern and ancient silica deposits – implications for the search for ancient life on Mars. Fifth Annual Midwest Geobiology Symposium, Cincinnati, OH.
- 2016 *Vrazo MB, Diefendorf AF, Crowley BE, and **Czaja AD**. Late Cretaceous marine arthropods relied on terrestrial organic matter as a food source: geochemical evidence from the Coon Creek lagerstätte in the Mississippian embayment. Geological Society of America Annual Meeting, Denver, CO. *Abstracts with Programs*, 48(7).
- 2016 *Lorber KN, **Czaja AD**, and Lee P. Variations in Biosignature Preservation: Geochemical Analysis of Kerogen Comparing Two Mars Analog Environments. Biosignature Preservation and Detection in Mars Analog Environments Conference, Lake Tahoe, NV.
- 2016 *Osterhout JT and **Czaja AD**. Organic geochemistry of a 1.4-billion-year-old evaporitic lake: insights for the Mars 2020 SHERLOC instrument. Biosignature Preservation and Detection in Mars Analog Environments Conference, Lake Tahoe, NV.
- 2015 *Osterhout JT, **Czaja AD**, and Beukes NJ. Isotopic evidence of photoautotrophy in an open marine ecosystem preceding the Great Oxygenation Event. Geological Society of America Annual Meeting, Baltimore, MD. *Abstracts with Programs*. 47(7): 705.
- 2015 *Lorber KN, **Czaja AD**, and Beukes NJ. Geochemical analysis of 2.5 billion-year-old microfossils exhibiting varying degrees of preservation. Fourth Annual Midwest Geobiology Symposium, Bloomington, IN.

- 2015 *Osterhout JT, **Czaja AD**, and Fralick, PW. Organic geochemistry of stromatolites in a 1.4 billion-year-old evaporitic lacustrine ecosystem. Fourth Annual Midwest Geobiology Symposium, Bloomington, IN.
- 2015 *Holbrook C, **Czaja AD**, and Boolchand P. Topological phases in modified oxides, 14th International Conference on the Physics of Non-Crystalline Solids, Niagara Falls, NY.
- 2015 *Holbrook C, Boolchand P, and **Czaja AD**. Onset of rigidity and thresholds in physical properties of barium-borate glasses, XXIV International Materials Research Congress, Cancun, Mexico.
- 2015 *Lorber KN, **Czaja AD**, and Beukes NJ. Preservational variations of 2.5 billion-year-old filamentous microfossils from the Gamohaam Formation of South Africa. NASA Astrobiology Science Conference, Chicago, IL.
- 2015 *Osterhout JT, **Czaja AD**, and Beukes NJ. Morphological and geochemical diversity of deep water microfossils from the 2.52 Ga-old Gamohaam Formation, South Africa. NASA Astrobiology Science Conference, Chicago, IL.
- 2015 *Holbrook C, Boolchand P, and **Czaja AD**. Topological phases in Ba-borate glasses. American Physical Society March Meeting, San Antonio, TX.
- 2014 *Lorber KN, and **Czaja AD**. Investigation of Archean microfossil preservation for defining science objectives for Mars sample return missions. American Geophysical Union Fall Meeting, San Francisco, CA.
- 2014 *Lorber KN, and **Czaja AD**. Current and future technologies employed in the search for Precambrian fossils with possible implications for astrobiology. Gordon Research Conference on the Origin of Life, Galveston, TX.

