**Curriculum Vitae**

**Frieder Klein**

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**EDUCATION**

2009 Dr. rer. nat., Geosciences, University of Bremen, Bremen, Germany.

2005 Dipl. Geow., Geosciences, University of Bremen, Bremen, Germany.

2003 B.S., Geosciences, University of Bremen, Bremen, Germany.

2002 Vordiplom, Geology & Paleontology, Philips University of Marburg, Germany.

**PROFESSIONAL EXPERIENCE**

2020-present Associate Scientist (tenured), Woods Hole Oceanographic Institution, Department of Marine Chemistry and Geochemistry.

2015-2020 Associate Scientist (untenured), Woods Hole Oceanographic Institution, Department of Marine Chemistry and Geochemistry.

2011-2015 Assistant Scientist, Woods Hole Oceanographic Institution, Department of Marine Chemistry & Geochemistry.

1. Postdoctoral Investigator, Woods Hole Oceanographic Institution, Department of Geology & Geophysics.

2010-2011 Visiting Research Associate, Laboratory for Atmospheric & Space Physics, University of Colorado, Boulder, CO.

2009-2011 Postdoctoral Scholar, Woods Hole Oceanographic Institution, Department of Geology & Geophysics.

2009 Postdoctoral Fellow, Instituto Andaluz de Ciencias de la Tierra (IACT), Consejo Superior de Investigaciones Científicas (CSIC), Granada, Spain.

2008-2009 Research Fellow, MARUM Center for Marine Environmental Sciences, University of Bremen.

2005-2008 Research Assistant, University of Bremen, Geosciences Department.

2000-2001 Alternative Civilian Service at Neurologische Fachklinik Hilchenbach (Neurological Clinic Hilchenbach)

**AWARDS & FELLOWSHIPS**

2021 Henry M. Stommel Chair in Oceanography

2020 The Fluid Underground Best Paper of 2019 Award

2017 Center for Advanced Studies Visiting Research Fellowship, Ludwig Maximilians University Munich (Germany)

2009 WHOI’s Deep Ocean Exploration Institute Postdoctoral Scholar Award

**RESEARCH INTERESTS**

My research concerns the chemical interactions between aqueous fluids and rocks in a broad array of geodynamic settings, including mid-ocean ridges, rifted margins, subduction zones, and ophiolites, as well as other planets, moons, and meteorite parent bodies that once had - or still have - liquid water. Trained as a marine geologist, petrologist, and aqueous geochemist, my research approach is to integrate field geology, analytical geochemistry, hydrothermal laboratory experiments, and thermodynamics to address the fundamental problem of how fluid-rock reactions work. I have studied the reaction pathways and redox conditions during serpentinization, abiotic synthesis of organic compounds, carbonation of serpentinized peridotite, mass transfer reactions between mafic and ultramafic rocks, mass transfer between the igneous oceanic basement and seawater during high- and low-temperature alteration processes, mixing of hydrothermal fluids with seawater, fluid inclusions, and the subseafloor biosphere in serpentinite and gabbro.

**PARTICIPATION IN EDUCATION:**

*Teaching and other educational activities:*

2021-present Summer Student Fellowship representative for the Marine Chemistry and Geochemistry Department

2018 MIT-WHOI thesis defense chair, Chawalit Charoenpong

2018-present MIT-WHOI 12.716 Essentials of Oceanic Petrology

2017 MIT-WHOI general Exam Chair, Chemical Oceanography

2015 MIT-WHOI thesis proposal defense chair, Chawalit Charoenpong

2014-2016 MIT-WHOI 12.759 Marine Chemistry Seminar: Landmark Papers in Chemical Oceanography

2013 MIT-WHOI 12.753 Marine Geodynamics Seminar

*Student and Postdoc Advising:*

2019-2021 Danielle P. Santiago Ramos, WHOI Postdoctoral Scholar

2017-2022 Emmanuel Codillo, MIT/WHOI Joint Program Ph.D. student

2017-2019 Emily Cooperdock, WHOI Postdoctoral Scholar

2016-2018 Academic advisor of 1st and 2nd year MIT-WHOI graduate students (Lydia Babcock-Adams, Jennifer Kenyon, Sharon Luk, Craig Mclean, Mallory Ringham, Julia Middleton)

