

# RACHEL Y. SHEPPARD

rachel.y.sheppard@jpl.nasa.gov ◊ rachelshppard.com

## PROFESSIONAL APPOINTMENTS

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**Jet Propulsion Laboratory, Caltech**  
*Postdoctoral Fellow*

August 2020 - present  
*Pasadena, CA*

## EDUCATION

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**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

## PEER-REVIEWED PUBLICATIONS (†STUDENT)

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**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. Under review at *Icarus*.

C. Lee, J. M. Weber, L. E. Rodriguez, **R. Y. Sheppard**, L. M. Barge, E. L. Berger, & A. S. Burton. The effects of binding and release during alteration on the chirality of organics and minerals. Submitted to *Symmetry* special issue *Chirality, Prebiotic Chemistry, and the Origins of Life*.

R. Vachula, **R. Y. Sheppard**, A. Cheung. Preservation biases are pervasive in Quaternary paleofire records. Under review at *Sedimentology*.

M. Prakash<sup>†</sup>, J. M. Weber, L. E. Rodriguez, **R. Y. Sheppard**, L. M. Barge. Database on carbon reduction: Implications for future research. Under review at *International Journal of Astrobiology*.

**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, pp. 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, pp. 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, pp. 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), pp. 99-102.

#### **PUBLICATIONS IN PREPARATION (DRAFT AVAILABLE, †STUDENT)**

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J. Ando<sup>†</sup>, **R. Y. Sheppard**, A. A. Fraeman, C. Seeger, V. Sun, A. Rudolph. Classes of diagenetic features within the Murray formation and their Mastcam multispectral properties. For submission to *Icarus*, April 2022.

H. T. Manelski<sup>†</sup>, **R. Y. Sheppard**, A. A. Fraeman, J. Johnson. Statistical classification of Gale crater targets based on ChemCam passive spectra. For submission to *Icarus*, April 2022.

L. E. Rodriguez, S. Lamm<sup>†</sup>, **R. Y. Sheppard**, A. Celestian, S. P. Perl, L. M. Barge. Classification of iron (oxy)hydroxides and sulfides using mission-ready spectroscopic techniques and machine learning. For submission to *Spectrochimica Acta: Atomic Spectroscopy*, April 2022.

M. Melwani Daswani, **R. Y. Sheppard**, J. Weber, L. Rodriguez, J. Barnes, M. Grady, S. Schwenzer, I. Wright. Isotopic and mineralogical analyses of ALH 84001 including hematite detection. For submission to *Meteoritics & Planetary Science*, February 2022.

**R. Y. Sheppard**, J. Frydenvang, A. A. Fraeman, R. E. Milliken. Comparison of orbital and *in situ* subtleties in the chemostratigraphy of Mt. Sharp: A statistical approach.

#### **OTHER PUBLICATIONS (WHITE PAPERS, INDUSTRY PAPERS, ETC.)**

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

**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).

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

## RESEARCH GRANTS

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**2022-2025** Mars Science Laboratory Participating Scientist Program (MSL-PSP). **Science 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.)

**2020-2022** Strategic Research and Technology Development Program, Jet Propulsion Laboratory. **Science PI**. “Experimental constraints on groundwater driven redox gradients on Mars.” (\$300,000.)

## RELEVANT EXPERIENCE

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<b>Mars Science Laboratory Team</b> <i>Participating Scientist</i> <i>Science Team Member</i>	May 2016 - present <i>2022-present</i> <i>2016-2022</i>
<b>Gemological Institute of America</b> <i>Research Laboratory, diamond color origin and spectroscopy</i>	October 2013 - June 2015 <i>New York, NY</i>
<b>Lamont-Doherty Earth Observatory</b> <i>Research Assistant</i>	May 2011 - August 2013 <i>Palisades, NY</i>

## AWARDS & FELLOWSHIPS

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**2019** Dissertation Fellowship, Brown University Graduate School, full stipend support (6 mo.).

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

**2015-2018** Presidential Fellowship, Brown University Graduate School, enhanced stipend support (3 yr.).

**2013** Walter C. Pitman III Award for excellence in thesis research and presentation, Columbia University Department of Earth and Environmental Sciences.

