# Lee M. Saper

**Postdoctoral Fellow, Jet Propulsion Laboratory**
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## Education

**Ph.D.** California Institute of Technology, Pasadena, California, USA (2021)
Geology, Experimental Petrology, Advisor: Edward Stolper

**M.S.** California Institute of Technology, Pasadena, California, USA (2018)
Geology, Experimental Petrology, Advisor: Edward Stolper

**B.Sc.** Brown University, Providence, Rhode Island, USA (2012)
Geology-Chemistry, with honors, Advisors: John Mustard, Yan Liang

## Professional Experience

**Postdoctoral Fellow**, Jet Propulsion Laboratory (2023–Present)
Sample Science
Artemis III Geology Team, Affiliate

**Postdoctoral Research Assistant**, University of Edinburgh (2021–2023)
Designed and implemented upgrades to high-temperature gas-mixing furnace laboratory
Co-supervised 2 PhD students in petrology and planetary science research projects

**Assistant Staff Scientist**, Malin Space Science Systems (2012–2015)
Mars Reconnaissance Orbiter (MRO) Science Operations Team
Mars Science Laboratory (MSL) Collaborator

## Awards and Recognition

- **Bernard Ray Hawke Next Lunar Generation Career Development Award** (2024)
- **Planetary Science Travel Grant**, Geochemical Society (2024)
- **Associated Students of Caltech Teaching Award** for outstanding graduate teaching (2019)
- **Ian Campbell Award** for outstanding performance in field work (2017)
- **Leon T. Silver Graduate Fellowship** (2016)
- **NASA Mars Science Laboratory Group Achievement Awards** (2014, 2015)
- **Weston Prize** for excellence in music, trombone performance (2012)
- **Rhode Island NASA Space Grant Scholar** (2011)

## Service and Public Outreach

**Conference Leadership and Workshop Participation:**

- American Geophysical Union Outstanding Student Presentation Awards. **Coordinator** (2024–Present)
- Keck Institute for Space Studies, Sample Return Across the Solar System. **Participant** (2024-2025)
- International Workshop on Electron Probe Microanalysis. **Panelist** (2022–2023)

**Public Outreach:**

- **Los Angeles Unified School District (LAUSD)**: Contributed to development of High School Framework for Earth Sciences curriculum; helped organize LAUSD STEAM Festival 2017

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## Supervision of Students

**PhD Student co-supervision:**

- Siobhan Kingham (University of Edinburgh, PhD 2025)
  "Lunar magmatic degassing mechanisms and their relation to the Moon's unique chlorine isotopic signature"
- Ri Cao (University of Edinburgh, PhD 2025)
  "Massive volcanic domes on Venus and the mobilization of crystal mush"

## Teaching Experience

**Graduate Technical Assistant, Caltech GPS Division Analytical Facility** (2017–2021)

- Supported user training and daily operations of the electron microbeam analytical facility

**Teaching Assistant:**

- Optical Mineralogy Laboratory (Caltech)
- Analytical Techniques Laboratory (Caltech)
- Petrology and Petrography: Igneous Petrology (Caltech)
- Metamorphic Petrology (Caltech; received student-nominated ASCIT Teaching Award, 2019)
- Earth, Moon, and Mars (Brown University)

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## Fundraising

**Competitive Grants Awarded**

- **NERC Ion Probe Facility**: $16,250 (2023) *PI G. Bromiley, written by L. Saper*
  "Constraining the primary sulfur concentration and isotopic composition of the Troodos ophiolite"
- **GSECARS Beamtime at Argonne National Laboratory**: $67,000 (2022–2023)
  "Fe XANES analysis of experimentally equilibrated sulfur-bearing silicate glasses"
- **University of Edinburgh EPS Small Grants**: $1,300 (2023) - *PI G. Bromiley, written by L. Saper*
  "SEM and EPMA analysis of sulfides in Troodos Ophiolite thin sections"
- **University of Edinburgh POT and DEV fund**: $4,000 (2021)
  "Critical upgrades to the Centre for Extreme Conditions 1-atm Gas-Mixing Furnaces"
- **NSF Graduate Research Fellowship Program (GRFP)**: $138,000 (2016–2021)

