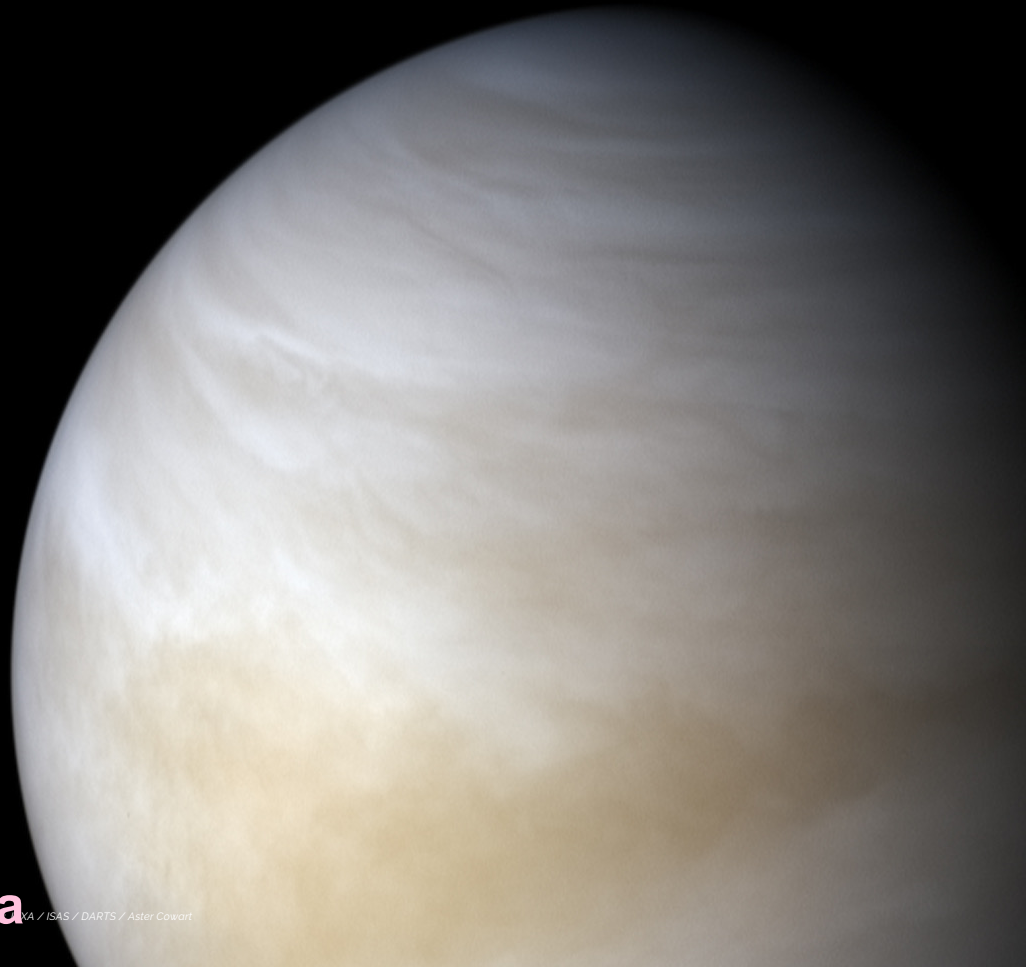

europlanet 2024
Research Infrastructure

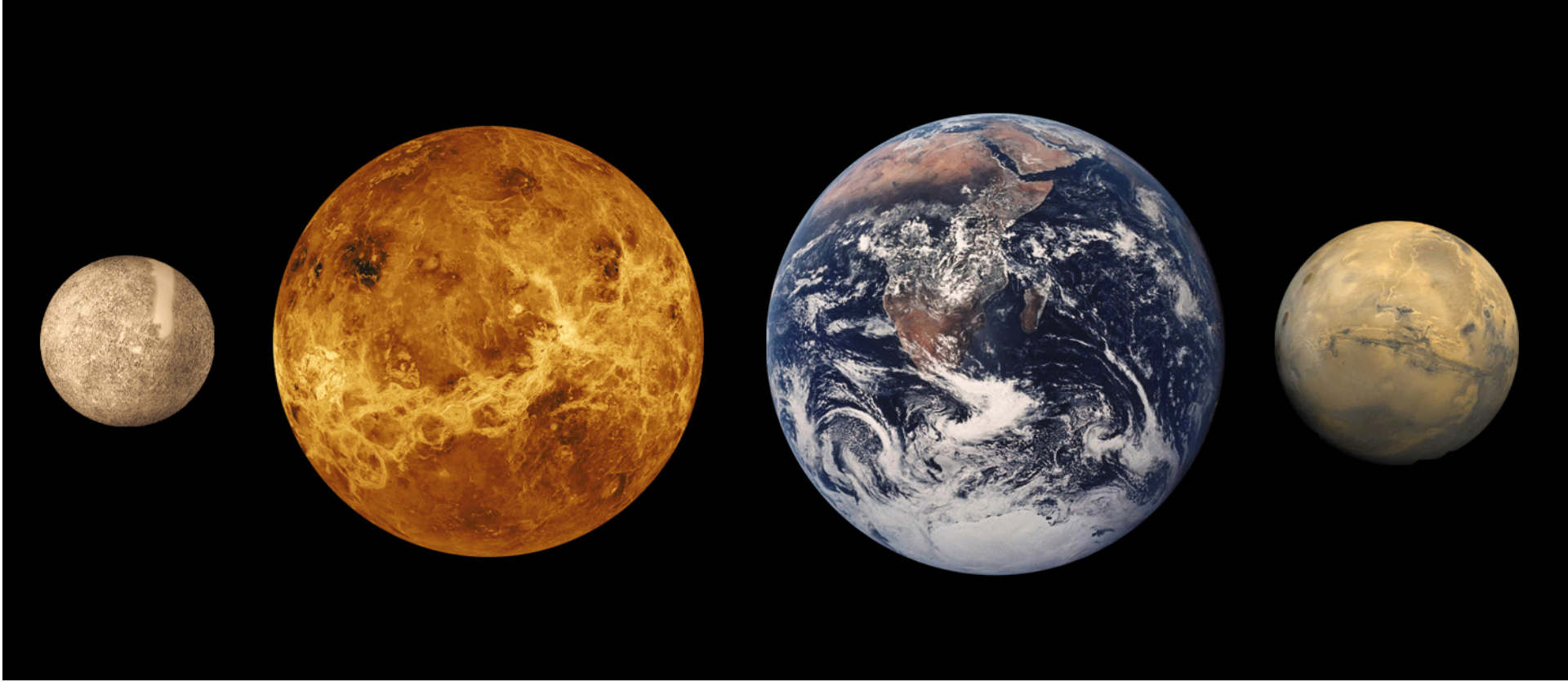
Geology & Planetary Mapping
Winter School

Venus

Introduction to Venus Geology

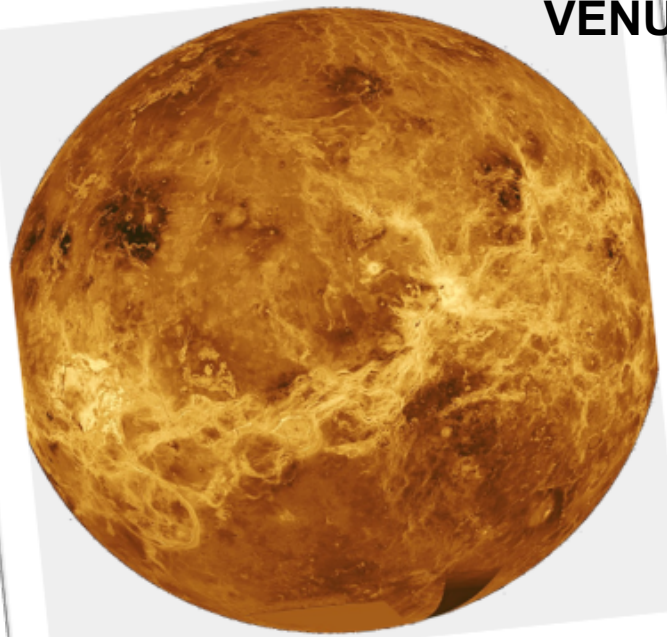
Lucia Marinangeli
Univ. G. d'Annunzio Chieti-Pescara





TERRESTRIAL PLANETS
Mercury, Venus, Earth and Mars

VENUS vs. EARTH



TWIN PLANETS

similar size but different geological evolution

the most brilliant star at the sunrise and sunset

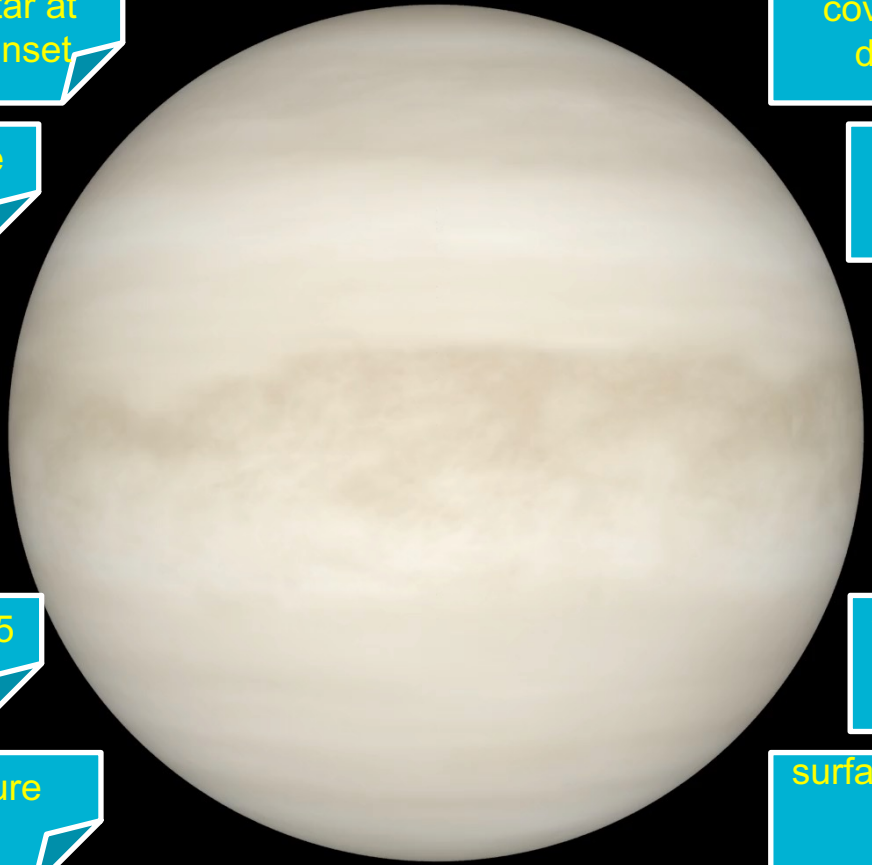
the hottest surface in the Solar System

the only internal planet with clock-wise rotation

a venusian day lasts 243 Earth days

a venusian year lasts 225 Earth days

high surface pressure 92 bars



covered by a thick and dense atmosphere

Atmospheric composition @ surface
Major: CO_2, N_2

Atmospheric composition @ surface
Minor (ppm): SO_2,Ar,H_2O

surface unveiled by radar instruments

surface topography shows highlands called TESSERA

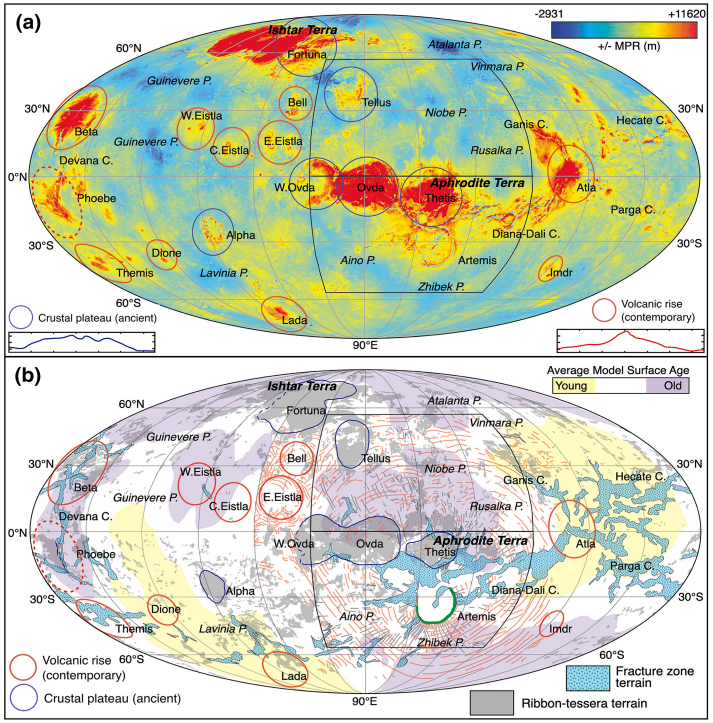
surface topography shows lowlands called PLANITIA

NASA/Goddard Space Flight Center Scientific Visualization Studio

TESSERAE TERRAINS

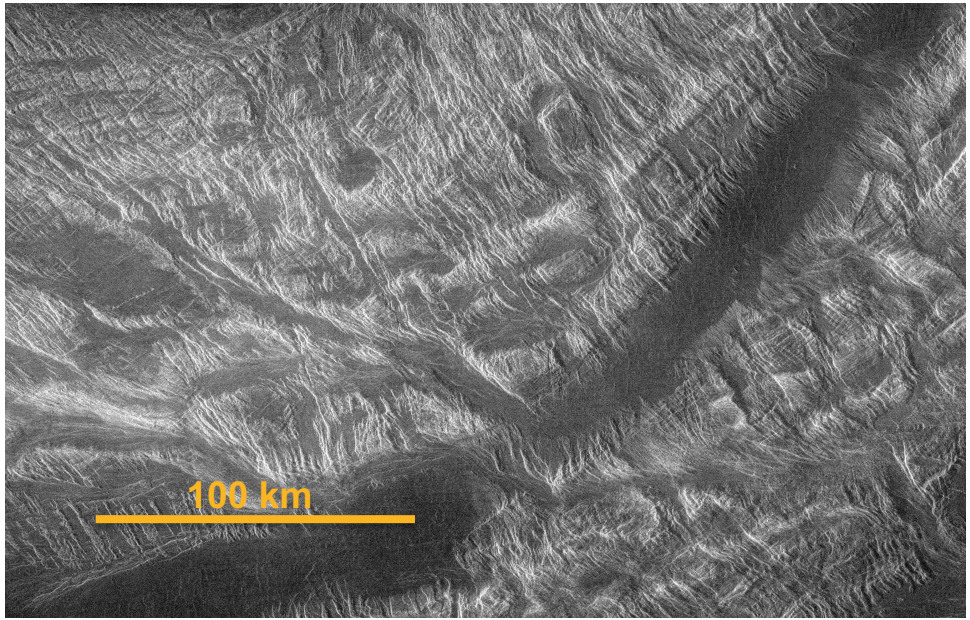
radar brightness/relief/complex pattern

Tesserae on Venus are characterized by **pervasive tectonic** deformation including normal faults, grabens, thrust faults, and folds and are stratigraphically **oldest** units preserved on the planet.



