Stanford



Laura Schaefer

Associate Professor of Earth and Planetary Sciences, by courtesy, of Geophysics

Earth & Planetary Sciences

Bio

BIO

Laura joined the department of Earth and Planetary Sciences in January 2019. She received her Bachelor's from Washington University in St. Louis in 2002, and then remained there or several years as a research assistant in Earth and Planetary Sciences, where she studied planetary atmospheres and their formation. In 2011, Laura began graduate school at the Harvard-Smithsonian Center for Astrophysics and received her PhD in Astronomy in 2016. Her thesis work focused on volatile cycles on rocky exoplanets, metal-silicate differentiation and atmosphere formation. In fall of 2016, Laura joined the School of Earth and Space Exploration at Arizona State University as a postdoctoral scholar where she worked on projects related to the evolution of mantle oxidation state and magma ocean evolution, as well as volatile cycles on planetesimals.

ACADEMIC APPOINTMENTS

- Associate Professor, Earth & Planetary Sciences
- Associate Professor (By courtesy), Geophysics

HONORS AND AWARDS

- Gabilan Faculty Fellow, Stanford University (2020-2021)

PROFESSIONAL EDUCATION

- PhD, Harvard University , Astronomy & Astrophysics (2016)
- B.A., Washington University in St. Louis , Earth and Planetary Science (2002)

LINKS

- Personal Site: http://web.stanford.edu/~lkschaef/
- Research Group Site: https://planets.stanford.edu/

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

I study atmosphere-interior exchange on rocky planets, both within our Solar System and beyond. I'm interested in the initial outgassed atmospheres of rocky planets and their evolution with time due to external factors and due to interaction with the solid planet. During planet formation, all the materials that make a planet are intimately mixed together, so the physical and chemical processes of accretion and differentiation can have long term effects on the composition of both the atmosphere and the interior. I study these early processes using a combination of magma ocean, atmospheric and internal structure models. The presence of extant magma oceans on some hot rocky exoplanets provide a window into the early planet differentiation processes of the Solar System.

In the Solar System, I have particular interest in understanding the atmospheric evolution of Venus and Jupiter's moon Io, which both may have experienced significant volatile loss, likely through very different mechanisms. These planets are excellent proxies for the rocky exoplanets that will be observable in the near-term with new telescopes like the James Webb Space Telescope.

I am also interested in understanding the conditions of early atmospheric formation that may help or hinder the origins of life both within the Solar System and on exoplanets. Long-term interactions of atmosphere and interior will also influence the stability of habitable conditions on rocky exoplanets and are therefore vital to understand as astronomical observations of these planets become more feasible.

Teaching

COURSES

2026-27

- Formation and Dynamics of Planets: EPS 119, EPS 219, GEOPHYS 109, GEOPHYS 209 (Aut)
- Introduction to Planetary Science: AA 124, EPS 124, GEOPHYS 124 (Spr)
- Planetary Science Reading: EPS 127, EPS 227 (Spr)

2025-26

- Finding a Habitable Planet: The search for exoplanets: AA 133, AA 233, EPS 196, EPS 296 (Spr)
- Geochemical Thermodynamics: EPS 164, EPS 264 (Win)

2024-25

- Formation and Dynamics of Planets: EPS 119, EPS 219 (Aut)
- Introduction to Planetary Science: AA 124, EPS 124, ESS 125, GEOPHYS 124 (Spr)

2023-24

- Geochemical Thermodynamics: EPS 164, EPS 264 (Win)
- Planetary Science Reading: EPS 127, EPS 227, GEOPHYS 126, GEOPHYS 226 (Win)

STANFORD ADVISEES

Postdoctoral Faculty Sponsor

Michelle Hill, Ryushi Miyayama, Bo Peng

Doctoral Dissertation Advisor (AC)

Monica Vidaurri, Andrea Zorzi

Doctoral (Program)