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## Publications List

*Submitted and in-prep*

1. **Saper, L.M.,** Liu, Y., Guan, Y., Ma, C., Bell, E.A., Agee, C.B. *(in review)* A Noachian hydrosphere component in the 4.1 Ga Martian meteorite Teghaza 001. *Science Advances*.
2. Liu, Y., **Saper, L.M.,** Bell, E.A., Ma, C., Li, H., Hu, J., Guan, Y., Melton, H., Cruz-Uribe, A.M., Yap, T.E., Tissot, F.L.H., Bucholz, C.E., Ziegler, K., Agee, C.B. *(in review)* Ancient Martian meteorite Teghaza 001: A new view of pre-Noachian Mars. *Science*.

3. **Saper, L.M.,** Harlov, D., Liu, Y. *(in prep)* Crystal-chemical control of Na substitution into Martian chlorapatite. *American Mineralogist.*

4. Kingham, S.E.L., Varnam M., **Saper, L.M.,** Bromiley, G.D. *(in review)* Major element zonation following rapid heating of homogeneous glass in wire-loop experiments. *Geochemistry*.

5. Cao, R., **Saper, L.M.,** Bromiley, G.D., Danyushevsky, L., Carter, E. (*in review*) Magma mixing and crystal-rich picrites from Margi, Cyprus. *Journal of Petrology.*

*2025*

6. **Saper, L.M.,** Bromiley, G., Cao, R., Brounce, M., Hughes, E.C., Woelki, D. (2025) The primary $\delta^{34}S$ of the Troodos Ophiolite and evidence for early and late sulfide saturation. *Lithos,* 518-519 108331 https://doi.org/10.1016/j.lithos.2025.108331

7. Hooper, N., Liang, Y., Zhou, D., Acquadro, J., Allan, E., **Saper, L.M.**, Bosenberg, J. (2025) A new generation of Al-in-olivine thermometers for unraveling thermal and magmatic history of martian meteorites. *Geochimica et Cosmochimica Acta,* https://doi.org/10.1016/j.gca.2025.11.002

8. **Saper, L.M.,** Liu, Y., Kipp, M.A., Burney, D., Ma, C., Tissot, F.L.H., Young, E., Treffkorn, J., Farley, K.A., Eiler, J.M. (2025) Chemical, isotopic (O, He, U), and petrological characteristics of a slowly cooled enriched gabbroic shergottite, Northwest Africa 13134. *Meteoritics and Planetary Science*, 60(5) pp. 1119-1150, https://doi.org/10.1111/maps.14345

9. Cao, R., **Saper, L.M.,** Bromiley, G.D., Antoshechkina, P.M., Hastie, A.R., Law., S. (2025) Formation of steep-sided domes on Venus via eruption of high crystallinity magmas. *Icarus*, https://doi.org/10.1016/j.icarus.2025.116524

*2024*

10. **Saper, L.M.,** Baker, M.B., Brounce, M., Hughes, E.C., Hofmann, A.E., Stolper, E.M. (2024) Experimental constraints on Fe and S redox equilibria and kinetics in basaltic melt inclusions. *Geochimica et Cosmochimica Acta*, 381, p. 75–96, https://doi.org/10.1016/j.gca.2024.07.018

11. **Saper, L.M.,** Brounce, M., Woelki, D., Cao, R., Bromiley, G. (2024) Variable oxidizing capacity of slab-derived fluids: insights from Fe and S speciation in glasses from the Troodos Ophiolite. *Earth and Planetary Science Letters*, 627, 118560, https://doi.org/10.1016/j.epsl.2023.118560

12. Hughes, E.C., Liggins, P., **Saper, L.M.,** Stolper, E.M. (2024) The effects of oxygen fugacity and sulfur on the pressure of vapor-saturation of magma. *American Mineralogist*, 109(3), https://doi.org/10.2138/am-2022-8739

13. Zhang, Y., Gaetani G., Pamukçu, A., Monteleone, B., **Saper, L.M.** (2024) Experimental investigation of hydrogen isotope fractionation during hydration of olivine-hosted melt inclusions: Implications for D/H in Baffin Island picrites. *Earth and Planetary Science Letters*, 647, 119052, https://doi.org/10.1016/j.epsl.2024.119052

