

1. RALPH EDWARD MILLIKEN

Department of Earth, Environmental & Planetary Sciences
Brown University
Box 1846
Providence, RI 02912
<http://www.geo.brown.edu/research/Milliken/Home.html>

Office: 401-863-1118
Ralph_Milliken@brown.edu

2. EDUCATION

- Ph. D. Brown University Department of Geological Sciences 2006
Quantifying and modeling the water content of geological materials using VIS-NIR reflectance spectroscopy: Applications for laboratory and spacecraft data
- Sc. M. Brown University Department of Geological Sciences 2003
Viscous flow features on the surface of Mars: Observations from high-resolution Mars Orbiter Camera (MOC) images
- B. S. Indiana University Department of Geological Sciences 2001
minors awarded in physics and mathematics
Microbial sulfate-reduction in waters from ultra-deep South African gold mines

3. PROFESSIONAL APPOINTMENTS/EXPERIENCE

- 2017 – present *Associate Professor* Brown University
- 2012 – present *Director, NASA Reflectance Experiment Laboratory*
2022 – present *Director, NASA Rhode Island Space Grant Consortium*
2022 – present *Director, NASA Rhode Island EPSCoR program*
- 2012 – 2017 *Assistant Professor* Brown University
- 2010 – 2012 *Assistant Professor* University of Notre Dame
- 2007 – 2010 *Research Scientist* Jet Propulsion Laboratory/Caltech
- 2006 – 2007 *Post-Doctoral Scholar* Caltech/Jet Propulsion Laboratory
advisor: Dr. John Grotzinger
- 2001 – 2006 *Graduate Student Research Assistant* Brown University
advisor: Dr. John Mustard
- 1999 – 2001 *Undergraduate Research/Lab Assistant* Indiana University
advisor: Dr. Lisa Pratt
- 1999 – 2000 *Undergraduate Research* Indiana University
advisor: Dr. Abhijit Basu
- 1998 – 2000 *GSA Editorial Assistant* Indiana University

4. NASA & INTERNATIONAL MISSION EXPERIENCE

- Participating Scientist on NASA Mars Science Laboratory (*Curiosity*) rover [NASA]
- Co-Investigator for Hayabusa2 NIRS3 instrument & sample analysis team [JAXA]
- Co-Investigator for OSIRIS-REx mission (sample analysis & data archiving) [NASA]
- Co-Investigator on Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) instrument on Mars Reconnaissance Orbiter [NASA]
- Collaborator with Mars Express OMEGA spectrometer team [ESA; IAS]

5. PUBLICATIONS

a. Books

Sedimentary Geology of Mars (2012) eds. J. P. Grotzinger and R. E. Milliken, *SEPM Special Paper*, SP102, 276 pp.

b. Refereed Journal Articles

In Preparation (2) (* indicates student advisee; † indicates postdoctoral advisee)

*Fisher, E. A., R.E. Milliken, K. Robertson and S. Li (2022), Determining the modal mineralogy of howardites and brecciated eucrites: A combined X-ray diffraction and visible-near infrared reflectance study, *Icarus*, submission by February 1, 2023.

*Li, S. and R.E. Milliken (2022), Geomorphological and mineralogical mapping of pyroclastic deposits at Sinus Aestuum and Rima Bode: Insights into their magmatism, *JGR Planets*, in prep. (unpublished thesis chapter).

Submitted/In Review (1) (* indicates student advisee; † indicates postdoctoral advisee)

Matsuoka, M., et al (2022), Visible to near-infrared spectra of asteroid Ryugu's surface in relation to its returned samples, *Scientific Reports*, in review.

Published (113) (* indicates student advisee; † indicates postdoctoral advisee)

2023

*Meyer, M., R.E. Milliken, J.A. Hurowitz and K. Robertson (2022), Ancient siliciclastic-evaporites as seen by remote sensing instrumentation with implications for the rover-scale exploration of Mars, *Astrobiology*, in press.

*Schultz, C., *B. Anzures, R.E. Milliken, T. Hiroi and K. Robertson (2022), Diversity of hydration features in CM2 chondrites as seen in μ FTIR reflectance spectra and implications for primitive asteroids, *Meteoritics & Planetary Science*, in press.

2022

Y. Zhuang, H. Zhang, P. Ma, T. Jiang, Y. Yang, R.E. Milliken, and W. Hsu (2022), Visible and near-infrared reflectance spectra of igneous rocks and their powders, *Icarus*, in press.

Nakamura, T. et al. (2022), Formation and evolution of carbonaceous asteroid Ryugu: Direct evidence from returned samples, *Science*, in press, doi: 10.1126/science.abn8671.

*Sheppard, R.Y., R.E. Milliken, and K.M. Robertson (2022), Presence of clay minerals can obscure spectral evidence of Mg sulfates: Implications for orbital observations of Mars, *Icarus*, 383, 115083, doi: 10.1016/j.icarus.2022.115083.

Robertson, K., R.E. Milliken, C.M. Pieters, L. Cheek, and P. Isaacson (2022), Textural and compositional effects of ilmenite on the spectra of high-Ti lunar basalts, *Icarus*, 375, doi: 10.1016/j.icarus.2021.114836.

2021

- Sheppard, R.Y., M. Thorpe, A. Fraeman, V.K. Fox, and R.E. Milliken (2021), 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*, 11(9), 986, doi: 10.3390/min11090986.
- Hiroi, T., H. Kaiden, N. Imae, K. Misawa, H. Kojima, S. Sasaki, M. Matsuoka, T. Nakamura, D.L. Bish, K. Ohtsuka, K.T. Howard, K.R. Robertson, and R.E. Milliken (2021), UV-visible-infrared spectral survey of Antarctic carbonaceous chondrite chips, *Polar Science*, 100723.
- Bristow, T.F. et al. (2021), Brine driven diagenesis of clay minerals in Gale Crater, Mars, *Science*, 373 (6551), 198-204, doi: 10.1126/science.abg5449.
- Johnson, B.C., R.E. Milliken, K.W. Lewis, and G.S. Collins (2021), Impact-generated porosity in Gale crater and implications for the density of sedimentary rocks in lower Aeolis Mons, *Icarus*, 366, 114539.
- *Sheppard, R.Y., R.E. Milliken, J.M. Russell, E.C. Sklute, M.D. Dyar, H. Vogel, M. Melles, S. Bijaksana, A.K.M. Hasberg, and M.A. Morlock (2021), Iron mineralogy and sediment color in a 100 m drill core from Lake Towuti, Indonesia, *Geochemistry, Geophysics, Geosystems*, 22, e2020GC009582, doi: 10.1029/2020GC009582.
- *Florez, D., C. Huber, R.E. Milliken, and J. Berkson (2021), Modeling lunar pyroclasts to probe the volatile content of the lunar interior, *JGR Planets*, 126, doi: 10.1029/2020JE006645.
- *Bramble, M., R.E. Milliken, and W. Patterson III (2021), Thermal emission measurements of ordinary chondrite mineral analogs in a simulated asteroid environment: 2. Representative mineral mixtures, *Icarus*, 369, doi: 10.1016/j.icarus.2020.114251.
- *Bramble, M., R.E. Milliken, and W. Patterson III (2021), Thermal emission measurements of ordinary chondrite mineral analogs in a simulated asteroid environment: 1. Constituent mineral phases, *Icarus*, 369, doi: 10.1016/j.icarus.2021.114561.
- Kitazato, K., R.E. Milliken, T. Iwata and 61 others (2021), Thermally altered subsurface material of asteroid 162173 Ryugu, *Nature Astronomy*, 5, 246-250, doi: 10.1038/s41550-020-01271-2.
- Riu, L., C. Pilorget, R.E. Milliken, K. Kitazato, T. Nakamura, Y. Cho, M. Matsuoka, S. Sugita, M. Abe, S. Matsuura, M. Ohtake, S. Kameda, N. Sakatani, E. Tatsumi, Y. Yokota, and T. Iwata (2021), Spectral characterization of the craters of Ryugu as observed by the NIRS3 instrument onboard Hayabusa2, *Icarus*, 357, 114253, doi: 10.1016/j.icarus.2020.114253.
- *Sheppard, R., R.E. Milliken, M. Parente, and Y. Itoh (2021), Updated perspectives and hypotheses on the mineralogy of lower Mt. Sharp, Mars, as seen from orbit, *JGR Planets*, 126, doi: 10.1029/2020JE006372.

2020

- *Anzures, B.A., S.W. Parman, R.E. Milliken, A. Lanzirrotti, and M. Newville (2020), XANES spectroscopy of sulfides stable under reducing conditions, *American Mineralogist*, 105(3), 375-381, doi: 10.2138/am-2020-7146.
- *Anzures, B., S. Parman, R.E. Milliken, O. Namur, C. Cartier, S.Wang (2020), Effect of sulfur speciation on chemical and physical properties of very reduced mercurian melts, *Geochimica et Cosmochimica Acta*, 286, 1-18, doi: 10.1016/j.gca.2020.07.024.
- *Sun, V. Z. and R.E. Milliken (2020), Characterizing the mineral assemblages of hot spring environments and applications to Mars orbital data, *Astrobiology*, 20 (4), doi: 10.1089/ast.2018.2003.

2019

- *Bramble, M.S., *Y. Yang, R.E. Milliken, W.R. Patterson II, J.F. Mustard and K. Donaldson Hanna (2019), Radiometric calibration of thermal emission data from the Asteroid Lunar Environment Chamber (ALEC), *Reviews of Scientific Instruments*, 90, 093101, doi: 10.1063/1.5096363.
- Kitazato, K., R.E. Milliken, T. Iwata and 61 others (2019), The surface composition of asteroid 162173 Ryugu from Hayabusa2 near-infrared spectroscopy, *Science*, 364, 272-275, doi: 10.1126/science.aav7432.
- *Sheppard, R., R.E. Milliken, J.M. Russell, M.D. Dyar, E.C. Sklute, H. Vogel, M. Melles, S. Bijaksana, M. Morlock, A. Hasberg, and the TDP Science Team (2019), Characterization of iron in Lake Towuti sediment, *Chemical Geology*, 512, 11-30, doi:10.1016/j.chemgeo.2019.02.029.
- *Kaplan, H.H., R.E. Milliken, C. M. O'D. Alexander, and C.D.K. Herd (2019), Reflectance spectroscopy of insoluble organic matter (IOM) and carbonaceous meteorites, *Meteoritics and Planetary Science*, 1-18, doi: 10.1111/maps.13264
- *Yang, Y., S. Li, R.E. Milliken, H. Zhang, K. Robertson and T. Hiroi (2019), Phase functions of typical lunar surface minerals derived for the Hapke model and implications for visible to near-infrared spectral unmixing, *Journal of Geophysical Research*, 124, doi:10.1029/2018JE005713
- *Bramble, M., T. Goudge, R.E. Milliken, and J.F. Mustard (2019), Testing the deltaic origin of fan deposits at Bradbury Crater, Mars, *Icarus*, 319, 363-366, doi:10.1016/j.icarus.2018.09.024.

