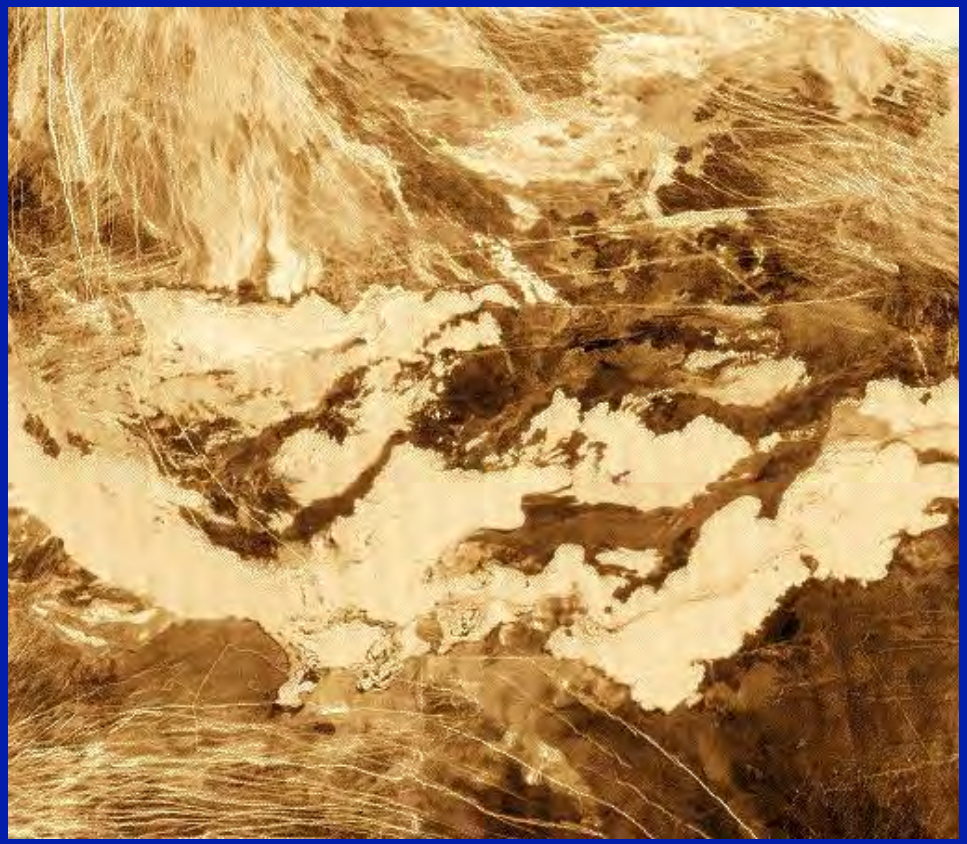
ASCENT AND ERUPTION OF MAGMA ON VENUS: CHANGES OF STYLE WITH GEOLOGIC TIME .

Lionel Wilson[1,2] and James W. Head[2]

[1]Lancaster University, [2] Brown University



Factors controlling volcanism on Venus:

1) Atmosphere: Presence, absence, density, pressure, thermal structure:
-Influences presence/absence, nature and structure of explosive eruptions, vesicularity/density of surface rocks.

2) Surface Temperature: Ambient, day/night:
-Influences cooling of lava flows, lengths, characteristics (pahoehoe/'a'a).

3) Crustal stratigraphy and density structure: Neutral Buoyancy Zones
-Can inhibit magma rise, form shallow reservoirs, encourage differentiation.

4) Thickness of Lithosphere: Nature of thermal boundary layer, brittle-ductile transition, and changes with time.
-Influence diapir rise rates & stalling depths, magma accumulation.
Determines whether lava flows are volume-limited or cooling-limited.

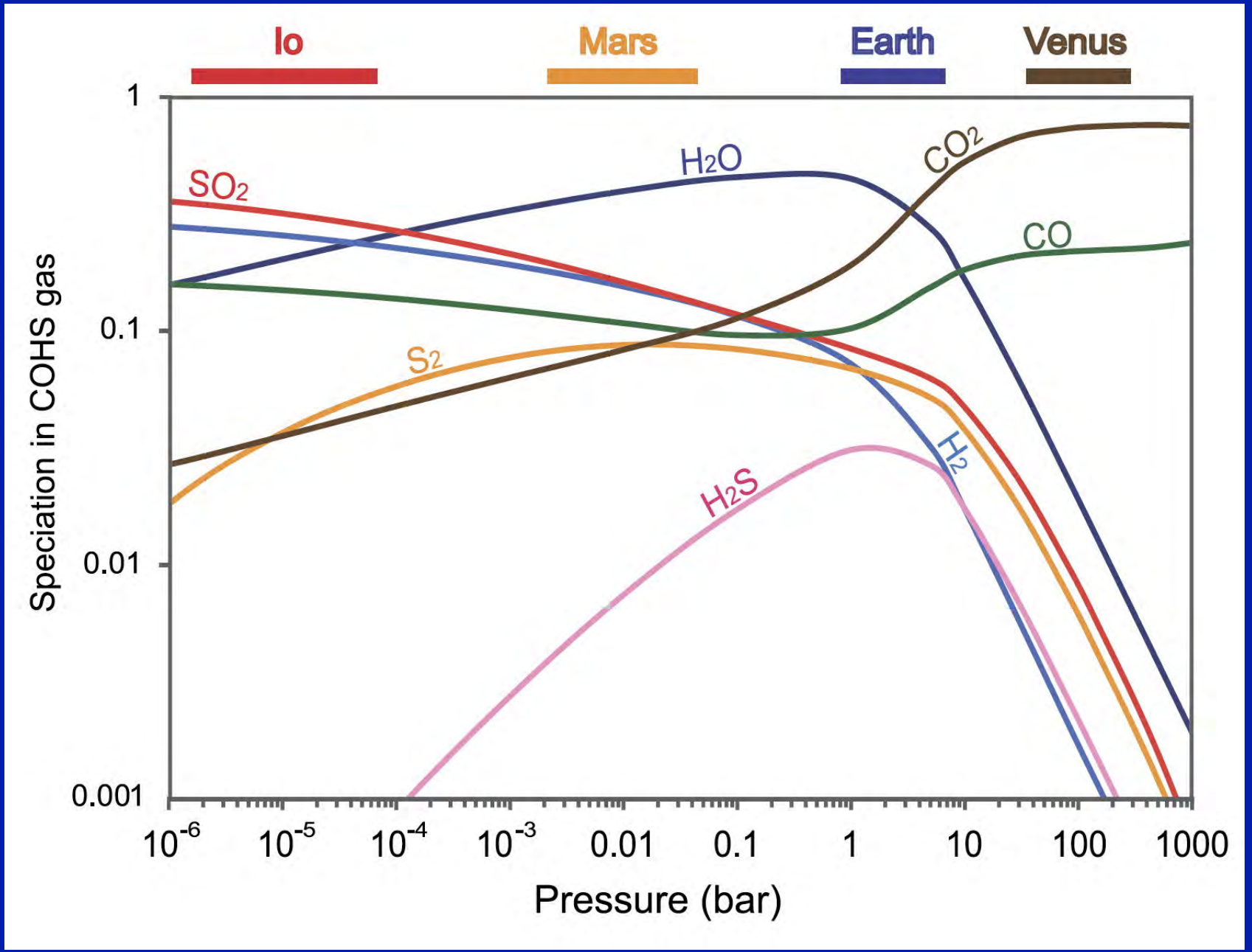
5) Global or Local Lithospheric State of Stress: Extensional, contractional.
-Can readily enhance or inhibit ascent and eruption of magma.

Can you have explosive eruptions on Venus?