*2023*

14. Hughes, E.C., **Saper, L.M.,** Liggins, P., Stolper, E.M. (2023) The sulfur solubility minimum and maximum in silicate melt. *The Journal of the Geological Society: Sulfur in the Earth System*, 180(3) https://doi.org/10.1144/jgs2021-125

*2022*

15. **Saper, L.M.,** Baker, M.B., Stolper, E.M. (2022) $Fe^{2+}$-Mg partitioning between olivine and liquid at low oxygen fugacity: an experimental and thermodynamic framework. *Contributions to Mineralogy and Petrology*. 174(94), https://doi.org/10.1007/s00410-022-01955-0

*2021*

16. Richter, F., **Saper, L.**, Villeneuve, J., Chaussidon, M., Watson, B.E., Davis, A.M., Mendybaev, R.A., Simon, S.S (2021) Reassessing the thermal history of martian meteorite Shergotty and lunar mare basalt Apollo 15555 using kinetic isotope fractionation of zoned minerals. *Geochimica et Cosmochimica Acta*, 295, https://doi.org/10.1016/j.gca.2020.11.002

*2020*

17. **Saper, L.,** Stolper, E.M. (2020) Controlled cooling-rate experiments on olivine-hosted melt inclusions: chemical diffusion and quantification of eruptive cooling-rates on Hawaii and Mars. *Geochemistry, Geophysics, Geosystems*, 21, https://doi.org/10.1029/2019GC008772

*2014*

18. **Saper, L.,** Liang, Y. (2014) Formation of plagioclase-bearing peridotite and plagioclase-bearing wehrlite and gabbro suite through reactive crystallization: an experimental study. *Contributions to Mineralogy and Petrology*, 167(985), https://doi.org/10.1007/s00410-014-0985-7

19. Dundas, C.M., Byrne, S., McEwen, A.S., Mellon, M.T., Kennedy, M.R., Daubar, I.J., **Saper, L.** (2014) HiRISE observations of new impact craters exposing Martian ground ice. *Journal of Geophysical Research: Planets*, 119 p. 109-127, https://doi.org/10.1002/2013JE004482

*2013*

20. **Saper, L.,** Mustard, J.F. (2013) Extensive linear ridge networks in Nili Fossae and Nilosyrtis, Mars: Implications for fluid flow in the ancient crust. *Geophysical Research Letters*, 40, p. 245-249, https://doi.org/10.1002/grl.50106

21. Bishop, J.L., Loizeau, D., McKeown, N.K., **Saper, L.,** Darby Dyar, M., Des Marais, D.J., Parente, M., Murchie, S.L. (2013) What the ancient phyllosilicates at Mawrth Vallis can tell us about possible habitability on early Mars. *Planetary and Space Science*, 86, p. 130-149, https://doi.org/10.1016/j.pss.2013.05.006

**MSL Science Team Publications** (2013–2015)

1. Bish, D.L., Blake, D., Vaniman, D., Chipera, S., Morris, R., Ming, D., Treiman, A., Sarrazin, P., Morrison, S., Downs, R., **MSL Science Team**, 2013. X-ray diffraction results from Mars Science Laboratory: Mineralogy of Rocknest at Gale crater. *Science* 341, 1238932.

2. Blake, D.F., Morris, R.V., Kocurek, G., Morrison, S., Downs, R.T., Bish, D., Ming, D., Edgett, K., Rubin, D., Goetz, W., **MSL Science Team**, 2013. Curiosity at Gale crater, Mars: Characterization and analysis of the Rocknest sand shadow. *Science* 341, 1239505.

3. Farley, K.A., Malespin, C., Mahaffy, P., Grotzinger, J.P., Vasconcelos, P.M., Milliken, R., Malin, M., Edgett, K., Pavlov, A.A., Hurowitz, J.A., **MSL Science Team**, 2014. In situ radiometric and exposure age dating of the Martian surface. *Science* 343, 1247166.

