

RACHEL Y. SHEPPARD

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PROFESSIONAL APPOINTMENTS

Institut d'Astrophysique Spatiale, Université Paris-Saclay <i>Marie Curie Postdoctoral Fellow</i>	June 2023 - present <i>Orsay, France</i>
Planetary Science Institute <i>Research Scientist</i>	August 2022 - present <i>Tucson, AZ</i>
Jet Propulsion Laboratory, Caltech <i>Postdoctoral Fellow</i>	August 2020 - September 2022 <i>Pasadena, CA</i>

EDUCATION

Brown University, Providence, RI

- ◊ **2020 Ph.D.**, Earth, Environmental & Planetary Sciences
Spatial and temporal variations in the chemistry and mineralogy of mafic lacustrine systems on Earth and Mars. Advisor: Ralph Milliken
- ◊ **2017 M.Sc.**, Earth, Environmental & Planetary Sciences
Spectroscopic analysis of iron cycling in a terrestrial ultramafic lake and its implications for martian sedimentary systems. Advisor: Ralph Milliken

Columbia University, New York, NY

- ◊ **2013 B.A.**, Earth Science
Extractable organic molecules are an effective thermometer of both naturally and artificially heated fault rocks. Advisors: Pratigya Polissar & Heather Savage

RESEARCH GRANTS

- 2023-2026** Mars Data Analysis Program (MDAP), NASA ROSES. **Co-I.** “Analyses of sulfates in chaos regions on Mars.” (\$540,000.)
- 2023-2025** Marie Skłodowska-Curie Actions research fellowship, European Commission (MSCA-EF). **PI.** “Spectral diversity within Ryugu.” (\$210,000.)
- 2022-2025** Mars Science Laboratory Participating Scientist Program (MSL-PSP), NASA ROSES. **PI.** “Understanding Mg-sulfate distribution, hydration state, and crystallinity in Mt. Sharp.” (\$300,000.)
- 2022** Spontaneous Research and Technology Development Program, Jet Propulsion Laboratory. **Co-I.** “Novel reaction design to test martian weathering.” (\$40,000.)
- 2022** Data Science Working Group, Jet Propulsion Laboratory. **Co-I.** “Developing machine learning models to facilitate the untargeted identification and classification of organics in complex mixtures via tandem mass spectrometry.” (\$50,000.)
- 2020-2022** Strategic Research and Technology Development Program, Jet Propulsion Laboratory. **Science PI.** “Experimental constraints on groundwater driven redox gradients on Mars.” (\$300,000.)

MISSION INVOLVEMENT

Hayabusa2 <i>MicrOmega Team</i>	June 2023 - present
Mars Science Laboratory (MSL) <i>Participating Scientist</i> <i>Science Team Collaborator</i>	May 2016 - present <i>2022-present</i> <i>2016-2022</i>

PEER-REVIEWED PUBLICATIONS (†STUDENT)

E. M. Martinez[†], L. E. Rodriguez, **R. Y. Sheppard**, S. Yi[†], C. Cid, A. Khodayari, L. M. Barge. Nitrate reactivity in iron (oxy)hydroxide systems: Effect of pH, iron redox state, and phosphate. Under review, *Environmental Science & Technology*.

2023 H. T. Manelski[†], **R. Y. Sheppard**, A. A. Fraeman, R. Wiens, J. Johnson, J. Frydenvang, N. Lanza, O. Gasnault. Compositional Variations in Sedimentary Deposits in Gale Crater as seen by ChemCam Passive and Active Spectra. *Journal of Geophysical Research: Planets*. 128, 3.

2022 **R. Y. Sheppard**, R. E. Milliken, K. M. Robertson. Presence of clay minerals can obscure spectral evidence of Mg sulfates: Implications for orbital observations of Mars. *Icarus*. 383, 115083.

2022 R. S. Vachula, **R. Y. Sheppard**, A. H. Cheung[†]. Preservation biases are pervasive in Holocene paleofire records. *Palaeogeography, Palaeoclimatology, Palaeoecology*. 602, 111165.

