Application Report for Hector Lamadrid

General Information

Name	Hector Lamadrid
Applicant ID	672949
Applicant Type	External Applicant
Applicant Status	010 Active
Job Opening	46341 - Assistant Professor, 9 Month Salaried (Earth, Ocean and Atmospheric Science)
Highest Education Level	J-Doctorate (Academic)
Date Submitted	2019-11-12T18:11:41.000000-0500
Total Years of Experience	0.0

Contact Information

Name Prefix		**Address**	101 Geology Building University of Missouri Columbia, MO 65201
First Name	Hector		
Middle Name			
Last Name	Lamadrid		
Name Suffix		**Preferred Contact**	Not Specified

Phone Numbers

Phone Type	Telephone	Extension	Country Code	Preferred
Home	573/639-1804			Yes

Email Addresses

Email Type	Email Address	Preferred
Home	lamadridh@missouri.edu	Yes

Vita/Resume and Attachments

CVHectorLamadrid.docx
CoverLetterHML.docx
ResearchInterests.docx
Statement_of_Teaching.docx
Diversity_Statement.docx
References.doc

Personal Information

POI Type	Unknown
Are you a former employee	No

Previous Termination Date

Resume

CURRICULUM VITAE

Hector M. Lamadrid

PERSONAL INFORMATION

101 Geology Building,
Columbia, MO 65201.
Tel: +1 (573) 639-1804
E-mail: lamadridh@missouri.edu
orcid.org/0000-0002-0903-7382

INTERESTS AND RESEARCH FOCUS

My research interests comprise a wide range of geological problems that focus on the role of fluids (aqueous-carbonic fluids, silicate melts, and other geofluids) in crustal processes, how these fluids interact with the surrounding rocks, and how the rocks evolve through time and space. These fluid-rock interactions are key to understand the physical, chemical and biological evolution of the Earth's system. In my research, I integrate field, laboratory and experimental observations coupled with microanalytical and computational techniques to decipher the rock and fluid history and to reveal the physical and chemical processes that control the geologic evolution of the planet.

EDUCATION

2016 **Ph.D.** *Virginia Tech*, Blacksburg, VA Dissertation: "Geochemistry of fluid-rock interactions".

2009 **MSc** *National University of Mexico*, UNAM, Campus Juriquilla, Mexico
Thesis: "Petrology and geochemistry of the high porosity microbialites of the Yucatan platform".

2005 **Undergraduate Research Thesis** *National University of Mexico, UNAM,* Campus Juriquilla, Mexico
Thesis: "Genesis of the celestine and fluorite deposits, El Tule, NE México: a Mississippi Valley- Type process".

2005 **BSc** Earth´s Sciences Engineering *Instituto Tecnologico de Ciudad Madero (ITCM)* Ciudad Madero, Mexico

PROFESSIONAL EXPERIENCE AND APPOINTMENTS

2018 - *current* Preparing Future Faculty for Faculty Diversity Postdoctoral Fellow, Department of Geological Sciences, University of Missouri.
2018 (honorary appointment) National Researcher Level C, National Researchers System, Mexico (*Sistema Nacional de Investigadores*).

2016-2018 Roger E. Dean Research Associate Fellow at the Department of Earth Sciences, University of Toronto.

2015 ConocoPhillips Summer Internship, Project: "Diagenetic Forward Modeling and Reactive Transport Modeling of mineralogical modifications and associated pore system in Presalt Angola carbonates".

2010 Research assistant in the Fluids of the Earth Research Lab, project "Geochemical studies in Maar volcanoes, microbialites and basin dolomites".

2007-2009 Research assistant in the Fluids of the Earth Research Lab, project REPSOL-UNAM, "Study of the dolomitization processes in the Campeche Sound: Implications for petroleum and related fluids genesis".

2006 Research assistant in the Fluids of the Earth Research Lab, project PEMEX-UNAM "Characterization of the cap rocks petrology, geochemistry of the diagenetic processes and the evolution of the oil brines in the SE basins of Mexico: Implications for the genesis of dolomites, oil migration and fluid dynamics."

TEACHING EXPERIENCE

Fall 2019 **Instructor** GEOL 4007/GEOL 7002, Fluid and Melt Inclusion Studies, joint undergraduate-graduate course, University of Missouri-Columbia.

Spr 2019 Guest Lecturer, 4007/GEOL 7004 Carbonate Depo-systems, Lecture on Dolomitization processes.
Guest Lecturer, GEOL 2600: Mineral and Energy Resources of the Earth, Lecture on Petroleum Exploration.

Fall 2018 Guest Lecturer, GEOL 4900 Igneous and Metamorphic Petrology, Lecture on Intrusive igneous rocks.
Guest Lecturer, GEOL 4900 Igneous and Metamorphic Petrology, Lecture on Extrusive igneous rocks

Fall 2014 Guest Lecturer, NANO 3015 Nanotechnology, Lecture on Vibrational Spectroscopy for the Material Sciences Department.

Spr 2013 Teaching Assistant, GEOS 4714/7014 Advanced Physical Volcanology, joint undergraduate-graduate course, Virginia Tech.
Guest Lecturer, GEOS 4714/7014 Advanced Physical Volcanology, Lecture on Economic impact of volcanic processes.

Fall 2012 Head Teaching Assistant, GEOS 1104 Physical Geology, undergrad course, Virginia Tech.

Fall 2011 Teaching Assistant, GEOS 1124 Resources in Geology Lab, undergrad course, Virginia Tech.

Spr 2011 Teaching Assistant, GEOS 4624 Mineral Deposits Lab, undergrad course teaching assistant, Virginia Tech.

Fall 2009 **Instructor,** Physical geology lecture for civil engineers, Marist College of Queretaro, Mexico.

STUDENT RESEARCH MENTORING

2017-2018 Michael Nienhuis, University of Toronto **(Advisor)**
- Experimental Petrology
- Low temperature alteration

Thesis Title: "Serpentinization rates in planetary processes"

2012-2016 Hanna Brooks, Virginia Tech, Metamorphic Petrology **(Mentor)**
- Fluid inclusion systematics
- Raman spectroscopy

Thesis Title: "A complex history of fluid-rock interaction during subduction and exhumation of blueschists"

Research mentor for Master's projects:

2018-2019 Grace Allison, University of Missouri, Th-REE deposits **(Mentor)**
- Fluid inclusion systematics
- Raman spectroscopy

Anticipated Thesis title: "Fluid inclusion evidence for the temperature and composition of ore fluids in the Lemhi Pass and Diamond Creek REE-TH districts, Idaho-Montana"

2014-2016 Matthew Sublett, Virginia Tech, Experimental Petrology **(Mentor)**
- Experimental petrology (synthetic fluid inclusions)
- Fluid inclusion systematics

Thesis title: "Partitioning of Na and K between liquid and vapor in the H_2O-NaCl-KCl system at 600–800 °C and 500–1000 bars"

Research mentor for Ph.D. projects:

2015-2019 Eszter Sendula, Virginia Tech, Serpentinization Reactions **(Mentor)**
- Experimental petrology (synthetic fluid inclusions)
- Fluid inclusion systematics
- High T-P Raman spectroscopy

Anticipated Title: "Carbonation, hydration and dehydration reactions on the oceanic lithosphere".

2016-2019 Matthew Sublett, Virginia Tech, Thermodynamics of fluids **(Mentor)**
- High T-P Raman spectroscopy
- Fluid inclusion systematics

Anticipated Title: "Thermodynamic constrains in geologic fluids from Raman spectroscopy"

AWARDS AND FUNDING

2006 CONACyT M.S. Scholarship from the Consejo Nacional de Ciencia y Tecnología (CONACyT, National Science and Technology Foundation, Mexico, awarded amount $168,000 MXP)

2010 Bicentennial Ph.D. Fellowship and Scholarship from the Consejo Nacional de Ciencia y Tecnología (CONACyT, National Science and Technology Foundation, Mexico; awarded amount $164,412 USD).

