

## RAINA V. GOUGH

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### Education:

**Ph.D.**, Analytical Chemistry, Dept. of Chemistry & Biochemistry, CU-Boulder **2010**  
**B.S.** in Chemistry, Montana State University, Bozeman, MT **2004**

### Experience:

Instructor, Department of Chemistry and Biochemistry **2014 - present**  
University of Colorado – Boulder  
Research Associate, Cooperative Institute for Research in **2013 – present**  
Environmental Sciences, University of Colorado – Boulder  
Chemistry Instructor, Front Range Community College, Westminster Campus **2012**  
National Research Council Postdoctoral Fellow, National **2011 - 2014**  
Institute of Standards and Technology, Boulder, CO  
Graduate Research Assistant, University of Colorado at Boulder, **2004 – 2010**

### Selected Honors and Awards:

Mars Science Laboratory Participating Scientist **2016 - 2021**  
NRC Postdoctoral Research Fellowship **2011 - 2013**  
Graduate Student Research Fellowship, CIRES, University of Colorado **2009 - 2010**

### Courses Taught:

Introductory Chemistry, General Chemistry 1 and 2, Environmental Chemistry 1 and 2

### Selected Publications:

1. **RV Gough**, DL Nuding, PD Archer Jr, MS Fernanders, SD Guzewich, MA Tolbert, AD Toigo, **2020**. Changes in soil cohesion due to water vapor exchange: A proposed dry-flow trigger mechanism for recurring slope lineae on Mars. *Geophys. Res. Lett.* 47 (11). DOI 10.1029/2020GL087618
2. CR Webster, et al., **2018** Background levels of methane in Mars' atmosphere show strong seasonal variations. *Science*. 360 (6393), p. 1093-1096.
3. EG Rivera-Valentin, **RV Gough**, VF Chevrier, KM Primm, GM Martinez, MA Tolbert. **2018**. Constraining the potential liquid water environment at Gale crater, Mars. *Journal of Geophysical Research – Planets*. DOI:10.1002/2018JE005558
4. KM Primm, **RV Gough**, VF Chevrier, MA Tolbert. **2017**. Freezing of perchlorate and chloride brines under Mars-relevant conditions. *Geochimica et Cosmochimica Acta*. 212, p 211-220.
5. **RV Gough**, J Wong, JL Dickson, JS Levy, JW Head, DR Marchant, MA Tolbert. **2017**. Brine formation via deliquescence by salts found near Don Juan Pond, Antarctica: Laboratory experiments and field observations. *Earth and Planetary Science Letters*. 476, p. 189 – 198.
6. DL Nuding, **RV Gough**, KJ Venkateswaran, JA Spry, MA Tolbert. **2017** Laboratory Investigations on the Survival of *Bacillus subtilis* Spores in Deliquescent Salt Mars Analog Environments, *Astrobiology*. 17(10), DOI: 10.1089/ast.2016.1545.
7. **RV Gough**, VF Chevrier, MA Tolbert. **2016**. Formation of liquid water at low temperatures via the deliquescence of calcium chloride: Implications for Antarctica and Mars. *Planetary and Space Science*. 131, p. 79 – 87.

8. DL Nuding, RD Davis, **RV Gough**, MA Tolbert. **2015**. The Aqueous Stability of a Mars Salt Analog: Instant Mars. *Journal of Geophysical Research: Planets*, 120, p. 588 – 598.
9. **RV Gough**, VF Chevrier, MA Tolbert. **2014**. Formation of aqueous solutions on Mars via deliquescence of chloride–perchlorate binary mixtures. *Earth & Planet Sci Letters*, 393, p. 73-82.
10. JD Rummel, et al. **2014**. A New Analysis of Mars “Special Regions”: Findings of the Second MEPAG Special Regions Science Analysis Group (SR-SAG2). *Astrobiology* 14 (11), p. 887-968.
11. DL Nuding, EG Rivera-Valentin, RD Davis, **RV Gough**, VF Chevrier, MA Tolbert. **2014**. Deliquescence and efflorescence of calcium perchlorate: an investigation of stable aqueous solutions relevant to Mars. *Icarus*, 243, p. 420-428.
12. **Gough, RV**, Chevrier, V, Baustian, K.J., Wise, ME, Tolbert, MA. Laboratory studies of perchlorate phase transitions: Support for metastable aqueous perchlorate solutions on Mars, *Earth and Planetary Science Letters*, **2011**, 312, p. 371–377.
13. Meslin, P-Y, **Gough, RV**, Lefevre, F, Forget, F. Variability of atmospheric methane induced by adsorption in the regolith. *Planetary & Space Science*, **2011**, 59, p. 247-258.
14. **Gough, RV**, Turley, JJ, Ferrell, GR, Cordova, KE, Wood, SE, DeHaan, DO, McKay, CP, Toon, OB, Tolbert, MA, Can rapid loss, high variability of Martian methane be explained by surface H<sub>2</sub>O<sub>2</sub>? *Planetary and Space Science*, **2011**, 59, p 238 – 246.
15. **Gough, RV**, Tolbert, MA, McKay, CP, Toon, OB, Methane adsorption on a Martian soil analog: An abiogenic explanation for methane variability in the Martian atmosphere, *Icarus*, **2010**, 207, 165–174.
16. Hatch, CD, **Gough, RV**, Toon, OB, Tolbert, MA, Heterogeneous nucleation of nitric acid trihydrate on clay minerals: Relevance to Type Ia polar stratospheric clouds. *Journal of Physical Chemistry B*, **2008**, 112(2), p. 612-620.