Chase Alvarado-Anderson, Monica Vidaurri, Andrea Zorzi

Publications

PUBLICATIONS

- **Hydrogen and Helium Dissolution, Outgassing, and Loss in Evolving Sub-Neptune Magma Oceans: Examining Demographic Features and Radius Evolution** *ASTROPHYSICAL JOURNAL*
  Tang, Y., Fortney, J. J., Schaefer, L. K., Gao, P.
  2026; 1010 (2)

- **An Evolving Cosmic Shoreline and Sandbar Bounding the Rocky Airless Valley** *ASTROPHYSICAL JOURNAL LETTERS*

Nguyen, B. K., Schaefer, L. K., Ji, X., Theissen, C. A., Dai, F., Peng, B., Tang, Y., Zorzi, A., Hill, M., Weiner Mansfield, M.
2026; 1008 (1)

- **Smaller Than Earth Habitability Model (STEHM): The Lower Size Limit for Atmosphere Retention in the Habitable Zone** *PLANETARY SCIENCE JOURNAL*
  Hill, M. L., Kane, S. R., Foley, B. J., Schaefer, L. K.
  2026; 7 (6)
- **The dark and featureless surface of rocky exoplanet LHS 3844 b from JWST mid-infrared spectroscopy** *NATURE ASTRONOMY*
  Zieba, S., Kreidberg, L., Coy, B. P., Bello-Arufe, A., Paragas, K., Lyu, X., Hu, R., Iyer, A., Kite, E. S., Koll, D. D. B., Wohlfarth, K., Whittaker, E., Knutson, et al
  2026
- **Coupled atmospHere Interior modeL Intercomparison (CHILI)-Protocol Version 1.0: A CUISINES Intercomparison Project of Magma Ocean Models** *PLANETARY SCIENCE JOURNAL*
  Lichtenberg, T., Schaefer, L., Krissansen-Totton, J., Miguel, Y., Sergeev, D. E., Baumeister, P., Cmiel, J., Janssen, L. J., Nguyen, T., Miyazaki, Y., Nicholls, H., Papesh, A., Pelissard, et al
  2026; 7 (5)
- **The Effect of Tidal Heating and Volatile Budgets on the Outgassed Atmosphere of 55 Cancri e** *ASTROPHYSICAL JOURNAL*
  Nguyen, B. K., Schaefer, L. K., Dai, F., Delgado-Diaz, H. E.
  2026; 999 (1)
- **Helium Depletion in Escaping Atmospheres of Sub-Neptunes: A Signature of Primary-to-secondary Transition** *ASTROPHYSICAL JOURNAL*
  Kobayashi, I., Kurokawa, H., Schaefer, L., Okuzumi, S.
  2026; 997 (1)
- **The Earth's magma ocean: Processes and current interpretations from an interdisciplinary perspective** *PHYSICS OF THE EARTH AND PLANETARY INTERIORS*
  Boukare, C., Schaefer, L. K., Rizo, H.
  2025; 369
- **Modeling Atmospheric Alteration on Titan: Hydrodynamics and Shock-induced Chemistry of Meteoroid Entry** *ASTROPHYSICAL JOURNAL*
  Miyayama, R., Schaefer, L., Kobayashi, H., Zorzi, A.
  2025; 989 (2)
- **Ignan Earths: Habitability of Terrestrial Planets With Extreme Internal Heating** *JOURNAL OF GEOPHYSICAL RESEARCH-PLANETS*
  Reinhold, M., Schaefer, L.
  2025; 130 (1)
- **Toward a Self-consistent Evaluation of Gas Dwarf Scenarios for Temperate Sub-Neptunes** *ASTROPHYSICAL JOURNAL*
  Rigby, F. E., Pica-Ciamarra, L., Holmberg, M., Madhusudhan, N., Constantinou, S., Schaefer, L., Deng, J., Lee, K. K. M., Moses, J. I.
  2024; 975 (1)
- **Ferric Iron Evolution During Crystallization of the Earth and Mars** *JOURNAL OF GEOPHYSICAL RESEARCH-PLANETS*
  Schaefer, L., Pahlevan, K., Elkins-Tanton, L. T.
  2024; 129 (9)
- **Outgassing Composition of the Murchison Meteorite: Implications for Volatile Depletion of Planetesimals and Interior-atmosphere Connections for Terrestrial Exoplanets** *PLANETARY SCIENCE JOURNAL*
  Thompson, M. A., Telus, M., Edwards, G., Schaefer, L., Dhaliwal, J., Dreyer, B., Fortney, J. J., Kim, K.
  2023; 4 (10)
- **No thick carbon dioxide atmosphere on the rocky exoplanet TRAPPIST-1 c.** *Nature*
  Zieba, S., Kreidberg, L., Ducrot, E., Gillon, M., Morley, C., Schaefer, L., Tamburo, P., Koll, D. D., Lyu, X., Acuña, L., Agol, E., Iyer, A. R., Hu, et al
  2023
- **A primordial atmospheric origin of hydrospheric deuterium enrichment on Mars** *EARTH AND PLANETARY SCIENCE LETTERS*
  Pahlevan, K., Schaefer, L., Elkins-Tanton, L. T., Desch, S. J., Buseck, P. R.
  2022; 595

