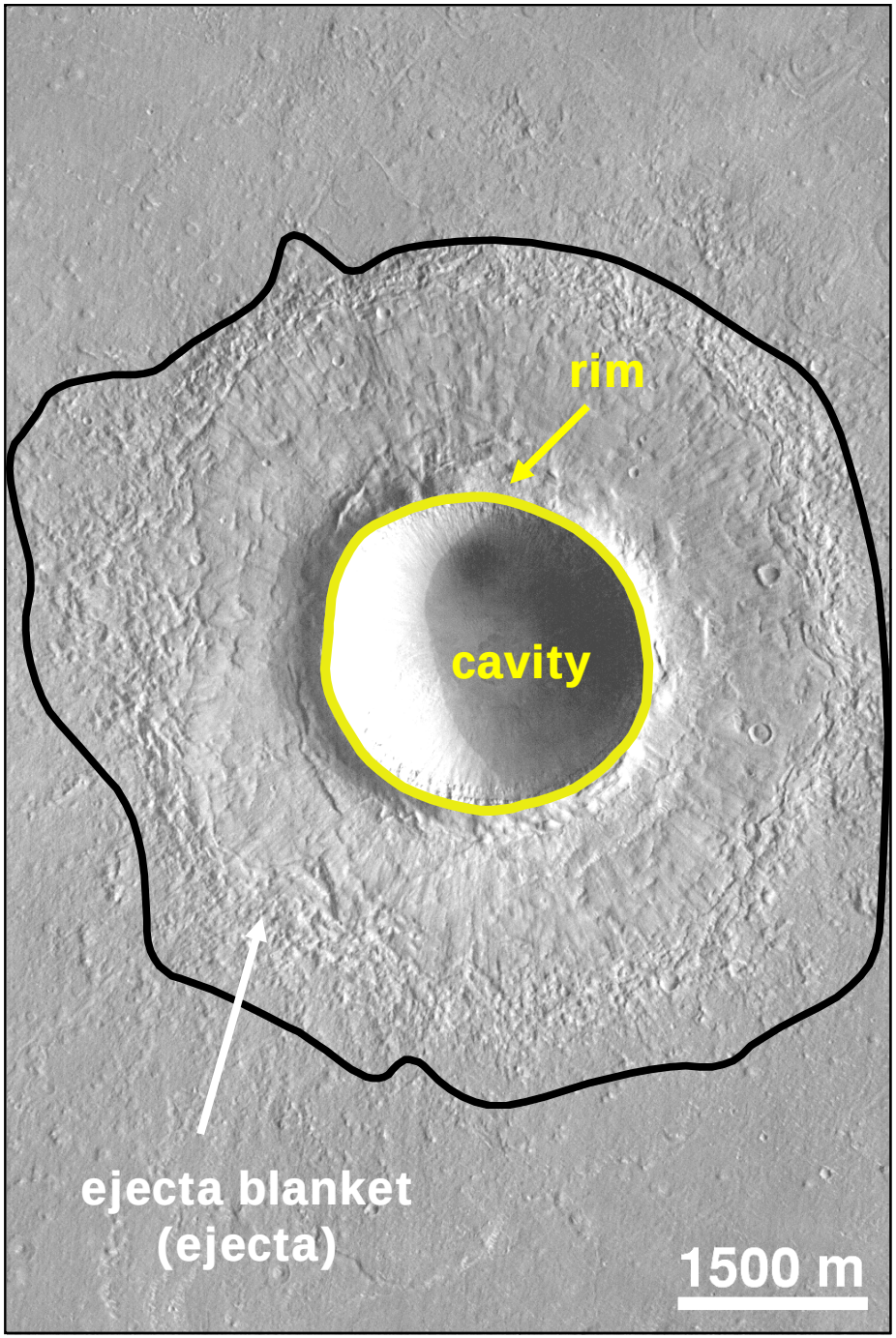
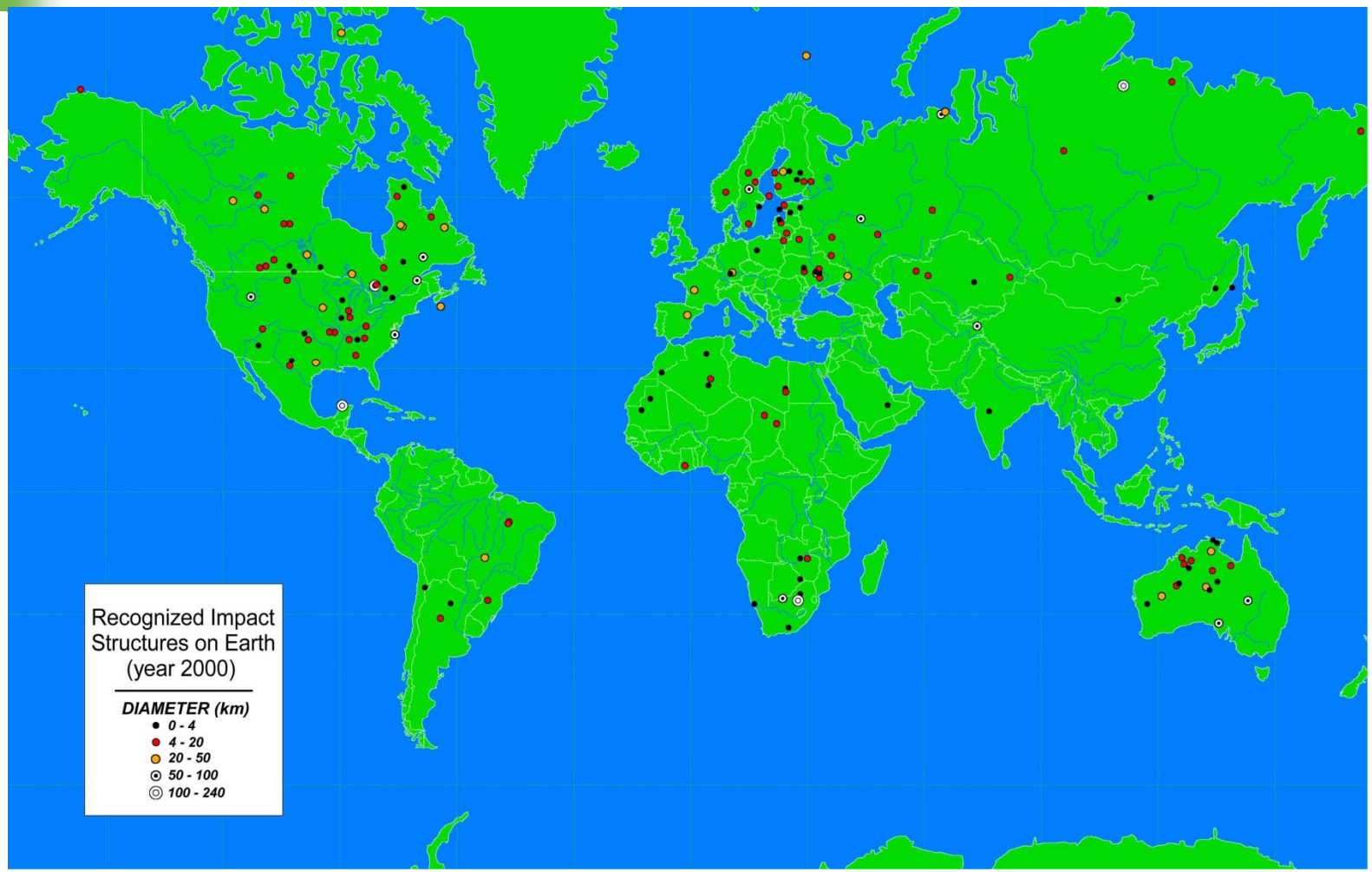
Impact Crater Morphology



Craters on Earth

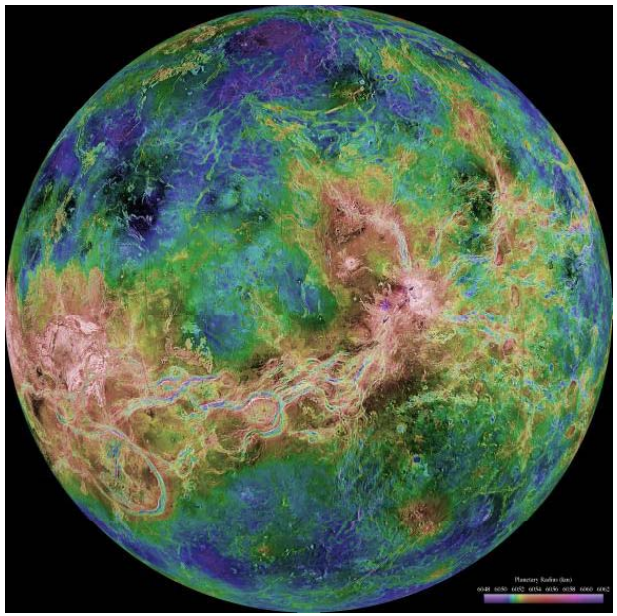


Meteor Crater, Arizona

Wolf Creek, Australia

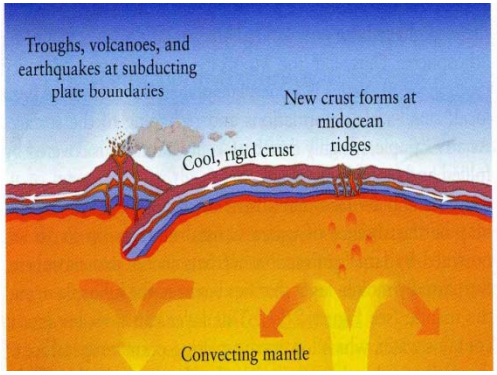
Venus as a Planet

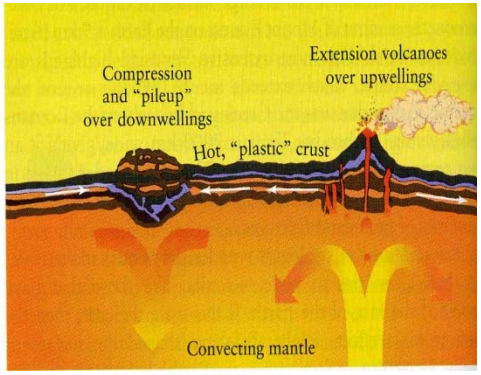
- Diameter = 12,104 km
- Density = 5.2 g/cm^3
- Rotation Period = 243 days (retrograde)
- Surface P = 92 x Earth's
- Ave. Surface T = 460^{o}C = 733 K = 860^o F
- Ave. Distance from Sun = 1.08 x 10^8 km



Introduction: Venus

- Elevation, unimodal = -3.9 to 12 km
- Mostly flat plains with some topographic swells, volcanoes, dune fields, rift valleys, ~ 1000 impact craters.
- No Plate Tectonics!!!





