

Michael S. Bramble

Brown University, Providence, RI, USA
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CONTACT INFORMATION

Department of Earth, Environmental, and Planetary Sciences
Brown University
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RESEARCH INTERESTS

- Advancing thermal 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 the martian surface
- Development of quantitative analytical techniques and instrumentation in the geological sciences

EDUCATION

2019, Anticipated PhD, Earth, Environmental, and Planetary Sciences
Brown University, Providence, RI
Candidate dissertation title: "Advancing thermal infrared spectroscopy as a tool for mineralogical analysis of airless planetary surfaces"
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

TEACHING EXPERIENCE

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

RESEARCH EXPERIENCE

Graduate Research Assistant August 2014 – Present
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. Studied physical characteristics and 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 cold stage to characterise high Arctic, temperature-sensitive samples in situ by microXRD.

Research Assistant – Musicology

September 2006 – May 2010

Dr. T. Gordon at Memorial University of Newfoundland, St. Johns, NL

- Research area: Moravian music in 18th to 19th cent. Labrador, Canada. – Transcribed handwritten 18th century musical notation using computer software. Edited and prepared music notation examples for publication and performance. Worked with documents up to 200 years old in German and Inuktitut.

Research Assistant – Musicology

April 2008 – April 2010

Dr. C. J. Gosine at Memorial University of Newfoundland, St. Johns, NL

- Research area: Cantatas of Charpentier. Transcribed handwritten 17th century musical notation using computer software. Prepared music notation examples for publication and performance. Worked with documents up to 300 years old and in Latin and French.

PEER–
REVIEWED
PUBLICATIONS

13. **M. S. Bramble**, R. E. Milliken, W. R. Patterson III, and J. F. Mustard. 2019. Thermal emission measurements of ordinary chondrite mineral analogs in a simulated asteroid environment: 1. Constituent mineral phases. *In prep.*
12. **M. S. Bramble**, R. E. Milliken, W. R. Patterson III, and J. F. Mustard. 2019. Thermal emission measurements of ordinary chondrite mineral analogs in a simulated asteroid environment: 2. Representative mineral mixtures. *In prep.*
11. **M. S. Bramble**, Y. Yang, R. E. Milliken, W. R. Patterson III, J. F. Mustard, and K. L. Donaldson Hanna. 2018. Radiometric Calibration of Thermal Infrared Data from the Asteroid and Lunar Environment Chamber (ALEC). *In prep.*
10. C. H. Kremer, J. F. Mustard, and **M. S. Bramble**. 2018. A widespread ultramafic ash on Mars. *In review.*
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 H₂ 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.
- FIRST–AUTHOR CONFERENCE PROCEEDINGS**
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 Syrtis 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 H₂ 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).
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 H₂ 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 H₂ 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 H₂ 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

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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. Amador. 2017. Northeast Syrtis 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*

SHORT

Biosignature2016

16–18 May 2016

COURSES AND NON-

Biosignature Preservation and Detection in Mars Analog Environments

- Attending professional and field trip to Steamboat Springs hydrothermal system

PRESENTING

CONFERENCES

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

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- 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, space-craft), 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 FTIR 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 with energy dispersive spectroscopy
 - 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-Traversal of Georgian Bay (4 days, Fall 2011)
 - Overviewing survey of the geology of the Georgian Bay area

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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, \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 (\$63,000)
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 (\$5625)
Undergraduate Student Bursary from the Royal Astronomical Society of Canada, Edmonton Centre, to attend the 76th Annual Meeting of the Meteoritical Society, Edmonton, AB (\$1500)
Undergraduate Student Research Award, NSERC, 2013, London, ON (\$5625)
Travel Award for the NASA Year of the Solar System Undergraduate Planetary Science Research Conference, Lunar and Planetary Institute, Houston, TX (\$1400)
Solomon Family Award in Planetary Science, 2012, London, ON (\$500)
Marion and Arthur Knight Bursary, 2012, London, ON (\$1500)
Advanced Materials and Biomaterials Interdisciplinary Undergraduate Research Award, Centre for Advanced Materials and Biomaterials Research, 2012, London, ON (\$5750)
Master of Arts, Musicology, 2 year Fellowship Award, University of Toronto, 2011, Toronto, ON (\$15,000 + tuition and travel, Declined)
Scholarships and bursaries, Memorial University of Newfoundland, 2006–2010 (\$5500)
Bursary from the Royal Canadian Legion, Branch No. 4, 2006, Fredericton, NB (\$1000)
E. Carl Jamieson Bursary, Capital Credit Union, 2006, Fredericton, NB (\$1000)
Various high school graduation bursaries, 2006, Fredericton, NB (\$2150)
Valedictorian Fredericton High School
Lord Strathcona Trust Fund Medal, 2005, Fredericton, NB

MUSIC COMPOSITION

Composition Commission by the Gower Community Band, 2011, St. Johns, NL
–*Heart of a Community* [Concert Band with Organ]
Terra Nova Composition Contest, 2009, St. Johns, NL (\$500)
–2nd Place, Chorale Prelude: *Ich ruf zu dir* [Concert Band]
Memorial University Chamber Orchestra, 2007, St. Johns, NL
–Winner, Composition Competition, *Sadness for those to come* [Chamber Orchestra]

TALKS AND PRESENTATIONS

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

Faculty of Science, University of Western Ontario

- Tours of the X-ray diffraction and Mineralogy laboratories to groups of students, potential clients, donors, and visitors.
- Various university open houses and recruitment events

COMMUNITY SERVICE

Professional development leader (2016–Present)

—Geoscience Graduate Student Club, Brown University

Data liaison person between the CRISM Science Operations Center and the European and Indian Space Agencies (2015–Present)

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)