

# Detectability and scientific implications of crustal remanent magnetism on Venus

**Joseph G. O'Rourke (ASU)**

C. Gillmann (ULB), P. Tackley (ETH Zurich)

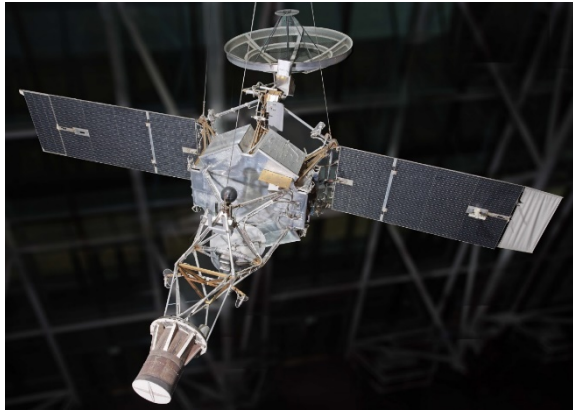
J. Buz (NAU), R. R. Fu (Harvard), R. J. Lillis (UCB)

**ASU**® **School of Earth and  
Space Exploration**

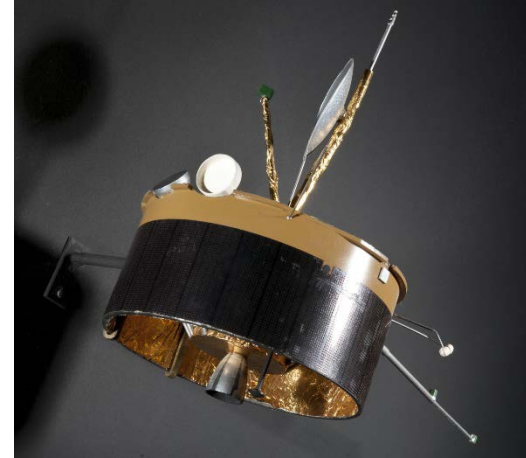
**Arizona State University**



# Magnetic Missions to Venus



**1967 | Venera 4**  
No crustal field  
at Eistla Regio



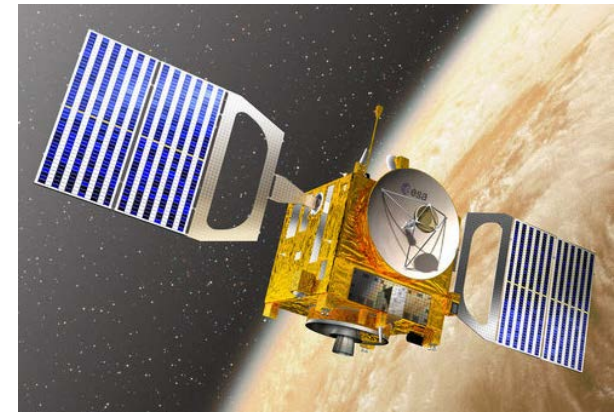
**2006 – 2014 |  
Venus Express**  
No detected crustal  
field at North Pole