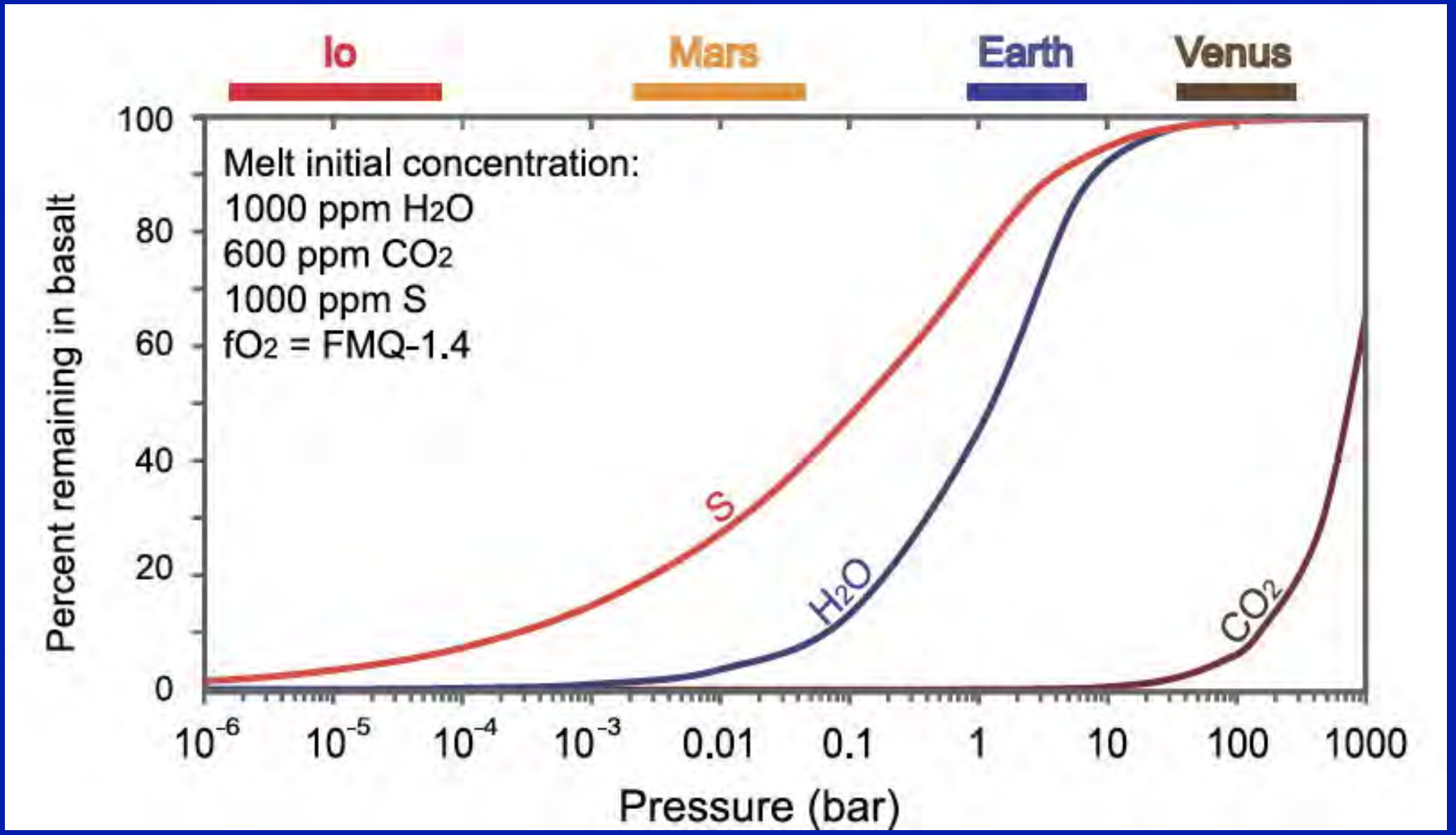
Minimum total volatile contents, n_{tot}, and minimum mafic magma source depths, D, to ensure steady explosive activity on Venus for 4 MPa and 9 MPa surface pressures.

Volatile Species	4 MPa pressure		9 MPa pressure	
	n_{tot} /wt%	D /km	n_{tot} /wt%	D /km
H_2O	1.1	1.1	2.3	3.0
CO_2	1.9	33	4.2	72

Implies that large (by Earth standards) magma volatile contents would be needed for explosive activity.



From Gaillard, F. and Scaillet, B. (2014) Earth Plan. Sci. Lett. 403, 307-316.



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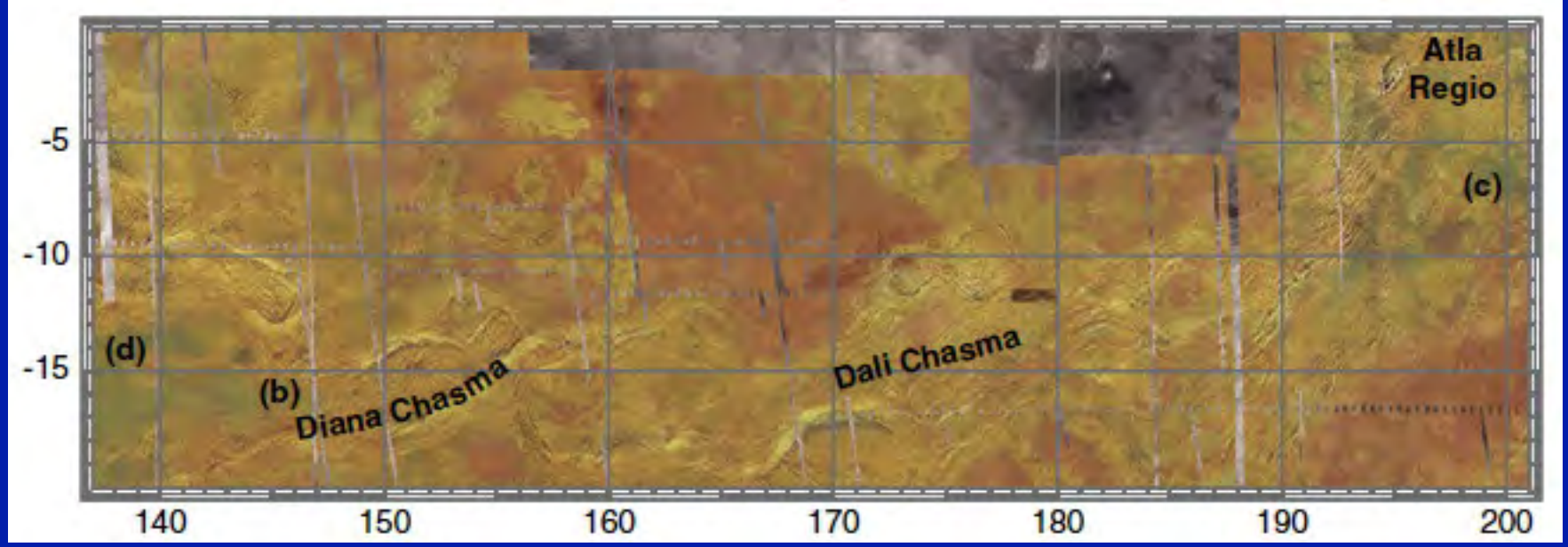
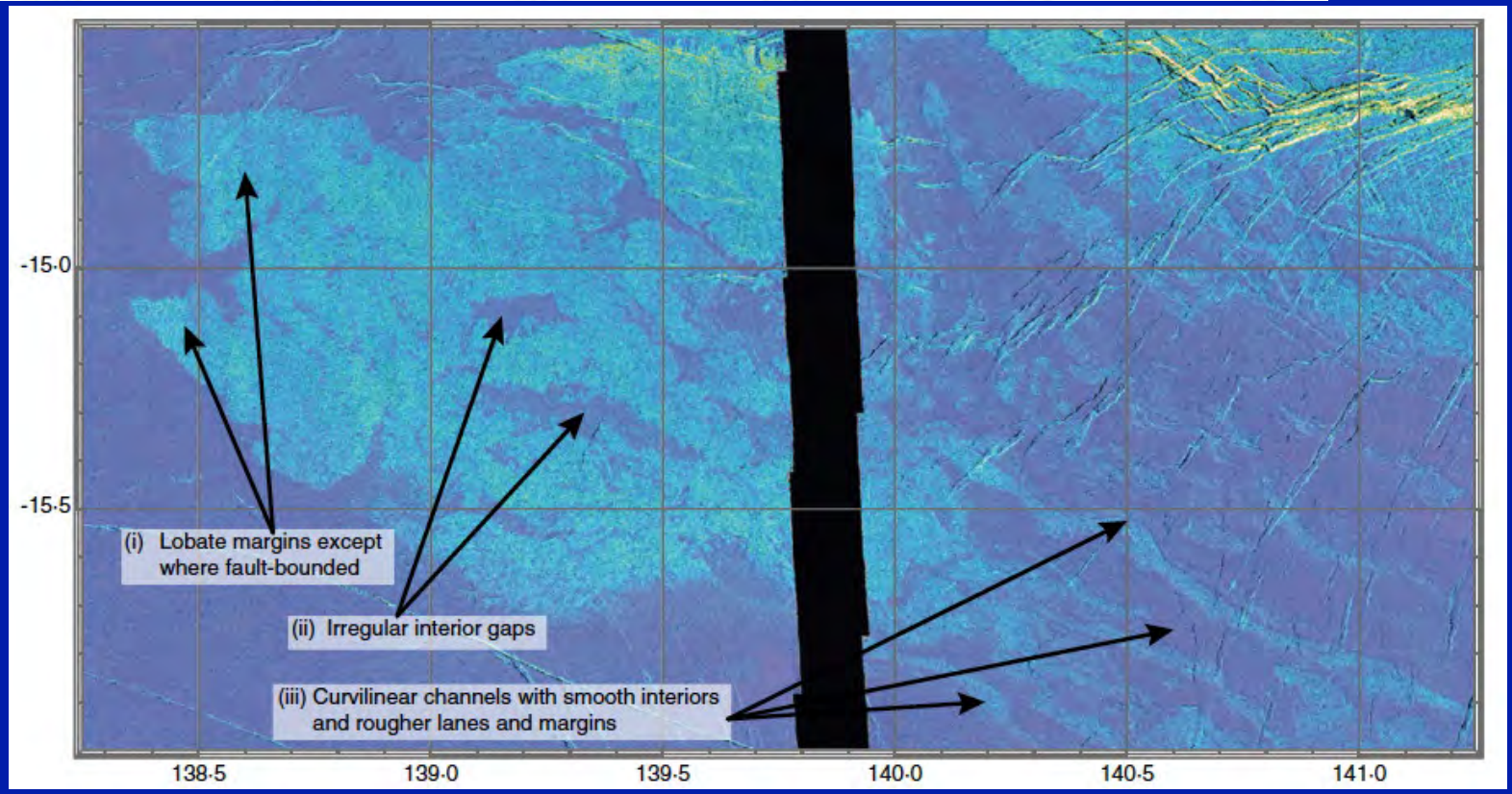
Pressure /bar	Bubble volume % when total CO_2 is: 600 ppm	1200 ppm	2400 ppm
40	57	59	63
50	51	54	58
60	47	49	53
70	43	45	49
80	40	42	46
90	37	39	43

