Atmosphere-Magma Interaction Across the Exoplanet Mass-Radius Diagram

Edwin Kite (U. Chicago, kite@uchicago.edu), Laura Schaefer (Stanford), Bruce Fegley (WUSTL), Megan Barnett (U. Chicago), Eric Ford (Penn State)

Strong indirect evidence implies that Kepler's sub-Neptunes are mostly silicate magma by mass, and mostly H_2-dominated atmosphere by volume (e.g. Owen & Wu ApJ 2017)

Our research program: model atmosphere-magma interaction for sub-Neptunes and their daughter Super-Earths.

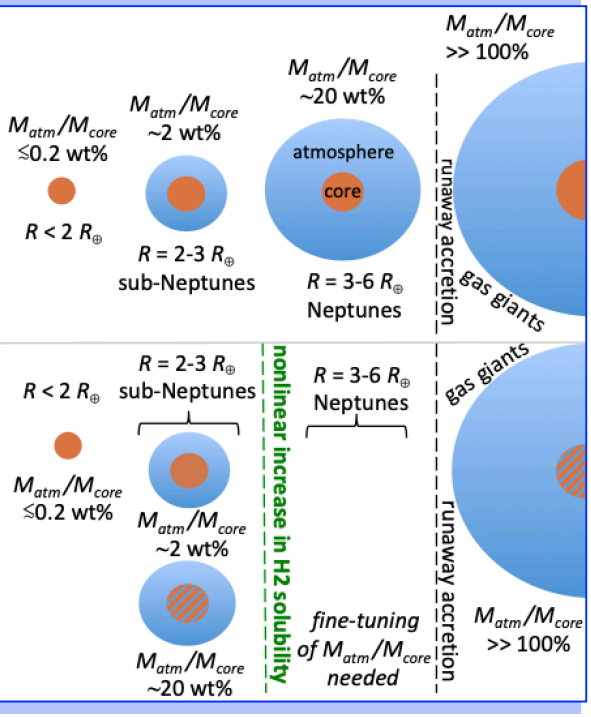
H_2 dissolving into magma explains Sub-Neptune superabundance

At R ~ 3 $R_\oplus$, base-of-atmosphere pressure becomes large enough for the atmosphere to readily dissolve into magma.

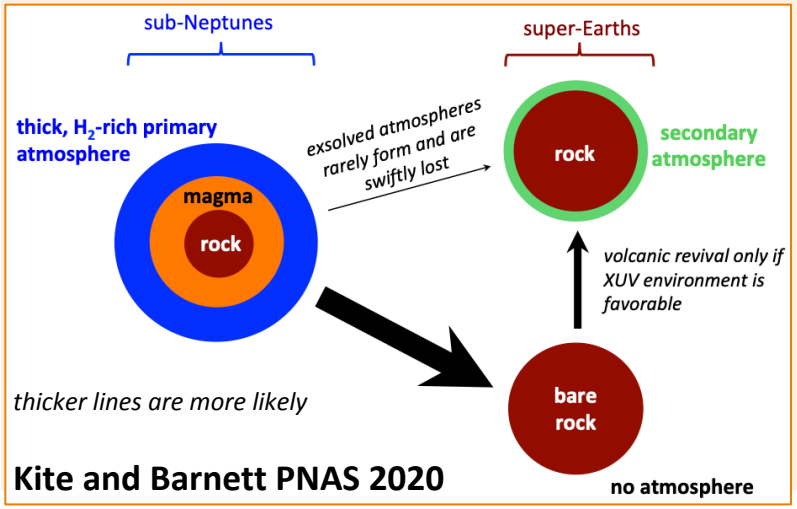
Kite et al. ApJL 2019

WITHOUT NON-LINEAR H_2 DISSOLUTION INTO MAGMA CORE:
need to tune core masses and/or accretion time to reproduce radius cliff ✗

WITH NON-LINEAR H_2 DISSOLUTION INTO MAGMA CORE:
naturally reproduces radius cliff ✔
robust to initial conditions ✔

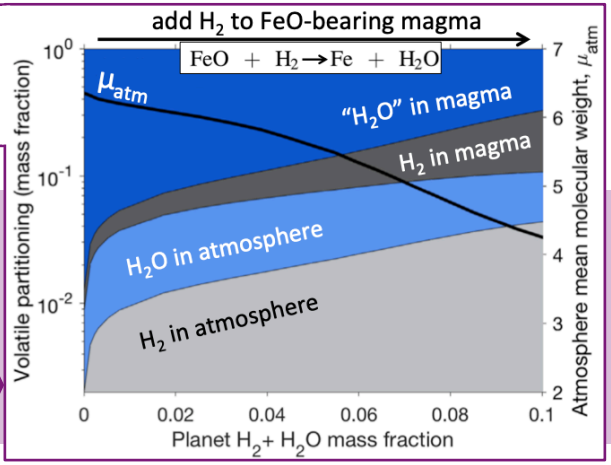


***Q:* Does being born as a sub-Neptune increase or decrease the chance that a super-Earth will have a secondary atmosphere?**
***A:* For T_{eq} > 400 K, exsolved secondary atmospheres are swiftly lost, but revived volcanic atmospheres are possible.**



Kite and Barnett PNAS 2020

Kite et al. ApJ 2020



Magma redox sets Sub-Neptunes' metallicity (Kite et al. ApJ 2020), and may endow large Super-Earths with H_2O-dominated, high-molecular weight atmospheres (Kite & Schaefer in prep.)

3.3 $M_\oplus$ magma ocean, H_2 solubility based on Hirschmann et al EPSL 2012. Simplified Fe-Mg-Si-O-H model (no Fe^{3+}). T at magma-atmosphere interface 3000 K. FeO content matching upper end of range of white dwarf data (Doyle et al. Science 2019).

Current work objective: predict the radius cliff position as a function of mass.

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