# Venus Surface and Interior Today

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International Venus Conference 2019

Niseko, Hokkaido

# Outline/ Focus: How did Venus resurface?

“.. Venus resurfaced ~ 500 my ago…”

Did it? Is Venus geologically dead?

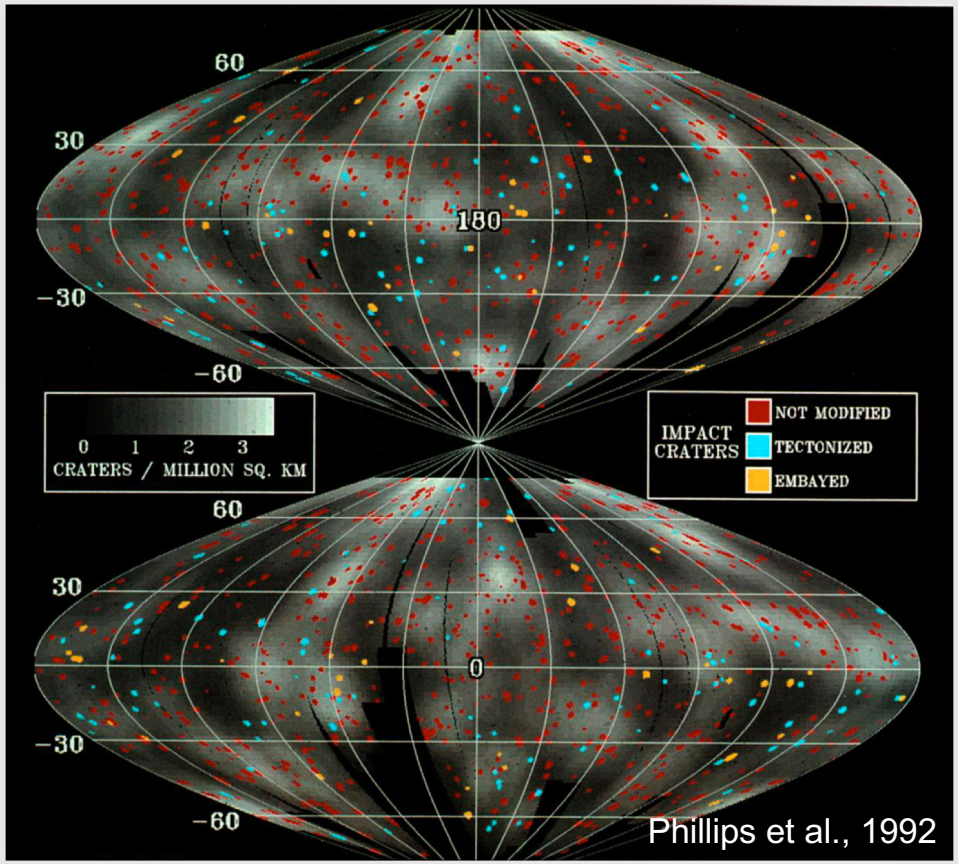
# Outline/Focus: How ~~did~~ does Venus resurface?

- ".. Venus resurfaced ~ 500 my ago…"

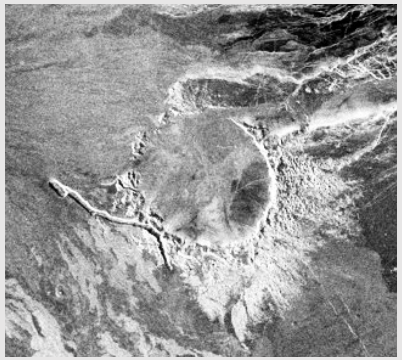
**Myth!**

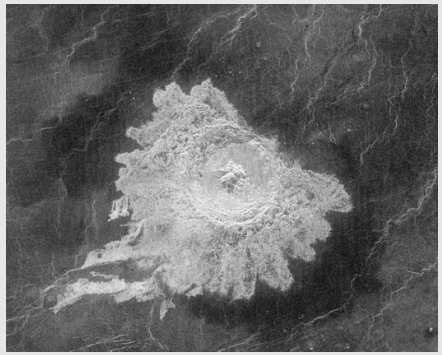
- Did it? Is Venus geologically dead?
  - Theories of resurfacing
  - Evidence for equilibrium resurfacing
- Geologic evidence for current activity
  - Emissivity anomalies
  - Interior mass distribution
  - Elastic thickness values
- Implications for the interior, surface & atmosphere

# Evidence for Catastrophic Resurfacing



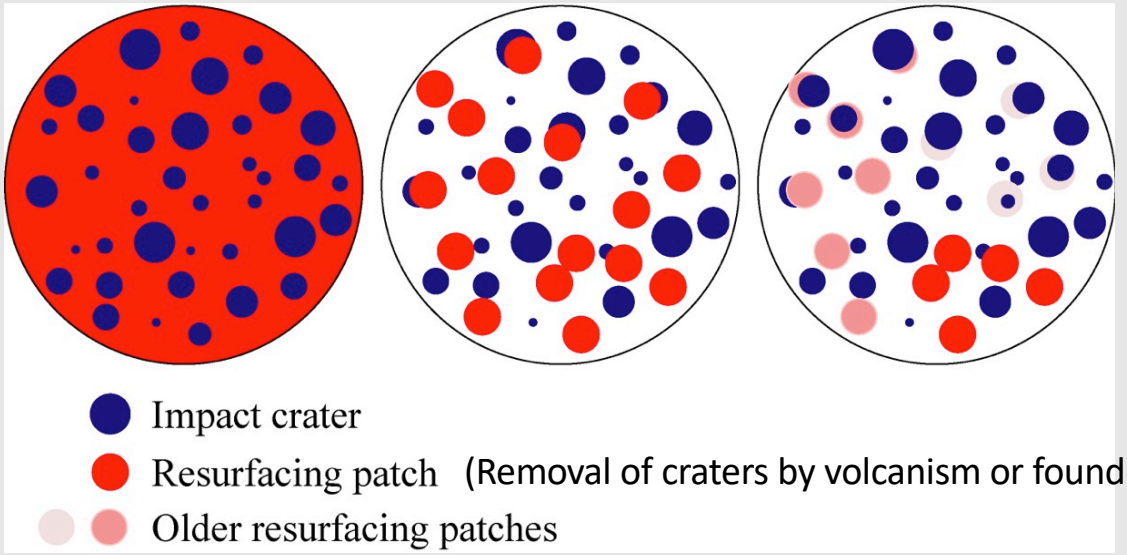

- Key observations:
  - Distribution of ~1000 craters can not be distinguished from a random one
  - Very few clearly modified craters
- Possible processes>consequences:
  - Massive volcanism> climate change
  - Lithospheric foundering > episodic (plate) tectonics





