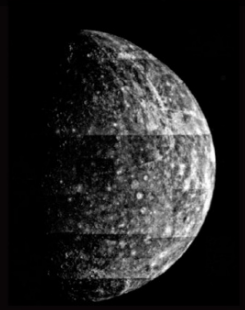
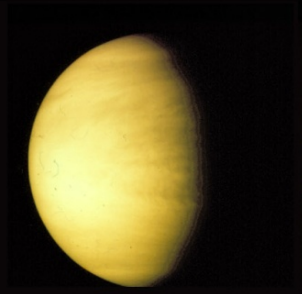
Venus: Craters, Coronae, and Chasmata

Donna M. Jurdy

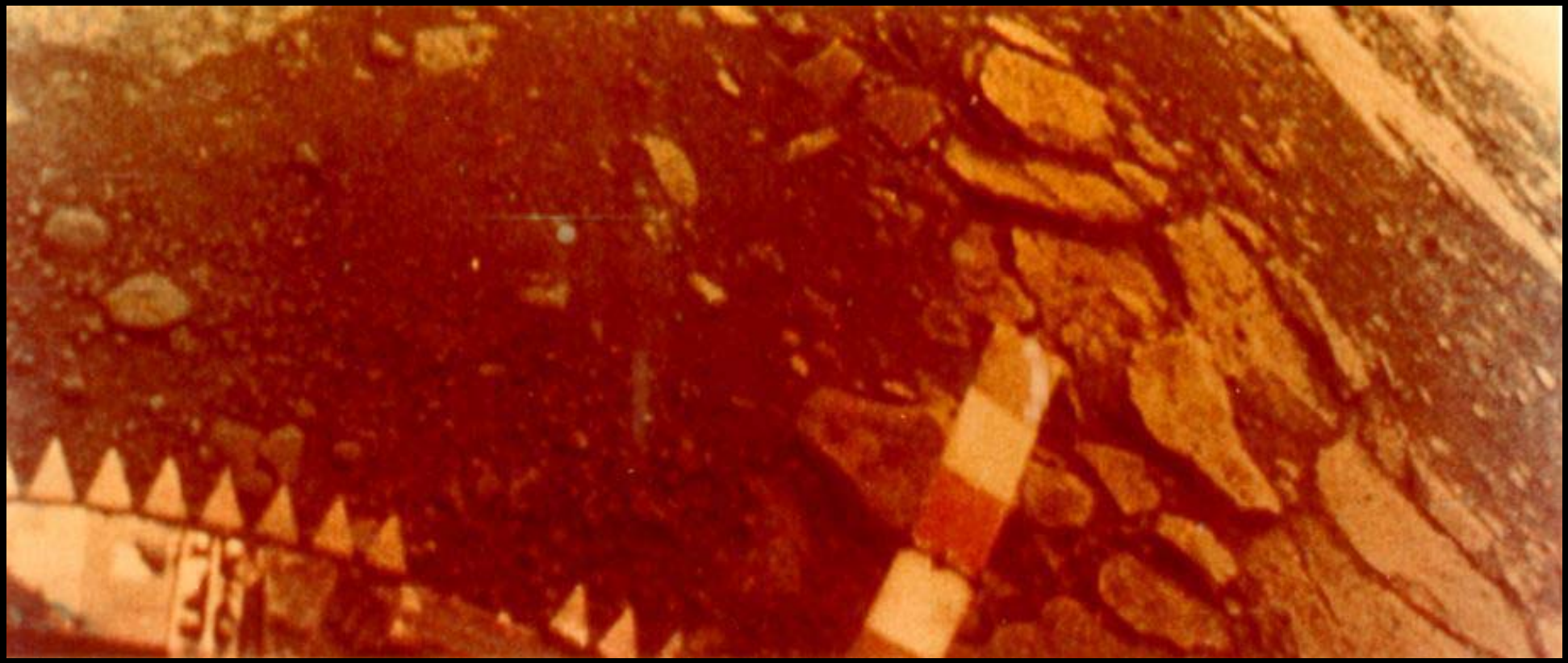
Northwestern University

Sci Fi View of Venus

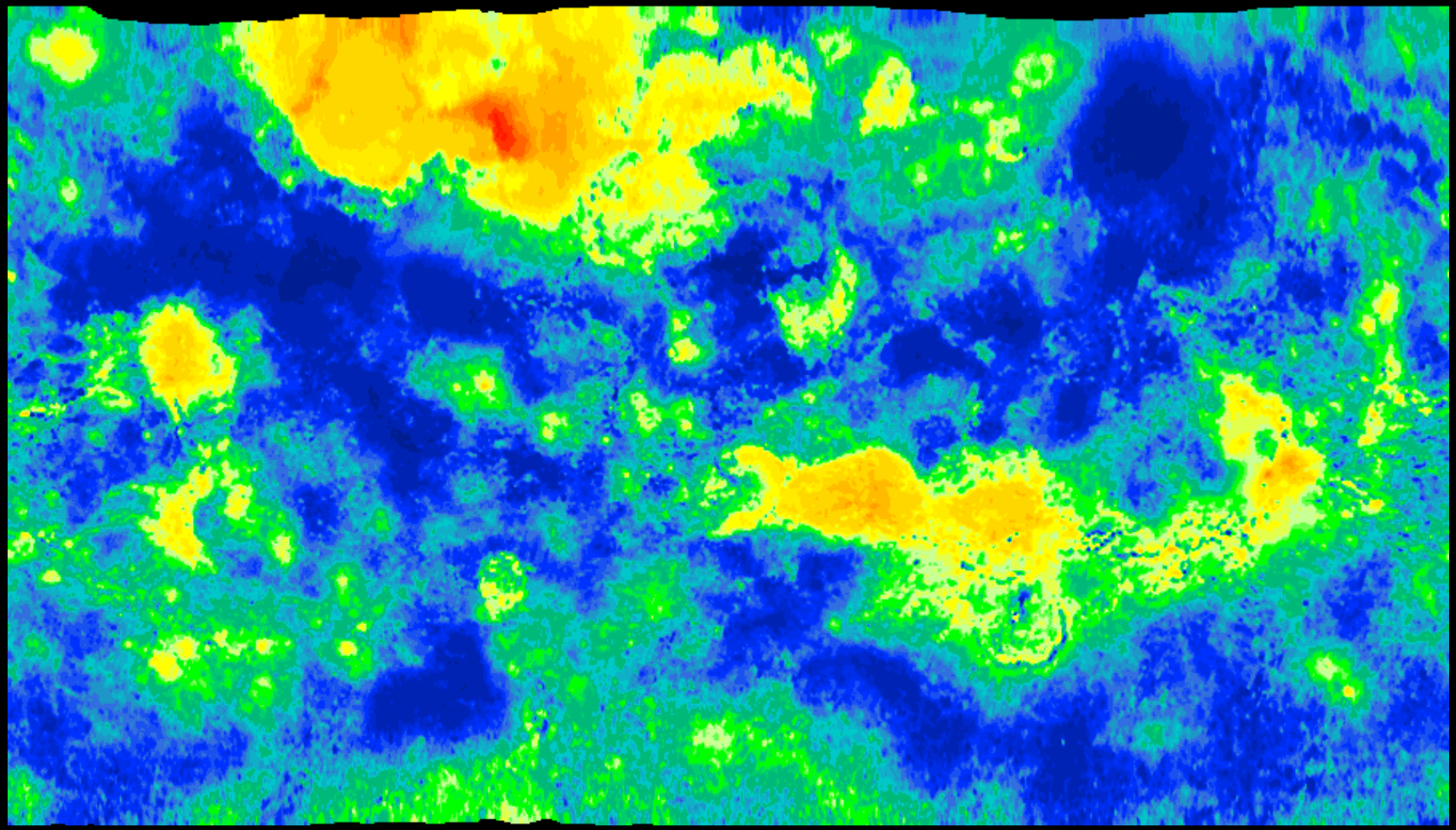
	Mercury	Venus	Earth	Moon	Mars
					
Radius (km)	2439	6052	6378	1738	3398
Mass (kg)	3.30×10^{23}	4.87×10^{24}	5.98×10^{24}	7.35×10^{22}	6.42×10^{23}
Density (kg/m^3)	5420	5250	5520	3340	3940
Distance from the Sun (A.U)	0.387	0.723	1.000	---	1.524
Mean Surface Pressure (bars)	---	92	1	---	0.006
Mean Surface Temp (K)	452	726	281	250	230
Atmosphere	---	CO_2	N_2, O_2	---	CO_2

Venus, photos by Veneras 9, 10

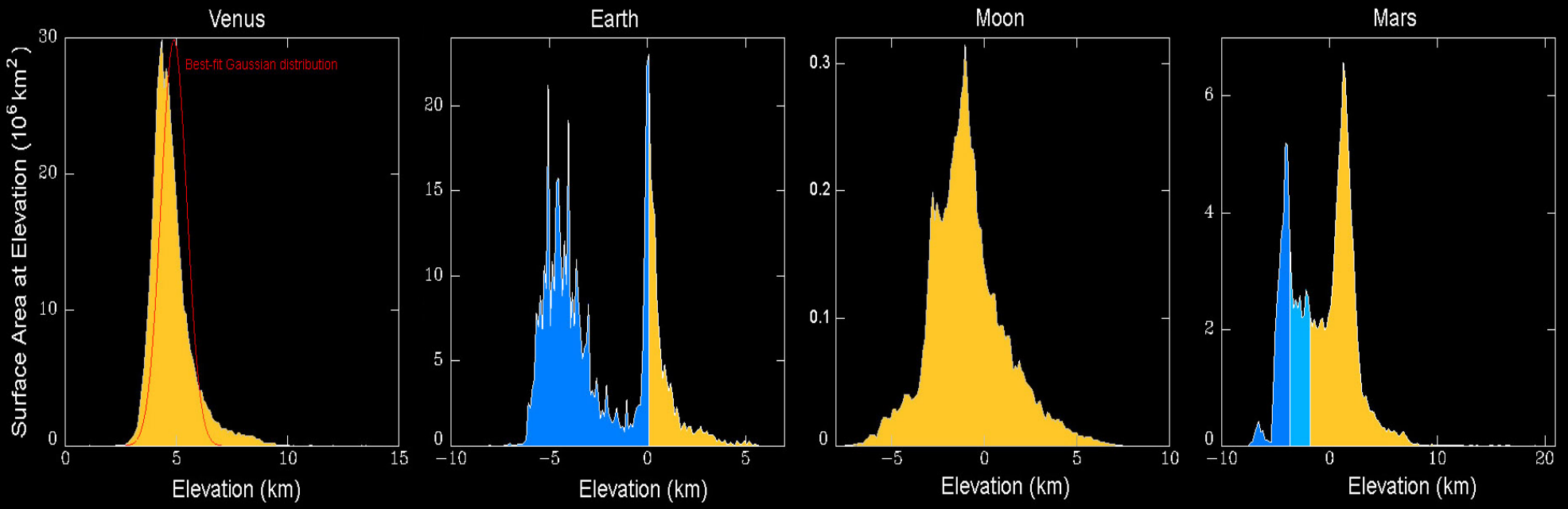
Venus as seen by Venera 13 (Mar. 2, 1982)