2022 C. Lee, J. M. Weber, L. E. Rodriguez, **R. Y. Sheppard**, L. M. Barge, E. L. Berger, & A. S. Burton. Chirality in organic and mineral systems: A review of reactivity and alteration processes relevant to prebiotic chemistry and life detection missions. *Symmetry* special issue, "Chirality, Prebiotic Chemistry, and the Origins of Life." 14(3), 460.

2022 M. Prakash[†], J. M. Weber, L. E. Rodriguez, **R. Y. Sheppard**, L. M. Barge. Database on carbon reduction: Implications for future research. *International Journal of Astrobiology*, 21(6), 423-440.

2021 **R. Y. Sheppard**, M. T. Thorpe, A. A. Fraeman, V. K. Fox, R. E. Milliken. Merging perspectives on secondary minerals on Mars: A review of ancient water-rock interactions in Gale crater inferred from orbital and in situ observations. *Minerals* special issue, "Expanding Views of Clays, Oxides, and Evaporites on Aquaplanets in the Solar System," 11(986).

2021 **R. Y. Sheppard**, R. E. Milliken, J. M. Russell, M. D. Dyar, E. Sklute, H. Vogel, M. Melles, S. Bijaksana, A. K. M. Hasberg, & M. A. Morlock. Iron mineralogy and sediment color in a 100 m drill core from Lake Towuti, Indonesia reflect catchment and diagenetic conditions. *Geochemistry, Geophysics, Geosystems*. 22, e2020GC009582.

2020 **R. Y. Sheppard**, R. E. Milliken, Y. Itoh, & M. Parente. Updated perspectives and hypotheses on the mineralogy of Lower Mt. Sharp, Mars, as seen from orbit. *Journal of Geophysical Research: Planets*. 26.

2020 J. Russell, H. Vogel, S. Bijaksana, M. Melles, A. Deino, A. Hafidz, A. Hasberg, M. Morlock, T. von Rintelen, **R. Y. Sheppard**, B. Stelbrink, & J. Stevenson. The Late Quaternary tectonic, biogeochemical, and environmental evolution of ferruginous Lake Towuti, Indonesia. *Palaeogeography, Palaeoclimatology, Palaeoecology*. 556, 109905.

2019 **R. Y. Sheppard**, R. E. Milliken, J. M. Russell, M. D. Dyar, E. Sklute, H. Vogel, M. Melles, S. Bijaksana, A. K. M. Hasberg, & M. A. Morlock. Characterization of iron in Lake Towuti sediment. *Chemical Geology*. 512, 11-30.

2017 B. C. Johnson, **R. Y. Sheppard**, A. C. Pascuzzo, E. A. Fisher, & S. E. Wiggins. Porosity and salt content determine if subduction can occur in Europa's ice shell. *Journal of Geophysical Research: Planets*. 122.

2015 **R. E. Sheppard**, P. J. Polissar, & H. M. Savage. Organic thermal maturity as a proxy for frictional fault heating: experimental constraints on methylphenanthrene kinetics at earthquake timescales. *Geochimica et Cosmochimica Acta*. 151, 103-116.

2014 H. M. Savage, P. J. Polissar, **R. Sheppard**, C. D. Rowe, & E. E. Brodsky. Biomarkers heat up during earthquakes: New evidence of seismic slip in the rock record. *Geology*. 42(2), 99-102.

OTHER PUBLICATIONS (TRADE JOURNALS, WHITE PAPERS, ETC.)

2021 Revolutionizing Access to the Mars Surface. Editors: C. J. Culbert, B. L. Ehlmann, A. A. Fraeman, editors. Final Workshop Report for the W. M. Keck Institute for Space Studies (KISS), Pasadena, CA.

2015 **R. E. Sheppard**, W. Wang, & T. Moses. Analysis of melee diamonds using FTIR spectroscopy. *Gems & Gemology*. 51(1).

2015 **R. E. Sheppard**, U. D'Haenens-Johansson, K. S. Moe, & W. Wang. HPHT synthetic diamond melee in high-quality mounted jewelry piece. *Gems & Gemology*. 51(1).

2014 W. Wang, M. Altobelli, C. Dieck, & **R. E. Sheppard**. Screening of small yellow melee for treatment and synthetics. *Gems & Gemology*. 50(4).