Implication is no explosive activity without some kind of concentration of volatiles: CO_2 collection at top of reservoir; strombolian activity in low-rise-speed magma; vulcanian activity in low-volume-flux activity.





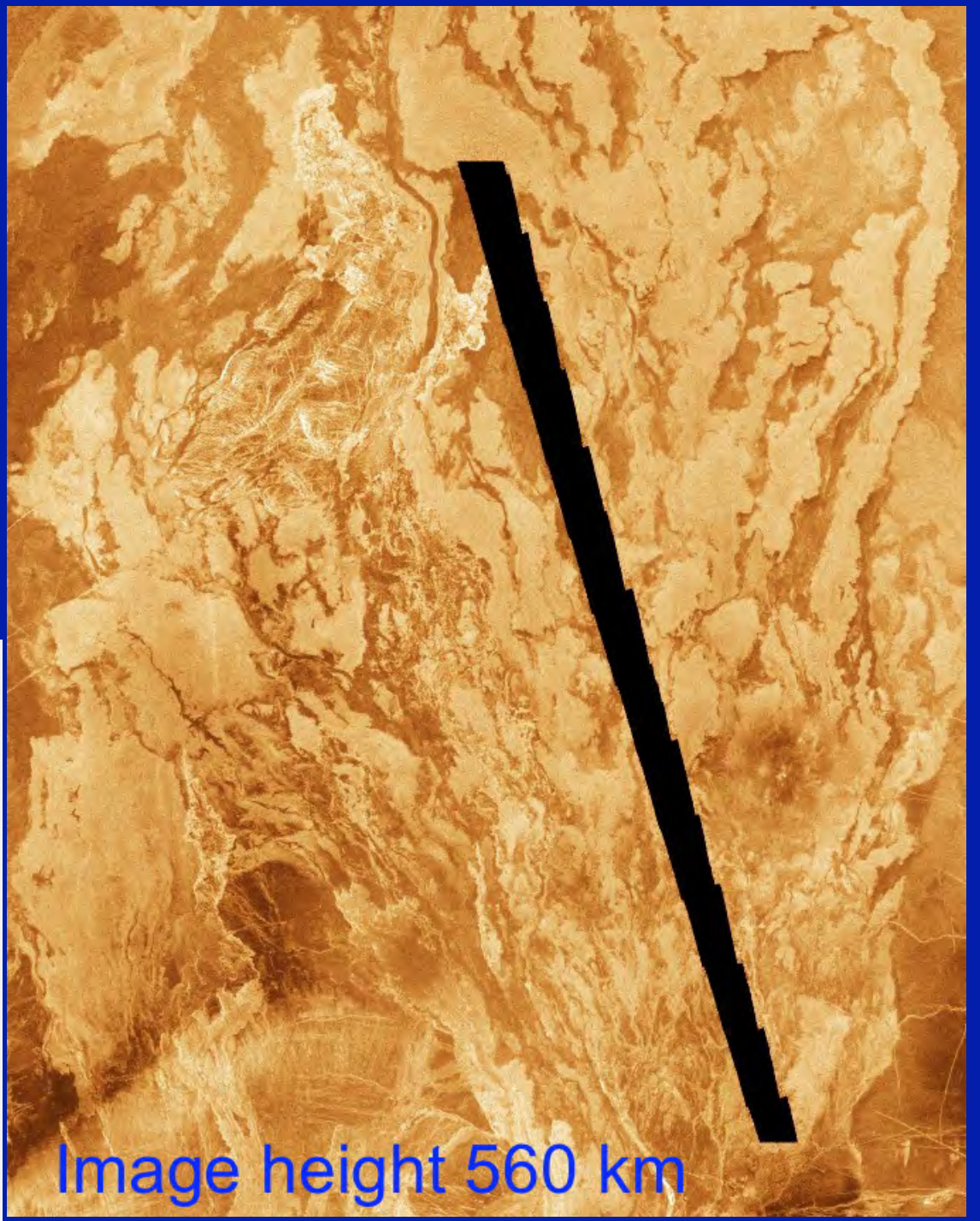
Ghail, R. C. and Wilson, L. (2014) A pyroclastic flow deposit on Venus. In Volcanism and Tectonism Across the Inner Solar System. Geol. Soc. London, Special Publication 401.

