Decoding the Featureless JWST/NIRISS SOSS Spectrum of the Underdense Super-Earth TOI-1685b

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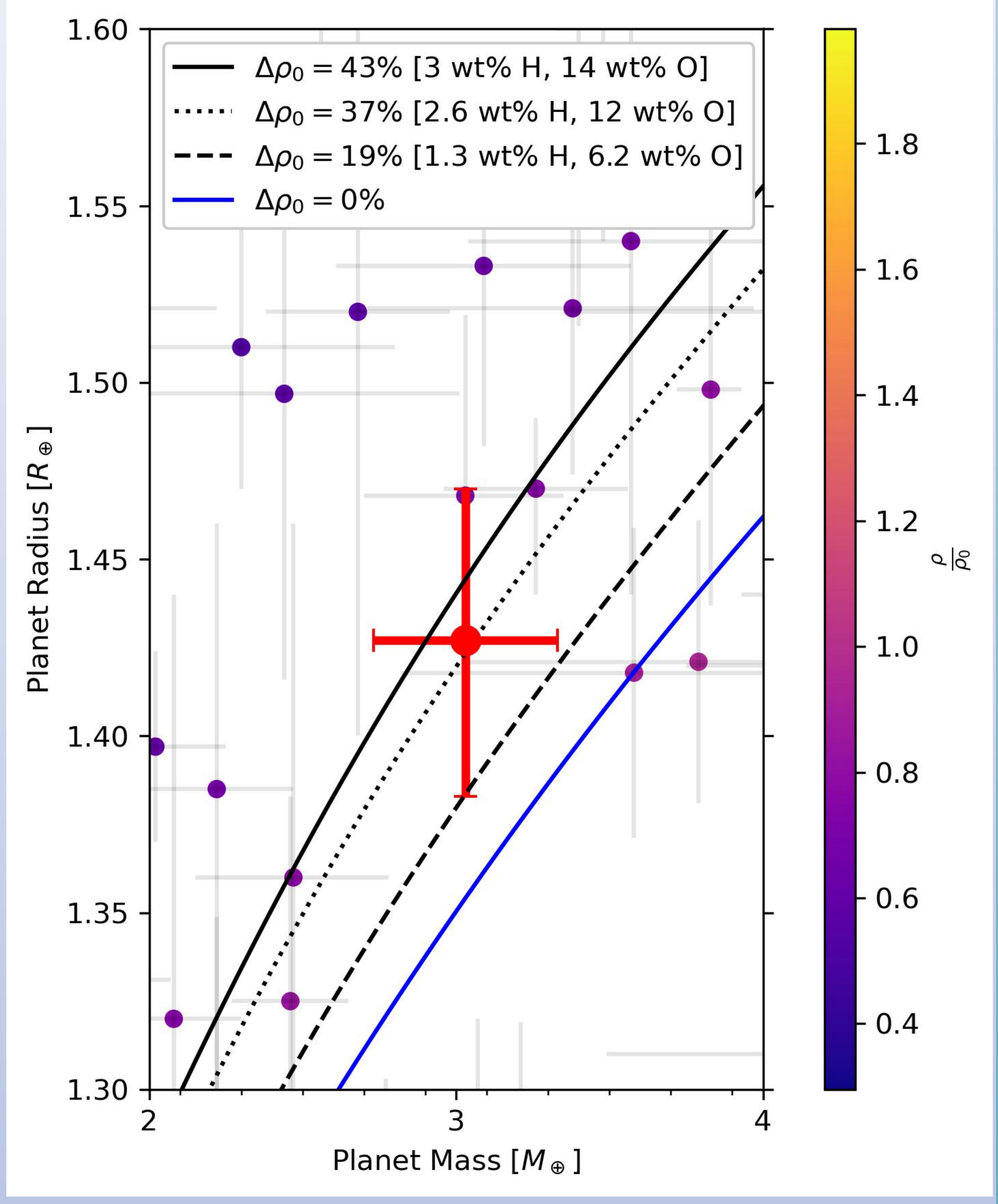
A CASE OF MISTAKEN IDENTITY: OBSERVATIONS OF "CANDIDATE" WATER WORLD

- **Cycle 2 JWST Program** (GO 4098; PI: Benneke, co-PI: Evans-Soma)
- **2 NIRISS SOSS transits** observed in January 2025
- TOI-1685 is a slow rotator (~18.2 days) — visits taken 15 hours apart — uniform stellar contamination model/spot & faculae variability across both visits