AWARDS & FELLOWSHIPS

2022 Seal of Excellence, European Commission, Marie Skłodowska-Curie Actions.

2019 Dissertation Fellowship, Brown University (6 mo.).

2017, 2015 NASA Group Achievement Award, MSL Science and Operations Team.

2015-2018 Presidential Fellowship, Brown University (3 yr.).

2013 Walter C. Pitman III Award, Columbia University Dept. Earth & Environmental Sciences.

CONFERENCE PRESENTATIONS (LAST 5 YEARS ONLY, *ORAL PRESENTATIONS)

2023 **R. Y. Sheppard***, J. M. Weber, L. E. Rodriguez, E. M. Hausrath, L. M. Barge. The effect of clay minerals on Li in a simulated martian groundwater environment. Goldschmidt, Lyon, France.

2023 **R. Y. Sheppard***, W. Rapin, V. Tu, L. Lim, T. Gabriel, M. Hughes, A. Fraeman, D. Vaniman. Updated orbital perspective of the Mt. Sharp upper sulfates in preparation for in situ exploration. European Geophysical Union, Vienna, Austria.

2023 **R. Y. Sheppard**, W. Rapin, V. Tu, L. Lim, T. Gabriel, M. Hughes, A. Fraeman, D. Vaniman. Updated orbital perspective of the Mt. Sharp upper sulfates in preparation for in situ exploration. Lunar and Planetary Science Conference, The Woodlands, TX.

2022 **R. Y. Sheppard**, A. A. Fraeman, L. M. Barge, J. M. Weber, L. Rodriguez, E. Martinez. Laboratory sediment columns to explore habitability of the martian subsurface under different groundwater conditions. AbSciCon, Atlanta, GA.

2022 R. Y. Sheppard*, A. A. Fraeman, L. M. Barge, J. M. Weber, L. Rodriguez, E. Martinez. Laboratory sediment column simulations of chemical and redox gradients in the martian groundwater environment. Lunar and Planetary Science Conference, The Woodlands, TX.

2021 R. Y. Sheppard*, L. Barge, A. A. Fraeman, J. M. Weber, L. Rodriguez, E. Flores, E. Martinez. Laboratory sediment column simulations of chemical and redox gradients in the martian groundwater environment. American Geophysical Union Fall Meeting, New Orleans, LA.

2021 R. Y. Sheppard, R. E. Milliken, J. M. Russell, M. D. Dyar, E. C. Sklute, S. Bijaksana, M. Melles, & H. Vogel. Mineral and chemical changes in a 100 m long sediment core from Lake Towuti, Indonesia and implications for mafic lacustrine sediments in Gale crater, Mars. American Geophysical Union Fall Meeting, New Orleans, LA.

2021 R. Y. Sheppard*, R. E. Milliken, & K. M. Robertson. Presence of clay minerals can obscure spectral evidence of Mg sulfates: Implications for orbital observations of Mars. Lunar and Planetary Science Conference, The Woodlands, TX.

2020 R. Y. Sheppard, R. E. Milliken, & K. M. Robertson. Reflectance measurements of clays and sulfates under Mars-like temperature and relative humidity cycles and implications for clay-sulfate assemblages in Gale crater. Lunar and Planetary Science Conference, The Woodlands, TX. (*Canceled due to Covid-19.*)

2020 R. Y. Sheppard, R. E. Milliken, J. M. Russell, M. D. Dyar, E. C. Sklute, S. Bijaksana, M. Melles, & H. Vogel. Mineral and chemical changes in a 100 m long sediment core from Lake Towuti, Indonesia and implications for mafic lacustrine sediments in Gale crater, Mars. Lunar and Planetary Science Conference, The Woodlands, TX. (*Canceled due to Covid-19.*)

2019 R. Y. Sheppard*, R. Milliken, & K. M. Robertson, Cycling of hydrous minerals and implications for the martian hydrological cycle. American Geophysical Union Fall Meeting, San Francisco, CA.

2019 R. Y. Sheppard, R. Milliken, Y. Itoh, & M. Parente. Mineral stratigraphy around Mt. Sharp suggests aqueous processes affected the entire mound: directions for upcoming rover observations from orbital data. Ninth International Conference on Mars, Pasadena, CA.