Possible

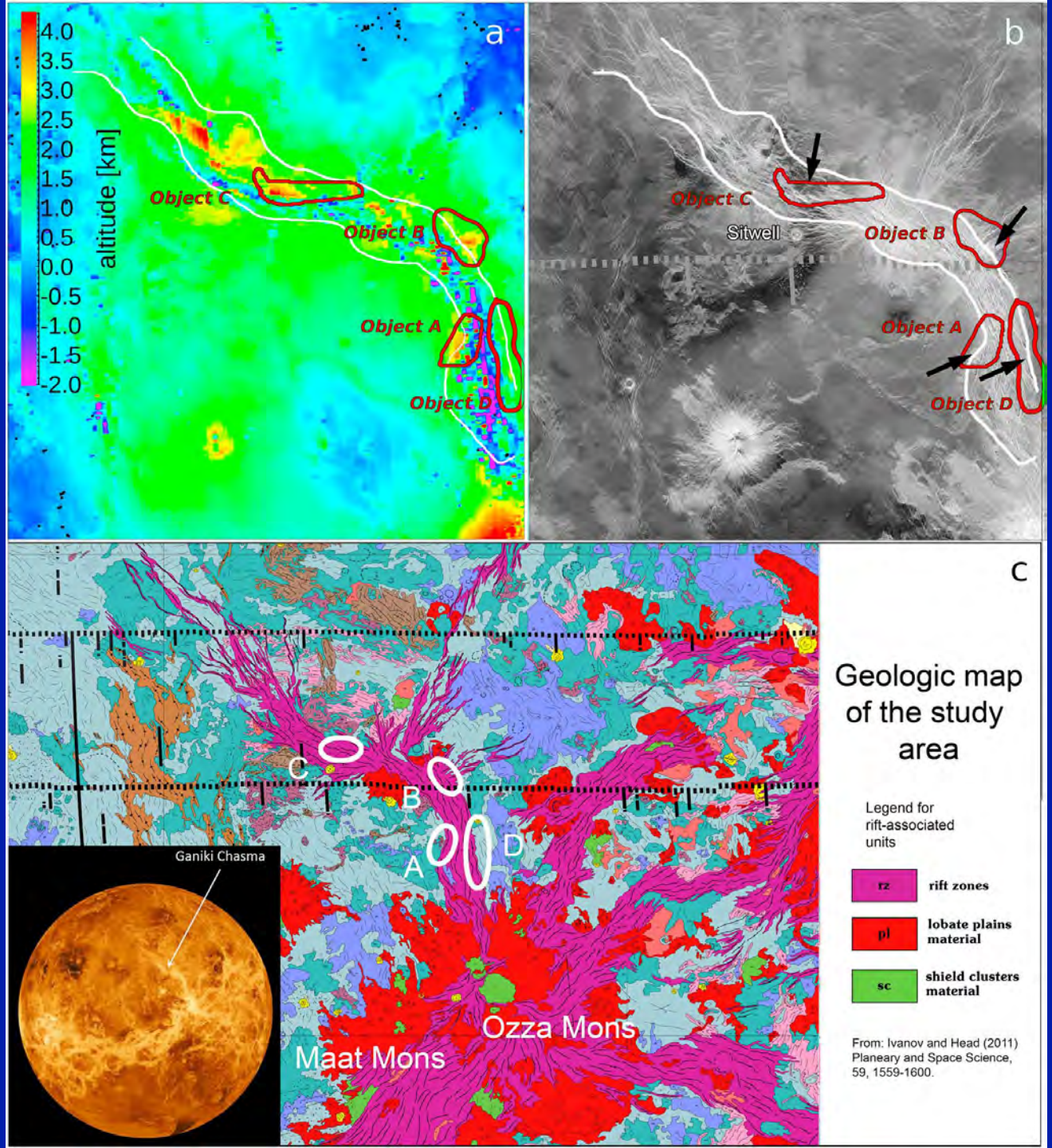
but

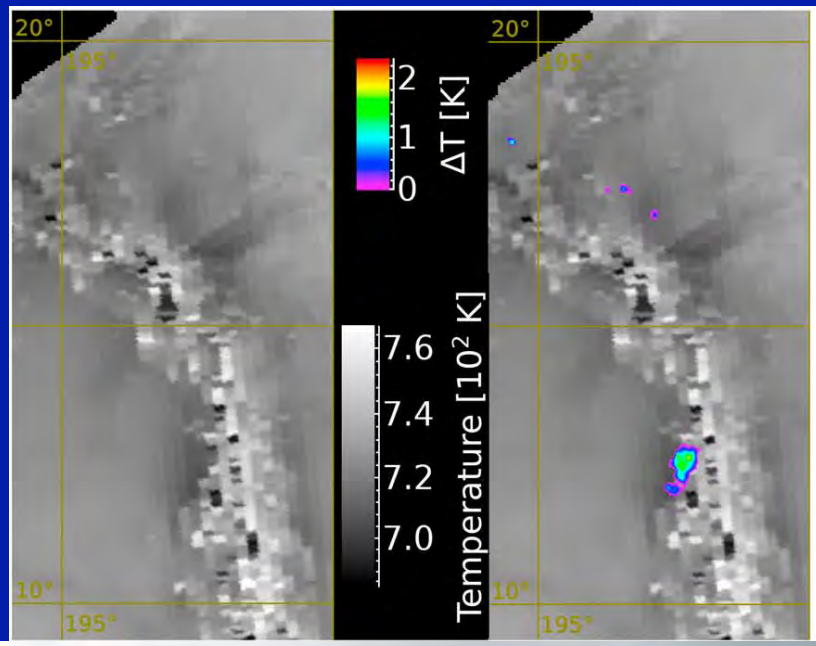
much more likely.

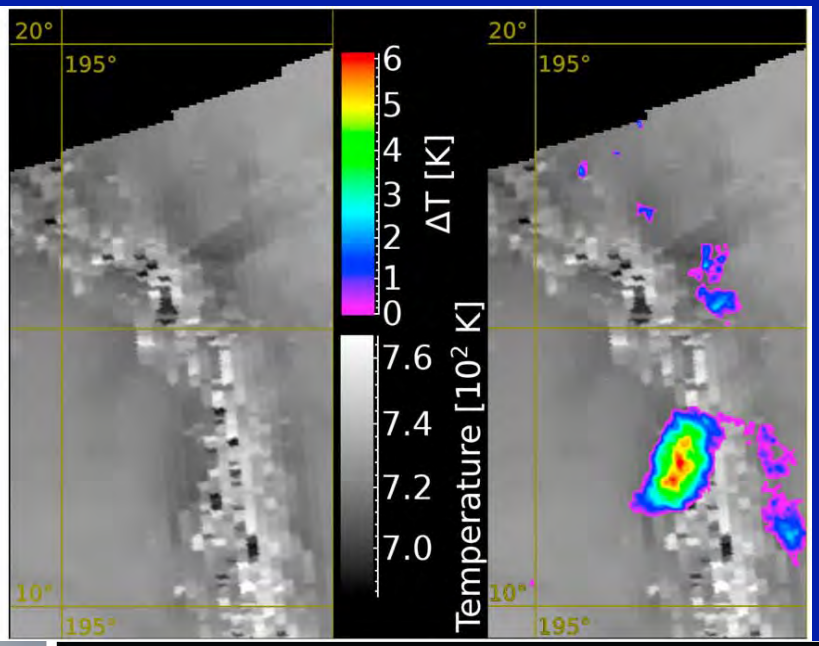
Thickness (poorly constrained) and length are keys to finding eruption conditions; extremely long flows imply very large effusion rates if they are cooling-limited; more likely to be supply volume-limited.



Shalygin, E. V., Markiewicz, W. J., Basilevsky, A. T., Titov, D. V., Ignatiev, N. I. and Head, J. W. (2015) Active volcanism on Venus in the Ganiki Chasma rift zone. Geophys. Res. Lett., 42, 4762–4769, doi: 10.1002/2015GL064088




20°
195°
10°
195°
2
1
0
ΔT [K]
7.6
7.4
7.2
7.0
Temperature [10² K]


