Venus: Craters, Coronae, and Chasmata
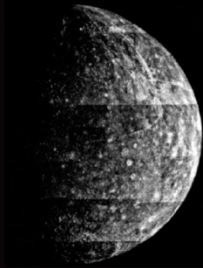

Donna M. Jurdy

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

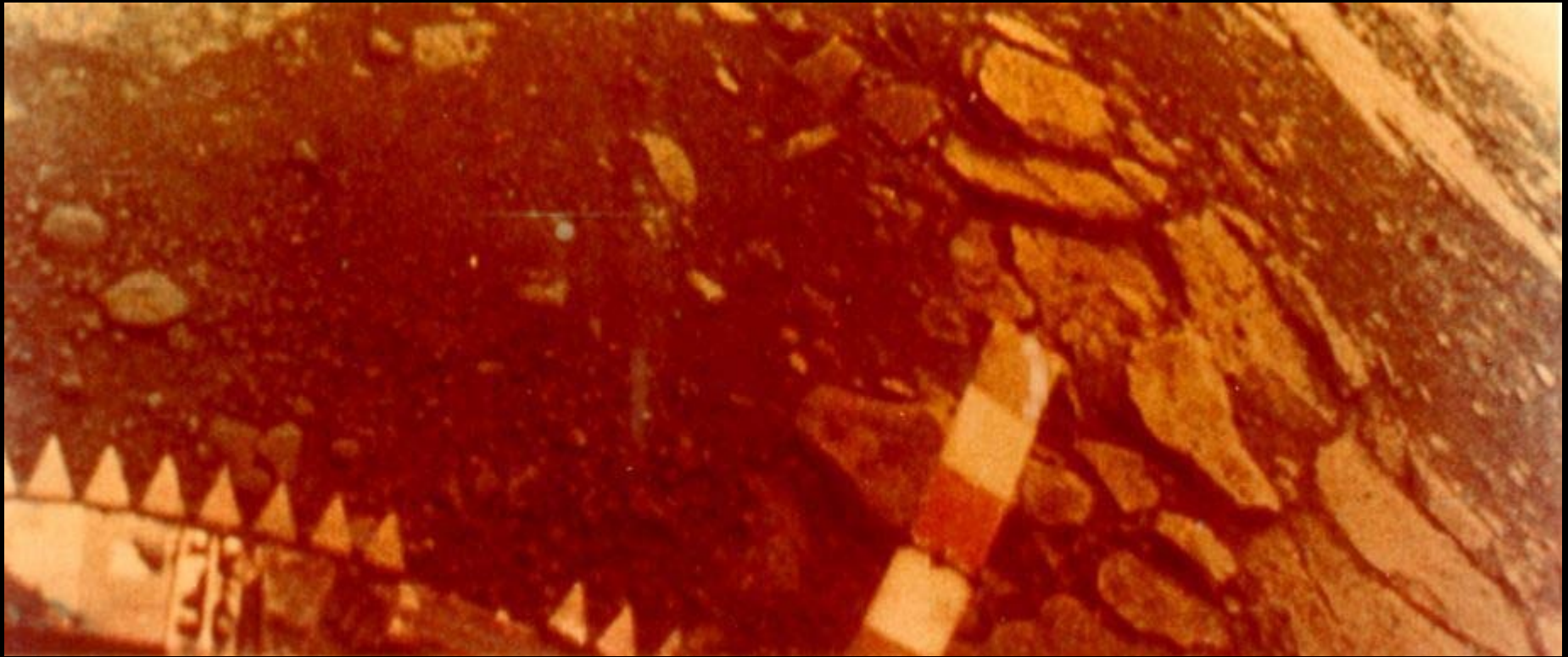# Venus, photos by Veneras 9, 10

ВЕНЕРА-9 22.10.1975 ОБРАБОТКА ИППИ АН СССР 28.2.1976
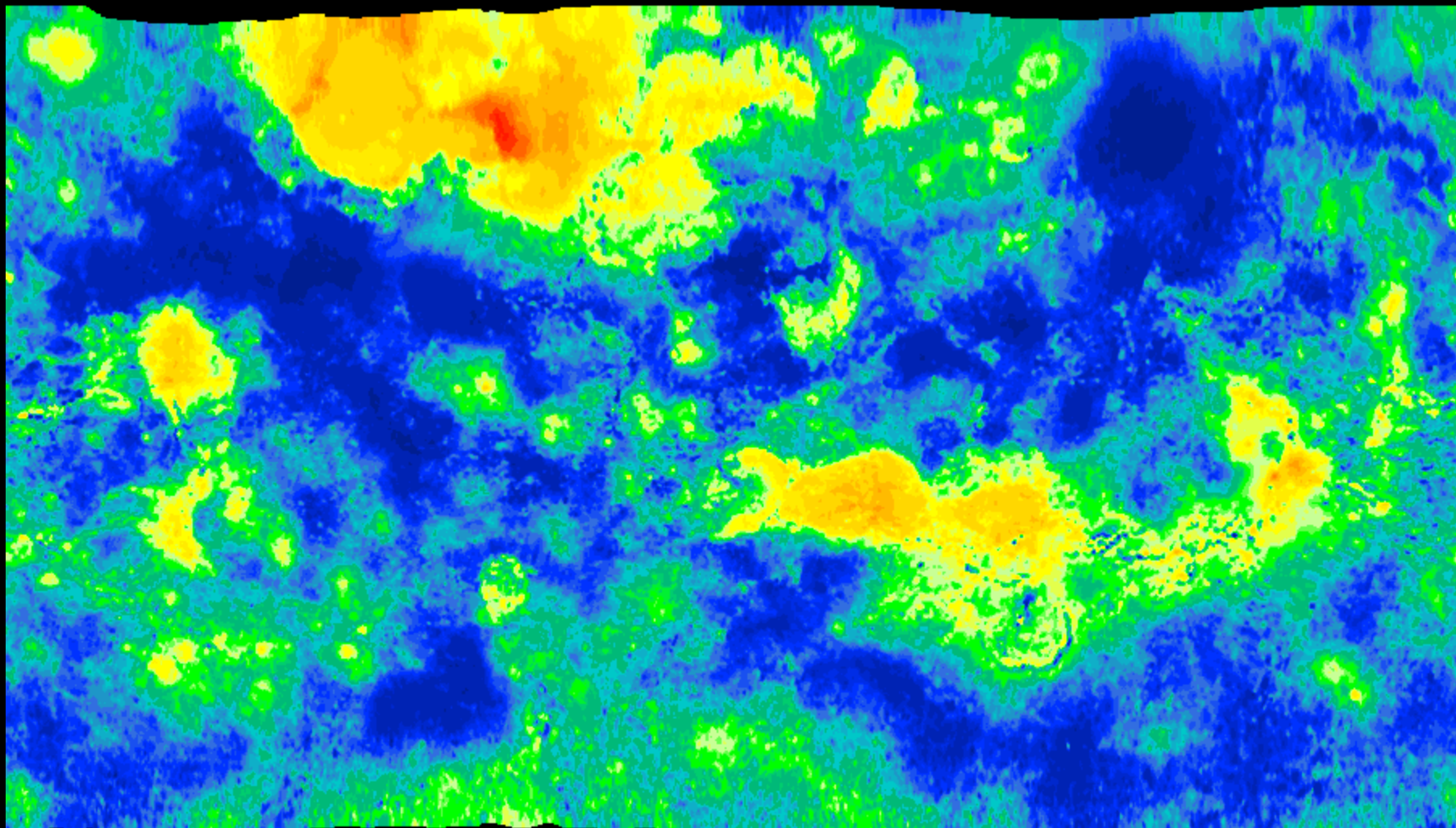
ВЕНЕРА-10 25.10.1975 ОБРАБОТКА ИППИ АН СССР 28.2.1976

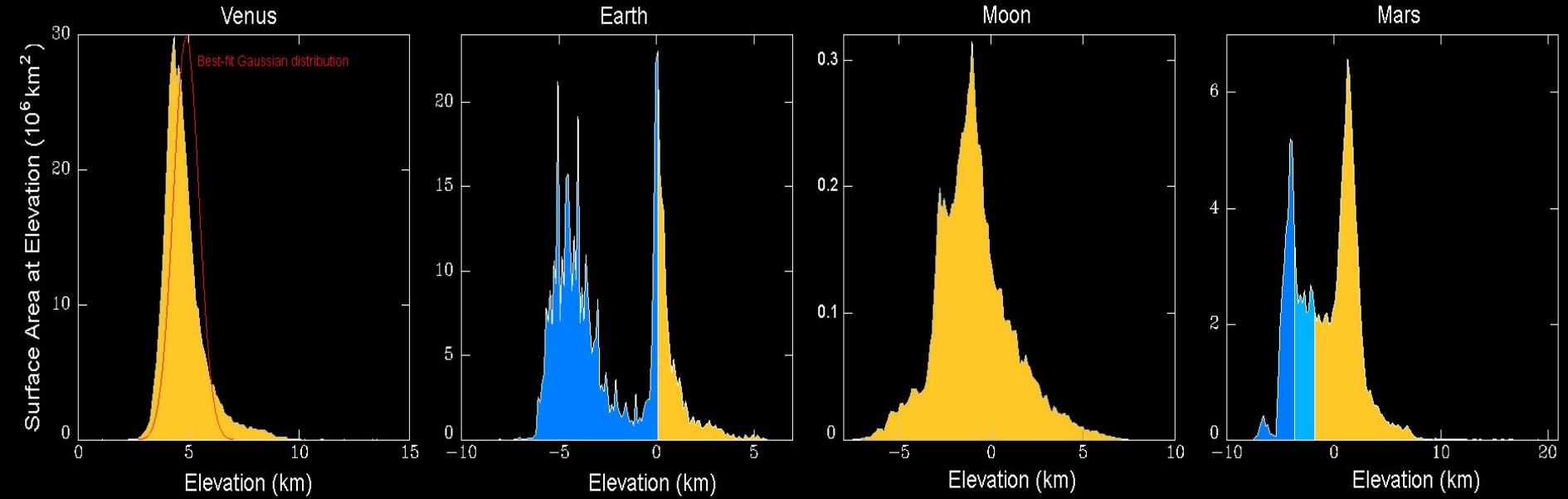# Venus as seen by Venera 13 (Mar. 2, 1982)

