Michael S. Bramble

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CONTACT INFORMATION

Jet Propulsion Laboratory
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Pasadena, CA 91109
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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 ocean 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
Candidate dissertation title: "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

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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

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

3. **M. S. Bramble**, R. E. Milliken, and W. R. Patterson III. 2020. Thermal emission characteristics of ordinary chondrites in a simulated asteroid environment. *In prep.*
2. **M. S. Bramble**, R. E. Milliken, and W. R. Patterson III. 2020. Thermal emission measurements of ordinary chondrite mineral analogs in a simulated asteroid environment: 1. Constituent mineral phases. *In prep.*
1. **M. S. Bramble**, R. E. Milliken, and W. R. Patterson III. 2020. Thermal emission measurements of ordinary chondrite mineral analogs in a simulated asteroid environment: 2. Representative mineral mixtures. *In prep.*

FIRST–AUTHOR CONFERENCE PROCEEDINGS

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 No. 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 No. 2139
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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 1658 (poster).
   —Also presented at the 2014 *NASA Year of the Solar System Undergraduate Planetary Science Research Conference*, abstract No. 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 No. 1729 (poster).
   —Also presented at the 2013 *NASA Year of the Solar System Undergraduate Planetary Science Research Conference*, abstract No. 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 No. 76 (talk).

ADDITIONAL CONFERENCE PROCEEDINGS

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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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 No. 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

Graduate Research Assistant August 2014 – January 2020
Planetary Geosciences Group, Brown University, Providence, RI

- Using laboratory experiments to constrain how infrared emissivity spectra alter due to near-surface thermal gradients produced on airless bodies.
- Analysis of remotely sensed spectral and optical data from Mars, including geomorphological mapping of Northeast Syrtis Major, Mars.

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Undergraduate Research Assistant May 2014 – August 2014
NSERC Undergraduate Student Research Award. Advisor: Dr. L. L. Tornabene

- Spectral analysis of Martian surface features using CRISM data.

Curatorial Assistant September 2013 – April 2014
Advisor: Dr. P. J. A. McCausland

- Assisted in the curation of the Western University meteorite collection. Analyzed vein-coating material in the Tagish Lake meteorite using SEM and XRD.

Undergraduate Research Assistant May 2013 – August 2013
NSERC Undergraduate Student Research Award. Advisor: Dr. P. J. A. McCausland

- Completed ∼750 sample subdivisions of Tagish Lake meteorite material. Led lithological investigation of these sample divisions using magnetic susceptibility, He pycnometry, and X-ray micro-CT scanning.

Research Assistant – X-Ray Diffraction Laboratory September 2012 – April 2013
Advisor: Dr. R. L. Flemming

- Operated two X-ray diffractometers in aid of 37 client data sets and research projects. Interpreted data and wrote reports summarizing findings.

Advanced Materials and Biomaterials Interdisciplinary Undergraduate Research Award
Supervisors: Dr. R. L. Flemming, Dr. J. L. Hutter May 2012 – August 2012

- Designed and built a temperature-controlled sample stage for a Bruker D8 Discover micro-X-ray Diffractometer. Used the stage to characterize high Arctic, temperature-sensitive samples.

Research Assistant – Musicology September 2006 – May 2010
Dr. T. Gordon at Memorial University of Newfoundland, St. John's, NL

- Research area: Moravian music in 18th to 19th cent. Labrador, Canada.

Research Assistant – Musicology April 2008 – April 2010
Dr. C. J. Gosine at Memorial University of Newfoundland, St. John's, NL

- Research area: Cantatas of Charpentier.

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.

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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 FieldSpec 3 Field Spectroradiometer
  – Nicolet Nexus 870 FT–IR Spectrometer
  – Bruker D8 Discover micro-X-ray Diffractometer
  – Bruker D2 PHASER X-ray Diffractometer
  – 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

Michael S. Bramble

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COMPUTER EXPERIENCE

- Proficient with Windows, Macintosh, and Linux-based operating systems (Ubuntu, Lubuntu, Xubuntu, Chrome OS) and their native productivity software suites.
- Proficient and highly experienced with ArcGIS, QGIS, ENVI, ISIS3, JMARS, MATLAB, GNU Octave, ImageJ, GIMP, InDesign, Photoshop, and Illustrator. Languages: UNIX, MATLAB, IDL, python, LaTeX.
- Highly experienced with NASA Planetary Data System data retrieval and image processing for major martian and terrestrial data sets.

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

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OUTREACH ACTIVITIES

Centre for Planetary Science and Exploration, University of Western Ontario

- K-12 Student Programs
  –'Mission Meteorite' workshops: multiple-period activities about meteorite classification and asteroid mining, presented throughout the year.
- Meteorite displays and demonstrations for various university functions.
- 'SO-Space' The Southern Ontario Space Research and Technology Festival
  –hands-on meteorites activities
- Southern Ontario Science Fiction Festival
  –hands-on meteorites activities, planetary games for children
- Canadian Space Agency's Public Speaker Training Program

Physics and Astronomy Department, University of Western Ontario
Outreach Events at the Cronyn observatory

- International Observe the Moon Nights (2011, 2012, 2013)
  –Public telescope viewing, lunar meteorite display, hands-on activities
- Transit of Venus
  –2000 visitors, large scale solar system display, safe solar observing
- Landing of Curiosity - 1:30 am
  –70 visitors, Eyes on the Solar System display

COMMUNITY SERVICE

Executive Secretary, NASA Review Panel (2019)
Reviewer for *Icarus*
Professional development leader (2016–2019)
—Geoscience Graduate Student Club, Brown University
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)

PROFESSIONAL AFFILIATIONS

- American Geophysical Union (since 2018)
- Sigma Xi (since 2018)
- Geological Society of America (since 2016)
- Mineralogical Association of Canada (since 2014)
- The Meteoritical Society (since 2013)
- Mineralogical Society of America (since 2013)
- The Planetary Society (since 2011)

CERTIFICATIONS

- Private Pilots License, Moncton Flight College (2005)
- Glider Pilots License, Atlantic Regional Gliding School (2004)
- Restricted Radio Operator Certificate (Transport Canada)
- Class 5 Drivers License (New Brunswick)