Venus: The Exoplanet Next Door

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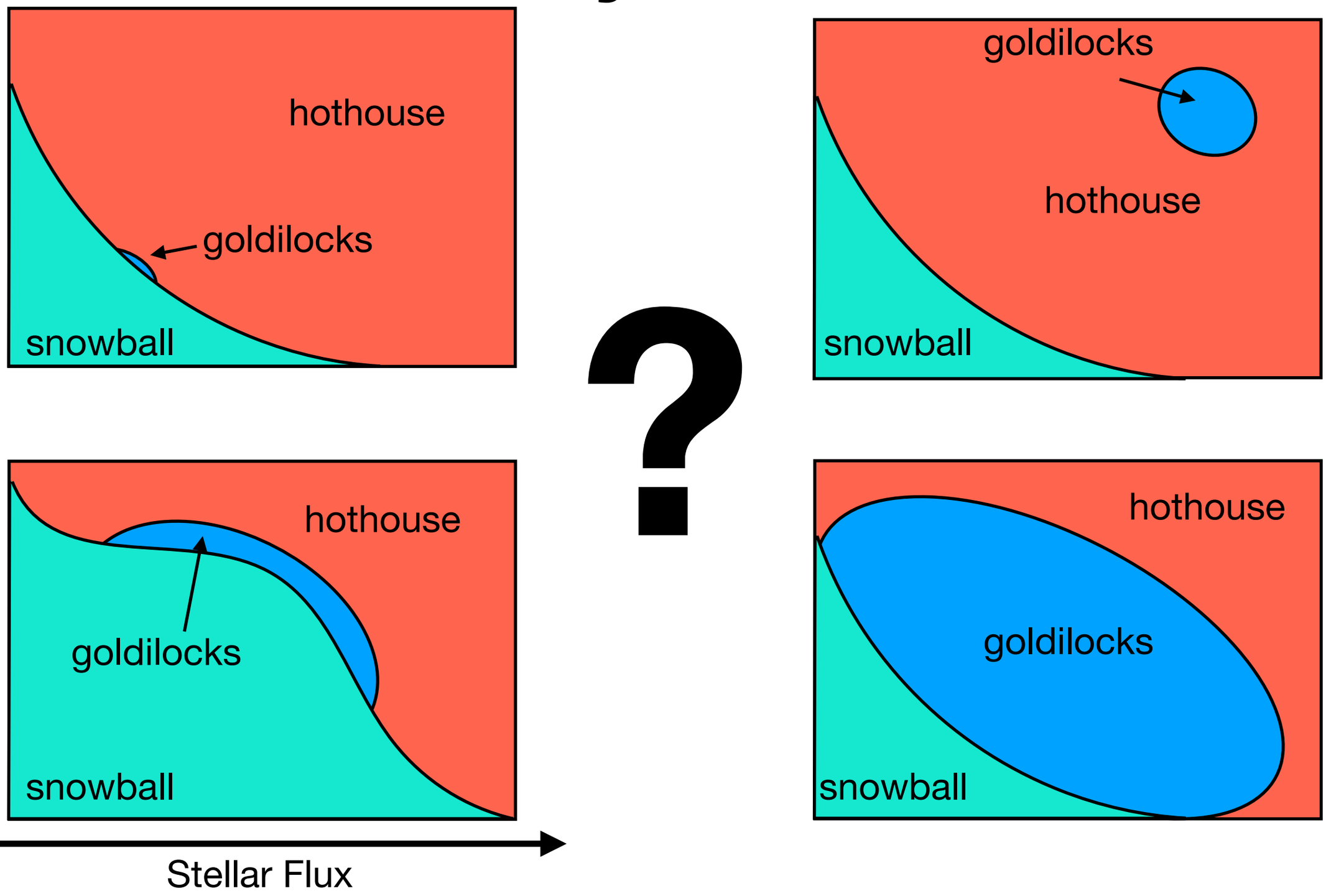
Model Planet?