- **The effects of bulk composition on planetesimal core sulfur content and size** *ICARUS*
  Bercovici, H. L., Elkins-Tanton, L. T., O'Rourke, J. G., Schaefer, L.
  2022; 380
- **The Air Over There: Exploring Exoplanet Atmospheres** *ELEMENTS*
  Schaefer, L. K., Parmentier, V.
  2021; 17 (4): 257-263
- **Composition of terrestrial exoplanet atmospheres from meteorite outgassing experiments** *NATURE ASTRONOMY*
  Thompson, M. A., Telus, M., Schaefer, L., Fortney, J. J., Joshi, T., Lederman, D.
  2021
- **Water on Hot Rocky Exoplanets** *ASTROPHYSICAL JOURNAL LETTERS*
  Kite, E. S., Schaefer, L.
  2021; 909 (2)
- **Atmosphere Origins for Exoplanet Sub-Neptunes** *ASTROPHYSICAL JOURNAL*
  Kite, E. S., Fegley, B., Schaefer, L., Ford, E. B.
  2020; 891 (2)
- **Observations, Meteorites, and Models: A Preflight Assessment of the Composition and Formation of (16) Psyche** *JOURNAL OF GEOPHYSICAL RESEARCH-PLANETS*
  Elkins-Tanton, L. T., Asphaug, E., Bell, J. F., Bercovici, H., Bills, B., Binzel, R., Bottke, W. F., Dibb, S., Lawrence, D. J., Marchi, S., Mccoy, T. J., Oran, R., Park, et al
  2020; 125 (3): e2019JE006296
- **Probing space to understand Earth** *Nature Reviews Earth & Environment*
  Lapôtre, M. G., O'Rourke, J. G., Schaefer, L. K., Siebach, K. L., Spalding, C., Tikoo, S. M., Wordsworth, R. D.
  2020; 1: 170-181
- **The Composition of Rocky Planets** *PLANETARY DIVERSITY*
  Unterborn, C., Schaefer, L., Krijt, S.
  edited by Tasker, E. J., Unterborn, C., Laneuville, M., Fujii, Y., Desch, S. J., Hartnett, H. E.
  2020
- **The Composition of Rocky Planets** *Planetary Diversity: Rocky planet processes and their observational signatures*
  Unterborn, C., Schaefer, L., Krijt, S.
  IOP Publishing.2020: 5-1 - 5-52
- **Superabundance of Exoplanet Sub-Neptunes Explained by Fugacity Crisis** *ASTROPHYSICAL JOURNAL LETTERS*
  Kite, E. S., Fegley, B., Schaefer, L., Ford, E. B.
  2019; 887 (2)
- **Hydrogen isotopic evidence for early oxidation of silicate Earth** *EARTH AND PLANETARY SCIENCE LETTERS*
  Pahlevan, K., Schaefer, L., Hirschmann, M. M.
  2019; 526
- **Absence of a thick atmosphere on the terrestrial exoplanet LHS 3844b.** *Nature*
  Kreidberg, L. n., Koll, D. D., Morley, C. n., Hu, R. n., Schaefer, L. n., Deming, D. n., Stevenson, K. B., Dittmann, J. n., Vanderburg, A. n., Berardo, D. n., Guo, X. n., Stassun, K. n., Crossfield, et al
  2019
- **Magma oceans as a critical stage in the tectonic development of rocky planets** *PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A-MATHEMATICAL PHYSICAL AND ENGINEERING SCIENCES*
  Schaefer, L., Elkins-Tanton, L. T.
  2018; 376 (2132)
- **Origin of Earth's Water: Chondritic Inheritance Plus Nebular Ingassing and Storage of Hydrogen in the Core** *JOURNAL OF GEOPHYSICAL RESEARCH-PLANETS*
  Wu, J., Desch, S. J., Schaefer, L., Elkins-Tanton, L. T., Pahlevan, K., Buseck, P. R.