4. Leshin, L., Mahaffy, P.R., Webster, C., Cabane, M., Coll, P., Conrad, P., Archer Jr, P., Atreya, S., Brunner, A., Buch, A., **MSL Science Team**, 2013. Volatile, isotope, and organic analysis of martian fines with the Mars Curiosity rover. *Science* 341, 1238937.

5. Mahaffy, P., Webster, C., Stern, J., Brunner, A., Atreya, S., Conrad, P., Domagal-Goldman, S., Eigenbrode, J., Flesch, G.J., Christensen, L.E., **MSL Science Team**, 2015. The imprint of atmospheric evolution in the D/H of Hesperian clay minerals on Mars. *Science* 347, 412–414.

6. Mahaffy, P.R., Webster, C.R., Atreya, S.K., Franz, H., Wong, M., Conrad, P.G., Harpold, D., Jones, J.J., Leshin, L.A., Manning, H., **MSL Science Team**, 2013. Abundance and isotopic composition of gases in the Martian atmosphere from the Curiosity rover. *Science* 341, 263–266.

7. McLennan, S.M., Anderson, R., Bell III, J., Bridges, J.C., Calef III, F., Campbell, J.L., Clark, B., Clegg, S., Conrad, P., Cousin, A., **MSL Science Team**, 2014. Elemental geochemistry of sedimentary rocks at Yellowknife Bay, Gale crater, Mars. *Science* 343, 1244734.
8. Meslin, P.-Y., Gasnault, O., Forni, O., Schröder, S., Cousin, A., Berger, G., Clegg, S., Lasue, J., Maurice, S., Sautter, V., **MSL Science Team**, 2013. Soil diversity and hydration as observed by ChemCam at Gale Crater, Mars. *Science* 341, 1238670.
9. Ming, D.W., Archer Jr, P., Glavin, D., Eigenbrode, J., Franz, H., Sutter, B., Brunner, A., Stern, J., Freissinet, C., McAdam, A., **MSL Science Team**, 2014. Volatile and organic compositions of sedimentary rocks in Yellowknife Bay, Gale Crater, Mars. *Science* 343, 1245267.
10. Stolper, E., Baker, M., Newcombe, M., Schmidt, M., Treiman, A., Cousin, A., Dyar, M., Fisk, M., Gellert, R., King, P., **MSL Science Team**, 2013. The petrochemistry of Jake_M: A Martian mugearite. *Science* 341, 1239463.
11. Vaniman, D.T., Bish, D., Ming, D., Bristow, T., Morris, R., Blake, D., Chipera, S., Morrison, S., Treiman, A., Rampe, E., **MSL Science Team**, 2014. Mineralogy of a mudstone at Yellowknife Bay, Gale crater, Mars. *Science* 343, 1243480.
12. Webster, C.R., Mahaffy, P.R., Atreya, S.K., Flesch, G.J., Farley, K.A., Team, M.S., Kemppinen, O., Bridges, N., Johnson, J.R., Minitti, M., **MSL Science Team**, 2013. Low upper limit to methane abundance on Mars. *Science* 342, 355–357.
13. Williams, R.M., Grotzinger, J.P., Dietrich, W., Gupta, S., Sumner, D., Wiens, R., Mangold, N., Malin, M., Edgett, K., Maurice, S., **MSL Science Team**, 2013. Martian fluvial conglomerates at Gale crater. *Science* 340, 1068–1072.