20°
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6
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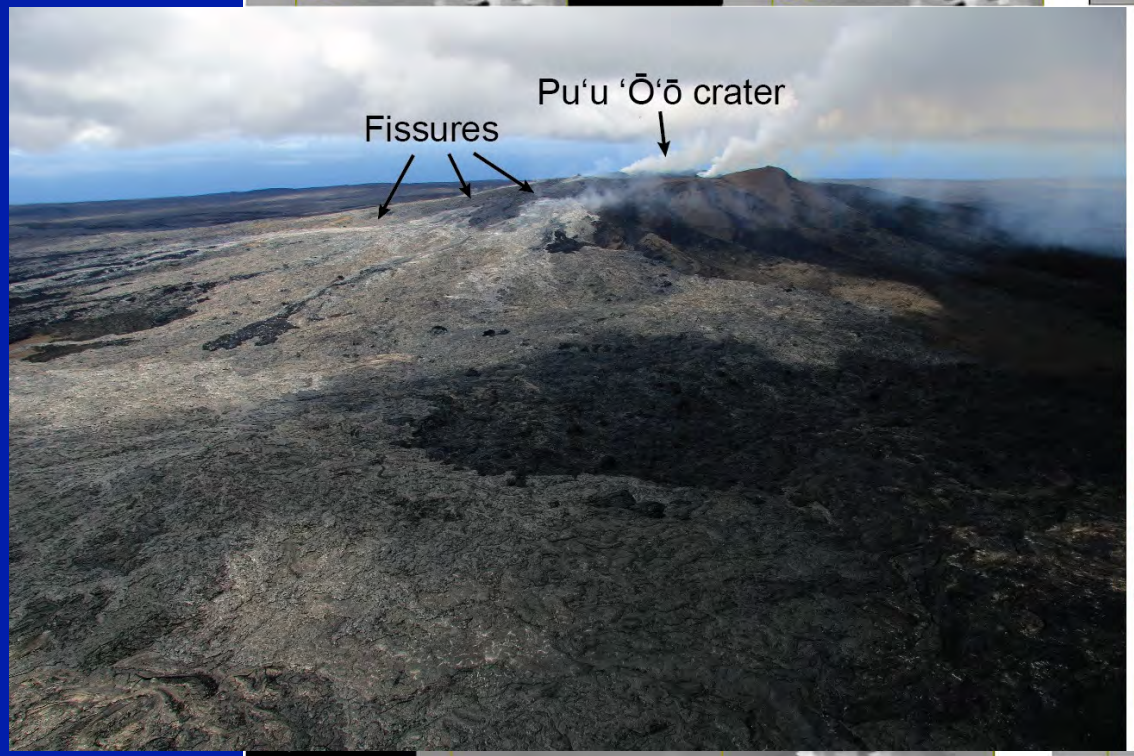
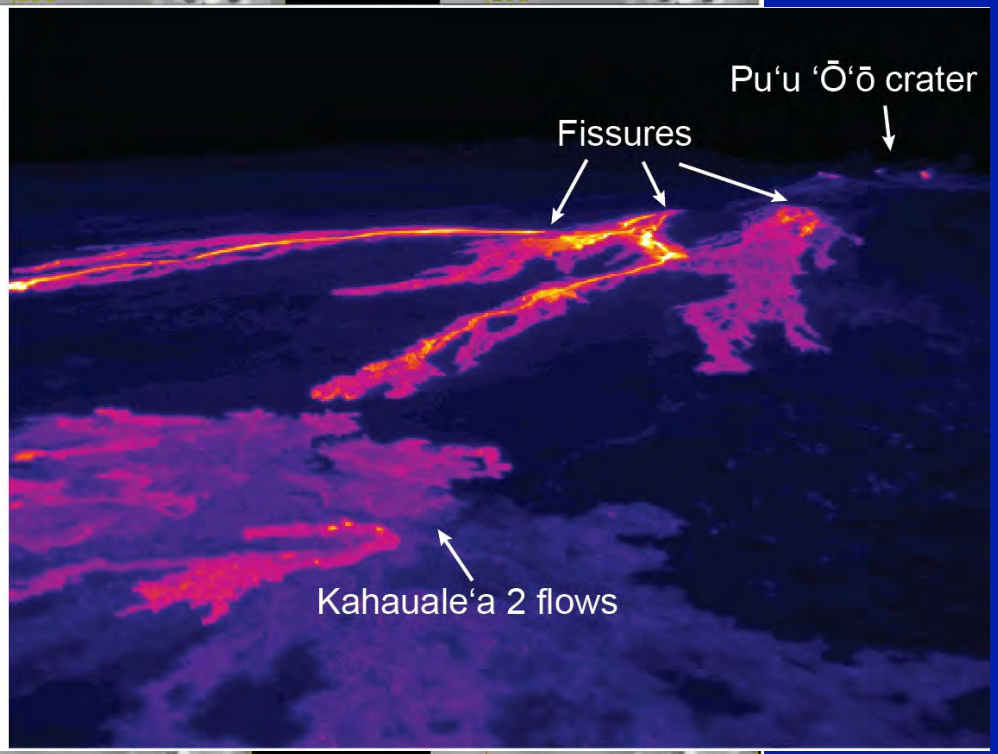
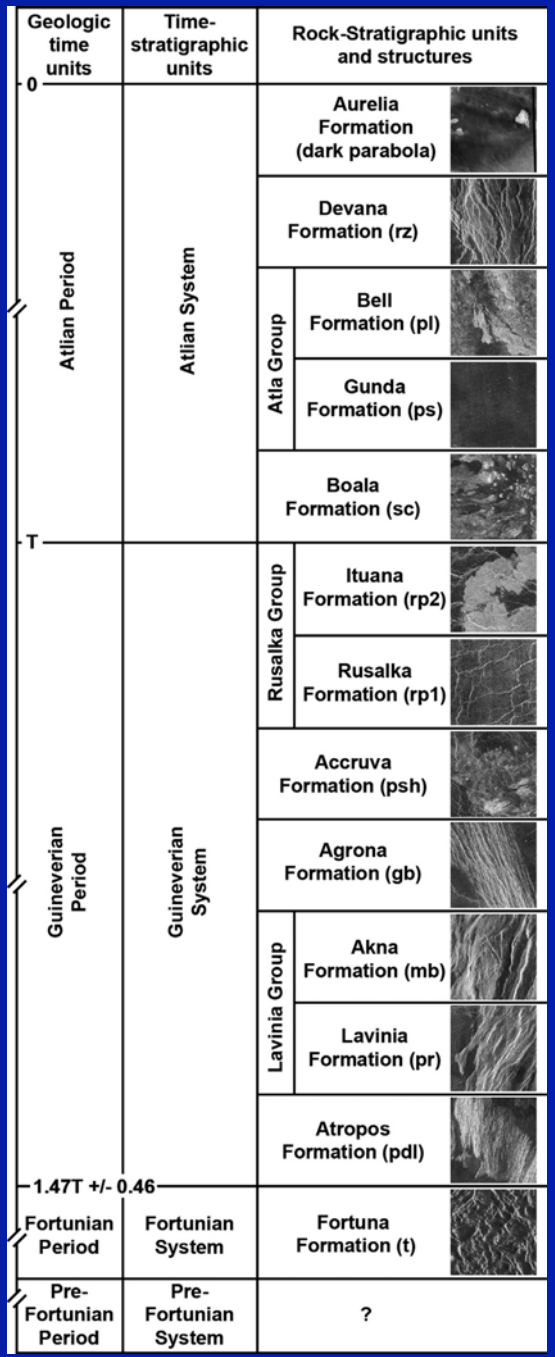
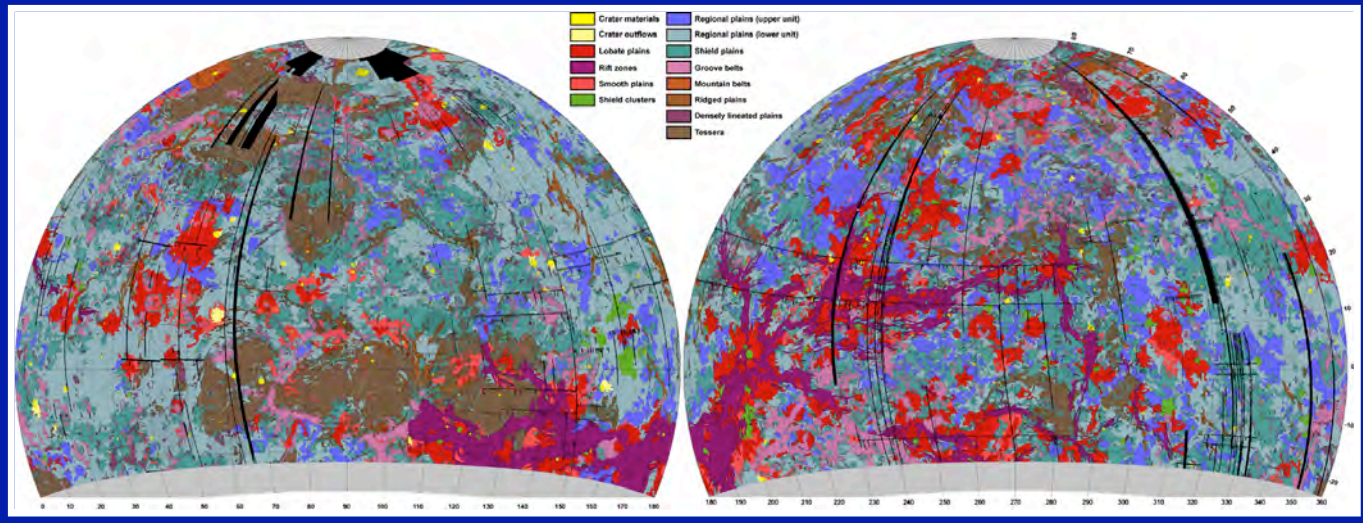
Temperature [10² K]