2018; 123 (10): 2691–2712

- **Redox Evolution via Gravitational Differentiation on Low-mass Planets: Implications for Abiotic Oxygen, Water Loss, and Habitability** *ASTRONOMICAL JOURNAL*
  Wordsworth, R. D., Schaefer, L. K., Fischer, R. A.
  2018; 155 (5)
- **PLANETARY SCIENCE A steamy proposal for Martian clays** *NATURE*
  Schaefer, L.
  2017; 552 (7683): 37–38
- **Thermodynamic Constraints on the Lower Atmosphere of Venus** *ACS EARTH AND SPACE CHEMISTRY*
  Jacobson, N. S., Kulis, M., Radoman-Shaw, B., Harvey, R., Myers, D. L., Schaefer, L., Fegley, B.
  2017; 1 (7): 422–30
- **Redox States of Initial Atmospheres Outgassed on Rocky Planets and Planetesimals** *ASTROPHYSICAL JOURNAL*
  Schaefer, L., Fegley, B.
  2017; 843 (2)
- **Metal-silicate Partitioning and Its Role in Core Formation and Composition on Super-Earths** *ASTROPHYSICAL JOURNAL*
  Schaefer, L., Jacobsen, S. B., Remo, J. L., Petaev, M. I., Sasselov, D. D.
  2017; 835 (2)
- **PREDICTIONS OF THE ATMOSPHERIC COMPOSITION OF GJ 1132b** *ASTROPHYSICAL JOURNAL*
  Schaefer, L., Wordsworth, R. D., Berta-Thompson, Z., Sasselov, D.
  2016; 829 (2)
- **ATMOSPHERE-INTERIOR EXCHANGE ON HOT, ROCKY EXOPLANETS** *ASTROPHYSICAL JOURNAL*
  Kite, E. S., Fegley, B., Schaefer, L., Gaidos, E.
  2016; 828 (2)
- **SOLUBILITY OF ROCK IN STEAM ATMOSPHERES OF PLANETS** *ASTROPHYSICAL JOURNAL*
  Fegley, B., Jacobson, N. S., Williams, K. B., Plane, J. C., Schaefer, L., Lodders, K.
  2016; 824 (2)
- **A disintegrating minor planet transiting a white dwarf** *NATURE*
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- **THE PERSISTENCE OF OCEANS ON EARTH-LIKE PLANETS: INSIGHTS FROM THE DEEP-WATER CYCLE** *ASTROPHYSICAL JOURNAL*
  Schaefer, L., Sasselov, D.
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- **THE ATMOSPHERES OF EARTHLIKE PLANETS AFTER GIANT IMPACT EVENTS** *ASTROPHYSICAL JOURNAL*
  Lupu, R. E., Zahnle, K., Marley, M. S., Schaefer, L., Fegley, B., Morley, C., Cahoy, K., Freedman, R., Fortney, J. J.
  2014; 784 (1)
- **Atmospheric composition of Hadean-early Archean Earth: The importance of CO: Comment**
  Schaefer, L., Fegley, B.
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  GEOLOGICAL SOC AMER INC.2014: 29–31
- **VAPORIZATION OF THE EARTH: APPLICATION TO EXOPLANET ATMOSPHERES** *ASTROPHYSICAL JOURNAL*
  Schaefer, L., Lodders, K., Fegley, B.
  2012; 755 (1)
- **COMPOSITIONS OF HOT SUPER-EARTH ATMOSPHERES: EXPLORING KEPLER CANDIDATES** *ASTROPHYSICAL JOURNAL LETTERS*