2018

- *Sun, V. and R.E. Milliken (2018), Distinct geologic settings of opal-A and more crystalline hydrated silica on Mars, *Geophysical Research Letters*, 45, doi:10.1029/2018GL078494.
- †Li, S., P. Lucey, R.E. Milliken, P. Hayne, E. Fisher, J.P. Williams, and R. Elphic (2018), Detection of water ice at the lunar poles using Moon Mineralogy Mapper Data, *Proceedings of the National Academy of Sciences*, 115(36), 8907-8912, doi:10.1073/pnas.1802345115.

*Kaplan, H.H. and R.E. Milliken (2018), Reflectance spectroscopy of organic matter in sedimentary rocks at mid-infrared wavelengths, *Clays and Clay Minerals*, 66(2), 173-189, doi:10.1346/CCMN.2018.064092.

*Kaplan, H.H., R.E. Milliken, C. M. O'D. Alexander (2018), New constraints on the abundance and composition of organic matter on Ceres, *Geophysical Research Letters*, 45, 5274-5282.

McMahon, S., T. Bosak, J.P. Grotzinger, R.E. Milliken, R.E. Summons, M. Daye, S.A. Newman, A. Fraeman, K.H. Williford, and D.E.G. Briggs (2018), A field guide to finding fossils on Mars, *Journal of Geophysical Research*, 123, 1012-1040.

2017

*Li, S. and R.E. Milliken (2017), Water on the Moon as seen by the Moon Mineralogy Mapper: Distribution, abundance and origins, *Science Advances*, 3, e1701471.

Milliken, R.E. and *S. Li (2017), Remote detection of widespread indigenous water in lunar pyroclastic deposits, *Nature Geoscience*, 10, 561-565.

Frydenvang, J. and 42 others (2017), Diagenetic silica enrichment and late-stage groundwater activity in Gale crater, Mars, *Geophysical Research Letters*, 44, 4716-4724.

Hurowitz, J.A., J.P. Grotzinger, W. W., Fischer, R.E. Milliken, N. Stein, A.R. Vasavada, D. F. Blake, E. Dehouck, J.L. Eigenbrode, A.G. Fairen, J. Frydenvang, R. Gellert, J.A. Grant, S. Gupta, K.E. Herkenhoff, S.M. McLennan, D.W. Ming, E.B. Rampe, M.E. Schmidt, K. Siebach, K. Stack-Morgan, D.Y. Sumner, R.C. Wiens (2017), Redox stratification of an ancient lake in Gale Crater, Mars, *Science*, 356, eaah6849, doi:10.1126/science.aah6849.

*Caswell, T. and R.E. Milliken (2017), Hydraulic fracturing of Yellowknife Bay, Gale Crater, Mars: Implications for burial depth and the history of aqueous activity, *Earth and Planetary Science Letters*, 468, 72-84.

Edgar, L.A., S. Gupta, D.M. Rubin, K.W. Lewis, G.A. Kocurek, R.B. Anderson, J.F. Bell III, G. Dromart, K.S. Edgett, J.P. Grotzinger, C. Hardgrove, L.C. Kah, R. Leveille, M.C. Malin, N. Mangold, R.E. Milliken, M. Minitti, M. Palucis, M. Rice, S.K. Rowland, J. Schieber, K.M. Stack, D.Y. Sumner, R.C. Wiens, R.M.E. Williams, A.J. Williams (2017), Shaler: In situ analysis of a fluvial sedimentary deposit on Mars, *Sedimentology*, 65, 96-122.

Wiens, R., D. Rubin, W. Goetz, A. Fairen, S. Schwenzer, J. Johnson, R.E. Milliken, and 24 others (2017), Centimeter to decimeter hollow concretions and voids in Gale crater sediments, Mars, *Icarus*, 289, 144-156.

*Goudge, T.A., R.E. Milliken, J.W. Head, J.F. Mustard, and C.I. Fassett (2017), Sedimentological evidence for a deltaic origin of the western fan deposit in Jezero crater, Mars and implications for future exploration, *Earth and Planetary Science Letters*, 458, 357-365.

2016

- *Li, S. and R.E. Milliken (2016), An empirical thermal correction model for Moon Mineralogy Mapper data constrained by laboratory spectra and Diviner temperatures, *Journal of Geophysical Research*, 121, 2081-2107, doi:10.1002/2016JE005035.
- Fraeman, A.A., B.L. Ehlmann, R.E. Arvidson, C.S. Edwards, J.P. Grotzinger, R.E. Milliken, D.P. Quinn, and M.S. Rice (2016), The stratigraphy and evolution of lower Mount Sharp from spectral, morphological, and thermophysical orbital data sets, *Journal of Geophysical Research*, 121, doi:10.1002/2016/JE005095.
- †Robertson, K.M., R.E. Milliken, and *S. Li (2016), Estimating mineral abundances of clay-gypsum mixtures using visible-near infrared reflectance spectroscopy, *Icarus*, 277, 171-186, doi: 10.1016/j.icarus.2016.04.034.
- *Kaplan, H.H. and R.E. Milliken (2016), Reflectance spectroscopy for organic detection and quantification in geologic materials: Effects of albedo, water content, and clay type, *Clays and Clay Minerals*, 64(2), 115-132.
- Litvak, M.L., I.G. Mitrofanov, C. Hardgrove, K.M. Stack, A.B. Sanin, D. Lisov, W.V. Boynton, F. Fedosov, D. Golovin, K. Harshman, I. Jun, A.S. Kozyrev, R.O. Kuzmin^{1,5}, A. Malakhov, R.E. Milliken, M. Mischna, J. Moersch, M. Mokrousov, S. Nikiforov, R. Starr, C. Tate, V.I. Tret'yakov, and A. Vostrukhin (2016), Hydrogen and chlorine abundances in the Kimberley formation of Gale crater measured by the DAN instrument onboard the Mars Science Laboratory Curiosity rover, *Journal of Geophysical Research*, 121, 836-845, doi: 10.1002/2015JE004960.
- *Kaplan, H.H., R.E. Milliken, D. Fernández-Remolar, R. Amils, K. Robertson, and A.H. Knoll (2016), Orbital evidence for clay and acidic sulfate assemblages on Mars and mineralogical analogs from Rio Tinto, Spain, *Icarus*, 275, 45-64.
- Wray, J. J., S. L. Murchie, J. L. Bishop, B. L. Ehlmann, R. E. Milliken, M. B. Wilhelm, K. D. Seelos, and M. Chojnacki (2016), Orbital evidence for more widespread carbonate-bearing rocks on Mars, *Journal of Geophysical Research*, 121, 652-677, doi:10.1002/2015JE004972.
- Ehlmann, B.L., G.A. Swayze, G.N. Breit, J.J. Wray, R.E. Milliken, J.F. Mustard, R.O. Rye, B. Gondet, F. Poulet, R.N. Clark, W.M. Calvin, W.M. Benzel, K.D. Seelos, and S.L. Murchie (2016), Discovery of alunite in Cross Crater, Terra Sirenum, Mars: Evidence for acidic, sulfuriferous waters, *American Mineralogist*, 101, 1527-1542, doi: 10.2138/am-2016-5574.
- 2015**
- *Sun, V.Z. and R.E. Milliken (2015), Ancient and recent clay formation on Mars as revealed from a global survey of hydrous minerals in crater central peaks, *Journal of Geophysical Research*, 120, 2293-2332, doi:10.1002/2015JE004918.
- *Li, S. and R.E. Milliken (2015), Estimating the modal mineralogy of eucrite and diogenite meteorites using visible-near infrared reflectance spectroscopy, *Meteoritics and Planetary Science*, 50(11), 1821-1850, doi:10.1111/maps.12513.
- Grotzinger, J., S. Gupta, D.M. Rubin, J. Schieber, D.Y. Sumner, K.M. Stack, A.R. Vasavada, R.E. Arvidson, F. Calef III, L. Edgar, W.F. Fischer, J.A. Grant, L.C. Kah, M.P. Lamb, K.W. Lewis, N. Mangold, M.E. Minitti, M. Palucis, M. Rice, K. sieback, R.M.E. Williams, R.A.

Yingst, D. Blake, D. Blaney, P. Conrad, J. Crisp, W.E. Dietrich, G. Dromart, K.S. Edgett, R.C. Ewing, R. Gellert, J. Griffes, J.A. Hurowitz, G. Kocurek, P. Mahaffy, M.C. Malin, M.J. McBride, S.M. McLennan, M. Mischna, D. Ming, R. Milliken, H. Newsom, D. Oehler, T.J. Parker, D. Vaniman, R.C. Wiens, S.A. Wilson (2015), Deposition, exhumation, and paleoclimate of an ancient lake deposit, Gale crater, Mars, *Science*, 350, aac7575, doi:10.1126/science.aac7575.

Tate, C.G., J. Moersch, I. Jun, D.W. Ming, I. Mitrofanov, M. Litvak, A. Behar, W.V. Boynton, L. Deflores, D. Drake, B. Ehresmann, F. Fedosov, D. Golovin, C. Hardgrove, K. Harshman, D.M. Hassler, A.S. Kozyrev, R. Kuzmin, D. Lisov, A. Malakhov, R. Milliken, M. Mischna, M. Mokrousov, S. Nikiforov, A.B. Sanin, R. Starr, A. Varenikov, A. Vostrukhin, C. Zeitlin (2015), Water equivalent hydrogen estimates from the first 200 sols of Curiosity's traverse (Bradbury Landing to Yellowknife Bay): Results from the Dynamic Albedo of Neutrons (DAN) passive mode experiment, *Icarus*, 262, 102-123, doi: 10.1016/j.icarus.2015.09.002.

Sanin, A.B., I.G. Mitrofanov, M.L. Litvak, D.I. Lisov, R. Starr, W. Boynton, A. Behar, L. DeFlores, F. Fedosov, D. Golovin, C. Hardgrove, K. Harshman, I. Jun, A.S. Kozyrev, R.O. Kuzmin, A. Malakhov, R. Milliken, M. Mischna, J. Moersch, M.I. Mokrousov, S. Nikiforov, V.N. Shvetsov, C. Tate, V.I. Tret'yakov, and A. Vostrukhin (2015), Data processing of the active neutron experiment DAN for a Martian regolith investigation, *Nuclear Instruments and Methods in Physics Research A*, 789, 114-127.

*Stack, K. and R.E. Milliken (2015), Modeling near-infrared reflectance spectra of clay and sulfate mixtures and implications for Mars, *Icarus*, 250, 332-356.

