Michael S. Bramble

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CONTACT INFORMATION

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RESEARCH INTERESTS

- Investigating mineral spectral alterations from cold, irradiated, and vacuum conditions to aid in deriving physical and chemical properties of small worlds
- Advancing visible and infrared spectroscopy for quantitative analysis of physical and chemical properties of airless planetary surfaces
- Using remote sensing to characterize the mineralogy, geological history, and surface processes observed on planetary surfaces
- Development of quantitative analytical techniques and instrumentation in the geological sciences

EDUCATION

2020 *PhD,* Earth, Environmental, and Planetary Sciences
Brown University, Providence, RI
Dissertation: "Advancing Thermal Emission Spectroscopy for Asteroid Compositional and Thermophysical Analyses with Laboratory Experiments in a Simulated Asteroid Environment"
Advisors: Dr. R. E. Milliken and Dr. J. F. Mustard

2016 *MSc,* Earth, Environmental, and Planetary Sciences
Brown University, Providence, RI
Thesis: "The geological history of Northeast Syrtis Major, Mars"
Advisor: Dr. J. F. Mustard

2014 *BSc,* Honors Specialization in Planetary Science
The University of Western Ontario, London, ON
Thesis: "Quantitative grain size determination by two-dimensional micro-X-ray diffraction and its application to the planetary sciences"
Advisors: Dr. R. L. Flemming and Dr. P. J. A. McCausland

2010 *BMus (Hons),* Music Theory and Composition
Memorial University of Newfoundland, St. John's, NL

PROFESSIONAL EXPERIENCE

Postdoctoral Scholar 2020 – Present
Jet Propulsion Laboratory, California Institute of Technology

Postdoctoral Research Associate 2020
Department of Earth, Environmental, and Planetary Sciences, Brown University

Graduate Student Research Assistant 2014 – 2020
Department of Earth, Environmental, and Planetary Sciences, Brown University

Updated: April 26, 2023

TEACHING EXPERIENCE

Graduate Teaching Assistant, Laboratory instructor
Remote Sensing of Earth and Planetary Surfaces (GEOL 1710)
Fall 2019, 10 students
Department of Earth, Environmental, and Planetary Sciences, Brown University

- Taught weekly lab sections; graded all assignments and held office hours

Graduate Teaching Assistant, Laboratory instructor
Global Environmental Remote Sensing (GEOL 1330)
Spring 2016, 24 students, and Spring 2017, 23 students
Department of Earth, Environmental, and Planetary Sciences, Brown University

- Taught weekly lab sections, updated laboratory assignments
- Aided students in developing and executing semester research projects
- Graded all assignments and held office hours

PEER–REVIEWED PUBLICATIONS

18. **M. S. Bramble** and K. P. Hand. 2022. Spectral evidence for irradiated sodium chloride on the surface of 1 Ceres. *Geophysical Research Letters* 49, e2021GL096973.
17. R. Ketzner, V. Ravindra, and **M. Bramble**. 2022. A robust, fast, and accurate algorithm for point in spherical polygon classification with applications in geoscience and remote sensing. *Computers & Geosciences*, Volume 167, 105185.
16. K. P. Hand, C.B. Phillips, A. Murray, [and 284 others, including **M. S. Bramble**]. 2022. Science Goals and Mission Architecture of the Europa Lander Mission Concept. *Planetary Science Journal* 3, 22.
15. **M. S. Bramble**, R. E. Milliken, and W. R. Patterson III. 2021. Thermal emission measurements of ordinary chondrite mineral analogs in a simulated asteroid environment: 1. Constituent mineral phases. *Icarus* 369, 114561.
14. **M. S. Bramble**, R. E. Milliken, and W. R. Patterson III. 2021. Thermal emission measurements of ordinary chondrite mineral analogs in a simulated asteroid environment: 2. Representative mineral mixtures. *Icarus* 369, 114251.
13. J. D. Tarnas, J. F. Mustard, H. Lin, T. A. Goudge. E. S. Amador-French, **M. S. Bramble**, C. H. Kremer, X. Zhang, Y. Itoh, M. Parente. 2019. Constraining the origin of hydrated silica in Jezero crater, Mars. *Geophysical Research Letters* 46, 12771–12782.
12. **M. S. Bramble**, Y. Yang, W. R. Patterson III, R. E. Milliken, J. F. Mustard, and K. L. Donaldson Hanna. 2019. Radiometric Calibration of Thermal Infrared Data from the Asteroid and Lunar Environment Chamber (ALEC). *Review of Scientific Instruments* 90, 093101.
11. A. M. Palumbo, A. N. Deutsch, **M. S. Bramble**, J. D. Tarnas, B. D. Boatwright, L. H. Lark, E. M. Nathan, J. A. Wilner, Y. Chen, B. A. Anzures, C. A. Denton, L. Tokle, G. Casey, A. G. Pimentel, J. W. Head, K. R. Ramsley, U. Shah, A. Kothandhapani, H. P. Gokul, J. Mehta, and V. Vatsal. 2019. Scientific exploration of Mare Imbrium with OrbitBeyond Inc.: Characterizing the regional volcanic history of the Moon. *New Space* 7, 137–150.
10. C. H. Kremer, J. F. Mustard, and **M. S. Bramble**. 2019. A widespread ultramafic ash on Mars. *Geology* 47, 677–681.
9. **M. S. Bramble**, T. A. Goudge, R. E. Milliken, and J. F. Mustard. 2019. Testing the Deltaic. Origin of Fan Deposits at Bradbury Crater, Mars. *Icarus* 319, 363–366.
8. J. D. Tarnas, J. F. Mustard, B. Sherwood Lollar, **M. S. Bramble**, K. M. Cannon, A. M. Palumbo, and A.–C. Plesa. 2018. Radiolytic H_2 Production on Noachian

Mars: Implications for Habitability. *Earth and Planetary Science Letters* 502, 133–145.