# Resurfacing Models

Catastrophic Equilibrium Regional




Successful patch radii from 100s to ~1000 km

(Removal of craters by volcanism or foundering of lithosphere)

3 possible models:

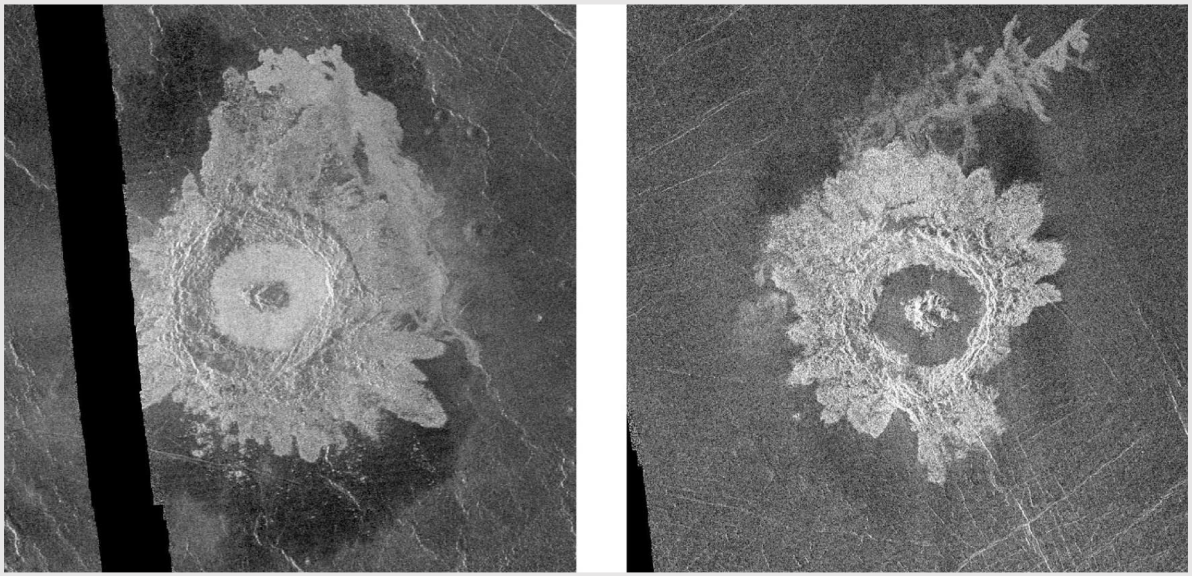
Catastrophic Resurfacing Model (CRM) [*Schaber et al.*, 1992, *Strom et al.*, 1994; *Phillips et al.*, 1992; Romeo & Turcotte, 2010]

Equilibrium Resurfacing Model (ERM) [Phillips et al., 1992]

Regional ERM (RERM) [Phillips et al., 1992; Hauck et al., 1998; Bond and Warner, 2006; Bjonnes et al., 2012; O'Rourke et al. 2014]

# Role of Volcanic Flooding

- How many craters are actually modified? 80% have dark floors
  - Herrick and Rumpf (2011) use stereo topography data for a subset of craters to suggest that dark floored craters are flooded; Implies the surface could be as young as 150 m.y.
- How old is the surface?
  - Bottke et al. (2016) suggest that impacts are due to Near Earth Objects; surface age ~130-250 m.y.



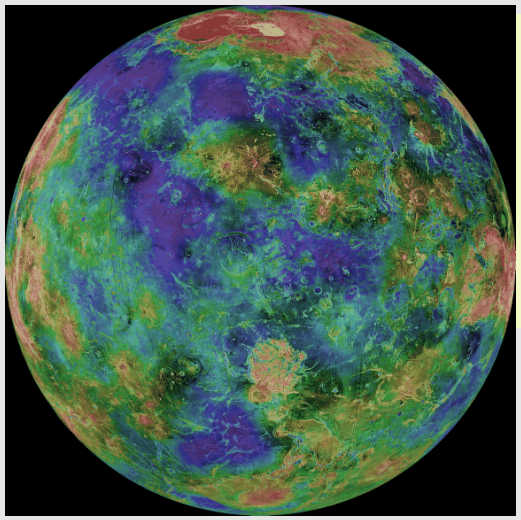
What makes crater floors radar dark?

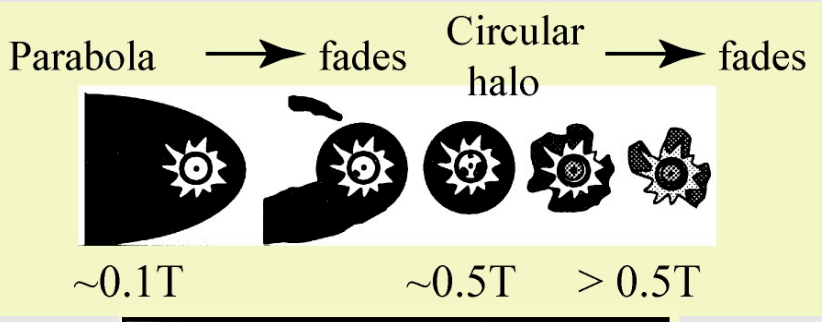
Volcanism?