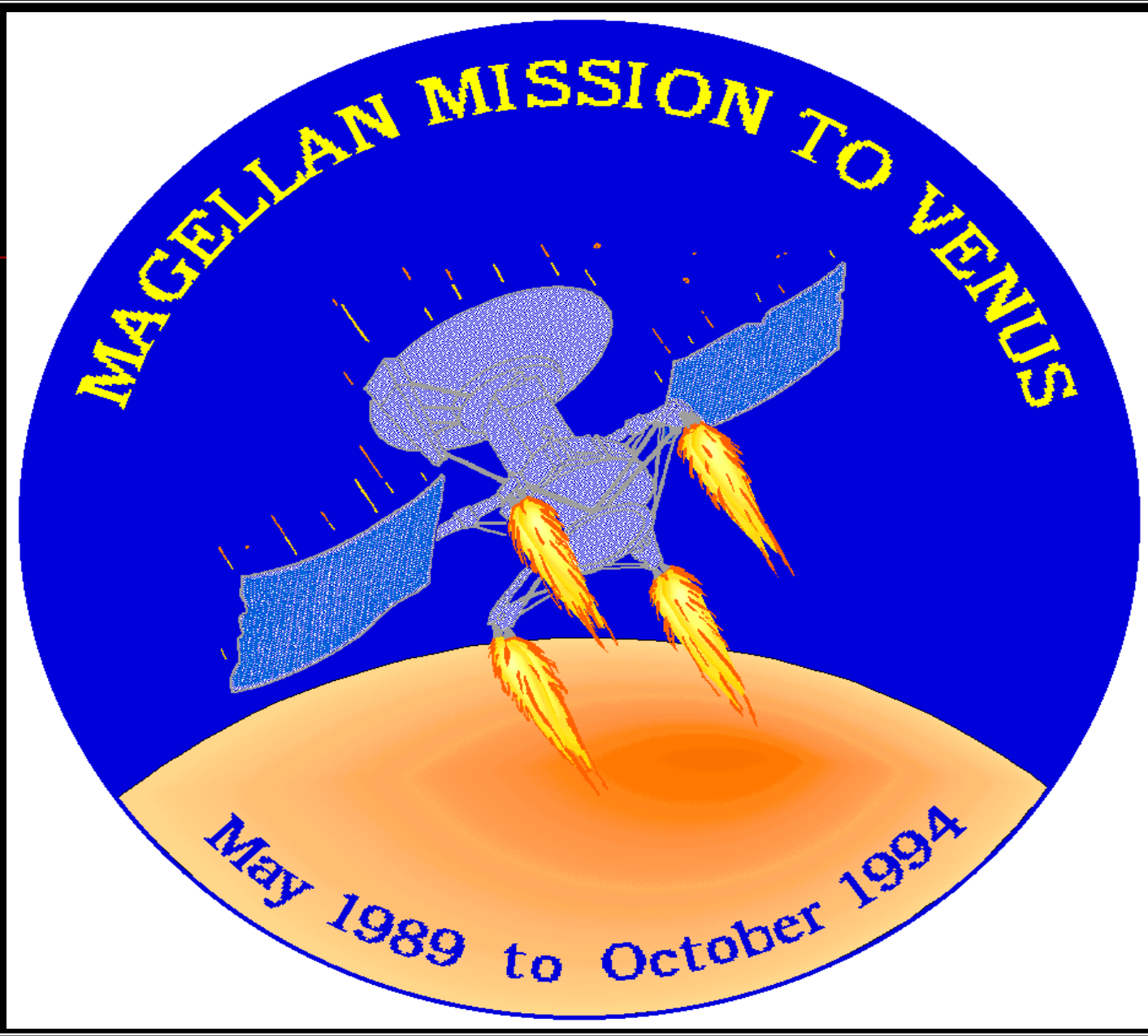


Pioneer Venus Topography



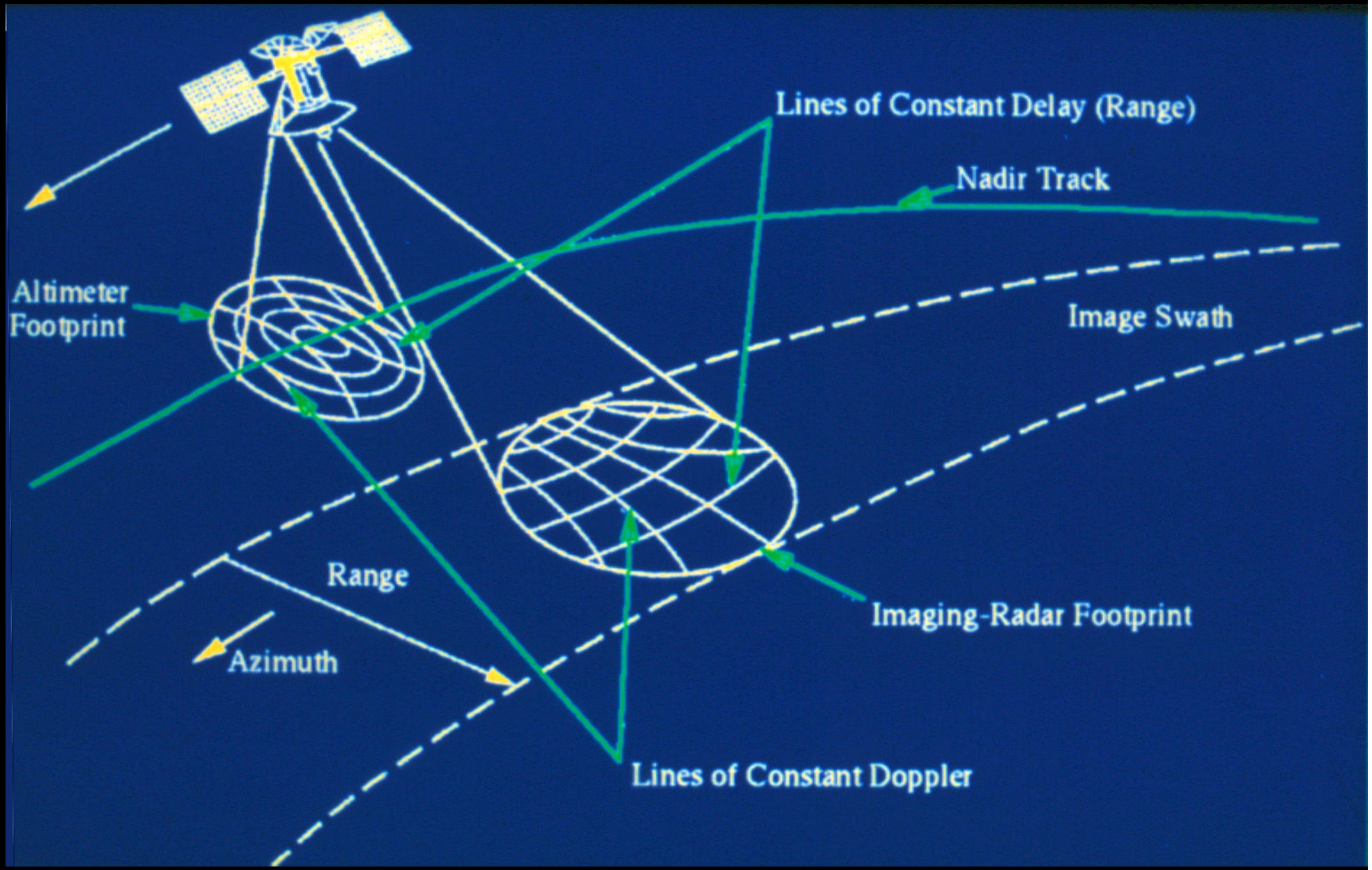
Inner Solar System Hypsography

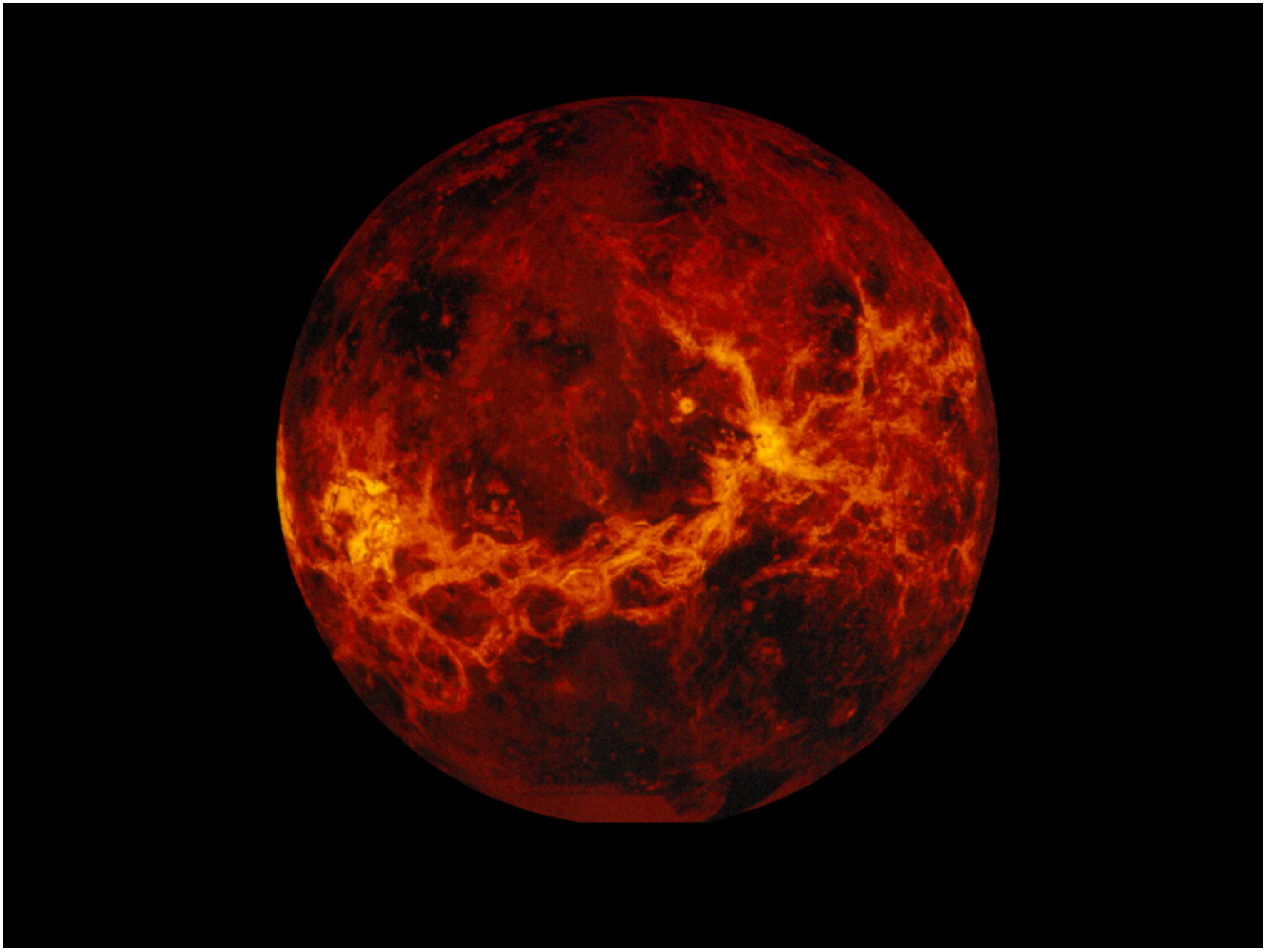



MAGELLAN MISSION TO VENUS
May 1989 to October 1994

Magellan Deployment

Magellan Radar Mapping



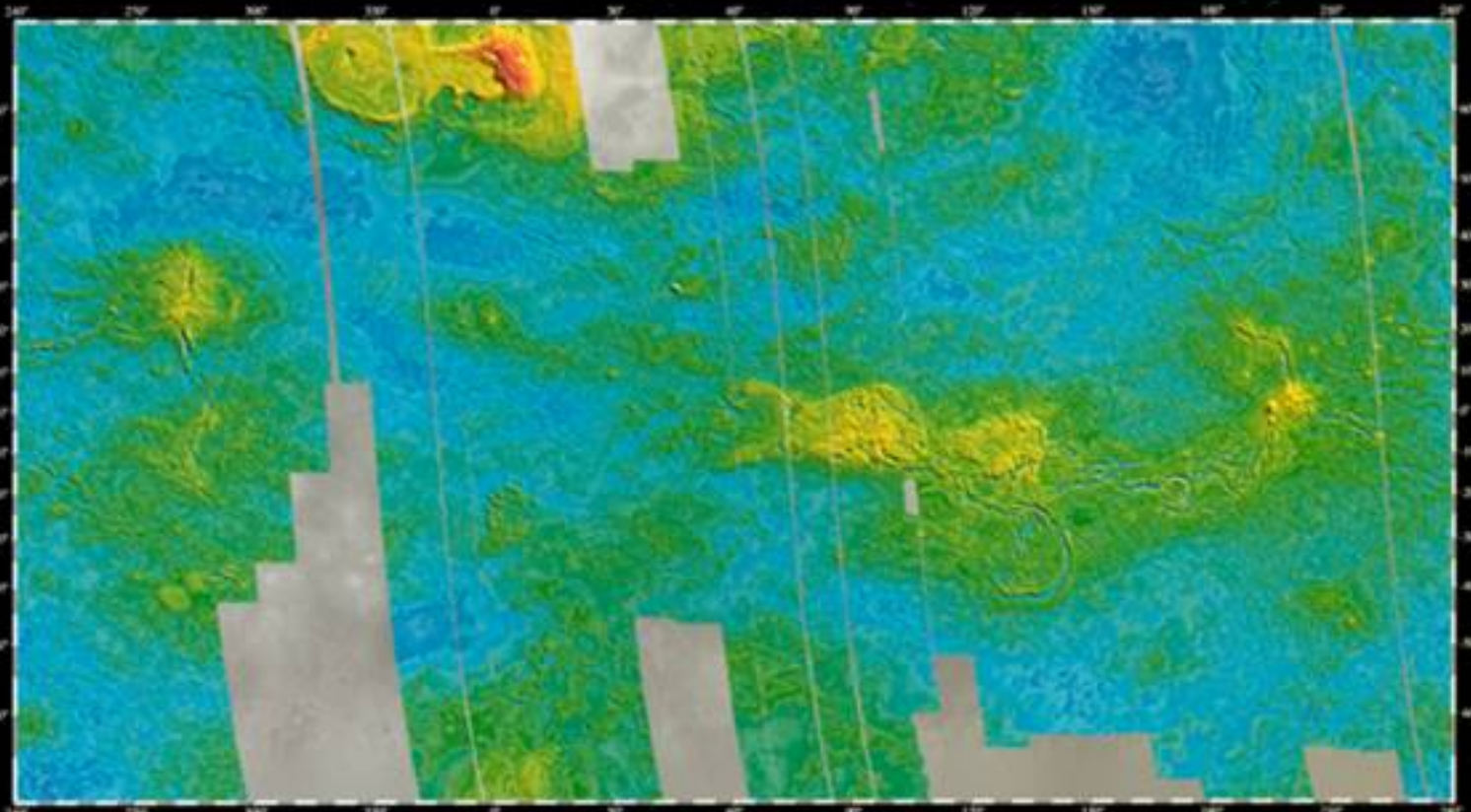


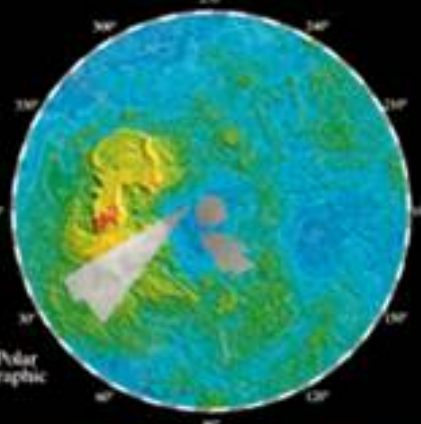
Massachusetts Institute of Technology | National Aeronautics and Space Administration | Jet Propulsion Laboratory

MAGELLAN

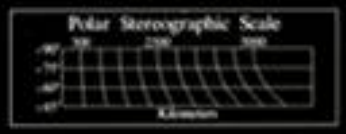
VENUS TOPOGRAPHY

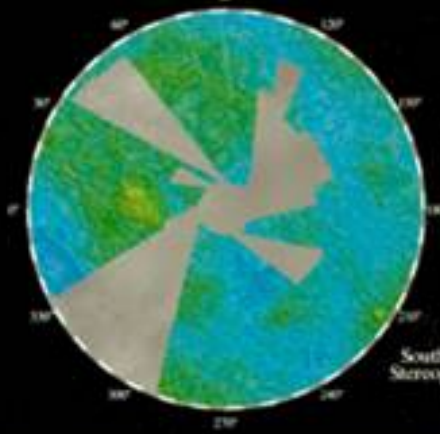
GTDRP.1;3



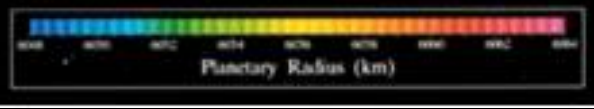


North Polar Stereographic





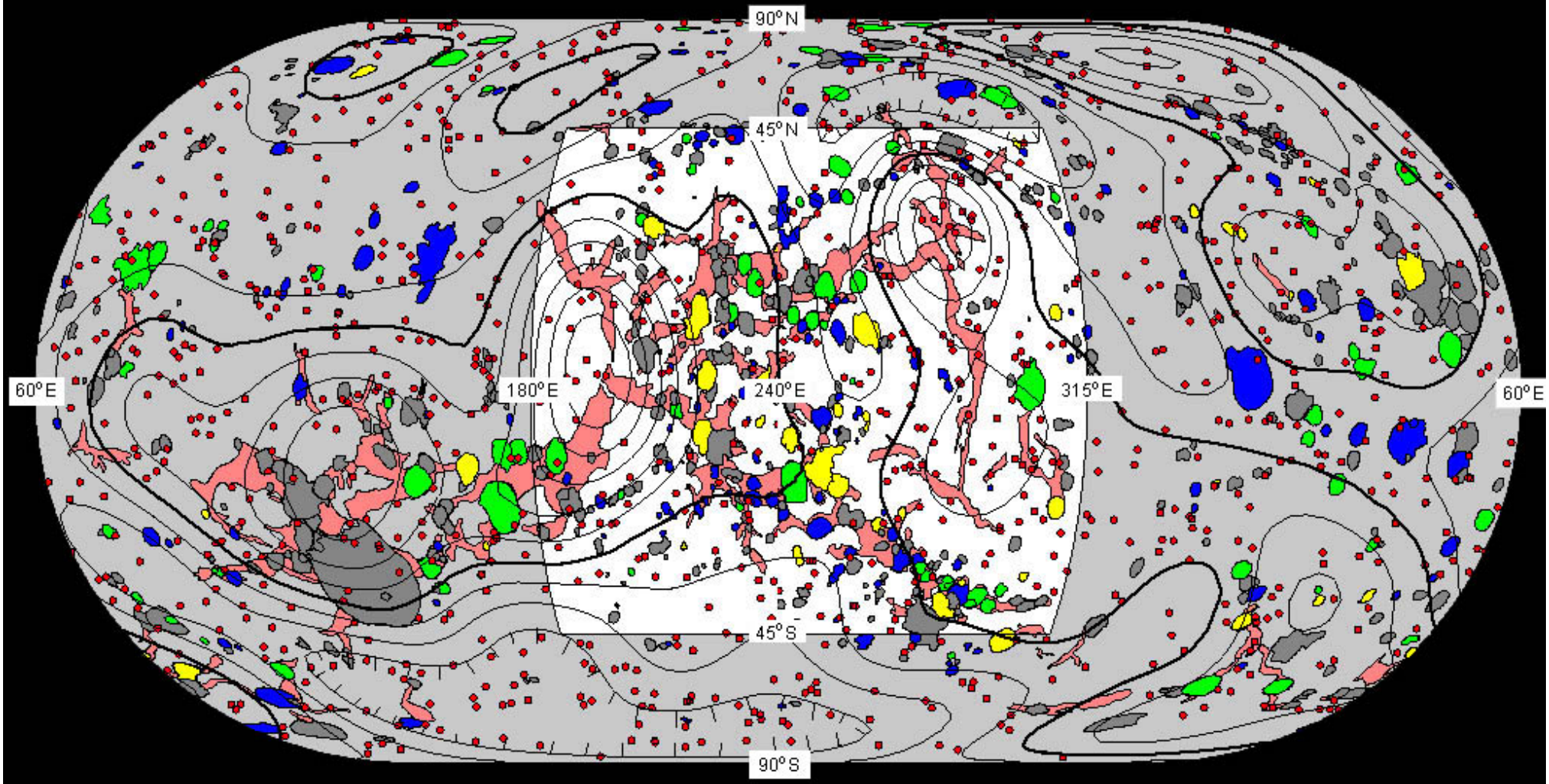
South Polar Stereographic

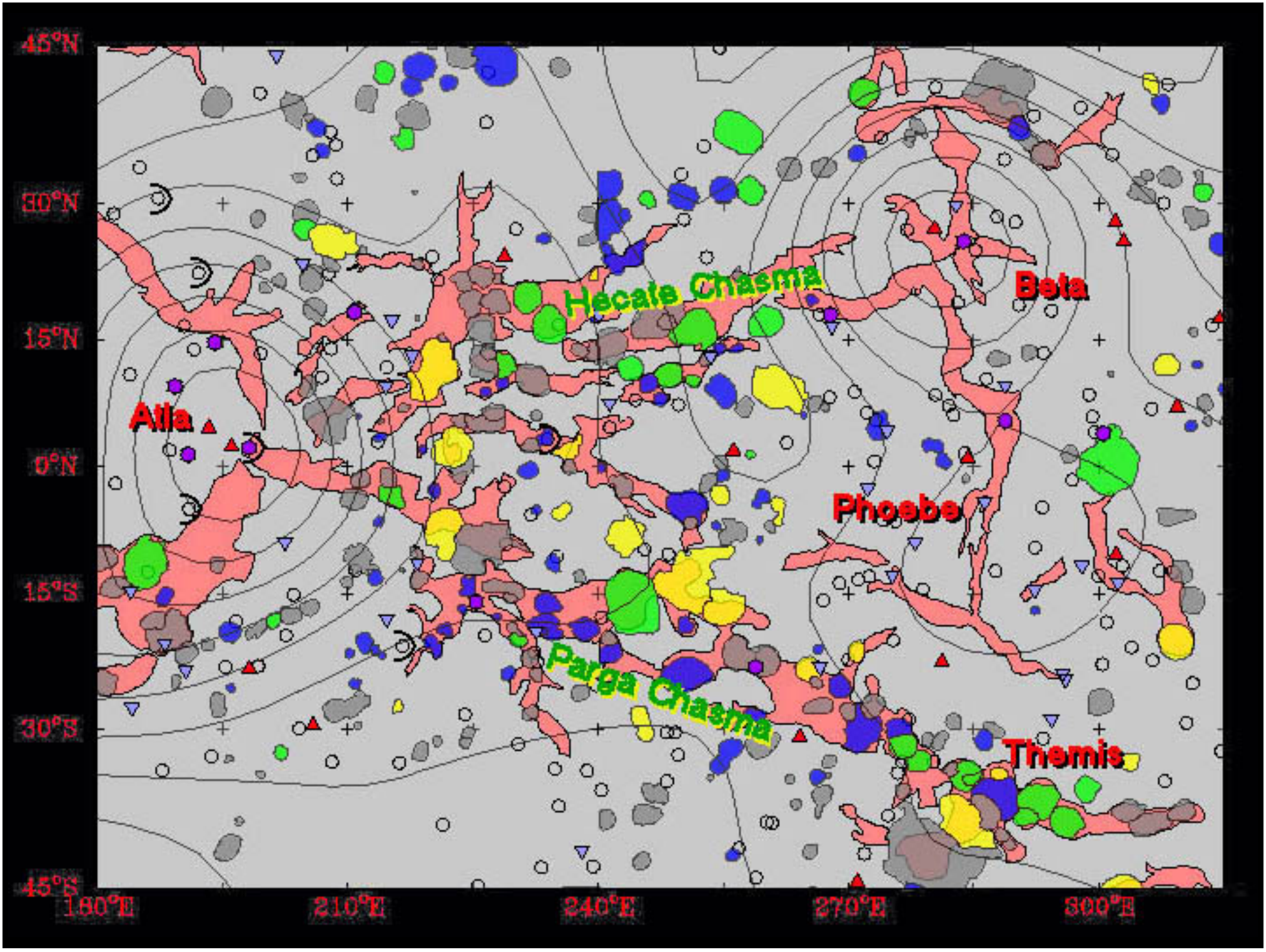


PRODUCT ID:	GTDRP.1;3	PRODUCTION DATE:	11/02/91
STARTING ORBIT:	376	PRODUCTION TIME:	13:19:13
ENDING ORBIT:	2586	HARDWARE VERSION:	01
PIXEL SIZE:	5×5 km	SOFTWARE VERSION:	02