From Freedman & Kaufmann III (2002)

- Surface = 500 m.y. old
  - Equilibrium Resurfacing Hypothesis
  - Global Catastrophe Hypothesis

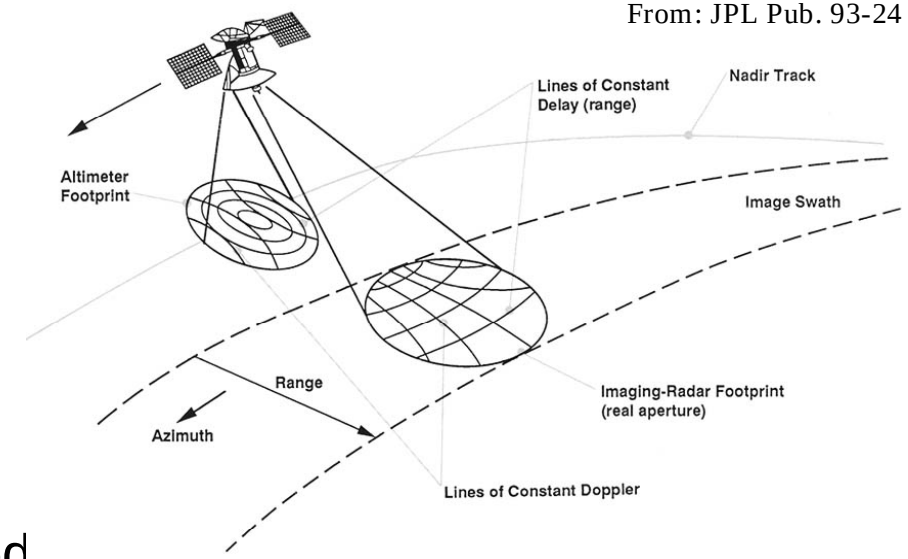
Objectives: Venus

- To interpret morphology & evolution of impact craters in the BAT region.
- Impact craters used to study plume related features.
  - Regiones – extending 1000's of km (Solomon et al., '91; Smrekar et al., '97)
  - Radiating graben-fissure systems – 100's of km (Grosfils and Head, '94; Ernst et al., '03)
  - Coronae – ave. D ~250 km (Stofan et al., '92)
- To assess thickness of parabolic deposits with crater Von Schuurman.

The Magellan Mission

- Launched: 1989
- Arrived: 1990
- Crashed: 1994
- Single instrument: SAR, altimeter, & radiometer
- Wavelength = 12.6 cm
- Pulse length = 26.5 microsec
- Frequency = 2.385 GHz
- 3 Cycles: 98% surface mapped
  - C1 – left
  - C2 – right
  - C3 - left

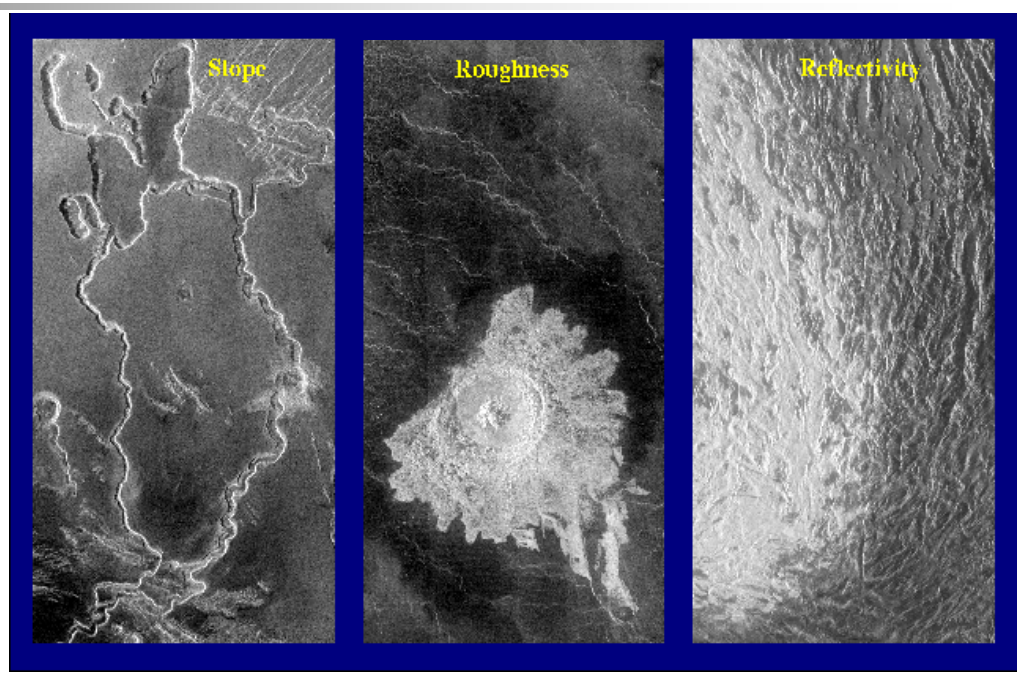
From: JPL Pub. 93-24

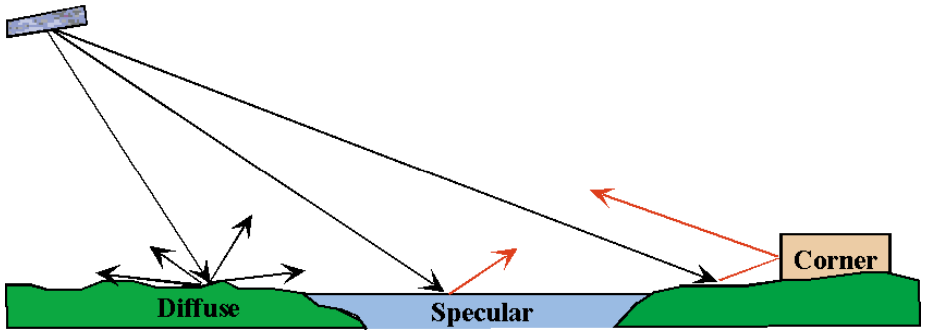


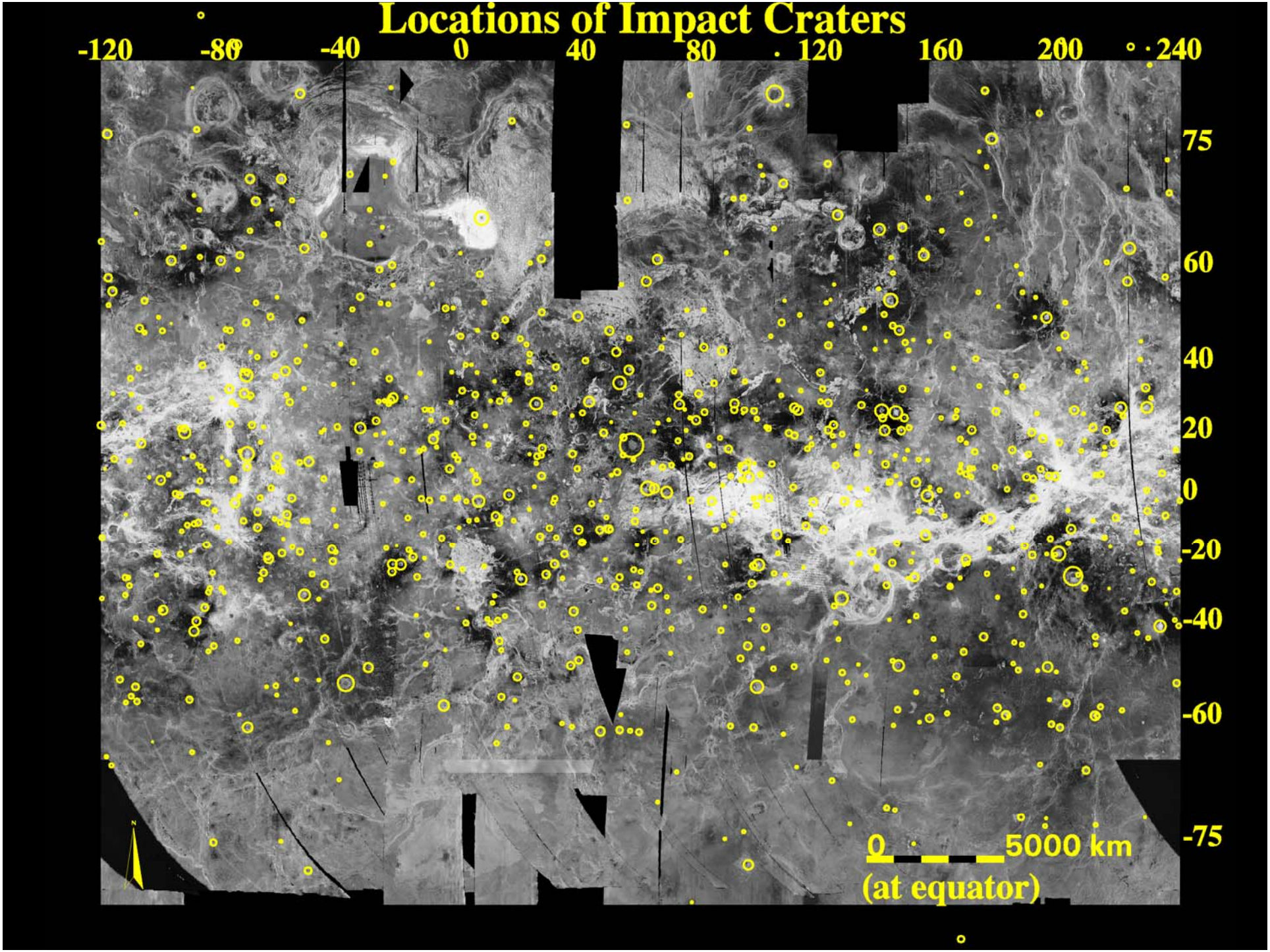
Venus, sweet mystical star
Earthlike, but hotter by far
No use to peruse
Unless you can use
Synthetic-Aperture-Radar
-- Anonymous

SAR images

- Slope (Ovda Regio)
  - Away – elongated, shadow
  - Towards – foreshortened, bright
- Roughness (Crater Aurelia)
  - Rough – diffuse reflectors
- Reflectivity (Maxwell Montes)
  - Above 4 km high, reflectivity is common
    - chemical weathering