**1962 | Mariner 2**  
No Earth-strength  
magnetosphere



**1978 – 1992 |  
Pioneer Venus Orbiter**  
No detected crustal field  
near the equator



# Magnetic Models of Venus

**Coupled geodynamic simulations with a hot, chemically homogeneous core**

## **Atmosphere (C. Gillmann)**

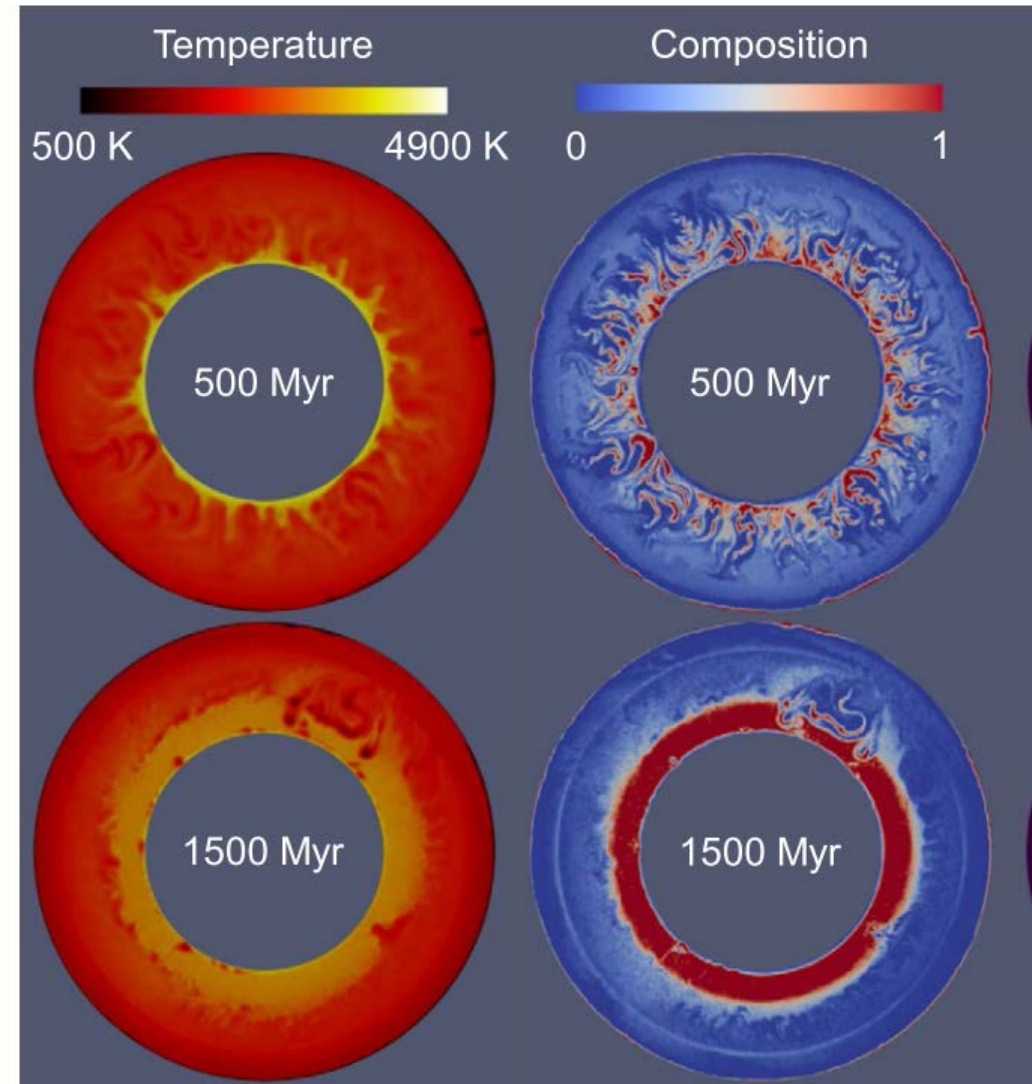
- 1D, radiative/convective

## **Mantle (P. Tackley)**

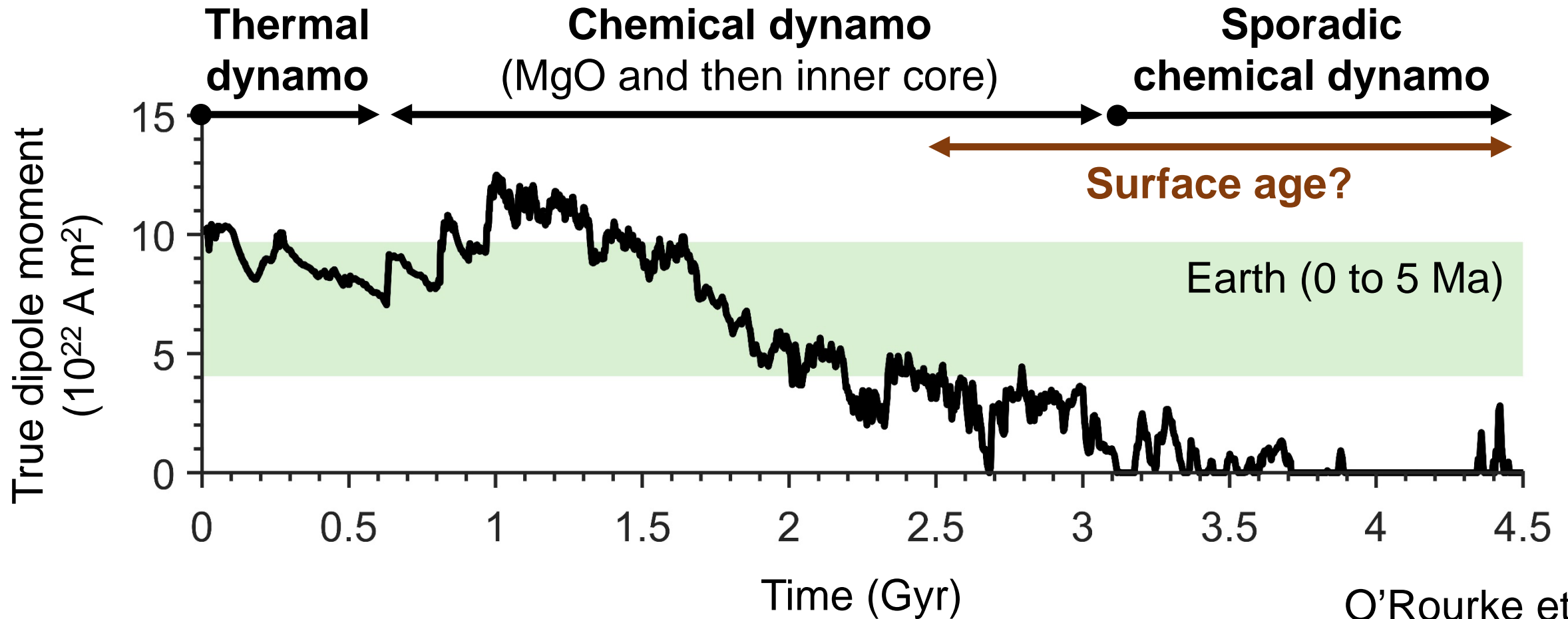
- 2D, StagYY

## **Core (J. O'Rourke)**

- 1D, 0.89x Earth's core radius



