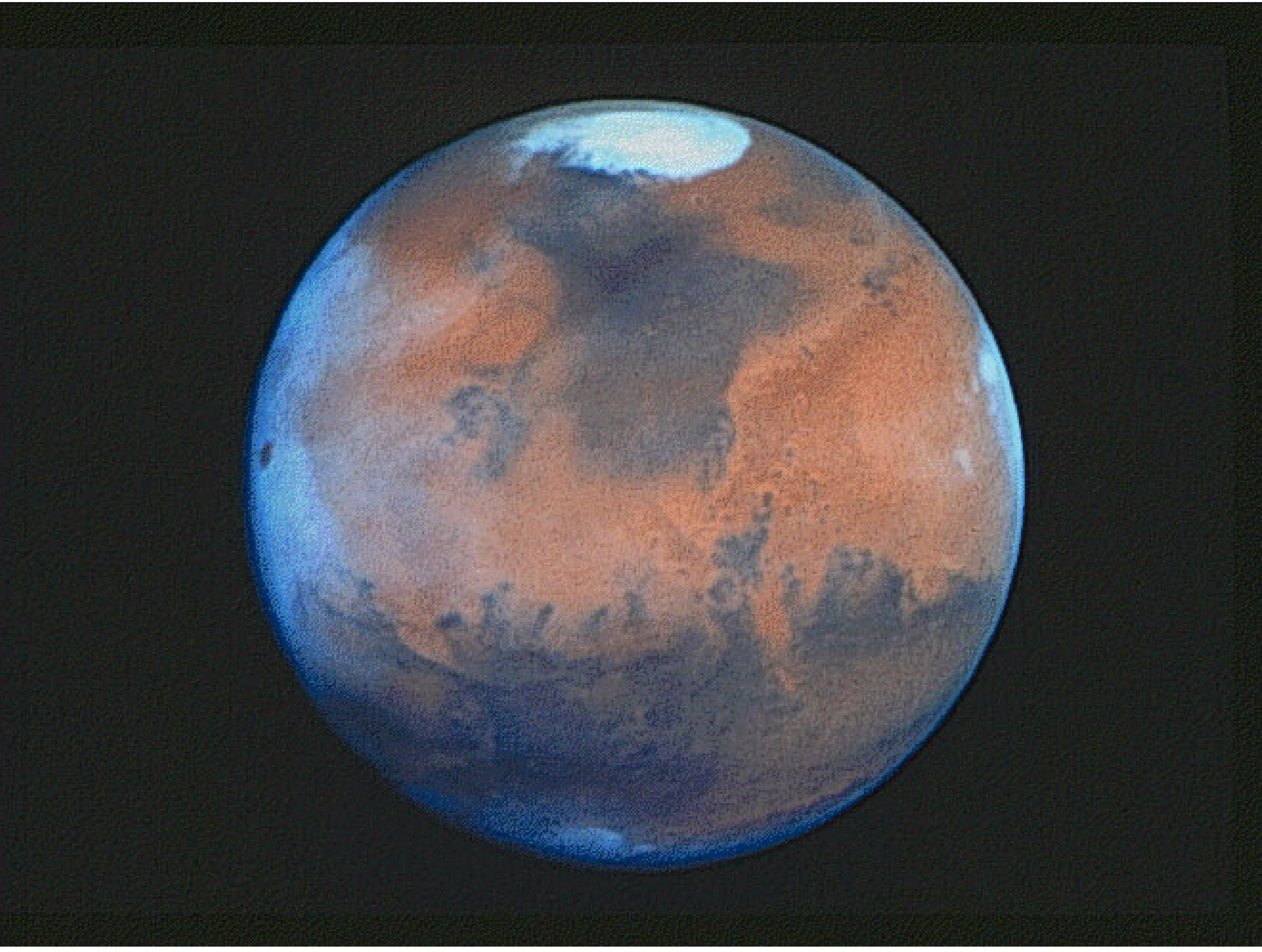
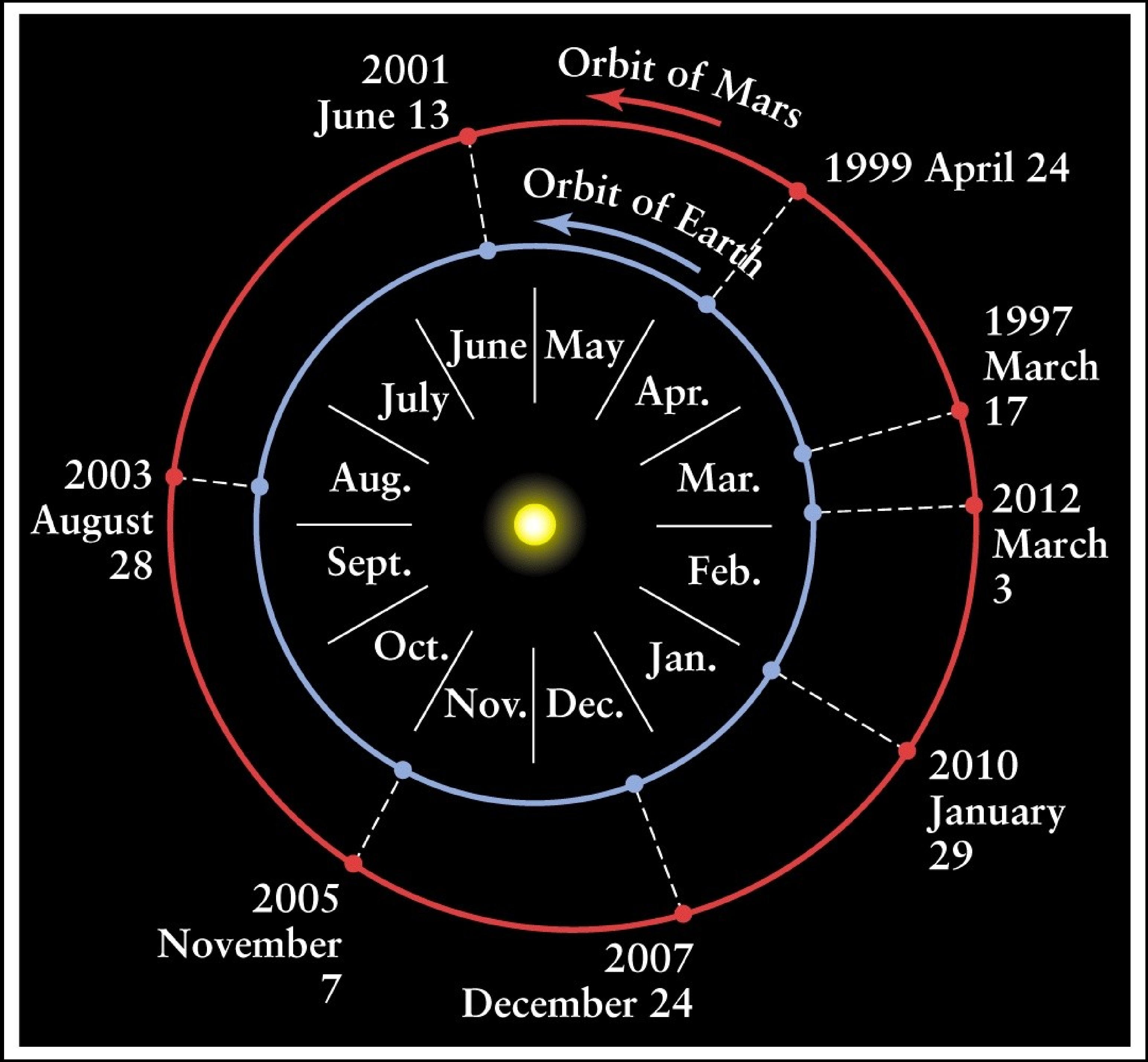
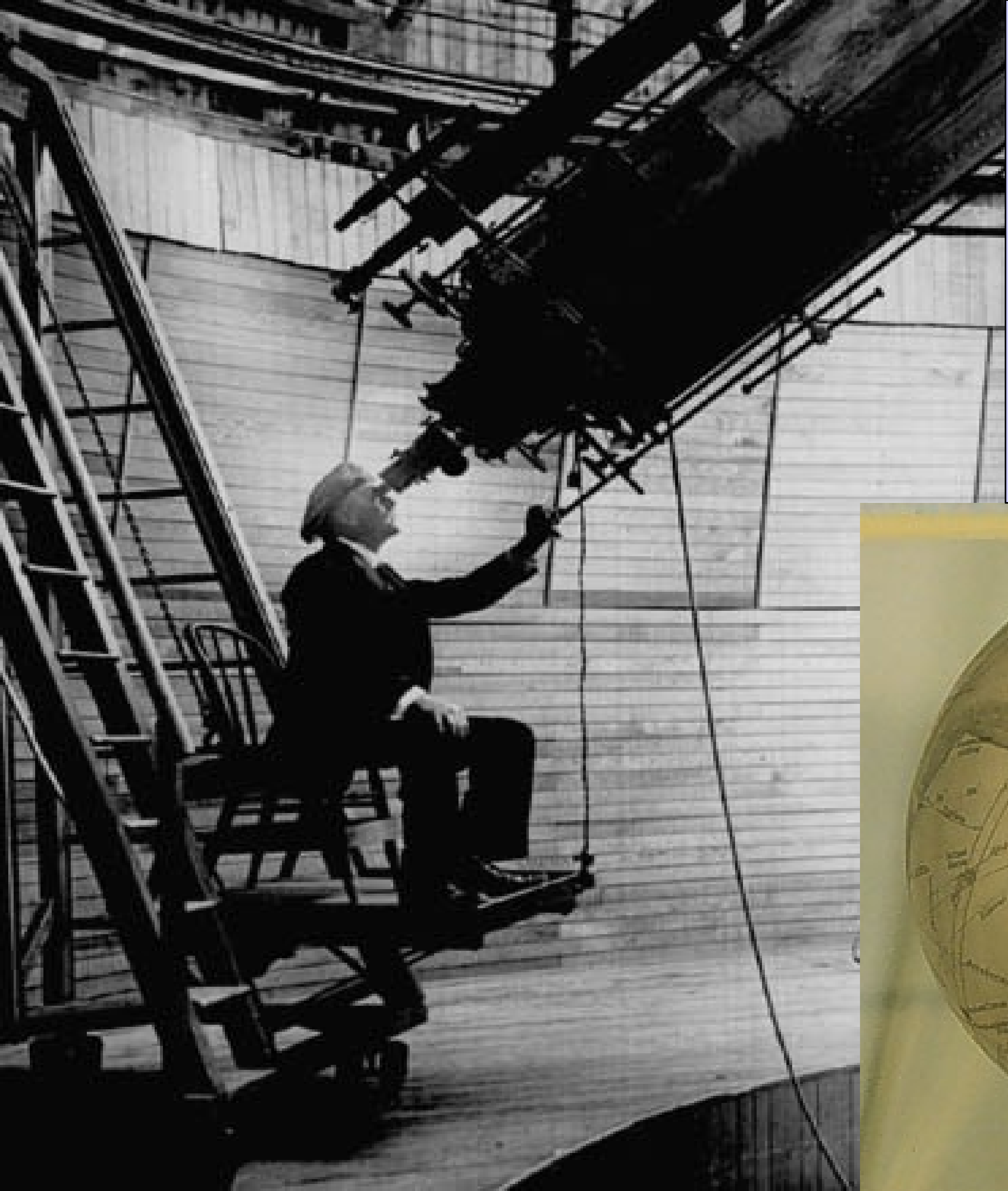
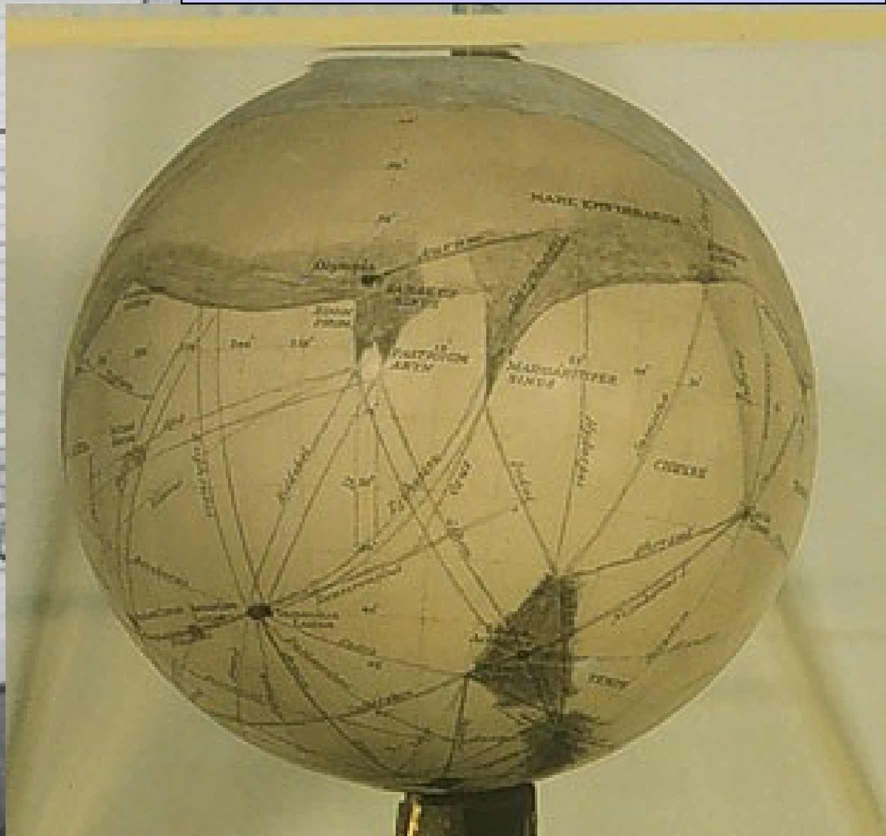



Orbit of Mars
Orbit of Earth
2001
June 13
1999 April 24
1997
March
17
2012
March
3
2010
January
29
2007
December 24
2005
November
7
2003
August
28
June
May
Apr.
Mar.
Feb.
Jan.
Dec.
Nov.
Oct.
Sept.
Aug.
July



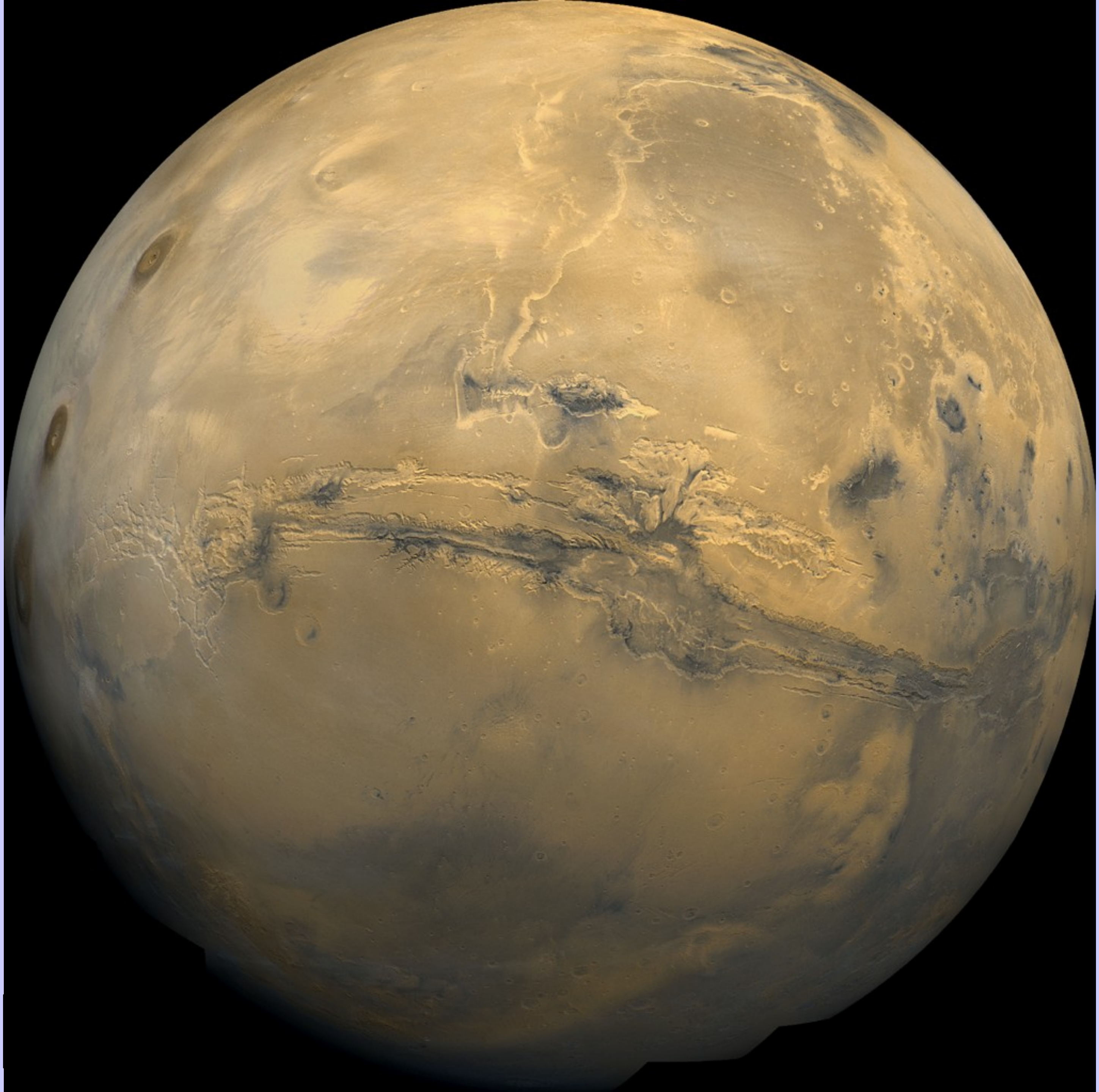
PERCIVAL LOWELL AT THE 24 INCH REFRACTOR, FLAGSTAFF, ARIZONA OBSERVING MARS DURING FAVORABLE OPPOSTION (PERIHELIC OPPOSTION) OF 1894