2015-2017 Emily Cooperdock, Ph.D. student, U. of Texas at Austin, Thesis Committee Member

2015-2016 Hector M. Lamadrid, Ph.D. student, Virginia Tech, Thesis Committee Member

2014-2016 Benjamin Bultel, U. Claude Bernard, Lyon 1, Thesis Committee Member

2013-2015 Lisa Falk, WHOI Postdoctoral Scholar

2012-2018 Niya Grozeva, MIT/WHOI Joint Program Ph.D. student

*MIT/WHOI Joint Program Generals Projects and Geodynamics Projects (12.753):*

2017 Ben Urann, MIT/WHOI Joint Program Ph.D. student, Geodynamics project

2015 Meghan Jones, MIT/WHOI Joint Program Ph.D. student, Geodynamics project

2013 Jordon Hemingway, MIT/WHOI Joint Program Ph.D. student, Geodynamics project

2012-2013 Gregory Horning, MIT/WHOI Joint Program Ph.D. student, generals project

*Visiting Students and Guest Investigators:*

2022 Timothy Schroeder (Bennington College)

2018 Elmar Albers (University of Bremen)

2017 Sebastian Gfellner (University of Vienna)

2016-2017 Karmina Aquino (University of the Philippines, Diliman)

2015 Hector M. Lamadrid (Virginia Polytechnic Institute and State University)

2015 Sara Niedenzu (University of Bremen)

2015 Francesca L. Toledo Cossu (University of Puerto Rico, Mayaguez)

2014 Benjamin Bultel (Laboratoire de Géologie de Lyon)

2014 Matthew Hodgkinson, (National Oceanography Centre, Southampton)

2014 Ma Quiang (Tongji University, Shanghai)

2013 Diane Bonnemains (Institut de Physique du Globe de Paris)

**CRUISE PARTICIPATION AND FIELD WORK**

07-08/2022 R/V Atlantis, DSV Alvin 6500 m Science Verification Expedition, San Juan – San Juan, 7 days.

03-04/2020 R/V Sonne, cruise 273, Cape Town – Emden, 47 days

07/2018: D/V Chikyu, OmanDP, Shimizu – Shimizu, 16 days

06-07/2017: M/V Alucia, cruise AL170602, Natal – Fortaleza, 21 days, chief scientist

03-04/2016: R/V Atlantis, cruise AT 33-03, Bridgetown – Charleston, 36 days

11/2012: San Andreas Fault, California, field work, 9 days

02/2012: R/V Atlantis, cruise AT 18-16, Ft. Lauderdale – Ft. Lauderdale, 23 days

10/2010: Appalachians, Vermont, field work, 3 days

08/2010: Josephine Peridotite, Oregon, field work, 9 days

05/2010: Troodos ophiolite, Cyprus, field work, 5 days

02/2009: F/S Maria S Merian, cruise MSM 11/1, Fort de France – Dakar, 24 days

11/2006: F/S Maria S Merian, cruise MSM 03/2, Fort de France – Fort de France, 22 days

06/2005: F/S Meteor, cruise M65/1, Dakar to Dakar, 21 days

05/2004: Troodos ophiolite, Cyprus, field work, 10 days

07/2003 Mosenberg, Eifel Volcanic Field, Germany, field work 12 days

**PROFESSIONAL ACTIVITIES**

*WHOI (Non-Education Related)*

2022 Alvin Pilot Science Evaluation Board for Richard Sanger

2017-present Seafloor Samples Laboratory committee member

2016-present Northeast National Ion Microprobe Facility (NENIMF) steering committee member