2019 R. Y. Sheppard, R. Milliken, Y. Itoh, & M. Parente. Lateral continuity of mineralogical and morphological contacts in Mt. Sharp: linking upcoming rover observations and orbital data. Lunar and Planetary Science Conference, The Woodlands, TX.

2018 R. Y. Sheppard*, R. Milliken, Y. Itoh, & M. Parente. Assessing Lateral Variations in the Mineralogical Stratigraphy of Mt. Sharp: Linking Rover and Orbital Observations. American Geophysical Union Fall Meeting, Washington, D.C.

2018 R. Y. Sheppard*, R. Milliken, J. Russell, H. Vogel, M. Melles, & S. Bijaksana. Signatures of iron cycling in a terrestrial redox-stratified lake and implications for Gale Crater, Mars. Lunar and Planetary Science Conference, The Woodlands, TX.

INVITED EXTERNAL TALKS & TEAM MEETINGS (LAST 5 YEARS ONLY)

2022 R. Y. Sheppard. Geoscience Research Colloquium, UNLV, Las Vegas, NV.

2022 R. Y. Sheppard. Planetary Science Institute, Tucson, AZ.

2022 R. Y. Sheppard. Astrobiology & Planetary Science Colloquium, Georgia Tech, Atlanta, GA.

2021 R. Y. Sheppard. Research Colloquium, EAPS, Purdue, West Lafayette, IN.

2020 R. Y. Sheppard. Research Colloquium, GPS, Caltech, Pasadena, CA.

2020 R. Y. Sheppard. Research Colloquium, Jet Propulsion Laboratory, Pasadena, CA. (*Cancelled due to Covid-19*)

2020 R. Y. Sheppard. Geochemistry Colloquium, Lamont-Doherty Earth Observatory, Palisades, NY.

2019 R. Y. Sheppard. Mars Science Laboratory team meeting, NASA Goddard, Greenbelt, MD.

2018 R. Y. Sheppard. Towuti Drilling Project team meeting, Makassar, Indonesia.

PRESENTATIONS: CONTRIBUTING AUTHOR (LAST 5 YEARS ONLY, †STUDENT)

2023 T. C. Marlin[†], J. M. Weber, **R. Y. Sheppard**, S. M. Perl, L. M. Barge. Chemical gardens as analogs for prebiotic chemistry on ocean worlds. European Astrobiology Network Association Conference, Madrid, Spain.

2023 W. Rapin, G. Dromart, J. Schieber, B.C. Clark, L. Kah, D. Rubin, S. Gupta, A. Roberts, G. Caravaca, **R. Y. Sheppard**, E. Dehouck, S. Le Mouelic, A. Bryk, B. Dietrich, P. Gasda, J. Frydenvang, O. Gasnault, N. Lanza. An aridification sequence in the clay-sulfate transition at Gale crater. LPSC, The Woodlands, TX.

2023 C. M. Weitz, K. M. Lewis, E. S. Kite, W. E. Dietrich, L. M. Thompson, C. D. O’Connell-Cooper, J. Schrieber, D. Rubin, P. Gasda, C. Mondro, W. Rapin, S. Gupta, A. Roberts, J. Frydenvang, J. Berger, H. Newsom, A. Bryk, M. P. Lamb, J. Grotzinger, W. W. Fischer, A. Cowart, J. Davis, J. Grant, A. Yingst, W. Farrand, T. Parker, A. Vasavada, A. Fraeman, R. Milliken, **R. Sheppard**, D. Ming, S. Simpson, E. Rampe, D. Fey, R. Arvidson. The marker band in Gale crater: A synthesis of orbital and ground observations. LPSC, The Woodlands, TX.

2023 A. A. Fraeman, R. E. Arvidson, K. M. Stack, J. Christian, **R. Y. Sheppard**. Mt. Sharp’s clay-sulfate transition: a regional perspective from orbital spectral and geomorphic datasets. LPSC, The Woodlands, TX.

2023 H. T. Manelski, **R. Y. Sheppard**, A. A. Fraeman, R. C. Wiens, J. R. Johnson, E. B. Rampe, J. Frydenvang, N. L. Lanza, O. Gasnault. Variability in Mt. Sharp group bedrock as seen by ChemCam passive and active spectra. LPSC, The Woodlands, TX.

