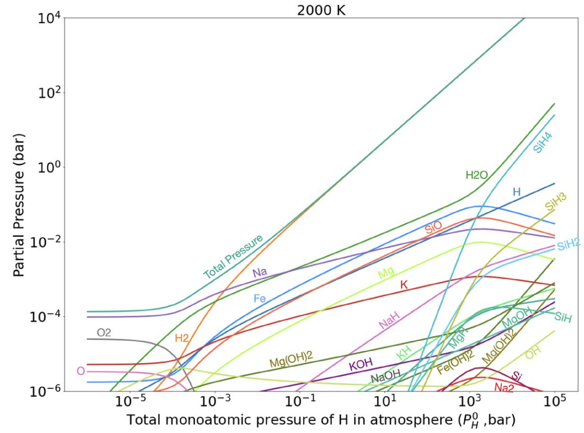
Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.19167



The effect of a small amount of H and H2O in magma-ocean rocky-exoplanets : atmospheric composition and escape

SEBASTIEN CHARNOZ[1], AURÉLIEN FALCO[2], PASCAL TREMBLIN[3], PAOLO A. SOSSI[4], PIERRE-OLIVIER LAGAGE[5] AND RAZVAN CARACAS[6]

[1]Université Paris Cité / IPGP/ CNRS / UMR 7154
[2]IPGP / CEA
[3]CEA
[4]ETH Zürich
[5]CEA/ UMR AIM
[6]IPGP

Presenting Author: charnoz@ipgp.fr

Ultra hot (> 1500K) rocky exoplanets may be covered by a magma-ocean, resulting in the formation of a vapor atmosphere rich in rocky components (e.g., Mg, Si, Fe) with in a low pressure and high molecular weight. They may have also captured some hydrogen during their formation stored either in the atmosphere or dissolved in the magma ocean (H2, H2O). Here we investigate how small amounts of hydrogen (<< planet's mass) may modify the atmospheric chemistry and the planet's thermal escape of such exoplanets. We use equilibrium chemistry codes to compute self-consistently the coupling of the magma-ocean with the atmosphere, taking into account the presence of H and dissolved H2O. We find that the atmospheric composition above a magma ocean is drastically modified by H, even for very modest amounts of H (<10^-6 planet mass). H consumes much of the O2(g). As a result evaporation of metals (Si, Mg, Na, K, Fe...) increases strongly and produces vast amounts of H2O (Figure 1). At high hydrogen pressure new species form like SiH4, while H, H2, H2O are always the dominant non-metal-bearing volatile species. The atmospheric composition depends sensitively on the planet’s mantle composition, opening the possibility to constraint the planet’s mantle through transit spectroscopy.

Using a simple energy-limited escape model we also investigate the thermal-escape of exoplanets (at 0.02 AU from their host star) with a small amount of captured H. We find that dissolved H2O in the magma-ocean may multiply up to 1000 the lifetime of the H layer against escape. Since H promotes the evaporation of metals from the planet’s mantle, under some conditions (high-temp, large amount of H) a significant fraction of the mantle may also evaporate (up to a few 10%) and be lost to space along H, leading to an increase in the exoplanet’s average-density.

We conclude that small amount of H, and dissolved H2O in the magma-ocean of rocky exoplanets have a strong impact on their atmosphere and long-term evolution. Atmospheric spectroscopic studies may provide new constraints on the planet’s mantle composition.