Mohit Melwani Daswani, Ph.D.

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The focus of my research is geochemistry as it pertains to water—rock interaction on Earth, Mars, icy ocean worlds and exoplanets, most often using numerical thermodynamic models and other computational methods. My research is driven by the following questions: 1) what are the limits of current thermodynamic parameterizations and how do they affect our understanding of aqueous fluid-gas-mineral-melt-organic equilibria at the wide range of temperatures and pressures found from the surfaces to the interiors of different planetary bodies? How can the current limits be resolved? 2) How can (and what do) thermodynamic predictions tell us about the existence and development of the mantle, crust, hydrospheres and climate on early Earth, Mars, and elsewhere? 3) How do planetary-scale processes such as differentiation, tidal dissipation and climate change affect fluid, melt and rock chemistry in time? And how does crustal and mantle chemistry affect nutrient and energy availability for life as we know it?

Employment

Research Scientist (2020 – Present), Jet Propulsion Laboratory, California Institute of Technology

Investigating the geochemistry, habitability and geophysics of ocean worlds, including Europa, Titan, Ceres, and TRAPPIST-1 system.

Characterizing martian meteorite petrology and geochemistry.

Preforming thermodynamic computations of organic, aqueous solution and salt reactions for planetary science.

Advising intern Jack Diab (Southern Oregon University). Former intern: Andrew Chan (Caltech).

Europa Clipper Project Science Affiliate (2019 – 2020)

Carrying out research for the Europa Clipper NASA mission Project Science Group, in preparation of Europa Clipper's science mission at Jupiter's moon Europa.

Postdoctoral Scholar (2018 – 2020), Jet Propulsion Laboratory, California Institute of Technology

Working with Dr. Steven Vance to investigate the geochemistry and interior structure of the moons of Jupiter and Saturn.

Constraining thermodynamic properties of confined ocean world fluid compositions using high pressure (up to 700 MPa) experiments. Former interns co-supervised: Katherine Vega (CU Boulder - Engineering Physics), Lacy Schneemann (USC, now at Boeing), and Jeremy Engels (UCLA).

Postdoctoral Scholar (2015 – 2017), Department of the Geophysical Sciences, University of Chicago

Working with Prof. Edwin Kite on (1) early Mars geochemistry; and (2) volatile envelopes of small-radius extrasolar magma planets.

Working with Prof. Philipp Heck on martian meteorite characterization, petrology and geochemistry.

Classified a new shergottite meteorite, now named NWA 11115.

Concurrent project: infrared spectroscopy and mineralogy of near-Earth asteroids, with Dr. Benjamin Rozitis, Open University, and Dr. Andreas Morlok, University of Münster).

Education

2011–2015: **Ph.D.** Planetary Science, The Open University. Thesis title: *Aqueous alteration on early Mars: New insights from the aqueous geochemistry and secondary mineralogy of meteorite ALH 84001.* Advisors: Susanne P. Schwenzer, Ian P. Wright and Monica M. Grady.

2009–2011: **M.Sc. (Erasmus Mundus European Commission initiative)** Geo-information Science and Earth Observation for Environmental Modelling and Management, at the University of Southampton, Lund University, University of Warsaw and ITC - University of Twente. Thesis title: *Mineral spectra extraction and analysis of the surface mineralogy of Mars with hyperspectral remote sensing.* Advisors: Frank J. A. van Ruitenbeek and Wim H. Bakker. Website: `http://www.gem-msc.org/`.

2003–2009: Geology, Autonomous University of Barcelona; plus Erasmus exchange year in Switzerland (2007–2008) at the Universities of Fribourg, Neuchâtel and Bern (host institute).

Peer-reviewed publications *(Preprints and reprints available upon request.)*

Melwani Daswani, M. and Castillo-Rogez, J. C. (2022). Porosity-filling metamorphic brines explain Ceres' low mantle density. *Planet. Sci. J.*, 3, 21, doi.org/10.3847/PSJ/ac4509.

MMD's contribution: leading. Performed research and thermodynamic models; wrote, edited, and revised paper.

Castillo-Rogez, J. et al. incl. **Melwani Daswani, M.** (2022). Science Drivers for the Future Exploration of Ceres: From Solar System Evolution to Ocean World Science. *Planet. Sci. J.*, 3(3), 64. doi.org/10.3847/PSJ/ac502b.

MMD's contribution: small.

Marusiak, A. G. et al., incl. **Melwani Daswani, M.** (2021). Exploration of Icy Ocean Worlds Using Geophysical Approaches. *Planet. Sci. J.*, 2(4), 150. doi.org/10.3847/psj/ac1272.

MMD's contribution: small.