Hansen and Lopez, *Earth and Space Science*, 2020

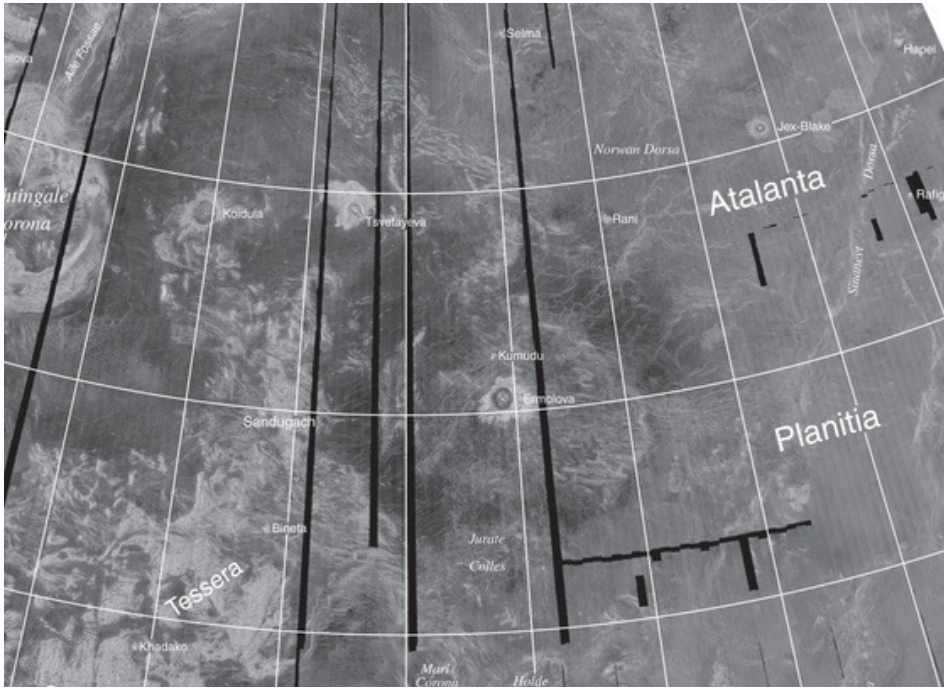
EXAMPLE OF TESSERA TERRAIN IN OVDA REGIO