7. A. N. Deutsch, J. W. Head, K. R. Ramsley, C. M. Pieters, R. W. K. Potter, A. M. Palumbo, **M. S. Bramble**, J. P. Cassanelli, E. R. Jawin, L. M. Jozwiak, H. H. Kaplan, C. F. Lynch, A. C. Pascuzzo, L. Qiao, D. K. Weiss. 2018. Science exploration architecture for Phobos and Deimos: The role of Phobos and Deimos in the future exploration of Mars. *Advances in Space Research* 62, 2174–2186.
6. M. R. Salvatore, T. A. Goudge, **M. S. Bramble**, C. S. Edwards, J. L. Bandfield, E. S. Amador, J. F. Mustard, and P. R. Christensen. 2018. Bulk mineralogy of the NE Syrtis and Jezero crater regions of Mars derived through thermal infrared spectral analyses. *Icarus* 301, 76–96.
5. **M. S. Bramble**, J. F. Mustard, and M. R. Salvatore. 2017. The Geological History of Northeast Syrtis Major, Mars. *Icarus* 293, 66–93.
4. M. A. McCraig, G. R. Osinski, E. A. Cloutis, R. L. Flemming, M. R. M. Izawa, V. Reddy, S. K. Fieber-Beyer, L. Pompilio, F. van der Meer, J. A. Berger, **M. S. Bramble**, and D. M. Applin. 2017. Fitting the curve in Excel: Systematic curve fitting of laboratory and remotely sensed planetary spectra. *Computers & Geosciences* 100, 103–114.
3. **M. S. Bramble**, R. L. Flemming, and P. J. A. McCausland. 2015. Grain size measurement from two-dimensional micro-X-ray diffraction: Laboratory application of a radial integration technique. *American Mineralogist* 100, 1899–1911.
2. **M. S. Bramble**, R. L. Flemming, J. L. Hutter, M. M. Battler, G. R. Osinski, and N. R. Banerjee. 2014. A temperature-controlled sample stage for in situ micro-X-ray diffraction: Application to Mars analog mirabilite-bearing perennial cold spring precipitate mineralogy. *American Mineralogist* 99, 943–947.
1. J. R. de Bruyn, M. Goiko, M. Mozaffari, D. Bator, R. L. Dauphinee, Y. Liao, R. L. Flemming, **M. S. Bramble**, G. K. Hunter, and H. A. Goldberg. 2013. Dynamic Light Scattering Study of Inhibition of Nucleation and Growth of Hydroxyapatite Crystals by Osteopontin. *PLoS ONE* 8(2): e56764.

MANUSCRIPTS IN REVIEW OR IN PREP

1. **M. S. Bramble**, R. E. Milliken, and W. R. Patterson III. 2021. Thermal emission characteristics of ordinary chondrites in a simulated asteroid environment. *In prep.*

FIRST–AUTHOR CONFERENCE PROCEEDINGS

23. **M. S. Bramble** and K. P. Hand. 2023. Electron Irradiation of Methane and Methane/Water Ices at 20 K Through 100 K. *Lunar and Planetary Science Conference LIV*, abstract 2464 (poster)
22. **M. S. Bramble** and K. P. Hand. 2022. Radiation-Formed Color Centers of Sodium Chloride on Inner Solar System Bodies. *AGU Fall Meeting*, paper P25F-2184, abstract 1178685 (poster)
21. **M. S. Bramble** and K. P. Hand. 2022. Spectral Evidence for Halite in the Faculae on Ceres as Observed by the Dawn VIR Spectrometer. *Lunar and Planetary Science Conference LIII*, abstract 2835 (poster)
20. **M. S. Bramble** and K. P. Hand. 2022. Consideration of the Martian Chloride Salt-bearing Deposits as a Target for a Low-cost Science Mission. *Low-Cost Science Mission Concepts for Mars Exploration*, abstract 5064 (poster)
19. **M. S. Bramble** and R. E. Milliken. 2020. The Thermal Emission of Ordinary Chondrites and Analog Mixtures at Simulated Asteroid Conditions. *Lunar and Planetary Science Conference LI*, abstract 2498 (poster)