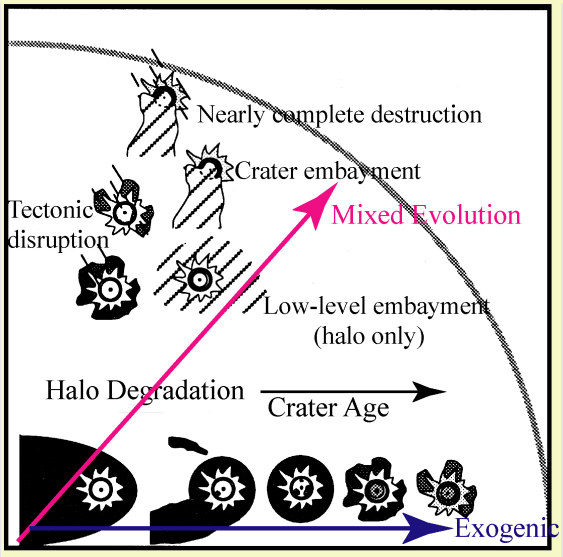
Aeolian fill?

# How is Extended Ejecta Removed?

- Models that account for erosion of 'halos' prefer equilibrium models (Phillips and Izenberg, 1995).





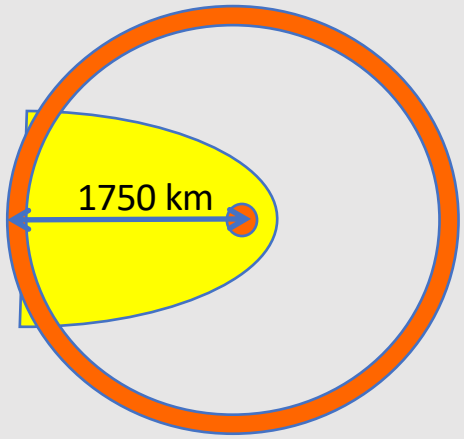




Erosion removes only halos
> high crater density & low halo density
> Relatively older areas

Volcanism removes halos & craters
>low crater and halo density
> Relatively young areas

# Method

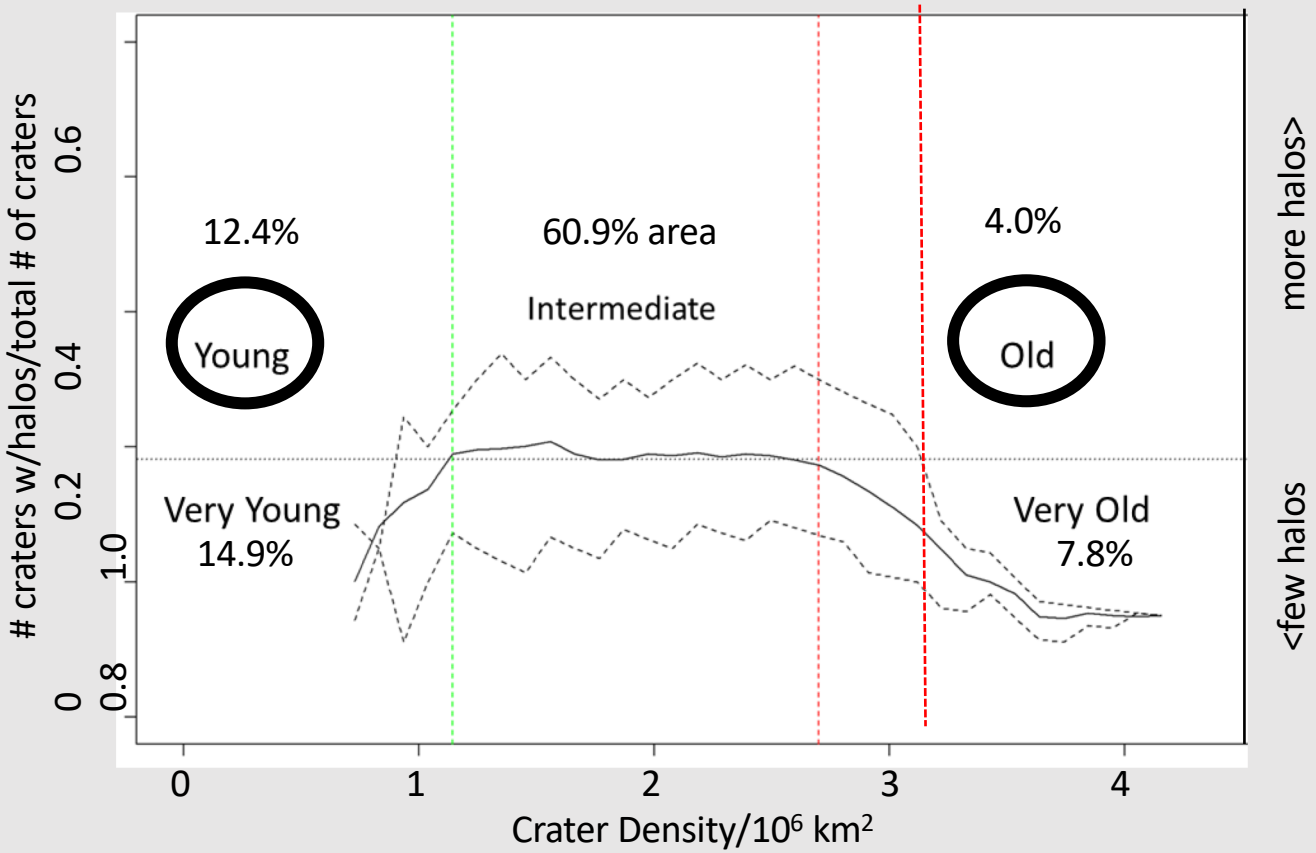
- Two approaches for counting circles:
  - 60,000 equal spaced points on a sphere
  - Centered on 1000 craters only
- Equal area counting circle radius = 1750 km (length of the largest parabola)
- Counting circles diam. of 1650, 3500, 8000 and 12000 km also examined; only 3500 km circles give the illustrated results, consistent with focus on parabola removal