## CONFERENCE PRESENTATIONS: FIRST AUTHOR (\*ORAL PRESENTATIONS)

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**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. (*Scheduled.*)

**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. (*Scheduled.*)

**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.
- 2017 R. Y. Sheppard**, R. Milliken, & J. Russell. Tracking changes in iron mineralogy through time in a terrestrial analogue for Gale Crater. American Geophysical Union Fall Meeting, New Orleans, LA.
- 2017 R. Y. Sheppard**, R. Milliken, & J. Russell. Iron oxidation state and cycling in sediments of Lake Towuti, Indonesia and implications for chemistry and mineralogy of Martian mudstones. Lunar and Planetary Science Conference, The Woodlands, TX.
- 2013 R. E. Sheppard**, P. J. Polissar, & H. M. Savage. Organic thermal maturity as a proxy for frictional fault heating: experimental constraints on biomarker kinetics at earthquake timescales. American Geophysical Union Fall Meeting, San Francisco, CA.
- 2012 R. E. Sheppard**, P. J. Polissar, & H. M. Savage. Rapid heating experiments demonstrate the usefulness of organic molecules as an earthquake thermometer. American Geophysical Union Fall Meeting, San Francisco, CA.

## INVITED EXTERNAL TALKS & TEAM MEETINGS

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- 2022 R. Y. Sheppard.** Research Colloquium, Astrobiology & Planetary Science, Georgia Tech, Atlanta, GA. (*Scheduled.*)
- 2021 R. Y. Sheppard.** Research Colloquium, EAPS, Purdue, West Lafayette, IN.
- 2020 R. Y. Sheppard.** Geoclub Seminar Series, 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, R. Milliken, Y. Itoh, & M. Parente.** Updated orbital view of mineral stratigraphy of Mount Sharp and implications for Curiosity's traverse. Mars Science Laboratory team meeting, NASA Goddard, Greenbelt, MD.
- 2018 R. Y. Sheppard, R. Milliken, & J. Russell.** Sedimentation in Lake Towuti & martian planetary processes. Towuti Drilling Project team meeting, Makassar, Indonesia.
- 2017 R. Y. Sheppard, R. Milliken, & J. Russell.** Lake Towuti as an analogue for trends seen in Gale Crater, Mars. Towuti Drilling Project team meeting, Bandung, Indonesia.
- 2016 R. Y. Sheppard, R. Milliken, & J. Russell.** Terrestrial analogs for chemical trends in Gale Crater: Ultramafic lakes in Indonesia and Iceland. NASA Astrobiology Institute (NAI) team meeting, Williamstown, MA.

## PRESENTATIONS: CONTRIBUTING AUTHOR (†STUDENT)

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- 2022 J. M. Weber, L. E. Rodriguez, R. Y. Sheppard, E. Martinez<sup>†</sup>, L. M. Barge.** Understanding habitability and prebiotic chemistry with continuous-flow terrestrial analogs. *Invited.* AbSciCon, Atlanta, GA.
- 2022 T. C. Marlin<sup>†</sup>, 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<sup>†</sup>, E. Flores<sup>†</sup>, E. Martinez<sup>†</sup>, R. Y. Sheppard, R. P. Hodyss, J. M. Weber, J. Castillo<sup>†</sup>, B. Henderson, L. M. Barge.** Sorption of prebiotic organics on iron sulfide minerals in ocean world analog systems. AbSciCon, Atlanta, GA.
- 2022 E. Martinez<sup>†</sup>, E. Flores<sup>†</sup>, D. Valadez<sup>†</sup>, J. M. Weber, T. C. Marlin<sup>†</sup>, 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<sup>†</sup>, R. Y. Sheppard, L. E. Rodriguez, L. M. Barge.** Mars weathering experiments: development and use of continuous-flow packed bed for geologic exploration. Lunar and Planetary Science Conference, The Woodlands, TX.
- 2022 H. T. Manelski<sup>†</sup>, R. Y. Sheppard, A. A. Fraeman, J. R. Johnson, R. Wiens, N. Lanza, J. Frydenvang.** Classification of ChemCam passive spectral targets in Gale crater. Lunar and Planetary Science Conference, The Woodlands, TX.
- 2022 J. K. Ando<sup>†</sup>, 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. Lunar and Planetary Science Conference, The Woodlands, TX.

