Cecilia B. Sanders, PhD

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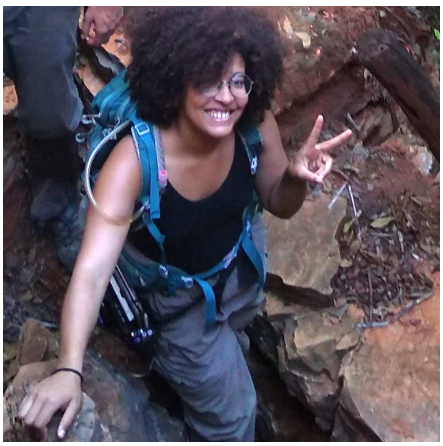

Deep Time Peter Buck Postdoctoral Fellow

Smithsonian National Museum of Natural History

Starting Summer 2024

Assistant Professor

University of Maryland Department of Geology

Starting 2025

Education

2018 – 2022 **Ph.D. Geobiology, Caltech** Geological and Planetary Sciences.
Doctoral Thesis: *Geological and Geochemical Explorations of the Salitre Formation Phosphorite, Eastern Brazil.* https://doi.org/10.7907/rd4m-7x08

2016 – 2018 **M.Sc. Planetary Science, Caltech** Geological and Planetary Sciences.

2012 – 2016 **B.A. Earth and Planetary Sciences and Astrophysics, Harvard University**
Senior thesis title: *Impact gardening as a mechanism for hydrothermal alteration and atmospheric evolution on Noachian Mars*.
Junior thesis title: *When planets breathe – Models constrain the circumstances for detection of biomarker gases on the terrestrial exoplanets of M Dwarfs*.

Awards

Awards and Achievements

2024 – present **Deep Time Peter Buck Postdoctoral Fellowship**, Smithsonian National Museum of Natural History.

2022 – 2024 **Morton K. Blaustein Postdoctoral Fellowship**, Johns Hopkins Department of Earth and Planetary Sciences.

2016 – 2022 **NSF Graduate Research Fellowship**, National Science Foundation.

2020 **Award for educational outreach**, Caltech Division of Geological and Planetary Sciences.

2018 **Ian Campbell Award for outstanding achievement in field geology courses**, Caltech Division of Geological and Planetary Sciences.

2015 **Leo Goldberg Prize in Astronomy**, Harvard-Smithsonian Center for Astrophysics. Junior thesis award.

Research Publications

Journal Articles

1 **Sanders**, **C. B.**, Present, T., Marroquin, S., & Grotzinger, J. (2024). Sulfur geochemistry of the salitre formation phosphorites: Implications for the role of microbial ecology and sulfur cycling in phosphogenesis on an ediacaran carbonate platform. *Geochimica et Cosmochimica Acta, 367*.
https://doi.org/10.1016/j.gca.2023.12.033

2. **Sanders**, **C. B.**, Eiler, J., & Grotzinger, J. (2023). Paragenesis of an ediacaran carbonate-platform phosphorite: Constraints from optical petrography and texture-specific clumped isotope paleothermometry. *Sedimentary Geology*, *444*. https://doi.org/10.1016/j.sedgeo.2022.106316

3. **Sanders**, **C. B.**, & Grotzinger, J. P. (2021). Sedimentological and stratigraphic constraints on depositional environment for Ediacaran carbonate rocks of the São Francisco Craton. *Precambrian Research*, *363*. https://doi.org/10.1016/j.precamres.2021.106328

4. Wordsworth, R., Kalugina, Y., Lokshtanov, S., Viagasin, A., Ehlmann, B., Head, J., **Sanders**, **C. B.**, & Wang, H. (2014). Transient reducing greenhouse warming on early mars. *Geophysical Research Letters*, *44*(2), 665–671. https://doi.org/10.1002/2016GL071766

Conference Proceedings

1. **Sanders**, **C. B.** (2023). Oral presentation: Interrogating the role of microorganisms in the genesis of sedimentary phosphorite deposits at the Precambrian-Cambrian boundary, In *Mid-Atlantic Geobiology Symposium*, Newark, DE.