N. Mangold, O. Forni, G. Dromart, O. Gasnault, M. Nachon, P.-Y. Meslin, R.C. Wiens, R. B. Anderson, B. Barraclough, J.F. Bell III, G. Berger, D. L. Blaney, J. C. Bridges, F. Calef, B. Clark, S. M. Clegg, A. Cousin, L. Edgar, K. Edgett, B. Ehlmann, C. Fabre, M. Fisk, J. Grotzinger, S. Gupta, K. E. Herkenhoff, J. Hurowitz, J. R. Johnson, L. C. Kah, N. Lanza, J. Lasue, S. Le Mouélic, R. Lévêillé, E. Lewin, M. Malin, S. McLennan, S. Maurice, N. Melikechi, A. Mezzacappa, R. Milliken, H. Newsom, A. Ollila, S. K. Rowland, V. Sautter, M. Schmidt, S. Schröder, K. Stack, D. Y. Sumner, C. d'Uston, D. Vaniman, and R. Williams (2015), Chemical variations of the Yellowknife Bay formation sedimentary rocks analyzed by ChemCam on board the Curiosity rover on Mars, *Journal of Geophysical Research*, 120, 452-482, doi:10.1002/2014JE004681.

2014

Milliken, R. E., R. Ewing, W. Fischer, J. Hurowitz (2014), Wind-blown sandstones cemented by sulfate and clay minerals in Gale Crater, Mars, *Geophysical Research Letters*, 41, 1149-1154, doi:10.1002/2013GL059097.

*Sun, V.Z. and R.E. Milliken (2014), The geology and mineralogy of Ritchey Crater, Mars: Evidence for post-Noachian clay formation, *Journal of Geophysical Research*, 119, 810-836, doi:10.1002/2013JE004602.

Audouard, J., F. Poulet, M. Vincendon, R.E. Milliken, D. Jouglet, J.-P. Bibring, B. Gondet, and Y. Langevin (2014) Water in the Martian regolith from OMEGA/Mars Express, *Journal of Geophysical Research*, 119, 1969-1989, doi:10.1002/2014JE004649.

Mitrofanov, I.G., M.L. Litvak, A.B. Sanin, R. Starr, D.I. Lisov, R.O. Kuzmin, A. Behar, W.V. Boynton, C. Hardgrove, K. Harshman, I. Jun, R. Milliken, M.A. Mischna, J.E. Moersch, and C.G. Tate (2014) Content of water and chlorine in the Martian soil along the first 1900 meters of the traverse of Curiosity, as measured by the DAN instrument onboard the rover, *Journal of Geophysical Research*, 119, 1579-1596, doi: 10.1002/2013JE004553.

- Litvak, M.L. et al. (2014), Local variations of bulk hydrogen and chlorine-equivalent neutron absorption content measured at the contact between the Sheepbed and Gillespie Lake units in Yellowknife Bay, Gale Crater, using the DAN instrument onboard Curiosity, *Journal of Geophysical Research*, 119, 1259-1275, doi:10.1002/2013JE004556.
- Mitrafanov, I.G., M.L. Litvak, A.B. Sanin, D.I. Lisov, R.O. Kuzmin, A. Behar, W.V. Boynton, C. Hardgrove, K. Harshman, I. Jun, R. Milliken, M.A. Mischna, J.E. Moersch, R. Starr, and C.G. Tate (2013) Studying water content in Mars' Gale Crater: The first results of the DAN experiment on the NASA Curiosity rover, *Doklady Physics*, Russian Academy of Sciences, 59(3), 126-128.
- Gainey, S.R., E.M. Hausrath, J.A. Hurowitz, and R.E. Milliken (2014), Nontronite dissolution rates and implications for Mars, *Geochimica et Cosmochimica Acta*, 126, 192-211.
- Farley, K.A., C. Malespin, P. Mahaffy, J. Grotzinger, P. Vasconcelos, R. Milliken, M. Malin, K. Edgett, A. Pavlov, J. Hurowitz, J. Grant, H. Miller, R. Arvidson, L. Beegle, F. Calef, P. Conrad, W. Dietrich, J. Eignebröde, R. Gellert, S. Gupta, V. Hamilton, D. Hassler, K. Lewis, S. McLennan, D. Ming, R. Navarro, S. Schwenzer, A. Steele, E. Stolper, D. Sumner, D. Vaniman, A. Vasavada, K. Williford, R. Wimmer, and the MSL Science Team (2014) In situ radiometric and exposure age dating of the Martian surface, *Science*, 343, DOI: 10.1126/science.1247166.
- Grotzinger, J.P., D. Y. Sumner, L.C. Kah, K. Stack, S. Gupta, L. Edgar, D. Rubin, K. Lewis, J. Schieber, N. Mangold, R. Milliken, P. Conrad, D. DesMarais, J. Farmer, K. Siebach, F. Calef III, J. Hurowitz, S. M. McLennan, D. Ming, D. Vaniman, J. Crisp, A. Vasavada, Kenneth S. Edgett, M. Malin, D. Blake, R. Gellert, P. Mahaffy, R. Wiens, S. Maurice, J. A. Grant, S. Wilson, R. Anderson¹³, L. Beegle, R. Arvidson, B. Hallet, R. Sletten, M. Rice, J. Bell, J. Griffes, B. Ehlmann, T. Bristow, M. Palucis, William. E. Dietrich, G. Dromart, J. Eigenbrode, A. Fraeman, C. Hardgrove, K. Herkenhoff, L. Jandura, G. Kocurek, S. Lee, L. A. Leshin, R. Leveille, D. Limonadi, J. Maki, S. McCloskey, M. Meyer, M. Minitti, D. Oehler, A. Okon, H. Newsom, T. Parker, S. Rowland, S. Squyres, A. Steele, E. Stolper, R. Summons, A. Treiman, R. Williams, A. Yingst (2014), A habitable fluvio-lacustrine environment at Yellowknife Bay, Gale Crater, Mars, *Science*, 343, DOI: 10.1126/science.1242777.
- Vaniman, D.T., D.L. Bish, D.W. Ming, T.F. Bristow, R.V. Morris, D. F. Blake, S. J. Chipera, S.M. Morrison, A.H. Treiman, E.B. Rampe, M. Rice, C.N. Achilles, J. Grotzinger, S.M. McLennan, J. Williams, J. Bell III, H. Newsom, R.T. Downs, S. Maurice, P. Sarrazin, A.S. Yen, J.M. Morookian, J.D. Farmer, K. Stack, R.E. Milliken, D.Y. Sumner, G. Berger, J.A. Crisp, J.A. Hurowitz, E.M. Stolper, K. Edgett, S. Gupta, and N. Spanovich (2014), Mineralogy of a mudstone at Yellowknife Bay, Gale Crater, Mars, *Science*, 343, DOI: 10.1126/science.1243480.

2013

- Kraus, R.G., S.T. Stewart, M.G. Newman, R.E. Milliken, and N.J. Tosca (2013), Uncertainties in the shock devolatilization of hydrated minerals: A nontronite case study, *Journal of Geophysical Research*, 118, 2137-2145.
- Hazen, R. D. Azzolini, D. Sverjensky, S. Elmore, L. Hinnov, R.E. Milliken, and D.L. Bish (2013), Clay mineral evolution, *American Mineralogist*, 98, 2007-2029.
- *Stack, K., J.P. Grotzinger, and R.E. Milliken (2013), Bed thickness distributions on Mars: An orbital perspective, *Journal of Geophysical Research*, 118, 1323-1349.
- Mischna, M.A., V. Baker, R.E. Milliken, M. Richardson, and C. Lee (2012), Obliquity-controlled water vapor/trace gas feedback in the Martian greenhouse cycle, *JGR*, 118, 560-576.

2012

- *Li, S., L. Li, R.E. Milliken, and K. Song (2012), Hybridization of Partial Least Squares and Neural Network Models for Quantifying Lunar Surface Minerals, *Icarus*, 221, 208-225.
- Grotzinger, J. P. and R. E. Milliken (2012), The sedimentary rock record of Mars: Distribution, origins, and global stratigraphy, in *Sedimentary Geology of Mars*, eds. J. P. Grotzinger and R. E. Milliken, *SEPM Special Paper*, SP102, 1-48.
- Beyer, R., *K. Stack, J. Griffes, R. E. Milliken, K. Herkenhoff, S. Byrne, J. Holt, and J. P. Grotzinger (2012), An atlas of Mars sedimentary rocks as seen by HiRISE, in *Sedimentary Geology of Mars*, eds. J. Grotzinger and R. E. Milliken, *SEPM Special Paper*, SP102, 49-96.
- Thollot, P., N. Mangold, V. Ansan, S. LeMouélic, R.E. Milliken, J.L. Bishop, C. Weitz, L. Roach, J.F. Mustard, and S.L. Murchie (2012), Most Mars minerals in a nutshell: Various alteration phases formed in a single environment in Noctis Labyrinthus, *Journal of Geophysical Research*, 117, E00J06.
- *Souness, C., B. Hubbard, D. Quincy, and R. E. Milliken (2012), An inventory and population-scale analysis of Martian glacier-like forms, *Icarus*, 217, 243-255.

2011

- †Bristow, T. and R. E. Milliken (2011), A terrestrial perspective on authigenic clay production in ancient Martian lakes, *Clays and Clay Minerals*, 59(4), 339-358.
- Rivkin, A. S., J.-Y. Ling, R. E. Milliken, L. F. Lim, A. J. Lovell, B. E. Schmidt, L. A. McFadden, and B. A. Cohen (2011), The surface composition of Ceres, *Space Science Reviews*, 163, 95-116.
- Feldman, W., A. Pathare, S. Maurice, T. Prettyman, D. Lawrence, R. E. Milliken, and B. Travis (2011), Mars Odyssey neutron data: 2. Search for buried excess water ice deposits at nonpolar latitudes on Mars, *Journal of Geophysical Research*, 116, E11009, doi:10.1029/2011JE003806.
- Thomson, B. J., N. T. Bridges, R. E. Milliken, A. Baldridge, S. J. Hook, J. K. Crowley, G. M. Marion, C. R. de Souza Filho, J. S. Kargel, A. J. Brown, and C. M. Weitz (2011), Constraints on the origin and evolution of the layered mound in Gale Crater, Mars using Mars Reconnaissance Orbiter data, *Icarus*, 214(2), 413-432.
- Grotzinger, J., D. Beaty, G. Dromart, S. Gupta, M. Harris, J. Hurowitz, G. Kocurek, S. McLennan, R.E. Milliken, G. Ori, and D. Sumner (2011), Mars sedimentary geology: Key concepts and outstanding questions, *Astrobiology*, 11(1), 77-87.