2017 Geology and Geophysics Department search committee member

2013-2017 (Deep) Ocean Exploration Institute Advisory Board member

2016 Marine Chemistry and Geochemistry Department search committee member

2011-2013 Marine Chemistry & Geochemistry Department seminar organizer

*Outside WHOI:*

2021 Session convener at the Goldschmidt Conference 2021 “Serpentinization and its Roles in Earth and Planetary Processes” Lyon, France

2020-present Guest Editor for *Lithos* special issue on “Fluids in the Earth’s Lithosphere: from Petrology to Geodynamics”

2019 Session convener at the AGU Fall Meeting 2019 “Hydrothermal Systems in 4-D”, San Francisco, CA

2019-present Associate Editor for *Geochimica et Cosmochimica Acta*

2018 Session convener at the Goldschmidt Conference 2018 "*Organic-microbe-rock interactions in hydrothermal systems*" Boston, MA

2018 NASA panel reviewer

2016 NSF-EAR panel reviewer

2016 Session convener at the AGU Fall Meeting 2016 "*4 billion years of serpentinization on Earth and beyond*", San Francisco, CA

2013 Session convener at the AGU Fall Meeting 2013 "*Carbon transformations in hydrothermal systems*", San Francisco, CA

2011 Session convener at the AGU Fall Meeting 2011 "*Peridotites and serpentinites from ridges to subduction zones: the role of fluids at low and high temperatures*", San Francisco, CA

2011 Session convener at the Goldschmidt Conference 2011 "*Submarine hydrothermal processes and alteration of the oceanic lithosphere*", Prague, Czech Republic

*Referee for the following scientific journals:*

American Mineralogist, Applied Geochemistry, Astrobiology, Contributions to Mineralogy and Petrology, Earth and Planetary Science Letters, Economic Geology, G-Cubed, Geochemical Perspectives Letters, Geochemical Transactions, Geochimica et Cosmochimica Acta, Geofluids, Geological Society of America Bulletin, Geology, Geophysical Research Letters, Journal of Geophysical Research - Planets, Journal of Geophysical Research – Solid Earth, Journal of Petrology, Journal of Physical Chemistry, Journal of Mineralogy and Geochemistry (Neues Jahrbuch für Mineralogie), Lithos, Marine and Petroleum Geology, Mineralogy and Petrology, Nature Communications, Nature Geoscience, Nature – Scientific Reports, Philosophical Transactions of the Royal Society A, Precambrian Research, Proceedings of the National Academy of Sciences of the United States of America, Rapid Communications in Mass Spectrometry, Science, Science Advances, Tectonics

*Referee for the following agencies:*

International Ocean Discovery Program, National Aeronautics and Space Administration (Solar System Workings, Exobiology), National Science Foundation (Division of Earth Sciences, Division of Ocean Sciences), Department of Energy (Basic Energy Sciences), Natural Environmental Research Council (UK), National Sciences and Engineering Research Council (Canada), French National Research Council (ANR), Deep Carbon Observatory, Stanford Synchrotron Radiation Lightsource (SSRL)

**SELECTED WORKSHOPS, MEETINGS, & PANELS**

04/2022 Investigating the oceanic life cycle of tectonic plates with mission specific scientific drilling, University of Plymouth (UK) / online

06/2020 Exploring Deep Oceanic Crust off Hawaiʻi, online workshop

08/2019 NSF PIRE: ExTerra Field Institute and Research Endeavour (E-FIRE), Western Alps

11/2018 Serpentinite in the Earth System, Royal Society London

11/2018 Sakigake-JpGU: Hard rock drilling focus group kick-off workshop, Kanazawa University, Japan

08/2018 NSF PIRE: ExTerra Field Institute and Research Endeavour (E-FIRE) workshop, Boston College

03/2018 Deep Carbon Observatory workshop "Earth in 5 Reactions", Washington D.C.