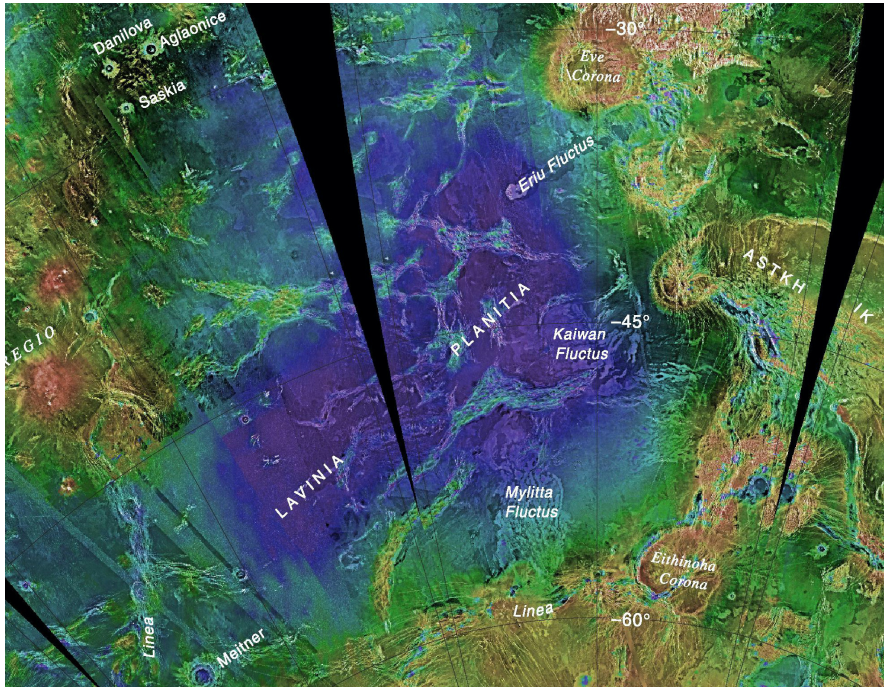


Credit NASA/JPL

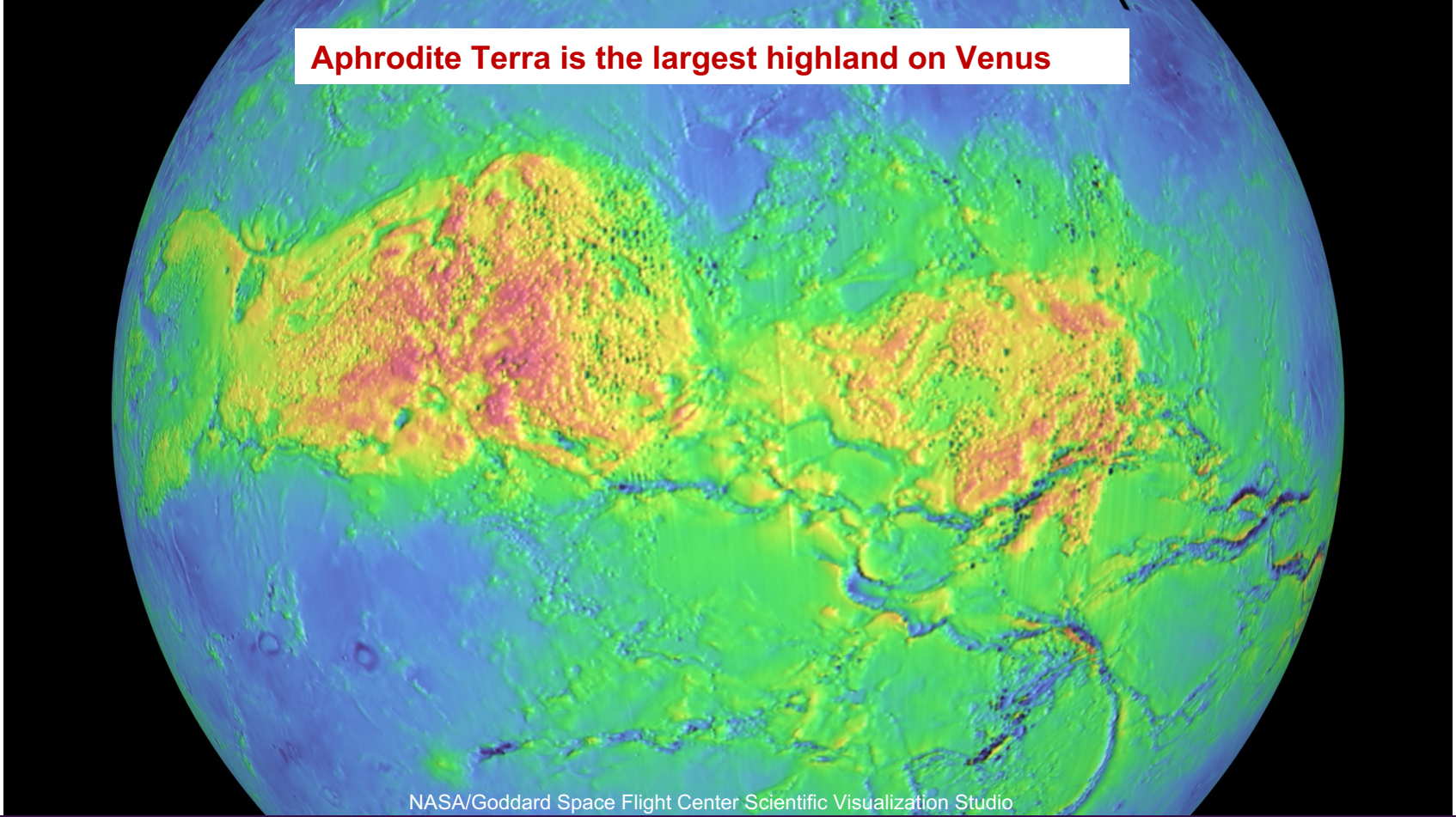
PLANITIAE – ~85% of the surface

radar dark/lowland/complex pattern

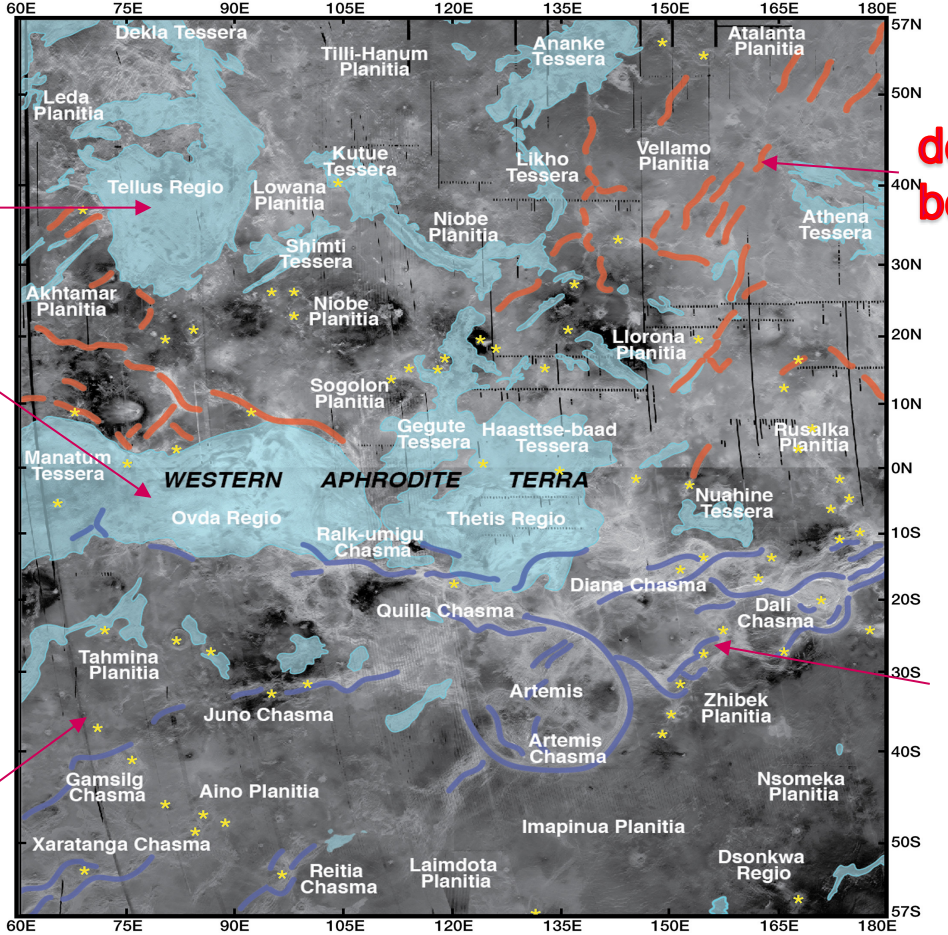




Aphrodite Terra is the largest highland on Venus



NASA/Goddard Space Flight Center Scientific Visualization Studio



tessera terrains

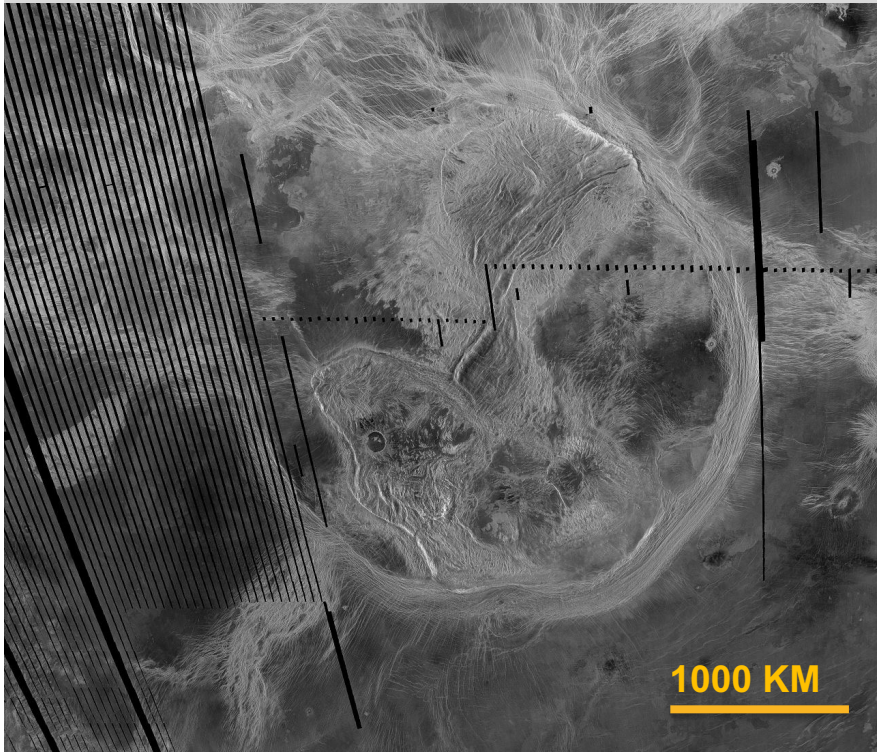
deformation belts

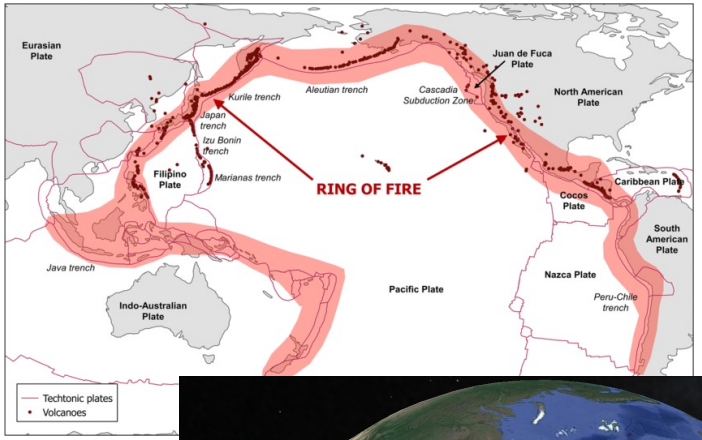
chasmata

coronae

Hansen and López, JGR Planets 2018

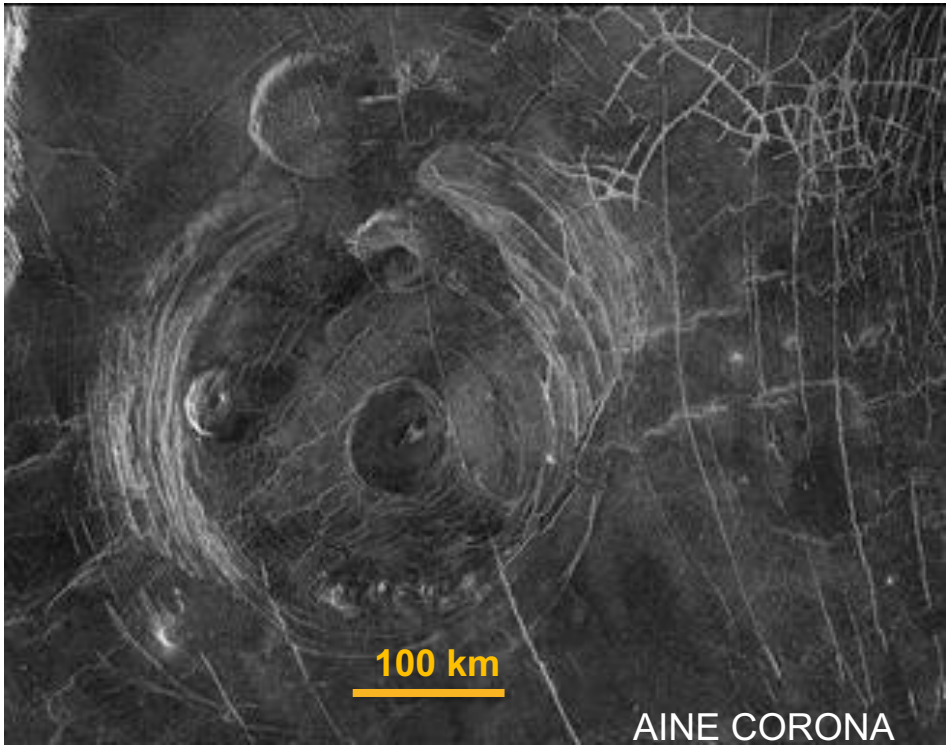
ARTEMIS CHASMA, THE LARGE CIRCULAR THROUGH

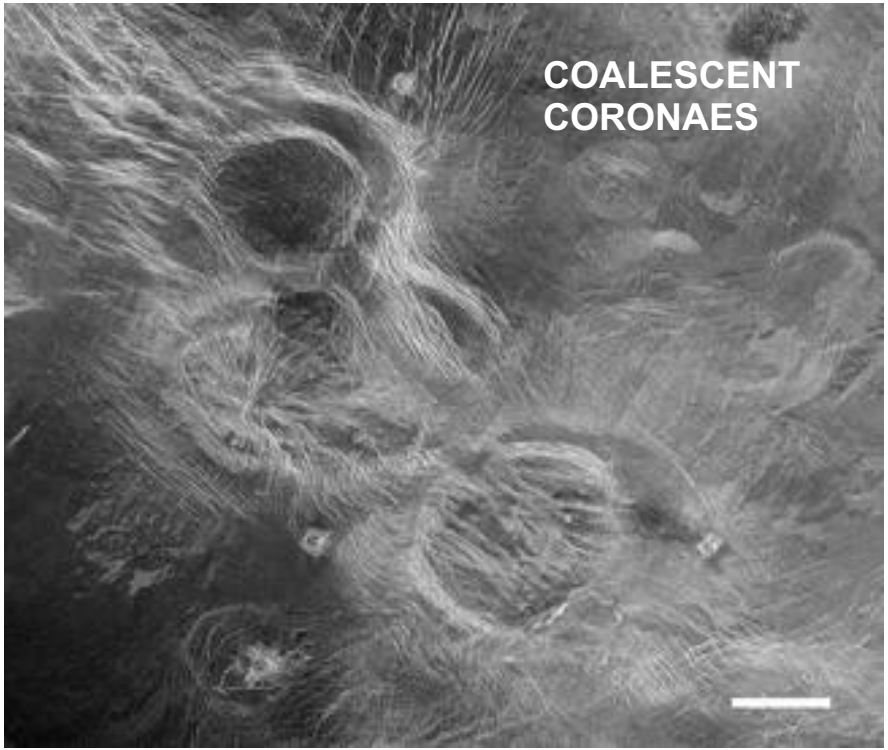




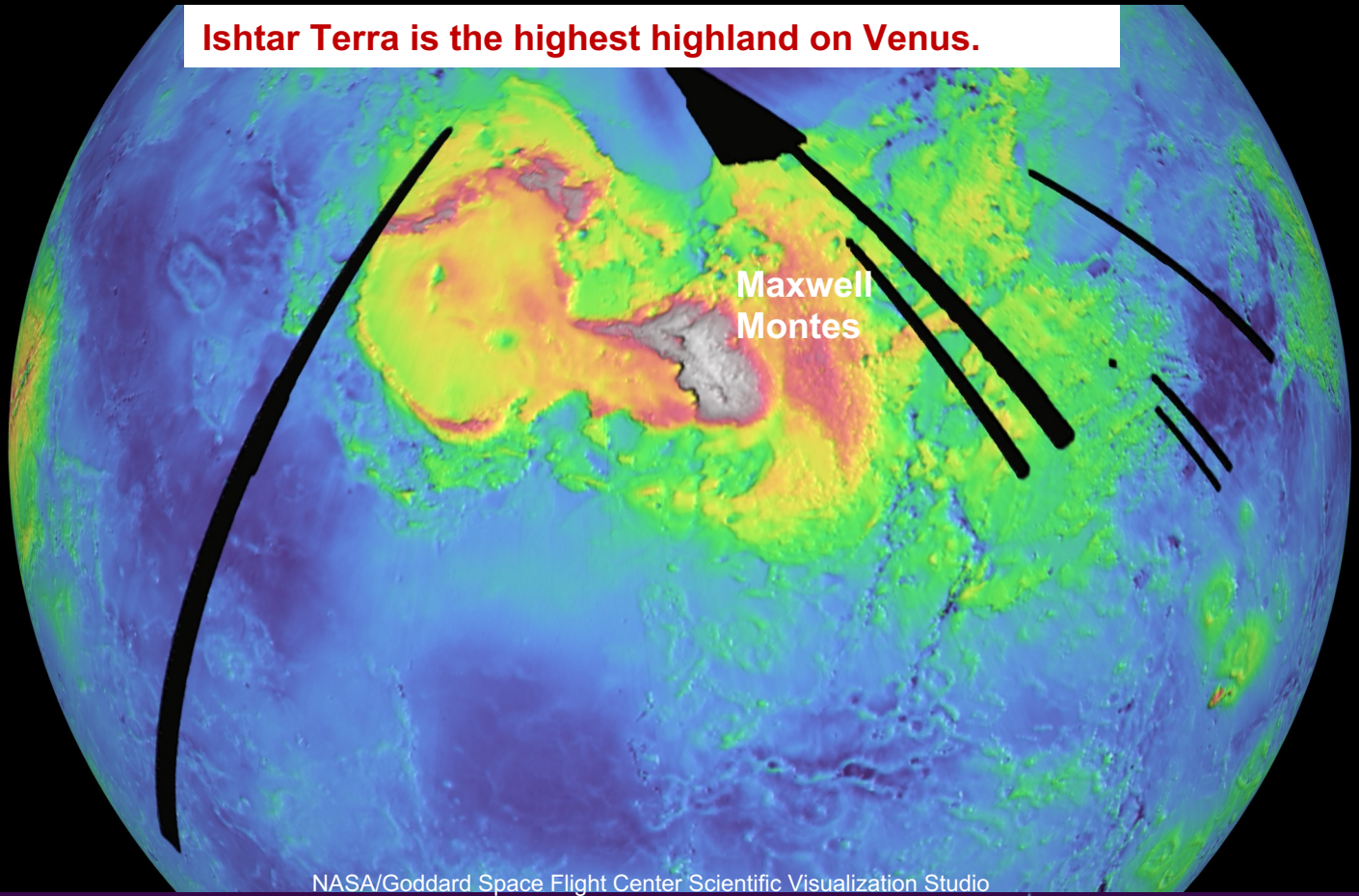
SUBDUCTION ZONES?

UNIQUE VOLCANO-TECTONIC FEATURE



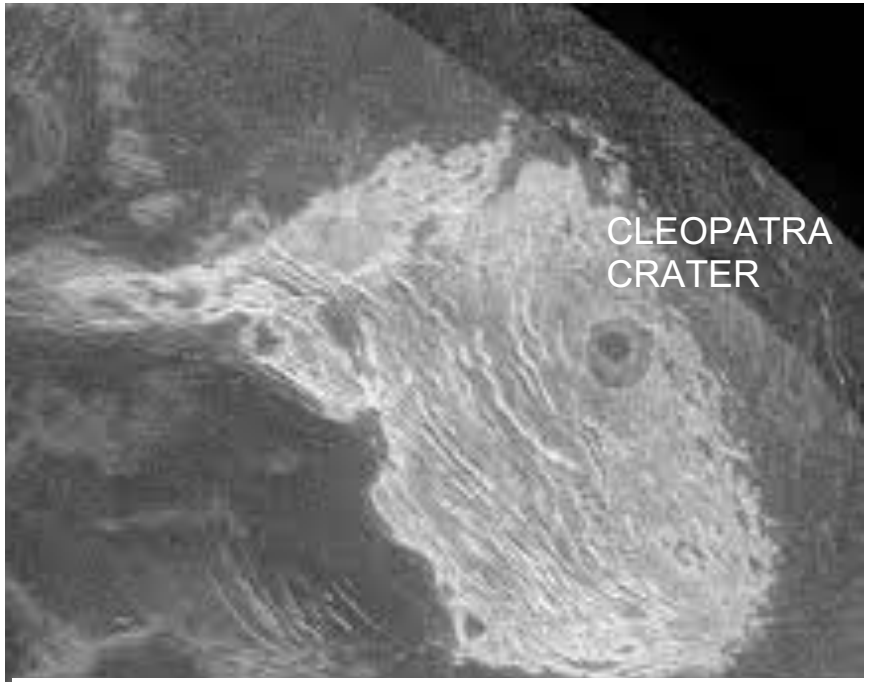


Ishtar Terra is the highest highland on Venus.