Selected coauthored presentations at conferences

- 2018 Van Kranendonk M, Baumgartner R, Boyd E, Cady S, Campbell K, **Czaja A**, Damer B, Deamer D, Djokic T, Fiorentini M, Gangidine A, Havig J, Mulkiidjanian A, Ruff S, Thordarson P. Terrestrial hot springs and the origin of life: Implications for the search for life beyond Earth. 49th Lunar and Planetary Science Conference, The Woodlands, TX
- 2017 Porter S, Riedman LA, **Czaja AD**, Calver C. Early Neoproterozoic biostratigraphy: life before the Cryogenian glaciations. International Meeting of Sedimentology, Toulouse, France.
- 2017 Returned Sample Science Board (Carrier BL, Beaty DW, McSween HY, **Czaja AD**, Goreva YS, Hausrath EM, Herd CDK, Humayun M, McCubbin FM, McLennan SM, Pratt LM, Sephton MA, Steele A, and Weiss BP). Strategies for investigating early Mars using returned samples. 4th Conference on Early Mars, abs. #3051.
- 2017 Smith AJB, Beukes NJ, Gutzmer J, Johnson CM, **Czaja AD**, and De Beer FC. Insights into oncoidal morphology and sedimentology of a Mesoarchean granular iron formation from southern Africa using 3D X-ray computed tomography (μ XCT), Abstracts of the V.M. Goldschmidt Conference Paris, France.
- 2017 Farley KA, Williford KH, Beaty DW, McSween HY, **Czaja AD**, Goreva YS, Hausrath EM, Hays LE, Herd CDK, Humayun M, McCubbin FM, McLennan SM, Pratt

- LM, Sephton MA, Steele A, and Weiss BP. Contamination knowledge strategy for the Mars 2020 sample-collecting rover. 48th Lunar and Planetary Science Conference, The Woodlands, TX, abs. #2535.
- 2016 Beaty DW, Weiss BP, McSween HY, **Czaja AD**, Goreva YS, Hausrath EM, Herd CDK, Humayun M, McCubbin FM, McLennan SM, Pratt LM, Sephton MA, Steele A, Hays LE, and Meyer MA. Planning for the Paleomagnetic Investigations of Returned Samples from Mars, American Geophysical Union Fall Meeting, abs. #GP23C-1350.
- 2016 Beaty DW, McSween HY, **Czaja AD**, Goreva YS, Hausrath EM, Herd CDK, Humayun M, McCubbin FM, McLennan SM, Pratt LM, Sephton MA, Steele A, Weiss BP and Hays LE. Planning for the collection of a compelling set of Mars samples in support of a potential future Mars sample return. Geological Society of America Annual Meeting, Denver, CO. *Abstracts with Programs*. Vol. 48, No. 7
- 2016 Beaty DW, McSween HY, **Czaja AD**, Goreva YS, Hausrath EM, Herd CDK, Humayun M, McCubbin FM, McLennan SM, Pratt LM, Sephton MA, Steele A, Weiss BP and Hays LE. Recommended maximum temperature for Mars returned samples. 47th Lunar and Planetary Science Conference, The Woodlands, TX.
- 2013 Zambito JJ IV, Benison KC, **Czaja AD**, and Lorber KN. Possibly ubiquitous preservation of microbes in Permian halite. Geological Society of America Annual Meeting, Denver, CO.

Research Funding

Pending External Grants

2020–2021	NASA Exobiology Program, “Trace elements as a biosignature for microbial life in modern and ancient hydrothermal systems: implications for the search for extraterrestrial life”	PI	\$497,893
2019–2023	NASA Exobiology Program, “Oxidizing Oases in the Paleoproterozoic Moodies Group, Barberton Greenstone Belt, South Africa”	Co-I	\$442,702 (UC portion)
2019–2023	NASA Mars 2020 mission Returned Sample Science Participating Scientist Program, “Searching for morphological and geochemical biosignatures on Mars to return to Earth”	PI	\$394,862
2019	National Science Foundation, EAGER, SGP, Paleontology and paleoecology of a Neoproterozoic microbial ecosystem living just prior to the Great Oxidation Event	PI	\$8,009

Funded External Grants

2016–2017	National Science Foundation, “Novel Molecular and Geochemical Approaches to Watershed Analysis”	Co-I	\$34,937
2014–2015	National Geographic Society (Waitt Grant for Exploration), “Exploration of the 2.5-billion-year-old Biosphere of South Africa”	PI	\$10,680
2016	Paleontological Society (Meeting Fund), “Midwest Geobiology Symposium”	PI	\$1,000

2016	Agouron Institute, “Midwest Geobiology Symposium”	Co-I	\$8,000
2016	Ohio Space Grant Consortium, “Midwest Geobiology Symposium”	Co-I	\$2,000
2015–2016	Paleontological Society (Outreach/Education Program), “Exploring invisible worlds with students using homemade microscopes”	PI	\$2,500
2010	American Philosophical Society, Lewis and Clark Field Scholar in Astrobiology, “Field trip to explore Archean and Proterozoic geology of Western Australia”	PI	\$4,925