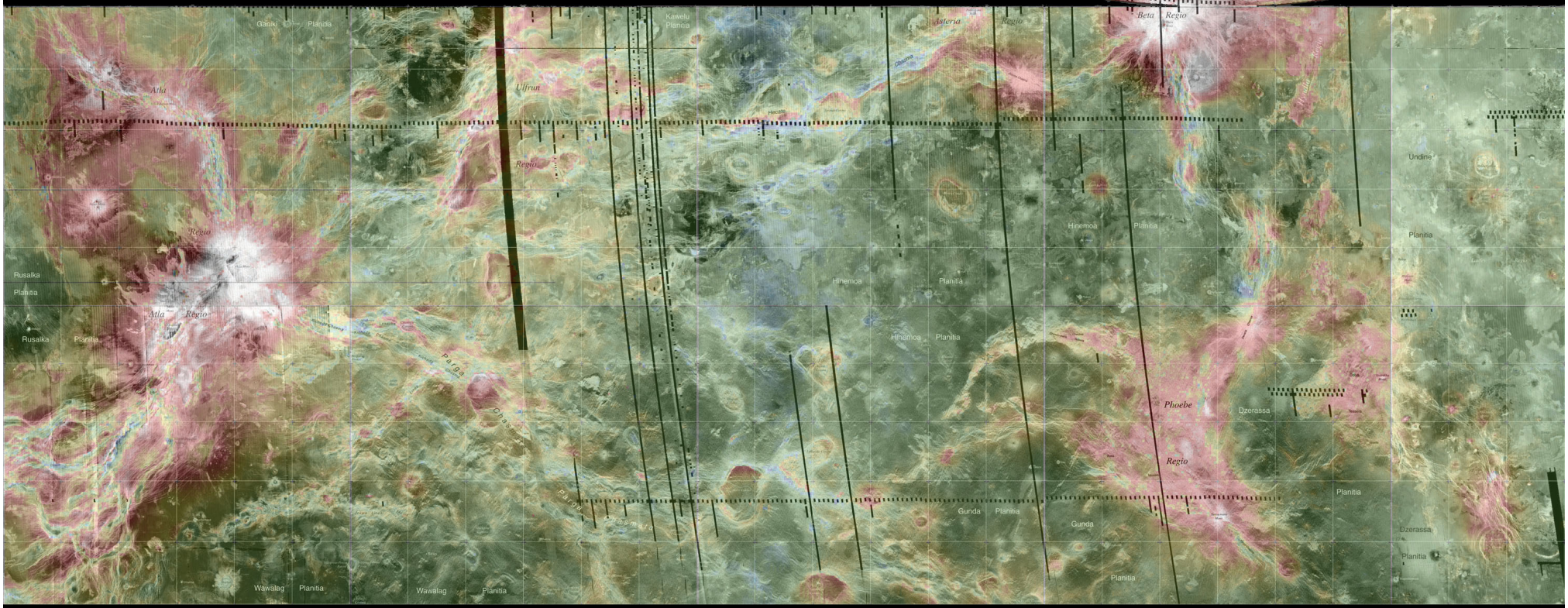
Venus Chasmata, Coronae, Craters, and Geoid

(Eckert IV projection)




45°N
30°N
15°N
0°N
15°S
30°S
45°S
180°E
210°E
240°E
270°E
300°E
Hecate Chasma
Parga Chasma
Beta
Phoebe
Themis
Atla

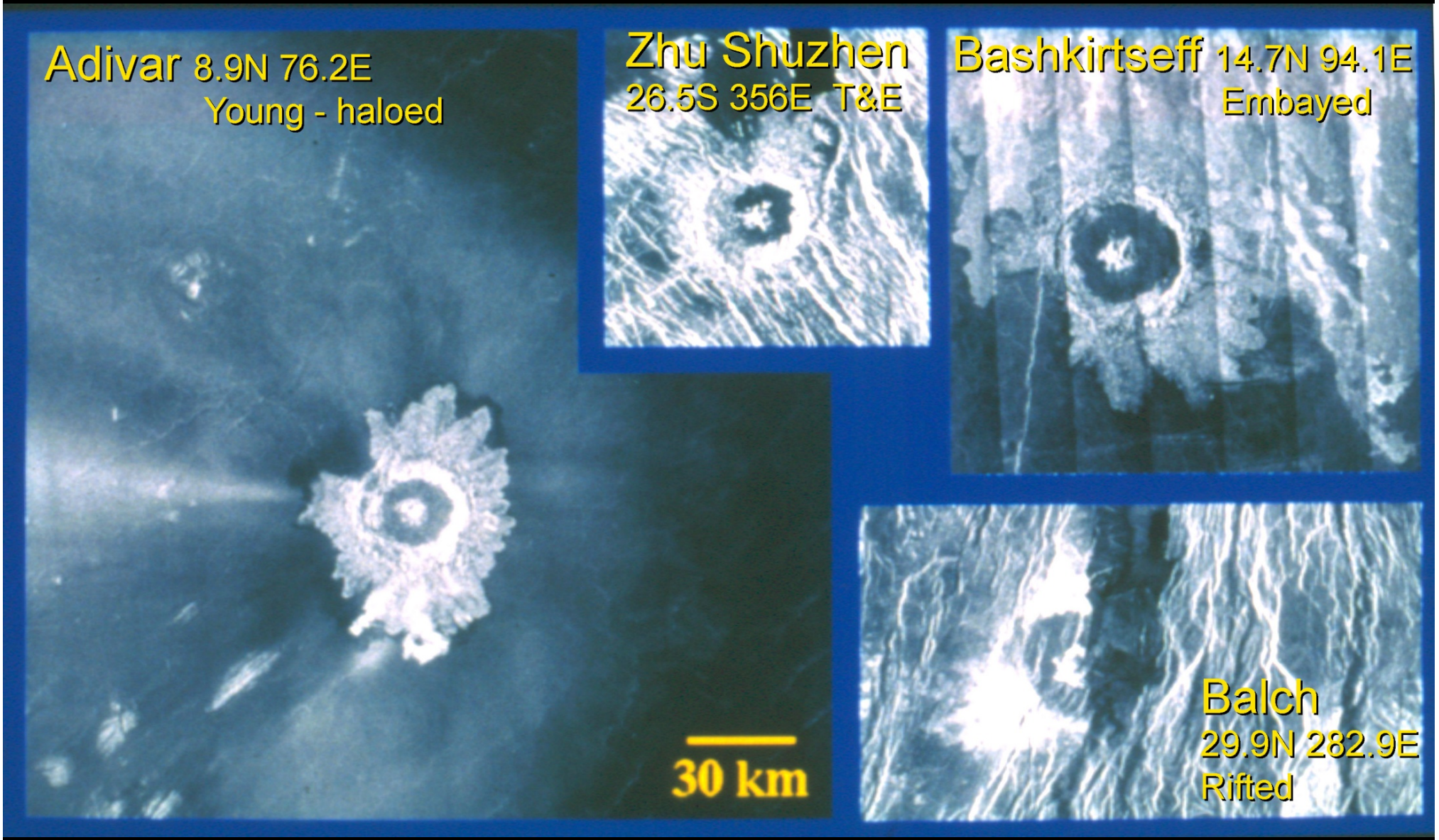
Beta-Atla-Themis (BAT) Region



Craters

- About 1000 globally
- Apparent random distribution
- Most pristine, some modified
  - Tectonization
  - Embayed
  - West-opening Haloes (very young craters)

Craters on Venus



Chasmata

- Probable analog to Earth rifts, great circles
- Strongest relief on Venus: >7km variation over 30 km distance
- Total length of Venus chasmata system similar (adjusted for planetary radius) to that of Earth's rift system (c. ~98%)

Venus Chasmata

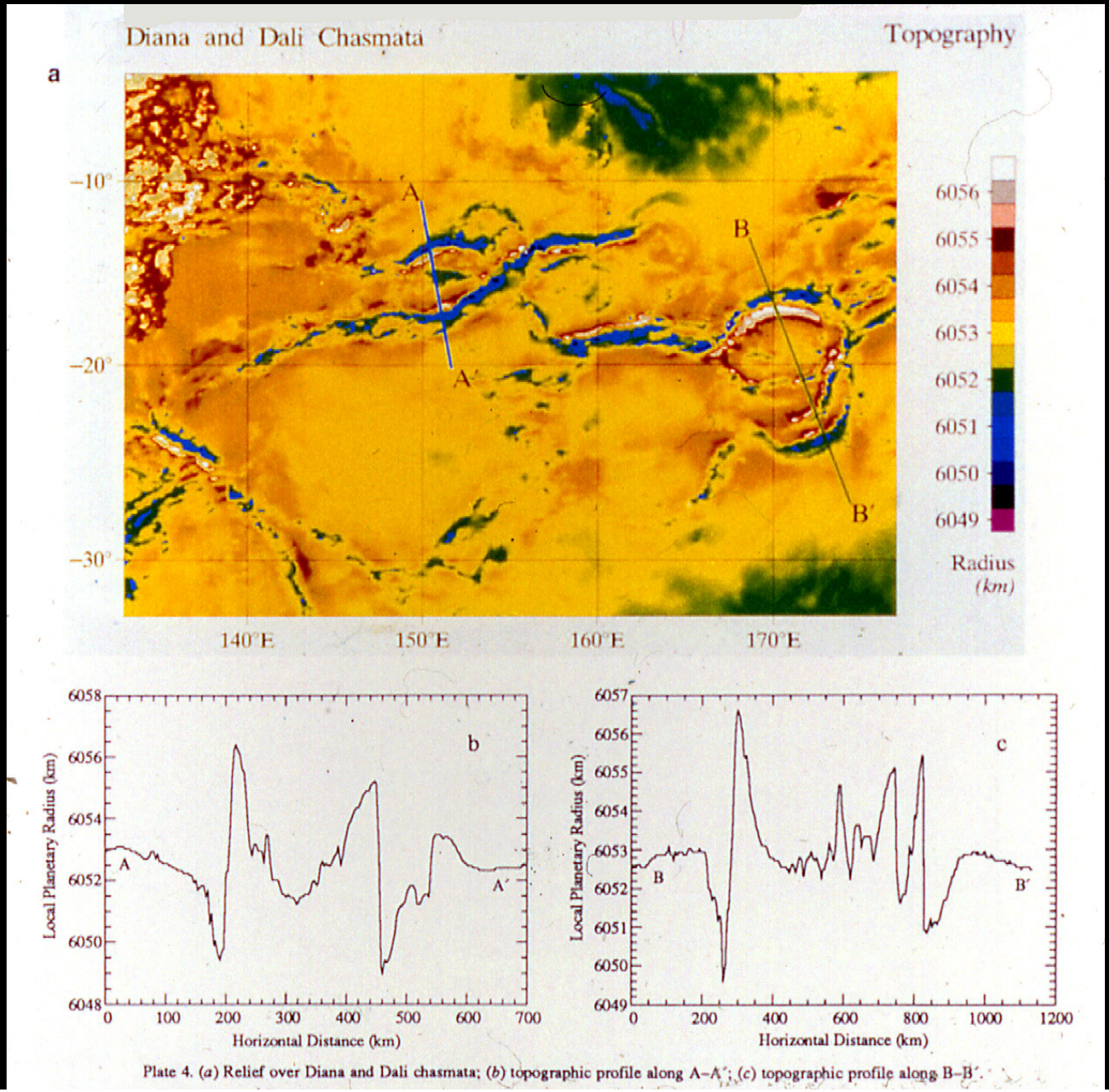
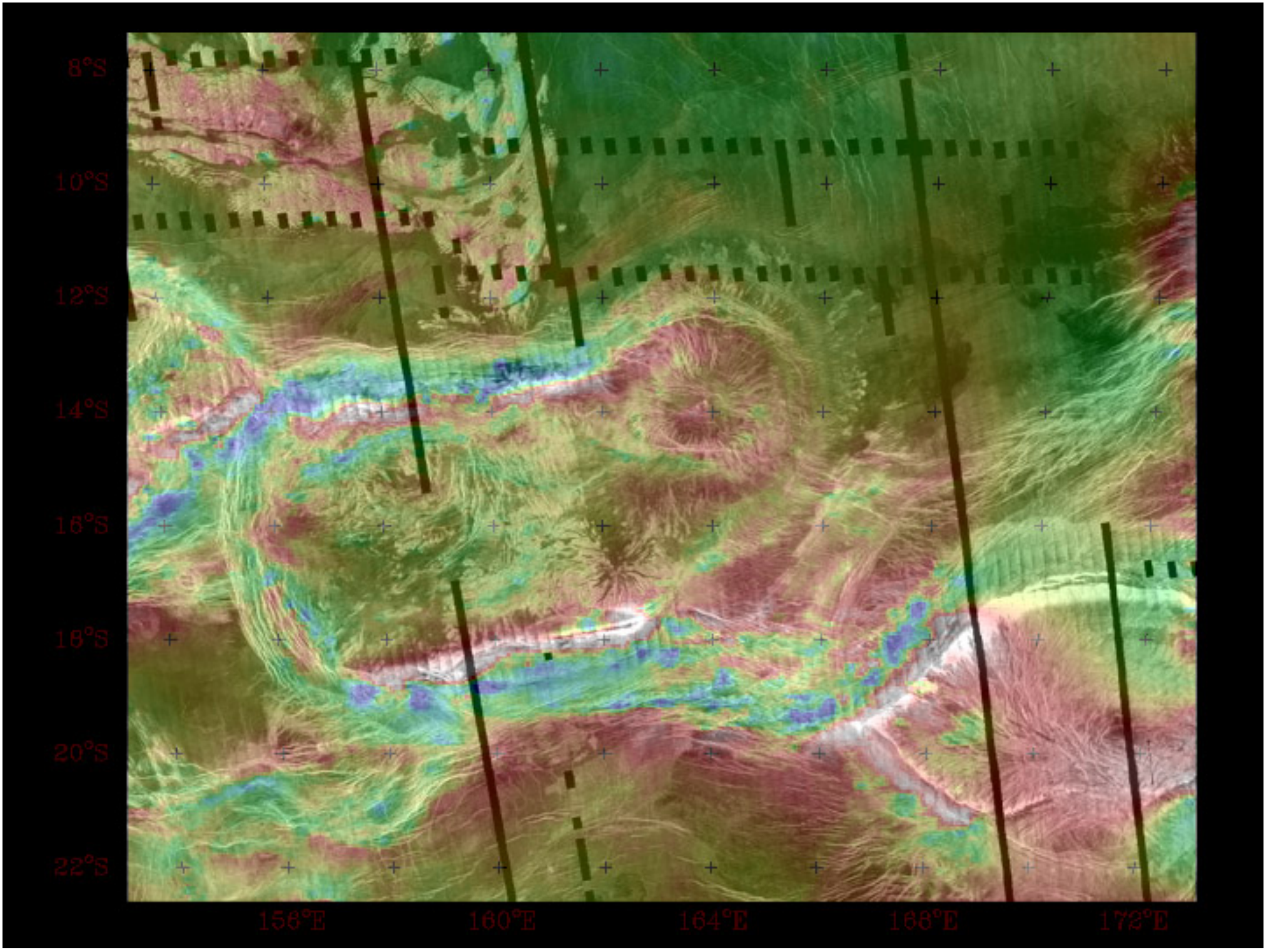


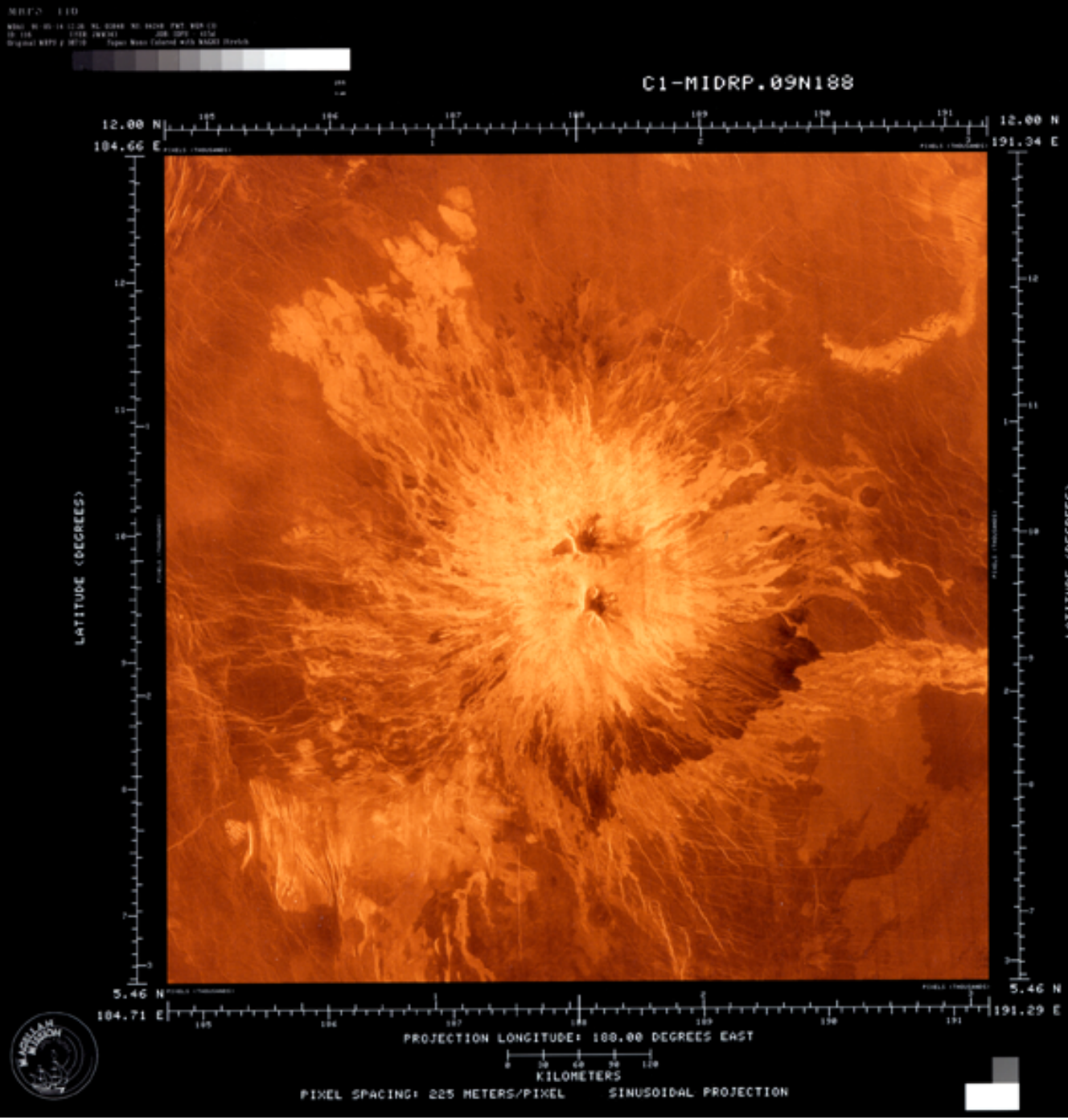
Plate 4. (*a*) Relief over Diana and Dali chasmata; (*b*) topographic profile along A–A′; (*c*) topographic profile along B–B′.