18. **M. S. Bramble** and R. E. Milliken. 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 (poster)
17. **M. S. Bramble**, R. E. Milliken, W. R. Patterson III, and J. F. Mustard. 2019. Thermal Infrared Characterization of Ordinary Chondrite Analogs in a Simulated Asteroid Environment with Implications for the Remote Analysis of Asteroid Mineralogy. *Lunar and Planetary Science Conference L*, abstract 2101 (talk)
16. **M. S. Bramble**, R. E. Milliken, W. R Patterson III, 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. *AGU Fall Meeting*, paper P53D–2997, abstract 458541 (poster)
15. **M. S. Bramble**, J. F. Mustard, and C. H. Kremer. 2018. Geological Continuity Between the Midway and NE Syrtis Candidate Landing Sites for the Mars 2020 Rover Mission. *4th Landing Site Workshop for the 2020 Mars Rover Mission* (talk)
14. **M. S. Bramble**, W. R. Patterson III, R. E. Milliken, Y. Yang, K. L. Donaldson Hanna, and J. F. Mustard. 2018. Radiometric Calibration of Thermal Emission Data from the Asteroid and Lunar Environment Chamber (ALEC). *Lunar and Planetary Science Conference XLIX*, abstract 1598 (poster)
13. **M. S. Bramble**, J. F. Mustard, C. I. Fassett, and T. A. Goudge. 2018. Stratigraphy of the Northeast Syrtis Major Mars 2020 Landing Site and the Ejecta of Jezero Crater, Mars. *Lunar and Planetary Science Conference XLIX*, abstract 1705 (poster)
12. **M. S. Bramble**, T. A. Goudge, R. E. Milliken, and J. F. Mustard. 2017. Testing the Deltaic. Origin of Fan Deposits at Bradbury Crater, Mars. *Lunar and Planetary Science Conference XLVIII*, abstract 2210 (poster)
11. **M. S. Bramble**, J. F. Mustard, and K. M. Cannon. 2017. Testing Carbonate Formation Mechanisms at Northeast Syrtis Major Using Manual and Automated Hyperspectral Analyses. *Lunar and Planetary Science Conference XLVIII*, abstract 2815 (talk)
10. **M. S. Bramble**, J. F. Mustard, B. L. Ehlmann, and M. R. Salvatore. 2017. Stratigraphy and Quantitative Mineralogy of Northeast Syrits Major: Constraints on Hypothesis of Formation and Evolution of the Region. *3rd Landing Site Workshop for the 2020 Mars Rover Mission* (talk)
9. **M. S. Bramble** and J. F. Mustard. 2016. Spectral stratigraphy constraining carbonate formation mechanisms at Nili Fossae, Mars. *GSA Annual Meeting*, abstract 284602 (poster)
8. **M. S. Bramble** and J. F. Mustard. 2016. Constraining H_2 production from the Noachian crust: Elemental composition, water capacity, and implications for habitability. *GSA Annual Meeting*, abstract 284609 (poster)
7. **M. S. Bramble** and J. F. Mustard. 2016. Stratigraphic Relationships in Northeast Syrtis Major, Mars: Approximately 250 Million Years of Geological History Spanning the Noachian–Hesperian Boundary. *Lunar and Planetary Science Conference XLVII*, abstract 2582 (talk)
6. **M. S. Bramble** and J. F. Mustard. 2016. Investigating the Antarctic meteorite analog of carbonate formation on Mars. *Lunar and Planetary Science Conference XLVII*, abstract 2553 (poster)

5. **M. S. Bramble** and J. F. Mustard. 2015. Stratigraphy of Olivine–Carbonate–Bearing Units Forming Mesas and Linear Features in Northeast Syrtis Major: Implications for Emplacement. *Lunar and Planetary Science Conference XLVI*, abstract 2090 (poster)

4. **M. S. Bramble**, P. J. A. McCausland, R. L. Flemming, and M. R. M. Izawa. 2014. Micro-X-ray diffraction and scanning electron microscopy investigation of enigmatic dun-coloured veins in the Tagish Lake carbonaceous chondrite. *GAC-MAC Annual Meeting*, abstract 263 (poster)

3. **M. S. Bramble**, R. L. Flemming, and P. J. A. McCausland. 2014. Grain Size, 'Spotty' XRD Rings, and CheMin: Two-Dimensional X-ray Diffraction as a Proxy for Grain Size Measurement in Planetary Materials. *Lunar and Planetary Science Conference XLV*, abstract 1658 (poster).
—Also presented at the 2014 *NASA Year of the Solar System Undergraduate Planetary Science Research Conference*, abstract 1008

2. **M. S. Bramble**, R. L. Flemming, and J. L. Hutter. 2013. A Temperature-Controlled Sample Stage for Micro-X-Ray Diffraction of Mirabilite-Containing Samples from Wolf Spring, Axel Heiberg Island, Nunavut, Canada. *Lunar and Planetary Science Conference XLIV*, abstract 1729 (poster).
—Also presented at the 2013 *NASA Year of the Solar System Undergraduate Planetary Science Research Conference*, abstract 3

1. **M. S. Bramble**, J. L. Hutter, and R. L. Flemming. 2012. A temperature-controlled cold stage for micro-X-ray diffraction of sodium sulphate bearing samples from the Canadian High Arctic. *CAMBR Distinguished Lecturer and Research Day*, abstract 76 (talk)

ADDITIONAL CONFERENCE PROCEEDINGS

50. S. W. Parman, J. F. Mustard, C. M. Pieters, C. H. Kremer, R. O. Green, **M. S. Bramble**, and L. Johnson. 2023. Mercury Scout: Mapping Mercury's Mineralogy. *Lunar and Planetary Science Conference LIV*, abstract 1607

49. J. M. Bretzfelder, K. G. Hanley, Q. McKown, E. M. Cangi, C. Sands, N. North, P. M. Miklavcic, **M. S. Bramble**, B. D. Byron, J. Caggiano, J. T. Haber, S. J. Laham, D. Morrison-Fogel, K. A. Napier, R. F. Phillips, S. Ray, M. Sandford, P. Sinha, T. Hudson, J. E. C. Scully, and L. Lowes. 2023. VULCAN: A Mission Concept to Explore Tidal Heating and Extreme Volcanism at Io. *Lunar and Planetary Science Conference LIV*, abstract 2861

48. C. H. Kremer, J. F. Mustard, C. M. Pieters, R. O. Green, S. W. Parman, and **M. S. Bramble**. 2023. Imaging Spectrometer for Lunar Silicate Compositional Determination and Direct Detection of H2O in the 4-8 Micron Intermediate Infrared (IMIR) Spectral Range. *Lunar and Planetary Science Conference LIV*, abstract 2151