BELOW IS A GLOBE CONSTRUCTED FROM HIS DRAWINGS

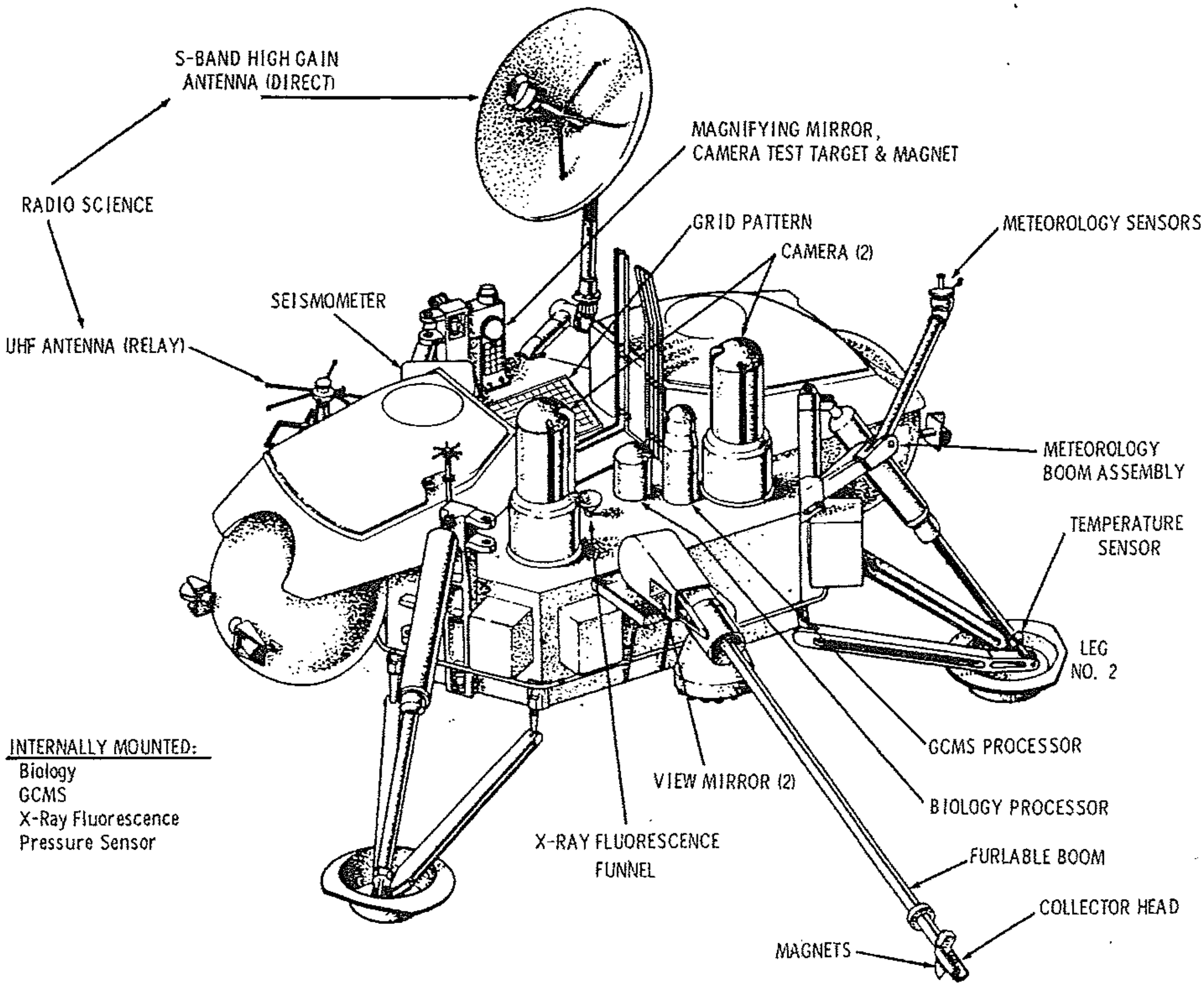


COMPOSITE IMAGE OF MARS TAKEN FROM SMALL TELESCOPES ONBOARD THE 2 VIKING ORBITERS

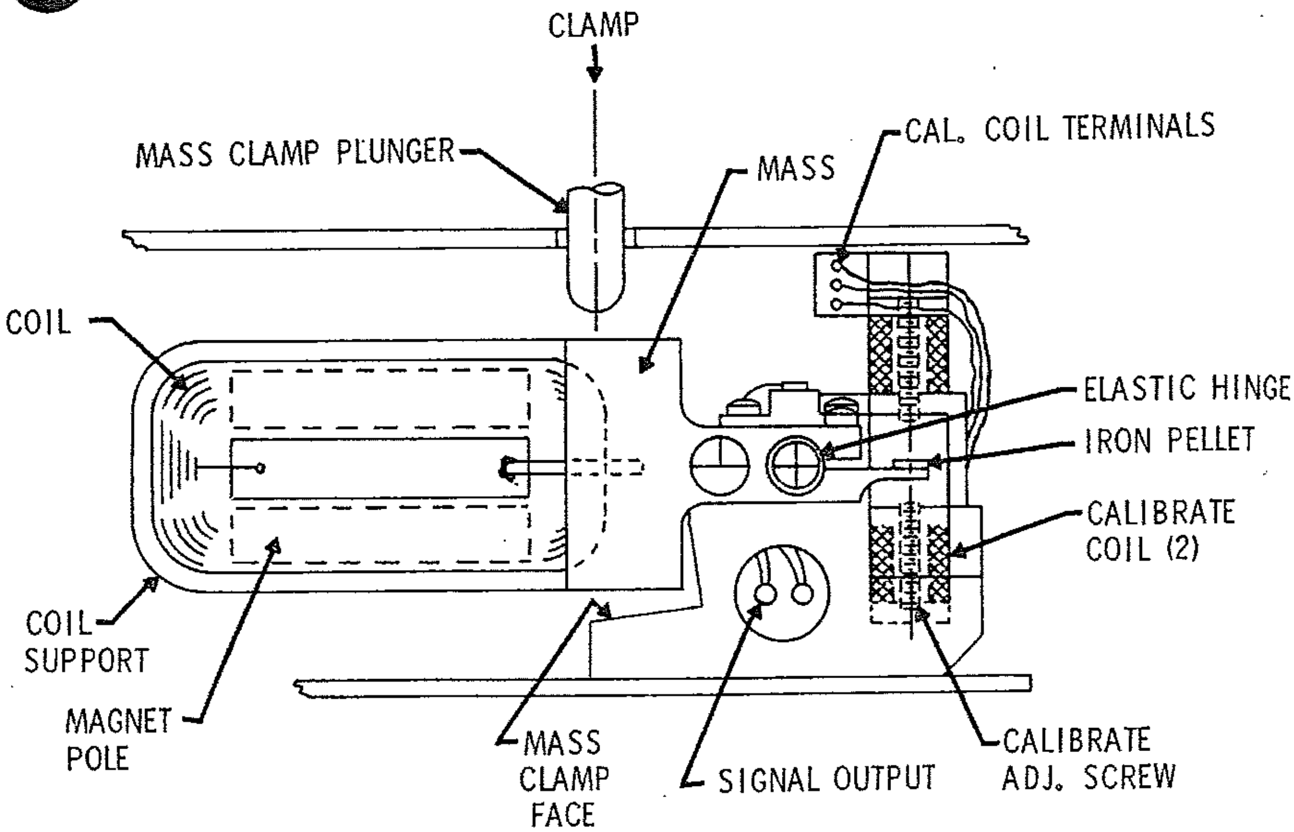
EARLY 1970'S



VIKING LANDED SCIENCE CONFIGURATION



SEISMOMETER SENSOR SCHEMATIC



Modes of operation may be changed by command from Earth to accommodate whatever seismic environment might be found on Mars; the modes may also be automatically cycled by internal controls.

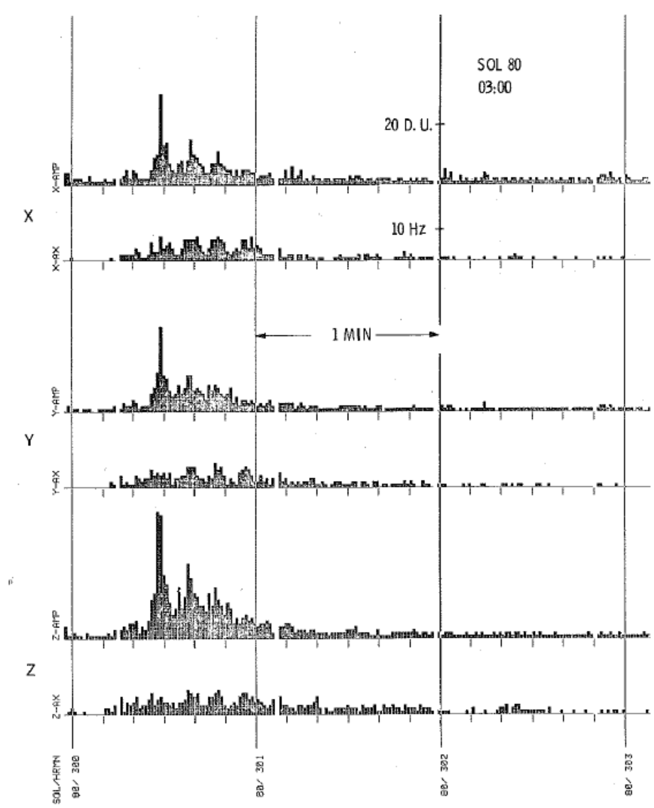


Fig. 21. Sol 80 0300 LLT event. This event is the most likely candidate for a Marsquake recorded to date. Because wind data were not recorded at the time of this event, it is possible that this event could also have been generated by the wind.

Mars Panorama

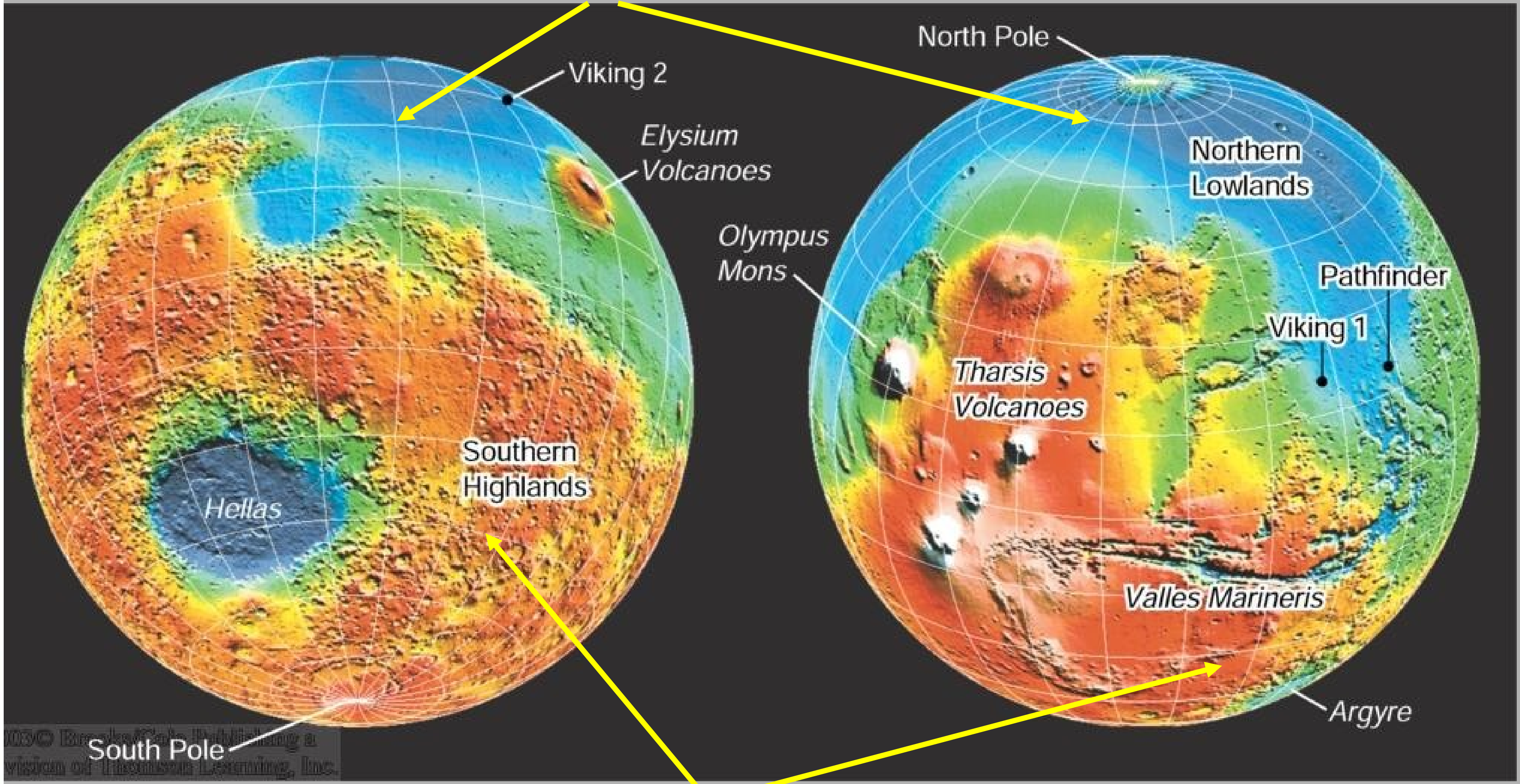
Figure 22.14

- Mars really is a 'red planet' due to iron oxide in its soil.
- This wonderful panorama from the surface was taken by the Pathfinder on July 4, 1997.
- The haze and clouds in its thin atmosphere are easily seen.

The Geology of Mars (2)

Northern Lowlands: Free of craters; probably re-surfaced a few billion years ago.

Possibly once filled with water.



Southern Highlands: Heavily cratered; probably 2 – 3 billion years old.