2010

- Milliken, R. E. and D. Bish (2010), Sources and sinks of clay minerals on Mars, *Philosophical Magazine*, 90(17), 2293-2308 (invited).
- Hubbard, B., R. E. Milliken, J. S. Kargel, A. Limaye, and C. Souness (2010), Geomorphological characterization and interpretation of a mid-latitude glacier-like form: Hellas Planitia, Mars, *Icarus*, 211(1), 330-346.
- Wray, J., R. E. Milliken, C. Dundas, G. Swayze, J. Andrews-Hanna, A. Baldridge, M. chojnacki, J. Bishop, B. Ehlmann, S. Murchie, R. Clark, F. Seelos, L. Tornabene, and S. Squyres (2010),

Columbus crater and other possible groundwater-fed paleolakes of Terra Sirenum, Mars, *J. Geophysical Research*, 116, E01001.

Skok, J. R., J. F. Mustard, B. L. Ehlmann, R. E. Milliken, and S. L. Murchie (2010), Silica deposits in the Nili Patera caldera on the Sytris Major volcanic complex, Mars, *Nature Geoscience*, 3, 838-841.

Metz, J., J. Grotzinger, C. Okubo, and R. E. Milliken (2010), Thin-skinned deformation of sedimentary rocks in Valles Marineris, Mars, *J. Geophysical Research*, 115, E11004.

Hurowitz, J. A., W. W. Fischer, N. Tosca, and R. E. Milliken (2010), Origin of acidic surface waters and the evolution of atmospheric chemistry on early Mars, *Nature Geoscience*, 3(5), 323-326.

Pratt, L. M. et al. (2010), The Mars Astrobiology Explorer-Cacher (MAX-C): A potential rover mission for 2018, *Astrobiology*, 10(2), 127-163.

Mangold, N., L. Roach, R. E. Milliken, et al. (2010), A late Amazonian alteration layer related to local volcanism on Mars, *Icarus*, 207(1), 265-276.

Milliken, R. E., K. Edgett, J. Grotzinger, and B. J. Thomson (2010), Paleoclimate of Mars as captured by the stratigraphic record in Gale Crater, *Geophysical Research Letters*, 37, L04201.

Roach, L., J. Mustard, G. Swayze, R. E. Milliken, J. Bishop, S. Murchie, and K. Lichtenberg (2010), Hydrated mineral stratigraphy of Ius Chasma, Valles Marineris, *Icarus*, 206(1), 253-268.

Weitz, C. M., R. E. Milliken, J. Grant, A. McEwen, R. Williams, J. Bishop, and B. Thomson (2010), Mars Reconnaissance Orbiter observations of light-toned layered deposits and associated fluvial landforms on the plains adjacent to Valles Marineris, *Icarus*, 205, 73-102.

McEwen, A. et al. (2010), The High Resolution Imaging Science Experiment (HiRISE) during MRO's Primary Science Phase (PSP), *Icarus*, 205, 2-37.

2009

Bishop, J. et al. (2009), Mineralogy of Juventae Chasma: Sulfates in light-toned mounds, mafic minerals in bedrock, and hydrated silica and hydroxylated ferric sulfate on the plateau, *J. Geophysical Research*, 114, E00D09.

Sunshine, J., T. Farnham, L. Feaga, O. Groussin, F. Merlin, R. E. Milliken, and M. A'Hearn, (2009), Temporal and spatial variability of lunar hydration as observed by the Deep Impact spacecraft, *Science*, 326, 565-568.

Metz, J., J. Grotzinger, D. Mohrig, R. E. Milliken et al. (2009), Sublacustrine depositional fans in southwest Melas Chasma, *J. Geophysical Research*, 114, E10002.

Milliken, R. E., W. Fisher, and J. Hurowitz (2009), Missing salts on early Mars, *Geophysical Research Letters*, 36, L11202.

Schon, S., J. Head III, and R. E. Milliken (2009), A recent ice age on Mars: Evidence for climate oscillations from regional layering in mid-latitude mantling deposits, *GRL*, 36, L15202.

Murchie, S., J. Mustard, B. Ehlmann, R. E. Milliken, et al. (2009), A synthesis of Martian aqueous mineralogy after one Mars year of observations from the Mars Reconnaissance Orbiter, *J. Geophysical Research*, 114, E00D06.

Ehlmann, B. et al. (2009), Identification of hydrated silicate minerals on Mars using MRO-CRISM: Geologic context near Nili Fossae and implications for aqueous alteration, *J. Geophysical Research*, 114, E00D08.

Milliken, R. E. and A. Rivkin (2009), Brucite and carbonate assemblages from altered olivine-rich materials on Ceres, *Nature Geoscience*, 2, 258-261, doi:10.1038/NGEO478.

Murchie, S. et al. (2009), Evidence for the origin of layered deposits in Candor Chasma, Mars, from mineral composition and hydrologic modeling, *J. Geophysical Research*, 114, E00D05.

2008

Ehlmann, B. L. et al. (2008), Orbital identification of carbonate-bearing rocks on Mars, *Science*, 322, 1828-1832.

Milliken, R. E., G. Swayze, R. Arvidson, J. Bishop, R. Clark, B. Ehlmann, R. Green, J. Grotzinger, R. Morris, S. Murchie, J. Mustard, and C. Weitz (2008), Opaline silica in young deposits on Mars, *Geology*, 36(11), 847-850, doi: 10.1130/G24967A.1.

Weitz, C. M., R. E. Milliken, J. Grant, A. McEwen, R. Williams, and J. Bishop (2008), Light-toned strata and inverted channels adjacent to Juventae and Ganges Chasmata, Mars, *Geophysical Research Letters*, 35, doi:10.1029/2008GL035317.

Bishop, J. L., E. Noe Dobrea, N. McKeown, M. Parente, B. Ehlmann, J. R. Michalski, R. E. Milliken, F. Poulet, G. Swayze, J. Mustard, S. L. Murchie, and J.-P. Bibring (2008), Phyllosilicate diversity and past aqueous activity revealed at Mawrth Vallis, Mars, *Science*, 321, 830-833.

Mustard, J. F., S. L. Murchie, S. M. Pelkey, B. L. Ehlmann, R. E. Milliken, J. A. Grant, J.-P. Bibring, F. Poulet, J. Bishop, L. Roach, F. Seelos, D. Humm, and the CRISM Science Team (2008), Hydrated silicate minerals on Mars observed by the CRISM instrument on MRO, *Nature*, 454, 305-309.

Grant, J. A., R. P. Irwin, III, J. P. Grotzinger, R. E. Milliken, L. L. Tornabene, A. S. McEwen, C. M. Weitz, S. W. Squyres, T. D. Glotch, and B. J. Thomson (2008), HiRISE imaging of impact megabreccia and sub-meter aqueous strata in Holden Crater, Mars, *Geology*, 36(3), 195-198.

McGuire, P. C. et al. (2008), MRO/CRISM retrieval of surface Lambert albedos for multispectral mapping of Mars with DISORT-based radiative transfer modeling, *IEEE Trans. Geoscience and Remote Sensing*, 46(12), 4020-4040.

2007

Milliken, R. E., J. F. Mustard, F. Poulet, D. Jouglet, J.-P. Bibring, B. Gondet, Y. Langevin, and the OMEGA team (2007), Hydration state of the Martian surface as seen by Mars Express OMEGA II: H₂O content of the surface, *J. Geophysical Research*, 112(E8), doi: 10.1029/2006JE002853.

Jouglet, D., F. Poulet, R. E. Milliken, J. F. Mustard, J.-P. Bibring, Y. Langevin, B. Gondet, and the OMEGA team (2007), Hydration state of the Martian surface as seen by Mars Express OMEGA I: Analysis of the 3 μ m hydration feature, *J. Geophysical Research*, 112(E8), doi: 10.1029/2006JE002846.

Milliken, R. E. and J. F. Mustard (2007), Estimating the water content of hydrated minerals using reflectance spectroscopy I: Effects of darkening agents and low-albedo materials, *Icarus*, 189, 550-573.

Milliken, R. E. and J. F. Mustard (2007), Estimating the water content of hydrated minerals using reflectance spectroscopy II: Effects of particle size, *Icarus*, 189, 574-588.

Pelkey, S. M., J. F. Mustard, S. Murchie, R. T. Clancy, M. Wolff, M. Smith, R. E. Milliken, J.-P. Bibring, A. Gendrin, F. Poulet, Y. Langevin, B. Gondet (2007), CRISM multispectral summary products: Parameterizing mineral diversity on Mars from reflectance spectra, *J. Geophysical Research*, 112(E8), doi: 10.1029/2006JE002831.

2005

Milliken, R. E., and J. F. Mustard (2005), Quantifying absolute water content of minerals using near-infrared reflectance spectroscopy, *J. Geophysical Research*, 110(E12), doi: 10.1029/2005JE002534.

2003

Head, J. W., J. F. Mustard, M. A. Kreslavsky, R. E. Milliken, and D. R. Marchant (2003), Recent ice ages on Mars, *Nature*, 426, 797-802.

Milliken, R. E., J. F. Mustard, and D. L. Goldsby (2003), Viscous flow features on the surface of Mars: Observations from high-resolution Mars Orbiter Camera (MOC) images, *J. Geophysical Research*, 108(E6), doi: 10.1029/2002JE002005.

c. Non-refereed Journal Articles (* indicates student advisee; † indicates postdoctoral advisee)

Milliken, R.E. and D. L. Bish (2011), Clays beyond Earth, *Clays and Clay Minerals*, 59(4), 337-338.

Grotzinger, J., D. Beaty, G. Dromart, S. Gupta, M. Harris, J. Hurowitz, G. Kocurek, S. McLennan, R.E. Milliken, G. Ori, and D. Sumner (2011), The sedimentary record of Mars, *The Sedimentary Record*, 9(2). 4-8.

6. INVITED TALKS

2019 *Harvard University*

Detecting water and organics on primitive asteroids: Lessons learned from the lab and new results from the Hayabusa2 and OSIRIS-REx asteroid sample return missions, Boston, MA (12/2019).

Harvard University

Water on the Moon, Boston, MA (5/2019).

2015 *46th Lunar and Planetary Science Conference*

The nature of hydrated minerals Mars: Linking orbital and rover observations to constrain the climatic evolution of Mars, Abstract #2736 (3/2015).

Indiana University

Water in the Solar System: A story in three acts, Bloomington, IN (3/2015).