47. S. A. Pérez-López, C. H. Kremer, J. F. Mustard, **M. S. Bramble**, C. M. Pieters, and R. O. Green. 2023. Consequences of Signal to Noise Ratio and Spectral Sampling for the Determination of Olivine Composition in the Intermediate Infrared Region. *Lunar and Planetary Science Conference LIV*, abstract 2388

46. S. W. Parman, J. F. Mustard, C. M. Pieters, C. H. Kremer, **M. S. Bramble**, R. O. Green, and L. Johnson. 2023. Mercury Scout: Mineral Mapping and High-Resolution Imaging. *Mercury Exploration Assessment Group (MExAG) Annual Meeting 2023*, abstract 6030

45. C. H. Kremer, J. F. Mustard, C. M. Pieters, R. O. Green, S. W. Parman, and **M. S. Bramble**. 2023. Mercury Science Questions Addressed with Imaging

Spectroscopy Observations Across the New Intermediate Infrared (IMIR) Spectral Range. *Mercury Exploration Assessment Group (MExAG) Annual Meeting 2023*, abstract 6035

44. S. Parman, J. Mustard, C. Pieters, C. Kremer, **M. Bramble**, R. Green, and L. Johnson. 2023. Mercury Scout. *2023 Technology Showcase for Future NASA Planetary Science Missions*

43. K. G. Hanley, Q. McKown, E. M. Cangi, C. Sands, N. North, P. Miklavcic, **M. S. Bramble**, J. M. Bretzfelder, B. D. Byron, J. Caggiano, J. T. Haber, S. Laham, D. Morrison-Fogle, K. A. Napier, R. Phillips, S. Ray, M. Sandford, P. Sinha, J. E. C. Scully, and T. Hudson. 2022. Vulcan: Exploring Tidal Heating & Extreme Volcanism at Io. *AGU Fall Meeting*, paper P55E-1612, abstract 1073625

42. M. E. Cameron, K. P. Hand, C. B. Phillips, J. Pitesky, E. J. Leonard, J. E. C. Scully, **M. S. Bramble**, S. M. Brooks, M. L. Cable, K. L. Craft, J. D. Hofgartner, A. E. Hofmann, K. J. Hurst, B. Kennedy, E. Klonicki, K. Kriechbaum, S. MacKenzie, M. Meacham, T. A. Nordheim, C. Paranicas, R. Perkins, D. M. Persaud, G. E. Reeves, L. R. Shiraishi, G. Tan-Wang, and the Europa Lander pre-Project Science and Engineering Teams. 2022. Science-driven Preparations for Europa Surface Operations. *AGU Fall Meeting*, paper P55G-1648, abstract 1162278

41. S. L. Matzen, **M. S. Bramble**, T. Ely, A. A. Wackett, M. Pacheco, C. R. German, A. Gartman, K. P. Hand, and B. M. Toner. 2022. Pyrite nanoparticles as biogeochemical tracers of hydrothermal activity on icy ocean moons. *Astrobiology Science Conference 2022*, abstract 212-04

40. K. P. Hand, C. B. Phillips, K. L. Craft, S. M. Brooks, J. Pitesky, J. E. C. Scully, E. J. Leonard, J. D. Hofgartner, D. M. Persaud, T. Nordheim, **M. S. Bramble**, K. J. Hurst, S. MacKenzie, C. Paranicas, G. Tan-Wang, G. E. Reeves, B. Kennedy, M. E. Cameron, L. R. Shiraishi , Europa Lander Science Definition Team, Project Science Team, and Project Engineering Team. 2022. Science Goals and Mission Architecture of the Europa Lander Mission Concept. *Astrobiology Science Conference 2022*, abstract 430-01

39. M. E. Cameron, K. P. Hand, C. B. Phillips, J. Pitesky, **M. Bramble**, S. M. Brooks, M. L. Cable, K. L. Craft, E. R. Duffy, J. D. Hofgartner, A. E. Hofmann, K. J. Hurst, B. Kennedy, E. Klonicki, K. Kriechbaum, E. J. Leonard, S. MacKenzie, M. Meacham, T. Nordheim, C. Paranicas, R. Perkins, D. M. Persaud, G. E. Reeves, J. E. C. Scully, L. R. Shiraishi, G. Tan-Wang, and Europa Lander Mission Concept Team. 2022. Destination Europa: Science-driven preparations for Touching an Unknown Surface. *Astrobiology Science Conference 2022*, abstract 406-01

38. K. P. Hand, C. B. Phillips, K. Craft, J. E. Pitesky, M. E. Cameron, E. J. Leonard, **M. Bramble**, S. M. Brooks, J. Hofgartner, K. Hurst, B. A. Kennedy, S. M. MacKenzie, T. A. Nordheim, C. P. Paranicas, M. Meacham, D. M. Persaud, J. E. C. Scully, E. Maize, G. E. Reeves, J. McNamee, L. R. Shiraishi, G. H. Tan-Wang and the Science Definition team and Project Engineering team. 2022. Science Goals and Mission Architecture of the Europa Lander Mission Concept. *Lunar and Planetary Science Conference LIII*, abstract 1788

37. M. E. Cameron, K. P. Hand, C. B. Phillips, J. E. Pitesky, **M. S. Bramble**, S. M. Brooks, M. L. Cable, K. Craft, E. R. Duffy, J. Hofgartner, A. E. Hofmann, K. Hurst, B. A. Kennedy, E. Klonicki, K. Kriechbaum, E. J. Leonard, S. M. MacKenzie, M. Meacham, T. A. Nordheim, C. P. Paranicas, R. Perkins, D. M. Persaud, G. E. Reeves, J. E. C. Scully, L. R. Shiraishi, G. H. Tan-Wang.