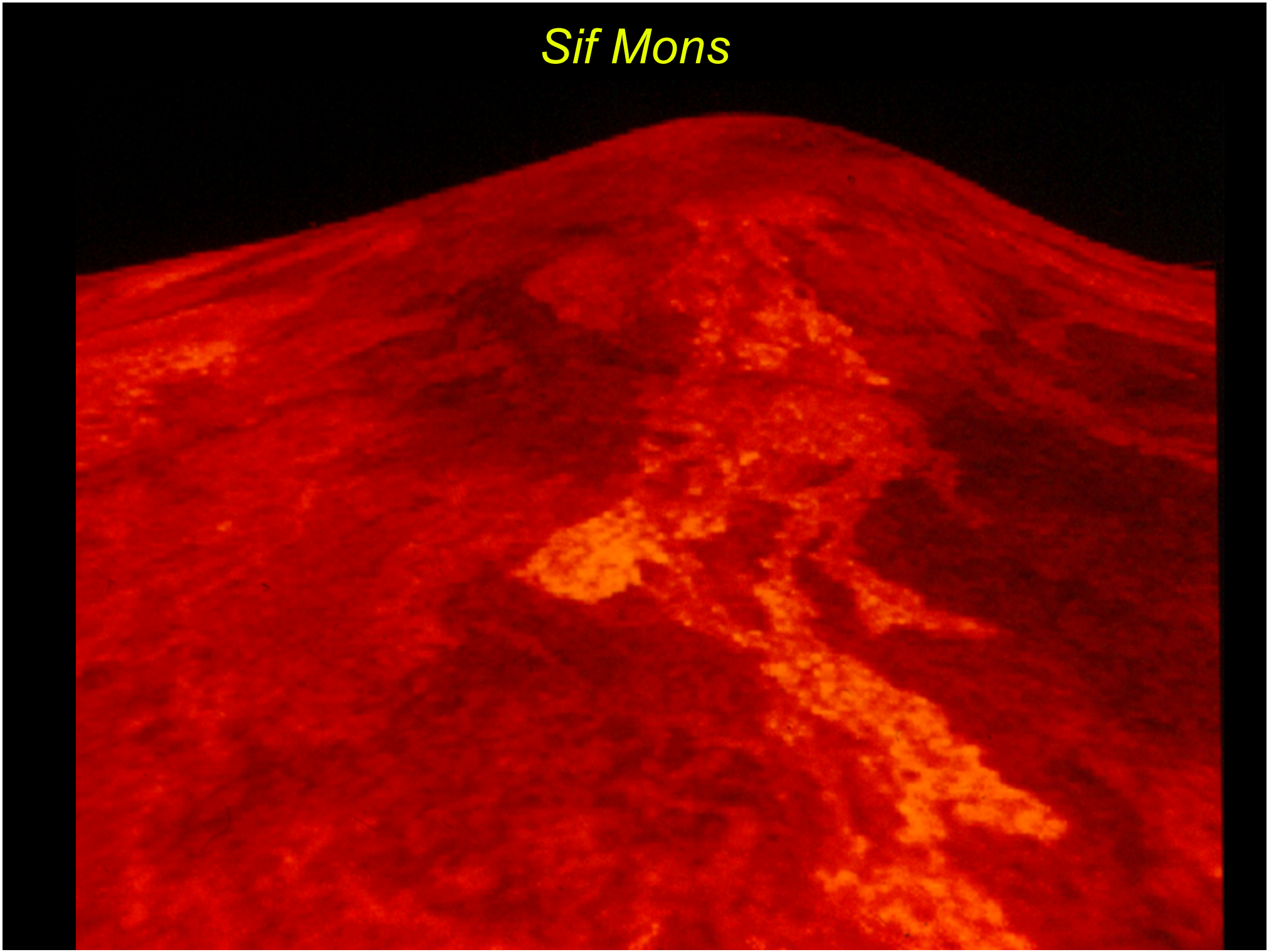

8°S
10°S
12°S
14°S
16°S
18°S
20°S
22°S
156°E
160°E
164°E
168°E
172°E

Coronae

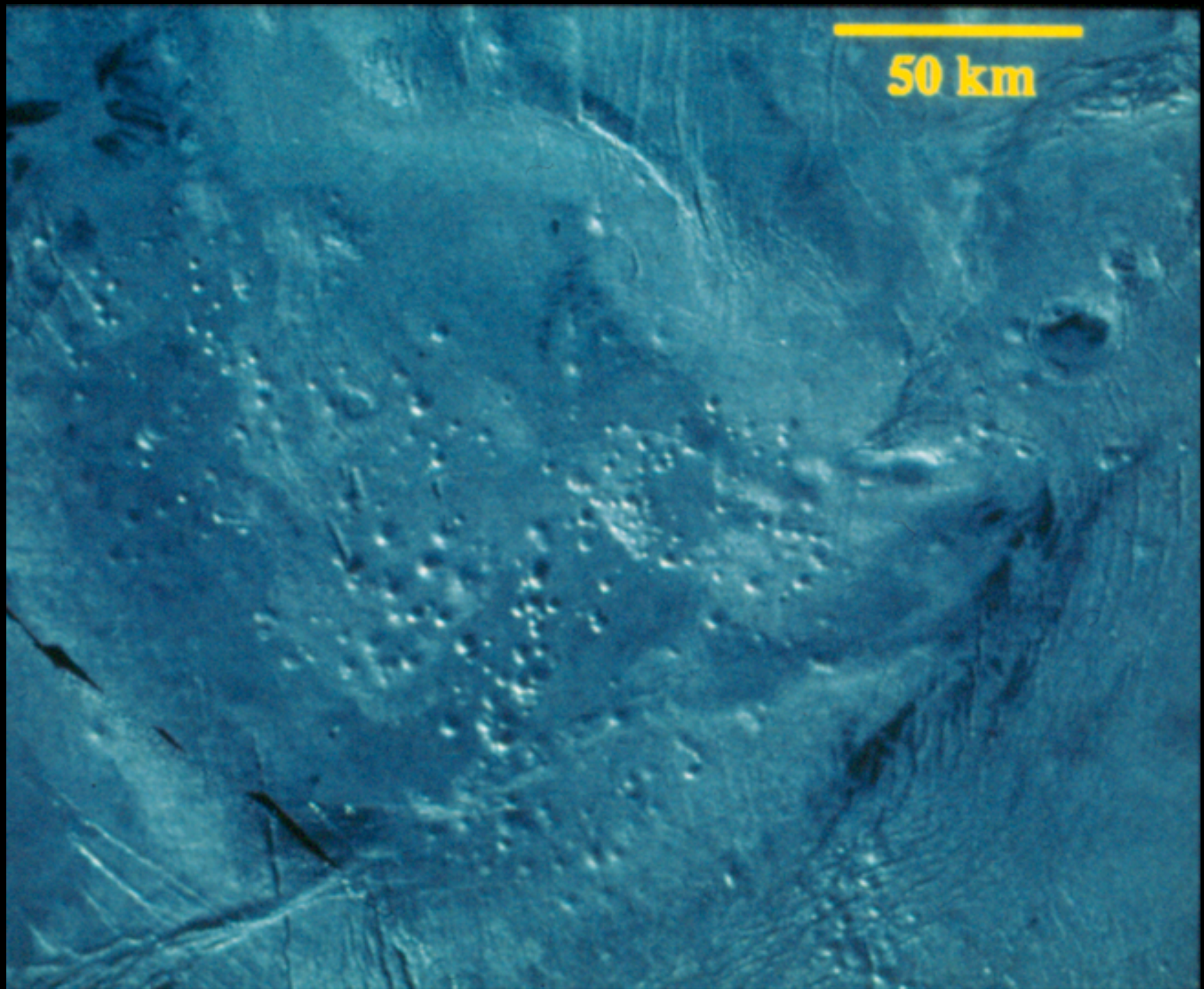
- Large volcanic features, marked by central topographic high or low, surrounded by annulus
- About 670 identified
- Not randomly distributed – concentrations near chasmata and in the B-A-T region
- Possible evolution scheme determined…