  Miguel, Y., Kaltenegger, L., Fegley, B., Schaefer, L.
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- **The extreme physical properties of the CoRoT-7b super-Earth** *ICARUS*
  Leger, A., Grasset, O., Fegley, B., Codron, F., Albarede, F., Barge, P., Barnes, R., Cance, P., Carpy, S., Catalano, F., Cavarroc, C., Demangeon, O., Ferraz-Mello, et al
  2011; 213 (1): 1–11
- **ATMOSPHERIC CHEMISTRY OF VENUS-LIKE EXOPLANETS** *ASTROPHYSICAL JOURNAL*
  Schaefer, L., Fegley, B.
  2011; 729 (1)
- **Earth's Earliest Atmospheres** *COLD SPRING HARBOR PERSPECTIVES IN BIOLOGY*
  Zahnle, K., Schaefer, L., Fegley, B.
  2010; 2 (10): a004895
- **Chemistry of atmospheres formed during accretion of the Earth and other terrestrial planets** *ICARUS*
  Schaefer, L., Fegley, B.
  2010; 208 (1): 438–48
- **Volatile element chemistry during metamorphism of ordinary chondritic material and some of its implications for the composition of asteroids** *ICARUS*
  Schaefer, L., Fegley, B.
  2010; 205 (2): 483–96
- **Cosmochemistry**
  Fegley, B., Schaefer, L.
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  SPRINGER.2010: 347–77
- **CHEMISTRY OF SILICATE ATMOSPHERES OF EVAPORATING SUPER-EARTHS** *ASTROPHYSICAL JOURNAL LETTERS*
  Schaefer, L., Fegley, B.
  2009; 703 (2): L113–L117
- **Chemistry and Composition of Planetary Atmospheres**
  Schaefer, L., Fegley, B.
  edited by Zaikowski, L., Friedrich, J. M.
  AMER CHEMICAL SOC.2008: 187–207
- **Outgassing of ordinary chondritic material and some of its implications for the chemistry of asteroids, planets, and satellites** *ICARUS*
  Schaefer, L., Fegley, B.
  2007; 186 (2): 462–83
- **Application of an equilibrium vaporization model to the ablation of chondritic and achondritic meteoroids**
  Schaefer, L., Fegley, B.
  SPRINGER.2005: 413–23
- **Silicon tetrafluoride on Io** *ICARUS*
  Schaefer, L., Fegley, B.
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- **Alkali and halogen chemistry in volcanic gases on Io** *ICARUS*
  Schaefer, L., Fegley, B.
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- **Predicted abundances of carbon compounds in volcanic gases on Io** *ASTROPHYSICAL JOURNAL*
  Schaefer, L., Fegley, B.
  2005; 618 (2): 1079–85
- **A thermodynamic model of high temperature lava vaporization on Io** *ICARUS*
  Schaefer, L., Fegley, B.
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- **Heavy metal frost on Venus** *ICARUS*
  Schaefer, L., Fegley, B.
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