2022. Science-Driven Preparations for Landing on Europa. *Lunar and Planetary Science Conference LIII*, abstract 2470.

36. M. E. Cameron, K. P. Hand, C. B. Phillips, [and 13 others including **M. S. Bramble**]. 2021. Terrain specification: Science-driven preparations for landing on Europa. *AGU Fall Meeting*, paper P25E–2190, abstract 913013.

35. S. M. Brooks, K. P. Hand, C.B. Phillips, [and 20 others, including **M. S. Bramble**]. 2021. The Europa Lander Mission Concept: Future Surface Exploration of a Potentially Habitable World. *53rd Annual Meeting of the Division For Planetary Sciences*, abstract 412.03.

34. J. D. Tarnas, J. F. Mustard, B. Sherwood Lollar, O. Warr, K. M. Cannon, A. M. Palumbo, A.-C. Plesa, and **M. S. Bramble**. 2019. Abiotic CH4 flux from the Precambrian Shield on Earth and during the Noachian, Hesperian, and Amazonian periods on Mars. *AGU Fall Meeting*, paper EP54B–03, abstract 519226.

33. C. H. Kremer, **M. S. Bramble**, and J. F. Mustard. 2019. An Integrated Sedimentary Geological System at Nili Fossae, Mars. *Ninth International Conference on Mars*, abstract 6332

32. J. F. Mustard, **M. S. Bramble**, C. H. Kremer, J. D. Tarnas, A. C. Pascuzzo, and J. W. Head. 2019. A Record of the First Billion Years of Solar System History at the Mars 2020 Landing Site. *Ninth International Conference on Mars*, abstract 6404

31. J. D. Tarnas, J. F. Mustard, B. Sherwood Lollar, K. M. Cannon, A. M. Palumbo, A.-C. Plesa, and **M. S. Bramble**. 2019. Mars Could have been Warmed by Eccentricity Variations or a Subsurface Biosphere. *Ninth International Conference on Mars*, abstract 6345

30. M. R. Salvatore, T. A. Goudge, **M. S. Bramble**, Y. Liu, and C. S. Edwards. 2019. The Composition and Thermophysical Character of Jezero Crater and its Surrounding Watershed. *Ninth International Conference on Mars*, abstract 6264

29. J. D. Tarnas, J. F. Mustard, B. Sherwood Lollar, K. M. Cannon, A. M. Palumbo, A.-C. Plesa, and **M. S. Bramble**. 2019. Is Abiotic Methane Production Sufficient for Warming Noachian and Hesperian Mars? *Astrobiology Science Conference 2019*, abstract 3381

28. M. R. Salvatore, T. A. Goudge, Y. Liu, and **M. S. Bramble**. 2019. The Composition of NASA's Mars 2020 Rover Landing Site at Jezero Crater: A Summary of Remote Spectral Analyses. *Lunar and Planetary Science Conference L*, abstract 1454

27. C. H. Kremer, **M. S. Bramble**, and J. F. Mustard. 2019. Lithologically Diverse Yardangs in the Circum-Isidis Region: Implications for Yardang Evolution Controls and In Situ Study at the Mars 2020 Landing Site. *Lunar and Planetary Science Conference L*, abstract 1639

26. C. H. Kremer, **M. S. Bramble**, and J. F. Mustard. 2019. A Hemispherically Integrated Sedimentary Geological System at Nili Fossae, Mars. *Lunar and Planetary Science Conference L*, abstract 1656

25. J. D. Tarnas, J. F. Mustard, H. Lin, T. A. Goudge, E. S. Amador, **M. S. Bramble**, and X. Zhang. 2019. Hydrated Silica in the Jezero Deltas. *Lunar and Planetary Science Conference L*, abstract 2551

24. J. D. Tarnas, J. F. Mustard, B. Sherwood Lollar, K. M. Cannon, A. M. Palumbo, A.-C. Plesa, and **M. S. Bramble**. 2019. An Insufficient Methane Budget for Warming Noachian and Hesperian Mars. *Lunar and Planetary Science Conference L*, abstract 2029

23. L. Tokle, A. Palumbo, A. Deutsch, B. Anzures, B. Boatwright, **M. Bramble**, G. Casey, Y. Chen, C. Denton, L. Lark, E. Nathan, A. Pimentel, J. Tarnas, J. Wilner, J. Head, K. Ramsley, U. Shah, A. Kothandhapani, H. Prasad Gokul, J. Mehta, and V. Vatsal. 2019. Scientific Exploration of Mare Imbrium with OrbitBeyond, Inc.: Characterizing the Regional Volcanic History of the Moon. *Lunar and Planetary Science Conference L*, abstract 2484

22. J. D. Tarnas, J. F. Mustard, B. Sherwood Lollar, **M. S. Bramble**, K. M. Cannon, A. M. Palumbo, and A.-C. Plesa. 2018. H_2 and CH_4 Production, Storage, and Release Over 4.5 Gyr of Martian History: Implications for Atmospheric Warming, Habitability, and ISRU. *AGU Fall Meeting*, paper P24D–03, abstract 437871

21. C. H. Kremer, **M. S. Bramble**, and J. F. Mustard. 2018. A hemispherically integrated sedimentary geological system at Nili Fossae, Mars. *GSA Annual Meeting*, paper 15–11, abstract 323706

