



Can we build an Earth like Planet?

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Motivation

- Understand planetary formation
- Habitability
- Comparisons of other planetary systems to Earth or planets in our solar system



Planetary Comparison

- True Earth Values
1.0 R_{\oplus} , 0.999 M_{\oplus}
- Mars Values
0.520 R_{\oplus} , 0.531 M_{\oplus}
- Mercury Values
0.422 R_{\oplus} , 0.383 M_{\oplus}

Looking At Different Iron to Magnesium ratios

Default Ratio Fe/Mg = 0.9

- 1 M \oplus
- 0.999 R \oplus
- CMF = 32.95
- CRF = 53.02
- CMB Pressure = 141.56 GPa

Equal Ratio Fe/Mg = 1

- 1 M \oplus
- 0.993 R \oplus
- CMF = 35.31
- CRF = 54.56
- CMB Pressure = 138.47 GPa

High Mg, low Fe Fe/Mg = 1e-6

- 1 M \oplus
- 1.078 R \oplus
- CMF = 0.20
- CRF = 11.65
- CMB Pressure = 149.43 GPa

High Fe, low Mg Fe/mg = 1e6

- 1 M \oplus
- 1.078 R \oplus
- CMF = 0.20
- CRF = 11.65
- CMB Pressure = 149.43 GPa

Moving

Iron

Out of the Core

Small amount of FeO

- 1 R \oplus
- CMF = 32.59
- CRF = 52.79
- CMB Pressure = 142.02 GPa
- Mantle Composition: FeO = 0.62, SiO₂ = 52.227, MgO = 38.926, Al₂O₃ = 4.431

Intermediate amount of FeO

- 1.004 R \oplus
- CMF = 25.92
- CRF = 48.72
- CMB Pressure = 155.48 GPa
- Mantle Composition :FeO = 11.165, SiO₂ = 46.687, MgO = 34.798, Al₂O₃ = 3.961, CaO = 3.389

Maximum amount of FeO

- 1.005 R \oplus
- CMF = 19.47
- CRF = 44.26
- CMB Pressure = 169.31 GPa
- Mantle Composition: FeO = 19.684, SiO₂ = 42.210, MgO = 31.461, CaO = 3.064, Al₂O₃ = 3.581

Adding

Lighter

Elements to the Core

Small Amounts of light Elements

- 1.002 R_{\oplus}
- CMF = 32.45
- CRF = 53.53
- CMB Pressure = 138.37 GPa
- Mantle Composition: FeO = 2.393, SiO₂ = 50.812, MgO = 38.634, CaO = 3.763, Al₂O₃ = 4.498

Intermediate Amounts of Light Elements

- 1.009 R_{\oplus}
- CMF = 31.13
- CRF = 55.71
- CMB Pressure = 126.84 GPa
- Mantle Composition: FeO = 10.280, SiO₂ = 44.872, MgO = 37.026, CaO = 3.606, Al₂O₃ = 4.215

Maximum Allowed amount of Light Elements

- 1.018 R_{\oplus}
- CMF = 31.06
- CRF = 59.62
- CMB Pressure = 111.12 GPa
- Mantle Composition: FeO = 18.962, SiO₂ = 37.592, MgO = 35.869, CaO = 3.493, Al₂O₃ = 4.083

Looking At Different Iron to Magnesium ratios

Default Ratio Fe/Mg = 0.9

- 1 M \oplus
- 0.999 R \oplus
- CMF = 32.95
- CRF = 53.02
- CMB Pressure = 141.56 GPa

Equal Ratio Fe/Mg = 1

- 1 M \oplus
- 0.993 R \oplus
- CMF = 35.31
- CRF = 54.56
- CMB Pressure = 138.47 GPa

High Mg, low Fe Fe/Mg = 1e-6

- 1 M \oplus
- 1.078 R \oplus
- CMF = 0.20
- CRF = 11.65
- CMB Pressure = 149.43 GPa