- 2022** W. Rabin, **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. Lunar and Planetary Science Conference, The Woodlands, TX.
- 2022** E. Martinez<sup>†</sup>, E. Flores<sup>†</sup>, T. C. Marlin<sup>†</sup>, D. Valadez<sup>†</sup>, 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. American Geophysical Union Fall Meeting, New Orleans, LA.
- 2021** A. A. Fraeman, M. Hughes, C. Seeger, J. Ando<sup>†</sup>, 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. American Geophysical Union Fall Meeting, New Orleans, LA.
- 2021** S. N. Lamm<sup>†</sup>, 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. Geological Society of America 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. Lunar and Planetary Science Conference, 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.
- 2018** D. Morriss, C. B. Sanders, J. P. Grotzinger, J. Busch, L. F. Cury, P. Daoust, W. W. Fischer, B. Howes, D. S. Jones, **R. Sheppard**, L. L. Nelson, J. P. Pu, D. P. Quinn, J. Wilcots, & R. Swart. Cap Sequence Post-dating Marinoan Glacial Deposits, Naukluft Mountains, Namibia. American Geophysical Union Fall Meeting, Washington, D.C.
- 2017** A. C. Pascuzzo, B. C. Johnson, **R. Y. Sheppard**, E. A. Fisher, & S. E. Wiggins. Porosity and salt content determine if subduction can occur in Europa's ice shell. Europa Deep Dive 1: Ice-Shell Exchange Processes, Houston, TX.
- 2015** H. Savage, P. J. Polissar, H. Rabinowitz, & **R. Sheppard**. Some like it hot: the spectrum of temperature rise during earthquakes. American Geophysical Union Fall Meeting, San Francisco, CA.
- 2012** H. Savage, P. J. Polissar, **R. Sheppard**, C. Rowe, & J. Kirkpatrick. Organic geochemical evidence for frictional heating of the NE Japan décollement in drillcores from Expedition 343: JFAST. American Geophysical Union Fall Meeting, San Francisco, CA.
- 2011** H. Savage, P. J. Polissar, **R. Sheppard**, E. Brodsky, & C. Rowe. Do faults stay cool under stress? American Geophysical Union Fall Meeting, San Francisco, CA.
- 2011** P. J. Polissar, H. Savage, **R. Sheppard**, C. Rowe, & E. Brodsky. What's Cooking? Evaluating frictional stress using extractable organic material in fault zones. American Geophysical Union Fall Meeting, San Francisco, CA.

## TEACHING EXPERIENCE

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**2018 Instructor**, summer course, Brown University's STEM II program.

**2018 Teaching Assistant**, *Planetary Geology* (GEOL0810), Brown University.

**2017 Teaching Assistant**, summer course, Brown University's STEM II program.

## MENTORING EXPERIENCE

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### **2021 Undergraduate advisees hosted by Caltech/JPL:**

◇ Henry Manelski

◇ Jordan Ando

### **2016-2020 Undergraduate advisees hosted by Brown University:**

◇ Ana Colón (*now a PhD student at U. of Oregon*)

◇ Christopher Yen (*now a PhD student at WashU*)

◇ Grant Rutherford (*now a PhD student at MIT*)

◇ Sarah Martinez

◇ Catherine Miranda

**2018 Leadership Alliance Summer Program Coordinator**, Brown University.

## OTHER SERVICE & OUTREACH

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**Journals recently reviewed for:** *Journal of Geophysical Research: Planets*, *Journal of Geophysical Research: Biogeosciences*, *Icarus*.

**2022 Session Convener**, AbSciCon, "*Surface Expressions of 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-present Participant**, semiannual Skype a Scientist program for K-12 students and incarcerated adults.

**2018-2020 GeoW+ Co-Founder, Graduate Student Leader**, Brown University. Intersectional mentoring group for geoscience undergraduates.

**2018-2020 Graduate Student Representative, Department Diversity and Inclusion Action Committee**, Brown University. Invited.

**2018-2020 Graduate Student Faculty Representative**, Brown University. Liaison between faculty and graduate students, invited attendee to faculty meetings. Elected.

**2018-2019 Planetary Climate Task Force Representative**, Brown University. Elected.

## FIELD WORK & SHORT COURSES

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

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

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

**2019** Effective Performance Workshop Series, **Trinity Repertory Theater & Brown University** (5 weeks).

**2016** Reflective Teaching, **Harriet W. Sheridan Center**, Brown University (12 weeks).

**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).