Melwani Daswani, M., Vance, S. D., Mayne, M. J., and Glein, C. R. (2021) A metamorphic origin for Europa's ocean. *Geophys. Res. Lett.*, 48, e2021GL094143. doi.org/10.1029/2021GL094143.

MMD's contribution: leading. Devised the research, perfomed the research and lead the paper. Garnered national and international press attention (The Times, Reuters, Smithsonian Magazine, CBC, Space.com, Science Alert, msn.com, NBC, Forbes, Many Worlds).

Běhounková, M., Tobie, G., Choblet, G., Kervazo, M., **Melwani Daswani, M.**, Dumoulin, C., and Vance S. D. (2021). Tidally-induced magmatic pulses on the oceanic floor of Jupiter's moon Europa. *Geophys. Res. Lett.*, 48, e2020GL090077. doi:10.1016/j.pss.2020.105078.

MMD's contribution: Significant. Performed geochemical models, edited and revised paper.

Perl, S. D. et al. including **Melwani Daswani, M.** (2021) A proposed geobiology-driven nomenclature for astrobiological in-situ observations and sample analyses. *Astrobiology*, Aug 2021, 954–967. doi.org/10.1089/ast.2020.2318.

MMD's contribution: small. Revised and edited the paper.

Morlok, A., Schiller B., Weber, I., **Melwani Daswani, M.**, Stojic, A. N., Reitze, M. P., Gramse, T., Wolters, S. D., Grady, M. M., and Helbert, J. (2020). Mid-infrared reflectance spectroscopy of carbonaceous chondrites and calcium-aluminum-rich inclusions. *Planet. Space Sci.*, 193: 105078. doi:10.1016/j.pss.2020.105078.

MMD's contribution: Significant. Co-wrote the paper and carried out the reduction of *Spitzer Space Telescope* infrared spectra for near Earth asteroids.

Vance, S. D., and **Melwani Daswani, M.** (2020). Serpentinite and the search for life beyond Earth. *Philos. Trans. R. Soc. A*, 378, 20180421. doi.org/10.1098/rsta.2018.0421.

MMD's contribution: Significant. Co-wrote and revised the paper; authored Mars section.

Kite, E. S., and **Melwani Daswani, M.** (2019). Geochemistry constrains global hydrology on Early Mars. *Earth. Planet. Sci. Lett.*, 524: 115718. doi:10.1016/j.epsl.2019.115718.

MMD's contribution: Significant. Performed research and thermodynamic calculations; revised the paper.

Melwani Daswani, M., and Kite, E. S. (2017). Paleohydrology constrained by mass balance and mineralogy of pre-Amazonian sodium chloride lakes on Mars. *J. Geophys. Res. Planets*, 122: 1802–1823. doi:10.1002/2017JE005319.

MMD's contribution: leading. Devised the research, performed the research and mapping, co-wrote the paper and revised the paper.

Melwani Daswani, M., Schwenzer, S. P., Reed, M. H., Wright, I. P., and Grady, M. M. (2016). Alteration minerals and fluids on early Mars: Predictions from 1D flow geochemical modelling of mineral assemblages in meteorite ALH 84001. *Meteorit. Planet. Sci.*, 51(11): 2154–2174. doi:10.1111/maps12713.

MMD's contribution: leading. Devised the research, performed the research, and co-wrote and revised the manuscript. This work was an outcome of MMD's Ph.D. thesis.

Gross, J., Filiberto, J., Herd, C. D. K., **Melwani Daswani, M.**, Schwenzer, S. P., and Treiman, A. H. (2013). Petrography, mineral chemistry, and crystallization history of olivine-phyric shergottite NWA 6234: A new melt composition. *Meteorit. Planet. Sci.*, 48(5): 854—871. doi:10.1111/maps.12092.

MMD's contribution: Small. Performed analyses of the meteorite and revised the paper.

Conference and workshop contributions *(Only significant contributions over the last three years shown, for brevity.)*

Melwani Daswani, M., Vance, S. D., and Glein, C. R. (2021). Clathrate blankets as (in)surmountable barriers for hydrothermal systems in Europa. *AGU Fall Meeting 2021.* Abstract #P54A-10. [Online.]

Melwani Daswani, M., and Castillo-Rogez, J. C. (2021). Metamorphic brine generation and the density of Ceres' mantle. *Goldschmidt 2021.* Abstract #6275. [Online.]

Běhounková, M., Tobie, G., Choblet, G., Kervazo, M., **Melwani Daswani, M.**, Dumoulin, C., and Vance S. D. (2020). Conditions for present-day magmatism in Europa's mantle. *Europlanet Science Congress 2020.* Abstract #EPSC2020-98. [Online.]