- We tend to use Earth as our model for Terrestrial planets despite having at least five alternate examples (Mercury, Venus, Moon, Mars, Io — icy bodies too?)
    - Only one of six with Plate Tectonics
    - Only one of six with surface water
    - Only one of six with disequilibrium atmosphere
    - Only one of six with life
    - etc…
- Is there a better choice?

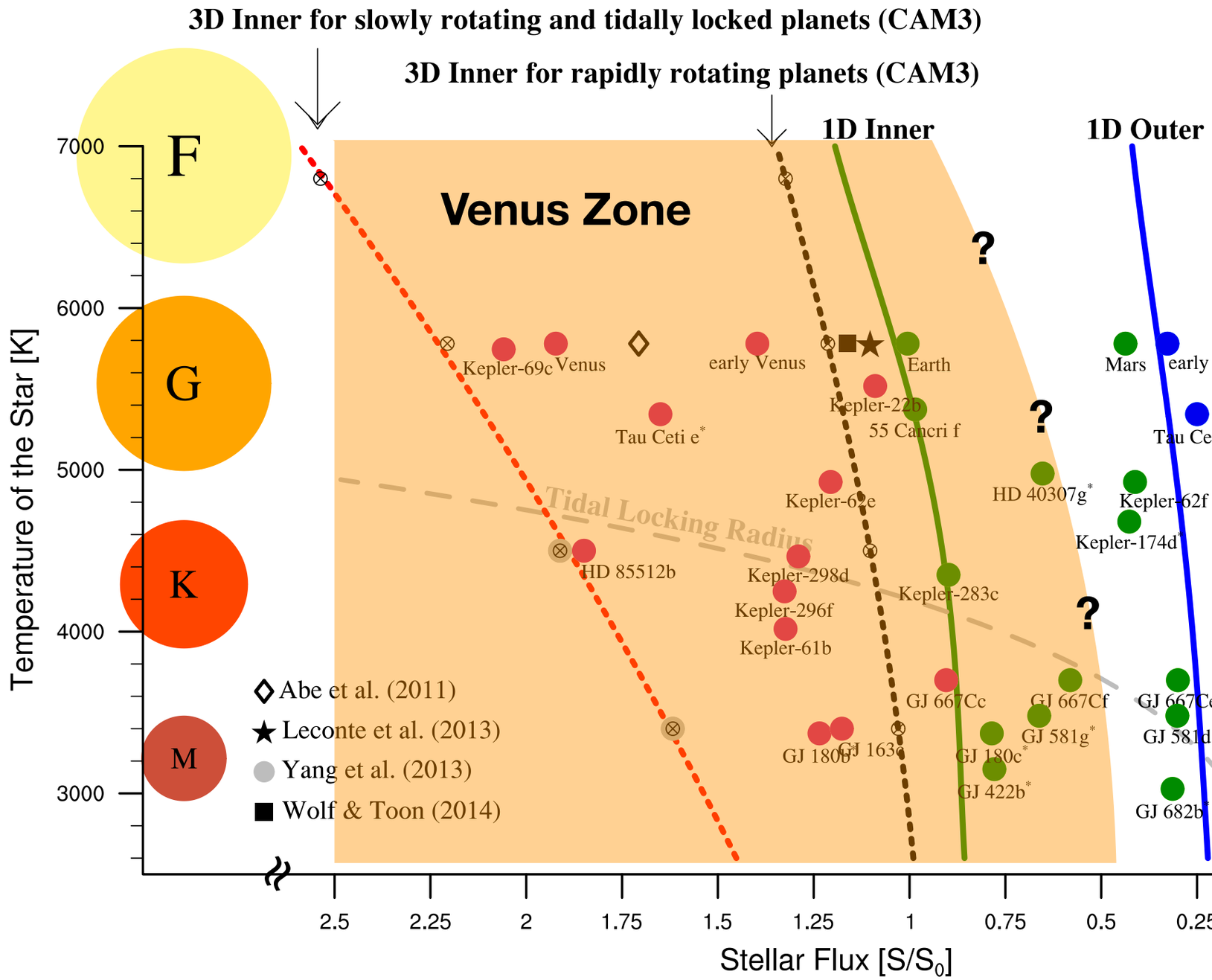
What is the Geography of Planetary Outcomes