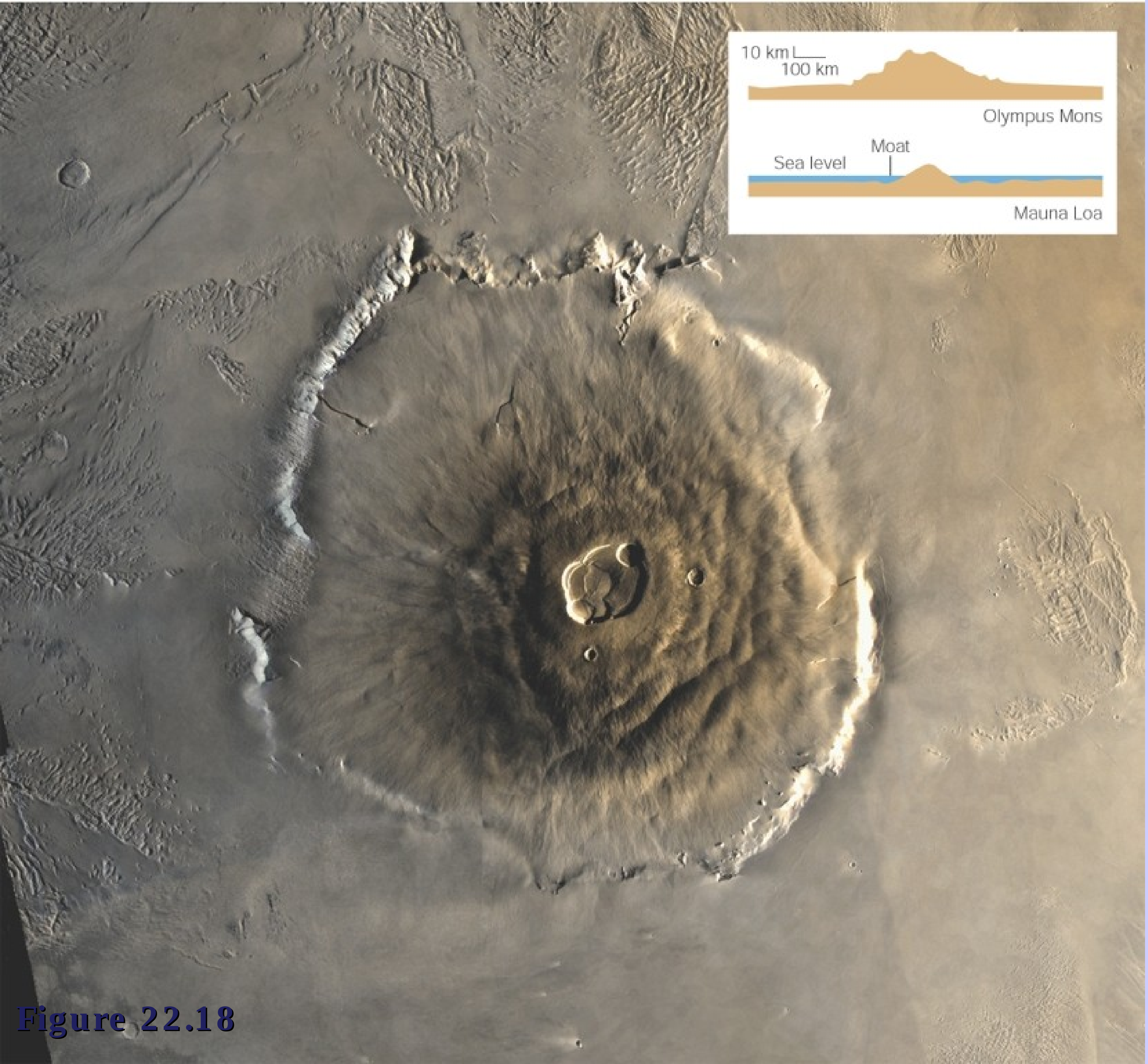
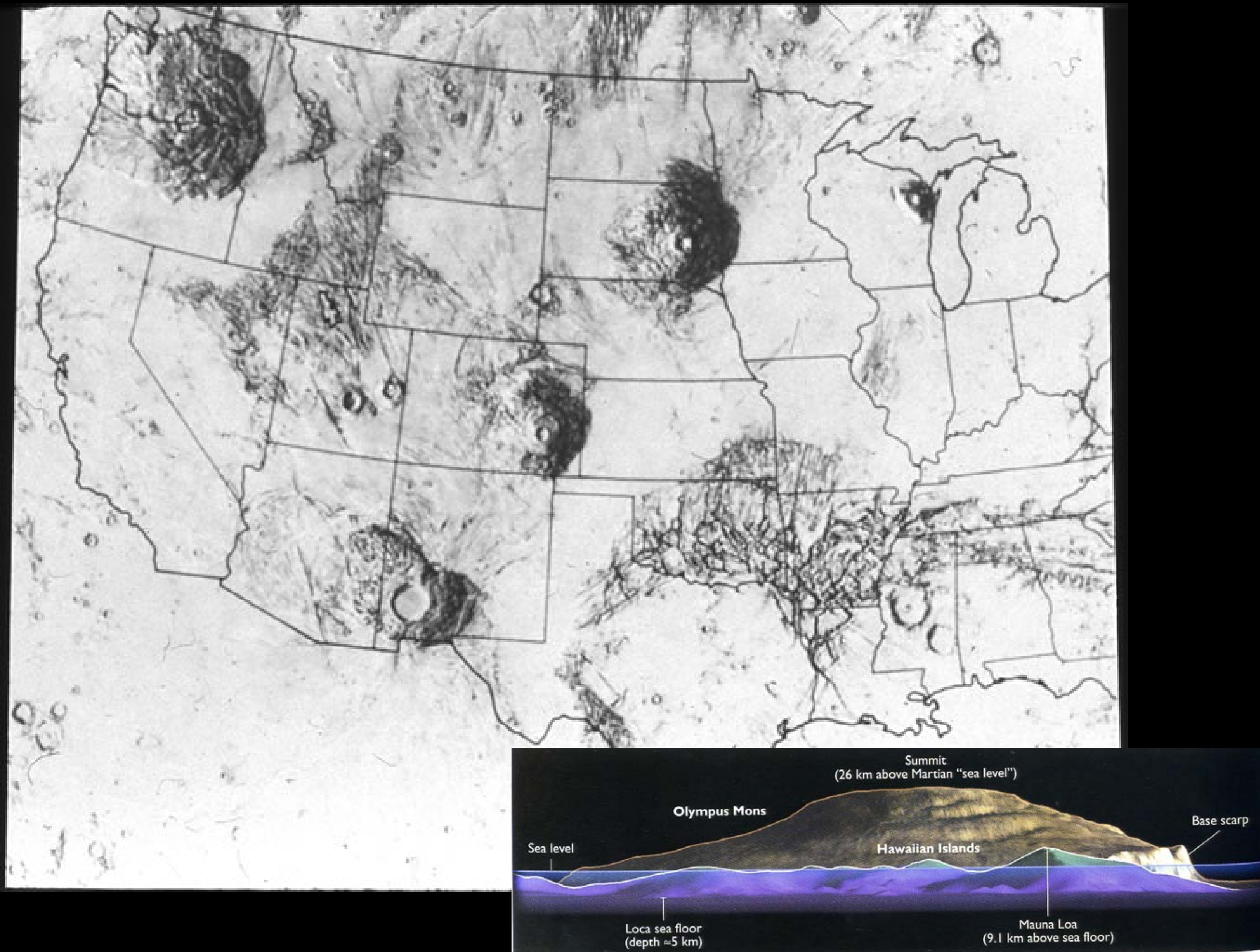


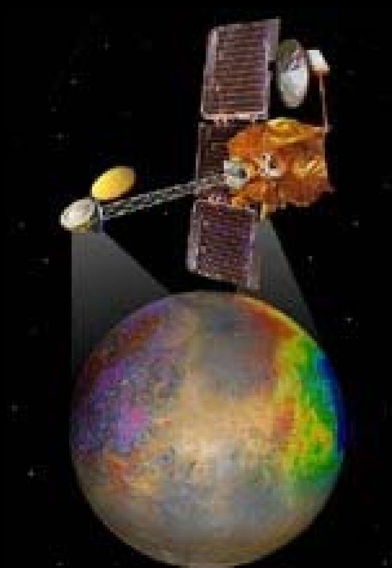
Figure 22.18

- ❖**Olympus Mons is the largest shield volcano in the solar system.**
- ❖**It is much larger than Mauna Loa, the largest shield**


Summit
(26 km above Martian "sea level")
Olympus Mons
Base scarp
Sea level
Hawaiian Islands
Loca sea floor
(depth ≈5 km)
Mauna Loa
(9.1 km above sea floor)

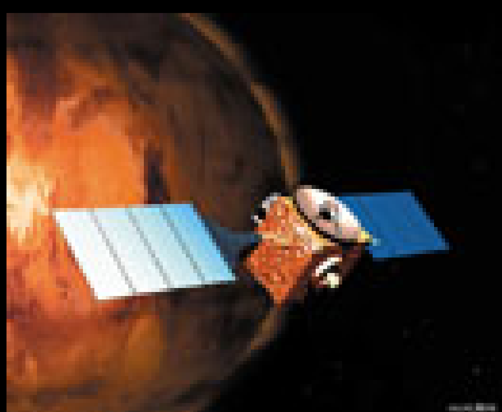
Mars Global Surveyor (MGS)

Mars Odyssey



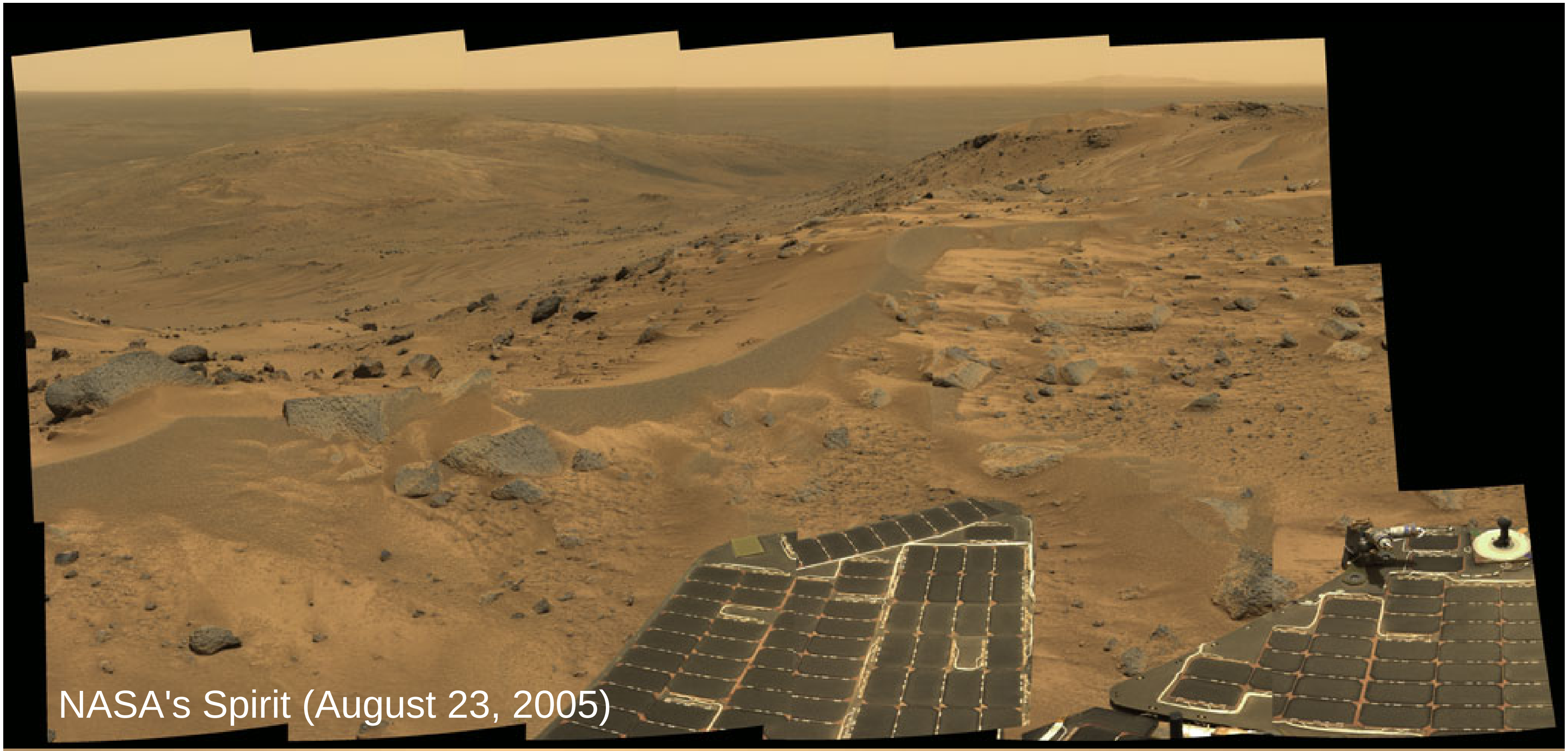
Mars Reconnaissance Orbiter

Mars Express

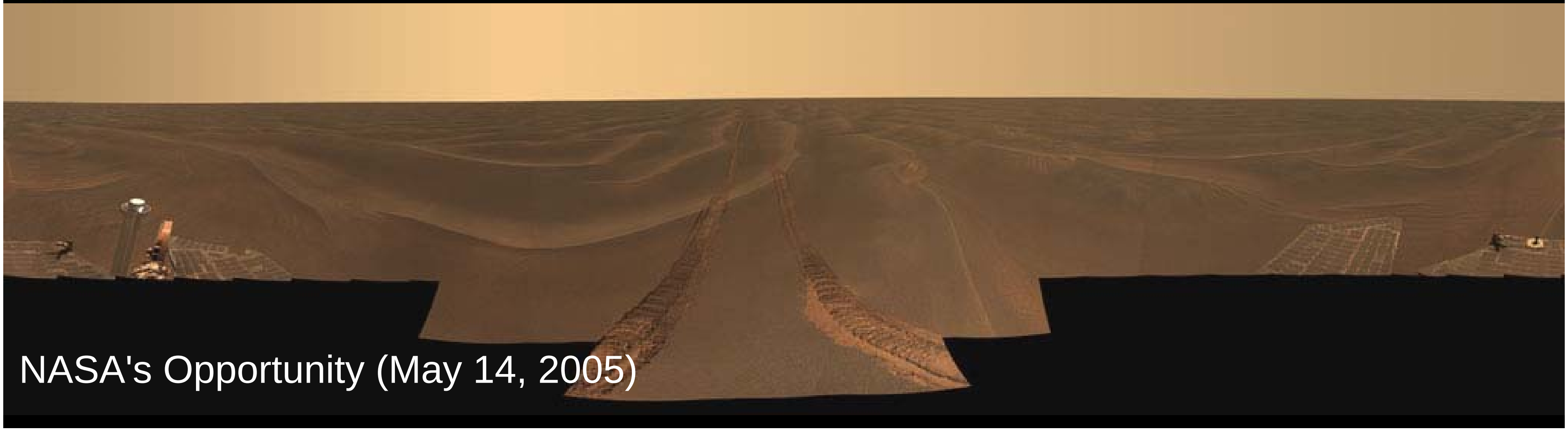


Mars Exploration Rovers (MERs)

Artist's simulation of a Mars Exploration Rover at work on Mars.

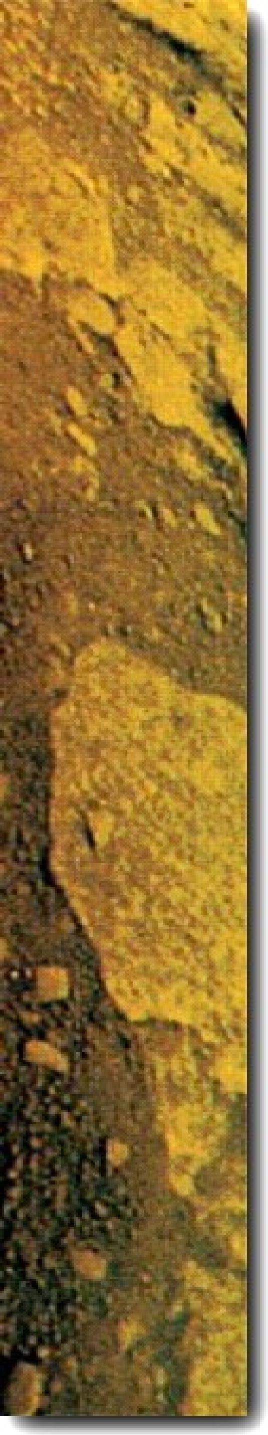


NASA's Spirit (August 23, 2005)



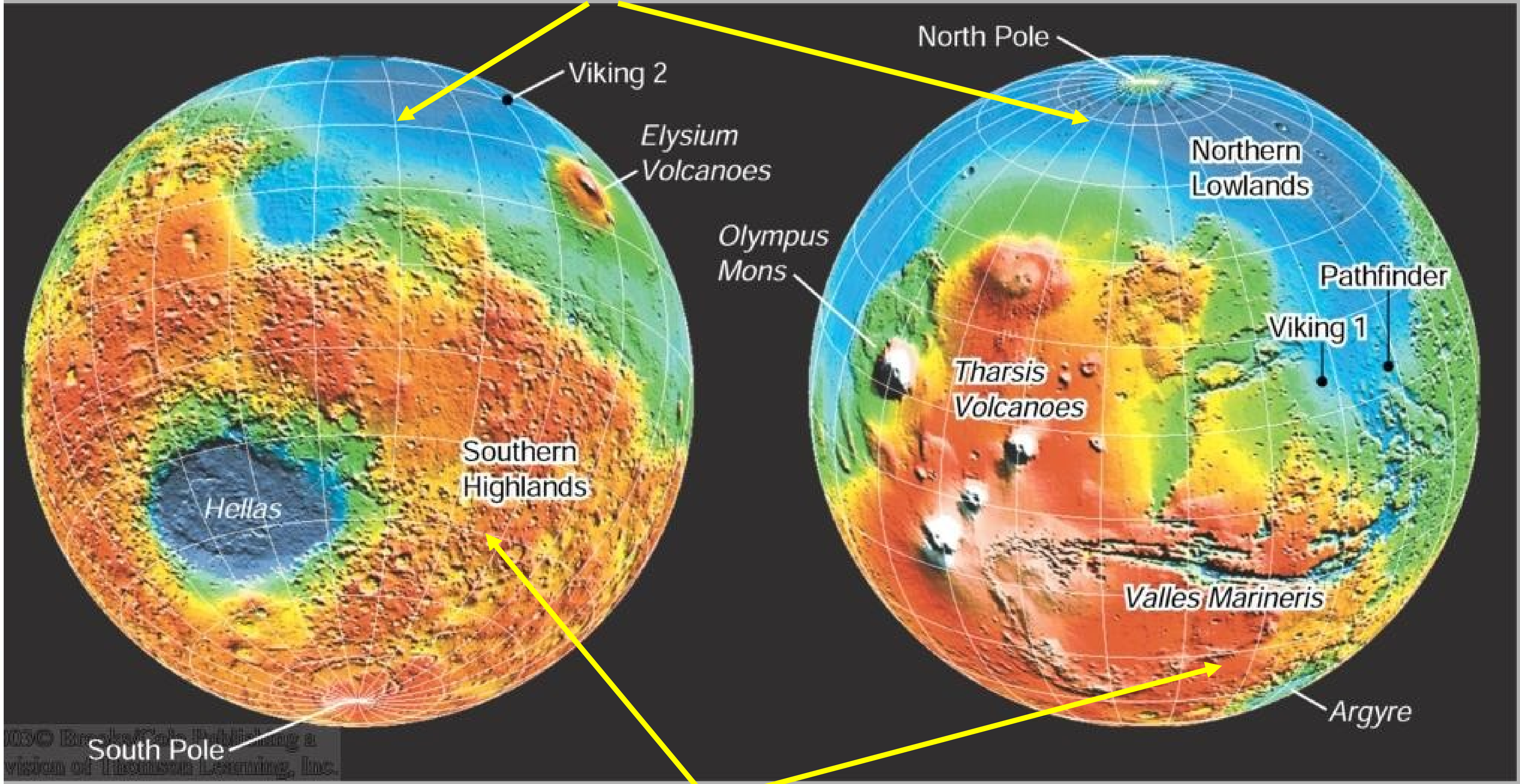
NASA's Opportunity (May 14, 2005)