Melwani Daswani, M., and Vance, S. D. (2020) Evolution of Volatiles from Europa's Interior into its Ocean. *Goldschmidt 2020.* Abstract #1777. [Online.]

Perl, S., and **Melwani Daswani, M.** (2020) Groundwater Upwelling Occludes Pores Compared to Top-Down Infiltration at the Burns Formation, Mars. *Goldschmidt 2020.* Abstract #2063. [Online.]

Melwani Daswani, M., and Vance, S. D. (2020). Europa's exsolved proto-ocean. *51st Lunar Planet. Sci.* Abstract #3056. [Online.]

Castillo-Rogez, J. C., **Melwani Daswani, M.**, Sori, M. M., Stein, N. T., Ehlmann, B. L., Ermakov, A. I., and Raymond, C. A. (2020). Rock thermal metamorphism as a late stage source of fluids and heat to the hydrospheres of volatile-rich bodies. *51st Lunar Planet. Sci.* Abstract #2987. [Online.]

Glein, C. R., McGrath, M. A., McKinnon, W. B., **Melwani Daswani, M.**, Miller, K. E., Ray, C., Vance, S. D., and Waite, J. H. (2019). What does Europa Smell Like? *AGU Fall Meeting 2019*. Abstract #P53B-08. [Poster.]

Vance, S. D., and **Melwani Daswani, M.** (2019). Hydrothermal Activity in the Solar System's Ocean Worlds. *AGU Fall Meeting 2019*. Abstract #V31B-04 . [Talk.]

Hermis, N., Barge, L. M., and **Melwani Daswani, M.** (2019). Simulation of Magnesium Silicate Hydrothermal Chimney System. *AGU Fall Meeting 2019*. Abstract #P53D-3488. [Poster.]

Melwani Daswani, M., and Vance, S. D. (2019). Organic molecule concentration by early differentiation, and dilution by later tidal dissipation in icy ocean worlds. *The First Billion Years: Habitability* LPI workshop. Abstract #1044. [Talk.]

Vance, S. D., Tobie, G., **Melwani Daswani, M.**, and Choblet, G. (2019). Tidal Signatures of Geochemically Rigorous Interior Structure for Ganymede. *EPSC-DPS Joint Meeting 2019*. Abstract #1149. [Talk.]

Recent (¡3 yrs) public and invited talks (See above for conference and workshop contributions.)

Oct 2021 **Brines Across the Solar System: Modern Brines Conference**. Title: *Our Salty Solar System Virtual Panel*.

Oct 2021 **University of Washington, Astrobiology Colloquium**. Title: *Metamorphic origins for the oceans of Europa and Ceres*.

Aug 2021 **University of Texas at Austin, Geo Fluid Dynamics Seminar**. Title: *A metamorphic origin for Europa's (and possibly Ceres') ocean.*

Jul 2021 **The Open University, School of Physical Sciences Seminar**. Title: *A metamorphic origin for Europa's ocean.*

Oct 2020 **The Open University, AstrobiologyOU modellers invited talk**. Title: *A metamorphic origin for Europa's ocean.*

Oct 2019 **Jet Propulsion Laboratory, Postdoctoral Seminar Series**. Title: *Geochemical evolution of icy ocean worlds of Jupiter and Saturn: What makes an ocean organic-rich?*

July 2019 **Earth-Life Science Institute, Tokyo Institute of Technology invited talk**, ELSI seminar. Title: *Habitability on ocean worlds tied to composition and orbital-thermal evolution.*

June 2019 **Astrobiology Science Conference invited talk**. Session: The Many Layers of Titan. Title: *Why should Titan's ocean be organic rich? What thermodynamic modeling of the dewatering of undifferentiated versus differentiated moons can tell us*.

Feb 2019 **University of Edinburgh invited talk**, UK Centre for Astrobiology seminar. Title: *Did solid tides prevent the thermodynamic death of Europa?*

Awarded external grants

Co-I for Australian Nuclear Science and Technology Organisation neutron beam time on the DINGO instrument, 2021. Proposal title: *Imaging Carbonate Veins in Martian Meteorites*. Period of research: 09/2021–08/2023.

Co-I for NASA ROSES Habitable Worlds 2020. Proposal title: *Habitability of Dwarf Planet Ceres Through Time*. Period of research: 09/2021–08/2023.

PI for NASA Planetary Science Early Career Award 2019. Proposal title: *Experimental and Computational Thermodynamics, Organics, and Planetary Structure Modeling (ECTOPlaSM)*. Period of research: 07/2020–06/2025.

PI for NASA ROSES Habitable Worlds 2018. Proposal title: *Did solid tides prevent the thermodynamic death of Europa?*) Period of research: 01/2020–12/2023.