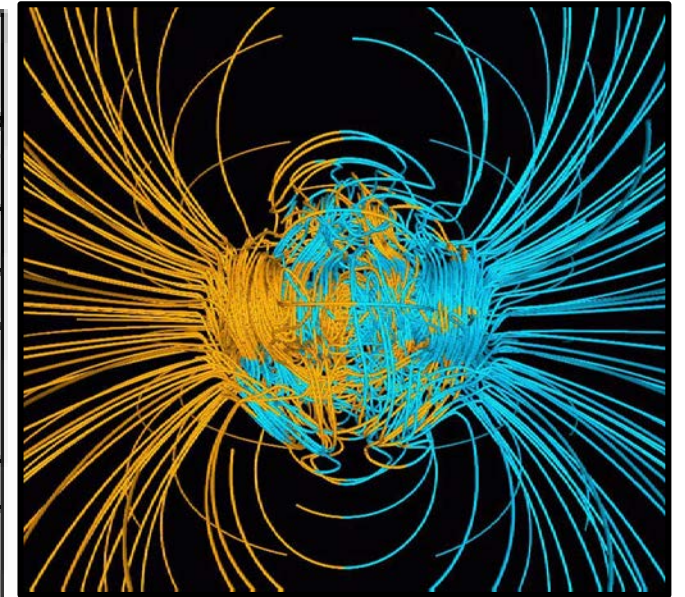
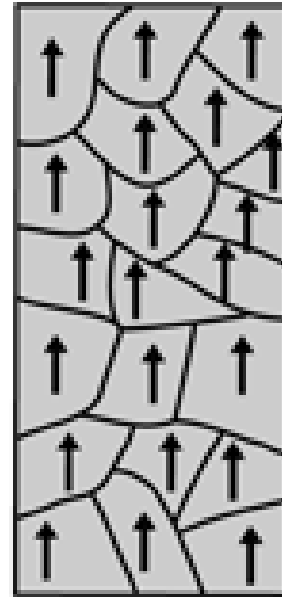
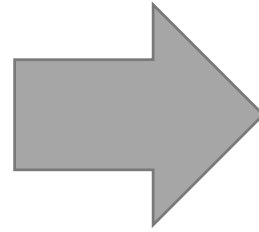
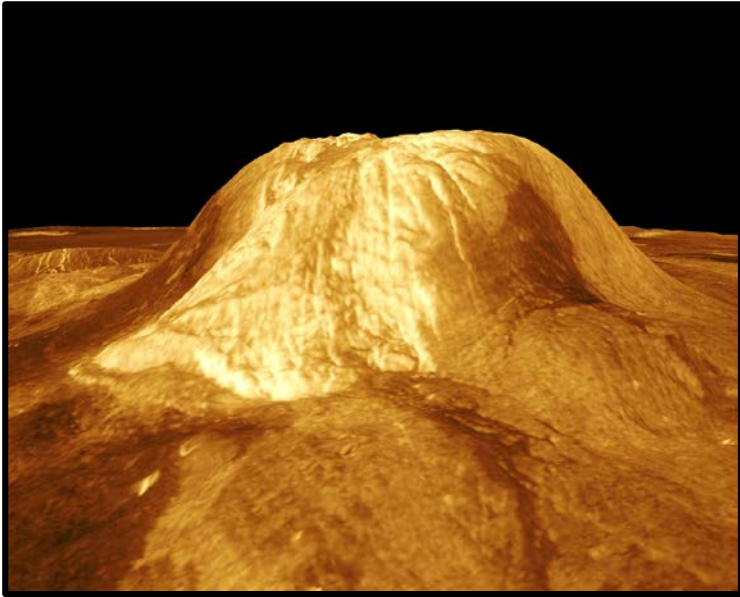
# Our Model Predicts a Recent Dynamo



O'Rourke et al.  
(2018 *EPSL*)



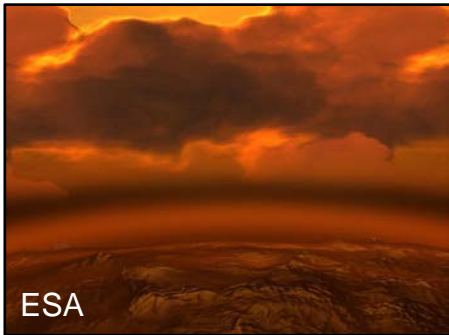
# Thermoremanent magnetization



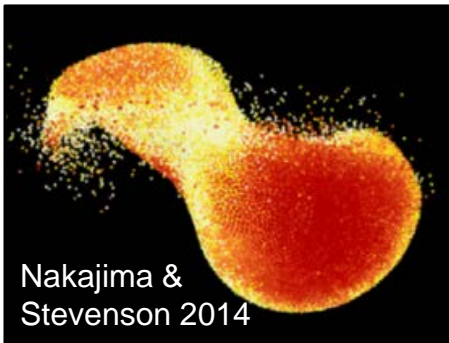
Igneous rocks cool below  
the Curie temperature...

...acquiring magnetization  
from the ambient field.