The Geology of Mars (2)

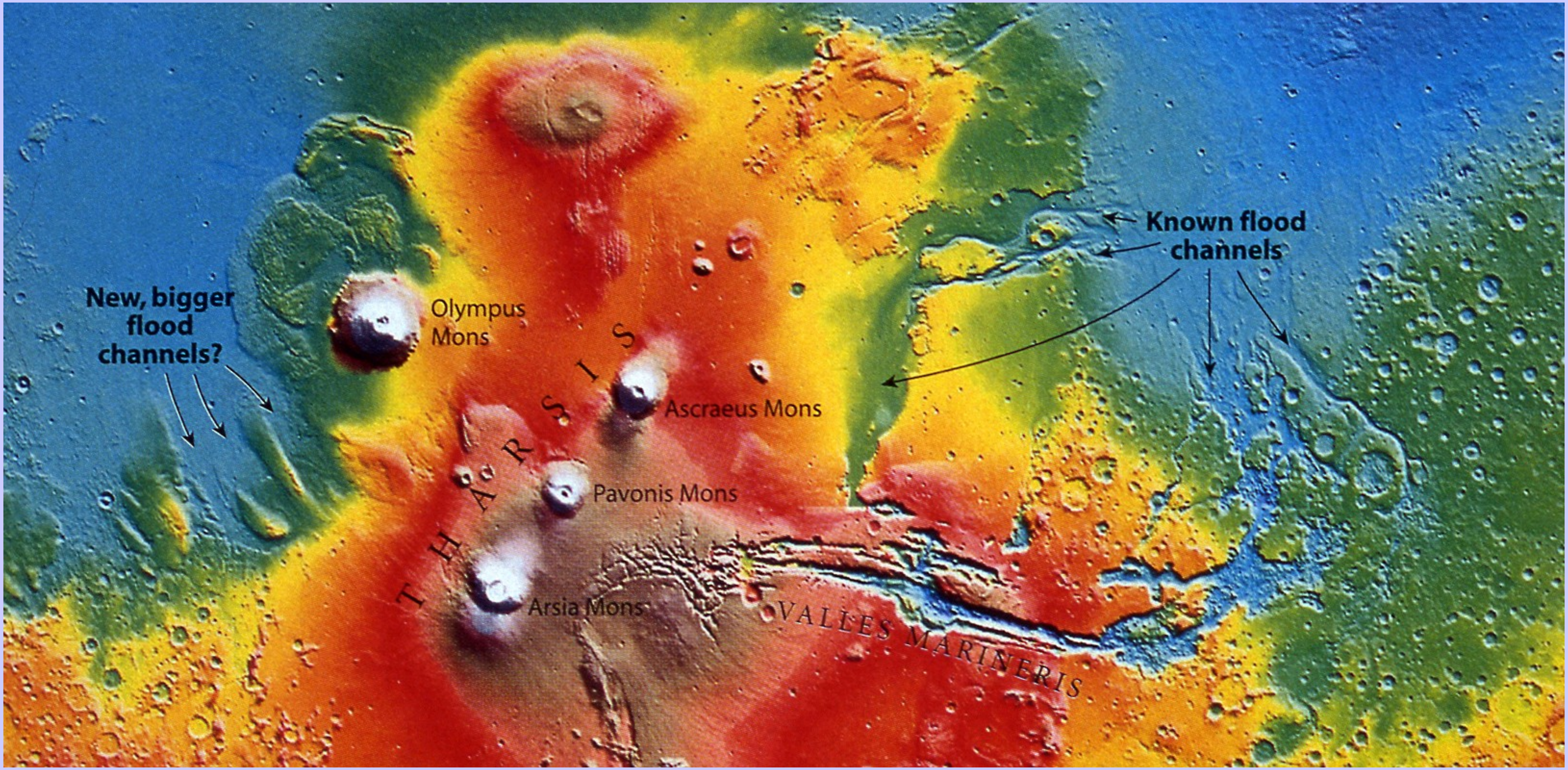


Northern Lowlands: Free of craters; probably re-surfaced a few billion years ago.

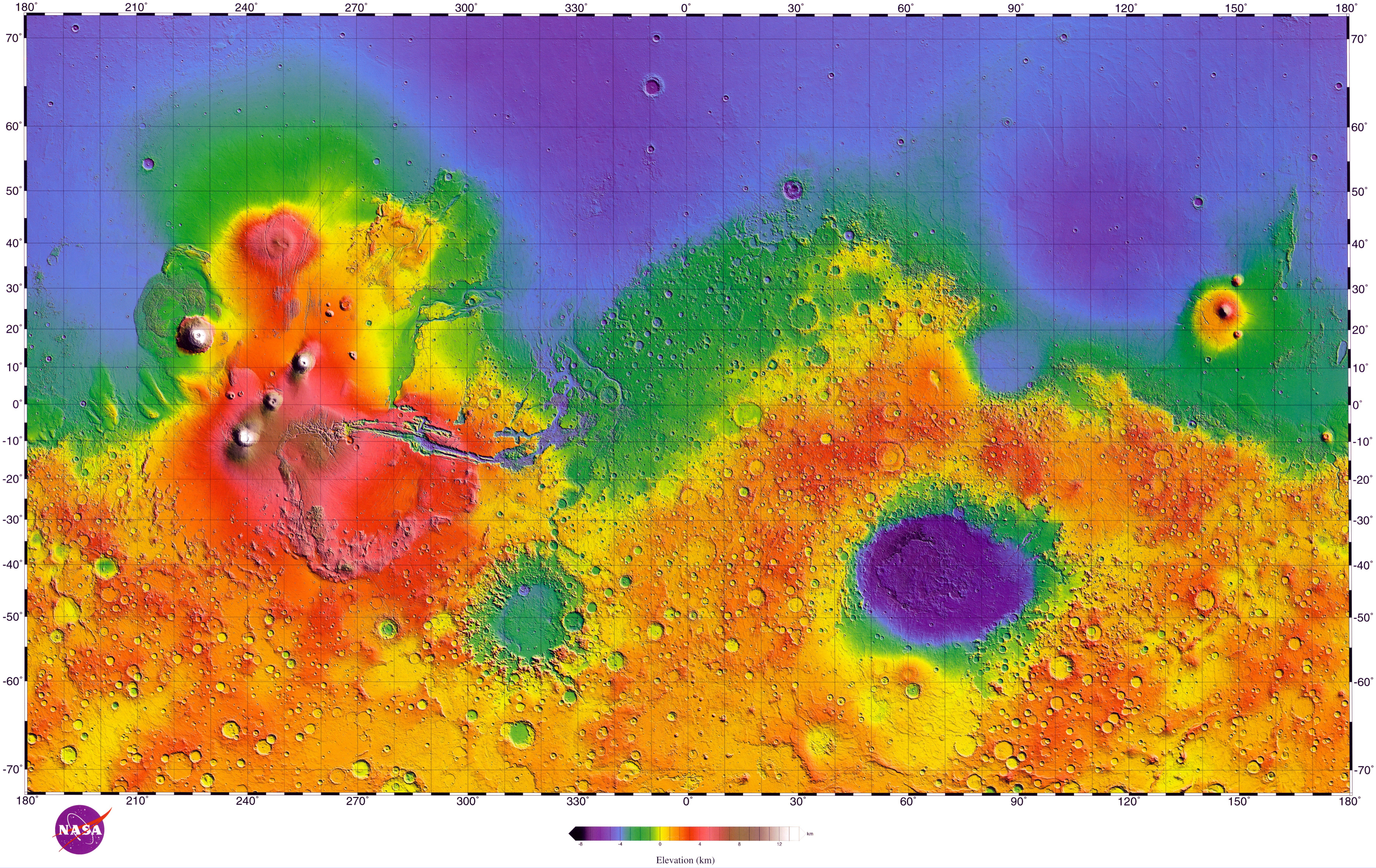
Possibly once filled with water.



Southern Highlands: Heavily cratered; probably 2 – 3 billion years old.

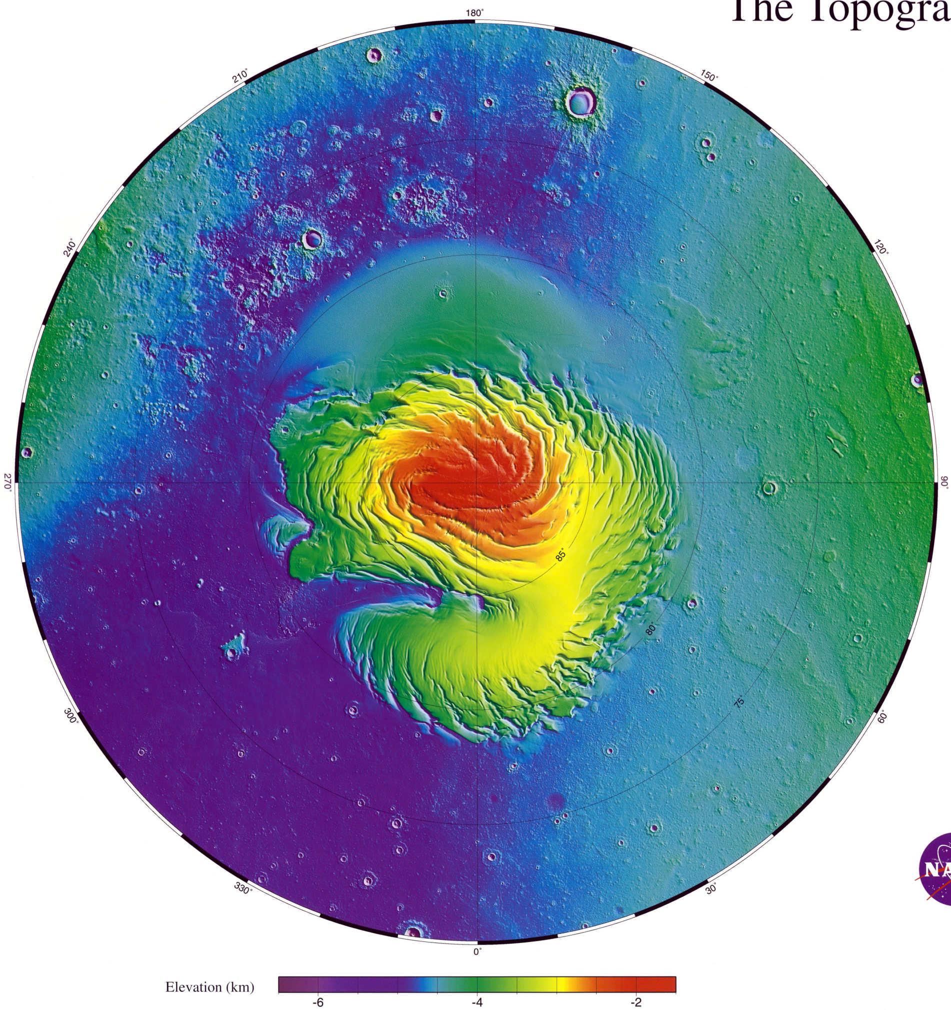

New, bigger flood channels?
Olympus Mons
THARSIS
Ascraeus Mons
Pavonis Mons
Arsia Mons
VALLES MARINERIS
Known flood channels