20. C. H. Kremer, J. F. Mustard, and **M. S. Bramble**. 2018. A widespread ultramafic sandstone on Mars. *GSA Annual Meeting*, paper 15–3, abstract 320588

19. J. F. Mustard, **M. S. Bramble**, C. H. Kremer, and A. C. Pascuzzo. 2018. Outstanding Mars and Planetary Science Questions from Returned Samples Collected from NE Syrtis, Midway and/or Jezero Delta. *4th Landing Site Workshop for the 2020 Mars Rover Mission*

18. C. H. Kremer, J. F. Mustard, and **M. S. Bramble**. 2018. Possible Clastic Origin for Olivine-Rich Rocks in the Nili Fossae Region: Implications for NE Syrtis, Midway, and Jezero Landing Site Science. *4th Landing Site Workshop for the 2020 Mars Rover Mission*

17. J. D. Tarnas, J. F. Mustard, H. Lin, E. S. Amador, T. A. Goudge, **M. S. Bramble**, and X. Zhang. 2018. Application of Dynamic Aperture Factor Analysis/Target Transformation for Mineral Detection: Presence of Opaline Silica in Jezero Crater and the Surrounding NE Syrtis Region. *4th Landing Site Workshop for the 2020 Mars Rover Mission*

16. C. H. Kremer, J. F. Mustard, and **M. S. Bramble**. 2018. A Pyroclastic Protolith for the most Widespread Serpentine- and Carbonate-Bearing Ultramafic Rock on the Martian Surface. *Goldschmidt 2018*

15. J. D. Tarnas, J. F. Mustard, B. Sherwood Lollar, **M. S. Bramble**, K. M. Cannon, A.-C. Plesa, and A. M. Palumbo. 2018. Production of H_2 on Mars Through Radiolysis and Implications for Habitability. *Goldschmidt 2018*

14. C. H. Kremer, J. F. Mustard, and **M. S. Bramble**. 2018. Origin and Emplacement of the Circum-Isidis Olivine-Rich Unit. *Lunar and Planetary Science Conference XLIX*, abstract 1545

13. J. D. Tarnas, J. F. Mustard, B. Sherwood Lollar, **M. S. Bramble**, K. M. Cannon, A. M. Palumbo, and A.-C. Plesa. 2018. Radiolytic H_2 Production, Transport, and Dissolution on Noachian Mars. *Lunar and Planetary Science Conference XLIX*, abstract 2073

12. Y. Yang, R. E. Milliken, W. R. Patterson III, **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. *Lunar and Planetary Science Conference XLIX*, abstract 1803

11. M. R. Salvatore, T. A. Goudge, **M. S. Bramble**, C. S. Edwards, J. L. Bandfield, E. S. Amador, J. F. Mustard, and P. R. Christensen. 2017. Bulk Mineralogy of the Northeast Syrtis and Jezero Crater Regions of Mars Derived Through

Thermal Infrared Spectral Analyses. 2017. *The Fourth International Conference on Early Mars*, abstract 3058

10. J. D. Tarnas, J. F. Mustard, B. Sherwood Lollar, **M. S. Bramble**, K. M. Cannon, and A. M. Palumbo. 2017. Radiolytic H_2 Production on Noachian Mars: Implications for Subsurface Habitability. *The Fourth International Conference on Early Mars*, abstract 3039
9. J. D. Tarnas, J. F. Mustard, B. Sherwood Lollar, and **M. S. Bramble**. 2017. Radiolytic Hydrogen Production on Noachian Mars. *Astrobiology Science Conference 2017*, abstract 3381
8. P. D. Cavanagh, **M. S. Bramble**, and L. M. Pratt. 2017. Efflorescence of Gypsum and Jarosite During Exposure of Sulfidic Lacustrine Sediment, Western Greenland. *Lunar and Planetary Science Conference XLVIII*, abstract 2677
7. J. D. Tarnas, J. F. Mustard, B. Sherwood Lollar, and **M. S. Bramble**. 2017. Radiolytic Hydrogen Production on Noachian Mars. *Lunar and Planetary Science Conference XLVIII*, abstract 2030
6. M. R. Salvatore, T. A. Goudge, **M. S. Bramble**, C. S. Edwards, J. L. Bandfield, E. S. Amador, J. F. Mustard, and P. R. Christensen. 2017. Bulk Mineralogy of the Northwest Isidis Region of Mars Derived Through Thermal Infrared Spectral Analyses. *Lunar and Planetary Science Conference XLVIII*, abstract 1154
5. J. F. Mustard, B. L. Ehlmann, **M. S. Bramble**, K. M. Cannon, J. W. Head, J. R. Skok, T. A. Goudge, and E. S. Amandor. 2017. Northeast Syrits Major: The Key to Unlocking the First 0.5 Billion Years of Mars' History. *3rd landing site workshop for the 2020 Mars Rover Mission*
4. P. J. A. McCausland, **M. S. Bramble**, P. G. Brown, J. U. Umoh, and D. W. Holdsworth. 2016. Many meteorites in one: Spatial scale and range of variation in bulk physical and lithological properties of the Tagish Lake C2 chondrite. *GAC-MAC Annual Meeting*, abstract 166
3. K. R. Ramsley, **M. S. Bramble**, J. P. Cassanelli, A. N. Deutsch, A. M. Horan, E. R. Jawin, L. M. Jozwiak, H. H. Kaplan, C. F. Lynch, A. C. Pascuzzo, R. W. K. Potter, L. Qiao, D. K. Weiss, J. W. Head. 2016. Science Exploration Architecture for Phobos and Deimos: Are the Moons of Mars in the Critical Pathway of Human Exploration of Mars? *Lunar and Planetary Science Conference XLVII*, abstract 2345
2. J. F. Mustard, T. A. Goudge, **M. S. Bramble**, B. L. Ehlmann, J. W. Head, J. L. Dickson, C. I. Fassett, and K. M. Cannon. 2015. Jezero Crater Watershed, Isidis Basin, Sulfate Deposits and Syrtis Major: A Compelling Exploration Zone for Human Exploration. *First Landing Site / Exploration Zone Workshop for Human Missions to the Surface of Mars*, abstract 1034
1. J. F. Mustard, B. L. Ehlmann, S. M. Wiseman, **M. S. Bramble**, K. M. Cannon, T. A. Goudge, C. E. Viviano-Beck, J. R. Skok, E. S. Amador, D. J. Des Marais, J. W. Head, M. R. Salvatore, R. E. Milliken, and D. P. Quinn. 2015. Multiple Habitable Environments across the Noachian-Hesperian Environmental Transition: Phyllosilicates, Carbonate, Sulfates, and Multiple Igneous Units in Stratigraphy at the Isidis-Syrtis Major Contact. *2nd Landing Site Workshop for the 2020 Mars Rover Mission*