2. **Sanders**, **C. B.**, & Grotzinger, J. (2020). Invited oral presentation: Sedimentary context and diagenetic history of phosphatic microbialites, Ediacaran Una-Bambuí carbonate platform, Eastern Brazil, In *American Geophysical Union Fall Meeting (ICEEE 2020)*, Virtual.

3. **Sanders**, **C. B.**, Orphan, V. J., Ehlmann, B. L., & Grotzinger, J. P. (2019). Oral presentation: Sweet Honey in the Rock – Cultivating and characterizing the biosignatures of chemolithotrophic microorganisms on Mars analog substrates, In *16th Annual Southern California Geobiology Symposium*, Pasadena, CA.

4. **Sanders**, **C. B.**, Orphan, V. J., Ehlmann, B. L., & Grotzinger, J. P. (2018a). Poster: Sweet Honey in the Rock – Cultivating and characterizing the biosignatures of chemolithotrophic microorganisms on Mars analog substrates, In *American Geophysical Union Fall Meeting 2018*, Washington, DC.

5. **Sanders**, **C. B.**, Orphan, V. J., Ehlmann, B. L., & Grotzinger, J. P. (2018b). Poster: Sweet Honey in the Rock – Cultivating and characterizing the biosignatures of chemolithotrophic microorganisms on Mars analog substrates, In *Simons Collaboration on the Origins of Life*, New York, NY.

6. **Sanders**, **C. B.**, & Wordsworth, R. (2016). Oral presentation: Impact gardening as a mechanism for hydrothermal alteration and atmopspheric evolution on Noachian Mars (Abstract 2634), In *47th lunar and planetary science conference*, The Woodlands, TX.

7. **Sanders**, **C. B.**, & Ciesla, F. (2014). Poster: Explaining the noble gas content of the planets – Theoretical models for argon-trapping by amorphous ices in the solar nebula, In *American Geophysical Union Fall Meeting (ICEEE 2014)*, San Francisco, CA.

Research Experience

2022 – present
Characterizing different styles of phosphate mineralization in Ediacaran and Lower Cambrian sedimentary rocks of Mongolia and Kazakhstan, through sedimentology, stratigraphy, petrography, and spatially resolved elemental and isotopic analyses. Johns Hopkins Department of Earth and Planetary Sciences. Advised by Profs. Emmy Smith and Maya Gomes.

2018 – 2022
Exploring mechanisms of phosphogenesis in Ediacaran Carbonate formations of the São Francisco Craton, Eastern Brazil, through sedimentology, stratigraphy, petrography, and spatially resolved elemental and isotopic analyses (Δ_{47}, $\delta^{13}C$, $\delta^{18}O$ of carbonate ions in calcite, dolomite, and francolite, $\delta^{34}S$ of sulfate in calcite, dolomite, and francolite, and $\delta^{34}S$ of sulfide in pyrite and extracted chromium-reducible sulfur). Caltech Division of Geological and Planetary Sciences. Advised by Profs. John Grotzinger and John Eiler.

Research Experience (continued)

2016 – 2018 **Cultivation and detection of microbial biosignatures on Mars-analog materials.** Caltech Division of Geological and Planetary Sciences. Advised by Profs. Bethany Ehlmann and Victoria Orphan.

2016 – 2019 **SIMS analysis for C-isotopes of microfossils in Gunflint Chert.** Caltech Division of Geological and Planetary Sciences. Advised by Prof. John Grotzinger and Kenneth Williford.

2015 – 2016 **Combined petrographic and theoretical study of meteor impacts as drivers of hydrothermal processes on Noachian Mars and analogs.** Harvard University Department of Earth and Planetary Sciences. Advised by Profs. Robin Wordsworth and Francis Macdonald.