**Conference Abstracts**

1. Liu, Y., **Saper, L.M.,** Bell, E., Ma, C., Li, H., Tissot, F., Hu, J., Ziegler, H., Bucholz, C., Guan, Y., Agee, C. Teghaza 001: A gabrroic diorite from the Noachian Martian Crust. *MetSoc 2025* #3088
2. **Saper, L.M.**, Brounce, M., Hughes, E.C., Cao, R., Woelki, D., Bromiley, G.D. Sources and fates of magmatic sulfur in the Troodos Ophiolite. *Goldschmidt 2025*, abs: 28656
3. Denevi, B.W., Edgar, L.A., Fassett, C.I., Gross, J., Hayden, T., Heldmann, J.K., Hostrawser, J., Hurley, D.M., Hurtado Jr., J.M., Izquierdo, K., Jolliff, B.L., Joy, K.H., Liu, Y., Madera, A., Moye, C., Osinski, G.R., **Saper, L.M.**, Sonke, A., Speyerer, E., Srivastava, A., Sweeney, T., Cohen, B., Evans, C., Ewing, R., Graff, T., Lawrence, S.J., Miller, M., Needham, A.W., Petro, N.E., Weber, R., Young, K.E. 2025. Artemis III Geology Priorities and Science Planning Progress. 56th Lunar and Planetary Science Conference abs#1920.
4. Adeloye, A.O., Ogliore, R.C., Hofmann, A.E., Choukroun, M., Ishii, H.A., Eiler, J.M., Freeman, A., Karimi, R., Shirashi, L., Aponte, J.C., Tachibana, S., Tissot, F.L.H., **Saper, L.M.**, Yap, T.E., Brown, M.E., Buczkowski, D.L., Forero, V., Gerakines, P., Jackson, J.M., Liu, Y., Meech, K.J, Meshoulam, A., Mojarro, A., Neveu, M., Raymond, C.A., Yabuta, H., Zolensky, M. 2025. Ionian Plumes: High-Value Targets for a Sample Return Mission. 56th Lunar and Planetary Science Conference abs#2717.
5. Hurtado Jr., J.M., Sweeney, T.L., Denevi, B.W., Fassett, C.I., Gross, J., **Artemis III Geology Team**. 2025. Artemis III Extravehicular Activity Science Imaging Use Cases and Needs. 56th Lunar and Planetary Science Conference abs#2747.
6. Moye, C.G., Jolliff, B.L., Malaret, E., Malaret, V., Heldmann, J.L., Hurley, D., Artemis III Geology Team. 2025. Artemis III Candidate Landing Regions: Illumination Constraints on the Likelihood of Ice Deposits in the Upper Meter of Regolith. 56th Lunar and Planetary Science Conference abs#2655.
7. Fassett, C.I., Denevi, B.W., Hostrawser, J.W., Izquierdo, K., Jolliff, B., Madera, A., Moye, C.G., Osinski, G.R., Sonke, A.J., **Artemis III Geology Team**. 2025. Figures of Merit for Candidate Artemis III

Exploration Areas Based on Geology Team-Defined Science Objectives. 56th Lunar and Planetary Science Conference abs#2149.