2014 Co-author with Robert J. Bodnar and Esther Schwarzenbach in NSF grant OCE 1459433 Division of Ocean Sciences (awarded amount $316,200 USD).

2012, 2013, 2014 and 2015 Virginia Tech Graduate Student Assembly Travel Grants (awarded amount $900 USD).

2015 Virginia Tech Graduate Student Assembly Research Development Fund 2015 (awarded amount $697 USD)

2017 Marsden fund preliminary research proposal: A breathing Earth: Storage and movement of water in Earth's upper mantle. (Associate Investigator). Status: *not awarded*

2019 National Science Foundation, MRI Program: Acquisition of High-Resolution Confocal Raman Mapping Microscope with a Wide Spectral Range for Research and Teaching ($351,000). P.I. Status: *not awarded*

PROFESSIONAL SERVICE

2019 GSA Co-Convener and Co-Chair Session Title: **"**Investigations of Hydrothermal Systems: Advances and Challenges"
2018 AGU Fall Meeting, San Francisco, CA, OSPA Judge
2016 AGU Fall Meeting, San Francisco, CA, OSPA Judge

PEER REVIEWS

Research grant proposals:
National Science Foundation OCE Ocean Technology and Interdisciplinary Coordination
National Science Foundation EAR Petrology and Geochemistry

Journal manuscripts:
American Mineralogist
Boletín de la Sociedad Geológica de México
Canadian Mineralogist
Chemical Geology
Chemistry Letters
Geochemistry, Geophysics, Geosystems (G^3)
Geochemical Journal

Geochimica et Cosmochimica Acta
Journal of Geophysical Research: Solid Earth
Journal of Volcanology and Geothermal Exploration
Minerals

PROFESSIONAL MEMBERSHIPS

AAGP, AGU, SEG (Society of Economic Geologist), GSA (Geologic Society of America, Geochemical Society.

MANUSCRIPTS IN PREPARATION AND UNDER REVIEW:

Sublett, D., **Lamadrid H.M.,** Steele-MacInnis M., Spiekermann, G., Bodnar, R.J. Shift in the Raman symmetric stretching band of N2, CO2, and CH4 as a function of temperature, pressure and density to 500 bars and temperatures from near critical up to 450°C. *Journal of Raman Spectroscopy* (under review).

Colleary, C., **Lamadrid, H.M.**, O'Reilly, S.S., Dolocan, A., Nesbitt, S., Molecular-scale preservation in mammoth bone and variation based on burial environment" *Scientific Reports* (under review).

Lamadrid, H.M., Zajacz, Z., Rimstidt, J.D. Bodnar, R.J., Synthetic Fluid Inclusions XXIII. Effect of temperature and fluid composition on rates of serpentinization of olivine in synthetic fluid inclusions. *Geochimica et Cosmochimica Acta* (Submitted).

Lamadrid, H.M., Zajacz, Z. Environmental constraints in the rates of serpentinization in pyroxene micro-reactors. Manuscript in preparation to be submitted to *Chemical Geology.*

Lamadrid, H.M., Sendula, E., Zajacz, Z., Bodnar, R.J. Micro-reactor a novel in situ technique to measure reaction rates. Manuscript in preparation to be submitted to Applied Geochemistry.

Lamadrid, H.M., The formation of halite deposits from serpentinization reactions in ultramafic rocks: a time impossibility. Manuscript in preparation to be submitted to *Scientific Reports*.

Sublett, D., **Lamadrid H.M.,** Steele-MacInnis M., Spiekermann, G., Bodnar, R.J. (in prep). Fugacities of N_2, CO_2 and CH_4 in N_2-CO_2-CH_4 mixtures from 10-500 bars determined by Raman spectroscopy. Manuscript in preparation to be submitted to *Geochimica et Cosmochimica Acta.*

CURRENT PROJECTS IN DEVELOPMENT:

Lamadrid, H.M., Nienhous, M., Zajacz, Z. The effect of $MgSO_4$ on serpentinization rates: Implications for the icy moons of Jupiter and Saturn. Experimental and analytical work in progress.

Lamadrid, H.M., Zajacz, Z. Kinetics of serpentine dehydration. Experimental and analytical work in progress.

Sendula E., **Lamadrid H.M,** Bodnar R.J. Carbonation reactions in ultramafic mineral micro-reactors. Experimental and analytical work in progress.

Lamadrid, H.M. Pollyea R., Reactive Transport Modeling of serpentinization reactions: constraints on the permeability, porosity, fluid composition and alteration mineral evolution of closed vs. open hydrothermal systems. Modeling work in progress.

Wieser, P.E., **Lamadrid, H.M.**, Edmonds, M., Maclennan, J., Jenner, F., Volatile contents (H_2O, CO_2, Cl, F, S) and chalcophile element systematics of melt inclusions of erupted products from the Lower East Rift Zone eruption, Kīlauea Volcano. Analytical work in progress.

Peña-Alonso, T., **Lamadrid, H.M.**, Molina-Garza, R.S., Loza-Aguirre, I., Abdulin, F., Chavez-Alvares, J., Estrada-Carmona, J., Ramirez-Fernandez, J.A., Sierra-Rojas., M.I. Duque-Trujillo, J.F. Multidisciplinary analyses of intrusive rocks affecting the Mexican Fold-Thrust Belt: A new approach to investigate the Mexican orogeny. Field work and analyses in progress.

PEER-REVIEWED PUBLICATIONS:

Worthington J.R., Ratschbacher, L., Stübner, K., Khan, J., Malz, N., Schneider, S., Paul Kapp1, Chapman, J.B., Stevens-Goddard A., Brooks, H.L., **Lamadrid, H.M.**, Steele-MacInnis, M., Rutte, R., Jonckheere, R., Pfänder, J., Hacker, B.R. Oimahmadov, I., and Gadoev, M. The Alichur dome, South Pamir, western India–Asia collisional zone: detailing the Neogene Shakhdara-Alichur syn-collisional gneiss-dome complex and connection to lithospheric processes. *Tectonics* (accepted, in press).

Brooks, H., Dragovic, B., **Lamadrid, H.M.,** Caddick, M.J., & Bodnar, R.J. (2019) Fluid ingress during exhumation of subducted lithologies: A fluid inclusion study from Sifnos, Greece. *Lithos* 332-333, 120-134. https://doi.org/10.1016/j.lithos.2019.01.014

Lamadrid, H.M., Steele-MacInnis, M., Bodnar, R.J. (2017): Relationship between Raman spectral features and fugacity in mixtures of gases. *Journal of Raman Spectroscopy,* 1–13. https://doi. org/10.1002/jrs.5304

Lamadrid, H.M., Rimstidt, J.D., Schwarzenbach, E.M., Klein, F., Ulrich, S., Dolocan, A. & Bodnar, R.J. (2017) Effects of water activity on the rates of serpentinization. *Nature Communications*, 8, 16107 doi: 10.1038/ncomms16107.

Lamadrid, H.M., Moore, L., Moncada, D., Rimstidt, J.D., Burrus, R. & Bodnar, R.J. (2017): Reassessment of the Raman CO_2 densimeter. *Chemical Geology*, 450, 210-222.

Esposito, R., **Lamadrid, H.M.,** Danyushevsky, L.V., Redi D., Steele-MacInnis, M., Bodnar, R.J., Manning, C.E., De Vivo, B., Cannatelli, C., Lima, A. (2016): Detection of liquid H_2O in vapor bubbles in melt inclusions: implications for magmatic fluid composition and volatile budgets of magmas? *American Mineralogist*, 101(7), 1691-1695.

Lamadrid, H.M., Lamb, W.M., Santosh, M., Bodnar, R.J., (2014) Raman spectroscopic characterization of H_2O in CO_2-rich fluid inclusions in granulite facies metamorphic rocks. *Gondwana Research*, 26 (1), 301-310.