Funded Internal Grants

2017	UC Faculty Development Council Individual Grant, “Attending NASA Astrobiology Conference, 2019”	PI	\$1,209
2017–2018	UC Research Council Interdisciplinary Faculty Collaboration Grant, “Water Quality and Its Impact on Pre-Industrial Civilization: Diatom, Microbiome and Microbotanical Analyses of Reservoir Sediments from the Ancient Maya City of Tikal”	PI	\$49,627
2017	UC Faculty Development Council Individual Grant, “Attending Gordon Research Conference on Geobiology”	PI	\$1,825
2017	UC Faculty Development Council Individual Grant, “Attending NASA Astrobiology Conference, 2017”	PI	\$1,300
2014	UC Faculty Development Council Individual Grant, “Learning about the Origin of Life – Conference in Nara, Japan”	PI	\$3,745
2013	UC Faculty Development Council Individual Grant, “SERC Workshop for Early Career Geoscience Faculty”	PI	\$1,390

Student/Postdoctoral Grants and Fellowships

2005	University of California, Los Angeles, Dissertation Year Fellowship		
2005	Eugene Waggoner Scholarship for Sustained Academic Achievement, UCLA, Dept. of Earth & Space Sciences		
2004	Geological Society of America, Student Research Grant		
2002	Sigma Xi, Grants-in-Aid of Research (Fall and Spring)		
2000	National Science Foundation, Graduate Research Fellowship		
2000	Institute of Geophysics and Planetary Physics, Center for the Study of Evolution and the Origin of Life Fellowship (UCLA)		

Grants Received By My Students

2019	Sigma Xi Grants in Aid of Research Award (Gangidine)		\$1,000
2019	NASA Early Career Collaboration Award (Corpolongo)		\$5,000
2019	Paleontological Society, Student Research Grant (Corpolongo)		\$1,200
2019	Ohio Space Grant Consortium SICHOP (Gangidine)		\$5,000
2018	NASA Early Career Collaboration Award (Gangidine)		\$5,000

2018	Ohio Space Grant Consortium SICHOP (Gangidine)	\$5,000
2018	Sigma Xi UC Chapter Grants in Aid of Research Award (Gangidine)	\$2,500
2018	2 nd International Mars Sample Return Conference travel award (Gangidine)	\$3,000
2018	Geological Society of America, Student Research Grant (Gangidine)	\$1,650
2017	American Philosophical Society, Lewis and Clark Field Scholar in Astrobiology (Gangidine)	\$2,600
2017	Geological Society of America, Student Research Grant (Gangidine)	\$1,775
2017	Ohio Space Grant Consortium, Student Grant (Gangidine)	\$5,000
2017	Paleontological Society, Student Research Grant (Gangidine)	\$800
2017	Mars 2020 3 rd Landing Site Workshop, Travel Award (Gangidine)	\$750
2016	University of Cincinnati Graduate Student Governance Association Research Fellowship (Gangidine)	\$1,200
2016	Sigma Xi, UC Chapter Grants in Aid of Research award (Osterhout)	\$3,000
2015	Geological Society of America, Student Research Grant (Osterhout)	\$2,500
2015	NASA Early Career Collaboration Award (Osterhout)	\$5,000
2015	NASA Early Career Collaboration Award (Lorber)	\$5,000
2014	UC Graduate Student Governance Association, Travel Grant (Osterhout)	\$1,120