The Topography of Mars

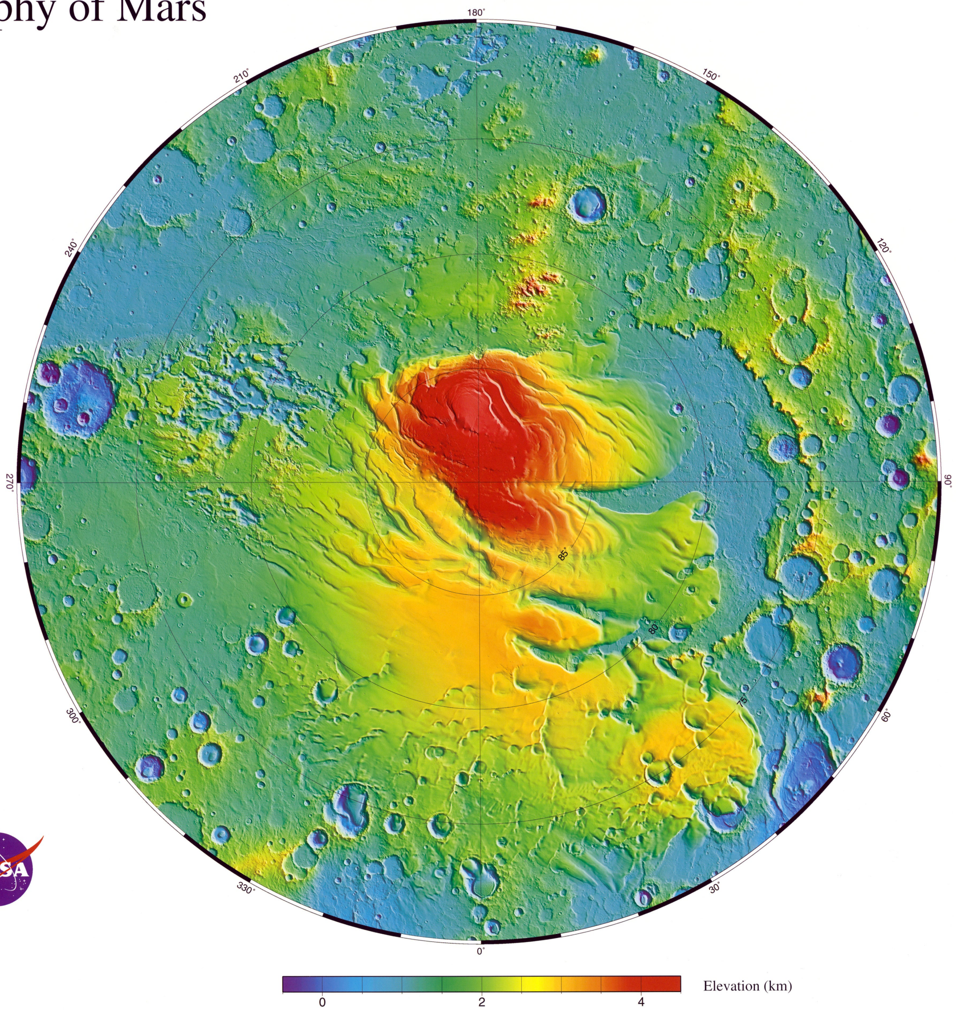


The Topography of Mars

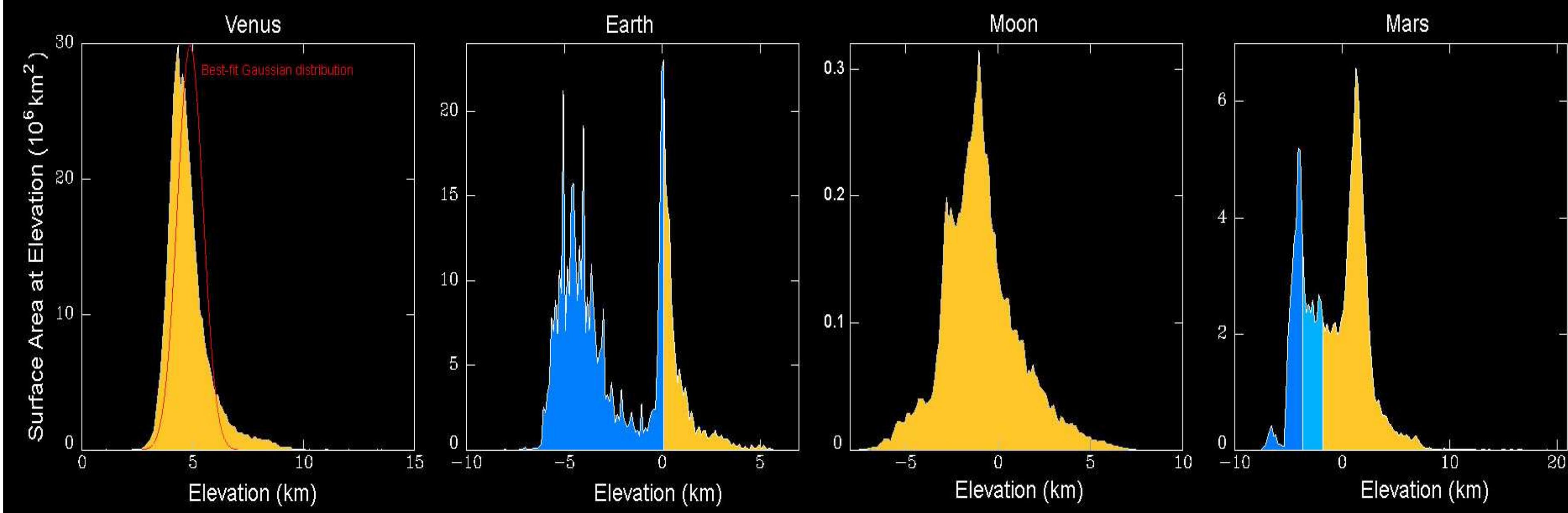
North Pole

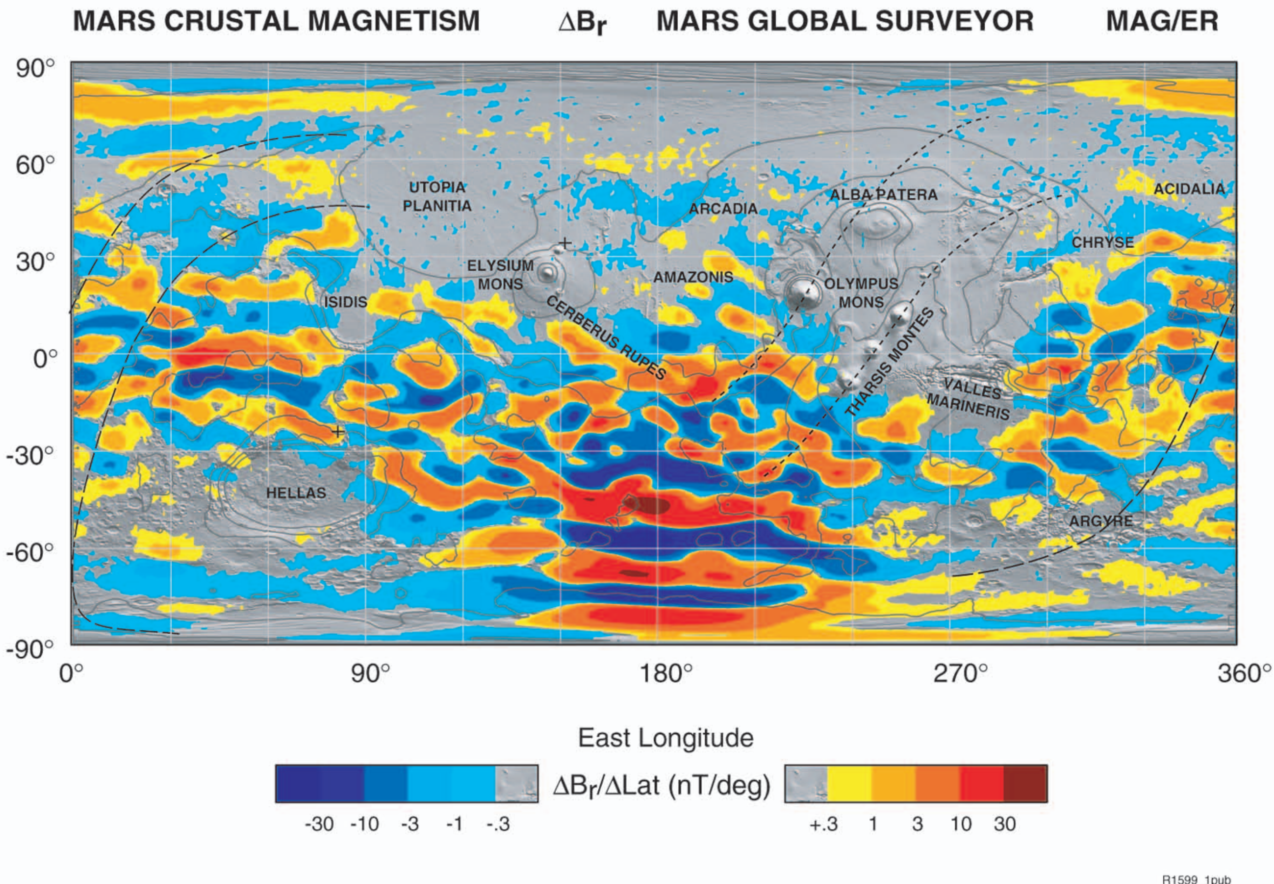


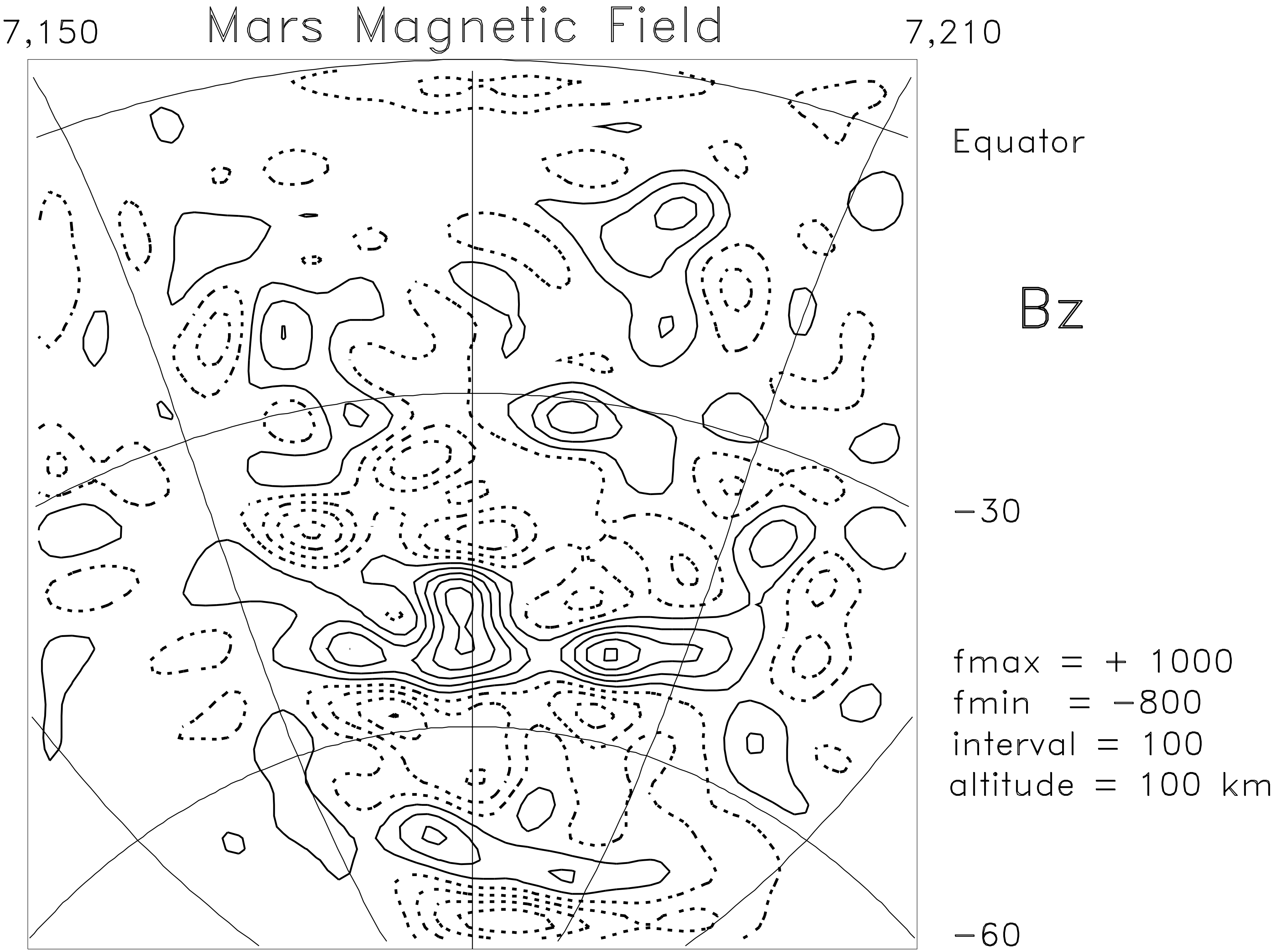
South Pole



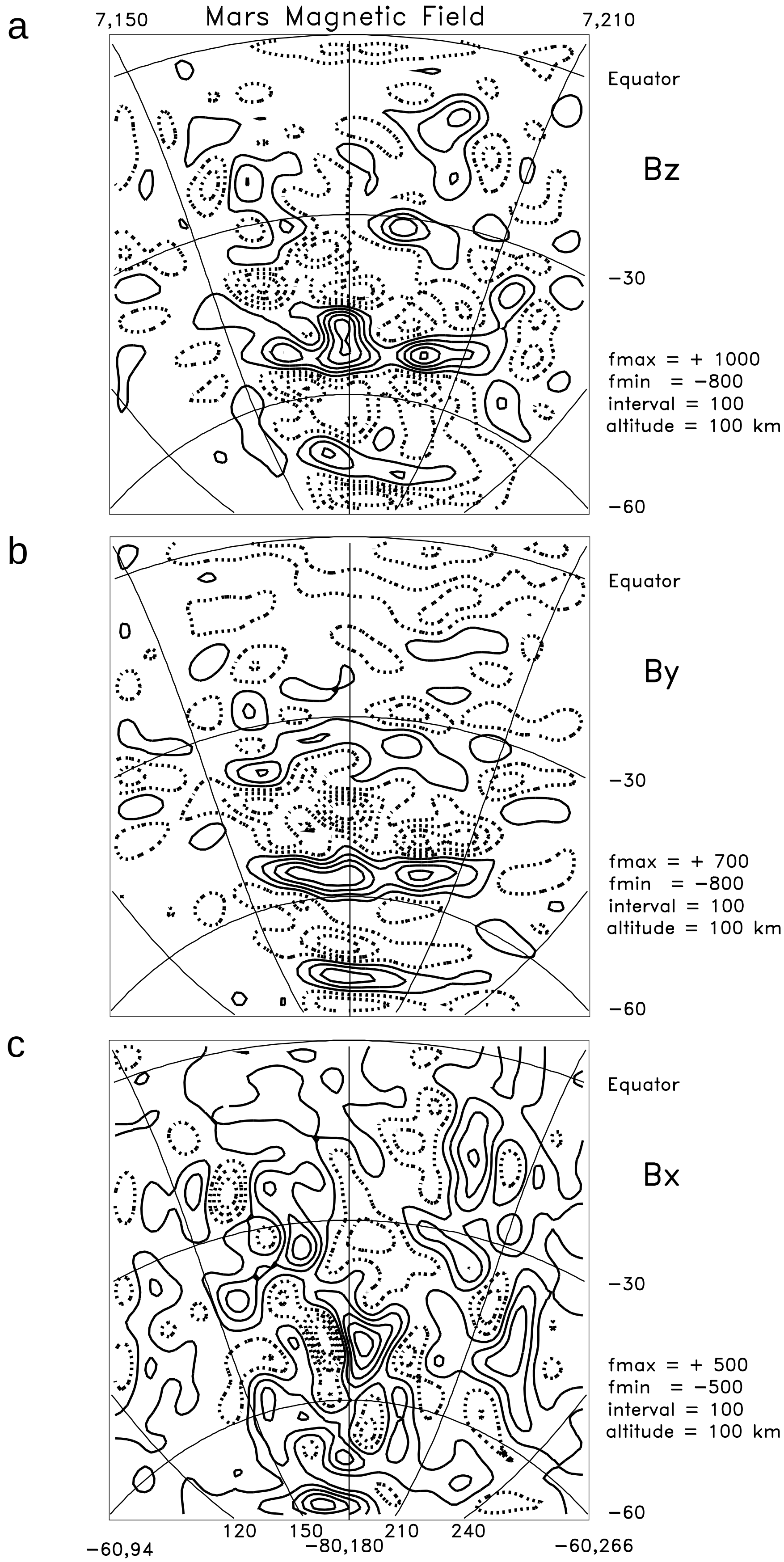
Inner Solar System Hypsographic Comparisons



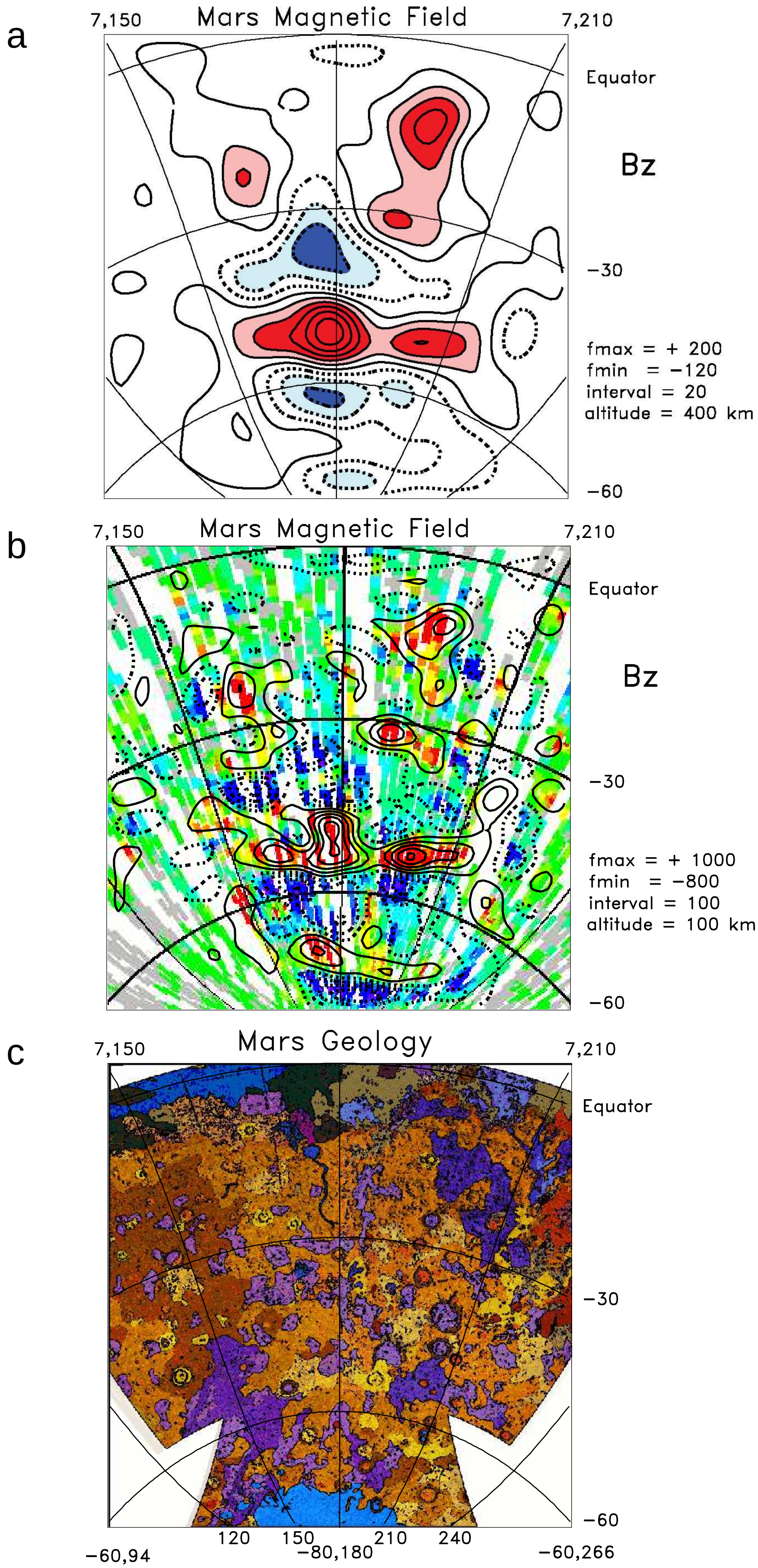

MARS CRUSTAL MAGNETISM
ΔBr
MARS GLOBAL SURVEYOR
MAG/ER
90°
60°
30°
0°
-30°
-60°
-90°
0°
90°
180°
270°
360°
UTOPIA PLANITIA
ARCADIA
ALBA PATERA
ACIDALIA
CHRYSE
ELYSIUM MONS
AMAZONIS
OLYMPUS MONS
ISIDIS
CERBERUS RUPES
THARSIS MONTES
VALLES MARINERIS
HELLAS
ARGYRE
East Longitude
ΔBr/ΔLat (nT/deg)
-30
-10
-3
-1
-.3
+.3
1
3
10
30
R1599_1pub