Tritlla J., **Lamadrid H.,** Levresse G., Bourdet J., Cardellach E. & Corona-Esquivel R., (2007) El Tule stratabound F-Sr deposit: a key to understanding the origin and mobilization of basinal brines in NE México. 9th Biennial SGA Meeting, Mineral Exploration and Research: Digging Deeper, Dublin, Ireland August

Tritlla, J., Levresse, G., Corona-Esquivel, R., Banks, D. A., Lamadrid, H., Bourdet, J., & Pinto-Linares, P. J. (2007). Epigenetic, low-temperature, carbonate-hosted Pb-Zn-Cu-Ba-F-Sr deposits in México: A Mississippi Valley–type classification. *Geological Society of America Special Papers*, 422, 417-432.

Tritlla, J., Levresse, G., Corona-Esquivel, R., Banks, D., **Lamadrid, H.M.,** Bourdet, J. (2006) Depósitos de Pb-Zn-Cu-Ba-F-Sr epigenéticos estratoligados en series sedimentarias en relación con salmueras de cuenca: depósitos de tipo "Mississippi Valley" (MVT) y similares en México. Volumen conmemorativo a los 100 años de la Sociedad Geológica Mexican. *Boletín de la Sociedad Geológica Mexicana*, P. 103-139.

BOOK CHAPTERS

Jordi Tritlla, Gilles Levresse, Rodolfo Corona-Esquivel, **Héctor Lamadrid de Aguinaco**, Julio Pinto-Linares y Eduardo Mascuñano (2009) Depósitos de filiación MVT (Mississippi Valley-type) en el Norte de México. En Guillermo Salas, Kenneth Clark y Rodolfo Cubillas (editores), Servicio Geológico Mexicano, "Geología Económica de México": segunda edición. 2009 p. 750-759.

INVITED TALKS

2018 "Hydrothermal alteration of the oceanic lithosphere and beyond", University of Missouri, Columbia Mo, U.S.A. Feb 7,.

2018 "Kinetic controls on the hydrothermal alteration of the oceanic lithosphere: new experimental and spectroscopic applications". Columbia University, Lamont-Doherty Earth Observatory, Palisades, NY, U.S.A. April 22,.

2016 "Procesos de hidratación en la litósfera oceánica: Nuevas aplicaciones experimentales." Centro de Geociencias, UNAM, Campus Juriquilla, Qro. Mexico, Oct.

KEYNOTE TALKS IN SCIENTIFIC CONFERENCES:

Lamadrid H.M. La serpentinización y su conexión con la evolución de la Tierra, el origen de la vida y la búsqueda de vida extraterrestre. IX Congreso Nacional de Estudiantes en Ciencias de la Tierra. May 16-18, 2018, UNAM Campus Juriquilla, Qro. Mexico.

ABSTRACTS IN SCIENTIFIC CONFERENCES (39)

1. Allison, G.K**.,** Appold, M. S., Gillerman, V.S., **Lamadrid, H. M**. Fluid inclusion evidence for the temperature and composition of ore fluids in the Lemhi Pass and

Diamond Creek REE-TH districts, Idaho-Montana. GSA 2019, Phoenix, AZ, Sept 22-25.

2. **Lamadrid H.M.**, Sendula E., Zajacz Z., Bodnar R.J. Serpentinization, carbonation and dehydration reactions in ultramafic minerals using synthetic fluid inclusions as micro-reactors: Recent experimental developments in the study of hydrothermal systems. GSA 2019, Phoenix, AZ, Sept 22-25.

3. Sublett, D.M., Sendula, E., **Lamadrid, H.M.**, Steele-MacInnis, M., Spiekermann, G. Bodnar, R.J. Raman-based N2, CH4, and CO2 densimeters and barometers from the liquid-vapor curve to elevated temperatures and pressures. ECROFI 2019, Budapest, Hungary June 23-27.

4. James R. Worthington, Lothar Ratschbacher , Konstanze Stübner , Jahanzeb Khan, Nicole Malz, Susanne Schneider, Paul Kapp, James B. Chapman, Andrea Stevens Goddard1,8, Hanna L. Brooks1,9,10, **Héctor M. Lamadrid**, Matthew Steele-MacInnis, Daniel Rutte, Raymond Jonckheere, Jörg Pfänder, Bradley R. Hacker, Ilhomjon Oimahmadov, and Mustafo Gadoev. The Alichur dome, South Pamir, western India–Asia collisional zone: detailing the Neogene Shakhdara–Alichur syn-collisional gneiss-dome complex and connection to lithospheric processes *34th Himalaya-Karakoram-Tibet Workshop* Montana, June 2019.

5. **Lamadrid HM**, Nienhuis M, Zajacz Z. The effect of MgSO4 on serpentinization rates: Implications for the icy moons of Jupiter and Saturn. AGU 2018, Washington D.C., Dec 10-15.

6. Sublett D, **Lamadrid HM**, Steele-MacInnis M, Spiekermann G, Bodnar RJ: Fugacities of N2-CO2-CH4 mixtures from 10-500 bars determined by Raman Spectroscopy. AGU 2018, Washington D.C., Dec 10-15.

7. **Lamadrid HM**, Zajacz, Z. Experimental determination of the serpentinization rates of orthopyroxene using synthetic fluid inclusions as micro-reactors. AGU 2018, Washington D.C., Dec 10-15.

8. Dragovic B, Brooks HM, **Lamadrid HM**, Caddick MJ and Bodnar RJ. Fluid Capture During Exhumation of Subducted Lithologies: A Fluid Inclusion Study from the Cycladic Blueschist Unit (Sifnos, Greece) AGU 2018, Washington D.C., Dec 10-15.

9. Sublett D, **Lamadrid HM**, Steele-MacInnis M, Spiekermann G, Bodnar RJ: Fugacities of N2-CO2-CH4 mixtures from 10-500 bars determined by Raman Spectroscopy. Goldschmidt 2018, Aug 12-17, Boston, Ma. U.S.A.

10. Sendula E, **Lamadrid HM**, Rimstidt JD & Bodnar RJ Reaction rates of olivine carbonation obtained from synthetic fluid inclusion studies. Goldschmidt 2018, Aug 12-17, Boston, Ma. U.S.A.

11. **Lamadrid HM,** Zajacz, Z: Rates of serpentinization in pyroxene micro-reactors. PACROFI XIV, Jun 12-14, Houston, Tx, U.S.A.

12. Sublett D, **Lamadrid HM**, Steele-MacInnis M, Spiekermann G, Bodnar RJ: N2, CO2, and CH4 fugacities determined for gas mixtures from 10-500 bars at 22 ºC using Raman Spectroscopy. PACROFI XIV, Jun 12-14, Houston, Tx, U.S.A.

13. **Lamadrid HM**, Steele-MacInnis M., Bodnar, RJ: Fugacity in gas mixtures determined from Raman Spectroscopy. GSA Meeting, Oct 22-25, 2017, Portland, Oregon.

14. **Lamadrid HM**, Sendula E., Zajacz Z., Rimstidt JD, Bodnar RJ: Micro-Reactors: A Novel in situ Tool to Monitor Chemical Reactions. Goldschmidt Conference, Aug 13-19, 2017, Paris, France.

15. Sendula E., **Lamadrid HM**, Bodnar RJ: *In situ* monitoring of the olivine to magnesite reaction using synthetic fluid inclusions as microreactors. ECROFI 24, July 2017, Nancy, France.

16. **Lamadrid HM**, Bodnar RJ, Rimstidt JD, Schwarzenbach EM, Ulrich, S., Klein, F. & Dolocan, A: Serpentinization rates using micro-reactors in olivine. AGU meeting. Dec 12-16, 2016, San Francisco, CA, USA.

17. Esposito R, **Lamadrid HM**, Redi D, Cannatelli C, Steele-MacInnis M, Lima A, Bodnar RJ & De Vivo B: Magmatic CO_2-H_2O-S fluids at Mt. Somma-Vesuvius: Insights from shrinkage bubbles of melt inclusions. AGU meeting. Dec 12-16, 2016, San Francisco, CA, USA.