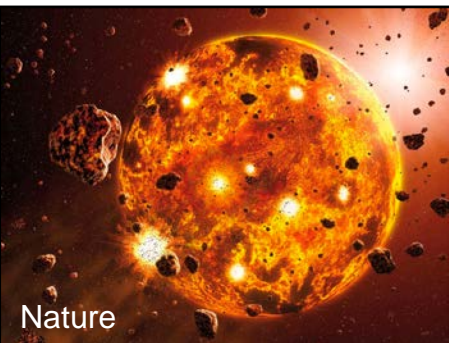
# Implications of Crustal Remanence



**Climate history** (Bullock & Grinspoon 2001)  
Surface temperatures & atmospheric escape

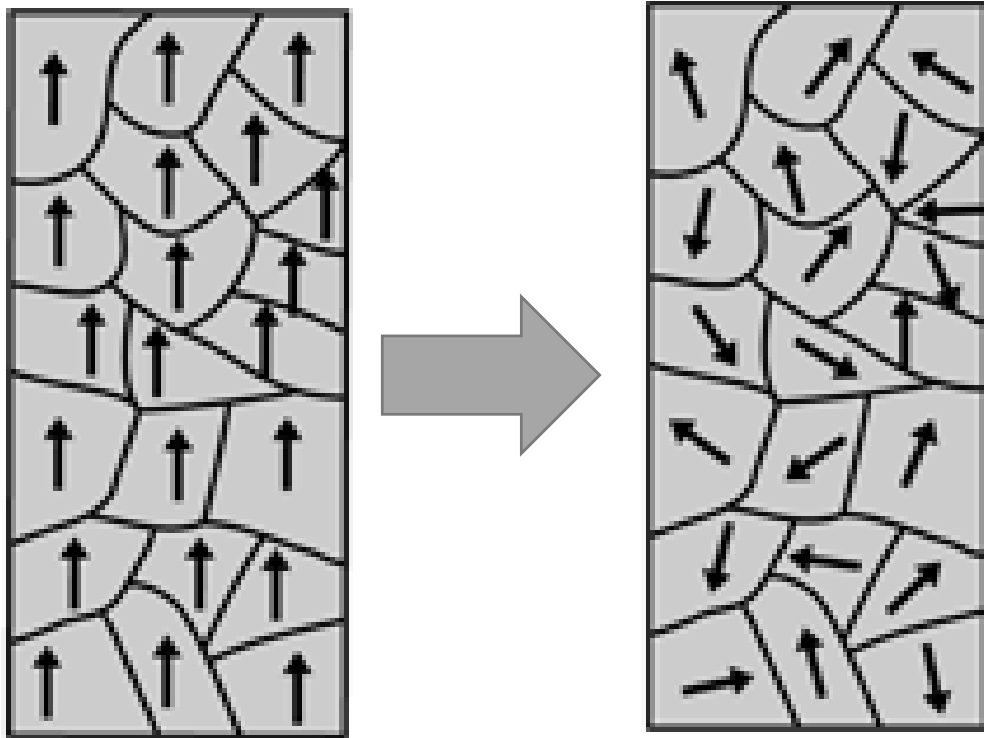


**Core composition** (O'Rourke & Stevenson 2016)  
Light elements (Si, O, Mg) drive convection



**Conditions of accretion** (Jacobson et al. 2017)  
Giant impacts mechanically mixed the core

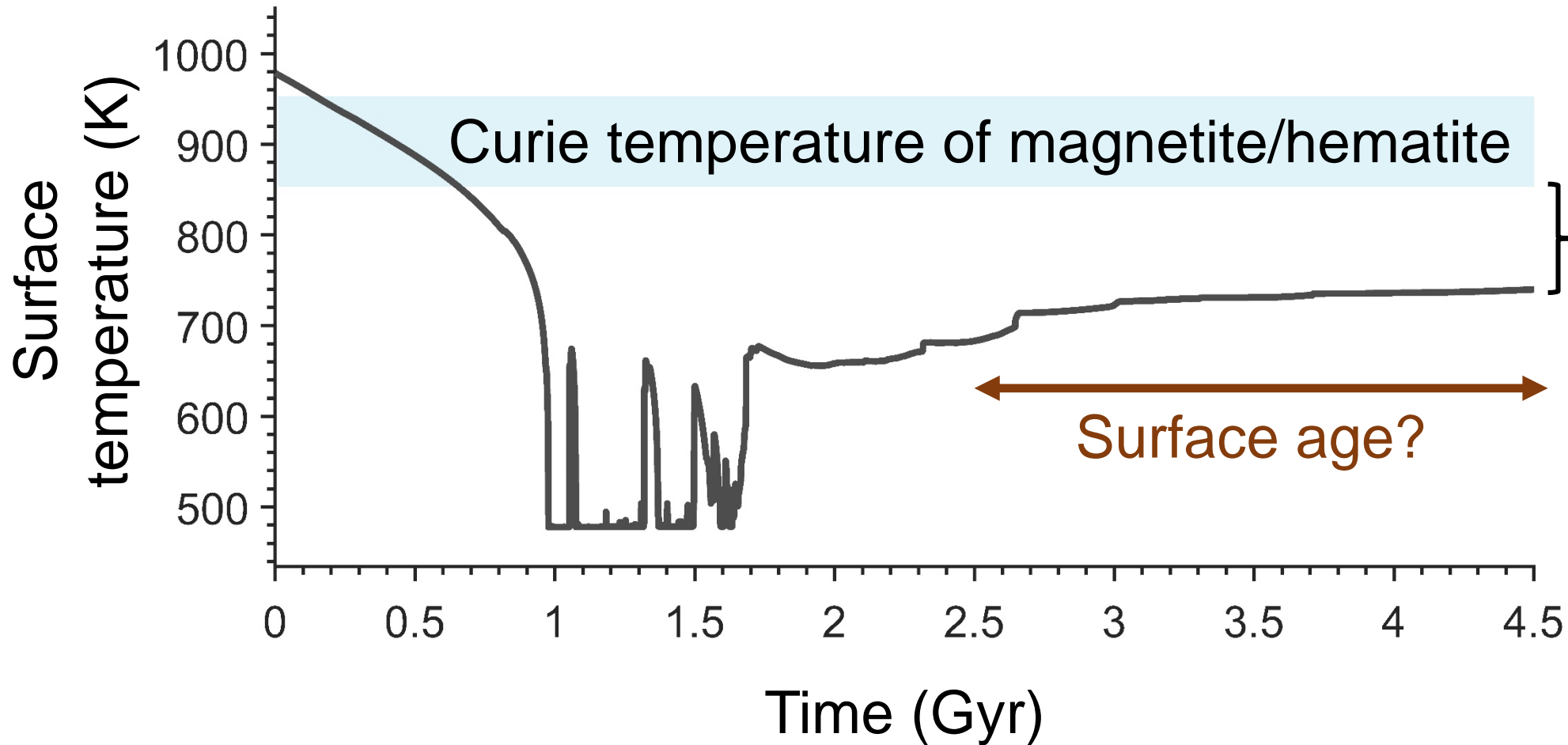
# Problem: Magnetic relaxation



Decay over time in  
zero field

“High surface temperatures  
should have prevented the  
recording of evidence of  
any ancient magnetic field.”  
—Anonymous