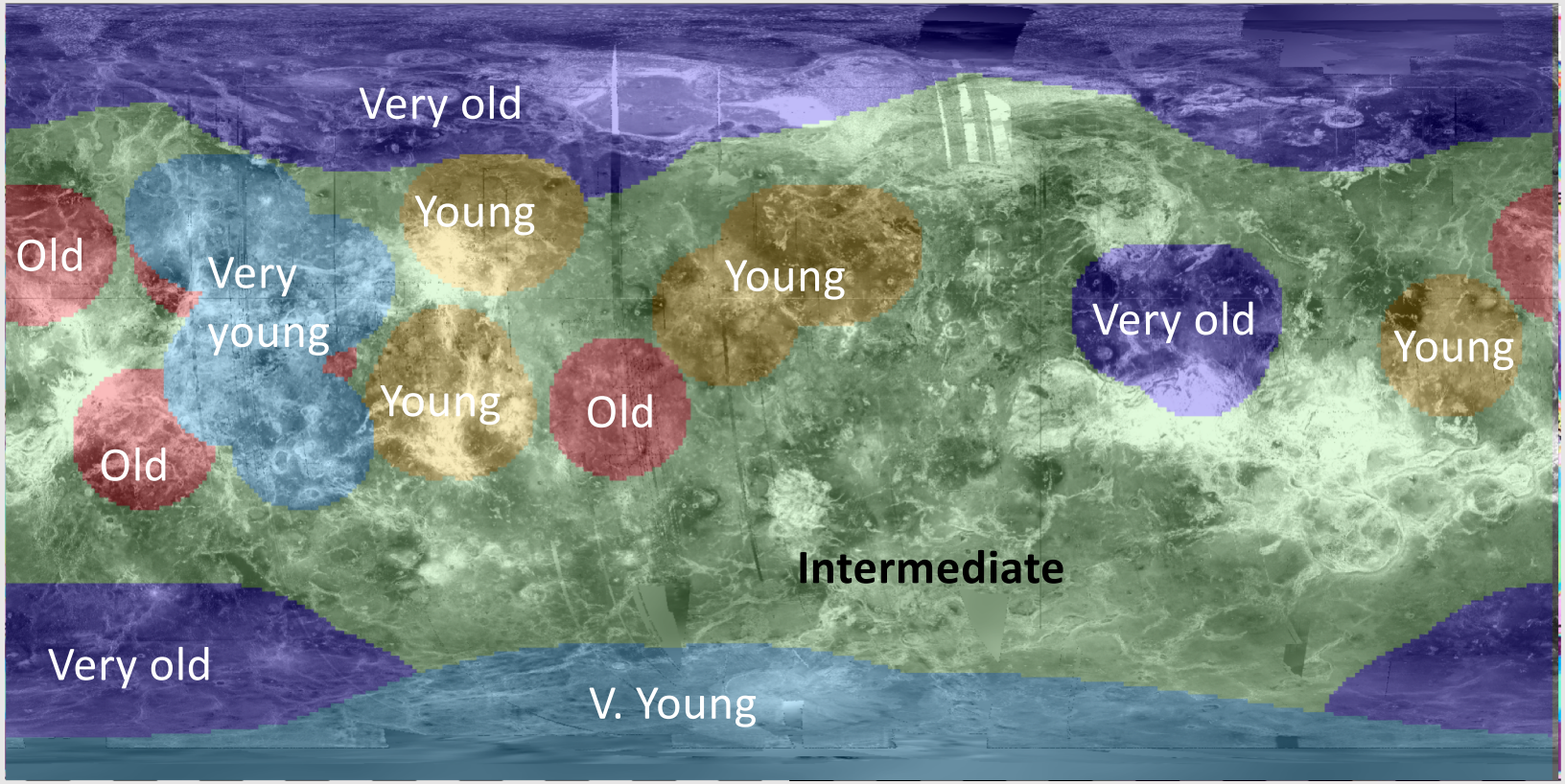

Caveats:

- Parabolas and craters may be masked in tessera or other rough areas
- Counting circle is 3500 km; smaller scale features are not well characterized

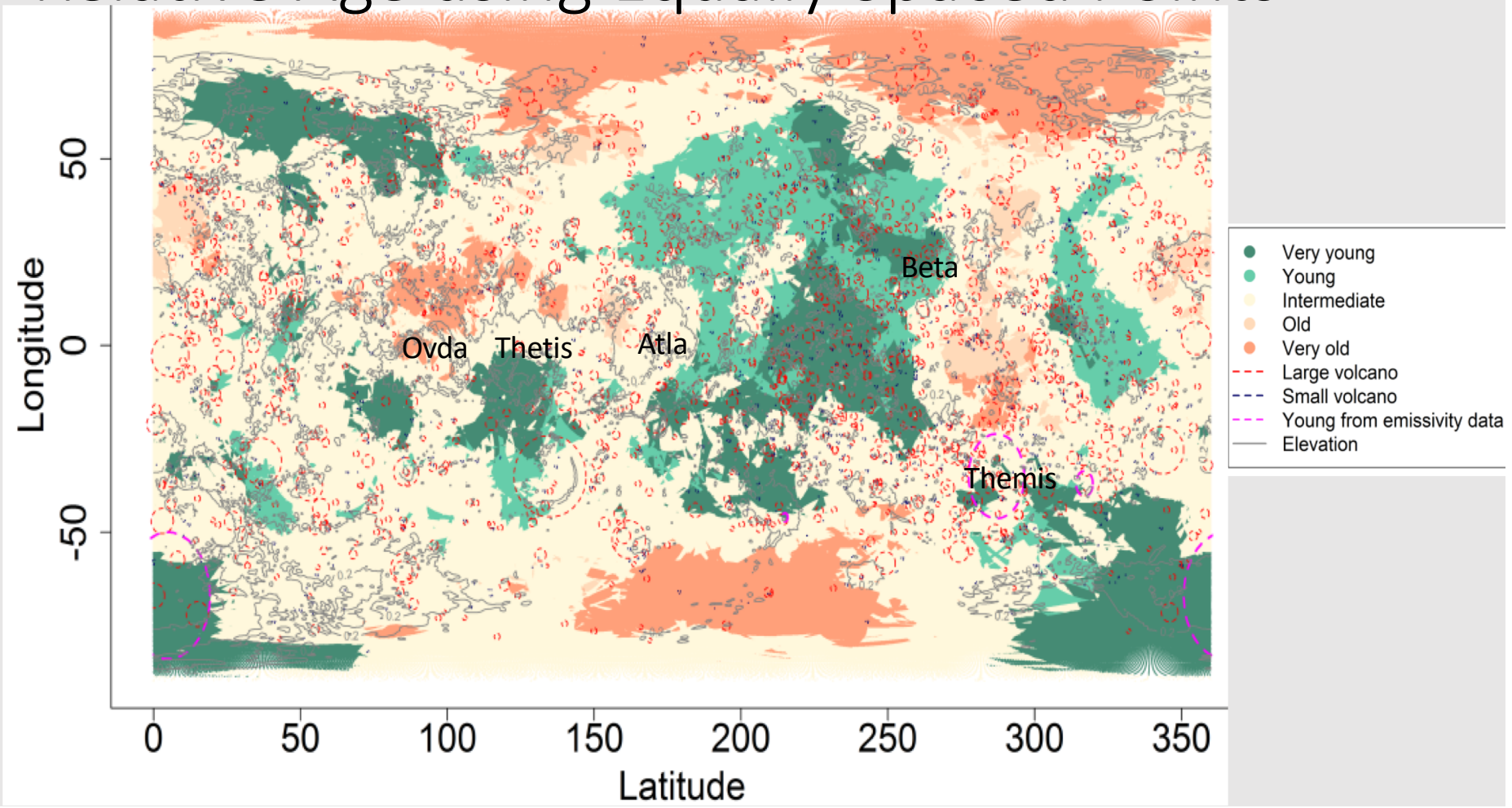
# Halo & Crater Density as a Relative Age Indicator