2023 R. S. Vachula, **R. Y. Sheppard**, A. H. Cheung. Preservation biases affect charcoal-based paleofire interpretations. INQUA, Rome, Italy.

2022 R. S. Vachula, **R. Y. Sheppard**, A. H. Cheung. Preservation biases affect charcoal-based paleofire interpretations. GSA Annual Meeting, Denver, CO.

2022 W. Rapin, **R. Y. Sheppard**, G. Dromart, J. Schieber, B. C. Clark, L. Kah, D. Rubin, B. L. Ehlmann, S. Gupta, G. Caravaca, N. Mangold, E. Dehouck, S. Le Mouelic, O. Gasnault, J. V. Clark, A. Bryk, B. Dietrich, R. C. Wiens. The Curiosity rover investigates an aridification sequence in the layered sulfate-bearing unit. Europlanet Science Conference, Granada, Spain.

2022 J. M. Weber, L. E. Rodriguez, **R. Y. Sheppard**, E. Martinez[†], L. M. Barge. Understanding habitability and prebiotic chemistry with continuous-flow terrestrial analogs. *Invited*. AbSciCon, Atlanta, GA.

2022 T. C. Marlin[†], J. M. Weber, **R. Y. Sheppard**, S. M. Perl, L. M. Barge. Chemical gardens as analogs for prebiotic chemistry on ocean worlds. AbSciCon, Atlanta, GA.

2022 D. Valadez[†], E. Flores[†], E. Martinez[†], **R. Y. Sheppard**, R. P. Hodyss, J. M. Weber, J. Castillo[†], B. Henderson, L. M. Barge. Sorption of prebiotic organics on iron sulfide minerals in ocean world analog systems. AbSciCon, Atlanta, GA.

2022 E. Martinez[†], E. Flores[†], D. Valadez[†], J. M. Weber, T. C. Marlin[†], **R. Y. Sheppard**, L. M. Barge. Organic acid adsorption onto iron (oxy)hydroxides under ocean world analog conditions. AbSciCon, Atlanta, GA.

2022 J. M. Weber, E. Martinez[†], **R. Y. Sheppard**, L. E. Rodriguez, L. M. Barge. Mars weathering experiments: development and use of continuous-flow packed bed for geologic exploration. LPSC, The Woodlands, TX.

2022 H. T. Manelski[†], **R. Y. Sheppard**, A. A. Fraeman, J. R. Johnson, R. Wiens, N. Lanza, J. Frydenvang. Classification of ChemCam passive spectral targets in Gale crater. LPSC, The Woodlands, TX.

2022 J. K. Ando[†], **R. Y. Sheppard**, A. A. Fraeman, V. Sun. Locations and multispectral features of distinct classes of diagenetic features within the Murray formation, Gale crater, Mars. LPSC, The Woodlands, TX. (*Received the LPSC Dwornik Award.*)

2022 W. Rapin, **R. Y. Sheppard**, G. Dromart, J. Schieber, B. Clark, L. Kah, D. Rubin, B. L. Ehlmann, S. Gupta, G. Caravaca, N. Mangold, E. Dehouck, S. Le Mouelic, O. Gasnault, J. V. Clark, A. Bryk, B. Dietrich, R. C. Wiens. The Curiosity rover is exploring a key sulfate-bearing orbital facies. LPSC, The Woodlands, TX.

2022 E. Martinez[†], E. Flores[†], T. C. Marlin[†], D. Valadez[†], J. M. Weber, **R. Y. Sheppard**, R. P. Hodyss, L. M. Barge. Organic acid adsorption on iron (oxy)hydroxides under ocean world analog conditions. Origins of Life Gordon Research Conference, Oxnard, CA. (*Canceled due to Covid-19*)

2021 T. F. Bristow, E. B. Rampe, **R. Sheppard**, R. Milliken. In situ mineralogy of a clay-sulfate transition in Gale crater. AGU Fall Meeting, New Orleans, LA.