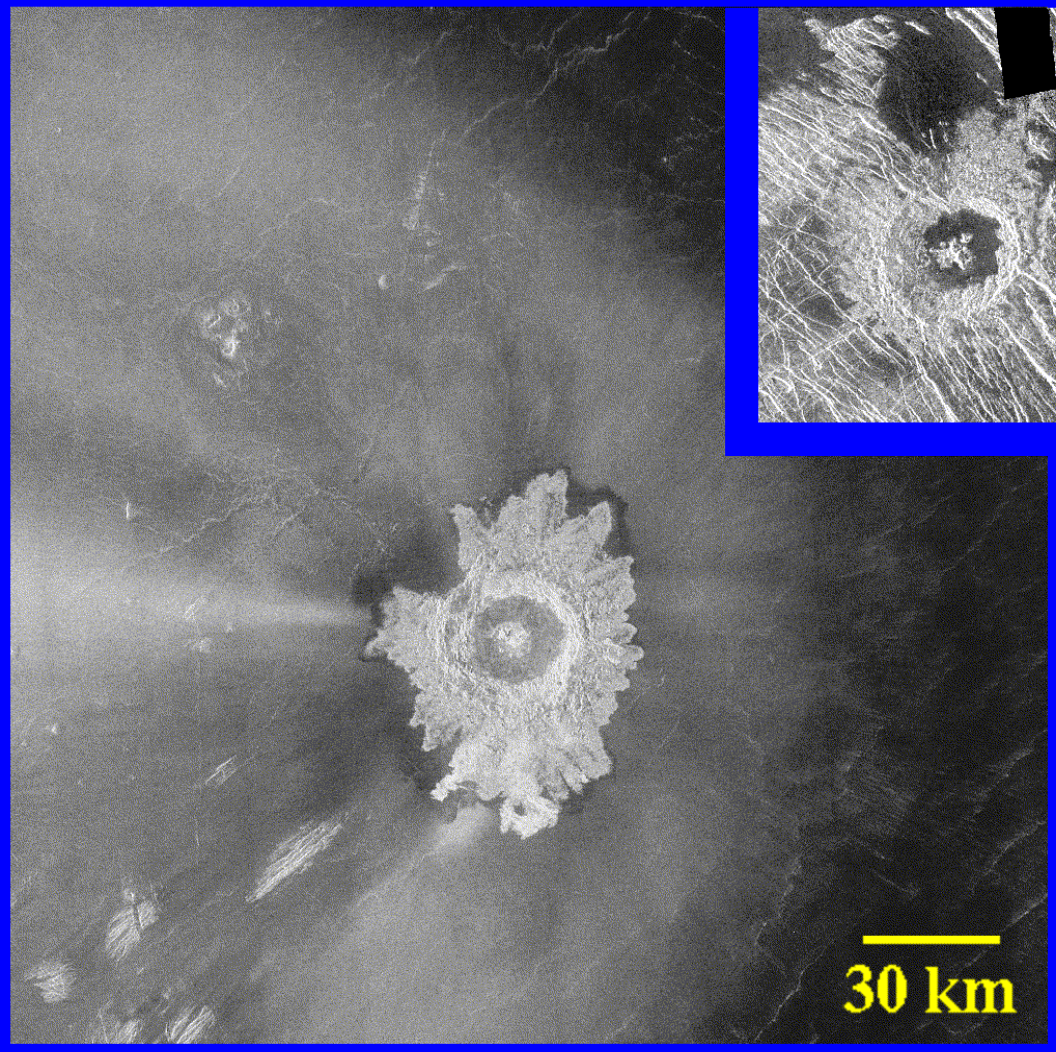


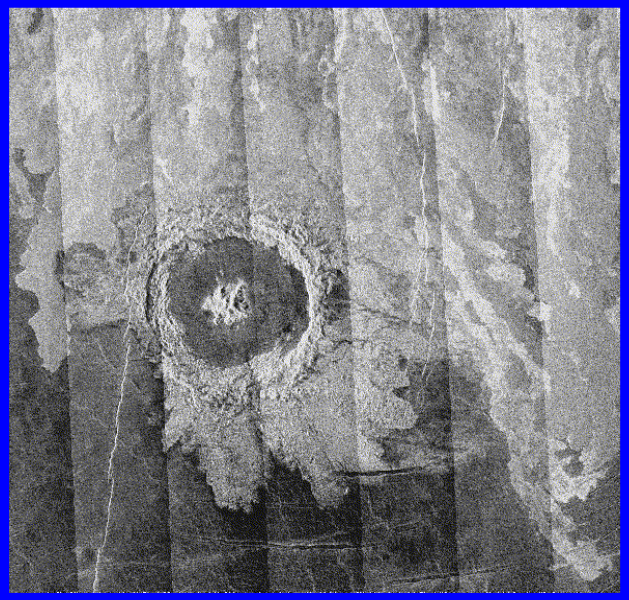


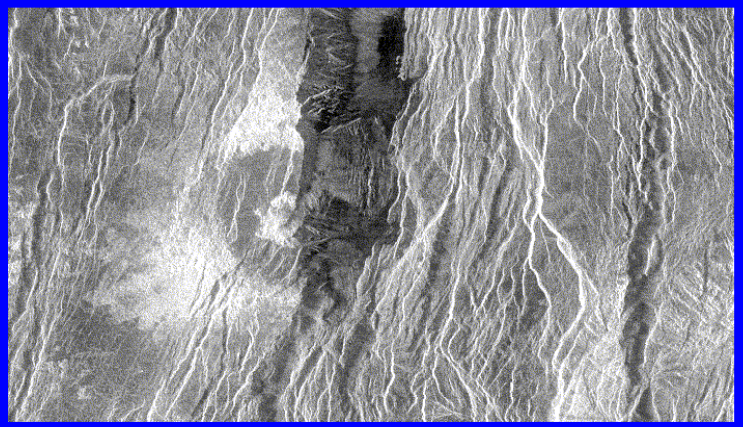

Locations of Impact Craters
-120
-80
-40
0
40
80
120
160
200
240
75
60
40
20
0
-20
-40
-60
-75
N
0
5000 km
(at equator)

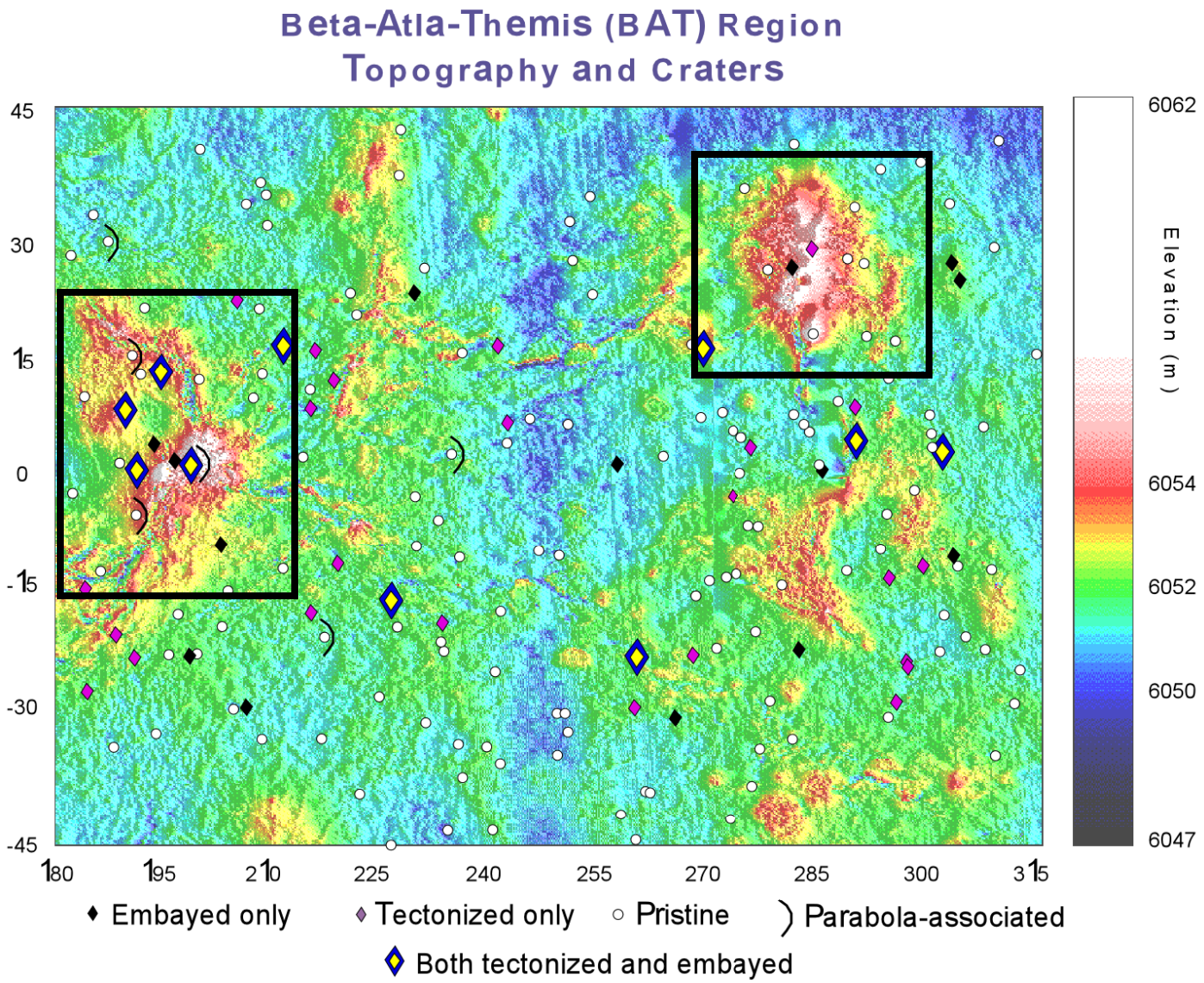
26% of impact craters on Venus have been modified:

158 T (~18%); 55 E (~6%) ; 19 TE (2%)



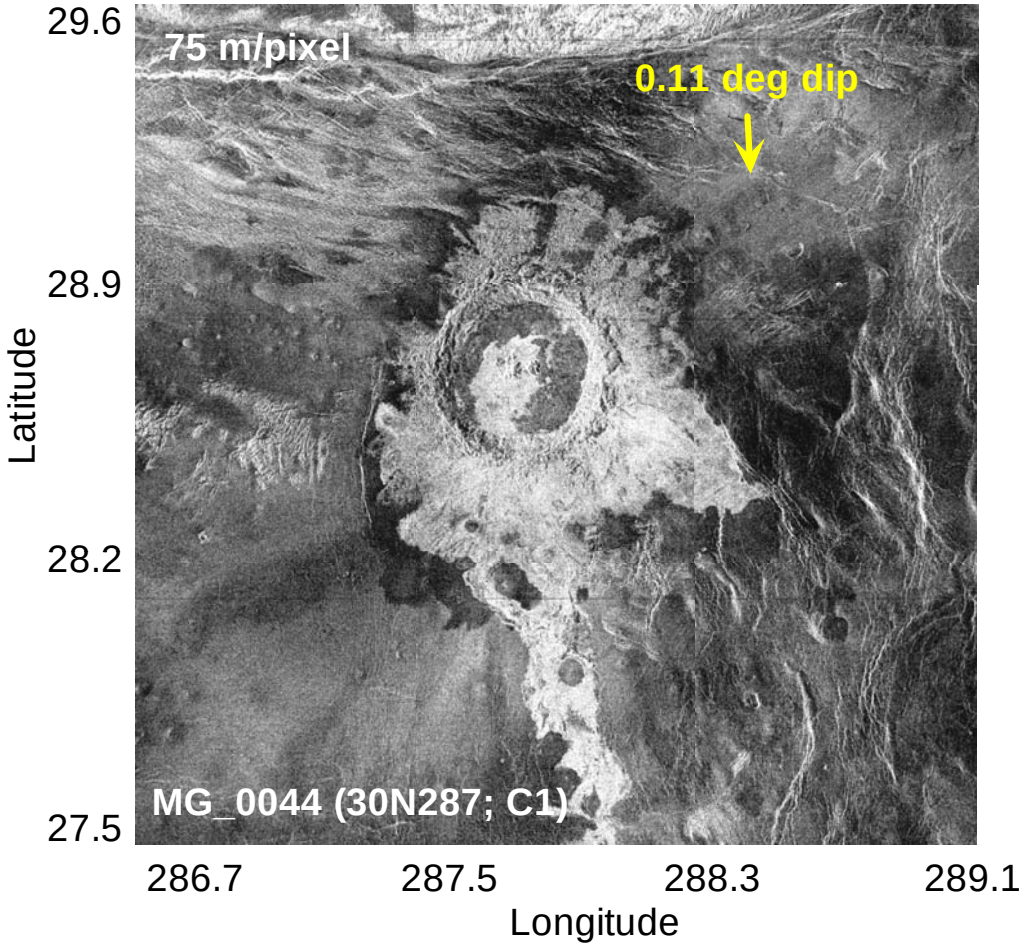


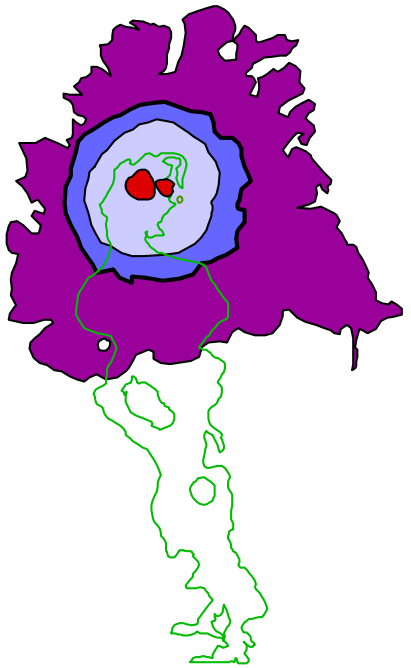



Beta-Atla-Themis (BAT) Region
Topography and Craters
45
30
15
0
-15
-30
-45
180
195
210
225
240
255
270
285
300
315
6062
6054
6052
6050
6047
Elevation (m)
Embayed only
Tectonized only
Pristine
Parabola-associated
Both tectonized and embayed

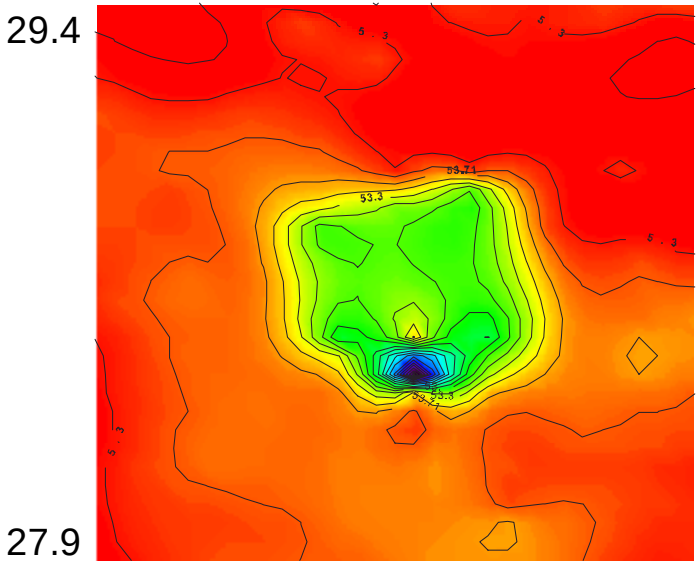
Analysis: Venus

- 38 impact craters
- Magellan radar images
  - F-MDIRs & C1-MDIRs – 75 & 225 m/pixel, respectively
  - Detailed geologic maps
- Magellan Altimetry
  - Topography 3-D view
- Dip for craters and surrounding area





Magellan Altimetry

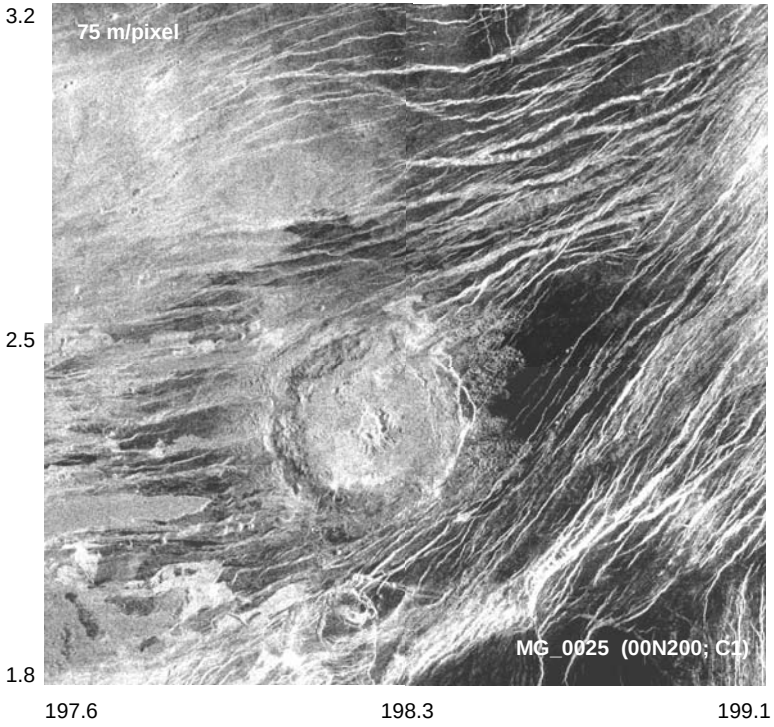


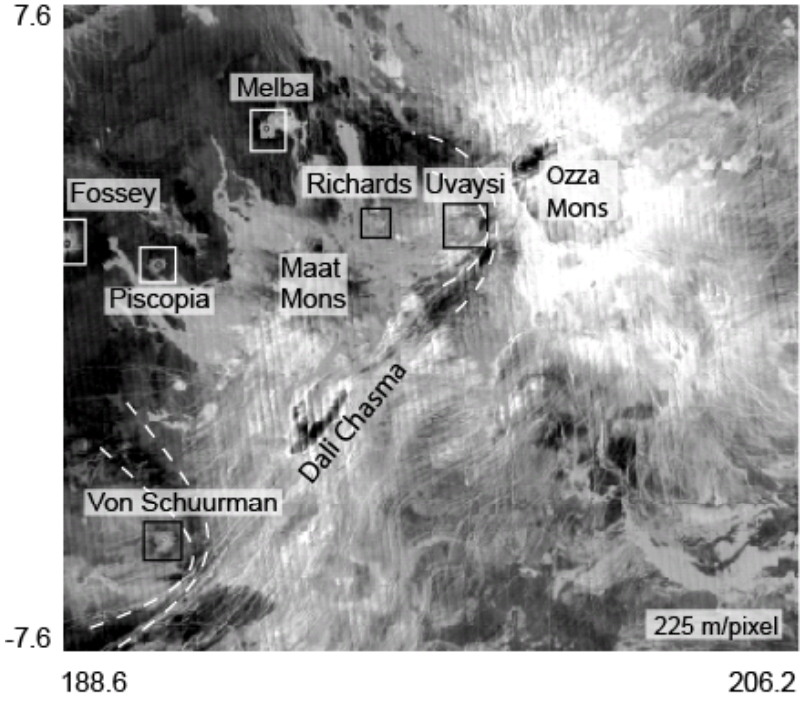
Truth (28.7 N, 287.8 E, 46.1 km)

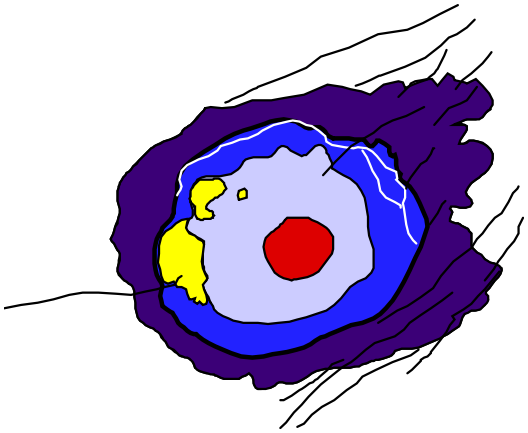
Pristine (Izenberg, Herrick, Schaber)

Images show a prominent radar-bright outflow feature to the south of this crater. The crater tilts to the south and the outflow apparently emanates from within the central peak area.

Uvaysi (2.3 N, 198.2 E, 38.0 km)







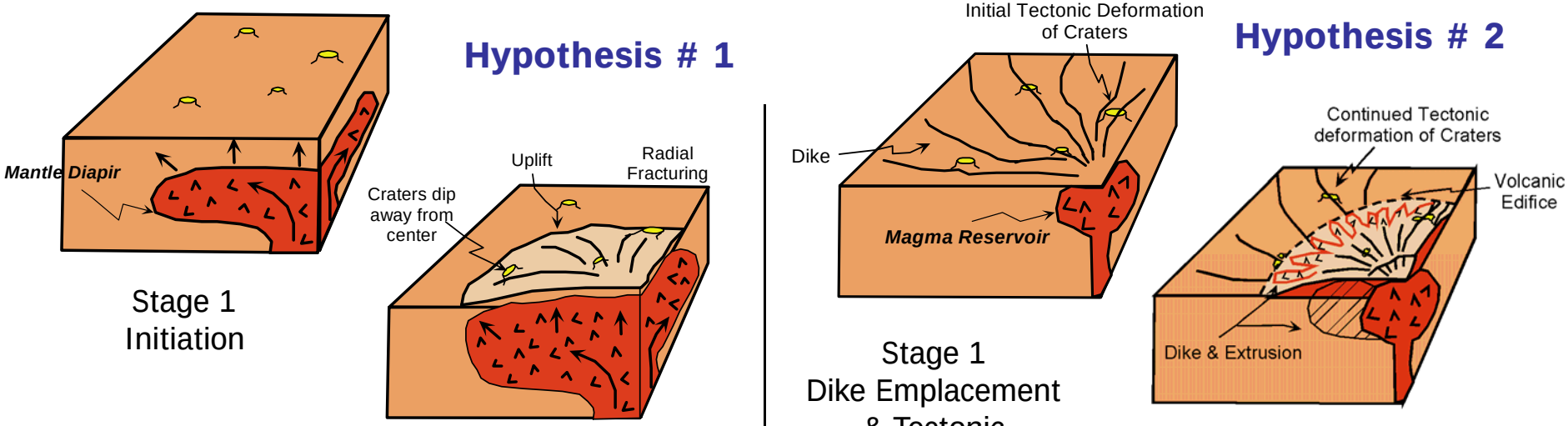
Parabola-associated crater
Tectonized & Embayed
Crater ejecta is strongly embayed on the WSW side, but it is not possible to identify episodes of individual flows.