Venus Volcanoes

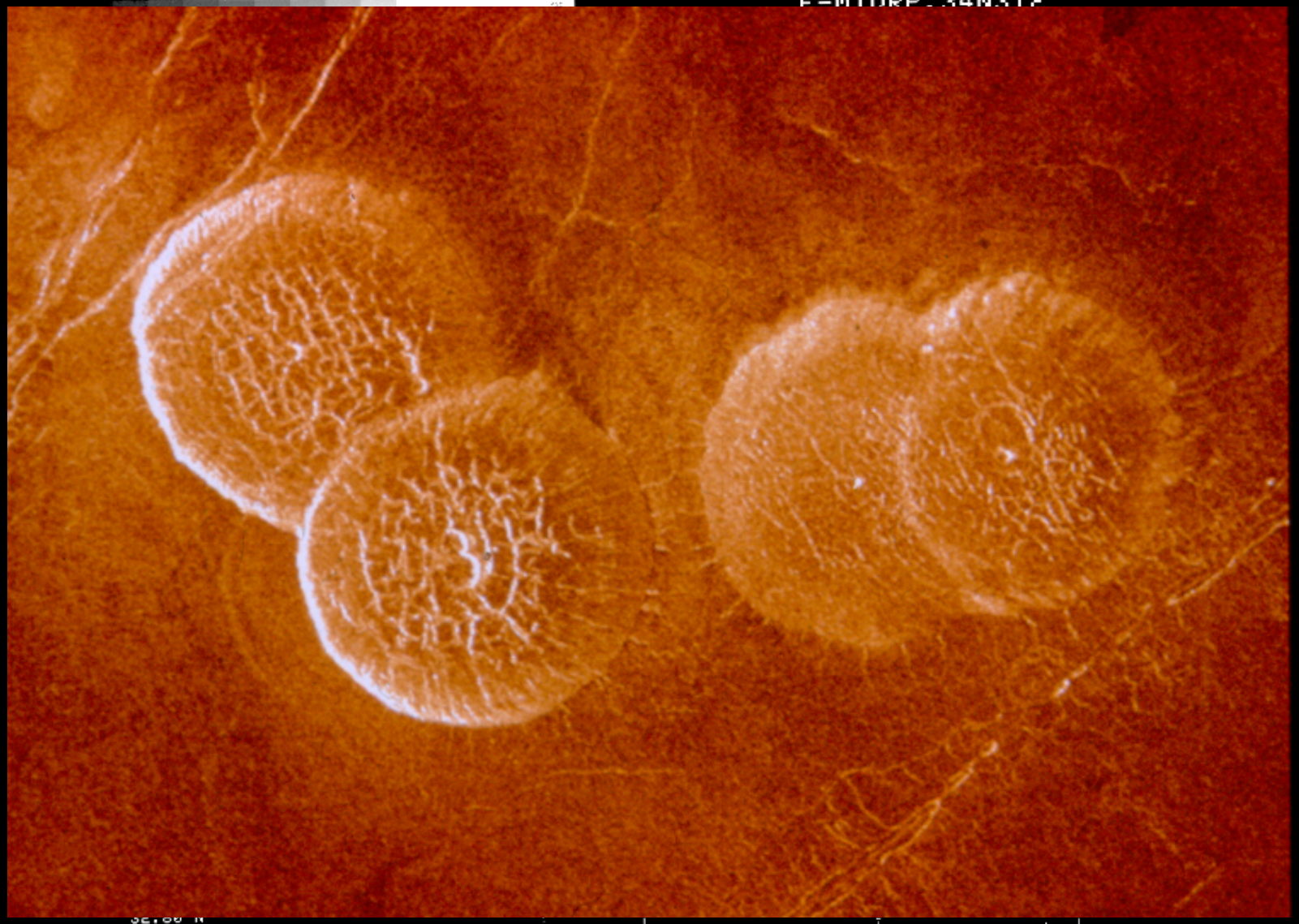



Sif Mons

Shield Field



Pancake Domes



Coronae

- Large volcanic features, marked by central topographic high or low, surrounded by annulus
- About 670 identified
- Not randomly distributed – concentrations near chasmata and in the B-A-T region
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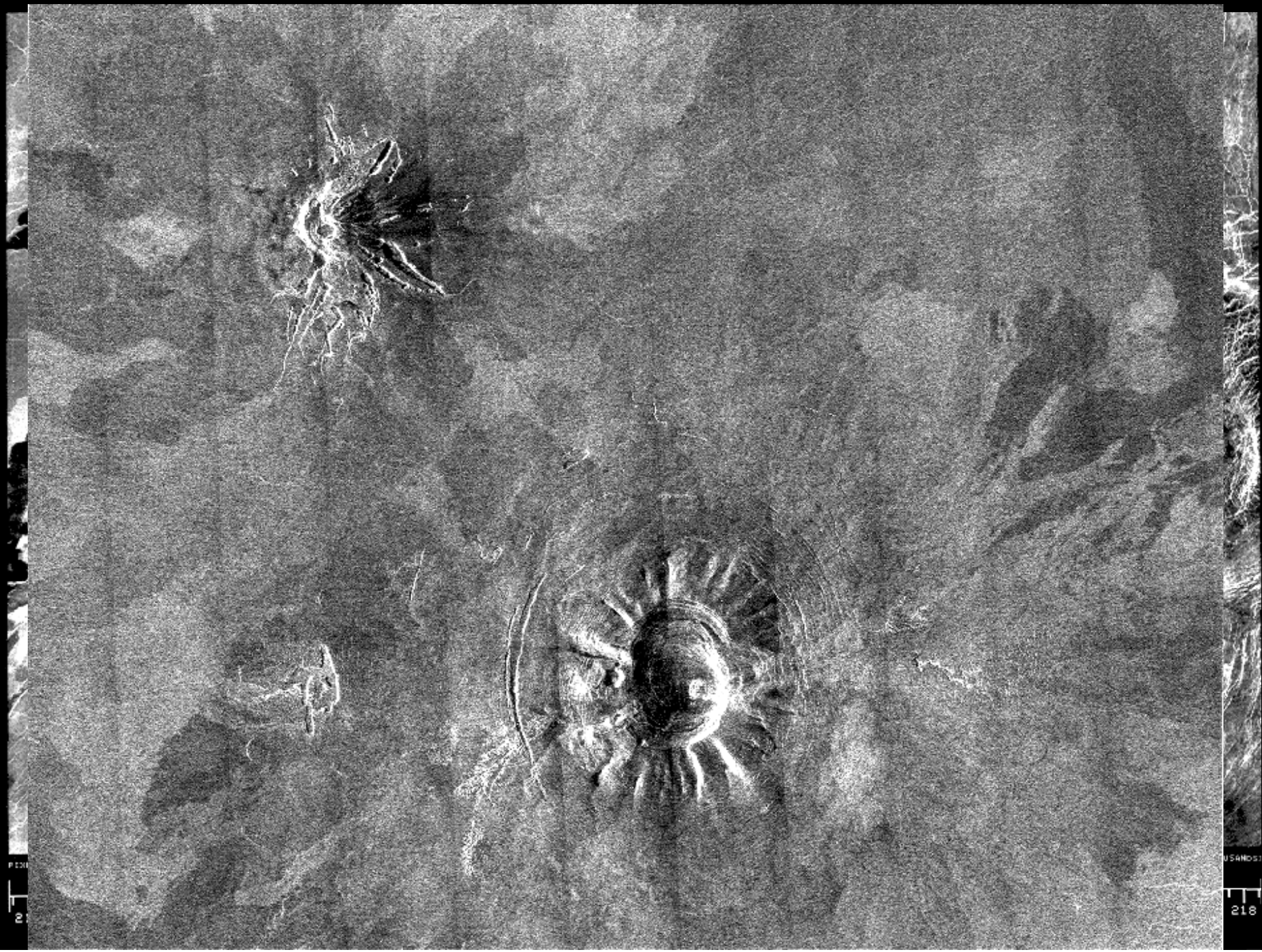
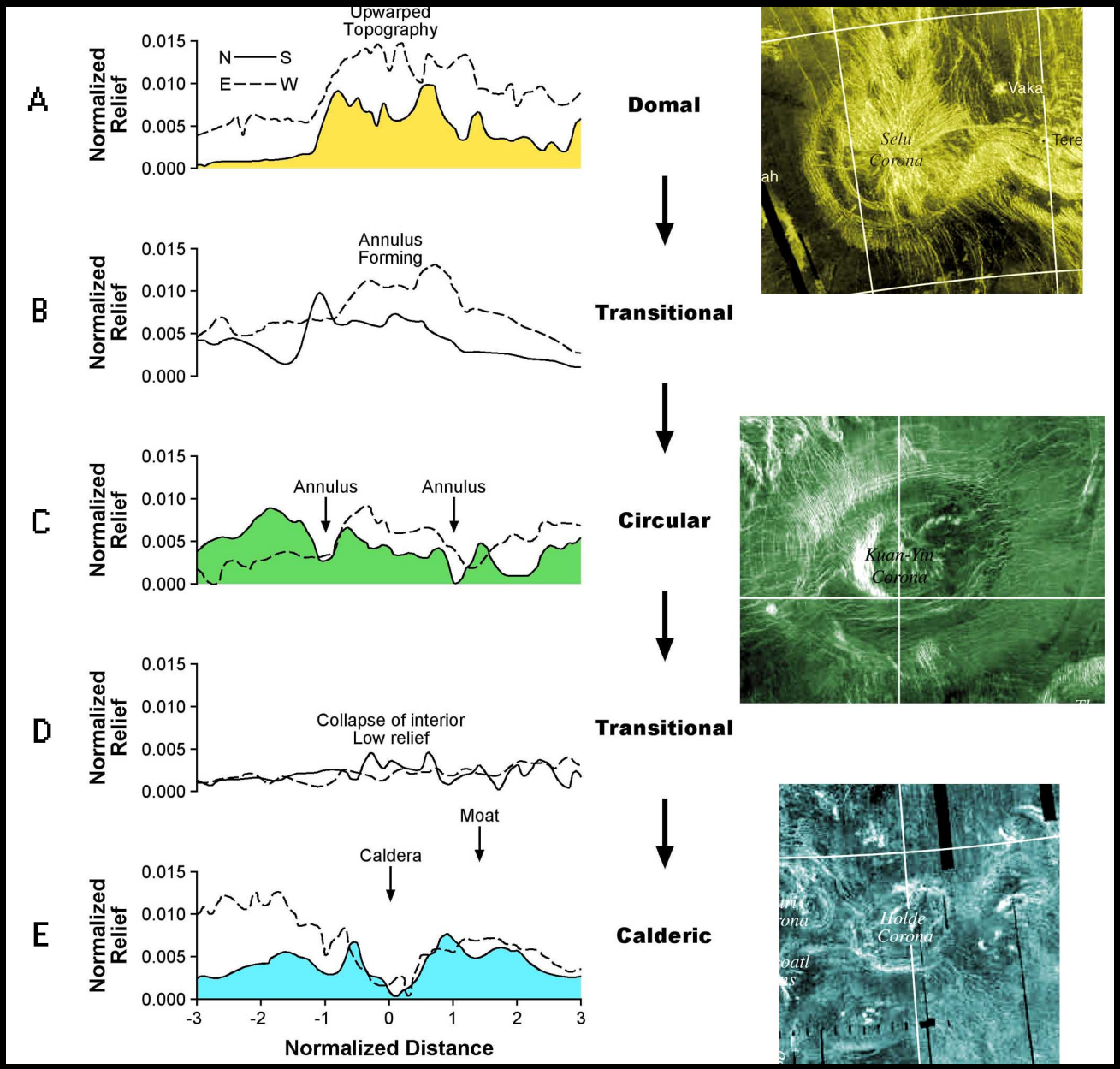
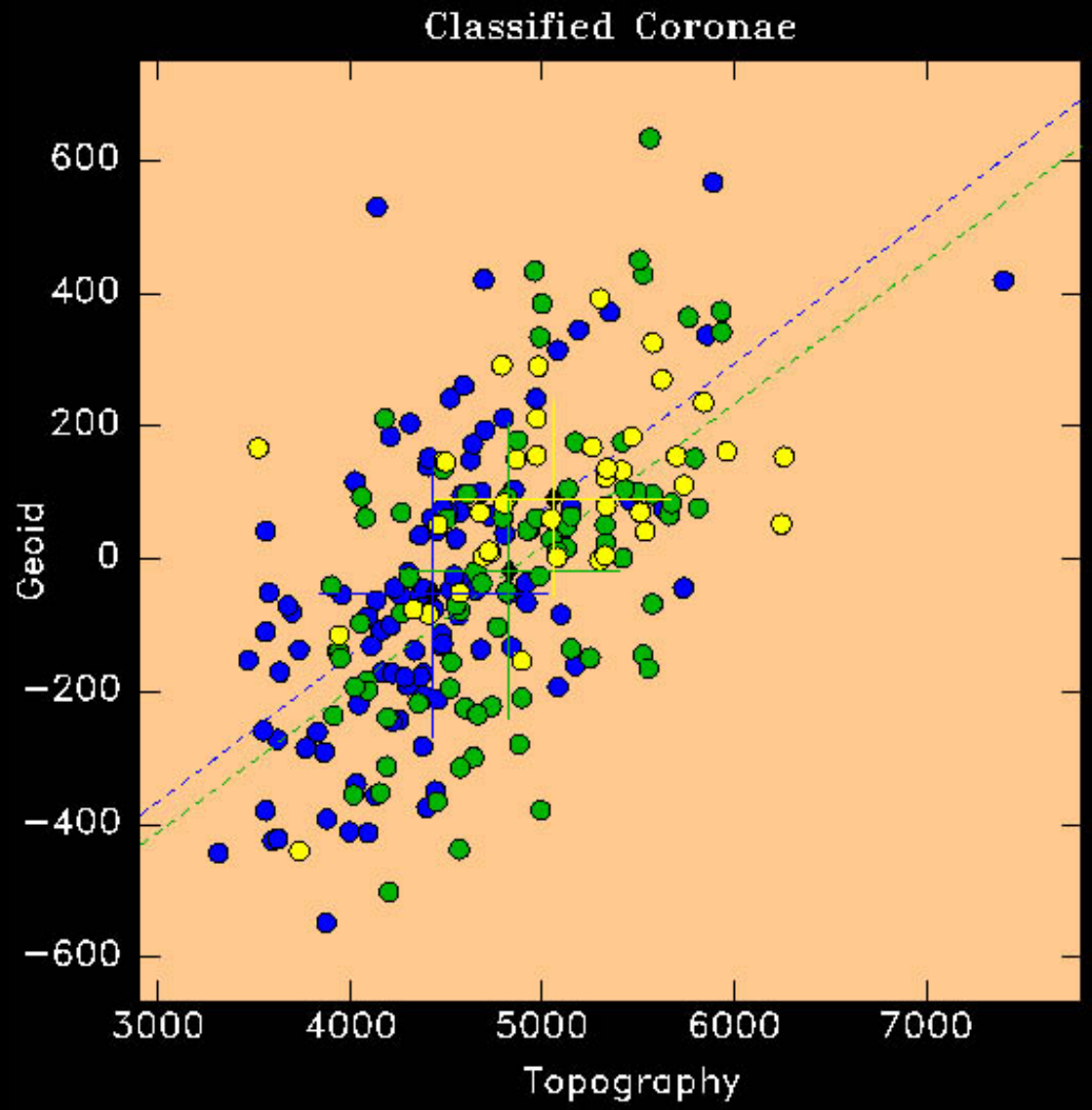
Coronae



Corona Evolution



Comparison of Coronae, by Type

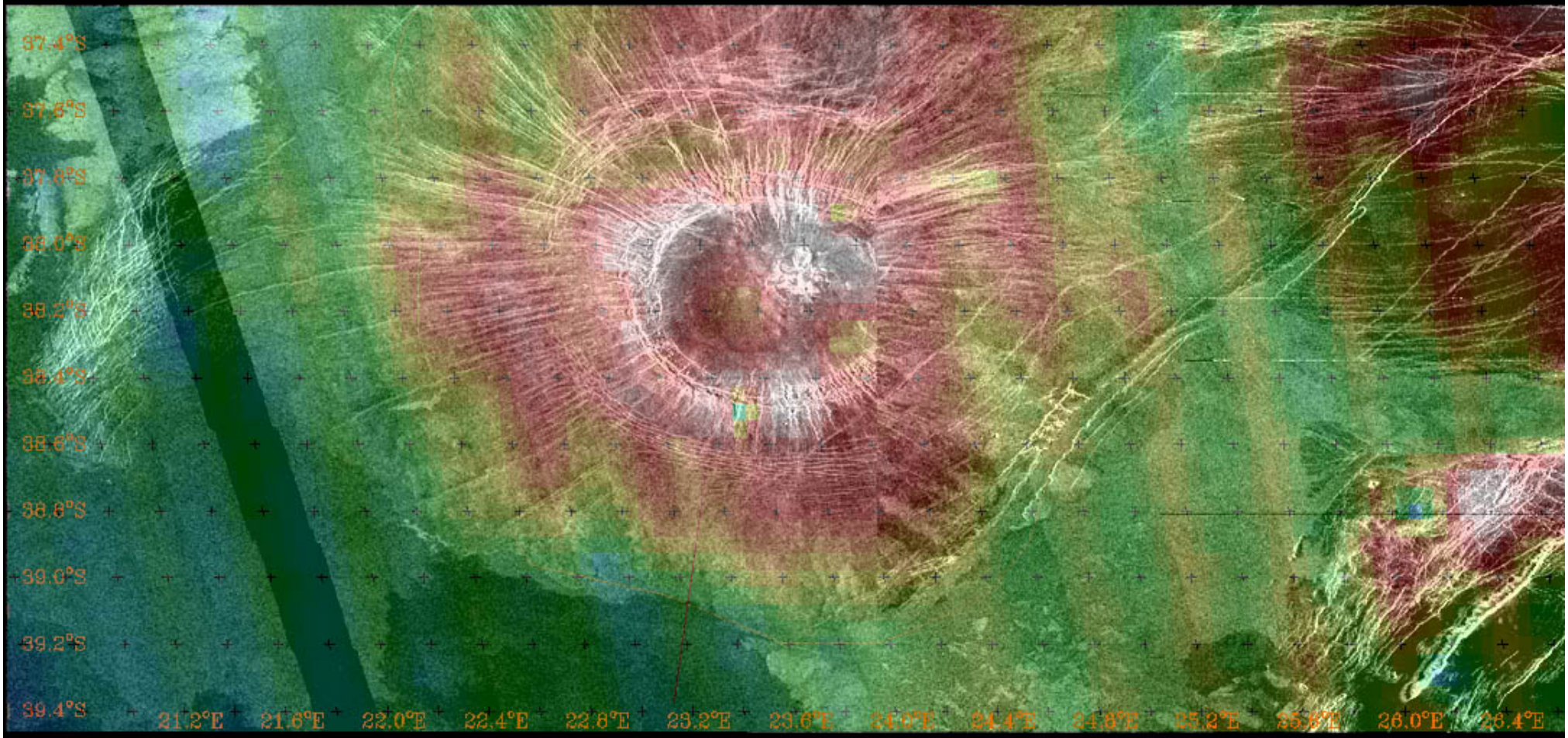


Craters vs. Coronae

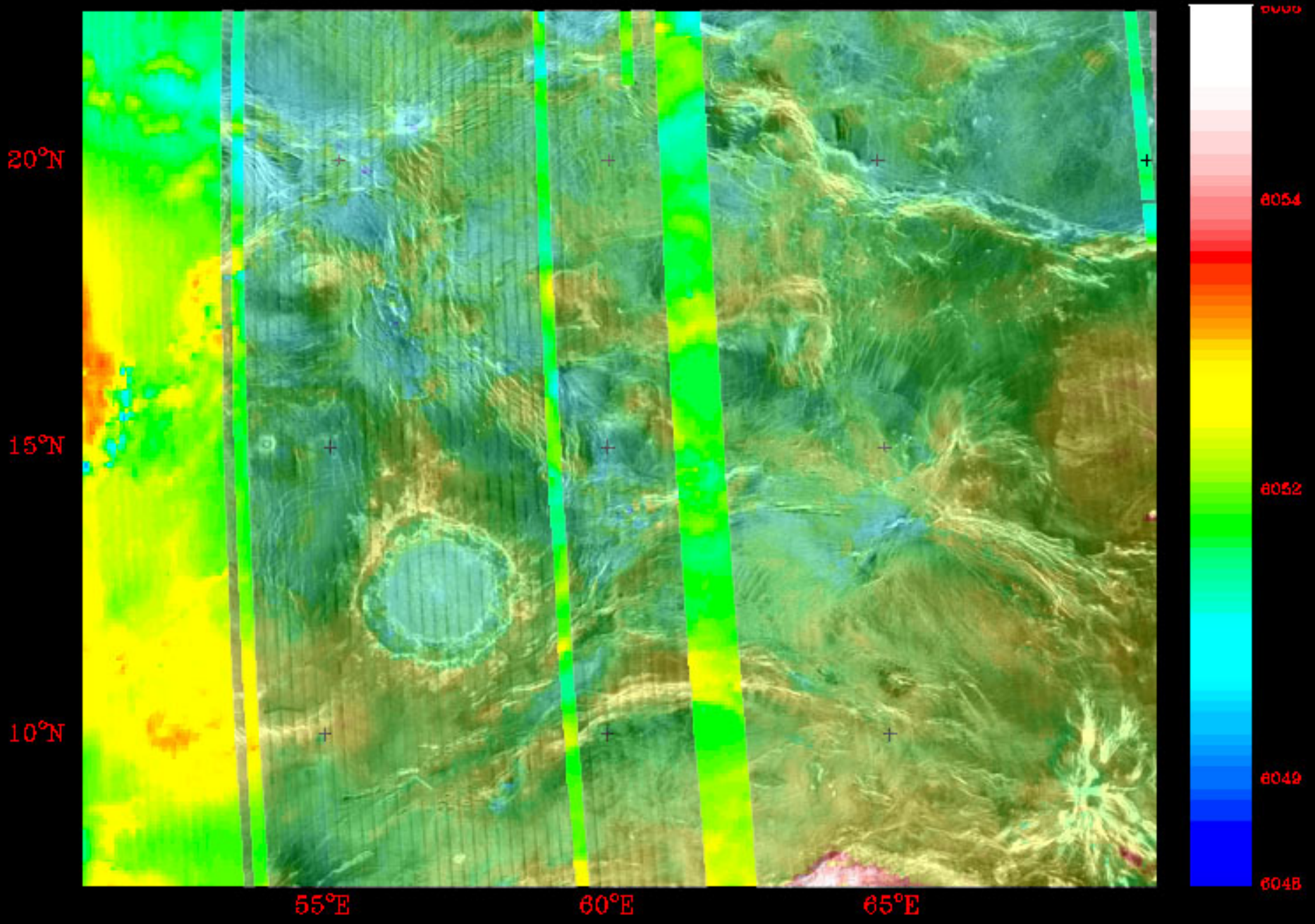
Recently, several researchers (Hamilton, Vita-Finzi, e.g.) have suggested that coronae are actually craters.

Comparison of topography may help assess this hypothesis.

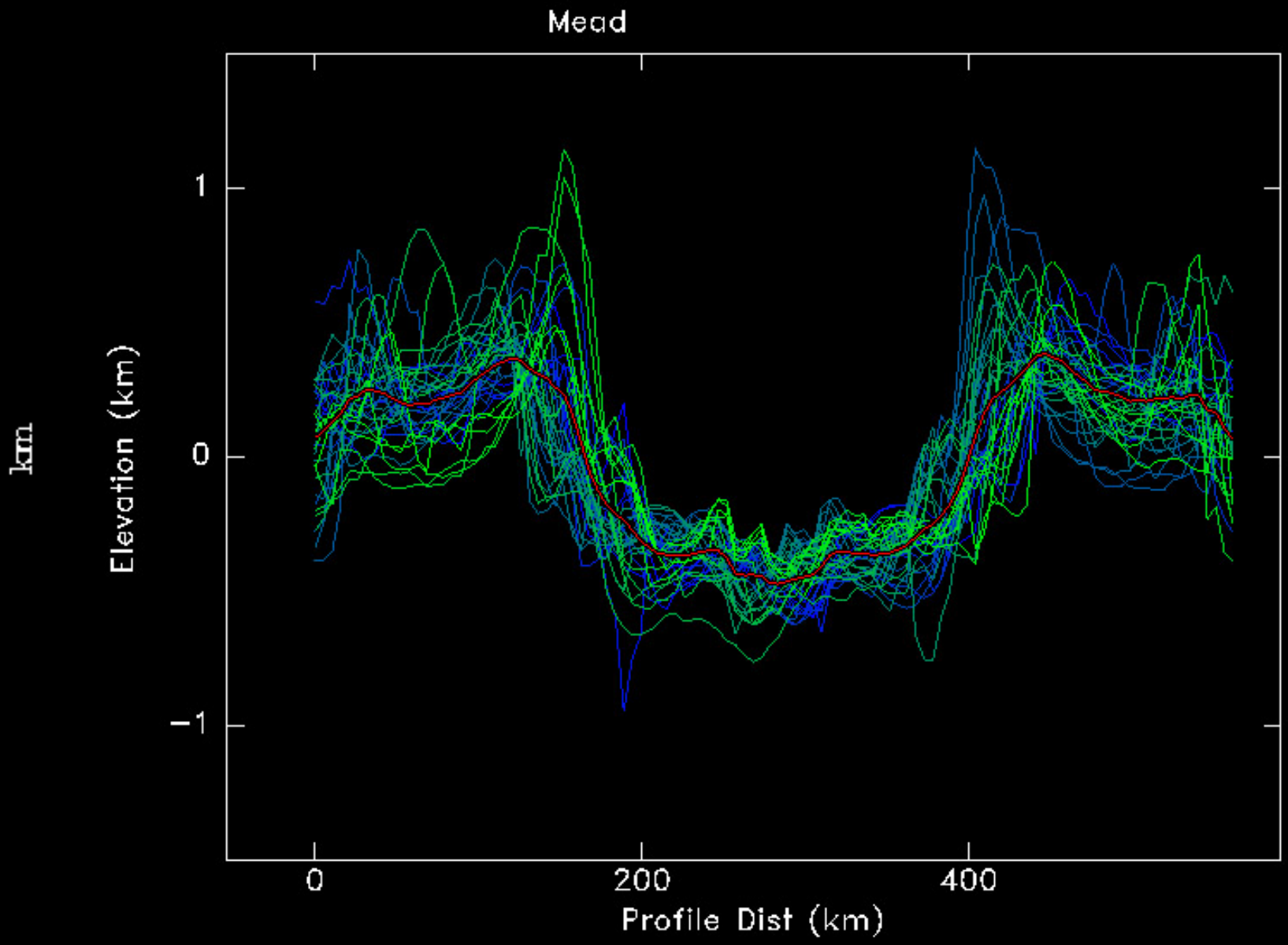
Ninhursag – Corona or Crater?