08/2017 Morss Colloquium "Life without Sunlight at Deep-sea Hot Springs" panelist "Implications for Life on Earth and Elsewhere", Woods Hole

08/2017 6th International Symposium on Chemosynthesis-Based Ecosystems (CBE6), Woods Hole

02/2017 NASA Astrobiology Institute Workshop Without Walls

12/2016 NSF PIRE: ExTerra Field Institute and Research Endeavour (E-FIRE) workshop, Marin

09/2016 Serpentine Days workshop, Sete (France)

08/2016 Ocean Worlds II meeting, Woods Hole

05/2016 DCO/C-DEBI Origins and Movements of Subsurface Microorganisms workshop, University of Southern California

07/2015 C-DEBI Basement workshop, Harvard University

05/2015 Indian Ocean Crust and Mantle Drilling workshop, Woods Hole

03/2014 International Workshop on Water Dynamics, Tohoku University, Sendai (Japan)

05/2010 AGU Chapman Conference "Detachments in oceanic lithosphere: Deformation, magmatism, fluid flow, and ecosystems", Agros (Cyprus)

09/2009 IODP New Ventures in Exploring Scientific Targets (INVEST), Bremen (Germany)

**KEYNOTE AND INVITED PRESENTATIONS**

07/2022 23rd General Meeting of the International Mineralogical Association, Lyon, France “Scientific drilling of oceanic serpentinite and its implication for subduction zone studies” (invited, presented by S. Angiboust)

09/2021 University of Victoria, School of Earth and Ocean Sciences “Aqueous Alteration of Ultramafic Rocks in Marine Environments on Earth and Other Planetary Bodies” (invited)

07/2021 Rifts and Rifted Margins Online Seminar, GFZ Potsdam “Abiotic Hydrogen Formation During the Breakup of Supercontinents Along Magma-poor Rifted Margins” (invited)

01/2020 Stony Brook University, Oceans and Atmosphere Colloquium, School of Marine and Atmospheric Sciences “Everything you always wanted to know about serpentinization\* (\*but were afraid to ask)” (invited)

09/2019 University of Pennsylvania, Department of Earth & Environmental Sciences Geoscience Colloquium “The deep biosphere, abiotic methane synthesis, and volume changes of serpentinization” (invited)

11/2018 The Royal Society, London "Fischer-Tropsch-type synthesis in olivine-hosted fluid inclusions: the origin of methane in serpentinization systems?" (invited)

10/2018 University of Delaware, Newark, Geological Sciences Seminars “Abiotic synthesis during serpentinization in olivine-hosted fluid inclusions: a common source of methane in hydrothermal systems, gas seeps, and alkaline springs" (invited)

03/2018 Lehigh University Earth and Environmental Sciences seminar "The pathways of serpentinization, hydrogen generation, and abiotic synthesis of methane" (invited)

03/2018 Deep Carbon Observatory workshop "Earth in 5 Reactions", Washington D.C "Abiotic organic synthesis in olivine-hosted fluid inclusions: The origin of methane in serpentinization systems?" (invited)

11/2017 Origins of Life Initiative Munich, Ludwig Maximilians Universität München "Serpentinization, hydrogen generation, and subseafloor life" (invited)

08/2017 Goldschmidt Conference, Paris "*Temperature effects on hydrogen generation during serpentinization*" (invited), presented by T. McCollom

02/2017 NASA Astrobiology Institute Workshop Without Walls "*Theoretical and experimental constraints on seafloor serpentinization*" (keynote)

09/2016 Brown University, Providence "*The petrology of seafloor serpentinization: phase relations, field observations, and laboratory experiments*" (invited)

07/2016 Goldschmidt Conference, Yokohama " *Serpentinization and its implications for subseafloor habitability and microbial dispersal*" (keynote)

05/2016 Bennington College "*Fluid-rock interactions and microbial life in the oceanic mantle*" (invited)

01/2016 Laboratoire de Géologie de Lyon: Terre, Planètes, Environnement at the Université Claude Bernard, Lyon1 "*Serpentinization and microbial life in the oceanic mantle*" (invited)