2014 – 2015 **Modeling of transmission spectra of oxygen- and methane-bearing atmospheres of Earth-like planets around M-dwarf stars.** Harvard-Smithsonian Center for Astrophysics. Advised by Prof. David Charbonneau.

Summer 2014 **Modeling of argon-trapping by amorphous ices in solar nebulae: a possble mechanism for noble-gas delivery to young planets.** University of Chicago, Leadership Alliance. Advised by Prof. Fred Ciesla.

2013 – 2014 **Preparation of samples for rare sulfur isotope analysis.** Harvard University Department of Earth and Planetary Sciences. Advised by Prof. David Johnston.

Summer 2013 **Characterization of Mars-analog geological samples using remote IR spectroscopy.** Caltech Division of Geological and Planetary Sciences, Jet Propulsion Laboratory, Summer Undergraduate Research Fellowship (SURF) Program. Advised by Prof. Bethany Ehlmann and Glenn Sellar.

Summer 2012 **Remote detection of methane on Mars via echelle spectroscopy data from Keck2.** NASA Goddard Space Flight Center, Center for Astrobiology. Advised by Geronimo Villanueva.

Summer 2011 **Characterization of surface ices on Saturn's icy moons via Cassini's Composite Infrared Spectrometer data.** NASA Goddard Space Flight Center. Advised by Terry Hurford.

Teaching, Outreach, and Science Communication

2023 – 2024 **Instructor**. *The Johns Hopkins University Dept. of Earth & Planetary Sciences*. Curriculum design, lecture, and lab instruction for graduate/undergraduate course, *How to Live Forever: The Making of the Geologic Record of Life*.

2022 – 2023 **Instructor**. *The Johns Hopkins University Dept. of Earth & Planetary Sciences*. Curriculum design, lecture, and lab instruction for Special Opportunities in Undergraduate Learning (SOUL) Course 23, *Beyond Bones: Microorganisms in the Rock Record*.

Oct. 2023 **Content Consultant and Interviewee for PBS NOVA**. *PBS NOVA and The BBC*. Scientist appearing in *Ancient Earth: Frozen* television episode.

2022 – 2023 **Diversity Postdoctoral Alliance Committee (DPAC) HBCU Mentoring Program**. *The Johns Hopkins Postdoctoral Association*. Mentoring/advising for undergraduate students at Mid-Atlantic HBCUs

2017 – 2021 **Visiting Scientist Program**. *Caltech Center for Teaching, Learning, and Outreach* (CTLO) and *Pasadena Unified School System* (PUSD). Science curriculum design and both in-person and virtual in-class teaching experience with Grades K-5.

2017 – 2020 **Science Night Exhibitions**. *Caltech Center for Teaching, Learning, and Outreach* (CTLO) and *Pasadena Unified School System* (PUSD). Series of extra-curricular STEM expos for K-12 students and families in Pasadena.

Teaching, Outreach, and Science Communication (continued)

2018 – 2019 **Teaching Assistant**. *Caltech Division of Geological and Planetary Sciences*. Ge 11b/104: Introduction to Geobiology.

2017 – 2018 **Teaching Assistant**. *Caltech Division of Geological and Planetary Sciences*. Ge 116: Analytical Methods.

Jul. 2019 **Caltech Astro Virtual Lecture Series**. *Caltech Astronomy*. Virtual public lecture. *You'll know it when you see it: Defining, describing, and detecting life in the universe*. https://youtu.be/VyzQpk2m5Hk

Jun. 2019 **Real Science**. CaltechLive! virtual public talk, discussion mediation for Grades 3-8. *Beyond Bones: Interrogating the fossil record of small, soft, profoundly Earth-shaping organisms in the Precambrian*.

Nov. 2019 **Southern California Paleontological Society Lecture Series**. Public lecture for all ages. *Micropaleontology: Interrogating the fossil record of small, soft, profoundly Earth-shaping organisms in the Precambrian*.

May 2019 **Astronomy On Tap – Los Angeles**. Public talk. *Pebbles on the shore: Reconstructing ancient alien habitats on Earth and Mars*.