8. **Saper, L.M.**, Heine, R., Liu, Y., Parekh, A., Sellar, R.G., 2024. Infrared Color Video for Artemis EVAs. Presented at the Annual Meeting of the Lunar Exploration Analysis Group, LPI, Houston, Texas, p. 5067.
9. **Saper, L.M.**, Brounce, M.N., Woelki, D., Hughes, E., Cao, R., Bromiley, G.D., 2024**.** MORB-like Primary Magmatic Sulfur Isotope Composition of the Troodos Ophiolite. Presented at the AGU24, AGU.
10. Liu, Y., Cohen, B.A., Denevi, B.W., Edgar, L.A., Fassett, C., Graff, T.G., Gross, J., Hayden, T., Heldmann, J.L., Hostrawser, J., Hurley, D., Hurtado, J.M., Izquierdo, K., Jolliff, B.L., Joy, K.H., Madera, A., Moye, C., Needham, A., Osinski, G.R., Robinson, M.S., **Saper, L. (presenting author)**, Sonke, A., Speyerer, E.J., Srivastava, A., Sweeney, T., 2024. Sample analyses as part of the geology and sampling planning for Artemis III mission. Presented at the AGU24, AGU.
11. Liu, Y., **Saper, L.M.**, Ma, C., 2024. Sulfide and Magnetite Assemblages in Gabbroic Shergottite Northwest Africa 13134 Indicate Slow Cooling and Post-Magmatic Oxidation**.** LPI Contributions 3036, 6078.
12. **Saper, L.M.**, Liu, Y., 2024. Merrillite-apatite disequilibrium textures in martian meteorites record late-stage crustal processes**.** 2024 Goldschmidt Conference.
13. **Saper, L.M.**, Wölki, D., Cao, R., Bromiley, G., Brounce, M., 2023**.** Speciation of Fe and S in volcanic glasses from Troodos, Cyprus: tracking the redox evolution and cycling of sulfur in supra-subduction zone ophiolites, in: Goldschmidt 2023 Conference.
14. Cao, R., **Saper, L.M.**, Bromiley, G.D., Hastie, A., Law, S., 2023. Formation mechanisms of steep-sided domes on Venus, in: AGU Fall Meeting Abstracts. pp. P42C-06.
15. Kingham, S.E., **Saper, L.M.**, Bromiley, G.D., Hastie, A., 2023. Lunar magmatic degassing mechanisms and their relation to the Moon's unique Cl isotopic signature, in: Goldschmidt 2023.
16. Hughes, E.C., **Saper, L.M.**, Liggins, P., Stolper, E., 2022. Behaviour of sulfur during volcanic degassing: insights using a thermodynamic model. 2022 Young Scientists Award, in: 2022 Goldschmidt Conference.
17. **Saper, L.M.**, Baker, M.B., Hughes, E.C., Brounce, M., Stolper, E., 2022. Experimental use of olivine-hosted melt inclusions to explore the thermodynamics and kinetics of Fe and S redox equilibria in silicate melts, in: 2022 Goldschmidt Conference.
18. **Saper, L.M.**, Stolper, E., 2017. Multicomponent Diffusion in Experimentally Cooled Melt Inclusions, in: AGU Fall Meeting Abstracts. pp. V43B-0527.
19. Bromiley, G.D., Dibble, F., **Saper, L.M.**, 2023. Core formation in planetesimals: the importance and geochemical legacy of immiscibility in metallic liquids, in: Goldschmidt 2023 Conference.
20. Hughes, E., Liggins, P., **Saper, L.M.**, Stolper, E., 2021. Effect of sulphur and oxygen fugacity on vapour-saturation pressure calculations. Goldschmidt2021• Virtual• 4-9 July.
21. Liang, Y., Wang, C., **Saper, L.M.**, Dygert, N.J., Xu, W., 2013. Melt-rock reaction in the asthenospheric mantle: Perspectives from laboratory dissolution experiments, in: AGU Fall Meeting Abstracts. pp. V23D-03.
22. Dundas, C.M., Byrne, S., McEwen, A.S., Mellon, M.T., Wu, M.R., Daubar, I., **Saper, L.M.**, 2013. Observations of ice-exposing impacts on Mars over three Mars years, in: AGU Fall Meeting Abstracts. pp. P31C-07.
23. Mustard, J.F., **Saper, L.M.**, 2012. Preferred orientation of Ridges in Phyllosilicate Terrains, Mars: Implications for Crustal Habitability, in: AGU Fall Meeting Abstracts. pp. P13E-03.
24. **Saper, L.M.**, Liang, Y., 2012. Formation of plagioclase-bearing peridotite and a peridotite-wehrlite-gabbro suite through melt-rock reaction: An experimental study, in: AGU Fall Meeting Abstracts. pp. V33C-2890.

25. **Saper, L.M.**, Allen, C.C., Oehler, D.Z., 2012. Rover Exploration of Acidalia Mensa and Acidalia Planitia: Probing Mud Volcanoes to Sample Buried Sediments and Search for Ancient and Extant Life, in: 43rd Lunar and Planetary Science Conference.

26. **Saper, L.M.**, Bishop, J.L., 2011. Reflectance spectroscopy of nontronite and ripidolite mineral mixtures in context of phyllosilicate unit composition at Mawrth Vallis, in: 42nd Annual Lunar and Planetary Science Conference. p. 2029.

27. Bishop, J.L., **Saper, L.M.,** Beyer, R.A., Lowe, D., Wray, J.J., McKeown, N.K., Parente, M., 2011. Possible sedimentary features in phyllosilicate-bearing rocks at Mawrth Vallis, Mars, in: 42nd Annual Lunar and Planetary Science Conference. p. 2374.

28. Bishop, J.L., **Saper, L.M.,** McKeown, N.K., Parente, M., Poulet, F., Mustard, J.F., 2010. Mineralogy of Mawrth Vallis Mars, as determined through analyses of CRISM images, in: 2010 GSA Denver Annual Meeting.