Selected Declined Proposals

2018	NASA Exobiology Program, “Trace elements as a biosignature for microbial life in modern and ancient hydrothermal systems: implications for the search for extraterrestrial life” (resubmitted Spring 2019)	PI	\$895,184
2018	NASA Exobiology Program, “Oxidizing Oases in the Paleoproterozoic Moodies Group, Barberton Greenstone Belt, South Africa” (resubmitted Spring 2019)	Co-I	\$387,694 (UC portion)
2016	NASA Exobiology Program, “Trace element biosignature for microbial life in modern and ancient organic matter” (resubmitted Spring 2018)	PI	\$599,139
2015	NASA Exobiology Program, “Detection of biochemical and diagenetic effects on preservation of microbial organic matter”	Co-I	\$58,931 (UC)
2014	NASA Exobiology Program, “Life in the deep ocean in deep time: microfossil and geochemical evidence of life in deep shelf environments from the Archean of South Africa”	PI	\$236,248
2014	Simons Foundation, Simons Collaboration on the Origin of Life Investigator Award (Pre-proposal)	PI	
2014	Templeton Foundation, “The world's first biosphere: discovering	PI	\$194,855

	life and biodiversity of Earth's first two billion years”		
2013	Petroleum Research Fund, “Preservation of ancient life and ecosystems in a Mesoproterozoic evaporitic lacustrine system”	PI	\$110,000
2013	National Science Foundation, “Did changes in biogeochemical cycling end production of Paleoproterozoic iron formations?”	PI	\$187,298

Other research positions

2000–2006	Graduate Research Assistant , UCLA, Dept. of Earth and Space Sciences. Precambrian and Eocene paleobiology, microscopic and micro-chemical characterization of permineralized fossils and microfossils
1998–2000	Research Technician , Univ. of Connecticut, Dept. of Ecology and Evolutionary Biology. Plant and soil ecology, plant physiology, forest ecology

Research/Technical Training

- Visible Raman and UV resonance Raman spectroscopy, 2–D and 3–D Raman imagery
- Confocal laser scanning microscopy
- Optical microscopy
- Laser-ablation and solution-based multi-collector inductively coupled plasma mass spectrometry
- Isotope ratio mass spectrometry
- Solid-state ^{13}C –nuclear magnetic resonance spectroscopy
- Pyrolysis–gas chromatography–mass spectrometry
- Scanning electron microscopy and energy dispersive spectroscopy
- X-ray diffraction
- Film and digital photomicrography, 2–D and 3–D image rendering/processing
- Thin section preparation

TEACHING

Summary of Teaching at the University of Cincinnati

Course	Level	Terms taught
Astrobiology (GEOL 1016)	Introductory	Sp 2013, Fa 2013, Fa 2014, Fa 2015, Fa 2016, Fa 2017, Fa 2018
Geochemistry (GEOL 3002/7010)	Upper level undergrad/Graduate	Fa 2017, Fa 2018
Earth’s Early Biosphere (GEOL 4037/6037)	Upper level undergrad/Graduate	Sp 2015, Sp 2018
Microscopy and Raman Spectroscopy for the Geosciences (GEOL 4049C/6049C)	Upper level undergrad/Graduate	Sp 2016
Geology Colloquium (GEOL 4052/7025)	Undergrad/Graduate	Fa 2013 – Sp 2017

Earth History, Life History: The Record of Deep Time (co-taught with Carl Brett) (GEOL 1001C)	Introductory	Fa 2015
Planetary Geology Seminar	Upper level undergrad/Graduate	Fa 2018

Other Courses Taught

2007	Lecturer , UCLA, Dept. of Earth and Space Sciences <i>ESS 5 – Environmental Geology of Los Angeles (Two academic quarters)</i>
2006–2007	Lecturer , California State University, Fullerton, Dept. of Geological Sciences <i>GEOL 101 – Physical Geology (three semesters)</i> <i>GEOL 101L – Physical Geology Laboratory (three semesters)</i>
2000–2005	Teaching Assistant , UCLA Dept. of Earth and Space Sciences <i>ESS 1 – Introduction to Earth Science; ESS 16 – Major Events in the History of Life; ESS 17 – Dinosaurs and Their Relatives; ESS 116 – Paleontology</i> Dept. of Ecology and Evolutionary Biology <i>OBEE 152 – Functional Plant Anatomy</i> Honors College <i>HC 70B – Non-Life to Life, Microbes to Man: Nature is Not Compartmentalized</i>

Students Mentored

As primary advisor

- Jeffrey T. Osterhout, M.S. 2016, "Diversity of Microfossils and Preservation of Thermally Altered Stromatolites from Anomalous Precambrian Paleoenvironments"
- Kira N. Lorber, M.S. (expected to finish in Spring 2020)
- Andrew J. Gangidine, Ph.D. (expected to finish in Spring 2020)
- Andrea Corpolongo, Ph.D. (expected to finish in Spring 2022)