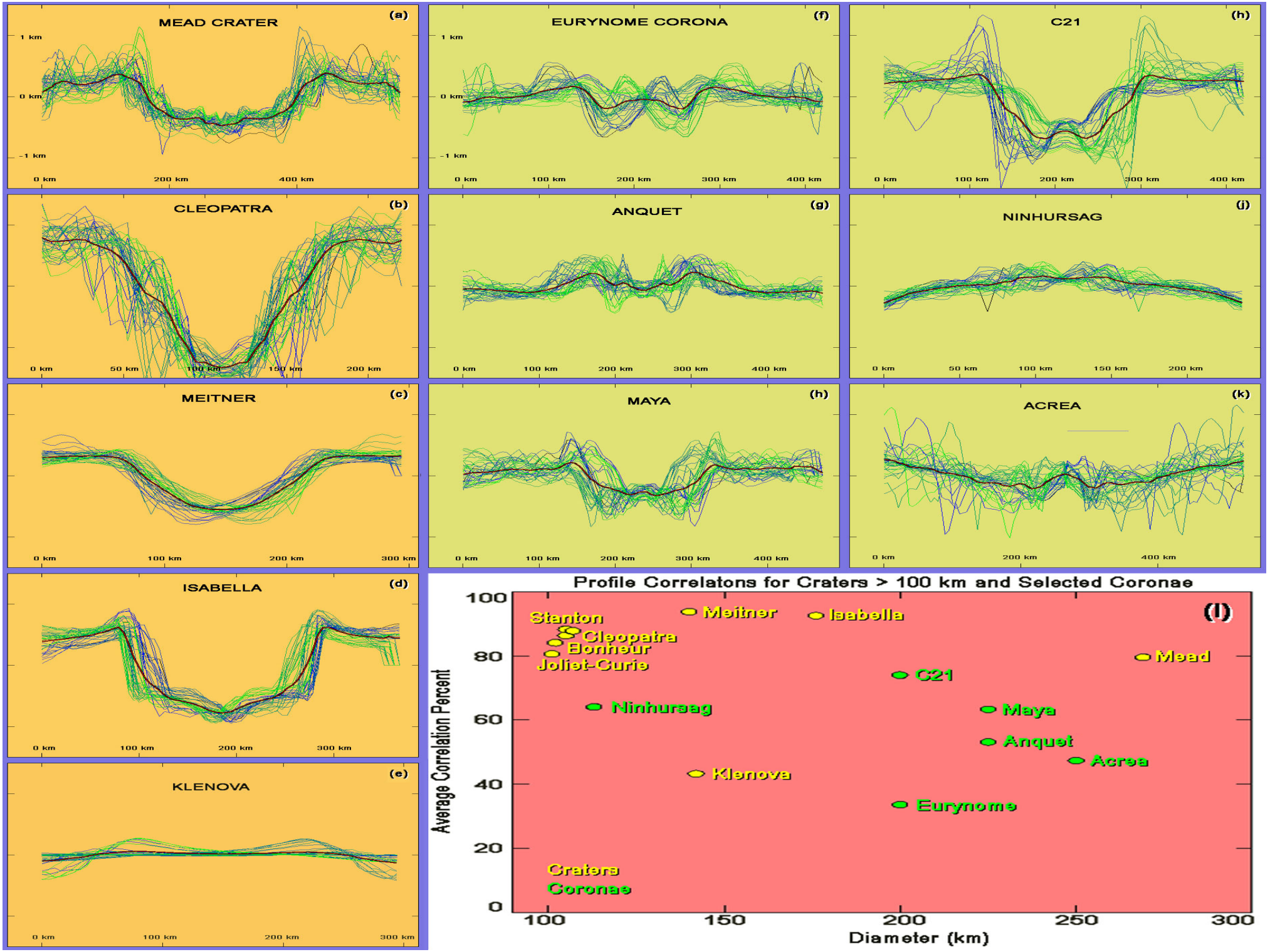


Mead Crater – Radar and Topography

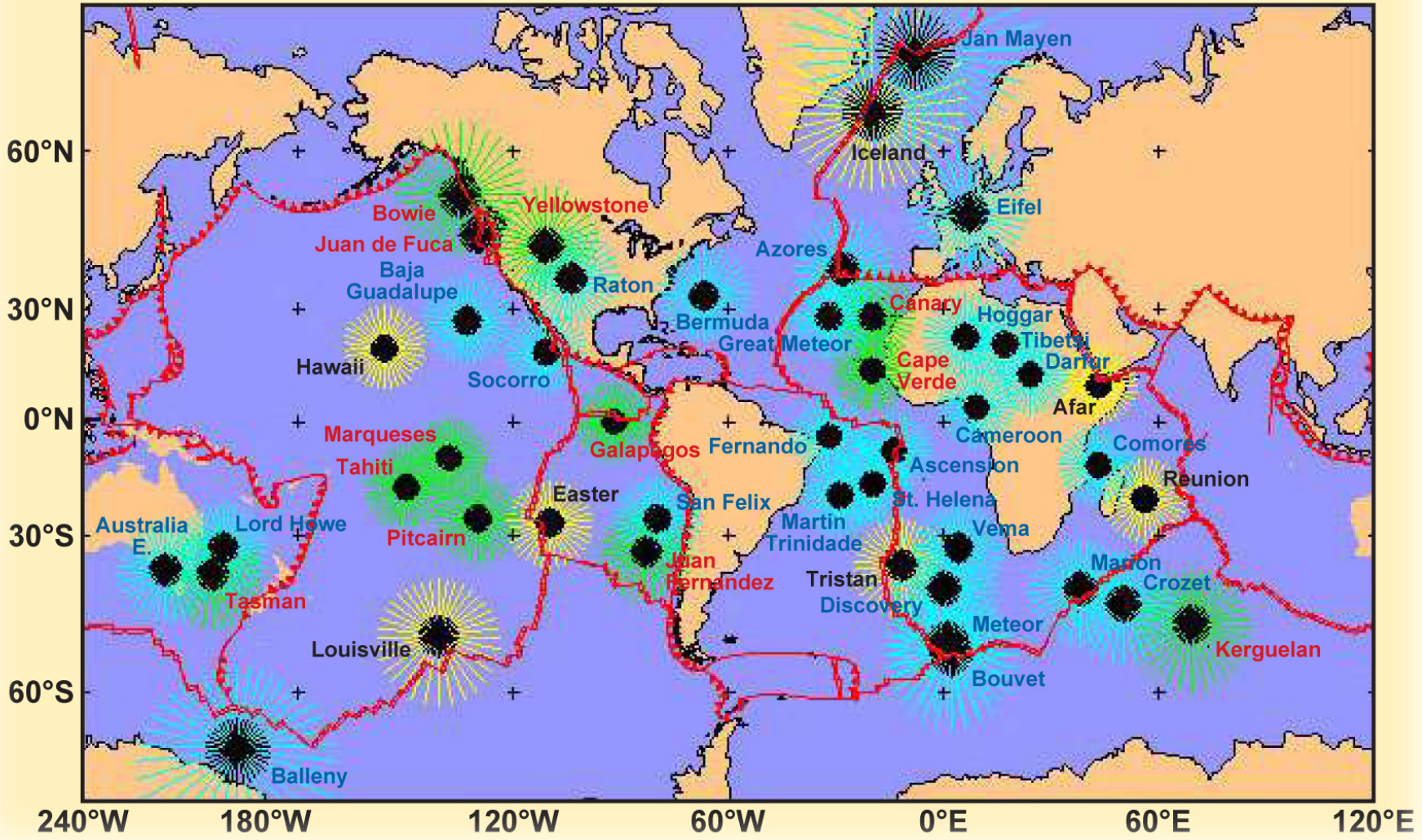


Cross-Correlation Mead Crater

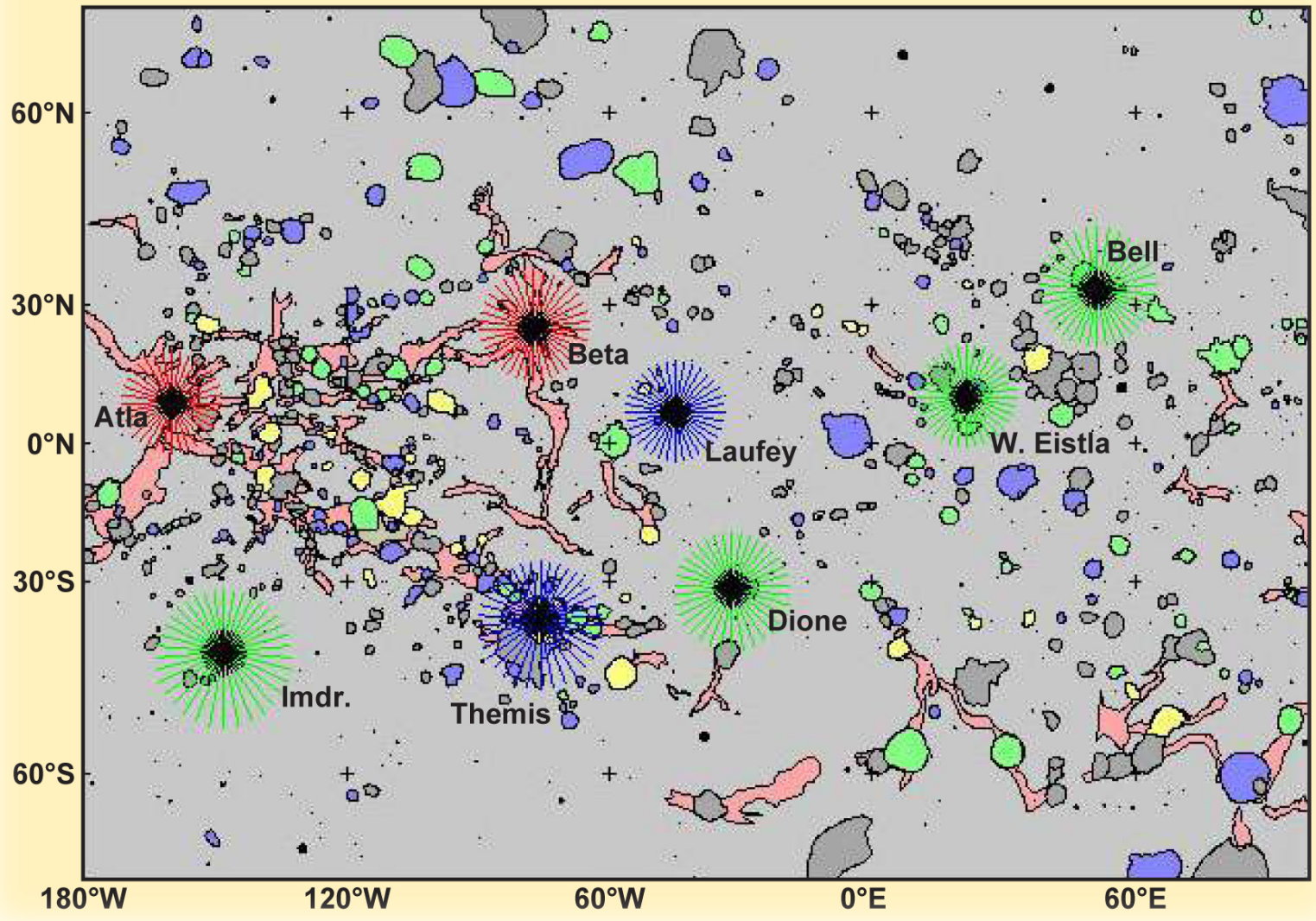



MEAD CRATER
(a)
1 km
0 km
-1 km
0 km
200 km
400 km
CLEOPATRA
(b)
0 km
50 km
100 km
150 km
200 km
MEITNER
(c)
0 km
100 km
200 km
300 km
ISABELLA
(d)
0 km
100 km
200 km
300 km
KLENOVA
(e)
0 km
100 km
200 km
300 km
EURYNOME CORONA
(f)
1 km
0 km
-1 km
0 km
100 km
200 km
300 km
400 km
ANQUET
(g)
0 km
100 km
200 km
300 km
400 km
MAYA
(h)
0 km
100 km
200 km
300 km
400 km
C21
(h)
0 km
100 km
200 km
300 km
400 km
NINHURSAG
(j)
0 km
50 km
100 km
150 km
200 km
ACREA
(k)
0 km
200 km
400 km
Profile Correlatons for Craters > 100 km and Selected Coronae
(l)
Average Correlation Percent
Diameter (km)
100
80
60
40
20
0
100
150
200
250
300
Stanton
Cleopatra
Bonheur
Joliet-Curie
Meitner
Isabella
Mead
C21
Ninhursag
Maya
Anquet
Acrea
Klenova
Eurynome
Craters
Coronae

Earth

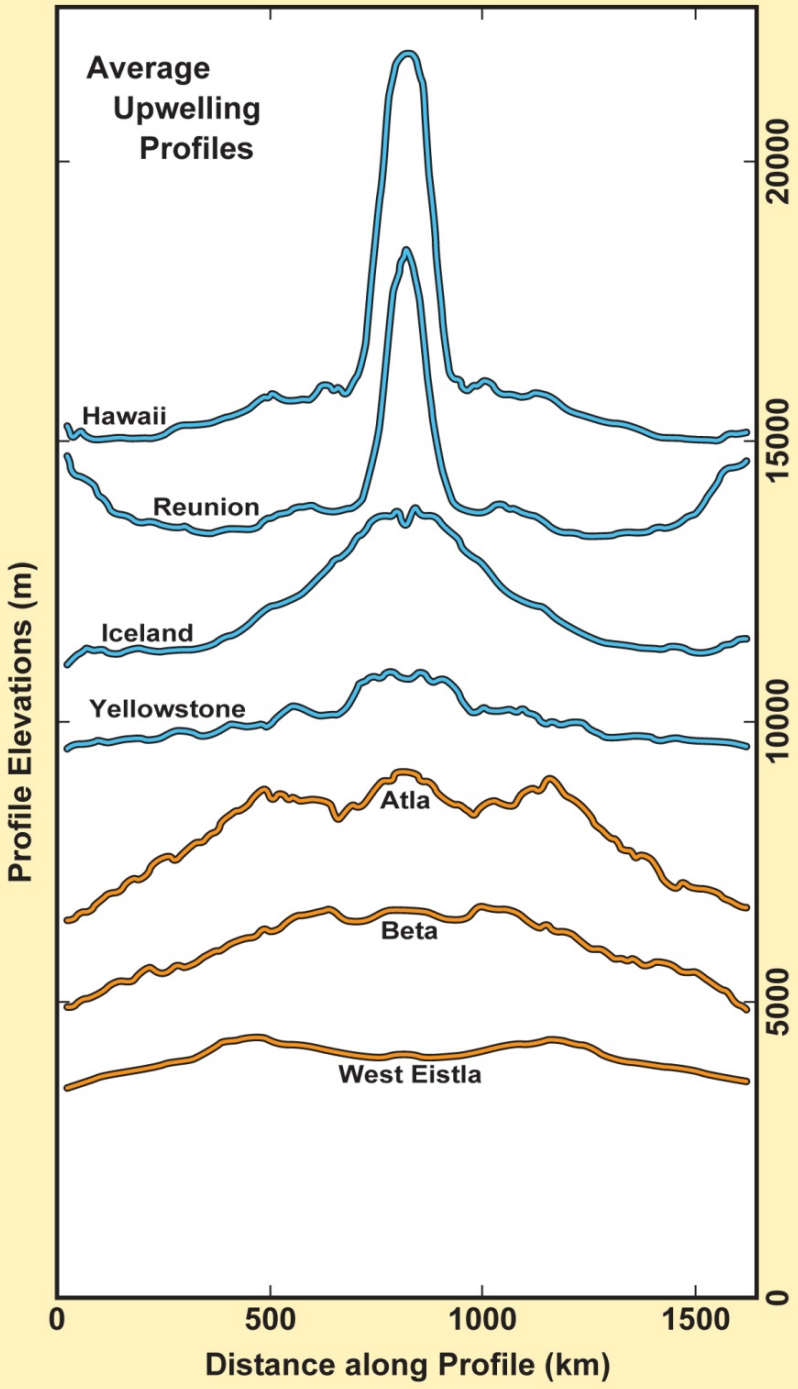

Jan Mayen
Iceland
Eifel
Bowie
Yellowstone
Juan de Fuca
Baja
Guadalupe
Raton
Azores
Canary
Hoggar
Bermuda
Great Meteor
Tibetsi
Hawaii
Socorro
Cape
Verde
Darfur
Afar
Marqueses
Tahiti
Galapagos
Fernando
Cameroon
Comores
Ascension
Reunion
Easter
San Felix
St. Helena
Australia
E.
Lord Howe
Pitcairn
Martin
Trinidade
Vema
Juan
Fernandez
Tristan
Marion
Crozet
Discovery
Tasman
Meteor
Louisville
Kerguelan
Bouvet
Balleny
60°N
30°N
0°N
30°S
60°S
240°W
180°W
120°W
60°W
0°E
60°E
120°E

Venus Profiles

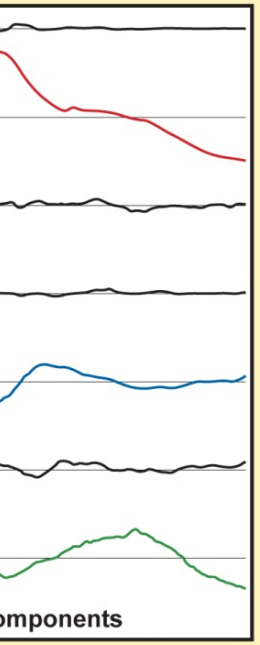


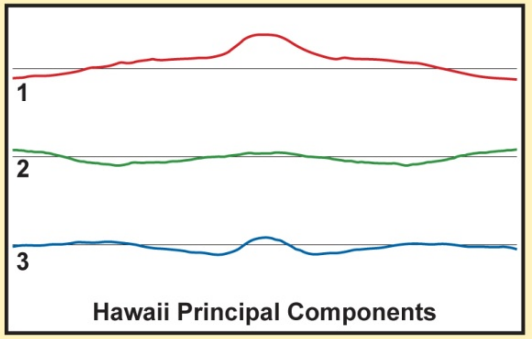
Venus profile lines for regiones. For each uplift feature, 36 radial profiles are taken through