Co-I for NASA ROSES Solar System Workings 2018. Proposal title: *Compositions of Ice Shells on Ocean Worlds* Period of research: 01/2020–12/2023.

Co-I for two other pending NASA ROSES grants for the period 06/2021–07/2024.

Selected awards

2020: **NASA Planetary Science Early Career Award**.

2014: (1) **Lunar and Planetary Institute Career Development Award** to present at the 45$^{\text{th}}$ Lunar and Planetary Science Conference (LPSC) in Houston, Texas. (2) **Mineralogical Society of Great Britain and Ireland**: bursary to present at the 45$^{\text{th}}$ LPSC.

2013: **UK Space Agency** and **Science and Technology Facilities Council** sponsorship to present at the European Planetary Science Congress in London, UK.

2009–2011: **European Commission**: M.Sc. studentship within the Erasmus Mundus framework.

Instruments and software used

Analytical instrument experience: EPMA/WDS (Cameca SX100), SEM/EDS (FEI Quanta and JEOL), stepped-combustion isotope mass spectrometry (H, C, N, and noble gases), Raman spectroscopy.

Field instruments used for archaeological geophysics: electrical resistivity tomography (IRIS Instruments), ground-penetrating radar, magnetometer.

Research software used: Thermodynamic reaction-transport modeling and geochemistry (CHIM-XPT, PHREEQC, MELTS, FrezChem, Geochemist's Workbench, NIST REFPROP, Perple_X, THERMOCALC, SUPCRT), remote sensing and GIS (ArcGIS, ENVI), Spitzer Space Telescope (Astrolib), N-body simulation (Mercury), Planetary science (PlanetProfile), geophysical prospection (DC2Dinv, DC3Dinv, Res2Dinv, Res3Dinv), statistics/programing (R). Author of planetary accretion/composition simulation code `AccretR (doi:10.5281/zenodo.3827540)`.

Field work experience

Field work leader for terrestrial ultramafic analogue rocks for martian meteorites in Archaean rocks, Outer Hebrides, Scotland, 2013.

Assistant field geophysicist for the Swiss archaeological campaign in Italy and Greece (2008), for PI Dr. David Jordan, University of Bern (now at Liverpool John Moores University).

Reviewing, public service and outreach

Nov 2021: Quoted in The Atlantic magazine article *Let's Talk About Brines. No, Not That Kind.*

Oct 2021: Science Organizing Committee member for the Lunar and Planetary Institute's Brines Aross the Solar System: Modern Brines conference.

Sep 2021: Host for the NASA Research Coordination Network for Ocean Worlds (NOW) Proposal Writing Seminar.

July 2021: Co-convener for Goldschmidt 2021 session on "Chemical geodynamics throughout the Solar System — Combining insights from observations, experiments, analogues, and models".

Co-author on three Community Papers for the National Academies of Sciences Engineering and Medicine Planetary Science and Astrobiology Decadal Survey 2023-2032. (Co-signee on three more.)

Reviewer for the journals *Nature Astronomy*, *Geophysical Research Letters*, *Icarus*, *Meteoritics & Planetary Science*, *Geochimica et Cosmochimica Acta*, *Journal of Geophysical Research: Planets*, *Geophysical Journal International*, *Minerals*, *Astrobiology*, *ACS Earth and Space Chemistry*, *Monthly Notices of the Royal Astronomical Society*, and one book chapter. Reviewer for the UK Space Agency, and ten times Review Panelist for NASA proposals/calls.

June 2020: Co-convener for Goldschmidt 2020 session on "Weathering: Long-Term Terrestrial Climate Change, Modern Quantification and Implications for Extraterrestrial Environments".

Sep–Nov 2019: Career Panelist for National Science Foundation "Bridge to Geosciences" Program between JPL and Citrus College, providing STEM career advice to undergraduate students from Citrus College (community college in California).

June 2019: Stepped in to co-chair session 316 (Interiors of habitable planets) at the Astrobiology Science Conference, Bellevue, WA.

Jan 2016: (1) Interview with the Chicago Tribune about the science of *The Martian*. (2) Panelist (with Prof. A. Davis and E. Kite, and Senior Scientist T. Economou) at *Doc Films* at the University of Chicago screening and discussion of *The Martian*.

July 2014: Royal Society Summer Science Exhibition (London, UK) volunteer at the "Catch a comet" stand, informing about ESA's Rosetta mission.

Feb 2014: European AstroFest (London, UK) volunteer at the Open University stand to attract new students to enroll in science degrees and massive open online courses.

Mar 2013: International FameLab regional finalist (Texas), with a public talk about water on Mars.

2001–2006: International Red Cross volunteer (Spain). Volunteer for hands-on remediation, prevention and outreach relating to climate and environment.