18. Rosario Esposito, **Hector M. Lamadrid**, Daniele Redi, Matthew Steele-MacInnis, Robert J. Bodnar, Craig E. Manning, Benedetto De Vivo, Claudia Cannatelli, and Annamaria Lima. Discovery of liquid H_2O in bubbles of reheated melt inclusions hosted in olivine associated with Mt. Somma-Vesuvius magmas. Asian Current Research on Fluid (ACROFI VI-2016), March 2016.

19. Esposito R., **Lamadrid H.M.,** Redi D., Steele-MacInnis M., Bodnar R.J., Manning C.E., De Vivo B., Cannatelli C. & Lima A.: Bubble-bearing melt inclusions as mini Magma chambers to study melt-volatile evolution. European Mineralogical Conference, Rimini, Italy, September 2016.

20. **Lamadrid HM**, Bodnar RJ, Rimstidt JD, Schwarzenbach EM, Sublett M & Dolocan, A: Real-time monitoring of reaction rate and chemistry of incipient serpentinization of oceanic lithosphere. GSA Annual Meeting in Baltimore, Maryland, USA, 1-4 November 2015.

21. Brooks, HL, **Lamadrid, HM**, Caddick, MJ, Dragovic, B, Bodnar, RJ and Baxter, EF: Insights into subduction zone fluid chemistries from fluid inclusions in blueschist from Sifnos, Greece. GSA Annual Meeting in Baltimore, Maryland, USA, 1-4 November 2015.

22. Moncada D, **Lamadrid HM,** Moore L, & Bodnar RJ: Effect of CO_2 on salinity determinations for fluid inclusions from the epithermal environment. European Current Research On Fluid Inclusions (ECROFI-XXIII), Leeds - UK, 27 - 29 June 2015

23. Moore L, **Lamadrid HM**, Moncada D & Bodnar RJ: The effects of densimeter choice on reconstructing the pre-eruptive CO_2 content of magmas based on Raman analysis of vapor bubbles in melt inclusions. European Current Research On Fluid Inclusions (ECROFI-XXIII), Leeds - UK, 27 - 29 June 2015

24. **Lamadrid HM**, Schwartzenbach E, Rimstidt D & Bodnar RJ: Using synthetic fluid inclusions as mini batch reactors to monitor serpentinization reactions in the oceanic lithosphere. European Current Research On Fluid Inclusions (ECROFI-XXIII), Leeds - UK, 27 - 29 June 2015.

25. Esposito R, **Lamadrid HM**, Danyushevsky LV, Redi D, Cannatelli C, Steele-MacInnis M, Lima A, Bodnar RJ & De Vivo B: Magmatic CO2-H2O-S fluids at Mt. Somma-Vesuvius: Insights from shrinkage bubbles of melt inclusions. European Current Research On Fluid Inclusions (ECROFI-XXIII), Leeds - UK, 27 - 29 June 2015.

26. **Lamadrid HM**, Bodnar RJ, Moore L & Moncada D: Re-evaluation of the Raman densimeter for determining CO_2 density based on the splitting of the Fermi diad. JOINT ASSEMBLY AGU-GAC-MAC-CGU Montreal, Canada 3-7 May 2015.

27. Moore L, **Lamadrid HM**, Moncada D & Bodnar RJ: Dependence of the Calculated CO_2 Content of Silicate Melt Inclusions on the Choice of Raman Densimeter Used to Estimate CO_2 Density. Joint Assembly AGU-GAC-MAC-CGU Montreal, Canada 3-7 May 2015.

28. **Lamadrid HM,** Schwarzenbach E, Caddick M, Rimstidt JD, and Bodnar RJ: Using synthetic fluid inclusions in olivine to monitor hydration – dehydration processes in the oceanic lithosphere. Pan-American Current Research on Fluid Inclusions (PACROFI-Xll) U.S. Geological Survey and Colorado State University, June 2014.

29. **Lamadrid HM**, Schwarzenbach, E; Bodnar, RJ: Monitoring serpentinization reactions in olivine in situ using synthetic fluid inclusions. South Eastern Section GSA, Blacksburg VA, March 2014.

30. **Lamadrid HM,** Schwarzenbach E, Caddick M, Rimstidt D & Bodnar RJ: Tracking serpentinization reactions in situ using synthetic fluid inclusions in ultramafic Minerals. Goldschmidt Conference, Geochemical Society of America, Sacramento, Ca, July 2014.

31. **Lamadrid HM,** Peterson G, Kamilli RJ & Bodnar, RJ: Chemical and thermal evolution of the Finlandia Epithermal Pb-Zn-Ag-Au deposit, Colqui District, central Peru. European Current Research on Fluid Inclusions (ECROFI XXII), Antalya, Turkey, June 2013.

32. **Lamadrid HM**, Santosh M, Lamb, W & Bodnar, RJ: Identification of trace amounts of H_2O in CO_2-rich fluid inclusions in granulite facies rocks, Goldschmidt Conference, Geochemical Society of America, Palais des Congrès, Montreal, Ca. June 2012.

33. **Lamadrid HM**, Santosh M, Lamb W & Bodnar, RJ: Water and hydrogarnet step-daughter minerals in CO_2-rich fluid inclusions in granulite facies rocks. Pan-American Current Research on Fluid Inclusions (PACROFI-XI), University of Windsor, Windsor, Ontario. Ca, June 2012.

34. **Lamadrid HM**, Levresse G y Aranda-Gómez JJ: Microbialites and bioconstructors: Key to understanding the biogeochemical processes of life in earth and beyond. Mexican Space Agency Scientific Forum, Ensenada B.C. 2010.

35. **Lamadrid HM**, Levresse G, Tritilla J, Ortega-Gonzalez V, Esteban M, Flores-Flores M.A: Petrology of the Mesozoic microbialites from the Campeche Sound, 18th International Sedimentological Congress (ISC), Mendoza, Argentina, Sept 2010.

36. Levresse G, Aranda-Gomez JJ, **Lamadrid HM,** Chacon-Baca E, Charles-Polo M, Ramos-Leal, JA: Carbonate microbialites from "Rincón de Parangueo" maar; an alkaline, hypersaline lake in central Mexico. 18th International Sedimentological Congress (ISC), Mendoza Argentina, Sept 2010.

37. Tritlla J, Levresse G, **Lamadrid HM,** Bourdet J, Corona-Esquivel R: Basinal brines as witnesses of fluid flow changes in a compressional-to extensional tectonic regime: the case of El Tule stratabound F-Sr deposit, NE México. ECROFI-XIX, European current research on fluid inclusions University of Bern, July 2007.

38. **Lamadrid HM**, Tritlla J, Levresse G & Bourdet J: Mineralized ore deposits formed by the migration of basinal brines in El Tule, Buda Formation, Sabinas Basin, Coahuila, Mexico. Mexican Geophysical Union. (UGM), Pto. Vallarta, México, Noviembre 2006.

39. **Lamadrid HM,** Tritlla J, Levresse G, Pironon, J, Bourdet, J & Carrillo-Chávez, A: Flujo de fluidos focalizados por estructuras corticales y su papel en la maduración de m.o.: el caso de El Tule, Fm. Buda, cuenca de Sabinas, Coahuila Simposium Plays y Yacimientos de Aceite y Gas en Rocas Carbonatadas, At Ciudad del Carmen, Campeche, México, March 2007.

FIELD WORK AND EXCURSIONS

2018 **Central and Northern Chile (class excursion),** I lead a group of undergraduate and graduate students to visit active mines, learn and map alteration assemblages and volcanic-igneous rocks in well exposed rocks of Chile (University of Toronto).

2013 **Turkey (ECROFI XXII field trip),** Alteration assemblages and ore deposits in the mediterranean margin of Anatolia (Virginia Tech).

2012 **North Ontario, Canada (PACROFI XI field trip).** Grenvillian orogeny intrusive and metamorphic rocks. Sudbury impact and associated ore deposits (Virginia Tech).

