

# Lowell R. Moore

PhD Candidate  
Department of Geosciences  
Virginia Tech

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## EDUCATION

<b>Doctor of Philosophy in Geosciences, Virginia Tech</b>	2019
Dissertation title: <i>The volatile contents of melt inclusions and implications for mantle degassing and ocean island evolution</i>	
Committee Chair: <i>Robert J. Bodnar</i>	
<b>Master of Science in Geosciences, Virginia Tech</b>	2014
Focus: <i>Geochemistry</i>	
<b>Bachelor of Science in Geology, James Madison University</b>	2012
Minor: <i>Mathematics</i>	

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## TECHNICAL SKILLS

**Electron Probe Microanalysis (EPMA)**  
**Scanning Electron Microscopy (SEM)**  
**Energy-Dispersive X-ray Spectroscopy (EDS)**  
**Raman Spectroscopy**  
**Secondary Ion Mass Spectrometry (SIMS)**  
**Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS)**  
**X-ray Fluorescence Spectrometry (XRF)**

**Polishing and sample preparation** – rotary lapping machine, single-grain polishing, thin section cutting and polishing

**Design & Prototyping** – circuit design, 2D/3D CAD, extrusion 3D printing, Arduino

**General computing**

- Windows (batch file scripting, command line interpreter)
- Linux (Bash shell scripting, command line interpreter)
- MacOS

**Statistical computing & Signal processing** – R, neuralnet, ggplot2, geoR, regular expressions

**Simulation and Modeling** – Python, pandas, numpy, openCV, pygame, tkinter

**Data Management and Organization** – Excel, Visual Basic for Applications, Microsoft Access

**Field Geology** – Water sampling and monitoring, Soils characterization and classification, geological field mapping

## EMPLOYMENT EXPERIENCE

<b>Research &amp; Teaching Assistant</b> – Virginia Tech	2012 – Present
<ul style="list-style-type: none"><li>- Conducted independent, NSF-funded research at an R1 academic institution</li><li>- Wrote successful grant proposals for research funding</li><li>- Assisted users in analytical facilities</li></ul>	

- Taught introductory and intermediate level undergraduate courses
- Mentored undergraduate students working on independent research projects
- Designed and coded software for signal processing and data analysis applications
- Presented scientific results at academic conferences
- Published scientific results in high-impact journals

**Produce Vendor** – *Bells Lane Farm*

2010 – 2012

- Managed produce stall at Staunton Augusta Farmers' Market
- Designed and built hoop house cold weather enclosure
- Designed and planted vegetable garden to maximize yield and efficiency
- Maintained and harvested vegetable crop
- Designed and built hydroponic deep-water culture vegetable growing system
- Designed and built Arduino™ water conductivity measurement system

**Projectionist** – *The Dixie Theater*

2008 – 2009

- Operated and maintained analog film projection systems
- Received and spliced 16-inch film reels
- Operated concession counter and ticket counter
- Reported daily film earnings to Motion Picture Association of America
- Counted and reported ticket and concessions sales

**Farm Hand** – *Bells Lane Farm*

2005-2010

- Operated and maintained heavy farm equipment
- Cut, raked, and baled hay
- Herded, handled, and medicated livestock
- Manufactured high-quality compost
- Performed landscaping maintenance tasks