### Selected Conference Proceedings and Invited Lectures

1. **Gough RV**, Nuding DL, Toigo A, Guzewich S, Tolbert MA, *An Examination of Atmospheric Water Vapor as a Source for Recurring Slope Lineae on Mars*, Ninth International Conference on Mars, Pasadena CA, July **2019** (oral presentation).
2. **Gough, RV** and Tolbert, MA, *Are hydrated salts evidence of liquid water on Mars*. American Geophysical Union, Fall Meeting, San Francisco, CA, Dec. **2016** (poster).
3. **Gough RV**. *Liquid water on Mars? Stable or metastable solutions formed via deliquescence*. North Pole Seminar Series, Lulea Institute of Technology, Kiruna, Sweden. Nov 17, 2016. (invited seminar).
4. **Gough, RV**, Nuding, DL, Chevrier, VF and Tolbert, MA, *The Formation and Stability of Perchlorate Liquid Brines on Mars*, The Present-Day Habitability of Mars meeting, University of California, Los Angeles, Feb. **2013** (invited oral presentation).
5. **Gough, RV**, Nuding, DL, and Tolbert, MA, *Experimental studies of the formation of aqueous solutions by deliquescence of Mars-relevant salt mixtures*, 3rd Conference on Terrestrial Mars Analogues, Marrakech, Morocco, October **2012** (oral presentation).
6. **Gough, RV**, Chevrier, V and Tolbert, M.A., *Deliquescence of Perchlorate/Chloride Mixtures: Implications for Stable and Metastable Aqueous Solutions on Mars*, 43<sup>rd</sup> Lunar and Planetary Science Conference, The Woodlands, TX, March **2012** (oral presentation).
7. **Gough, RV** *Liquid water on Mars? Laboratory studies of low temperature, metastable perchlorate phase transitions*, Astrobiology Seminar, University of Washington, Seattle, WA, May **2011** (invited).
8. **Gough, RV**, Turley, J, Ferrell, G, Cordova, K, Wood, S, De Haan, DO, McKay, CP, Toon, OB, Tolbert, MA. *Can rapid loss and high variability of Martian methane be explained by surface H<sub>2</sub>O<sub>2</sub>?* American Geophysical Union Meeting, San Francisco, CA, Dec. **2010** (oral presentation).
9. **Gough, RV**, Chevrier, VF, Baustian, KJ, Wise, ME, Tolbert, MA. *Metastable Aqueous Perchlorate Solutions at the Phoenix Landing Site: Experimental Studies of Phase Transitions Relevant to Mars*, Division of Planetary Sciences meeting, Pasadena, CA, Oct. **2010** (oral presentation).

10. **Gough, RV**, Tolbert, MA, McKay, CP, DeHaan, D.O., Toon, OB. *Laboratory investigation of the role of heterogeneous processes in Martian methane variability*, Workshop on Methane on Mars, Frascati, Italy, Nov. **2009**, (invited oral presentation).

### **Professional Activities:**

- Masters and PhD committee member for students in Atmospheric and Oceanic Sciences, Geological Sciences, Chemistry and Biochemistry.
- Frequent reviewer for journal manuscripts, grant proposals, fellowship proposals, etc.
- Participant in NASA Mars 2020 rover Pre-Landing Site Workshop Planetary Protection Review, **2018**.
- Participant in NASA Induced Special Regions on Mars workshop, **2018**.
- Member, Mars Exploration Program Science Analysis Group, Special Regions: “Review of Potential Habitats on Mars: Special Regions Definitions, Locations, and Resource Relationships”, **2013**.
- Session chair, “Mars: Modeling and Observations”, AGU Fall meeting **2010**.
- NASA Planetary Science Summer School, Jet Propulsion Laboratory, August **2010**.
- Student rapporteur for National Academy of Science Decadal Survey Meeting, Inner Planets Panel, Boulder, CO, **2010**.
- NASA Astrobiology Institute (NAI) International Summer School in Astrobiology, “Exploring Mars: The Next Ten Years,” Santander, Spain, July **2007**.

### **Current Funding**

#### **Principal Investigator on Grants Received**

"Improving predictions of duration and location of aqueous salt solutions at the MSL landing sites", Mars Science Laboratory Participating Scientist Program. NASA. 5 years, \$411,000. 4/15/2016 – 9/30/2021.

### **Press:**

"Flowing Water on Mars... Today? Debate and Discussion!", by Leonard David, <http://www.leonarddavid.com/flowing-water-on-marstoday-debate-and-discussion/> Dec 21, 2016

“New study raises doubts about liquid water flowing on planet Mars”, by Allan Adamson, Tech Times. <http://www.techtimes.com/articles/189539/20161220/experiments-raise-doubt-about-liquid-water-flowing-on-planet-mars.htm>.

"Are Mars' Dark Streaks Really Evidence of Liquid Water?", by Mike Wall, <http://www.space.com/35071-mars-dark-streaks-liquid-water-debate.html>, Dec 19, 2016.

"Mars rover scientist hopes to find more evidence of liquid water on the Red Planet" by Tomasz Nowakowski, <http://www.spaceflightinsider.com/missions/solar-system/mars-rover-scientist-hopes-find-evidence-liquid-water-red-planet/>, May 18, 2016.

“CU-Boulder’s Raina Gough joins NASA’s Mars rover science team”, CU Boulder Today, <http://www.colorado.edu/today/2016/03/11/cu-boulders-raina-gough-joins-nasas-mars-rover-science-team>, March 11, 2016

“Planetary science: a whiff of mystery on Mars”, Nature News, by Katharine Sanderson. <http://www.nature.com/news/2010/270110/full/463420a.html>, Jan 27, 2010.