Results: *Topographic Swells*

- Atla and Themis Regiones – craters predominantly tectonized
  - Exception: Richards & Uvaysi – multiple embayment
- Craters on Beta – mostly embayed
- Presence of parabolic craters on Atla – activity recent
- Atla contains higher concentration of modified craters than Beta
- Atla's craters dip away from rift

Results:
Radiating Fissure Systems

- Grosfils & Head (’94): 163 large radial systems
- Ernst et al. (’03): Northern Beta Regio
  - 6 giant radiating systems -> 5 dike swarms



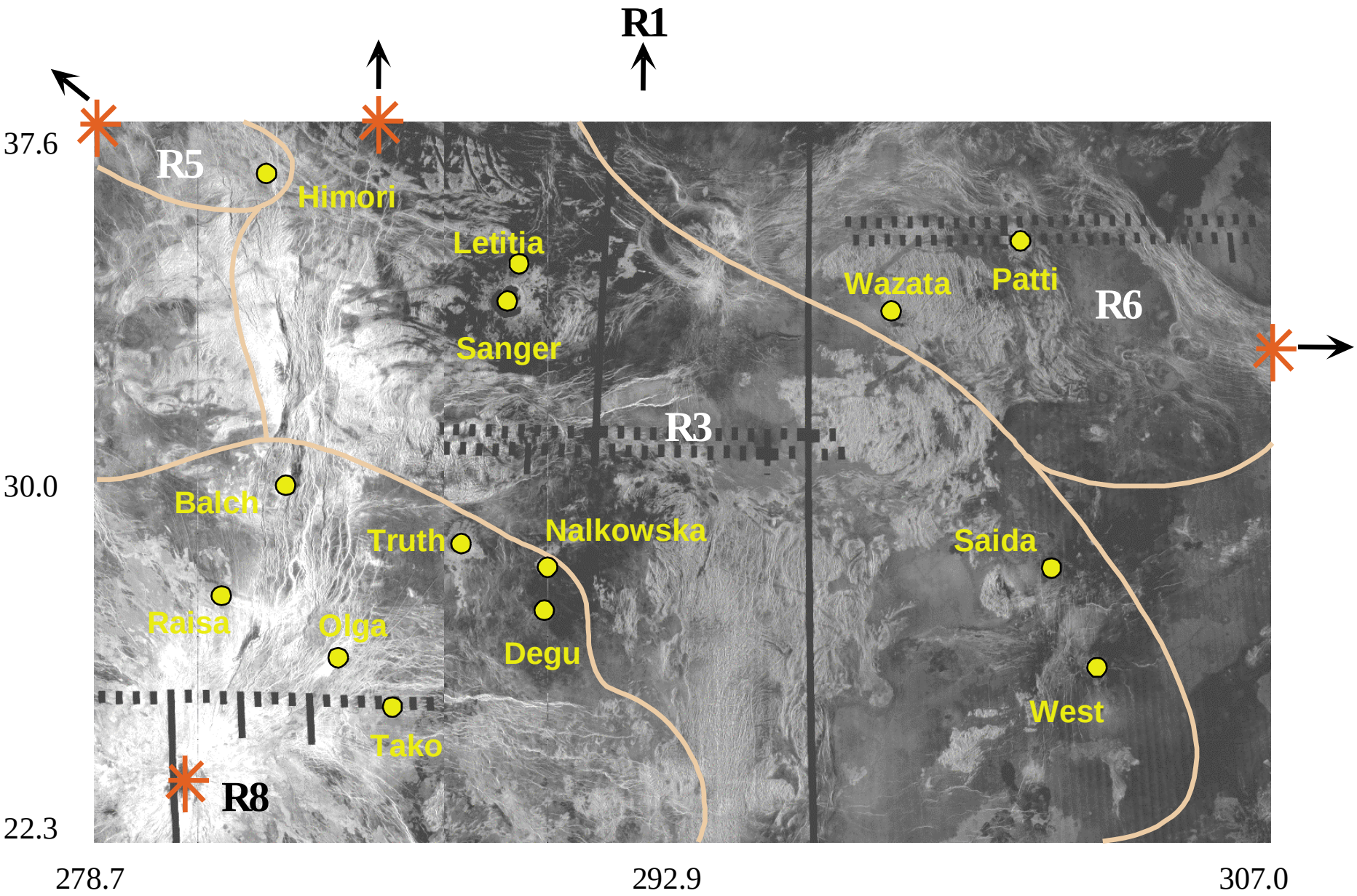
Stage 1
Initiation

Stage 2
Uplift with Radial Fracturing

Stage 1
Dike Emplacement & Tectonic Deformation

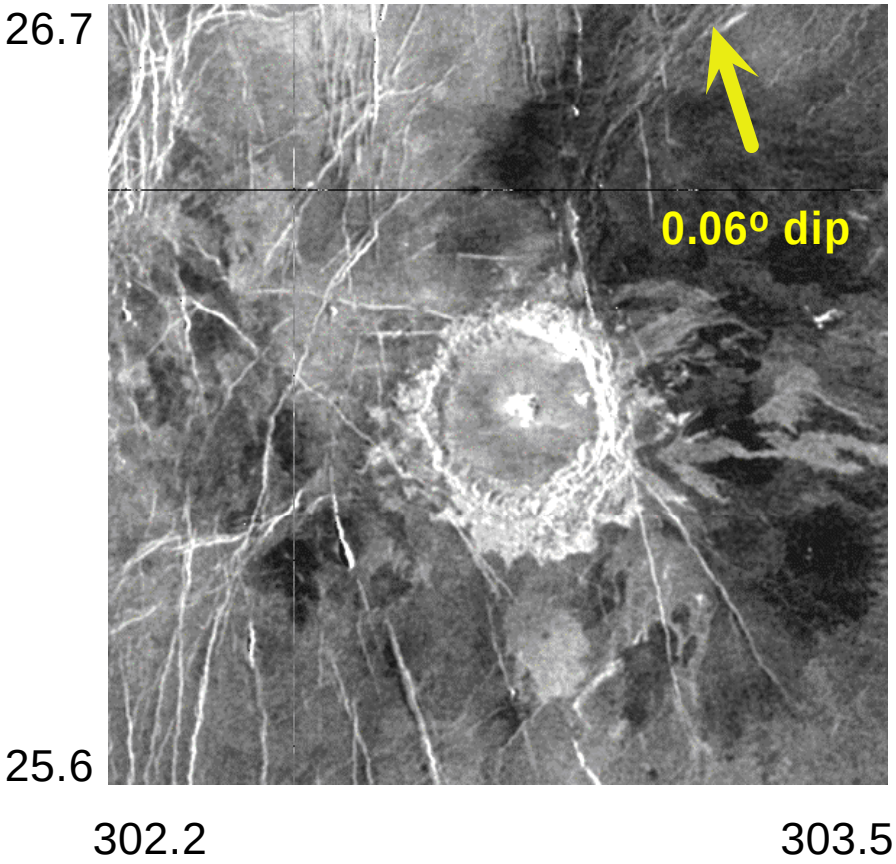
Stage 2
Dike Emplacement with Lava Flows & More Tectonic Deformation

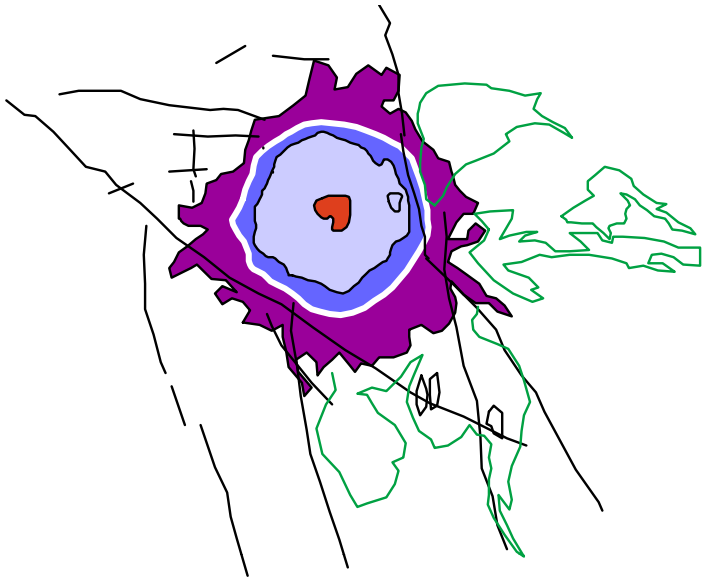
After Ernst et al. (1995)

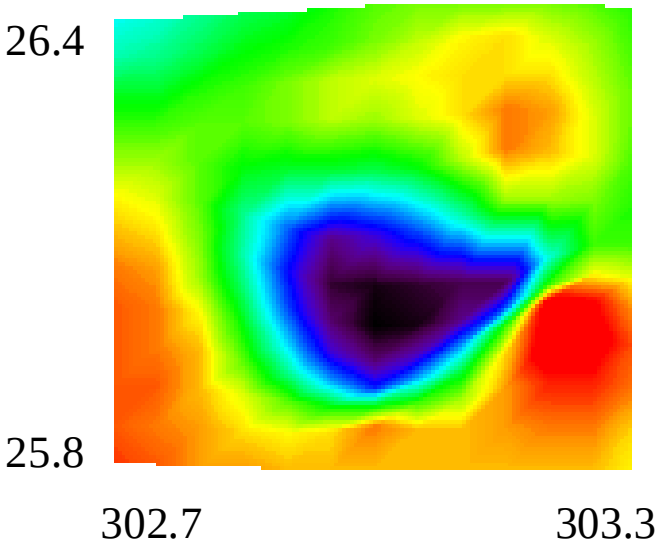

R1
R5
Himori
Letitia
Sanger
Wazata
Patti
R6
R3
Balch
Truth
Nalkowska
Saida
Raisa
Olga
Degu
West
Tako
R8
37.6
30.0
22.3
278.7
292.9
307.0

Results:
Radiating Fissure Systems

- Hypothesis # 1 – uplift
  - Truth and Nalkoswka – neither tilts away from radiating center
  - Collapse of the systems more than recent uplift (West, Sanger)
- Hypothesis # 2 - dikes
  - Little evidence of crater modification by volcanic or tectonic processes
  - Raisa – TE – on the youngest system
  - Central reservoir near surface unlikely or dikes never reach surface