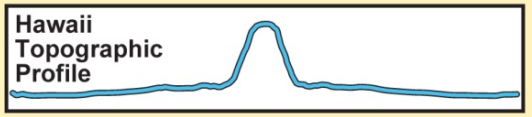
	Hawaii	Reunion	Iceland	Y'stone	Atla	Beta	W. Eistla
Hawaii	100	85	62	68	32	29	17
Reunion	85	100	39	41	9	11	25
Iceland	62	39	100	94	52	65	14
Yellowstone	68	41	94	100	60	66	15
Atla	26	7	43	49	100	89	77
Beta	24	9	53	54	89	100	63
W. Eistla	13	20	11	11	77	63	100
Principal Component Strength	**398.5**	**168.5**	4.8	16.78	10.52	**100.4**	0.53
Normalized PC	**0.57**	**0.241**	0.007	0.024	0.015	**0.143**	0.0008
Hawaii	**0.37**	**0.46**	0.46	0.54	0.16	**0.22**	0.28
Reunion	**0.27**	**0.49**	0.36	0.36	0.14	**0.53**	0.37
Iceland	**0.43**	**0.17**	0.49	0.45	0.35	**0.42**	0.23
Yellowstone	**0.44**	**0.16**	0.63	0.12	0.23	**0.38**	0.4
Atla	**0.41**	**0.42**	0.1	0.5	0.13	**0.04**	0.62
Beta	**0.42**	**0.36**	0.04	0.25	0.77	**0.13**	0.14
W. Eistla	**0.28**	**0.44**	0.1	0.22	0.41	**0.58**	0.41

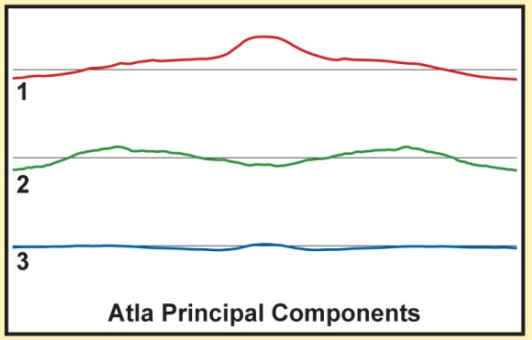


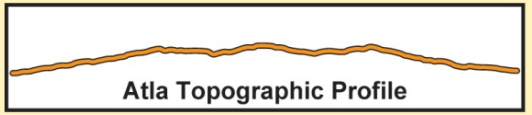
EXAMPLE: At left are shown profiles for 4 Earth hotspots: Hawaii, Reunion, Iceland and Yellowstone and 3 Venus regiones: Atla, Beta, and W. Eistla. The seven principal components derived from the covariance matrix are shown. Principal components are shown as representative traces, the sum of which, appropriately weighted, will reproduce the original profile. Summing the top 3 components (the second, seventh and fifth respectively, labeled 1, 2, and 3) accounts for 95% of the shape of the profiles in this example.

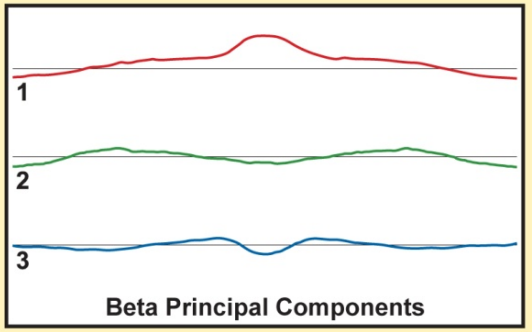


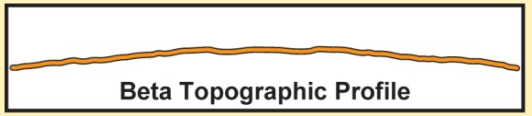












Procedure

Pick multiple profiles across mountain ranges Earth, Venus

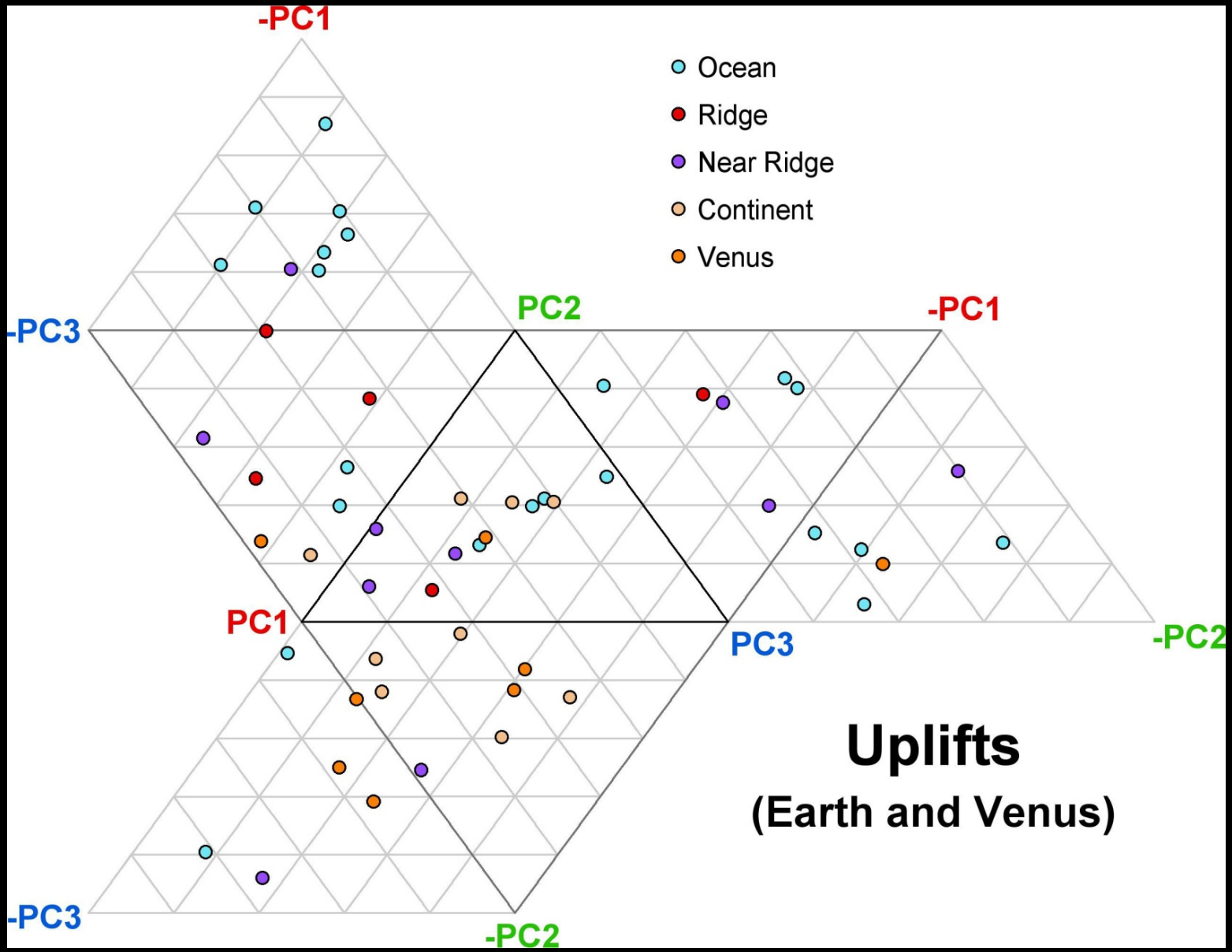
Cross-correlate each feature's profiles for best alignment

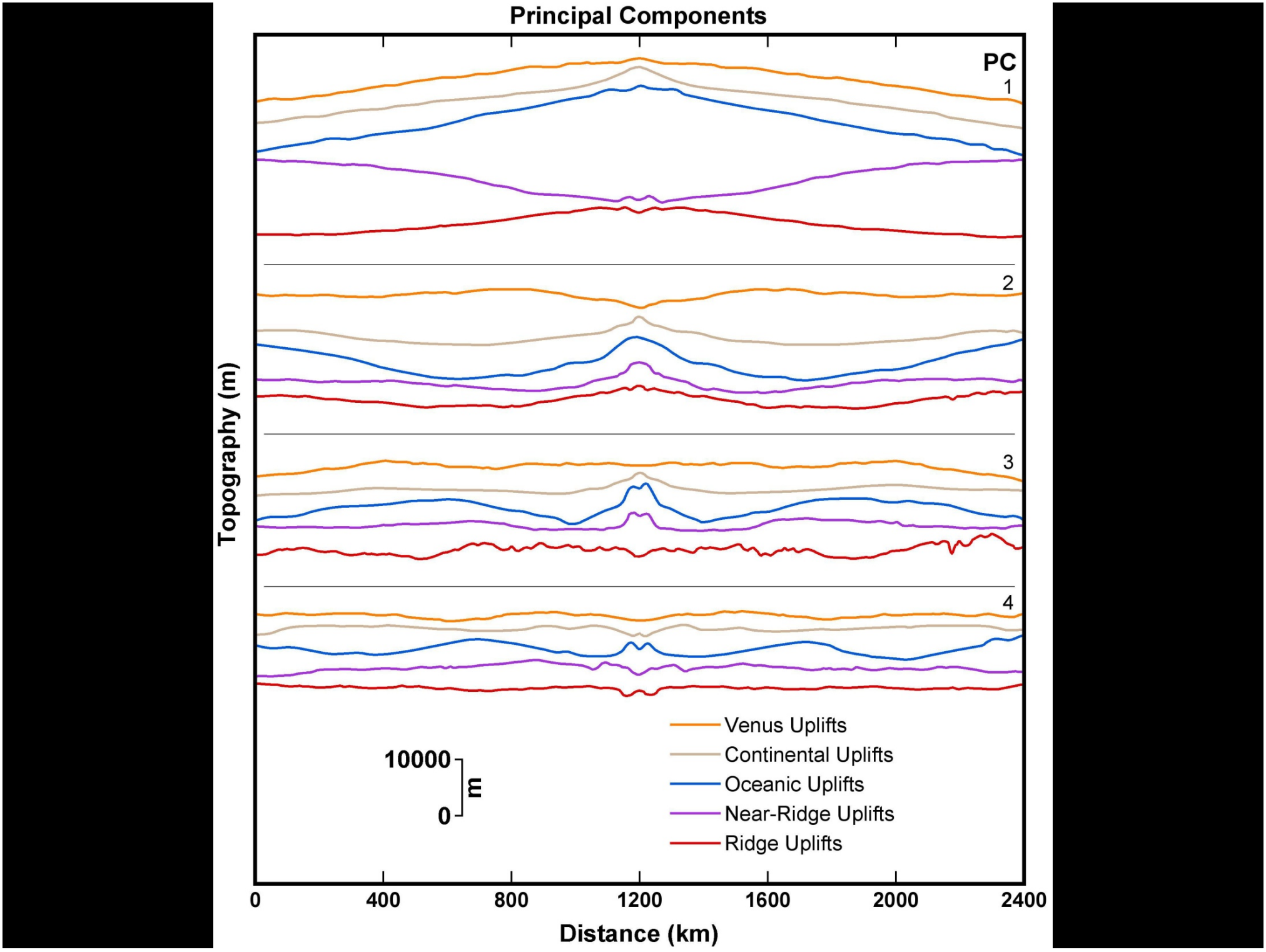
Using shifted profiles, find average profile for each feature

Cross-correlate average profiles to construct covariance matrix

Calculate eigenvalues, principal component profiles from matrix

Compare features using top 3 eigenvalues in a ternary diagram


-PC1
Ocean
Ridge
Near Ridge
Continent
Venus
-PC3
PC2
-PC1
PC1
PC3
-PC2
-PC3
-PC2
Uplifts
(Earth and Venus)


Principal Components
PC
1
2
3
4
Topography (m)
10000
0
m
Venus Uplifts
Continental Uplifts
Oceanic Uplifts
Near-Ridge Uplifts
Ridge Uplifts
0
400
800
1200
1600
2000
2400
Distance (km)

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared for the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ATLAS OF VENUS
1:10,000,000 SERIES
V 10M 90/0 RTK, 1998
I-2490 SHEET 4 OF 4

NOTES ON BASE

This sheet is one in a series of maps of Venus at nominal scales of 1:50,000,000 and 1:10,000,000 (Planetary Cartography Working Group, 1984, 1993; Batson, 1994). It is based on data from the Magellan Synthetic Aperture Radar (SAR) and radar altimetry instruments. The Magellan Mission was described by Saunders and Pettengill (1991). Magellan radar characteristics were described by Pettengill and others (1991).

ADOPTED FIGURE

The figure of Venus used for the computation of the map projection is a sphere with a mean radius of 6,051.0 km, consistent with the preliminary gravity figure reported by Phillips and others (1979) that was used for previous maps of Venus. Slightly larger values of the mean radius of Venus have subsequently been reported based on Pioneer Venus (Pettengill and others, 1980) and Magellan altimetry (Ford and Pettengill, 1992).

PROJECTION

The Mercator projection is used for this sheet. The scale is 1:16,354,349 at 0° latitude; it is 1:9,145,190 at ±56.0° latitude, as is the scale at this latitude in the polar stereographic projection. Due to the retrograde rotation of Venus, longitude increases from west to east in accordance with usage of the International Astronomical Union (1971).

CONTROL

Planimetric control is derived from the radio-tracked position of the spacecraft. The first meridian passes through the central peak of the crater Ariadne, at lat 43.8° N., according to current International Astronomical Union convention. (Ariadne replaces the feature "Eve," which, at the same longitude, originally fixed the location of the prime meridian (Davies and others, 1986).) The venusian cartographic coordinate system was described by Davies and others (1992).

CONTOURS

Because Venus has no surface water and hence no sea level, the topographic datum (the 0 km contour) is defined as a sphere with a radius of 6,051.0 km. Data for topographic contours were derived from computer processing of Magellan radar altimetric data provided by the Massachusetts Institute of Technology (Pettengill and others, 1991). These contours were then vectorized and brought into accord with the relief image (see Mapping Techniques, below).

MAPPING TECHNIQUES

Topographic information obtained from Magellan radar altimeter measurements has been shown as shaded relief by converting the slope segments between elevation values to reflectance values, using methods described by Edwards (1987). All landforms are shown as if illuminated from the west. Data for shaded relief were derived from computer processing of radar altimetric information provided by the Massachusetts Institute of Technology (Pettengill and others, 1991).

Interpretive image processing was used to remove artifacts, to enhance the digital-image details, and to add distinctive surface features taken from SAR images by use of portrayal and photointerpretive methods previously used in airbrush cartography described by Inge and Bridges (1976). Gaps in coverage by the Magellan radar altimeter were filled by lower resolution image data from the Pioneer Venus and Venera 15 and 16 missions, precluding uniform portrayal of detail. Contours were generated at one kilometer elevation intervals from the altimetry data and matched to the new relief image. From these modified contours the color slice was generated.

Colors were chosen to lead the viewer to intuitively accept elevation information, that is, the colors help the viewer automatically see one elevation as higher or lower than other elevations. Also, colors selected suggest a rocky landscape rather than water or vegetation. A deliberate color contrast between a malachite green and a sienna (brown) was chosen to demarcate the 0 km contour boundary (radius of 6,051.0 km). The color slice was then merged with the relief image.

Shaded relief image (interpretation and portrayal), elevation contours, and cartographic processing by Ralph Aeschliman.

NOMENCLATURE

V 10M 90/0 RTK: Abbreviation for Venus; 1:10,000,000 series; center of map, lat 90° N., long 0°; shaded relief (R) with contours (T) and color slice (K).

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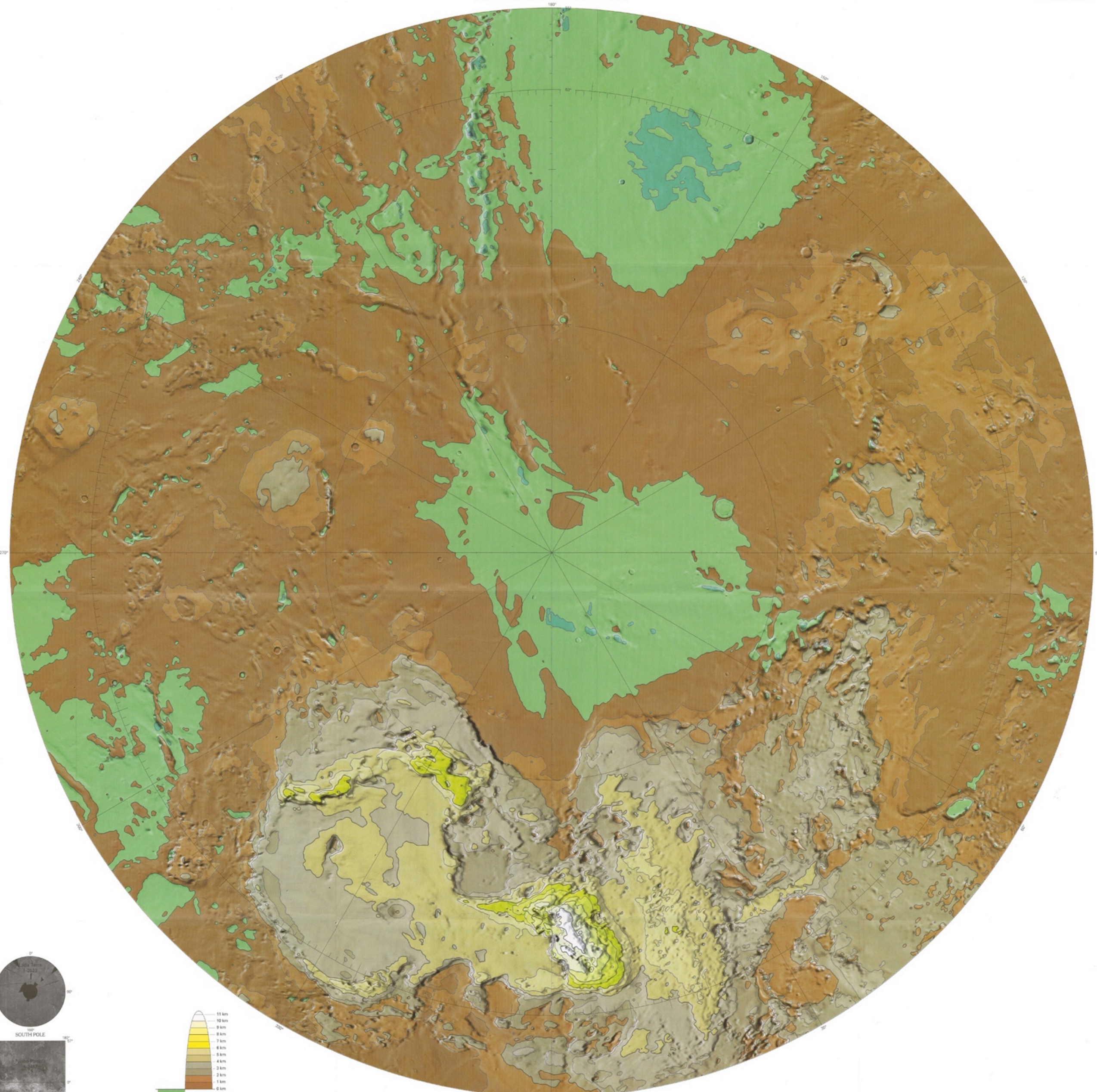
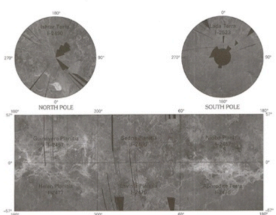


SCALE 1:9 145 190 (1 mm = 9.14 km) AT 56° LATITUDE
1:10 000 000 AT 90° LATITUDE
POLAR STEREOGRAPHIC PROJECTION



INDEX OF THE 1:10,000,000 SCALE MAP SERIES OF VENUS
Number preceded by "I" indicates published map.