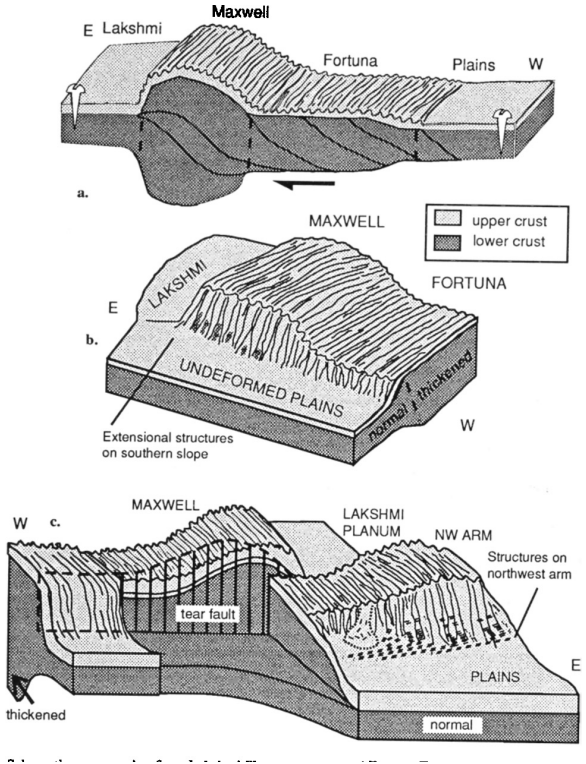


NASA/Goddard Space Flight Center Scientific Visualization Studio

MAXWELL MONTES, THE TALLEST MOUNTAIN RANGE IN THE SOLAR SYSTEM, 11 KM ABOVE MPR

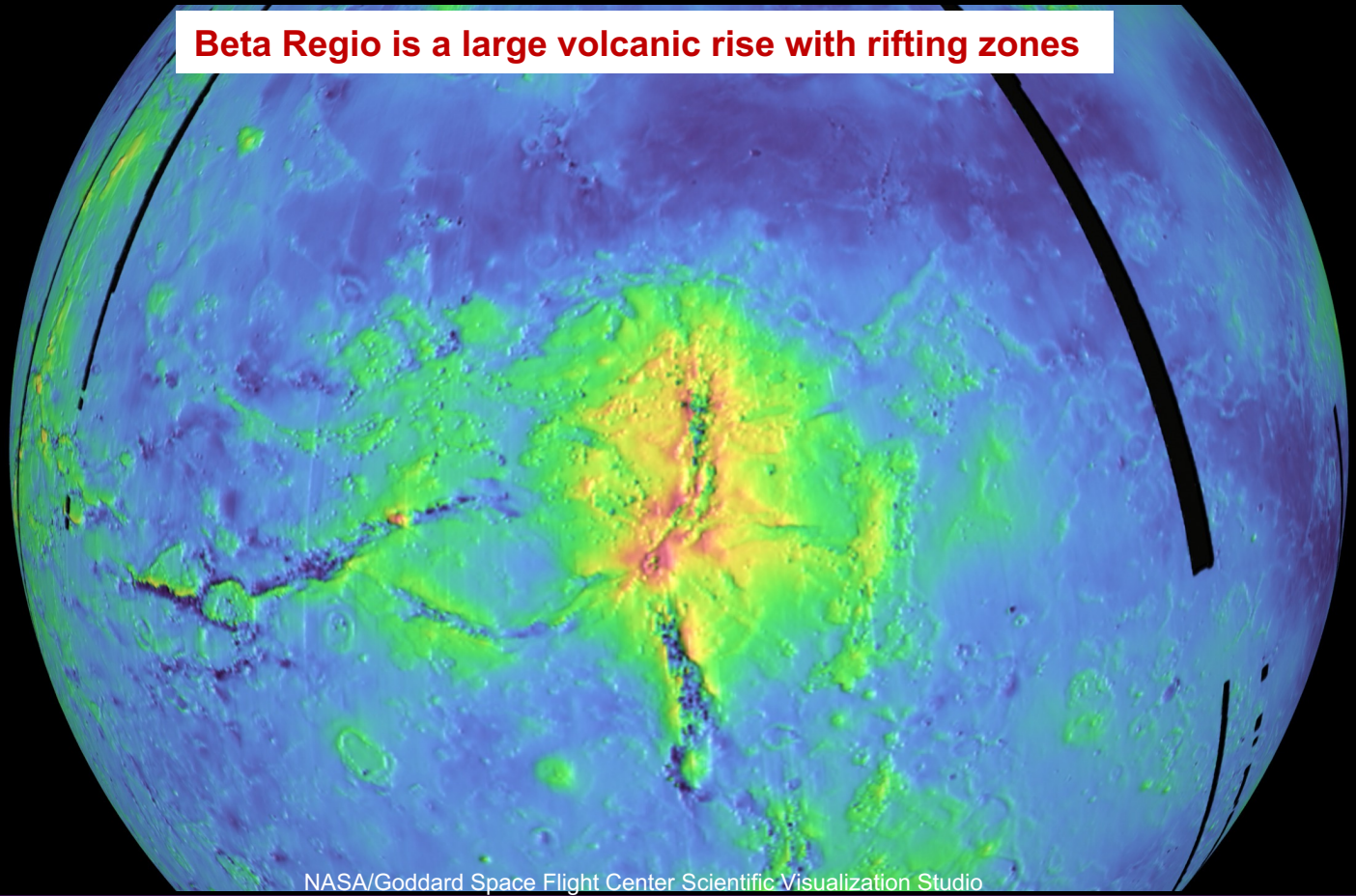


the material responsible for the very bright radar return probably is only stable in a particular range of atmospheric conditions and therefore a particular elevation range.

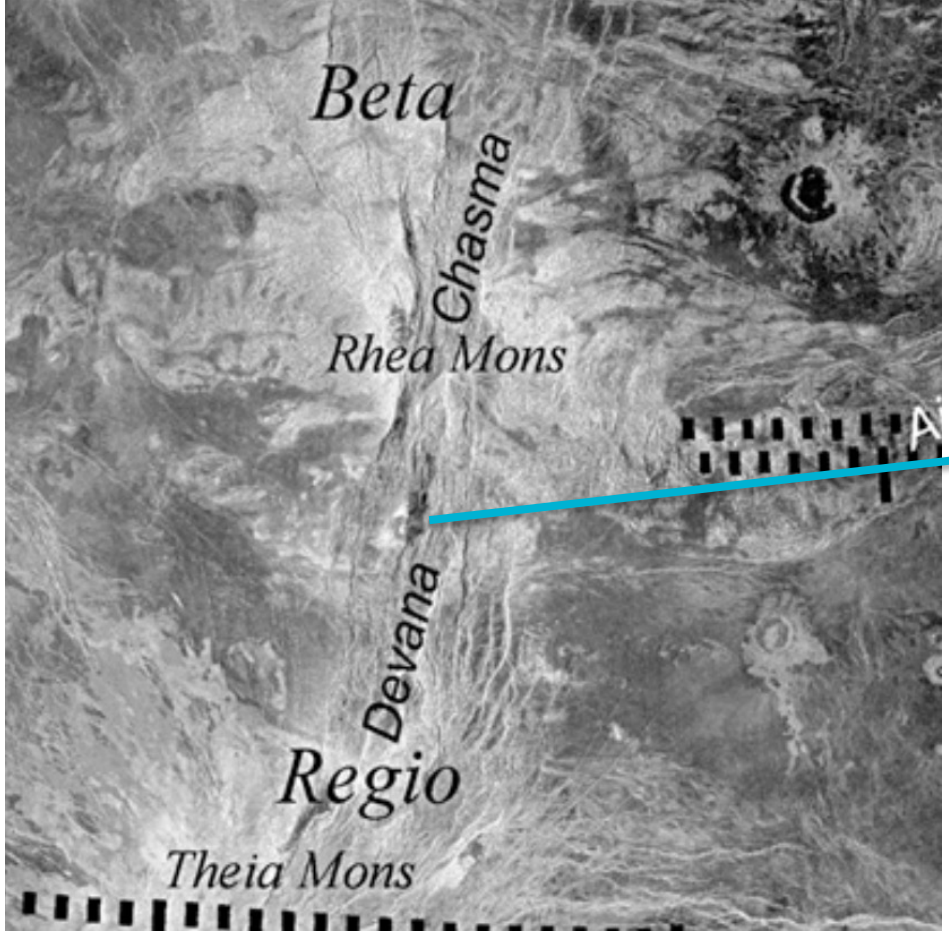


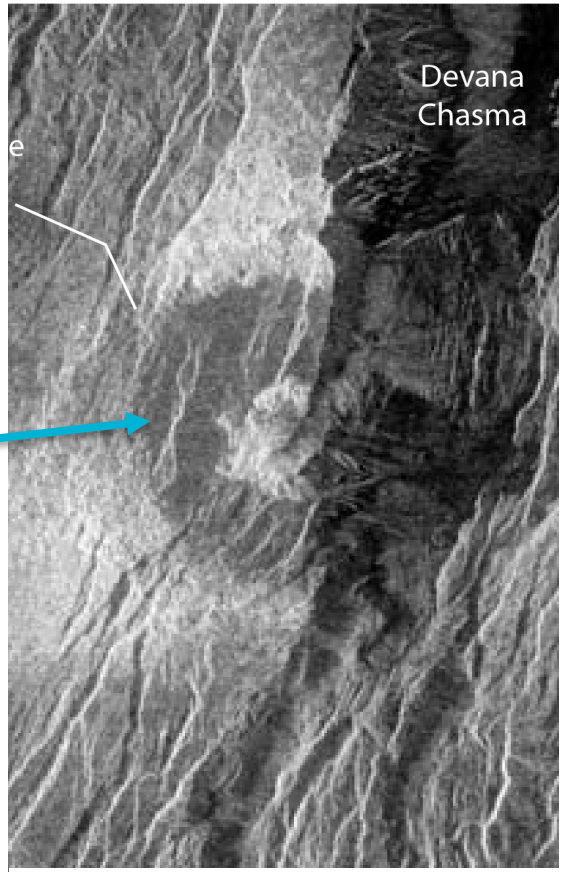
Keep and Hansen, Journal of Geophysical Research, 1994

Beta Regio is a large volcanic rise with rifting zones



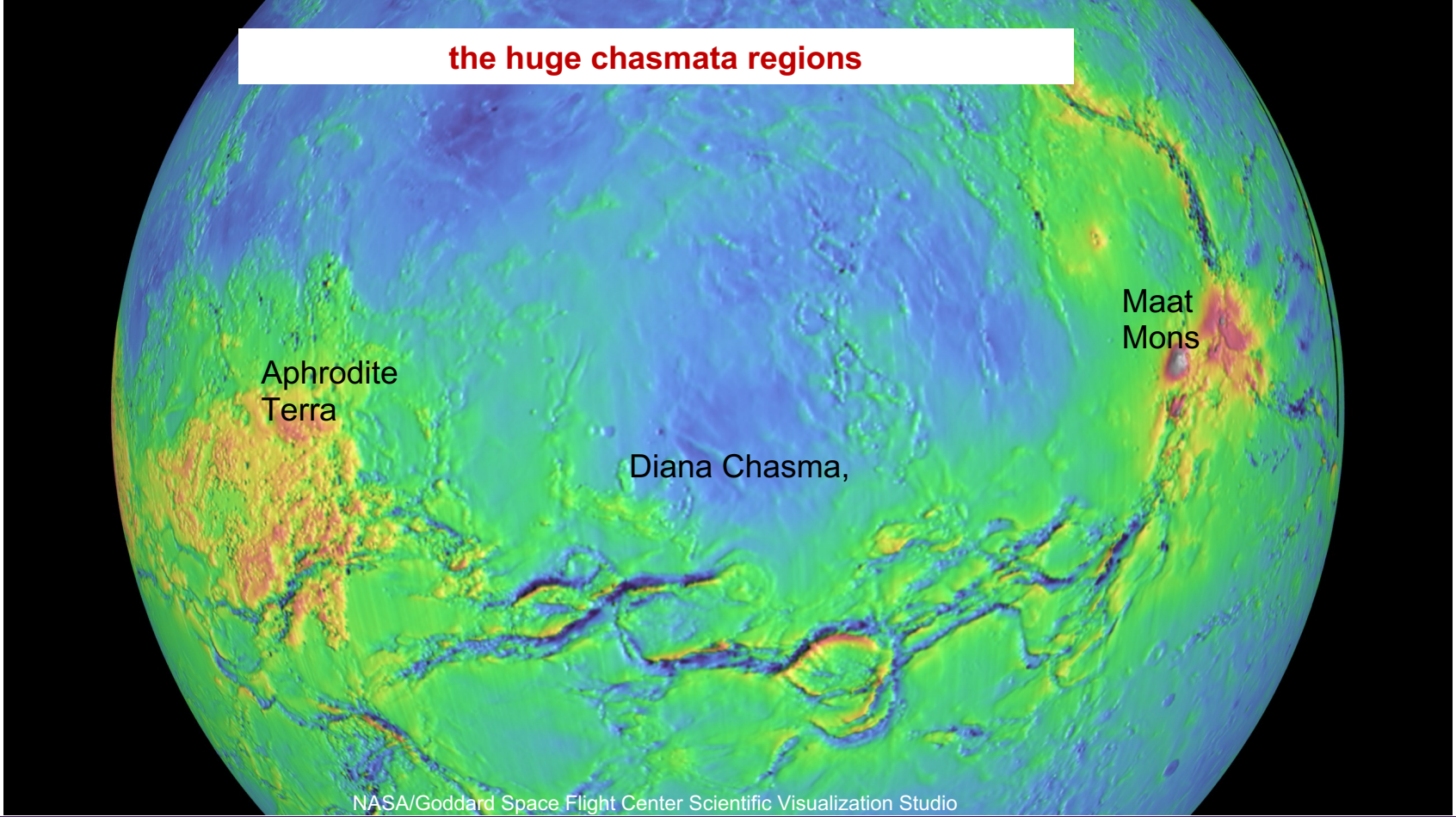
NASA/Goddard Space Flight Center Scientific Visualization Studio