**TEACHING EXPERIENCE** (Virginia Tech)

**Head Teaching Assistant** – *Physical Geology Lab*

2012-2014

**Teaching Assistant** – *Field Observations*

2015

**Teaching Assistant** – *Elements of Geology*

2015

**SERVICE ACTIVITIES**

**ESL Tutor** – *Language Volunteers of the New River Valley*

2019-Present

- Planned English lessons and provided tutoring services for non-native speakers

**Reviewer** – *Journal of Volcanology & Geothermal Research, Chemical Geology, Canadian Mineralogist*

2017-Present

- Reviewed research articles for publication in academic journals

**Workshop contributor** – *Workshop on Mineral Hosted Melt Inclusions*

2017, 2018

- Provided lecture and contributed to summary volume for international

workshop on melt inclusions hosted by Woods Hole Oceanographic Institute (Woods Hole, MA)	
<b>Workshop contributor</b> – <i>Workshop on carbon in the deep earth</i>	2017, 2018
- Provided lecture and contributed to summary volume for international workshop on carbon forms, pathways, and processes in the earth hosted by the Lake Como School (Como, Italy)	
<b>Planning Committee Chair</b> – <i>Geoscience Student Research Symposium</i>	2016-2017
- Coordinated fundraising, catering, and logistical activities for student-organized annual departmental research symposium	
<b>Secondary Standards Provider</b> – <i>VT Fluid Inclusions Lab</i>	2016
- Created and characterized secondary melt inclusion standards for Raman labs at the Smithsonian Institution and University of Berlin	
<b>Fundraising Chair</b> – <i>Geoscience Student Research Symposium</i>	2015-2016
- Raised funds and provided operating budget for student-organized annual departmental research symposium	
<b>Lab guide</b> – <i>James Madison University Geology Lab Methods class</i>	2014
- Assisted undergraduate student visitors using the fluid inclusions sample preparation lab and vibrational spectroscopy (Raman) lab	
<b>Volcano Demonstration Operator</b> – <i>Virginia Science Festival</i>	2013
- Performed demonstrations using model volcanoes with different eruptive styles for a science festival at Virginia Tech attended by over 5000 students and members of the public	
<b>Volunteer</b> – <i>Pulaski Tornado Recovery Fund</i>	2011-2012
- Participated in community home construction and rebuilding effort led by Central United Methodist Church (Staunton VA)	
<b>Musician</b> – <i>Stonewall Brigade Band</i>	2007-2008
- Performed at community events with the oldest continuously operating community band in the United States	

## WORKSHOPS ATTENDED

<b>Analytical methods in Geosciences (AMiGeo) workshop,</b> <i>Washington DC, USA</i>	2018
<b>Melt inclusion methods,</b> <i>Woods Hole MA, USA</i>	2017
<b>Carbon Forms and Pathways,</b> <i>Como, Italy</i>	2017
<b>SZO thematic institute,</b> <i>Boise ID, USA</i>	2016
<b>DCO thematic institute,</b> <i>Berkeley CA, USA</i>	2015
<b>Fluid and melt inclusion analytical methods,</b> <i>Antalya, Turkey</i>	2013
<b>Basic Welding,</b> <i>Valley Vocational Technical Center</i>	2010
<b>Basic Carpentry,</b> <i>Valley Vocational Technical Center</i>	2009
<b>Basic Auto Mechanics,</b> <i>Valley Vocational Technical Center</i>	2009

## SELECTED RESEARCH EXPERIENCE

<b>Volatile budget of Haleakala, Maui (Hawaii)</b>	2014-Present
- Processed whole rock samples using rock saw, jaw crusher, alumina	

- ball mill, and hand selection for alteration minerals
  - Analyzed major and trace element composition of whole rock samples using XRF
    - o **PANalytical Epsilon 3 XL X-ray Spectrometer**, *Virginia Tech*
  - Separated olivine grains with Frantz magnetic separator
  - Analyzed fluid bubbles in melt inclusions using Raman spectroscopy
    - o **J-Y Horiba LabRam HR**, *Virginia Tech*
  - Prepared Indium grain mounts for high-vacuum analyses
  - Analyzed melt inclusion glasses using SIMS
    - o **Cameca IMS 1280**, *Woods Hole Oceanographic Institute*
  - Analyzed melt inclusion glasses and host olivine using EPMA
    - o **Cameca SXFive**, *Syracuse University*
  - Analyzed melt inclusions using LA-ICP-MS
    - o **Agilent 7500ce ICPMS + Geolas laser ablation system**, *Virginia Tech*
  - Wrote and coded software for processing LA-ICP-MS data
- Fractional crystallization modeling of Gale crater samples (Mars)** 2016
- Designed and coded software for automating Monte Carlo simulation of alphaMELTS models
  - Designed and coded software for processing, analyzing, and visualizing model results
- Volatile budget of Klyuchevsky volcano (Kamchatka)** 2016-2018
- Analyzed fluid bubbles in melt inclusions using Raman spectroscopy
    - o **J-Y Horiba LabRam HR**, *Virginia Tech*
  - Prepared Indium grain mounts for high-vacuum analyses
  - Analyzed melt inclusion glasses using SIMS
    - o **Cameca IMS 1280**, *Woods Hole Oceanographic Institute*
  - Analyzed melt inclusion glasses and host olivine using EPMA
    - o **Cameca SX-50**, *Virginia Tech*
  - Designed and coded software to model the processes of decompression and fluid exsolution within cooling melt inclusions
- Machine learning investigation of melt inclusion volatile contents** 2017
- Designed and coded software for geochemical data analysis using an artificial neural network (ANN)
  - Designed and coded software for statistical analysis of geochemical data and results of ANN model
- Investigation of fluid inclusions in Martian Meteorite** 2015
- Analyzed Martian meteorite sample using petrographic methods to identify fluid inclusions
  - Analyzed fluid bubbles in melt inclusions using Raman spectroscopy
    - o **J-Y Horiba LabRam HR**, *Virginia Tech*
  - Analyzed solid material in meteorite sample using EDS