2008 **Cofre del Perote Volcano, Veracruz, Mexico (field work).** Study of the volcanic instability of the Cofre de Perote, debris flows and volcanic avalanches (CGEO – UNAM)

2008 **Durango Volcanic Complex, Durango, Mexico (field work).** Study of the volcanic stratigraphy and major fault system (CGEO – UNAM).

2007 **Michoacan-Guanajuato Volcanic Complex, Guanajuato, Mexico (class excursion).** Study of the volcanic stratigraphy and maar eruption compositions (CGEO – UNAM).

2006 **Central Mexica Deformation system (class excursion).** Volcanic stratigraphy, intrusions and major structural and deformational system of the Central Mexican Valley (CGEO – UNAM).

2005 **Sierra Madre Oriental, Mexico (class excursion).** Study of the associated volcanic-magmatic emplacements in the Mexican Fold-Thrust Belt (ITCM).

2004 **Sierra Madre Oriental, San Luis Potosi, Mexico (class excursion).** Study of the major deformation system of the Mexican Fold-Thrust Belt (ITCM).

2003 **Chicontepec, Mexico (SLB-PEMEX workshop).** Lead a group of sedimentary scientist and petroleum geologist to visit the Chicontepec outcrops to understand the stratigraphy and lithofacies associated with density flows in clastic systems (ITCM-Schlumberger).

2003 **Sierra Madre Oriental, Tamaulipas, Mexico (class excursion).** Study of the carbonate stratigraphy of the Mexican Fold-Thrust Belt (ITCM).

TECHNICAL EXPERTISE

- Expertise in fluid inclusion petrography and microthermometry (Linkam 600, Chaixmec, USGS Gas Flow stage).
- Expertise in spectroscopic techniques: Raman spectroscopy, infrared microscopy (FTIR), Ultraviolet Microscopy (UV), and Confocal microscopy.
- Expertise in high pressure and temperature experimental techniques (Cold seal pressure vessels, Piston Cylinder).
- Synthetic Fluid Inclusions in quarts, olivine, garnets, pyroxene, calcite, etc.
- High-pressure Raman studies on fluids using a High-Pressure Optic Cell (HPOC).
- X ray diffraction (XRD).
- Thin and double polished side section preparation.
- Sedimentary, igneous and metamorphic petrography.
- Scattering electronic microscopy (SEM).
- Chemical analyses: EMPA, LA-ICPMS and TOF-SIMS
- Synchrotron X-Ray Tomography
- Computer fluid-rock simulators TOURGHREACT, PetraSim5, EQ3/6, GWB, Thermocalc, Perple_X.

FEATURED PAPERS IN SOCIAL MEDIA

2017 **Investigacion y Desarrollo:** Estudia mexicano en Canadá reacciones químicas en donde se cree apareció la vida en la Tierra (http://invdes.com.mx/agencia-id/estudia-mexicano-canada-reacciones-quimicas-donde-se-cree-aparecio-la-vida-la-tierra/)

2016 **Deep Carbon Observatory**: New Estimates of Volatiles in Melt Inclusions (https://deepcarbon.net/feature/new-estimates-volatiles-melt-inclusions#.WbLtXZOGNE4)

OTHER ACTIVITIES AND OUTREACH

- Producer and presenter of the science outreach radio show “Sinapsis” 2008-2010, Querétaro, Mexico.
- Short Course of Salt Tectonics and Stratigraphic Sequences, Dr. Tim Lawton, University of New Mexico, 2008.
- President of the Organizing Committee of the First National Congress of Students of Geosciences in México, April 2008, CAC, UNAM Juriquilla, Queretaro, Mex.
- Short Course “P-T Modeling Aqueous and Hydrocarbon Fluid Inclusions” by Jacques Pironon, CREGU, Nancy, France.
- Short Course “Introduction to Sequence Stratigraphy and Marine Carbonates” by Maya Eldrich, University of New Mexico. USA.
- Short Course “Metals pollution in Aquifers”, Geoscience Research Center UNAM.
- Short Course “Raman Spectroscopy” by Juan Tellez, University of Sao Paolo, Brazil.
- Committee member of the Second National Congress of Earth´s Sciences Engineering (ITCM 2005).
- Workshop of Predictive Sedimentology by Dr. Carlos Zavala, Southern University, Cordoba, Argentina, Schlumberger 2004.
- Workshop of Structural Geology by Dr. Eduardo Rosselo, Buenos Aires University, Argentina, Schlumberger 2003.
- Vice president of the Organizing Committee of the First National Conference of Earth´s Sciences Engineering (ITCM 2003).
- Committee member of the First National Meeting of Women in Engineering (ITCM 2003).
- Secretary of the High School Liaison Committee, ICT 1999.

References

REFERENCES

Robert J. Bodnar

Distinguished Professor Virginia Tech

Email: rjb@vt.edu

Address: Department of Geosciences (MC0420) Derring Hall Room 4044 1405 Perry Street Virginia Tech Blacksburg, VA 24061

Phone: +1.540.231.7455

Esteban Gazel

Email: egazel@cornell.edu

Address: 4164 Snee Hall 112 Hollister Drive Ithaca, NY 14853-1504

Matt Steele-MacInnis

Assistant Professor University of Alberta

Email: steelema@ualberta.ca

Address: 1-26 Earth Sciences Building University of Alberta Edmonton, Alberta Canada T6G 2E3

Phone: +1780-492-7906

Zoltan Zajacz

Associate Professor University of Geneve

Email: zajacz@unige.ch

Address: Université de Genève 13, Rue des Maraîchers 1205 Genève SwitzerlandPhone:

Phone:+41 022 379 66 22

Martin Appold

Professor University of Missouri

Email:appoldm@missouri.edu

Address:304 Geological Sciences Bldg. Columbia, MO 652011

Phone: +1573-882-0701

Cover Letters

Geological Sciences
University of Missouri

101 Geology Building, Department of Geological Sciences, Columbia, MO
Office: (573) 639-1804 Fax: (573) 882-5458 E-mail: lamadridh@missouri.edu

Nov 15, 2019

Prof. Mainak Mookherjee
Chair of theSearch Committee
Department of Earth, Ocean and Atmospheric Sciences
Florida State University
1017 Academic Way Tallahassee, FL 32306-4520

Dear. Prof. Mookherjee,

I am writing this letter to formally apply for the tenure-track Assistant Professor in Solid Earth Processes in the Lithosphere at the Department of Earth, Ocean and Atmospheric Sciences at Florida State University.

I am a geologist specialized in fluid-rock interactions in a variety of crustal processes. I started my career in the National Autonomous University of Mexico working on the mineralogical and geochemical alterations produced by fluid circulation in sedimentary sequences with a focus on energy and mineral resources. I obtained my Ph.D. from Virginia Tech (2011-2016) working with Prof. Robert Bodnar on low to high temperature geochemistry and experimental petrology. I studied fluid-rock interactions in natural systems (metasomatism of mantle rocks, arc volcanism, lower crust metamorphism) and the thermodynamic properties of fluids. Later, I was appointed the Roger E. Deane Postdoctoral Fellow at the University of Toronto (2016-2018) working with Prof. Zoltan Zajacz developing new experimental (piston-cylinder, cold seal) and analytical methodologies to better constrain the physical and chemical factor that affect the hydration (serpentinization), carbonation and dehydration reactions that occur in hydrothermal systems associated with ultramafic rocks on Earth and other planetary bodies. Currently, I am a postdoctoral fellow in the Preparing Future Faculty Diversity Program at the University of Missouri where I am developing undergraduate and graduate courses, as well as continuing my research on fluid-rock interactions and their role in the evolution of the crust.

My goal is to develop a world-leading multidisciplinary research group that focuses on the role of fluids in crustal processes using field observations, cutting-edge analytical, modeling, and experimental techniques. Furthermore, I want to become a leader and a referent in the community and become involved in scientific and cultural outreach programs and that will help break the social paradigm (stigma) about science, and the roles of the Hispanic and Latino community in society.