# Venus is hot, but not too hot

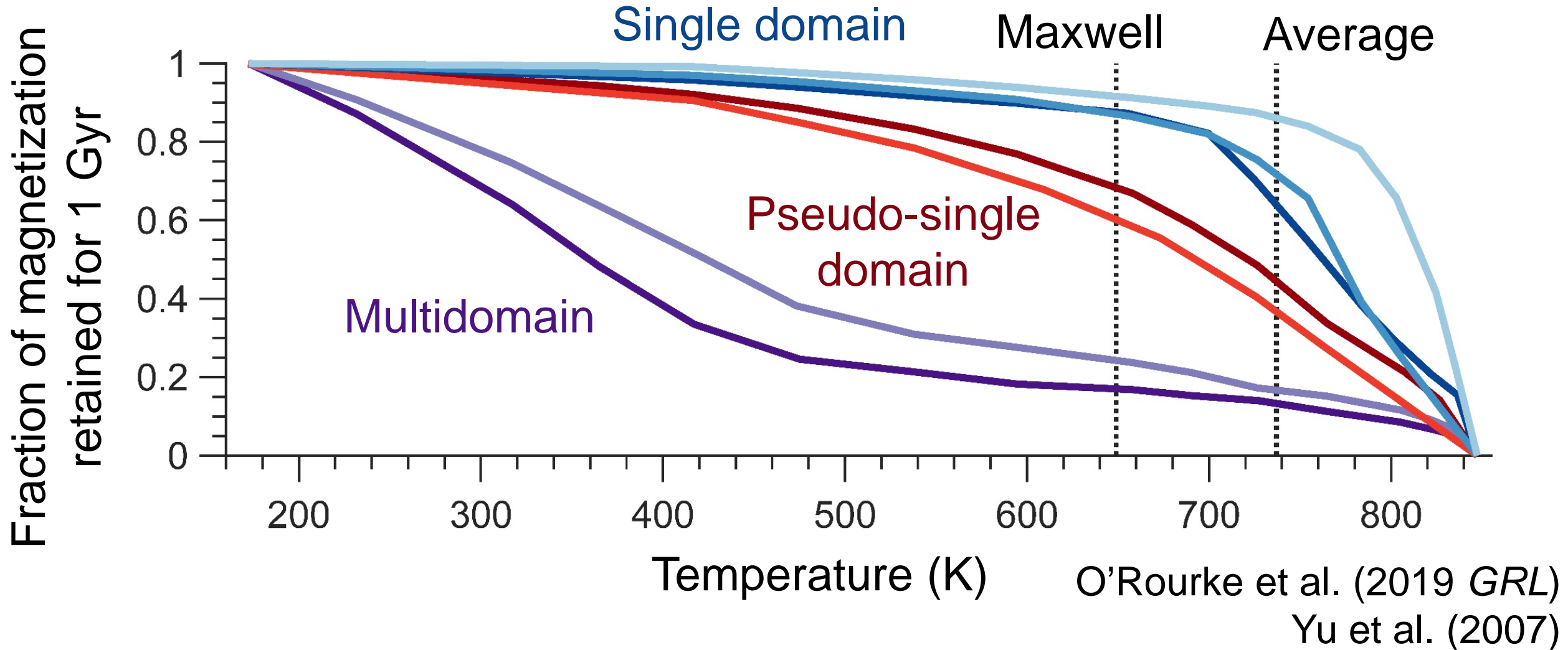


Rocks often can retain magnetism close to the Curie point

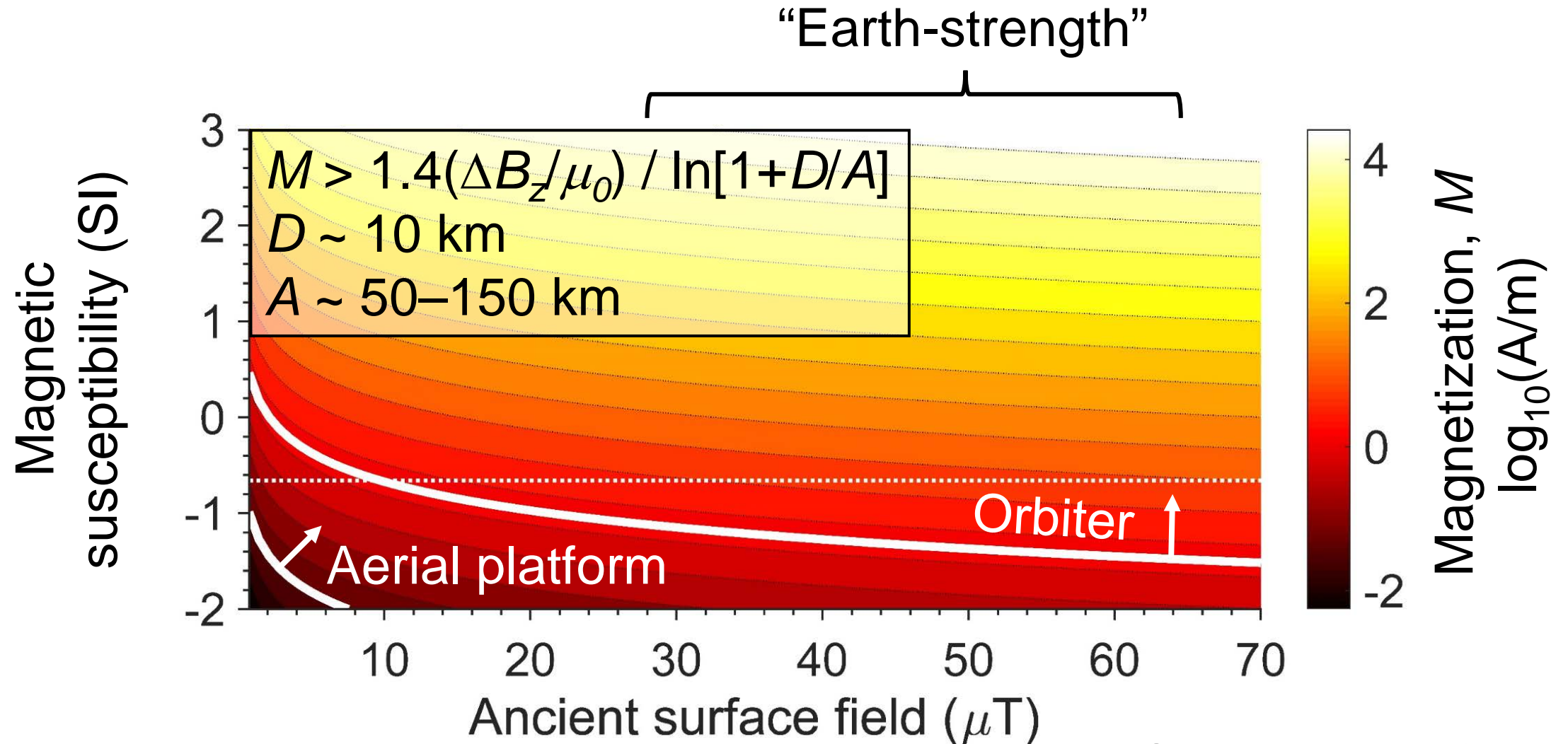
O'Rourke et al.  
(2018 *EPSL*)