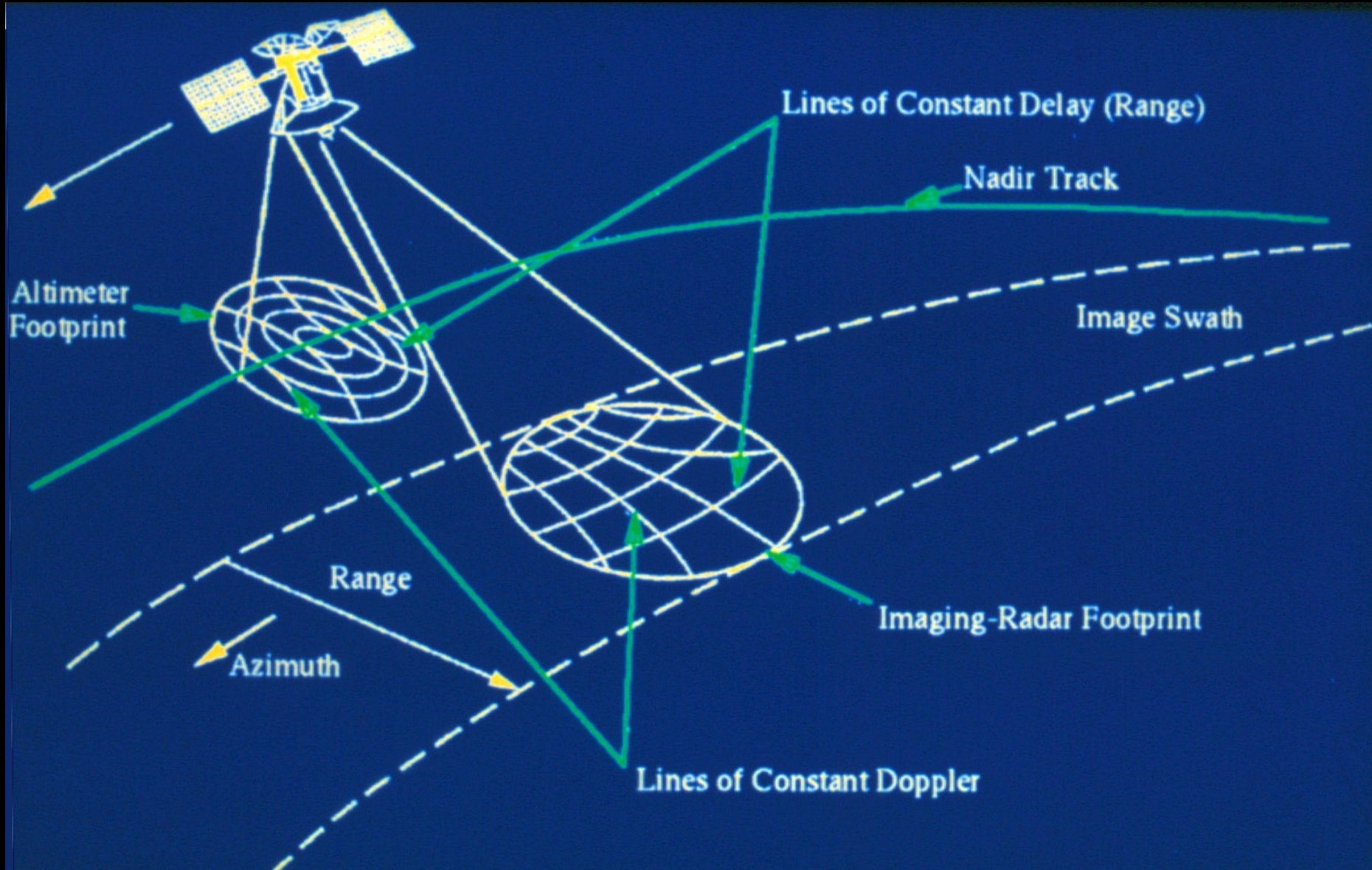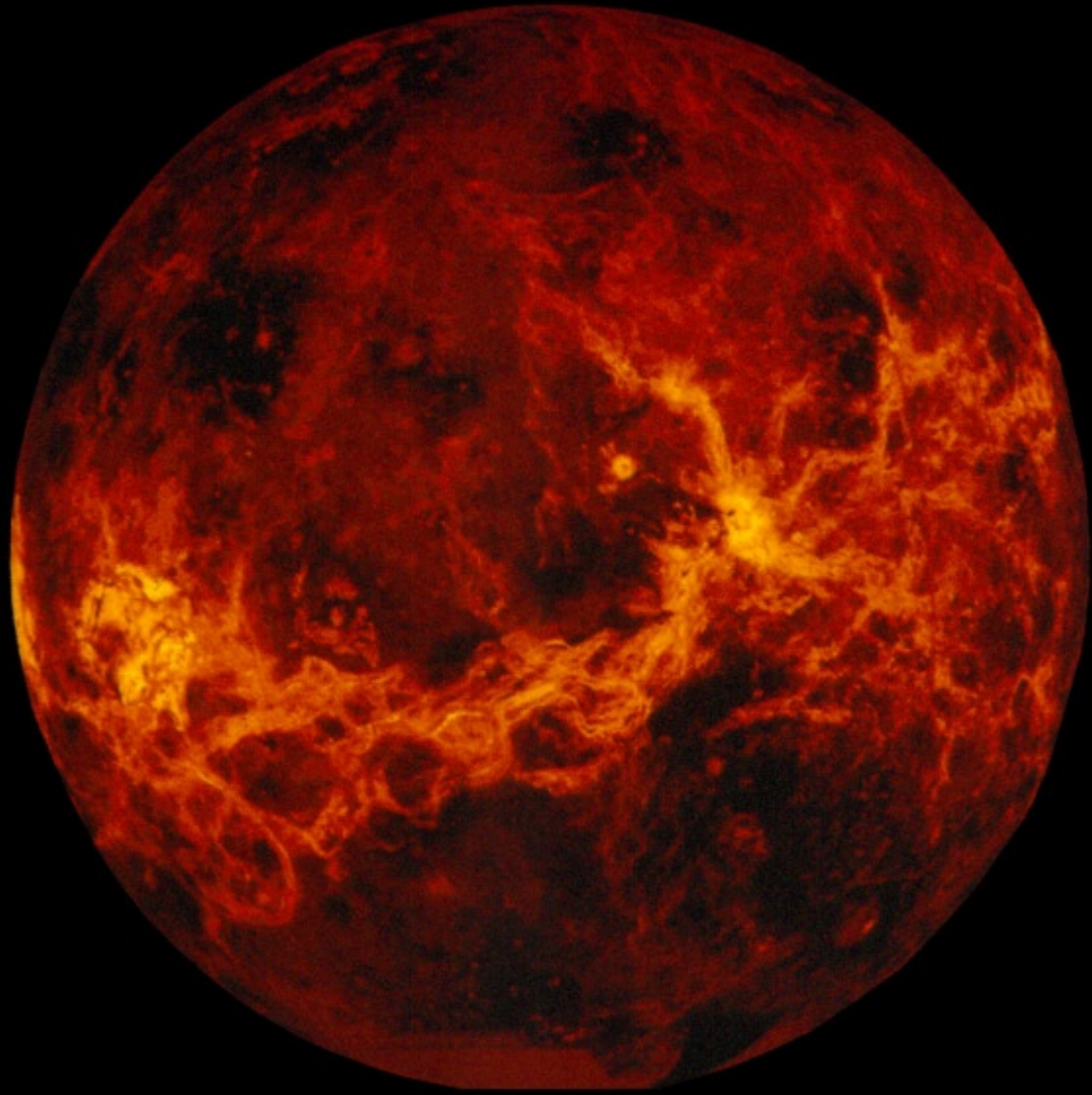*Pioneer Venus Topography*

Inner Solar System Hypsography

Magellan Radar Mapping

Lines of Constant Delay (Range)

Nadir Track

Altimeter Footprint

Image Swath

Range

Azimuth

Imaging-Radar Footprint

Lines of Constant Doppler

MAGELLAN   VENUS TOPOGRAPHY   GTDRP.1;3

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

Mercator Scale

Polar Stereographic Scale

North Polar Stereographic

South Polar Stereographic

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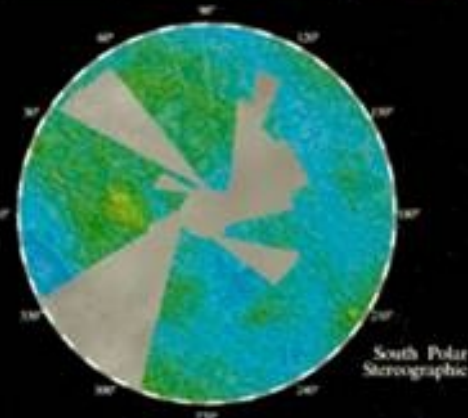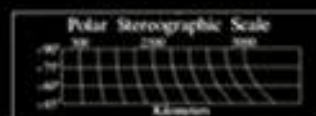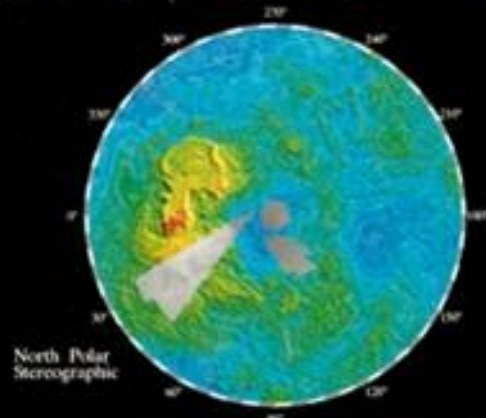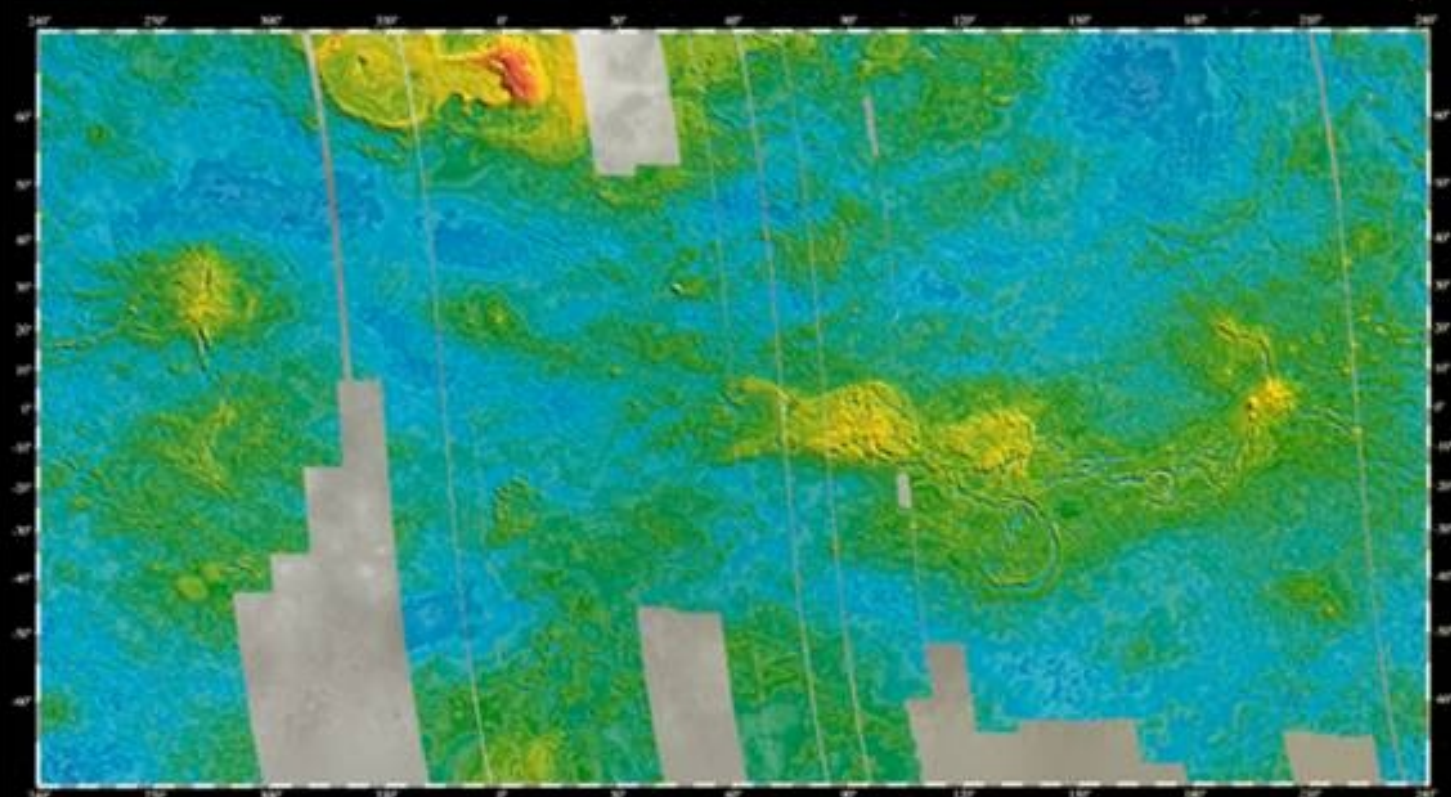
PRODUCT ID:	GTDRP.1;3	PRODUCTION DATE:	11/02/91
STARTING ORBIT:	376	PRODUCTION TIME:	13:19:13
ENDING ORBIT:	2586	HARDWARE VERSION:	01
PIXEL SIZE:	5×5 km	SOFTWARE VERSION:	02