RESEARCH EXPERIENCE

- Europa Lander mission concept — 2020 – present
  Member of the Project Science Team
- Mars 2020 Landing Site Selection — 2014 – 2018
  Leading advocate for Northeast Syrtis Major as a landing site for Mars2020

- Compact Reconnaissance Imaging Spectrometer for Mars 2014 – 2018
  Science Team member at large; Data liaison between SOC and ESA and ISRO
- *Graduate Research Assistant* 2014 – 2020
  Planetary Geosciences Group, Brown University, Providence, RI
- *Undergraduate Research Assistant* 2014
  NSERC Undergraduate Research Award; Advisor: Dr. L. L. Tornabene
- *Curatorial Assistant* 2013 – 2014
  Advisor: Dr. P. J. A. McCausland, Western University meteorite collection
- *Undergraduate Research Assistant* 2013
  NSERC Undergraduate Research Award; Advisor: Dr. P. J. A. McCausland
- *Research Assistant – X-Ray Diffraction Laboratory* 2012 – 2013
  Advisor: Dr. R. L. Flemming
- *CAMBR Undergraduate Research Award* 2012
  Advisors: Dr. R. L. Flemming and Dr. J. L. Hutter
- *Research Assistant – Musicology* 2008 – 2010
  Dr. C. J. Gosine at Memorial University of Newfoundland, St. John's, NL
- *Research Assistant – Musicology* 2006 – 2010
  Dr. T. Gordon at Memorial University of Newfoundland, St. John's, NL

SHORT COURSES AND NON–PRESENTING CONFERENCES

Biosignature2016 16–18 May 2016
Biosignature Preservation and Detection in Mars Analog Environments
- Attending professional and field trip to Steamboat Springs hydrothermal system

Planetary Science Short Course 2–8 September 2013
Centre for Planetary Science and Exploration, Western University, London, ON
- Lectures and laboratories in cosmogony, planetary interiors, planetary surfaces, planetary atmospheres, astrobiology, and exoplanets.
- Mission planning group project designing a Mars sample return mission including objectives and landing site selection as well as spacecraft design.

76th Annual Meeting of the Meteoritical Society 29 July – 2 August 2013
- Attending professional.

Bruker AXS 2-Dimensional X-Ray Diffraction Short Course 12 June 2013
Bruker AXS, McMaster University, Hamilton, ON
- Techniques and applications of 2-dimensional detectors in the study of various materials by X-ray diffraction.

CSA-ASTRO Astromaterials Short Course 13–15 May 2013
Canadian Space Agency, London, ON
- Talks and hands-on experience with astromaterials, missions, and laboratory methods including stable isotopes, radiogenic isotopes, micro-XRD, ZAPlab SEM, X-ray micro-computed tomography, and meteor physics.

Reflectance Spectroscopy Short Course 15 June 2012
Dr. E. Cloutis at Western University, London, ON
- Topics include: Principles of reflectance spectroscopy, instrumentation (lab, spacecraft), calibration and absolute reflectance, causes of absorption bands, and applications.

CSA-ASTRO Astromaterials Short Course 22–23 May 2012
Canadian Space Agency, Toronto, ON

- Introduction with hands-on experience of meteorites and planetary materials, and discussions of analytical and classification techniques.

LABORATORY EXPERIENCE

- Extensive experience in scientific laboratory equipment operation and maintenance, and data collection and analysis, including: thermal emission spectroscopy, reflectance spectroscopy, micro- and powder-XRD, Rietveld refinement, petrography, SEM–EDX, He pycnometry, magnetic susceptibility, and X-ray micro-CT scanning.
- Extensive experience in operating environmental chambers at non-ambient temperatures and pressures, handling of compress gasses and refrigerated liquids, and working in a pressurized cleanroom environment.
- Proficient at sample preparation, including: powdered samples, thin sections, meteorites, whole rock samples, SEM pins, and coated samples; and handling temperature-sensitive, time-sensitive, precious, and radioactive materials.
- Laboratory instruments with formal training and experience:
  – Analytical Spectral Devices Field/Lab-Spec Spectroradiometers
  – Nicolet Nexus 870 FT–IR Spectrometer
  – Nicolet iG50/iS50 FTIR Spectrometers
  – Bruker D8 Discover micro-X-ray Diffractometer
  – Bruker D2 PHASER X-ray Diffractometer
  – MIDAC M4500 series Illuminator FTIR Spectrometer
  – Princeton Instruments Acton grating spectrometer
  – Rigaku Geigerflex D/MAX X-ray Diffractometer
  – Hitachi 3400-N Variable Pressure Scanning Electron Microscope
  – Quantachrome Instruments Multipycnometer
  – Sapphire Instruments SI2B Magnetic Susceptibility and Anisotropy Meter