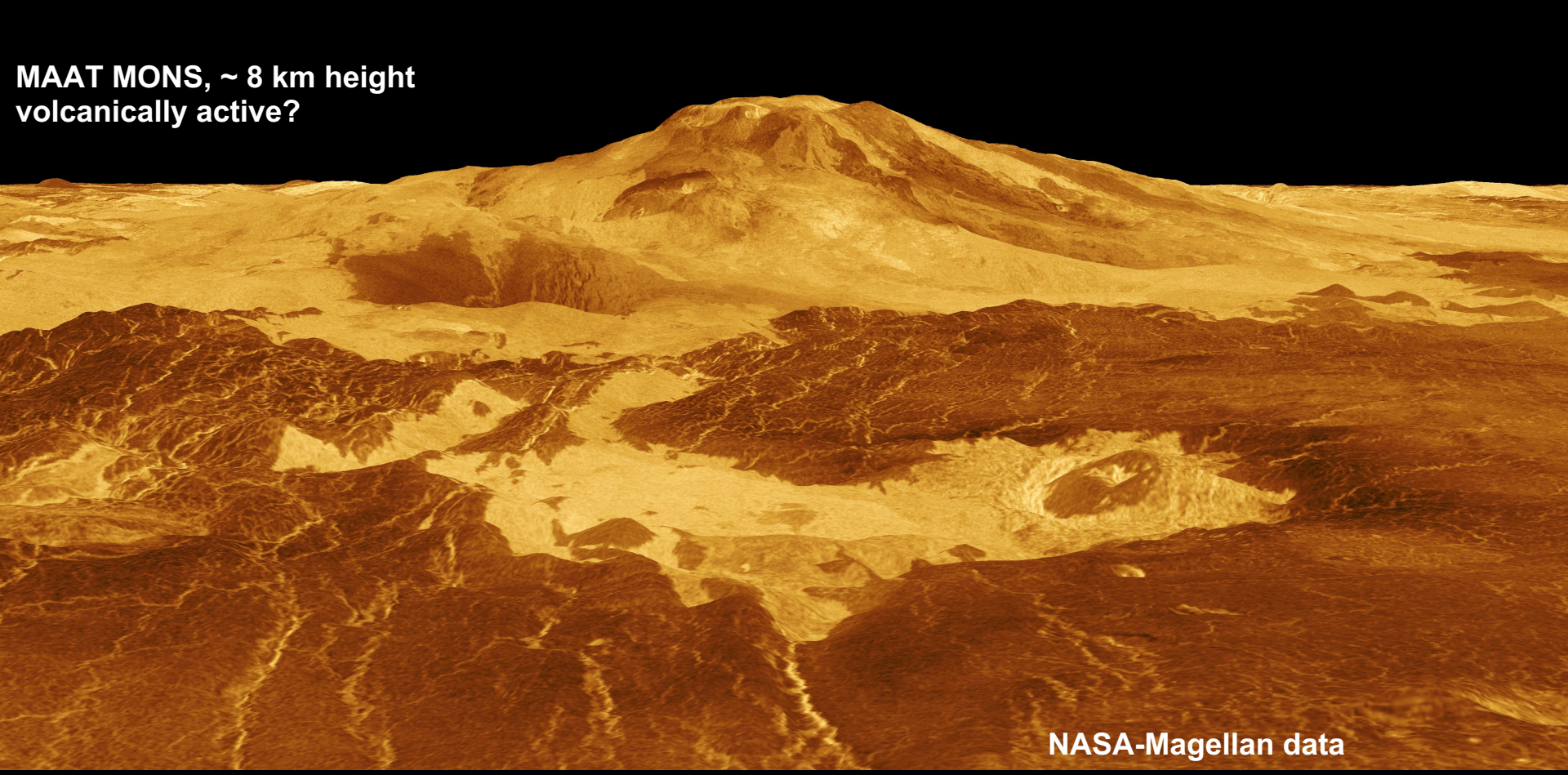


Sommerville crater

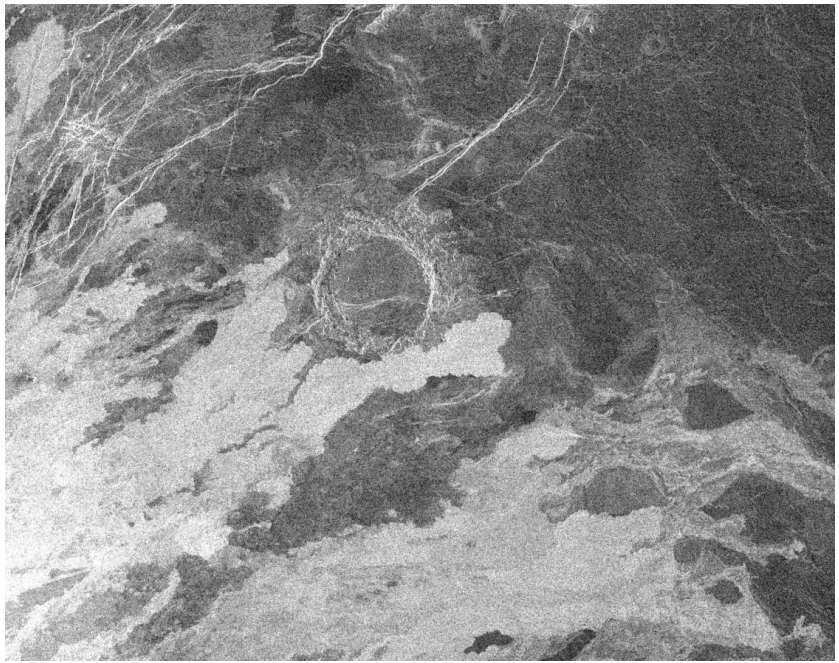
the huge chasmata regions



NASA/Goddard Space Flight Center Scientific Visualization Studio

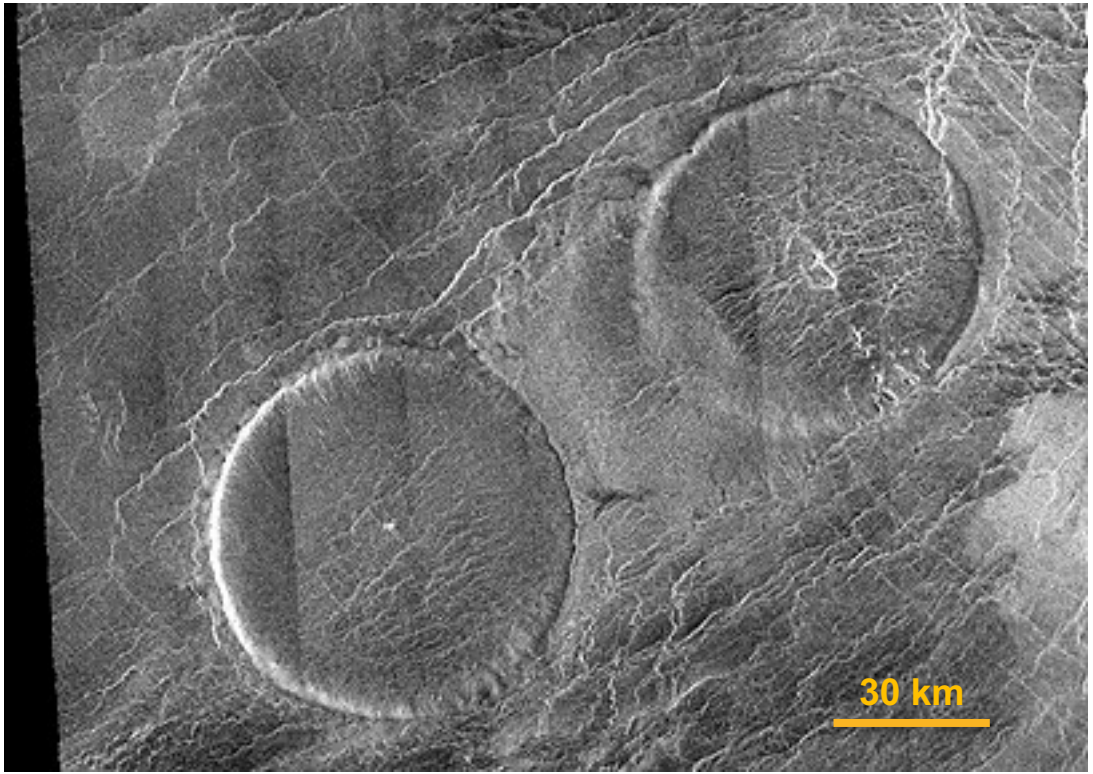

MAAT MONS, ~ 8 km height
volcanically active?
NASA-Magellan data

WIDESPREAD VOLCANIC ACTIVITY



Radar-bright overlapping lobate flows

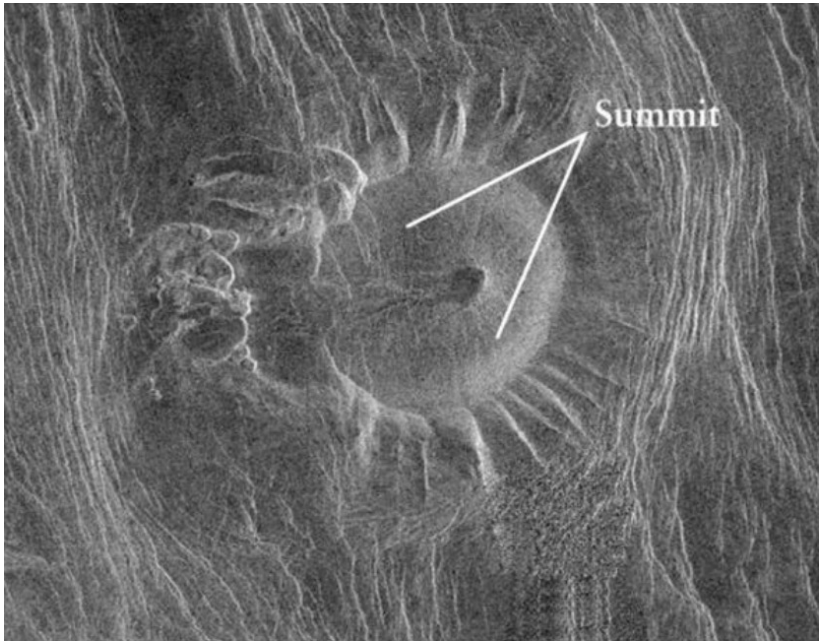
VENUS



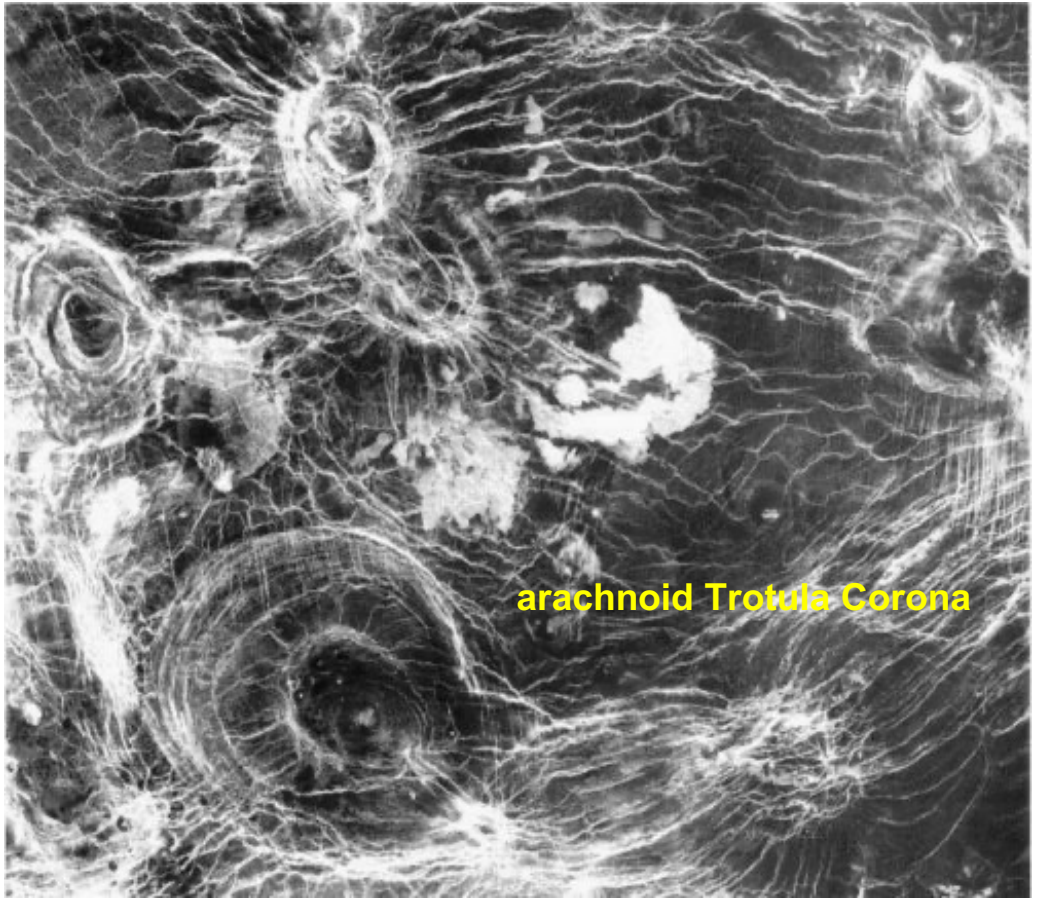
EARTH

volcanic "pancake" domes in Tinatin Planitia, Venus

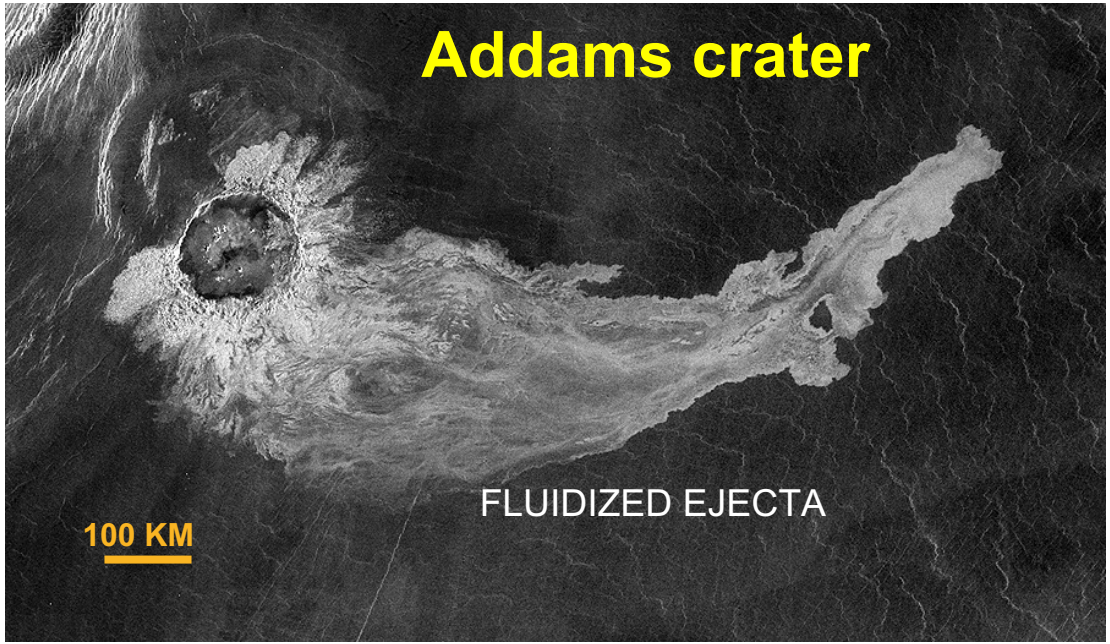
ARACHNOID FEATURES

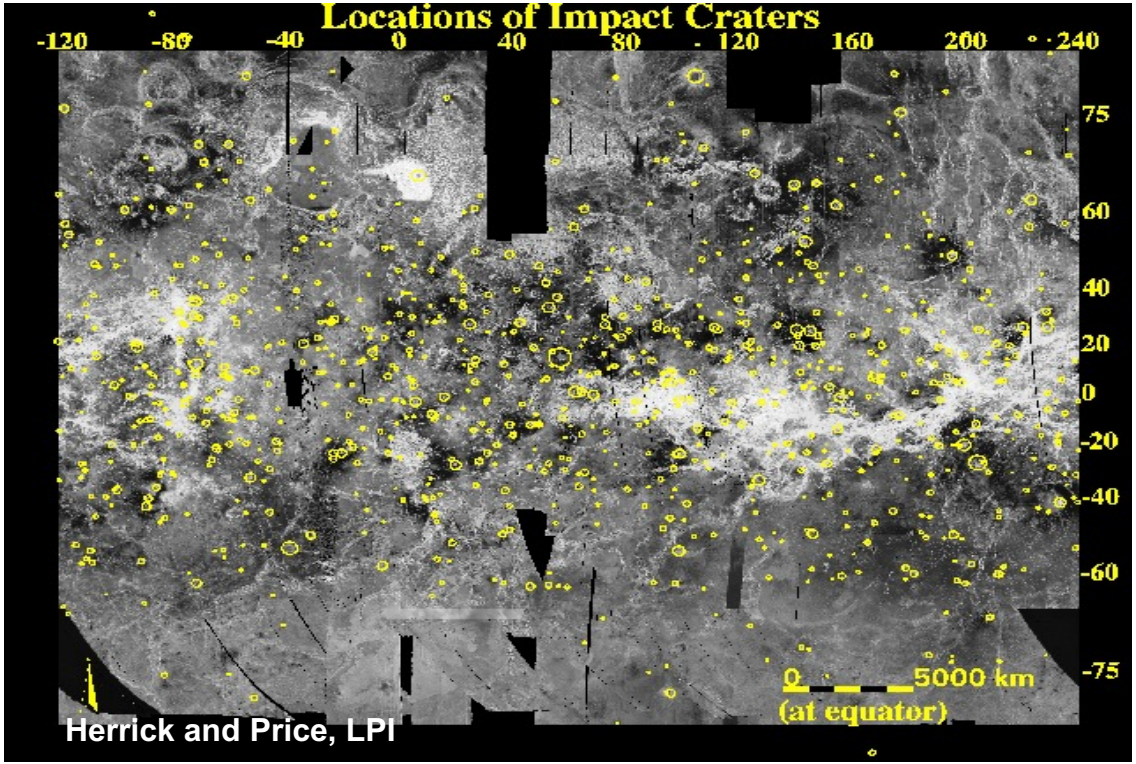


NASA-Magellan



THE VENUSIAN IMPACT CRATERS RECORD



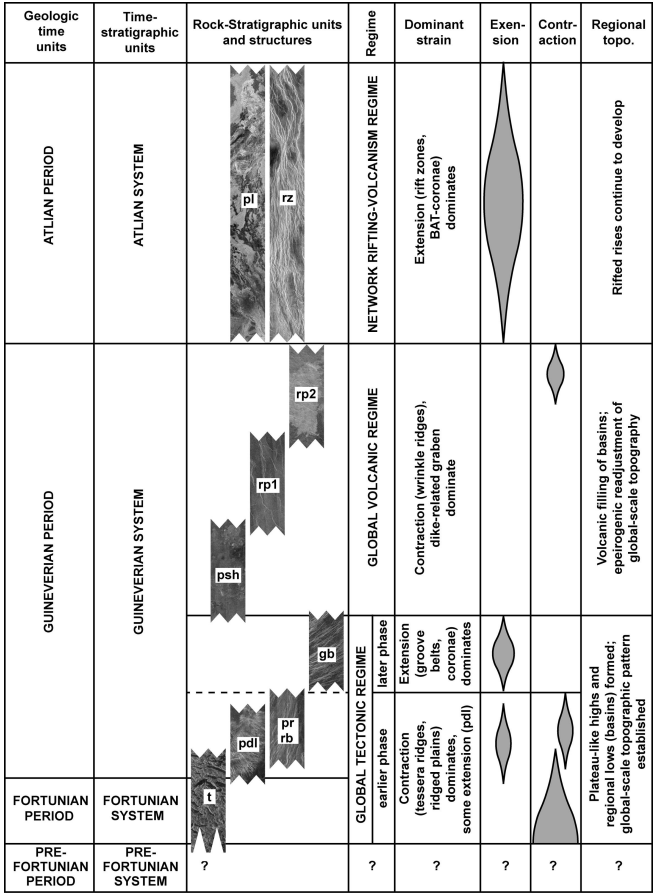


- RANDOMLY DISTRIBUTED