As a committee member

- Mike Lees, M.S. 2017, "Corrosion of Brass Meters in Drinking Water: The Influence of Alloy Composition and Water Chemistry on Metal Release and Corrosion Scale"
- Abigail Padgett, M.S. 2018, "Early-Middle Holocene Cultural and Climate Shifts in NW Africa: Paleoenvironmental Reconstruction Using Stable Isotopes of Land Snail Shells"
- Evan New, M.S. 2018, "Aminochronology and Time-Averaging of Quaternary Land Snail Assemblages from Colluvial Soils in The Madeira Archipelago"
- Cory Perfetta, M.S. (Biological Sciences, expected to finish in 2019)
- Leah Trutschel, Ph.D. (Biological Sciences, expected to finish in 2022)

SERVICE

Professional service

- 2019–present Editor for the journal *Life* (astrobiology section)
- 2015–2018 Member of the Mars2020 mission Return Sample Science Board
- 2015–2018 Member of the Mars2020 mission Landing Site Working Group
- 2015 NSF proposal review panelist
- 2014–present Geological Society of America Campus Representative

- 2014 Organized and chaired proposal sub-panel for the NASA PICASSO program
- 2013–present NASA Astrobiology Institute Early Earth Focus Group co-chair
- 2008 NASA ASTID program proposal review panelist

Ad hoc proposal reviews

National Science Foundation (2), NASA (1), Department of Energy (1), Petroleum Research Fund (1)

Ad hoc manuscript reviews

BioResources, Chemical Geology, Earth and Planetary Science Letters, Environmental Geochemistry and Health, European Journal of Mineralogy, Geobiology, Geochimica et Cosmochimica Acta, Geology, Geomicrobiology Journal, GSA Bulletin, Nature Communications, Nature Geoscience, Palaios, Planetary and Space Science, Precambrian Research, PNAS, Sedimentary Geology, and Sedimentology.

Also reviewed a chapter for the book, *Biosignatures in Astrobiology*

Professional Meeting Service

- 2016 Co-organized the Midwest Geobiology Symposium at the University of Cincinnati
- 2015–2017 American Geophysical Union (AGU), session co-chair
- 2015 NASA Astrobiology Science Conference Student poster judge and meeting mentor for high school students
- 2013 Co-organized a NASA Astrobiology “Workshop without Walls” on the topic of the Hadean Earth
- 2012, ’15, ’17 NASA Astrobiology Science Conference, session chair
- 2011, 2014 AGU OSPA Judge for student presentation competition
- 2010, 2012 Goldschmidt Conference, session co-chair
- 2007 Geological Society of America Annual Meeting, session co-chair

Professional Affiliations

American Geophysical Union, Geochemical Society, Geological Society of America, International Society for the Study of the Origin of Life, Paleontological Society, Phi Beta Kappa, Sigma Xi

University/Departmental Service

- 2018 UC Department of Geology Graduate Program Review Committee
- 2017–present Member of UC College of Arts & Sciences Gateway Concentration Committee
- 2017 Volunteer for *UC Helping Hands* (helping with undergrad move-in day)
- 2016–2017 Departmental STEM Fee Award selection committee
- 2016 Lead discussion of academic paths for UC Preparing Future Faculty program
- 2014–present UC Department of Geology curriculum committee
- 2014 UC Department of Geology doctoral qualifying exam review committee
- 2014 Organized a student trip to the University of Kentucky for lecture by Prof. Andrew Knoll of Harvard, Spring 2014
- 2013 UC Department of Geology doctoral enhancement grant committee
- 2012–present Faculty Advisor to UC Graduate Geoclub