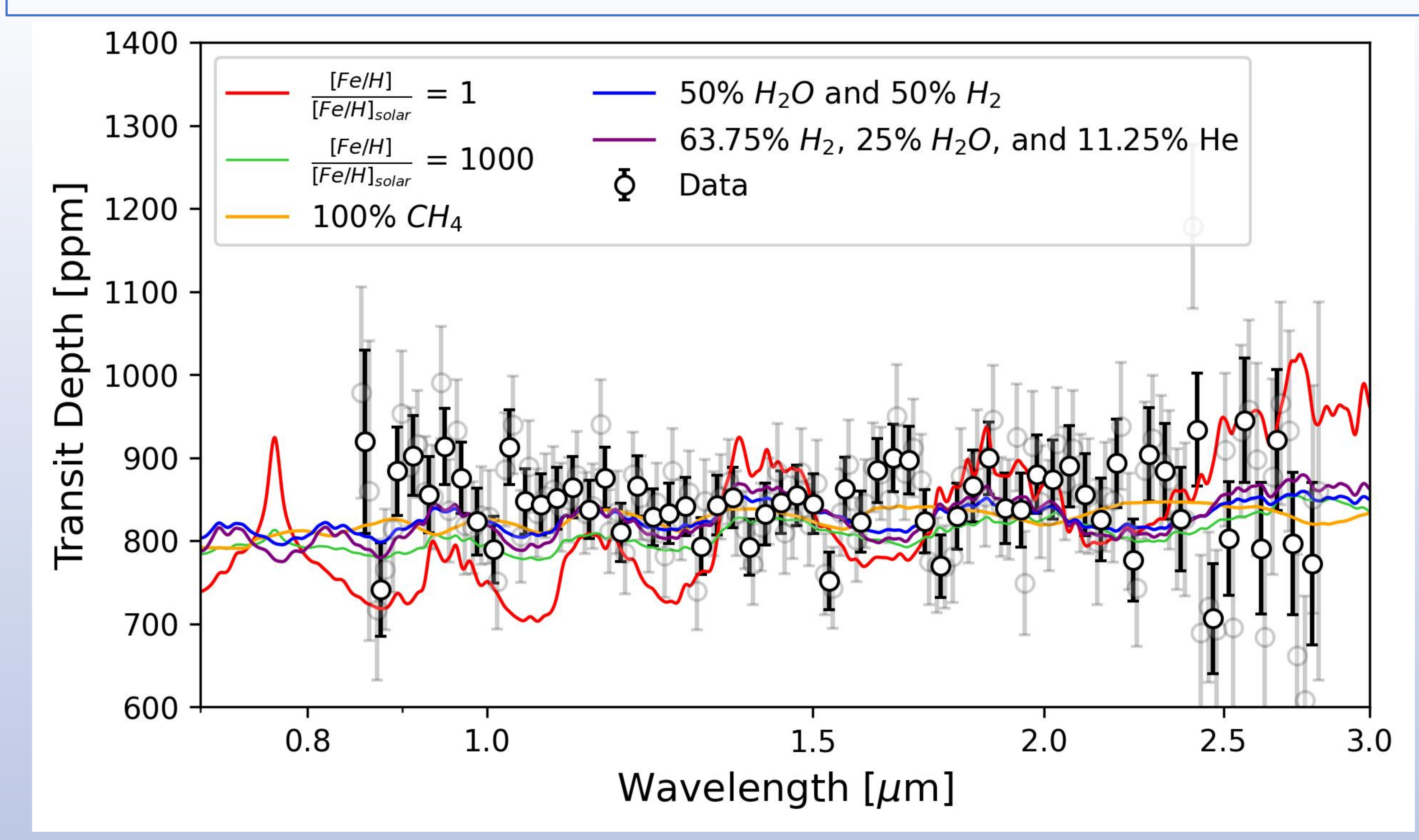


CHARACTERIZING TOI-1685b AROUND A QUIET M-DWARF

TOI-1685 (star)	
Spectral Type^a	M2.5V
Effective Temperature^a T_{eff} (K)	3575 ± 53
Metallicity^a (Fe/H)	0.3 ± 0.1
Stellar Mass^a ($M_\odot$)	0.454 ± 0.018
Stellar Radius^a ($R_\odot$)	0.4555 ± 0.0128
TOI-1685 b (planet)	
Orbital Period^a P (days)	0.66913924
Planetary Radius R_p ($R_\oplus$)	1.427 ± 0.043
Planetary Mass^a M_p ($M_\oplus$)	$3.03^{+0.33}_{-0.32}$
Equilibrium Temperature^a $T_{eq,A=0}$ (K)	1062 ± 27