High Fe, low Mg Fe/mg = 1e6

- 1 M \oplus
- 1.078 R \oplus
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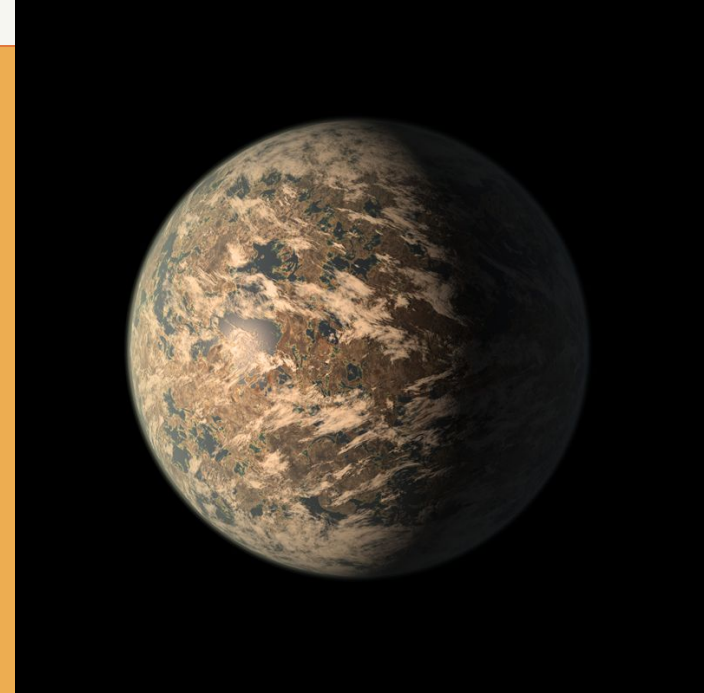


Model for TRAPPIST-1e

- $\text{Mg/Fe} = 0.08$
- $\text{Si/Fe} = 0.07$
- $\text{Fe/H} = 0.04$
- $\text{Mg/H} = 0.12$
- $\text{Si/H} = 0.11$
- $X/\text{mg} = 10^{((x/\text{H})-(\text{Mg}/\text{H}))}$
- $\text{Fe/Mg} = 0.0832$
- $\text{Si/Mg} = 0.977$

TRAPPIST-1e Characteristics

- Likely rocky planet
- Around 0.0000522 times the luminosity of the sun
- $0.772 M_{\oplus}$
- $0.91 R_{\oplus}$
- 1.024 times the density of Earth
- Uncertainties in the Mass of the planet around 0.026 or -0.027
- $\text{Fe/Mg} = 1.361$
- $\text{Si/Mg} = 0.977$
- Si in core fraction = 0.015
- O in core fraction = 0.005
- S in core fraction = 0.025



Possible Combinations for our Planet

Radius (R _⊕)	Mass (M _⊕)	Density (ρ/ρ _⊕)	[Fe/Mg]	[Si/Mg]	FeO (mantle)	Si (core)	O (core)	S (core)	Mantle Composition (%)
0.910	0.772	1.024	1.300	0.977	0	0	0	0	SiO ₂ =54.6 MgO=37.5 CaO=3.7 Al ₂ O ₃ =4.3
0.935	0.772	0.944	0.832	0.977	0.15	0.03	0	0.01	SiO ₂ =50.3 MgO=36.2 CaO=3.5 Al ₂ O ₃ =4.1
0.934	0.772	0.947	0.832	0.977	0	0	0	0	SiO ₂ =54.6 MgO=37.5 CaO=3.7 Al ₂ O ₃ =4.3
0.935	0.772	0.944	0.832	0.977	0.15	0.05	0	0.03	SiO ₂ =47.8 MgO=35.5 CaO=3.5 Al ₂ O ₃ =4.1
0.923	0.772	0.982	1.023	0.977	0.12	0.005	0	0.035	SiO ₂ =53.6 MgO=37.2 CaO=3.6 Al ₂ O ₃ =4.2
0.910	0.772	1.024	1.160	0.670	0.2	0.03	0	0.05	SiO ₂ =53.6 MgO=37.2 CaO=3.6 Al ₂ O ₃ =4.2
0.910	0.772	1.024	1.361	0.977	0.15	0.015	0.01	0.025	SiO ₂ =50.8 MgO=36.4 CaO=3.5 Al ₂ O ₃ =4.1

In Conclusion

- TRAPPIST-1e and Earth are nearly the same
- Iron can be seen in the Mantle
- Iron is solely in the Earth's Core in comparison
- TRAPPIST-1e Cannot accommodate a Hydrogen dominated atmosphere as a result of its lighter core
- Uncertainties in the known Mass and Radius estimates as a result of all possible combination
- TRAPPIST-1e as a very heavy core like Earth

Mantle Minerology	TRAPPIST-1e (%)	Earth (%)
Fe	0.07	0
FeO	5.04	0
SiO ₂	50.8	52.5
MgO	36.4	39.2
CaO	3.5	3.8
Al ₂ O ₃	4.1	4.5