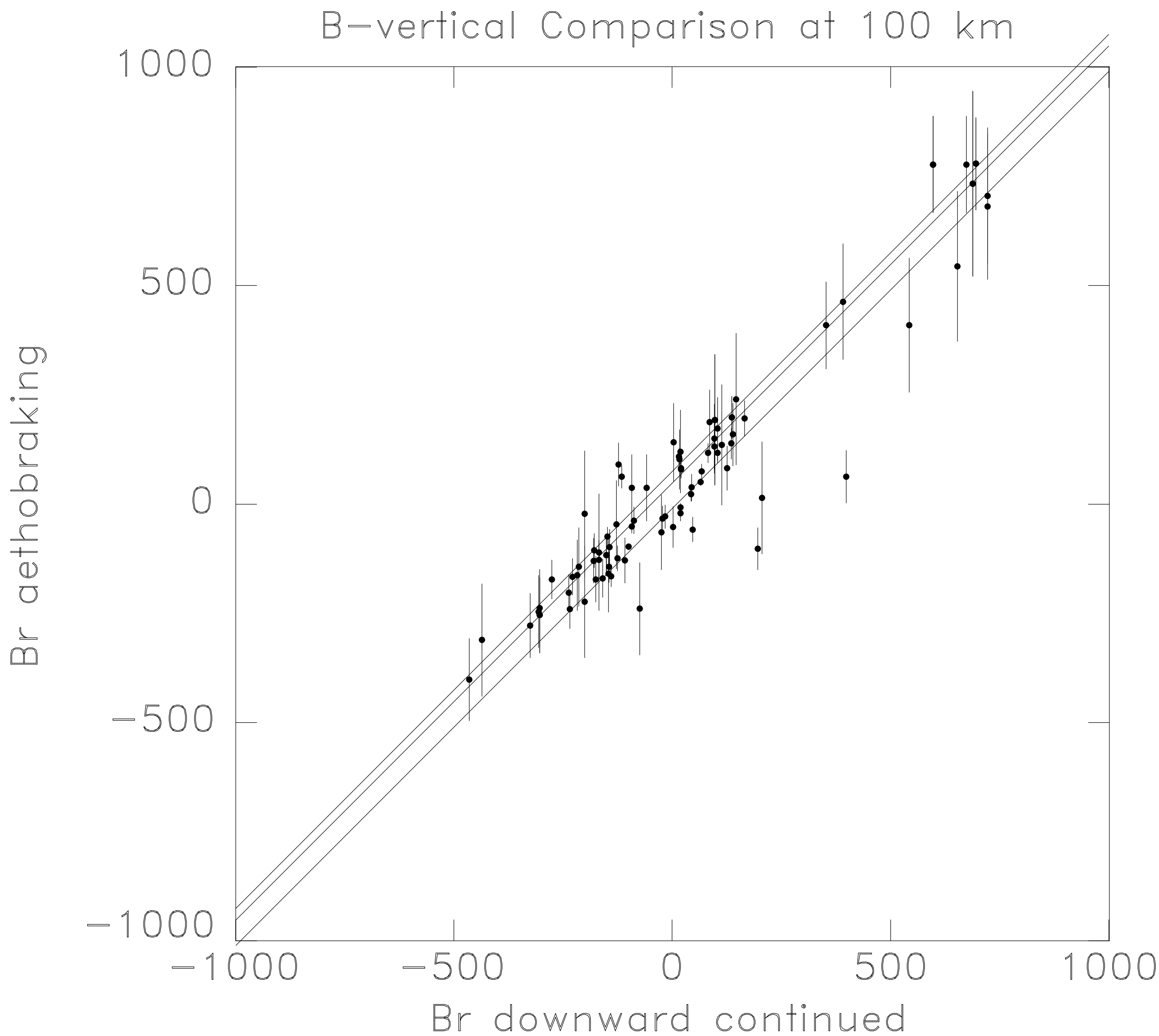


Mars Magnetic Field
7,150
7,210
Equator
Bz
−30
fmax = + 1000
fmin = −800
interval = 100
altitude = 100 km
−60

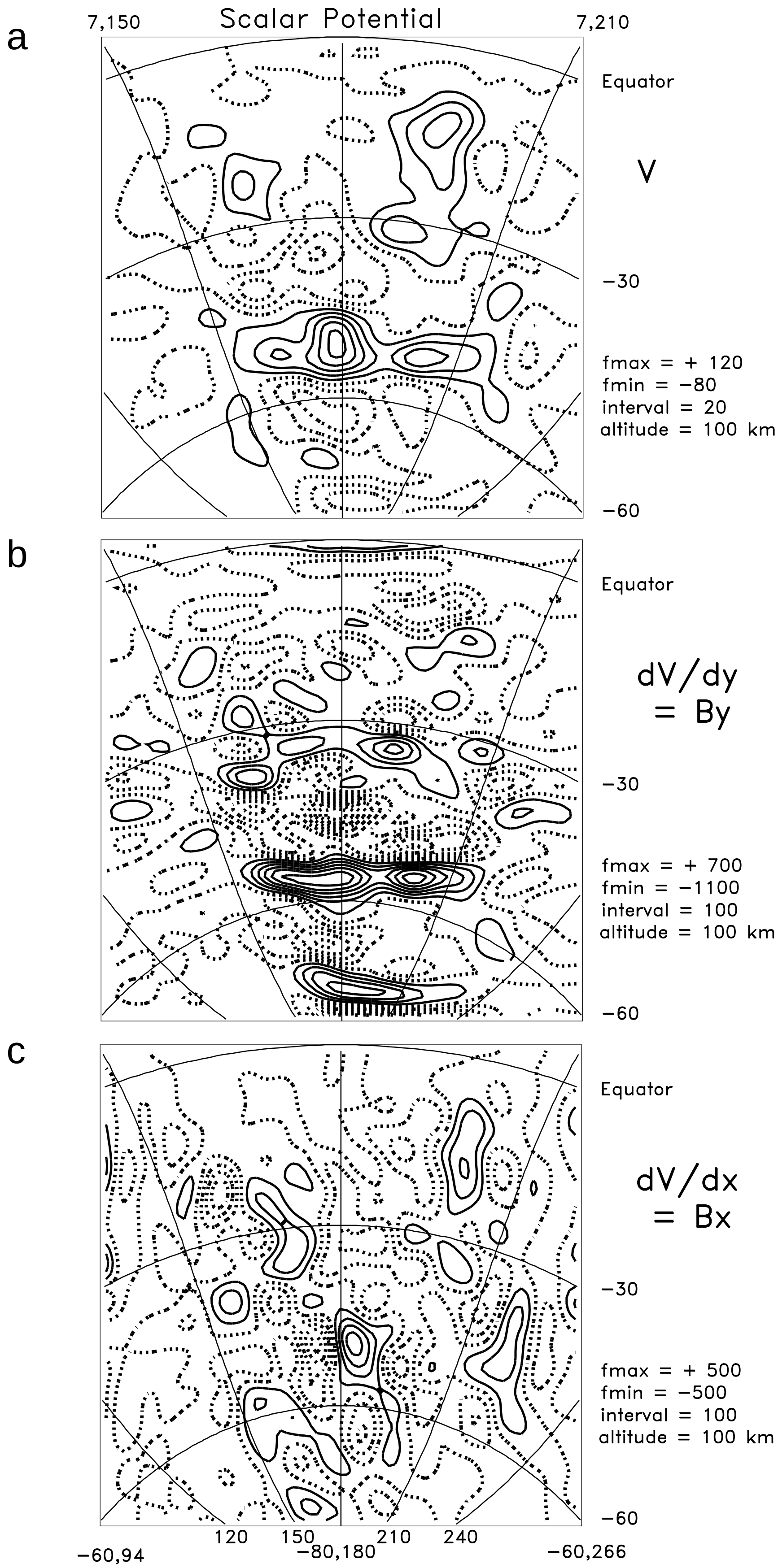


a
Mars Magnetic Field
7,150
7,210
Equator
Bz
−30
fmax = + 1000
fmin = −800
interval = 100
altitude = 100 km
−60
b
Equator
By
−30
fmax = + 700
fmin = −800
interval = 100
altitude = 100 km
−60
c
Equator
Bx
−30
fmax = + 500
fmin = −500
interval = 100
altitude = 100 km
−60
120
150
210
240
−60,94
−80,180
−60,266


a
7,150
Mars Magnetic Field
7,210
Equator
Bz
−30
fmax = + 200
fmin = −120
interval = 20
altitude = 400 km
−60
b
7,150
Mars Magnetic Field
7,210
Equator
Bz
−30
fmax = + 1000
fmin = −800
interval = 100
altitude = 100 km
−60
c
7,150
Mars Geology
7,210
Equator
−30
−60
120
150
210
240
−60,94
−80,180
−60,266

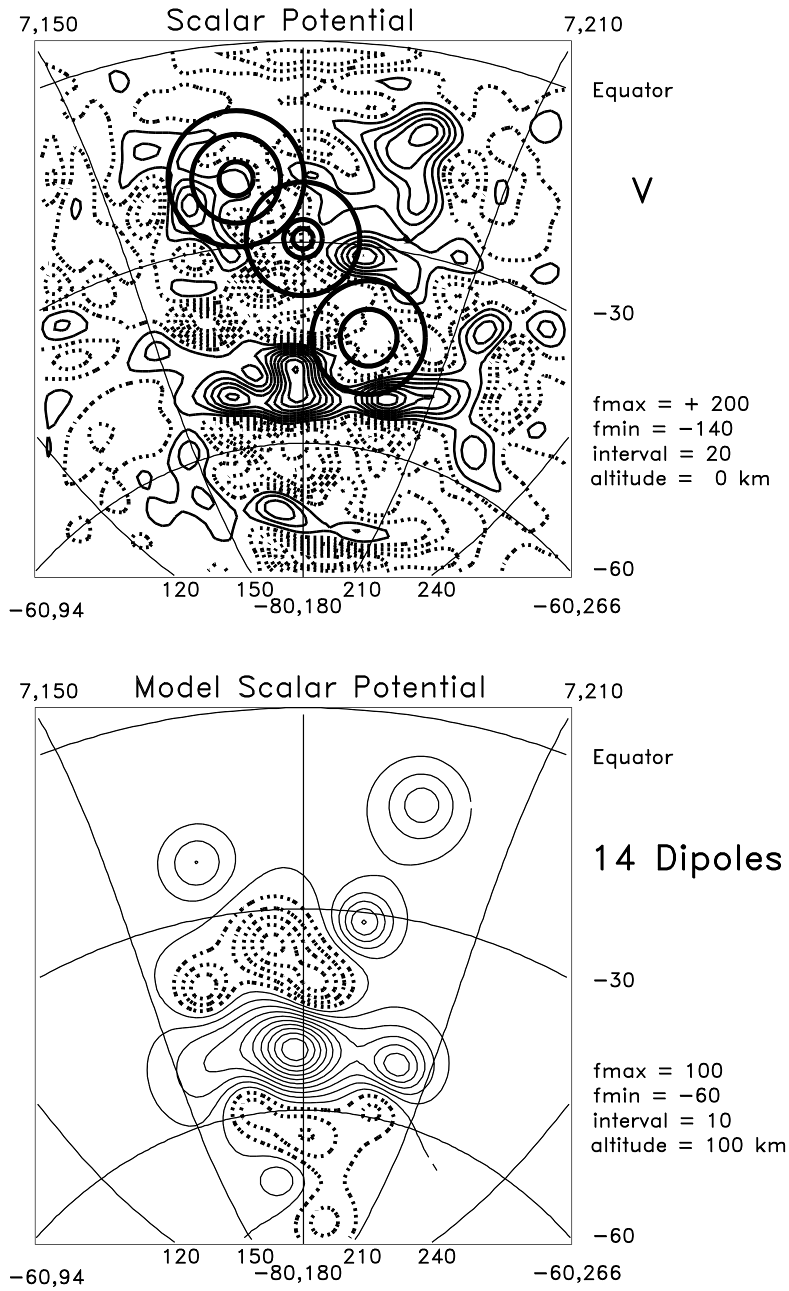


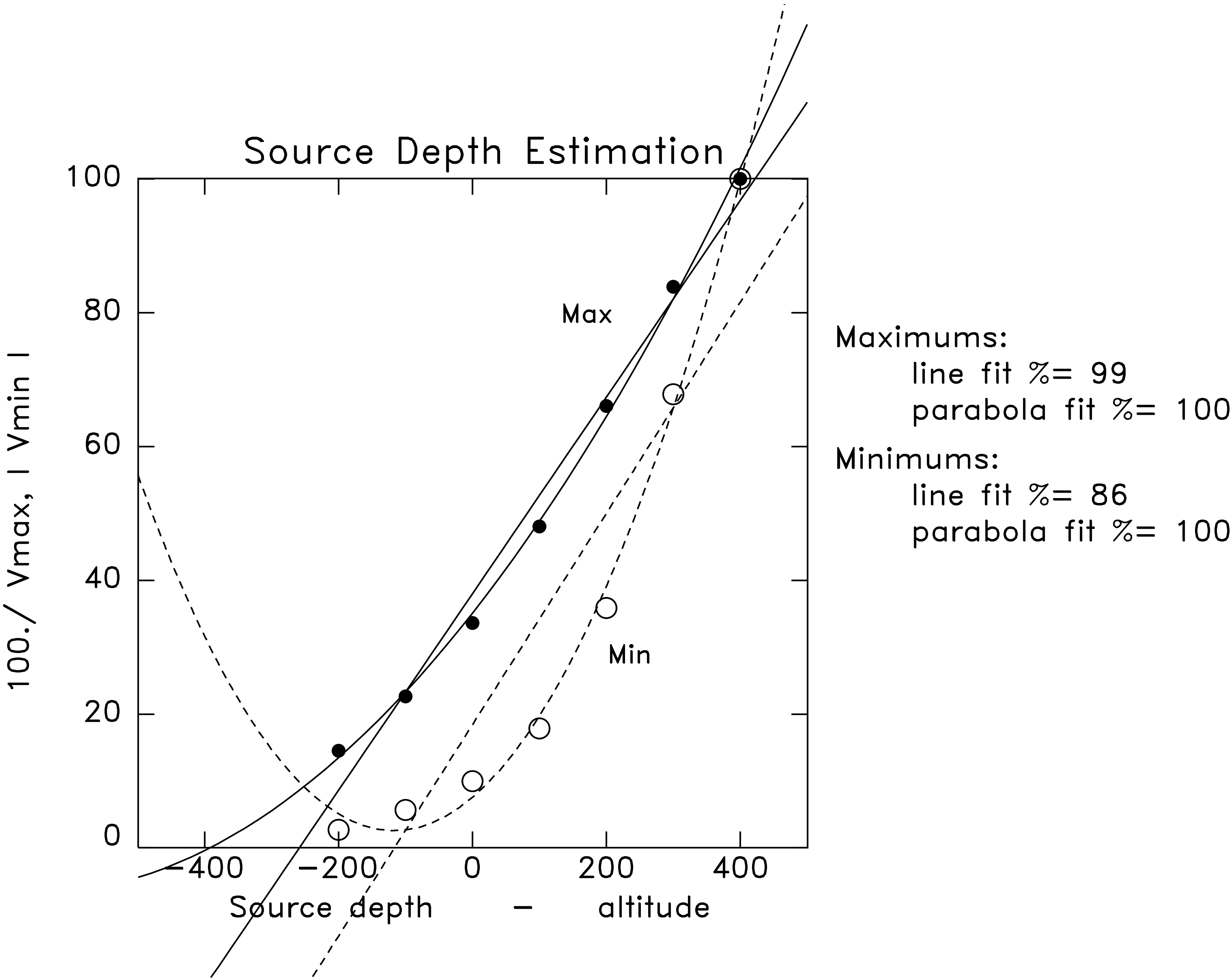
B-vertical Comparison at 100 km
1000
500
0
-500
-1000
-1000
-500
0
500
1000
Br aethobraking
Br downward continued