09/2015 'Hydrogène Naturel' special meeting of the Geological Society of France at the Ministère de l’Education nationale, de l’Enseignement supérieur et de la Recherche (The Ministry of National Education, Higher Education and Research) in Paris: "*Hydrogen generation during serpentinization of peridotite: constraints from thermodynamic modeling, field observations and laboratory experiments*" (invited)

09/2015 Invited lecturer, ECORD Summer School, Bremen, Germany

05/2015 Workshop for Scientific Ocean Drilling in the Indian Ocean Crust & Mantle, Woods Hole "*Reaction pathways and hydrogen generation during serpentinization of abyssal peridotite*" (invited)

04/2015 Geodynamics seminar, Lamont Doherty Earth Observatory (invited) "*Serpentinization of abyssal peridotite: reaction pathways, hydrogen generation and reaction-driven fracturing*"

03/2015 Virginia Tech "*Serpentinization of abyssal peridotite*" (invited)

12/2014 AGU Fall Meeting 2014 "*Experimental constraints on fluid-rock reactions during incipient serpentinization of harzburgite*" (invited)

10/2014 Tech Talk seminar, University of Texas, Austin "*4.56 billion years of serpentinization*" (invited)

06/2014 Goldschmidt Conference 2014, Sacramento, CA "*Low-temperature serpentinization produces abundant hydrogen within the temperature limits of life*" (invited)

06/2014 Santa Fe Conference on Rock Magnetism, Santa Fe, NM "*Magnetite in seafloor serpentinite*" (keynote)

04/2014 EAPS seminar, Massachusetts Institute of Technology "*Serpentinization of mantle peridotite and the release of hydrogen within the temperature limits of life*" (invited)

03/2014 11th International Workshop on Water Dynamics, Tohoku University, Japan "*Thermal controls on magnetite formation during serpentinization*" (invited)

04/2013 EGU General Assembly 2013, Vienna, Austria "*Redox controls and reaction pathways during serpentinization of abyssal peridotite*" (invited)

06/2012 Short course on 'Metasomatism in Geological Processes', Montreal "*Metasomatism within the ocean crust*" (invited)

05/2012 GES Department Seminar, Stanford University "*Redox conditions during serpentinization: field observations, theoretical constraints and hydrothermal experiments*" (invited)

05/2011 Frontiers in Earth Surface System Interactions, Yale University "*Redox conditions during serpentinization of abyssal peridotite: field observations, theoretical constraints and hydrothermal experiments*" (keynote)

12/2010 AGU Fall Meeting 2010, San Francisco, CA "*On serpentinization and mineral carbonation of serpentinite*" (invited)

09/2010 Geodynamics seminar, Lamont Doherty Earth Observatory "*Mineral carbonation of serpentinized peridotite*" (invited)

06/2010 Goldschmidt Conference 2010, Knoxville, TN "*Intrinsic silica metasomatism during serpentinization*" (keynote)

05/2010 School of Earth Science seminar, University of Bristol, UK "*Serpentinization of abyssal peridotite*" (invited)

**SUBMITTED PUBLICATIONS (**\*student**)**

[53] Pavia, F.J., Cooperdock, E.H.G., de Obeso, J.C., Sims, K.W.W., Tissot, F.L.H., **Klein, F.** (in review) Uranium isotopes as tracers of serpentinite weathering. Submitted to *Earth and Planetary Science Letters.*

[52] \*Helmbrecht, V., Weingart, M., **Klein, F.,** Braun, D., Orsi, W.D. (in review) White and green rust chimneys accumulate RNA in a ferruginous chemical garden. Submitted to *Geobiology*.

**PEER-REVIEWED PUBLICATIONS (**\*student**)**

[51] Triaud, A.H.M.J., deWit, J., **Klein, F.**, Turbet, M., Rackham, B.V., Prajwal N., \*Glidden, A., Jagoutz, O.E., Pec, M., Petkowski, J.J., Seager, S., Selsis, F (accepted) Atmospheric carbon depletion as a tracer of water oceans and biomass on temperate terrestrial exoplanets. *Nature Astronomy*.