- **(a) Physical Properties of TOI-1685 & TOI-1685b taken from [3].**
- **Radius measurement extracted from best WLC fit across Order 1 of Visits 1 & 2 — This Work**

FEATURELESS SPECTRUM CHALLENGES MODEL PREDICTIONS



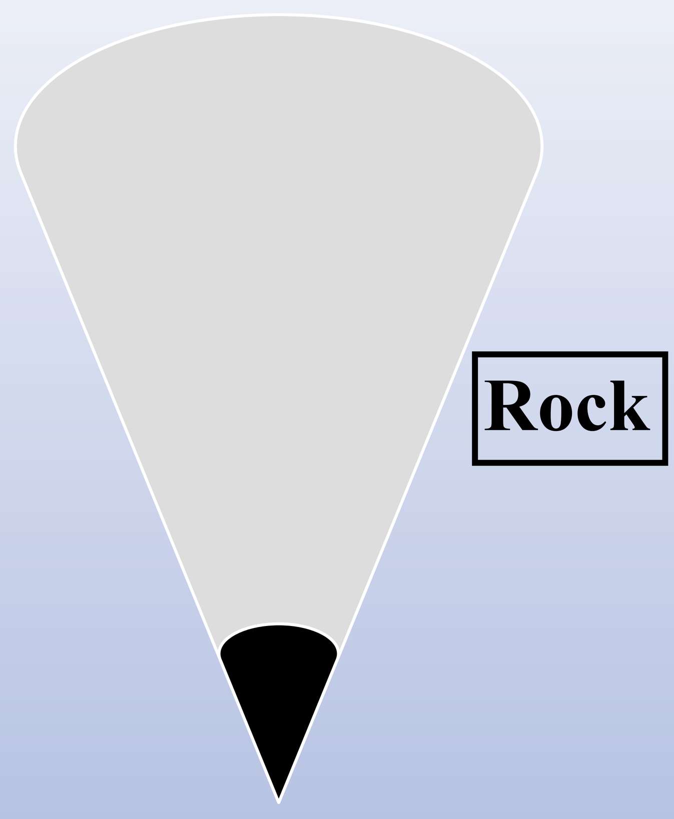
- ExoTEDRF Reduction[4] & EXOTEP Broadband and Spectroscopic Light-Curve Fits[5,6]

REFERENCES

[1] Fisher, C., Akin, C.J., Allen, N., et al. 2023, Constraining the Oxidation State of Super-Earth TOI-1685b, JWST Proposal. Cycle 2, ID. #4195 [2] Luque, R., Coy, B. P., Xue, Q., et al. 2025, AJ, 170, 49 [3] Burt, J. A., Hooton, M. J., Mamajek, E. E., et al. 2024, ApJL, 971, L12 [4] Radica, M., Welbanks, L., Espinoza, N., et al. 2023, MNRAS, 524, 835 [5] Benneke, B., Werner, M., Petigura, E., et al. 2017 ApJ, 834, 187 [6] Benneke, B., Wong, I., Piaulet, C., et al. 2019b, ApJL, 887, L14 [7] Benneke, B. & Seager, S. 2012, ApJ, 753, 100 [8] Schlichting, H. & Young, E. D., 2022, PSJ, 3, 1 [9] Gao, P., Wakeford, H. R., Moran, S. E., et al. 2021, JGRE, 126, e06655