ELEVATION CONTOURS
"0 km" equals a planetary radius of 6051.0 km

TOPOGRAPHIC MAP OF THE ISHTAR TERRA REGION OF VENUS
V 10M 90/0 RTK
1998

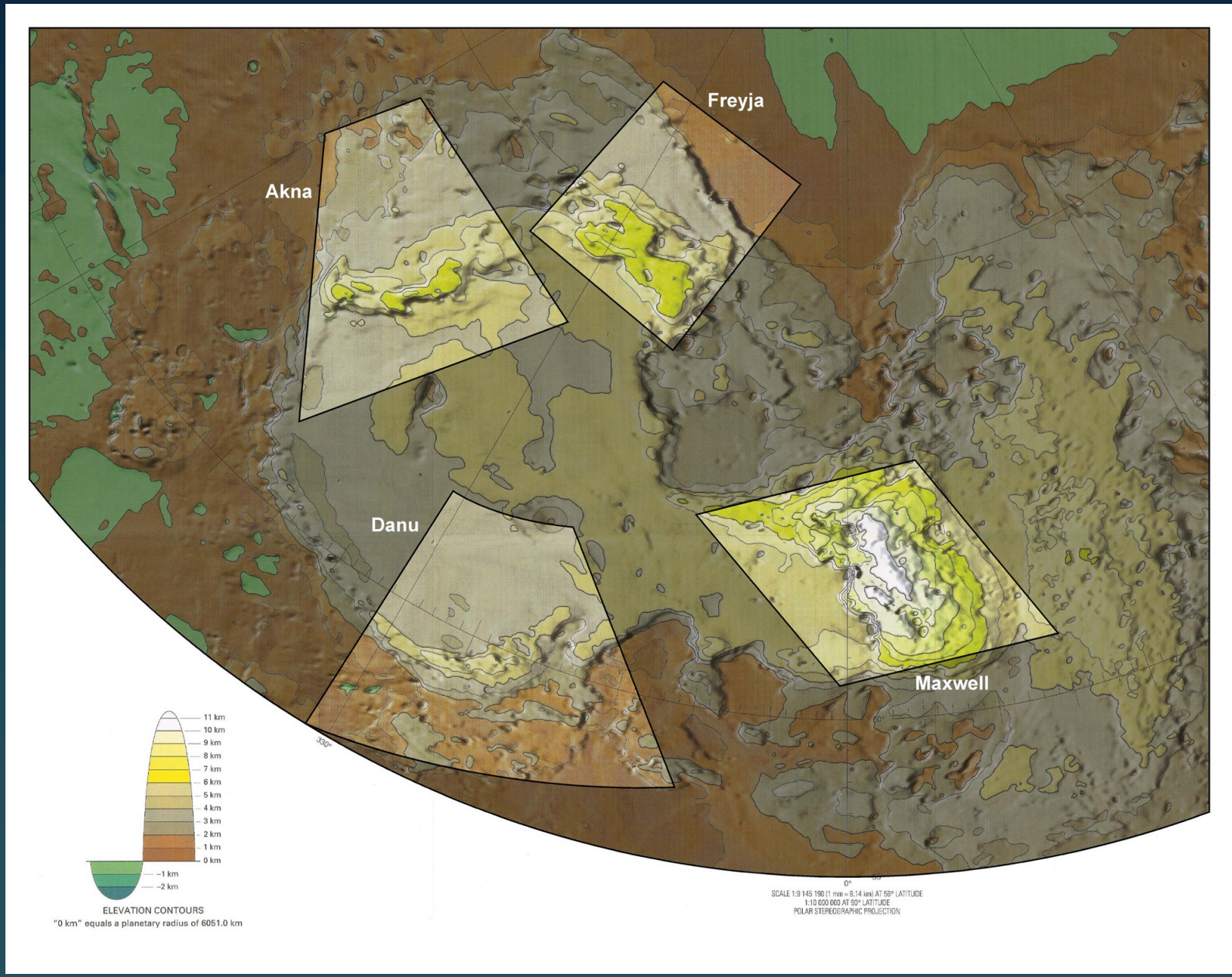
NOTE TO USERS

Users noting errors or omissions are urged to indicate them on the map and to forward it to U.S. Geological Survey, Building 4, Room 451, 2255 N. Gemini Drive, Flagstaff, AZ 86001. A replacement copy will be returned.

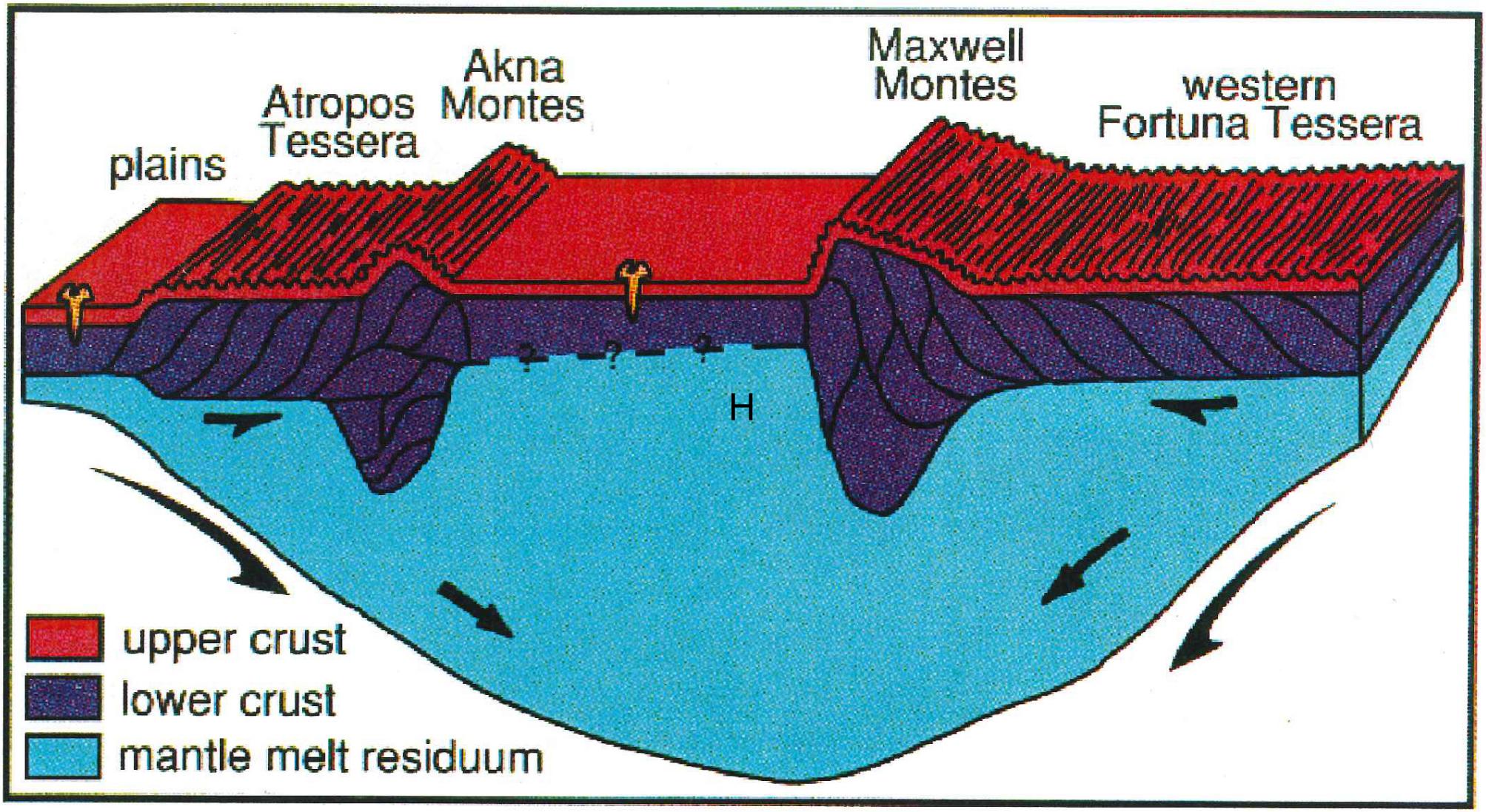
Prepared on behalf of the NASA Planetary Geology and Geophysics program and the Magellan Project Office of the Jet Propulsion Laboratory
Edited by Derrick Hirsch; cartography by Roger D. Carroll and Darlene A. Casebier
Manuscript approved for publication April 28, 1994

For sale by U.S. Geological Survey, Information Services, Box 25286, Federal Center, Denver CO 80225

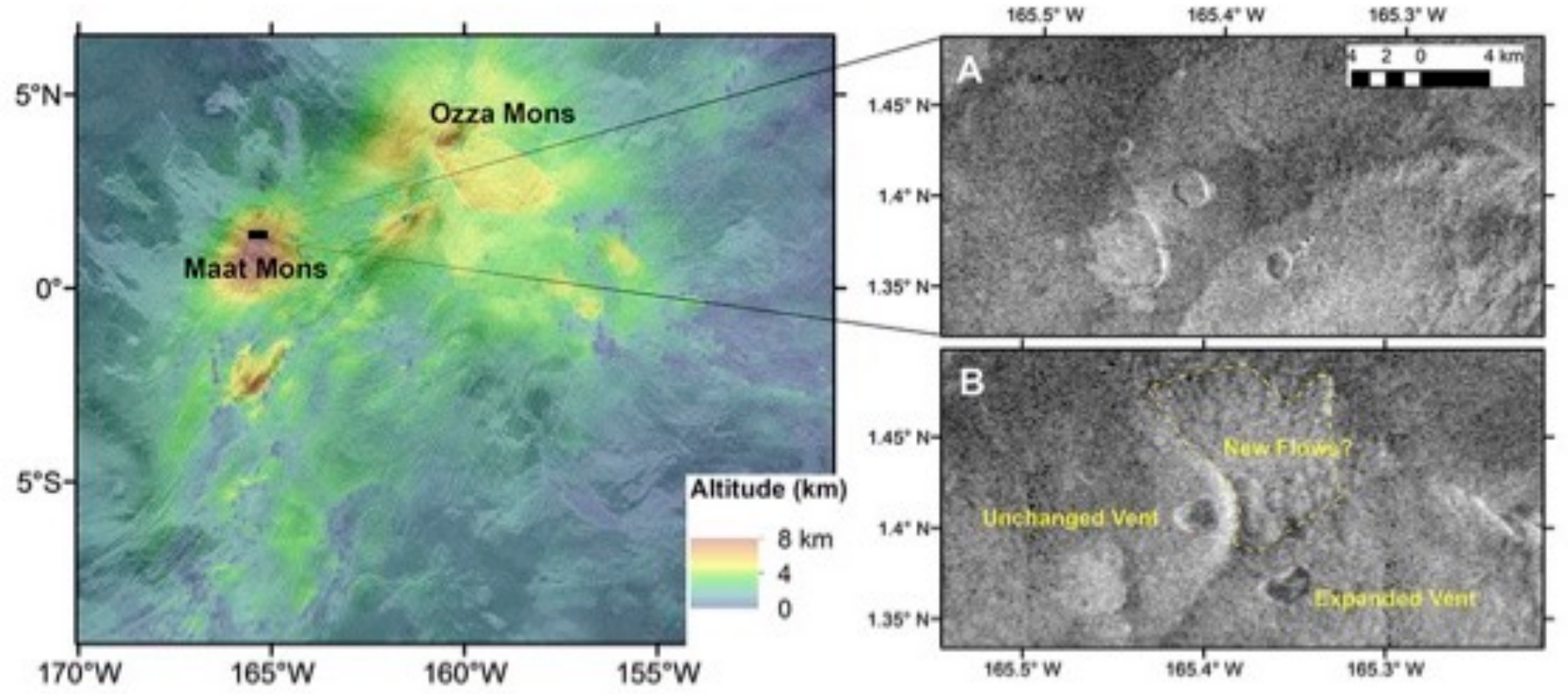
Venus Mountains



Orogenic Model – (Hansen & Phillips, 1995)



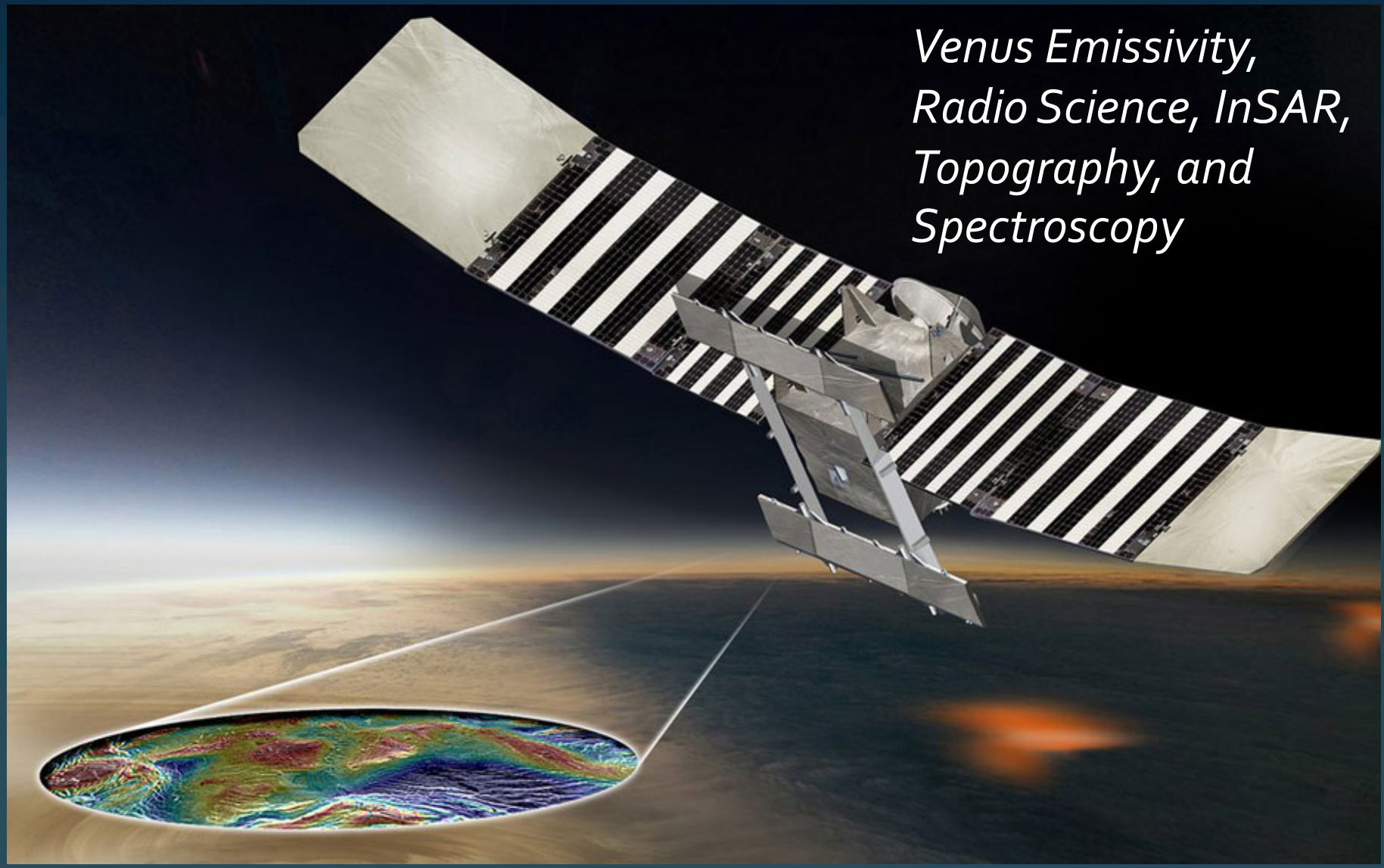
NASA's Magellan Data Reveals Volcanic Activity on Venus



In a first, scientists have seen direct evidence of active volcanism on Earth's twin, setting the stage for the agency's VERITAS mission to investigate.

Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging

3/31/23


Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy

Conclusions

Venus closely resembles Earth globally, but significant differences exist:

- Atmosphere: pressure, composition, temperature
- Tectonic Style: PT vs global overturn
- Crater distribution, age of surface

Conclusions

- Venus may have been totally resurfaced in a very short time frame (~100 Ma?) between 300 Ma and 1 Ga.
- If features classified as coronae actually are craters, this history must be rewritten.
- Analysis indicates that classification must be done carefully, feature-by-feature