Venus, Model Planet

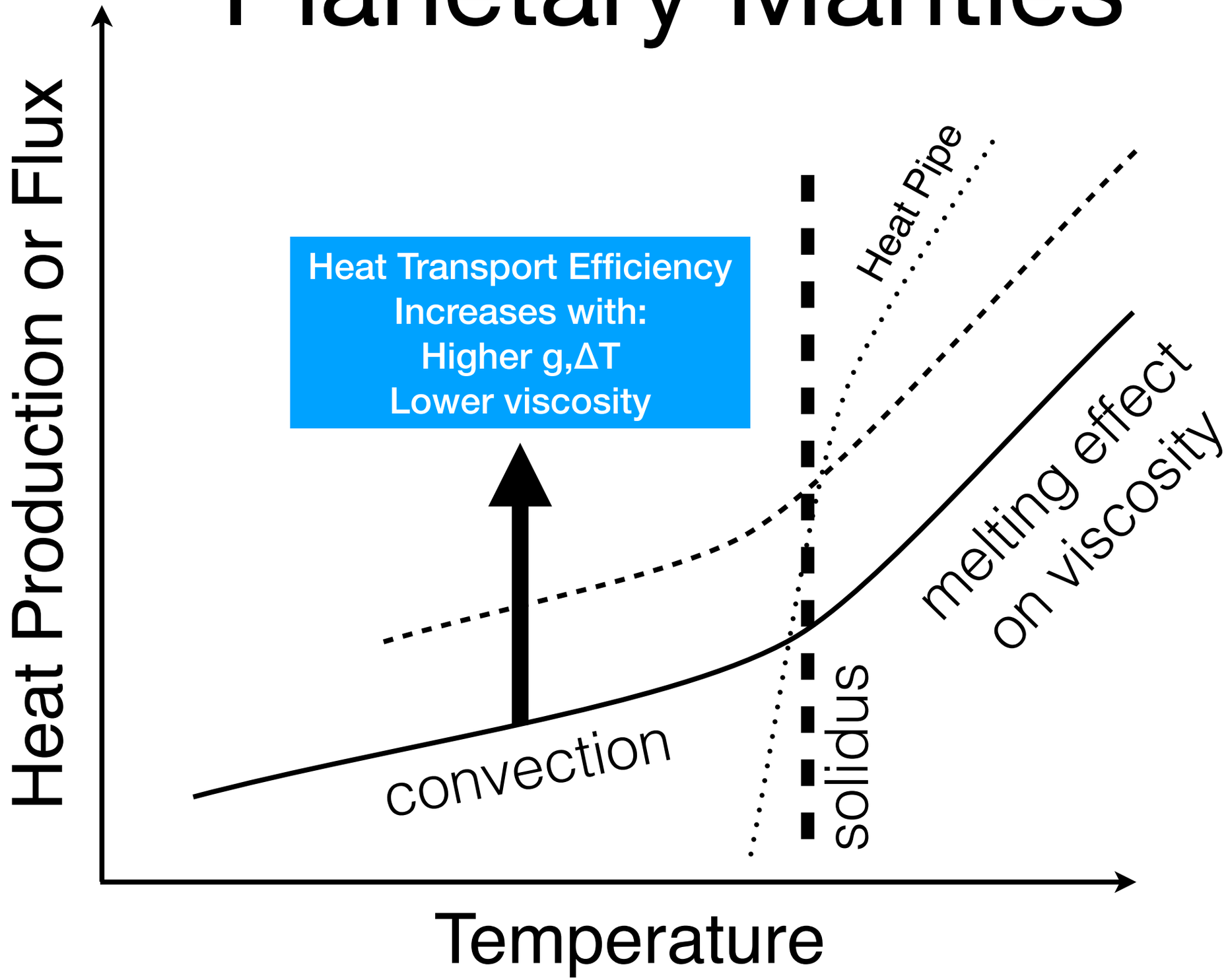
- Rock-Iron mix comparable to other bodies.
- "Normal" tectonic behavior — rigid lid (and heat pipe).
- Geochemical cycling with the interior weak and mostly one-way
- Atmosphere is expected outcome of one-way cycling
- Extremely stable climate — likely dominant for the vast majority of observable lifespan
- Primary atmospheric component resilient to erosion (heavy) even in absence of magnetic field

How Far Out can Venus be Venus?