Attached to this letter, you will find a complete CV and a brief description of my teaching philosophy and my research interests. I look forward to further discuss the future directions of my research.

Sincerely,
Hector M. Lamadrid

Miscellaneous

Contributions to diversity, leadership, community and outreach

I come from a family of immigrants. My grandparents, victims of the social and political climate of the first half of the 20th century, emigrated from Spain and Cuba running away from war and oppression. Almost 80 years later now parents are immigrants themselves, being pushed away by the increasing levels of violence in Mexico.

Immigration gives people a different perspective on life. The struggles that come from adapting to a new language, culture, food, and idiosyncrasies expands the way you see the world, and at the same time strengthens your sense of empathy for others that are experiencing similar circumstances. Strangely, although the environment seems to be more hostile towards you because of the succinct differences of how you look, sound or behave, you become more willing to take action and help people.

I am now also an immigrant; although my reasons, "competitive science", are not as perilous as the reasons behind my family and millions of others to leave everything behind, the consequences of growing up in a household of immigrants, and now experiencing them by myself has made me understand the struggles of being, looking and thinking different. In academia, this is to some extent normal, but the roles we decide to take as scientist varies widely from complete cultural isolation, as most scientists do, to having an active role in outreach and community building. My role throughout time is closer to the second part and is now at the core of my plans to attract a diverse group of students to my research group.

In my time in the U.S. and Canada, my role has been slightly different. For most of the people that I meet, I am the first Mexican that they have ever encounter outside of the social, political and historical roles we usually have. As a scientist, I completely break with the mental template they have about my country. In the social and political climate in which we live now, I carry a further responsibility as a Mexican, a Hispanic and a Latino. The key to be an effective scientific communicator and to engage people into exploring the world of science, originates from sharing who we are, our stories and our passion towards science.

During my years as a graduate student in Mexico, I was deeply involved in organizing outreach efforts that spanned from creating new research symposiums, public lectures about the role of science in our daily life, and I was the producer and host of a weekly science radio show that had the objective of bringing science to the people outside of the university. We focused not only on the content of our scientific subjects but in sharing the excitement and our passion towards science. Science is not only important, but it can be inspiring and fun. My proudest accomplishment outside research is that most of these outreach activities including the radio show were taken over by new graduate students. Now after 12 years all these outreach avenues are still growing, and several of the undergraduate and high school students involved in our events are now graduate students, college instructors, and researchers.

My role as an educator go further than the classroom and I have the obligation to further engage in the necessary conversations about immigration, my story, my family history and the need to construct a society based on information, science, empathy and mutual understanding. I want to become a leader and referent in the community and become involved in scientific and cultural outreach programs and that will help break the social paradigm (stigma) about science and our role as scientists.

Teaching Philosophy

Statement of Teaching

Hector Lamadrid

Introduction:

I come from a diverse and *sui generis* background. I grew up in a household of immigrants, my grandparents migrated to Mexico from different parts of the world (Spain and Cuba) in the early 20th century, and as much as my parents were born in Mexico, most of the things that I learn at home were slightly different. For the better part of my early life this meant that in order to be functional in my social interactions I had to be able to find ways to communicate and explain things differently and adapt to the environment quickly to not lose my audience. In this case, 11-year-old kids that were amazed that at home we ate bread instead of tortillas. Thirty years in the future, now myself also an immigrant, having lived and worked in three countries (and now an avid tortilla consumer) I find myself in the same position as when I was kid, but with the need to explain foreign (almost alien) scientific concepts like geologic time and thermodynamics to an audience without losing them. Teaching is as much as a sophisticated tool to train and prepare the future generation of scientists, as it is a style of deep social interaction. My approach to teaching aligns with the later.

Teaching philosophy:

Most classes and topics are different from each other, and the teacher-student interactions have to be different, rather because we are in small or big classes or because the subject is an introductory or advanced course. However, I always start the class semester with a deep explanation of who I am and where I come from. I discovered that students, especially in the U.S.A, come from diverse backgrounds and can empathize with my journey. I take this journey even further in introductory classes and use my ancestry background and explain not only where my family came from, but going further in time to the big human and hominid migrations out of Africa, and even further back in time using concepts like evolution of the species, mass and heat transfer in the crust, plate tectonics, planetary differentiation, the solar nebula and the supernovas that fertilized our solar system with all the heavy elements. I am not only an immigrant, but we all as a species, as living organism, as part of a cosmic system traveling further back in time to the Big Bang, we are all immigrants.

Students are like sponges. Sponges that rather be somewhere else than in the class room. So, it is imperative for me to establish a connection with them. As such, I like personalized one to one interactions with the students. In big room lectures, however, this becomes impossible. To overcome this barrier, the use of other realms like pop culture, social media, politics, economy, sports, etc., aid to provide the students a more wholesome explanation of a simple scientific concept. With the elimination of basic science (earth sciences classes in particular) from elementary and middle school curricula around the world, we are encountering a fundamental lack of scientific literacy that affects social stratums differently. As instructors in higher education our job is to bridge those gaps by building classes that foments critical thinking rather than just be driven by content. In my classes I use the big picture outside of math, physics, chemistry, and geology, to help the students generate personal conceptual connections and bridge theory and practice. Specifically, I have found that making the connections between the geosciences and the daily trivial nuances like the resources we consume (oil, mineral, technology industries), geopolitics, history and the environment (contamination, natural or human-made) help students to bridge the concepts.

Geology is the science that unravels the story of Earth. So for geoscience majors, I like to approach the classes with the objective not to teach the story of Earth but rather to help the student to become the story tellers. To develop these storytelling abilities students need to be exposed to field work and hands on experience with rocks are fundamental and an important component of the classes I want to teach.

As an experimentalist part of our mantra is that failure brings us closer to understand nature and its processes. However, for students, this path is full of pain and frustration and can jeopardize their entire academic record. I measure academic excellence, but also, I measure how the students react against struggle and how they overcome it. Innovation sparks through overcoming struggle. Teaching, as a form of communication and social interaction, is a two-way road, in which we all need to learn in order to succeed. My responsibility as a teacher is not only to be a fair and efficient communicator of science but be open to learn and to share my excitement about science.

Experience and teaching goals:

During my academic career, I have taught several classes both as a teaching assistant (TA) and as an instructor. Also, I have routinely helped several professors with guest lectures that overlapped with my specific scientific background in ore deposits, carbonate petrology, igneous and metamorphic petrology and vibrational spectroscopy. As a TA I taught introductory and advanced labs: Physical Geology, Resources of Geology, Advanced volcanology (graduate and senior undergraduate class), and Mineral deposits (last year undergraduate students). As a lecturer in the Marist University of Queretaro (Mexico): Physical Geology for Civil Engineers. Currently, I am teaching a joint undergraduate and graduate course on the use of Fluid and Melt Inclusions to study different geologic processes and environments.

The wide diversity of research projects and interactions with the energy and mineral industries that I had in my career makes me confident on teaching introductory and geology core courses like physical, environmental and resources in geology, mineralogy, igneous and metamorphic petrology, carbonate petrology and diagenesis. I can teach advanced or graduate courses in economic geology: mineral deposits and petroleum geology; volcanology, hydrothermal systems and geothermal resources, as well as a field component for any of those courses. I can teach graduate especial courses in high temperature geochemistry, petrology, fluids in the crust, fluid and melt inclusions and thermodynamics in aqueous systems, as well as applications of vibrational spectroscopy and theory (Raman, FTIR, UV).

I plan to develop new joint multidisciplinary classes with instructors from other disciplines that focus in big picture subjects. For example, using my background in serpentinization and hydrothermal systems I want to create a course with people from Biology and Planetary Sciences about “The origin of life on life and other planetary bodies” where we can discuss the current hypotheses and active research on exploring the origins of life Earth and in other planetary bodies. Similarly, I have been always intrigued with the assigned value to certain natural resources like gold, diamonds (and other gems) and oil. I want to develop joint courses that focus both in the geological component and how we explore and produce some of these resources, but also explore the geopolitical and economic aspects.