- 2014 *Stony Brook University*
Water beyond Earth, Stony Brook, NY (11/2014).
- Geological Society of America Annual Meeting*
Diagenesis on Mars and indications of prolonged water-rock interaction, Vancouver, BC (10/2014).
- AAPG Annual Meeting*
Mineral mapping of Gale Crater using orbital data: results from visible-near infrared reflectance spectroscopy, Houston, TX (4/2014).
- 2013 *Geological Society of America Annual Meeting*
Water on the Moon: Quantitative spatial and temporal variations as seen by the Moon Mineralogy Mapper, Denver, CO (10/2013).
- 2012 *Geological Society of America Annual Meeting*
Gale Crater as a key reference section in understanding the global stratigraphy of Mars, Charlotte, NC (11/2012).
- Harvard University*
Water beyond Earth, Boston, MA (3/2012).
- 2011 *Fall Meeting of the American Geophysical Union*
Mixed-layered clays as evidence for widespread diagenesis on Mars, San Francisco, CA (12/2011).
- Fall Meeting of the American Geophysical Union*
The mineralogical stratigraphy of Gale Crater: A record of changing environmental conditions on ancient Mars, San Francisco, CA (12/2011).
- Brown University*
Water beyond Earth: A story of hydration in three acts, Providence, RI (11/2011).
- Purdue University*
Water beyond Earth, West Lafayette, IN (2/2011).
- 2010 *Geological Society of America Annual Meeting*
Water beyond Earth: A remote-sensing perspective on the role of aqueous processes in the Solar System, Denver, CO (11/2010).
- 2009 *Univ. Montana, Missoula, Winston-Thompson Symposium*
Types, origins, and long-term stability of clays on Mars, Missoula, MT (9/2009).
- University of Notre Dame*
Alteration minerals as indicators of environmental change in the rock record, South Bend, IN (4/2009).
- Mineralogical Society of Southern California*
Opal and other mysterious minerals on Mars, Pasadena, CA (1/2009).
- 2008 *Geological Society of America Annual Meeting*
Understanding sedimentary sources and sinks on Mars from orbit, Houston, TX (10/2008).
- University of Tennessee*

Clay minerals and opal on Mars: Formation mechanisms and depositional environments, Knoxville, TN (2/2008).

Ground Truth from Mars: Science Payoff from a Sample Return Mission Workshop
Interpreting and constraining the composition and depositional environments of phyllosilicates on Mars, #4036, Albuquerque, NM (4/2008).

7. SELECTED ABSTRACTS (Past 5 Years) (*student advisee; † postdoctoral advisee)

2022

Amano, K., Matsuoka, M., Nakamura, T., Kagawa, E., Fujioka, Y., Potin, S. M. et al. (2022). Visible-IR Spectroscopic Diversity of Ryugu Coarse Grains and Comparison to Spectral Properties of Carbonaceous Chondrites. *85th Annual Meeting of The Meteoritical Society*, Abstract #6166.

Amano, K., Matsuoka, M., Nakamura, T., Kagawa, E., Hiroi, T., Tatsumi, E. et al. (2022). Reflectance Spectral Comparison Between a Large Ryugu Returned Sample and Carbonaceous Chondrites. *53rd LPSC*, Houston, TX, Abstract #1789.

Das, E., Glotch, T. D., Edwards, C. S., Ye, C., & Milliken, R. E. (2022). Hapke-Based Laboratory and Remote Determination of Martian Chloride Salt Abundances. *53rd LPSC*, Houston, TX, Abstract #1480.

Das, E., Glotch, T. D., Edwards, C. S., Ye, C., & Milliken, R. (2022). Investigating the Age, Abundance and Origin of Chloride Salt-Bearing Deposits on Mars, *Fall Meeting of the American Geophysical Union*.

Hiroi, T., Ohtsuka, K., Zolensky, M. E., Rutherford, M. J., & Milliken, R. E. (2022). Tagish Lake is Still the Only Possible Meteorite Sample from D-Type Asteroids. *53rd LPSC*, Houston, TX, Abstract #1149.

Lantz, C., Brunetto, R., Dionnet, Z., Nakamura, T., Aléon-Toppani, A., Baklouti, D. et al. (2022). Visible and IR Hyperspectral Imaging of Ryugu Samples Compared to Meteorites and to Remote Sensing of Bennu and Other Primitive Asteroids. *53rd LPSC*, Houston, TX, Abstract #1866.

*Meyer, M. J., Milliken, R. E., & Robertson, K. M. (2022). Testing Airborne-Based Mineralogical and Geologic Mapping of Sedimentary Rocks: A Case Study in the Guadalupe Mountains, New Mexico and Implications for Mars. *53rd LPSC*, Houston, TX, Abstract #1941.

*Meyer, M. J., Milliken, R. E., & Stack, K. M. (2022). Ground Truthing Orbital Layer Boundaries In Situ Along Curiosity's Traverse: Markers of Change in Sedimentary Textures, Diagenesis, Both, or Neither. *53rd LPSC*, Houston, TX, Abstract #1934.

Milliken, R. E., Hiroi, T., *Schultz, C., Robertson, K., Brunetto, R., Lantz, C. et al. (2022). Spectroscopic Ground Truthing of a Carbonaceous Asteroid: Initial Reflectance Spectra of Ryugu Samples and Implications for Remote Observations. *53rd LPSC*, Houston, TX, Abstract #1556.

Nakamura, T., Matsumoto, M., Amano, K., Enokido, Y., Zolensky, M., Mikouchi, T. et al. (2022). Analysis of “Stone” Samples from C-Type Asteroid Ryugu. *85th Annual Meeting of The Meteoritical Society*, Abstract #6190.

Nakamura, T., Matsumoto, M., Amano, K., Enokido, Y., Zolensky, M. E., Mikouchi, T. et al. (2022). Early History of Ryugu’s Parent Asteroid: Evidence from Return Sample. *53rd LPSC*, Houston, TX, Abstract #1753.

*Schultz, C. D., Anzures, B. A., Milliken, R. E., & Hiroi, T. (2022). How Variable are Hydration Signatures of CM2 Chondrites? — Comparing Spectra of Meteorite Powders and Chips Across Multiple Spatial Scales. *53rd LPSC*, Houston, TX, Abstract #1572.

*Wilk, K. A., Mustard, J. F., Kremer, C. H., & Milliken, R. E. (2022). Exploring the Utility of the Water Absorption Feature at 6.1 Microns. *53rd LPSC*, Houston, TX, Abstract #2704.

*Wilson, M. M., Milliken, R. E., & Gough, R. V. (2022). Water Cycling of Hydrated Minerals Under Mars-Relevant Conditions and Implications for Interpreting Near-IR Spectra of Mars. *53rd LPSC*, Houston, TX, Abstract #2364.

2021

*Meyer, M. J., Milliken, R. E., Hurowitz, J. A., & Robertson, K. M. (2021). Primary Depositional and Secondary Diagenetic Fabrics in Evaporite Rocks as Seen by Perseverance Rover’s PIXL Instrument. *52nd Lunar and Planetary Science Conference*, Abstract #1461.

*Anzures, B. A., Parman, S. W., Milliken, R. E., Namur, O., & Cartier, C. (2021). Sulfide Speciation in Mercurian Magmas. *52nd Lunar and Planetary Science Conference*, Abstract #2238.

*Sheppard, R. Y., Milliken, R. E., & Robertson, K. M. (2021). Presence of Clay Minerals Can Obscure Spectral Evidence of Mg Sulfates: Implications for Orbital Observations of Mars. *52nd Lunar and Planetary Science Conference*, Abstract #1560.

*Wilson, M. M., Milliken, R. E., & Gough, R. V. (2021). Water Cycling in Clay Minerals Under Mars-Relevant Conditions: A Near-IR and Mid-IR Reflectance Spectroscopy Study. *52nd Lunar and Planetary Science Conference*, Abstract #2548.

*Schultz, C. D., *Anzures, B. A., Milliken, R. E., & Hiroi, T. (2021). An Investigation of the Sub-mm-Scale Spectral Diversity of the ~3 μm OH/H₂O Absorption Feature in CM2 Carbonaceous Chondrites. *52nd Lunar and Planetary Science Conference*, Abstract #1611.

*Anzures, B. A., *Schultz, C. D., Milliken, R. E., & Hiroi, T. (2021). Assessing Effects of Particle Size on Water Content Estimates of Carbonaceous Chondrites and Their Parent Bodies. *52nd Lunar and Planetary Science Conference*, Abstract #2255.

Milliken, R. E., Hiroi, T., Scholes, D., Slavney, S., & Arvidson, R. (2021). The NASA Reflectance Experiment LABORatory (RELAB) Facility: An Online Spectral Database for Planetary Exploration. *Astromaterials Data Management in the Era of Sample-Return Missions Community Workshop*, Abstract #2021.

Bristow, T. et al. (2021), Climate driven diagenetic processes in Gale Crater, Mars, *Fall Meeting of the AGU*, P21A-01.

*Sheppard, R. et al. (2021), Mineralogical and chemical trends in a 100 m drill core from Lake Towuti, Indonesia reflect catchment, water column, and diagenetic conditions, *Fall Meeting of the AGU*, EP45H-1592.

Bristow, T. et al. (2021), In situ mineralogy of a clay-sulfate transition in Gale Crater, *Fall Meeting of the AGU*, P24A-03.

2020

*Sheppard, RY, RE Milliken, JM Russell, MD Dyar, EC Sklute, S Bijaksana, M Melles, H Vogel (2020), 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, 51st LPSC, Houston, TX, 2347.

*Wilson, MM, RE Milliken, and MM Osterloo (2020), An Updated Study of Chloride Deposits on Mars: Do they Exhibit Macroscopic Evidence for Deliquescence or Recrystallization?, 51st LPSC, Houston, TX, 2395.

*Wilner, JA, AJ Evans, RE Milliken, MM Sori (2020), Spectroscopy of Domes on Ceres and Implications for Emplacement, 51st LPSC, Houston, TX, 2798.

*Meyer, MJ, RE Milliken, KM Robertson, JA Hurowitz (2020), Microscale Chemical and Spectral Characterization of Clay-Bearing Evaporites and Implications for the Mars 2020 Rover, 51st LPSC, Houston, TX, 1705.

Milliken, RE, JP Grotzinger, R Sheppard, RC Wiens, R Gellert, LM Thomson, A Vasavada, T Bristow, N Mangold (2020), Rover Observations and Orbital Predictions of an Ancient Lacustrine Sequence on Mars, 51st LPSC, Houston, TX, 2228.

Hiroi, T, RE Milliken, KM Robertson, H Kaiden, K Misawa, R Shimana, S Sasaki, M Matsuoka, T Nakamura, K Kitazato, E Tatsumi, S Sugita, K Ohtsuka (2020), Meteorite Hills 00639 as an Analogue of Asteroid 162173 Ryugu Based on Space Weathering Simulations of Carbonaceous Chondrites, 51st LPSC, Houston, TX, 1043.

*Fisher, EA, JF Mustard, CM Pieters, RE Milliken, K Robertson (2020), A Proposed Approach for Evaluating Water Adsorption and Speciation Through Remotely Acquired Spectra of the Lunar Surface, 51st LPSC, Houston, TX, 2960.