[50] \*Peterson, L.D., Newcombe, M.E., Alexander, C.M. O’D., Wang, J., **Klein, F.**, Bekaert, D.V., Nielsen, S.G. (in press) The H content of aubrites: An evaluation of bulk versus in situ methods for quantifying water in meteorites. *Earth and Planetary Science Letters*.

[49] \*Phillips, R.F., Wang, Y., **Klein, F.**, Farfan, G., Ostrander, C.M., Gadol, H., Hansel, C.M., Nielsen, S.G. (in press) The role of manganese oxide mineralogy in thallium isotopic fractionation upon sorption. Submitted to *Geochimica et Cosmochimica Acta*.

[48] Angiboust, S., Cambeses, A., Fagereng, A., Menegon, L., **Klein, F.,** Raimondo, T., Prigent, C. (2023) Fluids in the Earth’s lithosphere: From petrology to geodynamics. Lithos, 107226. doi.org/10.1016/j.lithos.2023.107226.

[47] McCollom, T.M., Hoehler, T., Fike, D., Bell, A., **Klein, F.**, Moskowitz, B., Solheid, P. (in press) Formation of mixed-layer sulfide-hydroxide minerals from the tochilinite-valleriite group during experimental serpentinization of olivine. *American Mineralogist*. doi.org/10.2138/am-2022-8625.

[46] \*Codillo, E.A., **Klein, F.**, Marschall, H.M. (2022) Preferential formation of chlorite over talc during Si-metasomatism of ultramafic rocks in subduction zones. *Geophysical Research Letters*, 49, e2022GL100218.

[45] McCollom, T.M., **Klein, F.**, Moskowitz, B., Solheid, P. (2022) Experimental serpentinization of iron-rich olivine (hortonolite): Implications for hydrogen generation and secondary mineralization on Mars and icy moons. *Geochimica et Cosmochimica Acta*, 335, 98-110.

[44] **Klein, F.**, Goldsby, D., Lin, J., Andreani, M. (2022) Carbonation of serpentinite in creeping faults of California. *Geophysical Research Letters*. 49, e2022GL099185. https://doi.org/10.1029/2022GL099185

[43] \*Codillo, E.A., **Klein, F.**, Dragovic, B., Marschall, H.R., Baxter, E., Scambelluri, M., Schwarzenbach, E. (2022) Fluid-mediated mass transfer between mafic and ultramafic rocks in subduction zones. *Geochemistry Geophysics Geosystems*, 23, e2021GC010206. https://doi.org/10.1029/2021GC010206

[42] McCollom, T.M., **Klein, F.,** Ramba, M. (2022) Hydrogen generation from serpentinization of iron-rich olivine on Mars, icy moons, and other planetary bodies. *Icarus*, 372, 114754

[41] Zhang, Y., Gazel, E., Gaetani, G., **Klein, F.** (2021) Serpentinite-derived slab fluids control the oxidation state of the sub-arc mantle. *Science Advances,* 7, DOI: 10.1126/sciadv.abj2515

[40] \*Coskun, Ö., Vuillemin, A., Schubotz, F., **Klein, F.** Sichel, S., Eisenreich, W., Orsi, W.D. (2021) Quantifying the effects of hydrogen on carbon assimilation in a seafloor microbial community associated with ultramafic rocks. *The ISME Journal*. https://www.nature.com/articles/s41396-021-01066-x

[39] Umino, S., Moore, G.F., Boston, B. Coggon, R., Crispini, L., D’Hondt., S, Garcia, M.O., Hanyu, T, **Klein, F.**, Seama, N., Teagle, D.A.H., Tominagana, M., Yamashita, M., Harris, M., Ildefonse, B., Katayama, I., Kusano, Y., Suzuki, Y., Trembath-Reichert, E., Yamada, Y., Abe, N., Xiao, N., Inagaki, F. (2021) Workshop Report: Exploring Deep Oceanic Crust off Hawaiʻi. *Scientific Drilling*, 29, 69–82.