2021 A. A. Fraeman, M. Hughes, C. Seeger, J. Ando[†], S. Jacob, J. Johnson, **R. Sheppard**, R. Arvidson, M. Rice, J. Bell. Spectral properties of diagenetic features near the clay-sulfate transition in Mt. Sharp. AGU Fall Meeting, New Orleans, LA.

2021 S. N. Lamm[†], L. E. Rodriguez, **R. Y. Sheppard**, S. M. Perl, A. J. Celestian, L. M. Barge. Classification of iron (oxy)hydroxides and sulfides using mission-ready spectroscopic techniques and machine learning. GSA Annual Meeting, Portland, OR.

2020 R. E. Milliken, J. P. Grotzinger, **R. Sheppard**, R. Wiens, R. Gellert, L. M. Thompson, A. Vasavada, T. Bristow, & N. Mangold. The chemistry and mineralogy of an ancient lacustrine sequence on Mars: observations, interpretations, and future prospects. LPSC, The Woodlands, TX. (*Canceled due to Covid-19*)

2019 R. E. Milliken, J. P. Grotzinger, R. Wiens, R. Gellert, L. M. Thompson, **R. Sheppard**, A. Vasavada, T. Bristow, & N. Mangold. The chemistry and mineralogy of an ancient lacustrine sequence on Mars: lessons learned from integrating rover and orbiter datasets. Ninth International Conference on Mars, Pasadena, CA.

MENTORING EXPERIENCE

2021 Undergraduate advisees hosted by Caltech/JPL:

- ◇ Jordan Ando – *LPSC Dwornik Award 2022. Now a PhD student at the University of Hawaii*
- ◇ Henry Manelski – *now a PhD student at Purdue*

2016-2020 Undergraduate advisees hosted by Brown University:

- ◇ Ana Colón – *now a PhD student at the University of Oregon*
- ◇ Christopher Yen – *LPSC Dwornik Award Honorable Mention 2019. Now a PhD student at WashU*

- ◇ Grant Rutherford – *now a PhD student at MIT*
- ◇ Catherine Miranda
- ◇ Sarah Martinez

2018 Leadership Alliance Summer Program Coordinator, Brown University.

SERVICE & OUTREACH (LAST 5 YEARS ONLY)

Recent journal referee work: *Nature Geoscience, Journal of Geophysical Research: Planets, Journal of Geophysical Research: Biogeosciences, Icarus, Advances in Space Research.*

2022 Session Convener and Chair, AbSciCon, “*Diagenesis and subsurface habitable environments.*”

2021 Reviewer, Graduate Women In Science (GWIS) National Fellowship Program.

2020 Panelist, NASA review panel.

2019 Session Convener and Chair, American Geophysical Union Fall Meeting, “*Evidence of water-rock interaction throughout the Solar System,*” oral and poster session.

2019 Executive Secretary, NASA review panel.

2019 Workshop Leader, Girl Scout Senior Leadership Conference, Salve Regina University. “*Craters, spacecraft, and the surfaces of our Solar System.*”

2019-2023 Participant, semiannual Skype a Scientist outreach program for K-12 students and incarcerated adults across the world.

2018-2020 GeoW+ Co-Founder, Graduate Student Leader, Brown University DEEPS. Inter-sectional mentoring group for geoscience undergraduates.

2018-2020 Diversity & Inclusion Action Committee, Brown University DEEPS. Committee consisted of faculty, staff, and graduate students. *Invited by Department Chair.*

FIELD WORK & SHORT COURSES

2021 Revolutionizing Access to the Martian Surface, **Keck Institute for Space Studies**, Caltech (10 day workshop, invited).

2018 Agouyon Institute Advanced Geobiology Field School, Caltech, **Naukluft Mountains, Namibia** (12 days in the field, invited).

2016 Sedimentary Cycle of Earth and Mars field intensive, Brown University, **Guadalupe Mountains, TX** (5 days in the field).

2016 Reflective Teaching, Harriet W. Sheridan Center, Brown University (12 week course).

2013 Research sample collection from the Punchbowl Fault, **San Gabriel Mountains, CA** (3 days in the field).

2012 Geologic Mapping intensive, Columbia University, **Catskill Mountains, NY** (12 days in the field).

2011 Research sample collection from the Champlain Thrust Fault, **Adirondack Mountains, VT** (2 days in the field).