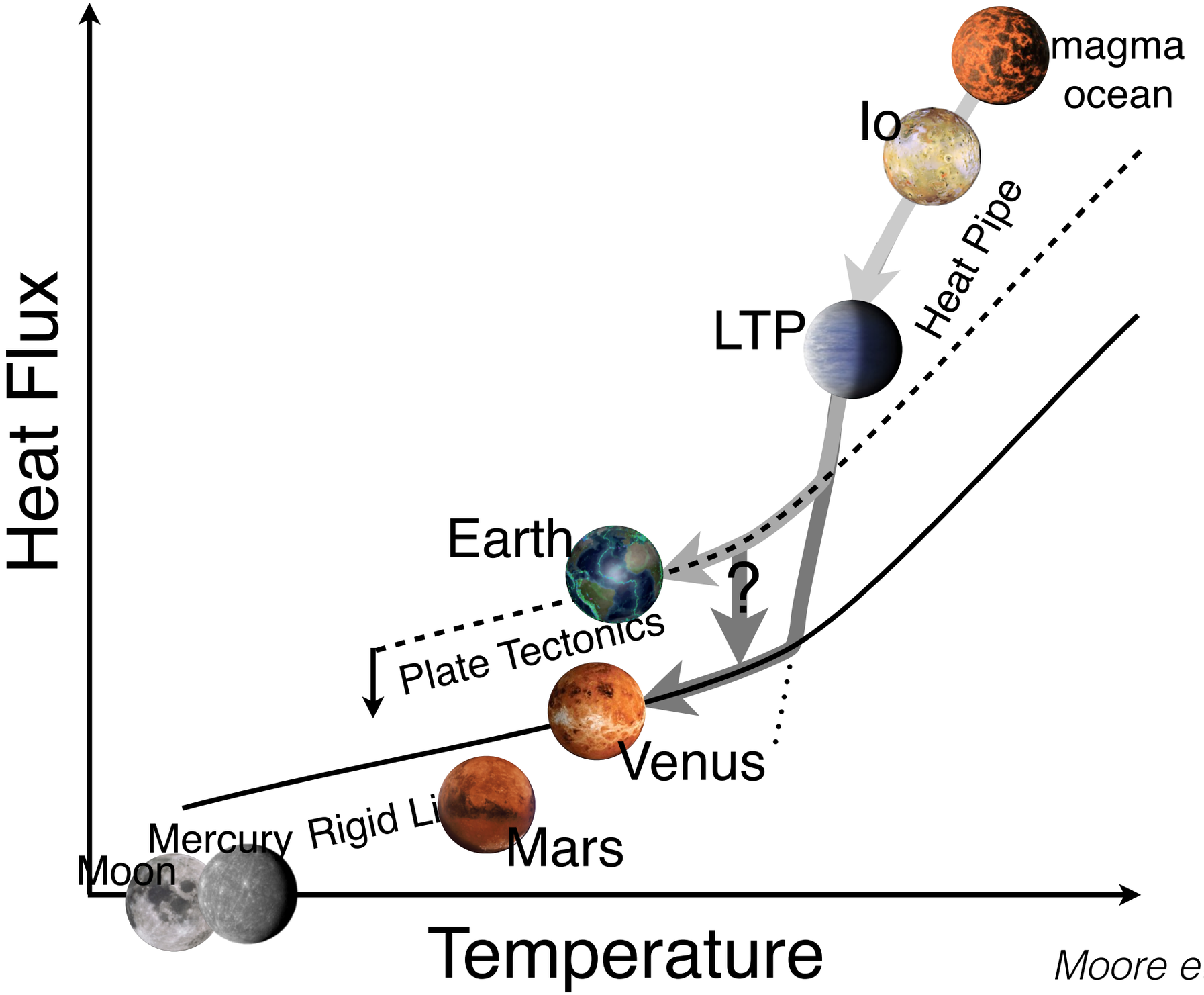


modified from Yang, et al., ApJ 2014

Thermal Equilibria in Planetary Mantles

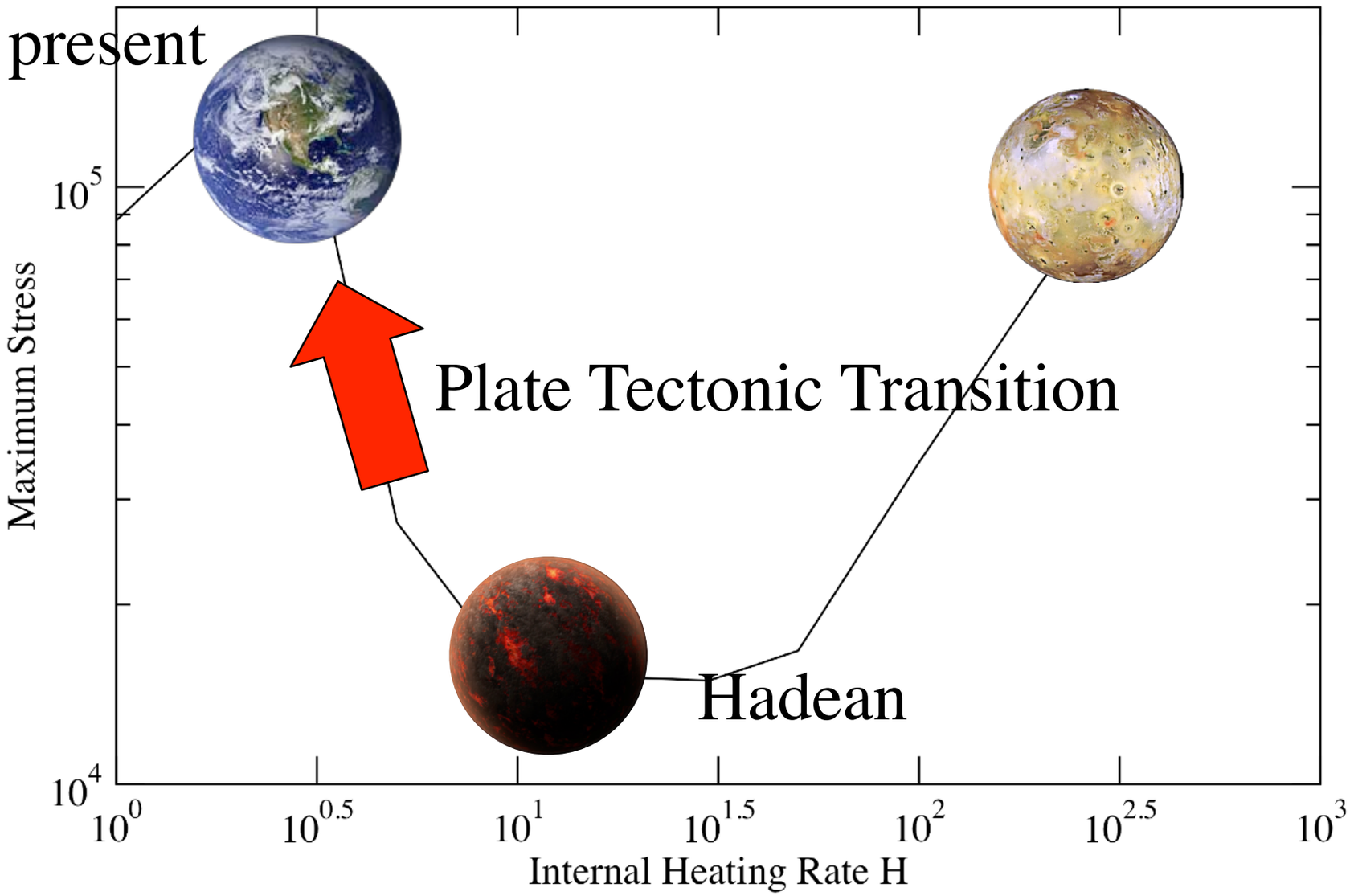


Heat Pipes: A Universal Stage in Terrestrial Planet Evolution



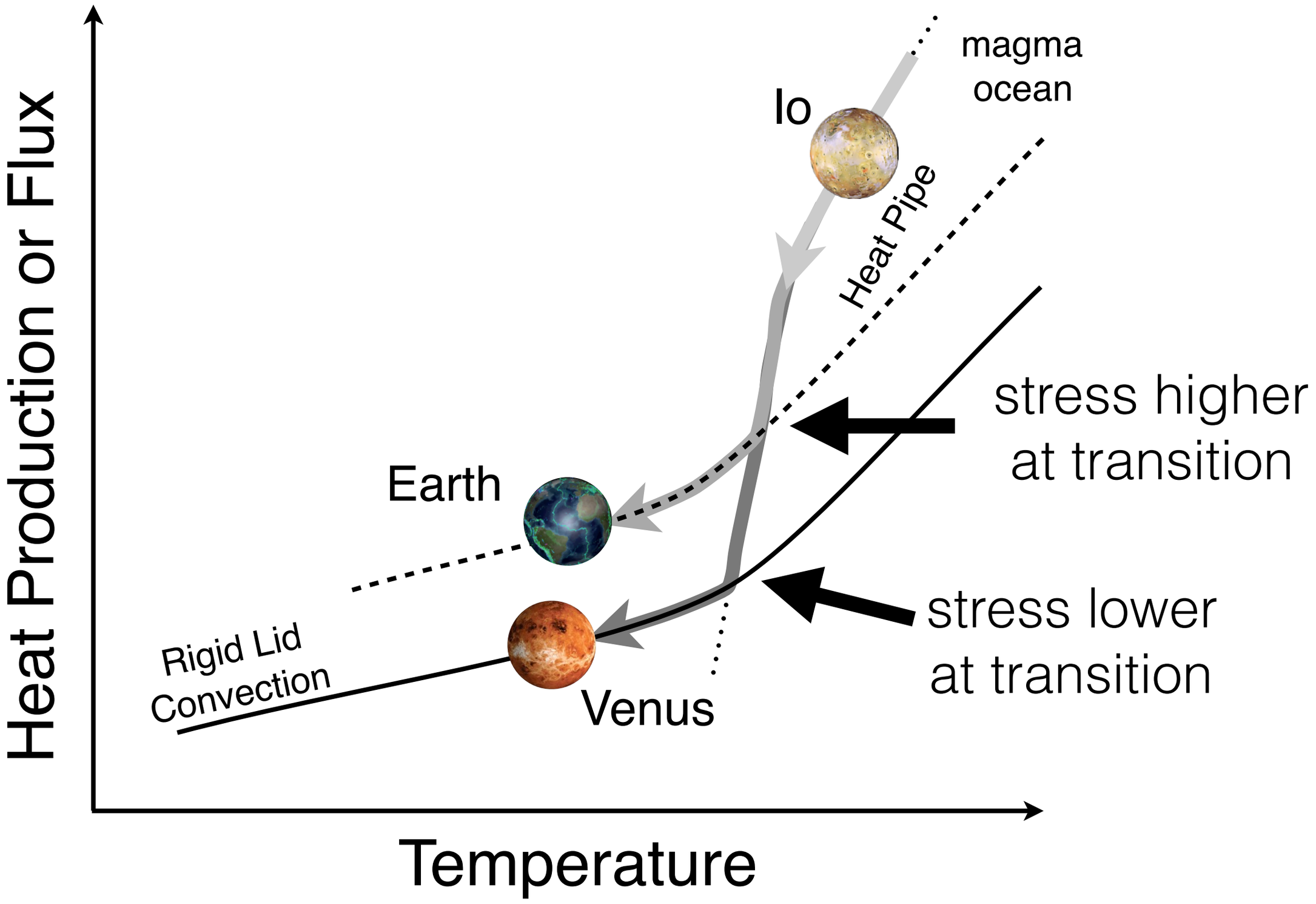
Moore et al., EPSL 2017