Venus Chasmata, Coronae, Craters, and Geoid
(Eckert IV projection)
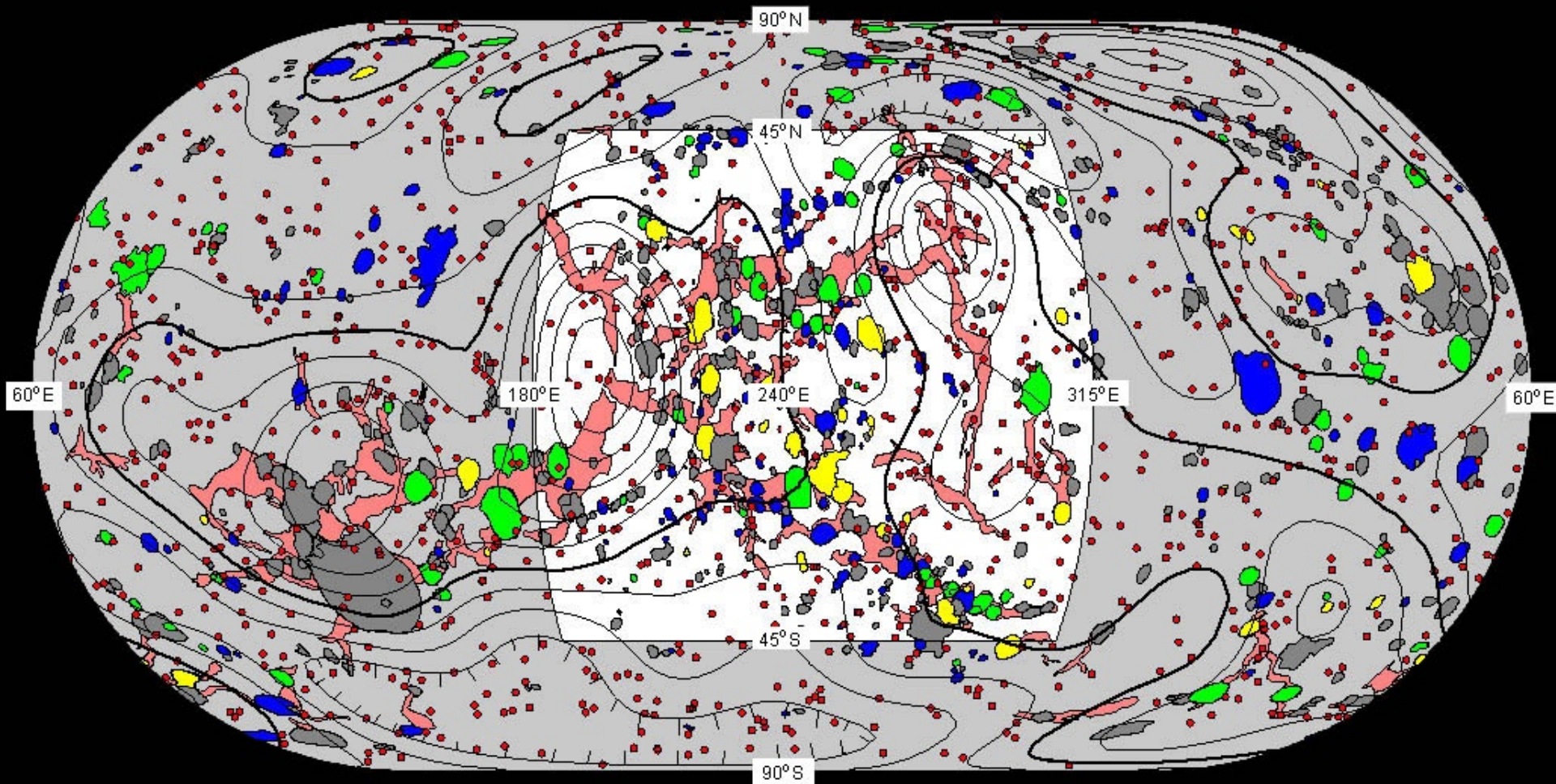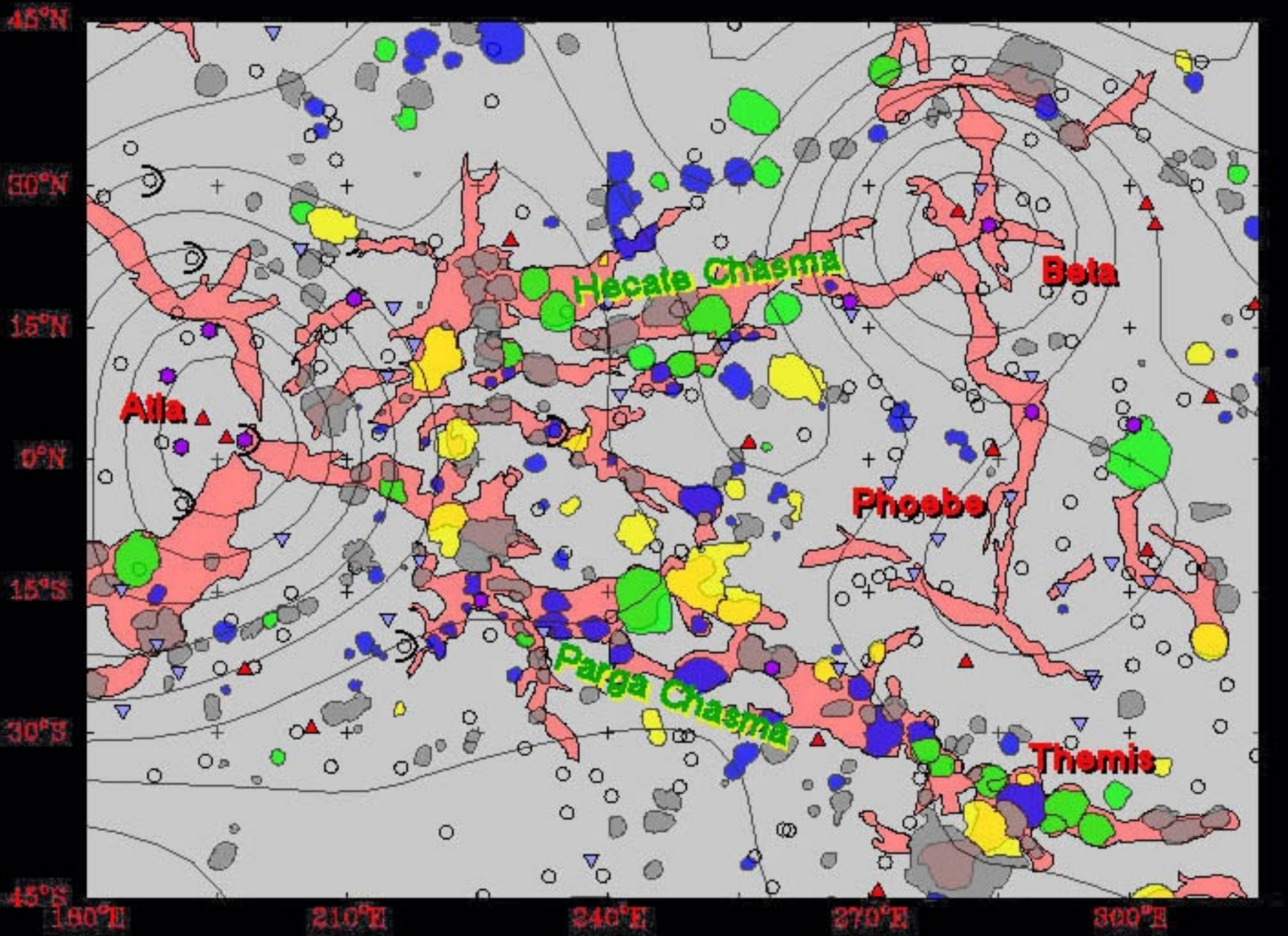
Beta-Atla-Themis (BAT) Region
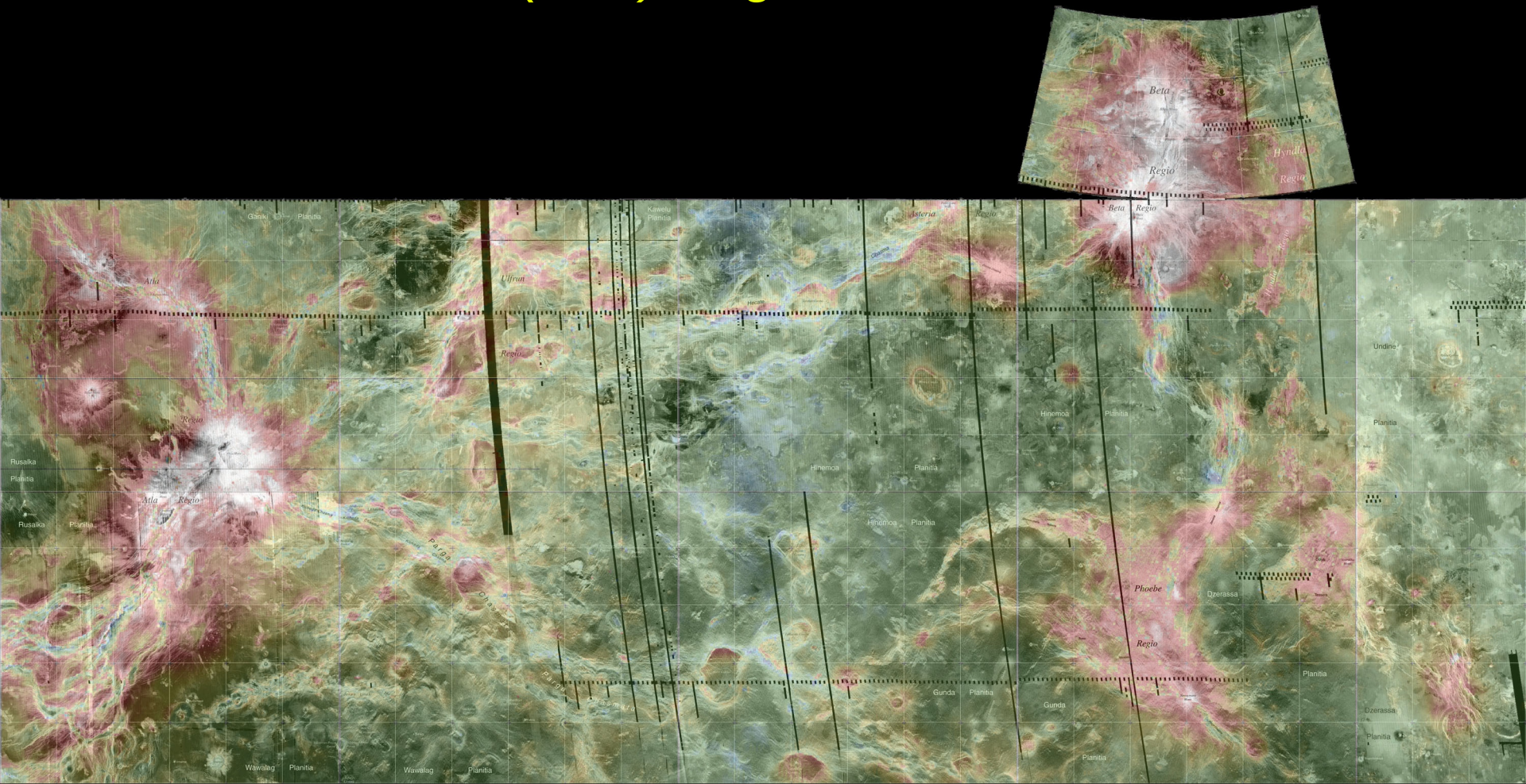
Craters

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

Craters on Venus

Adivar 8.9N 76.2E
Young - haloed
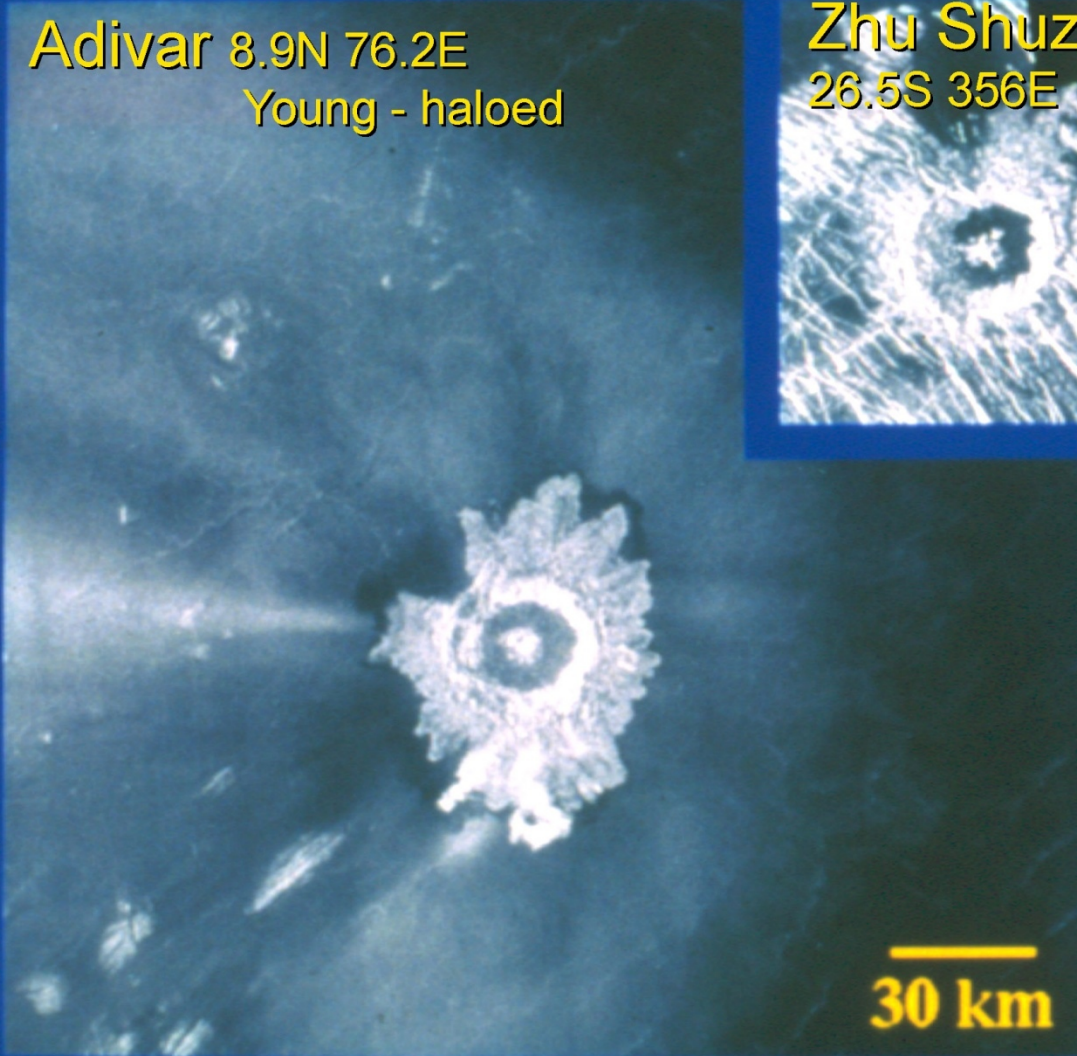
Zhu Shuzhen
26.5S 356E T&E
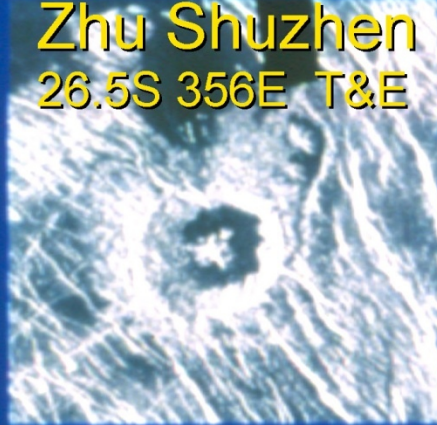
Bashkirtseff 14.7N 94.1E
Embayed