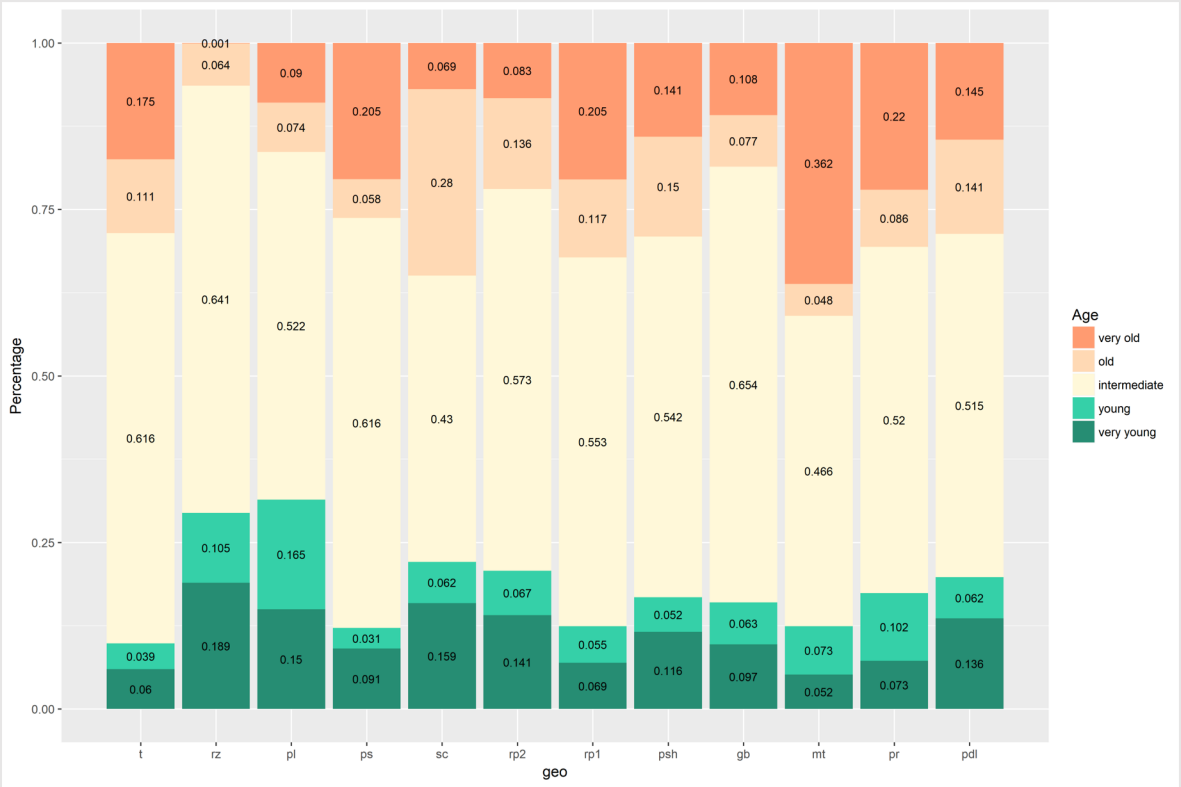
# Relative Age using Crater-Centered Circles