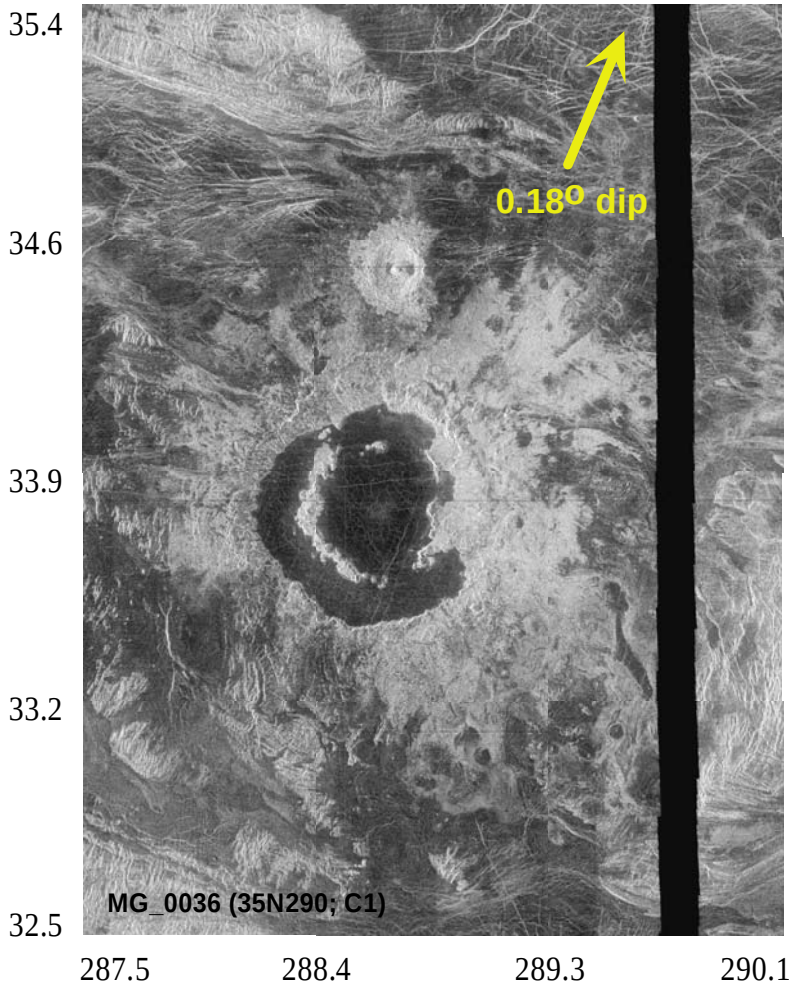


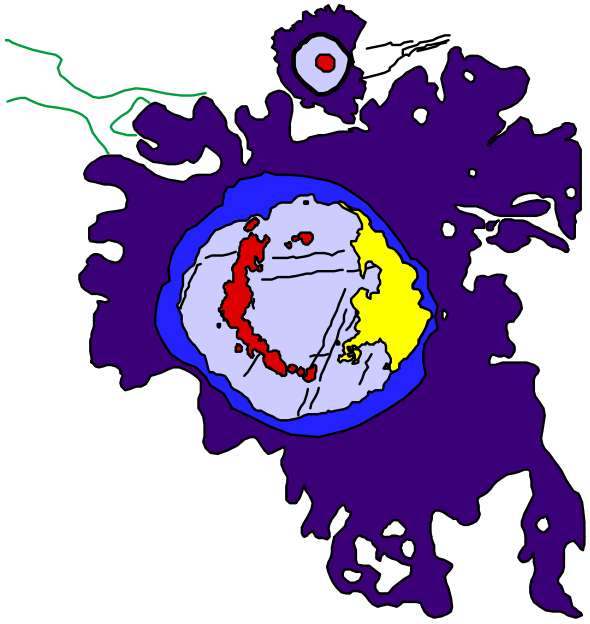


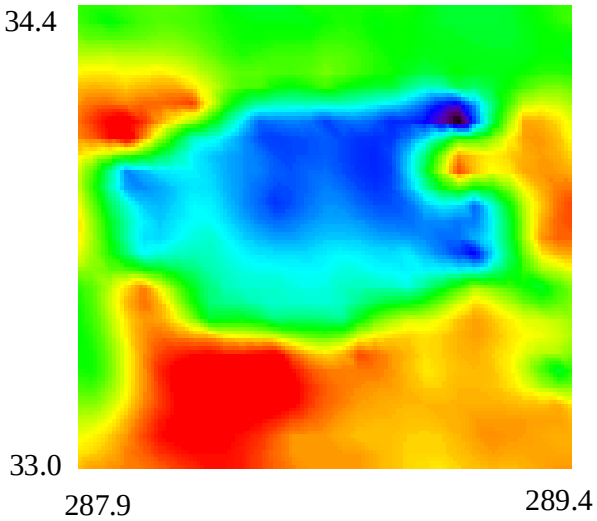


West (26.1º N, 303.0º E, 28.0 km)

Embayed-only, but image reveals a slightly disturbed ejecta blanket. Note the radar-bright outflows to the E and SE opposite in direction to current dip.







Sanger (33.8 N, 288.6 E, 83.8 km)

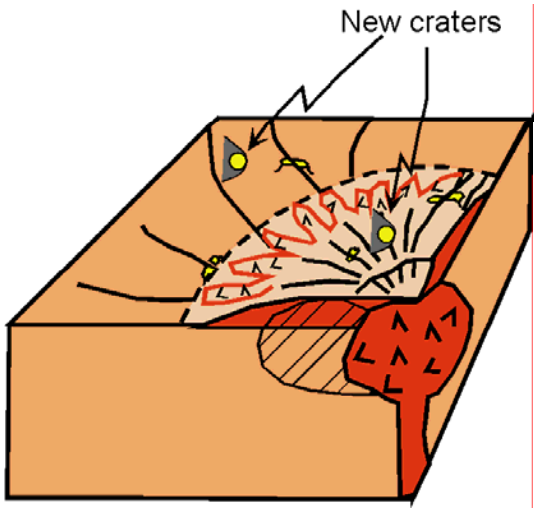
Possibly tectonized and embayed. Clear halo crater according to Basilevsky and Head (2002) with outflows in the NW (< 250 Ma).

Conclusions: Venus

- Ongoing obliteration of impact craters, BAT area
- Uvaysi - establishes the timing of activity there as recent (30-75 m.y)
- Atla is younger, more active than Beta
- Modified craters: 33% Atla vs. 23% Beta
  - On Atla E craters are negligible, T craters occur only at low elevations; 4 TE craters cluster near geoid high
  - Beta's modified craters are randomly distributed

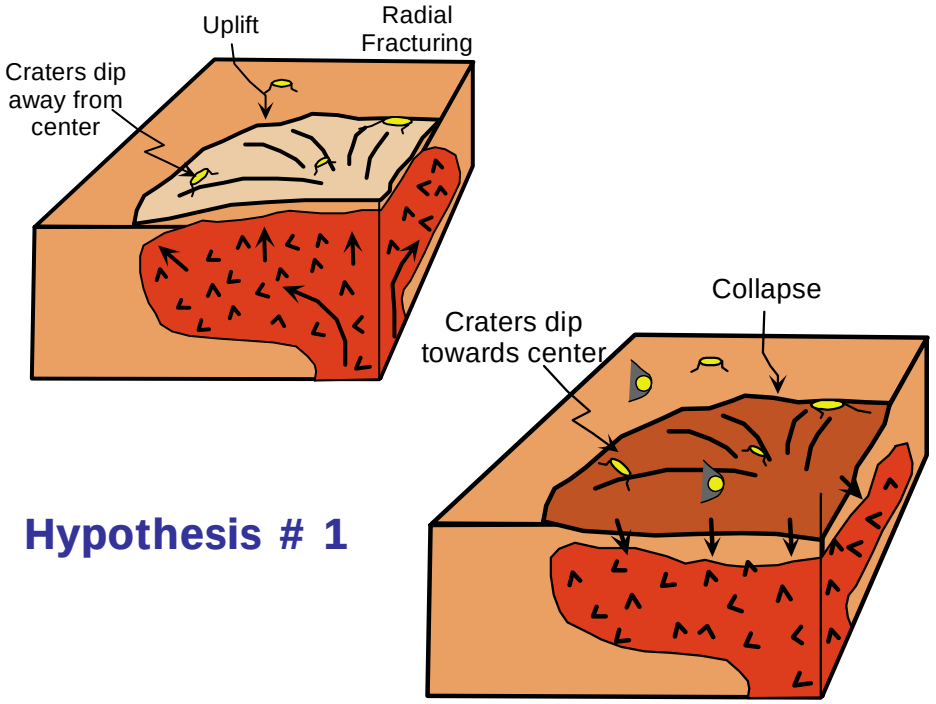
Conclusions: Venus

- Radiating fissure systems have caused little modification of impact craters

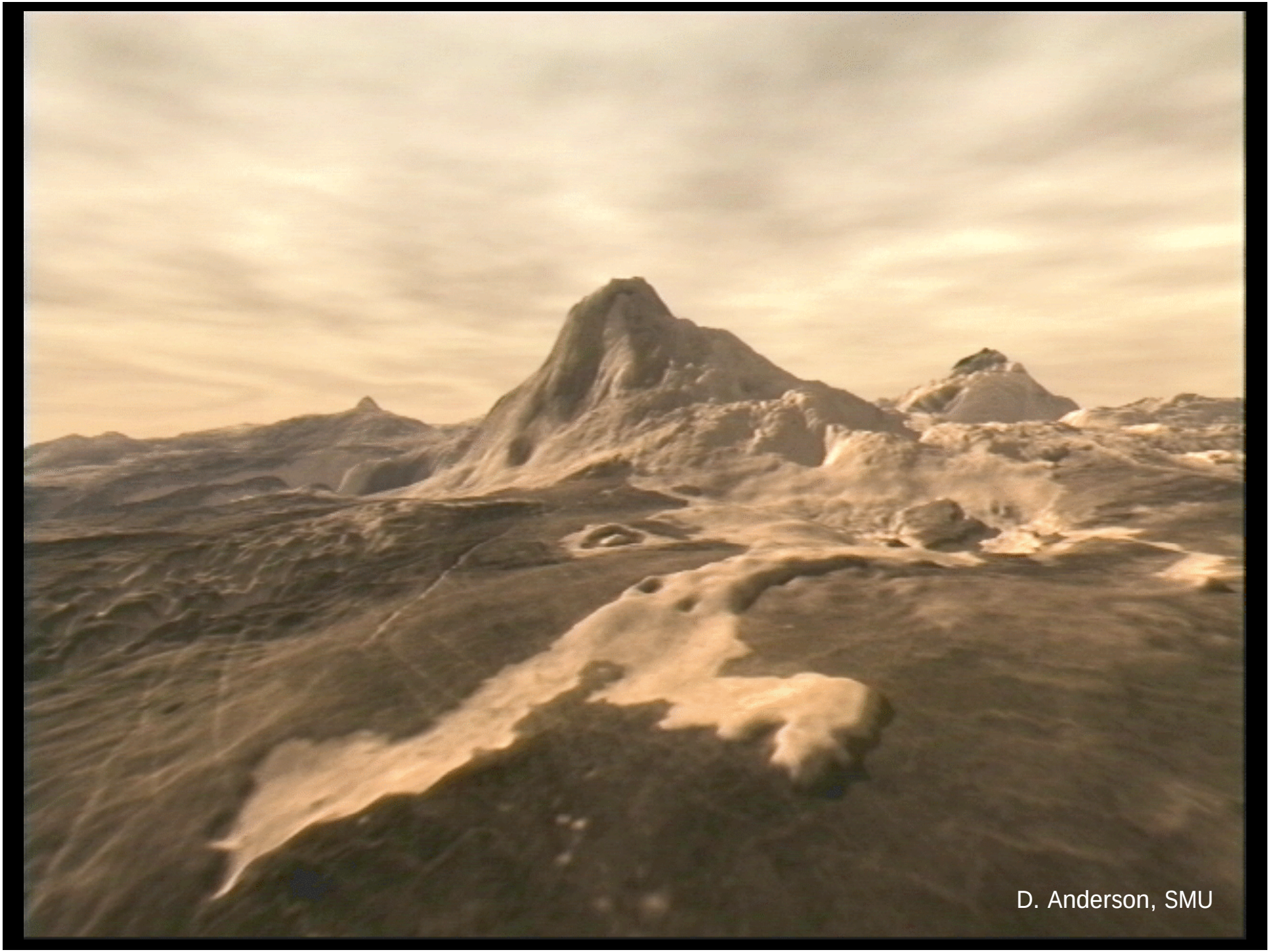


Hypothesis # 2

- Dips of craters suggest collapse of the radiating systems (R3, R8)