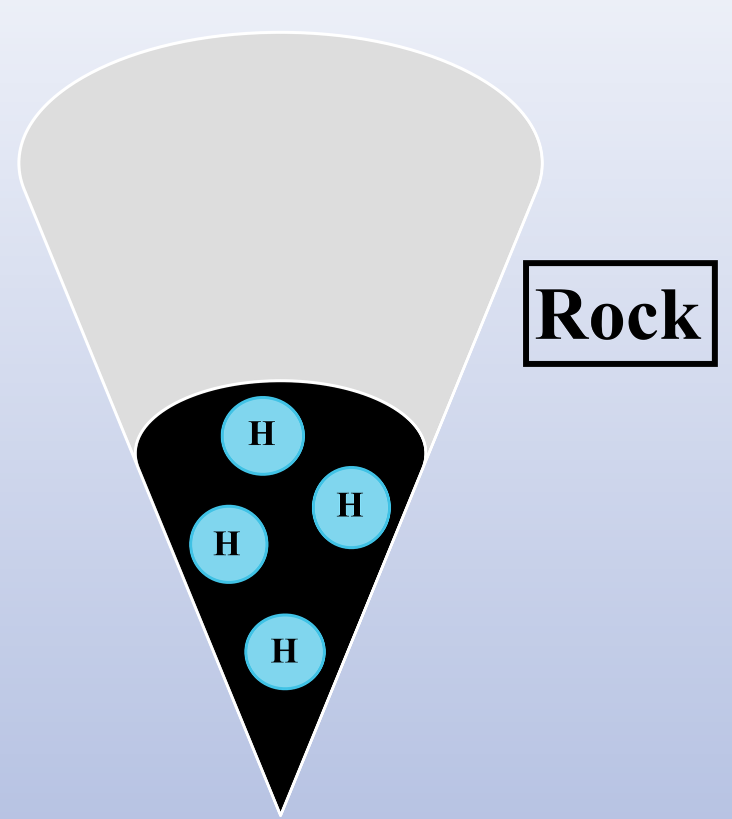
THREE POSSIBLE COMPOSITIONAL SCENARIOS

1 Iron Deficit in Core



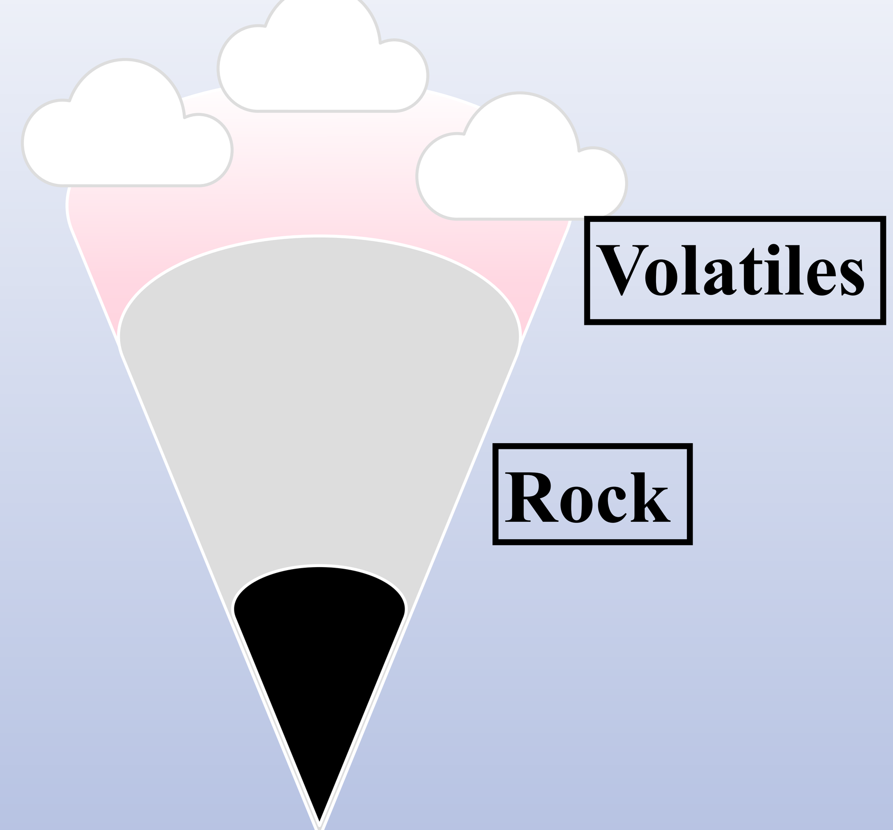
- **Reduced Fe abundance** in core which **decreases the CMF** ($CMF_{Fe\_Poor} < 32.5\%$)
- Likely challenging, from a planet formation perspective, to form a core with $CMF_{Fe\_Poor} < 32.5\%$ if star is **metal-rich**

2 Sequestration of H in Core



- **Core density deficit** can justify low bulk density[8]
- **TOI-1685b spans 28 to 43% deficit curves**
- **20 to 40 % core density deficit** justifiable by planets that have lost primordial envelopes (few% H) to core-powered mass loss or photoevaporative stripping

3 High-altitude Clouds



- **Feature amplitudes** are **dampened** by clouds
- Planet's **TP profile** becomes **lower** than **condensation curve** of a species, aerosols form:
  - **$MgSiO_3$, Mg_2SiO_4, Al_2O_3, & alkali salts** — TOI-1685b cloud composition possibilities[9]