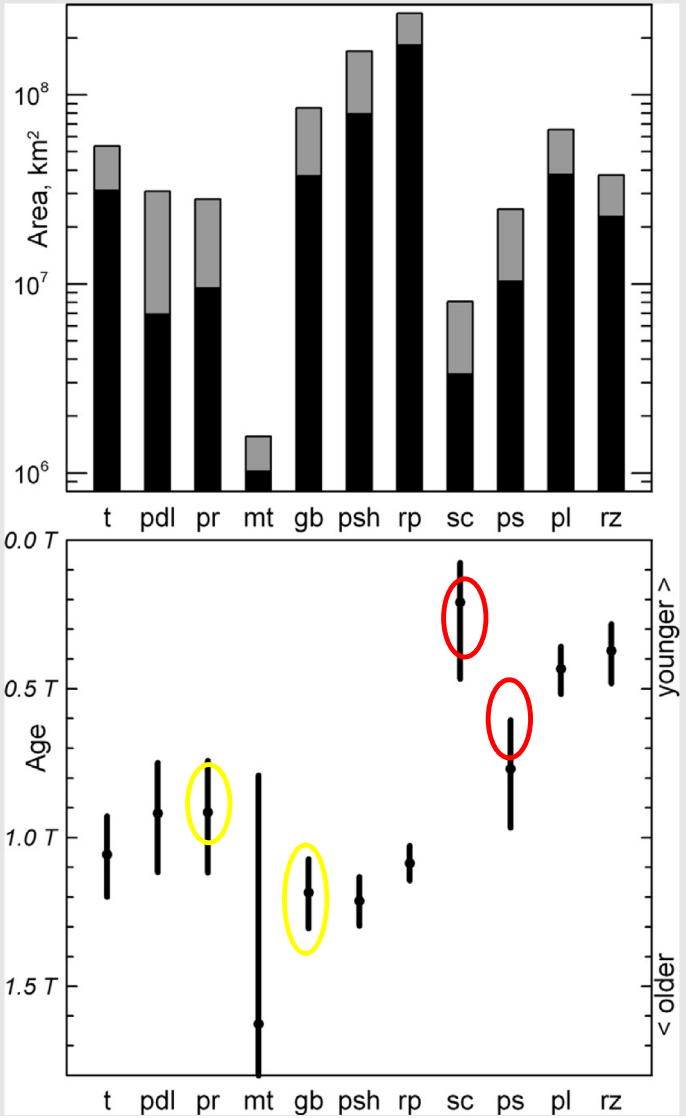


# Relative Age using Equally Spaced Points



# Comparison to geologic unit relative age

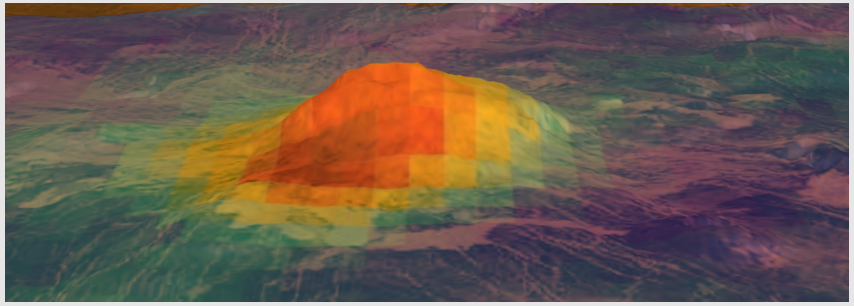


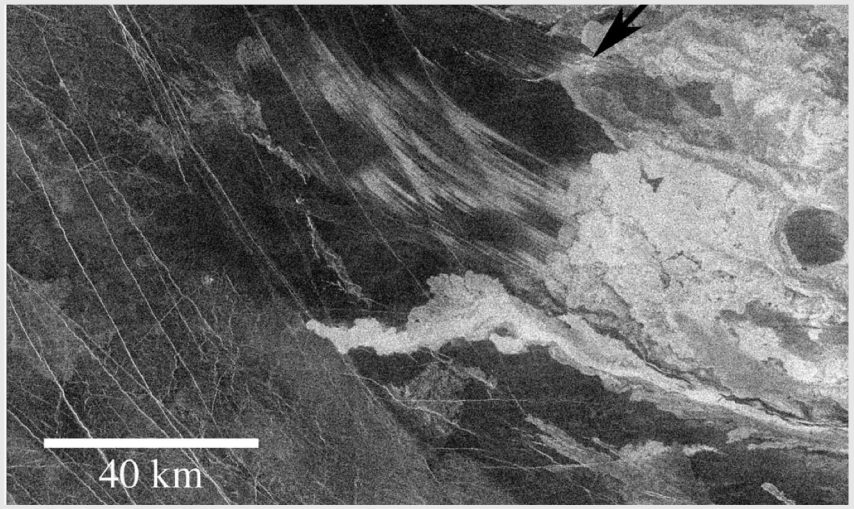




Kreslevsky, Ivanov & Head, 2015

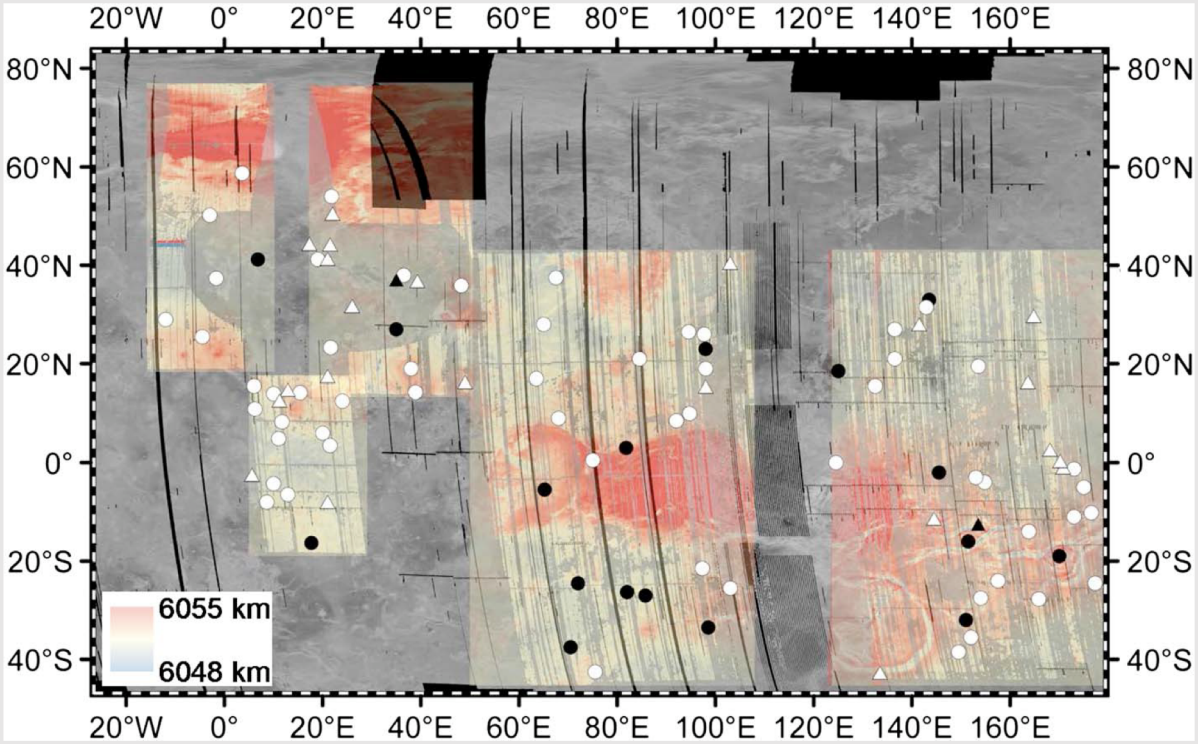
# Evidence for Recent Volcanism

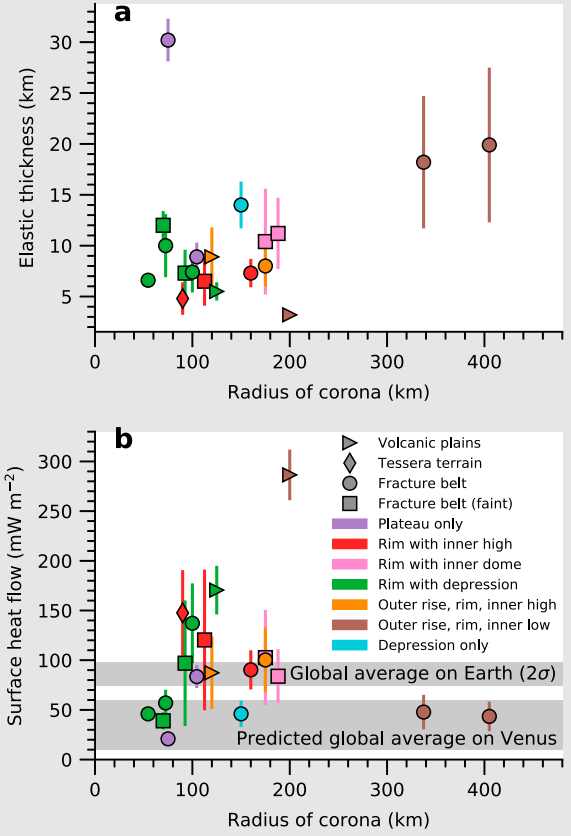
- VIRTIS high emissivity anomalies suggest ‘recent’, unweathered volcanism
  - Helbert et al., 2008; Mueller et al., 2008; Smrekar et al., 2010.