Robertson, KM, L Togle, CM Pieters, RE Milliken (2020), Spectral Effect of Ilmenite Abundance and Composition on the Spectral Parameters of Pyroxene in the VIS-NIR Wavelength Range, 51st LPSC, Houston, TX, 2174.

*Anzures, BA, SW Parman, JS Boesenberg, RE Milliken (2020), Volatile (S, C, F, Cl) Contents of Enstatite in Reduced Meteorites as Indicators of Oxygen Fugacity and Volatile Conditions in the Early Solar Nebula, 51st LPSC, Houston, TX, 1207.

*Fisher, EA, RE Milliken, K Robertson, S Li (2020), Determining the Modal Mineralogy of Howardites and Brecciated Eucrites with Radiative Transfer Modeling: A Combined XRD-VNIR Study and Implications for Vesta, 51st LPSC, Houston, TX, 2320.

- *Sheppard, RY, RE Milliken, KM Robertson (2020), Reflectance Measurements of Clays and Sulfates Under Mars-Like Temperature and Relative Humidity Cycles and Implications for Clay-Sulfate Assemblages in Gale Crater, 51st LPSC, Houston, TX, 2357.
- *Bramble, MS, RE Milliken (2020), The Thermal Emission of Ordinary Chondrites and Analog Mixtures at Simulated Asteroid Conditions, 51st LPSC, Houston, TX, 2498.
- *Schultz, CD, BA Anzures, RE Milliken, T Hiroi (2020), Assessing the Spatial Variability of the 3 μm OH/H₂O Absorption Feature in CM2 Carbonaceous Chondrites, 51st LPSC, Houston, TX, 2303.
- Milliken, RE, K Kitazato, L Riu, T Iwata, M Abe, M Ohtake, S Matsuura, Y Nakauchi, T Nakamura, M Matsuoka, H Senshu, N Hirata, T Hiroi, C Pilorget, R Brunetto, F Poulet, J-P Bibring, D Takir, DL Domingue, F Vilas, MA Barucci, D Perna, E Palomba, A Galiano, K Tsumura, T Osawa, M Komatsu, A Nakato, T Arai, N Takato, T Matsunaga, Y Takagi, K Matsumoto, T Kouyama, Y Yokota, E Tatsumi, N Sakatani, Y Yamamoto, T Okada, S Sugita, R Honda, T Matora, S Kameda, H Sawada, C Honda, M Yamada, H Suzuki, K Yoshioka, M Hayakawa, K Ogawa, Y Cho, Y Takei, T Saiki, S Nakazawa, S Tanaka, M Yoshikawa, S Watanabe, Y Tsuda (2020), A Global View of the Near-Infrared Reflectance Properties of Ryugu as Seen by the NIRS3 Spectrometer on Hayabusa2, 51st LPSC, Houston, TX, 1944.

2019

- Milliken, R. E., Grotzinger, J. P., Wiens, R., Gellert, R., Thompson, L. M., Sheppard, R. et al. (2019). The Chemistry and Mineralogy of an Ancient Lacustrine Sequence on Mars: Lessons Learned from Integrating Rover and Orbiter Datasets. *9th International Conference on Mars*, Abstract #6191.
- Kitazato, K., Milliken, R. E., Iwata, T., Abe, M., Matsuura, S., Arai, T. et al. (2019). Near-Infrared Spectral Variability on Asteroid Ryugu. *Asteroid Science in the Age of Hayabusa2 and OSIRIS-REx*, Abstract #2106.
- Fraeman, A. A., Catalano, J. G., Edgar, L. A., Fischer, W. W., Grotzinger, J. P., L'Haridon, J. et al. (2019). Vera Rubin Ridge and Iron Oxide Bearing Sedimentary Rocks on Mars: The Integrated View from Curiosity and Orbital Data. *Ninth International Conference on Mars*, Abstract #6237.
- Matsuoka, M., Nakamura, T., Hiroi, T., Kitazato, K., Iwata, T., Abe, M. et al. (2019). Infrared Spectra of Asteroid Ryugu: Comparison to Laboratory-Measured Carbonaceous Chondrites. *50th Lunar and Planetary Science Conference*, Abstract #1534.
- Hiroi, T., Milliken, R. E., Robertson, K. M., Kaiden, H., Misawa, K., Tanaka, H. et al. (2019). Gaussian Deconvolution of the 2.7-Micron Band of Hayabusa2/NIRS3 Spectrum of Asteroid Ryugu — Possibly a Heavily Space-Weathered CM Chondrite Body. *50th Lunar and Planetary Science Conference*, Abstract #1129.
- Riu, L., Kitazato, K., Milliken, R., Abe, M., Ohtake, M., Matsuura, S. et al. (2019). Global View of the Mineralogy and Surface Properties of the Asteroid Ryugu Using NIRS3 Near-Infrared

Spectrometer on Board Hayabusa2. *50th Lunar and Planetary Science Conference*, Abstract #1154.

Milliken, R. E., Kitazato, K., Riu, L., Iwata, T., Abe, M., Ohtake, M. et al. (2019). A Global View of the Near-Infrared Reflectance Properties of Ryugu as Seen by the NIRS3 Spectrometer on Hayabusa2. *Asteroid Science in the Age of Hayabusa2 and OSIRIS-REx*, Abstract #2132.

Nakamura, T., Matsuoka, M., Amano, K., Kobayashi, S., Mita, H., Brunetto, R. et al. (2019). Possible Interpretations of Visible/Near-Infrared Spectra of Asteroid Ryugu Obtained by the Hayabusa2 Mission. *50th Lunar and Planetary Science Conference*, Abstract #1681.

Takir, D., Kitazato, K., Milliken, R. E., Iwata, T., Abe, M., Ohtake, M. et al. (2019). Spectral Characteristics of Asteroid (162173) Ryugu with Hayabusa2 NIRS3. *82nd Annual Meeting of The Meteoritical Society*, Abstract #6096.

*Sheppard, R. Y., Milliken, R. E., Itoh, Y., & Parente, M. (2019). Lateral Continuity of Mineralogical and Morphological Contacts in Mt. Sharp: Linking Upcoming Rover Observations and Orbital Data. *50th Lunar and Planetary Science Conference*, Abstract #2124.

*Sheppard, R. Y., Milliken, R. E., Itoh, Y., & Parente, M. (2019). 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*, Abstract #6289.

Robertson, K. M., Milliken, R. E., Pieters, C. M., & Isaacson, P. (2019). Textural and Compositional Considerations for Mapping Ilmenite on the Lunar Surface Using VIS-NIR Reflectance Spectroscopy. *50th Lunar and Planetary Science Conference*, Abstract #2513.

*Anzures, B. A., Parman, S. W., Boesenberg, J. S., & Milliken, R. E. (2019). Using Volatile (S, C, H, F, Cl) Contents of Enstatite in Reduced Meteorites to Estimate Oxygen Fugacity and Equilibrium Melt Compositions. *50th Lunar and Planetary Science Conference*, Abstract #2179.

*Bramble, M. S., Milliken, R. E., Patterson, W. R. I. I. I., & Mustard, J. F. (2019). Thermal Infrared Characterization of Ordinary Chondrite Analogs in a Simulated Asteroid Environment with Implications for the Remote Analysis of Asteroid Mineralogy. *50th Lunar and Planetary Science Conference*, Abstract #2101.

Farrell, K. W. J., Bomse, D. S., Milliken, R. E., Mustard, J. F., & Head, J. W. I. I. I. (2019). Lunar Laser Surface Solar Occultation (LLSSO), a Payload Concept for Lunar Landers. *50th Lunar and Planetary Science Conference*, Abstract #2080.

Kaiden, H., Hiroi, T., Misawa, K., Tanaka, H., Sasaki, S., Robertson, K. M. et al. (2019). Changes in Reflectance Spectra of a CM2 Carbonaceous Chondrite: Simulation of Space Weathering by Ultraviolet Irradiation. *82nd Annual Meeting of The Meteoritical Society*, Abstract #6451.

Yen, C. J.-K., Milliken, R. E., Fraeman, A. A., Itoh, Y., Parente, M., & Dickson, J. L. (2019). An Updated Orbital Analysis of Ancient Strata in Terby Crater, Mars: The Thickest Deltaic Sequence on Mars. *50th Lunar and Planetary Science Conference*, Abstract #2215.

Kaiden, H., Hiroi, T., Misawa, K., Tanaka, H., Sasaki, S., Robertson, K. M. et al. (2019). Space Weathering of Olivine and the Murchison CM2 Carbonaceous Chondrite Simulated by Ultraviolet Irradiation. *50th Lunar and Planetary Science Conference*, Abstract #2630.

*Bramble, M. S., & Milliken, R. E. (2019). Thermal Emission Spectroscopy of Ordinary Chondrites at Simulated Asteroid Conditions with Implications for Asteroid Thermophysical and Compositional Interpretations. *Asteroid Science in the Age of Hayabusa2 and OSIRIS-REx*, Abstract #2139.

2018

Li, S., P. Lucey, and R. Milliken (2018), Exploiting water resource in pyroclastic deposits and cold traps on the Moon, *Fall Meeting of the AGU*, P12A-02.

Matsuoka, M. et al. (2018), Interpretation of infrared spectra of asteroid Ryugu based on comparison to carbonaceous chondrites and other meteorites, *Fall Meeting of the AGU*, P13A-05.

Brunetto, R. et al. (2018), Hayabusa2/NIRS3 spectral observations of asteroid (162173) Ryugu, *Fall Meeting of the AGU*, P22A-02.

*Sheppard R., R.E. Milliken, Y. Itoh, and M. Parente (2018), Assessing lateral variations in the mineralogical stratigraphy of Mt. Sharp: Linking rover and orbital observations, *Fall Meeting of the AGU*, P41A-08.

*Bramble, M., R.E. Milliken, W.R. Patterson, and J.F. Mustard (2018), Thermal infrared characterization of ordinary chondrite analogs in a simulated asteroid environment with implications for the interpretation of asteroid physical and chemical properties, *Fall Meeting of the AGU*, P53D-2997.

Pieters, C.M., T. Hiroi, R. Milliken, L. Cheek (2018), Abundance and distribution of lunar primary crust anorthosite: the featureless plagioclase challenge, *49th Lunar and Planetary Science Conference*, #1698.

Hiroi, T., R.E. Milliken, H. Kaiden, S. Sasaki, M. Matsuoka, T. Nakamura (2018), Gaussian deconvolution of the 3-micron hydration band of carbonaceous chondrites for identifying their parent bodies using a spectrometer in space, *49th Lunar and Planetary Science Conference*, #1056.

*Kaplan, H.H., R.E. Milliken, and C.M. O'D. Alexander (2018), New constraints on abundance and composition of organic matter on Ceres, *49th Lunar and Planetary Science Conference*, #1155.