- ~1000 COUNTED
- NONE >3 KM – SMALL BOLIDES ARE LIKELY BURNED IN THE ATMOSPHERE

THE SURFACE IS YOUNG ~ 500 My

Geologic units, stratigraphy and global correlation

Basilevsky and Head, Planet. Space Sci., 2000



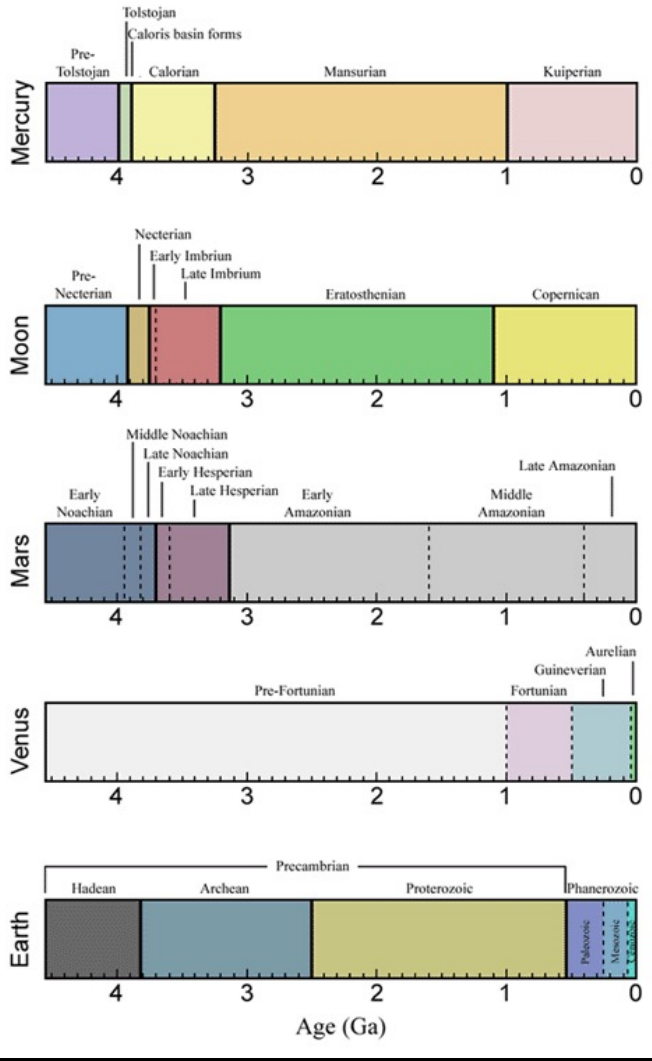
GLOBAL TECTONIC REGIME

GLOBAL VOLCANIC REGIME

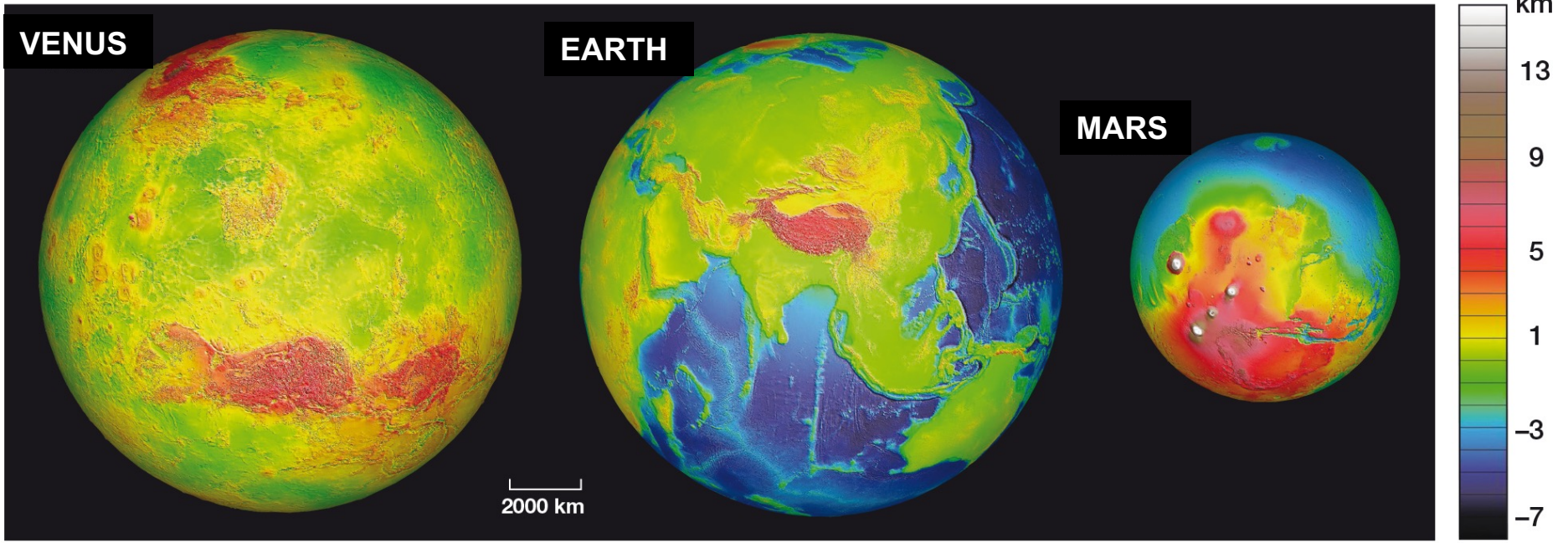
RIFTING+ VOLCANIC REGIME

TIME

CHRONOSTRATIGRAPHY COMPARISON



UNIQUE STRATIGRAPHIC RECORD

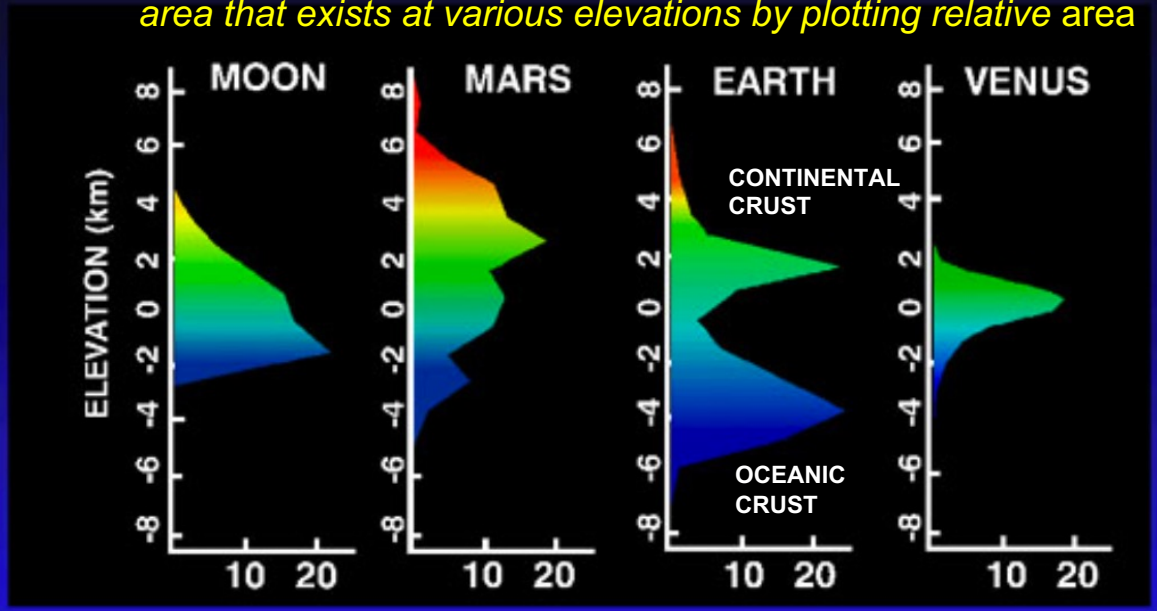


TOPOGRAPHY COMPARISON

surface topography is the result of endogenic and exogenic processes

COMPARATIVE HYPSOMETRIES

hypsometric curve is a graph *that shows the proportion of land area that exists at various elevations by plotting relative* area