Fissures
Pu‘u ‘Ō‘ō crater

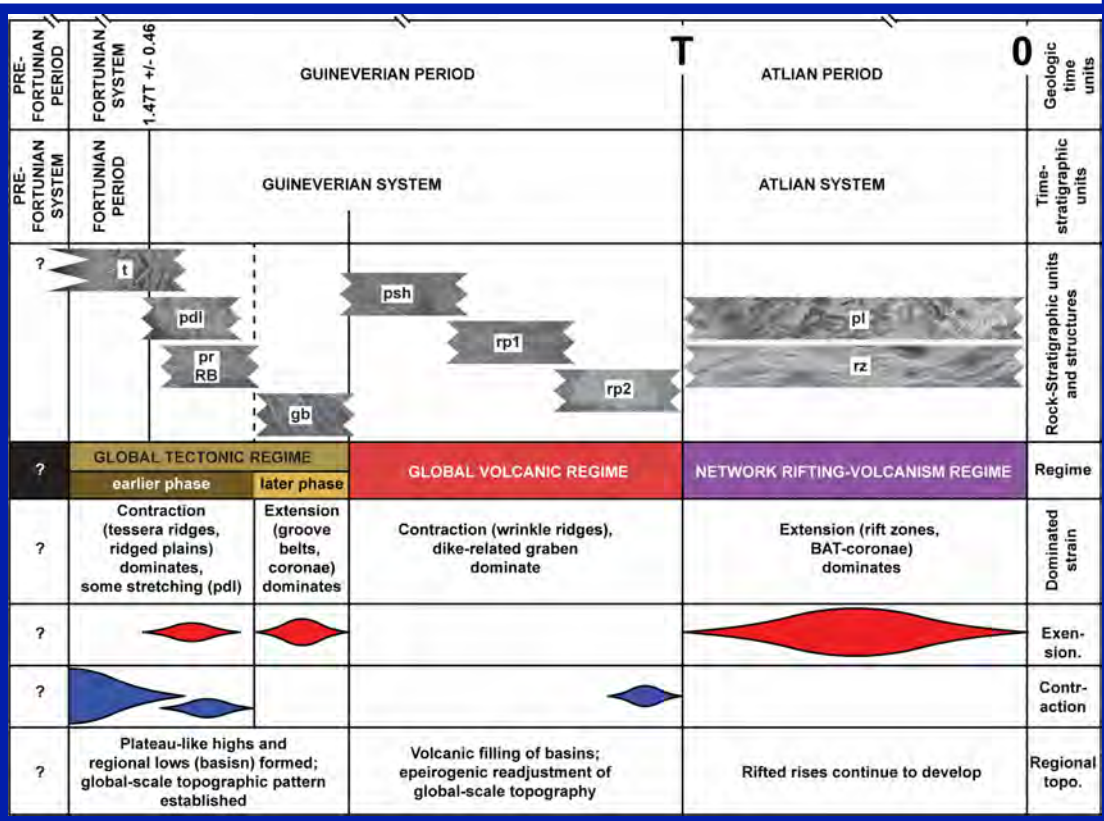

Pu‘u ‘Ō‘ō crater
Fissures
Kahauale‘a 2 flows

What can we learn about volcanic/tectonic resurfacing from global stratigraphy?



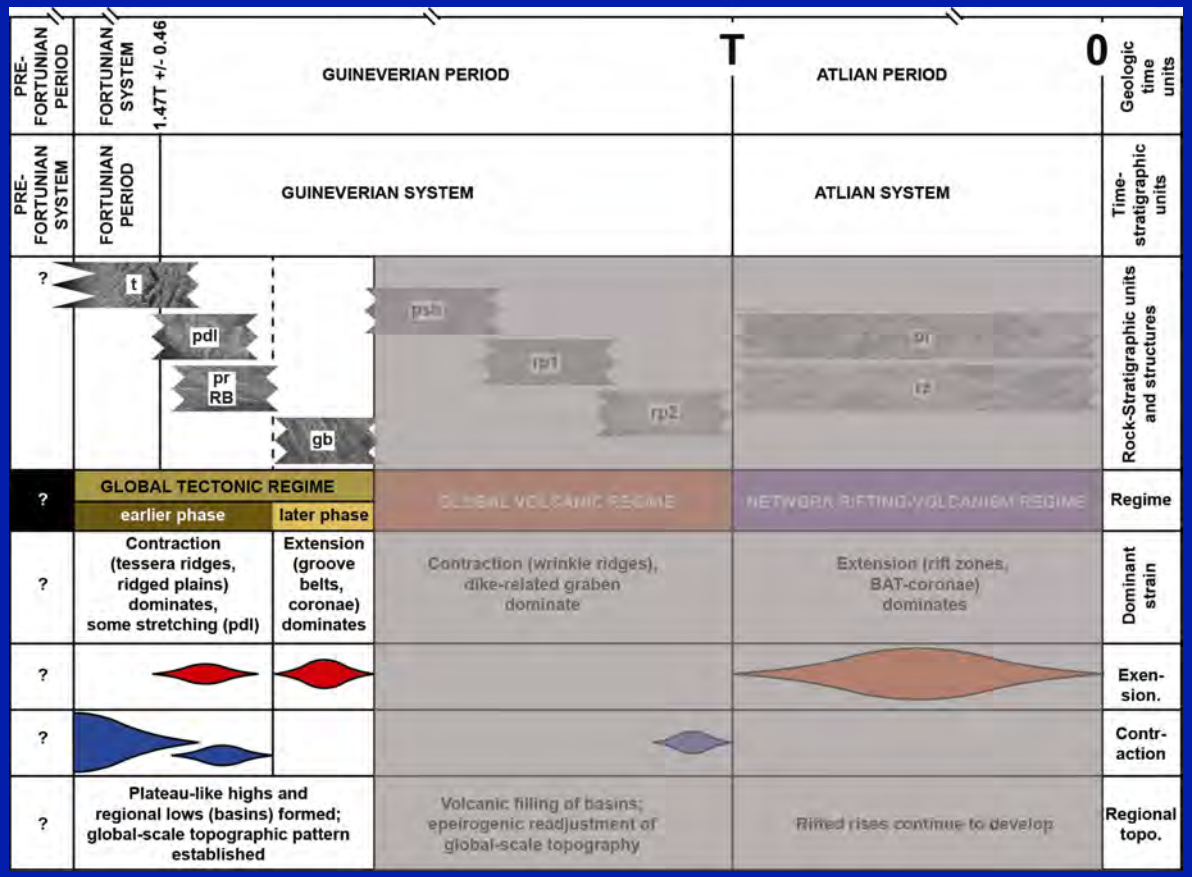


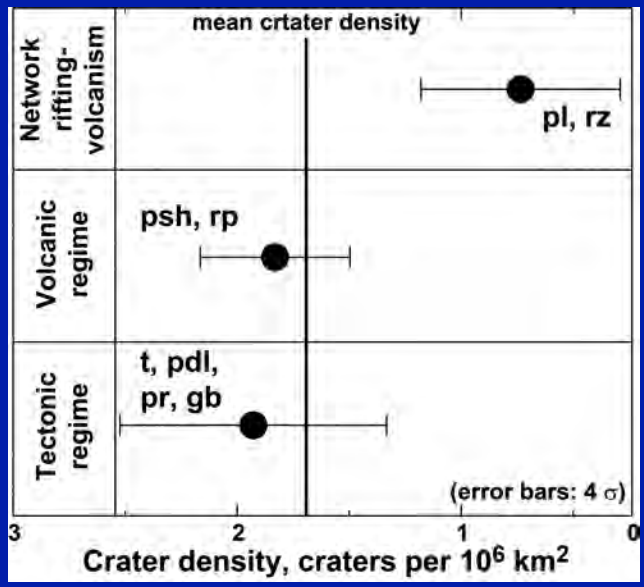
(Ivanov and Head, 2011)



(Alexander Basilevsky, Mikhail Ivanov)