- **Braker XFlash Compact EDS system, Virginia Tech**

#### **Assessment of the role of vapor bubbles in melt inclusions** 2012-2014

- Identified and characterized melt inclusion-bearing olivine grains using petrographic methods
- Designed and utilized new analytical protocol for analyzing melt inclusion vapor bubbles using Raman spectroscopy
  - **J-Y Horiba LabRam HR, Virginia Tech**
- Derived mass balance method account for fluid contained in melt inclusion fluid bubbles
- Prepared Indium grain mounts for high-vacuum analyses
- Analyzed melt inclusion glasses using SIMS
  - **Cameca IMS 1280, Woods Hole Oceanographic Institute**
- Analyzed melt inclusion glasses and host olivine using EPMA
  - **Cameca 6f, Carnegie Institution**

#### **Riparian vadose water monitoring** 2011-2012

- Installed moisture probes on a Virginia farm
  - **UMS soil suction lysimeter, James Madison University**
- Collected vadose water samples from installed probes.
- Measured vadose cation concentrations
  - **Atomic Absorption Spectrophotometer, James Madison University**
- Measured anion concentrations in vadose water samples
  - **Dionex Ion Chromatograph, James Madison University**

#### **Virginia soil carbon survey** 2010-2011

- Collected soil samples from a Virginia farm.
- Conducted field analysis of soil depth, texture, and structure
- Determined soil organic content by oven drying and loss on ignition.
- Calculated bulk density of soil profile
- Extrapolated baseline volumetric carbon per area of pasture

### **PUBLICATIONS**

**Moore, L.R., Bodnar, R.J.** (2019) “A Pedagogical Approach to Estimating the CO<sub>2</sub> Budget of Magmas,” *Journal of the Geological Society of London*, published online January 2019.

**Moore, L.R., Mironov, N., Portnyagin, M., Gazel, E., Bodnar, R.J.** (2018) “A comparative study of volatile contents of primitive arc bubble-bearing melt inclusions determined by mass-balance versus experimental homogenization methods,” *Journal of Volcanology and Geothermal Research*.

Trela, J., Gazel, E., **Moore, L.**, Sobolev, A., Bizimis, M., Jicha, B., Batanova, V., (2017). “The hottest lavas of the Phanerozoic and the survival of ancient Archean reservoirs,” *Nature Geoscience*, **10**, 451-456.

- Steele-MacInnis, M., Esposito, R., **Moore**, L.R., Hartley, M.E. (2017) “Heterogeneously entrapped, vapor-rich melt inclusions record pre-eruptive magmatic volatile contents” *Contributions to Mineralogy and Petrology*, **172**, 18 p.
- Lamadrid, H.M., **Moore**, L.R., Moncada, D., Rimstidt, J.D., Burruss, R.C., Bodnar, R.J. (2016) “Reassessment of the Raman CO<sub>2</sub> densimeter,” *Chemical Geology*, 14 p.
- Aster E.M., Wallace P.J., **Moore** L.R., Watkins J., Gazel E., Bodnar R.J. (2016) “Reconstructing CO<sub>2</sub> concentrations in basaltic melt inclusions using Raman analysis of vapor bubbles.” *Journal of Volcanology and Geothermal Research*, **323**, 148-16.
- Moore**, L.R., Gazel, E., Tuohy, R., Lloyd, A.S., Esposito, R., Steele-Macinnis, M., Hauri, E.R., Wallace, P.J., Plank, T., Bodnar, R.J. (2015) “Bubbles matter: An assessment of the contribution of vapor bubbles to melt inclusion budgets” *American Mineralogist*, **100**, 806-823.