Balch
29.9N 282.9E
Rifted

30 km

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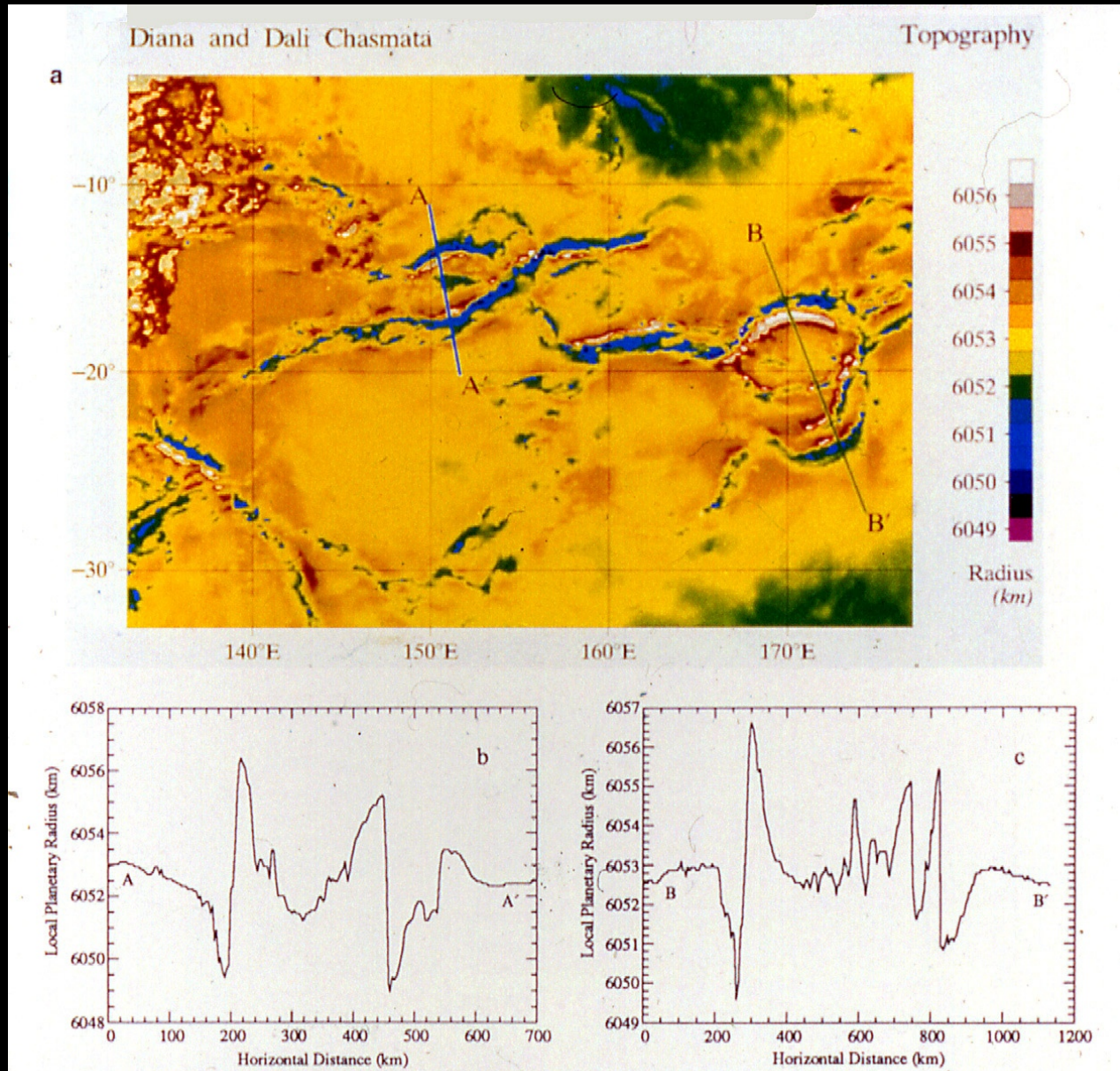
Plate 4. (a) Relief over Diana and Dali chasmata; (b) topographic profile along A–A'; (c) topographic profile along B–B'.
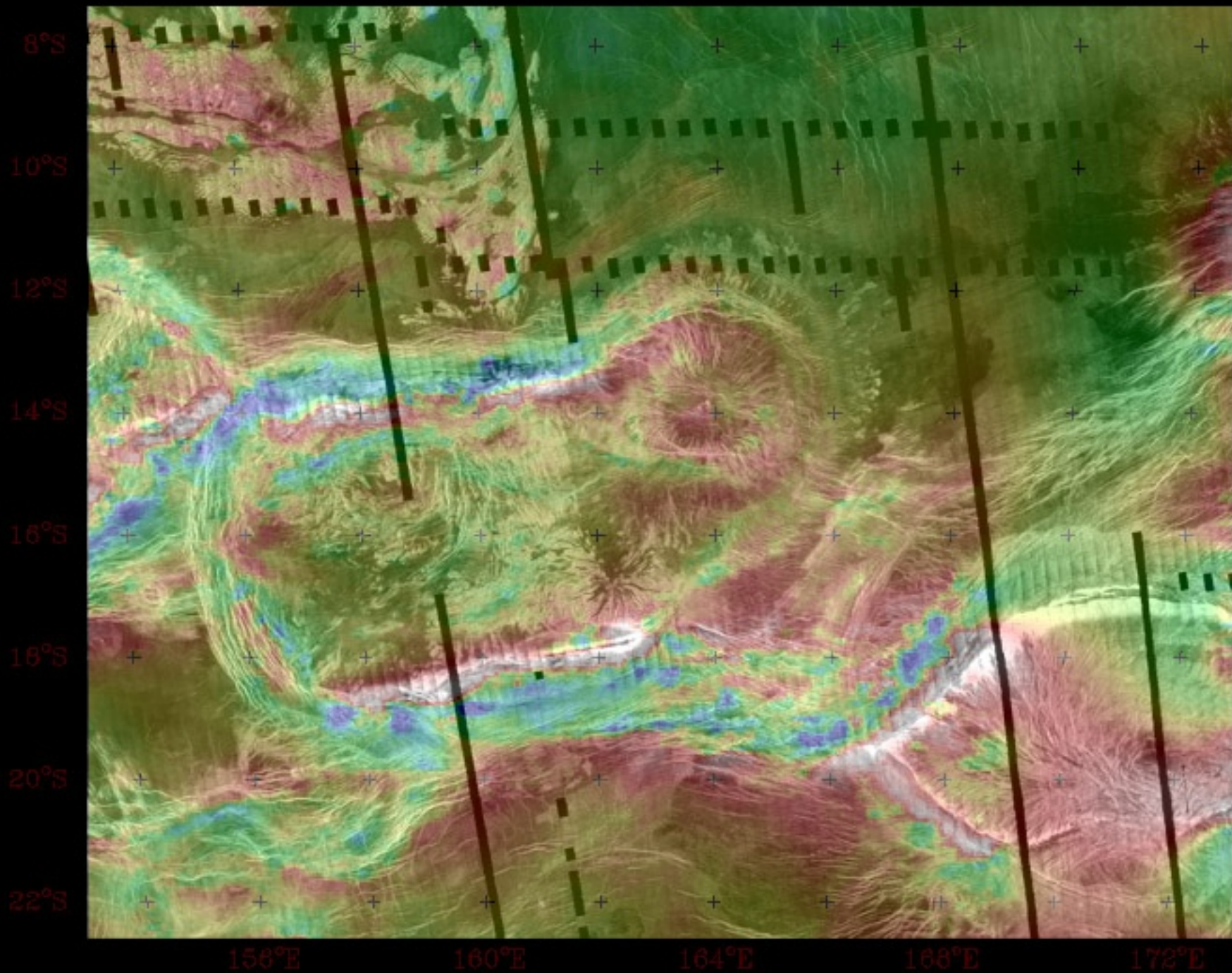
Coronae

- 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

50 km

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
- Possible evolution scheme determined…

Coronae
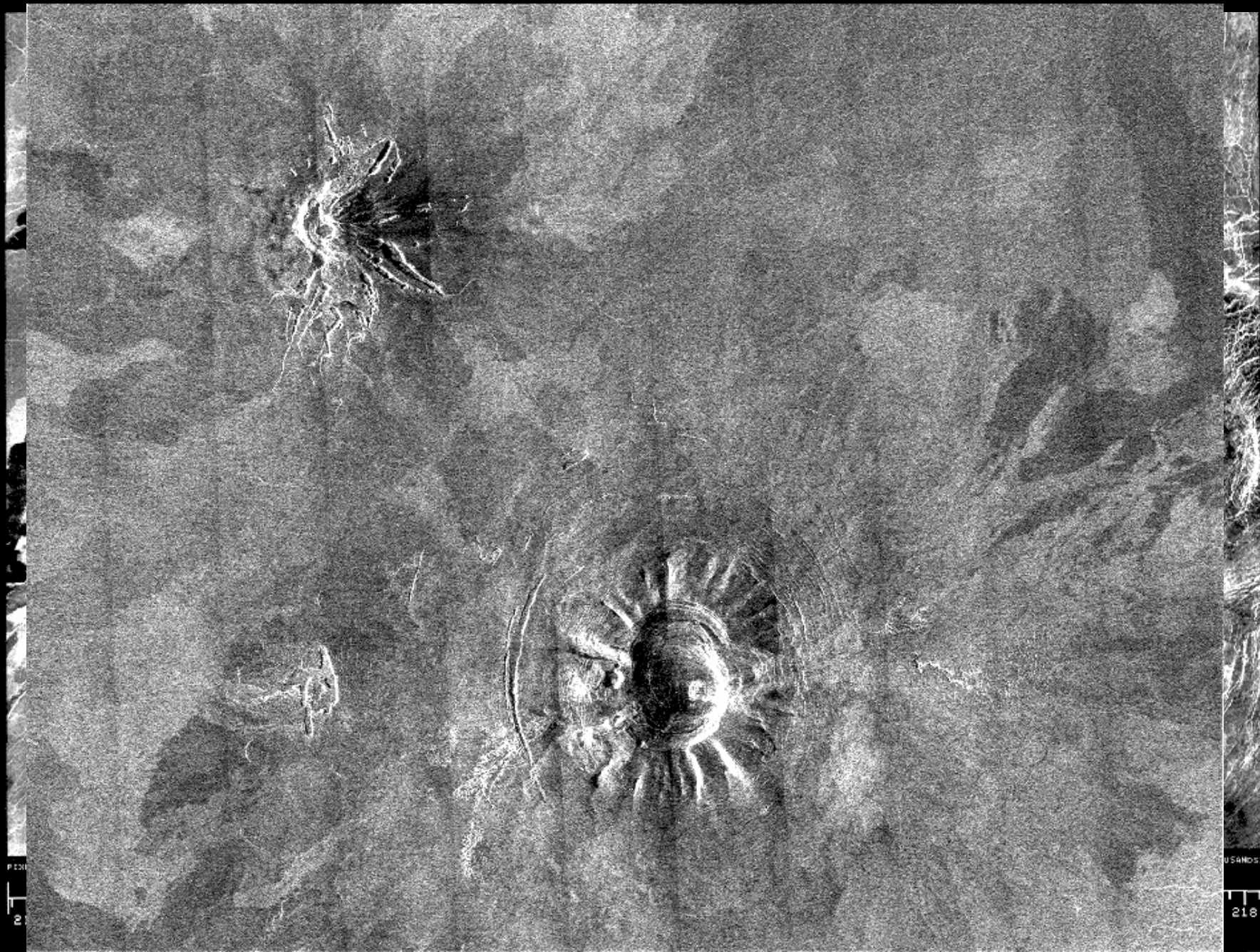
Corona Evolution
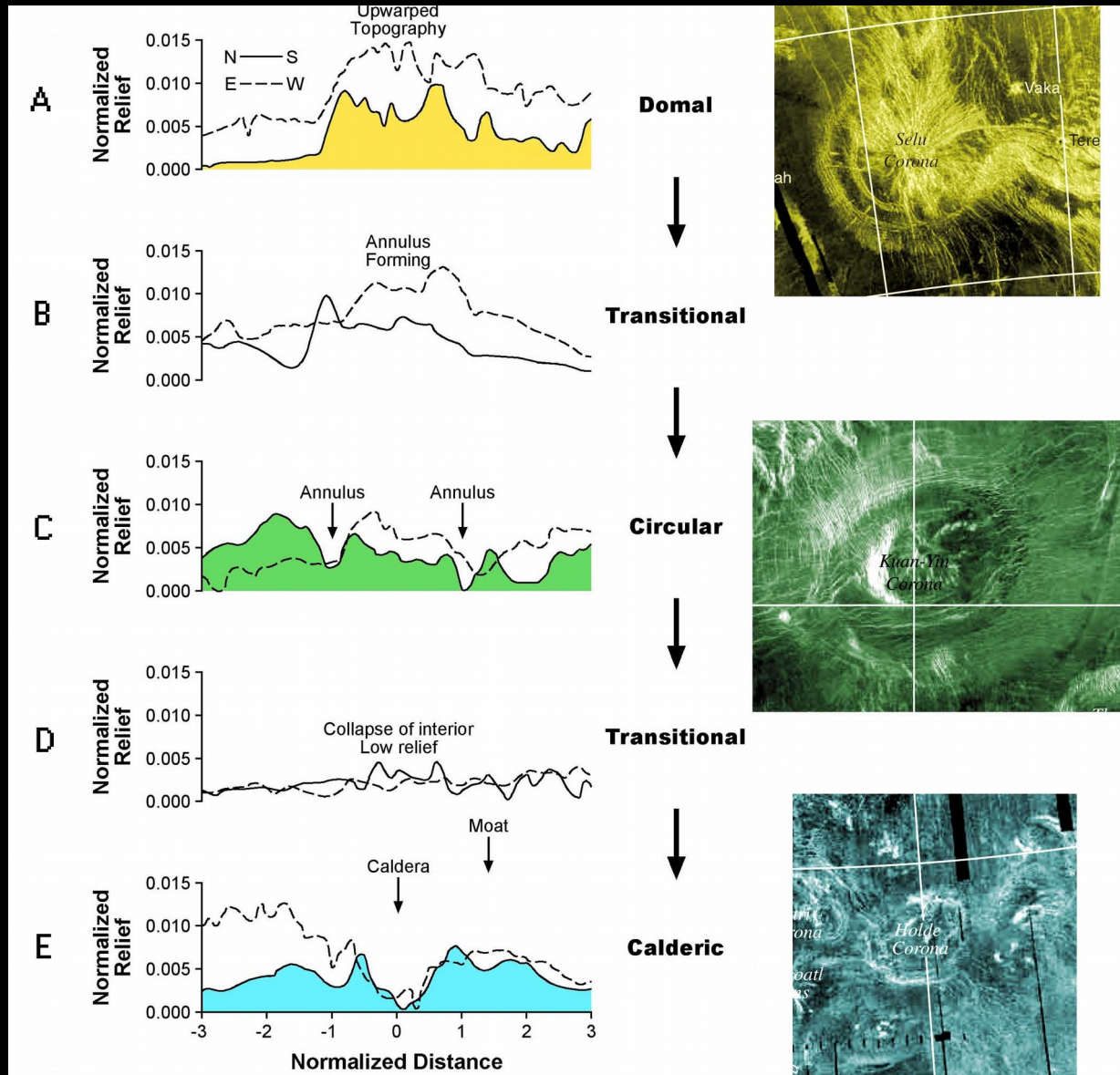
Comparison of Coronae, by Type
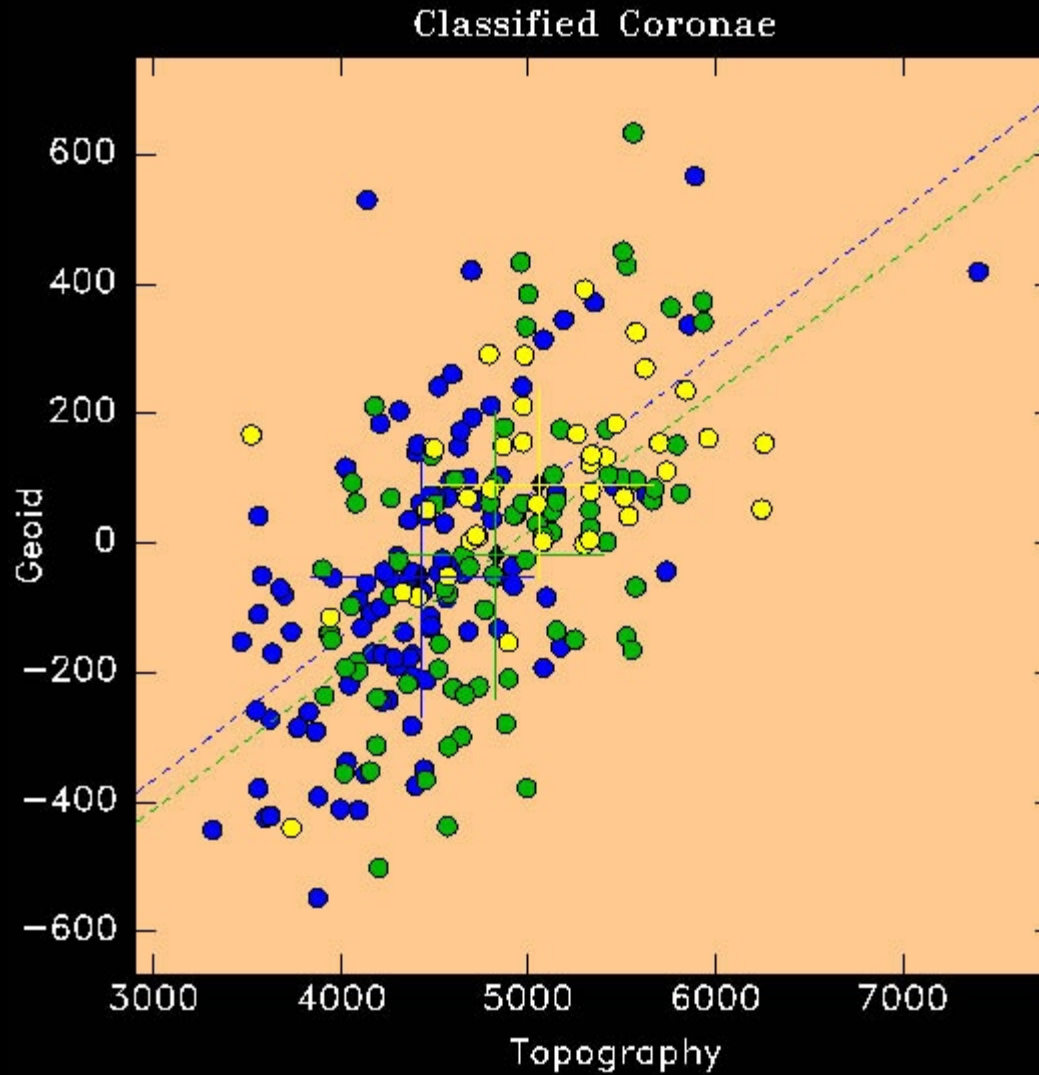
Craters vs. Coronae