Apr. 2019 **Science Symposium Talk**. Lecture at Sequoyah High School Science Symposium. *Geomicrobiology*.

Reel Science. CaltechLive! Public talk, discussion mediation for Grades 3-8. *Galapagos: The islands that changed the world*.

Feb. 2017 **Caltech Astro Lecture Series**. *Caltech Astronomy*. Panelist, facilitating discussion after public lecture. *The Science of Star Trek – Michael Wong, Ph.D.*

Reviewer Experience

2022 – present *Proceedings of the National Academy of Sciences* (2 articles), *Precambrian Research* (1 article), *Sedimentary Geology* (1 article), *Global and Planetary Change* (1 article), *Acta Geochimica* (1 article)

Skills

Analytical Methods SEM/EDS/EBSD; XRF; XRD; Raman Spectroscopy; micro CT; SIMS/nanoSIMS; IRMS for Δ_{47}, $\delta^{13}C$, and $\delta^{18}O$ of carbonate in calcite, dolomite, and francolite, $\delta^{34}S$ of sulfate in calcite, dolomite, and francolite, and $\delta^{34}S$ of sulfide in pyrite and extracted chromium-reducible sulfur; optical imaging and characterization of petrographic thin sections; chemical assays for sulfur and iron species, maintenance of microbial cultures; preparation of mineralogical and biological samples for any of the previously listed methods; field geology (campaign logistics, mapping, description, measurement, geological sample collection and archiving); CRS extraction; bulk CAS and PAS extraction and purification; and trace CAS extraction and purification.

Coding Python, Matlab, LaTeX

Misc. Scientific writing, hand and digital illustration, graphic design (logos, posters, documents, infographics), public speaking, in-classroom teaching (K-12, undergraduate, and graduate-level courses)

References

- **Emmy Smith**, *Associate Professor*

  Johns Hopkins University Department of Earth & Planetary Sciences
  3400 N. Charles Street, Olin Hall 208
  Baltimore, MD 21218

  E-mail: **efsmith@jhu.edu**
  Phone: +1 (214) 384 8884

  Relationship: Postdoctoral Fellowship Adviser

- **John P. Grotzinger**, *Harold Brown Professor of Geology, Ted and Ginger Jenkins Leadership Chair*

  Caltech Division of Geological and Planetary Sciences
  1200 E California Blvd, MC 170-25
  Pasadena, CA 91125

  E-mail: **grotz@gps.caltech.edu**
  Phone: +1 (626) 395 6785

  Relationship: Doctoral Thesis Adviser, Collaborator

- **John Eiler**, *Robert P. Sharp Professor of Geology and Geochemistry*

  Caltech Division of Geological and Planetary Sciences
  1200 E California Blvd, MC 100-23
  Pasadena, CA 91125

  E-mail: **eiler@gps.caltech.edu**
  Phone: +1 (626) 395 6942

  Relationship: Doctoral Thesis Committee Member, Collaborator

- **Victoria Orphan**, *James Irvine Professor of Environmental Science and Geobiology, Allen V.C. Davis and Lenabelle Davis Leadership Chair, Center for Environmental Microbial Interactions, Director: Center for Environmental Microbial Interactions*

  Caltech Division of Geological and Planetary Sciences
  1200 E California Blvd, MC 100-23
  Pasadena, CA 91125

  E-mail: **vorphan@gps.caltech.edu**
  Phone: +1 (626) 395 1786

  Relationship: Doctoral Thesis Committee Member, Collaborator

- **Kathryn "Kitty" Cahalan**, *Outreach Program Manager*

  Caltech Center for Teaching, Learning, & Outreach
  1200 E California Blvd, MC 369-86
  Pasadena, CA 91125

  E-mail: **kcahalan@caltech.edu**
  Phone: +1 (626) 395 2468

  Relationship: Coordinator/Advisor for Education/Outreach Volunteer Work