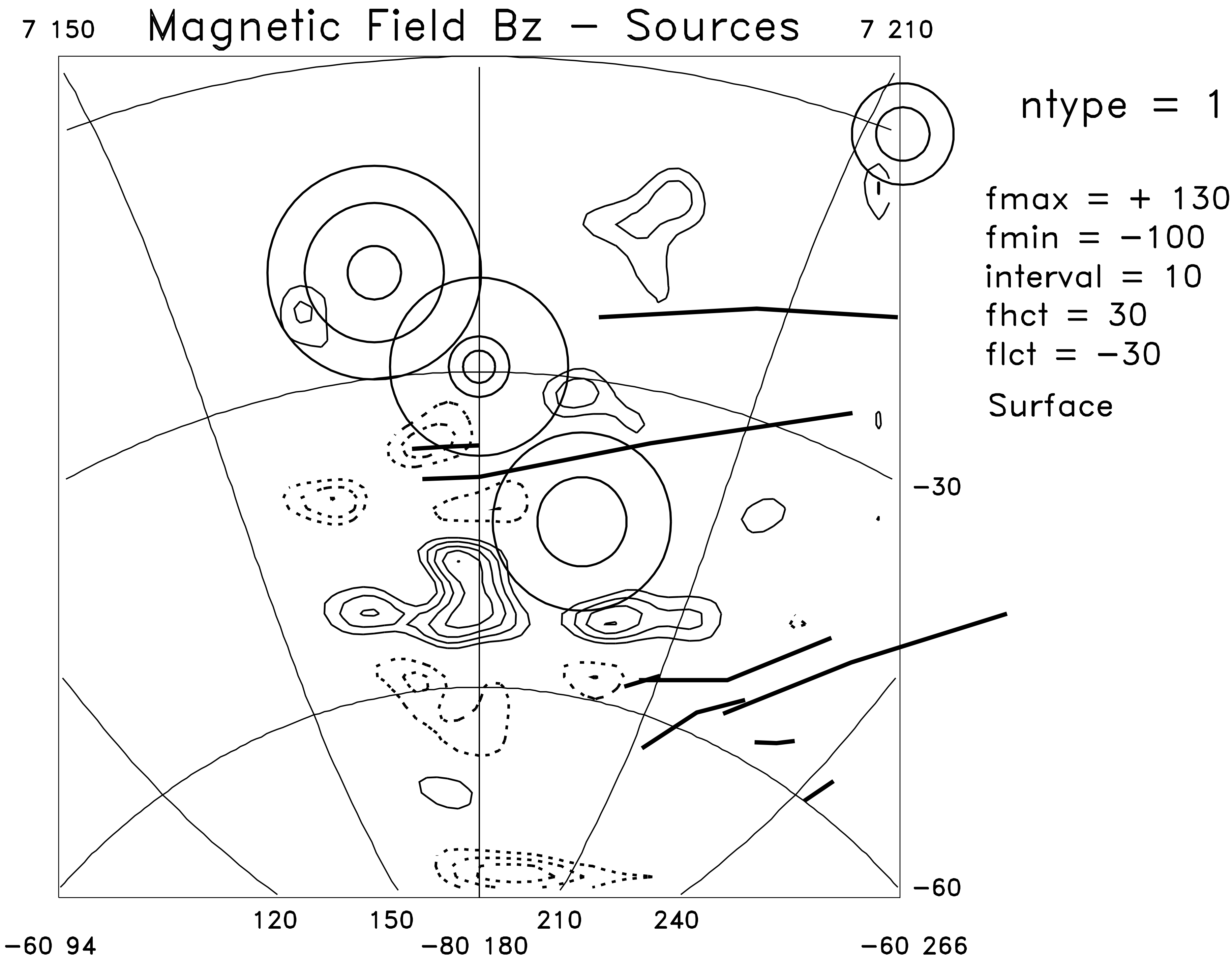

a
Scalar Potential
7,150
7,210
Equator
V
−30
fmax = + 120
fmin = −80
interval = 20
altitude = 100 km
−60
b
Equator
dV/dy
= By
−30
fmax = + 700
fmin = −1100
interval = 100
altitude = 100 km
−60
c
Equator
dV/dx
= Bx
−30
fmax = + 500
fmin = −500
interval = 100
altitude = 100 km
−60
120
150
210
240
−60,94
−80,180
−60,266

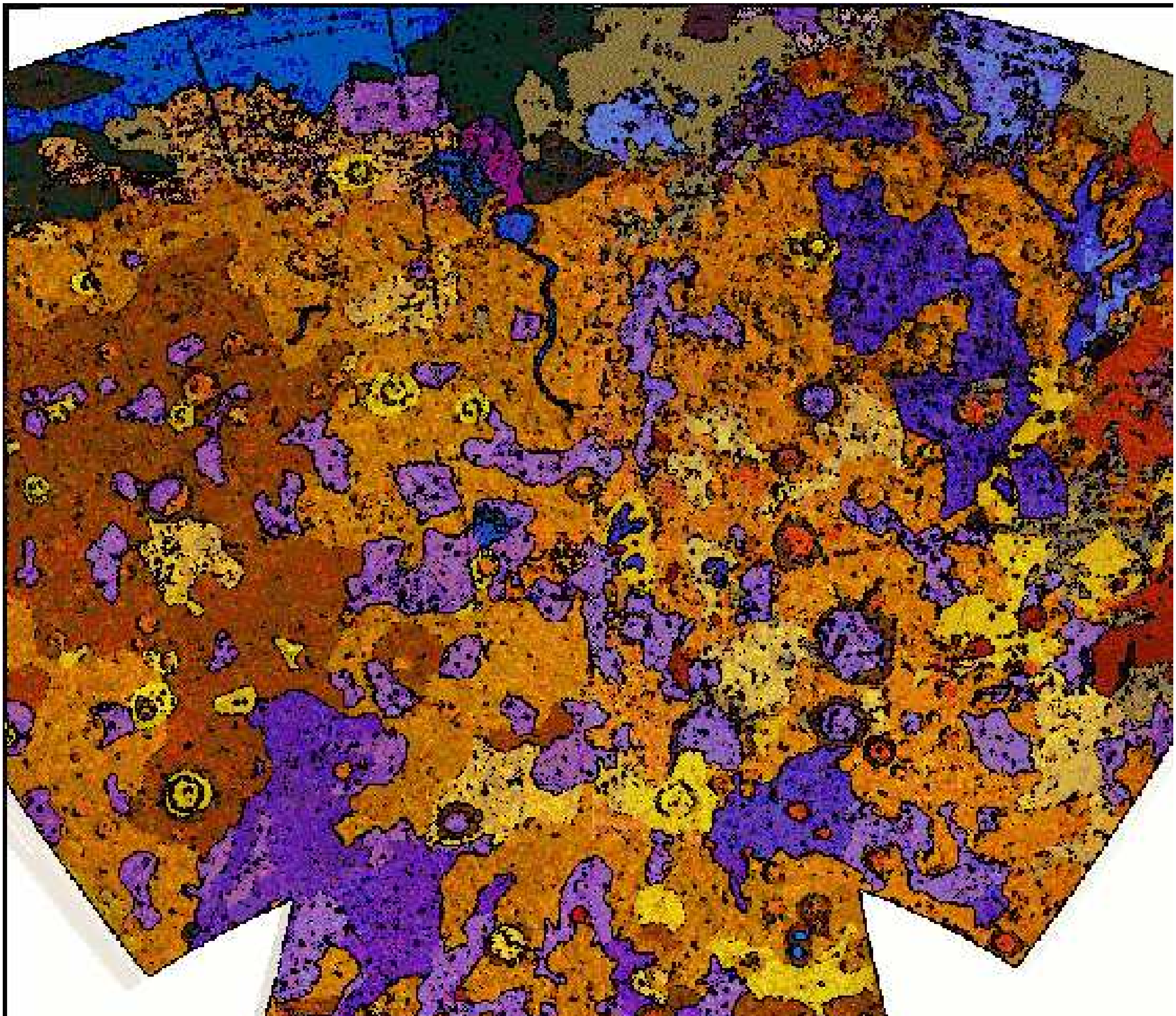
a

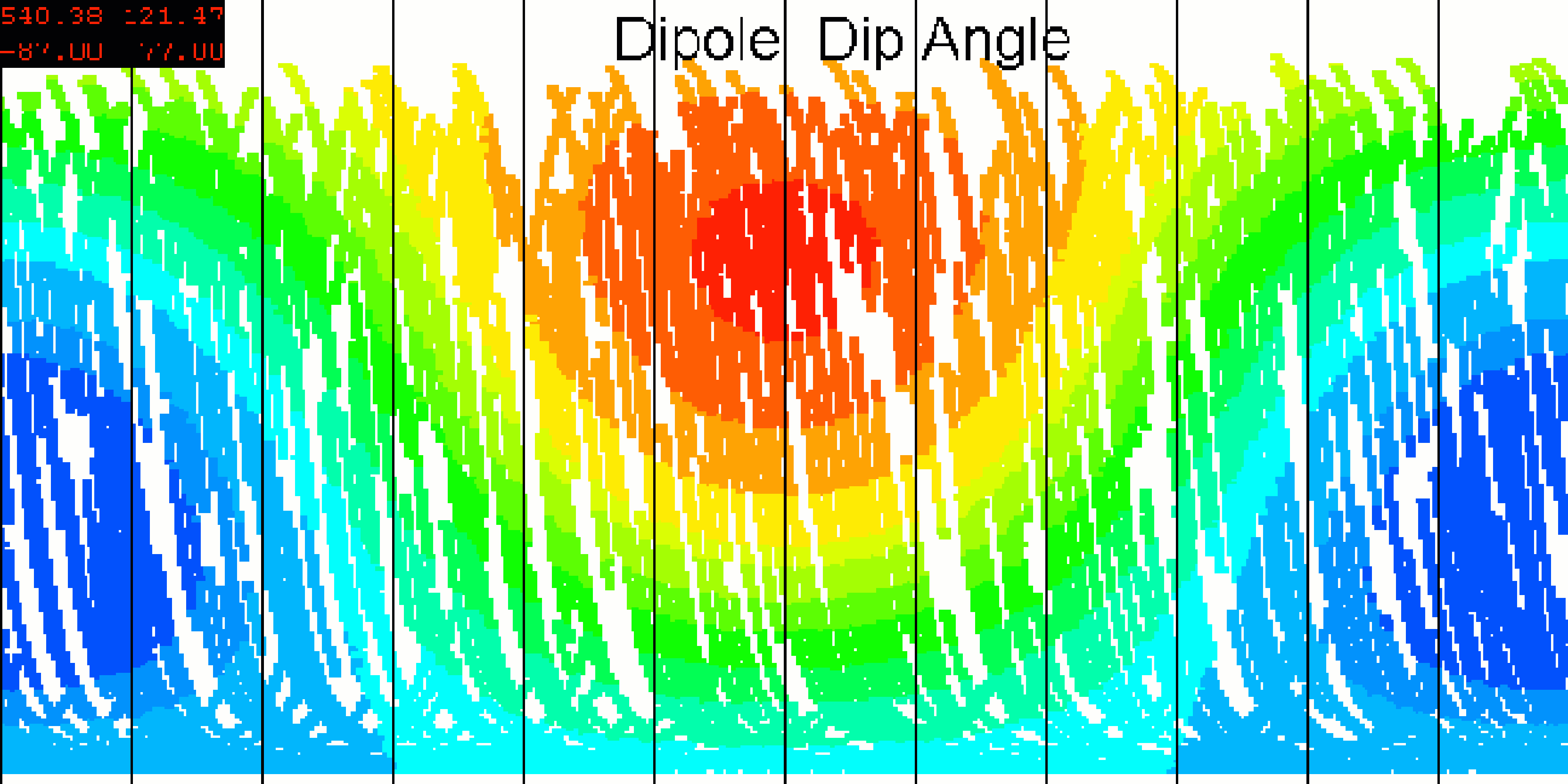
b


Scalar Potential
7,150
7,210
Equator
V
−30
fmax = + 200
fmin = −140
interval = 20
altitude = 0 km
−60
120
150
210
240
−60,94
−80,180
−60,266
Model Scalar Potential
7,150
7,210
Equator
14 Dipoles
−30
fmax = 100
fmin = −60
interval = 10
altitude = 100 km
−60
120
150
210
240
−60,94
−80,180
−60,266


Source Depth Estimation
100
80
60
40
20
0
-400
-200
0
200
400
Source depth - altitude
100./ Vmax, | Vmin |
Max
Min
Maximums:
line fit %= 99
parabola fit %= 100
Minimums:
line fit %= 86
parabola fit %= 100


7 150
Magnetic Field Bz – Sources
7 210
ntype = 1
fmax = + 130
fmin = −100
interval = 10
fhct = 30
flct = −30
Surface
−30
−60
120
150
210
240
−60 94
−80 180
−60 266

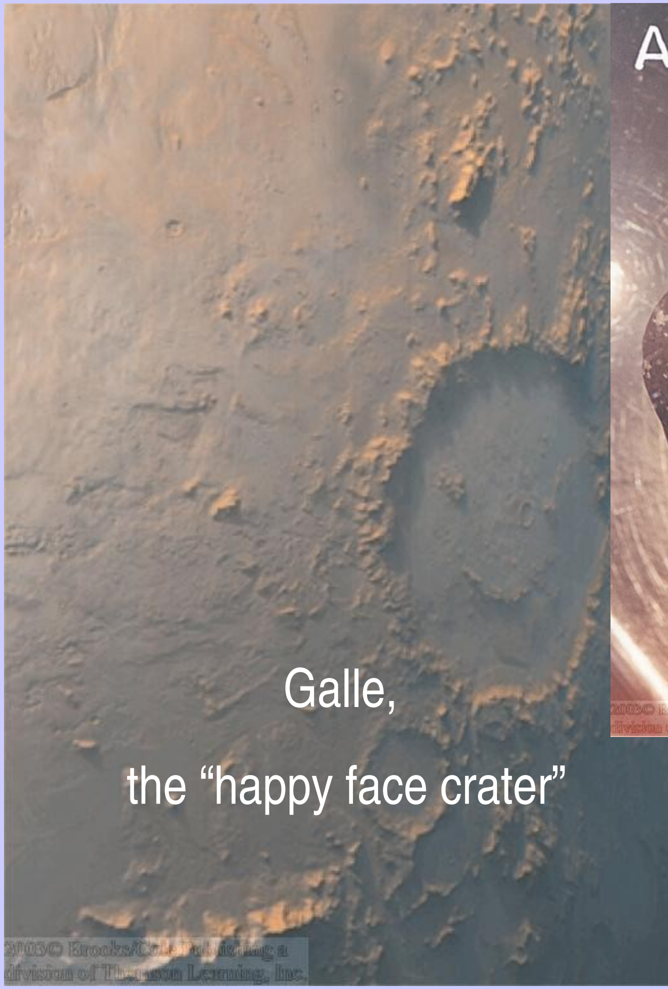




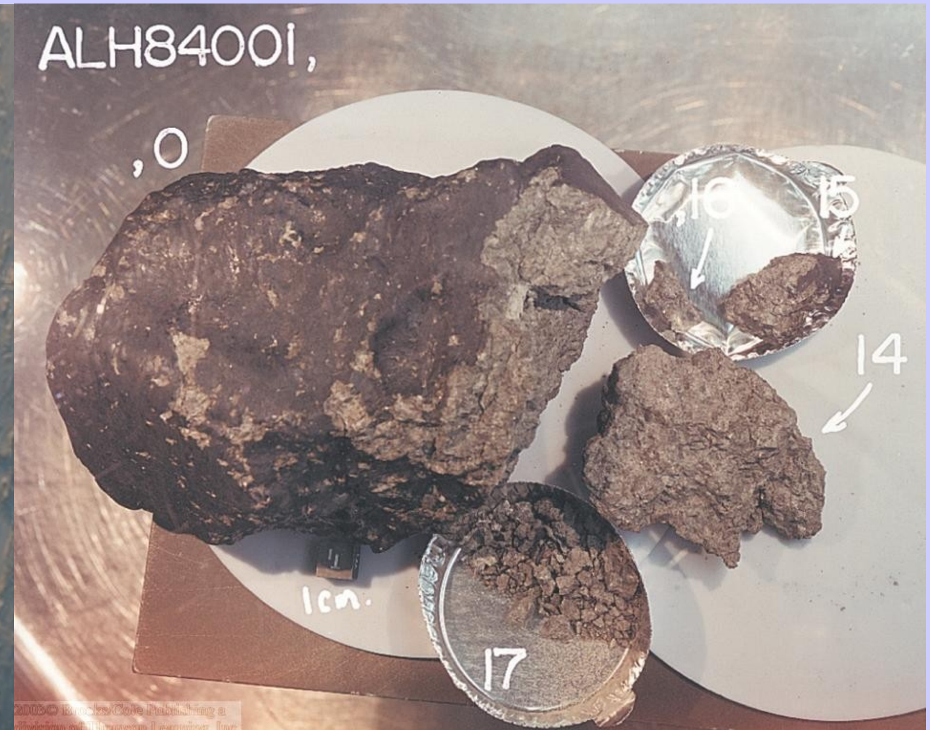
Dipole Dip Angle
540.38

Grasmere
Rw
Vv1
Vdi
V
EVATON
Q
POTCHEFSTROOM
VREDEFORT DOME
Rv
Vaal
PARYS
Zg2
Rc
Vredefort
Jd
Vredefort dome
Koppies
Koppiesdam
Pe

Evidence for Water on Mars



Large impacts may have ejected rocks into space.