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?
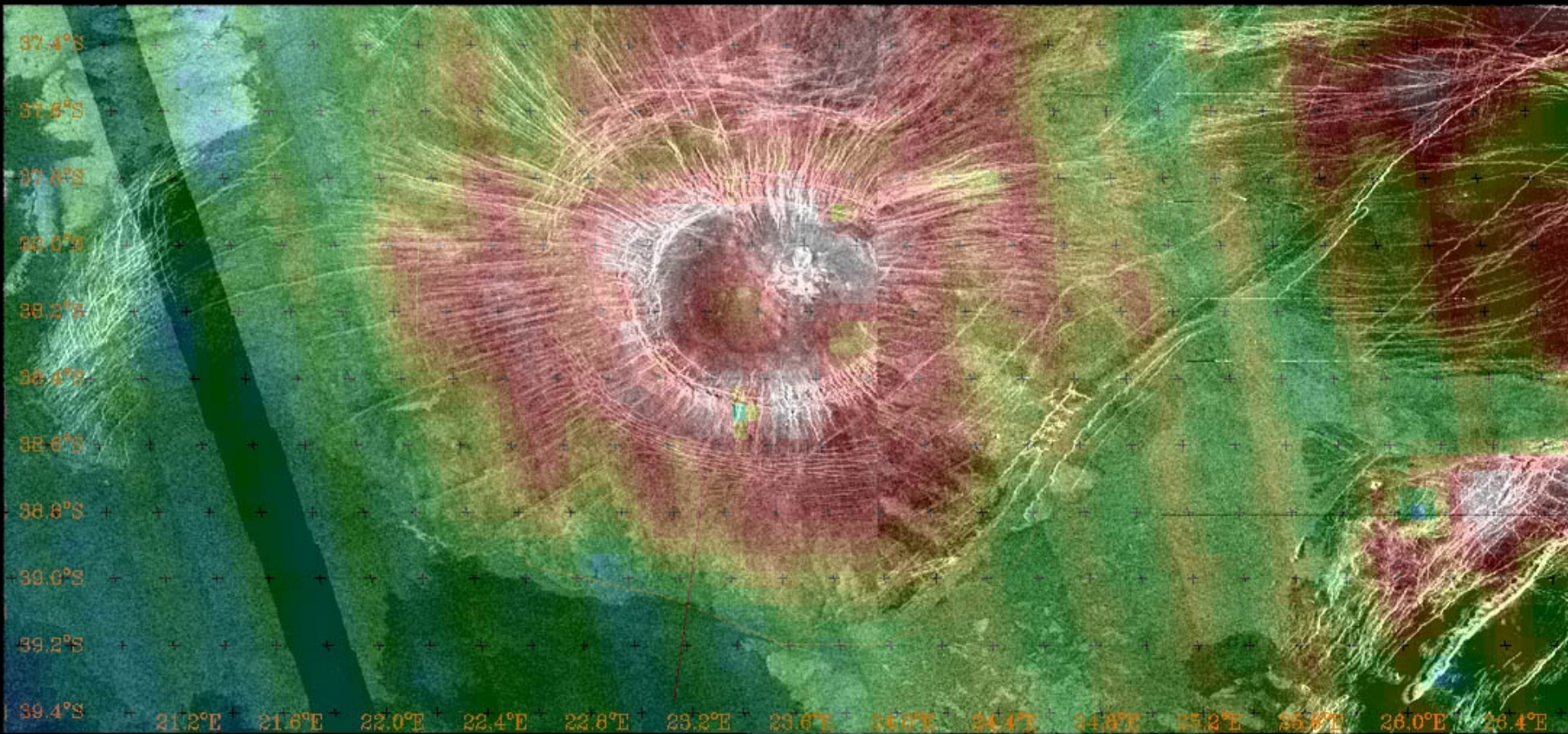
Mead Crater – Radar and Topography
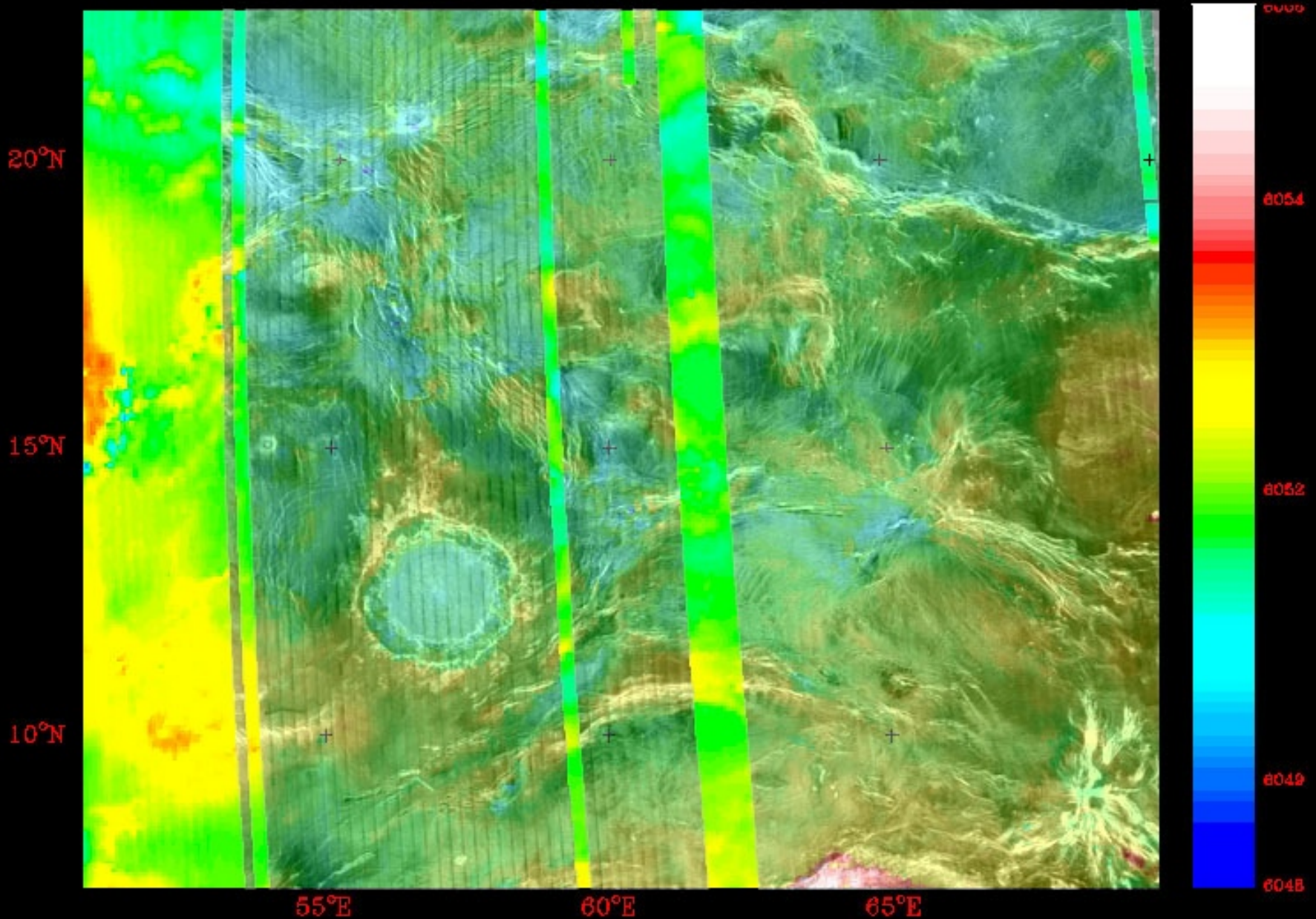
Cross-Correlation Mead Crater