FIELD EXPERIENCE

- Triangle Lake, near Kangerlussuaq, Greenland (5 days, October 2016)
  —Study of acidic lake precipitates with Indiana University colleagues
- NASA Planetary Volcanology Field Workshop (7 days, July 2016)
  —Study of volcanic features at Hawaiian volcanoes analogous to those on Mars
- Brown University
  Sedimentary Rock Cycle of Earth and Mars Field Trip (5 days, June 2016)
  —Permian Platform and Basin Outcrops of the Guadalupe Mountains
  Geoscience Graduate Trip (7 days, August 2014)
  —Overviewing survey of the geology of Colorado
- The University of Western Ontario
  Bancroft Igneous Petrology Field Trip (3 days, October 2012)
  —Field relationships of igneous and metamorphic rocks
  Geo-Traverse of Georgian Bay (4 days, Fall 2011)
  —Overviewing survey of the geology of the Georgian Bay area

COMPUTER EXPERIENCE

- Proficient with Windows, Macintosh, and Linux-based operating systems and their native productivity software suites.
- Proficient and highly experienced with ArcGIS, QGIS, ENVI, ISIS, GDAL, JMARS, MATLAB, GNU Octave, ImageJ, GIMP, InDesign, Photoshop, and Illustrator.
  Languages: Bash/UNIX, MATLAB, IDL, python, LaTeX.
- Highly experienced with NASA Planetary Data System data retrieval, image processing, and analysis for major data sets of Mars, Ceres, Europa, and Enceladus.

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SELECT AWARDS AND DISTINCTIONS

ACADEMIC
Dissertation Fellowship, Brown University, 2018, Providence, RI
Postgraduate Scholarship–Doctoral, NSERC, 2016, Canada
First Year Graduate Fellowship, Brown University, 2014, Providence, RI
Donald R. Hay Prize, Western University, 2014, London, ON
Western University Gold Medal – Honors Specialization in Planetary Science, 2014
Undergraduate Student Research Award, NSERC, 2014, London, ON
Undergraduate Student Research Award, NSERC, 2013, London, ON
Solomon Family Award in Planetary Science, 2012, London, ON
Marion and Arthur Knight Bursary, 2012, London, ON
Advanced Materials and Biomaterials Interdisciplinary Undergraduate Research Award, Centre for Advanced Materials and Biomaterials Research, 2012, London, ON
Master of Arts, Musicology, 2 year Fellowship Award, University of Toronto, 2011, Toronto, ON (Declined)
Various scholarships and bursaries, Memorial University of Newfoundland, 2006–2010
Valedictorian Fredericton High School
Lord Strathcona Trust Fund Medal, 2005, Fredericton, NB
MUSIC COMPOSITION
Composition Commission by the Gower Community Band, 2011, St. John's, NL
–*Heart of a Community* [Concert Band with Organ]
Terra Nova Composition Contest, 2009, St. John's, NL
–2nd Place, *Chorale Prelude: Ich ruf zu dir* [Concert Band]
Memorial University Chamber Orchestra, 2007, St. John's, NL
–Winner, Composition Competition, *Sadness for those to come* [Chamber Orchestra]

TALKS AND PRESENTATIONS

Sippican Philosophical Society, 6 MAY 2019
Lunar and Planetary Science Conference L, 21 MAR 2019
4th Landing Site Workshop for the 2020 Mars Rover Mission, 17 OCT 2018
Planetary Science Seminar, Caltech, 16 OCT 2018
Planetary Lunchtime Seminar, Brown University, 26 APR 2018
New Bedford Science Cafe, 3 APR 2018
Lunar and Planetary Science Conference XLVIII, 22 MAR 2017
3rd Landing Site Workshop for the 2020 Mars Rover Mission, 9 FEB 2017
Planetary Lunchtime Seminar, Brown University, 26 JAN 2017
Lunar and Planetary Science Conference XLVII, 21 MAR 2017
CRISM Team Meeting, Applied Physics Lab, 6 NOV 2015
Planetary Lunchtime Seminar, Brown University, 1 OCT 2015
CAMBR Distinguished Lecturer and Research Day, Western University, 13 NOV 2012

COMMUNITY SERVICE

Reviewer for *Icarus*, *Journal of Geophysical Research: Planets*, *Earth and Space Science*, *Space Science Reviews*, and NASA ROSES
Panelist, NASA Review Panel (2020)
Executive Secretary, NASA Review Panel (2019)
Professional development leader (2016–2019)
—Geoscience Graduate Student Club, Brown University
Safety Officer, Geoscience Graduate Student Club, Brown University (2018–2019)
Mentor, 1st Year Graduate Mentoring Program, Brown University (2017-2018)
Data liaison person between the CRISM Science Operations Center and the European and Indian Space Agencies (2015–2018)
Treasurer, Geoscience Graduate Student Club, Brown University (2015–2016)
Secretary, Avalon Chapter, Royal Canadian College of Organists (2008–2010)

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CERTIFICATIONS

- Private Pilots License, Moncton Flight College (2005)
- Glider Pilots License, Atlantic Regional Gliding School (2004)
- Restricted Radio Operator Certificate (Transport Canada)