- Weathering, as observed in the NIR, is likely to occur on timescale of years
  - Filiberto et al. LPSC 2019; Teffeteller et al. LPSC. 2019
- Pyroclastic deposits are ‘rapidly’ (10s my?) eroded by winds
  - Campbell et al. 2017
- Variations in atmospheric $SO_2$
  - Marcq et al. 2012





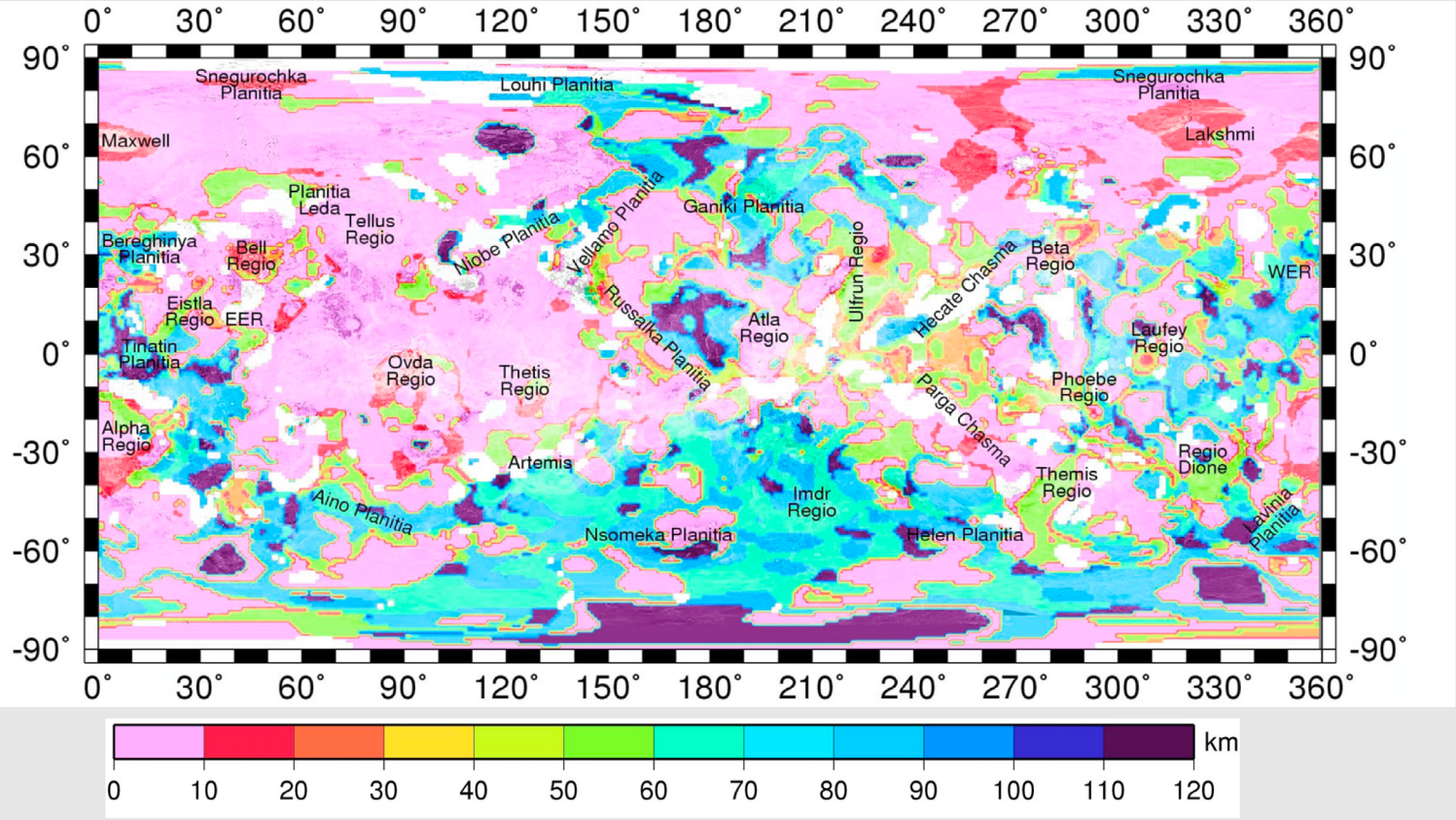
# Evidence for locally thin lithosphere: Coronae




Coronae with a topographic flexure signature in stereo topography
O'Rourke and Smrekar, 2018