*Bramble, M.S., W.R. Patterson III, R.E. Milliken, *Y. Yang (2018), Radiometric calibration of thermal emission data from the asteroid and lunar environment chamber (ALEC), *49th Lunar and Planetary Science Conference*, #1598.

*Fisher, E.A., R.E. Milliken, K. Robertson, and S. Li (2018), Determining the modal mineralogy of howardites and brecciated eucrites: A combined XRD-VNIR study and implications for Vesta, *49th Lunar and Planetary Science Conference*, #1650.

- *Yang, Y., S. Li, R.E. Milliken, K. Robertson, T. Hiroi, and H. Zhang (2018), Particle phase functions of typical lunar minerals derived from photometric spectral measurements, *49th Lunar and Planetary Science Conference*, #1784.
- *Yang, Y. R.E. Milliken, W.R. Patterson, M.S. Bramble, K.L. Donaldson Hanna, and H. Zhang (2018), Data reduction of FTIR thermal emission measurements under cold vacuum conditions: Processing of interferograms vs. spectra, *49th Lunar and Planetary Science Conference*, #1803.
- †Robertson, K.M., S. Li, R.E. Milliken, C.M. Pieters and P. Isaacson (2018), Radiative transfer modeling of ilmenite in lunar basalts, physical mixtures, and implications for mapping of titanium on the Moon, *49th Lunar and Planetary Science Conference*, #1968.
- Tokle, L, K.M. †Robertson, and R.E. Milliken (2018), Development of an Fe-Mg compositional calibration for the ilmenite-geikielite solid-solution using XRD and reflectance spectroscopy, *49th Lunar and Planetary Science Conference*, #2095.
- Milliken, R.E., S. Li, and C. Huber (2018), Orbital evidence for water in pyroclastics at Taurus-Littrow and other dark mantle deposits on the Moon: Abundance, resource implications, and future directions, *49th Lunar and Planetary Science Conference*, #2639.
- *Sheppard, R.Y., R.E. Milliken, J.M. Russell, H. Vogel, M. Melles, and S. Bijaksana (2018), Signatures of iron cycling in a terrestrial redox-stratified lake and implications for Gale crater, Mars, *49th Lunar and Planetary Science Conference*, #1471.
- *Anzures, B.A., S.W. Parman, and R.E. Milliken (2018), Effect of sulfur speciation on chemical and physical properties of heavily reduced mercurian melts, *49th Lunar and Planetary Science Conference*, #1694.

8. FUNDING

a. Current & Pending

Pending

Title: Lunar Structure, Composition, and Processes for Exploration (LunaSCOPE)
PI: Alex Evans (Brown University)
Role: Co-I
Source: NASA SSERVI
Amount: \$6M Duration: 2023-2028

Funded/Active

Title: NASA Rhode Island Space Grant Program
PI: Ralph Milliken (Brown University)
Role: PI
Source: NASA OSTEM (National Space Grant College & Fellowship Program)
Amount: \$3.33M (entirety to Brown) Duration: 2020-2024

Title: Established Program to Stimulate Competitive Research (EPSCoR) – Research Infrastructure Development (RID)
PI: Ralph Milliken (Brown University)
Role: PI
Source: NASA OSTEM (EPSCoR)
Amount: \$1M (entirety to Brown) Duration: 2022-2027

Title: The Reflectance Experiment LABORatory (RELAB) facility
PI: Ralph Milliken (Brown Univ.)
Role: PI
Source: NASA Planetary Science Enabling Facilities
Amount: \$1.1M (entirety to Milliken) Duration: 2023–2026

Title: OSIRIS-REx Mission – Bennu sample analysis support
PI: Dante Lauretta (University of Arizona)
Role: Co-I
Source: NASA OSIRIS-REx Mission
Amount: \$459k (entirety to Milliken) Duration: 2020-2023

Title: An experimental approach to assessing the role of hydrous minerals in the martian hydrological cycle
PI: Ralph Milliken (Brown University)
Role: PI
Source: NASA Solar System Workings Program
Amount: \$437k (\$404k to Milliken) Duration: 2019-2022

Title: Remote geologic interpretation at rover, airborne, and orbital scales: Improving our ability to recognize potential biosignatures on Mars
PI: Ralph Milliken (Brown University)
Role: PI; Future Investigator (FI): Ms. Melissa Meyer
Source: Future Investigators in NASA Earth & Space Science & Technology (FINESST)

Amount: \$135k (entirety to PI/PI) Duration: 2020-2023
 Title: Enhancing the RELAB spectral database for the modern era of planetary science
 PI: Dr. Ralph Milliken (Brown Univ.)
 Role: PI
 Source: NASA SMD Standalone Submission 2022
 Amount: \$50k Duration: 2022–2023

b. Completed

Title: Enhancing the RELAB spectral database for the modern era of planetary science
 PI: Ralph Milliken (Brown University)
 Role: PI
 Source: NASA Planetary Data Archiving, Restoration, and Tools (PDART)
 Amount: \$990k (\$862k to Milliken) Duration: 2016-2022
 (includes funding for operation and management of NASA RELAB facility)

Title: Global modal mineralogy of Vesta and links to HEDs using Dawn VIR data
 PI: Ralph Milliken (Brown University)
 Role: PI
 Source: NASA Discovery Data Analysis Program (DDAP)
 Amount: \$358k (entirety to Milliken) Duration: 2017-2022

Title: The Chemical and Mineralogical Stratigraphy of Mt. Sharp
 PI: Ralph Milliken (Brown University)
 Role: PI
 Source: NASA MSL Rover Participating Scientist Program (MSL-PS2)
 Amount: \$421k (entirety to Milliken) Duration: 2016-2022

Title: SSERVI: Evolution and Environment of Exploration Destinations
 PI: Carle Pieters (Brown University)
 Role: Co-I
 Source: NASA Solar System Exploration Research Virtual Institute (SSERVI)
 Amount: \$6M (\$353k augmentation to Milliken for RELAB) Duration: 2014-2019

Title: Compact Reconnaissance Imaging Spectrometer for Mars
 PI: John Mustard (Brown University)
 Role: Co-I
 Source: NASA Mars Reconnaissance Orbiter, Extended Mission 4
 Amount: \$228k (\$50k to Milliken) Duration: 2016-2019

Title: Foundations of complex life: Evolution, preservation and detection
 PI: Roger Summons (MIT)
 Role: Co-I / Brown Univ. PI
 Source: NASA Astrobiology Institute (NAI)
 Amount: \$7.95M (\$372k to Milliken) Duration: 2013-2017

Title: Quantifying the hydration state of the lunar surface
 PI: Ralph Milliken (Brown University)
 Role: PI
 Source: NASA Lunar Advanced Science & Exploration Research (LASER)
 Amount: \$211k (entirety to Milliken) Duration: 2011-2016

Title: Quantifying hydration properties on Mars: Linking rover, orbital, & lab data
 PI: Ralph Milliken (Brown University)
 Role: PI
 Source: NASA MSL Rover Participating Scientist Program (MSL-PS1)
 Amount: \$680k (entirety to Milliken) Duration: 2011-2016

Title: Martian clays: Types, origins, and geothermometers
 PI: Ralph Milliken (Brown University)
 Role: PI
 Source: NASA Mars Data Analysis Program (MDAP)
 Amount: \$302k (entirety to Milliken) Duration: 2012-2015

Title: Obliquity-controlled water vapor/trace gas feedback on Mars
 PI: Michael Mischna (Jet Propulsion Lab)
 Role: Co-I
 Source: NASA Mars Fundamental Research (MFRP)
 Amount: \$360k (\$37k to Milliken) Duration: 2011-2014

Title: Laboratory and field studies of silica deposits with relevance to Mars
 PI: Steve Ruff (Arizona State University)
 Role: Co-I
 Source: NASA Mars Fundamental Research Program (MFRP)
 Amount: \$606k (\$106k to Milliken) Duration: 2011-2015

9. SERVICE

a. University & Department

- Ph.D. Thesis Committee Member (former; not including primary advisees)

Timothy Goudge (2015)	Rebecca Greenberger (2015)
Kevin Cannon (2017)	William Daniels (2017)
Terik Daly (2017)	Tess Caswell (2018)
Richard Vachula (2019)	Nora Richter (2020)
Jennifer Kowalczyk (2023)	
- Preliminary Examination Committee Member (former; not including primary advisees)

Timothy Goudge (2013)	Rebecca Greenberger (2013)
Brooks Proctor (2014)	Kevin Cannon (2014)
Terik Daly (2014)	Erica Jawin (2015)
Leif Tokle (2017)	Michael Bramble (2017)
Nora Richter (2018)	Ariel Deutsch (2018)
Alyssa Pascuzzo (2018)	Jesse Tarnas (2019)
Sierra Kaufman (2019)	Evan Bjonnes (2019)
Jennifer Kowalczyk (2020)	
- Graduate Student Advising Committee Member (current; not including primary advisees)

Jennifer Kowalczyk	Fiona Nichols-Fleming
Kierra Wilk	Sebastian Perez-Lopez
- Curriculum Committee (DEEPS, 2013-present; committee chair for 2015-2021)
- DEEPS Diversity & Inclusion Action Committee (2019 – 2021)
- Radiation Safety Committee (University, 2017-2022)
- College Curriculum Council (University, July 2016-July 2018)
- Outside Lecturers (DEEPS, Spring 2014)
- Physical Facilities (DEEPS, 2013-2015)
- Participant in Brown “Google Hangout” for admitted STEM students (video chat) (4/2014)
- Member of search committee for faculty hire in planetary science (2014-2015)

- Chair of committee for targeted faculty hire in planetary science (2018)

b. Profession

- Science manager & director of NASA Reflectance Experiment Laboratory (RELAB) facility at Brown University (2013-present)
- Reviewer of numerous articles (~5/year) for peer-reviewed journals including:

Science	Nature	Nature Geoscience
Geology	J. Geophysical Research	Geophysical Research Letters
Icarus	Clays & Clay Minerals	Meteoritics & Planetary Science
Clay Minerals	Space Science Reviews	Proc. National Academy of Science
- Reviewer of numerous proposals (~6-8/year) for various NASA and NSF funding programs as well as international funding agencies (e.g., NWO [Netherlands], SNSF [Switzerland], JAXA [Japan], NKFIH [Hungary], PRESTIGE Marie Curie fellowship [France]).
- Panel chair and panel member for various NASA review panels
- Reviewer of NASA Dawn mission (VIR instrument) data delivery to Planetary Data System public archive (2011 – 2019)
- Co-organizer of the *First International Conference on Mars Sedimentology and Stratigraphy*, Lunar and Planetary Institute, held in El Paso, TX of April 2010.
- Co-editor of a special issue on extraterrestrial clays for *Clays and Clay Minerals* (2011, vol. 59, no. 4).
- Co-organizer for a session on extraterrestrial clays for the *14th International Conference on Clays (ICC)* held in Italy, 2009 and for *16th ICC* held in Spain, 2017
- Co-organizer of sessions at GSA, AGU and Goldschmidt conferences.