## PRESENTATIONS & PUBLISHED ABSTRACTS

- Invited* – **Moore**, L.R. “Applications of Raman spectroscopy for fluid and solid inclusions” *Mineral Sciences department seminar*, Smithsonian Institution NMNH, November 2018.
- Invited* – **Moore**, L.R., Bodnar, R.J. “Fluid bubbles in mineral-hosted melt inclusions,” *Mineral-hosted melt inclusion workshop*, Woods Hole Oceanographic Institute, August 2018.
- Invited* – **Moore**, L.R., Bodnar, R.J. “The CO<sub>2</sub> Budgets of Magmas, Carbon Forms, Pathways, and Processes,” *Lake Como School*, Como, Italy, August 2017.
- Invited* – **Moore**, L.R., Gazel, E., Tuohy, R., Lloyd, A.S., Esposito, R., Steele-Macinnis, M., Hauri, E.R., Wallace, P.J., Plank, T., Bodnar, R.J. “Bubbles matter: An assessment of the contribution of vapor bubbles to melt inclusion budgets,” *Geology and Environmental Science department seminar*, James Madison University, October 2015.
- Moore**, L.R., Gazel, E., Bodnar, R.J. “The volatile budget of Haleakala (Maui): implications for melting, crystallization, and degassing recorded by melt inclusions,” AGU Fall meeting, December 2018.
- Moore**, L.R., Gazel, E., Bodnar, R.J., Carracedo, J. “Volcanic volatile budgets and fluxes inferred from melt inclusions from post-shield volcanoes in Hawaii and the Canary Islands,” *AGU Fall meeting*, December 2017.
- Moore**, L.R., Nironov, N., Portnyagin, M., Gazel, E., Bodnar, R.J. “A comparative study of volatile contents of primitive arc bubble-bearing melt inclusions determined by Raman-spectroscopy and mass-balance versus experimental homogenization methods,” *American Geophysical Union*, December 2016.
- Moore**, L.R., Lamadrid, H.M., Moncada, D., Bodnar, R.J., “Dependence of the Calculated CO<sub>2</sub> Content of Silicate Melt Inclusions on the Choice of Raman Densimeter Used to Estimate CO<sub>2</sub> Density,” *AGU/GAC/MAC/CGU Joint assembly*, Montreal, May 2015.
- Moore**, L.R., Lamadrid, H.M., Moncada, D., Bodnar, R.J. “The effects of densimeter choice on reconstructing the pre-eruptive CO<sub>2</sub> content of magmas based on Raman analysis of

vapor bubbles in melt inclusions,” *The Sorby Conference on Fluid and Melt Inclusions*, Leeds, United Kingdom, June 2015.

**Moore** L.R., Gazel, E., Esposito, R., Bodnar, R.J., “Micro Raman densimetry of vapor bubbles and applications for melt inclusions”, *Deep Carbon Observatory Thematic Institute*, Berkeley, California, July 2015.

**Moore**, L., Esposito, R., Gazel, E., Touhy, R., Wallace, P., Bodnar, R. J., “Hawaiian melt inclusion ‘shrinkage bubbles’ contain dense CO<sub>2</sub> vapor: Implications for inferred CO<sub>2</sub> contents of the trapped melts” *European Current Research on Fluid Inclusions*, Antalya, Turkey, June 2013.

## **ACADEMIC AWARDS & HONORS**

GSRS “Best in session” outstanding presenter award	2018
Charles E. and Frances P. Sears Summer Scholarship	2016
David R. Wones Research Scholarship	2015
Geological Society of America graduate student research grant: \$1000	2014
Geological Society of America graduate student research grant: \$1200	2015
Dean’s List, JMU Department of Science and Mathematics	2012
Sigma Gamma Epsilon, academic honor society in geology	2010
Sigma Alpha Lambda, academic honors fraternity	2010
President's List, Blue Ridge Community College	2007
National Honors Society	2006