# Evidence for Regionally Thin Lithosphere



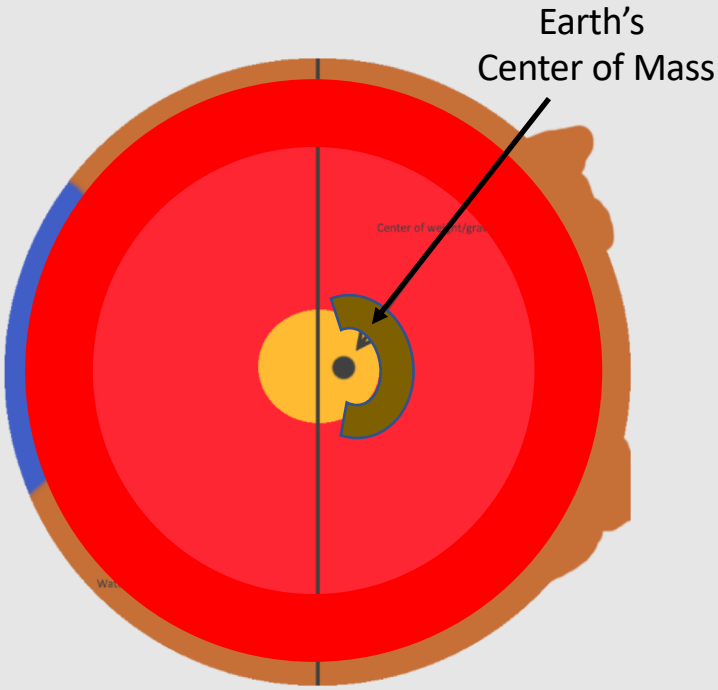

Anderson and Smrekar, 2006

Local and regional Values generally agree> many areas of thin lithosphere

"A key finding is that the lithospheric properties typically vary over scales of 1000 km or less except in some plains and crustal plateau regions."

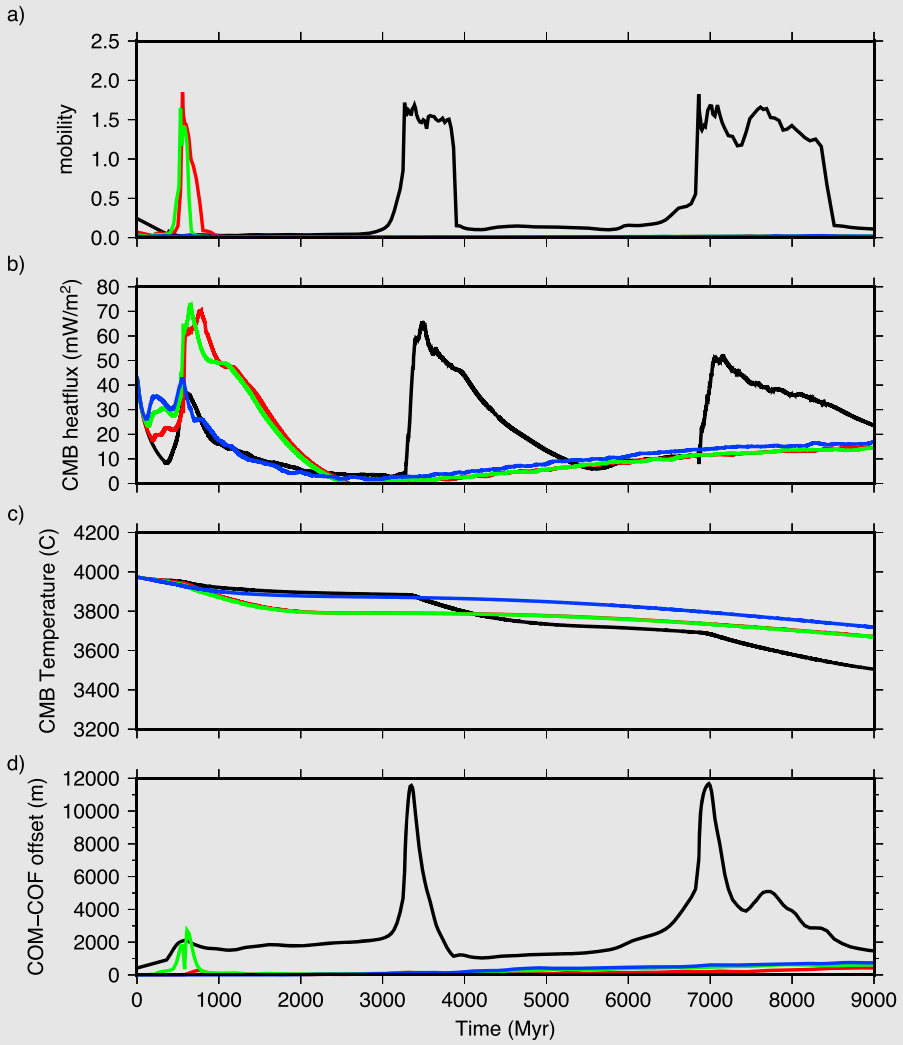
# Geophysical Evidence Against Catastrophic Overturn-1

- Venus' center of figure – center or mass offset is
  - 280 m
  - 2.1 km on Earth
- Global overturn implies that huge amount of cold material are transported to the core-mantle-boundary (CMB) – surface area is ~4x that of the CMB.
  - E.g. , a 100 km thick thermal lithosphere would produce a ~400 km thick layer at the CMB



# Geophysical Evidence Against Catastrophic Overturn

- King (JGRP, 2018) runs a series of numerical simulations of global mantle overturn to show that if there is significant overturn within the last 750 m.y., the CF-CM offset would be much larger.



# Venus is likely still resurfacing!

**Implications**

- **Surface:**
  - **Resurfacing generally occurs on scales < 1300 km**
  - **Multiple mechanisms, in addition to volcanism are possible**
    - **Plume-induced subduction (Davaille et al. 2017)**
    - **Crustal blocks (Byrne et al. 2018)**
  - **Not all areas must be the same avg. age**
- **Interior:**
  - **No requirement for episodic overturn**
  - **Models should consider regionally variable lithospheric thickness, and processes that produce resurfacing**
- **Atmosphere:**
  - **Likely affected by volcanic outgassing and surface weathering**