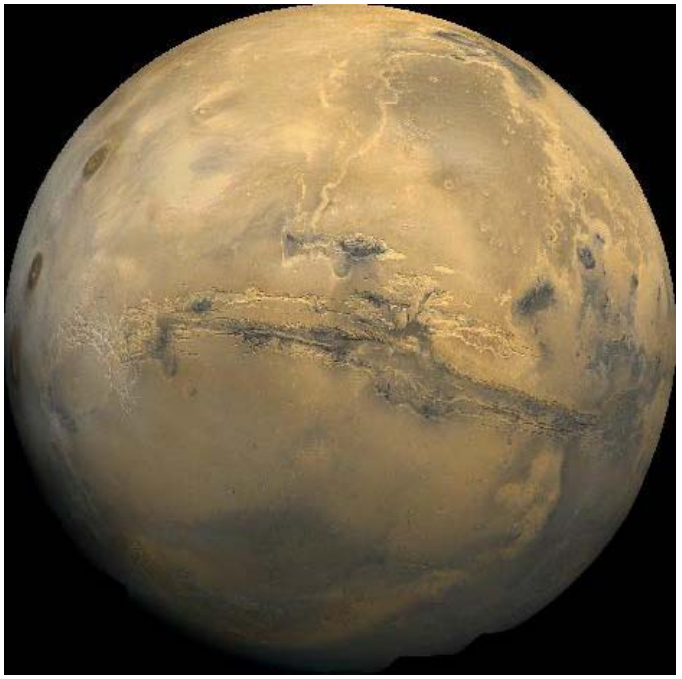


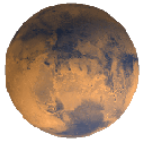
Hypothesis # 1


D. Anderson, SMU

Mars: The Red Planet

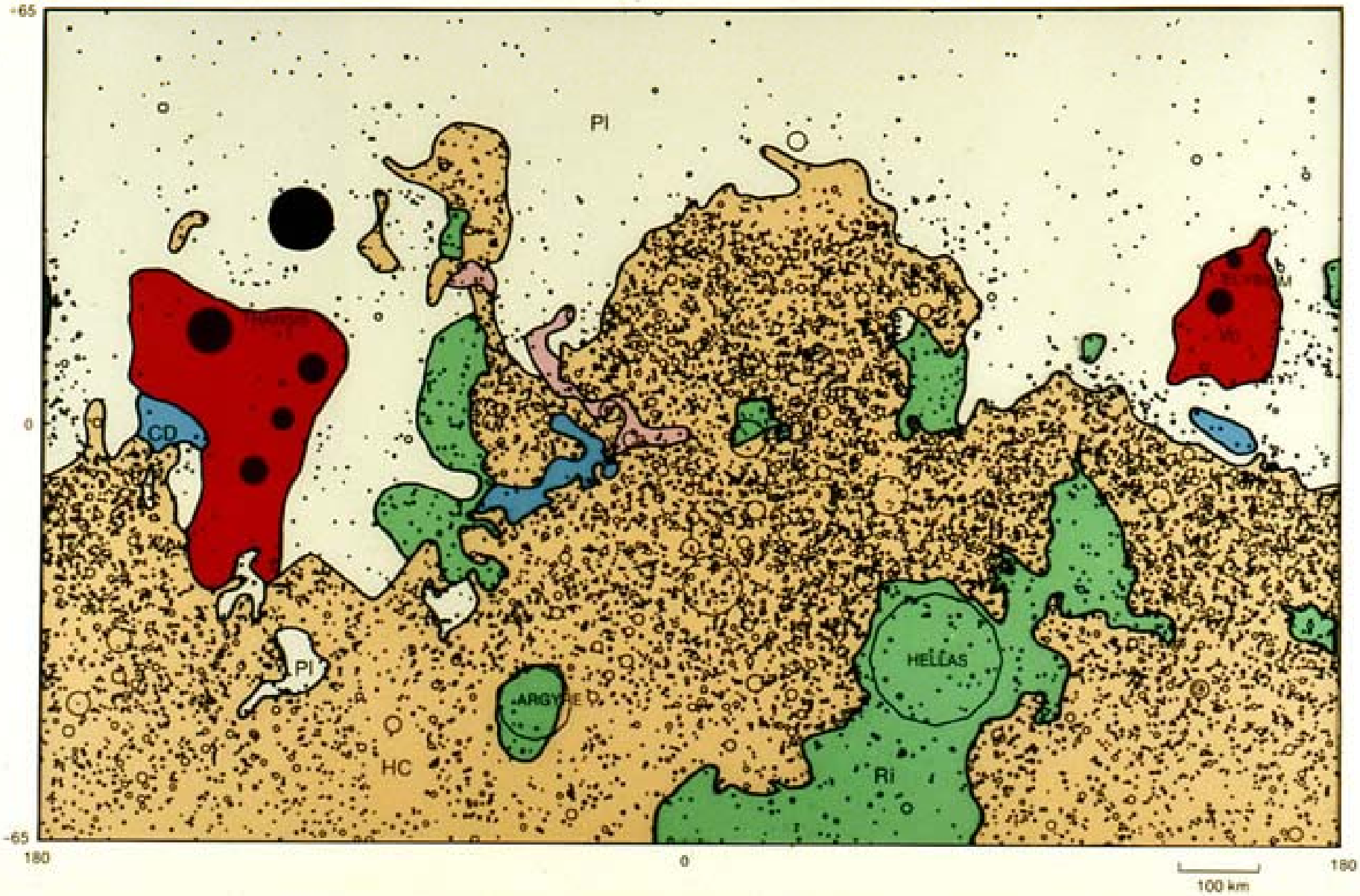
- Diameter = 6,794 km
- Density = 3.9 g/cm^3
- Rotation Period = 24:37:22 days
- Surface P = 0.1 x Earth‘s
- Mean Surface T = -53^{o}C
  = 220 K = -63^o F
- Ave. Distance from Sun = 2.28 x 10^8 km





Objectives: Mars

- To examine enigmatic deposits forming a bulge with 3 craters of similar size, mid-latitudes



