Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.15457

# Narrow loophole for $H_2$-dominated atmospheres on habitable rocky planets around M dwarfs

**RENYU HU**[1], FABRICE GAILLARD[2] AND EDWIN KITE[3]

[1]Jet Propulsion Laboratory
[2]Institut des Sciences de la Terre d'Orléans
[3]University of Chicago

Presenting Author: renyu.hu@jpl.nasa.gov

Habitable rocky planets around M dwarfs that have $H_2$-dominated atmospheres, if they exist, would provide the eminent possibility to characterize habitable exoplanets with detailed spectroscopy using JWST, owing to their extended atmospheres and small stars. However, the $H_2$-dominated atmospheres that are consistent with habitable conditions cannot be too massive, and a moderate-size $H_2$-dominated atmosphere will lose mass to irradiation-driven atmospheric escape on rocky planets around M dwarfs. We evaluate volcanic outgassing and serpentinization as two potential ways to supply $H_2$ and form a steady-state $H_2$-dominated atmosphere. For rocky planets of 1-7 Earth mass and early, mid, and late M dwarfs, the expected volcanic outgassing rates from a reduced mantle fall short of the escape rates by $\gtrsim$1 order of magnitude, and a very generous upper limit of the serpentinization rate is still less than the escape rate by a factor of a few. Special mechanisms that may sustain the steady-state $H_2$-dominated atmosphere include direct interaction between liquid water and mantle, heat-pipe volcanism from a reduced mantle, and hydrodynamic escape slowed down by efficient upper-atmospheric cooling. It is thus unlikely to find moderate-size, $H_2$-dominated atmospheres on rocky planets of M dwarfs that would support habitable environments.