Research Interest

Research Statement

Hector Lamadrid

I.- Motivation:

My research interests span a wide range of geological and geochemical problems that focus on the role of fluids in crustal processes, how fluids interact with the surrounding rocks, and how these interactions evolve through time and space. Mainly, I am interested in process driven studies that relate together fluid-rock interactions, the associated alteration assemblages, the fluids and melts trapped during these processes, and the equilibrium and disequilibrium reactions (and their kinetic and thermodynamic mechanisms) to reconstruct the sequences of events and understand the evolution of the Earth's system.

II.- Current research:

a) Serpentinization reactions in planetary processes.

Serpentinization is a critical geologic process that occurs when ultramafic minerals (mantle rocks) interact with aqueous fluid circulation (Bach et al. 2004). The chemical and petrological processes that accompany serpentinization and the interactions between the ocean and the oceanic lithosphere have become one of the most important subjects in the scientific literature, and are key to understand the physical, chemical and biological evolution of the Earth's system (Früh-Green et al. 2003; Kelley et al. 2001), and is central to current origin of life hypotheses (Martin et al. 2008), as well as the search for microbial life on the icy moons of Jupiter and Saturn (Glein et al. 2015; Hsu et al., 2015; Vance et al. 2016; Waite et al., 2017).

Rates of serpentinization in ultramafic minerals. Despite the pivotal role that serpentinization plays in a number of geological and biological processes, few experimental studies have attempted to determine the rates of serpentinization reactions, and the rates that have been reported diverge widely (McCollom et al. 2016). Moreover, the specifics on how the environmental factors (like temperature, fluid composition, fO_2, salinities, etc.) control the serpentinization reactions are not completely understood. My research showed that fluid composition and salinity have a major role in the kinetics of the serpentinization reaction (Lamadrid et al., 2017 *Nat. Comm.*). I use high P-T experiments (piston cylinder and cold seal vessels) to trap synthetic fluid inclusions in olivine and pyroxene as micro-batch reactors to monitor fluid-rock reactions *in situ* and in real time (Lamadrid et al., 2017 *Nat. Comm.*). The results from this work will constrain the effects of temperature and different fluid compositions (Mg, CO_2, Ca, SO_4, Al_2O_3) appropriate to the different set of conditions in which serpentinization occurs on Earth. To monitor reaction progress, I use a set of indirect techniques like petrography, microthermometry, Raman Spectroscopy, X-ray Micro CT and Synchrotron nano CT Tomography, and to characterize the chemistry and mineralogy of the reaction products FIB SEM and TOF SIMS.

Serpentinization reactions in other planetary bodies. Serpentinization is a planetary process that has been observed and inferred in other planetary bodies (meteorites, Mars, icy moons of Saturn and Jupiter) (Glein et al., 2015; Schulte et al., 2006; Vance et al., 2016). While the Earth is characterized by a great range of different environmental conditions (P-T, fO_2, and fluid compositions) at which serpentinization occurs, every planetary body will have specific physical and chemical constraints that will create in conjunction a unique hydrothermal system. Recent studies on rates of serpentinization (Lamadrid, 2016; Lamadrid et al. 2017, *Nat. Comm*; Lamadrid et al., *Submitted GCA.*) have shown that the serpentinization reaction of olivine is sensitive to the fluid composition and salinity of the fluid, and even small increases in salinity and addition of Mg^{2+} and CO_2 to the fluid the reaction slows down several orders in magnitude. As such, I work

on recreating the hydrothermal systems conditions of the rocky cores of this ocean worlds (pressures ~100 to 500 bar, and low temperatures 150-250 ºC) to determine the rates of serpentinization reaction using a range of the most probable fluid compositions found in the oceans of Enceladus and Europa (e.g. H_2O-$MgSO_4$, H_2O-$NaCO_3^-$, NH_3 among others.). Preliminary results show that serpentinization reactions are at least 1 order of magnitude slower with $MgSO_4$ rich fluids. The ultimate goal is to provide a more robust answer to the questions of habitability outside the Earth's system.

Carbonation reactions associated with ultramafic and mafic systems. Dealing with the excess of CO_2 in the atmosphere has become one of the major focus of interdisciplinary research on the world. Currently, I am collaborating with the Fluid Research Group at Virginia Tech using the micro-reactor technique at low to high temperatures (room to 300 ºC) to determine rates and pathways of CO_2 sequestration at different environmental conditions. We are using the knowledge obtained from the experimental work carried on ultramafic systems to obtain specific kinetic and thermodynamic data necessary to understand the carbonation reactions at different

Kinetics of the dehydration reactions of the serpentinized slab during subduction. As serpentinized oceanic lithosphere is subducted into the mantle, serpentine dehydration is expected to occur and release H_2O (600-700ºC and depths of 120 to 170 km). Serpentine minerals can hold up to 16 wt.% H_2O (13 wt.% on average) in their molecular structure and will release this H_2O during dehydration. Some of the released fluids percolate upwards into the overlying mantle wedge and, depending on the temperature of the mantle in this region, the water reacts with mantle minerals to form more serpentine, or can trigger partial melting. Following completion of the serpentinization experiments, I set the serpentinized samples to the high temperature-high pressure vessels and equilibrate the SFI at T 500-800°C to observe and monitor the back reaction (serpentine + brucite = olivine + water), to calculate the rates in which the serpentine species dehydrate.

Reactive transport modeling of serpentinization and carbonation reactions. The new rate data and the additional information that is derived from experimental work that I currently working on will provide the rate laws that I plan to use in quantitative intensive computing simulations (e.g. TOUGHREACT) that simultaneously consider mineral speciation and precipitation, permeability evolution, heat balance, water flow, volume and strain evolution.

b) Understanding the P-T-X evolution of the fluid-rock system during the exhumation history of rocks in subducted lithologies and in collisional events.

Fluid-rock interactions during the deformation of the crust are recorded in the form of primary mineral assemblages, secondary minerals (alteration assemblages) and fluid and melt inclusions trapped at each of these stages. Studying these features allows us to understand the chronology of events, as well as the physical and chemical evolution of the rocks. Fluid inclusions record the P-T-V-X of geologic processes. They are tiny vessels of the original fluid compositions and record the depths and temperatures of emplacement of rocks, as well as the metamorphic and metasomatic history. Along with careful petrology studies and geochronology I reconstruct the geologic history of rocks. I have worked with rocks from exhumed subducted lithologies of Sifnos (Brooks et al., 2019) and exhumed batholiths from the Himalayas (Worthington et al., under review). Currently, I am studying the deformation and batholith emplacement (cretaceous-tertiary magmatism) associated to the Mexican Orogeny in NE Mexico with colleges form the Autonomous University of Tamaulipas, Autonomous University of Guanajuato and the National Autonomous University of Mexico.

Combined petrological and fluid inclusion study of serpentinized ultramafic rocks in fossilized serpentinized systems (fossilized hydrothermal systems in ophiolites and drilled cores from active systems). Most of the knowledge about the volatile formation (H_2 and CH_4) in serpentinization processes comes from experimental studies and direct probing by submersible

research vessels near hydrothermal vents where the fluids produced by serpentinization are mixed with seawater. Through the study of fluid inclusions, we can study the evolution of the pressure, temperature, and composition of the hydrothermal system in time and space, and from the formation of the original rock through the subsequent alteration events (hydrothermal pulses). I plan to conduct detailed fluid inclusion studies from core samples retrieved from drillings and hand samples from obducted ophiolites from Mexico and Oman ophiolites to obtain the fluid compositions and volatile concentrations from the ultramafic and alteration assemblages to understand the fluid evolution, in time and space, of these active hydrothermal systems. The paleo-fluids can be accurately characterized by using non-destructive (Raman, FTIR) and destructive techniques (LA-ICPMS, TOF SIMS, etc.) to obtain fluid compositions and precise volatile concentrations (CO_2, CH_4, and H_2). The aim of this study is to infer paleo-mass fluxes through time and compare to the estimates of the natural systems like the Oman ophiolite and MOR.

c) Study of the fundamental link between the thermodynamic properties and spectral features of geologic materials.