Profile Correlatons for Craters > 100 km and Selected Coronae
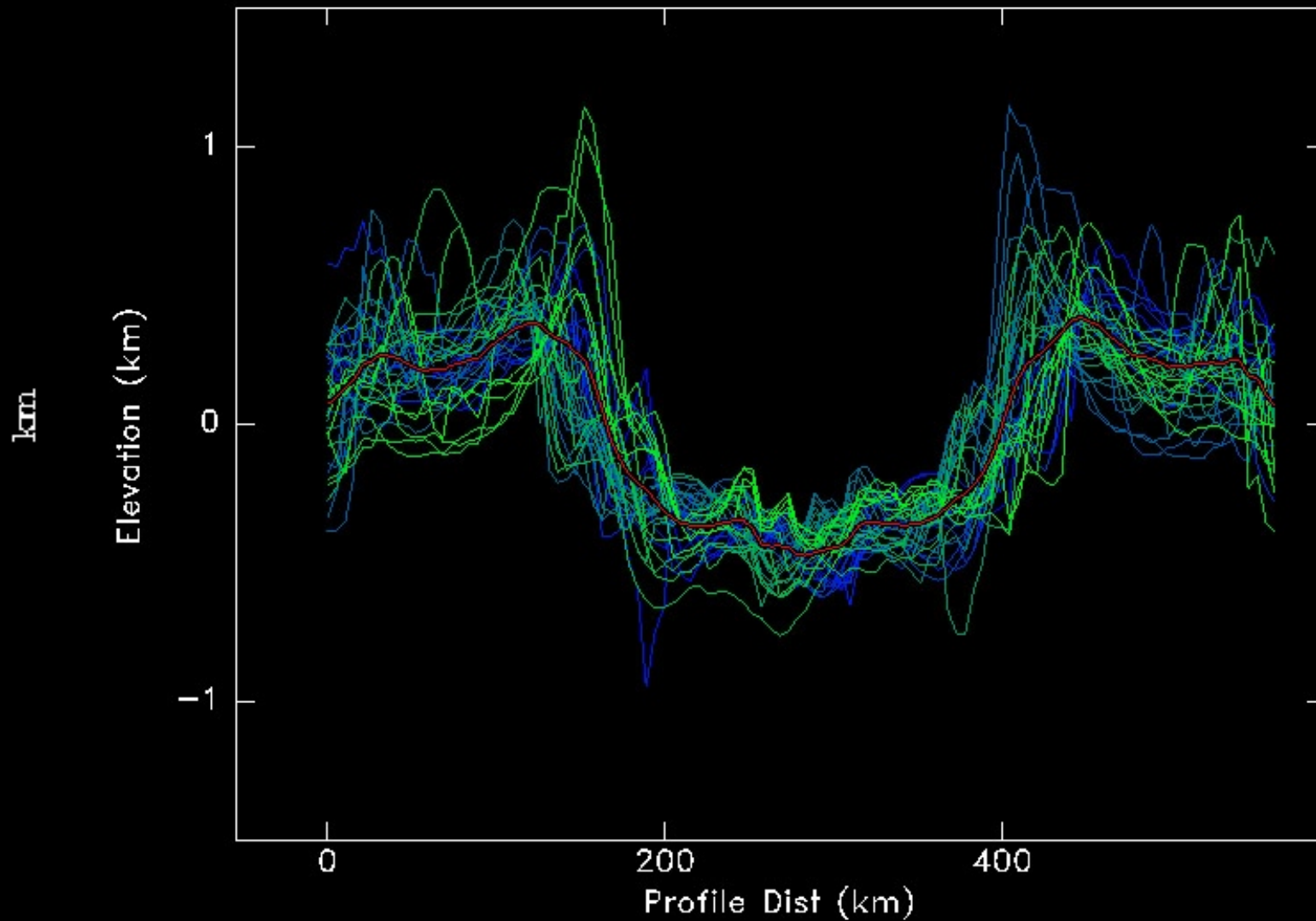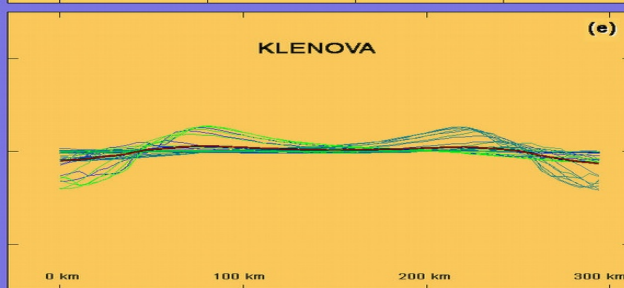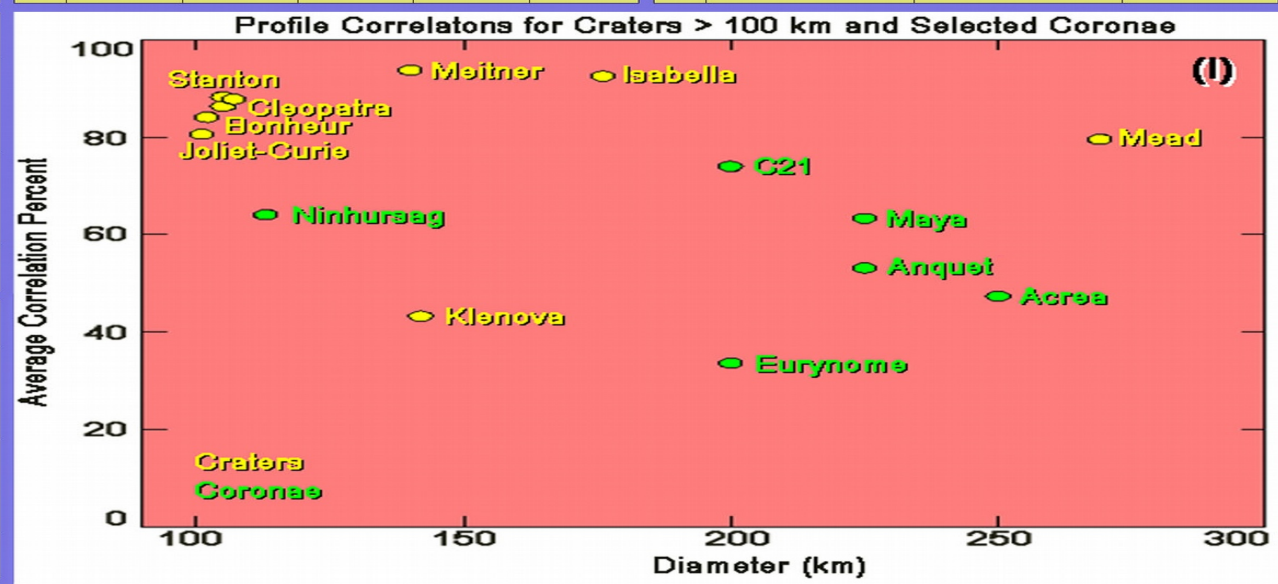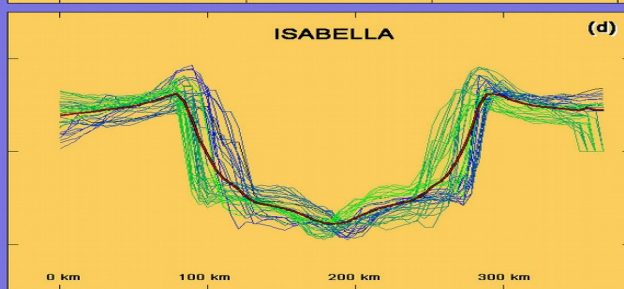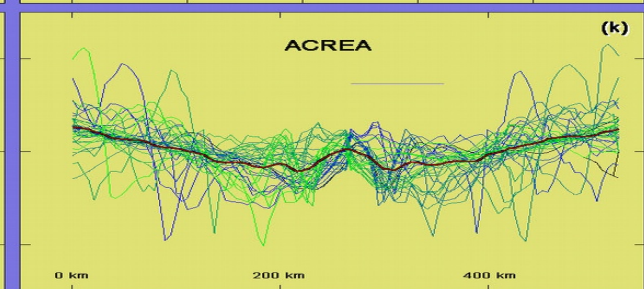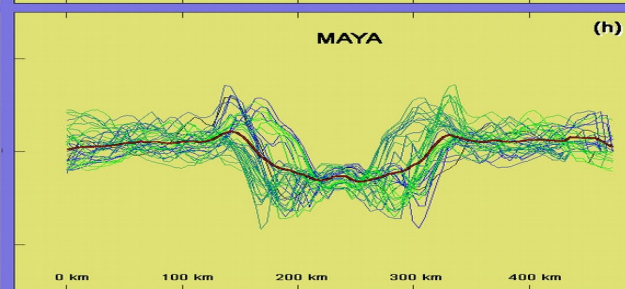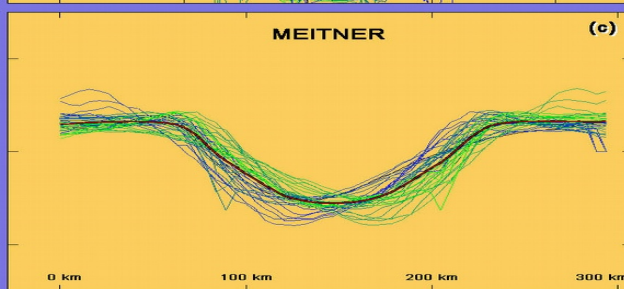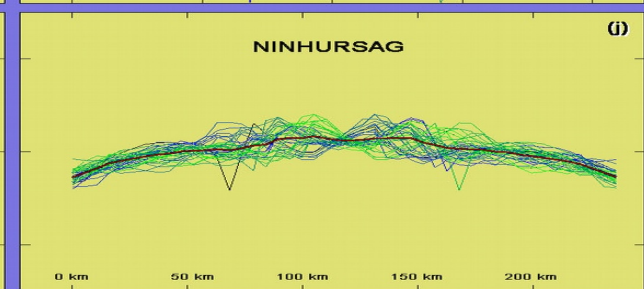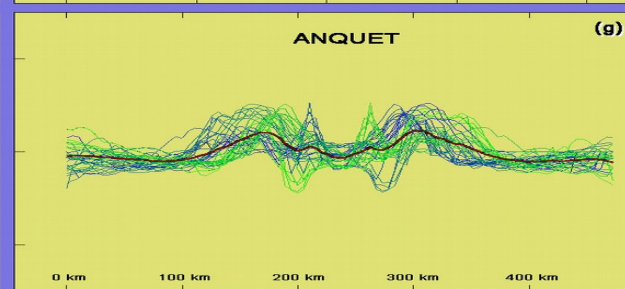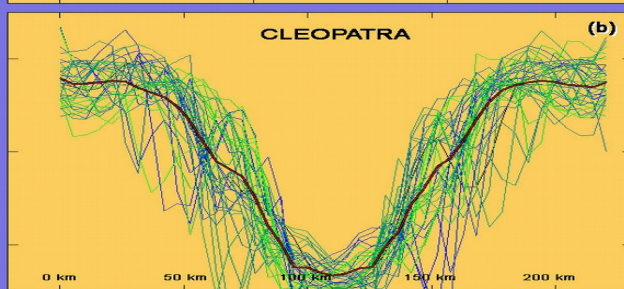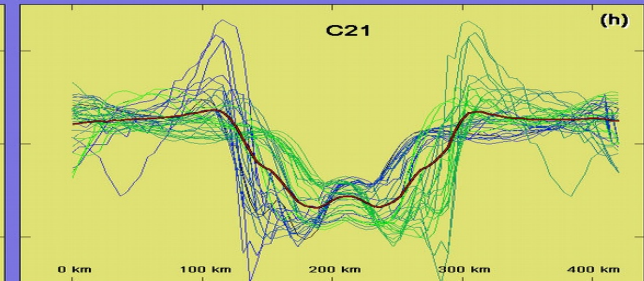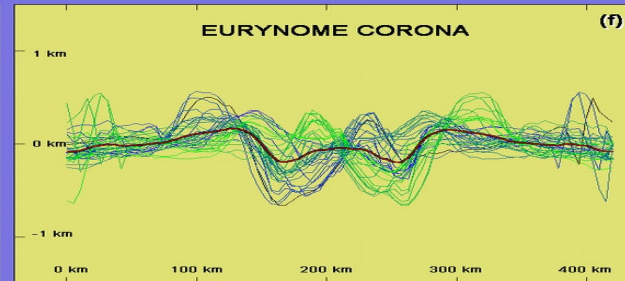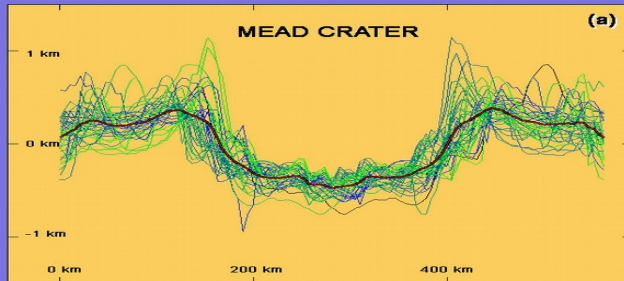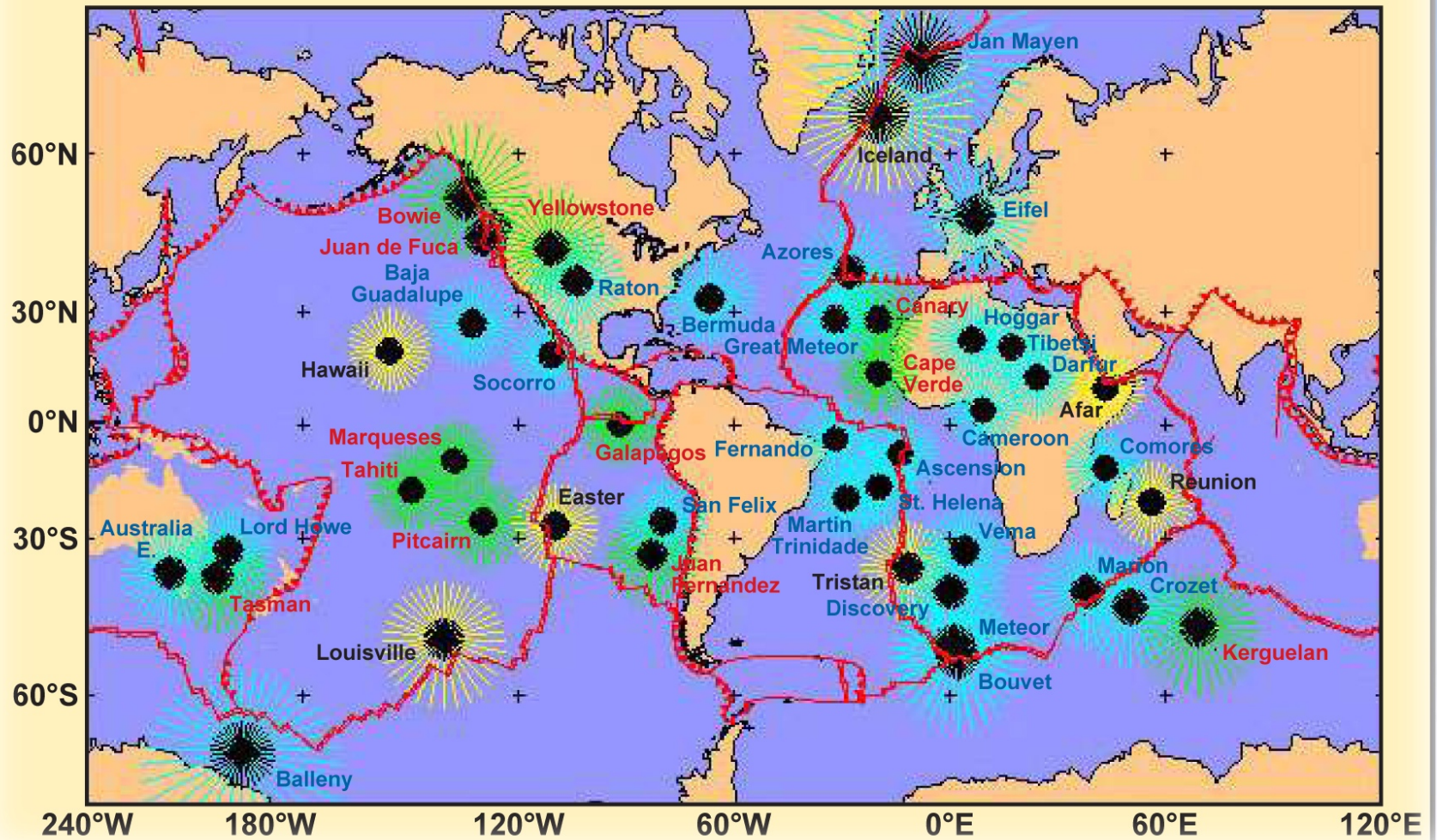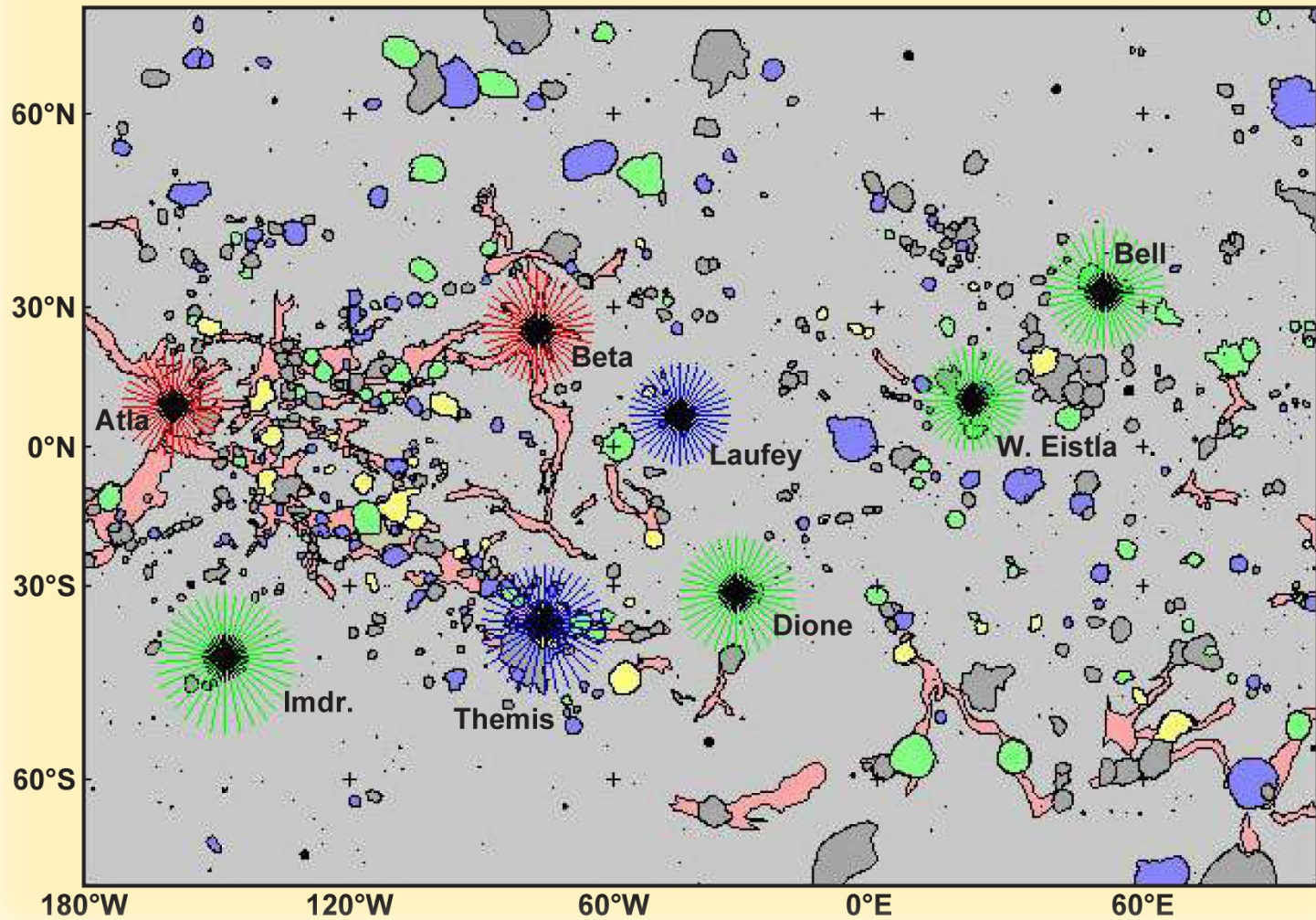
Venus Profiles