PLAINS—Pl

HEAVILY CRATERED—HC

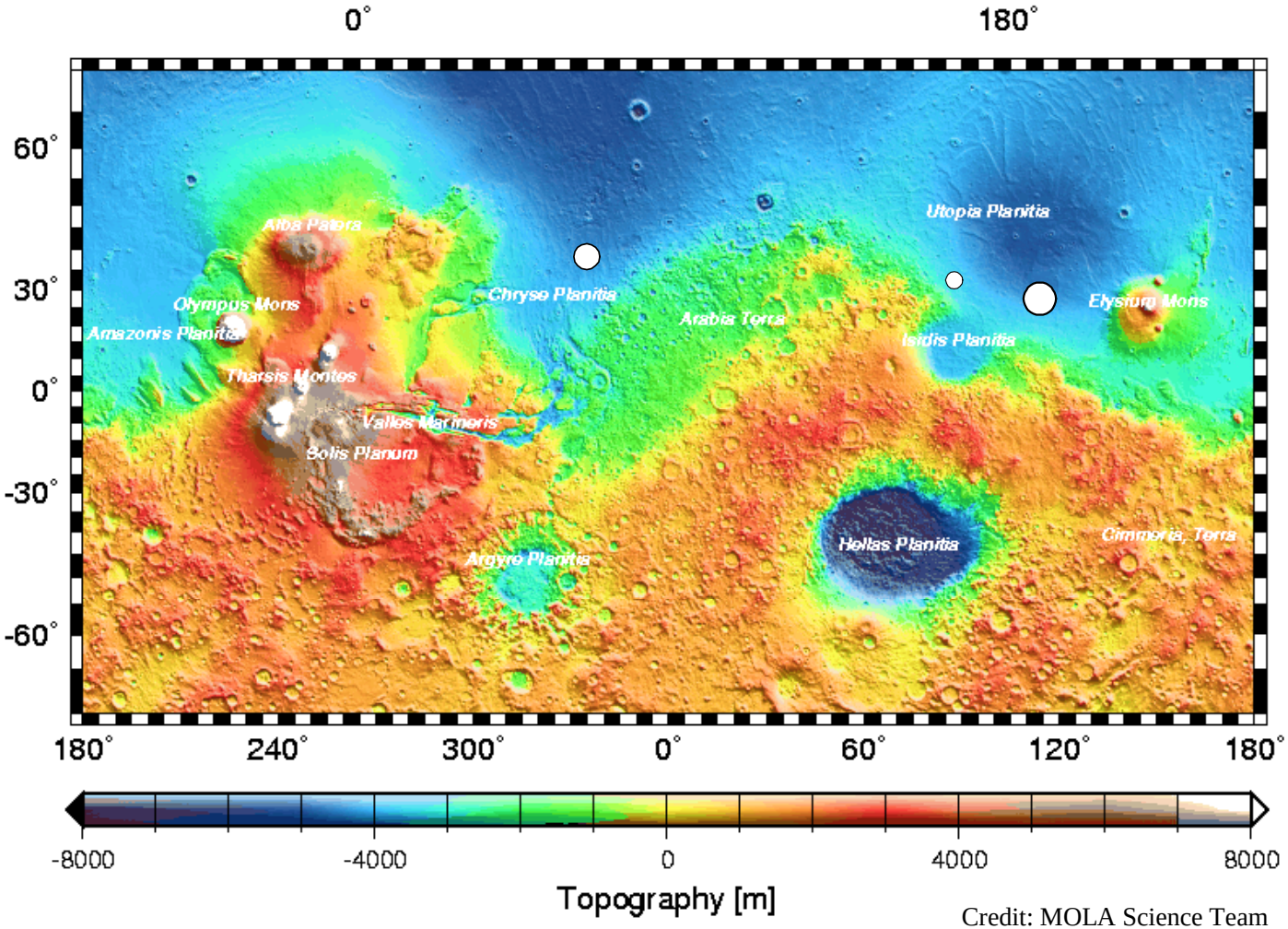
RIDGED PLAINS—Ri

VOLCANIC PLAINS—Vo

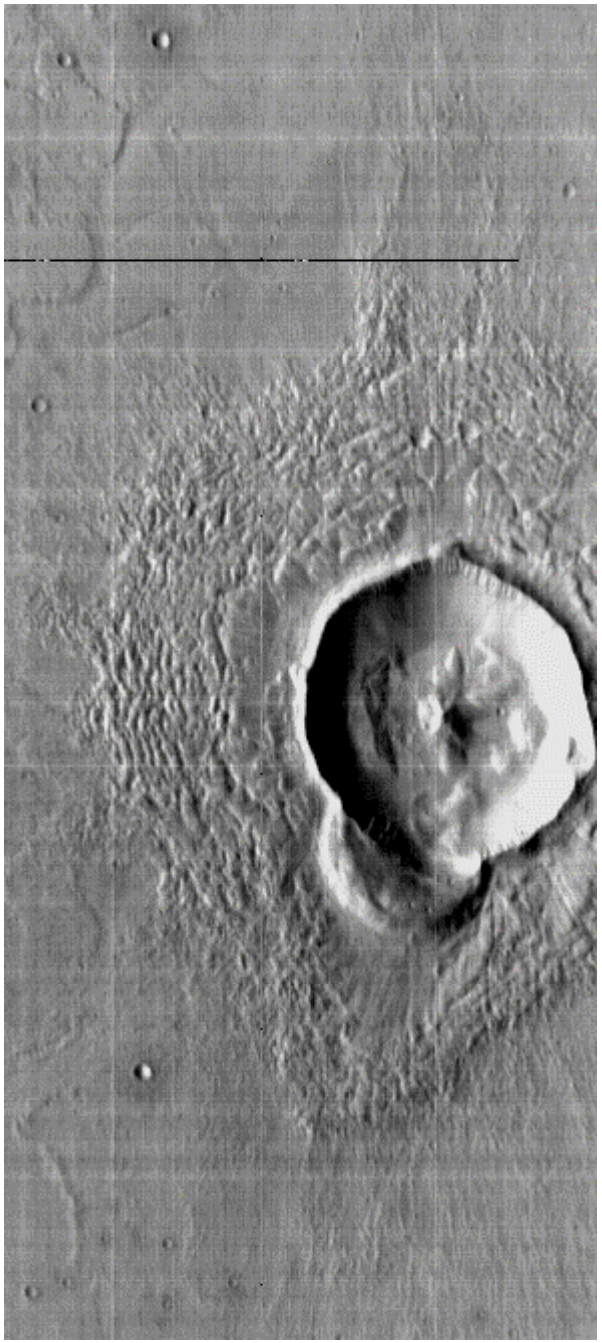
CANYON/DEPOSITS—CD

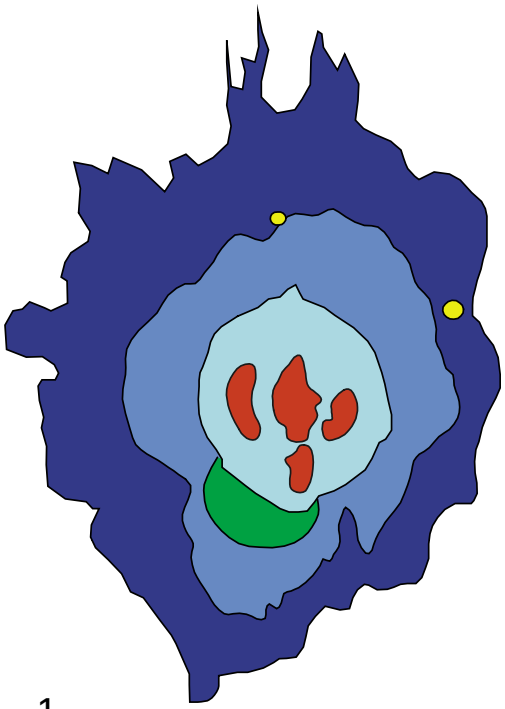
CHANNELS/CHAOTIC—Ch

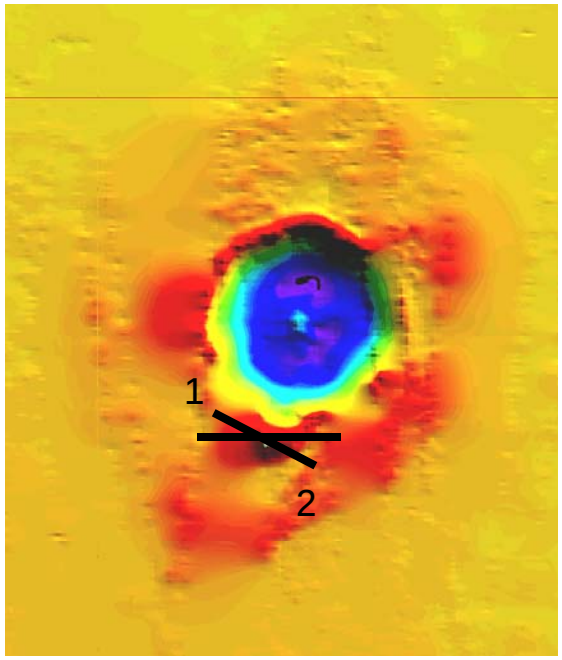
Analysis: Mars



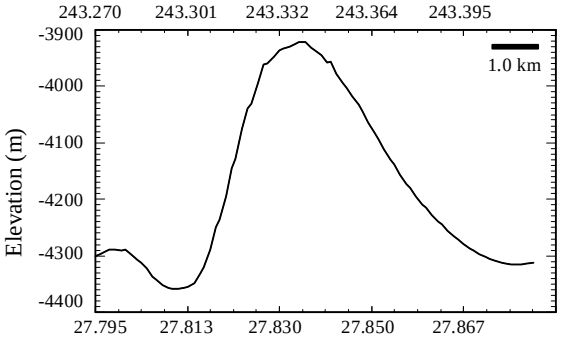
Credit: MOLA Science Team



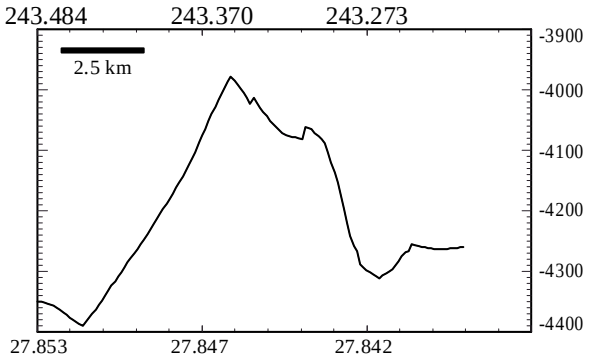



1
2

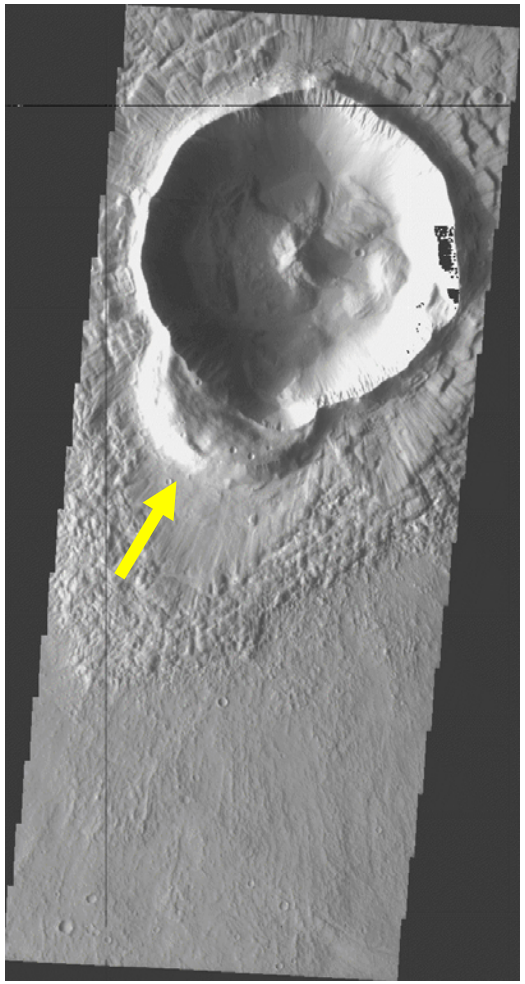
1


243.270
243.301
243.332
243.364
243.395
-3900
-4000
-4100
-4200
-4300
-4400
Elevation (m)
1.0 km
27.795
27.813
27.830
27.850
27.867

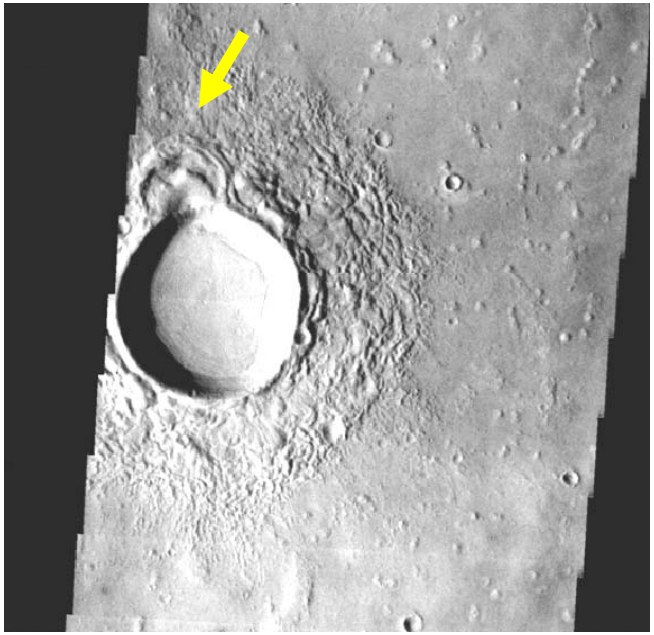
2


243.484
243.370
243.273
2.5 km
-3900
-4000
-4100
-4200
-4300
-4400
27.853
27.847
27.842

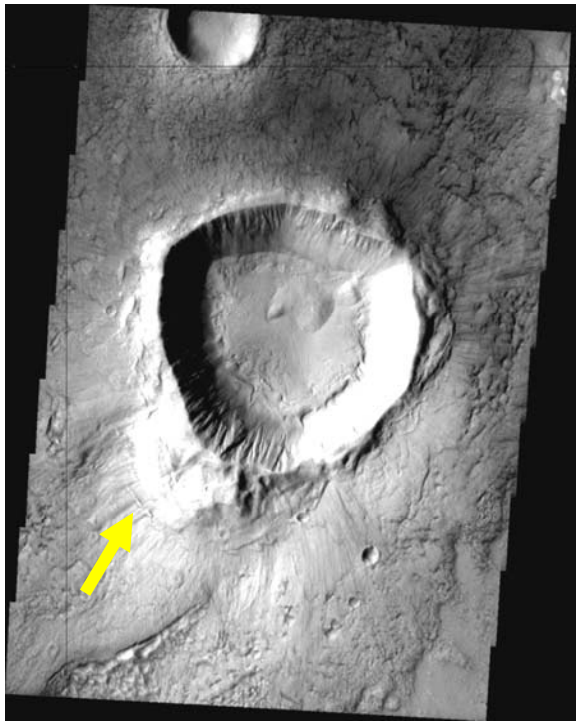
28.3 N, 116.7 E
14.9 km



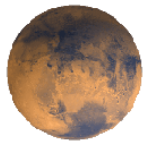
31.2 N, 88.7 E
7.3 km



38.0 N, 338.8 E
11.6 km



Distance	4.5 km	2.9 km	4.6 km
Bulge R	4.5 km	1.8 km	4.6 km
Ratio	0.6 **R**	0.8 **R**	0.6 **R**



Summary: Mars

- 3 similar-sized lobate ejecta craters, within a 10-degree band in the mid-latitudes, display an unusual bulge, western rim.
- 5 possible origins: pre-existing crater, oblique impact, ground-ice (GI), pre-existing topography, and oblique impact w/ GI.
- Formed by same process