[38] Lin, H., \*Tarnas, J.D., Mustard, J.F., Zhang, X., Wei, Y. Wan, W. **Klein, F.**, Kellner, J.R. (2021) Dynamic Aperture Factor Analysis/Target Transformation (DAFA/TT) for Serpentine and Mg-Carbonate Mapping on Mars with CRISM Near-Infrared Data. *Icarus,* 355, 114168

[37] Lamadrid, H., Zajacz, Z., **Klein, F.**, Bodnar, R.J. (2021) Synthetic fluid inclusions XXIII. Effect of temperature and fluid composition on rates of serpentinization of olivine. *Geochimica et Cosmochimica Acta*, 292, 285-308.

[36] \*Jones, M.R., Soule, S.A., Liao, Y., \*Brodsky, H., Le Roux, V., **Klein, F.** (2020) Quantitative vesicle analyses and total CO2 reconstruction in mid-ocean ridge basalts. *Journal of Volcanology and Geothermal Research*, 407, 107109.

[35] **Klein, F.**, Humphris, S.E., Bach, W (2020) Brucite formation and dissolution in oceanic serpentinite. *Geochemical Perspectives Letters*, 16, 1-5*.*

[34] **Klein, F.** & Le Roux, V. (2020) Quantifying the Volume Increase and Chemical Exchange During Serpentinization. *Geology*, 48, 552-556.

[33] McCollom, T.M., **Klein, F.**, Moskowitz, B., Berquó, T., Bach, W., Templeton, A. (2020) Hydrogen generation and iron partitioning during experimental serpentinization of olivine-pyroxene mixtures. *Geochimica et Cosmochimica Acta*. 282, 55-75.

[32] Li, J., Mara, P., Schubotz, F., Sylvan, J.B., Burgaud, G., **Klein, F.**, Beaudoin, D., \*Wee, S.-Y., Dick, H., \*Lott, S., Cox, R., \*Meyer, L.A.E., \*Quémener, M., Blackman, D.K., Edgcomb, V.P. (2020) Recycling and metabolic flexibility dictate life in the lower oceanic crust. *Nature,* 579, 250-255.

[31] **Klein, F**., \*Tarnas, J., Bach, W. (2020) Abiotic sources of molecular hydrogen on Earth. *Elements,* 16, 19-24.

[30] McGlynn, S.E., Glass, J.B., Johnson-Finn, K., **Klein, F**., Sanden, S.A., Schrenk, M.O., Ueno, Y., Vitale-Brovarone, A. (2020) Hydrogenation reactions of carbon on Earth: Linking methane, and margarine, and life. *American Mineralogist*, 105, 599-608.

[29] \*Grozeva, N.G, **Klein, F**., Seewald, J.S., Sylva, S. (2020) Chemical and isotopic analyses of hydrocarbon-bearing fluid inclusions in olivine-rich rocks. *Philosophical Transactions of the Royal Society A: Mathematical, Physical, and Engineering Sciences* 378, 20180431. doi.org/10.1098/rsta.2018.0431

[28] McCollom, T.M., **Klein. F.,** Solheid, P., Moskowitz, B. (2020) The Effect of pH on rates of reaction and hydrogen generation during serpentinization. *Philosophical Transactions of the Royal Society A: Mathematical, Physical, and Engineering Sciences*, 378, 20180428. doi.org/10.1098/rsta.2018.0428

[27] Morishita, T., Umino, S., Kimura, J.I., Yamashita, M., Ono, S., Michibayashi, K., Tominaga, M., **Klein, F**., Garcia, M. (2019) Workshop report on hard rock drilling into mid-Cretaceous Pacific oceanic crust on the Hawaiian North Arch. *Scientific Drilling*, 26, 47-58.

[26] **Klein, F.,** \*Grozeva, N.G., Seewald, J.S. (2019) Abiotic methane synthesis and serpentinization in olivine-hosted fluid inclusions. *Proceedings of the National Academy of Sciences of the United States of America*, 116, 17666-17672.