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

Average Upwelling Profiles

Hawaii

Reunion

Iceland

Yellowstone

Atla

Beta

West Eistla

Profile Elevations (m)

20000

15000

10000

5000

0

Distance along Profile (km)

0   500   1000   1500
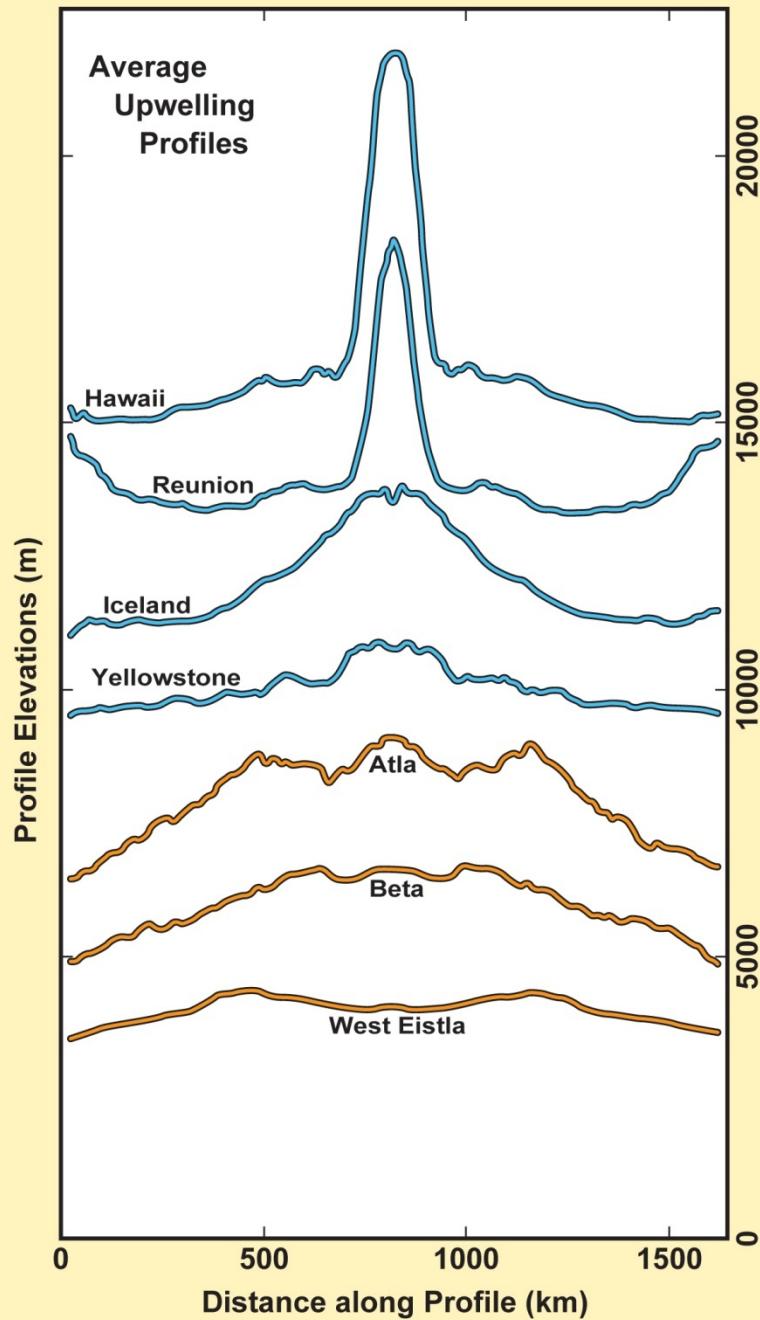
EXAMPLE: At left are shown profiles for 4 Earth hotspots: Hawaii, Reunion, Iceland and Yellowstone and 3 Venus regiones: Atla, Beta, and W. Eistla. The seven principal components derived from the covariance matrix are shown. Principal components are shown as representative traces, the sum of which, appropriately 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.

1

2

3

Hawaii Principal Components

Hawaii Topographic Profile

1

2

3

Atla Principal Components

Atla Topographic Profile

1

3

2

Principal Components

1

2

3

Beta Principal Components

Beta Topographic Profile
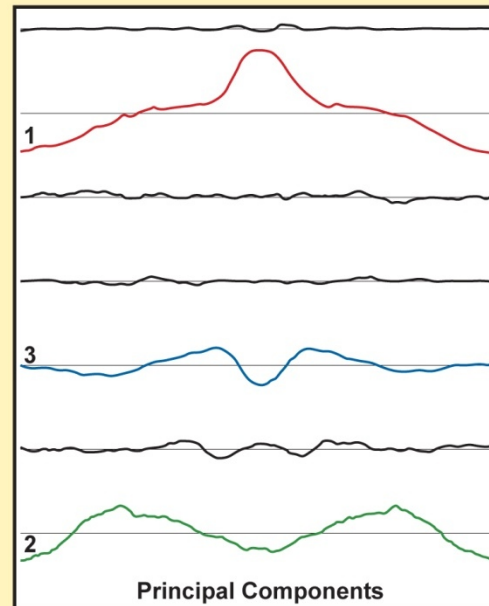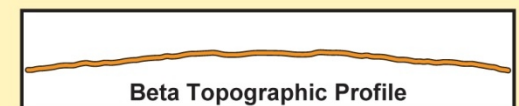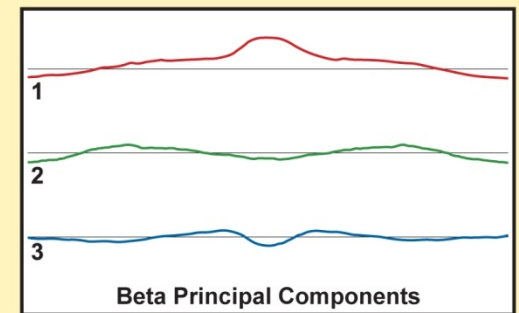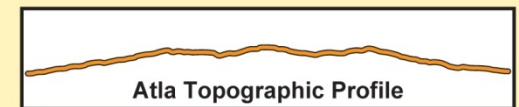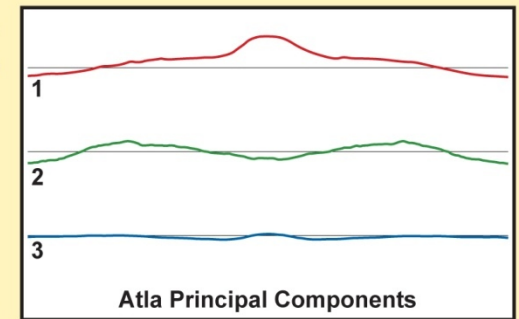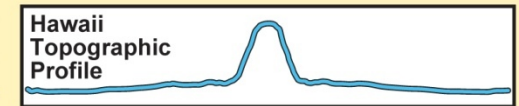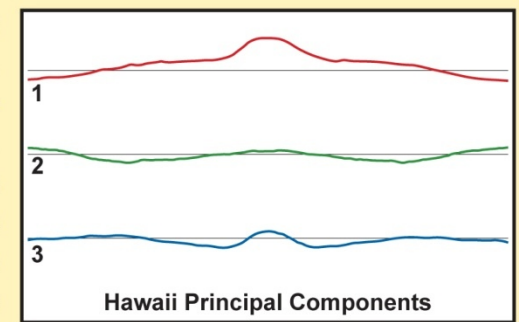
Procedure

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

Uplifts
(Earth and Venus)

Legend:
- Ocean
- Ridge
- Near Ridge
- Continent
- Venus

Principal Components

Topography (m)

Distance (km)

PC 1

PC 2

PC 3

PC 4

10000 m

0

— Venus Uplifts
— Continental Uplifts
— Oceanic Uplifts
— Near-Ridge Uplifts
— Ridge Uplifts

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

Prepared for the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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 ±56.6° latitude, as is the scale at the latitude of a true 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 83.8° 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 revision 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 (small areas near the north pole, and along 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 malachite green and a sienna brown was chosen to demarcate the 6 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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Phillips, R.J., and five others, 1979, The gravity field of Venus: A preliminary analysis: Science, v. 205, no. 4401, p. 93–96.