Cooling Planets Experience a Stress Maximum



Moore and Webb, Nature, 2013

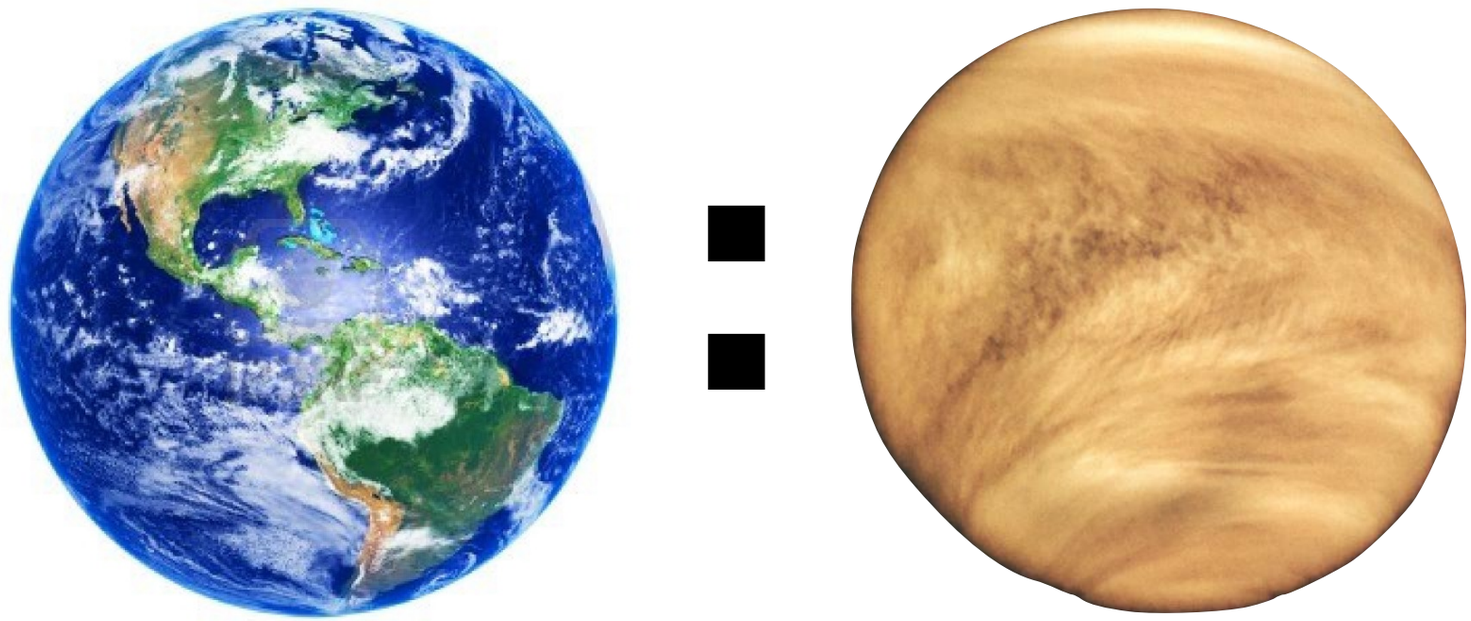
Venus Missed the Train to Plate Tectonics



Venus' Atmosphere: Robust and Stable

- Escape limited by NO, CO_2 cooling (no Magnetic Field needed)
- Venus Thermosphere is the coldest part of its atmosphere
- Induced Magnetosphere produces "polar" wind effect
- No effective mechanisms to exchange with solid planet

What is the hothouse:goldilocks ratio?



- We will soon be making measurements that address this.

- Our theoretical understanding will be greatly enhanced if we can understand the hothouse example next door.

Venus as an Exoplanet

Three big things we can learn about exoplanets from studying Venus

- The role of tectonics/volcanism in atmospheric & climatic outcomes
- The role of atmospheric composition in escape processes
- The importance of stochastic events (giant impacts) in shaping planetary destiny