c. Community

Education & Public Outreach Talks

2019

Skyscrapers Inc. (~50 attendees)	Water on the Moon	N. Scituate, RI
Apollo 50 th Celebration @ WaterFire Arts Center (~50 attendees)	Water on the Moon	Providence, RI
Nayatt Elementary School 1 st grade (~15 students)	Asteroids!	Barrington, RI
Nayatt Elementary School 3 rd grade (~25 students)	Asteroids!	Barrington, RI

2016

Summer@Brown class (1 lecture; 24 attendees)	Habitability on Mars	Providence, RI
STEM I Conference @ Brown (middle schools; ~36 students)	Curiosity Rover	Providence, RI
SPARK class guest lecture (6 th -7 th graders; ~12 students)	Roving on Mars	Providence, RI

2015

Summer@Brown class (1 lecture; 15 attendees)	Habitability on Mars	Providence, RI
Vartan Gregorian Elementary (~60 students)	Searching for Life Beyond Earth	Providence, RI
STEM Day @ Brown University (~50 students)	The Curiosity Rover	Providence, RI

2014

Palmer River Elementary School (3 rd /4 th grade; ~280 students)	Roving Mars	Rehoboth, MA
Summer@Brown class (1 lecture; 14 attendees)	Habitability on Mars	Providence, RI
Brown Univ. Staff Advisory Committee (~25 attendees)	The Curiosity Rover	Providence, RI
STEM Day @ Brown University (~50 attendees)	The Curiosity Rover	Providence, RI
250 th Anniversary @ Brown (RI middle schools) (~40 students)	Roving Mars	Providence, RI

2013

Spectroscopy Society of Pittsburgh (~80 attendees)	A Year of Roving Mars	Pittsburgh, PA
Science Café (Brown University) (~30 attendees)	A Year of Roving Mars	Providence, RI
Maria Mitchell Association (~35 attendees)	A Year on Mars	Nantucket, MA
Summer@Brown class (1 lecture; 14 attendees)	Habitability on Mars	Providence, RI
Brown Univ. Staff Development Day (~50 attendees)	The Curiosity Rover	Providence, RI
Brown Univ. Staff Advisory Committee (~24 attendees)	The Curiosity Rover	Providence, RI
RI Space Grant Spring Symposium (~50 attendees)	The Curiosity Rover	Providence, RI
STEM Day @ Brown University (~40 attendees)	The Curiosity Rover	Providence, RI
South Shore Natural Science Center (~50 attendees)	Water on Mars	Norwell, MA
Skyscrapers Inc. (~50 attendees)	The Curiosity Rover	N. Scituate, RI
Vartan Gregorian Elementary School (~200 students)	Roving on Mars	Providence, RI
Gordon School 7 th Grade (~45 students)	Roving on Mars	E. Providence, RI
Gordon School 6 th Grade (~45 students)	Roving on Mars	E. Providence, RI

2012

Marquette Elementary School 5 th grade (~60 students)	The Geology of Mars	South Bend, IN
Marquette Elementary School 6 th grade (~50 students)	The Geology of Mars	South Bend, IN
Warren Elementary School 4 th grade (~60 students)	The Geology of Mars	South Bend, IN
Warren Elementary School 5 th grade (~60 students)	The Geology of Mars	South Bend, IN

Other

2009	Summer Undergraduate Research Fellowship Mentor	Caltech
2008	Summer Undergraduate Research Fellowship Mentor	JPL/Caltech
2006	Supplemental Science Instructor, 4 th grade	Providence Public Schools
2005	Supplemental Science Instructor, 4 th grade	Providence Public Schools

10. AWARDS, HONORS, & RECOGNITION

2014	Honored with naming of asteroid 9003 <i>Ralphmilliken</i> by the IAU	
2012	#1 most-highly-cited paper published in the journal <i>Geology</i> for year 2008: Milliken et al. (2008), Opaline silica in young deposits on Mars, <i>Geology</i> , v.36, 847-850. (source: GSA, December 2012) http://geology.gsapubs.org/content/40/12/1147/T1.expansion.html	
2012	Portrait on stamp from Guinea commemorating the landing of the NASA Mars Curiosity rover in Gale Crater	
2009	Mariner/Ranger Award for Outstanding Publication	JPL
2006	Juokowsky Foundation Outstanding Dissertation Award nominee	Brown Univ.

11. TEACHING & ADVISING

a. Regular Courses & Field Trips

Brown

AY 2021/2022

(Spring)	EEPS 0810: <i>Planetary Geology</i>	72 enrolled
(Fall)	EEPS 2840: <i>Asteroids and Meteorites</i>	6 enrolled
(Fall)	STS 1970: Independent Study in Science, Technology & Society	1 enrolled

AY 2020/2021

(Spring)	EEPS 0810: <i>Planetary Geology</i>	123 enrolled
(Fall)	EEPS 2330: <i>Advanced Remote Sensing</i>	11 enrolled

AY 2019/2020

(Spring)	GEOL 0810: <i>Planetary Geology</i>	48 enrolled
(Spring)	GEOL 2920C: <i>The Sedimentary Rock Cycle of Earth & Mars</i>	6 enrolled
(Fall)	GEOL 1710: <i>Remote Sensing of Earth and Planetary Surfaces</i>	12 enrolled

AY 2018/2019

Sabbatical, no courses taught

AY 2017/2018

(Spring)	GEOL 0810: <i>Planetary Geology</i>	47 enrolled
(Spring)	GEOL 2920C: <i>The Sedimentary Rock Cycle of Earth & Mars</i>	9 enrolled
(Fall)	GEOL 1970: <i>Independent Study</i>	1 enrolled
(Fall)	GEOL 1710: <i>Remote Sensing of Earth and Planetary Surfaces</i>	13 enrolled

AY 2016/2017

(Spring)	GEOL 0810: <i>Planetary Geology</i>	76 enrolled
(Spring)	GEOL 2840: <i>Asteroids and Meteorites</i>	8 enrolled
(Fall)	Junior Sabbatical, no courses taught this semester	

AY 2015/2016

(Spring)	GEOL 0810: <i>Planetary Geology</i>	66 enrolled
(Spring)	GEOL 2920C: <i>The Sedimentary Rock Cycle of Earth & Mars</i>	8 enrolled
(Spring)	GEOL 1970: <i>Independent Study</i>	1 enrolled
(Fall)	DEEPS Fall Field Trip	19 attendees
(Fall)	GEOL 1710: <i>Remote Sensing of Earth and Planetary Surfaces</i>	6 enrolled

AY 2014/2015

(Spring)	GEOL 0810: <i>Planetary Geology</i>	35 enrolled
(Spring)	GEOL 2840: <i>Asteroids and Meteorites</i>	8 enrolled
(Fall)	GEOL 1710: <i>Remote Sensing of Earth and Planetary Surfaces</i>	6 enrolled

AY 2013/2014

(Spring)	GEOL 2920C: <i>The Sedimentary Rock Cycle of Earth & Mars</i>	9 enrolled
(Fall)	GEOL 2840: <i>Asteroids and Meteorites</i>	7 enrolled

AY 2012/2013

(Spring)	GEOL 1710: <i>Remote Sensing of Earth and Planetary Surfaces</i>	9 enrolled
(Spring)	GEOL 2920K: <i>The Hydrological Cycle of Mars (w/Prof. J. Head III)</i>	9 enrolled
(Fall)	Teaching Relief (in residence at JPL for Mars Curiosity rover operations)	

Previous – University of Notre Dame

AY 2011/2012

2012 (Spring)	ENVG 10900/20900: <i>Planetary Geology</i>	25 enrolled
---------------	--	-------------

2012 (Spring) ENVG 45200: *Geology Field Trip* 13 enrolled
2011 (Fall) ENVG 40610: *Remote Sensing of Our Environment* 11 enrolled

AY 2010/2011

2011 (Spring) ENVG 10900/20900: *Planetary Geology* 38 enrolled
2011 (Spring) ENVG 45200: *Geology Field Trip* 23 enrolled

c. Student & Postdoc Advisees

Current Graduate Students

Melissa Meyer (Advisor for Ph.D.; entered 9/2019)
Cody Schultz (Advisor for Ph.D.; entered 9/2019)
Margaret Wilson (Advisor for Ph.D.; entered 9/2019)

Former Graduate Students

Brendan Anzures (Co-Advisor for Ph.D.; Postdoctoral Researcher at Johnson Space Center)
Rachel Sheppard (Research Scientist at Planetary Science Institute)
Michael Bramble (Postdoctoral Researcher at Jet Propulsion Lab)
David Tersegno (Advisor for Sc.M.)
Elizabeth Fisher (Advisor for Sc.M.; currently Ph.D. student at Univ. Hawaii)
Yazhou Yang (Co-Advisor; visiting student through Chinese Scholarship Council)
Vivian Sun (Systems Engineer at Jet Propulsion Lab/Caltech)
Hannah Kaplan (Research Space Scientist at NASA Goddard)
Shuai Li (Assistant Professor at U. of Hawaii, Manoa)
Kathryn Stack (Co-Advisor; Ph.D. at Caltech w/ Dr. John Grotzinger; Research Scientist at JPL/Caltech; Deputy Project Scientist for NASA Perseverance Mars rover)

Former Postdocs

Dr. Thomas Bristow (Research Scientist at NASA Ames)
Dr. Shuai Li (Assistant Researcher at U. of Hawaii, Manoa)
Dr. Kevin Robertson (Research Associate at Brown University)

d. Honors, Master's and Ph.D. Theses Directed

Ph.D.

Brendan Anzures (Sc.M. Brown University, 2018; Ph.D., Brown University, 2021)
Rachel Sheppard (Sc.M. Brown University, 2017; Ph.D., Brown University, 2020)
Michael Bramble (Sc.M. Brown University, 2016; Ph.D., Brown University, 2020)
Hannah Kaplan (Sc.M. Brown University, 2015; Ph.D., Brown University, 2018)
Vivian Sun (Sc.M. Brown University, 2015; Ph.D., Brown University, 2017)
Shuai Li (Sc.M. Brown University, 2014; Ph.D., Brown University, 2016)
Kathryn Stack (Ph.D. co-advisor, Caltech 2014)

Sc.M.

Elizabeth Fisher (Sc.M., Brown University, 2020)
David Tersegno (Sc.M., Brown University, 2021)

B.S./Honors Theses

Christopher Yen (Sc.B. in Geology w/Honors, Brown University 2019)
Amanda Siemann (B.S. in Geology w/ Honors, Univ. of Notre Dame 2012)