Thermodynamic properties of gases are fundamental quantities, needed in a huge array of geochemical and industrial applications such as deciphering fluid-driven processes in the deep Earth and developing fluid-moderated manufacturing and processing procedures. In a recent study (Lamadrid et al. 2017 *J. Raman Spect.*) we discovered that fugacities of gas species can be obtained *in situ* and at elevated pressure directly from spectroscopic data. This contribution underscores a fundamental and deeper link between physical processes and spectroscopy and can potentially several profound implications on the way we obtain thermodynamic data.

Development of new thermodynamic databases of gases at high P-T. The fugacity-Raman discovery represents a tractable method to efficiently obtain large datasets on thermodynamic properties of gas mixtures and may lead to a viable method for developing non-ideal mixing rules for other substances, such as crystalline solid solutions and aqueous ions and electrolytes, both of which show characteristic variations in Raman spectra composition. New experimental work undertaken in collaboration with the USGS, University of Alberta and Virginia Tech at high temperature and pressures will expand the fugacity correlation to new gas compositions.

Molecular dynamics simulations of the Raman fugacity. Currently, in collaboration with researchers from University of Alberta, Virginia Tech, and GFZ Potsdam, we are conducting molecular dynamic simulations (classical MD and *ab initio*) to estimate the density of states as a function of pressure for the pure gases compared to the mixed gases might provide insights into molecular underpinning and will help to create a robust theoretical model of the relationship between thermodynamic properties and spectroscopy.

Future work will involve the use of DAC (diamond anvil cell) and synthetic fluid and melt inclusions to study *in situ* fugacities, pressures and densities of other aqueous fluids and gaseous species (*e.g.* C, O, H, N, etc.) and their diffusion in an out of minerals at mantle conditions.

III.- Future directions of research

Experimental determination of the effects of pressure and density on the serpentinization rates of reaction of ultramafic minerals. In serpentinization studies, pressure and density despite being one of the key parameters in experimental petrology, have not been systematically studied as a variable that can affect the rates of reaction. Given the critical aspects of serpentinization reactions in different geologic systems, especially on the subduction zone, the effect of pressure and densities are key to model accurately the hydration and dehydration reactions, the mass flux of volatiles and the P-T-* space where serpentinization occurs.

Rates of alteration assemblages in hydrothermal systems. The micro-reactor technique I developed provides a novel and promising tool to monitor fluid-rock reactions *in situ* and in real

time and can be applied to a wide variety of host minerals, reaction products, temperatures, and different starting fluid compositions. Future applications can be to follow an quantify: hydration of garnet, ionic substitution of Na, K and Ca in feldspars (processes observed in hydrothermal alteration assemblages), weathering processes and the formation of clays.

Dolomitization and diagenetic studies in carbonate basins. Dolomitization of carbonates in diagenetic and hydrothermal systems has been the focus of research in economic geology, sedimentology, microbiology, and geochemistry for over a century and still little is known about the kinetics of this reaction. As such, I plan to conduct a set of different low and high-temperature experiments to understand the kinetics of the dolomite formation and dolomitization as a function of fluid chemistry and salinity using the micro-reactors and apply the results to Diagenetic Forward Modelling using reactive transport simulations with the objective of providing predictive exploration strategies for the oil and gas industry.

Study of fossil hydrothermal and magmatic systems, mineral resources and their impact on society. The increase in the demand of energy, metal and mineral resources is pushing the needs to better understand how and where anomalous concentrations of mineral resources are formed. I plan to develop a research program to study the geochemical pathways of mineral alteration and the role of fluids in the formation of mineral deposits.

References

Bach, W. et al., 2004. Seawater-peridotite interactions: First insights from ODP Leg 209, MAR 15°N. *Geochemistry, Geophysics, Geosystems*, 5(9).

Brooks, H., Dragovic, B., Lamadrid, H.M., Caddick, M.J., & Bodnar, R.J. (2019) Fluid ingress during exhumation of subducted lithologies: A fluid inclusion study from Sifnos, Greece. Lithos 332-333, 120-134.

Früh-Green, G.L. et al., 2003. 30,000 Years of hydrothermal activity at the Lost City vent field. *Science*, 301, pp.495–498.

Glein, C.R., Baross, J.A. & Waite, J.H., 2015. The pH of Enceladus' ocean. *Geochimica et Cosmochimica Acta*, 162, pp.202–219.

Hsu, H. W., Postberg, F., Sekine, Y., Shibuya, T., Kempf, S., Horányi, M., ... & Kuwatani, T. (2015). Ongoing hydrothermal activities within Enceladus. Nature, 519(7542), 207-210.

Kelley, D.S. et al., 2001. An off-axis hydrothermal vent field near the Mid-Atlantic Ridge at 30 degrees N. *Nature*, 412(6843), p.145–149.

Lamadrid, H.M., Lamb, W.M., Santosh, M., Bodnar, R.J., (2014) Raman spectroscopic characterization of H2O in CO2-rich fluid inclusions in granulite facies metamorphic rocks. Gondwana Research, 26 (1), 301-310.

Lamadrid, H.M., Geochemistry of Fluid-Rock Interactions. (2016). Ph.D. Dissertation. Virginia Tech, Blacksburg, VA.

Lamadrid, H.M., Rimstidt, J.D., Schwarzenbach, E.M., Klein, F., Ulrich, S., Dolocan, A. & Bodnar, R.J., (2017): Effects of water activity on the rates of serpentinization. *Nature Communications* 8, 16107.

Lamadrid, H.M., Moore, L., Moncada, D., Rimstidt, J.D., Burrus, R. & Bodnar, R.J. (2017): Reassessment of the Raman CO_2 densimeter. *Chemical Geology*, 450, 210-222.

Lamadrid, H.M., Zajacz, Z., Rimstidt, J.D., Bodnar, R.J. Temperature and fluid composition constraints in the rates of serpentinization in olivine micro-reactors. Submitted to *Geochimica et Cosmochimica Acta* Lamadrid, H.M., Steele-McCinnes, M., Bodnar, R.J.: Relationship between Raman spectral features and fugacity in mixtures of gases. *Journal of Raman Spectroscopy*, 1-13. https://doi. org/10.1002/jrs.5304

Martin, W. et al., 2008. Hydrothermal vents and the origin of life. *Nature Reviews Microbiology*, 6(11), p.805.

McCollom, T.M. et al., 2016. Temperature trends for reaction rates, hydrogen generation, and partitioning of iron during experimental serpentinization of olivine. *Geochimica et Cosmochimica Acta*, 181, pp.175–200.

Schulte M., Blake D., Hoehler T. and McCollom T. (2006) Early Earth and Mars. Astrobiology **6**, 364–376.

Vance, S.D., Hand, K.P. & Pappalardo, R.T., 2016. Geophysical controls of chemical disequilibria in Europa. *Geophysical Research Letters*, 43(10), pp.4871–4879.

Waite, J. H., Glein, C. R., Perryman, R. S., Teolis, B. D., Magee, B. A., Miller, G., ... & Lunine, J. I. (2017). Cassini finds molecular hydrogen in the Enceladus plume: Evidence for hydrothermal processes. Science, 356(6334), 155-159.

Worthington J.R., Ratschbacher, L., Stübner, K., Khan, J., Malz, N., Schneider, S., Paul Kapp1, Chapman, J.B., Stevens-Goddard A., Brooks, H.L., Lamadrid, H.M., Steele-MacInnis, M., Rutte, R., Jonckheere, R., Pfänder, J., Hacker, B.R. Oimahmadov, I., and Gadoev, M. The Alichur dome, South Pamir, western India–Asia collisional zone: detailing the Neogene Shakhdara-Alichur syn-collisional gneiss-dome complex and connection to lithospheric processes. Tectonics (accepted).