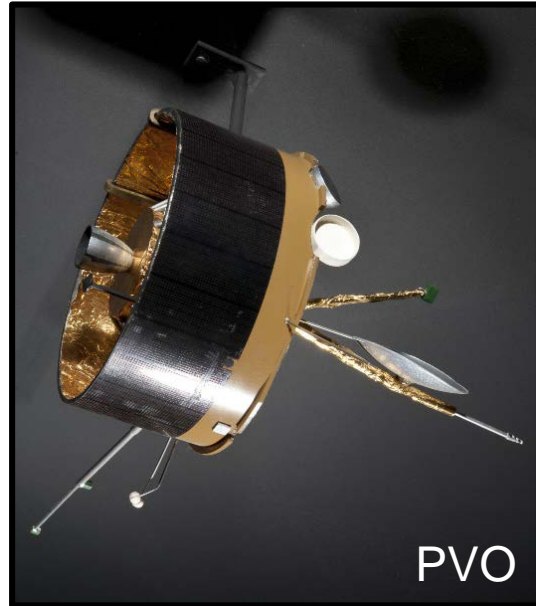
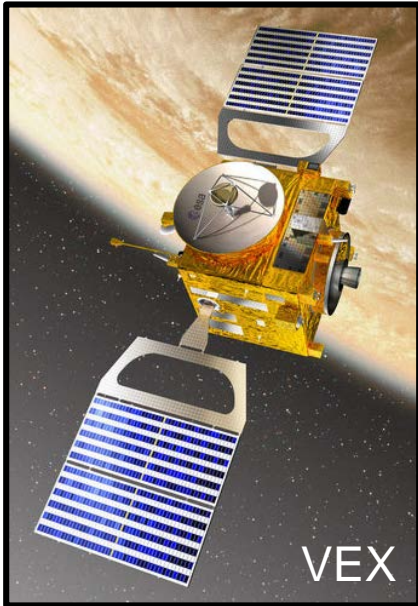
# Magnetite retains magnetization