[25] \*Miller, W.G.R, Maclennan, J., Shorttle, O., Gaetani, G.A., Le Roux, V., **Klein, F.** (2019). Estimating the carbon content of the deep mantle with Icelandic melt inclusions. *Earth & Planetary Science Letters*., 523, 115699.

[24] \*Albers, E., Bach, W., **Klein, F.**, Menzies, C.D., Lucassen, F., Teagle, D.A.H (2019) Fluid-rock interactions in the shallow Mariana forearc: carbon cycling and redox conditions. *Solid Earth*, 10, 097-930, doi.org/10.5194/se-2019-51.

[23] \*Jones, M., Wanless, V.D., Soule, S.A., Kurz, M.D., Mittelstaedt, E., Fornari, D.J., Curtice, J., **Klein, F.**, Le Roux, V. \*Brodsky, H., \*Péron, S., \*Schwartz, D. (2019). New constraints on mantle carbon from Mid-Atlantic Ridge popping rocks. *Earth and Planetary Science Letters*, 511, 67-75.

[22] Parnell-Turner, R.E. Mittelstaedt, E., Kurz, M.D., \*Jones, M. Soule, S.A. **Klein, F.** Wanless, V.D., Fornari, D.J. (2018) The final stages of slip and volcanism on an oceanic detachment fault at 13°48’N, Mid-Atlantic Ridge. *Geochemistry, Geophysics, Geosystems*, doi.org/10.1029/2018GC007536.

[21] Humphris, S.E. and **Klein, F.** (2018) Progress in deciphering the controls on the geochemistry of fluids in seafloor hydrothermal systems. *Annual Review of Marine Science*, 10, 315-343.

[20] **Klein, F.**, Marschall, H.R., Bowring, S.A., Humphris, S.E., \*Horning, G.W. (2017) Mid-ocean ridge serpentinite in the Puerto Rico Trench: From seafloor spreading to subduction. *Journal of Petrology,* 58, 1729-1754.

[19] \*Lamadrid, H., Rimstidt, J., Schwarzenbach, E., **Klein, F.**, Urlich, S., Dolocan, A., Bodnar, R. (2017) Effect of water activity on rates of serpentinization of olivine. *Nature Communications*, 8, doi: 10.1038/ncomms16107.

[18] \*Grozeva, N.G, **Klein, F**., Seewald, J.S., Sylva, S. (2017) Experimental study of carbonate formation in oceanic peridotite. *Geochimica et Cosmochimica Acta*, 199, 264-286.

[17] McCollom, T.M., **Klein, F.**, Robbins, M., Moskowitz, B., Berquó, T.S., Jöns, N., Bach, W., Templeton, A. (2016) Temperature trends for reaction rates, hydrogen generation, and partitioning of iron during experimental serpentinization of olivine. *Geochimica et Cosmochimica Acta,* 181, 175-200.

[16] Nielsen, S.G., **Klein, F.**, Kading, T., Blusztajn, J., Wickham, K. (2015) Thallium as a tracer of fluid-rock interaction in the shallow Mariana forearc. *Earth and Planetary Science Letters*, 430, 416-426.

[15] **Klein, F.**, Humphris, S.E., Guo, W., Schubotz, F., Schwarzenbach, E.M., Orsi, W. (2015) Fluid mixing and the deep biosphere of a fossil Lost City-type hydrothermal system at the Iberia Margin. *Proceedings of the National Academy of Sciences of the United States of America*, 112, 12036-12041.

[14] Salman, V., Yang, T., Berben, T., **Klein, F.**, Angert, E., Teske, A. (2015) Calcite-accumulating large sulfur bacteria of the genus Achromatium in Sippewissett Salt Marsh. *The* *ISME Journal, 1-12*.

[13] **Klein, F.**, \*Grozeva, N.G., Seewald, J.S., McCollom, T.M., Humphris, S.E., Moskowitz, B., Berquó, T.S., Kahl, W.-A. (2015) Experimental constraints on fluid-rock interactions during incipient serpentinization of harzburgite. *American Mineralogist* 100, 991-1002.

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