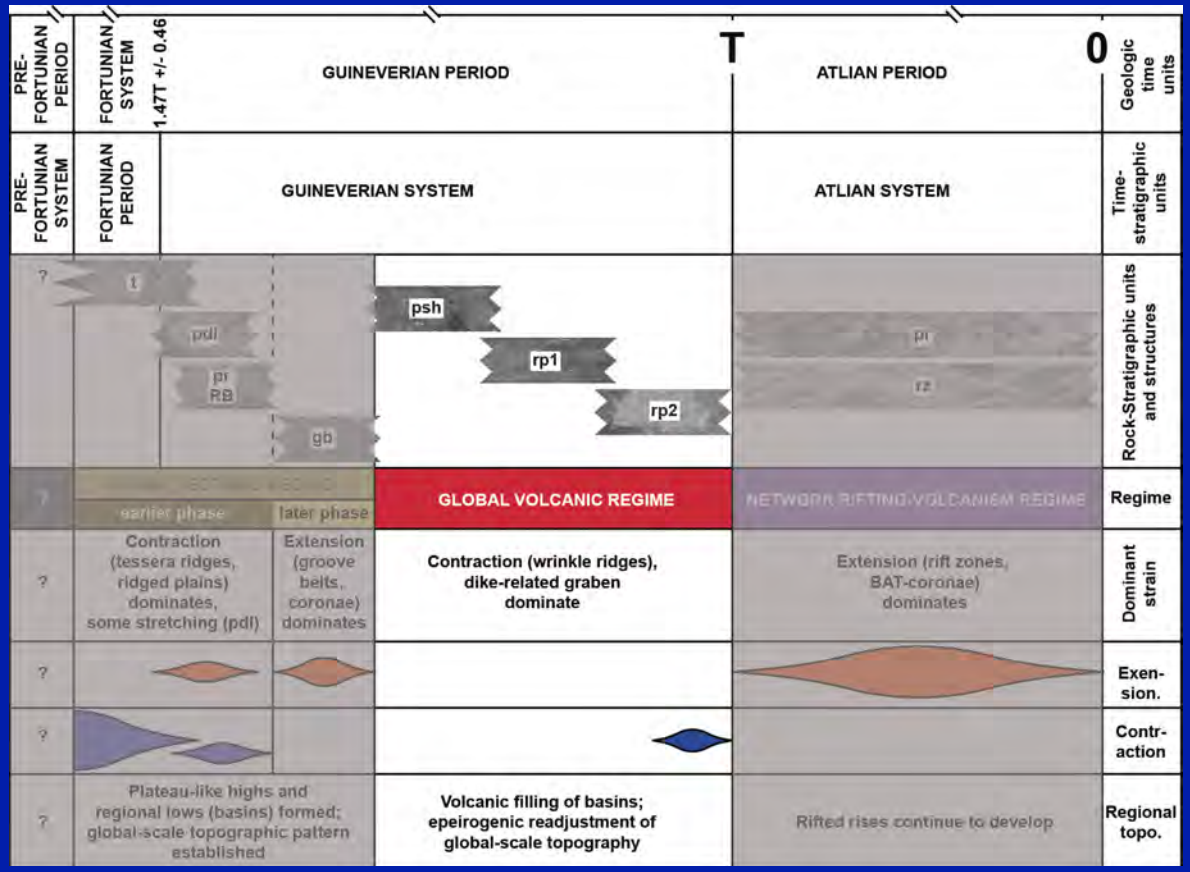
Global Tectonic Regime

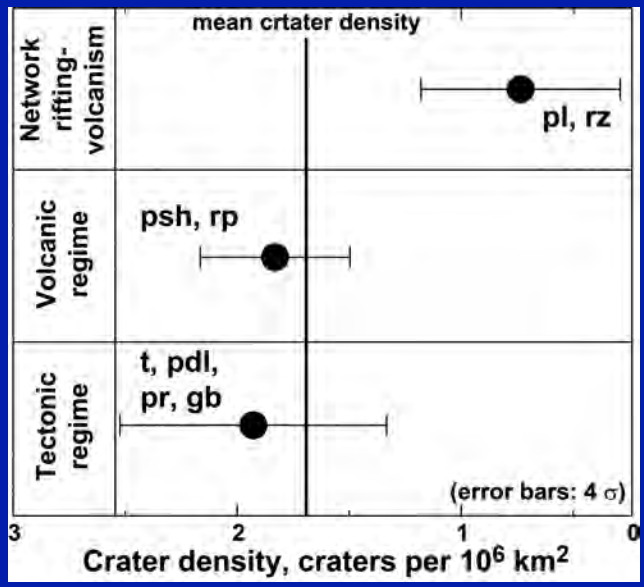




- Intensive and extensive tectonic deformation at the beginning of visible geologic history.
- Tectonics dominated, overwhelmed volcanic activity. Tectonized units formed.
- Majority of coronae formed during the later phase of Global Tectonic Regime.