# Magnetized crust is detectable



# Searching for crustal remanence

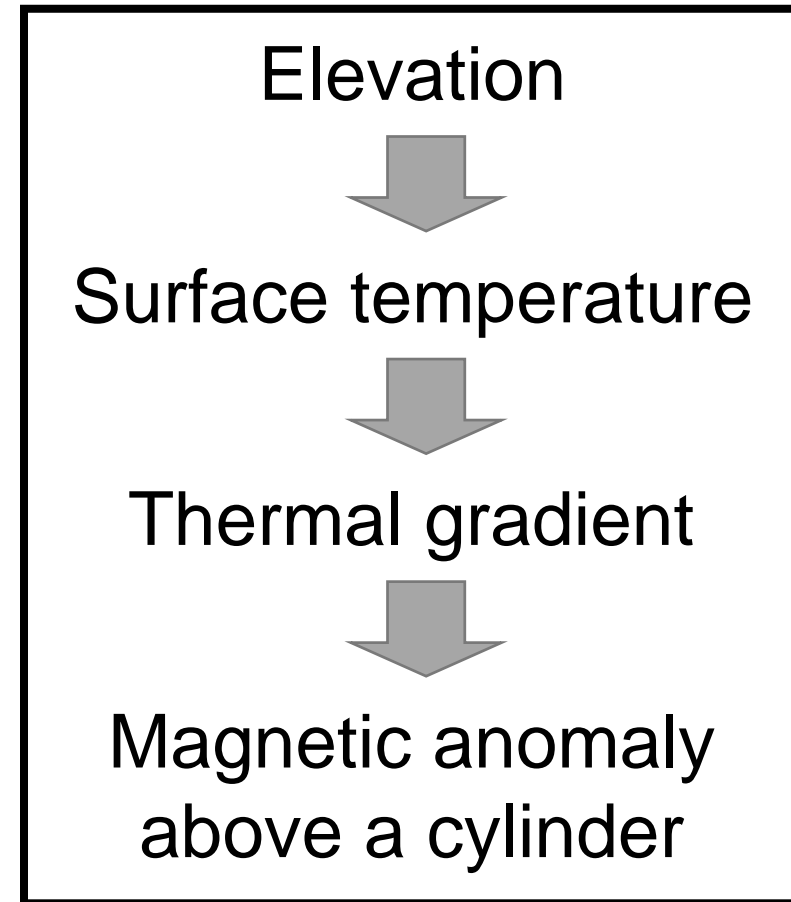
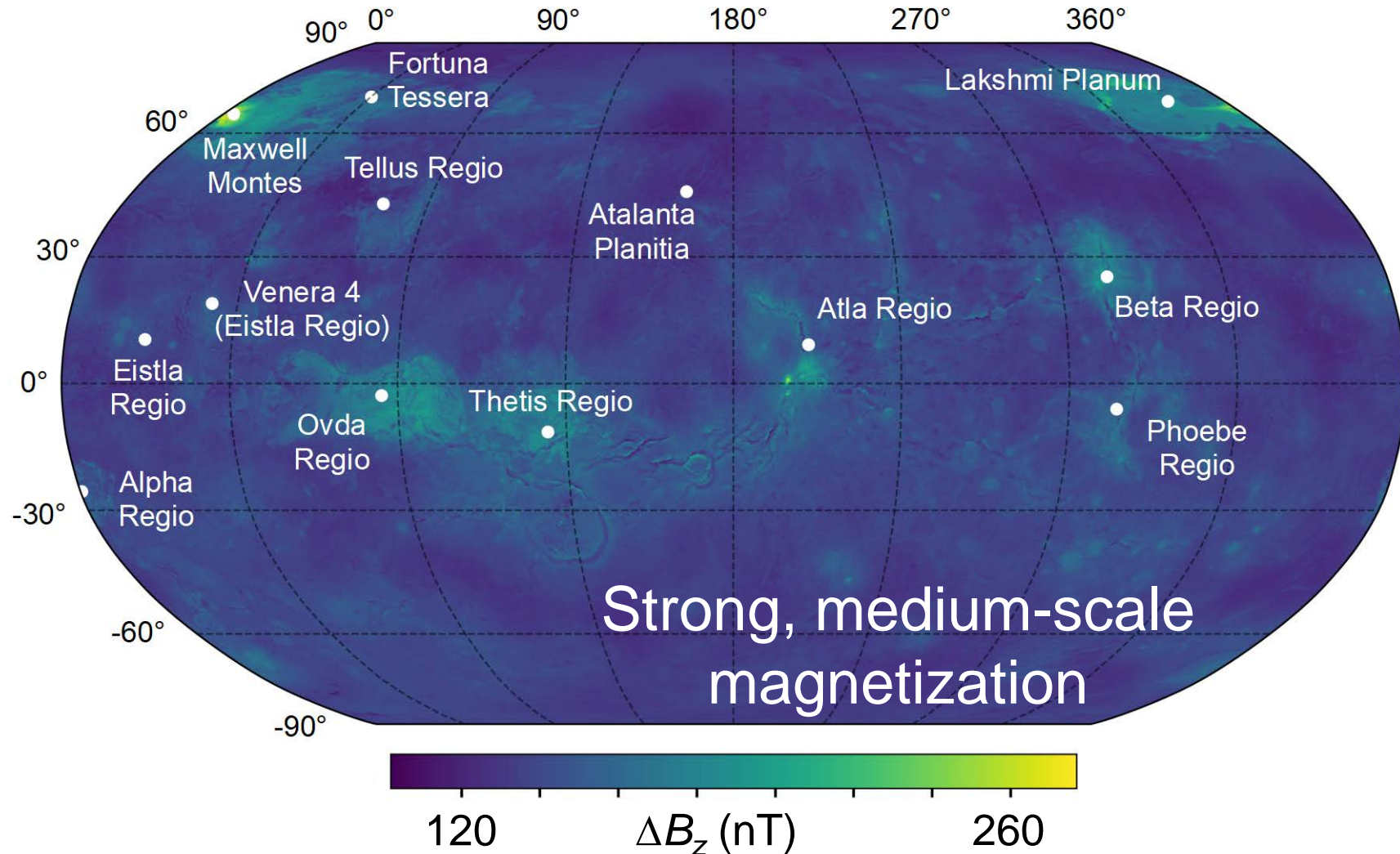


Orbiters exclude strong,  
large-scale magnetization  
only north of  $40^{\circ}$  S