2012 Reviewed UC University Research Council student grant proposals at departmental level

Speakers hosted

2018 Catherine Macris, IUPUI
2017 Sally Potter-McIntyre, Southern Illinois University
2015 Matthew Pasek, University of Southern Florida
2015 Bethany Ehlmann, CalTech, Distinguished Lecturer for the Mineralogical Society of America
2015 Sora Kim, University of Chicago. I wrote a successful proposal to the UC LEAF program to invite Dr. Kim to speak about her research as well as work-life balance for students and faculty in the UC Department of Geology.
2014 Shuhai Xiao, Virginia Tech University
2014 Lori Peek (co-hosted), Co-director of the Center for Disaster and Risk Analysis, Colorado State Univ., for a Taft Research Center Lecture
2014 Steven Dornbos, University of Wisconsin, Milwaukee
2014 Kyle Straub, Distinguished Lecturer for the GeoPRISMS program and arranged for him to give a talk at the Cincinnati Museum Center
2014 Julie Bartley, Gustavus Adolphus College
2013 Sandra Passchier, Montclair University, Distinguished Lecturer from the Consortium for Ocean Science
2013 Jay Zambito, Wisconsin Geological and Natural History Survey
2013 Michael Mischna, Jet Propulsion Laboratory, to present Mars Science Lab results to the University

Education/Public Outreach

2019 Interviewed on Cincinnati 700 WLW about impact of Chinese Moon landing.
2018 Lecture on Mars 2020 mission to the Milford, OH Junior High School Engineering Club
2017 Interviewed on Cincinnati Public Radio (91.7 WVXU) about my participation on the Mars 2020 rover project (See below)
2017 Judge for junior high school science fair at Annunciation Catholic School (Cincinnati, OH)
2016 Presentation on “Time and Space” to Our Lady of Grace Catholic School (Cincinnati, OH)
2015 All-day presentation on the “Invisible World” to 4 sixth grade science classes at Clifton-Fairview School (Cincinnati, OH). I instructed students on how to build and use smartphone microscopes. Materials bought with a grant from the Paleontological Society.
2015 Lecture on “Life as a Precambrian Paleobiologist/Astrobiologist” for students at North Adams High School. Short lecture and Q&A session by video conference (Cincinnati, OH)

Media Attention

My work with the Mars 2020 Returned Sample Science Board and Landing Site Working Group
Miller, M. “[Mars or bust](http://magazine.uc.edu/editors_picks/recent_features/mars2020.html)”, University of Cincinnati Magazine, online edition, June 22, 2017,
http://magazine.uc.edu/editors_picks/recent_features/mars2020.html
Heyne, M. “In Search Of Life On Mars” Radio interview, Cincinnati Edition 91.7 FM WVXU, July 12, 2017, <http://wvxu.org/post/search-life-mars#stream/0>

Press for my 2016 paper in Geology on 2.52-billion-year-old sulfur-oxidizing bacteria

- Schefft, M. “Life before oxygen”, University of Cincinnati Magazine, online edition, November 28, 2016, http://magazine.uc.edu/editors_picks/recent_features/bacteria.html.
- Pappas, S. “2.5-Billion-Year-Old Fossils Predate Earth's Oxygen”, Live Science, December 1, 2016, <https://www.livescience.com/57051-ancient-life-fossils-predate-earth-oxygen.html>
- Schefft, M. “Geologist uncovers 2.5 billion-year-old fossils of bacteria that predate the formation of oxygen” Phys.org, November 29, 2017 <https://phys.org/news/2016-11-geologist-uncovers-billion-year-old-fossils-bacteria.html>.
- Shivni, R. “How Early Life Thrived without Oxygen”, Biotechniques News, January 11, 2017 <http://www.biotechniques.com/news/How-Early-Life-Thrived-without-Oxygen/biotechniques-365418.html?autnID=344275#.WHUKXJL89mU>.
- O’Hare, R. “Life before oxygen: Fossils of 2.5 billion-year-old bacteria reveal organisms thrived despite early Earth's harsh conditions”, DailyMail.com, November 30, 2016, <http://www.dailymail.co.uk/sciencetech/article-3985582/Life-oxygen-Fossils-2-5-billion-year-old-bacteria-reveal-organisms-thrived-despite-early-Earth-s-harsh-conditions.html>.
- TimesLive (South Africa) <http://www.timeslive.co.za/scitech/2016/11/30/Ancient-fossil-find-in-Northern-Cape-rocks-geologists-world>