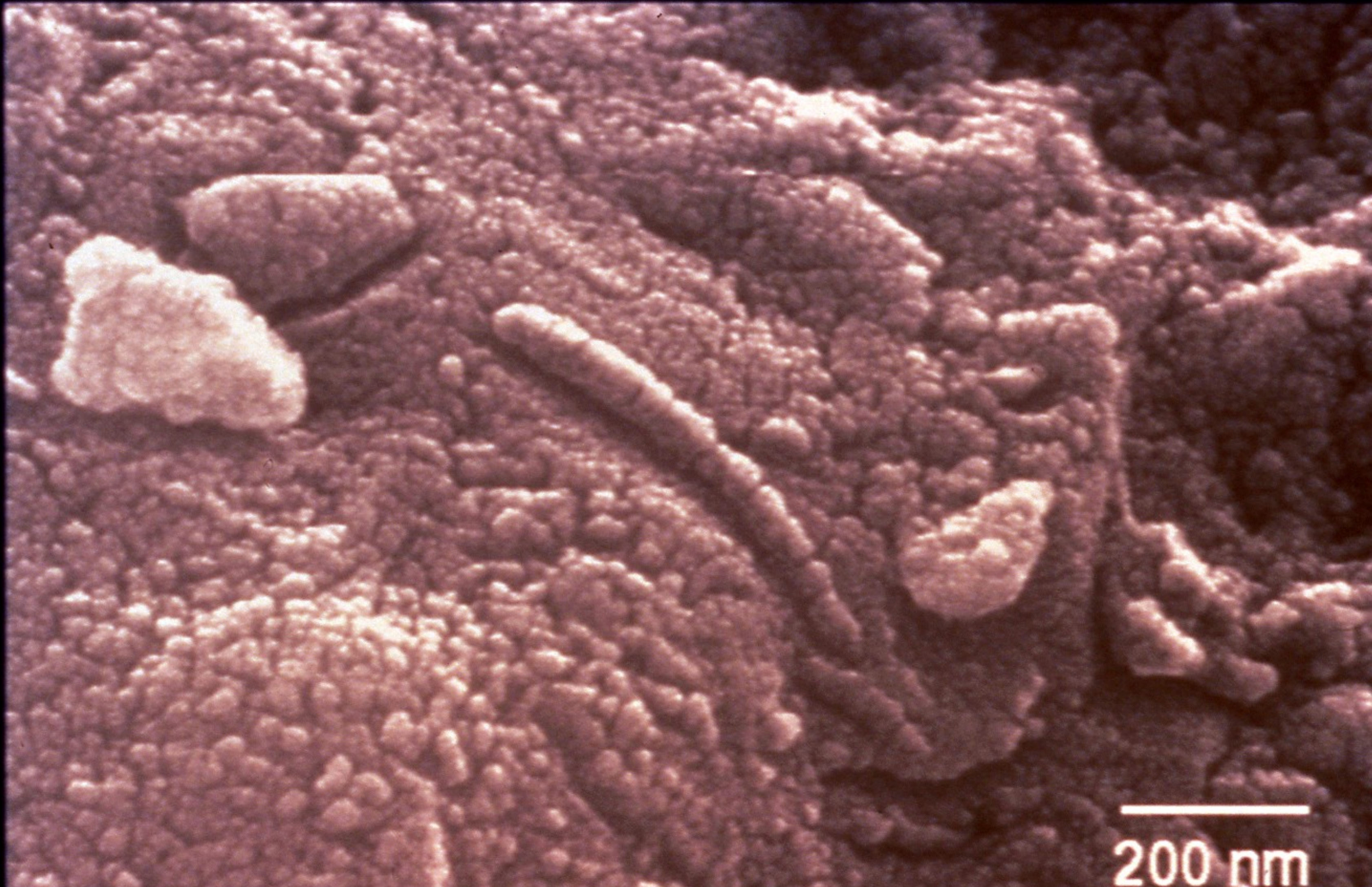
Meteorite ALH84001:

Identified as ancient rock from Mars.

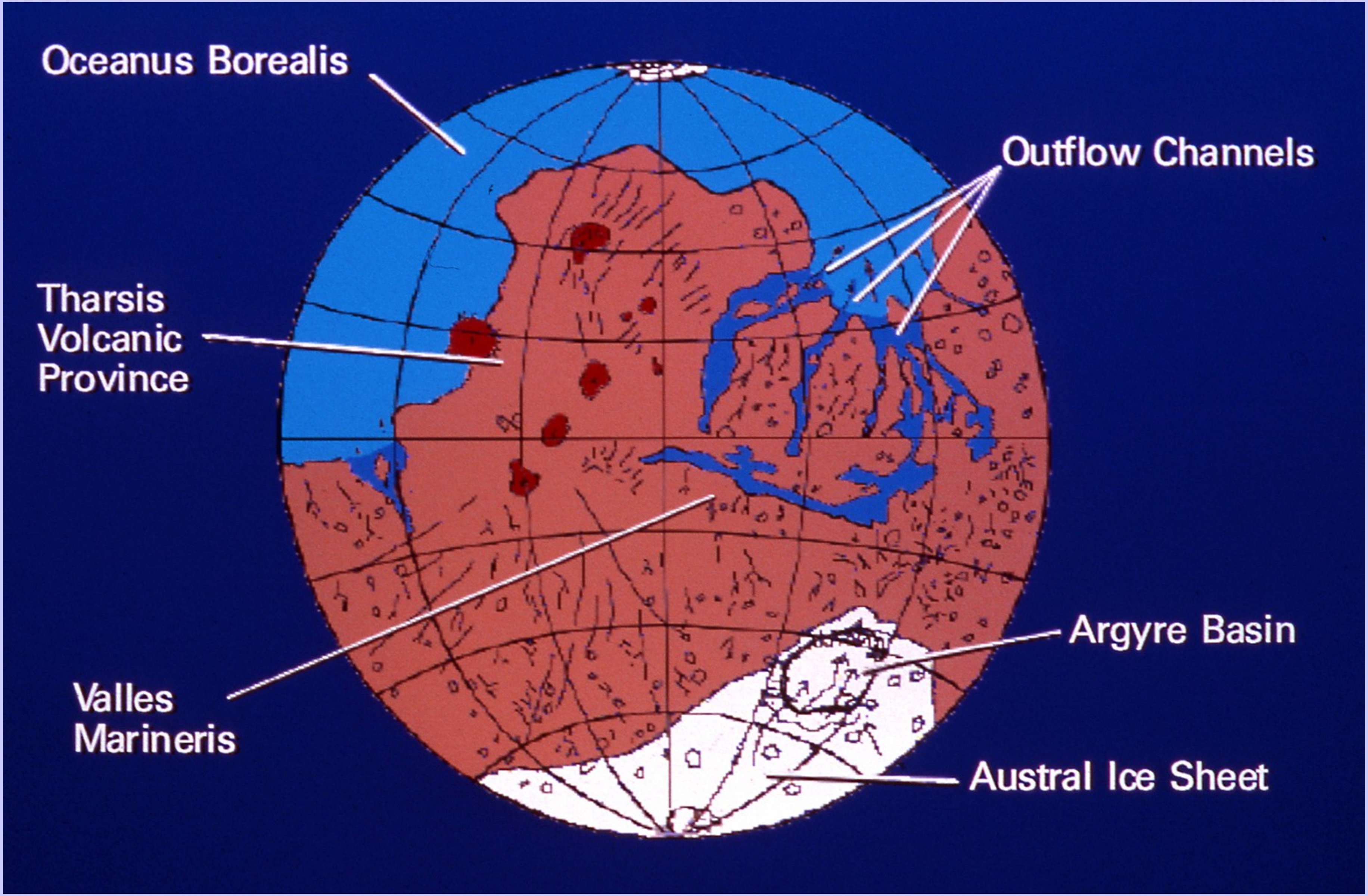
Some minerals in this meteorite were deposited in water → Martian crust must have been richer in water than it is today.

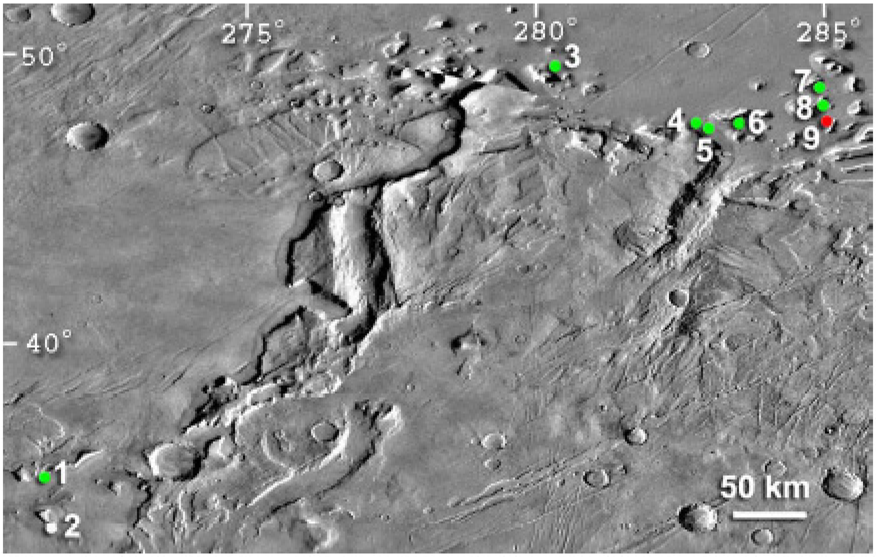

ALH84001,0
N
1 cm

ALH84001

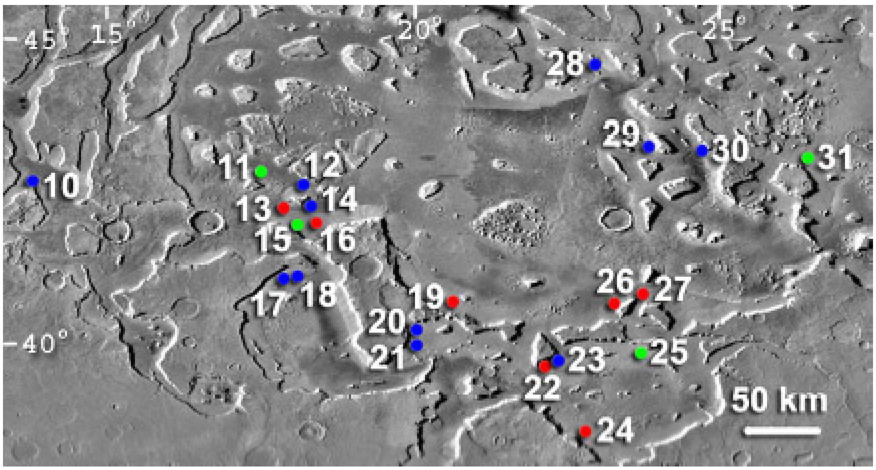



August 1999
300 m
September 2005
North
new deposit

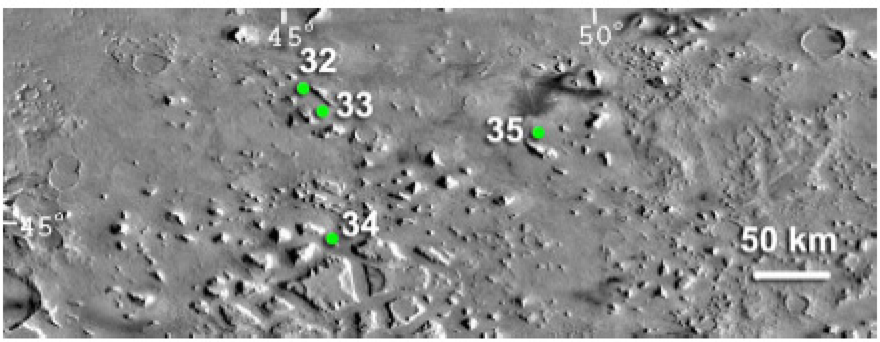

Oceanus Borealis
Outflow Channels
Tharsis
Volcanic
Province
Argyre Basin
Valles
Marineris
Austral Ice Sheet



(a)



(b)



(c)

Fig. 1. Debris aprons in (a) Mareotis Mensae (centered at 46° N, 278° E), (b) Deuteronilus Mensae (centered at 41.5° N, 20° E), and (c) Protonilus Mensae (centered at 45° N, 47.5° E). Labels indicate aprons analyzed in this study. Refer to Table 1 for the MOLA track number, location, and measurements of each debris apron. Base maps from USGS Mars Global Digital Image Mosaic (MDIM) version 2.1 with a resolution of 64 pix/degree. Map (a) is part of quadrangle MC-3 (Arcadia). Maps (b) and (c) are parts of quadrangle MC-5 (Ismenius Lacus). North is up.

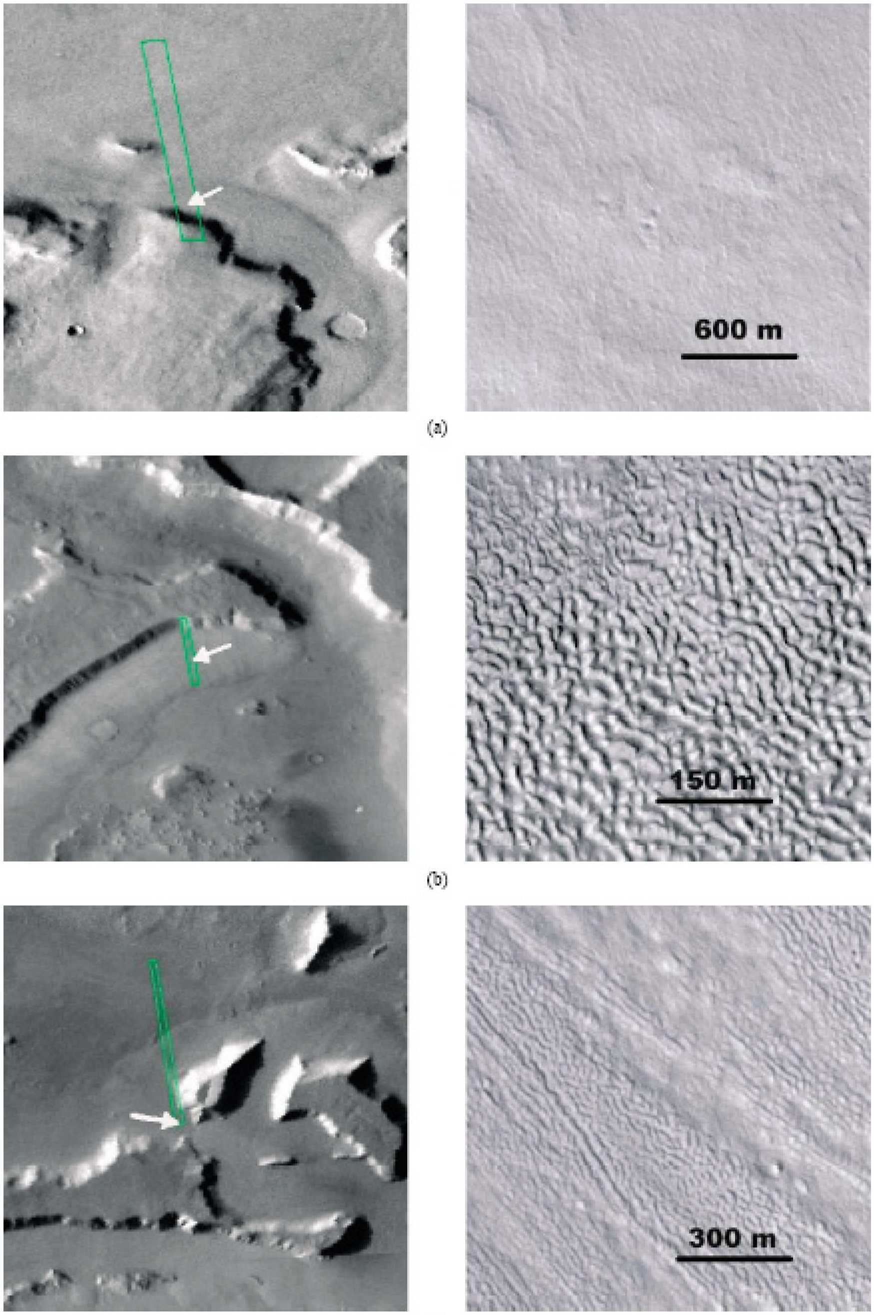


Fig. 2. Surface textures of debris aprons. Left column: MOC wide angle images as context (40 km wide), with white arrows indicating locations of narrow angle images. Right column: MOC narrow angle images showing surface textures. (a) Smooth surface texture (MOC image M0401207, 6 m/pix) may represent original apron surface; (b) pitted surface texture (MOC image FHA00877, 1.5 m/pix) may develop through ice sublimation induced collapse; (c) ridged texture (MOC image M704710, 3 m/pix). Sun is from the left. North is up.

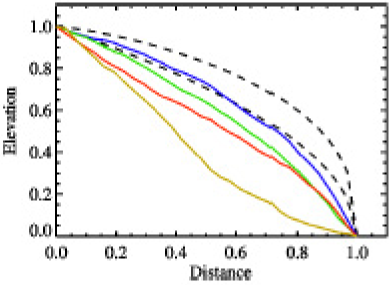


Fig. 6. Composite profiles of three types of lobate debris aprons and Valles Marineris landslide, normalized to unit length and thickness. Blue (highest solid curve) = type I ($n = 14$), green (second highest solid curve) = type II ($n = 14$), red (second lowest curve) = type III ($n = 7$), olive green (lowest curve) = Valles Marineris ($n = 3$). Lower and higher dashed lines represent simple plastic and power law model profiles, respectively.