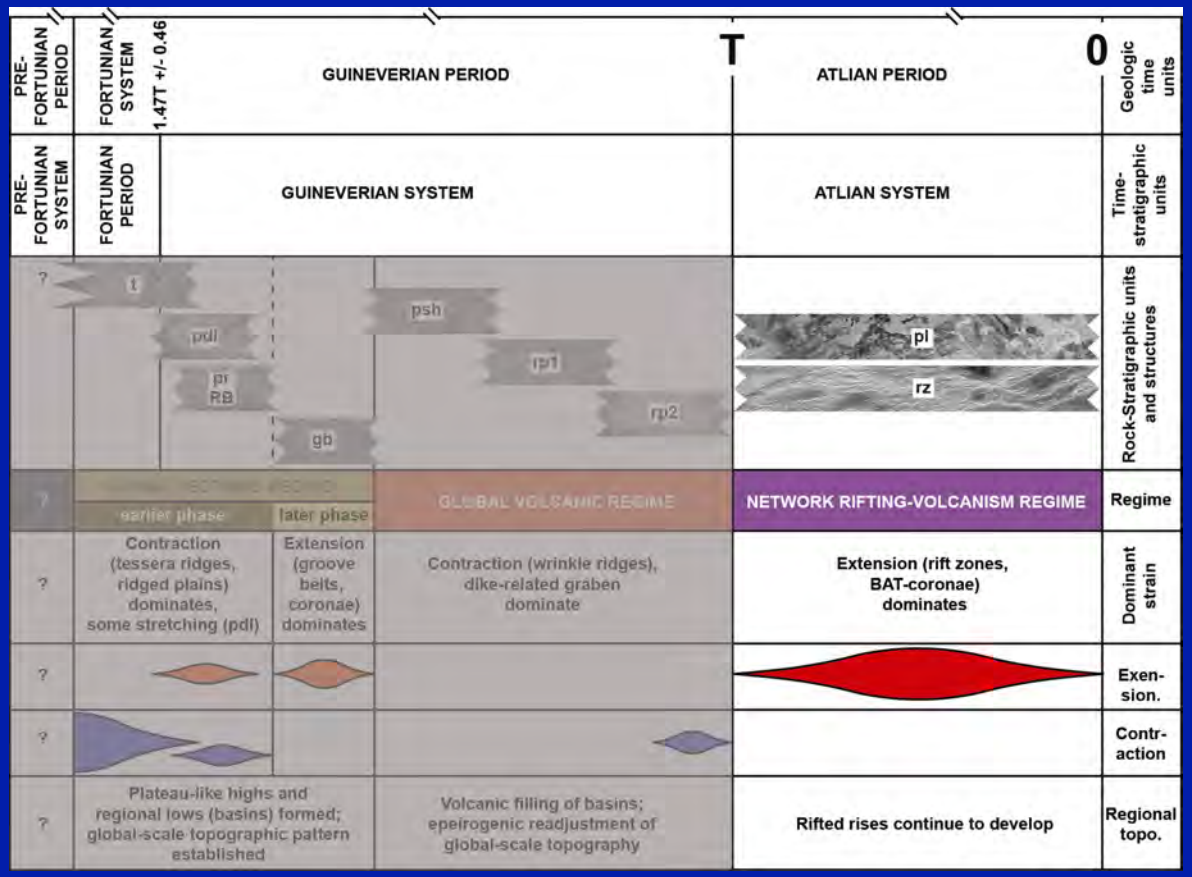
Global Volcanic Regime

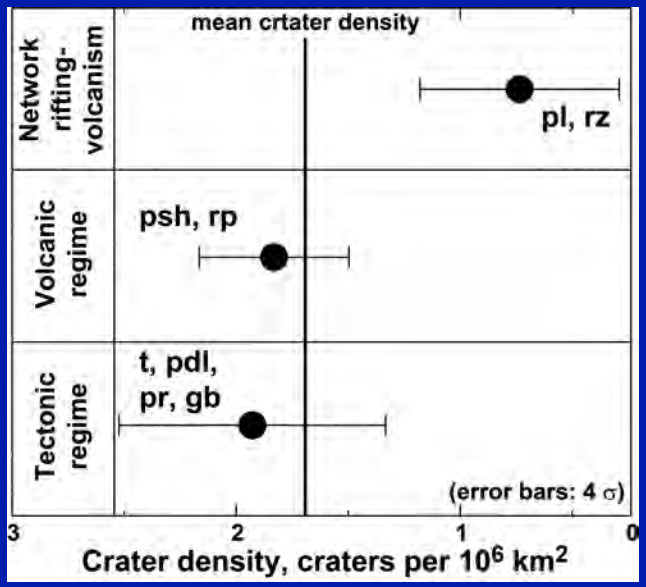




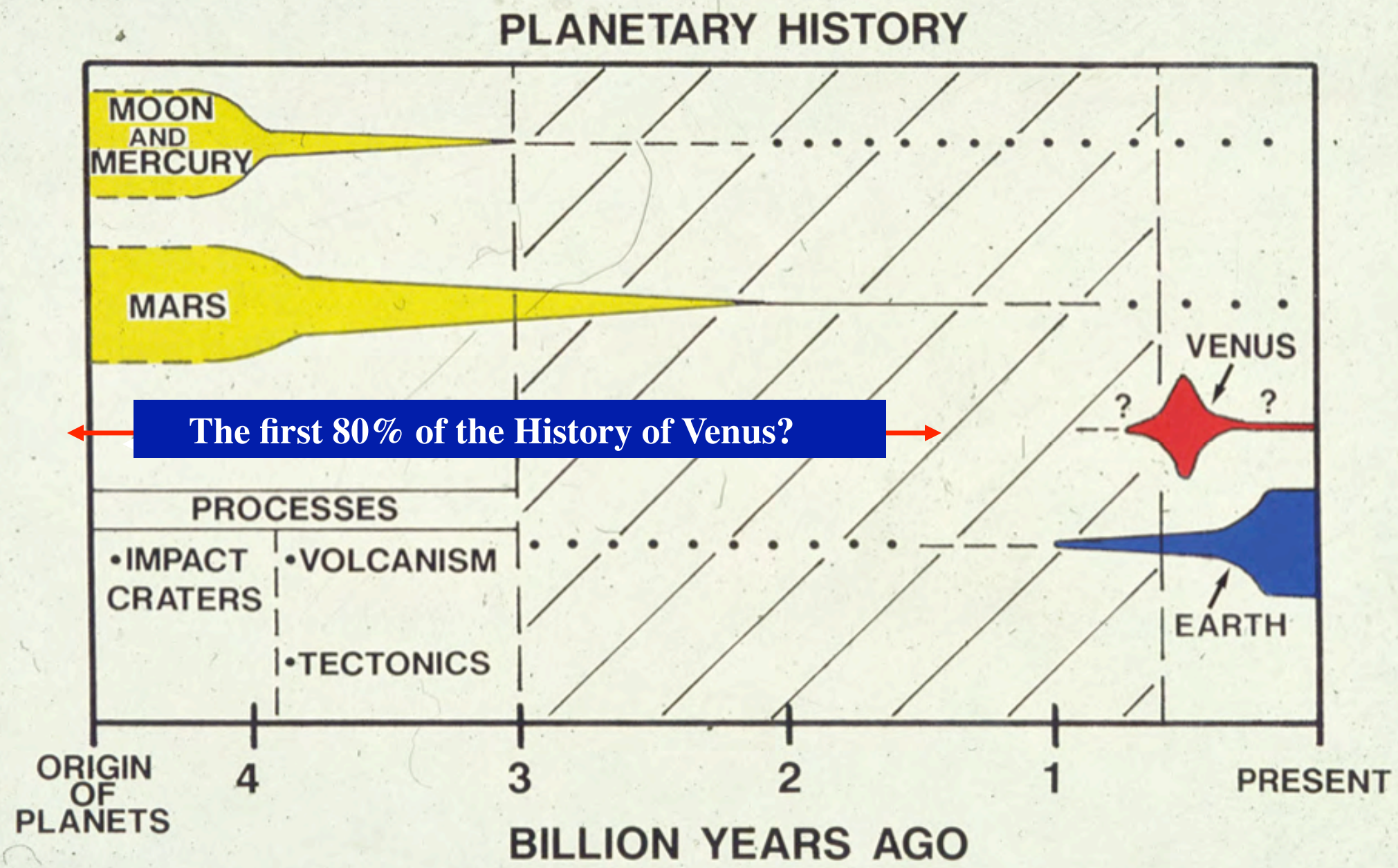
- Volcanism dominated, subordinate tectonic activity.
- End of Global Volcanic Regime: ~85% of the surface was resurfaced.
- Global-wide change of volcanic style from shield-building to regional plains.
- Crater densities: rapid transition from Tectonic to Volcanic Regimes. Rapid resurfacing during the first 1/3 of visible history.

Network Rifting-Volcanism Regime





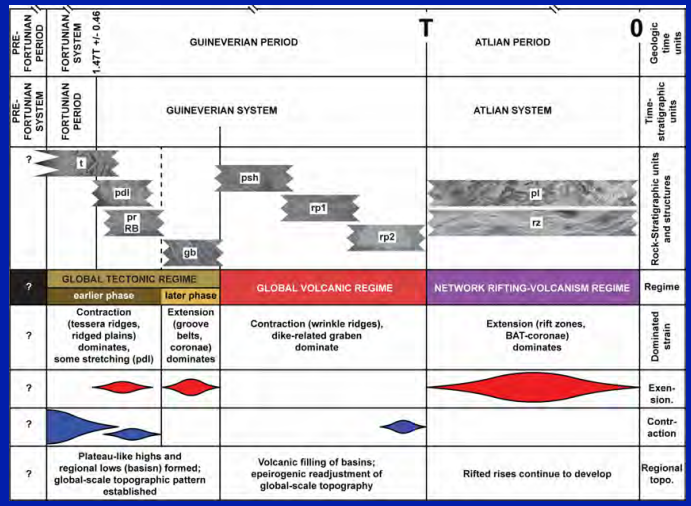
- Volcanism and tectonics are about equally important. Only ~15% of the surface was modified and resurfaced.
- Global-scale change of volcanic style from regional plains to lobate plains.
- Crater densities: prolonged but sluggish resurfacing during ~2/3 of visible history.


PLANETARY HISTORY
MOON AND MERCURY
MARS
VENUS
? ?
The first 80% of the History of Venus?
PROCESSES
•IMPACT CRATERS
•VOLCANISM
•TECTONICS
EARTH
ORIGIN OF PLANETS
4
3
2
1
PRESENT
BILLION YEARS AGO

Evolution of Volcanism on Venus: Conclusions

- Significant changes occurred in ***volcanic style*** during recent history:
- **1. Global Tectonic Phase**:
  - Intense global tectonic deformation.
  - Forms tessera and highlands.

- **2. Global Volcanic Phase**:
  - Globally distributed shield plains (psh).
  - Associated viscous domes and flows.
  - Regional flood volcanism (rp1,2).



- **3. Global Network Tectonic and Volcanism Phase**:
  - Lobate flows (pl) primarily associated with rift zones.

  - Significant changes occurred in ***volcanic flux*** during recent history:
  - 1. Estimated total volume erupted during ***Global Volcanic Phase*** (psh, rp1,2) is ~140 to 200 x 10^6 km^3.

  - 2. In sharp contrast, total estimated volume during ***Global Network Tectonic and Volcanism Phase*** of lobate plains (pl) is much smaller, ~20-30 x10^6 km^3.

  - These major changes in style and flux favor ***catastrophic resurfacing*** models: Using observations for ***petrogenetic/geodynamic modeling***.