UNDIFFERENTIATED ? BODY

LIKELY DIFFERENTIATED BODY

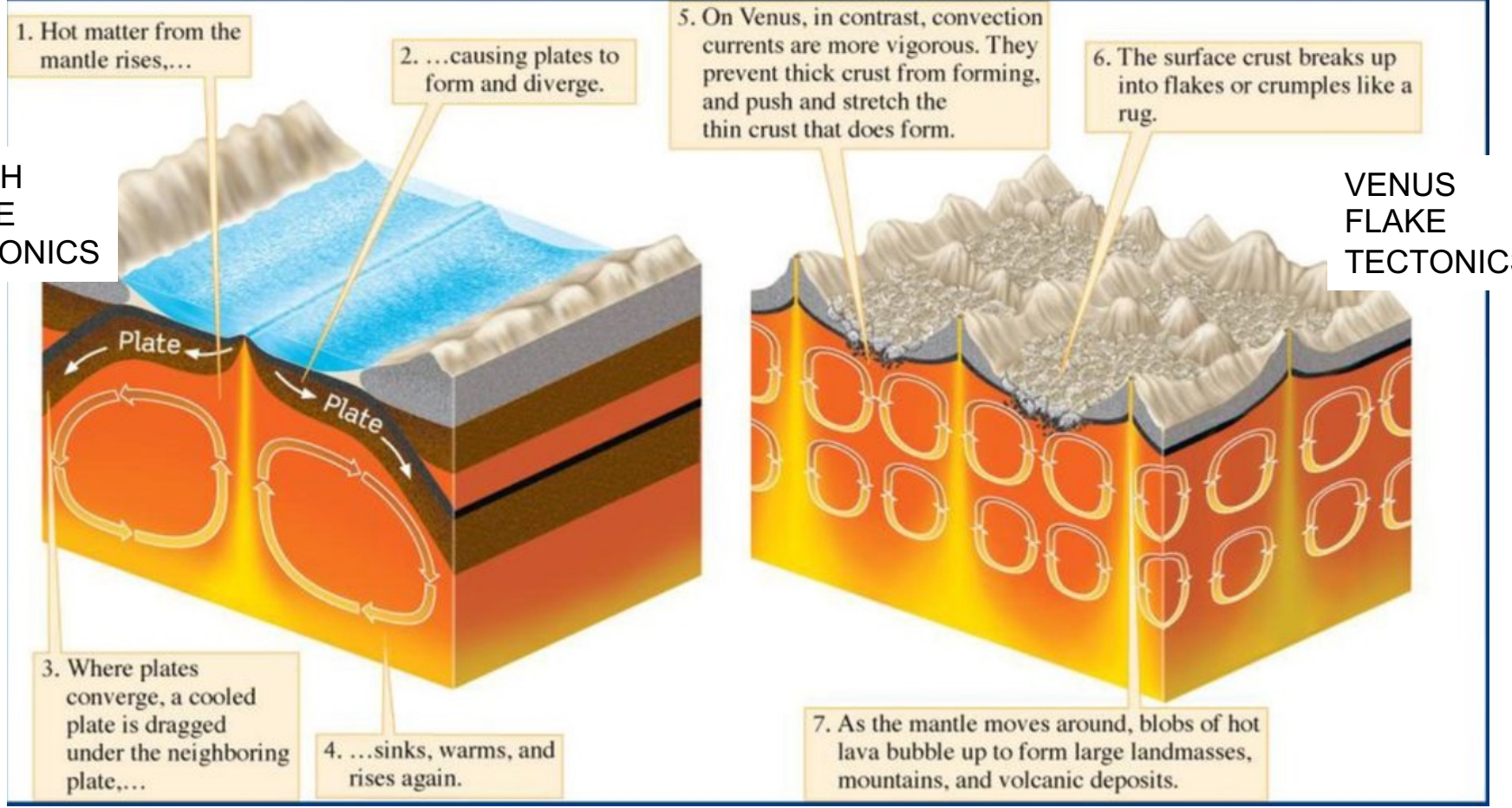
STRONGLY DIFFERENTIATED BODY

UNDIFFERENTIATED ? BODY

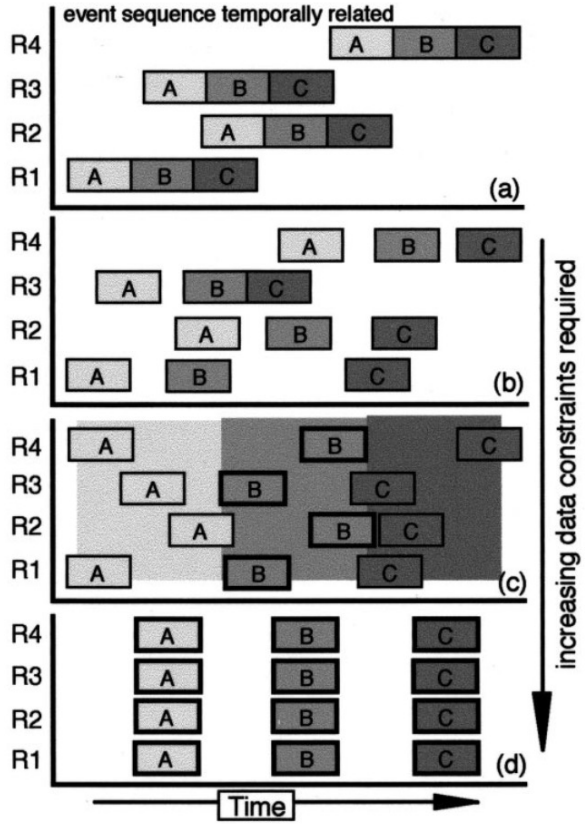
URL: http://comp.uark.edu/~sboss

University of Arkansas

EARTH
PLATE
TECTONICS



VENUS
FLAKE
TECTONICS



Hansen, Geologic mapping of tectonic planets, Earth and Planetary Science Letters, 2000

CAN TECTONIC FEATURE BE PART OF A GEOLOGICAL UNIT OR SHOULD BE MAPPED SEPARATELY?

Idealized models of the surface evolution of a theoret-ical planet. Three arbitrary events (A, B, and C in which age of AsBsC) and four arbitrary regions (R1^R4) illustrate spatial and temporal relations of events: (a) A, B, and C are genetically linked (must be independently demonstrated), but not necessarily global synchronous; (b) the broadest of interpretations in which A, B, and C are spatially and temporally unrelated - the most conservative interpretation lacking abso- lute ages; (c) a minimum of four speci¢c absolute ages (bold boxes) could indicate that at R1^R4 A precedes B, which precedes C; (d) interpretation following the global strati- graphic method - requires at least 12 specic absolute ages (bold boxes) to document.

VENUS SURFACE COMPOSITION

Geochemical data from flows adjacent to the Venera 14 and Vega 2 landers (Barsukov et al., 1982, 1986) indicate **basalt**.

Filiberto (2014) used crystallization experiments on Venera 14 and Vega 2 compositions to suggest the prevalence of **olivine tholeiitic basalts** similar to mid-ocean or continental hot spots

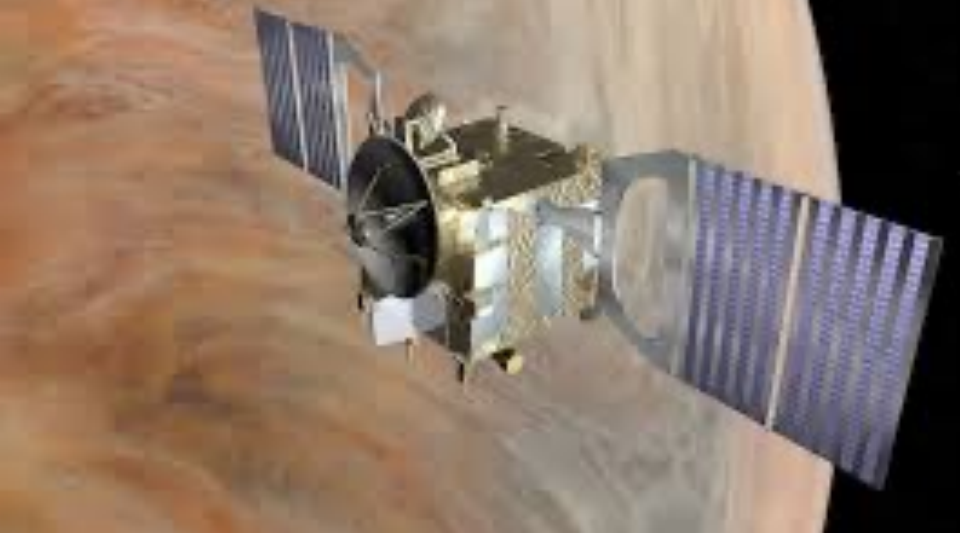
Venera 13 geochemistry suggested the possible presence of **alkaline rock** types on Venus (Barsukov et al., 1982)

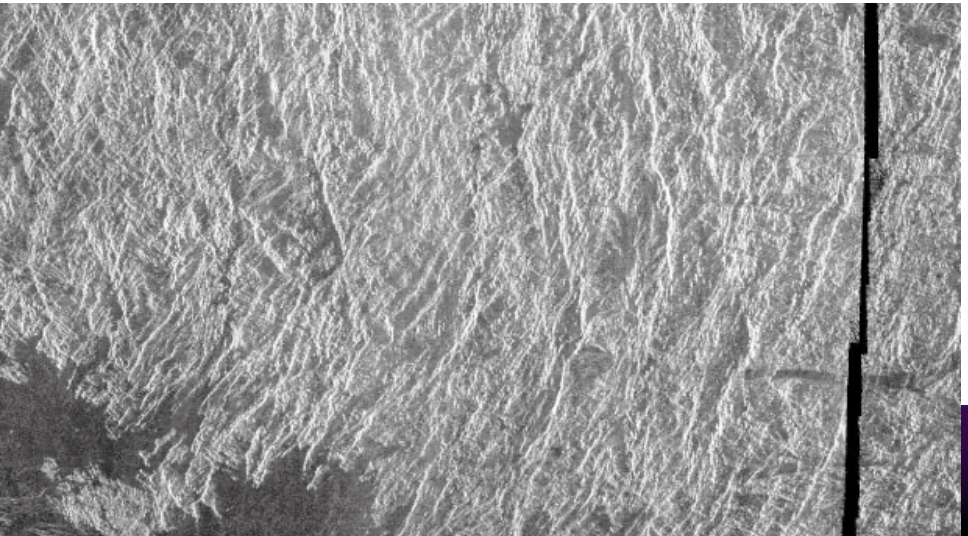
from Dyar et al., Geophys. Res. Letters, 2020

TABLE II. Measured Composition of Venus Rocks (Percentage by weight)

Element (oxide)	Venera 13 (upland)	Venera 14 (lowland)
MgO	11.4±6.2	8.1±3.3
Al_2O_3	15.8±3.0	17.9±2.6
SiO_2	45.1±3.0	48.7±3.6
K_2O	4.0±0.63	0.2±0.07
CaO	7.1±0.96	10.3±1.2
TiO_2	1.59±0.45	1.25±0.41
MnO	0.2±0.1	0.16±0.08
FeO	9.3±2.2	8.8±1.8
Σ	95	97

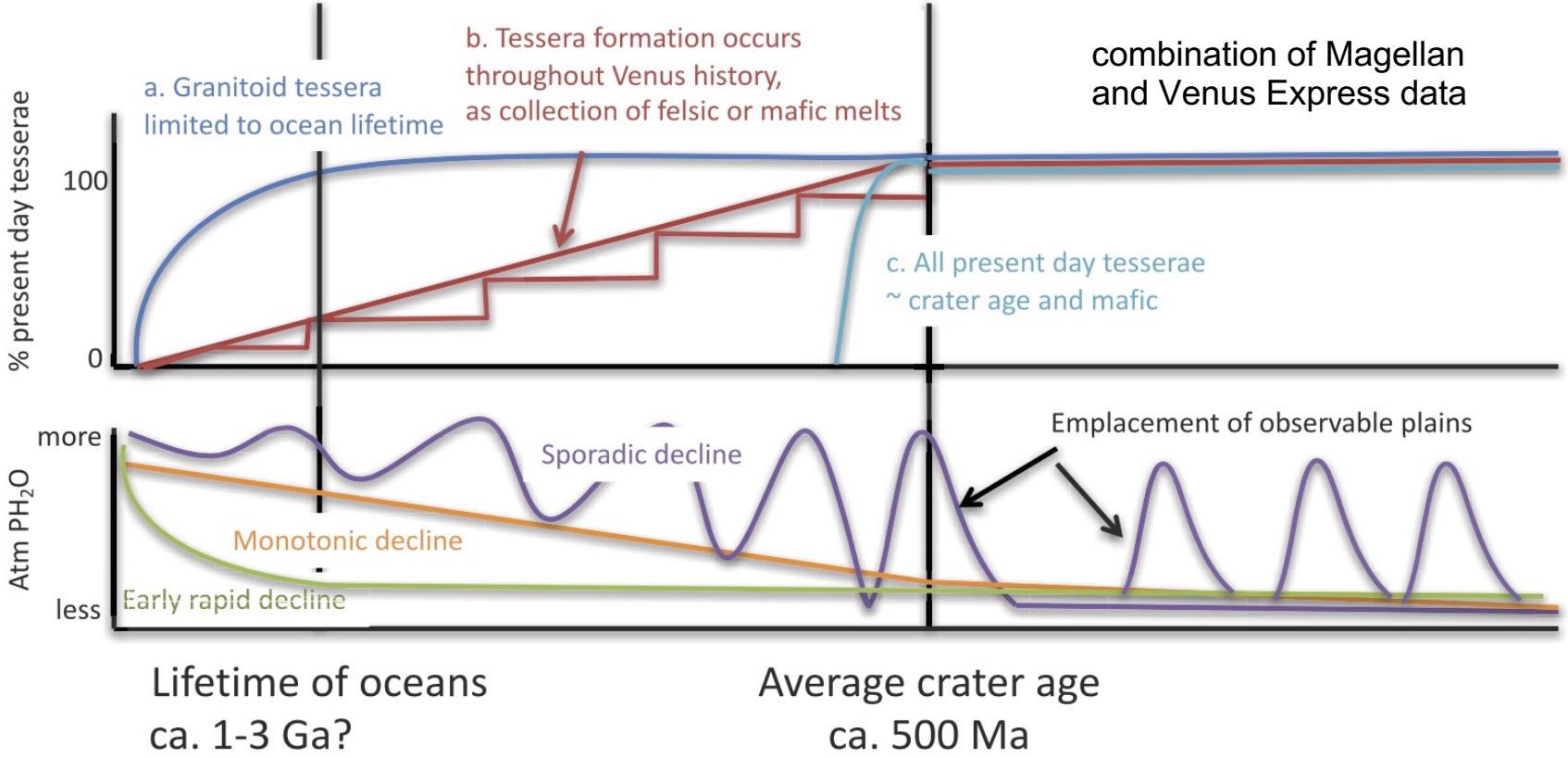
Surkov et al., 1982





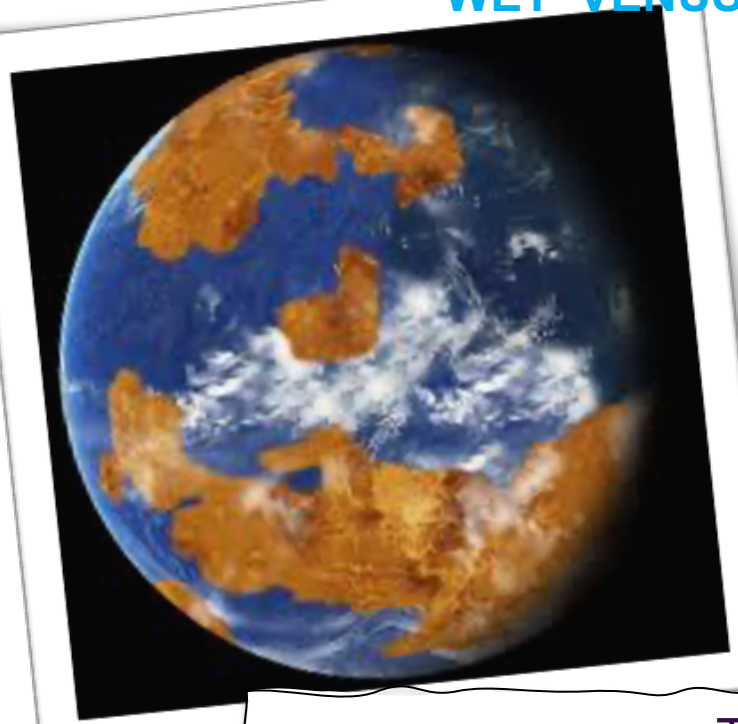
Venus Express mission revealed different composition between tessera and planitiae.