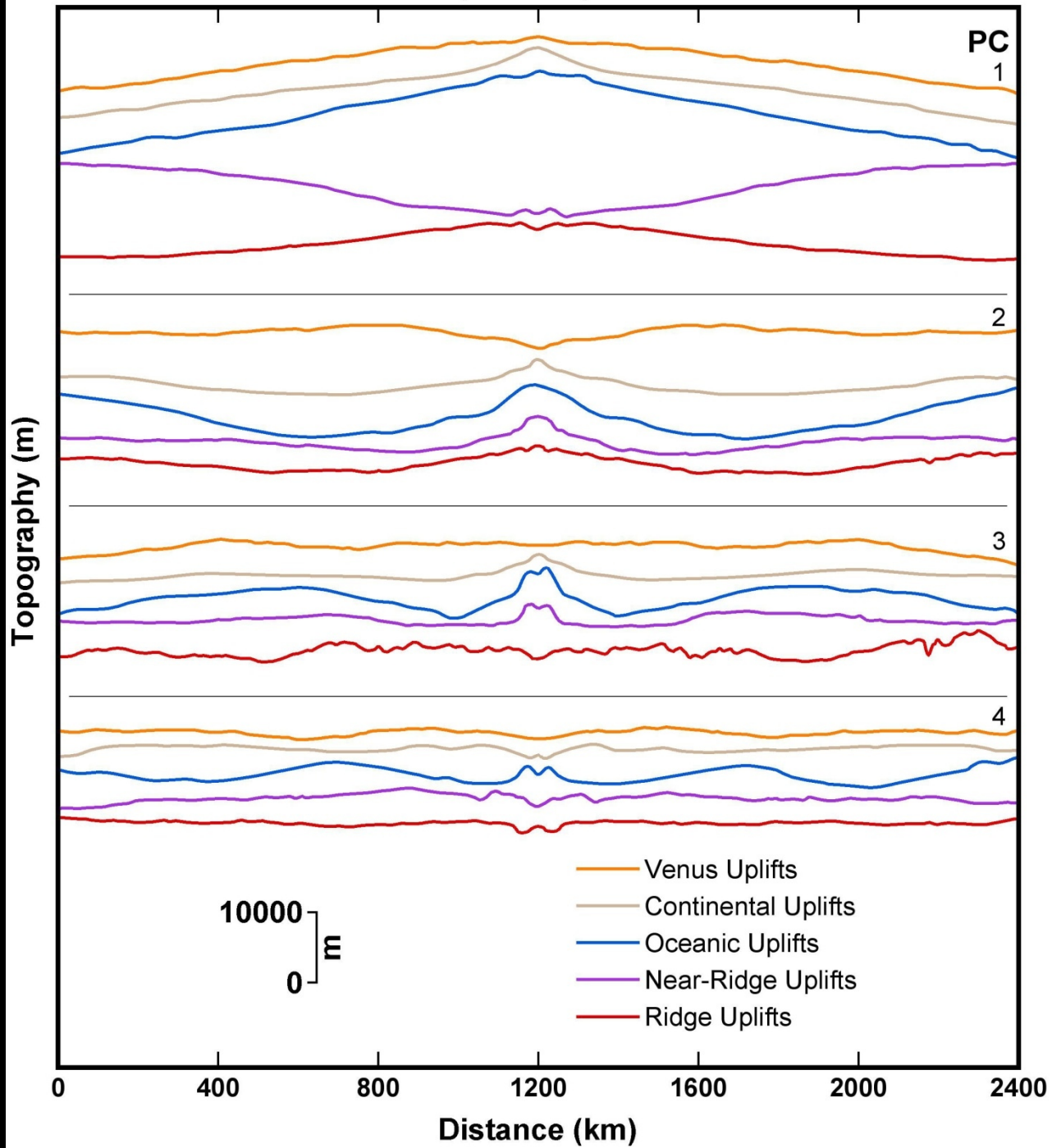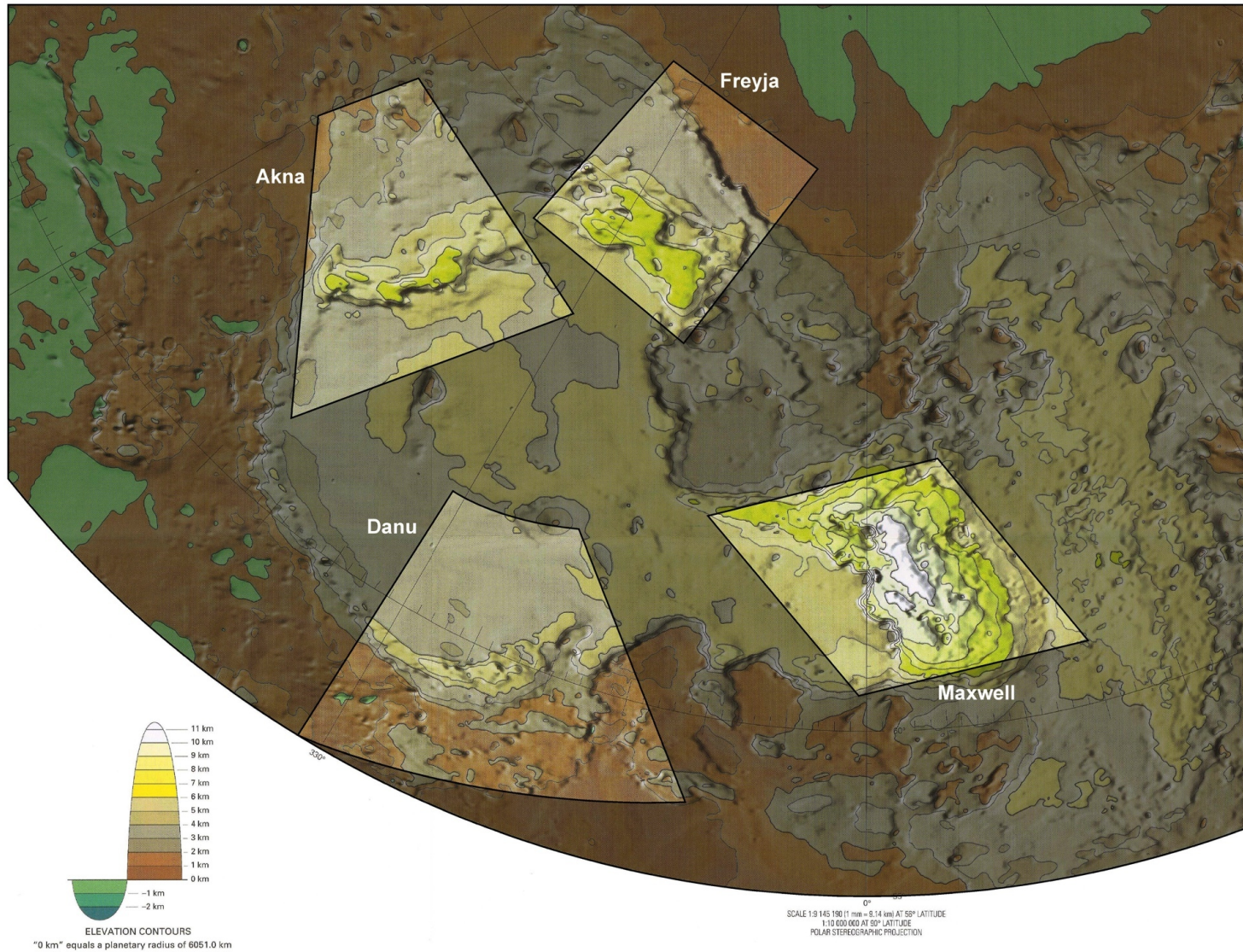Planetary Cartography Working Group (Sturm, R.G., and ten others), 1984, Planetary cartography in the next decade (1984–1994): National Aeronautics and Space Administration Special Publication 475, 71 p.

Planetary Cartography Working Group (Zimbelman, J.R., and sixteen others), 1993, Planetary cartography 1993–2003: National Aeronautics and Space Administration, Planetary Cartography Working Group, 50 p.

Saunders, R.S., and Pettengill, G.H., 1991, Magellan Mission summary: Science, v. 252, no. 5003, p. 247–249.

NORTH POLE   SOUTH POLE

INDEX OF THE 1:10,000,000 SCALE MAP SERIES OF VENUS
Number preceded by "V" indicates mapped.

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

11 km
10 km
9 km
8 km
7 km
6 km
5 km
4 km
3 km
2 km
1 km
0 km
−1 km
−2 km

POLAR STEREOGRAPHIC PROJECTION

KILOMETERS

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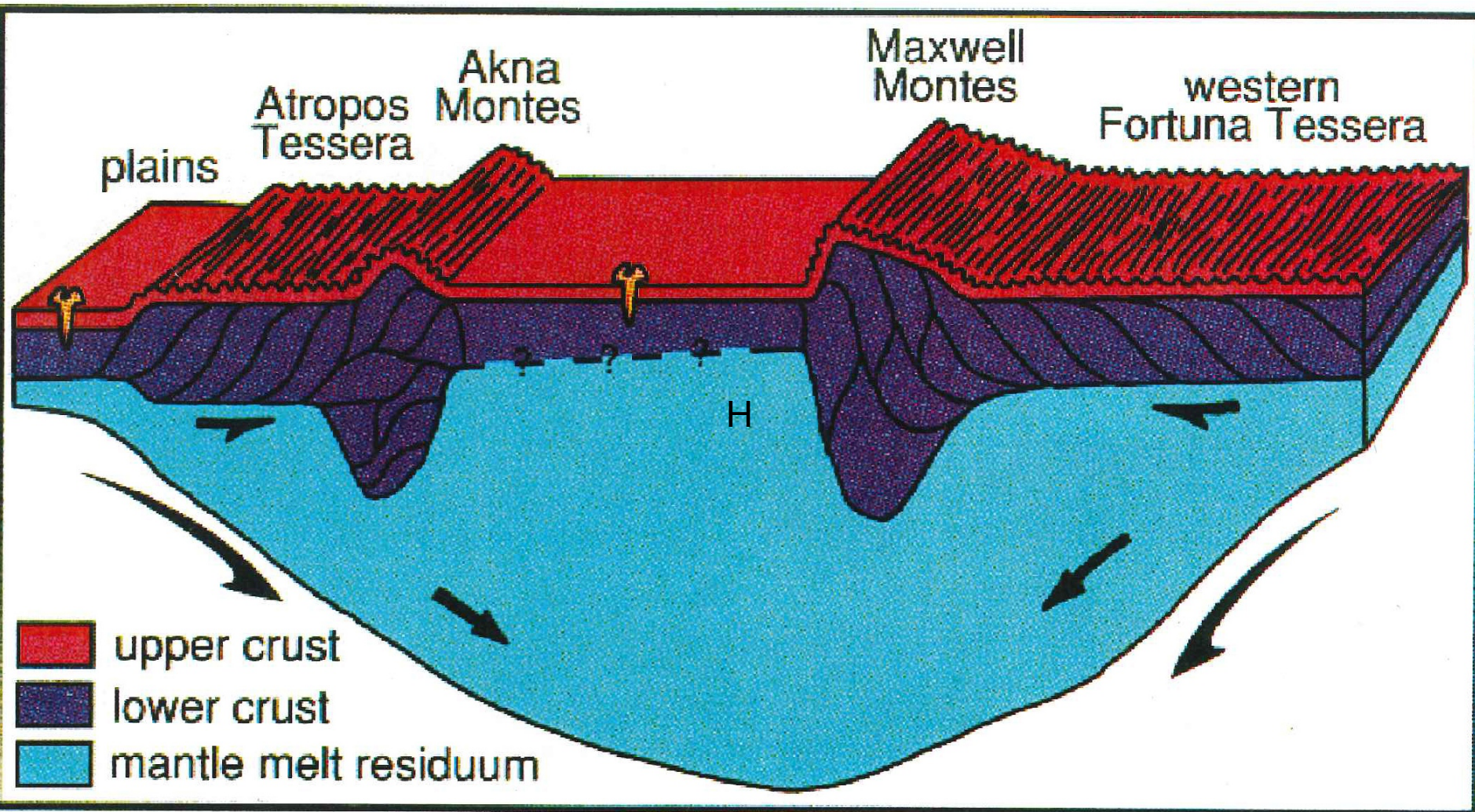
V 10M 90/0 RTK

1998

Venus Mountains

Orogenic Model – *(Hansen & Phillips, 1995)*

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