Weak, large-scale or strong,  
small-scale magnetization  
could exist anywhere

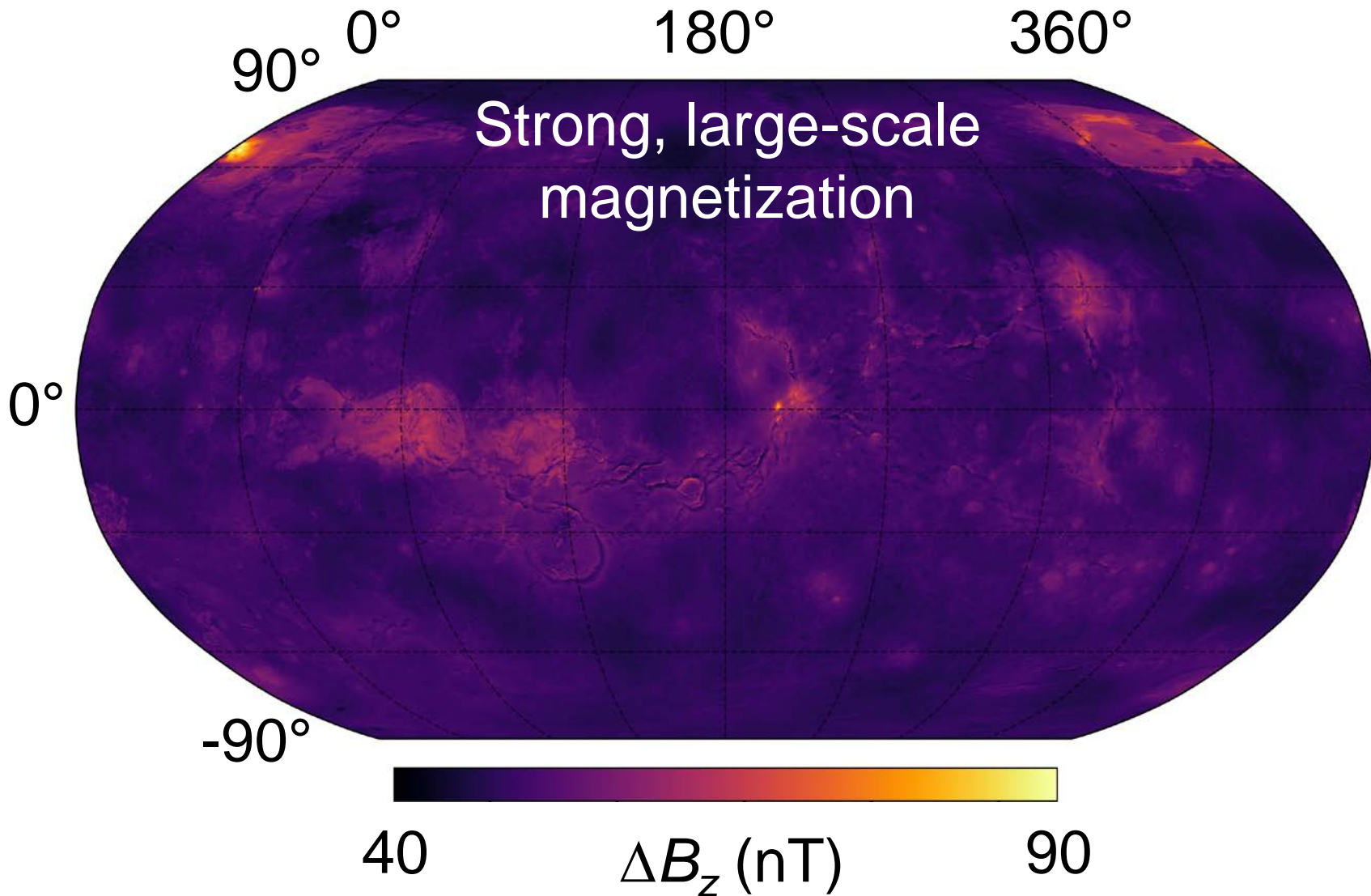


# Strong Signals for Aerial Platforms



O'Rourke et al. (2019 *GRL*)

# Orbital signals possible in the south



↑ PVO and VEX would have discovered strong >150 km-scale magnetization if it existed in the north

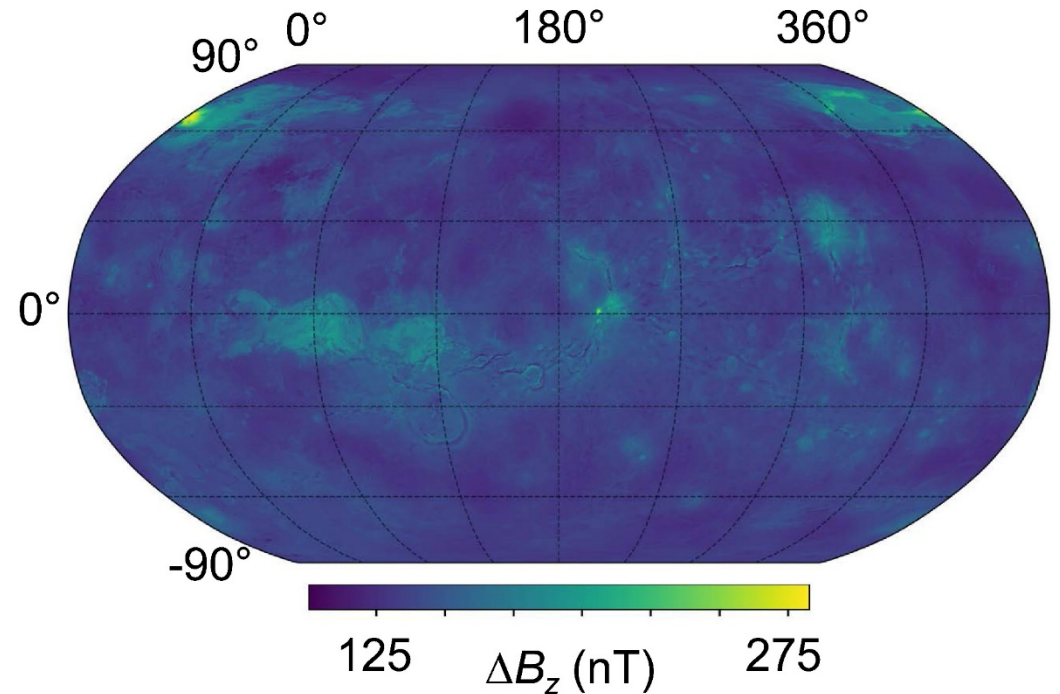
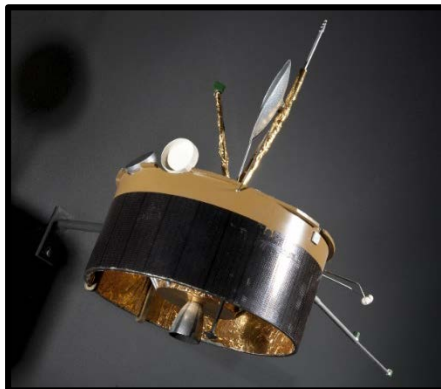
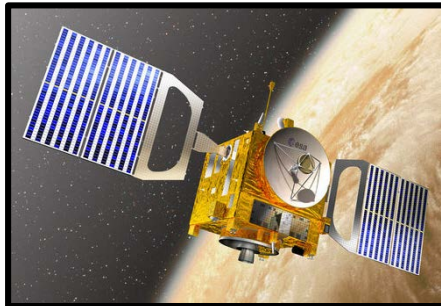
↓ Could still await discovery!

O'Rourke et al. (2019 *GRL*)



# Conclusions

Crustal remanent magnetism may await detection on Venus & would provide unique constraints on planetary climate/core composition/accretion





# Strong signals for aerial platforms