Tesserae appear more sialic in composition → differentiated crust



Gilmore et al., Space Science Review, 2023

‘WET’ VENUS



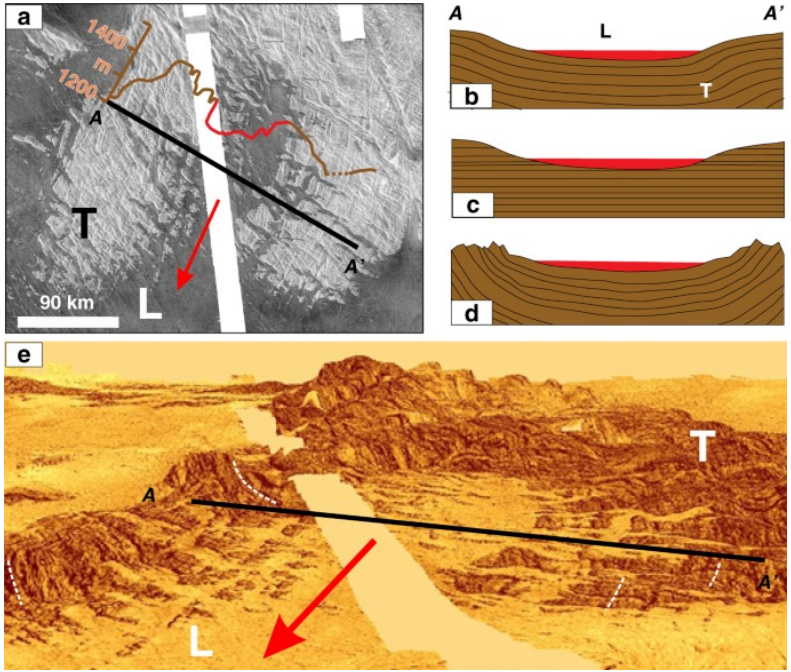
VS.

EARTH

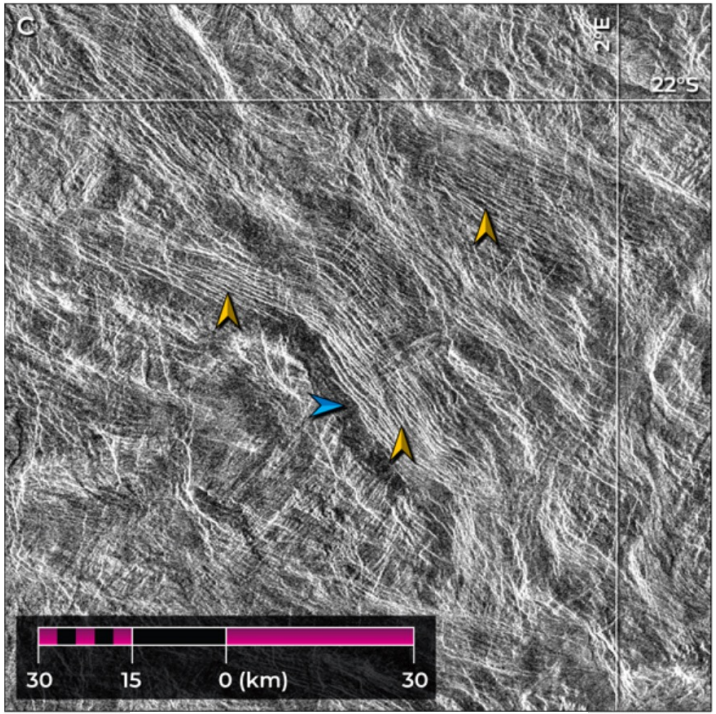
TWIN PLANETS
very similar during part of their geological evolution?

TESSERAE TERRAINS

EVIDENCES OF A ‘WET’ VENUS PAST



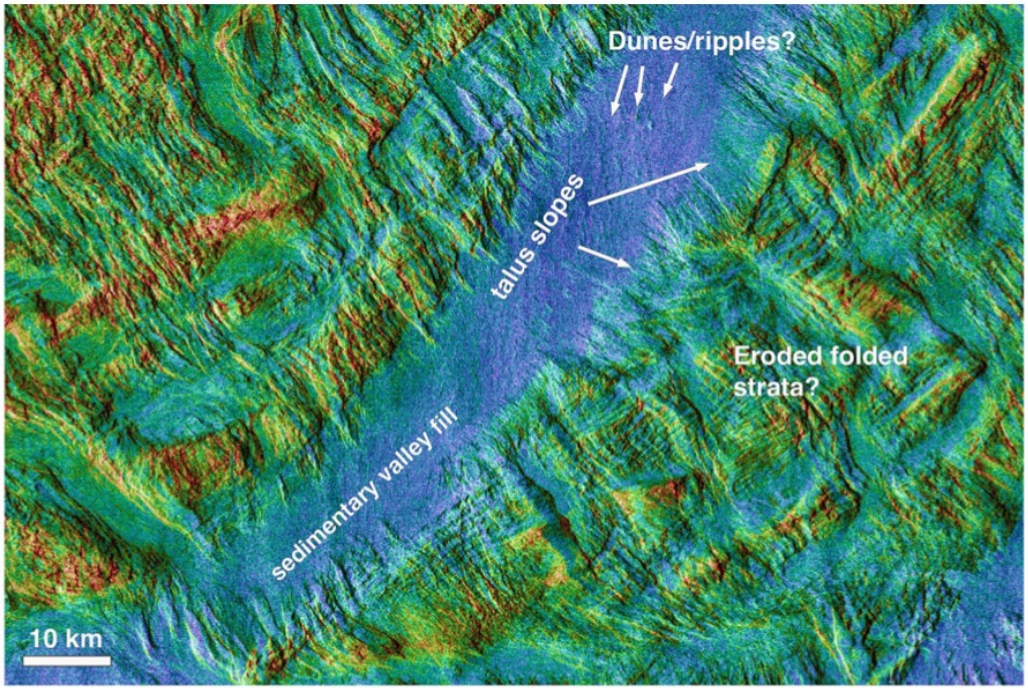
Khawja, *et al. Nat Commun* **11**, 5789 (2020)



Paul K. Byrne et al, *Geology* - 2020

SEDIMENTARY DEPOSITS ON VENUS

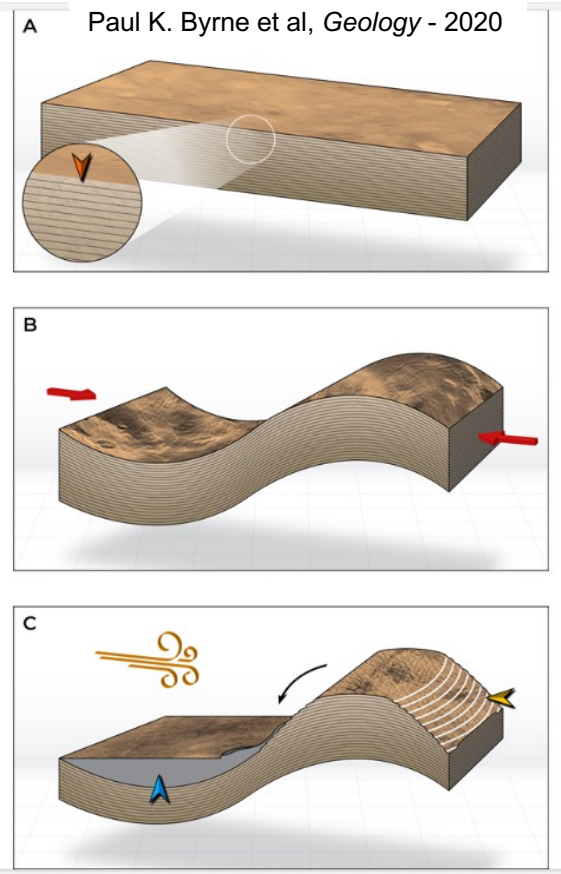
layered terrain of sedimentary origin?



pseudo-full colour image of a portion of Tessera in the equatorial region

Carter et al., Space Science Reviews (2023)

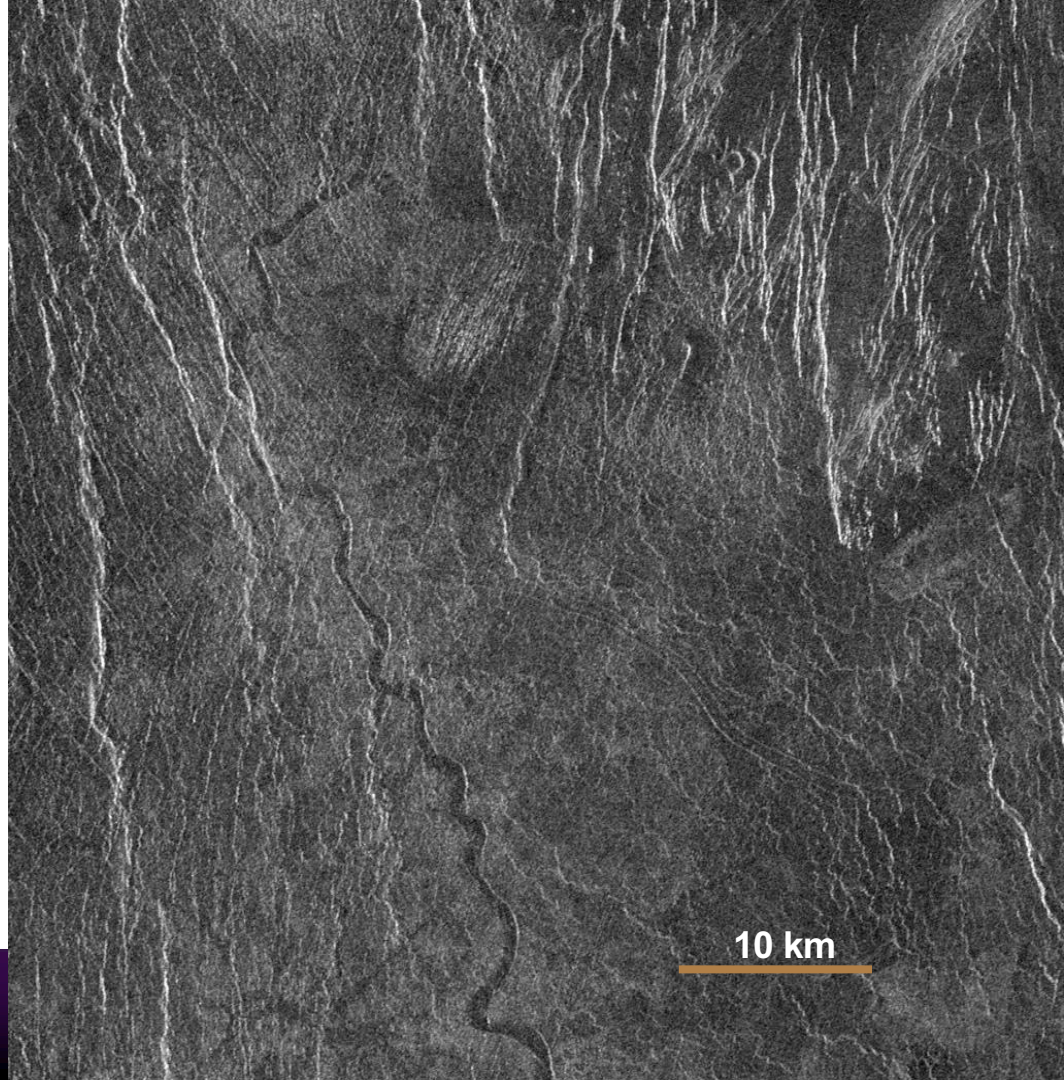
Paul K. Byrne et al, *Geology* - 2020



The Venusian canali revealed by Magellan images were interpreted as formed by very fluid lava (i.e. komatiite)

or they can be the remnants of a wet Venus?

open question for future missions



GMAP
Geological Mapping

FINAL REMARKS

VENUS SHOWS A UNIQUE GEOLOGICAL HISTORY

- VOLCANISM IS WIDESPREAD AND CHARACTERISED BY VARIOUS SETTINGS AND SHAPES
- TECTONICS HAS EXTENSIVELY MODIFIED THE SURFACE
- BOTH VOLCANISM AND TECTONICS MAY BE STILL ACTIVE
- PAST VENUS MAY HAVE BEEN RICH OF WATER

LET'S WAIT FOR FUTURE MISSIONS!

SEE ALSO THE IVAN'S PRESENTATION